MULTISOURCE

Urban water management scenarios developed

Deliverable 5.3

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EXECUTIVE SUMMARY

Urban water management scenarios have been developed to compare different strategies to mitigate the impact of urban flooding on cities. Each scenario allocates and dimensions the technologies to retain or pre-treat stormwater volumes at different spatial scales within the urban catchment. A detailed presentation of the scenarios is in Milestone MS15. We started the urban stormwater management scenarios for the Ecully catchment, Lyon metropolitan area, for which the results are presented in this deliverable. From the Hydraulic Disconnection Module (INSA) presented in D5.2, the estimated volumes of Combined Sewer Overflow (CSO) following several design storms, from 5 to 100 years of return period, are assumed as the target stormwater volumes to be managed. In the decentralised scenario, bio-retention cells (BRC) within the urban blocks are the scenario with Nature Based Solution (NBS). In the grey technology scenario, infiltration shafts are planned for the households. The semi-centralised scenario includes BRC in the upper sub-catchments to retain runoff volumes. In the grey technology scenario, small retention treatment basins (RTB) are located downstream of the sub-catchments at the main sewer junctions to retain the runoff volumes mixed with wastewater collected from the combined sewers. For the centralised scenario, the constructed wetland (CW) is dimensioned and located directly at the CSO discharge location. In the equivalent grey scenario, a large RTB is sized using general rules for grey infrastructure dimensioning.

With the aim to compare the developed scenarios, each targets the same volume reduction in urban runoff volume based on the CSO spill resulting from storm design events with 5 to 100-year return periods. This way, the scenarios are comparable and will be evaluated according to their project costs and co-benefits. Future activities involve a life-cycle cost assessment (LCCA), for which the implementation of the cost functions foresee the collaboration with data from the pilots (WP1) and cost databases (WP3). At the same time, environmental impact and co-benefits will be gained from the linkages with the Technology Selection Tool (WP4). The evaluation and ranking of the presented scenarios will be detailed in the final deliverable *D5.5 - Urban water management scenarios ranked* (M48). Specific scenarios for other MULTISOURCE municipalities will be presented and discussed within the final stage of the project.

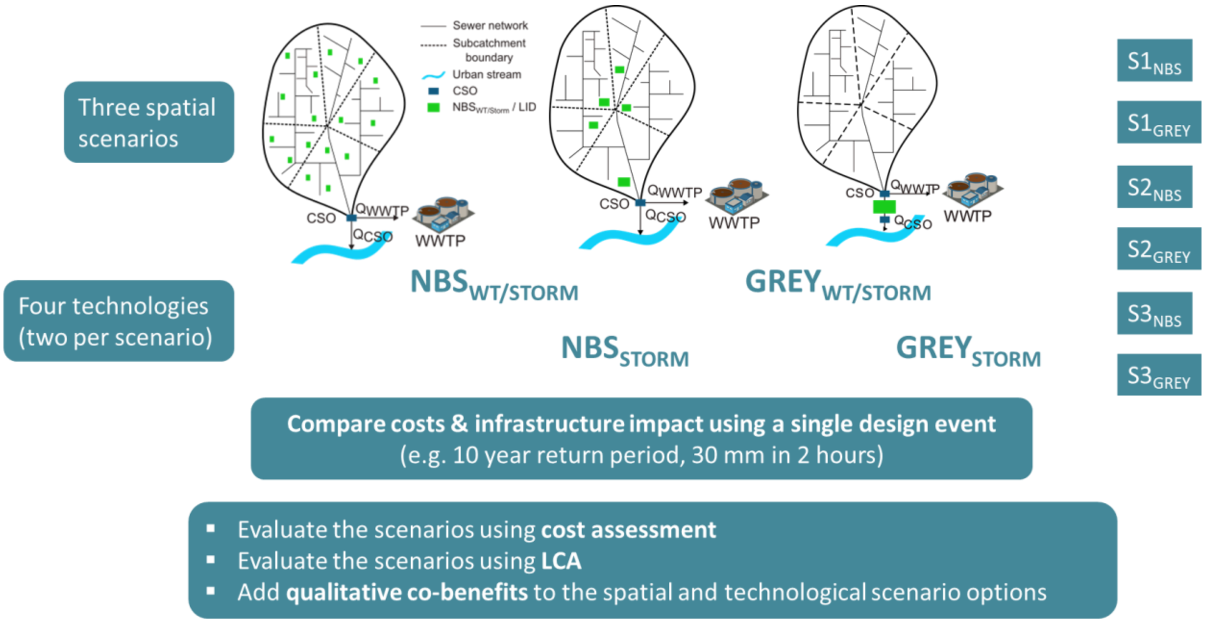
1.0 OVERVIEW OF THE SCENARIOS

The scenarios developed at the Helmholtz Centre for Environmental Research (UFZ) are a product of the WP5 - Planning Platform. The management of urban stormwater is crucial to increase resilience of European cities, requiring investment in the modernisation and expansion of the sewer system. The implementation of green-blue infrastructures and the adoption of integrated stormwater management strategies for sustainable urban drainage are necessary to mitigate the impacts of urban flooding. Currently, in many European cities, the combined sewer system is overloaded due to urban floods, leading to combined sewer overflow (CSO) and untreated sewage and stormwater being discharged directly into water bodies. Retaining urban runoff volumes and thus relieving the pressure in sewers reduces the frequency and severity of CSO events, minimising pollution in river bodies and protecting the environment. Urban stormwater management scenarios can provide decision-makers with a range of strategies to achieve this objective.

These strategies include options such as disconnecting rainwater volumes from the main sewer by using decentralised solutions instead of traditional centralised ones. Decentralised strategies intercept impervious runoff and convey it within the urban blocks, ensuring that road runoff is excluded and therefore, no specific treatment is required for this type of runoff apart from sediment trapping. On the other hand, centralised strategies involve the retention of stormwater and untreated wastewater, which requires at least pre-treatment directly at the location of the CSO, thus at the catchment outlet. Semi-centralised strategies are instead implemented at the sub-catchment level.

For these reasons, the scenarios can be implemented with the following technologies: in the decentralised scenario, bio-retention cells (BRC) as nature-based solution (NBS) and infiltration shafts (IF) as grey solution are planned at the block-level. The semi-centralised scenario has always BRC in the upper sub-catchments as nature-based solution to retain runoff volumes, while as grey-technology, small retention treatment basins (RTB), are located downstream of the sub-catchments at the main sewer junctions to retain the runoff volumes mixed with wastewater from the combined sewers. For the centralised scenario, the constructed wetland for Combined Sewer Overflow (CSO-CW) is the nature-based solution to treat the water from the CSO, while in the equivalent grey scenario, a large RTB is used for CSO pre-treatment. A conceptual summary of the urban stormwater management scenarios is reported below in Figure 1.1, and details on the technologies in the scenarios are reported in Fig. 1.2.

Figure 1.1 Urban Stormwater Scenarios developed within the WP5 - Planning Platform.



Three spatial scenarios

Four technologies (two per scenario)

$\text{NBS}_{\text{WT/STORM}}$

$\text{GREY}_{\text{WT/STORM}}$

$\text{NBS}_{\text{STORM}}$

$\text{GREY}_{\text{STORM}}$

$S1_{NBS}$

$S1_{GREY}$

$S2_{NBS}$

$S2_{GREY}$

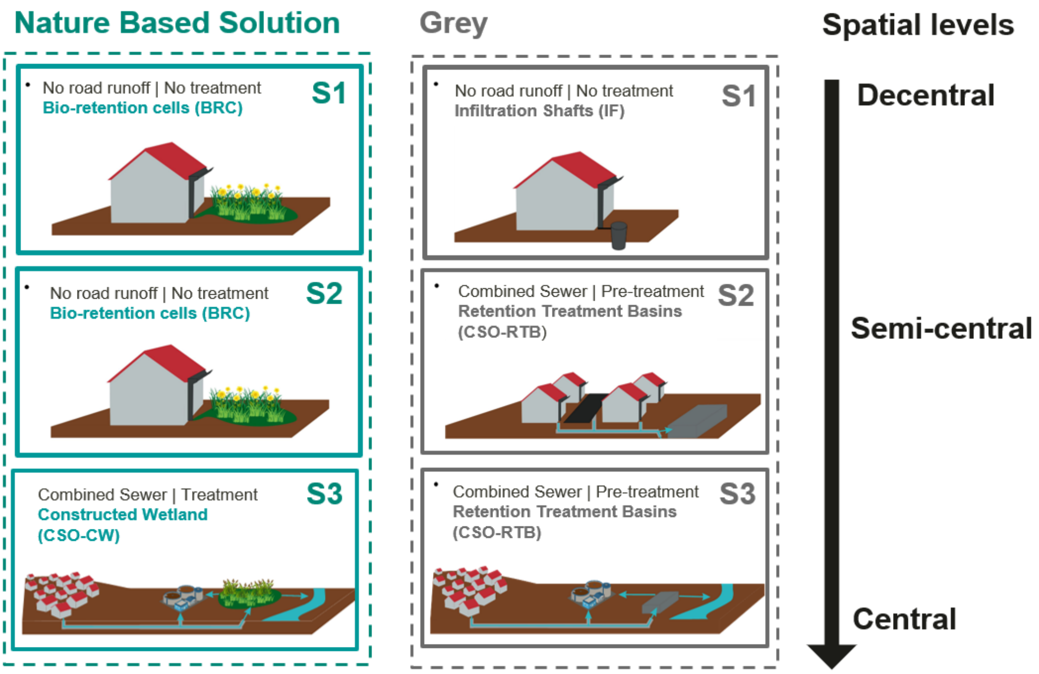
$S3_{NBS}$

$S3_{GREY}$

Compare costs & infrastructure impact using a single design event
(e.g. 10 year return period, 30 mm in 2 hours)

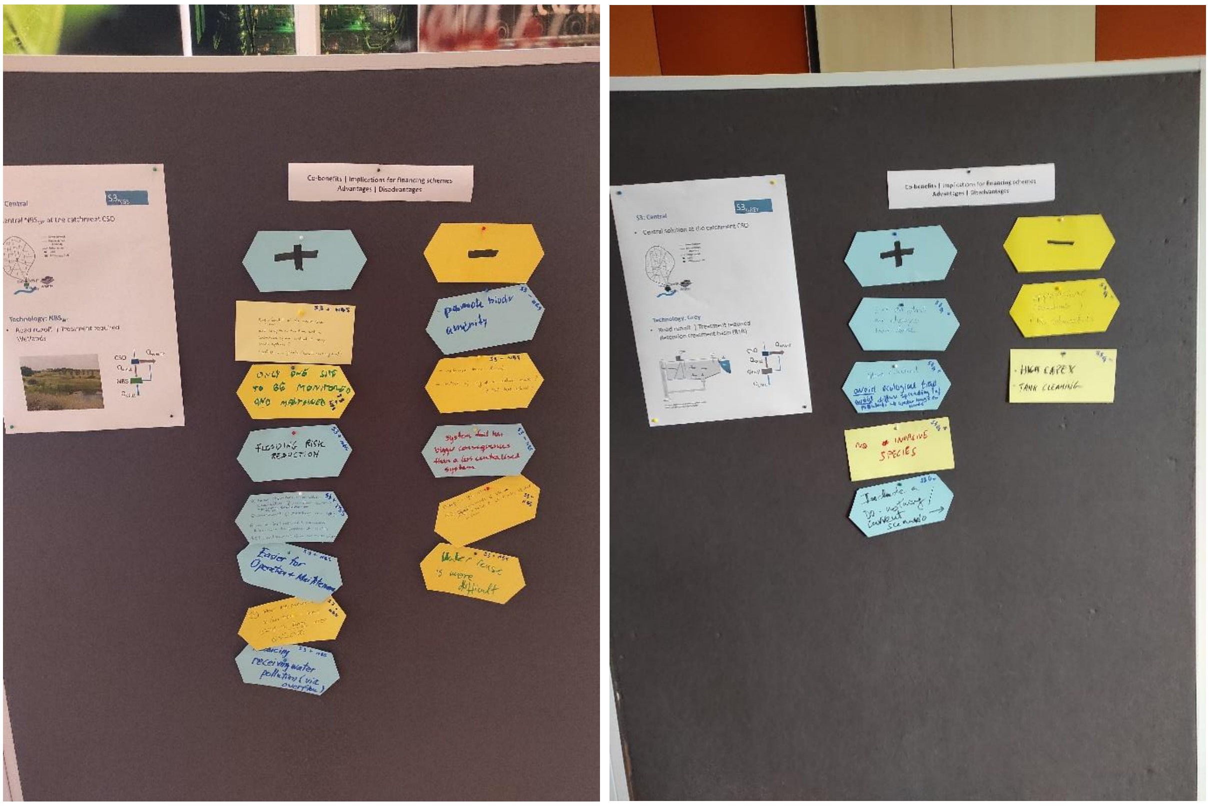
- Evaluate the scenarios using **cost assessment**
- Evaluate the scenarios using **LCA**
- Add **qualitative co-benefits** to the spatial and technological scenario options

Figure 1.2 Technologies used for the urban stormwater management scenarios



During the Annual Meeting in Leipzig in 2023, MULTISOURCE participants were asked to outline the advantages and disadvantages of decentralised/centralised and NBS/grey scenarios during the dedicated WP5 workshop (Fig. 1.3). Different co-benefits, implications for financing schemes and maintenance liability can arise depending on the spatial scale and the location of intervention. The main highlighted points between decentralised and centralised scenarios are presented in the following paragraphs: 1.1 Decentralised scenarios and 1.2 Semi- and centralised scenarios.

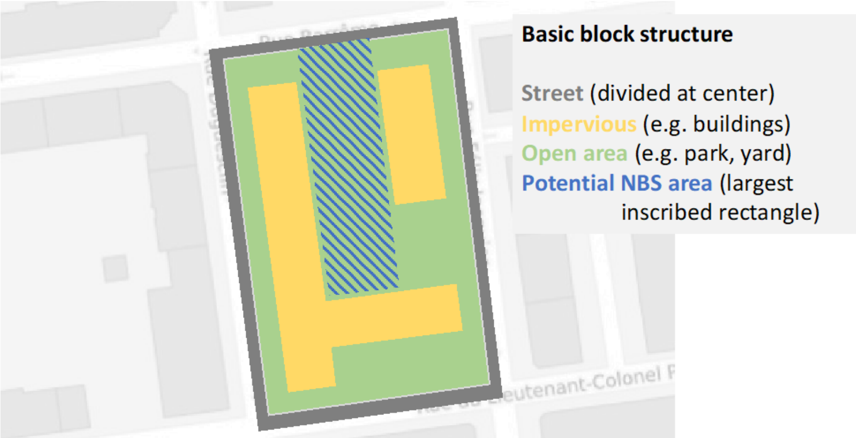
Figure 1.3 WP5 workshop of the Annual Meeting in Leipzig 2023 on the urban stormwater management scenarios.



1.1 Decentralised scenarios

The decentralised scenario focuses on capturing and treating storm runoff at the block level. The block is the smallest functional unit in the urban environment, delimited by traffic roads. The urban block is a fundamental component of urban design and planning, serving as the building unit for space organisation. It has been described thoroughly in D5.1 "Urban Archetype Maps". A conceptual illustration is reported in Fig. 1.4.

Figure 1.4 : Schematic block-level structure, used to plan decentralised scenarios.



The block level is the relevant scale for planning decentral solutions. Decentralised scenarios have the benefit that smaller units are easier to integrate within the urban texture, fitting more harmoniously with the surrounding built environment. The runoff from the roofs can be reused locally for irrigation or slowly infiltrated into the ground. Decentralised scenarios provide the opportunity for community engagement by involving local residents within the urban blocks. The co-management of green spaces can encourage social interaction and cohesion through recreational activities, even empowerment. Moreover, NBS solutions enhance the urban area's biodiversity and provide the well-known benefits of green spaces, such as regulating temperature and improving air quality.

On the other side, the involvement of multiple stakeholders and private land-owners in this scenario requires dedicated, innovative business models for long-term financing and O&M. Conflicts might arise over disagreements on who benefits most from the green area or who should bear most of the financial burden. Managing a large number of decentralised sites for urban stormwater can be resource-intensive and require ongoing maintenance to ensure the system's longevity. In economically disadvantaged or marginalised communities, decentralised sites can be more susceptible to neglect or abandonment. Another important aspect to consider for business models, is that decentralised sites may span multiple properties owned by private individuals or different entities, this can potentially complicate decision-making, leading to conflicts over access rights and management responsibilities. Moreover, the implementation of NBS is restricted to the available green area within the urban environment, which can be a limitation in achieving targeted stormwater volume reductions or ecosystem benefits. On the other side, implementing smaller grey-distributed infrastructure is not limited to the existing green space but has higher capital expenses than larger-scale grey solutions.

1.2 Semi- and centralised scenarios

The semi-centralised scenario for urban stormwater management targets reducing runoff volumes at the urban sub-catchment level, while the centralised scenario foresees installing the urban stormwater technology at the CSO discharge point to derive the entire volume for pre-treatment. Centralising stormwater systems can reduce dependencies on multiple stakeholders, thereby making governance easier. Conventional partnerships can still apply within a centralised stormwater management system, facilitating collaboration between the public and private sectors. Moreover, centralised and semi-centralised scenarios offer advantages with respect to decentralised ones in terms of easier control for operation and maintenance. Centralised systems can be implemented and managed entirely within the existing wastewater treatment plant (WWTP) area, having dedicated staff with high expertise levels. This means reduced travel time and faster response to maintenance, ensuring the long-term functionality of the system. Centralised systems are also more likely to achieve their objectives in the long term through centralised management, monitoring and early detection of breakdowns, although a system failure means a greater impact than decentralised systems.

Conversely, NBS centralised systems require more available land for implementation at one location, and the co-benefits remain outside the urban area, namely biodiversity, temperature regulation and potential for local water reuse. Grey infrastructures offer more control by pollution management, avoiding the creation of an ecological trap and habitats for invasive species. Despite grey infrastructures being the most traditional approach and often chosen because of previous experience, initial investment costs can be high.

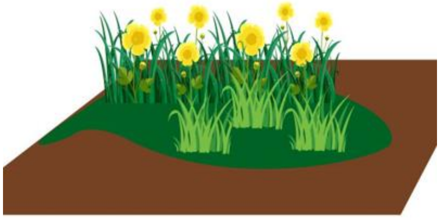
2.0 TECHNOLOGIES OF THE SCENARIOS

The four technologies implemented within the six scenarios are illustrated in the paragraph below, and the design parameters characterising the technology are reported in tables. The main result of each scenario will be (1) the location and (2) dimensioning of the related technologies. Through the linkage to the Technology Selection Tool (WP4), there will the possibility to replace a technology with another one that conforms to the user's needs, or determine the relative scores for the environmental, social or operational criteria.

2.1 Bio-Retention Cell (BRC)

Bio-retention cells are landscape depressions composed of a ponding zone with plants and soil, an engineered filter media and a storage layer that allows drainage to the underlying soil. The design parameter values of the Bio-retention cell in Table 2.1 are taken from Khurelbaatar et al. (2021). Within the generation of the scenarios, the layered depths and materials of the NBS are kept constant, while only the surface parameter is varied based on the incoming inflow from the sealed surfaces to adapt the capacity. The sizing of the bio-retention cell is limited to the NBS potential area, given the maximum connected open area within the block. This is determined by geospatial data within the *Block Module* in the Planning Platform, as largely described in Sec. 1.1.1 from *MS17 - Software structure & links to tools*. The sizing of the bio-retention cells determines the stormwater volumes that can be retained at the block-level without entering the sewer network. Based on the rainfall time series, the hydrographs generated from the impervious surfaces are computed for the individual blocks, and the bio-retention cells are sized based on the flux that the soil layer is able to infiltrate, given the maximum surface storage volume. The design parameters and material properties of the NBS layers ensure that the sizing criteria based on the maximum surface retention also fulfil the storage volume requirements.

Figure 2.1 Bio-Retention cell



The following parameters have been implemented for this technology:

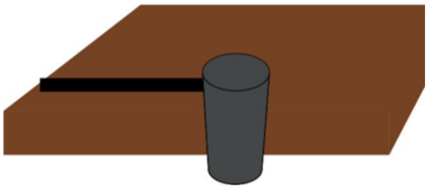
Table 2.1 Design Parameters for the Bio-Retention Cell

Design Parameter	Value
Depth surface layer (m)	0.25
Thickness soil layer (m)	0.3
Thickness storage layer (m)	1
Hydraulic Conductivity of the soil layer (mm/h)	145.91
Porosity of the soil layer	0.45
Porosity of the storage layer	0.35
Soil textural class:	Soil layer = Loamy Sand; Storage = Gravel

2.2 Infiltration Shaft (IF)

Infiltration shafts are typically constructed by excavating a vertical shaft into the ground and lining it with materials, such as concrete, to prevent collapse. The shaft is filled with coarse gravel or other permeable materials to facilitate water infiltration into the surrounding soil and aquifer. These technologies can be located next to residential developments to convey the runoff from the household roofs. Within this functionality and to allow max capacity, a gravel layer of 20 cm at the bottom is assumed for the scenario. The main parameters are taken from Khurelbaatar et al. (2021). Within the scenario, starting from a minimum of 1 m diameter, several sizes of infiltration shafts can be allocated with an increase of 500 litres per capacity, which is in line with the models of infiltration shafts available on the market. Spatial constraints that could constrain the implementation of infiltration shafts within the blocks are not considered.

Figure 2.2 Infiltration Shaft



The following parameters have been implemented for this technology:

Table 2.2 Design Parameters for the Infiltration Shaft

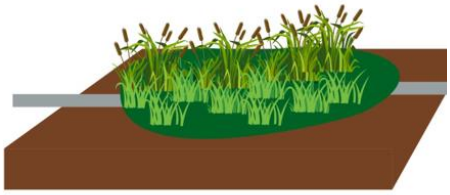
Design Parameter	Value
Depth Infiltration Shaft (m)	2
Minimum Diameter (m)	1
Thickness drainage layer (m)	0.20
Porosity of the drainage layer	0.35

2.3 Constructed Wetland (CW)

Constructed wetlands are designed to improve water quality through natural processes provided by wetland vegetation, soil and microorganisms. For this scenario, the designated type would be a CSO-constructed wetlands, which are designed to retain high volumes and mitigate the environmental impacts of combined sewer overflows. This constructed wetland should be located in proximity to the CSO location. The CSO-CW removes pollutants such as suspended solids, nutrients, pathogens and organic matter before the water is discharged into the receiving water body.

The design parameters for CSO-CW in Table 2.3 are derived from Meyer et al. (2012), taking the common values for the Italian and French CSO-CW. For the scenario implementation, the beds are assumed to be filled in parallel for extreme events, in compliance with what reported in the surveyed CSO-CW. Thus, the subdivision of the number of beds, four for the Italian and two for the French CSO-CW, is not relevant when handling high volumes with diluted concentrations of pollutants.

Figure 2.3 Constructed Wetland



The following parameters have been implemented for this technology:

Table 2.3 Design Parameters for the CSO-Constructed Wetland

Design Parameter	Value
Max ponding depth (m)	0.8
Filtration Layer depth (m)	0.6
Filtration Layer material	Gravel
Saturated Layer depth (m)	0.2
Saturated Layer material	Gravel
Porosity Gravel	0.35
Max. hydraulic loads ($m^3/m^2/year$)	40-120
Outflow rates (L/m^2s)	0.02

2.4 Retention Treatment Basin (RTB)

A Retention Treatment Basin, or also indicated as CSO-Tank, is a concrete storage tank containing the spill from the combined sewer system that would otherwise be released into the receiving water body. RTB systems are composed of a long sedimentation chamber and a bypass overflow for higher inflows. Once the sewer system gains flow capacity again, the tank slowly releases the water back into the sewer system. As reported in the CSO technology fact sheet for RTB from EPA, rectangular-shaped basins are the most cost-effective in terms of construction and maintenance. The design parameter values below in Table 2.4 are taken from RTBs in Germany (Brombach et al., 2008). Also in this case, the RTB technology should be placed at the location of the CSO.

Figure 2.4 Retention Treatment Basin

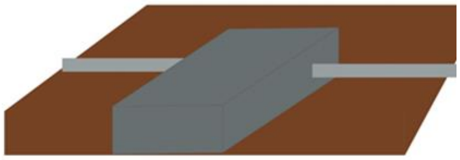


Table 2.4 Design Parameters for the Retention Treatment Basin

Design Parameter	Value
Storage Volume (m^3)	CSO spill
Basin Shape	Rectangular
Depth (m)	2.30
Length/Width	4
Emergency spill	yes

3.0 DEVELOPED SCENARIOS FOR THE ECULLY CATCHMENT

This section shows how the urban stormwater management scenarios are implemented for the study case of the Ecully catchment, in the Lyon metropolitan area, by spatially allocating and sizing technologies to retain or pre-treatment stormwater volumes within the urban catchment, from simulated extreme storm design events with return periods from 5 to 100 years. Evaluating scenarios for different design storms is a critical part of the planning process. This approach allows a meaningful comparison of options by considering storms with different probabilities of occurrence, such as a 10-year storm (10% probability of occurrence) or a 100-year storm (1% probability of occurrence). By analysing scenarios for design storms, engineers and planners can effectively assess risk and ensure that the stormwater system is designed to handle expected extreme weather events.

3.1 Target volume reduction

As defined in the Milestone MS15 – *Baseline Scenarios*, the urban water management scenarios must have a comparable target volume. Namely, each decentralised\centralised scenario with the related technology solution is designed toward a targeted reduction in stormwater volume, using storm design events from 5 to 100-year return periods (yT). The generation of extreme design events and synthetic rainfall time series is explained in detail in *MS17 - Software structure & links to tools*. For the Ecully Catchment, the Combined Sewer Overflow (CSO) spill is the target volume to be retained within the urban catchment. For each synthetic rainfall of 2 hours duration and associated return period T, constituting the extreme storm design event, the CSO spill discharge was simulated by INSA through their Hydraulic Disconnection Module (HDM) calibrated for the Ecully Catchment. More details about the hydraulic-hydrological model is reported in *MS16 Disconnection module.*

Figure 3.1 Data Exchange between UFZ and INSA to determine CSO spill volumes (Q_{up_CSO}) in output from the HDM (INSA) simulations given the rainfall time series Rain (2h, T) from the design storms.

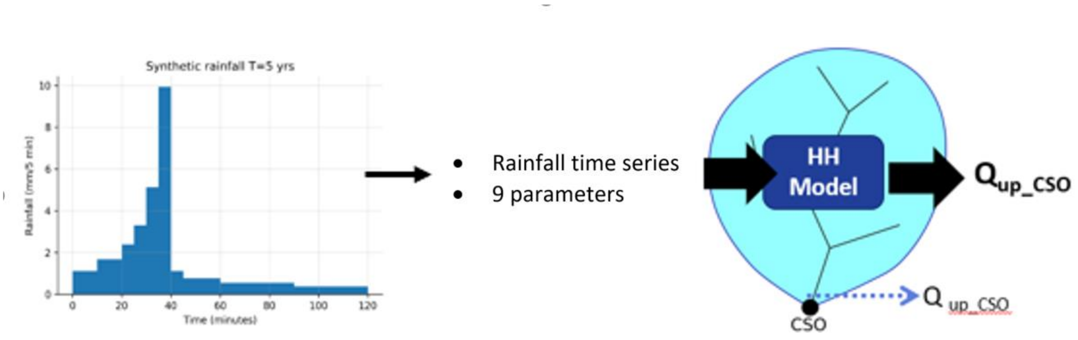


Figure 3.2 Simulation results of the CSO outflow from the HDM (INSA) given the synthetic rainfall time series for the design storm events 5yT and 100yT.

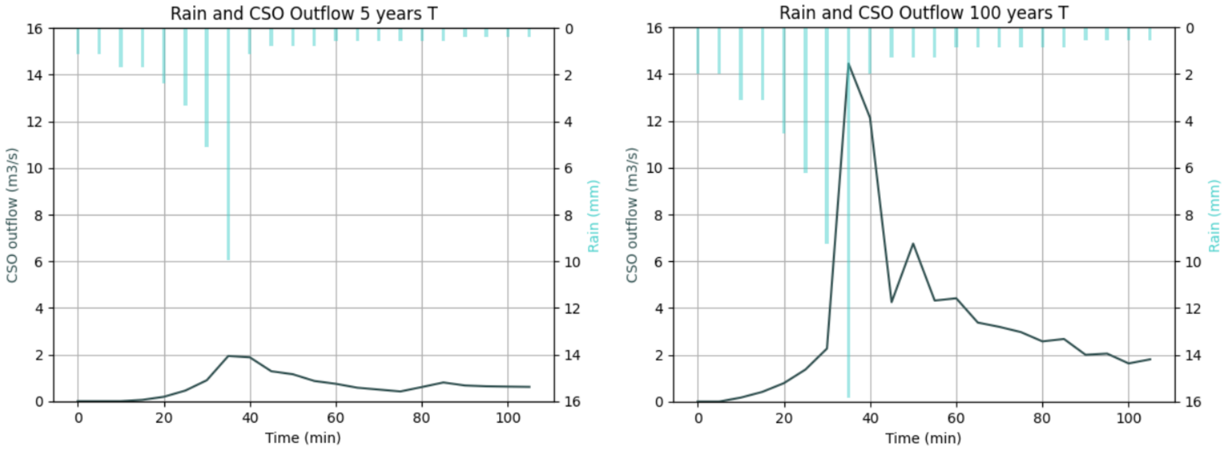


Table 3.1 Cumulated values in output from the HDM (INSA) for the CSO spill volume

Design Storm Event	Rain(2h,5T)	Rain(2h,10T)	Rain(2h,20T)	Rain(2h,30T)	Rain(2h,50T)	Rain(2h,100T)
Volume Outflow (m^3)	10102	14913	19642	22370	25783	30391
Volume CSO spill (m^3)	4832	8817	13039	15530	18683	22985

3.2 Decentralised Scenario with NBS technology

The decentralised scenario with NBS technologies is illustrated in this paragraph. The bio-retention cells are sized based on the runoff volume from the sealed surfaces within the blocks. The sites shown in Table 3.2 are prioritised by the quantity of generated runoff and the surrounding available NBS potential area. Locations are selected within the urban catchment until the total volume retention meets the CSO target defined in Table 3.1. Within the tables below, divided into extreme design storms events, the resulting blocks-ID for the intervention, the sizing, and the retained volume for the designed NBS are reported.

Next to the table, it is shown the map of the Ecully Catchment, illustrating the spatial distribution of the bio-retention cells technologies generated by the Planning Platform for the design storm.

Table 3.2 5-year return period

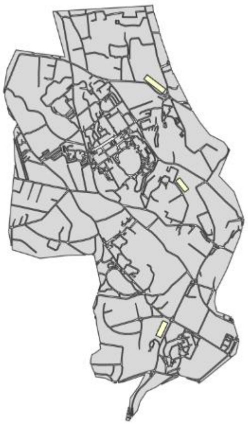
	ID_block	NBS_area_5yT (m^2)	VolRet_5yT (m^3)	
BioRetCell	290	5242.55	2709.45	
BioRetCell	40	3789.35	1628.25	
BioRetCell	156	3051.56	1311.23	
SUMMARY		Tot Area (m^2)	Tot Volume retained (m^3)	
		12083.46	5648.93	

Table 3.2.a 10-year return period

	ID_block	NBS_area_10yT (m^2)	VolRet_10yT (m^3)	
BioRetCell	290	5242.55	2709.45	
BioRetCell	40	4548.97	1937.58	
BioRetCell	156	3663.27	1560.33	
BioRetCell	285	3183.27	1355.88	
BioRetCell	51	3100.93	1320.80	
SUMMARY		Tot Area (m^2)	Tot Volume retained (m^3)	
		19738.98	8884.03	

Table 3.2.b 20-year return period

	ID_block	NBS_area_20yT (m^2)	VolRet_20yT (m^3)	
BioRetCell	40	5242.55	2709.45	
BioRetCell	290	5301.93	2244.67	
BioRetCell	156	4212.76	1804.96	
BioRetCell	285	3710.18	1570.78	
BioRetCell	228	3590.80	1520.23	
BioRetCell	51	3295.31	1515.14	
BioRetCell	48	2471.49	1277.31	
BioRetCell	11	2883.40	1247.35	
SUMMARY		Tot Area (m^2)	Tot Volume retained (m^3)	
		30708.41	13889.89	

Table 3.2.c 30-year return period

	ID_block	NBS_area_30yT (m^2)	VolRet_30yT (m^3)	
BioRetCell	40	5746.24	2426.08	
BioRetCell	290	5242.55	2709.45	
BioRetCell	156	4212.76	1932.83	
BioRetCell	285	4021.10	1697.72	
BioRetCell	228	3891.72	1643.09	
BioRetCell	51	3295.31	1622.48	
BioRetCell	48	2883.40	1335.72	
BioRetCell	11	2471.49	1277.31	
BioRetCell	151	2359.15	1219.25	
SUMMARY		Tot Area (m^2)	Tot Volume retained (m^3)	
		34123.71	15863.94	

Table 3.2.d 50-year return period

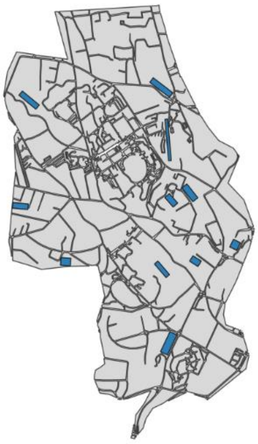
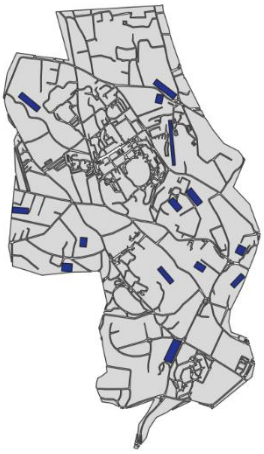
	ID_block	NBS_area_50yT (m^2)	VolRet_50yT (m^3)	
BioRetCell	40	5242.55	2709.45	
BioRetCell	290	6313.50	2657.86	
BioRetCell	285	4212.76	2092.83	
BioRetCell	228	4418.06	1859.92	
BioRetCell	156	4275.90	1800.07	
BioRetCell	51	3295.31	1703.08	
BioRetCell	78	2883.40	1446.29	
BioRetCell	48	2471.49	1277.31	
BioRetCell	157	3015.99	1269.67	
BioRetCell	11	2359.15	1219.25	
BioRetCell	151	2834.81	1193.40	
SUMMARY		Tot Area (m^2)	Tot Volume retained (m^3)	
		41322.91	19229.14	

Table 3.2.e 100-year return period

	ID_block	NBS_area_100yT (m^2)	VolRet_100yT (m^3)	
BioRetCell	40	6590.63	2948.92	
BioRetCell	290	5242.55	2709.45	
BioRetCell	285	4212.76	2177.24	
BioRetCell	228	4968.60	2085.05	
BioRetCell	156	4808.72	2017.96	
BioRetCell	78	3295.31	1703.08	
BioRetCell	51	2883.40	1490.20	
BioRetCell	157	3391.81	1423.36	
BioRetCell	48	3188.05	1337.85	
BioRetCell	13	2471.49	1277.31	
BioRetCell	11	2359.15	1219.25	
BioRetCell	151	2755.45	1156.32	
BioRetCell	68	2190.64	1132.16	
BioRetCell	274	2022.12	1045.07	
SUMMARY		Tot Area (m^2)	Tot Volume retained (m^3)	
		50380.67	23723.24	

3.3 Decentralised scenario with grey technology

The infiltration shafts are distributed within the blocks by sizing them from the minimum diameter of 1 m, and by allocating the number of infiltration shafts homogeneously along the blocks of the urban catchment, consistently accounting for the runoff generated within the blocks. An increment of 500 litres per capacity of the infiltration shaft is assumed for the planning. The blocks with sealed surfaces of less than 50 m^2 have been excluded, since they would generate for a 5yT storm event a runoff volume below the capacity of an infiltration shaft with a minimum 1 m diameter. The results from the Planning Platform for the 5-year and 100-year return period scenarios are shown below. Within the Ecully map, the sized infiltration shafts are located at the centroid of the block, only for visualisation purposes. The optimal redistribution of infiltration shaft numbers and relative capacity should be further discussed. The Tables 3.3a and 3.3.b show the information related to the first 15 blocks. The shafts are distributed in the 5 and 100 year return periods between 167 blocks, following the above described criteria.

Table 3.3.a 5 years return period

	ID_block	InfShaft_area_5yT (m^2)	VolRet_5yT (m^3)	
InfShaft	0	21.5	43	
InfShaft	1	21.5	43	
InfShaft	2	21.5	43	
InfShaft	3	1.75	3.5	
InfShaft	4	21.5	43	
InfShaft	5	1.25	2.5	
InfShaft	6	11.75	23.5	
InfShaft	7	21.5	43	
InfShaft	8	21.5	43	
InfShaft	10	1	2	
InfShaft	11	21.5	43	
InfShaft	12	21.5	43	
InfShaft	13	21.5	43	
InfShaft	14	21.5	43	
InfShaft	15	14.25	28.5	
	…	…	…	
SUMMARY		Tot Area (m^2)	Tot Volume retained (m^3)	
		2429.5	4859	

Table 3.3.b 100 years return period

	ID_block	InfShaft_area_100yT (m^2)	VolRet_100yT (m^3)	
InfShaft	0	45.75	91.5	
InfShaft	1	134.75	269.5	
InfShaft	2	167.5	335	
InfShaft	3	3	6	
InfShaft	4	168.75	337.5	
InfShaft	5	1.75	3.5	
InfShaft	6	19.75	39.5	
InfShaft	7	168.75	337.5	
InfShaft	8	168.75	337.5	
InfShaft	10	1.75	3.5	
InfShaft	11	168.75	337.5	
InfShaft	12	39.5	79	
InfShaft	13	168.75	337.5	
InfShaft	14	130.25	260.5	
InfShaft	15	24.25	48.5	
	…	…	…	
SUMMARY		Tot Area (m^2)	Tot Volume retained (m^3)	
		11495	22990	

3.4 Semi-centralised scenario with NBS technology

For the semi-centralised scenarios, it was initially proposed to disconnect the sewage volumes from the main sewer, given the flow time series at the outflow of the sub-catchment. This scenario with NBS technology raised several concerns due to the need to pump from a sewer system at a certain depth (e.g. 3 m) and install the NBS solution for sewage pre-treatment within the urban environment. For this reason, it was preferred to design this scenario at the sub-catchment level, allocating the space and retaining the water volumes at the upstream sub-catchments before entering the sewer system. In this scenario, the intervention is prioritised in the sub-catchments that generate higher runoff, given the higher degree of sealed surfaces.

Table 3.4.a 5 years return period

	ID_block	NBS_area_20yT (m^2)	VolRet_20yT (m^3)	
BioRetCell	156	3051.56	1311.23	
BioRetCell	11	2270.27	975.51	
BioRetCell	7	1441.70	745.10	
BioRetCell	157	1701.45	731.10	
BioRetCell	4	786.38	347.77	
BioRetCell	8	781.29	335.71	
BioRetCell	2	496.88	213.51	
BioRetCell	1	399.85	171.81	
BioRetCell	0	135.51	58.23	
SUMMARY		Tot Area (m^2)	Tot Volume retained (m^3)	
Sub-catchment (ID=2)		11064.89	4889.97	

Table 3.4.b 100 years return period

	ID_block	NBS_area_100yT (m^2)	VolRet_100yT (m^3)	
BioRetCell	156	4212.76	2177.24	
BioRetCell	157	3188.05	1337.85	
BioRetCell	11	2471.49	1277.31	
BioRetCell	7	1441.70	745.10	
BioRetCell	8	1463.93	614.33	
BioRetCell	4	786.38	406.42	
BioRetCell	2	931.02	390.70	
BioRetCell	1	449.36	232.24	
BioRetCell	0	149.79	77.41	
BioRetCell	319	169.28	71.04	
BioRetCell	236	153.60	64.46	
BioRetCell	230	112.34	58.06	
BioRetCell	226	112.34	58.06	
BioRetCell	….	….	….	
SUMMARY		Tot Area (m^2)	Tot Volume retained (m^3)	
Sub-catchment (ID=1,2,3,4)		49075.73	23001.34	

3.5 Semi-centralised scenario with grey technology

This semi-centralised scenario is based on the precipitation depth to be subtracted from the sub-catchments, which is the conventional sizing of centralised systems. For RTB systems, the sewage flow from the outlet of the sub-catchment can be retained and pre-treated before being released to the main sewer system. Given the work progress of the HDM by INSA, instead of the flow time series to disconnect at the sub-catchment outlets, it was considered the mm of rainfall to be removed from the sub-catchments sealed surfaces, as suggested in Montoya-Coronado et al. (2024).

The following millimetres of Precipitation are assumed to be retained within the sub-catchments.

Table 3.5.a Water depth to remove (mm) to retain the CSO spill volume within the sub-catchments

Design Storm event	Rain(2h,5T)	Rain(2h,10T)	Rain(2h,20T)	Rain(2h,30T)	Rain(2h,50T)	Rain(2h,100T)
Volume CSO spill (m^{3})	4832	8817	13039	15530	18683	22985
Water depth to remove (mm)	5.46	9.96	14.72	17.53	21.10	25.95

Table 3.5.b 5 years return period

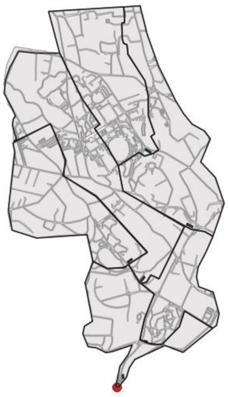
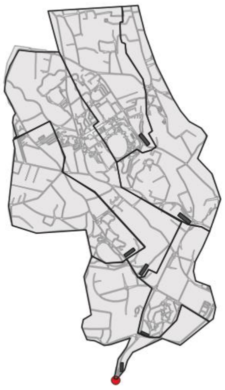
	Sub-Catchment	Area Tank (m^{2})	Volume Retained (m^{3})	
Small RTB	1	471.41	1084.23	
Small RTB	2	515.29	1185.17	
Small RTB	3	354.99	816.47	
Small RTB	4	380.17	874.39	
Small RTB	5	168.70	388.01	
Small RTB	6	210.32	483.73	
SUMMARY		Tot Area (m^{2})	Tot Volume retained (m^{3})	
		2100.87	4832	

Table 3.5.c 100 years return period

	Sub-Catchment	Area Tank (m^2)	Volume Retained (m^3)	
Small RTB	1	2242.39	5157.51	
Small RTB	2	2451.15	5637.64	
Small RTB	3	1688.61	3883.80	
Small RTB	4	1808.41	4159.34	
Small RTB	5	802.47	1845.68	
Small RTB	6	1000.45	2301.03	
SUMMARY		Tot Area (m^2)	Tot Volume retained (m^3)	
		9993.48	22985	

3.6 Centralised Scenario with NBS Technology

For the centralised scenario, the constructed wetlands (CW) have been sized based on the flow time series of Q_spill from the urban catchment outlet provided by the HDM model. The CSO spill is conveyed to the CW, and the latter is sized based on the parameters defined in Table 2.3. It should be noted that up to a 50% of the CW area might be additionally required for the construction site.

Table 3.6 CSO-CW for the different design events

	Return Period	Area (m^2)	VolRet (m^3)	
CSO-CW	5yT	4053+2026.5	4832	
CSO-CW	10yT	7446.12+3723.06	8817	
CSO-CW	20yT	11119.37+5559.68	13039	
CSO-CW	30yT	13360.08+6680.04	15530	
CSO-CW	50yT	16118.89+4029.72	18683	
CSO-CW	100yT	19881.75+9940.87	22985	

3.7 Centralised scenario with grey technology

The centralised scenario with the Retention Treatment Basin (RTB) is sized according to the total volume for the single event Q_spill in the same way as the centralised scenario with the NBS technology. Typically, urban stormwater infrastructures are designed to retain a volume of runoff over an impermeable area. A critical storm intensity of q_{crit} = 15 L/(s·ha) times the impervious catchment is defined by German standards. Considering the sealed surface of 110.25 ha in the Ecully Catchment, the critical storm intensity would correspond to an inflow close to the 5-year return period scenario. However, addressing the same target volume among the scenarios, the RTB technology is sized for the total accumulated spill volume. When running long-term simulations on hydrological years, the traditional dimensioning based on the impervious area of the catchment could be compared with the one based on the spill volume from the design events.

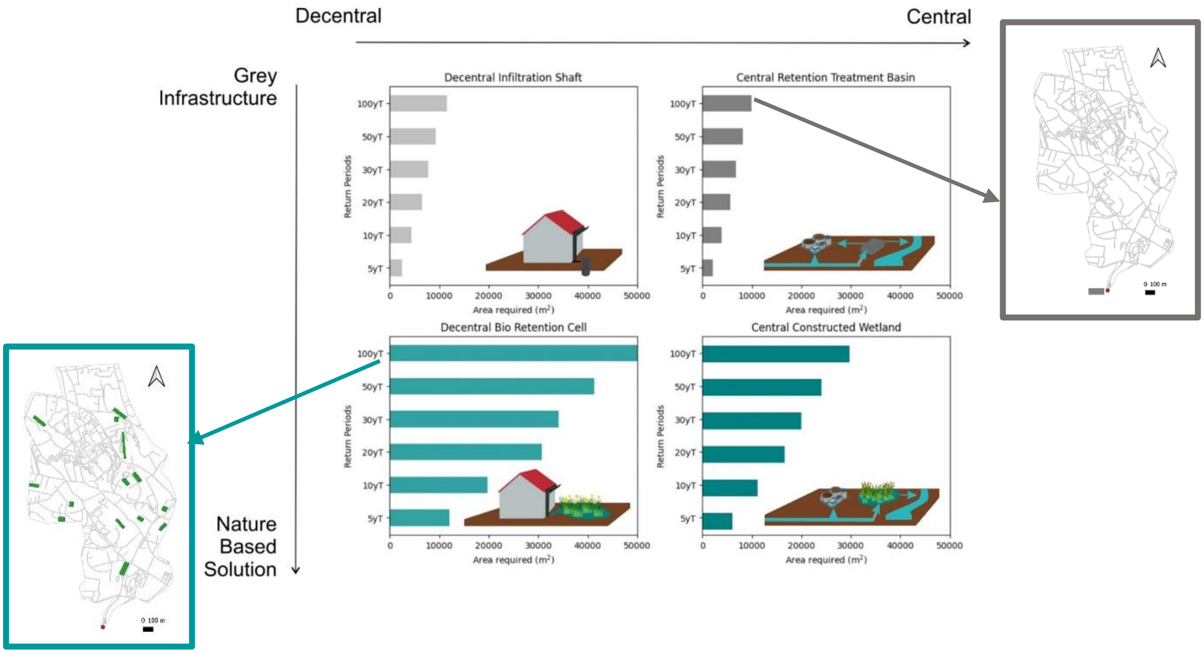
Table 3.7 5 years return period

	Return Period	Area (m^2)	VolRet (m^3)	
RTB	5yT	2100.86	4832	
RTB	10yT	3833.47	8817	
RTB	20yT	5669.13	13039	
RTB	30yT	6752.17	15530	
RTB	50yT	8123.04	18683	
RTB	100yT	9993.47	22985	

3.8 Overall result of the urban stormwater management scenarios

The following table summarises the results of the scenarios. It is decided to compare only the decentralised strategy with the centralised strategy since the semi-decentralised NBS strategy with bio-retention cells does not lead to a relevant difference in the area required compared to the decentralised scenario always being with bio-retention cells. In fact, the semi-decentralised scenario with BRC would have 8.43% less required area compared to the total decentralised scenario, when planning for a 5-years return period storm. While planning for a design storm of 100-year return period, there would be a required area of 2.59% more compared to the decentralised scenario. On the other side, for the semi-decentralised scenario, since smaller retention treatment basins (RTB) are required to pre-treat the stormwater volumes from the combined sewer at the sewer junctions, the dimensioning rules based on the volume are the same as in the centralised scenario. Thus, the summed-up area required for the distributed RTB interventions would be the same as in the centralised scenario with RTB. For future scenario rankings and evaluations, we will only compare decentralised infrastructure against centralised infrastructure.

Figure 3.3 Overall comparison of required area for the urban stormwater management scenarios, given the spatial and technological gradient.



4.0 OUTLOOK

This deliverable provides information on the sizing of the technologies, the volume of stormwater retained, and the spatial allocation of the sites for the scenarios developed. With the developed methodology, shown here for the Ecully Catchment, the scenarios can be evaluated and ranked on the basis of costs and co-benefits. Based on the design parameters and the sizing of the technologies, the project's total costs over the infrastructure's lifetime will be estimated in the cost module, which is part of the Planning Platform. For this module, more detailed data for cost functions on CSO-CW will be developed in collaboration with IRIDRA (WP1). From the Technology Selection Tool, given the technologies database from WP4, co-benefits such as biodiversity, social benefits, and circularity will be integrated into the ranking of urban stormwater management scenarios. Table 4 summarises the indicators that will rank the urban stormwater management scenarios, in collaboration with other work packages. The outcome will be presented in the deliverable *D5.5 Urban water management scenarios ranked* (M48).

Table 4 Indicators for the ranking of Urban Water Management Scenarios

Indicator	Tool	Work Packages Involved
Project Total Costs (Present Value)	Cost Module	WP1 – WP5
Co-Benefits	Technology Selection Tool	WP4 – WP5
Other costs	property pricing or insurance costs?	WP3 – WP4 – WP5

This deliverable only shows scenarios developed for the Ecully Catchment since the CSO reduction target is clear for this urban catchment based on the model results provided by INSA. This study case was ideal for developing and testing the Planning Platform tools. It is important to note that the work within the Planning Platform has been organised and developed so that it can be replicated in other urban catchments and also in relation to different objectives for other urban contexts.

In the final phase of the MULTISOURCE project, we wish to extend the development of urban stormwater management scenarios to other municipalities and assess the potential for implementing decentralised NBS, in comparison to more traditional stormwater practices, for stormwater mitigation, on the basis of collaboration and data provision.

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ANNEX: Review comment rebuttal

The information on page 2 is incomplete (e.g. the year of submission in date due and date submitted). The deliverable is short and rather coarse. The background, baseline and connection is unclear. The integrated solutions are just a fraction- will others be added?

We further detailed the deliverable and included additional figures (e.g. Fig 1.1 and Fig 1.3) to improve understanding of the deliverable for readers who haven't read previous deliverables and milestones. We were initially concerned that this would have led to repetition, but for clarity, we have now decided to include additional information in this deliverable. We hope that the background and baseline are now more evident. We have also added Section 3.8 *Overall result of urban stormwater management scenarios* with Fig. 3.3 to summarise the main results of the scenarios in terms of area requirements, which is the scope of the current deliverable. Evaluations in terms of costs with the LCCA and co-benefits with the Technology Selection Tool will be part of the final deliverable D5.5 *Urban water management scenarios ranked* (M48). Also, we would like to clarify that although the solutions proposed here are restricted to four technologies, and this was due to discussions with our MULTISOURCE colleagues, the work can be extended to other technologies by changing the design parameters. We further aim to extend the urban stormwater management scenarios to other urban catchments within the MULTISOURCE municipalities to reduce CSO spill volumes. To accommodate different data availabilities we also developed different metrics based on open-geospatial data through which we assess the potential for decentralised NBS within the urban environment. The implementation of further case studies and further specific urban stormwater management scenarios will depend upon the collaboration with stakeholders and data provision.

The overall goal of MULTISOURCE is to, together with local, national, and international stakeholders, demonstrate a variety of about Enhanced Natural Treatment Solutions (ENTS) treating a wide range of urban waters and to develop innovative tools, methods, and business models that support citywide planning and long-term operations and maintenance of nature-based solutions for water treatment, storage, and reuse in urban areas worldwide. The project includes seven pilots treating a wide range of urban waters. Two individual municipalities (Girona, Spain; Oslo, Norway), two metropolitan municipalities (Lyon, France; Milan, Italy), and international partners in Brazil, Vietnam, and the USA will contribute to each of the main project activities: ENTS pilots, risk assessment, business models, technology selection, and the MULTISOURCE Planning Platform. The use of urban archetypes in the Planning Platform will enable users to quickly classify regions (in both developed or developing countries) suitable for the application of nature-based solutions for water treatment (NBSWT) and compare scenarios both with and without NBSWT.

MULTISOURCE
enhanced natural treatment solutions

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