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Level(s) indicator 3.1: Use stage water consumption

User manual: overview, guidance and instructions (Publication version 1.0)

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Title
Level(s) indicator 3.1: Use stage water consumption. User manual: overview, guidance and instructions (Publication version 1.0)

Abstract

Developed as a common EU framework of core indicators for the sustainability of office and residential buildings, Level(s) provides a set of indicators and common metrics for measuring the performance of buildings along their life cycle. As well as environmental performance, which is the main focus, it also enables other important related performance aspects to be assessed using indicators and tools for health and comfort, life cycle cost and potential future risks to performance.

Level(s) aims to provide a common language of sustainability for buildings. This common language should enable actions to be taken at building level that can make a clear contribution to broader European environmental policy objectives. It is structured as follows:

1. Macro-objectives: An overarching set of six macro-objectives for the Level(s) framework that contribute to EU and Member State policy objectives in areas such as energy, material use and waste, water and indoor air quality.
2. Core Indicators: A set of 16 common indicators, together with a simplified Life Cycle Assessment (LCA) methodology, that can be used to measure the performance of buildings and their contribution to each macro-objective.

In addition, the Level(s) framework aims to promote life cycle thinking. It guides users from an initial focus on individual aspects of building performance towards a more holistic perspective, with the aim of wider European use of Life Cycle Assessment (LCA) and Life Cycle Cost Assessment (LCCA) methods.

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How this indicator user manual works

Level(s) is a framework of core indicators of sustainability that can be applied to building projects in order to report on and improve their performance. The supporting documentation has been designed to be accessible to all the actors that may be involved in this process.

If you are new to the assessment of a building's sustainability, we recommend reading the **first part of the Level(s) user manual**. This will provide you with an introduction to the basic concepts behind Level(s) and how you can apply it to a building project.

If you haven't yet set up your building project to use Level(s), including completing the project plan and the building description, then we recommend reading the **second part of the Level(s) user manual**.

This indicator user manual forms the third part of the Level(s) user manual where you will find instructions on how to use the indicators themselves. It is designed to help you apply your chosen indicator to a building project. It will help you to do this in the following way:

- **Introductory briefing:** This section provides an overview of the indicator, including:
  - ✓ why you may wish to measure performance with it,
  - ✓ what it measures,
  - ✓ at which stages in a project it can be used,
  - ✓ the unit of measurement, and
  - ✓ the relevant calculation method and reference standards.
- **Instructions on how to use the indicators at each level**: This section provides:
  - ✓ step by step instructions for each level,
  - ✓ what is needed to make an assessment,
  - ✓ a design concept checklist (at Level 1), and
  - ✓ the reporting formats.

The instructions often refer to the guidance and further information which can be found after the instructions.

- **Guidance and further information for using the indicator**: This section provides more background information and guidance to support you in following specific steps in the instructions, including the design concepts introduced at Level 1 and the practical steps to calculate or measure performance at Levels 2 and 3. They are all cross-referenced to specific instruction steps at either level 1,2 or 3.

This indicator user manual is structured so that once you are familiar with using the indicator and you know how to work with it, you may no longer need to refer to the guidance and background information, but only work directly with the instructions at the level of your choice.

Technical terms and definitions used

"Green facade" means a vertical structure where climbing or hanging plants are directly or indirectly supported to grow up or down the structure. The growing media for these plants is ground-based for climbing plants and plant-trough-based for hanging plants.

"Green roof" means vegetated landscapes that are installed on a roof surface in a loose-laid or modular format. Green roofs may be further classified as extensive, semi-intensive or intensive depending on the depth of the substrate installed and vegetation planted.

"Green wall" means a vertical structure that is normally fitted with modular, pre-planted panels that contain wall-bound growing media.

"Greywater" means domestic wastewater, excluding wastewater from WCs and urinals. This term is normally applied to wastewater from sinks, wash basins, showers, baths, washing machines and dishwashers. A sub-division into "*light greywater*" may be used for domestic wastewater from showers, baths and wash-basins, due to their inherently lower organic loads.

"Irrigation" means the practice of supplying water to an area of land through pipes, sprinklers or channels so that vegetation will grow.

"Potable water" means water, in its original state or after treatment, that is wholesome and clean and therefore suitable for human consumption for drinking, cooking, food preparation and other domestic purposes. The term can be considered as synonymous with "*drinking water*".

"Rainwater harvesting" means the collection and storage of rainwater to partially or fully meet current and future water demand. Rainwater is normally collected from roofs but may also be collected from other impermeable or pervious ground surfaces depending on the risk of contamination and the intended end use.

Introductory briefing

Why measure performance with this indicator?

Around 21% of all water abstracted in the EU is used for public supply, the majority of which is used in buildings. On average, each EU citizen uses 160 L/day of water. The trend towards larger urban populations is placing more pressure on water supply in urban areas. Water consumption is also an operational cost to building owners/users.

Reducing water consumption will reduce the embodied environmental impacts of delivering water to the point of demand (i.e. from water abstraction, treatment and pumping through the distribution network). In the case of hot water, better efficiency also delivers significant energy savings for consumers. A more efficient use of water will reduce pressure on freshwater resources, especially in river basins that experience continual or seasonal water scarcity. In areas where desalination is necessary for water supply (especially in southern Europe), the cost and environmental benefits of efficient water use are significantly higher because much more energy is needed to treat that water.

The objectives of this indicator are therefore:

- to allow users to understand the main sources of water consumption associated with their building;
- to be aware of the relative importance of water scarcity in the region where the building is located;
- to be able to estimate potential water savings in building design due to rainwater harvesting and greywater reuse;
- to be able to estimate potential water savings in building fit-out due to the choice of water efficient sanitary fittings/devices, and
- to optimise and assess the potential impact of irrigation of vegetated areas.

What does it measure?

The total consumption of water is measured for an average building occupant, with the option to split this value into potable and non-potable water.

At what stage of a project

The stages at which an assessment can be made reflect the three 'levels':

- ✓ Level 1: In the conceptual design, information is provided to prompt discussion and decision making for the project about aspects that will directly or indirectly affect the consumption of water, especially potable water, during the use of the building.
- ✓ Level 2: During the detailed design and construction stages, the influence of different design features and purchases of different devices on estimates of use stage water consumption can be made using the excel-based Level(s) water calculator.
- ✓ Level 3: The as-built and in-use performance of how the building performs can be reported using actual water consumption data from onsite meter readings (m^3/annum) and can be normalised to the common unit of m^3/occupant/annum by considering occupancy rates over the same period.

Unit of measurement

Water consumption during the use phase of the building life cycle is measured in units of **m^3 per occupant per year**, allowing for comparison to buildings of different sizes and occupancy rates.

System boundary

The indicator is focused on the B7 stage (operational water use) of the building life cycle, as per EN 15978. It includes water used inside the building (i.e. for drinking, for sanitation and for heating, cooling, ventilation and humidification) and outside the building (e.g. irrigation of vegetated areas, fountains etc.) so long as the outdoor uses fall within the curtilage of the building area.

Scope

The scope for making estimates of use stage water consumption under Level 2 reporting is slightly different depending on the building type:

Table 1. Comparison of scopes for residential and office buildings

	Residential buildings	Office buildings
Sanitary fittings	Toilets, bathroom taps, showers, bath-tubs and kitchen taps.	Toilets (incl. urinals), bathroom taps, showers and kitchenette taps.
Water using appliances	Dishwashers and washing machines	-
Other*	Irrigation	Irrigation, floor cleaning, window cleaning

For real meter readings taken for Level 3 reporting, all sources of water consumption from mains water will be measured and there is the option to factor in consumption from other sources such as borehole abstraction onsite, collected rainwater and reused greywater. Attention must be paid to occupancy rates as any inaccuracies here directly impact results for the unit of measurement used.

Calculation method and reference standards

The calculation used for Level 2 is defined in a bespoke excel calculation sheet. The excel sheet is populated with default occupation rates and default values for water consumption for different water using appliances and sanitary fittings/devices. These default values should be used in cases where users do not have specific data to insert. Level 3 measurements should be taken from actual water meter readings and estimates of actual occupation rates should be made.

Instructions on how to use the indicators at each level

Instructions for Level 1

L1.1. The purpose of Level 1

The focus of Level 1 is to make the reader aware of five highly relevant aspects for reducing and optimising use stage water consumption, regardless of whether they intend to make estimates at Level 2 or report real meter readings at Level 3. Users should briefly describe how these Level 1 aspects were considered (or not) during discussions and decision-making at the concept design stage in a summary table provided in L1.4.

L1.2. Step-by step instructions

These instructions should be read in conjunction with the accompanying Level 1 technical guidance and supporting information (see page 16 onwards).

1. Consult the checklist under L1.4 of water efficient design concepts and read the background descriptions in the Level 1 technical guidance.
2. Within the design team, review and identify how water efficient design concepts can be introduced into the design process.
3. Once the design concept is finalised with the client, record the water efficient design concepts that were taken into account using the L1 reporting format.

L1.3. Who should be involved and when?

At the concept design stage, the main actors would be the concept architect, the building owner and the relevant building authority that grants the permit for the construction or renovation activity. If relevant, a specialist in the design and planning for novel vegetated areas such as green roofs and vertical gardens should be involved (either directly with the architect or being sub-contracted by the architect).

Especially for larger building projects, part of the permitting process will involve the relevant water utility company for the sake of ensuring that a connection to the mains drinking water and mains sewer networks can be made. Their involvement may be required even if existing connections are in place. For example if the occupancy rate will increase significantly and if overflow connections for greywater and rainwater are needed are planned.

Later in the project and as appropriate, the contractor and any specialist sub-contractors will be responsible for the procurement of efficient water using devices/fittings and the design and installation of rainwater harvesting systems, greywater reuse systems, landscaping of vegetated areas, irrigation systems and any additional water metering beyond the mains connection.

L1.4. Checklist

The following water efficient design concepts have been identified from best practice and literature reviewed by the Joint Research Centre as proxies for achieving better performance.

Table 2. Level 1 checklist for design concepts relevant to use stage water consumption

Level 1 design concept	Brief description
1. Specification of water efficient sanitary devices and fittings	Consider the ranges of performance for different choices of sanitary devices and fittings (e.g. tap and showerhead flow rates in L/min, toilet flush volumes in L/flush etc.). Consult national or international labelling schemes.
2. The relevance of water scarcity as a driver for reducing water demand.	Cross-check water exploitation index (WEI+) data for the river basin in which the building will be located and compare this to other European river basins. Any average summer WEI+ value >20% should be flagged as water scarcity being a definite concern.
3. Examine the potential to use non-potable water to substitute for potable water demand.	Consider the potential of the building and site for: – rainwater harvesting (i.e. look at collection area available and rainfall patterns) – greywater reuse (i.e. consider relevant uses such as toilet flushing and irrigation together with relevant sources of greywater such as showers and bathroom wash basins).
4. Water efficient vegetated areas	When assessing whether or not to have vegetated areas at the building site, consider how the following aspects can reduce irrigation water demand: – the choice of low water demand plants – the use of efficient irrigation techniques – staging of vegetation and other factors that can create microenvironments that reduce evaporation rates.
5. Metering plan	To install multiple meters onsite to better monitor where water consumption is happening in the building, to better quantify the significance of irrigation and any contributions of harvested rainwater and reused greywater to total water consumption.

L1.5. Reporting format

Table 3. Level 1 reporting format for indicator 3.1 (with example answers provided)

Water consumption design concept	**Addressed? *(yes/no)***	**How has it been incorporated into the building project? *(provide a brief description)***
1. Specification of water efficient sanitary devices and fittings	Yes	The use of low-flush toilets with dual buttons (5L full flush and 3L partial flush) have been specified for replacing the original 7L flush toilets in the bathrooms. All original bathroom taps were found to have a flow rate of 12 L/min and will be replaced by taps with a flowrate of no more than 8 L/min.
2. Consider the importance of water scarcity in the river basin where the building is located.	Yes	The building project is located in the Ebro river basin in Spain with an average summer WEI+ value of 30,44% during the years 2002-2014. According to the Level(s) excel tool, this is the 10th most water scarce river basin in Europe (out of 105). Hence, water scarcity is definitely a strong driver for reducing water consumption.
3. Potential of rainwater harvesting and greywater reuse	Yes	Greywater reuse (from bathroom wash basins) has been considered for irrigation only. The potential of rainwater harvesting is low, but any rainwater falling on the roof or paved areas will be diverted to the sump for irrigation water.
4. Consider water efficiency aspects in any vegetated areas	Yes	The building will include an interior patio garden to be populated with a lawn area and flowers, which is fed via a closed loop irrigation system that also includes a fountain and zen water feature. Spray irrigation during early morning hours is foreseen, with programmable timing and manual override controls. The outer curtilage of the building site and car park will be surrounded by a green border of native shrubs and trees with low water demand suited to the local climate. Sub-surface drip irrigation is planned to be installed in these parts. The detailed design shall be sub-contracted to specialist consultants.
5. Consider a metering plan	Yes	Apart from the normal billing meter for the whole building, separate meters will be installed to monitor: (i) greywater flows to the irrigation system; (ii) the intermittent flows of rainwater to the irrigation system and (iii) any necessary potable water flows to the irrigation system.

Instructions for Level 2

L2.1. The purpose of Level 2

The purpose of Level 2 is to allow users to estimate the per person water consumption in the building as a function of the water consuming devices, appliances and irrigated areas via an excel-based calculator. The minimisation of potable water consumption can be evaluated by the specification of more efficient devices and appliances and by rainwater harvesting and/or greywater reuse.

L2.2. Step-by-step instructions

These instructions should be read in conjunction with the accompanying Level 2 technical guidance and supporting information (see page 27 onwards).

1. Download the Level(s) water calculator.
2. Generate the average summer WEI+ value (a measure of water scarcity) in the "*L2 estimate*" worksheet by selecting the country (cell B1) and the river basin (cell B2) in which the building is located.
3. Fill out the green cells in columns G and I (also in columns J and L for office buildings) to generate estimates of the total water consumption of the sanitary devices and water using appliances.
4. If there are any vegetated areas to be irrigated, use the "*Irrigation Calc.*" worksheet or enter a direct estimate provided by the specialist contractors.
5. If any rainwater is to be harvested or greywater to be reused, provide an answer for each of the green cells in columns M, N and Q.
6. A full breakdown of the results is presented in cells F21 to J33 for residential buildings (F75 to J90 for office buildings). A graphical output of water consumption is also provided in cells M33 to R47 for residential buildings (M90 to R104 for office buildings).
7. If the results generated are just one option and the user wishes to compare them to other design options for minimising potable water consumption, the cells from O24 to O31 for residential buildings (O78 to O87 for office buildings) should be copied and pasted as values into the "*L2 comparison*" worksheet.

L2.3. What do you need to make an assessment?

The main items needed are as follows:

- A completed Level(s) building description
- The excel-based Level(s) water calculator
- The design details that relate to water consuming devices, fittings and appliances that will be used in the building.
- As far as possible, further details that influence water consumption (e.g. toilet flush volumes, maximum flow rates for taps, size of irrigated areas etc.). In the absence of these details, default values are suggested in the calculator.

L2.4. Who should be involved and when?

The specification of sanitary devices and fittings should be agreed between the building owner and the contractor. Fittings should be sought that match the estimates entered into the water calculator as far as possible. If such fittings cannot be sourced, the data entered into the Level(s) water calculator should be adjusted to match the devices/fittings that are purchased.

Any architecturally significant building features that relate to water consumption (e.g. gardens, green roofs, green walls etc.) should involve the architect and specialist consultants/landscapers. When it comes to construction and installation, it is vital that the contractor/sub-contractor is aware of all relevant specifications and instructions. Consultation with planning authorities will normally be necessary to ensure that local, regional or national standards are complied with. The local water utility may need to be consulted about where to direct any rainwater or greywater overflows.

L2.5. Ensuring the comparability of results

Between design options for the same building: the "*L2 comparison*" worksheet has been developed to allow for different design options of the same building to be compared side by side.

Between different buildings: Not all buildings will have irrigated areas and there may be significant other uses included for some buildings but not for others (e.g. some offices with showers, some without). By breaking the results down into individual sanitary fittings and devices etc., and by normalising the estimates to a per occupant level, it is possible to compare these results between buildings with different occupation rates.

L2.6. Going a step further

The following steps can be taken in order to make the water consumption estimations more accurate:

- Obtain specific water consumption rate data from suppliers/manufacturers of sanitary devices, fitting and appliances to be procured – ideally using information based on standard labelling schemes.
- Where more than one variety of (e.g. toilets with different flush volumes) is to be installed in the building, take a weighted average flush volume and consider in the weighting if some toilets will be used more than others based on anticipated building use patterns.
- Where urinals are to be installed, check if the flushing system is automatically triggered by a timer, automatically triggered by presence sensors or manual triggered.
- Where an office building has shower facilities, consider the likelihood of bicycle access, local climate and the likelihood of physical activities onsite (e.g. classes for yoga, pilates etc.) that may influence usage rates of onsite showering facilities.
- Try to separately meter other significant sources of water consumption onsite that cannot be accurately estimated (e.g. canteen, swimming pool etc.).

L2.7. Format for reporting the results of an assessment

The Level(s) water calculator provides a more detailed breakdown of the total value, which is slightly different for residential and office buildings.

Residential building

Summer WEI+ =	4.09	Total Water Consumption (m^3/o/a)	Of which potable (m3/o/a)	Of which non-potable (m3/o/a)
Sanitary fittings and devices (e.g. toilets, taps, baths and showers).	Toilets	8.54	0.00	8.54
	Bathroom taps	4.19	4.19	0.00
	Showers	24.12	24.12	0.00
	Bath-tub	6.82	6.82	0.00
	Kitchen taps	16.08	16.08	0.00
	Sub-Total	59.75	51.20	8.54
Water using appliances (e.g. dishwashers and washing machines).	Dishwashers	1.54	1.54	0.00
	Washing machines	4.37	4.37	0.00
	Sub-Total	5.91	5.91	0.00
Irrigation	Irrigation	11.49	0.00	11.49
	TOTAL (m^3/o/a)	77.15	57.12	20.04
	TOTAL (%)	100	74.0	26.0

Office building

Summer WEI+ =	4.09	Total Water Consumption (m^3/o/a)	Of which potable (m3/o/a)	Of which non-potable (m3/o/a)
Sanitary fittings and devices (e.g. toilets, taps, baths and showers).	Toilets & urinals	3.75	0.00	3.75
	Bathroom taps	1.88	1.88	0.00
	Showers	1.50	1.50	0.00
	Kitchenette taps	1.50	1.50	0.00
	Sub-Total	8.63	4.88	3.75
Cleaning	Floor cleaning	0.16	0.16	0.00
	Window cleaning	0.02	0.02	0.00
	Sub-Total	0.17	0.17	0.00
Irrigation	Irrigation	11.49	0.00	11.49
Other uses (e.g. fountains, swimming pools, HVAC etc.)	Other-1 (please spe	0.00	0.00	0.00
	Other-2 (please spe	0.00	0.00	0.00
	Other-3 (please spe	0.00	0.00	0.00
	Sub-Total	0.00	0.00	0.00
	TOTAL (m^3/o/a)	20.29	5.05	15.24
	TOTAL (%)	100	24.9	75.1

Figure 1. Level(s) water calculator output for indicator 3.1 use stage water consumption

A separate entry is available for office cleaning and undefined "*other uses*". The residential buildings have a specific entry for washing machines and dishwashers. The calculator output provides a result in common units for both residential and office buildings (of m^3/o/a).

Instructions for Level 3

L3.1. The purpose of Level 3

Taking measures of actual water consumption requires little more effort than reading the water bill (presuming that the supply is metered) over the course of one year. However, because the meter readings do not account for occupancy rates (units are m^3/annum), and the Level(s) reporting does (units are m^3/occupant/annum), it is important that some guidance is provided about how to: (i) estimate occupation rates of the building, and (ii) compare Level 2 estimates with Level 3 measures.

L3.2. Step-by-step instructions

The following instructions are provided for converting the meter readings (in m^3/annum) to an average per occupant consumption rate (in m^3/occupant/annum). These instructions are written with a focus on office buildings, but the same principles can be generally applied to residential buildings as well:

1. Estimate the number of days that the building is occupied for normal use (e.g. offices may close for weekends and national holidays, residents may go on holiday).
2. Estimate the number of full time equivalent staff in the office. This may be based on information relating to human resources and employee contracts. Personal holiday entitlements should also be factored into the calculation. A full time-equivalent day is considered as 8 hours in the office for one person.
3. Consider if visitor numbers are significant compared to the office employees. When assessing visitor numbers, it should also be considered against full time equivalents (e.g. 4 visitors staying for 2 hours could be equivalent to 1 person working 8 hours).
4. From the information in steps 2 and 3, calculate the full time equivalent occupants in the office building and enter it into cell E20 (or cell E5 for residential buildings) of the "*L3 measure*" worksheet..
5. Enter the actual meter reading (m^3/a) into cell E21 for office buildings (or cell E6 for residential buildings) of the "*L3 measure*" worksheet.
6. (optional comparisons) If users want to convert the Level 2 estimate into an estimated meter reading, for direct comparison with the actual Level 3 meter reading, they should fill out the estimated occupancy rate (yellow cells D5 or D20 in the "*L3 measure*" worksheet). . For residential buildings, there is the additional option to compare values to national per capita water consumption averages in households.

L3.3. What do you need to make an assessment?

The main items needed are as follows:

- A completed Level(s) building description
- Meter readings of potable water consumption (from the water utility) and, potentially, meter readings of supplied rainwater and/or greywater.
- A calculation to estimate the occupancy rate of the building (average full time equivalent occupants in the building per day).

L3.4. Who should be involved and when?

The building owner, occupier or whoever pays the water bill must provide the real potable water consumption data over a one year period. The occupier(s) of the building should be responsible for estimating the occupancy rate. With this data, any user can then carry out the Level 3 measure (in units of m^3/o/a).

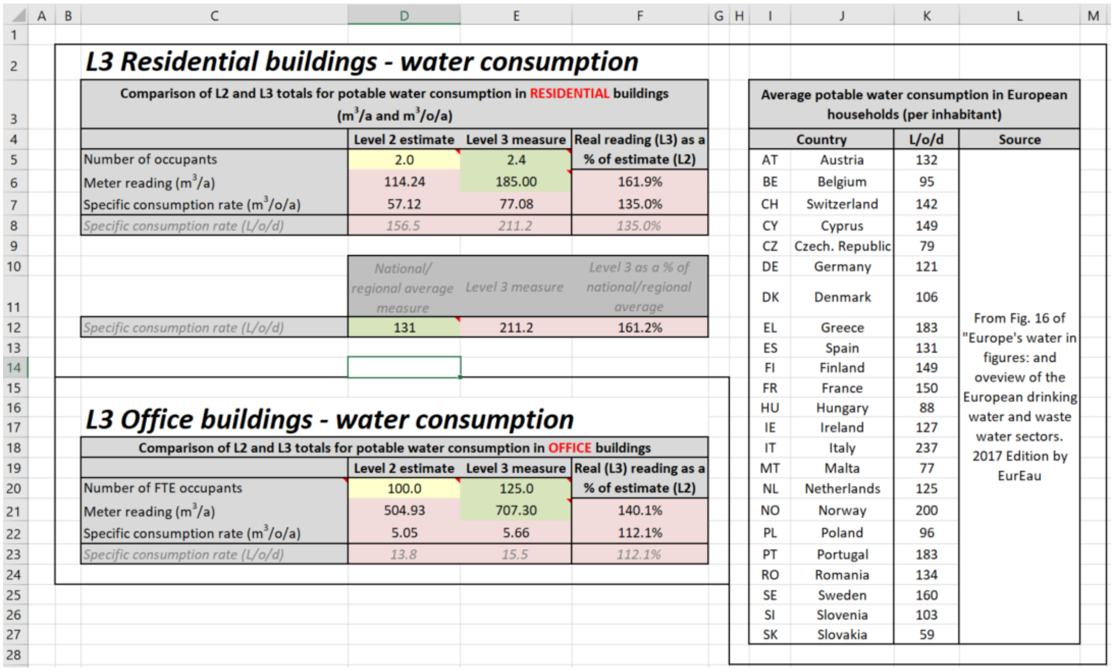
The water utility may be able to provide additional background data about normal consumption patterns in the local or regional area in similar types of building (or in the old building in cases of renovation projects).

L3.5. Ensuring the comparability of results

By normalising the water meter readings to a per occupant basis (i.e. m^3/o/a), the Level 3 result can be compared between different buildings.

L3.6. Format for reporting the results of an assessment

The calculator output provides a final result in common units for both residential and office buildings (of m^3/o/a). The result is also expressed as L/o/d to allow for direct comparison with national averages for residential buildings. Unlike Level 2 reporting, no breakdown of water consumption for different devices and appliances is provided, because meter readings will not provide such detail.



L3 Residential buildings - water consumption

Comparison of L2 and L3 totals for potable water consumption in RESIDENTIAL buildings (m^3/a and m^3/o/a)			
	Level 2 estimate	Level 3 measure	Real reading (L3) as a % of estimate (L2)
Number of occupants	2.0	2.4	
Meter reading (m^3/a)	114.24	185.00	161.9%
Specific consumption rate (m^3/o/a)	57.12	77.08	135.0%
Specific consumption rate (L/o/d)	*156.5*	*211.2*	*135.0%*

	National/ regional average measure	*Level 3 measure*	*Level 3 as a % of national/regional average*
Specific consumption rate (L/o/d)	131	211.2	161.2%

L3 Office buildings - water consumption

Comparison of L2 and L3 totals for potable water consumption in OFFICE buildings			
	Level 2 estimate	Level 3 measure	Real (L3) reading as a % of estimate (L2)
Number of FTE occupants	100.0	125.0	
Meter reading (m^3/a)	504.93	707.30	140.1%
Specific consumption rate (m^3/o/a)	5.05	5.66	112.1%
Specific consumption rate (L/o/d)	*13.8*	*15.5*	*112.1%*

Average potable water consumption in European households (per inhabitant)

	Country	L/o/d	Source
AT	Austria	132	From Fig. 16 of "Europe's water in figures: and oveview of the European drinking water and waste water sectors. 2017 Edition by EurEau
BE	Belgium	95	
CH	Switzerland	142	
CY	Cyprus	149	
CZ	Czech. Republic	79	
DE	Germany	121	
DK	Denmark	106	
EL	Greece	183	
ES	Spain	131	
FI	Finland	149	
FR	France	150	
HU	Hungary	88	
IE	Ireland	127	
IT	Italy	237	
MT	Malta	77	
NL	Netherlands	125	
NO	Norway	200	
PL	Poland	96	
PT	Portugal	183	
RO	Romania	134	
SE	Sweden	160	
SI	Slovenia	103	
SK	Slovakia	59	

Figure 2. Screenshot of "L3 measure" reporting format.

The number of equivalent occupants (for Level 2 or 3) is always an estimate, but should be as accurate as possible. It is clear that the difference in Level 2 estimates and Level 3 measured values is influenced directly by any differences in occupancy rate. If users wish to cancel these differences out, they could see what happens when matching the occupancy rates for Level 2 to those that were calculated for Level 3.

Guidance and further information for using the indicator

Guidance and information for Level 1

The guidance supports following five Level 1 aspects: **L1.4 concept 1 – Considering how to reduce water demand from sanitary fittings** **L1.4 concept 2 – Understanding water scarcity in the context of building location** **L1.4 concept 3 – Consider rainwater harvesting and greywater reuse** **L1.4 concept 4 – Consider the incorporation of vegetation on building surface(s)** **L1.4 concept 5 – Potential metering plans**

L1.4 concept 1 – Reduce water demand from sanitary fittings

The three main sources of water consumption in buildings all relate to sanitary fittings: toilets, showers/baths and bathroom/kitchen taps.

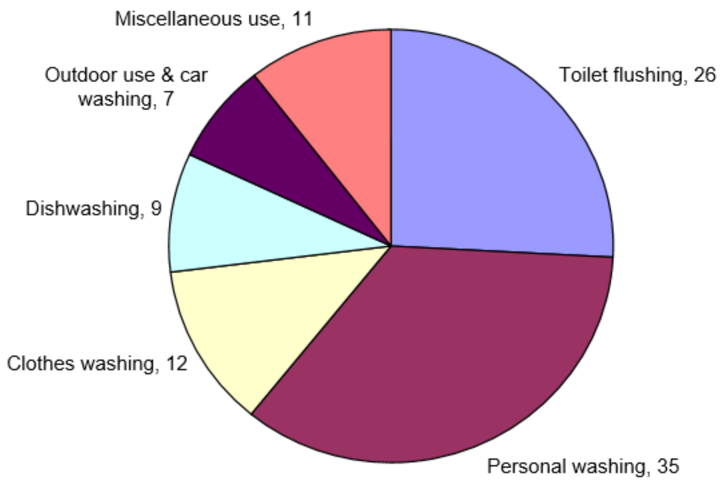


Figure 3. Split of water consumption in households in England and Wales

Source: Environment Agency, 2010[1].

In residential buildings, the use of toilets, bathroom taps and showers accounts for around 61% of total household water consumption. A check of products listed on the European Water Label website[2] shows the following ranges of performance of tap, shower, bathtub, urinal and toilet performance.

Table 4. Ranges of performance reported under the European water label catalogue.

Type of product	No. products (Sept. 2020)	Most efficient	Least efficient	General range of performance	General improvement potential
WC suite	ca. 3700	1.5 L/flush	9.0 L/flush	2.95-6.0 L/flush	Factor of 2
Bath-tub	ca. 3700	11 L	360 L	80-185 L	Factor of 2.3
Shower controls	ca. 530	4.0 L/min	8.0 L/min	4.0-8.0 L/min	Factor of 2
Shower handsets	ca. 800	4.0 L/min	50.0 L/min	6.0-12.0 L/min	Factor of 2
Wash basin tap	ca. 3700	1.3 L/min	150.5 L/min	4.0-12.0 L/min	Factor of 3
Kitchen sink tap	ca. 820	1.3 L/min	106.4 L/min	4.0-12.0 L/min	Factor of 3

[1] Environment Agency, 2011. Greywater for domestic users: an information guide.

[2] http://www.europeanwaterlabel.eu/findaproduct.asp?country=&category=4&rating=&manufacturer=&order=2#page=1

For all types of product listed above, a minimum improvement factor of 2 in specific water consumption can be achieved for activities relating to personal washing and toilet flushing if values reported in the catalogue are considered (ignoring extremely high and low consumption products listed in the catalogue).

L1.4 concept 2 – The relative importance of regional water scarcity

While improving the water efficiency of buildings via design choices is important in all cases for the environmental benefits it can deliver, it is even more important in areas that suffer from continuous or seasonal water scarcity. Water scarcity is measured by the EEA via a measurement known as the Water Exploitation Index (WEI+).

What is the Water Exploitation Index (WEI+)?

The basic conceptual model of the WEI+ indicator is shown below.

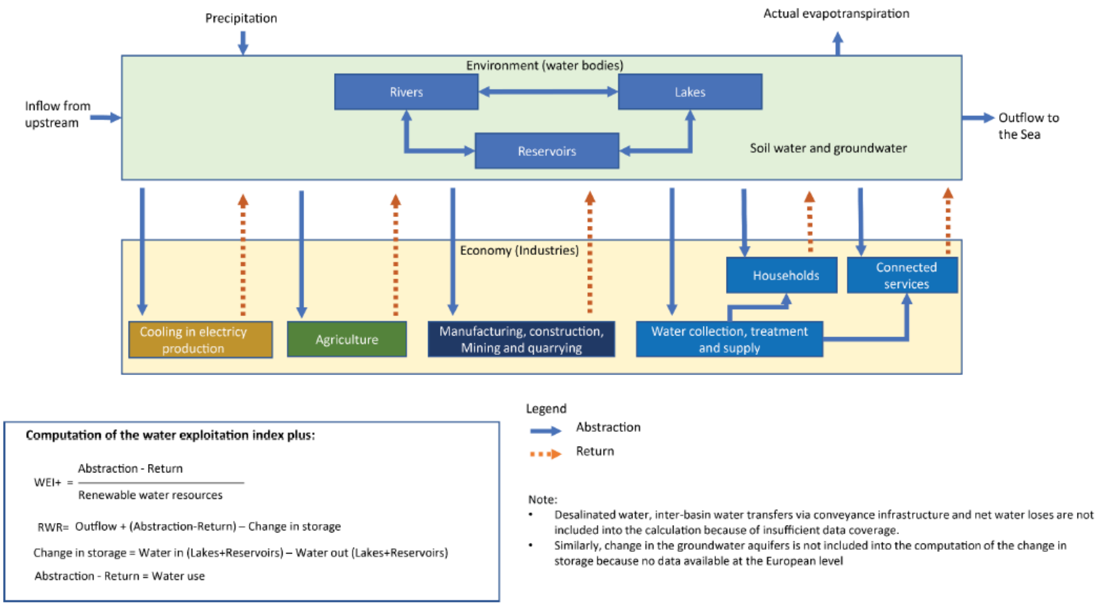


Figure 4. Conceptual model of the WEI+ indicator

Source: https://www.eea.europa.eu/data-and-maps/indicators/use-of-freshwater-resources-3/assessment-4

The WEI+ value over a defined period of time is essentially the net quantity of water abstracted from a defined river basin by human activity divided by the average renewable freshwater resources present in that basin during that time. The four main abstraction types relate to agriculture, electricity production, manufacturing and public water supply. Water consumption is one part of the public water supply.

According to Raskin et al. (1997)[3], when human abstraction exceeds 20% of freshwater resources, the river basin is suffering from water scarcity. When abstraction exceeds 40%, severe water scarcity is assumed. The EEA has produced an interactive map of European river basins where WEI+ values are colour coded depending on what percentage range they lie in.

[3] Raskin, P., Gleick, PH., Kirshen, P., Pontius, RG. Jr., Strzepek, K., 1997. Comprehensive assessment of the freshwater resources of the world. Stockholm Environmental Institute, Sweden.

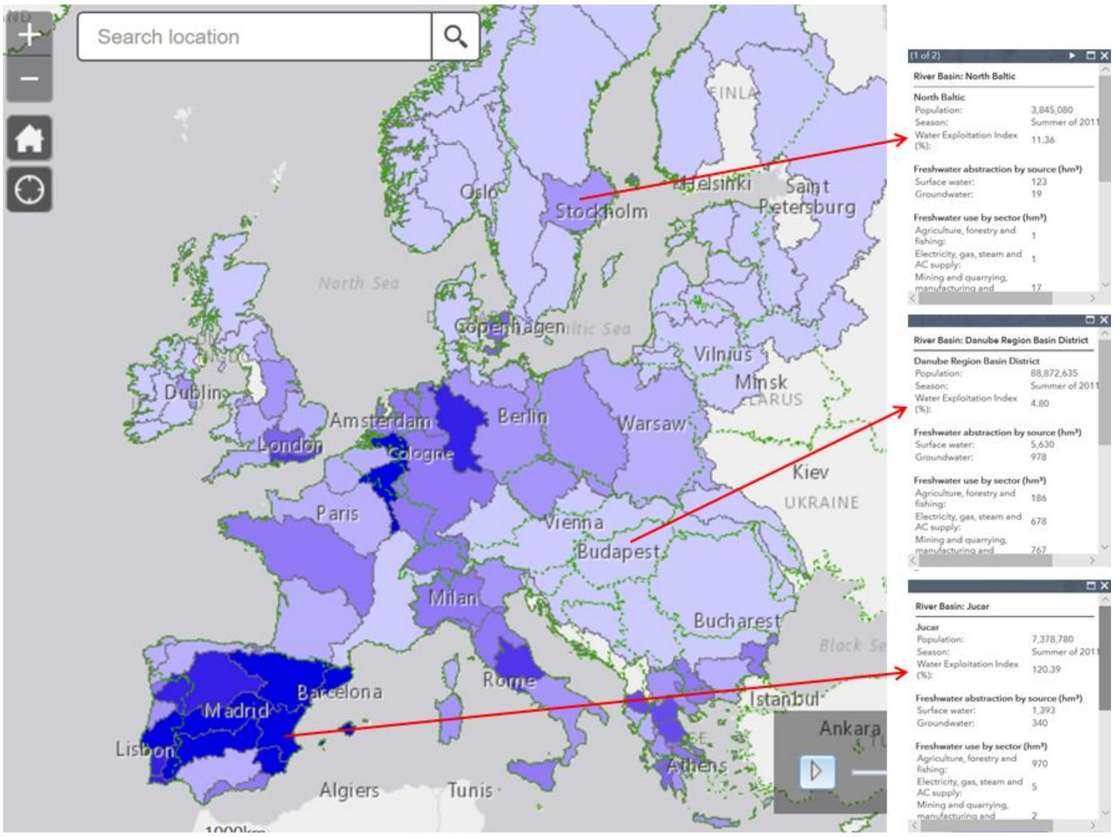


Figure 5. A snapshot of the EEA WEI+ map of European river basins (summer 2011)

Source: https://www.eea.europa.eu/data-and-maps/indicators/use-of-freshwater-resources-3/assessment-4

In the Figure above it is clear that the WEI+ values vary considerably from one river basin to another in the summer of 2011. Summer water scarcity is notably higher in most of the southern European river basins, especially in Spain, Greece, Cyprus and Malta. However, summer water scarcity can also occur in other parts of Europe due to prolonged periods of low rainfall in basins where there is major agricultural activity and/or where there are high density urban populations.

For convenience, the Level(s) water calculator allows users to see the annual average summer WEI+ index for their river basin simply by selecting the relevant options from two dropdown menus. Furthermore, the specific summer WEI+ value is averaged over 12 years of data (from 2002 to 2014) and is ranked with the other 104 river basins for which average summer WEI+ values could be generated (see below).

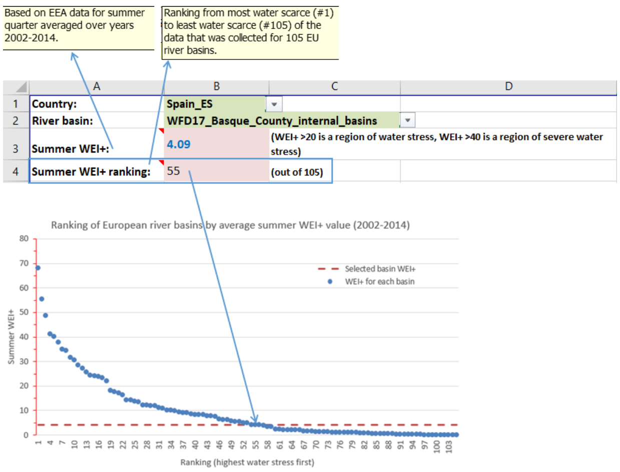


Figure 6. Screenshot of the input (cells B1 and B2) and output (cells B3, B4 and the red line on the graph) of WEI+ in the Level(s) water calculator

In the river basin chosen above, the Level(s) water calculator output (on the "*L2 estimate*" worksheet) shows that the average summer WEI+ is 4.09%, implying that the river basin is not subject to water scarcity. Compared to other river basins in Europe, it ranks 55th out of 105. The graph also shows that 18 of the 105 river basins have average summer WEI+ values that exceed 20% (i.e. suffer from summer water scarcity).

L1.4 concept 3 – Consider rainwater harvesting and greywater reuse

Even if rainwater harvesting or greywater reuse is not to be carried out for in the new/renovated building, there is the possibility for construction/renovation activities to leave sufficient space in service conduits for additional piping to be installed in the future. This way, any future renovation could be carried out with relatively little additional complication and disruption. Given the potentially long life times of buildings, potential future changes in regional water scarcity and different attitudes of potential future owners/occupiers, making provision for future rainwater harvesting and greywater reuse infrastructure is to be encouraged.

Rainwater harvesting

The two crucial factors to take into account when considering rainfall harvesting potential are: (i) the total annual rainfall data and (ii) the area available for collecting rainfall. If one factor is limited, the other would need to compensate to harvest a given amount of rainwater.

In cases where rainwater harvesting is of potential interest, it is worth considering the direct and indirect impacts listed below.

Table 5. Potential benefits and inconveniences of rainwater harvesting and greywater reuse systems

Potential benefits	Potential inconveniences
Reduced potable water demand from public supply – associated environmental benefits.	Need for periodic inspection and maintenance of filters and first-flush devices.
Reduced potable water demand from public supply – associated cost benefits.	Need for tank(s)/pond(s) volume to store rainwater.
Increased potential for water features and vegetated areas onsite – aesthetic, biodiversity, well-being and evaporative cooling benefits.	Rainwater may be contaminated by bird droppings, turn stagnant or attract insects if not filtered and stored adequately.
Reduced storm runoff rates to natural watercourses or combined sewers – reduced flood risk or reduced risk of sewer overflow	Reduced intensity of storm-related flushing of mains sewerage network in areas where combined sewers are installed.
If rainwater is stored on a green roof, improved cooling of roof on outer surface.	Green roofs need to be quite flat and require careful structural design to account for varying loads and impermeablisation.

Rainwater harvesting systems are low-tech and can be installed completely external to the building, (e.g. collecting water from the roof for garden irrigation) or it can be integrated into the building plumbing in cases where it can be used as a source of water for flushing toilets.

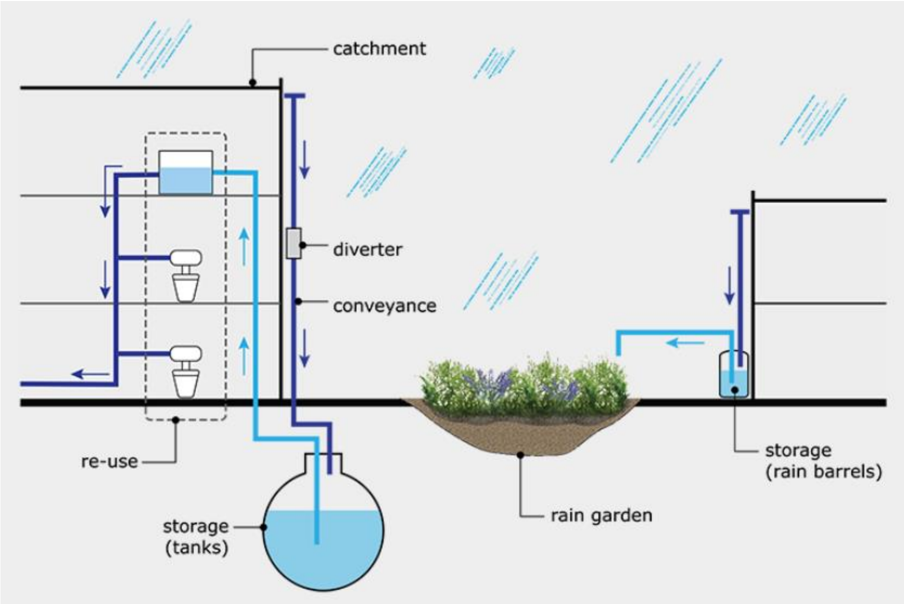


Figure 7. Illustration of rainwater collection for toilet flushing (left) and garden irrigation (right)

Source: https://www.next.cc/journey/design/rain-water-harvesting

Rainwater is generally free of impurities but it may pick up dust, bird droppings and leaf litter as it flows across collection surfaces. There are no standard quality requirements for harvested rainwater. If used for irrigation or toilet flushing, simple filtration or first-flush diversion may be all that is needed. However, if used for other sanitary purposes, the harvested rainwater might need to be disinfected, for example via exposure to UV light.

Treatment of rainwater can be applied upstream (e.g. screening >1mm), within (e.g. sedimentation) or downstream (e.g. filter and/or disinfection) of the rainwater storage device.

The main design considerations for rainwater harvesting are presented in EN 16941-1. The location of rainwater storage tanks is an important consideration to make. It is recommended that collection rainwater always flows by gravity or siphonic action to the collection tank. Tanks are normally the most expensive part of the harvesting system. The choice of material (e.g. polyethylene, metal, fibreglass, concrete etc.) and whether it is above or below ground will influence the cost. Underground storage is more expensive but leaves free space on the ground and the stored rainwater will be subject to less diurnal temperature variation. In more creative solutions, some or all of the rainwater harvesting capacity could be incorporated into surface ponds.

The sizing of the storage tank(s) will depend on how much rainwater can be harvested and how much potable water demand the designer wishes to substitute. In climates with prolonged dry seasons, the storage capacity should ideally be sufficient to cover the targeted needs during the dry months. However, a larger storage capacity will increase the cost.

Harvesting rainwater also reduces the risk of flooding in downstream areas. Such risks have increased in many areas due to the development of floodplain sites and the general impermeablisation of the ground. In urban areas with standard drainage systems, storm water is much more rapidly conveyed from the surface to the nearest watercourse than in an equivalent greenfield area.

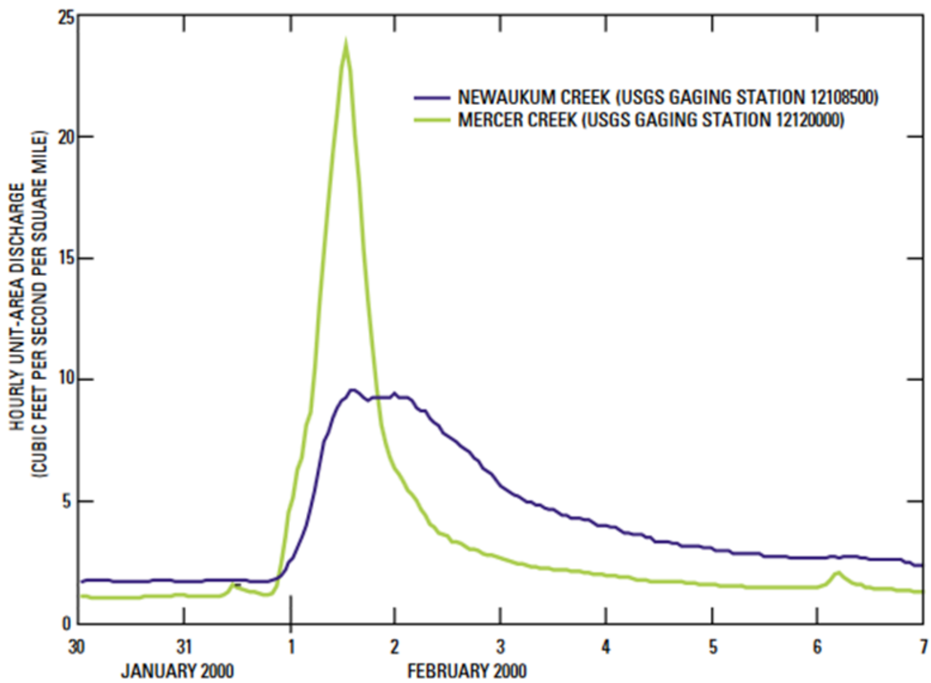


Figure 8. Specific runoff rates in an urban stream (green) and a rural stream (purple) that are located in the same area.

Source: Konrad, 2003.[4] USGS Fact Sheet FS-076-03. Effects of urban development on floods.

Due to short-medium term storage of rainwater in the rural catchment, a lower peak flow in downstream watercourses (purple line) is observed, translating into a reduced risk of flooding for a given storm event or sequence of events. The exact same hydrographic tendency in the Figure above can be applied to combined sewers (i.e. sewers which collect both sewage and stormwater).

Peak flow in combined sewers is important because sewage works are designed only to accept a maximum hydraulic flow of wastewater. If this flow is exceeded, the excess flow is diverted to overflow tanks, which in turn drain back to the works inlet or to the nearby watercourse. In catchment areas where rainwater is collected, the peak flow arriving at the sewage treatment plant is lower and so the probability of sewage overflowing directly to the local watercourse is reduced. In extreme cases, in some areas, parts of the sewerage network can become saturated, leading to the backflow of sewage out of manholes and into the street. In areas where the sewerage network is prone to such backflows, rainwater harvesting and the decoupling of stormwater flows from combined sewers should be a priority for local authorities.

In cases where rainwater storage capacity is exceeded, an overflow device must be in place to divert the excess rainwater away from the site (e.g. to a natural watercourse, storm drains or sewer network. Conversely, in cases where rainwater supply is insufficient, a back-up supply of potable water or non-potable water from other sources should be available for the relevant water using devices and appliances.

Greywater reuse

The reuse of greywater is relevant for all building types, regardless of climate and building morphology. Greywater is basically domestic wastewater that comes from wash basins, showers, bathtubs, washing machines, dishwashers and kitchen sinks. Normal building use activities are constantly generating greywater but as soon as it is mixed with the flushings of toilets, it can no longer be considered as such.

Consequently, for greywater reuse to be feasible, it is necessary to:

- Have separate collection networks for greywater and for other domestic wastewater.

[4] Konrad CP., 2003. USGS Fact Sheet FS-076-03. Effects of urban development on floods.

- Have a treatment system for greywater installed onsite.
- Have a distribution network to take the treated greywater to the point of reuse.

Design considerations

Volumetric demand and supply: The demand for greywater should dictate how many sources should supply greywater. The number and type of supplying sources should be considered together with their total daily volumetric inputs, their usage patterns and their peak flowrates.

Greywater storage capacity: The standalone storage of untreated greywater is not recommended. Any storage prior to treatment should be linked to directly to the inlet of the treatment system. The necessary storage volume for treated greywater will be influenced by the demand and supply patterns. However, as a general rule of thumb, storage capacity of no more than 1 day of greywater supply is normally sufficient. To remedy any excess of supply, greywater storage tanks must have an overflow that diverts excess greywater to the sewer or other suitable outlet. For situations of excessive greywater demand, potable water inputs to the greywater tank (or directly to the devices or appliances accepting greywater) should be possible via installed connections.

Organic load of the greywater: Organic matter will be metabolised by bacteria and can lead to the water turning anoxic or anaerobic, with subsequent formation of odorous gases. There is a higher organic load in greywater from kitchen sinks and dishwashers (due to fats, oils, grease and food waste) than greywater from washing machines, showers and bathroom wash basins. For this reason, the preferred sources of greywater inputs are in the following order (lowest organic load first): shower and bathtubs < bathroom wash basins < washing machines < kitchen sink and dishwasher.

Treatment of greywater: There are a variety of treatment options available which, in order of increasing complexity are generally as follows:

- direct reuse systems with no treatment (only recommended for sub-surface and non-spray irrigation);
- short retention systems with basic skimming and limited sedimentation of large particles;
- basic filtration and disinfection systems where suspended solids are removed and disinfection may be carried out by the addition of chemicals and/or exposure to UV light.
- biological systems where bacteria metabolise dissolved organic material
- bio-mechanical systems, which operate under the same principles as biological systems, but which also include mechanical aeration and the separation of solids (e.g. via sedimentation, filtration or floatation)..

The extent of treatment required is also influenced by the source and intended use of the greywater. Toilet flushing and non-spray irrigation with greywater from showers will lead to fewer concerns about greywater treatment level than laundry or spray-irrigation applications with greywater from kitchen sinks.

Although Regulation (EU) 2020/741[5] sets minimum requirements for treated urban wastewater prior to reuse in agriculture, there are no such EU level requirements set for the reuse of greywater. Any quality requirements for greywater reuse should be checked at the local, regional or national level (e.g. BS 8525-1[6] in the UK and various regulations in Spain[7]). For example in the UK, guideline values for monitoring of the performance of greywater systems refer to Ecoli, intenstinal enterococci, legionella pneumophila, total coliforms, turbidity, pH and residual chlorine/bromine.

[5] Regulation (EU) 2020/741 of the European Parliament and of the Council of 25 May 2020 on minimum requirements for water reuse. OJ L 177, 5.6.2020, p.32-55

[6] BS 8525-1:2010. Greywater Part 1 – a code of practice, see www.standardsuk.com

[7] Domenech L. and Valles M., 2014. Local regulations on alternative water sources: greywater and rainwater use in the metropolitan region of Barcelona. Investigaciones Geograficas, 61, pp. 87-96. DOI: 10.14198/INGEO2014.61.06

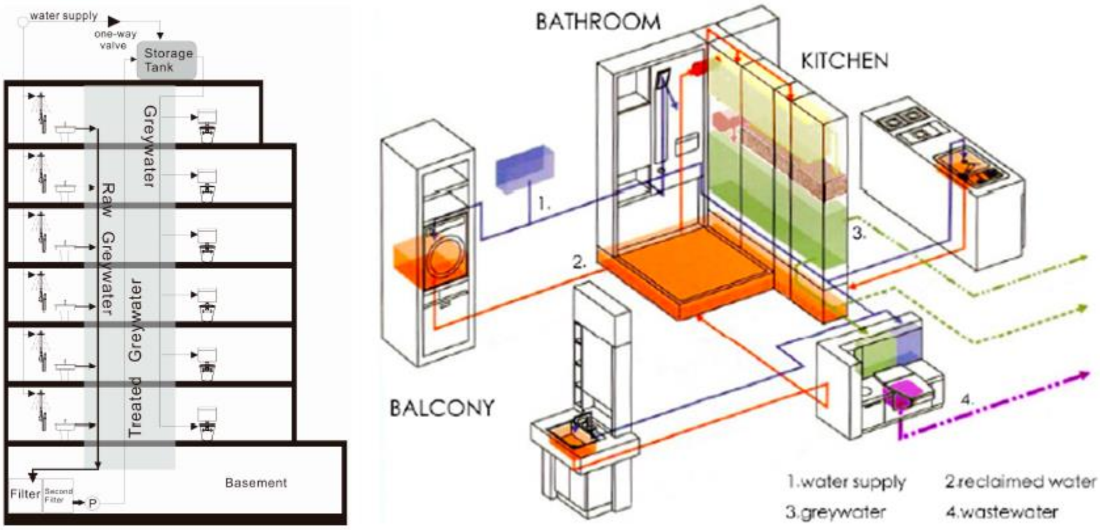


Figure 9. Examples of a multi-dwelling (left) and single dwelling (right) greywater system.

Source: Juan et al., 2016.[8]

In the multi-dwelling approach shown above, greywater from showers and bathroom wash basins is fed by gravity to a greywater filtration system in the basement. The filtered greywater will then be collected in a sump and pumped to a treated greywater storage tank in the attic or roof area of the building. From this tank, greywater is fed exclusively to toilets in the dwelling by gravity. The sump in the basement, the pump and the attic storage tank need to be carefully sized to ensure that there is normally enough greywater to meet most or all of the toilet flushing needs. If the greywater supply exceeds toilet flushing demand (e.g. residents taking long showers and using low-flush volume toilets, then a secondary use for the excess greywater overflow should be sought (e.g. irrigation of communal gardens or periodic street cleaning. While the centralised multi-dwelling system is relatively simple and space efficient, it could be argued that it is not energy efficient for greywater to flow down from the top floor to the basement before being pumped back up to the roof again. This could have notable impacts on the carbon footprint associated with water consumption[9].

In the single dwelling example above, the potable water supply comes via the blue line to the shower, toilet, wash basin, kitchen sink and washing machine. Greywater from the shower, wash basin, kitchen sink and washing machine is fed by gravity along the orange lines to an underfloor greywater collection sump. From there it is pumped through a vertical standing filtration system, producing a treated greywater (green line) that is fed to the toilet and other potential outlets (e.g. irrigation). Toilet flushings are sent to the mains sewer via the purple line.

Adequate labelling of pipes and values is highly recommended when installing any greywater reuse system and the same cost arguments apply about greywater storage tanks as for rainwater storage tanks. However, the scale of rainwater storage capacity should be much greater than that of greywater due to the regular production of greywater, the concerns about greywater turning anaerobic and the need to optimise rainwater supply for prolonged dry periods.

L1.4 concept 4 – Water efficient vegetated areas

Irrigation water is required for vegetated areas to compensate for water that is lost by **evapotranspiration**. This term accounts for losses of water by **evaporation** from the soil, and from **transpiration** by plants. Evaporation rates depend on climatic conditions like wind speed, humidity, air temperature and soil temperature. Transpiration rates depend very much on the plant species in

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8 Juan Y-K., Chen Y., Lin J-M., 2016. Greywater reuse system design and economic analysis for residential buidings in Taiwan. Water, 8, 546; doi:10.3390/w8110546

9 Environment Agency 2010. Energy and carbon implications of rainwater harvesting and greywater recycling. Report SC090018. ISBN: 978-1-84911-198-0.

question, its anatomy, physiology and biochemistry, which in turn determine how it responds to the given environmental conditions.

Plants transpire water since it is the medium by which mineral nutrients are absorbed by roots, and transported throughout the plant (via xylem) and released to the air via special pores in leaves/shoots and flowers called "*stomata*". The release of water by transpiration generates to pressure drop necessary for more water to be taken up by the roots. The water demand of vegetated areas depends on a number of factors which can broadly be grouped as follows:

- Plant species: the inherent amount of water for the physiological functions of the plant to be correctly maintained. Under any given set of conditions, one plant species will need more or less water than another. This is basically the plant water demand.
- Below ground factors: such as the water absorption capacity of the soil, soil cover, soil temperature and soil permeability.
- Above ground factors: basically microclimatic conditions like exposure to wind, sunlight, other heat sources and humidity.
- Irrigation system efficiency: this depends on how precisely the water is delivered to the point of demand (i.e. to the soil surrounding the plant roots).

These factors act in combination as well. For example, using spray irrigation at 3pm in the afternoon will reduce irrigation efficiency both due to a certain fraction of the water not reaching the plant roots and due to the increased evaporation rate of the water since it is being sprayed at the hottest part of the day.

Choice of plant species

The careful consideration of plants that are well adapted for the local climate will mean that they are unlikely to require any additional irrigation. The natural variations in rainfall throughout the seasons should suffice for native plants most of the time. Perhaps only intermittent irrigation would be needed during periods of prolonged drought.

Especially in areas with low annual rainfall in general, xeriscaping principles could be applied. Xeriscaping is a term commonly used for the landscaping of areas with low or very low water demand plants. It should be noted that xeriscaped areas may differ significantly from an aesthetic point of view when compared to more heavily irrigated areas such as a grass lawn. Such plants are especially relevant in Mediterranean climates, where a number of low water demand plant varieties have been reviewed[10].

Regardless, users should be aware of the wide range of different water demands across different plant types (e.g. trees, bushes, creeping plants, lawn grass etc.), herbaceous perennials, annual flowering and bedding plants, turfgrass) and individual species within each plant type. A method for determining plant water demand, specifically for landscaping plants is set out in: "*ANSI/ASABE S623.1: Determining landscape plant water demands*", published by the American Society of Agricultural and Biological Engineers in 2017.

If large plant species are to be incorporated, attention must be paid to the space needed for proper root anchorage and to any potential conflicts between root systems, nearby infrastructure and nearby hardscaped areas, for the benefit of all three. A variety of considerations are presented by Watson et al. (2014)[11].

Below ground factors

In the conceptual design, attention should be paid to aspects such as the impermeable liners in bedding areas where vegetation shall be established. The benefit here would be that water is not lost during excessive irrigation or rainfall, but can be conveyed to a desired point or retained in the soil profile.

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[10] Baltzoi P., Fotia K., Kyrkas D., Nikolaou K., Paraskevopoulou AT., Accogli AR., Karras G., 2015. Low water-demand plants for landscaping and agricultural cultivations – a review regarding local species of Epirus/Greece and Apulia/Italy. Agriculature and Agricultural Science Procedia 4, 250-260.

[11] Watson GW., Hewitt AM., Custic M., Lo M., 2014. The management of tree root systems in urban and suburban settings II: A review of strategies to mitigate human impacts. Arboriculture & Urban Forestry, 40(5) p.249-271.

The incorporation of organic matter into the soil will improve its water retention capacity. The application of a mulch layer at the surface (e.g. a layer of bark chips, pine needles, grass cuttings, leaves and/or straw) provides an input of organic matter that can be periodically replenished and also serves to reduce evaporative losses from the underlying soil.

Above ground factors

The location of any vegetated areas can be considered in the conceptual design. For the sake of minimising soil evaporation, microclimate factors such as wind barriers (e.g. from walls), the potential heat island effect and exposure to direct sunlight should be considered. The staging of vegetation (e.g. bushes or grass under trees) should be considered too. In addition to the use of a surface mulch layer, these factors can also help reduce soil erosion.

Efficient irrigation systems

At the Level 1 stage, it is enough to consider the range of efficiencies of different irrigation techniques. The most appropriate technique will be partly influenced by the uniformity of water distribution necessary. For example, lawn grass will have a dense but shallow root zone equally spread across the vegetated area. The simplest way to cover the entire area is via spray irrigation techniques, but these are not so uniform in their distribution and often the way to compensate for poor uniformity is to increase the area covered, the number of spraying points or the irrigation time, all of which will lead to higher specific irrigation water consumptions. For larger plants with deeper and more extensive root systems, uniformity is not important and drip-fed subsurface irrigation is particularly useful.

In order to be able to evaluate the efficiency of the planned irrigation system, the possibility of controls that are easy to reprogram based on observations of the state of the vegetation and soil should be foreseen. In a similar vein, control features such as soil moisture sensors or rainfall monitoring to automatically determine if irrigation is actually necessary on a given day would be beneficial[12] (e.g. no point irrigating after a thunderstorm in the summer). Other features that can improve the operability of the system, such as strainers/filters, electrically actuated valves, one-way valves, pressure release valves, air bleeding valves and drain/flush valves should be considered in the conceptual design.

There are a number of different types of irrigation system, all of which can have their own irrigation efficiency. Broadly speaking, the following systems can be considered:

- Drip irrigation via buried pipes.
- Drip irrigation via pipes on ground surface.
- Bubblers and micro-sprinklers.
- Sprinklers (stationary type, pop-up type, rotary type, with varying operating pressures).

The choice of sprinkler system will depend on the layout of vegetation and the importance given to water efficiency. Different irrigation systems may be used on the same landscaped area, with each system targeting different parts.

Novel vegetated areas

The incorporation of vegetation into the building can also be achieved on vertical surfaces (green walls or green facades) and on the roof of the building (green roofs). Such vegetated areas can have a striking visual impact, can reduce building overheating due to evaporative cooling and can improve the quality of the surrounding air. These design features are covered in more detail under indicator 5.1. However, they are mentioned here because the means of irrigation and specific irrigation rates may differ significantly from those for normal vegetated areas on the ground.

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[12] Myriounis C., Tsirogiannis IL., Malamos N., Barouchas P., Babilis DI., Chalkidis I., 2015. Agricultural and urban green infrastructure irrigation systems auditing – A case study for the region of Epirus. Agriculture and Agricultural Science Procedia 4, p.300-309.

L1.4 concept 5 – Potential metering plans

A common saying in management circles is: "*If you can't measure it, you can't manage it*". While this is not a universal truth, it can certainly be applied to water consumption in buildings.

The Level(s) water calculator allows users to define the various sources of water consumption down to the individual sanitary fitting level per person. However in reality, most buildings may only have one single water meter and may make no attempt to estimate or monitor the occupancy rate.

Hence, when it comes to comparing estimates with real meter readings, the following different situations can arise:

- Readings (Level 3) actually agree well with estimates (Level 2) because the estimates were very accurate for all water-consuming activities.
- Readings actually agree well with estimates because, even though some estimates were too high, others were too low, and they subsequently balanced out.
- Readings are much higher/lower than estimates because estimates were too low/too high.
- Readings are much higher/lower than estimates because estimated occupancy rate was too low/too high.

For estimates to accurately match real readings, it has to be remembered that Level 2 estimates are in units of m^3/o/a and real readings will provide numbers in units of m^3/a. The missing conversion factor is the occupancy rate.

For office buildings, this should be estimated and measured in terms of full time equivalent employees (i.e. 8 hours per day). For residential buildings, it should be estimated in terms of full time residents. It will be necessary to try to account for visitors and guests if these numbers are significant compared to the normal building occupants.

Further complications can arise in office buildings in cases where only part of the building is dedicated to use as an office and other parts for other activities (e.g. a restaurant or cafeteria in the ground floor). In such cases, it would be best if the metering of water consumption is separate for the cafeteria kitchen at least. Another obvious application for separate metering would be for irrigation, since this has absolutely no relationship to occupation rate and is instead dependent on the day-to-day weather. Likewise, separate metering for any swimming pool in residential buildings would make sense.

Regardless of the degree of agreement between estimates and real readings, detailed sub-metering can also help building managers and occupants better understand and optimise their real water consumption. Advanced sub-metering of water consumption in buildings is possible based on the use of meters with wireless reporting to a web-based user-interface portal. Such metering does not only provide a much higher resolution image of the sources of water consumption in real time, but can also help detect leaks if there is apparent water consumption during periods of non-consumption.

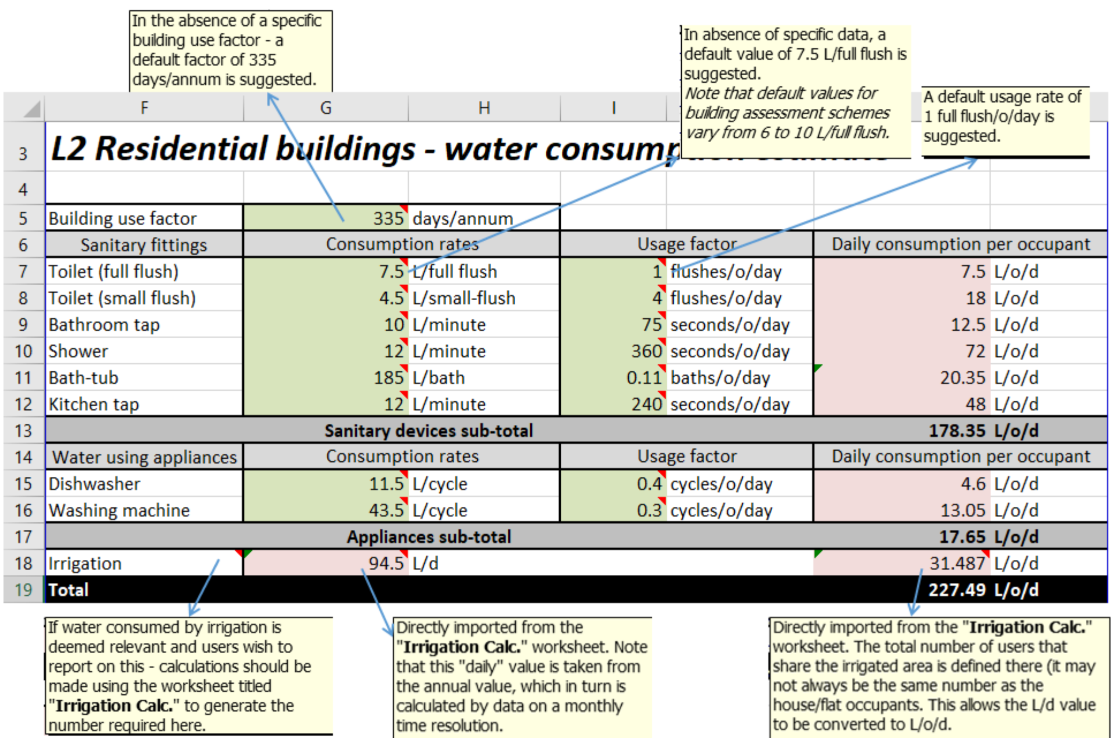
Guidance and information for Level 2

The guidance supports the following Level 2 instruction steps:

L2.2 step 2 – Generating an average summer WEI+ (see L1.4 concept 2 – The relative importance of water scarcity on page 15)
L2.2 step 3 – Filling out cells in Column G and I (and also J and L for office buildings) in the Level(s) water calculator
L2.2 step 4 – (optional) Estimating minimum irrigation water requirements
L2.2 step 5 – Rainwater harvesting or greywater reuse inputs
L2.2 step 7 – Comparing design options side by side

L2.2 step 3 – Filling out cells in columns G and I:

The cells that require input from users are highlighted in green in the Level(s) water calculator. The cells that need to be filled out for residential buildings in columns G and I are shown in the screenshot below.



	F	G	H	I	J	K	L
3	**L2 Residential buildings - water consump…**						
4							
5	Building use factor	335	days/annum				
6	Sanitary fittings	Consumption rates		Usage factor		Daily consumption per occupant	
7	Toilet (full flush)	7.5	L/full flush	1	flushes/o/day	7.5	L/o/d
8	Toilet (small flush)	4.5	L/small-flush	4	flushes/o/day	18	L/o/d
9	Bathroom tap	10	L/minute	75	seconds/o/day	12.5	L/o/d
10	Shower	12	L/minute	360	seconds/o/day	72	L/o/d
11	Bath-tub	185	L/bath	0.11	baths/o/day	20.35	L/o/d
12	Kitchen tap	12	L/minute	240	seconds/o/day	48	L/o/d
13	**Sanitary devices sub-total**					**178.35**	**L/o/d**
14	Water using appliances	Consumption rates		Usage factor		Daily consumption per occupant	
15	Dishwasher	11.5	L/cycle	0.4	cycles/o/day	4.6	L/o/d
16	Washing machine	43.5	L/cycle	0.3	cycles/o/day	13.05	L/o/d
17	**Appliances sub-total**					**17.65**	**L/o/d**
18	Irrigation	94.5	L/d			31.487	L/o/d
19	**Total**					**227.49**	**L/o/d**

Figure 10. Screenshot of Level(s) water calculator (columns F-L, residential buildings)

Each of the green cells has an embedded comments which suggests default values for users in case they do not have specific data. The values for sanitary fittings and water using appliances in columns G and I are multiplied together to automatically generate the values in Column K (red cells).

For irrigation, the value in G18 and K18 are automatically generated from the "*Irrigation Calc.*" worksheet although, as the embedded comments explain, these can be overwritten if other design estimates are available. The value in K18 is basically the value of G18 divided by the number of building occupants that are linked to the irrigated area.

It should be noted that the Level(s) calculation for irrigation water represents the minimum water needed in order to compensate for evapotranspiration. In reality, actual water consumption for irrigation may be much higher, and estimations much easier, when the control is simply to run a pump at a certain rate for a certain period during a certain number of days each year.

For office buildings, the input cells differ as follows:

- It is necessary to consider the gender balance of occupants (cell G53), due to the potential influence of urinals on toilet flushing values.
- There is an input specifically for urinals.
- The % of occupants that use a shower at the office needs to be defined (cell L54).
- In offices, there is a "*kitchenette tap*" rather than a "*kitchen tap*".
- There is the possibility to define water consumption for floor cleaning and for window cleaning.
- There is the possibility to define other water uses (e.g. fountains, HVAC, swimming pools etc.).

As with residential water consumption, users need to insert values in the green cells, which leads to automatically generated values appearing in the red cells.

L2.2 step 4 – (optional) Estimating minimum irrigation water requirements

This requirement is optional because it only applies if there are areas to be irrigated in the first place and, even if there are, there may be other ways to estimate irrigation water consumption that are preferred by users or specified by local, regional or national requirements.

In all cases, whenever vegetated areas form part of a building project, the best management practices for irrigation published by the IA and the ASIC[13].

Irrigation water needs with the Level(s) water calculator

The Level(s) irrigation calculation is related to the approach defined in the VERDE building assessment scheme[14] and uses rainfall and evaporation data set at the level of the river basin in which the building is located. The calculation considers the area(s) to be irrigated, the vegetation type, the vegetation type, the vegetation density, its inherent water demand, microclimate and irrigation system efficiency. The VERDE method is based upon the Landscape Coefficient Method published by Costello and Jones (2000)[15]. However, there are also a number of other methods which can be used[16].

Due to the fact that different vegetated sub-areas can be defined (up to 9 are foreseen in the Level(s) water calculator), the complexity of calculations justifies a separate worksheet (titled "*Irrigation Calc.*").

The user needs to select again the country and river basin in which the building will be located (this must be the same as the river basin chosen in the "*L2 estimate*" worksheet). Step by step instructions are then

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13 IA/ASIC, 2014. Landscape irrigation best management practices. Prepared by the Irrigation Association and the American Society of Irrigation Consultants.

14 VERDE NE (Nueva Edificacion) Residencial, Oficinas. Guia para los evaluadores acreditados. V.1.c. Marzo 2015.

15 Costello, L.R. and K. S. Jones. 2000. A Guide to Estimating Irrigation Water Needs of Landscape Plantings in California: The Landscape Coefficient Method and Water Use Classification of Landscape Species III (WUCOLS III). Sacrament: California Department of Water Resources and University of California Cooperative Extension.

16 Pittenger D., 2014. Methodology for estimating landscape irrigation demand. Review and recommendations.

stated in the worksheet in yellow text boxes and bold red text. Users only need to provide values in green cells. Automatically generated numbers appear in red cells.

	A	B	C	D
1	**Country:**	Spain_ES		
2	**River basin:**	FD17_Basque_County_internal_basi		
3				
4		**Rain (mm/month)**	**Actual ET (mm/month)**	**Balance (mm/month)**
5	**January**	66.7	41.9	24.8
6	**February**	49.9	47.0	2.8
7	**March**	50.8	65.0	-14.2
8	**April**	44.3	66.1	-21.8
9	**May**	45.8	70.3	-24.5
10	**June**	31.7	61.9	-30.2
11	**July**	20.5	51.3	-30.9
12	**August**	28.9	41.6	-12.6
13	**September**	32.2	34.7	-2.5
14	**October**	51.1	32.3	18.8
15	**November**	81.7	27.8	53.8
16	**December**	62.7	33.7	29.0
17	**Total**	**566.4**		**-136.6**

Figure 11. Screenshot of Level(s) water calculator ("Irrigation Calc." worksheet – climate data).

As shown in the figure above, by selecting the country and river basin for cells B1 and B2, the rainfall and evapotranspiration data are automatically generated in columns B and C. The result of Column B minus Column C is presented in Column D. Irrigation is only considered necessary when the values in Column D are negative.

The Level(s) calculator assumes the need of irrigation water as compensating for any negative balances in Column D. Users are allowed to overwrite the data in Column D if they have more representative data for the building location.

The next step is to define each vegetated sub-area (up to 9 are provided in the excel sheet).

For trees, enter the area as the expected area covered by the tree trunk and extended branches.
If the area beneath the tree is also vegetated (e.g. with lawn grass) then this particular area should be counted twice).

Can vary in different sub-areas of the same building depending on degrees of shading by buildings, degrees of shelter from winds and extent of hard paved ares.

The extent to which vegetation is vertically and horizontally structured (i.e. high density is associated with trees/bushes surrounded by grass and with branches overlapping with neighboring trees/bushes; low density is associated with isolated trees/bushes surrounded by open soil or pavement).

	A	B	C	D	E	F	G	H	I	J	K
19		**Area**		**Vegetation type**	**Water demand**	K_{Sp}	**Microclimate / Heat island effect**	K_M	**Density of vegetation**	**Density (shading) factor (K_d)**	**Vegetated area coeffieicnt K_{VA}**
20											
21											
22	Sub area-1	140	m2	Lawn grass	High water demand	0.8	High	1.2	Medium density	1.00	**0.96**
23	Sub area-2	65	m2	Trees	Medium water demand	0.5	High	1.4	Medium density	1.00	**0.7**
24	Sub area-3	15	m2	Bushes	Medium water demand	0.5	High	1.3	High density	0.50	**0.325**
25	Sub-area-4	10	m2	Creeping plants	High water demand	0.7	Low	0.5	Low density	1.10	**0.385**
26	Sub area-5		m2								
27	Sub area-6		m2								
28	Sub area-7		m2								
29	Sub area-8		m2								
30	Sub area-9		m2								
31	**Total vegetated area**	**230**	**m2**								

Figure 12. Screenshot of Level(s) water calculator ("Irrigation Calc." worksheet – landscape areas and coefficients).

The areas in Column B need to be defined by the user. The vegetation type in Column D is chosen from a drop-down list of limited options ("*Trees*", "*Bushes*", "*Creeping plants*", "*Mixed planting*" or "*Lawn grass*"). In Column E, users can select from "*High*", "*Medium*" or "*Low*" water demand. The combination of inputs in Columns D and E automatically determines the species coefficient in Column F.

In Column G, the potential heat island effect can be defined as "*High*", "*Medium*" or "*Low*". A higher heat island effect results in a higher coefficient and thus a higher irrigation water demand. In Column I, the density of vegetation can be defined also as "*High*", "*Medium*" or "*Low*". In this case, high densities translate to lower coefficients and thus lower irrigation water demand.

The three coefficients in Columns F, H and J are then multiplied together to produce an overall coefficient for each sub-area in Column K.

The factor for the irrigation efficiency is factored into the calculations for cells Y22 to Y30.

L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB
Net water balance without irrigation (mm/month)												Total			Irrigation system	Irrigation system efficiency
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	mm/yr	$m^3/m^2/yr$	m^3/yr		
0.0	0.0	-14.2	-21.8	-24.5	-30.2	-30.9	-12.6	-2.5	0.0	0.0	0.0					
0.0	0.0	-13.7	-20.9	-23.5	-29.0	-29.6	-12.1	-2.4	0.0	0.0	0.0	-131.1	0.187	26.2	Sprinklers	0.70
0.0	0.0	-10.0	-15.2	-17.1	-21.1	-21.6	-8.8	-1.7	0.0	0.0	0.0	-95.6	0.101	6.5	Perforated pipes installed underground	0.95
0.0	0.0	-4.6	-7.1	-7.9	-9.8	-10.0	-4.1	-0.8	0.0	0.0	0.0	-44.4	0.055	0.8	Diffusers and micro-sprinklers	0.80
0.0	0.0	-5.5	-8.4	-9.4	-11.6	-11.9	-4.9	-1.0	0.0	0.0	0.0	-52.6	0.088	0.9	Manual or other	0.60
												0.0	#N/A			#N/A
												0.0	#N/A			#N/A
												0.0	#N/A			#N/A
												0.0	#N/A			#N/A
												0.0	#N/A			#N/A
													Total	34.5		

	occupants	m3/o/yr
Relevant number of occupants related to the building area (note that this may be higher than simply the occupants of the single residential building, office or office block in question in cases where vegetated spaces are common to multiple buildings).	3	11.493

Figure 13. Screenshot of Level(s) water calculator ("Irrigation Calc." worksheet – conversion into actual water demand).

The data in Columns L to W are automatically generated based on the rainfall-evapotranspiration data in Column D and the sub-area coefficient. The negative values are totalled in Column X.

The final two inputs that the user has to make are in Column AA, where the irrigation system type has to be defined (options are "*Perforated pipes installed underground*"; "*Perforated pipes installed on ground*", "*Diffusers and micro-sprinklers*"; "*Sprinklers*" and "*Manual or other*"). Each option has its own efficiency coefficient. Finally, the user has to define the number of occupants that the landscaped area serves (cell Y34). Note that this might not be the same as the number of building occupants in cases where the landscaped area is shared between more than one building.

The efficiency coefficient is accounted for in Column Y and the area of the sub-area in Column Z. The Column Z values are then totalled (cell Z31) and divided by the number of occupants (cell Y34). The $m^3/o/a$ value is provided in cell Z34 and is carried over into the "*L2 estimate*" sheet (specifically cells G18 and G63 for residential and office buildings respectively).

L2.2 step 5 – Rainwater harvesting and greywater reuse inputs:

The Level(s) water calculator allows users to define inputs of rainwater and/or greywater to the system and where they would be directed. It is not optional because even if no rainwater harvesting or greywater reuse is considered, the user still needs to actively select "*no*" from the dropdown menus. The cells related to these inputs and outputs are shown below.

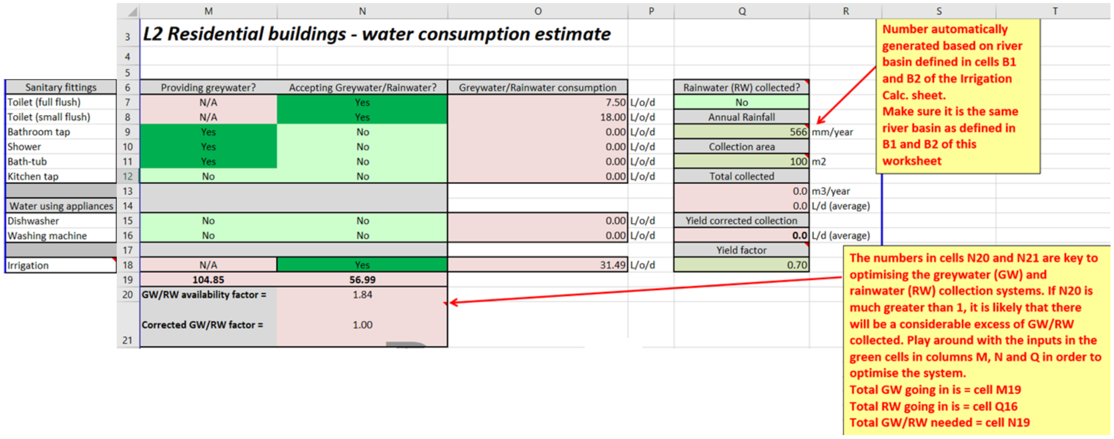


Figure 14. Input and output cells for rainwater and greywater in the Level(s) water calculator.

In column M, any sanitary fittings or water using appliances that can be considered to generate greywater are defined. They contribute to a total input value in cell M19. Rainwater inputs can also be defined in Column Q (by filling out the green cells). These inputs also contribute to the value in cell M19.

Next, it needs to be defined if irrigation or if any fittings, devices or appliances will accept greywater or rainwater (these values total in cell N19).

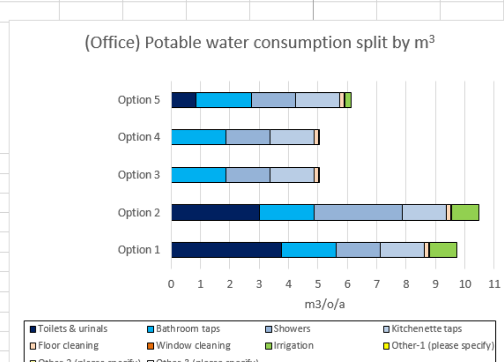
The inputs and outputs of greywater and rainwater are compared in cell N20. If the value is greater than 1.00, it means supply exceeds demand. Users should try to match supply and demand quite closely (i.e. values close to 1.00) in order to minimise the volume of tanks needed and/or overflowing of the tank. If greywater is stored for too long, the water will turn anoxic/anaerobic, generating odorous gases.

L2.2 step 7 – Comparing results for different options

Users can also save one separate excel file for each design option. If they wish to compare different design options side by side, they should use the "*L2 comparison*" worksheet.

Office building water consumption

	Brief description of options				
In the cells to the right, briefly describe the scenario. If needed. Expand on the description via an embedded comment.	Baseline scenario (5% of people using shower)	Replace 7.5L/4.5L dual flush toilets with 6L/3L dual flush toilets, 10% of people use shower	Same as option 1 but collecting RW over 50m2 for flushing and irrigation	Same as option 3 but with 2500m2 lawn instead of 450m2	Same as option 1 but using GW from bathroom taps and shower for flushing and irrigation
	Option 1	**Option 2**	**Option 3**	**Option 4**	**Option 5**
Toilets & urinals	3.75	3.00	0.00	0.00	0.86
Bathroom taps	1.88	1.88	1.88	1.88	1.88
Showers	1.50	3.00	1.50	1.50	1.50
Kitchenette taps	1.50	1.50	1.50	1.50	1.50
Floor cleaning	0.16	0.16	0.16	0.16	0.16
Window cleaning	0.02	0.02	0.02	0.02	0.02
Irrigation	0.93	0.93	0.00	0.00	0.21
Other-1 (please specify)	0.00	0.00	0.00	0.00	0.00
Other-2 (please specify)	0.00	0.00	0.00	0.00	0.00
Other-3 (please specify)	0.00	0.00	0.00	0.00	0.00
TOTAL (m3/o/a)	**9.72**	**10.47**	**5.05**	**5.05**	**6.13**



The cells in green here should be filled in by the user for up to 5 different design options. The values for office buildings should be copied from cells O78-O87 of the "L2 estimate" worksheet and pasted as "values".

Figure 15. Screenshot of example comparison of office building design options.

In principle, the most logical comparison is of potable water consumption, because this is influenced not only by choices of more or less efficient devices, fittings and appliances, but also by the incorporation (or not) of rainwater harvesting and greywater reuse.

As stated in the red text in the screenshot, values for each option need to be manually copied and pasted "*as values*" into the tables in the "*L2 comparison*" spreadsheet.

In the example above, the difference between option 1 and option 2 shows that introducing more efficient toilets would not fully compensate for an increase from 5% to 10% of office workers using the shower. The numbers also show that rainwater collection can easily meet all toilet flushing and irrigation needs (options 3 and 4).