Authors' responses to reviewer comments

We thank the reviewers for their constructive feedback on our manuscript. Following are our responses to their comments. Blue color indicates our responses, *italic is used for citations from the manuscript*, and ***bold shows implemented changes***. All the lines, figures, or tables mentioned below, refer to the revised manuscript.

The following paragraph summarizes our main changes, followed by a specific response for reviewers.

A major revision addresses the reviewers' comments and improve the manuscript. We are happy to submit the revised manuscript for your review and consideration. The revision aimed to improve the readability and clarity of the model description, further discuss the upscaling opportunities and module's applicability, improve methodological shortcomings, and enhance the analysis. Specifically, we have:

1. Revised the model development and description section and included a table describing the modules' variables.
2. We have emphasized the differentiation between the basic (or simple) and the advanced mode of operation. The case study demonstrated the latter, whereas the former fits a global analysis.
3. We have slightly modified the research design, forming a set of calibration scenarios (S0-S2, similar to those presented in the original manuscript) and reclamation scenarios to demonstrate the module's potential uses. We have recalibrated our model separately for each calibration scenario.
4. We revised the discussion section to focus on the upscaling potential, identifying currently available and suitable data sources, indicating data gaps, and proposing solutions to overcome them.
5. We have enhanced our analysis, particularly for the calibration and validation sections, and included some sensitivity analysis as supplementary material.
6. We add model settings for all the scenarios this manuscript presents as part of the supplementary material.

Author responses to RC1

The study introduces and describes a new "wastewater reclamation module" for the global hydrological model CWatM, evaluating the impact of the new module from a water quantity perspective by comparing observed and simulated river discharge for a case study location (Ayalon basin). This is an important area of research for (large-scale) hydrological models, with both aspects of water quantity and quality associated with wastewater have been largely overlooked and simplified in existing models. However, I find it somewhat difficult to fully follow the approach taken, and therefore I find that the manuscript would benefit greatly from a more comprehensive description of the three stages included in the workflow (i.e. pre-treatment; treatment; post-treatment), in addition to justifications for the assumptions made.

We greatly appreciate your constructive comments. We have clarified and simplified the module components and processes introduction, as presented in section 2.2 (lines 89-218). Specifically,

- We distinguish between two different modes of operation: a basic setup with a minimum data requirement, which is already feasible at the global scale, and an advanced (and optional) setup, which fits case studies where data availability is higher.
  In lines 89-95, we state:

*The wastewater treatment and reclamation module (**WTRM**) enhances the capacity of CWatM to simulate the human-water interface at **high** spatial resolution. It introduces wastewater generation, collection, treatment, discharge, storage, and reclamation to CWatM. **Large scale modeling shall utilize the basic setup of the WTRM for which sufficient data is available globally. Case studies for which data availability is higher, may benefit from a set of optional advanced function. The following section distinguishes between basic and advanced (optional) functionalities. Error! Reference source not found.**A demonstrates **WTRM** workflow**, split into three sub-processes**: (1) pre-treatment; (2) treatment; (3) post-treatment.*

- We describe all input data requirements (of the WTRM) associated with a simple/advanced simulation, potential data sources for global modeling, and default values (see Table 4, lines 555-559).

For example:

1. Line 115: "User-defined collection areas". What exactly does this mean/ how is the service area of a wastewater treatment plant defined? How applicable is the methodology for applying in areas lacking detailed information on wastewater treatment plants (i.e. export share, designed HRT)? While not tackled directly in this paper, the authors state that this work "sets the plans of "developing global input data for wastewater treatment and reclamation", but it seems to rely on plant-specific information that is not always readily available.

The term' *user-defined collection areas'* is indeed unclear. We have replaced it by the term' service area' and indicated that it is an input map (line 112).

WWTP service areas (or collection areas) are model input that defines the linkages between location of wastewater generation (individual grid cells, denoted by l) to wastewater treatment plants (denoted by j).

Some processes (e.g., minimum HRT) available via the WTRM are not intended to be used in a global setting. The distinction between the simple and advanced modes of operation is emphasized now in the 'Module development and description' chapter and particularly in section 2.2, Table 4 (see above), and in a revised section of the discussion where we state, for example (lines 519-524):

Following the CWatM modular and flexible structure, the WTRM was developed with that notion in mind, facilitating a simple mode of operation with minimal data requirements, but including advanced procecsses when data is available. The results presented and discussed show a significant incerase in model performance as a result of a simpler implementation of the module (i.e., without urban runoff colleciton), which together with the reclmation scenarios, point on the potential impact of upscaling the analysis to cover other urbanized watersheds, and water stressed regions.

The 'export share' is irrelevant for the global model, as it is only helpful if one needs to account for reclamation outside the simulated area (as noted in Table 4, lines 555-559).

Table 4, followed by a dedicated discussion of the model application, directly tackles the upscaling of the module and, to our taste, proves that global application is feasible. For example, in lines 524-534, we describe the following:

Recent development of different global datasets provide an opportunity for upscaling this analysis, though, these data would have to undertake some processing to fit CWatM data structure. Hydrowaste (Ehalt Macedo et al., 2022) is a global WWTP dataset describign plants' location, treatment level, operational

status, population served, overflow discharge point, and daily capacity. It was recently used to deteremine the impact of droughts on water quality (Graham et al., 2024), and to account for the global microplastic fiber pollution from laundary (Wang et al., 2024). Second, Jones et al. (2021) compiled a global gridded dataset (at a 5 arc minuts resolution) describing wastewater generation volumes, and collection, treatement, and reclamation rates. The data has already been used to force global studies on water quality (van Vliet et al., 2021).

These two datasets provide sufficient global data at a spatial resolution of 5 arc minutes, to accommodate six out of the seven mandatory variables required to setup a simple simlation (see *Error! Reference source not found.****).***

2. How is seasonality in produced wastewater (and therefore reclamation) accounted for in the model? Line 127 suggests daily influent versus daily treatment capacity is considered; but does produced wastewater from e.g. domestic and industrial water uses actually vary at that temporal resolution? Similarly, in some areas, treated wastewater reuse may only occur intermittently throughout the year. How would the model deal with this/ is there a scheme for allowing temporal variability in wastewater reuse?

As CWatM simulates hydrological processes in a daily time step, the WTRM consistently operates at a similar resolution. Estimated wastewater generation (e.g., return flows) in CWatM (see lines 101-102 cited below) is a model input, usually available at annual or monthly (i.e., when considering the effects of temperature on water withdrawal) temporal resolution. The absolute amount of return flows is also capped by the water availability, e.g., in case of high water scarcity (during seasonal patterns).

Wastewater generation in CWatM is represented by non-irrigation return flows, which are a function of water availability and sectoral allocation scheme, and the ratio between the consumptive and total water withdrawal.

Another contributing factor is wastewater influent seasonality, which is associated with the collection system and dominates seasonal patterns in this manuscript. The collection of an urban runoff fraction increases the volume of collected fraction during rain events (i.e., wet season), resulting in a seasonal pattern, as shown in Figure 5 (lines 409-411) and in lines 394-397:

Overall, the model underestimates the inflow to the Ayalon WWTP, as shown in the top panel of *Error! Reference source not found.****, during the dry months (e.g., April to June), which is probably due to the use of annual water withdrawal inputs, that do***

not capture seasonality. Seasonality is only captured by the 'Wastewater with urban runoff' (S2) scenario as a direct result of urban runoff collection.

3. Line 127: "excess wastewater is discharged into pre-specified discharge locations". What exactly does this mean, and how are these specified? Are these specified discharge locations storage basins, or the surface water network itself (i.e. overflows)?

We differentiate between the potential destinations of the treated wastewater flowing out from WWTP (lines 194-196):

The basic module has two post-treatment options: river discharge and reclamation. Direct reclamation (e.g., for irrigation purposes) is possible by using CWatM reservoirs to operate through the water demand module. This option requires data on the linkages between WWTP and reservoirs.

It follows that river discharge, as in overflow, occurs on '***predefined overflow locations***' specifying that wastewater from WWTP can be released into the stream network and under which cases. See lines 200-203.

If all related reservoirs are full, access water is discharged on predefined overflow locations. Discharge into streams/rivers is the default behavior if no reservoir is associated with a treatment plant. Finally, untreated wastewater is discharged if a plant's inflows exceed the plant's peak capacity (see minimally allowed HRT in section 2.2.2).

For this assessment, we have used the exact location for the outflow and WWTP (see Table 1; lines 249-250). At a global scale, we propose a different data source (see Table 4; lines 555-559).

4. Line 140: How is the "surface area of treatment pools" estimated? Why is the estimated pool depth set to 6m? Then line 153 says the depth is set to 1m (does it differ for extensive and intensive systems; it is not clear)? Also, what is the rationale for assuming three treatment pools?

We thank the reviewer for this comment, as we have failed to include the logic behind these technical parameters. These parameters, which are the number of treatment pools (extensive system) and pool depth, are only used to calculate the water surface area and the evaporation losses. In this analysis, they are relatively low (lines 361-365):

In the Ayalon basin case study, the largest share (68%) of the influents is being treated in the Shafdan WWTP outside of the basin of interest (i.e., Sewage

exported; also see Figure 2), and approximately 14% are sent to reservoirs for reclamation. The remaining share includes the discharge of treated wastewater (4%) and raw sewage (8%). Evaporation loss from WWTP is marginal (<4%) and is represented by one of the unlabeled wedges on the wastewater circle.

The treatment systems and process representation were simplified, and the assumptions used to describe them technically are now added to the manuscript.

Regarding intensive systems (lines 159-163, and Appendix B in lines 591-606):

Calculating the surface area of the treatment pools is different for intensive and extensive systems. ***The surface area of an intensive WWTP is defined as the ratio between the plant volume and the pool depth. For that purpose, a simplified representation of WWTP treatment pool is adopted based on a clarifier design (used during both primary and secondary treatment; Pescod, 1992), and the pool depth is estimated at 6 meters (WEF, 2005; see Figure B1)***

Regarding extensive systems (lines 164-166):

Extensive systems are modeled as ***natural biological*** *treatment ponds, alternately filling up and treating water.* ***These processes consist of a relatively short anaerobic treatment in deeper ponds followed by a long-term (20-40 days) residence in facultative shallow ponds*** *(see Figure 1B****; also refer to Pescod, 1992****).*

We also took the opportunity to adjust our initial assumption (guided by information collected for the case study) to the general guidelines proposed by Pescod (1992; lines 173-178). The model code is also re-published.

The surface area of each treatment pool is calculated by dividing the pool's volume by its depth (see Equation 2; Depth, ***currently set to 1.5 meters, as the depth of a facultative pond; Pescod, 1992****). Each pool volume is derived by multiplying the daily capacity (VolCap) with the pool filling time. The latter is a function of the total treatment time (TreatTime) and a predefined number of treatment pools (TreatPool; currently set to* ***two; Pescod, 1992****).* ***Although evaporation losses are overall small (see Figure 4), we allow modelers to change these default technical values with their own estimates (see Appendix B).***

5. Line 173: "collected untreated wastewater is exported form the simulated region if the WWTP associated with the collection area does not exist". Please elaborate, I do not understand what is meant here.

We have rephrased the text to distinguish between two cases of interbasin wastewater transfers: (a) sending treated wastewater to other basins for reclamation purposes; (b) sending collected wastewater to treatment in other basins. The latter occurs if a service area is defined but is not associated with any WWTP in the simulated catchment (see lines 212-218).

The module is designed to allow inter-basin transfers of wastewater or treated wastewater, yet this advanced option is not required in the case of a global model. Interbasin transfer of treated wastewater aims to account for cases in which the reclamation areas extend beyond the borders of the simulated river basin. In that case, WWTP-specific export-share parameters indicate the daily fixed percent of treated wastewater that is transferred for reclamation in other basins. The interbasin transfer of untreated wastewater represents cases in which treated wastewater collected in one basin is treated in another basin. It occurs automatically in case a defined service area is not associated with any WWTP located within the simualted basin.

6. Line 178: How is it determined if a reservoir is accepting treated wastewater? What is the data source for reservoirs and their "associations" with wastewater treatment plants?

Data on reservoir attributes and association to WWTP and command areas based on publicly available online reports from the treatment plants associations and from a national survey was collected for the purpose of this analysis (see Table 1 lines 249-250).

At a global scale, we have proposed a scenario-based approach to assess the potential of wastewater reclamation or to construct a 'virtual' reservoir on the exact location of the WWTP to simulate direct reclamation. See Table 4 and lines 546-554:

As advanced simulations are not pursued globally, data sources for their required variables are not sought. Reclamation and reservoirs' connections are an exception, stemming from the large impact of simulating reclamation on model performance and water resource management analysis. The reclamation rates estimated by Jones et al., (2022) can be used for that purpose. However, as it is not linked to any specific WWTP or reservoir, as required by the WTRM, it would require some pre-processing and simplifying assumptions. Some on-going efforts to identify potential wastewater reclamation for specific WWTP can support this processing (Fridman et al., 2023), yet both data sources would involve high uncertainties at the grid scale. Two other approaches could be taken to assess different reclamation scenarios, including indirect reclamation from waterbodies

(e.g., rivers and lakes) or simulating on-site type-4 reservoirs with command areas set as fixed buffers. Such reclamation scenarios could also explore reclamation by other non-agricultural sectors.

The case study and scenarios are interesting. However, the model is applied and validated against observed discharge in only a single basin, which is both water scarce and already largly reliant on treated wastewater reuse. I find it therefore difficult to assess the applicability of the proposed approach in other hydrological conditions and with different levels of data availability. Being a module of a global hydrological model, I can imagine the eventual intention is to scale up this to be applicable for modelling the globe. I understand the push towards a multi-resolution modelling framework, but I currently struggle to see how/if this wastewater module would be implemented at more coarse spatial resolutions and in more data poor regions.

We have made an effort to clarify these points of criticism, aiming to show the potential of the WTRM to advance global/large-scale hydrological modeling (lines 467-470):

The importance of including wastewater treatment and reclamation in high resolution (i.e., ~1km) hydrological modeling is also aligned with recent findings, as these models are susceptible to the effects of human activity on the water cycle and often require better representation of these processes and more precise data (Hanasaki et al., 2022).

And since (lines 512-514): ***The need for better representing wastewater treatment and reclamation in global, regional and local hydrological modeling is linked to its increasing potential as a water resource.***

We also demonstrated (as described in our comments and revised manuscript) that upscaling to a global coarser (5 arc minutes) spatial resolution is already feasible, but additional efforts could be dedicated to improving currently available data.

Author responses to RC2

In this manuscript, the authors introduce a new module that considers wastewater treatment and reclamation (WRTM) to the Community Water Model (CWatM). Additionally, the manuscript also provides model performance analysis of multiple scenarios with and without the new module as well as some additional wastewater balance analysis for a case study location (Ayalon basin). In general, the manuscript targets wastewater processing, which is an important aspect of research in large-scale hydrological modeling that is often overlooked. However, similar to RC1, I believe the manuscript still needs major revisions before it can be considered for publication.

We thank the reviewer for the valuable comments allowing us to improve the manuscript's readability and the quality of the analysis.

Major comments:

1. Module variables: while there are brief explanations of each variable following equations, I find some of those explanations confusing.

The text describing the module and its variables has been through a major revision (see section 2.2, lines 89-218). We included a table summarizing all the WTRM variables (Table 4; lines 555-559). Below, see our specific comments:

For example: line 109, "...a logical variable (e.g., Ddom).", what do you mean by logical? Or line 110, "...share coefficient (Cs) representing sewer connection rates and leakages", so does that mean if Cs is set at 100, the sewer system will have 100% connection with no leakage?

The term 'logical' has been replaced with 'boolean' (e.g., True/False, 1/0; lines 119-122).

Modelling sector-specific WWTP (e.g., treatment of only industrial wastewater) is an advanced model functionality, and to-date does not fit a global application. It uses a boolean variable (e.g., D_{Dom}), which equales one if the treatment plant recieves a specific wastewater stream (e.g., domestic). A default value of one for both sectors is set in place, in case of missing data.

We have rephrased to distinguish the sewer connection rate (Cs) and leakage from storm management systems to sewers (Rf x α; lines 112-118).

WWTP service areas (or collection areas) are model input that defines the linkages between location of wastewater generation (individual grid cells, denoted by l) to wastewater treatment plants (denoted by j). Wastewater collection is also a function of the sewer connection rate (Cs_l; where a value of one indicates all wastewater is collected and sent to a WWTP), and can include urban runoff (Rf_l), due to leakage or integrtation of the urban stormwater and wastewater systems. The α coefficient defines the level of systems' integration and ranges between zero (no integration) to one (complete systems-integratuion). The total wastewater collected in all grid cells l associated with a WWTP $_j$ are registered as the treatement plant's inflow.

Considering that this module is intended to be publicly used, it would be beneficial to both the manuscript and readers if the authors would provide a much more detailed description of the variables in Equ.1 on: (1) How can they be identified? (2) What are the ranges and units (if any) of each variable? And (3) What do specific values of each variable mean? Please consider providing additional sensitivity analysis on these parameters as well.

We have revised the text in section 2.2 (lines 89-218) to be clearer and better describe the module's processes and inputs. We added Table 4 (lines 555-559), describing all the WTRM variables, including default values. Moreover, we include a sensitivity analysis of the minimally allowed HRT in the main text (lines 398-400) and supplementary materials (lines 81-115 in the supplementary materials).

Points to adress

2. Module inputs: Table 1 has provided a summary of the model's input; however, it is unclear to the reader what the specific temporal (hourly, daily, or monthly? Timeseries or fixed value?) and spatial (gridded or vector-based?) requirements of the local datasets which hindered the possibilities of replicating this manuscript results or future applications of new model users. Additionally, it is unclear which input is critical and which is optional making it challenging to consider applying the module in other data-limited regions.

Table 1 provides an overview of the overall data requirements by CWatM and the adjustments made/new data collected to enhance model performance at a ~1 km resolution. We adjusted the structure of Table 1 better to communicate the data format, and spatial and temporal resolution.

See lines 241 -243:

The CWatM provides global datasets at 0.5 degree and 5 arc-minutes as described in Burek et al. (2020). *This high-resolution analysis combines global and local data sources to better represent the case-study hydrologic processes and human-hydrologic interactions (Hanasaki et al., 2022).*

and lines 246 -247:

… ***A complete documentation of the dataset associated with this publication is available at https://doi.org/10.5281/zenodo.12752967.***

We added another Table 4 (lines 555-559) specifically describing the data requirements of the WTRM and indicating data availability at a global scale.

3. Model calibration: results from Table 3 suggest that while there are significant improvements when the module is applied, the simulated dry season mean flow is still substantially higher than observed data. Additionally, results in Fig B1 suggest that simulated results overestimate ET substantially across the entire calibration period (line chart) while normalized differences are also high, where the majority of the basin in spring and many locations in summer have ~70 to >100%. Thus, please consider further improving the model performance and provide additional comparisons for the validation period as well.

We thank the reviewer for pointing out this critical point. In response, we have recalibrated the models and set the following calibration scenarios:
S0: No wastewater module,
S1: Wastewater reclamation without urban runoff collection,
S2: Wastewater reclamation with urban runoff.
The results indicate that introducing the wastewater reclamation (S1, S2) and the urban runoff collection (S2) have a significant impact on model performance (section 4.1, lines 317-327).

Calibration with different features of the wastewater module also utilizes different parameters, so the calibrated model for S1 and S2 results in lower evapotranspiration flows (ET; lines 47-80 in the Supplementary material).

Further, we have enhanced the comparison of simulated ET with remote-sensing derived ET dataset by comparing with different models and expanding the discussion (section 4.1, lines 47-80 in the Supplementary material, and lines 328-336 in the revised manuscript). We have dropped the spatial comparison, as it is meaningful with some of the datasets with large to very large grid cells.

4. Model validation: considering that this paper focuses on introducing a new module, I'm struggling to see a clear comparison of model performance before and after the module is applied. It is rather difficult to distinguish the difference between simulated and observed results in Figure 3, thus, please consider providing an additional figure showing the hydrographs in a shorter period (i.e., 1 year) and displaying results from all scenarios so that the comparison is more visually clear how the new module can improve model performance. Additionally, since wastewater inflow is also a factor in evaluating model performance, please consider adding additional statistical values in Figure 5 (i.e., NSE, KGE).

Figure 3 (lines 337-339) now shows a comparison between the calibartion scenarios – for a selected year. In the supplementary materials, figures S1-S3 (lines 3-26 of the supplementary materials) show a scatter plot of observed and simulated discharge along the complete modeling period (1995-2019), for different calibartion scenarios.

Finally, table S5 (line 119 of the supplementary material) provides some metrics to compare the two scenarios to the observed WWTP inflows, as stated in lines 406-408:

The wasterwater with urban runoff collection (S2) scenario out perfromes the scenario without wastewater collection based on multiple parametrs (showing lower bias, and higher NSE and correlation; see Table S5).

5. Study area: similar to RC1, I find it difficult to assess the applicability of the module with just validation of one basin/one gauging station. I'd suggest the authors consider adding additional analysis on other basins where there is either less or more data available.

While applying this modelling onto additional basins is our wish, we could not allocate the resources for this task. Still, the revised manuscript indicates that a global implementation of this module is already feasible. Our argument is based on, among others, Table 4 (lines 555-559) and the revised discussion on applicability in lines 507-559.

Minor comments

1. Title, I believe the new module not only considers wastewater reclamation but also additional treatment time right, perhaps a different title that contains WRTM?

We propose a revised title including the word treatment:

Wastewater matters: Incorporating wastewater ***treatment and*** *reclamation into a process-based hydrological model (CWatM v1.08)*

2. Line 91, "hyper-spatial resolution", while 1km grid is relatively high-resolution compared to most global models, please consider editing this term across the manuscript since there are other small-scale models that can simulate wastewater process at much higher resolution.

Although used by Hanasaki et al. (2022) to describe a 2 km hydrological model, we have agreed to change hyper resolution to high resolution.

3. Line 87, "MODFLOW6" and line 226, "Modflow", are these two the same? If so, please be consistent across the manuscript.

All appearances are now aligned with the form MODFLOW6.

4. Figure 2, currently, the legend is rather difficult to read with all the visualization mixed in. Please consider turning all areas outside of the study area to white color in the main map to make the figure more visible.

We have remade the figure, turning the background to white over the land and blue over the sea. We have only left the OSM background for the locator map. See Figure 2, lines 288-291.

5. Figure 4, in-figure text size is too small, please consider increasing it.

We have remade all the figures and increased the font size to ensure readability.

6. Line 281-284, "... simulated evapotranspiration with a satellite derived product... the simulated monthly influent flows into the Ayalon WWTP with observed data...", please reference these figures.

Figures refs are added.

7. The "detrended values" shown in Figure 5 are not mentioned specifically anywhere in the main text, thus consider changing the text to have more linkage while adding more detailed information on the detrend technique. Additionally, there seems to be a clear increasing trend in the top panel of

Figure 5, which might be eliminated if the authors consider running an additional spin-up period to stabilize the model.

The text referring to the detrended results is in lines 401-404:

Rain events during the wet season often result in increased inflows into the wastewater treatment plants (e.g., during December 2016 or January 2018). ***The scenario that includes urban runoff collection (S2) can simulate these peaks, though it slightly overestimates theme, whereas no peaks are simualted for scenario S1 in which no urban runoff is collected*** *(see Figure 5 bottom panel).*

The detrending formula is now written on the y-axis label of Figure 5 bottom panel (lines 409-411).

8. All tables, table sizing, and alignments are inconsistent, please revise.

All tables' widths, alignments, font sizes, and formatting are revised for consistency.

Author responses to RC3

The manuscript titled "Wastewater matters: Incorporating wastewater reclamation into a process-based hydrological model (CWatM v1.08)" introduces a novel development by integrating a wastewater treatment and reclamation module into the CWatM model. This advancement is important as it incorporates human-related activities into large-scale hydrological modeling. The overall structure of the paper is sound and logically organized. However, several aspects of the methodology require further detail and clarification. Additionally, there are concerns regarding the model calibration and validation design, which could influence the results and their discussion. I recommend major revisions to address the methodology section and enhance the robustness of the model evaluation.

Detailed comments

Line 89: Please verify whether the acronym "WRTM" is correct or if it is a typographical error. The acronym for "Wastewater Treatment and Reclamation Module" should be "WTRM" rather than "WRTM". If it is a typo, please correct it throughout the manuscript.

We thank the reviewer for noticing. This was definitely a typo that slipped through. We have changed to 'WTRM' across the manuscript.

Lines 122-124: Please clarify the criteria for defining a wastewater treatment plant (WWTP) with a hydraulic retention time (HRT) ranging from 24 hours to 2 days. Would it be intensive or extensive?

Our statement was unclear. We have adapted the text as follows (lines 127-133):

The two options are intensive and extensive treatment plants, as described in Figure 1b. Intensive treatment refers to the conventional wastewater treatment technology charcterized by low residence time and low area requirements. It usually treats water to secondary or tertiary level over less than 24 hours (Pescod, 1992). As CWatM uses a daily timestep, the intensive treatment plant's treatment period is set to one day. Any WWTP with a longer treatment period (i.e., >= 2 days) would be classified as extensive. Extensive treatment refers to natural biological systems, consist of a short primary treatment in a relatively deep anaerobic pond, followed by a longer residence time (20 -40 days) in a shallow facultative pond for secondary treatment (Pescod, 1992).

Lines 127-130: The description here is unclear. Line 127 states that if the influent exceeds the designed capacity, the excess wastewater is discharged to a pre-specified location. This implies that the inflow is managed below designed capacity by discharging excess wastewater. However, Line 128 mentions that treatment plants allow inflows to exceed the designed capacity, which appears contradictory.

Please clarify whether "daily treatment capacity" and "designed capacity" refer to the same or different metrics.

The designed capacity can be exceeded with a potential impact on removal efficiency. These sentences, however, refer to two different modules' modes of operation. The simple mode, where data on a minimally allowed HRT is unavailable, and an advanced mode. The revised manuscript differs between these modes, for example (lines 142-146):

According to the basic model setup, excess wastewater beyond** the plant's daily treatment capacity **is discharged to the predefined outflow location (see Table 4). However, the model holds advanced modelling capabilities enabling higher WWTP to accept larger inflows to handle temporal fluctioations (e.g., due to significant rain events). Inflows higher that the designed capacity shortens the hydrological retention time (HRT, or residence time), resulting in less effective wastewater treatment.

Line 136-137: Please clarify what "an increase of 25% in the operational daily capacity" is compared to? E.g., compared to HRT = 1 day?

Correct, see lines 153-155.

*For example, a minimally allowed HRT of 0.8 days implies an increase of 25% in the operational daily capacity **in the case of a treatment time of 1 day.***

Lines 154-155: The term "total treatment time" is ambiguous. Is this time fixed for treating fully filled treatment pools, or does it vary based on the storage conditions? Please provide a more detailed explanation.

It has changed to a 'designed treatment time', e.g., 30 days. Lines 175-177.

*The latter is a function of the **designed** treatment time (TreatTime) and a predefined number of treatment pools (TreatPool; **currently set to two**; Pescod, 1992).*

Line 180: How are WWTPs assigned to "associated reservoirs"? For instance, must the reservoir be downstream of the WWTP, or can users assign reservoirs to WWTPs freely? Please clarify.

Reservoirs are freely associated with WWTP and provided as a model input. These, of course, should represent existing or planned conveyance systems/reclamation projects. Clarified in lines 195-197:

*This option requires data on the linkages between WWTP and reservoirs**, that should represnet existing or planned water conveyance systems.***

Lines 266-267: Please clarify whether Scenario S2 was used for model calibration and if the calibrated parameters were applied across all scenarios. If so, this approach might not be appropriate, particularly in the context of the model performance evaluation discussed in Section 4.1 (e.g., Table 3). Scenarios S0 and S1 may underperform because they were not calibrated for these specific scenarios. Please explain why separate calibration for each scenario was not performed.

We highly appreciate this comment as it precisely indicates our initial research process. Unfortunately, we have not saved these results and have had to recalibrate them. Thus, we have separately calibrated each of the calibration scenarios S0, S1, and S2 (lines 295 – 298):

In the first scenario (S0) we disable the wastewater treatement and reclamation module. The second (S1) and third (S2) include wastewater treatment and reclamation without and with urban runoff collection, respectively. The share of urban runoff flowing into the sewers is set as a calibartion parameter in S2.

The results were replicated relative to the former version of the manuscript and are communicated in Figure 3 (lines 337-339), Table 3 (lines 354-355), figures S1-S4 (lines 2-40 in the supplementary materials), and Figure S7 (lines 79-80 in the supplementary materials).

Figures

Figure 2: The reservoirs, canals, and other water features are difficult to distinguish due to the busy map. Consider increasing the transparency of the background map, removing it altogether, or using thicker lines to better highlight the water features.

We have remade the figure, turning the background white over the land and blue over the sea. We have only left the OSM background for the locator map. See Figure 2, lines 288-291. We also slightly modified the coloring of the reservoirs and waterbodies, and added labels and names to the reservoirs.

Figure 4: The figure is confusing, as it is unclear which text corresponds to which circle. It would be helpful to use different colors for the text associated with the circles and the text indicating different flows to improve clarity. In addition, the texts in the circles are too small to see.

We have added clear and readable labels to the wedges of the circles, along with distinct titles representing different CWatM modules. The image layout has been adjusted to enhance readability. Additionally, we opted to retain black text to avoid graphical oversaturation and maintain visual clarity. Instead, we have used different font faces, e.g., bold, normal, italic, to distinguish between circles labels, titles, and flows. See lines 378-380.

References

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