MAHLERAN Manual

Part One

1. Description

MAHLERAN (Model for Assessing Hillslope-Landscape Erosion, Runoff and Nutrients) is a soil erosion and nutrient transport model developed over a number of years by John Wainwright and various collaborators. The model employs a conceptualization of soil-erosion processes which takes account of the fact that interrill flow on hillslopes is dominated by rolling or sliding along surfaces or in short steps akin to movement of bedload. Parameterizations of the different soil detachment and transport mechanisms that occur under rainfall are used to better capture the reality of soil-erosion processes. A full exposition of the theory underlying MAHLERAN can be found in:

- Wainwright, J, AJ Parsons, EN Müller, RE Brazier, DM Powell and B Fenti 2008 `A transport-distance approach to scaling erosion rates: 1. background and model development´, Earth Surface Processes and Landforms 33, 813–826. DOI: 10.1002/esp.1624.;
- Wainwright, J, AJ Parsons, EN Müller, RE Brazier, DM Powell and B Fenti 2008 `A transport-distance approach to scaling erosion rates: 2. Sensitivity and evaluation of Mahleran´, Earth Surface Processes and Landforms 33, 962–984. DOI: 10.1002/esp.1623;
- Wainwright, J, AJ Parsons, EN Müller, RE Brazier, DM Powell and B Fenti 2008 `A transport-distance approach to scaling erosion rates: 3. Evaluating scaling characteristics of Mahleran´, Earth Surface Processes and Landforms 33, 1113–1128, DOI: 10.1002/esp.1622.

There are two ways in which to run MAHLERAN:

1. From an executable version of the program. This requires only that you collect data and set up the input files specified in the rest of this part of the manual.
2. Using the FORTRAN source code. If you are a developer and would like to work with the FORTRAN source code it can be downloaded from an online repository. In addition to the MAHLERAN code you will need a compiler and development environment in which to work.

Executable versions of MAHLERAN are available on request for general users, and access to an online repository can be gained for developers by contacting John Wainwright at Durham University, john.wainwright@dur.ac.uk. The remainder of this part of the manual deals with using an executable version of MAHLERAN. To use the FORTRAN source code refer to Part Four of this manual.

2. Using an executable version of the program

In order to use an executable version of MAHLERAN you will first need to set up the a single folder that contains the executable version of MAHLERAN, the file mahleran_input.xml and the input and output folders. In Windows10, the program runs from windows powershell, so open this application and the folder that contains these files and folders.

mahleran_input

Your interaction with MAHLERAN is through the file mahleran_input.xml. This file specifies the names of the files that contain the input you need to provide, as well as specifying parameters that the model uses. The minimum of data you will require to run MAHLERAN is a digital elevation map (DEM) of the site you are interested in and some rainfall data. You will need to specify other information, even if that information has zero values, or you adopt the default values of the model.

Appendix I gives an example from a working input file of the content of mahleran_input.xml. It is useful to have a printed copy of the file to hand as you work through it and edit it to provide the information required, or selected. Below, the elements of the input file are described, and the various options associated with these elements are given.

Model type value

Must be set to <1>

Runtype value

MAHLERAN usually runs as an event-based erosion model but other versions (continuous and MiC (see Cooper et al. 2012) are available). These other versions are described in Parts Two and Three of this Manual. The timestep (s) used in the model is specified in < time_step value=>

Input and Output folder values

You need to specify the names of the folders containing input files and the folder to which output files will be written. Typically, these may have the names <input> and <output>, but here they are subfolders within these named folders.

Input files

You must provide a DEM of your study area, and rainfall data. <Dem value> and <rainfall data value> specify the names of these files. All other <map value> files are optional. If you provide them, then they will also need to be in the input folder. If you do not, just leave the pair of “” marks, as in this case for <suction map value>.

All files that contain spatial data (the DEM and all <map value> files must have an .asc extension. The format of these files is as follows.

The header (i.e. the first six lines) of the file must contain the following:

1. the number of columns (ncols);
2. the number of rows (nrows);
3. the x coordinate of the lower left-hand corner cell (xllcorner);
4. the y coordinate of the lower left-hand corner cell (yllcorner);
5. the cell-size of the image in metres (cellsize);
6. a nodata_value of -9999. This value is used in the model to indicate that data are missing for a particular cell (and this is used in some instances to generate output).

Important note: It is essential that the header information is consistent across all of the **.asc** files. If it is not the program will fail to run.

An example of the format used in given below:
ncols 24
nrows 49
xllcorner 0.00000000
yllcorner 0.00000000
cellsize 0.29900000
nodata_value -9999

All rows and columns in these files must begin and end with the nodata value -9999. You can have more than one such value at the beginnings and ends of rows and columns if the study area is not a rectangle. The format of entry can be as a 2-d array, or as a 1-d string of values provided that at the beginning and end of every ‘virtual’ row and column the nodata value is present

Rainfall
Rainfall information may be entered in one of 4 ways as specified in < rain_type value=> where
1 = constant rainfall rate

2 = storm read from file rainfall.dat, which has the following format:

The first line of this file is the start time and subsequent lines contain the time and the rainfall intensity in mm/h during the time period between the current and the previous times. The times MUST be in the format hh:mm:ss.ss followed by a SINGLE SPACE. The rainfall intensities should be in floating point notation, no more than ten characters long. Below is an example of the first four lines of a rainfall data file:

13:57:00.00
13:58:00.00 63.4228188
13:59:00.00 42.2818792
14:00:00.00 21.1409396

3 = rainfall value is a random number drawn from a normal distribution with mean rainfall given by <mean_rainfall value=>, standard deviation given by <std_dev_rainfall value=>, and distribution skewness given by <skewness_rainfall value=>

4 = a spatial map of constant rainfall.

For all but 2, in which case the model will automatically recognize the end of the file, the storm length (in seconds) must be specified in < stormlength value=>

In addition to the temporal information about the rainfall as given above, if you have spatial information on the rainfall intensity (i.e you know more rain than average fell on some cells but less on others), you can specify this information in the <rainfall-scaling_map value> file. After the header information this file consists of a string of numbers by which the rainfall for each time period is multiplied by. So, in the trivial case, if all of these numbers is 1 then rainfall is spatially uniform. **However, this file must always be present because the map is also used to define the areas outside of the plot being investigated, which are used to determine where outputs are calculated. Set the outside plot areas to –9999. If this is not done, the runoff and erosion will be incorrectly output.**

Surface characteristics

You can provide two surface characteristics for each cell: the vegetation cover,as a percentage (vegetation-cover_map value), and the percentage of the cell covered by pavement(=stones)(pavement_map value). In addition you can specify one or more surface types (surface-type_map value), which are used to control other parameters (see below).

Infiltration

The model includes an infiltration component based on the Smith and Parlange approach. There are two options under <infiltration model value>: 1 derives from Smith & Parlange (1978); 2 uses an exponential approximation of parameters. You need to specify a final infiltration rate (mm/s), wetting-front suction (mm), a drainage parameter, initial soil moisture (wt/wt), saturated soil moisture (wt/wt), and soil thickness (m). These parameters may be defined in maps, or as a single value (with the option of specifying a standard deviation) for each surface type. If they are defined in maps then set the <use … map value> to <true>. In the example in Appendix 1, there is a map for the initial soil moisture and saturated soil moisture for each cell, but all other parameters are given a single value, with a standard deviation of zero. In the example there is only one surface type, so the lines in the input file would need to be repeated for each surface type in the case of more than one.

Flow hydraulics

Overland flow is modelled using a kinematic wave approximation to the 2D shallow water equations combined with the Darcy-Weisbach flow equation to calculate velocity. Flow is assumed to be in direction of steepest descent in 4 cardinal directions (as specified in <flow_direction value=>). A consequence of this assumption is that the DEM must not contain any pits unless using option 6 below. Four flow-routing solutions are available, as specified in < flow-routing_solution_method value=>, where 1 = Euler simple backward difference (after Scoging, 1992), 2 = Crank-Nicolson with Newton Raphson solution (efficient algortithm), 5 = Crank-Nicolson with bisection method, and 6 = Crank-Nicolson with bisection method and automatic overtopping of sinks. Note: Options for iroute = 3, 4 are not available in the current version of the code.

The model requires information on the Darcy-Weisbach friction factor. This comprises the friction factor type in which values 1 to 8 denote 1) deterministic, 2, stochastic, 3) feedback, 4) deterministic with feedback based on Re, 5)modified deterministic with feedback based on Re, 6) deterministic with feedback based on Re^0.33, 7) deterministic with feedback based on discharge, and 8) based on Lawrence (1997). As for the infiltration parameters, information on friction factor may be entered as a map or as a value for each surface type.

Sediment detachment and transport

Sediment is divided into six size classes in order to account for differing behaviour of particles of different size and is transported by splash, flow (concentrated/unconcentrated) or in suspension. Detachment is assumed to occur in one of three ways: (1) as a function of raindrop detachment alone when there no overland flow; (2) raindrop detachment modified to account for surface layer effects in the case of unconcentrated overland flow; and (3) concentrated erosion when flow is turbulent. Deposition is modelled using a transport-distance approach described by an exponential distribution function. Information on the six size classes of sediment may be entered via surface type or as a map. Density of particles (g/cm^3) is specified in <particle_density value=>

Raindrop detachment parameters are determined by particle size. In the example given these parameter values are taken from Wainwright et al. 2008b.

Sediment routing solution method is set to the Euler method if given a value of 1, and to the Crank-Nicholson with Newton-Raphson method for a value of 2. 1 is conditionally stable with a Courant number <=1. If the Euler method is used for flow routing, then this criterion has to be met for sediment routing (because sediment velocity <= water velocity). If C-N is used for flow routing, this condition doesn't necessarily still hold, so it's best then to use option 2. In theory, using C-N is unconditionally stable, but can cause the model to run quite slowly for short timesteps.

The active layer sensitivity value is typically D_{50} for the surface per timestep.

Topographic updating
The model provides the option to update the topography in response to sediment movement (<update_topography value=>), including the number of timesteps between updates.

Nutrient movement and transport
[Refer to Mueller et al., 2009 – details to follow heree]

Other versions of MAHLERAN
For the section of the section of the <mahleran input> file beginning <mahleran_continuous name="data for continuous runs"> see Part Two of this manual.
For the section of the <mahleran input> file beginning <mahleran_mic name="data for Marker-in-Cell runs"> see Part Three of this manual.

Output Files
MAHLERAN will produce a range of output files and write them to the specified output folder. These files are listed in the Table below. Setting the logical variable to <true> causes the file to be written to the output folder. Throughout the Table, the file name is given with ******* replacing the run number, i.e. ******* is the consecutive number 001, 002 etc. Thus for example for the 1st run **theta***.asc** would be a file called **theta001.asc** while for the 26th run it would be a file called **theta026.asc**.

Output file name	Description
theta*.asc**	map of soil-moisture content at end of simulation [m m^{-1}]. **This file must be present for consecutive numbering of model runs to be active**.
param*.dat**	Echoes the input parameters for reference
p_nut*.dat**	Particulate-bound nutrient concentrations for nitrate, ammonium TN, TP, IC, TC followed by particulate-bound nutrient fluxes for nitrate, ammonium TN, TP, IC, TC (12 columns)
hydro*.dat**	Hydrological results in 12 columns in the format: time, rainfall, plot discharge, 3 cross-section discharges, 3 c-s depths, 3 c-s velocities (time in seconds, discharges in mm^{3}s^{-1} , depths in mm, velocities in mms^{-1}. Cross sections are at 25%, 50% and 75% from the top of the plot)
disch*.dat**	Hydrograph in 1 minute intervals. Note: will only be correct if time steps of 1s or 0.5s are used.
sedtr*.dat**	Sediment results in 16 columns in the format: time, plot sediment output, plot sediment flux, 3 c-s fluxes, plot yield per unit area, 3 c-s yields per unit area, plot particle size out (six size classes)
nutri*.dat**	Nutrient [NH_4, NO_3, P] concentrations in [mg/l], and then fluxes in [mg/s] in the format: time, [NH_4 NO_3 P] concentrations for plot, [NH_4 NO_3 P] flux for plot, [NH_4 NO_3 P] concentrations for c-s1, [NH_4 NO_3 P] flux for c-s1, [NH_4 NO_3 P] concentrations for c-s2, [NH_4 NO_3 P] flux for c-s2, [NH_4 NO_3 P] concentrations for c-s3, [NH_4 NO_3 P] flux for c-s3
seddetach*.dat**	Total detached sediment [kg m^{-2}] in 7 columns in the format: time, detached sediment (six size classes)
seddepos*.dat**	Total deposited sediment [kg m^{-2}] in 7 columns in the format:

	time, deposited sediment (six size classes)
seddepth*.dat**	Total sediment depth [kg m^{-2}] in 7 columns in the format: time, sediment depth (six size classes)
sedveloc*.dat**	Total average sediment velocity [kg m^{-2}] in 7 columns in the format: time, sediment velocity (six size classes)
seddisch*.dat**	Total sediment discharge [kg m^{-2}] in 7 columns in the format: time, sediment discharge (six size classes)
sedpropn*.dat**	Total sediment proportion [kg m^{-2}] in 7 columns in the format: time, sediment proportion (six size classes)
sedconcn*.dat**	Average sediment concentration [kg m^{-2}] in 7 columns in the format: time, average sediment concentration (six size classes)
nutri*. asc**	Map of NH_4 transport [total ammonium mass in mg]
dschg*. asc**	Map of total event discharge [m^3]
aspct*. img**	IDRISI map of slope aspect (1='N', 2='E', 3='S', 4='W')
depth*. asc**	Map of peak flow depth [mm]
veloc*. asc**	Map of peak flow velocity [mm s^{-1}]
sedtr*. asc**	Map of sediment transport [total sediment mass in kg]
ksat_*.asc**	Map of ksat
detac*.asc**	Map of total detachment {detach_tot} [kg **?**]
depos*.asc**	Map of {depos_tot} [kg **?**]
soild*.asc**	Map of {dmax_soil} [m ?]
soilv*.asc**	Map of {vmax_soil} [ms^{-1} ?]
neter*.asc**	Map of {detach_tot - depos_tot} [kg **?**]
radet*.asc**	Map of {raindrop_detach_tot} [kg **?**]
fldet*.asc**	Map of {flow_detach_tot} [kg **?**]
pnitr*.asc**	Map of particulate-bound nitrate flux from each cell (g)
pammo*.asc**	Map of particulate-bound ammonium flux from each cell (g)
pTNxx*.asc**	Map of particulate-bound TN flux from each cell (g)
pTPxx*.asc**	Map of particulate-bound TP flux from each cell (g)
pICxx*.asc**	Map of particulate-bound IC flux from each cell (g)
pTCxx*.asc**	Map of particulate-bound TC flux from each cell (g)
z_chng*.dat**	Provides a sequence of maps of the change in topography during the program run.
run*ord####.dat**	Sequence of files showing the order in which the flow routing calculations are made in the case where the topography is being updated. #### is a number (starting from 0001) indicating which order. A new file is created each time the order array is recalculated.
endtopog*.asc**	Map of the final topography (i.e. DEM at the end of the run).
drain*. asc**	Map of drainage at base of soil profile [not currently output]

Other files in the input folder

As well as files contained in this folder that are needed to run MAHLERAN, the folder may contain three other files: <calib.dat> , <hydpoints.dat> and <hydrows.dat>. <calib.dat> can be used to scale (uniformly), the ksat and suction moisture parameters. The file contains two lines, the first line is a *ksat* multiplier, and the second a suction-moisture multiplier. If the file is not present, these multipliers default to 1. As an example:

0.5

1.5

<hydpoints.dat> contains a list of cell coordinates (Note these are NOT real coordinates from the DEM but the respective row and column number), then hydrographs, sedigraphs and nutrigraphs are output for each of these cells.

Similarly, if a file called **hydrows.dat** is present in the specified input folder containing a set of row numbers, then hydrographs for those rows are output.

Appendix 1


```xml
<?xml version="1.0" encoding="UTF-8"?>
<mahleran_input name="rfid_2014">
  <version value="1.2.1" />
  <model_type value="1" />
  <runtype value="event" />
  <time_step value="1.0" />
  <input_folder value=".\Input\RFID_2014\" />
  <output_folder value=".\Output\RFID_2014\" />
  <dem value="rfid_2014_dem1.asc" />
  <rainfall_data value="rfid_2014_rainfall.dat" />
  <rainfall-scaling_map value="rfid_2014_scaling1.asc" />
  <vegetation-cover_map value="rfid_2014_veg.asc" />
  <pavement_map value="rfid_2014_pave.asc" />
  <surface-type_map value="rfid_2014_surf.asc" />
  <rain_type value="2" />
  <stormlength value="2700.0" />
  <mean_rainfall value="138.1068" />
  <std_dev_rainfall value="0.0" />
  <skewness_rainfall value="0.0" />
  <infiltration_model value="1" />
  <final_infiltration_map value="rfid_2014_inf.asc" />
  <suction_map value="" />
  <drainage-map_map value="" />
  <infiltration-parameter_type value="1" />
  <drainage-parameter_type value="4" />
  <number_of_surface_types value="1" />
  <final_infiltration_rate_mean values="by_surface_type">
    <type_1>0.01</type_1>
  </final_infiltration_rate_mean>
  <final_infiltration_std_dev values="by_surface_type">
    <type_1>0.001</type_1>
  </final_infiltration_std_dev>
  <wetting_front_suction_mean values="by_surface_type">
    <type_1>23.3</type_1>
  </wetting_front_suction_mean>
  <wetting_front_suction_std_dev values="by_surface_type">
    <type_1>0.0</type_1>
  </wetting_front_suction_std_dev>
  <drainage_parameter_mean values="by_surface_type">
    <type_1>0.05</type_1>
  </drainage_parameter_mean>
  <drainage_parameter_std_dev values="by_surface_type">
    <type_1>0.0</type_1>
  </drainage_parameter_std_dev>
  <initial_soil_moisture_mean values="by_surface_type">
    <type_1>0.004</type_1>
  </initial_soil_moisture_mean>
  <initial_soil_moisture_std_dev values="by_surface_type">
    <type_1>0.0</type_1>
  </initial_soil_moisture_std_dev>
  <soil_thickness values="by_surface_type">
```

```
  <type_1>0.21</type_1>
</soil_thickness>
<initial_soil-moisture_map value="rfid_2014_ism_004.asc" />
<saturated_soil-moisture_map value="rfid_2014_ssm_036.asc" />
<use_final_infiltration_map value="false" />
<use_suction_map value="false" />
<use_drainage_map value="false" />
<use_initial_soil_moisture_map value="true" />
<use_saturated_soil_moisture_map value="true" />
<finalInfiltrationRateDistribution value="normal" />
<wettingFrontSuctionDistribution value="deterministic" />
<drainageParameterDistribution value="deterministic" />
<initialSoilMoistureDistribution value="deterministic" />
<saturatedSoilMoistureDistribution value="deterministic" />
<flow_direction value="4" />
<flow-routing_solution_method value="2" />
<friction_factor_type value="1" />
<friction_factor_map value="" />
<friction_factor_mean values="by_surface_type">
  <type_1>8.71</type_1>
</friction_factor_mean>
<friction_factor_std_dev values="by_surface_type">
  <type_1>0.0</type_1>
</friction_factor_std_dev>
<use_friction_factor_map value="false" />
<frictionFactorDistribution value="deterministic" />
  <particle_size_map values="by_particle_size">
  <phi_1 "rfid_2014_phi1.asc"/>
  <phi_2 "rfid_2014_phi2.asc"/>
  <phi_3 "rfid_2014_phi3.asc"/>
  <phi_4 "rfid_2014_phi4.asc"/>
  <phi_5 "rfid_2014_phi5.asc"/>
  <phi_6 "rfid_2014_phi6.asc"/>
</particle_size_map>
<use_map_phi value="true" />
<mean_particle_size values="by_surface_type">
  <type>1</type>
  <phi_1>0.2</phi_1>
  <phi_2>0.2</phi_2>
  <phi_3>0.2</phi_3>
  <phi_4>0.2</phi_4>
  <phi_5>0.1</phi_5>
  <phi_6>0.1</phi_6>
</mean_particle_size>
<std_dev_particle_size values="by_surface_type">
  <type>1</type>
  <phi_1>0.0</phi_1>
  <phi_2>0.0</phi_2>
  <phi_3>0.0</phi_3>
  <phi_4>0.0</phi_4>
  <phi_5>0.0</phi_5>
  <phi_6>0.0</phi_6>
</std_dev_particle_size>
```

```xml
<particle_density value="2.65" />
<Raindrop_detachment_a_parameter_size values="by_particle_size">
  <phi_1>4.25E-5</phi_1>
  <phi_2>8.07E-4</phi_2>
  <phi_3>5.1E-4</phi_3>
  <phi_4>8.07E-4</phi_4>
  <phi_5>8.07E-5</phi_5>
  <phi_6>8.49E-6</phi_6>
</Raindrop_detachment_a_parameter_size>
<Raindrop_detachment_b_parameter_size values="by_particle_size">
  <phi_1>1.2</phi_1>
  <phi_2>1.08</phi_2>
  <phi_3>0.79</phi_3>
  <phi_4>0.75</phi_4>
  <phi_5>0.75</phi_5>
  <phi_6>0.5</phi_6>
</Raindrop_detachment_b_parameter_size>
<Raindrop_detachment_c_parameter_size values="by_particle_size">
  <phi_1>0.23</phi_1>
  <phi_2>0.21</phi_2>
  <phi_3>0.11</phi_3>
  <phi_4>1.06</phi_4>
  <phi_5>0.1</phi_5>
  <phi_6>0.1</phi_6>
</Raindrop_detachment_c_parameter_size>
<Raindrop_detachment_d_parameter_size values="by_particle_size">
  <phi_1>9.844</phi_1>
  <phi_2>7.464</phi_2>
  <phi_3>8.184</phi_3>
  <phi_4>8.386</phi_4>
  <phi_5>27.17</phi_5>
  <phi_6>679.2</phi_6>
</Raindrop_detachment_d_parameter_size>
<Raindrop_detachment_max_parameter_size values="by_particle_size">
  <phi_1>1000.0</phi_1>
  <phi_2>1000.0</phi_2>
  <phi_3>1000.0</phi_3>
  <phi_4>1000.0</phi_4>
  <phi_5>1000.0</phi_5>
  <phi_6>1000.0</phi_6>
</Raindrop_detachment_max_parameter_size>
<sediment-routing_solution_method value="2" />
<update_topography value="n" />
<topography_update_interval value="1" />
<particle_density value="2.65" />
<active_layer_sensitivity value="1.52E-6" />
<Cs_NH4 value="12.5" />
<Cs_NO3 value="14.95" />
<Cs_PO value="61.0" />
<mass-transfer_coefficient_NH4 value="3.0E-5" />
<mass-transfer_coefficient_NO3 value="7.0E-5" />
<mass-transfer_coefficient_PO value="4.0E-5" />
<Particulate_bound_NH4 values="by_particle_size">
```

```
   <phi_1>0.019</phi_1>
   <phi_2>0.016</phi_2>
   <phi_3>0.007</phi_3>
   <phi_4>0.003</phi_4>
   <phi_5>0.0</phi_5>
   <phi_6>0.0</phi_6>
  </Particulate_bound_NH4>
  <Particulate_bound_NO3 values="by_particle_size">
   <phi_1>0.002</phi_1>
   <phi_2>0.002</phi_2>
   <phi_3>0.003</phi_3>
   <phi_4>0.002</phi_4>
   <phi_5>0.0</phi_5>
   <phi_6>0.0</phi_6>
  </Particulate_bound_NO3>
  <Particulate_bound_TN values="by_particle_size">
   <phi_1>3.065</phi_1>
   <phi_2>2.249</phi_2>
   <phi_3>1.26</phi_3>
   <phi_4>0.72</phi_4>
   <phi_5>0.0</phi_5>
   <phi_6>0.0</phi_6>
  </Particulate_bound_TN>
  <Particulate_bound_TP values="by_particle_size">
   <phi_1>0.918</phi_1>
   <phi_2>0.65</phi_2>
   <phi_3>0.592</phi_3>
   <phi_4>0.451</phi_4>
   <phi_5>0.0</phi_5>
   <phi_6>0.0</phi_6>
  </Particulate_bound_TP>
  <Particulate_bound_IC values="by_particle_size">
   <phi_1>8.933</phi_1>
   <phi_2>6.3</phi_2>
   <phi_3>4.15</phi_3>
   <phi_4>2.55</phi_4>
   <phi_5>0.0</phi_5>
   <phi_6>0.0</phi_6>
  </Particulate_bound_IC>
  <Particulate_bound_TC values="by_particle_size">
   <phi_1>31.628</phi_1>
   <phi_2>29.858</phi_2>
   <phi_3>13.25</phi_3>
   <phi_4>6.725</phi_4>
   <phi_5>0.0</phi_5>
   <phi_6>0.0</phi_6>
  </Particulate_bound_TC>
  <rainfall_dissolved_NH4_conc value="0.23" />
  <rainfall_dissolved_NO3_conc value="0.212" />
  <rainfall_dissolved_PO_conc value="0.011" />
  <KE_model_type value="2" />
  <verbose_output value="false" />
 <within_storm_output value="false" />
```

```
 <within_storm_interval value="60" />
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