**Overview of HRU-DATA.HRU**

1. The master HRU definition file is HRU-DATA.HRU, as inputted in line 9 in FILE.CIO
2. HRU\_NAME is used in HRU.CON for hydrograph connection:
   1. NAME (HRU name in HRU-DATA.HRU), area, lat/long, elevation, weather station ID, and downstream objects where fractions of the total flow from the HRU flow into.
3. HRUTOPO links the HRU to a topographic properties defined in TOPOGRAPHY.HYD
   1. HRU (topo name in HRU-DATA.HRU), slope, slope length, lateral length, distance to the channel, and deposition coefficient
4. HYDRO links the HRU to hydrologic properties in HYDROLOGY.HYD
   1. NAME (HRU name), LAT\_TTIME (days of lateral soil flow across the hillslope), LAT\_SED (sediment conc in lateral flow g/l), max canopy storage (mm), ESCO, EPCO, OrgN enrichment ratio, OrgP enrichment ratio, CN-III, BIOMX, PERCO (0-1), LAT\_ORGN, LAT\_ORGP, HARG\_PET (Hargreves PET coefficient = 0.0023), and LATQ\_CO (lateral flow adjustment factor)
5. SOIL linkes the HRU to a particular soil in SOILS.SOL
6. LU\_LM links the HRU to a landuse type in LANDUSE.LUM
   1. CAL\_GROUP (this is a place holder, and not used)
   2. PCOM\_NAME: plant community as defined in PLANT.INI
   3. MGT\_NAME: scheduled management as defined in MANAGEMENT.SCH
   4. CN2: this assigns a landuse type to assign a curve number from CNTABLE.LUM
   5. CONS\_PRAC: name of a conservation practice in CONS\_PRACTICE.LUM
   6. URB\_NAME: urban landuse type in URBAN.URB
   7. URB\_FLAG: sediment/nutrient yield method (“usgs\_reg” or “buildup\_washoff” or “null”)
   8. OV\_MANN: landuse type to assign a Manning’s "n" coefficient from OVN\_TABLE.LUM
   9. TILE: tile drainage pointer to TILEDRAIN.STR
   10. SEPTIC: septic tanks pointer to SEPTIC.STR
   11. VFS: filter strips pointer to FILTERSTRIP.STR
   12. GRWW: grass waterways pointer to GRASSEDWW.STR
   13. BMP: user specified removal efficiency pointer to BMPUSER.STR
7. SOIL\_PLANT\_INIT links the HRU to initial property of soil/plant nutrient in SOIL\_PLANT.INI
   1. NAME: SOIL\_PLANT\_INIT in HRU-DATA.HRU must have a matching NAME in SOIL\_PLANT.INI
   2. SW\_FRAC: this seems not being used.
   3. NUTRIENT: If not “NULL”, this should have a matching NAME in NUTRIENTS.SOL
   4. PESTICIDES: If not “NULL”, this should have a matching NAME in PEST\_HRU.INI
   5. PATHOGENS: If not “NULL”, this should have a matching NAME in PATH\_HRU.INI
   6. HEAVY\_METALS: If not “NULL”, this should have a matching NAME in HMET\_HRU\_INI
   7. SALTS: If not “NULL”, this should have a matching NAME in SALT\_WATER.INI
8. SURF\_STOR links the HRU to a wetland in WETLAND.WET
9. SNOW links the HRU to snow properties in SNOW.SNO
10. FIELD links the HRU to a field defined in FIELD.FLD

**Paddy Setting**

1. [FILE.CIO] line 7: add WEIR.RES, WETLAND.WET, and HYDROLOGY.WET
2. [HRU\_DATA.HRU] Set SURF\_STOR as “paddy” which points to a wetland definition in WETLAND.WET
3. To set a paddy management schedule, the user has three options
   1. Use only MANAGEMENT.SCH
      1. No auto management schedule is added (NUMB\_AUTO=0 in MANAGEMENT.SCH line 3)
   2. Use only LUM.DTL (NUMB\_OPS=0)
   3. Ues MANAGEMENT.SCH and LUM.DTL combindly to build a management schedule (NUMB\_AUTO and NUMB\_OPS are nonzero)
4. Manual operations in MANAGEMENT.SCH
   1. Operation “Fertilize”
      1. OP4: set this as 1 if fertilizer is applied to the standing water. If injected/drilled, then set OP4=0 to add it to the soil.
   2. Operation “WEIR”
      1. OP1: Name of the weir to read from WEIR.RES
      2. OP2: Not used.
      3. OP3: Weir height in mm. This value overrides WEIR.RES.
      4. OP4: Weir width in meters. A non-zero value overrides WEIR.RES.
   3. Operation “PLNT”
      1. OP1: input a name for rice selected from PLANTS.PLT
      2. OP4: input “1” to set this a transplanting operation and “0” for seed planting
   4. Operation “PUDL”

Puddle operation sets sediment concentration using the SEDCON from puddle.ops. Then, it calls NEWTILLMIX\_WET subroutine to mix nutrients and redistribute between ponding water and tillage depth soil layers.

* + 1. OP1: Name of the tillage operation in tillage.til
    2. OP2: Name of the puddling operation in puddle.ops
    3. OP3/OP4 are not used.
  1. Operation “IRRP”

This is a new Irrigation type for paddy management. It is different from the conventional manual irrigation, IRRM.

* + 1. OP1: Name of the irrigation to read irrigation water quality details from IRR.OPS. Set this to “ponding” for paddy simulation.
    2. OP2: Source of irrigation. Irrigation volume is limited by the available water in the source. If the designated source does not exist, swat+ resets the source to unlimited source.
       1. AQU: The aquifer this HRU is connected to.
       2. CHA: The channel this HRU is connected to.
       3. RES: The reservoir this HRU is connected to.
       4. UNLIM: Unlimited source.
    3. OP3: Target depth in mm. Current irrigation stops when ponding depth reaches the target depth.
    4. OP4: Threshold depth in mm. Once IRRP is initiated, irrigation is triggered in the following days if the ponding depth gets lower than the threshold depth.

Graphical user interface, table, Excel

Description automatically generated

1. New Conditions added to LUM.DTL
   1. “wet\_depth” compares the current ponding depth of the wetpond/paddy with either of the following LIM\_VARs
      1. If LIM\_VAR= Hwater then: read LIM\_CONST as a user input ponding depth (m) and compare with the ponding depth.
      2. Else (no input or null): read current weir height and compare.
   2. “weirh” compares the current weir height (m) with the input value in LIM\_CONST.
2. New Actions added to LUM.DTL
   1. “weir\_adj” changes weir height of the wetland/paddy
      1. OPTION: “wet” is required to set this as a wetland management
      2. CONST: a new weir height (mm)
      3. FILE\_POINTER: name of the current weir in weir.res
   2. “irrigate” action can set irrigation with a target/threshold depths in a wetland/paddy
      1. OPTION: “ponding” is required to set paddy irrigation
      2. CONST: input for a target ponding depth (mm) at which irrigation stops
      3. CONST2: input for a threshold ponding depth (mm). Irrigation is triggered if ponding depth becomes lower than the threshold depth.
   3. “puddle” implements a puddling operation which is the same as a ploughing operation if no standing water exists. A puddling operation is conducted only when standing water exists and the plough depth soil is saturated. The operation mixes standing water and the plough depth soils to redistribute mineral/organic N/P and increases sediment concentration using the user input value in puddle.ops.
   4. Fertilize operation will add fertilizer to the ponding water if applied to a wetland/paddy inundation periods.
      1. OPTION: fertilizer name to read from fertilizer.frt
      2. CONST: fertilizer application rate (kg/ha)
      3. CONST2: number of applications. A value of 2 will apply fertilizer two consecutive days so the total application amount is twice the application rate in CONST2.
      4. FP: application type from chem app ops. Choose one having SURF\_FRAC=1 for fertilizer to dissolve in the standing water.

**Other Notes**

1. A paddy HRU is equivalent to a wetland HRU with management practices implemented. An HRU is set as a paddy by providing a name under SUR\_FSTO in hru-data.hru. The name must be one of the wetland type in wetland.wet.
2. The paddy field is handled as a wetland HRU in the SWAT+ such that surface runoff is calculated based on the water balance between rainfall/irrigation and soil saturation, but not by the CN method.
3. A paddy HRU is assumed to have a flat bottom. Any standing water makes the same ponding depth and infiltrates evenly over then entire surface area.
4. Daily water infiltration from standing water to soils is calculated in the following order:
   1. The percolation of soil water between soil layers is calculated by soil water subroutines including PERCMAIN, PERCMACRO, PERCMICRO, and SAT\_EXCESS where vertical water movement through the sil profile is calculated bidirectoionally (top to bottom, then bottom to top) to ensure water balance is closed every day.
   2. These subroutines are called later in the HRU processes calculation than the wetland processes. Thus, the model does not know how much water to infiltration from the standing water to soils when paddy processes are calculated on a day. As nutrients seep to the soil rootzone alongside water, an arrangement is made to simulate water and nutrient infiltration properly.
   3. Infiltration of standing water to the topsoil layer is calculated based on an effective Ksat, which is updated daily based on topsoil’s SMC and FC and the smallest Ksat of the entire soil profile and the topsoil’s Ksat. The effective Ksat is close to the Ksat of layer 1 if the topsoil SMC is low and it increases as the topsoil SMC goes up. The topsoil Ksat becomes close to the lowest Ksat of the soil profile if the topsoil SMC is higher than its FC.
5. MUSLE is used to estimate soil erosion if a rainfall event occurs when there is no standing water.
6. When a paddy has standing water on a day, sediment settling is estimated based on the current sediment concentration and residual sediment concentration (NSED: a user input in sediment.res linked from wetland.wet).