# CHAPTER 33

# SWAT INPUT DATA: .OPS

The Scheduled Management Operations (.ops) file is an optional file which allows the simulation of non-reoccurring management related activities. The .ops file is particularly useful to initialize conservation measures mid-simulation. After their initialization, the practices remain in effect for the remainder of the simulation. The day and relevant operational parameters must be specified. Several conservation measures such as grassed waterways and filter strips are only available through the .ops file.

# 33.1 SCHEDULED MANAGEMENT OPERATIONS

SWAT will simulate 8 different types of management operations. The first four variables on all management lines are identical, these set the date and operation number. If the date is blank, the operation will be scheduled for the first day of the simulation. The remaining ten variables are operation specific. The type of operation simulated is identified by the code given for the variable MGT_OP.

The different codes for MGT_OP are:

| | |
|---|---|
| 1 | **terracing operation:** this operation simulates a terrace to the HRU on the specified day |
| 2 | **tile drainage:** this operation simulates a tile to the HRU on the specified day |
| 3 | **contouring:** this operation simulates a contour to the HRU on the specified day |
| 4 | **filter strip**: this operation simulates a vegetative filter strip to the HRU on the specified day |
| 5 | **strip cropping:** this operation simulates strip cropping to the HRU on the specified day |
| 6 | **fire:** this operation simulates fire to the HRU on the specified day |
| 7 | **grassed waterways:** this operation simulates grassed waterways to the HRU on the specified day |
| 8 | **plant parameter update:** this operation updates crop parameters to the HRU on the specified day |
| 9 | **residue management:** this operation restricts tillage to maintain the specified minimum residue |
| 10 | **generic conservation practice:** this operation applies user specified conservation practice efficiencies by constituent. |

For each year of management operations provided, the operations must be listed in chronological order starting in January.

## 33.2.1 TERRACING

A terrace is an embankment within in a field designed to intercept runoff and prevent erosion. A terrace is constructed across slope on a contour. A field generally contains several regularly spaced terraces. Terracing in SWAT is simulated by adjusting both erosion and runoff parameters. The USLE Practice (TERR_P) factor, the slope length (TERR_SL) and curve number (TERR_CN) are adjusted to simulate the effects of terracing. Appropriate curve number for terraced field can be found in Table 20-1. TERR_P values based on field slope are given in Table 33-1. TERR_SL should be set to a maximum of the distance between terraces.

Table 33-1 Universal Soil Loss Equation crop Practice (P) factors derived from Haan et al. (1994).

| Condition | Slope range (%) | P factor |
|---|---|---|
| Strait Row | 0-25 | 1.00 |
| Contour | 0-2 | 0.90 |
| Contour | 2-5 | 0.80 |
| Contour | 5-8 | 0.70 |
| Contour | 8-12 | 0.60 |
| Contour | 12-16 | 0.50 |
| Contour | 16-20 | 0.50 |
| Contour | 20-25 | 0.60 |
| Terraced | 0-2 | 0.12 |
| Terraced | 2-8 | 0.10 |
| Terraced | 8-12 | 0.12 |
| Terraced | 12-16 | 0.14 |
| Terraced | 16-20 | 0.16 |
| Terraced | 20-25 | 0.18 |

The variables which may be entered on the planting line are listed and described below.

| Variable name | Definition |
|---|---|
| MONTH | Month operation takes place. (Required) |
| DAY | Day operation takes place. (Required) |
| IYEAR | Year operation takes place. (Required) |
| MGT_OP | Management operation number.<br>MGT_OP = 1 for terracing. |
| TERR_P | USLE practice factor adjusted for terraces |
| TERR_CN | Initial SCS curve number II value |
| TERR_SL | Average slope length (m). Should be set to the interval between terraces. |

The format of the terracing operation line is

| Variable name | Position | Format | F90 Format |
|---|---|---|---|
| MONTH | space 2-3 | 2-digit integer | i2 |
| DAY | space 5-6 | 2-digit integer | i2 |
| IYEAR | space 12-15 | 4-digit number | i4 |
| MGT_OP | space 17-18 | 2-digit integer | i2 |
| TERR_P | space 36-47 | decimal (xxxxxx.xxxxx) | f12.5 |
| TERR_CN | space 49-54 | decimal (xxx.xx) | f6.2 |
| TERR_SL | space 56-66 | decimal (xxxxx.xxxxx) | f11.5 |

## 33.2.2 TILE DRAINAGE OPERATION

Tile drains remove excess water for an area to optimize plant growth. Drains may be added at the beginning of the simulation in the .mgt file. To account for the installation of tile drains mid-simulation, the option was included as a schedulable operation. The variables which may be entered on the irrigation line are listed and described below

| Variable name | Definition |
|---|---|
| MONTH | Month operation takes place. (Required) |
| DAY | Day operation takes place. (Required) |
| IYEAR | Year operation takes place. (Required) |
| MGT_OP | Management operation number.<br>MGT_OP = 2 for tile drainage. |
| DRAIN_D | Depth to the sub-surface drain (mm) |
| DRAIN_T | Time to drain soil to field capacity (hours) |
| DRAIN_G | Drain tile lag time. The amount of time between transfer of water from the soil to the drain tile and the release of the water from the drain tile to the reach (hours) |
| DRAIN_IDEP | Depth to impermeable layer (mm) Default = 6000.0 |

The format of the tile drainage line is

| Variable name | Position | Format | F90 Format |
|---|---|---|---|
| MONTH | space 2-3 | 2-digit integer | i2 |
| DAY | space 5-6 | 2-digit integer | i2 |
| IYEAR | space 12-15 | 4-digit integer | i4 |
| MGT_OP | space 17-18 | 2-digit integer | i2 |
| DRAIN_D | space 36-47 | decimal (xxxxxx.xxxxx) | f12.5 |
| DRAIN_T | space 49-54 | decimal (xxx.xx) | f6.2 |
| DRAIN_G | space 56-66 | decimal (xxxxx.xxxxx) | f11.5 |
| DRAIN_IDEP | space 68-75 | decimal (xxxxx.xx) | f8.2 |

## 33.2.3 CONTOUR PLANTING

Contour planting is the practice of tilling and planting crops following the contour of the field as apposed to strait rows. These contours are orientated at a right angle to the field slope at any point. Small ridges resulting from field operations increase surface storage and roughness, reducing runoff and sediment losses. Contour planting is simulated in SWAT by altering curve number (CONT_CN) to account for increased surface storage and infiltration (Table 20-1) and the USLE Practice factor (CONT_P) to account for decreased erosion (Table 33-1). The variables which may be entered on the fertilization line are listed and described below.

| Variable name | Definition |
|---|---|
| MONTH | Month operation takes place. (Required) |
| DAY | Day operation takes place. (Required) |
| IYEAR | Year operation takes place. (Required) |
| MGT_OP | Management operation number.<br>MGT_OP = 3 for contouring. |
| CONT_CN | Initial SCS curve number II value |
| CONT_P | Contouring USLE P Factor |

The format of the contour planting line is

| Variable name | Position | Format | F90 Format |
|---|---|---|---|
| MONTH | space 2-3 | 2-digit integer | i2 |
| DAY | space 5-6 | 2-digit integer | i2 |
| IYEAR | space 12-15 | 4-digit integer | i4 |
| MGT_OP | space 17-18 | 2-digit integer | i2 |
| CONT_CN | space 36-47 | decimal (xxxxxx.xxxxx) | f12.5 |
| CONT_P | space 49-54 | decimal (xxx.xx) | f6.2 |

## 33.2.4 FILTER STRIPS

A filter strip is a strip of dense vegetation located to intercept runoff from upslope pollutant sources and filter it. Filter strips remove contaminants by reducing overland flow velocity which results in the deposition of particulates. The filter strip area also acts as an area of increased infiltration, reducing both the runoff volume and non-particulate contaminants. The filter strip used algorithm used in SWAT was derived from White and Arnold (2009). Filter strips reduce sediment, nutrients, bacteria, and pesticides, but do not affect surface runoff in SWAT. The variables which may be entered on the pesticide application line are listed and described below.

| Variable name | Definition |
|---|---|
| MONTH | Month operation takes place. (Required) |
| DAY | Day operation takes place. (Required) |
| IYEAR | Year operation takes place. (Required) |
| MGT_OP | Management operation number.<br>MGT_OP = 4 for filter strips. |
| FILTER_I | Flag for the simulation of filter strips (VFSI = 1/0 active/inactive). |
| FILTER_RATIO | Ratio of field area to filter strip area (unitless). Ranges from 0 to 300 with values from 30-60 being most common. Default value is 40 |
| FILTER_CON | Fraction of the HRU which drains to the most concentrated ten percent of the filters strip area. Runoff generated upslope a filter strip is not uniformly distributed across the entire length of the strip. Ten percent of the filter strip can receive between 0.25 and 0.75 of the runoff from the entire filed. Default value is 0.5. |
| FILTER_CH | Fraction of the flow within the most concentrated ten percent of the filter strip which is fully channelized (dimensionless). Flow which is fully channelized is not subject to filtering or infiltration effects. Default value is 0.0 |

The format of the filter strips line is

| Variable name | Position | Format | F90 Format |
|---|---|---|---|
| MONTH | space 2-3 | 2-digit integer | i2 |
| DAY | space 5-6 | 2-digit integer | i2 |
| IYEAR | space 12-15 | 4-digit integer | i4 |
| MGT_OP | space 17-18 | 2-digit integer | i2 |
| FILTER_I | space 20-23 | 4-digit integer | i4 |
| FILTER_RATIO | space 29-34 | decimal (xxx.xx) | f6.2 |
| FILTER_CON | space 36-47 | decimal (xxxxxx.xxxxx) | f12.5 |
| FILTER_CH | space 49-54 | decimal (xxx.xx) | f6.2 |

## 33.2.5 STRIP CROPPING

Strip cropping is the arrangement of bands of alternating crops within an agricultural field. The bands are generally positioned based on the contours of the field. Strip Cropping is simulated in SWAT by altering the Manning' N value for overland flow (STRIP_N) to represent increased surface roughness in the direction of runoff. Curve Number (STRIP_CN) may be adjusted to account for increased infiltration. USLE Cropping Factor (STRIP_C) may be adjusted to reflect the average value for multiple crops within the field. The USLE Practice factor may also be updated to represent strip cropping conditions. The variables which may be entered on the harvest and kill line are listed and described below.

| Variable name | Definition |
|---|---|
| MONTH | Month operation takes place. (Required) |
| DAY | Day operation takes place. (Required) |
| IYEAR | Year operation takes place. (Required) |
| MGT_OP | Management operation number.<br>MGT_OP = 5 for strip cropping. |
| STRIP_N | Manning's N value for overland flow in strip cropped fields |
| STRIP_CN | SCS curve number II value for strip cropped fields |
| STRIP_C | USLE Cropping factor for strip cropped fields |
| STRIP_P | USLE Practice factor for strip cropped fields |

The format of the strip cropping operation line is

| Variable name | Position | Format | F90 Format |
|---|---|---|---|
| MONTH | space 2-3 | 2-digit integer | i2 |
| DAY | space 5-6 | 2-digit integer | i2 |
| IYEAR | space 12-15 | 4-digit integer | i4 |
| MGT_OP | space 17-18 | 2-digit integer | i2 |
| STRIP_N | space 36-47 | decimal (xxxxxx.xxxxx) | f12.5 |
| STRIP_CN | space 49-54 | decimal (xxx.xx) | f6.2 |
| STRIP_C | space 56-66 | decimal (xxxxx.xxxxx) | f11.5 |
| STRIP_P | space 68-75 | decimal (xxxxx.xx) | f8.2 |

## 33.2.6 FIRE OPERATION

Fire may have a significant effect on hydrology which is represented via an adjustment to the curve number (FIRE_CN). Fire in SWAT does not account for biomass reduction due to fire. The variables for the tillage operation are listed and described below.

| Variable name | Definition |
|---|---|
| MONTH | Month operation takes place. (Required) |
| DAY | Day operation takes place. (Required) |
| IYEAR | Year operation takes place. (Required) |
| MGT_OP | Management operation number.<br>MGT_OP = 6 for fire. |
| FIRE_CN | Post fire SCS curve number II value |

The format of the fire operation line is

| Variable name | Position | Format | F90 Format |
|---|---|---|---|
| MONTH | space 2-3 | 2-digit integer | i2 |
| DAY | space 5-6 | 2-digit integer | i2 |
| IYEAR | space 12-15 | 4-digit integer | i4 |
| MGT_OP | space 17-18 | 2-digit integer | i2 |
| FIRE_CN | space 36-47 | decimal (xxxxxx.xxxxx) | f12.5 |

## 33.2.7 GRASS WATERWAYS OPERATION

Grassed waterways are vegetated channels which transport runoff from a field. Vegetation within the waterways reduces flow velocities, and protects the waterway from the scouring potential of concentrated flow. These are generally broad and shallow channels; the channel simulated in SWAT has a side slope of 8:1. Grasses waterways trap sediment and other contaminants by reducing flow velocities which increases deposition of particulate contaminates. The variables for the tillage operation are listed and described below.

| Variable name | Definition |
|---|---|
| MONTH | Month operation takes place. (Required) |
| DAY | Day operation takes place. (Required) |
| IYEAR | Year operation takes place. (Required) |
| MGT_OP | Management operation number.<br>MGT_OP = 7 for grass waterways. |
| GWATI | Flag for the simulation of grass waterways (GWATI = 1/0 active/inactive). |
| GWATN | Manning's N value for overland flow. (Default 0.35) |
| GWATSPCON | Linear parameter for calculating sediment in Grassed waterways (default 0.005) |
| GWATD | Depth of grassed waterway channel from top of bank to bottom (m). If no value of GWATD is entered, depth is set to 3/64 * GWATW |
| GWATW | Average width of grassed waterway (m) (Required) |
| GWATL | Length of grassed waterway (km). If no value for GWATL is entered, length defaults to a single side of a square HRU) |
| GWATS | Average slope of grassed waterway channel (m). If no value for GWATS is entered, the HRU slope * 0.75 is used. |

The format of the grass waterways operation line is

| Variable name | Position | Format | F90 Format |
|---|---|---|---|
| MONTH | space 2-3 | 2-digit integer | i2 |
| DAY | space 5-6 | 2-digit integer | i2 |
| IYEAR | space 12-15 | 4-digit integer | i4 |
| MGT_OP | space 17-18 | 2-digit integer | i2 |
| GWATI | space 20-23 | 4-digit integer | i4 |
| GWATN | space 29-34 | decimal (xxx.xx) | f6.2 |
| GWATSPCON | space 36-47 | decimal (xxxxxx.xxxxx) | f12.5 |
| GWATD | space 49-54 | decimal (xxx.xx) | f6.2 |
| GWATW | space 56-66 | decimal (xxxxx.xxxxx) | f11.5 |
| GWATL | space 68-75 | decimal (xxxxx.xx) | f8.2 |
| GWATS | space 77-82 | decimal (xx.xx) | f6.2 |

## 33.2.8 PLANT PARAMETER UPDATE

In modern agriculture, there is significant variability in individual cultivars. The rapid generation and adoption of improved varieties may be problematic in long simulations. The plant parameter update option allows new varieties with differing growth characteristics to be adopted mid-simulation. The variables for the tillage operation are listed and described below.

| Variable name | Definition |
|---|---|
| MONTH | Month operation takes place. (Required) |
| DAY | Day operation takes place. (Required) |
| IYEAR | Year operation takes place. (Required) |
| MGT_OP | Management operation number.<br>MGT_OP = 8 for plant parameter update. |
| CROPNO_UPD | Updated crop number |
| HI_UPD | Updated harvest index |
| LAIMX_UPD | Updated maximum LAI |

The format of the plant parameter update operation line is

| Variable name | Position | Format | F90 Format |
|---|---|---|---|
| MONTH | space 2-3 | 2-digit integer | i2 |
| DAY | space 5-6 | 2-digit integer | i2 |
| IYEAR | space 12-15 | 4-digit integer | i4 |
| MGT_OP | space 17-18 | 2-digit integer | i2 |
| CROPNO_UPD | space 20-23 | 4-digit integer | i4 |
| HI_UPD | space 36-47 | decimal (xxxxxx.xxxxx) | f12.5 |
| LAIMX_UPD | space 49-54 | decimal (xxx.xx) | f6.2 |

## 33.2.9 RESIDUE MANAGEMENT

Residue management is a common conservation practice to prevent excess soil erosion and particulate nutrient losses. This practice is typically implemented by reducing or delaying tillage to maintain surface residue above a specified level necessary to protect the soil. In the model, this component reduces or eliminates soil mixing due tillage operations to maintain soil residue near user specified levels. Tillage operation specified in the .mgt file need not be modified. These operations may or may not occur as scheduled, or may occur with reduced mixing efficiencies depending upon the surface residue prior to each operation and specified SO_RES. Non-tillage processes which reduce surface residue such as biological mixing, fire, and natural decay are not affected.

The variables which may be entered for residue management are listed and described below.

| Variable name | Definition |
|---|---|
| MONTH | Month operation takes place. (Required) |
| DAY | Day operation takes place. (Required) |
| IYEAR | Year operation takes place. (Required) |
| SO_RES_FLAG | Conservation practice code (range 0-1) |
| SO_RES | Residue (kg/ha) (range 0-5000.0) |

The format of the terracing operation line is

| Variable name | Position | Format | F90 Format |
|---|---|---|---|
| MONTH | space 2-3 | 2-digit integer | i2 |
| DAY | space 5-6 | 2-digit integer | i2 |
| IYEAR | space 12-15 | 4-digit integer | i4 |
| SO_RES_FLAG | space 20-23 | 4-digit integer | i4 |
| SO_RES | space 36-47 | decimal (xxxxxx.xxxxx) | f12.5 |

## 33.2.10 GENERIC CONSERVATION PRACTICE

There are many conservation practices for which approximate removal efficiencies have been established which are unsupported by SWAT or any other existing model. To allow these practices to be included, this generic conservation practice operation allows fixed removal efficiencies to be specified by constituent. Approximate efficiencies for several practices were derived from Tetra Tech. 2005 and NCTCOG 2006 and are listed below:

| Landuse | Description | Nitrogen Reduction (%) | Phosphorus Reduction (%) | Sediment Reduction (%) | Bacteria Reduction (%) |
|---|---|---|---|---|---|
| Cropland | Diversion | 10 | 30 | 35 | - |
| Cropland | Streambank stabilization and fencing | 75 | 75 | 75 | - |
| Forest | Road dry seeding | - | - | 41 | - |
| Forest | Road grass and legume seeding | - | - | 71 | - |
| Forest | Road hydro mulch | - | - | 41 | - |
| Forest | Road straw mulch | - | - | 41 | - |
| Forest | Road tree planting | - | - | 50 | - |
| Forest | hydro mulch/seed/fertilizer | - | - | 71 | - |
| Forest | hydro mulch/seed/fertilizer/transplants | - | - | 69 | - |
| Forest | steep slope seeder/transplant | - | - | 81 | - |
| Forest | straw/crimp seed/fertilizer/transplant | - | - | 95 | - |
| Forest | straw/crimp/net | - | - | 93 | - |
| Forest | straw/net/seed/fertilizer/transplant | - | - | 83 | - |
| Forest | straw/polymer/seed/fertilizer/transplant | - | - | 86 | - |
| Feedlots | Diversion | 45 | 70 | - | - |
| Feedlots | Runoff Mgmt System | - | 82.5 | - | - |
| Feedlots | Solids Separation Basin | 35 | 31 | - | - |
| Feedlots | Solids Separation Basin w/Infilt Bed | - | 80 | - | - |
| Feedlots | Waste Mgmt System | 80 | 90 | - | - |
| Feedlots | Waste Storage Facility | 65 | 60 | - | - |
| Urban | Concrete Grid Pavement | 90 | 90 | 90 | - |
| Urban | Extended Wet Detention | 55 | 68.5 | 86 | - |
| Urban | Grass Swales | 10 | 25 | 65 | - |
| Urban | Infiltration Basin | 60 | 65 | 75 | - |
| Urban | Infiltration Devises | - | 83 | 94 | - |
| Urban | LID/Bioretention | 43 | 81 | - | - |
| Urban | LID/Filter/Buffer Strip | 30 | 30 | 60 | - |
| Urban | LID/Infiltration Swale | 50 | 65 | 90 | - |
| Urban | LID/Infiltration Trench | 50 | 50 | 90 | - |
| Urban | LID/Vegetated Swale | 7.5 | 17.5 | 47.5 | - |
| Urban | Oil/Grit Separator | 5 | 5 | 15 | - |
| Urban | Settling Basin | - | 51.5 | 81.5 | - |
| Urban | Weekly Street Sweeping | - | 6 | 16 | - |
| Urban | Wet Pond | 35 | 45 | 60 | - |

| | | | | | |
|---|---|---|---|---|---|
| Urban | Bioretention Areas | 50 | 60 | 80 | - |
| Urban | Grass Channel | 20 | 25 | 50 | - |
| Urban | Enhanced Dry Swale | 50 | 50 | 80 | - |
| Urban | Enhanced Wet Swale | 40 | 25 | 80 | - |
| Urban | Alum Treatment | 60 | 80 | 80 | 90 |
| Urban | Filter Strip | 20 | 20 | 50 | - |
| Urban | Dry Detention | 30 | 50 | 65 | 70 |
| Urban | Organic Filter | 40 | 60 | 80 | 50 |
| Urban | Planter Boxes | 40 | 60 | 80 | 50 |
| Urban | Sand Filters | 25 | 50 | 80 | 40 |
| Urban | Underground Sand Filter | 25 | 50 | 80 | 40 |
| Urban | Gravity (Oil-Grit) Separator | 5 | 5 | 40 | - |
| Urban | Downspout Drywell | 60 | 60 | 80 | 90 |
| Urban | Infiltration Trench | 60 | 60 | 80 | 90 |
| Urban | Soakage Trench | 60 | 60 | 80 | 90 |
| Urban | Storm Water Ponds | 30 | 50 | 80 | 70 |
| Urban | Green Roof | 25 | - | 85 | - |
| Urban | Porous Paver Systems | 80 | 80 | - | - |
| Urban | Porous Concrete | 65 | 50 | - | - |
| Urban | Storm Water Wetlands | 30 | 40 | 80 | 70 |
| Urban | Submerged Gravel Wetland | 20 | 50 | 80 | 70 |

The variables which may be entered on the generic conservation line are listed and described below.

| Variable name | Definition |
|---|---|
| MONTH | Month operation takes place. (Required) |
| DAY | Day operation takes place. (Required) |
| IYEAR | Year operation takes place. (Required) |
| RO_BMP_FLAG | Code to turn on/off user BMP (range 0-1)( mgt1i) |
| RO_BMP_SED | Sediment removal by BMP (%) (range 0-100) |
| RO_BMP_PP | Particulate (Organic) phosphorous removal by BMP (%) (range 0-100) |
| RO_BMP_SP | Soluble phosphorous removal by BMP (%) (range 0-100) |
| RO_BMP_PN | Particulate (Organic) nitrogen removal by BMP (%) (range 0-100) |
| RO_BMP_SN | Soluble nitrogen removal by BMP (%) (range 0-100) |
| RO_BMP_BAC | Bacteria removed by BMP (%) (range 0-100) |

The format of the conservation practice operation line is

| Variable name | Position | Format | F90 Format |
|---|---|---|---|
| MONTH | space 2-3 | 2-digit integer | i2 |
| DAY | space 5-6 | 2-digit integer | i2 |
| IYEAR | space 12-15 | 4-digit integer | i4 |
| RO_BMP_FLAG | space 20-23 | 4-digit integer | i4 |
| RO_BMP_SED | space 29-34 | decimal (xxx.xx) | f6.2 |
| RO_BMP_PP | space 36-47 | decimal (xxxxxx.xxxxx) | f12.5 |
| RO_BMP_SP | space 49-54 | decimal (xxx.xx) | f6.2 |
| RO_BMP_PN | space 68-75 | decimal (xxxxx.xx) | f8.2 |
| RO_BMP_SN | space 77-82 | decimal (xxx.xx) | f6.2 |
| RO_BMP_BAC | space 83-87 | decimal (xx.xx) | f5.2 |

# REFERENCES

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North Central Texas Council of Governments (NCTCOG). 2006, iSWM™ Design Manual for Site Development, Available at :http://iswm.nctcog.org/archives-resources.asp.

Tetra Tech. 2005, Spreadsheet Tool for the Estimation of Pollutant Load (STEPL). Available at: http://it.tetratech-ffx.com/steplweb/STEPLmain_files/STEPLGuide310.pdf