Integrated Water Flow Model version 4.0
(IWFM v4.0)

Guidelines for Workshop Examples

Hydrology Development Unit
Modeling Support Branch
Bay-Delta Office
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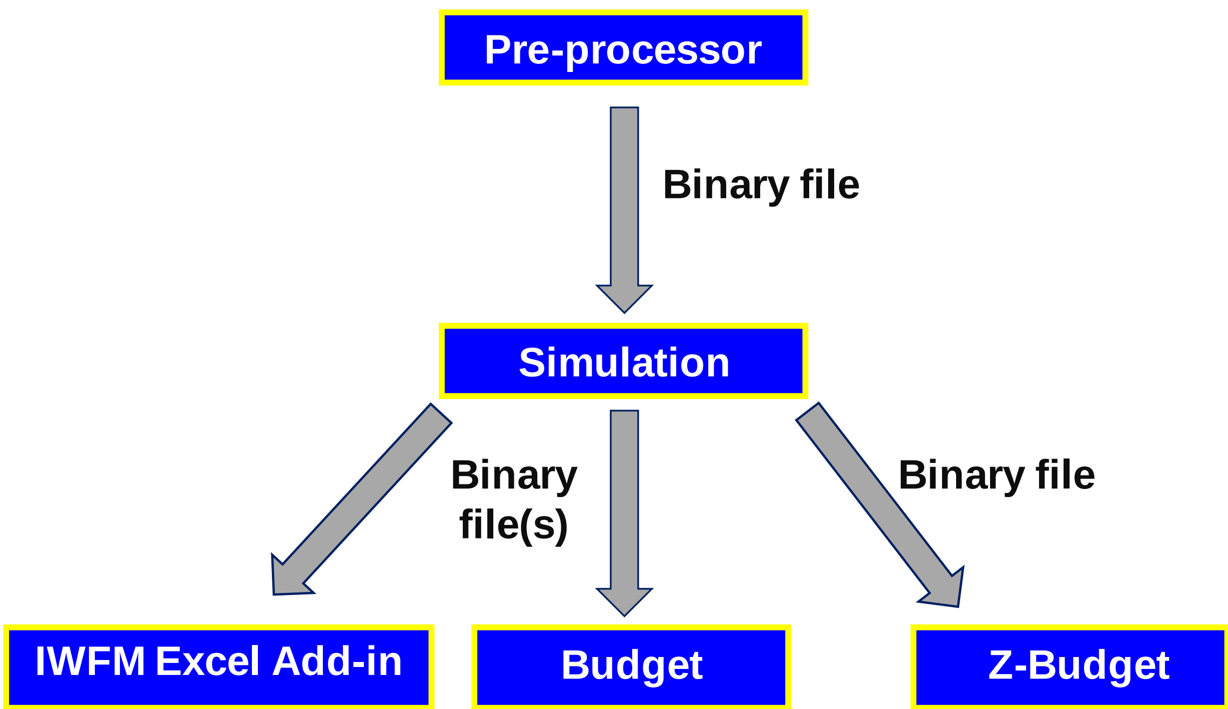
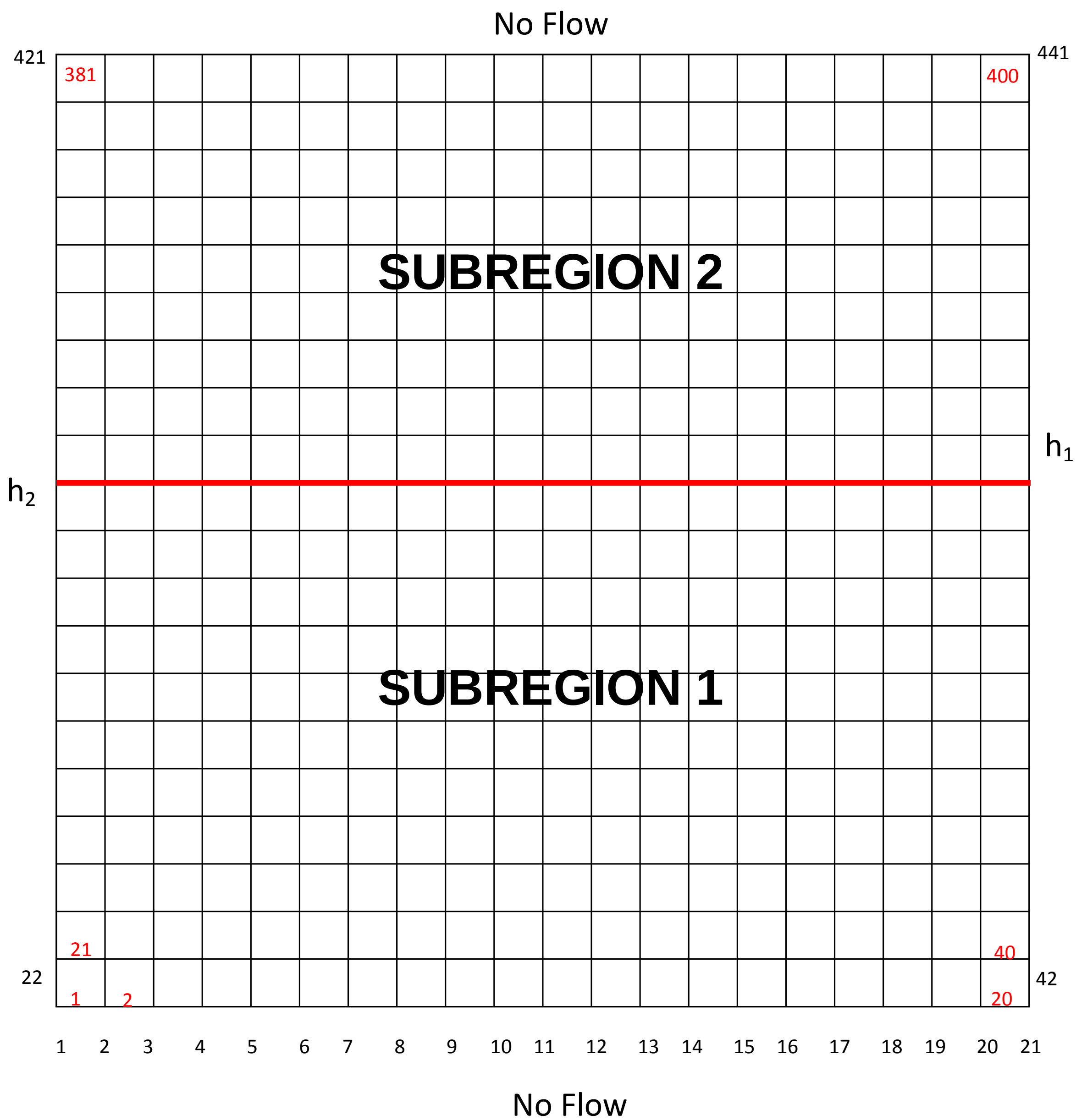
IWFM v4.0 Program Execution



Useful Conversion Factors

From	To	Factor
Centimeter	Feet	0.0328
Meter	Feet	3.2808
Inch	Feet	0.0833
Acre (ac)	Square Feet	43560
Acre Feet (ac.ft.)	Cubic Feet	43560
Square Feet	Acre (ac)	2.29568E–5
Cubic Feet	Acre Feet (ac.ft.)	2.29568E–5
Day	Second	86400

Example 1 – Groundwater Flow



Description:

- Single layer aquifer 40000 meters in x-direction and 40000 meters in y-direction. Ground surface elevation is at 500 ft. Aquiclude/aquitard thickness is 0 ft. Aquifer thickness is 500 ft.
- 400 elements with 441 nodes. $\Delta x = \Delta y = 2000$ meters
- Cells 1-200 represent subregion 1 and cells 201-400 represent subregion 2.
- ***Hydraulic conductivity***, K = 100 ft/day
- ***Specific yield***, $S_y = 0.25$
- ***Specific storage***, $S_o = 0.000001$ 1/ft
- ***Boundary conditions:***
  - No flow on north and south boundaries
  - Specified head on east boundary, $h_1 = 400$ ft
  - Specified head on west boundary, $h_2 = 50$ ft
- ***Initial head***, $h_o = 400$ ft.
- ***Time step*** = 1day.
- ***Simulation period*** = September 30, 1997 midnight through September 30, 2001 midnight.
- ***Convergence criteria*** for groundwater heads = 0.0001 ft
- ***Maximum number of iterations*** = 150
- ***Matrix inversion method*** = Generalized preconditioned conjugate gradient method

Directions:

Pre-processor:

- *PREPROCESSOR_MAIN.IN*
  1) The files that will be used to set up the computational grid and stratigraphy for the model are listed below. Enter these filenames into the *PREPROCESSOR_MAIN.IN* file.
     - *Element.dat* (element configuration file)
     - *NodeXY.dat* (node coordinates file)

- *Stratigraphy.dat* (stratigraphy data file)
- *..\Simulation\Output1.bin* (binary output file that will be generated under the Simulation folder and that will hold the pre-processed model data)

2) Set KOUT = 1 to print geometric and stratigraphic information to the standard output file.

3) Set KDEB = 2 to print messages on the screen during program execution.

Simulation:

- *SIMULATION_MAIN.IN*

1) The filenames that will be used for the model are listed below. Enter these filenames to *SIMULATION_MAIN.IN* file.
   - Output1.bin (binary file that stores pre-processed data; enter for unit 1)
   - Parameter.dat (parameter data file; enter for unit 2)
   - BC.dat (boundary conditions data file; enter for unit 6)
   - Print.dat (file that stores locations for which hydrographs will be printed; enter for unit 8)
   - IC.dat (initial conditions data file; enter for unit 9)
   - ..\Results\ZBudget.bin (binary output data file that will be generated under *Results* folder and will store Z-Budget information for groundwater; enter for unit 17)
   - ..\Results\GWBud.bin (binary output file that will be generated under *Results* folder and will store groundwater budget information for each subregion; enter for unit 19)
   - ..\Results\GWHyd.out (text output file that will be generated under *Results* folder and will store groundwater hydrographs at selected nodes listed in the *Print.dat* file; enter for unit 23)
   - ..\Results\GWBud.bin (binary output file that will be generated under *Results* folder and will store groundwater budget information for each subregion; enter for unit 19)
   - FinalResults.out (text output file that will store the final simulation results for all simulated hydrologic components; enter for unit 28)
   -

2) Simulation period starts at midnight of September 30, 1997. Set variable BDT accordingly.

3) Simulation time step is 1 day. Enter variable UNITT, accordingly.

4) Simulation period ends at midnight of September 30, 2001. Set variable EDT, accordingly.

5) Set KDEB = 0 to only print out the simulation timestep on the screen during program execution.

6) Generalized preconditioned conjugate method will be used for matrix inversion. Set variable

MSOLVE, accordingly.

7) Maximum number of iterations for the solution of equations is 150. Set variable MXITER, accordingly.

8) A convergence criterion for the simulation of groundwater flow is 0.0001 ft. Set variable STOPC, accordingly.

9) Set variable KOPTDV =00 since there are no pumping or diversions to be adjusted in this example.

- *Parameter.dat*

  1) Homogeneous aquifer parameters will be assigned to each finite element node using a single parametric grid having a single quadrilateral element. Set variable NGROUP = 1.

  2) Enter the following conversion factors for aquifer parameters specified at the parametric grid:

     – FX = 3.2808 (to convert coordinates of the parametric grid nodes from meters to feet)

     – FKH = 1.0 (to convert length unit of horizontal hydraulic conductivity from feet to feet)

     – FS = 0.000001 (to represent the exponential component of specific storage coefficient)

     – FN = 1.0 (weighting factor for specific yield)

     – FV = 1.0 (to convert length unit of aquitard hydraulic conductivity from feet to feet)

     – FL = 1.0 (to convert the length unit of aquifer vertical hydraulic conductivity from feet to feet)

     – Enter 0.0 for the rest of the conversion factors

  3) The rest of parametric grid information and aquifer parameters at the parametric grid is already specified.

  4) There are no anomalies in hydraulic conductivity values. Set variable NEBK = 0.

  5) Unsaturated zone is not simulated. Set variable NUNSAT = 0.

  6) Small watershed boundary conditions are not simulated. Set NSW = 0. The rest of the variables for the small watersheds are already specified.

- *BC.dat*

  1) Since there no specified-flux-type boundary conditions, set variable NQB = 0 for aquifer layer 1. The rest of the parameters related to specified-flux boundary conditions are already specified.

  2) There are a total of 42 specified head boundary conditions to be defined (21 nodes on the west and 21 nodes on the east side of the model domain). Set variable NHB for aquifer layer 1accordingly.

3) The specified boundary conditions are given in feet. Set the conversion factor FACT, accordingly.

4) The boundary nodes and the specified heads are already listed in the file.

5) Since there no general-head-type boundary conditions, set variable NGB = 0 for aquifer layer 1. The rest of the parameters related to the general head boundary conditions are already specified.

6) Since small watershed boundary conditions are not simulated, set NTWB = 0. The rest of the parameters related to the small watershded boundary conditions are already specified.

- *IC.dat*

  The initial groundwater head is 400 feet. This is already specified in this file for each of the 441 finite element nodes.

- *Print.dat*

  1) Simulated groundwater hydrographs at 21 nodes (nodes 211 through 231) will be printed. Set NOUTH accordingly.

  2) Since the hydrograph print-out locations are specified at nodes (as opposed to x-y coordinates) set FACT = 0.0.

  3) The aquifer layer and groundwater node numbers for hydrograph locations are already specified in the file.

Budget:

- *Budget.in*

  This file is already set up to process the *GWBud.bin* output file in the *Results* folder and to create groundwater budget at each model subregion as well as at the entire model domain.

Z-Budget:

- *ZBudget_E210.in*

  1) The path and filename of the Z-Budget binary file to be processed is *..\Results\ZBudget.bin*. Set variable BINFILE, accordingly.

  2) Zone numbering scheme will be defined for the horizontal plane and will be used for all aquifer layers. Set variable ZEXTENT, accordingly.

  3) The Z-Budget output will have units of ac.ft. Specify variables FACTVLOU and UNITVLOU, accordingly.

  4) The start and end date and time of the Z-Budget print-out (variables BDT and EDT, respectively) are already specified to cover the entire simulation period.

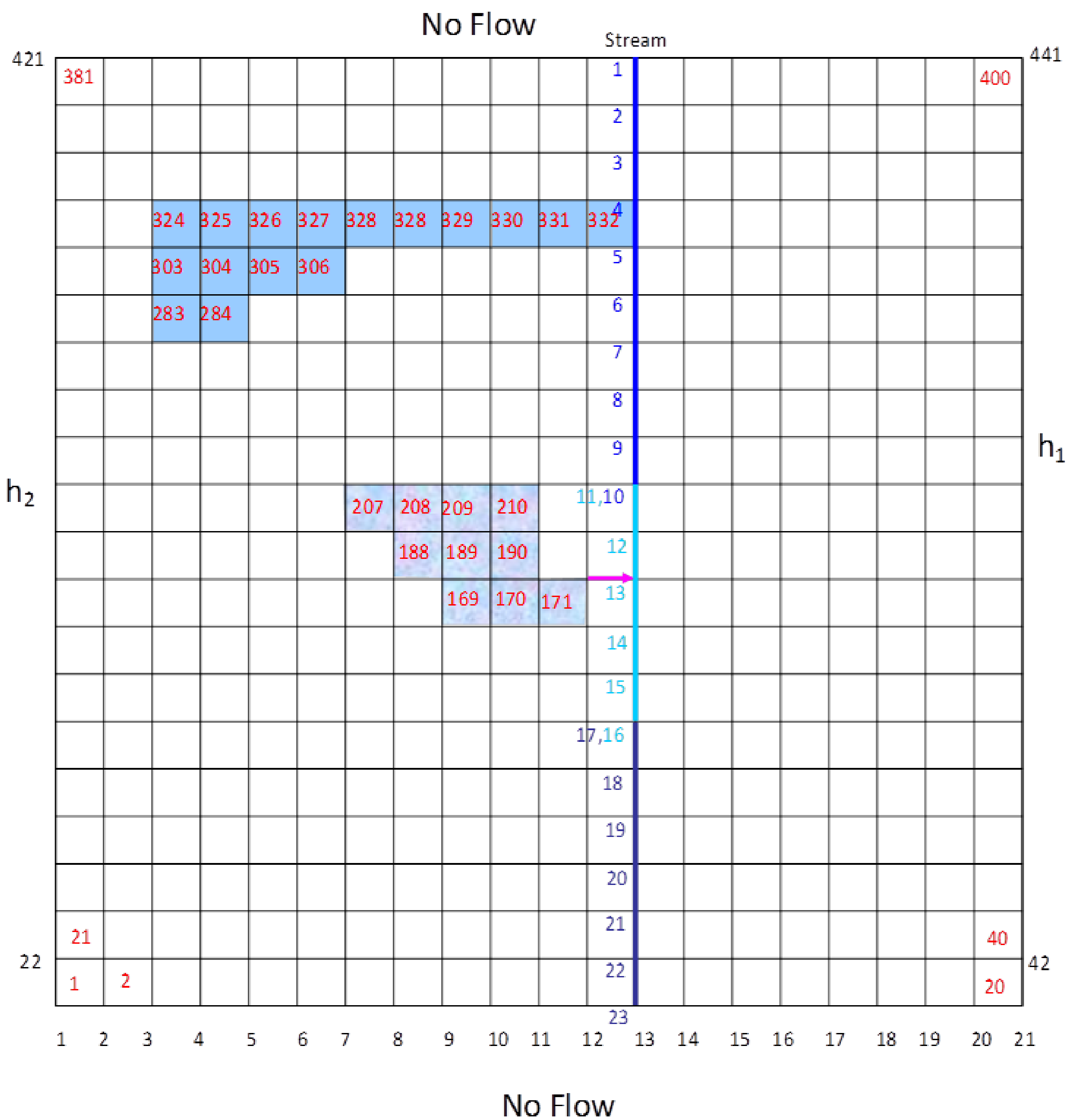
5) Element 210 will be given a zone number of 210. Set variables IE and ZONE, accordingly.

6) Set variable ZPRINT = 210 to print out detailed grounwater budget for element 210 (i.e. zone 210).

- *ZBudget_SR.in*

  This Z-Budget input file is already set up to print out detailed groundwater budget at each model subregion.

Example 2 – Streams and Lakes



Description:

- Single layer aquifer whose characteristics are similar to the one in previous example.
- ***No flow*** north and south boundary conditions.
- ***Specified head*** at the east boundary; h_1 = 290 ft.
- ***Specified head*** at the west boundary; h_2 = 290 ft.
- ***Initial condition***, h_o = 292 ft.
- A ***stream*** runs parallel to y-axis at x = 24,000 m (corresponds to the 13^{th} column from the left in the current finite element mesh). It is divided into 3 reaches.
- There is a steady ***stream inflow*** of 1000 cfs to the upstream node (stream node 1).
- The ***stream bed hydraulic conductivity*** is 10 ft/day and the ***stream bed material thickness*** is 1 ft.
- ***Stream node characteristics*** used for each node are as follows:

Reach	Stream node	Groundwater node	Bottom elevation (ft)	Wetted perimeter (ft)
1	1	433	300	150
	2	412	298	150
	3	391	296	150
	4	370	294	150
	5	349	292	150
	6	328	290	150
	7	307	288	150
	8	286	286	150
	9	265	284	150
	10	244	282	150
2	11	244	282	150
	12	223	280	150
	13	202	278	150
	14	181	276	150
	15	160	274	150
	16	139	272	150
3	17	139	272	150
	18	118	270	150
	19	97	268	150
	20	76	266	150
	21	55	264	150
	22	34	262	150
	23	13	260	150

- ***Rating table*** used for all nodes is as follows:

Stream depth (ft)	Stream flow (cfs)
0.0	0.00
2.0	734.94
5.0	3299.29
15.0	19033.60
25.0	41568.45

- A ***bypass*** is used to simulate artificial aquifer recharge. 25% of the stream flow is diverted at stream node 4 and used for artificial recharge. The diversion canal runs through elements 332, 331, 330, 329, 328 and 327. 30% of the diversion is lost through canal leakage at these elements (i.e. each element receives 5% of the total diversion as canal leakage). The remaining 70% of the diversion is delivered to elements 326, 325, 324, 323, 303, 304, 305, 306, 283 and 284 (i.e. each of the elements receives 7% of the total diversion as artificial aquifer recharge).

- A ***lake*** that spans 10 elements (elements 169, 170, 171, 188, 189, 190, 207, 208, 209 and 210) is modeled.

- ***Maximum lake elevation*** is 285 ft.

- ***Lake outflow*** flows into stream node 13.

- The ***ground surface elevation at the lowest point of the lake bottom*** is at 250 ft. ***Ground surface elevation at the edges of the lake*** is 270 ft.

- ***Hydraulic conductivity of the lake bottom*** is 10 ft/day and the ***lake bottom thickness*** is 1 ft.

- ***Precipitation*** and ***evaporation*** measured at the lake are given in the following table and used for each simulation year:

Month	Precipitation (in)	Evaporation (in)
Jan	6.75	1.1
Feb	5.56	1.8
Mar	4.21	2.8
Apr	0.25	3.9
May	0.40	5.1
Jun	0.00	7.2
Jul	0.11	7.5
Aug	0.66	6.4
Sep	0.40	4.8
Oct	5.74	3.7
Nov	3.25	1.8
Dec	4.92	1.2

- ***Initial lake elevation*** is 280 ft.
- ***Time step*** = 1 day
- ***Simulation period*** = September 30, 1997 midnight through September 30,2001 midnight

Directions:

Pre-processor:

- *PREPROCESSOR_MAIN.IN*

  Enter the filenames for the stream network data (*Stream.dat*) and lake configuration data (*Lake.dat*).

- *Stratigraphy.dat*

  The modified ground surface elevations for the lake are already entered. .

- *Lake.dat*

  1) Only one lake is simulated. Specify variable NLAKE, accordingly.
  2) The lake elements as well as the lake outflow destination (stream node 13) are specified above. Populate variables ID, TYPDEST, DST, NELAKE and IELAKE, accordingly.

- *Stream.dat*

  1) There are 3 stream reaches, 23 stream nodes and the rating table at each stream node has 5 data pairs. Specify variables NRH, NR and NRTB, accordingly.
  2) For reach 1, specify the stream configuration and corresponding groundwater nodes (stream configuration for reaches 2 and 3 are already specified).
  3) Stream bed elevation and stream flow depth are given in feet. Set variable FACTLT accordingly.
  4) Rating table flow rates are given in cfs. Set variables FACTQ and TUNIT, accordingly (since IWFM does not recognize a time interval of *1 second*, set variable FACTQ to convert cfs to ft^3/day, then set TUNIT = 1day).
  5) Stream bed elevations and rating tables are already specified in the file.

Simulation:

- *SIMULATION_MAIN.IN*

  Enter filenames for stream data (*Stream_MAIN.dat*), lake data (*Lake_MAIN.dat*), lake precipitation data (*Precip.dat*) and lake evaporation data (*ET.dat*).

- *BC.dat*

  Modify the file so that boundary condition at each of the east and west boundary nodes is 290 ft.

- *ET.dat*

  Lake evaporation data is given above and listed under the ***Evaporation*** tab in ***the Example2_Data.xlsx*** file. Properly specify NCOLET and FACTET variables and generate the time-series data for the lake evaporation using year 4000 flag.

- *Precip.dat*

  Lake precipitation data is given above and listed under the ***Precipitation*** tab in ***the Example2_Data.xlsx*** file. Properly specify NRAIN and FACTRN variables and generate the time-series data for the lake precipitation using year 4000 flag.

- *MaxLakeElev.dat*

  Maximum lake elevation is given as 285 ft. Set variables NCOLHLMX and FACTHLMX accordingly, and generate the time series data for maximum lake elevation.

- *Lake_MAIN.dat*

  1) Specify filename for the maximum lake elevation data file (*MaxLakeElev.dat*).
  2) Specify a filename to create the binary budget file output for the lake under the *Results* folder.
  3) Based on the lake bottom parameters given above, specify unit conversion variables FACTK, TUNITK and FACTL as well as variables IL, CLAKE, DLAKE, ICHLMAX, ICETLK and ICPCPLK.
  4) Initial lake elevation is specified as 280 ft. Specify variables FACT, ILAKE and HLAKE, accordingly.

- *StreamInflow.dat*

  Stream inflow is 1000 cfs at stream node 1 during the simulation period. Set variables NCOLSTRM, FACTSTRM and IRST, and prepare the stream inflow time series data (remember that unit of cfs will need to be converted to ft^3/day).

- *BypassSpec.dat*

  1) 25% of flow at stream node 4 is diverted for aquifer recharge operations and all of this water goes to recharge the aquifer (i.e. no non-recoverable loss). Based on this information specify variables ID, IA, TYPEDEST, DEST, IDIVC, DIVRL, DIVNL, DIVX and DIVY.
  2) There a total of 16 elements where aquifer receives recharge through the bypass (elements 327 – 332 get 5% of the diverted water through canal leakage, and the rest of the elements get 7% of the diverted water through settling basin). Variables ID, NERELS and IERELS are already populated. Based on the percentages given, specify variable FERELS for each recharge-receiving element.

- *Stream_MAIN.dat*

  1) Specify filenames for the stream inflow data file (StreamInflow.dat) and bypass specifications data file (BypassSpec.dat). Also specify filename for the binary stream flow budget output file that will be created under *Results* folder.
  2) Simulated stream flow hydrographs at each of the 23 stream nodes will be printed (in terms of stream flows as opposed to stream surface elevations). Specify variables NOUTR and IHSQR, accordingly. The rest of the variables used for the printing of the hydrographs are already specified.
  3) Stream flow budget at selected stream nodes is not needed. Therefore, variable NBUDR is already set to 0 and the name of the output file (variable STNDBUDFL) is left blank.
  4) Stream bed parameters and wetting perimeter for each stream node are listed above. Enter variables CSTRM, DSTRM and WETPR, accordingly.

Budget:

- *Budget.in*

  This file is already set up to process the budget files for groundwater, lake and stream flows in the *Results* folder.

Z-Budget:

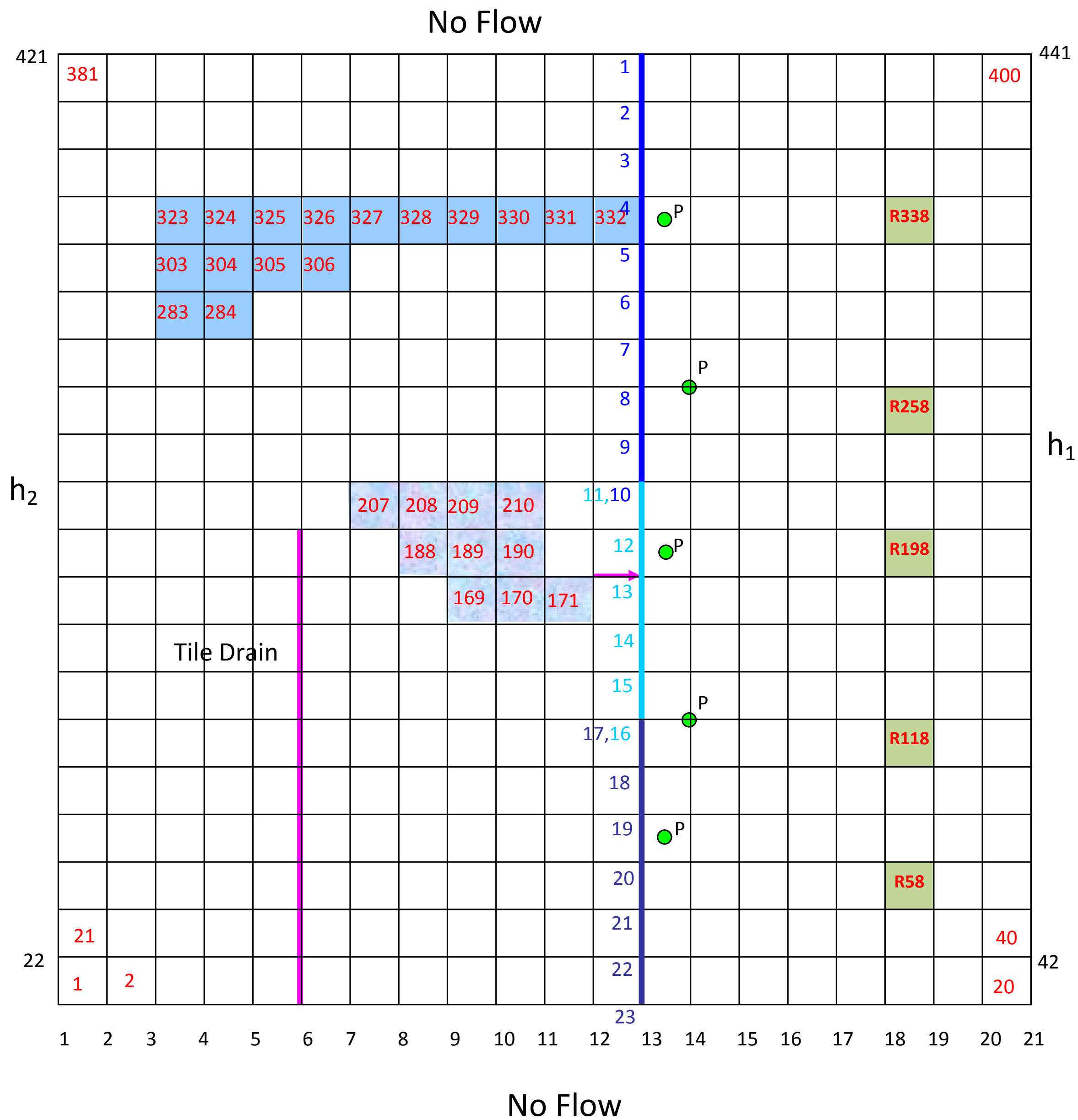
- *ZBudget_E210.in*

  This file is already set up to generate the detailed groundwater budget at element 210.

- *ZBudget_SR.in*

  This file is already set up to generate the detailed groundwater budget at each subregion.

Example 3 – Tile Drains, Subsidence, Pumping and Recharge



Description:

- Single layer aquifer whose characteristics and boundary conditions are similar to the one in previous example. Stream characteristics, stream boundary inflow and lake characteristics are also the same as in the previous example.

- ***Initial groundwater head*** is 292 ft.

- ***Tile drains*** are located at 280 ft elevation parallel to y-axis at nodes 6, 27, 48, 69, 90, 111, 132, 153, 174, 195 and 216. The conductance of the interface between the tile drains and the aquifer is 20000 ft^2/day. Flow from tile drains contribute to stream node 20.

- There are 5 ***pumping wells*** modeled. The following well characteristics are defined:

Well #	x-coord. (m)	y-coord. (m)	Well diameter (ft)	Elevation of top perforation (ft)	Elevation of bottom perforation (ft)
1	575000	4407000	1	400	0
2	576000	4412000	1	400	0
3	575000	4419000	1	400	0
4	576000	4426000	1	400	0
5	575000	4433000	1	400	0

- There are 5 elements (elements 58, 118, 198, 258 and 338) used for artificial recharge of the aquifer. In other words, there are 5 ***element pumping*** specifications.

- The following ***pumping and recharge rates*** (pumping is distributed equally among the wells and recharge is distributed equally among elements) are used:

Time (month)	Pumping (TAF/month)	Recharge (TAF/month)
Oct	0	0
Nov	0	0
Dec	70	0
Jan	70	0
Feb	70	0
Mar	70	0
Apr	0	40
May	0	40
Jun	0	40
Jul	0	40
Aug	0	40
Sep	0	40

- For the simulation of ***subsidence***, the following parameters are used:

Elastic storage coefficient	= 5 x 10^{-6} 1/ft
Inelastic storage coefficient	= 5 x 10^{-5} 1/ft
Interbed thickness	= 10 ft
Minimum interbed thickness	= 2 ft
Pre-compaction hydraulic head	= 270 ft

- ***Time step*** = 1 day
- ***Simulation period*** = September 30, 1997 midnight through September 30, 2001 midnight.

Directions:

Pre-processor:

There are no files in Pre-processor that need to be modified.

Simulation:

- *SIMULATION_MAIN.IN*

  Specify the filenames for irrigation fractions data file (*IrrigFrac.dat* for unit 10), tile drain data file (*TileDrain.dat* for unit 14), pumping data file (*Pumping_MAIN.dat* for unit 15) and output file for subsidence hydrographs at selected nodes *(..\Results\SubsHyd.out* for unit 20).

- *IC.dat*

  Initial groundwater head is 292 ft. Modify the file accordingly (Hint: select the old initial head values and use your text editor's *Search and Replace* feature).

- *IrrigFrac.dat*

  Although pumping in this example will not be used for irrigation, this file still needs to be supplied to IWFM. Generate the time series data so that all water supply goes to agricultural irrigation (i.e. irrigation fraction is 1.0).

- *Print.dat*

  Subsidence hydrographs at 3 nodes (60, 77 and 413) will be printed out. Specify variables NOUTS, FACT, IOUTSL and IOUTS, accordingly.

- *Parameter.dat*

  1) Specify the conversion factors FSCE, FSCI, FDC, FDCMIN and FHC for the simulation of

subsidence.

2) Parameter values to simulate subsidence are listed above. Enter these values for the parametric grid.

- *TileDrain.dat*

1) There are a total of 11 tile drain nodes and the tile drain parameters are given above. Specify variable NTD and the conversion factors, accordingly.

2) The tile drain nodes are already entered into the file. Based on the parameter values listed above, specify variables ELEVDR, CDCDR, TYPDST and DST for each tile drain node (Hint: enter these parameters for only the first tile drain node, then copy these parameters and paste them for the rest of the nodes).

3) Since subsurface irrigation is not modeled, variable NSI is already set to 0, and the conversion factors are already specified randomly.

4) Simulated tile drain hydrographs at tile drain IDs 1 and 11 are required to be printed out to file under the *Results* folder in units of AF/day. Set variable NOUTTD, ID and IDTYP accordingly (data for unit conversion as well as the output filename are already specified).

- *Pumping_MAIN.dat*

Enter the filenames for well specifications data file (*WellSpecs.dat*), element pumping specifications data file (*ElemPumpSpecs.dat*) and the pumping/recharge rates time series data file (*PumpRate.dat*).

- *PumpRate.dat*

Pumping and recharge rates are specified above and supplied under the ***PumpRate*** tab in the ***Example3_Data.xlsx*** file. Populate the PumpRate.dat file, accordingly.

- *WellSpecs.dat*

1) There are 5 wells whose coordinates are given in meters while the rest of the parameters are given in feet. Populate variables NWELL, FACTXY, FACTRW and FACTLT, accordingly.

2) Well diameter and the elevations of top and bottom perforations of the wells are specified above. Enter variables RWELL, PERFT and PERFB for each well, accordingly (the coordinates of the wells are already entered).

3) The simulated wells pump a total amount of 70 TAF each month from December through March (pumping is distributed equally between the wells). The pumped water is delivered outside the model area. Based on this information, populate variables ICOLWL, FRACWL, IOPTWL, TYPDSTWL and DSTWL for each well.

- *ElemSpecs.dat*

  1) There are 5 elements that are used for recharging the aquifer. Set variable NSINK, accordingly.
  2) The elements are being used to recharge the aquifer a total amount of 40 TAF each month from April through September (recharge is distributed equally between the elements). Based on this information populate variables ICOLSK, FRACSK, IOPTSK, FRACSKL(1), TYPDSTSK and DSTSK for each element.

Budget:

- *Budget.in*

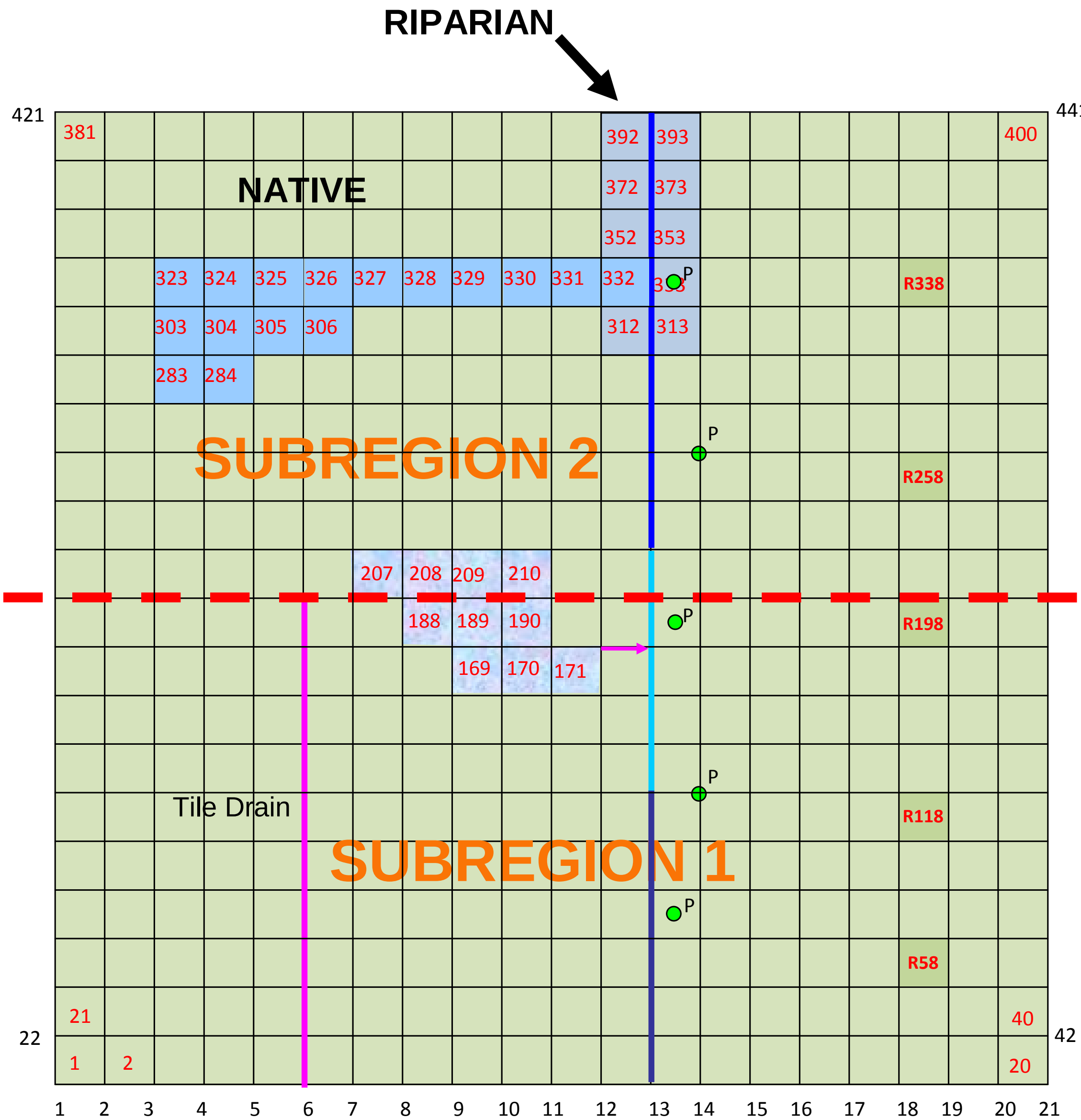
  This file is already set up to process the budget files for groundwater, lake and stream flows in the *Results* folder.

Z-Budget:

- *ZBudget_ALL.in*

  This file is already set up to generate the detailed groundwater budget for the entire model area.

Example 4 – Routing Water through Land Surface, Root Zone and Unsaturated Zone



Description:

- The simulation grid is the same as in previous example. All parameters and initial conditions are the same.

- Cells 312, 313, 332, 333, 352, 353, 372, 373, 392 and 393 are covered with riparian vegetation while the rest of the cells are covered with native vegetation.

- ***Soil parameters*** (*from Rawls et al., 1982*):

Cells	Texture Class	Wilting Point (cm/cm)	Field Capacity (cm/cm)	Total Porosity (cm/cm)	Pore Size Dist. Index	Hydraulic Conductivity (cm/hour)
1–100	Sandy loam	0.10	0.20	0.45	0.62	2.60
101–200	Silt loam	0.12	0.33	0.50	0.36	0.68
201–300	Clay	0.27	0.40	0.48	0.29	0.01
301–400	Silty clay	0.25	0.37	0.47	0.32	0.15

- The following ***precipitation*** pattern is repeated for each simulation year:

Month	Cells 1 – 10 (in/mon)	Cells 11 – 400 (in/mon)
Jan	5.98	6.75
Feb	6.29	5.56
Mar	8.63	4.21
Apr	2.81	0.25
May	0.38	0.40
Jun	0.07	0.00
Jul	0.00	0.11
Aug	0.04	0.66
Sep	0.48	0.40
Oct	2.81	5.74
Nov	5.70	3.25
Dec	2.71	4.92

- The following ***evapotranspiration*** (in/mon) pattern is repeated for each simulation year:

Month	Native veg.	Riparian veg.
Oct	3.4	4.6
Nov	1.6	2.2
Dec	1.0	1.4
Jan	1.1	1.4
Feb	1.8	2.4
Mar	3.0	3.9
Apr	4.5	5.8
May	5.9	7.6
Jun	7.3	9.3
Jul	7.9	10.1
Aug	6.6	8.5
Sep	5.2	6.8

- ***Curve numbers*** *(for both native and riparian vegetation)*:

Cells	Curve number
1–100	65
101–200	75
201–300	90
301–400	85

- ***Rooting depths*** for both native and riparian vegetation are 3.0 feet.
- ***Initial soil moisture content*** is equal to the field capacity at each cell.
- ***Convergence criteria for soil moisture routing*** = 0.0001 ft/ft
- ***Maximum number of iteration for soil moisture routing*** = 200.
- ***Surface runoff*** from cells 1 – 200 flow outside the model area while surface runoff from cells 201 – 400 flow into stream node 6.
- ***Unsaturated zone*** will be simulated using 2 layers.
- ***Unsaturated zone parameters*** for all layers and cells are as follows:
  Unsaturated layer thickness = 50 ft.
  Total porosity = 0.43 ft/ft
  Pore size distribution index = 0.8
  Saturated hydraulic conductivity = 20 ft/day
  Method to compute vertical flow = Campbell's equation
- ***Unsaturated zone initial moisture contents*** are 0.25 ft/ft and 0.1 ft/ft for layers 1 and 2, respectively.
- ***Time step*** = 1 day
- ***Simulation period*** = September 30, 1997 midnight through September 30, 2001 midnight.

Directions:

Pre-processor:

There are no files in Pre-processor that need to be modified.

Simulation:

- *SIMULATION_MAIN.IN*

  Specify the filename (*RootZone_MAIN.dat* for unit 3) that stores the data to simulate land surface and root zone flow processes.

- *Parameter.dat*

  1) Unsaturated zone will be simulated using 2 layers. Set variable NUNSAT, accordingly.
  2) Unsaturated zone parameters will be specified for each cell (as opposed to using parametric grid). Set variable NGROUP, accordingly.
  3) Saturated hydraulic conductivity and layer thickness for unsaturated zone are given in units of feet/day and feet, respectively. Set unit conversion variables FD, FK and TUNITZ, accordingly. Since parametric grid option is not used, you can set variable FX (conversion factor for parametric grid coordinates) to any value.
  4) The unsaturated zone parameters are already specified under the section titled *OPTION 2 (for Unsaturated Zone Parameter Definition).*

- *IC.dat*

  Initial unsaturated zone moisture contents are 0.25 and 0.1 ft/ft for layers 1 and 2, respectively. Modify the IC.dat file, accordingly.

- *ET.dat*

  ET rates for native and riparian vegetation are listed above and supplied under the ***ET*** tab of the ***Example4_Data.xlsx*** file. Copy the ET data into ET.dat file and modify the necessary variables, accordingly.

- *Precip.dat*

  Precipitation rates for native and riparian vegetation are listed above and supplied under the ***Precipitation*** tab of the ***Example4_Data.xlsx*** file. Copy the precipitation data into Precip.dat file and modify the necessary variables, accordingly (Note: Precipitation rates given for cells 11 – 400 are the same as those given for the lake. Therefore, you will only need to enter precipitation rates for cells 1 – 10).

- *ROOTZONE_MAIN.dat*

  1) Convergence criteria for the iterative moisture routing will be 0.0001 ft/ft. Set variable RZCONV accordingly.
  2) Set maximum number of iterations (RZITERMAX) to 200.
  3) Factor to convert inches to feet is 0.0833; set FACTCN accordingly.

4) All the data required to simulate native and riparian vegetation will be listed in file *NVRV_MAIN.dat*. Set variable NVRVFL accordingly.

5) Root zone budget data will be printed out to a file named *RootZone.bin* under the *Results* folder. Set variable RZBUDFL, accordingly (Hint: *..\Results\RootZone.bin*).

6) The saturated hydraulic conductivity values will be listed in units of cm/hour. Set the conversion factor FACTK to convert cm to feet (= 0.0328) and list the time unit of hydraulic conductivity (TUNITK) as 1HOUR.

7) The soil parameters (wilting point, field capacity, total porosity, pore size distribution index and saturated hydraulic conductivity) are already listed for each element using the values listed above.

8) For all elements, van Genucten-Mualem equation will be used in calculating the deep percolation. Set variable RHC for each element accordingly.

9) First 10 elements will use the precipitation rates listed in the second column of the Precip.dat file while the rest of the elements will use rates from column 1. Set variable IRNE accordingly.

10) Set variable FRNE for all elements to 1.0 (i.e. precipitation rates read in from the Precip.dat file will be used without modification).

11) Since there is no generic source of moisture set variable IMSRC to 0 (zero) for all elements.

12) Surface runoff from the first 200 elements flow outside the model area while surface runoff from the rest of the elements flow into stream node 6. Set variables TYPDEST and DEST for each cell, accordingly.

- *NVRV_MAIN.dat*

1) The native and riparian vegetation areas for each element are specified in file *NVRVArea.dat*. Set variable LUFLNVRV accordingly.

2) Root zone depths for both native and riparian vegetation are 3.0 feet. Set variables FACT, ROOTNV and ROOTRV, accordingly.

3) The curve numbers for each cell are already listed based on the information given in the *Description* section.

4) ET rates for native vegetation in each cell are listed in column 2 of ET.dat file while ET rates for riparian vegetation are listed in column 3. Set variables ICETNV and ICETRV, accordingly.

5) Initial moisture content at each cell for native and riparian vegetation is equal to the field capacity of that cell. These initial conditions are already specified in the file.

- *NVRVArea.dat*

This file is already populated based on the land use distribution shown in the figure above. Please take note of the format of the time stamp used for the land use areas that will stay constant over the simulation period (i.e. the year is set to 2500 which is greater than the ending year of the simulation period).

Budget:

- *Budget.in*

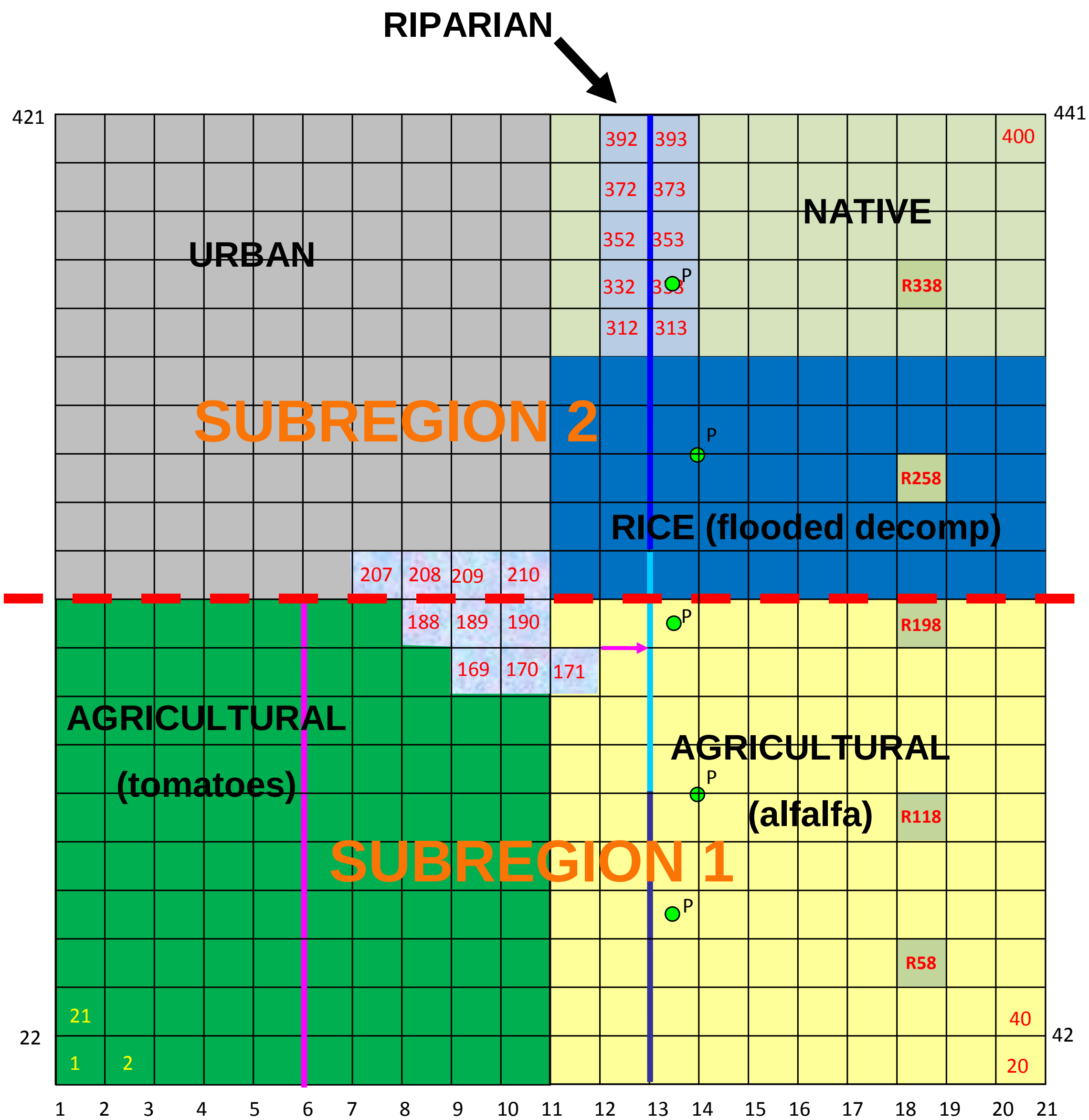
  This file is already set up to process the budget files for groundwater, lake, stream and root zone components in the *Results* folder.

Z-Budget:

- *ZBudget_ALL.in*

  This file is already set up to generate the detailed groundwater budget for the entire model area.

Example 5 – Agricultural and Urban Water Demands



Description:

- The system setup is the same as in the previous example except that there are no artificial groundwater recharge operations through the use of IWFM bypass feature. There is also an urban area as well as rice with flooded decomposition, tomatoes and alfalfa planted in the model domain.

Urban Data:

- 50% of each urban cell is ***unpaved*** (i.e. pervious).
- ***Population*** of the city is 1000.
- ***Per capita water use*** in the city is as follows:

Period	Water Use (ac.ft./person)
Jan – Jun	0.3
Jul – Dec	0.4

- ***Fraction of total urban water used indoors*** is as follows:

Month	Indoor water use fraction
Oct	0.5
Nov	0.7
Dec	0.8
Jan	1.0
Feb	1.0
Mar	0.6
Apr	0.5
May	0.45
Jun	0.4
Jul	0.4
Aug	0.4
Sep	0.4

- ***Return flow fraction*** is 0.15.
- ***Reuse fraction*** is 0.0.
- ***Rooting depth*** for urban parks, yards, etc. is 2.0 ft.
- ***Curve numbers*** for urban lands at each element is the same as those for native/riparian vegetation:

Cells	Curve number
1–100	65
101–200	75
201–300	90
301–400	85

- The following ***evapotranspiration*** pattern is repeated for each simulation year:

Month	ET (in/mon)
Oct	3.4
Nov	1.6
Dec	0.5
Jan	0.5
Feb	1.8
Mar	3.2
Apr	4.9
May	6.1
Jun	7.3
Jul	7.9
Aug	6.4
Sep	5.2

- ***Initial soil moisture*** content is equal to the field capacity at each cell. 90% of it is due to precipitation.

Non-Ponded Crop Data:

- ***Maximum rooting depths*** for tomatoes and alfalfa are 5.0 and 6.0 feet, respectively. The following root growth pattern given as the ***fraction of the maximum rooting depth*** will be used for each simulation year:

Month	Tomatoes	Alfalfa
Oct	0.20	1.00
Nov	0.20	1.00
Dec	0.20	1.00
Jan	0.20	1.00
Feb	0.20	1.00
Mar	0.20	1.00
Apr	0.30	1.00
May	0.65	1.00
Jun	1.00	1.00
Jul	1.00	1.00
Aug	1.00	1.00
Sep	1.00	1.00

- The cropping season (i.e*. **irrigation period***) for tomatoes is from April 1st through September 31st, and for alfalfa from March 1st through October 31st.

- The ***minimum soil moisture*** to trigger irrigation is 60% and 45% of TAW for tomatoes and alfalfa, respectively.

- ***Irrigation target soil moisture*** is equal to the field capacity for both tomatoes and alfalfa.

- ***Initial return flow*** for both crops is 10% of applied water.

- ***Reuse*** for both crops is 6% of applied water.

- ***Curve numbers*** for both tomatoes and alfalfa at each element is the same as those for native and riparian vegetation as well as urban lands:

Cells	Curve number
1–100	65
101–200	75
201–300	90
301–400	85

- The following ***evapotranspiration*** pattern is repeated for each simulation year:

Month	Tomatoes (in/mon)	Alfalfa (in/mon)
Oct	3.4	3.5
Nov	1.6	1.6
Dec	1.0	1.0
Jan	1.0	1.0
Feb	1.8	1.8
Mar	3.0	3.0
Apr	4.5	4.1
May	5.9	5.4
Jun	7.3	6.8
Jul	7.9	7.7
Aug	6.6	6.8
Sep	5.2	5.4

- ***Initial soil moisture content*** for both crops is equal to the field capacity at each cell. 90% of the initial soil moisture content is due to precipitation.

Ponded Crop Data:

- ***Rooting depth*** for rice is 2 ft.

- ***Growing season*** for rice is from May 1st through September 30th.

- ***Decomposition by flooding*** the fields takes place from October 1st through December 31st.

- ***Curve numbers*** for rice at each element is the same as in previous examples

Cells	Curve number
1–100	65
101–200	75
201–300	90
301–400	85

- The following ***ponding depths*** are used during growing season and decomposition period:

Month	**Growing season (in)**	**Decomposition period (in)**
Oct	0.0	3.0
Nov	0.0	3.0
Dec	0.0	2.0
Jan	0.0	0.0
Feb	0.0	0.0
Mar	0.0	0.0
Apr	0.0	0.0
May	3.0	0.0
Jun	5.0	0.0
Jul	8.0	0.0
Aug	8.0	0.0
Sep	8.0	0.0

- The following flow-through (i.e. ***return flow***) rates are used:

Month	**Flow-through (in/mon)**
Oct	0.0
Nov	0.0
Dec	0.0
Jan	0.0
Feb	0.0
Mar	0.0
Apr	0.0
May	4.0
Jun	2.0
Jul	2.0
Aug	2.0
Sep	1.0

- ***Reuse*** for rice is zero.

- The following ***evapotranspiration*** pattern is repeated for each simulation year:

Month	**Rice ET (in/mon)**
Oct	2.2
Nov	1.6
Dec	1.0
Jan	1.0
Feb	1.8
Mar	3.0
Apr	8.0
May	9.1
Jun	10.4
Jul	9.7
Aug	7.0
Sep	1.9

- ***Initial soil moisture content*** is equal to the field capacity at each cell. 90% of the initial moisture is due to precipitation.

Directions:

Pre-processor:

There are no files in Pre-processor that need to be modified.

Simulation:

- *ET.dat*

  ET rates for urban area, tomatoes, alfalfa and rice are listed above and supplied under the ***ET*** tab of the ***Example5_Data.xlsx*** file. Copy the ET data into ET.dat file and modify the necessary variables, accordingly.

- *RootZone_MAIN.dat*

  1) Enter the filenames *NonPondedAg_MAIN.dat*, *PondedAg_MAIN.dat* and *Urban_MAIN.dat* for the files that store information to simulate non-ponded crops, ponded crops and urban lands, respectively.
  2) Enter filenames for return flow fractions data file (*ReturnFlowFrac.dat*), re-use fractions data file (*ReuseFrac.dat*) and irrigation period data file (*IrigPeriod.dat*).
  3) Enter the filename for the binary land and water use budget file that will generated under the *Results* folder (*..\Results\LandWater.bin*).

- *ReturnFlowFrac.dat*

  The return flow fractions for urban lands and non-ponded crops (both tomatoes and alfalfa) are *0.15* and 0.10, respectively, for the entire simulation period. Populate variable NCOLRT, accordingly and specify the timestamp as well as the RTRNF variable.

- *ReuseFrac.dat*

  The reuse fractions for urban lands and non-ponded crops (both tomatoes and alfalfa) are *0.0* and 0.06, respectively, for the entire simulation period. Populate variable NCOLRUF, accordingly and specify the timestamp as well as the RUF variable.

- *IrigPeriod.dat*

  Irrigation period for tomatoes, alfalfa and rice are listed above and supplied under the ***IrigPeriod*** tab of the ***Example5_Data.xlsx*** file. Copy the irrigation period flags into IrigPeriod.dat file and modify the necessary variables, accordingly.

- *UrbanAreas.dat*

  The urban areas are already specified in this file.

- *Population.dat*

  The population for the entire urban area is 100000. Specify variable NCOLPOP, and create the population time-series data with appropriate value and timestamp.

- *PerCapWaterUse.dat*

  The per capita water use data is given above and listed under the ***PerCapWaterUse*** tab in ***the Example5_Data.xlsx*** file. Properly specify NCOLWU and FACTWU variables and generate the time-series data for the per capita water use.

- *UrbanWaterUseSpecs.dat*

  The fraction of total urban water that is used indoors is listed above and also in the ***UrbanWaterUseSpecs*** tab of ***Example5_Data.xlsx*** file. Specify the NURBSP variable and generate the time-series data by copying values from the Excel file and properly time-stamping the data.

- *Urban_MAIN.dat*

  1) Enter the filename *UrbanAreas.dat* for variable LUFLU.
  2) Rooting depth for urban vegetation is 2.0 ft. Specify variables FACT and ROOTURB, accordingly.
  3) Enter the filenames *Population.dat*, *PerCapWaterUse.dat* and *UrbanWaterUseSpecs.dat* for variables POPULFL, WTRUSEFL and URBSPECFL, respectively.
  4) Element number (IE), fraction of pervious area to total urban area (PERV), curve numbers (CNURB) and the fractions to distribute urban demand to individual cells (FRACDM) are already specified.
  5) Based on the time-series data files you generated in the previous steps (return flow fraction data file, reuse fraction data file, ET data file, population data file, per capita water use data file and urban water use specifications data file) specify variables ICPOPUL, ICWTRUSE, ICETURB, ICRTFURB, ICRUFURB and ICURBSPEC for each grid cell.
  6) Initial soil moisture and the fraction due to precipitation are already specified in the file.

- *MinMoist.dat*

  Minimum moisture to trigger irrigation for tomatoes and alfalfa are 60% (0.6) and 45% (0.45) of the Total Available Water (TAW), respectively. Modify the MinMoist.dat file, accordingly.

- *RootDepthFrac.dat*

  The rooting depth as a fraction of the maximum root depth for tomatoes and alfalfa are specified above and supplied under the ***RootDepthFrac*** tab in the ***Example5_Data.xlsx*** file. Modify the RootDepthFrac.dat file, accordingly.

- *NonPondedAg_MAIN.dat*

  1) There are *2* non-ponded crops simulated: tomatoes and alfalfa. Since simulation time step length is 1 day, the soil *moisture at the beginning of time step* will be used in computing crop water demands. Crop codes to be used in output files for tomatoes and alfalfa are *TO* and *AL*, respectively. Crop acreages are already specified in data file *CropAreas.dat*. Based on this information specify variables NCROP, FLDMD, CCODE and LUFLNP.
  2) Land and water use as well as the root zone budgets for tomatoes and alfalfa will be generated in the *Results* folder. The name of the crop-specific land and water use budget will be *LandWater_Crops.bin* and the name of the root zone budget is *RootZone_Crops.bin*. Based on this information specify variables NBCROP, BCCODE, CLWUBUDFL and CRZBUDFL.
  3) Maximum rooting depths for tomatoes and alfalfa are *5 ft* and *6 ft*, respectively. Rooting depth fractions are already specified in the file *RootDepthFrac.dat*. Based on this information specify variables RZFRACFL, FACT, IC, ROOT and ICROOT.
  4) Curve numbers for tomatoes and alfalfa at each element are already specified for you.
  5) ET rates for tomatoes and alfalfa are already specified in the ET.dat file. Enter the ET data column numbers to be used for tomatoes and alfalfa at each element by specifying the variables IE and ICET, accordingly (Hint: Since the same ET column numbers can be used for each grid cell, you can set IE to 0 (zero) instead of specifying the ICET variable for every grid cell).
  6) Agricultural water supply requirement (i.e. crop water demand) will be simulated internally by IWFM. Therefore, ICAW variable for tomatoes and alfalfa are already specified as 0 (zero).
  7) Irrigation periods for tomatoes and alfalfa are specified in the IrigPeriod.dat file. Specify variables IE and ICIP, accordingly.
  8) Minimum soil moisture values to be used as irrigation trigger are already specified in the file *MinMoist.dat* file for both tomatoes and alfalfa. Specify variables MINSMFL, IE and ICMSM, accordingly.
  9) The default value for the target soil moisture for irrigation (i.e. field capacity) will be used for each element and crop. Therefore, the section titled *Target Soil Moisture for Irrigation* in the data file will be skipped.
  10) Return flow fractions for both tomatoes and alfalfa are already specified in the *ReturnFlowFrac.dat* file. Specify variables IE and ICRTRNF, accordingly.

11) Reuse fractions for both tomatoes and alfalfa are already specified in the *ReuseFrac.dat* file. Specify variables IE and ICRRUF, accordingly.

12) There are no minimum deep percolation values specified. Skip the section titled *Minimum Deep Percolation Fractions*.

13) Initial soil moisture conditions at each element are equal to the field capacity and 90% of the initial soil moisture content is due to precipitation. These values are already specified in the data file.

- *PondDepth.dat*

  Ponding depths during growing season and decomposition period are specified above. They are also supplied under the ***PondDepth*** tab in the ***Example5_Data.xlsx*** file. Modify the data file accordingly (Hint: Ponding depths for growing season and decomposition period must be combined into a single time-series data).

- *RiceOps.dat*

  Flow-through (i.e. return flow) rates are specified above and supplied under the ***Flow-through*** tab in the ***Example5_data.xlsx*** file. Also, reuse for rice is zero. Modify the data file, accordingly (Hint: Create 2 data columns; one for return flows and one for re-use).

- *PondedAg_MAIN.dat*

1) The rice acreage is already specified in file *RiceAreas.dat*. Enter the filename for variable LUFLP.

2) Root zone as well as land and water use budget files for rice with flooded decomposition will be generated under folder *Results.* The filename for land and water use budget will be *LandWater_Rice.bin*, and the filename for root zone budget will be *RootZone_Rice.bin*. Specify variables NBCROP, BCCODE, CLWUBUDFL and CRZBUDFL, accordingly.

3) Rooting depth for rice is 2 ft. Specify relevant variables (Hint: You can enter any value for ponded crops that are not simulated).

4) Curve numbers for all cells and ponded crops are already specified in the data file. Skip this section.

5) ET rates for rice are specified in the ET.dat file. Specify variables IE, ICETRI_*** and ICETRF_***, accordingly (Hint: Specify the ET data column numbers for the ponded crops that are not simulated the same value as the one specified for the rice with flooded decomposition. Also remember to use the IE = 0 option for efficient data entry).

6) Since water demand will be computed internally in IWFM, ICAWRI_*** and ICAWRF_*** variables are all set to zero. Skip the section titled *Water Supply Requirement*.

7) Irrigation period flags are specified in the file IrigPeriod.dat. Specify variables IE, ICIP_*** and ICIPRF_***, accordingly (Hint: Specify the irrigation period data column number for the ponded crops that are not simulated the same value as the one specified for rice with flooded decomposition. Also, remember to use the IE = 0 option).

8) Ponding depths are listed in file *PondDepth.dat*, and return flow and re-use rates in file *RiceOps.dat*. Specify variables PNDTHFL and FLOWFL, accordingly.

9) Ponding depths are specified in file PondDepth.dat. Specify variables IE, ICPDRI_*** and ICPDRF_***, accordingly (Hint: Specify the ponding depth data column number for the ponded crops that are not simulated the same value as the one specified for rice with flooded decomposition. Also, remember to use the IE = 0 option).

10) Although rice with non-flooded decomposition is not simulated, application depths for non-flooded rice decomposition still needs to be specified. Variable ICDWRI_NFL is already specified in the data file for you.

11) Return flow depths are specified in file RiceOps.dat. Set variables IE, ICRTRI_*** and ICRTRF_***, accordingly (Hint: Specify the return flow data column number for the ponded crops that are not simulated the same value as the one specified for rice with flooded decomposition. Also, remember to use the IE = 0 option).

12) Reuse is specified as zero in file RiceOps.dat. Set variables IE, ICRUFRI_*** and ICRUFRF_***, accordingly.

13) Initial soil moisture content is equal to the field capacity at each cell and 90% of the initial moisture is due to precipitation. This data is already specified in the data file.

Budget:

- *Budget.in*

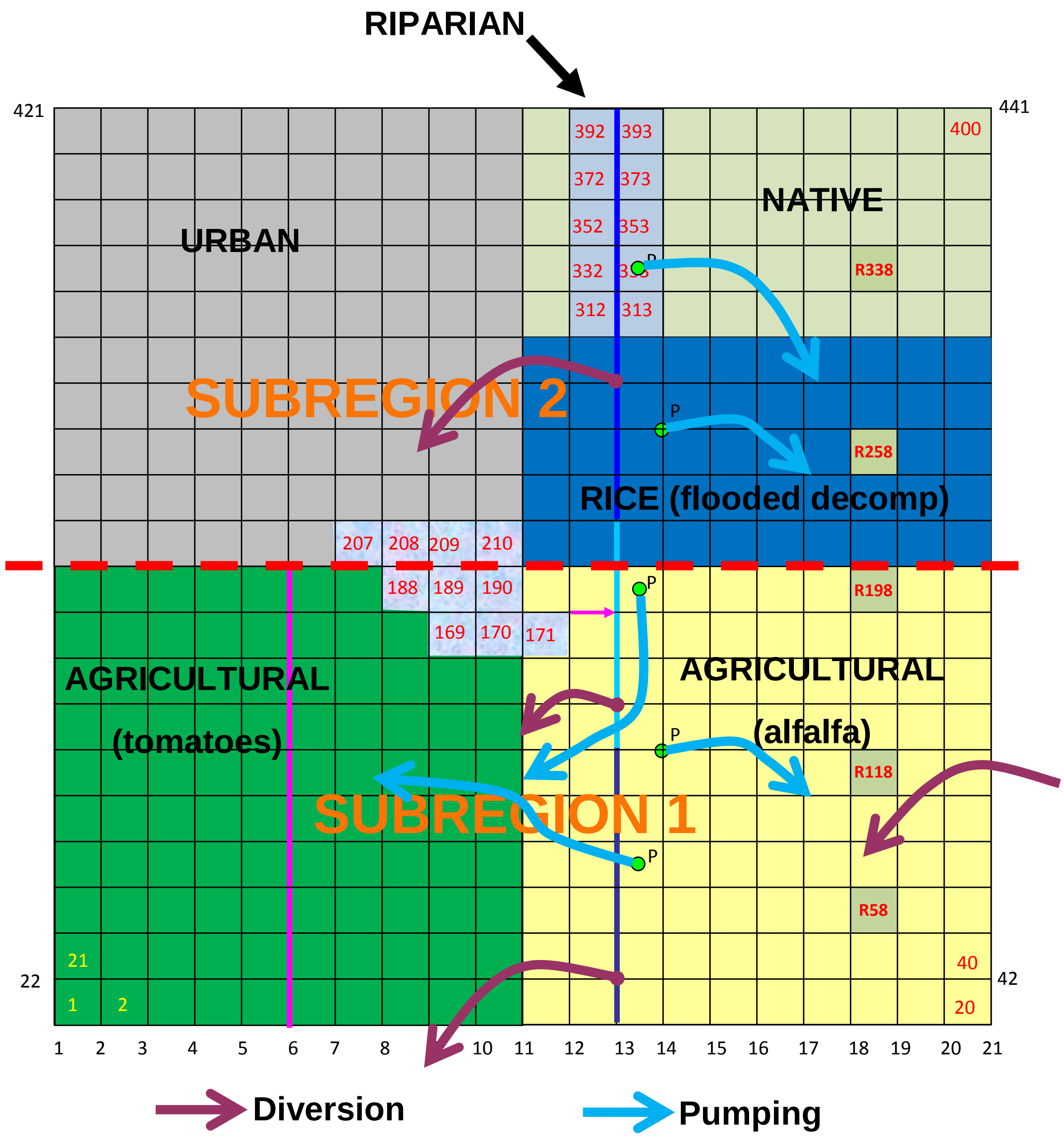
This file is already set up to process the budget files for groundwater, lake, stream and root zone components as well as the land and water use budget in the *Results* folder.

Z-Budget:

- *ZBudget_ALL.in*

This file is already set up to generate the detailed groundwater budget for the entire model area.

Example 6 – Diversions and Pumping as Water Supply



Description:

- The system setup is the same as in the previous example.
- Five pumping wells are used to meet the agricultural water demand as follows:

Well #	Target Demand
1	Tomatoes in subregion 1
2	Alfalfa in subregion 1
3	Agricultural demand in subregion 1
4	Rice in subregion 2
5	Rice in subregion 2

- Four diversions are introduced with the following characteristics:

Diversion #	Stream Node	Diversion Amount (TAF/mon)	Recoverable Loss	Non-Recoverable Loss	Target Demand
1	22	15.0	0%	5%	Outside model area
2	0	100.0	2%	2%	Alfalfa in subregion 1
3	15	100.0	20%	3%	Ag. demand in subregion 1
4	7	50.0	5%	0%	Urban demand in subregion 2

- The following elements receive recoverable recharge (distributed equally to each element) from each diversion:

Diversion #	Elements Receiving Recoverable Recharge
1	None
2	76 – 80
3	121 – 140
4	290 – 292

Directions:

Pre-processor:

There are no files in Pre-processor that need to be modified.

Simulation:

- *IrrigFrac.dat*

  Based on the description above water supplies (pumping or diversion) are either used to meet agricultural or urban water demand. Specify the number of irrigation fractions data columns for variable NCOLIRF, and generate the time-series data sets to represent agricultural and urban water supplies.

- *WellSpecs.dat*

  1) Based on the information given above, set variables TYPDSTWL and DSTWL to represent the delivery locations for each well pumping (Hint: Water from wells 1 and 2 will be delivered to a group of elements. These elements will be listed later in the file for each element).
  2) All wells are being used to meet agricultural water demand. Based on the time-series data columns you have specified in file *IrrigFrac.dat*, set variable ICFIRIGWL for each well.
  3) Water from wells 1 and 2 are being delivered to separate element groups. The elements for each well are supplied under the ***WellDestElems*** tab in ***Example6_Data.xlsx*** file. Copy these element lists to WellSpecs.dat file and properly populate variables NGRP, ID, NELEM and IELEM.

- *DiversionRate.dat*

  The diversion rates for each diversion are given above. Based on this information, specify variables NCOLDV, FACTDV and diversion rate time-series data.

- *DiversionSpecs.dat*

  1) Specify the number of diversions (variable NRDV).
  2) Based on the information given above, set diversion numbers (variable ID) and the stream node that each diversion is originating from (variable IRDV).
  3) Recoverable and non-recoverable loss fractions for each diversion are given above. Set variables ICOLRL, FRACRL, ICOLNL and FRACNL, accordingly (Hint: The recoverable and non0-recoverable loss column numbers should be the same as the diversion column numbers).
  4) Based on the delivery location given above for each diversion, set variables TYPDSTDL and DSTDL (Hint: Diversion 2 will be delivered to a group of elements. These elements will be listed later in the file.).
  5) Based on the recoverable and non-recoverable loss fractions given for each diversion, calculate the final delivery fraction and set variables ICOLDL and FRACDL, accordingly.
  6) First three diversions are agricultural diversions while the last diversion is for urban use. Based on this information and the data columns specified in the IrrigFrac.dat file, set variable ICFSIRIG for each diversion.
  7) The list of elements that diversion 2 will be delivered to is supplied in the ***DiverDestElems*** tab in ***Example6_Data.xlsx*** file. Copy the list of elements into this file and set variables NGRP, ID, NELEM and IELEM, accordingly.
  8) The list of elements that receive the recoverable losses from each diversion are given above and supplied in the ***DiverRecoverableLossElems*** tab in ***Example6_Data.xlsx*** file. Copy these element numbers to this file and set variables ID, NERELS, IERELS and FERELS, accordingly. Remember that recoverable loss from each diversion is distributed equally among the corresponding elements (Hint: Specify FERELS as the same value for each diversion).

- *Stream_MAIN.dat*

  Specify filenames *DiversionSpecs.dat* and *DiversionRate.dat* for variables DIVSPECFL and DIVFL, respectively. Also specify the filename *..\Results\DiverDetail.bin* to generate a diversion details binary output file under the *Results* folder to be processed later.

Budget:

- *Budget.in*

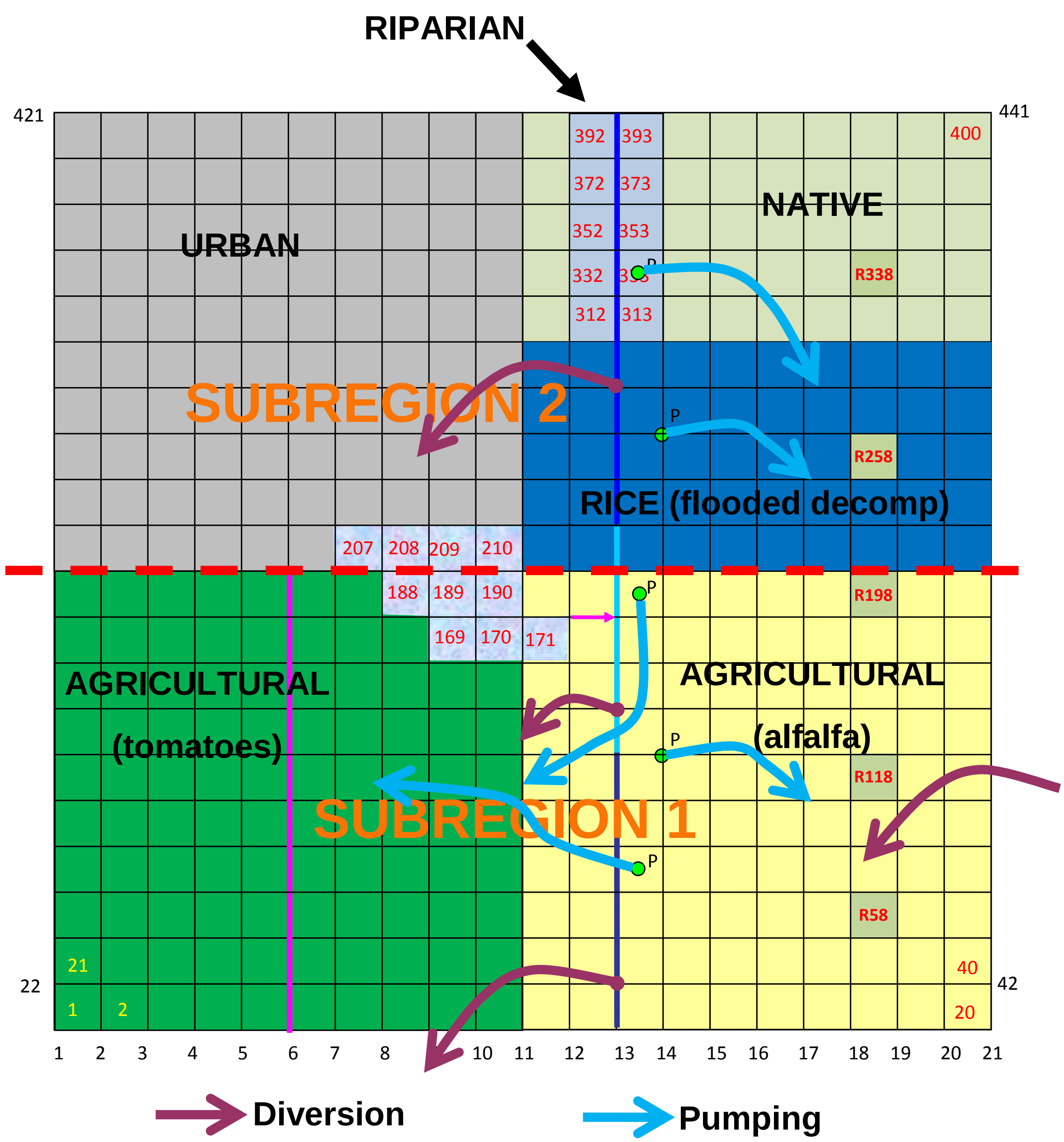
  This file is already set up to process the budget files for groundwater, lake, stream and root zone components as well as the land and water use budget in the *Results* folder.

Z-Budget:

- *ZBudget_ALL.in*

  This file is already set up to generate the detailed groundwater budget for the entire model area.

Example 7 – Automated Supply Adjustment



Description:

- The system setup is the same as in the previous example.
- All ***well pumping is adjusted to meet the agricultural water demand*** at their target destinations.
- Diversion 1 that is exported outside the model domain is not adjusted. ***Diversions 2 – 3 are adjusted to meet the agricultural demand*** at their target destinations whereas ***diversion 4 is adjusted to meet the urban water demand***.
- There is a 100 TAF/mon ***maximum diversion*** imposed on diversions 2 and 3.

Directions:

Pre-processor:

There are no files in Pre-processor that need to be modified.

Simulation:

- *SupplyAdjustSpecs.dat*

  Specify variables NCOLADJ, ITADJ and KADJ so that there are 2 time-series data columns: one to adjust a water supply to meet agricultural water demand only, and another one to adjust a water supply to meet urban water demand only.

- *SIMULATION_MAIN.IN*

  1) Specify the filename (*SupplyAdjustSpecs.dat*) that stores the supply adjustment specifications data for unit 11.
  2) Specify variable KOPTDV so that automated supply adjustment feature is on to adjust both pumping and diversions.

- *DiversionRate.dat*

  Maximum diversion rates for diversions 2 and 3 are specified to be 100 TAF/mon. Specify variable NCOLDV, accordingly and specify the maximum diversion rate time-series data.

- *DiversionSpecs.dat*

  1) Diversions 2 and 3 are assigned a maximum diversion rate of 100 TAF/mon. Based on the maximum diversion rate time-series data that you prepared in the previous step, set variables ICDVMAX and FDVMAX for each of the diversions.

2) The information regarding which diversion is being adjusted to meet what type of demand is specified above. Based on this information and the time-series supply adjustment specifications data given in *SupplyAdjustSpecs.dat* file, define variable ICADJ for each of the diversions.

- *WellSpecs.dat*

1) Pumping at all wells is adjusted to meet the agricultural water demand. Based on this information and the time-series supply adjustment specifications data given in *SupplyAdjustSpecs.dat* file, define variable ICADJWL for each well.

2) No maximum pumping capacities are imposed on the wells. Specify variables ICWLMAX and FWLMAX for each well accordingly.

Budget:

- *Budget.in*

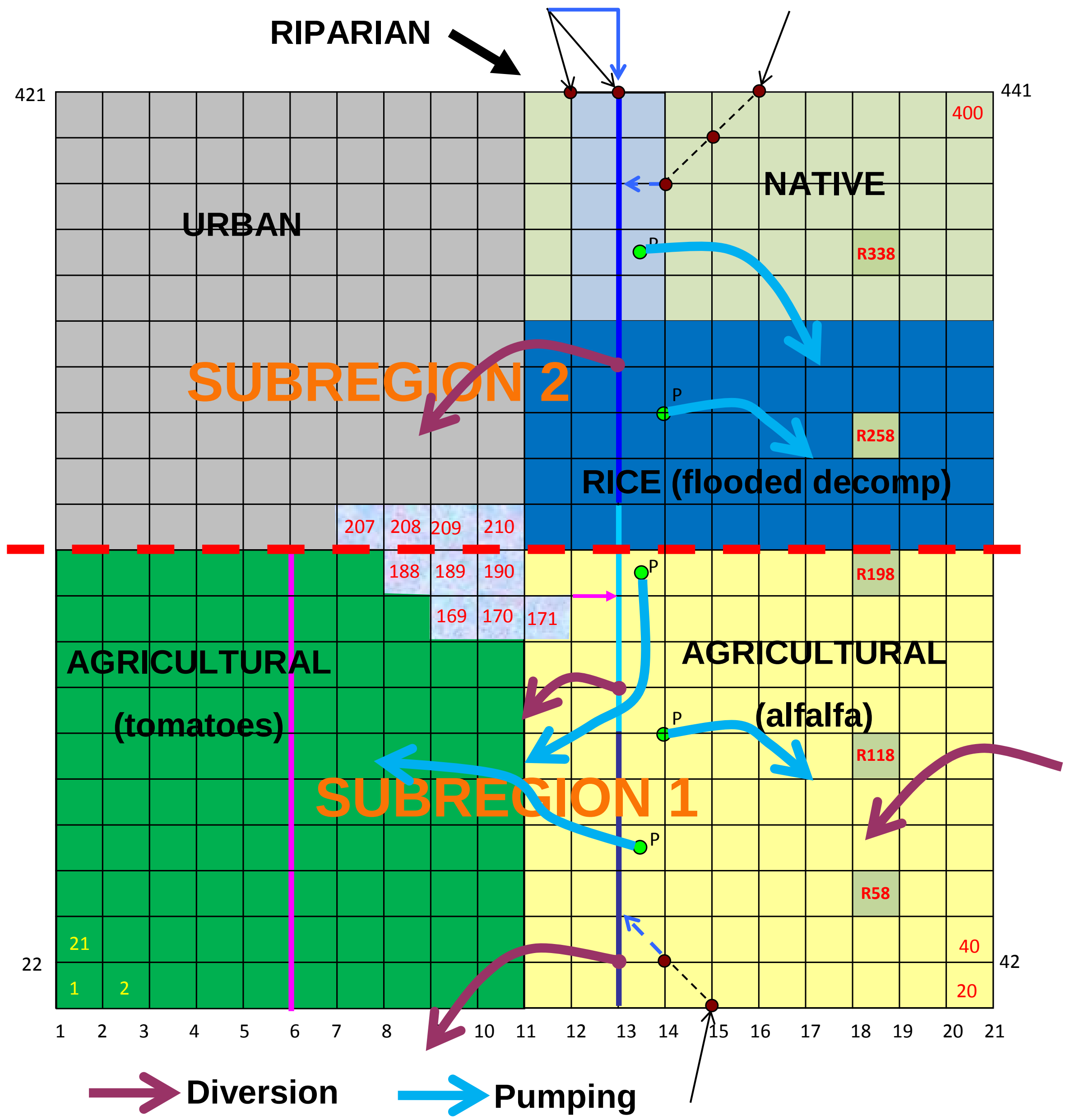
This file is already set up to process the budget files for groundwater, lake, stream and root zone components as well as the land and water use budget in the *Results* folder.

Z-Budget:

- *ZBudget_ALL.in*

This file is already set up to generate the detailed groundwater budget for the entire model area.

Example 8 – Small Watersheds and Multiple Aquifer Layers



Description:

- The system setup is similar to the one in the previous example except that there are 2 aquifer layers and 3 small watershed boundary conditions that are introduced.

- The two aquifer layers are separated by an aquitard. The ***elevation of the bottom of the top aquifer layer*** is at 200 ft. The ***thickness of the aquitard and the bottom aquifer*** are 15 and 185 ft, respectively.

- The following ***parameter values are used for the aquifer*** layers:

Parameter	Aquifer Layer 1	Aquifer Layer 2
Horizontal K (ft/day)	100.0	50.0
Vertical K (ft/day)	0.5	0.3
Specific storage (1/ft)	1.0×10^{-6}	0.7×10^{-6}
Specific yield (ft/ft)	0.25	0.23
Elastic storage coeff. (1/ft)	5.0×10^{-6}	3.0×10^{-6}
Inelastic storage coeff. (1/ft)	5.0×10^{-5}	3.0×10^{-5}
Interbed thickness (ft)	10.0	5.0
Min. interbed thickness (ft)	2.0	2.0
Precompcation hydraulic head (ft)	270.0	300.0

- The ***aquitard vertical hydraulic conductivity*** is 0.01 ft/day.

- The ***boundary conditions for the top aquifer layer*** are the same as in the previous example (i.e. no flow boundary conditions on north and south sides, specified head at 290 ft on the east and west sides).

- There are ***no-flow boundary conditions on all sides of the lower aquifer***.

- ***Initial head*** at the top and bottom aquifers are 290 and 150 feet, respectively.

- There are ***3 small watersheds*** adjacent to the model boundary with the following characteristics:

Parameter	Small Watershed 1	Small Watershed 2	Small Watershed 3
Area (TAC)	6.0	10.0	5.0
Stream node receiving runoff	1	3	21
GW node and aquifer layer for baseflow	432 (layer 1) 433 (layer 1)	436 (layer1) 436 (layer 2)	15 (layer 1)
GW node for percolation and percolation rate	None	414 (10 AF/day) 392 (5 AF/day)	35 (2 AF/day)
Precipitation gage	2	2	1
ET rate (in/mon)	Same as native veg.	Same as native veg.	Same as native veg.
Field capacity (ft/ft)	0.12	0.17	0.20
Total porosity (ft/ft)	0.46	0.56	0.41
Pore size dist. Index	0.25	0.42	0.41
Root depth (ft)	3.0	3.5	2.0

Root zone hydraulic conductivity (cm/hour)	5.2	3.1	0.8
Deep perc. computation method	Campbell's eq.	Campbell's eq.	Campbell's eq.
Curve number	60	65	92
GW storage threshold for surface runoff generation (ft)	10.0	10.0	3.0
Recession coeff. for surface runoff (1/day)	0.4	0.4	0.8
Recession coeff. for baseflow (1/day)	2.0×10^{-5}	2.0×10^{-5}	2.0×10^{-3}

- ***Initial root zone moisture contents for small watersheds*** are at field capacity.
- ***Initial groundwater storage for small watersheds*** 1, 2 and 3 are at 10 ft, 10 ft and 3.0 ft, respectively.
- The ***artificial recharge occurring at 5 elements*** are injected into aquifer layer 2.

Directions:

Pre-processor:

- *Stratigraphy.dat*

  There are 2 aquifer layers separated with an aquitard. Based on the stratigraphy information given above, specify variables NL, FACT, W(2), W(3) and W(4) (Hint: The ground surface elevation is already specified in the file. Copy this information into Excel and calculate/enter the aquifer and aquitard thicknesses at each node. Then copy this information back to the *Stratigraphy.dat* file).

Simulation:

- *BC.dat*

  1) No-flow boundary conditions are defined for the lower aquifer layer. Populate the necessary variables for aquifer layer 2, accordingly (boundary conditions for aquifer layer 1 are already specified in the file).
  2) There are 3 small watersheds defined and their characteristics are listed above. Accordingly, specify all the relevant variables (Hint: Variable IWBS is already set equal to the small watershed ID number referring to the parameter set that will be specified later in the *Parameter.dat* file).

- *Parameter.dat*

    1) The parameter values for the second aquifer layer as well as the vertical hydraulic conductivities for both aquifer layers and the aquitard are given above. Based on this information, populate the necessary variables (most parameter values for the top aquifer layer are already specified in the file).

    2) Parameter values for the small watersheds are listed above. Populate the necessary variables, accordingly.

- *IC.dat*

    1) The initial groundwater head for the bottom aquifer layer is given as 150 ft. Populate the necessary variables accordingly (Hint: Copy the initial conditions for the top aquifer layer and copy them for the bottom aquifer layer. Then use TextPad's Select and Replace features to replace 292.0 with 150.0).

    2) Initial root zone moisture content and the groundwater storage for small watersheds are listed above. Specify the small watershed initial conditions, accordingly.

    3) Although already specified in the file, notice that initial interbed thickness and initial preconsolidation head values are defined for aquifer layer 2 in a way not to override the values listed in the *Parameter.dat* file.

- *ElemPumpSpecs.dat*

    The artificial recharge occurring at 5 elements are all injected into the bottom aquifer. Set variables FRACSKL(1) and FRACSKL(2), accordingly.

- *SIMULATION_MAIN.IN*

    Small watersheds budget binary file will be printed out to file *SmallWatershed.bin* and the vertical flows between aquifer layers will be printed out to file *VerticalFlow.out* under the *Results* folder. Specify filenames for unit 18 and 25, accordingly.

Budget:

- *Budget.in*

    This file is already set up to process the budget files for groundwater, lake, stream and root zone components as well as the land and water use budget in the *Results* folder.

Z-Budget:

- *ZBudget_ALL.in*

    This file is already set up to generate the detailed groundwater budget for the entire model area.