User's Manual of the Pond Simulation Spreadsheet PondSim.XLS

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Abstract

PondSim is an Excel workbook (stack of worksheets) for the simulation of water flow in a set of ponds, specifically, the managed units at Quivira National Wildlife Refuge. For each day, the volume of water in the pond is calculated as the sum of the previous day's volume of water and the net inflow of the previous day's gains and losses. From the volume, the area and water level of the pond are calculated by looking the volume up in a volume-elevation-area table.

Presently, ponds can gain or lose water through rainfall, evaporation, groundwater, and surface-water. Fluxes can be explicitly entered (for example, inflow along a river) or calculated from other data, such as finding evaporation as the product of area and evaporation rate or outflow through a control structure using formulas involving water level, structure dimensions, and structure status. In the latter example, adjusting the structure status allows simulation of management strategies.

Introduction

PondSim is an Excel workbook for the simulation of water flow in a set of ponds. A workbook is a stack of worksheets. A worksheet is an array of cells. Each cell can contain text, a value (a number directly entered by the user), a formula that calculates a value based on the contents of other cells, or nothing at all (be empty). In addition, a cell has a style (named format): PondSim uses styles to indicate overall cell contents, such as whether the cell contains a model parameter or a value that varies from day to day and is under user control. Spreadsheets are usually used to perform calculations, such as computing average test scores or sales totals. PondSim is used to predict water volumes and levels at the Quivira National Wildlife Refuge.

For each day, the volume of water in the pond is calculated as the sum of the previous day's volume of water and the net inflow of the previous day's gains and losses. From the volume, the area and water level of the pond are calculated by looking the volume up in a volume-elevation-area table. This water level and area are then used in calculating the next step's net inflow.

Each pond (or pond cluster) is represented by a worksheet, that calculates the water budget for that pond. Some of these terms are the same from pond to pond, such as evaporation calculated as the product of pond area and evaporation rate, while others–specifically, the water control-structures leaving that pond–differ from pond to pond. Water control structures are on the worksheet of the pond they flow out of. In addition to ponds, a few channels have their own sheets.

In PondSim, ponds can gain or lose water through rainfall, evaporation, groundwater, and surface-water. Fluxes can be explicitly entered (for example, inflow along a river) or calculated from other data, such as finding evaporation as the product of area and evaporation rate or outflow through a control structure using formulas involving water level, structure dimensions, and structure status.

Management strategies are simulated by adjusting the state of water control structures – such as the height of a board-gate or whether a pipe is opened or closed – or by directly entering a flux through the control structure.

Styles have been used to provide the user with visual cues as to whether the cell is something that should be modified for a simulation. The user can alter the format of a style to improve its appearance or override the format of a particular cell, but should not change a cell's style without a very good reason.

The following table lists the styles defined by PondSim and their meanings.

Style Name and Color*	Use	Comments
Model Input Daily Green	Values that change on a daily basis under user control (like board-gate settings) or are predictions of something that changes on a daily basis (like rainfall)	These are used to define strategies for a model. Tweaking these is how you simulate strategies.
Model Input Startup Green	Starting conditions of the model	These are used to set starting conditions, and should probably only be altered at the start of a session
Model Formula Blue	Calculations based on other cells	These should generally not be changed by users
Label Column Black, bold	Labeling a column or area	If you dis-like the name, change it, but it won't affect flow.
Label Units Black, italic	Indicates the units of the following data.	NEVER change these. These indicate what units measurements are in
Model Parameter Purple	Values that are fixed or change rarely, like control structure dimensions or pond volume-elevation-area curves	These should be changed rarely if ever. These should only be altered to adjust model fit or to test proposed engineering alterations, such as an altered control structure.
CopiedCell Dark Blue	A cell copied for convenience to some other locations, such as columns of dates throughout a spreadsheet to make it easy to read	These can be deleted or inserted freely.

*The colors are those used when the model shipped: they may have been changed.

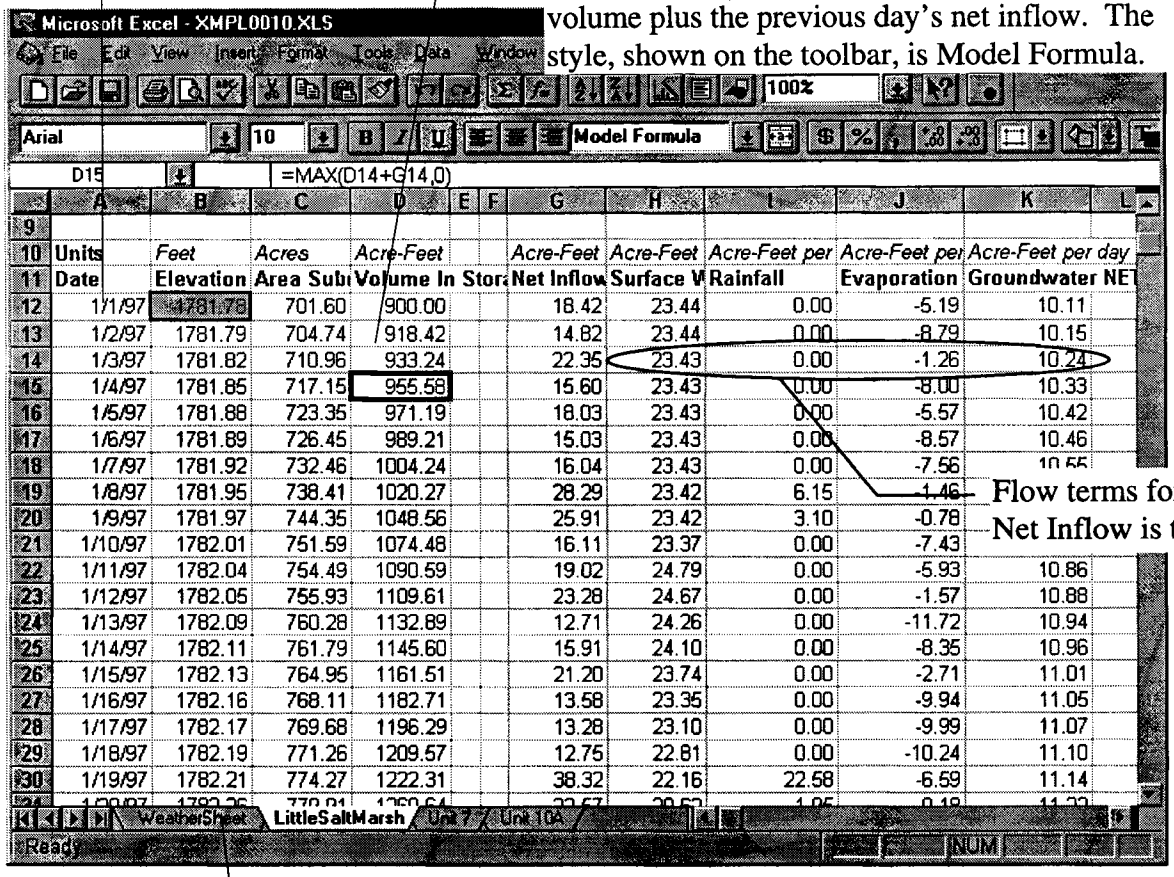
For example, cells that contain control state information are in a style called Model Input Daily, while cells that contain structure dimensions or pond volume-elevation-area curves are in a style called Model Parameter. The former should be manipulated by the user in strategy testing. The latter should only be modified very rarely in response to initial mis-entry or major civil engineering activities.

Each pond in PondSim gets a separate worksheet. This worksheet contains information about that pond, including

1. Formulas for calculating the volume of water in the pond, the elevation of the pond surface, and the area of the pond. Model Formula.
2. Structure state information Model Input Daily
3. Flows into and out of the pond Model Formula or Model Input Daily.
4. Structure dimensions Model Parameter
5. Volume-elevation-area curve. Model Parameter

Dates copied from weather sheet.

This is the currently active cell. It contains a formula for calculating that day's water volume, as the maximum of zero or the previous day's water volume plus the previous day's net inflow. The style, shown on the toolbar, is Model Formula.



	A	B	C	D	E	F	G	H	I	J	K	L
9												
10	Units	*Feet*	*Acres*	*Acre-Feet*			*Acre-Feet*	*Acre-Feet*	*Acre-Feet per*	*Acre-Feet per*	*Acre-Feet per day*	
11	Date	Elevation	Area Sub	Volume In Stor			Net Inflow	Surface W	Rainfall	Evaporation	Groundwater NET	
12	1/1/97	1781.78	701.60	900.00			18.42	23.44	0.00	-5.19	10.11	
13	1/2/97	1781.79	704.74	918.42			14.82	23.44	0.00	-8.79	10.15	
14	1/3/97	1781.82	710.96	933.24			22.35	23.43	0.00	-1.26	10.24	
15	1/4/97	1781.85	717.15	955.58			15.60	23.43	0.00	-8.00	10.33	
16	1/5/97	1781.88	723.35	971.19			18.03	23.43	0.00	-5.57	10.42	
17	1/6/97	1781.89	726.45	989.21			15.03	23.43	0.00	-8.57	10.46	
18	1/7/97	1781.92	732.46	1004.24			16.04	23.43	0.00	-7.56	10.55	
19	1/8/97	1781.95	738.41	1020.27			28.29	23.42	6.15	-1.46		
20	1/9/97	1781.97	744.35	1048.56			25.91	23.42	3.10	-0.78		
21	1/10/97	1782.01	751.59	1074.48			16.11	23.37	0.00	-7.43		
22	1/11/97	1782.04	754.49	1090.59			19.02	24.79	0.00	-5.93	10.86	
23	1/12/97	1782.05	755.93	1109.61			23.28	24.67	0.00	-1.57	10.88	
24	1/13/97	1782.09	760.28	1132.89			12.71	24.26	0.00	-11.72	10.94	
25	1/14/97	1782.11	761.79	1145.60			15.91	24.10	0.00	-8.35	10.96	
26	1/15/97	1782.13	764.95	1161.51			21.20	23.74	0.00	-2.71	11.01	
27	1/16/97	1782.16	768.11	1182.71			13.58	23.35	0.00	-9.94	11.05	
28	1/17/97	1782.17	769.68	1196.29			13.28	23.10	0.00	-9.99	11.07	
29	1/18/97	1782.19	771.26	1209.57			12.75	22.81	0.00	-10.24	11.10	
30	1/19/97	1782.21	774.27	1222.31			38.32	22.16	22.58	-6.59	11.14	
31	1/20/97	1782.26	779.01	1260.64			22.67	20.62	1.95	-0.18	11.22	

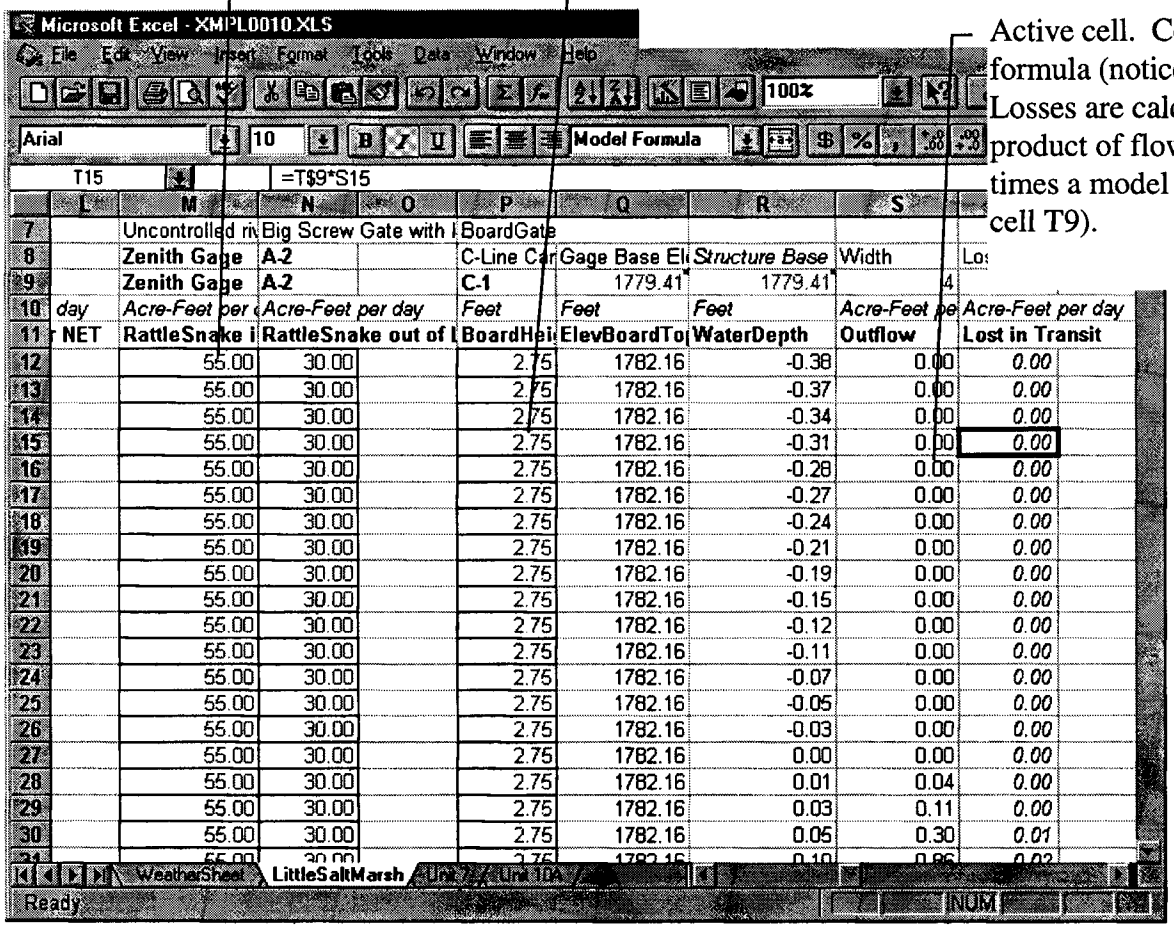
Flow terms for each process
Net Inflow is the sum of these

This sheet contains the data and estimated rainfall and evaporation rates

Inflow on river is a predicted value for each day. Outflow, although controlled, is not easily predicted, so this flux is entered directly

Board-gate height is user-controlled. Outflow is found using a formula.

Active cell. Contains a formula (notice style) Losses are calculated as product of flow in the channe times a model parameter (in cell T9).



	L	M	N	O	P	Q	R	S	
7		Uncontrolled ri	Big Screw Gate with I		BoardGate				
8		Zenith Gage	A-2		C-Line Ca	Gage Base El	*Structure Base*	Width	Lo
9		Zenith Gage	A-2		C-1	1779.41	1779.41	4	
10	*day*	*Acre-Feet per*	*Acre-Feet per day*		*Feet*	*Feet*	*Feet*	*Acre-Feet pe*	*Acre-Feet per day*
11	NET	RattleSnake i	RattleSnake out of I		BoardHei	ElevBoardTo	WaterDepth	Outflow	Lost in Transit
12		55.00	30.00		2.75	1782.16	-0.38	0.00	*0.00*
13		55.00	30.00		2.75	1782.16	-0.37	0.00	*0.00*
14		55.00	30.00		2.75	1782.16	-0.34	0.00	*0.00*
15		55.00	30.00		2.75	1782.16	-0.31	0.00	*0.00*
16		55.00	30.00		2.75	1782.16	-0.28	0.00	*0.00*
17		55.00	30.00		2.75	1782.16	-0.27	0.00	*0.00*
18		55.00	30.00		2.75	1782.16	-0.24	0.00	*0.00*
19		55.00	30.00		2.75	1782.16	-0.21	0.00	*0.00*
20		55.00	30.00		2.75	1782.16	-0.19	0.00	*0.00*
21		55.00	30.00		2.75	1782.16	-0.15	0.00	*0.00*
22		55.00	30.00		2.75	1782.16	-0.12	0.00	*0.00*
23		55.00	30.00		2.75	1782.16	-0.11	0.00	*0.00*
24		55.00	30.00		2.75	1782.16	-0.07	0.00	*0.00*
25		55.00	30.00		2.75	1782.16	-0.05	0.00	*0.00*
26		55.00	30.00		2.75	1782.16	-0.03	0.00	*0.00*
27		55.00	30.00		2.75	1782.16	0.00	0.00	*0.00*
28		55.00	30.00		2.75	1782.16	0.01	0.04	*0.00*
29		55.00	30.00		2.75	1782.16	0.03	0.11	*0.00*
30		55.00	30.00		2.75	1782.16	0.05	0.30	*0.01*

Using PondSim

To see the outcome of a water management strategy, you need to enter a variety of data. It is best to copy the workbook-file and use the copy, so that if you make a mistake, it doesn't completely destroy the model.

There are two sets of data to enter: the starting conditions and weather predictions, that you typically enter once per session (in Model Input Startup style); and control state information that is used to set the management strategy (in Model Input Daily style). As originally shipped, both of these styles were green and all others were not green. You alter green cells to simulate management strategy; input is a word, a distance in feet, or a flow rate in acre-feet per day. (Purple cells are used for calibrating the model, and blue cells are "the model" –the set of equations describing the physical laws governing the phenomena).

As you enter data, Excel simulates your strategy by using the various formulas that make up the model. If this is too slow, see Appendix 1.

First, make sure the range of dates is what you want (WeatherSheet). If it isn't, enter the starting date for the simulation period, erase all the other dates in that column, and use Edit|Fill|Series to fill in the dates (You can also do this by hand.) Enter your predictions of rainfall and evaporation, based on weather forecasts or some previous year's example.

Second, enter the starting water level for each pond. This usually comes from adding a staff gage reading to the zero-elevation of that gage. PondSim uses the starting water level to calculate the initial amount of water in storage.

For uncontrollable fluxes, such as river inflow, enter these directly. For example, river inflow and poorly-controllable outflows need to be entered as flows in acre-feet per day.

Finally, enter your strategy by entering state information for control structures and view the results.

For example, let's say you want to fill Unit 10B from Unit 10A by controlling boardgate 10A. You enter each day's board setting for structure 10A into the column for this. The spreadsheet then calculates the water flow out of the structure. Since the structure is associated with Unit 10A, go to the sheet Unit 10A. Then find the area for structure 10A. Then enter the board-heights for each day. (See Appendix 1 for tips.)

You can enter your own formulas to find derivative information of interest to you. For example, if you want to find the total water lost to evaporation in a given simulation, you would enter a formula that totals the evaporation lost in each pond for each day. You can also enter a formula to calculate gage-height in a pond by subtracting the gage's zero-elevation from the pond's water elevation, to get water depth at that gage.

You can use Excel's graphing capabilities to produce graphs. For example, you could have water level versus date and board-height on each outlet structure for a pond to see the effects of a strategy.

Discussion

PondSim uses formulas, construction parameters, user-input, and a number of assumptions to calculate water budgets. For each day, PondSim calculates the volume of water in each pond. The water budget is only as good as the assumptions, user-input, construction formulas, and formulas that went into the model: if the water budgets are inaccurate, these need to be changed.

The Calibrator's Manual for PondSim.XLS provides instructions for adjusting seepage losses on channels, capacity curves, and such. Accurate measurements and records of water transfers between ponds and measurements of stream flow are needed to produce a calibrated model. This may be difficult or impossible at QNWR, where hydraulic conditions change rapidly. The model parameters need to change as hydraulic conditions change.

The Programmer's Manual for PondSim.XLS provides instructions for major modifications to the network like adding control structures or changing the type of a control structure, adding/removing ponds, and adding/removing channel.

PondSim budgets will be meaningless under flood conditions, where flow is occurring outside the channels and control structures defined in PondSim or where water is outside the ponds defined in PondSim.

In many ways, PondSim is like a financial-planning program that lets the user simulate different investment options (management strategies) by apportioning assets (water) among different investment opportunities (ponds) with different yields (pond capacity curves), risks (no analogue), and fees (channel seepage, groundwater losses, and evaporative losses) where both fees and yields are uncertain and changing.

Before deciding to devote effort to calibrating the model, decide how accurate the model needs to be and what you are willing to pay for that accuracy. If you spend too much labor on choosing the best investment, you can lose money that way: if you jump at the first investment with a high yield and high risk, you can lose money there as well.

Summary

PondSim is an Excel workbook for simulating water management strategies in a group of ponds at Quivira National Wildlife Refuge. PondSim uses formulas, construction parameters, user-input, and a number of assumptions to calculate water budgets. For each day, PondSim calculates the volume of water in each pond. The water budget is only as good as the assumptions, user-input, construction formulas, and formulas that went into the model: if the water budgets are inaccurate, these need to be changed.

Appendix 1: Some Tips for Using Microsoft Excel

If you find re-calculation every time you change an entry takes too long, you can change Excel's calculation mode to manual using Tools|Options|Calculation . If Excel is in manual calculation mode, you can hit F9 to force a calculation when you want to see the effects: the statusbar indicates when the numbers are out of synch and a calculation needs to be performed.

An easy way to find a particular column (like one for a particular structure) is to get to the top-left of the sheet with CTRL-HOME) and jump to the right with CTRL-RIGHT to find the right area. See the Excel User's Guide or on-line help for "Moving around in a sheet" for more detail.) Find the column labeled "BoardHeight" and enter your settings. Sometimes, the Edit|Find command can be useful, if you know the exact contents.

Entering a value for each day is time-consuming. You can enter a value for each day by typing it in, or type it once and copy it to the days to which it applies, or you can use a simple formula to repeat the previous day's reading (To do this, first enter the board setting in the top cell for BoardHeight. Go to the cell immediately below it. Enter an = sign, then point at the cell immediately above it with the mouse. [If you were in cell M13 and did this, you should see the formula =M12 in the cell.] Hit Enter to accept. Then copy the cell down the entire column.) If you use a formula to repeat settings, you can change the setting by over-writing the formula on the day you want to change. That day will be at whatever value you set, the subsequent days, which are repeating the previous day's values, will have that value also.

Finding the correct cell can be difficult. Excel provides an easy way to let you keep a set of cells in view at all times. Select the menu item Window|Split to divide the screen into four areas. The upper left and right pair are locked together vertically, as are the two lower quarters. The two left quarters are locked together horizontally. To use this to your advantage, you want to only work with the lower-right quarter. Use the lower left quarter to show you date and water level, and the upper right quarter to show you the column headings. You can adjust the size of the splits using the mouse.

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