Excel for Hydrology

Section 6

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Solver Add-IN
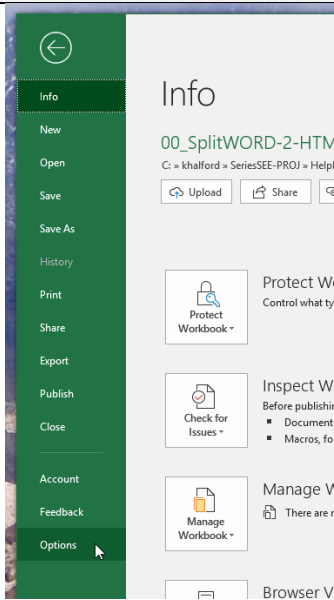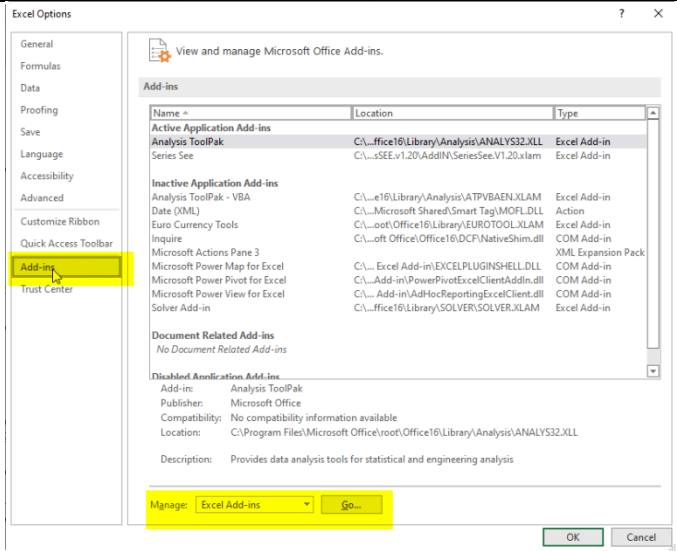
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06_Solver

Solver allows maximum flexibility in fitting equations or models to data sets in Excel. Solver can be better than linear regression functions because outliers can be weighted less. Solver also will work with multiple parameter problems with as many as 200 parameters.
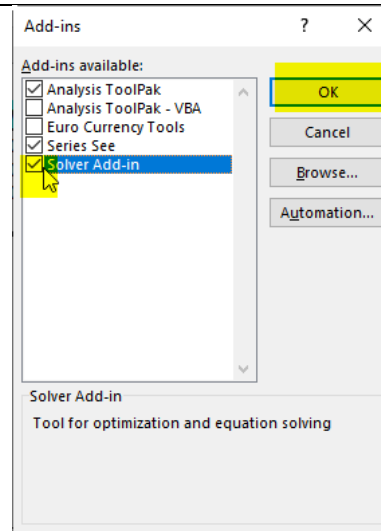
Install SOLVER—Through Options

Solver Add-IN Installation	
Click on Options under the File menu.	
Select Add-ins on Excel Options form Click Go button in center, bottom of form Manage: Excel Add-ins ▾ Go...	
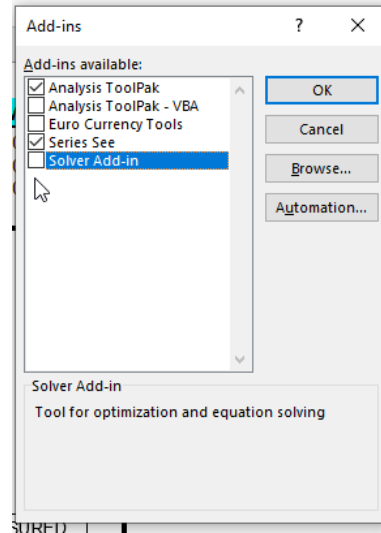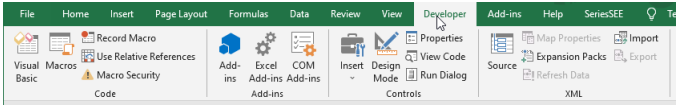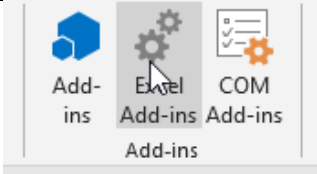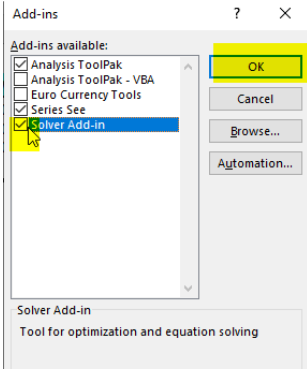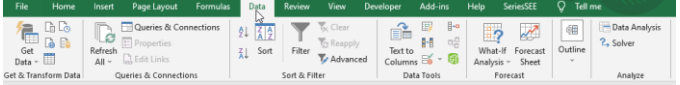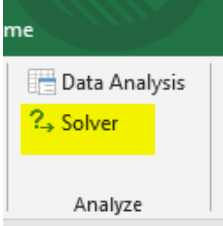
Add-ins form will appear.	
Check Solver Add-in and Click OK button.	
Select Data tab on ribbon.	
Solver option will appear in Analyze group at far right end of ribbon.	

Install SOLVER—Through Developer tab on ribbon

Solver Add-IN Installation

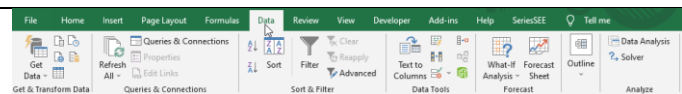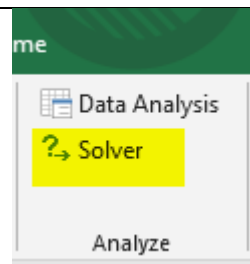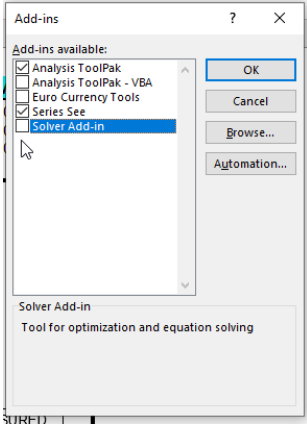|	
Select Developer tab on ribbon, which is visible only after selecting view Developer tab under options.	
Select Excel Add-ins in the Add-ins group on the ribbon.	
Add-ins form will appear.	
Check Solver Add-in and Click OK button.	
Select Data tab on ribbon.	
Solver option will appear in Analyze group at far-right end of ribbon.	

01_Theis_Solution+Sensitivity.xlsm – Apply Solver and Weighting Effects

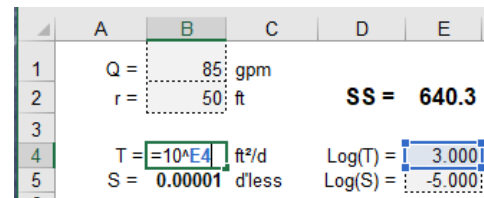| Solver and Weights	
Objective function defined in cell E2, =SUMSQ(Theis!N3:N214) Cell E2 is named range **SSerror**.	
Estimable parameters are Log(T) and Log(S) in cells E4:E5. Log(T) and Log(S) are transformed to T and S in cells B4:B5, which are named ranges **Transmissivity** and **Storage**, respectively.	

Initial parameters are,
    Log(T) = 3;   Transmissivity = 1,000 ft²/d
    Log(S) = -5; Storage = 0.00001
 	
Theis solution underestimates measured drawdowns.	
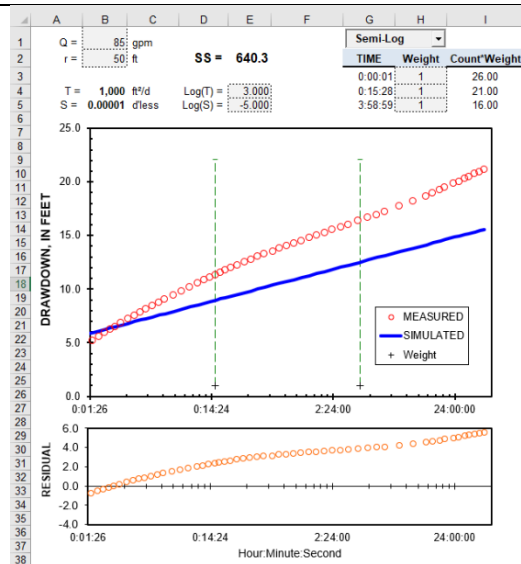
Select Data tab on ribbon. Solver option will appear in Analyze group at far-right end of ribbon.	

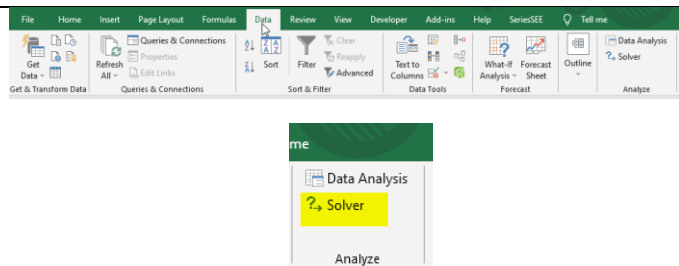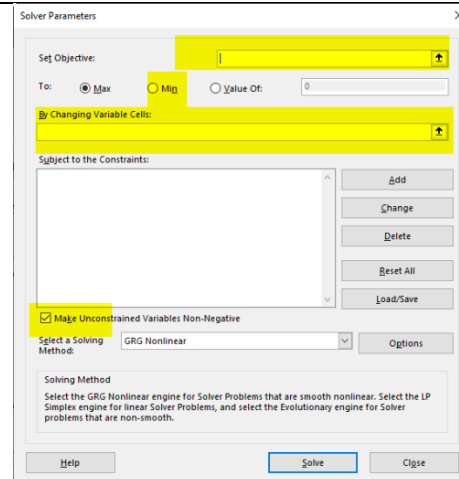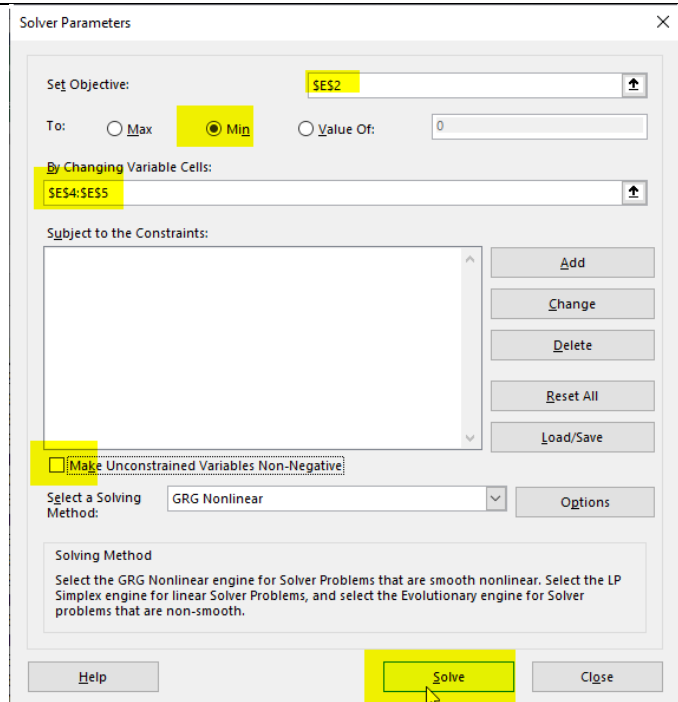|	
Solver Parameters form will appear. Highlighted fields need to be filled or changed before pressing Solve button at bottom of form.	
Fields to be filled from top to bottom are: • Set Objective, Select range identifier on form and cell E2 in worksheet, • Select Min to minimize objective. • Set "**By Changing Variable Cells:**", parameters, by selecting range identifier on form and cells E4:E5 in worksheet, • Uncheck "**Make Unconstrained Variables Non-Negative**" Press Solve button at bottom of form.	
Solver Results form will appear. Press OK button to dismiss form and revise parameter estimates on worksheet.	
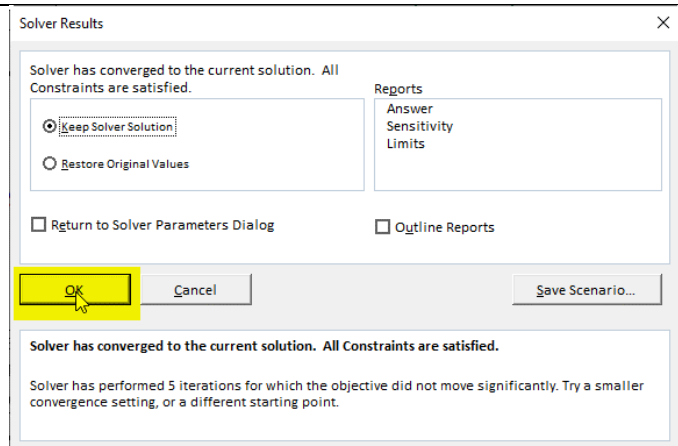
	SS error reduced from 640 to 25 ft².

SS error reduced from 640 to 25 ft².

Fitted parameters are,
  Log(T) = 2.78;   T = 604 ft²/d
  Log(S) = -4.36;   S = 0.000044

Theis solution fit to all data, which includes early time where well-bore storage is significant.
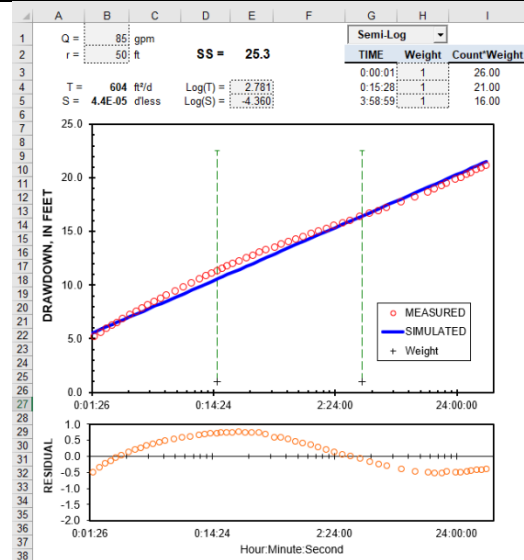
Repeat with early time weighted to 0.

Revised T estimate is 701 ft²/d, which better characterizes the lower-rock aquifer.

02_Velocity-Stage-Relation.xlsm – 3-Parameter Model

Estimate 3 parameters with Solver

Surface-water velocity is simulated as, $$\overline{V} = (A + HB)(vi + C)$$, where H is stage, vi is velocity index, and A, B, & C are fitting coefficients.	
Initial parameter estimates for A, B, & C are 0.	
Select Data tab on ribbon. Solver option will appear in Analyze group at far-right end of ribbon.	
Fields to be filled from top to bottom are: • Set Objective, Select range identifier on form and cell I8 in worksheet, • Select Min to minimize objective. • Set "**By Changing Variable Cells:**", parameters, by selecting range identifier on form and cells I4:I6 in worksheet, • Uncheck "**Make Unconstrained Variables Non-Negative**" Press Solve button at bottom of form.	

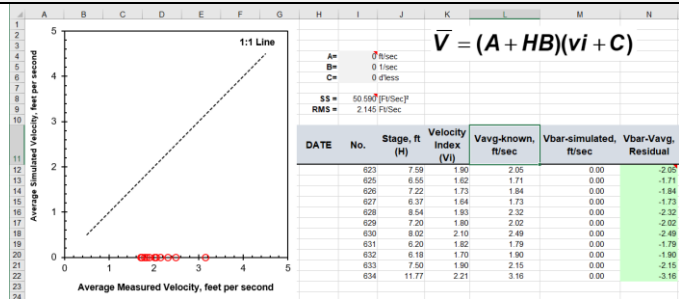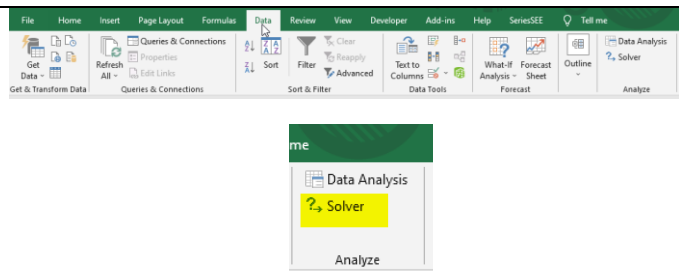|	
Solver Results form will appear. Press OK button to dismiss form and revise parameter estimates on worksheet.	**Solver Results** ✕ Solver has converged to the current solution. All Constraints are satisfied. Reports Answer Sensitivity Limits ⊙ Keep Solver Solution ○ Restore Original Values ☐ Return to Solver Parameters Dialog ☐ Outline Reports [OK] Cancel Save Scenario... **Solver has converged to the current solution. All Constraints are satisfied.** Solver has performed 5 iterations for which the objective did not move significantly. Try a smaller convergence setting, or a different starting point.

SS error reduced from 50.6 to 0.05 [ft/sec]².
 	
Fitted parameters are,
      A = 0.592096 ft/sec
      B = 0.070562 1/sec
      C = 0.006487 d'less
		H	I	J

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4	A=	0.592096	ft/sec
5	B=	0.070562	1/sec
6	C=	0.006487	d'less
7			
8	SS =	0.049	[Ft/Sec]²
9	RMS =	0.067	Ft/Sec	
Measured and simulated velocities agree within 0.1 ft/sec.	