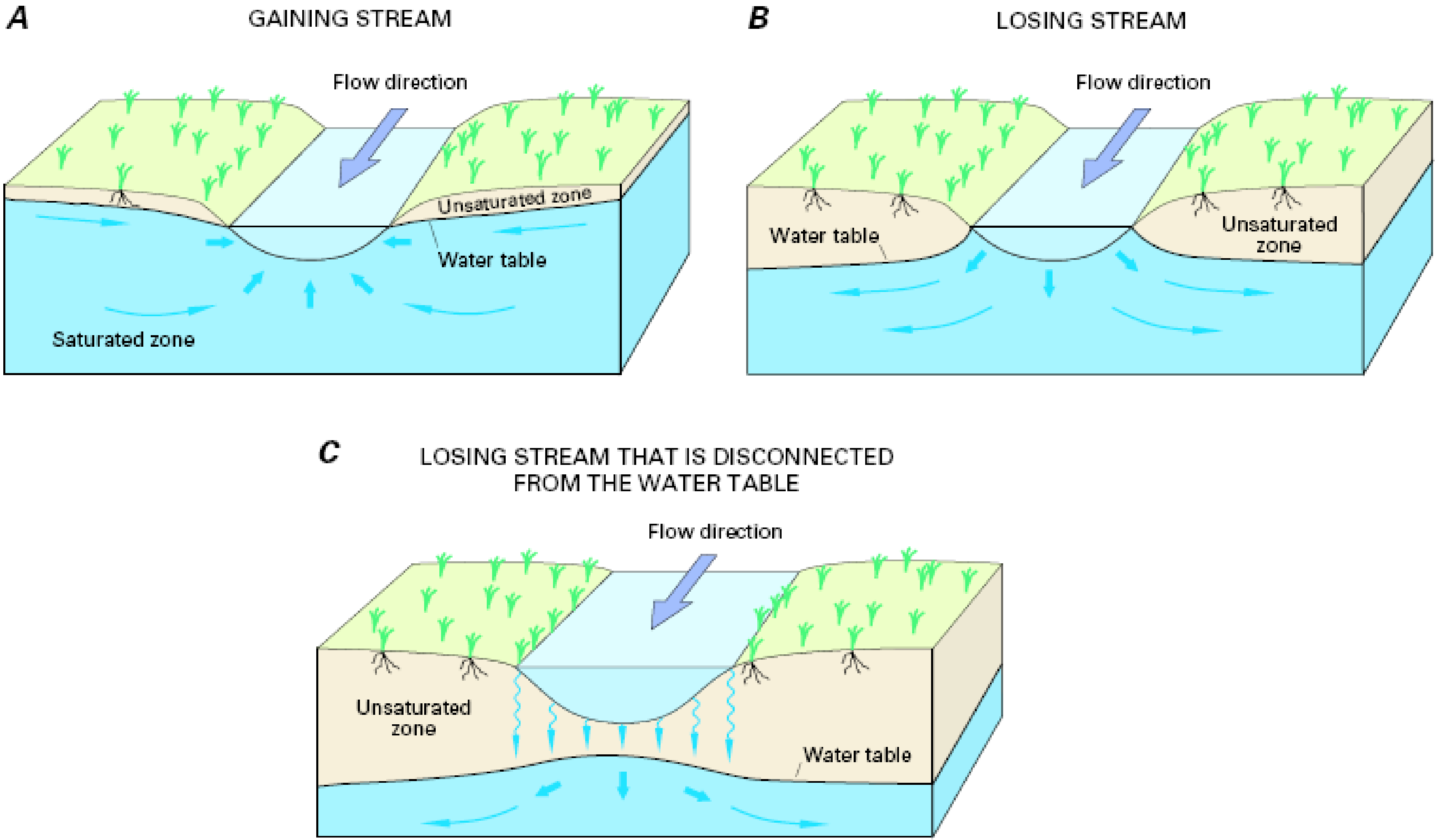
Technical Aspects of Groundwater/ Surface Water Interaction

Peter Leffler

February 2, 2011

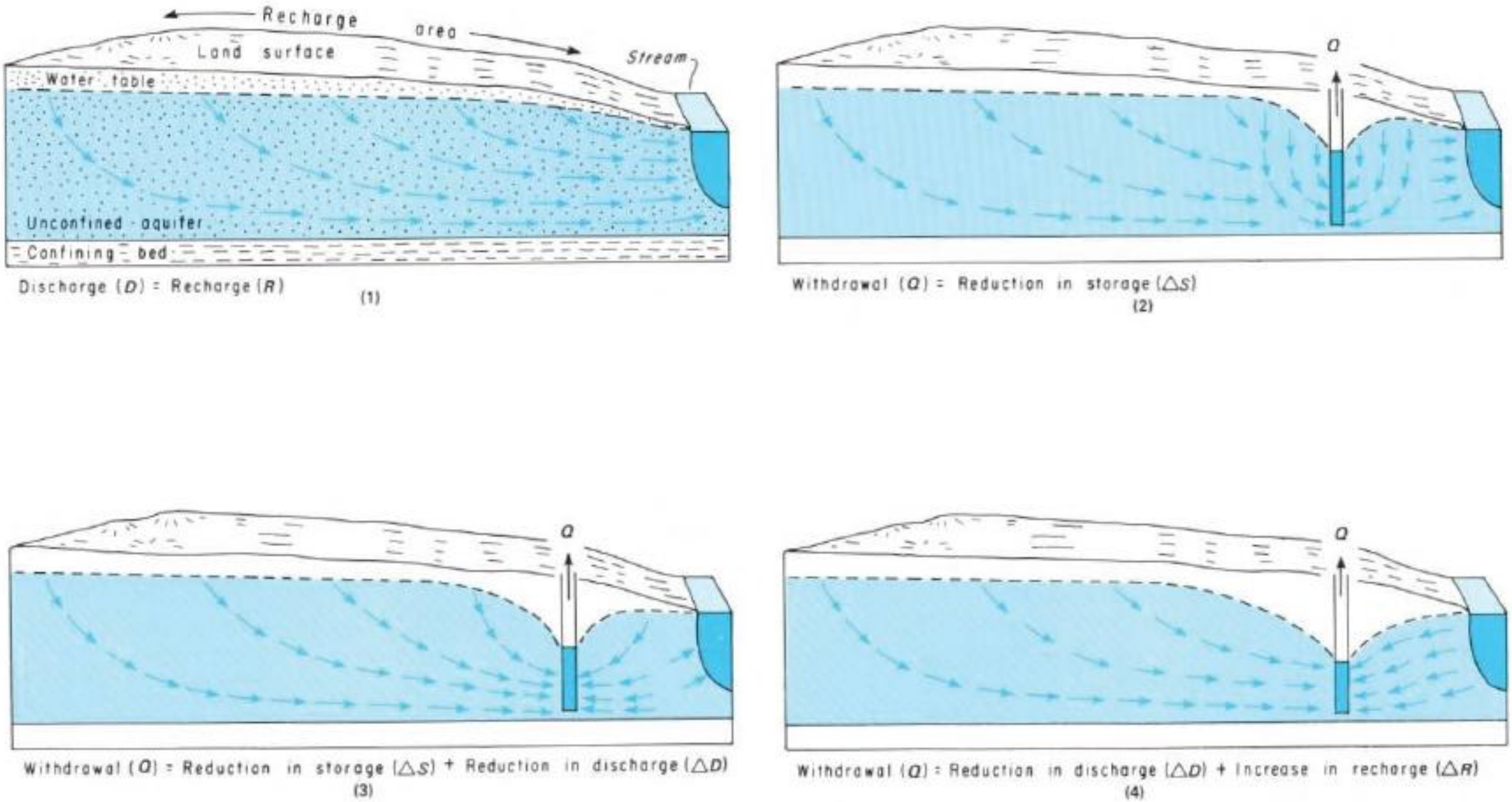
Nevada Water Resources Association

Types of Groundwater/Surface Water Interaction



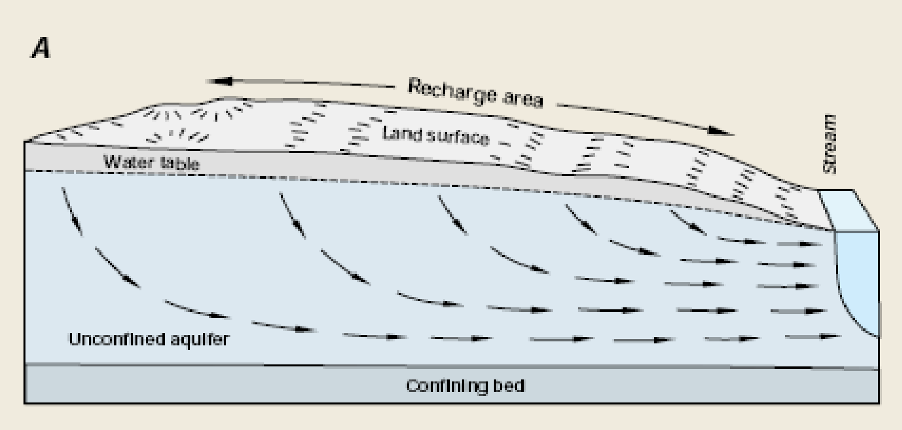
(USGS Circular 1186)

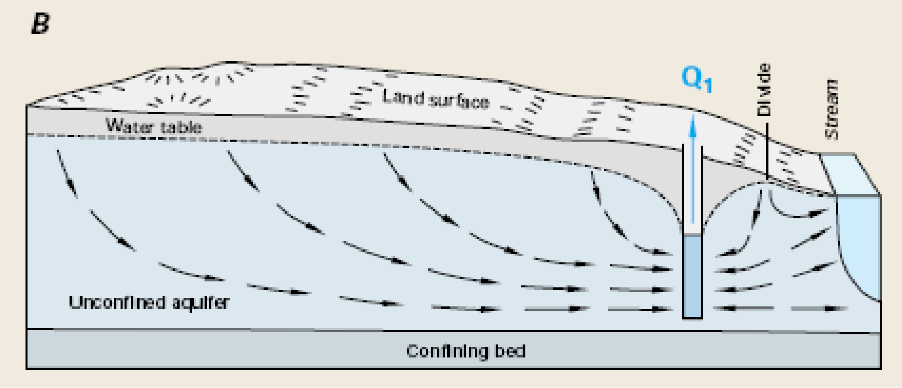
Short- to Long-Term Groundwater Pumping Near A Gaining Stream

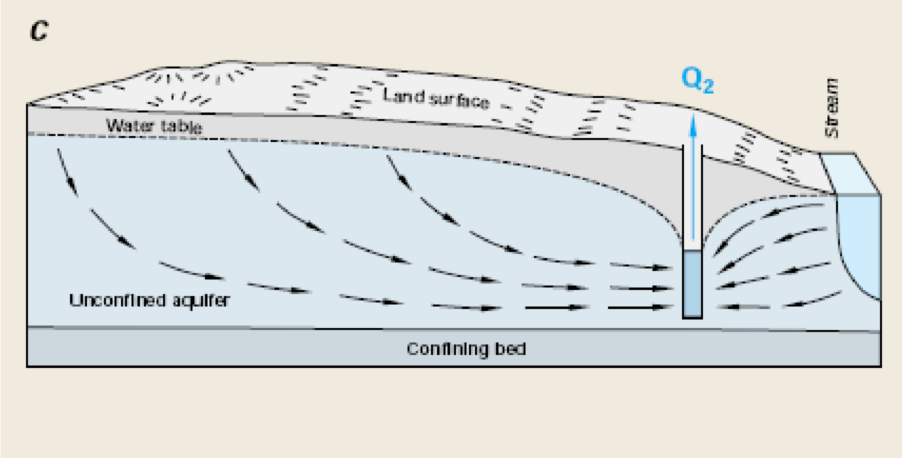


(USGS Water Supply Paper 2220)

Long-Term Steady State Conditions When Pumping Near a Gaining Stream



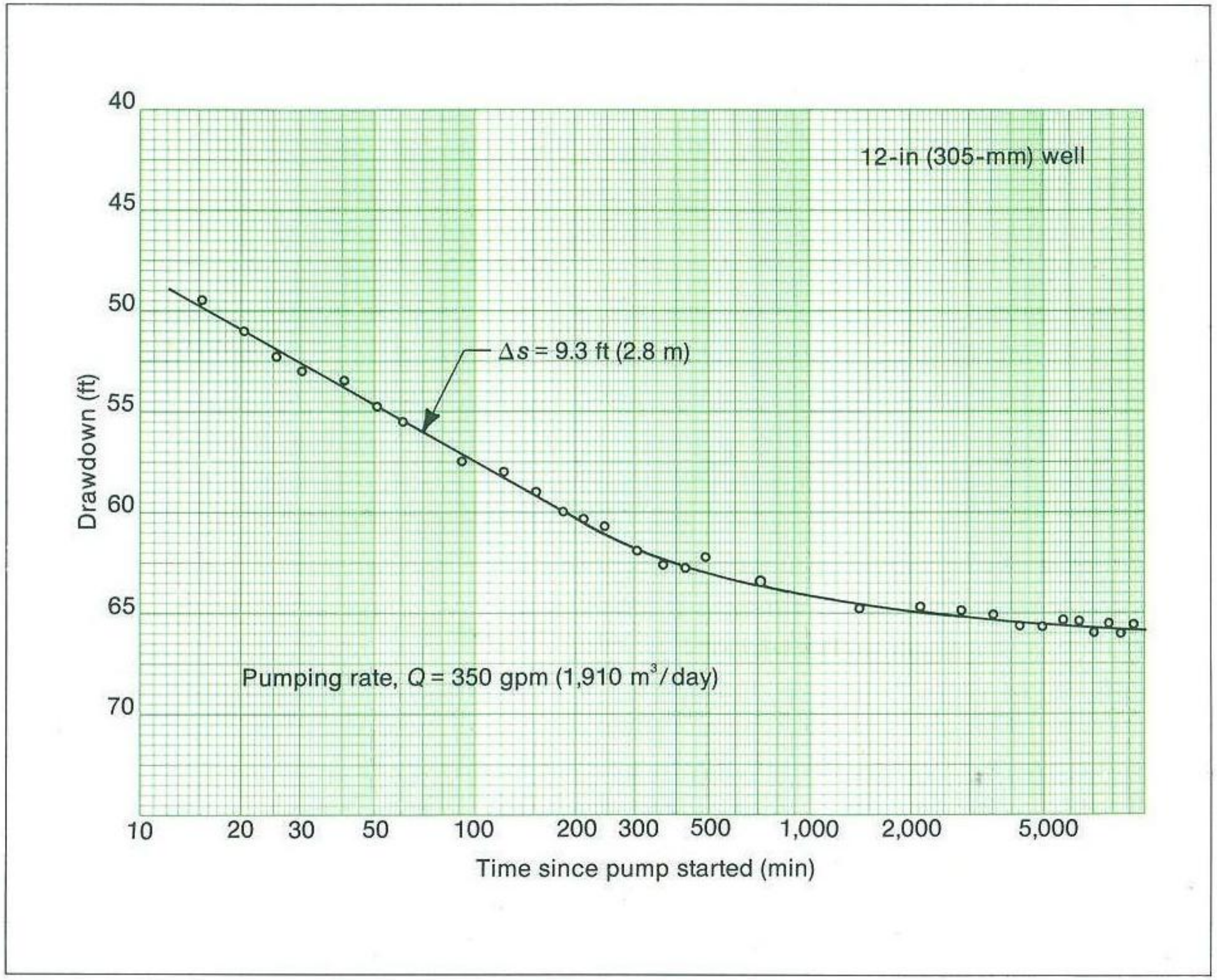




(USGS Circular 1139)

Technical Analysis of Groundwater/Surface Water Interaction – Field Testing

Evaluation of pumping test results (recharge boundary condition)



(Driscoll, 1996)

Technical Analysis of Groundwater/Surface Water Interaction – Field Testing

- Set up stream flow monitoring stations upstream and downstream of anticipated pumping well cone of depression
- Collect stream flow data for sufficient time periods before pumping begins and after pumping stops
- Evaluate for reduction in flow at downstream station that does not occur at upstream station
- Comparison of stream flow chemistry vs. groundwater chemistry

Technical Analysis of Groundwater/Surface Water Interaction – Analytical Approaches

- Stream depletion by groundwater pumping (e.g., Jenkins, 1968)
- Stream depletion = reduction of flow to stream and direct depletion from stream
- Assumptions: isotropic, homogeneous, unconfined but drawdown negligible, fully penetrating stream and well
- Important variables/parameters: transmissivity, specific yield, time since pumping began, distance from well to stream, pumping rate

Technical Analysis of Groundwater/Surface Water Interaction – Analytical Approaches

Jenkins analytical method may overestimate stream depletion when (Butler, 2001):

a) Aquifer not homogeneous/isotropic

b) Streambed K < aquifer K

c) Stream not fully penetrating

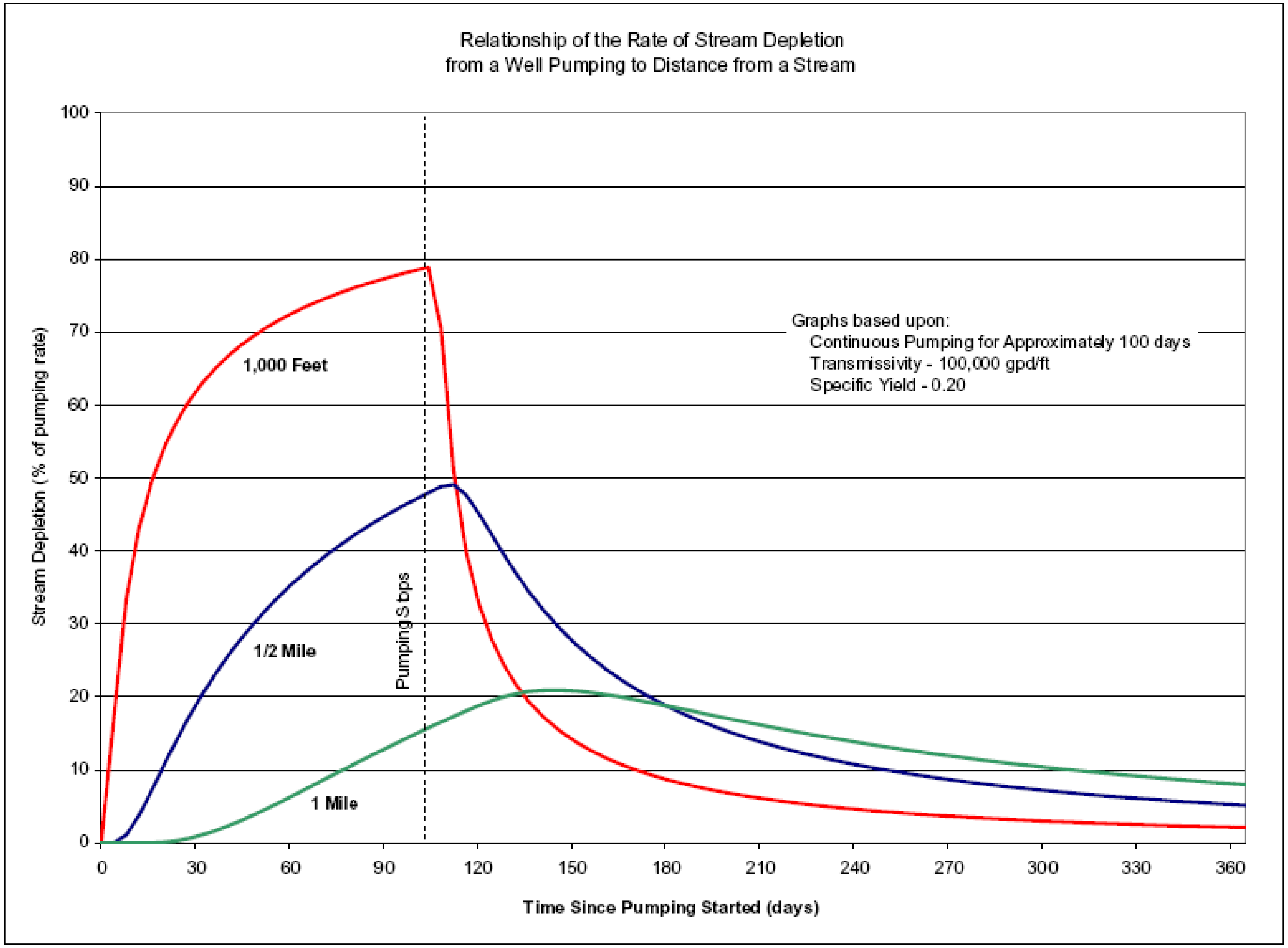
d) Recharge sources other than stream

e) Aquifer groundwater level below stream bed

Analytical results should only be used as a preliminary tool to identify wells that may deplete stream flow – more detailed analysis required

Technical Analysis of Groundwater/Surface Water Interaction – Analytical Approaches

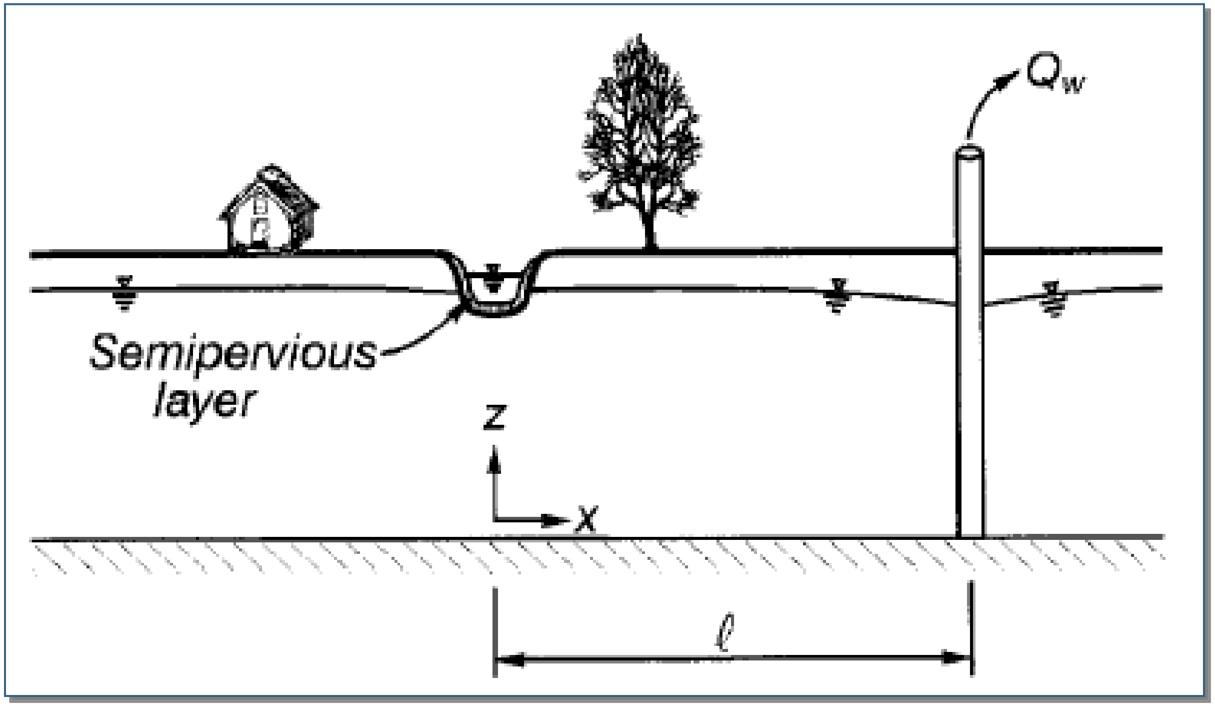
Jenkins Method



(Stetson, 2008)

Technical Analysis of Groundwater/Surface Water Interaction – Analytical Approaches

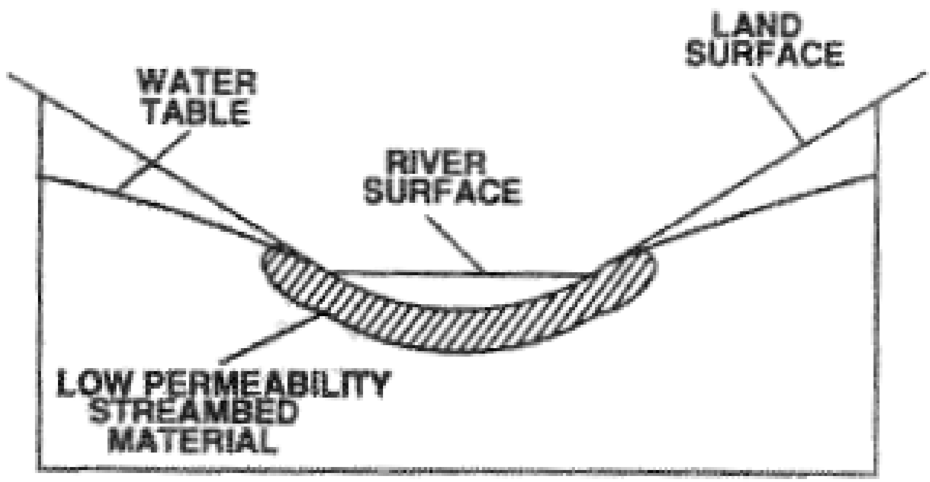
- Stream depletion by groundwater pumping (Hunt, 1999)
- Assumptions: allows for partially penetrating stream with semipervious streambed layer
- Requires value for additional parameter known as leakage coefficient, which can be difficult to estimate

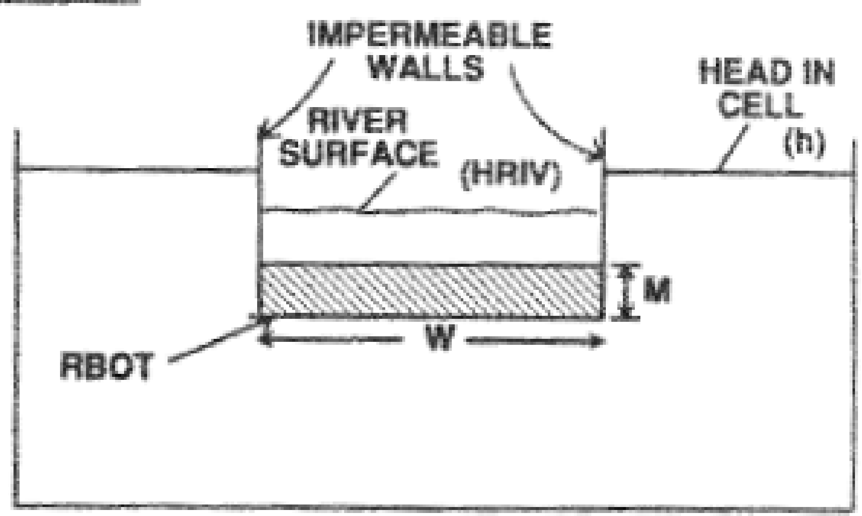


Technical Analysis of Groundwater/Surface Water Interaction – Numerical Modeling Approaches

- MODFLOW – river and stream packages
- Can deal with more complex hydrogeologic conditions
- Can distinguish between reduction in flow to stream and increase in flow from stream to aquifer related to groundwater pumping stresses
- More data intensive

Technical Analysis of Groundwater/Surface Water Interaction – Numerical Modeling Approaches



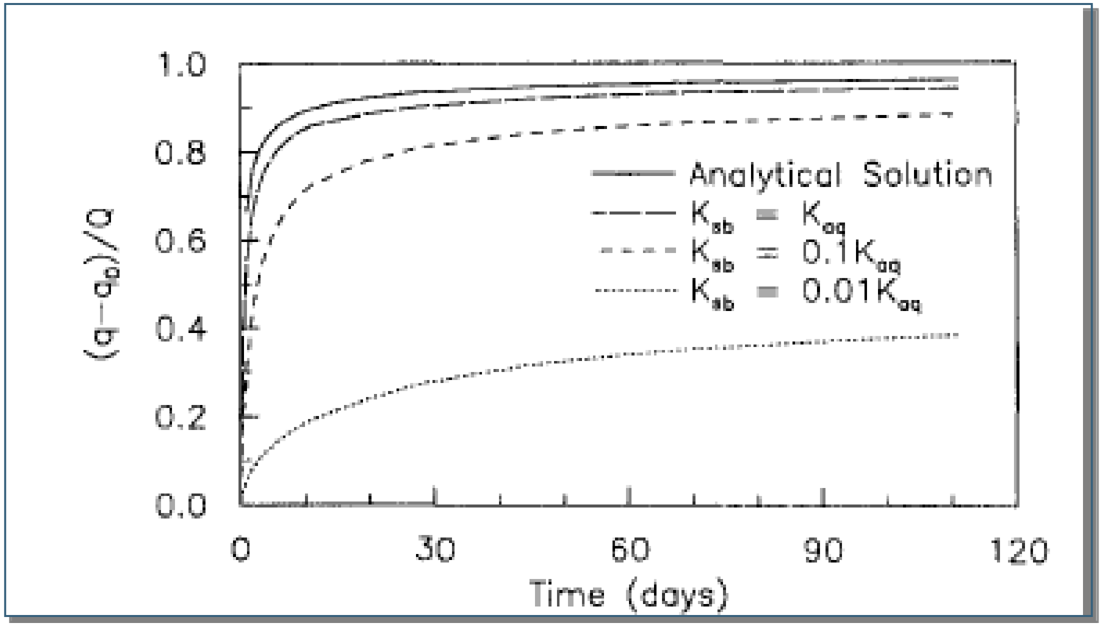


(Anderson and Woessner, 1992)

Technical Analysis of Groundwater/Surface Water Interaction – Comparison of Approaches

- Evaluation of Glover (1974)/Jenkins (1970) analytical approach using MODFLOW (Sophocleous et. al., 1995)

- Comparison of MODFLOW results to analytical results indicates most important assumptions are:
  1) K contrast between stream bed layer and aquifer
  2) Degree of stream partial penetration
  3) Aquifer heterogeneity



SWRCB Groundwater Classification in California

- State Board classifies groundwater as either a) subterranean stream or b) percolating groundwater

- Groundwater defined as subterranean stream is subject to California Water Code and permitting/regulation by SWRCB

- Groundwater defined as percolating groundwater is governed by case law and no SWRCB permit is required

SWRCB Groundwater Classification in California

Characteristics needed for subterranean stream classification are:

a) A subsurface channel is present with “impermeable” bed and banks relative to channel alluvium

b) Course of channel must be known or reasonably inferred

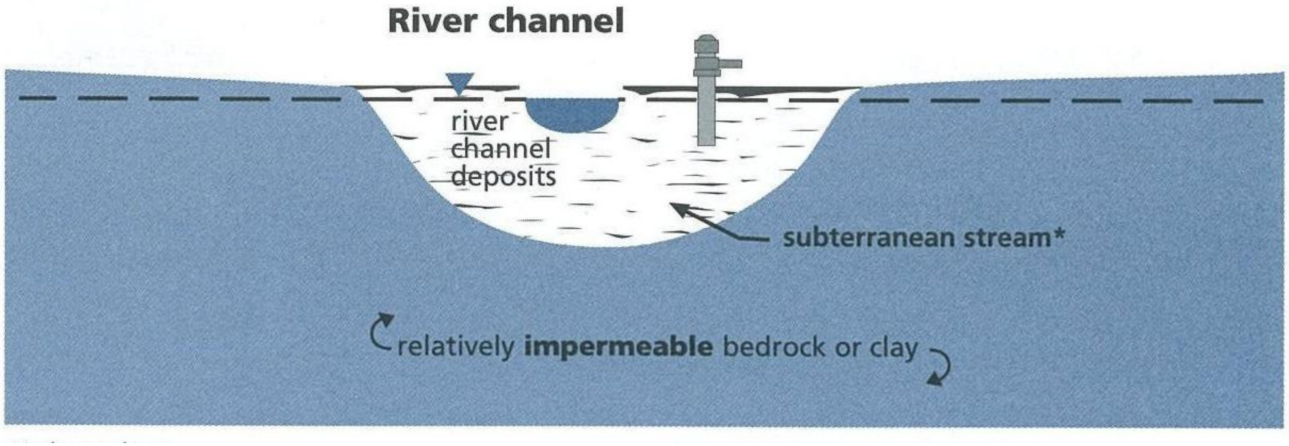
c) Groundwater must be flowing in the channel – generally parallel to the course of the river/stream.

SWRCB Groundwater Classification in California

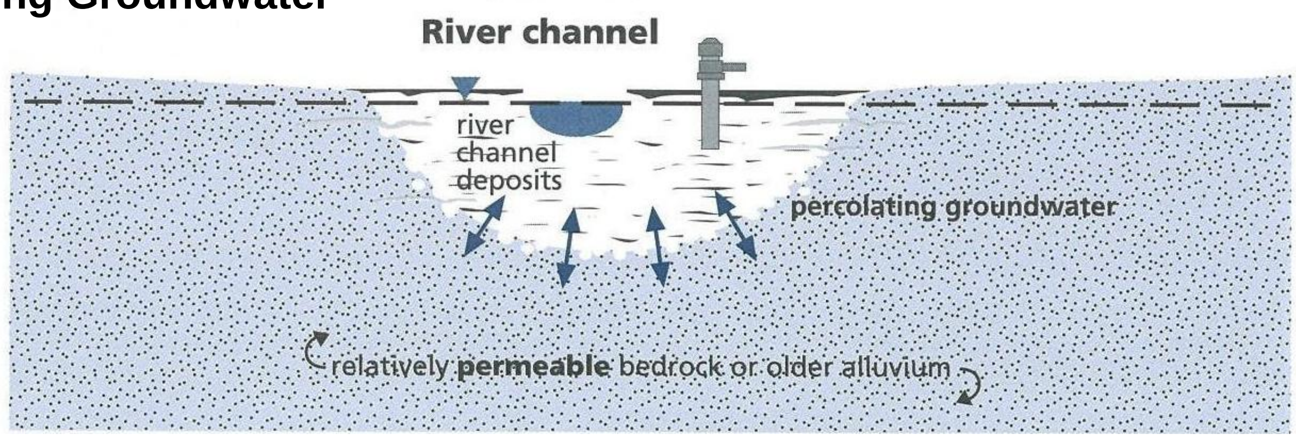
- Burden of proof is on the party claiming subterranean stream
- Interaction between groundwater and surface water not a defining characteristic of a subterranean stream
- Any groundwater not classified as Subterranean Stream is considered to be Percolating Groundwater

Subterranean Stream vs. Percolating Groundwater

Subterranean Stream



Percolating Groundwater



(GRA, 2005)

SWRCB Groundwater Classification in California

- Late 1990's - concern that subterranean stream classification could become so broad as to encompass extremely large alluvial areas (e.g., the entire central valley of California bounded by Sierra Nevada on the east and Coast Ranges on the west)
- Led to a study being conducted by Professor Sax on this issue
- Sax Report of 2002 - recommended that the test for subterranean stream be changed to impact assessment (e.g., pumping tests)
- Sax Report – controversial; not adopted by the State Board

Summary/Conclusions

- Evaluation of groundwater/surface water interaction – field testing/monitoring, analytical methods, numerical models
- California Water Law – most groundwater not permitted by State
- Subterranean Stream – groundwater permitted by SWRCB, still defined by subsurface channel bed and banks test

Thank You