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Overview of Ground-Water/Surface-Water Relationships

San Jacinto – Trinity River Basin & Bay Stakeholder Committee

San Jacinto River Authority

Conroe, TX

09-02-2009

Overview of Presentation

- Definitions of some important terms
- Emphasis on water-quantity issues and interactions of ground water and streams
- Highlight some of the important scientific and management issues in GW/SW Interactions

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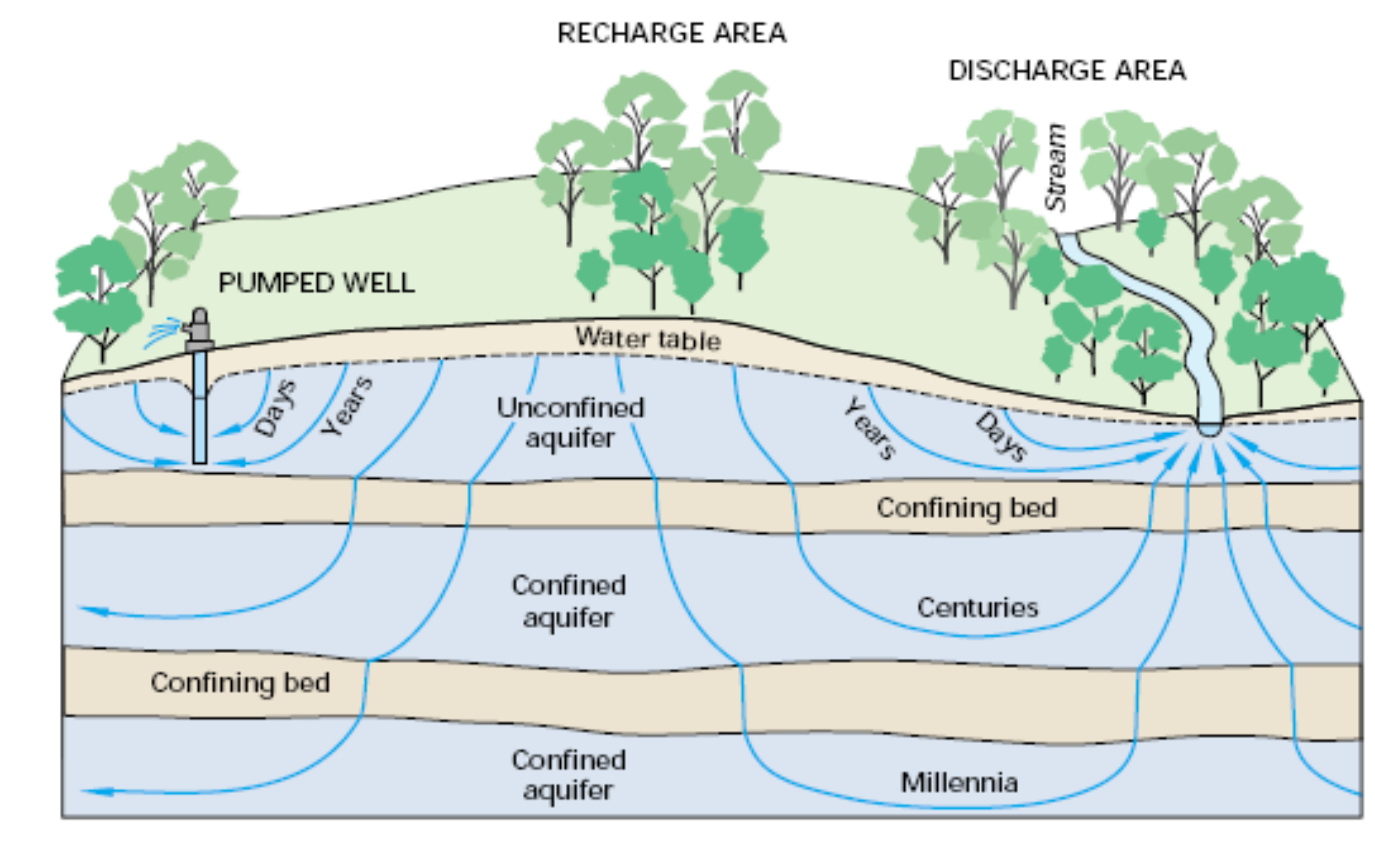

Ground-water flowpaths vary in length, depth, and traveltime from points of recharge to points of discharge

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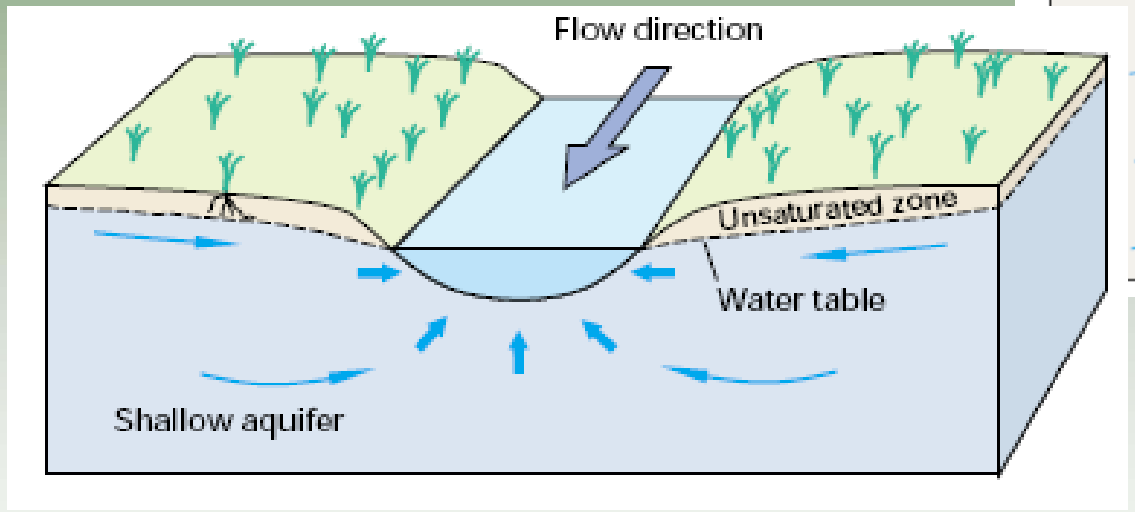
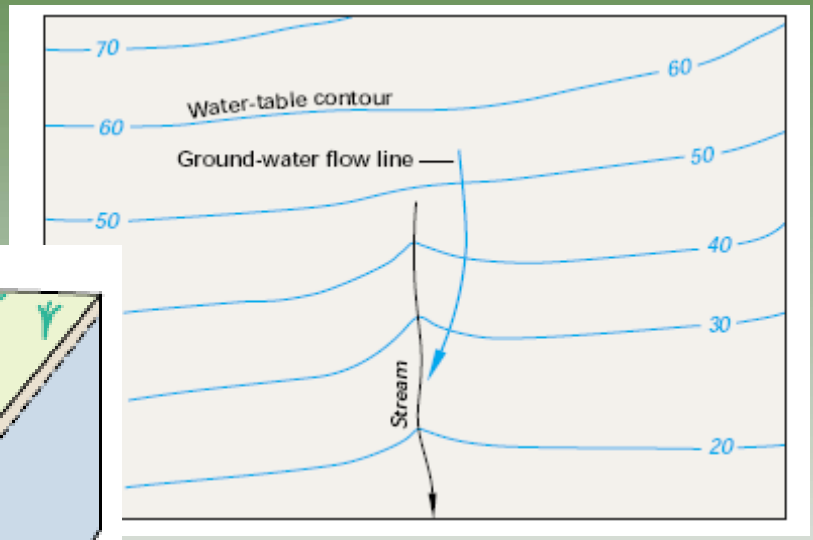
Interaction of Ground Water and Streams: Gaining Streams





Gaining streams receive water from the ground-water system. Contour lines point in the upstream direction where they cross the stream.

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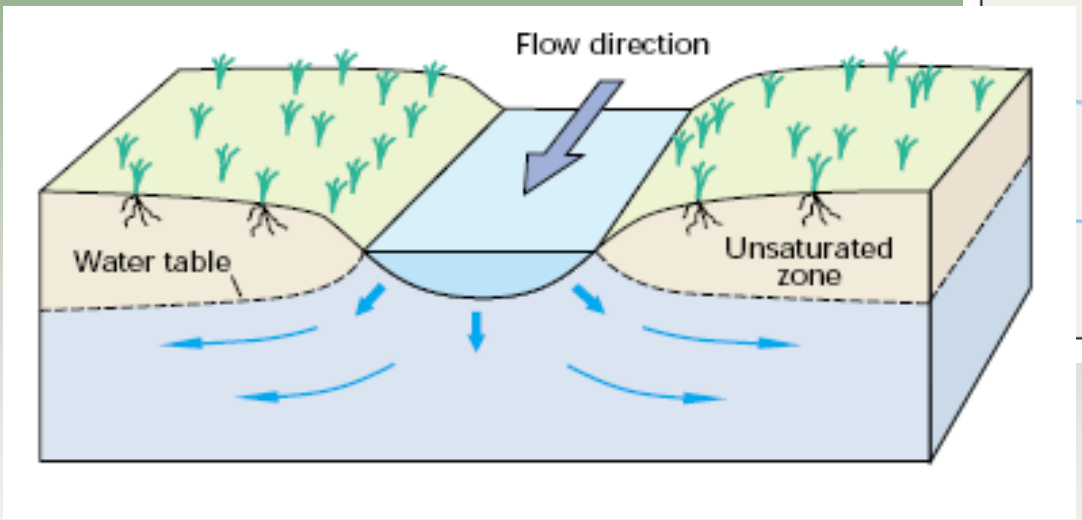
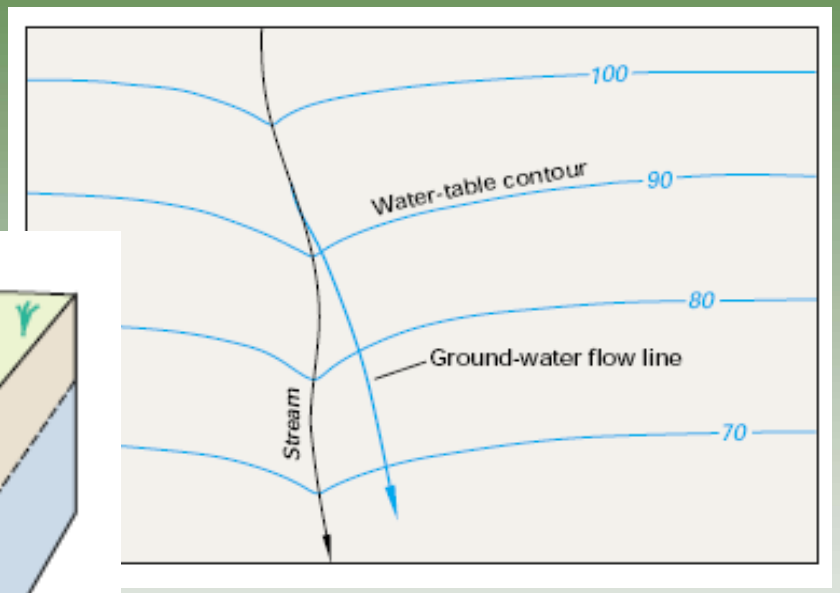
Interaction of Ground Water and Streams: Losing Streams





Losing streams lose water to the ground-water system. Contour lines point in the downstream direction where they cross the stream. Here, the stream is underlain by a saturated zone.

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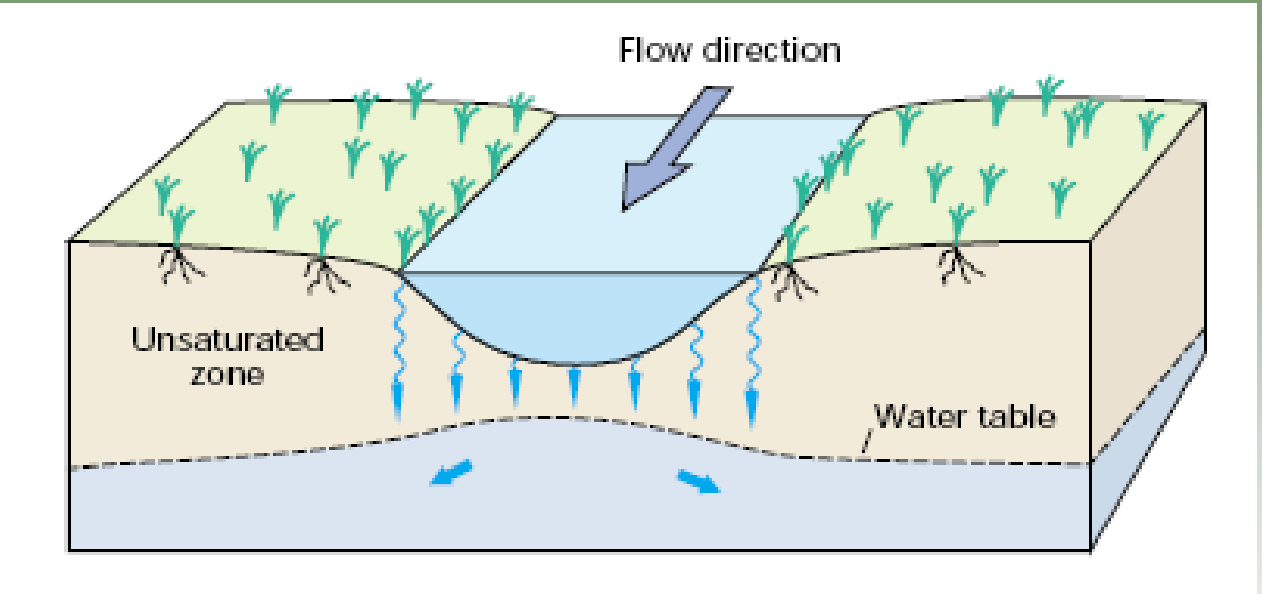
Interaction of Ground Water and Streams: Disconnected Streams



Disconnected streams are separated from the ground-water system by an unsaturated zone.

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And reaches may change with time from gaining to losing depending on hydrologic conditions and pumping rates.
(USGS PP 1636)

Table 3. Gains and losses of streamflow in the Hunt–Annaquatucket–Pettaquamscutt stream-aquifer system, Rhode Island

[Stream reaches are shown on figure 6. Streamflow is given in cubic feet per second and, in parentheses, million gallons per day. --, no data]

Stream reach	Gain or loss (-) in streamflow					
	September 20, 1995		April 24, 1996		October 8, 1996	
Hunt River Basin						
A–C	1.15	(0.74)	6.82	(4.41)	1.55	(1.00)
C–D	3.21	(2.08)	7.20	(4.65)	1.74	(1.12)
E–F	.51	(.33)	1.60	(1.03)	.17	(.11)
D–G	1.09	(.70)	3.30	(2.13)	2.44	(1.58)
G–I	-1.96	(-1.27)	4.82	(3.12)	-4.35	(-2.81)
J–K	-.29	(-.19)	-1.40	(-.91)	2.89	(1.87)
L–M	--	--	2.36	(1.53)	.72	(.47)
M–N	.70	(.45)	1.62	(1.05)	.92	(.59)
N–O	-.07	(-.05)	1.81	(1.17)	.33	(.21)
K–P	1.39	(.90)	15.2	(9.82)	1.95	(1.26)
Annaquatucket River Basin						
R–S	--	--	1.16	(.75)	-.59	(-.38)
S–T	--	--	16.9	(10.90)	10.3	(6.68)

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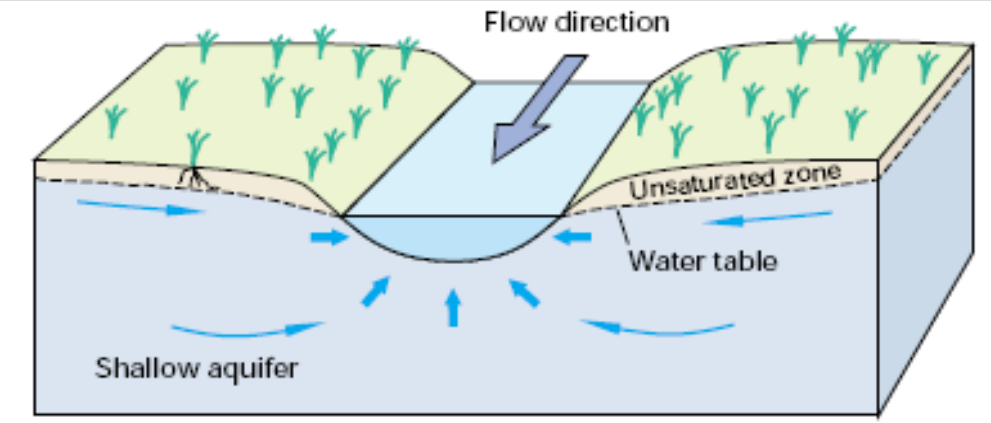
Partially and Fully Penetrating Streams

- Most streams are shallow relative to the thickness of the aquifer in which they lie. Such streams often are referred to in the literature as partially penetrating streams.
- Seepage between a partially penetrating stream and the contiguous aquifer occurs both horizontally and vertically through streambank and streambed materials:



A shallow stream that partially penetrates an aquifer.

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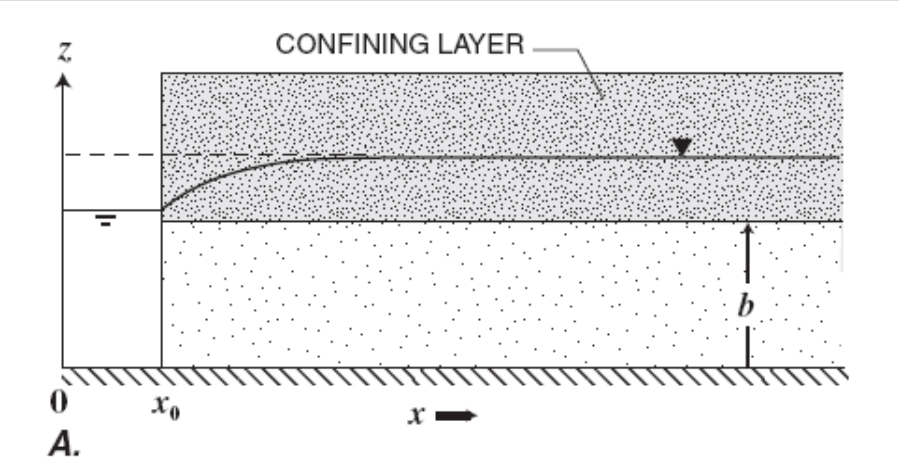
Partially and Fully Penetrating Streams

- There are probably relatively few streams that are deep enough to penetrate the full thickness of the aquifer in which they lie. Such streams often are referred to in the literature as fully penetrating streams.
- Seepage between a fully penetrating stream and the contiguous aquifer occurs horizontally through streambank materials:



A deep stream that fully penetrates an aquifer.

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Partially and Fully Penetrating Streams

- Although partially penetrating streams are more often the norm, for analytical- and numerical-modeling purposes, a simplifying assumption is often made that a stream fully penetrates an aquifer.

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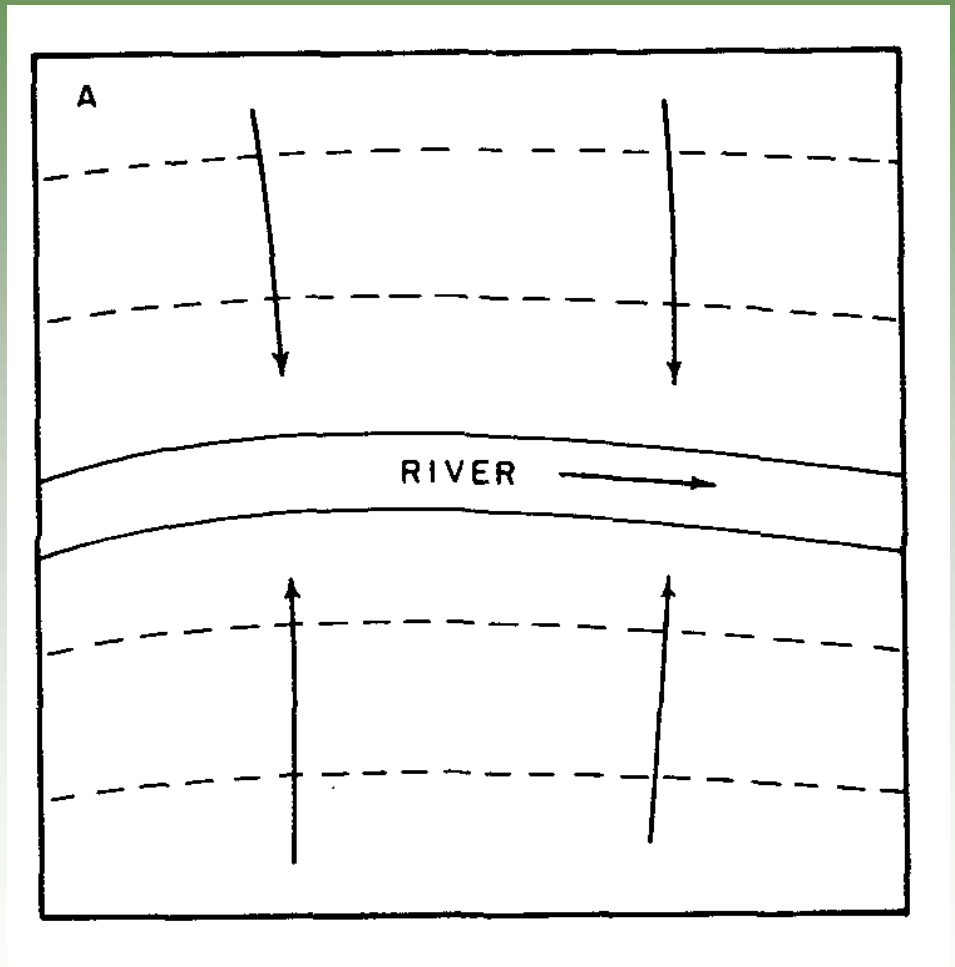
Baseflow and Underflow Components of Ground-Water Flow



The baseflow component of ground-water flow moves perpendicular to the river

See Larkin and Sharp, 1992, GSA Bulletin, v. 104, p. 1608-1620.

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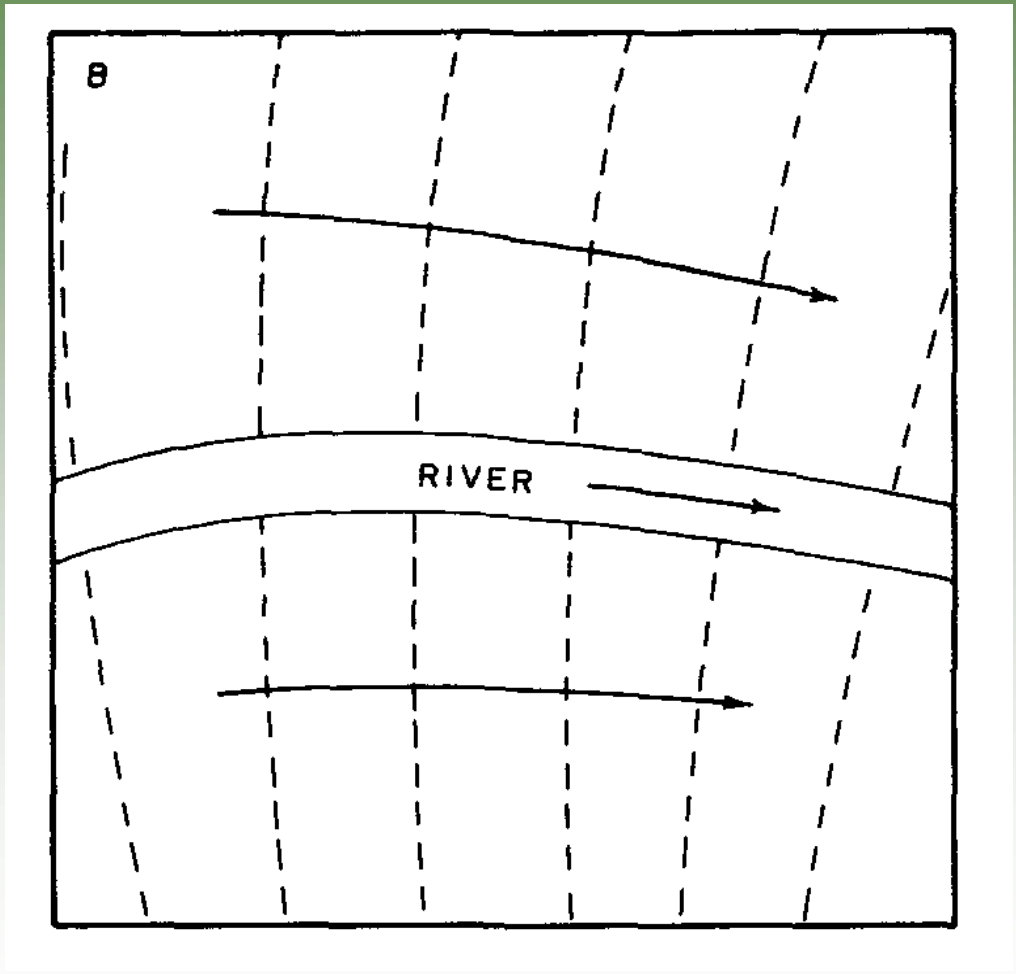
Baseflow and Underflow Components of Ground-Water Flow



The underflow component of ground-water flow moves parallel to the river in the same direction as streamflow

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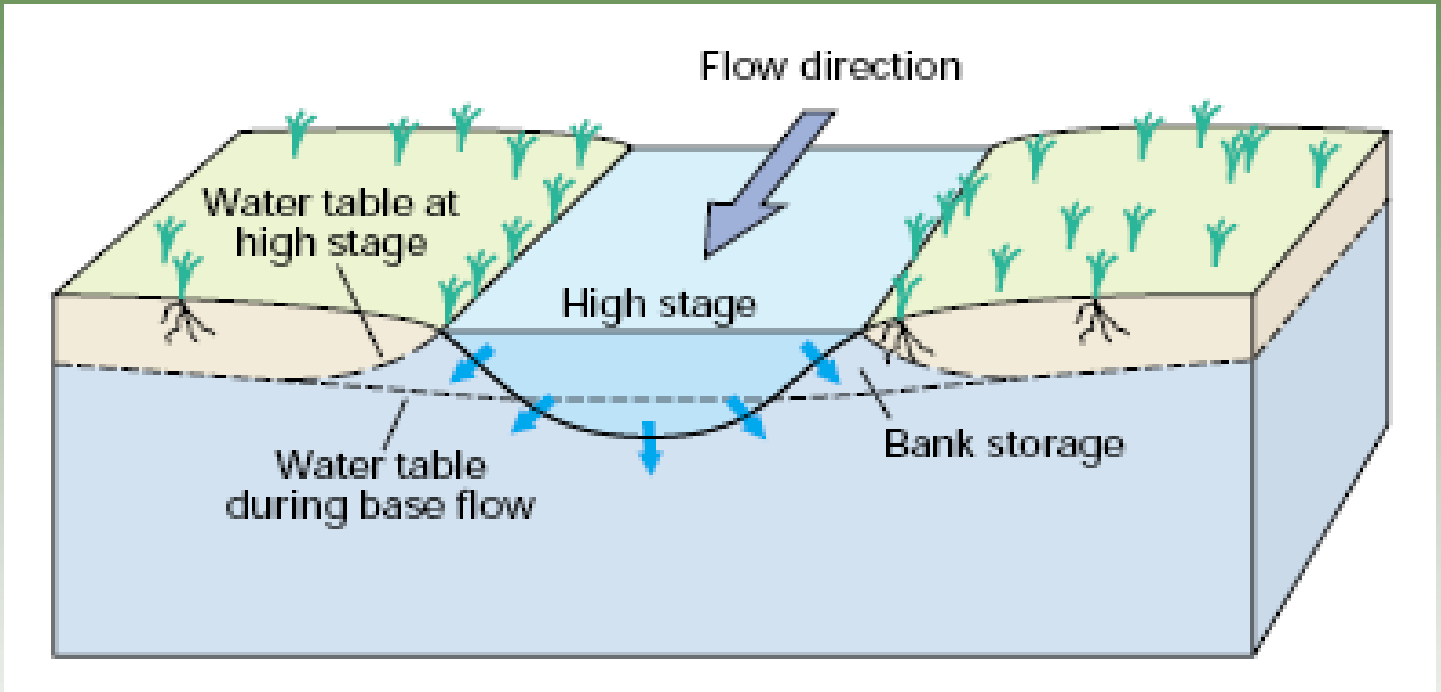
Interaction of Ground Water and Streams: Bank Storage



A rapid rise in stream stage can cause water to move from the stream into the streambanks as bank storage.

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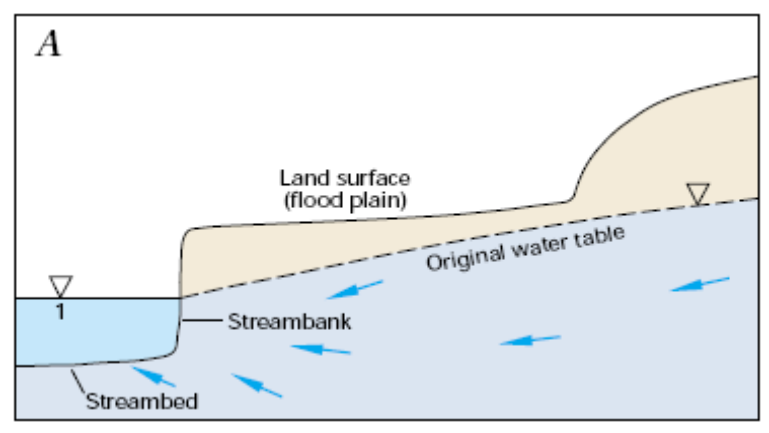

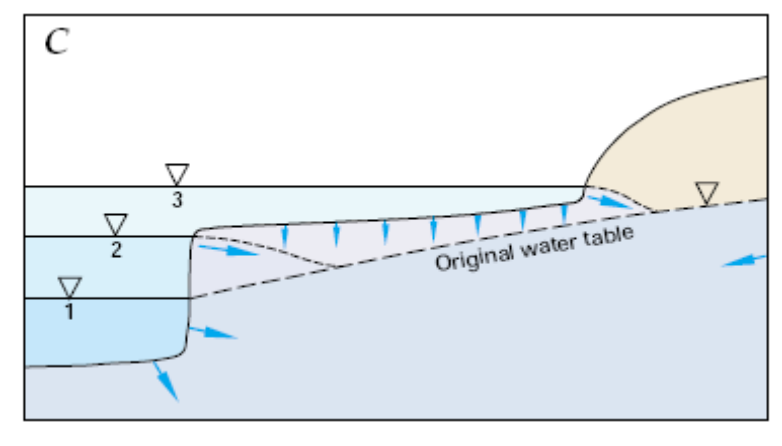

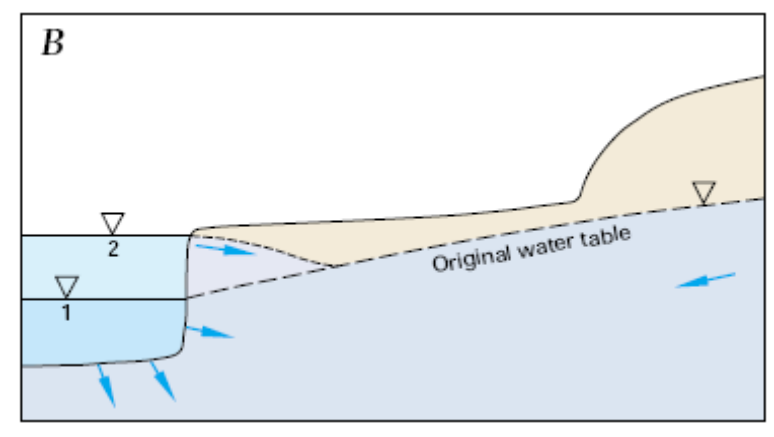

EXPLANATION

1 2 3 Sequential stream stages

Approximate direction of ground-water flow or recharge through the unsaturated zone

Widespread recharge to the water table can occur in a flooded area if the rise in stream stage is sufficient to overtop the streambanks

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Base Flow—The Ground-Water Component of Streamflow

- Ground water contributes to streams in most physiographic and climatic settings, yet the proportion of stream water that is derived from ground-water inflow varies across these settings.

- Streamflow hydrograph-separation techniques can be used to estimate the amount of gw that contributes to streamflow; that is, the ground-water component, or base flow, of streamflow.

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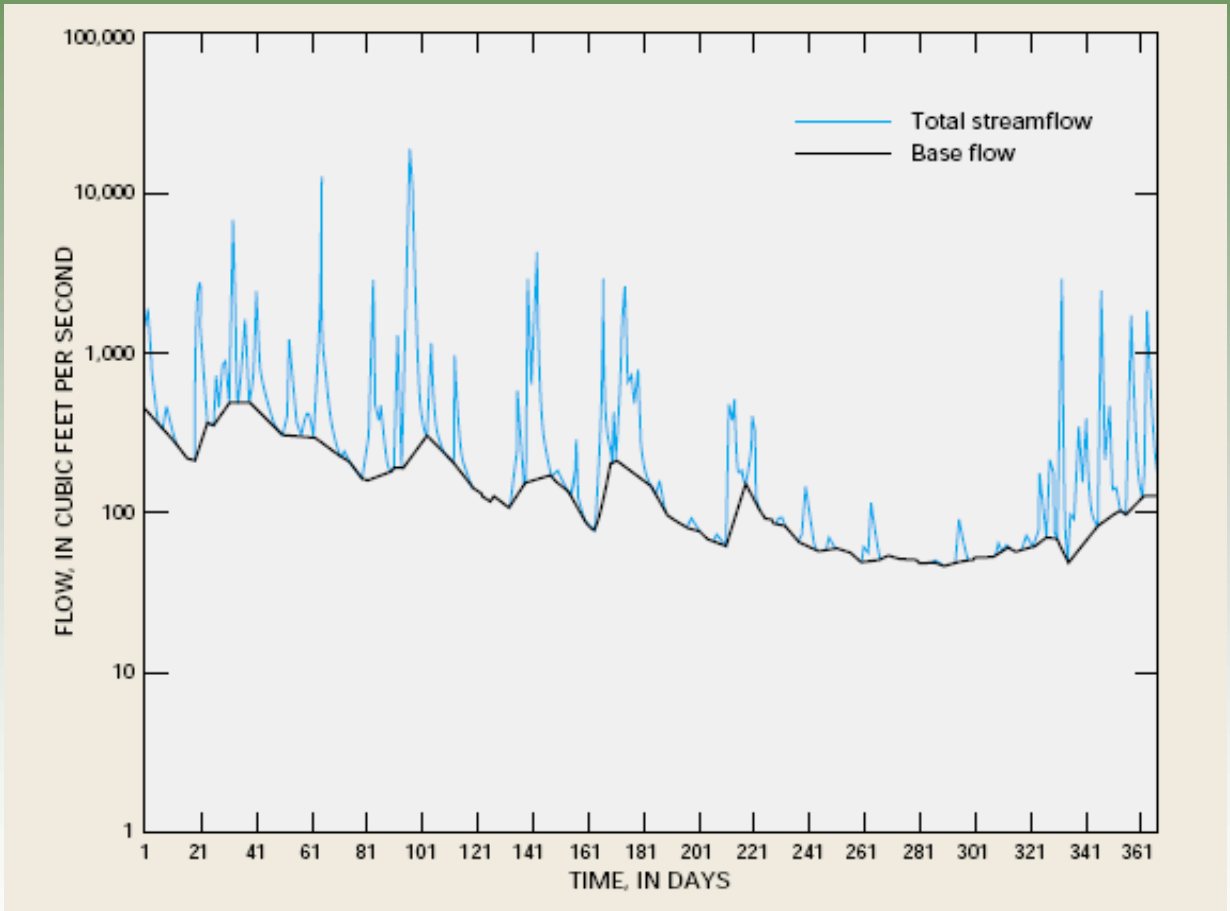
The base-flow component of streamflow estimated from a streamflow hydrograph for the Homochitto River, Mississippi



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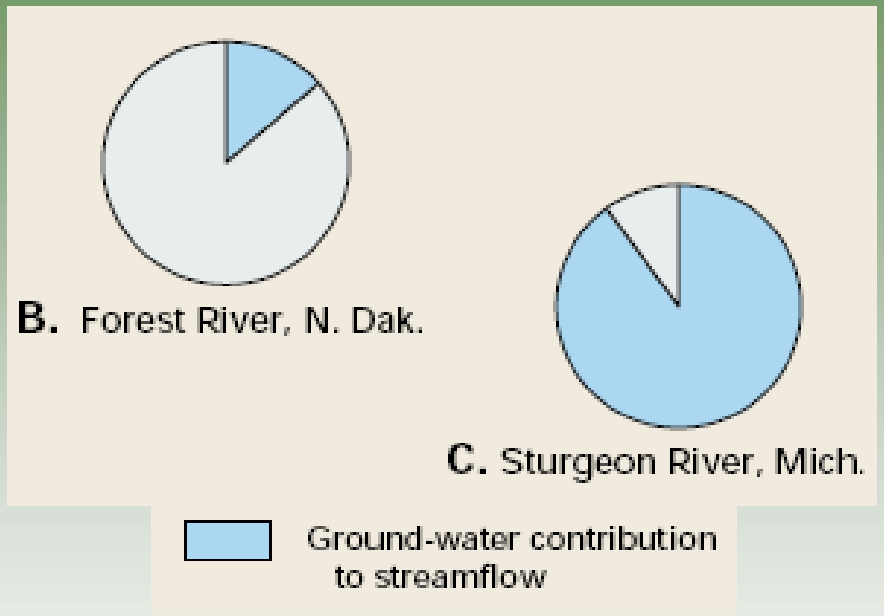
The base-flow component of streamflow varies by physiographic, geologic, and climatic settings.



The Forest River is underlain by poorly permeable silt and clay, with relatively little gw discharge to the river.

The Sturgeon River is underlain by highly permeable sand and gravel, with a large contribution of gw discharge to the river.

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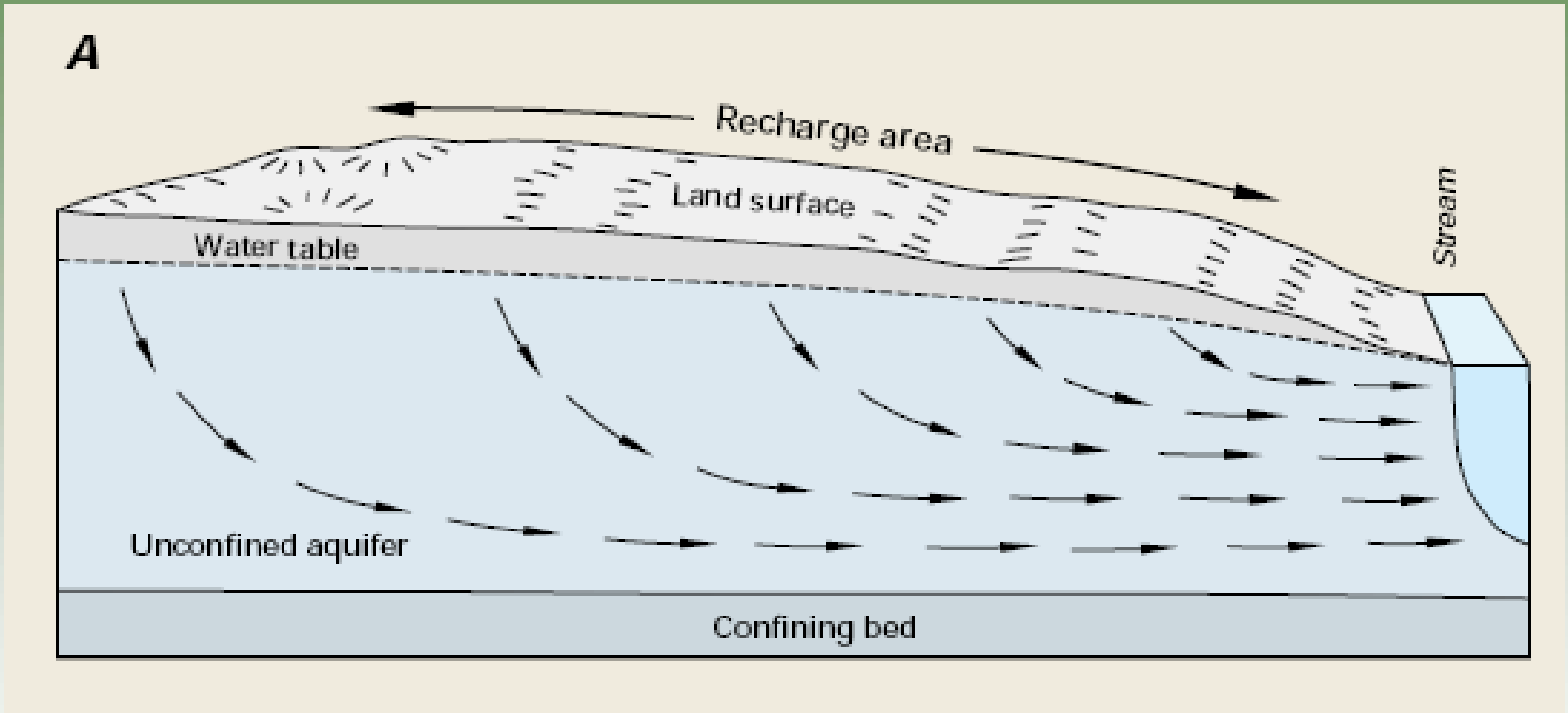
Effects of Ground-Water Pumping on Streamflow



Ground-water discharges to stream under natural conditions

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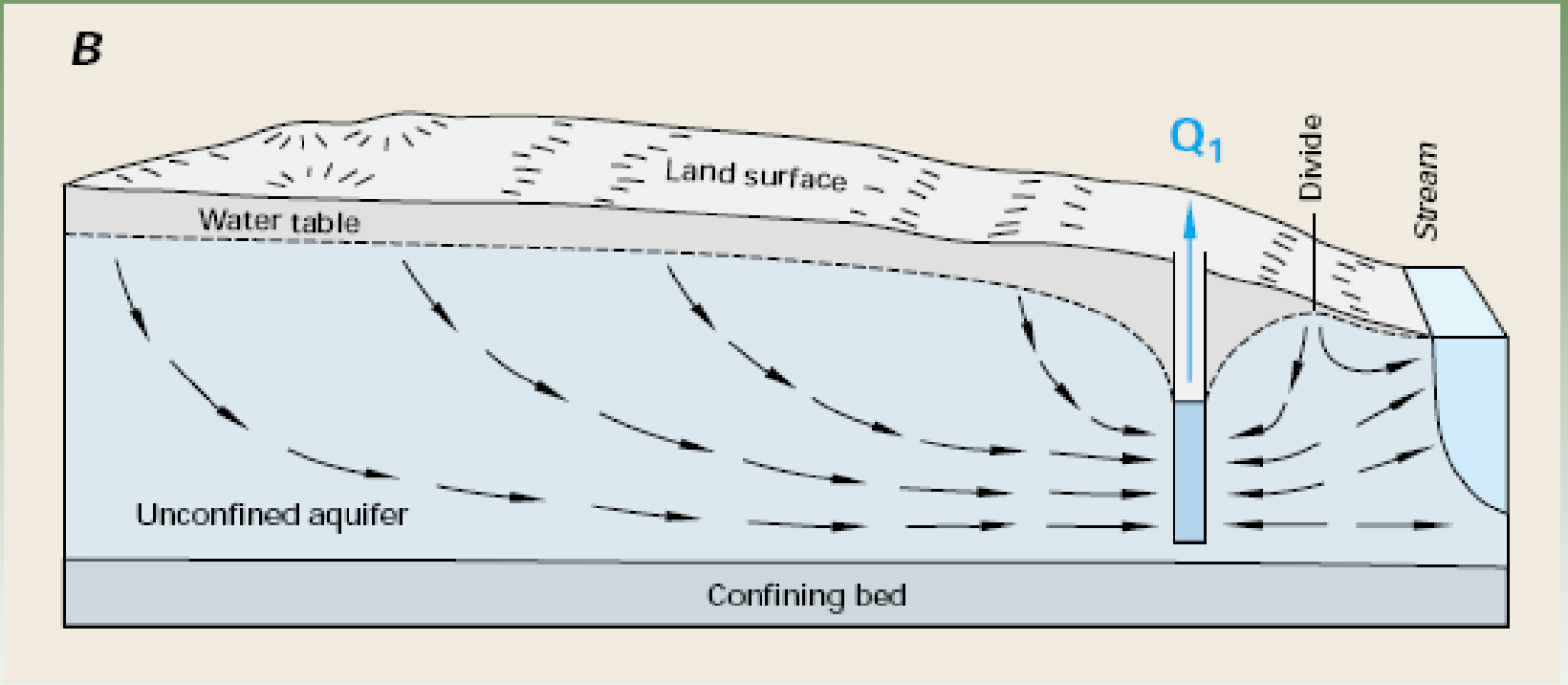
Effects of Ground-Water Pumping on Streamflow



At lower pumping rates, or large distances of a well from a stream, pumping captures ground water that would otherwise have discharged to the stream

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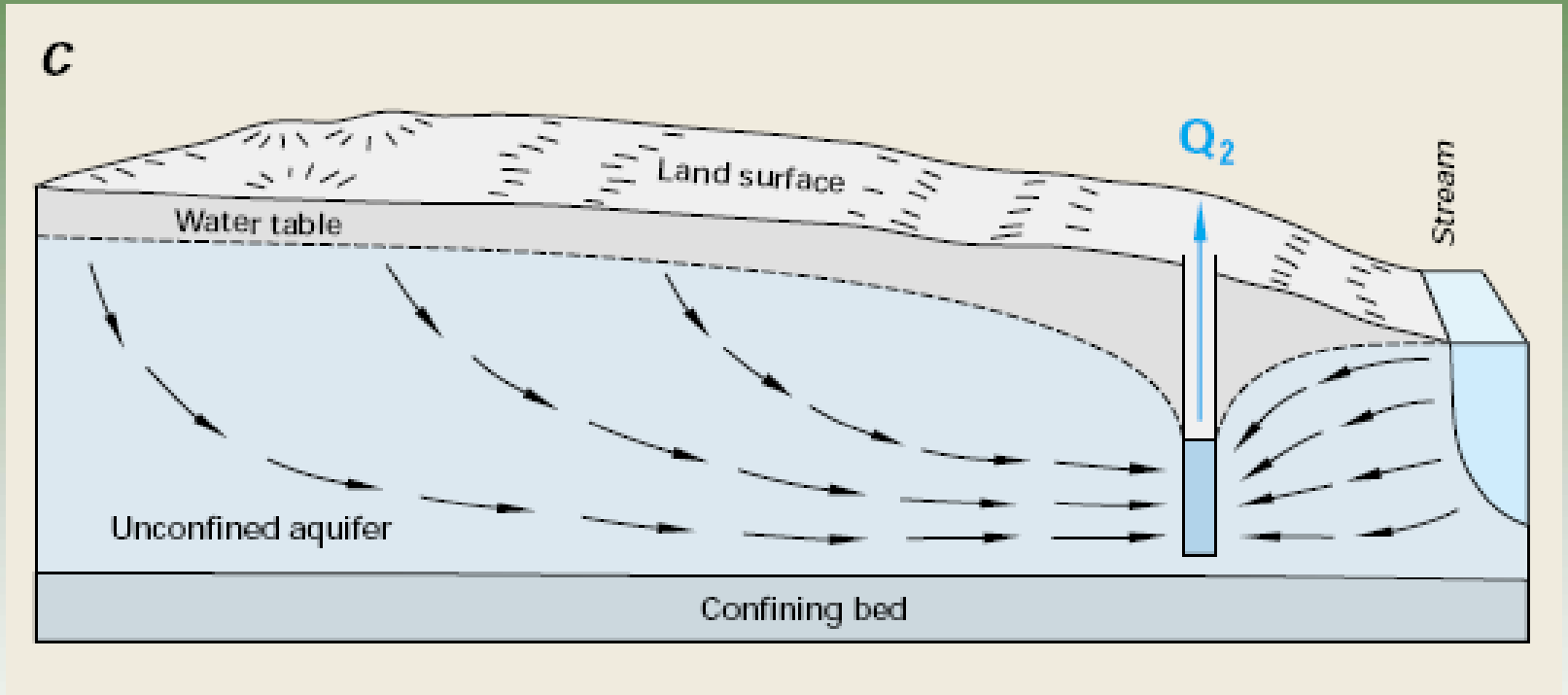
Effects of Ground-Water Pumping on Streamflow



At increased pumping rates, the well captures (1) ground water that would otherwise have discharged to the stream and (2) induced infiltration of streamflow into aquifer

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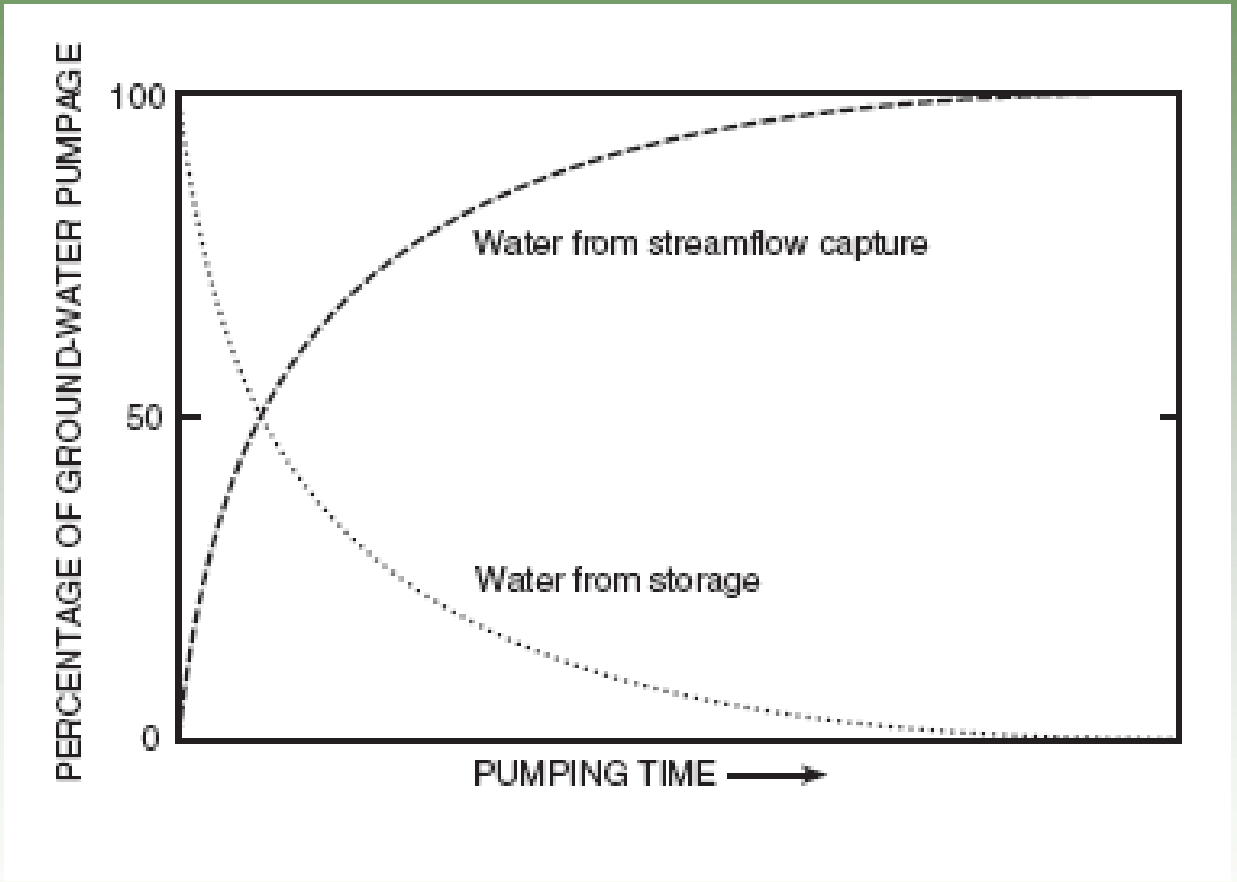
Sources of Water to a Well as a Function of Time



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Ground-water withdrawals deplete streamflow and stress aquatic communities in the Ipswich River, Massachusetts

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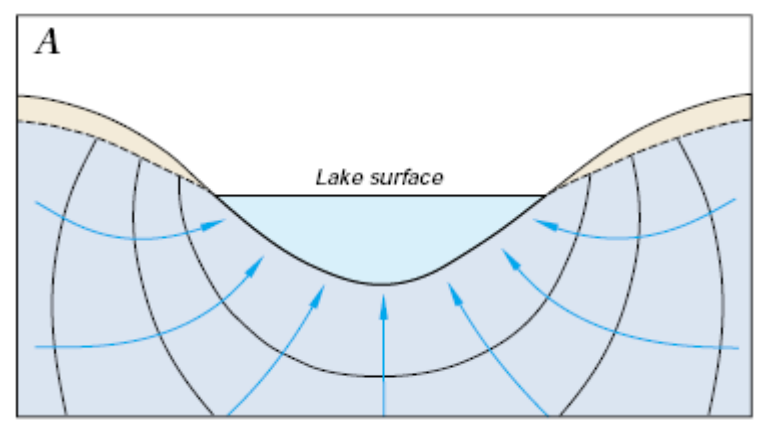
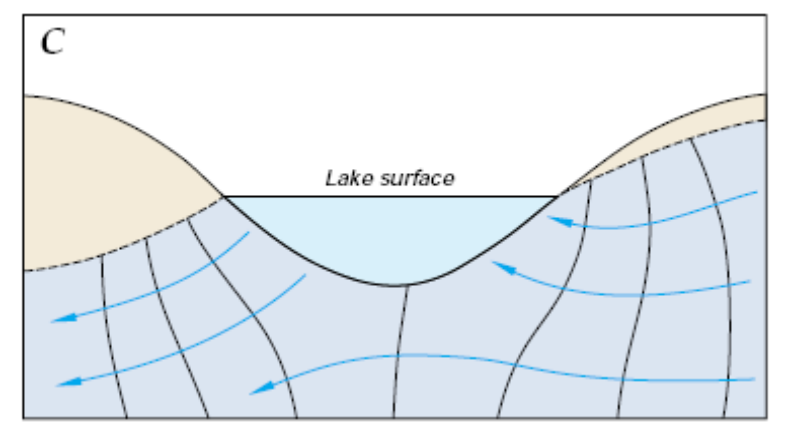
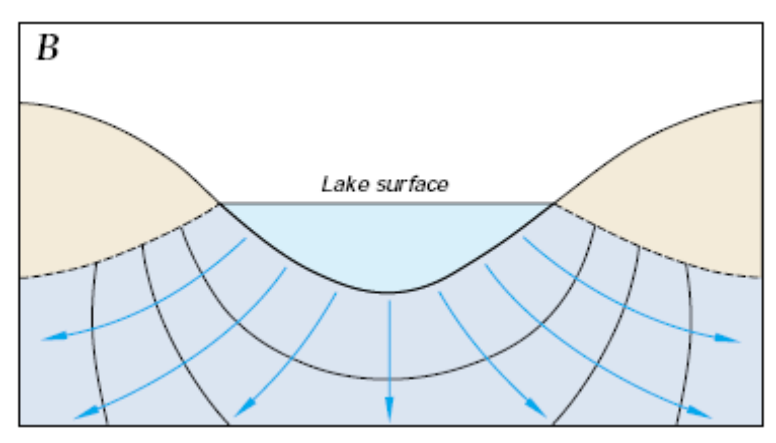
Interaction of Ground Water and Lakes







Lakes can receive ground-water inflow (A), lose water as seepage to ground water (B), or both (C).

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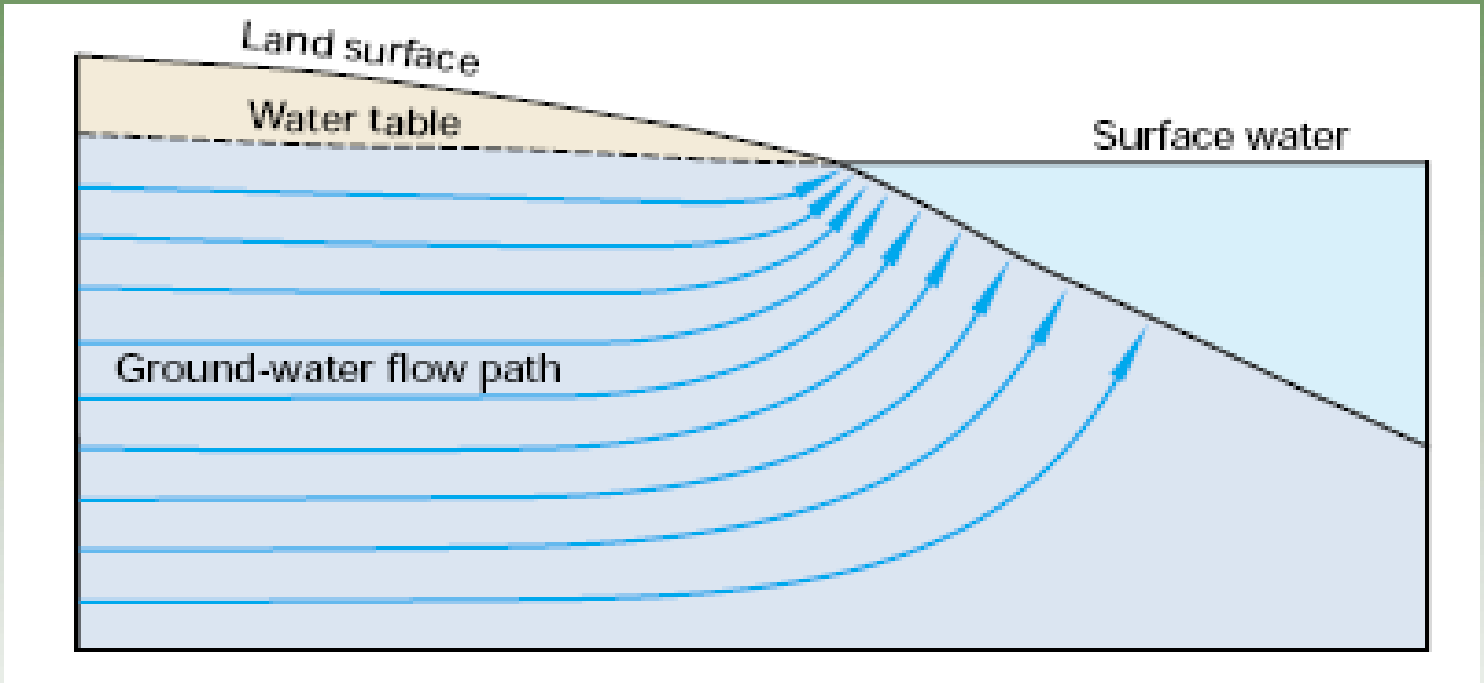
Ground-Water Seepage Into Surface Water



Seepage rates are usually greatest near shore and decrease nonlinearly away from the shoreline

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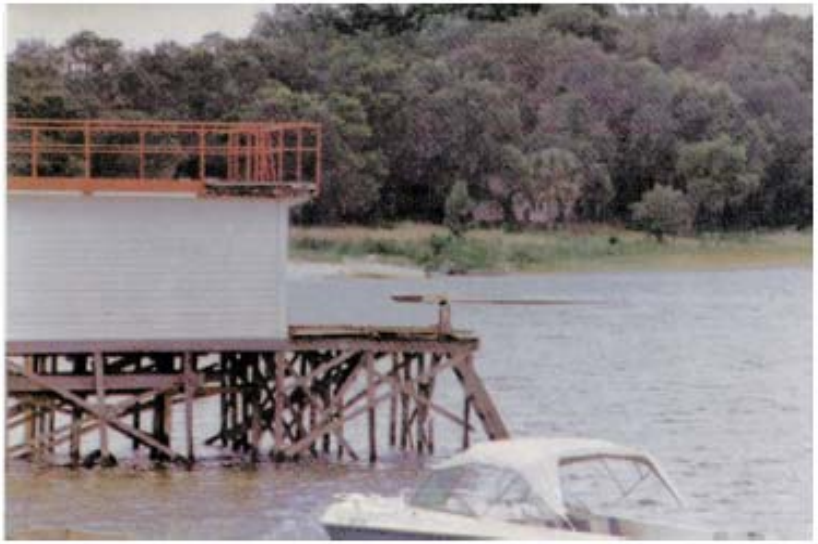
Ground-Water Pumping Can Also Affect Lake Levels, Which Affect Lake Ecosystems and Lake Esthetics



Dock on Crooked Lake in central Florida in the 1970's.

The same dock in 1990.

In highly developed areas of west-central Florida, lake levels declined and wetlands dried out over a two-decade period as a result of both extensive pumping from the Floridan aquifer and low precipitation as a result of drought conditions.

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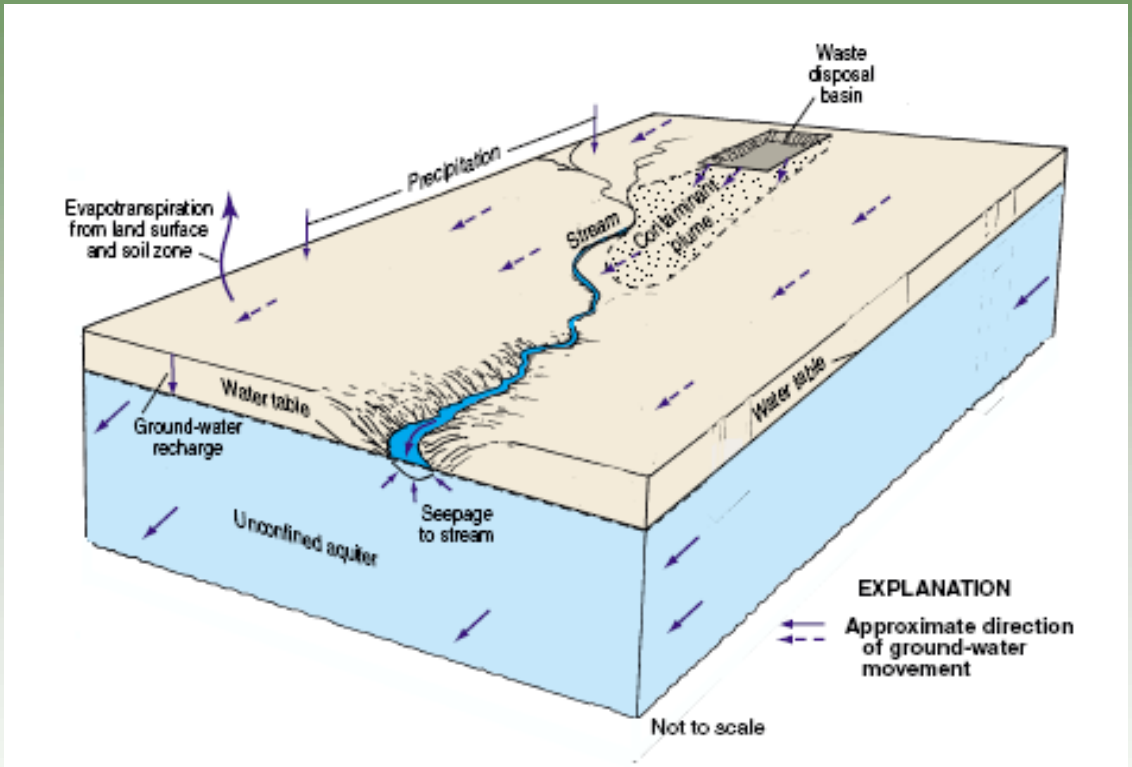
The Quality of Discharging Ground Water Can Affect the Quality of the Receiving Stream



Simplified representation of a contaminant plume in ground water.

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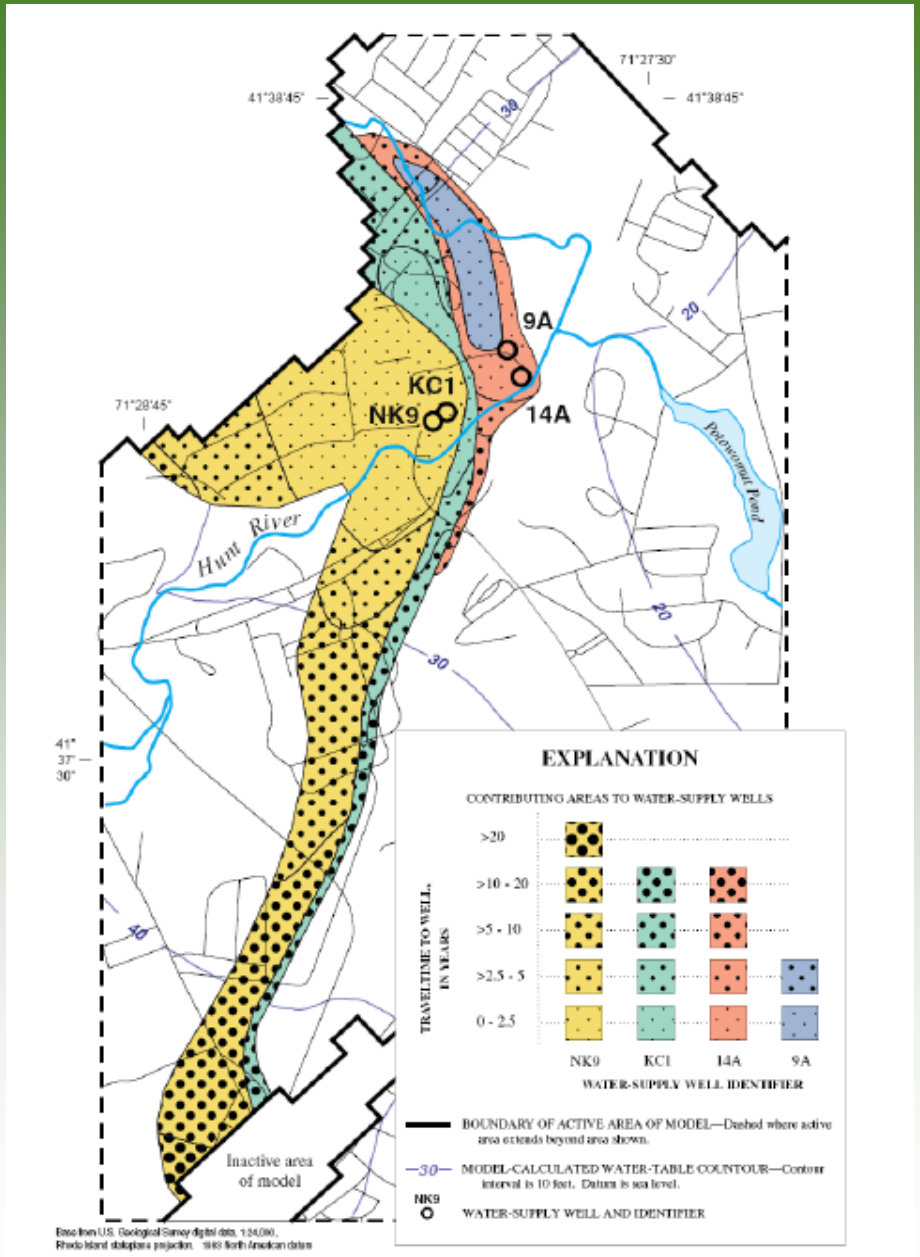

Conversely, the Quality of Streamflow Seeping into an Aquifer, Perhaps Due to Induced Infiltration Caused by Pumping, Can Affect the Quality of the Receiving Aquifer and Wells

Induced infiltration from the Hunt River, RI, is a source of water to wells 14A, KC1, and NK9, as shown by the contributing areas to the wells, which overlie the river.

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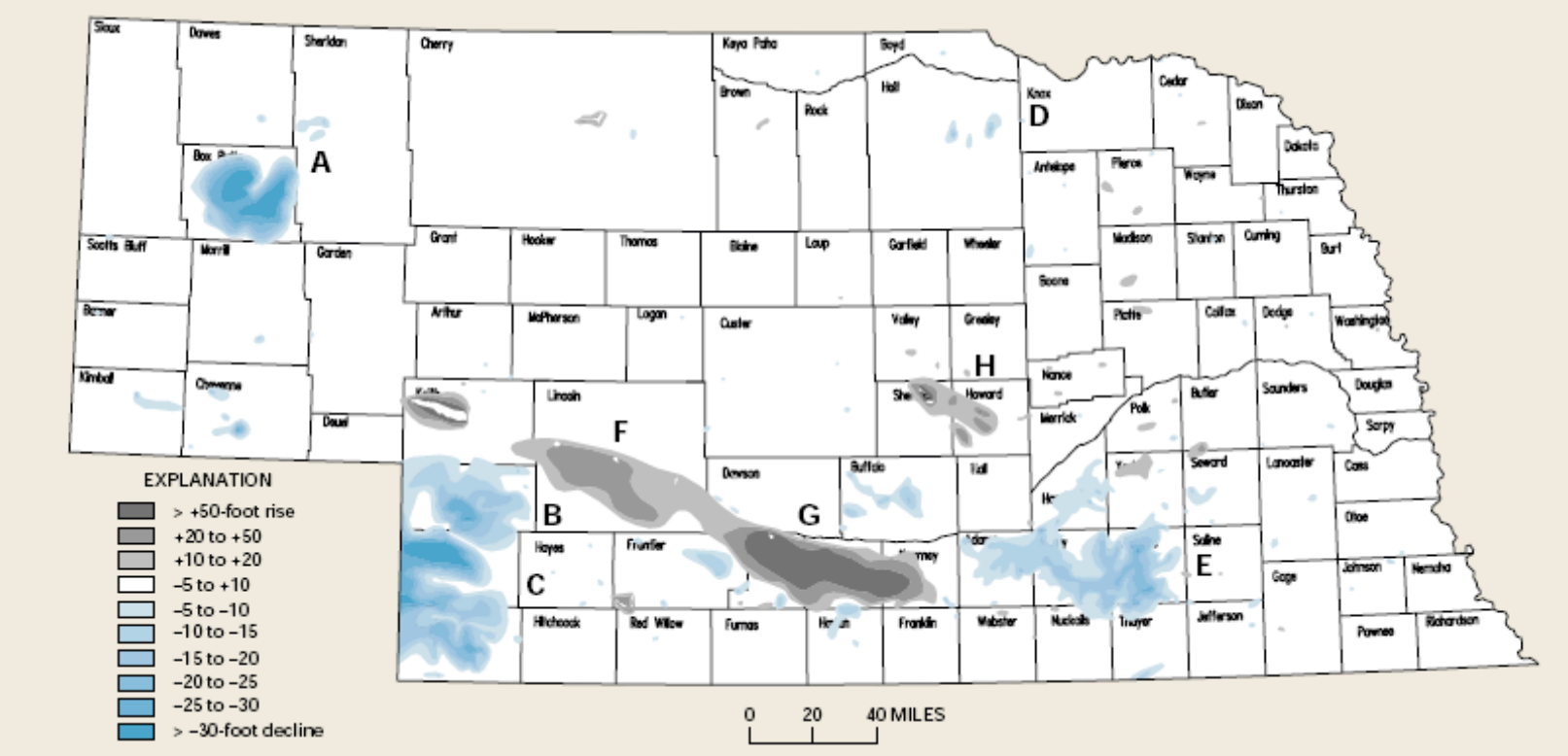
Human Effects on GW/SW Interactions

- Ground-water pumping for water supply, irrigation, and so forth
- Recharge from irrigation systems



The use of both gw and sw for irrigation has resulted in significant rises and declines in gw levels in different parts of Nebraska.

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Human Effects on GW/SW Interactions

- Contamination of ground-water and surface-water systems by agricultural chemicals, chemicals used in urban and industrial settings, and so forth
- Drainage of landscapes for agricultural and urban development, which can change the distribution of gw recharge and discharge
- Changes to gw recharge and discharge patterns due to the construction of levees and reservoirs and removal of natural vegetation

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What are Some of the Current Scientific and Management Issues in GW/SW Interactions?

- The role of gw discharge in sustaining low flows, instream flows, and environmental flows
- Physical, chemical, and biological processes in the hyporheic zone
- Continued interest in the mechanics and timing of streamflow depletion by wells (and accretion by irrigation return flows)
- Advanced methods for coupled gw/sw models, such as GSFLOW
- Improved methods for conjunctive-management of gw/sw systems, including optimization techniques

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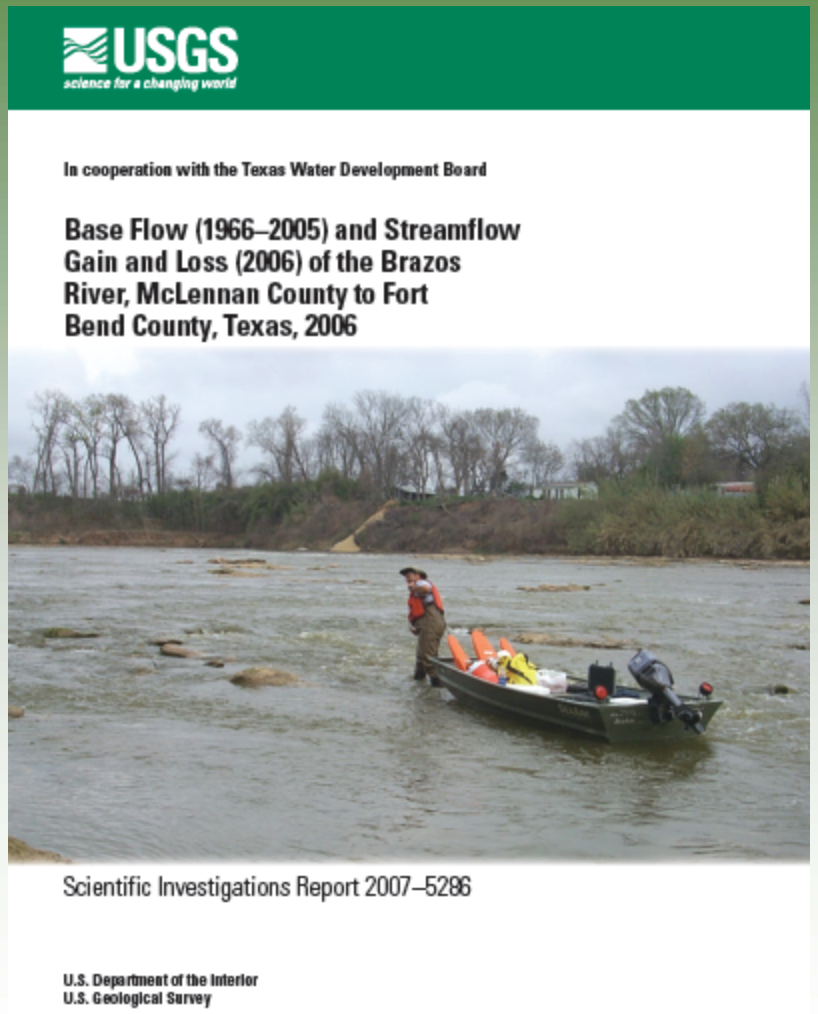
Questions – Contact



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