RTDF Sediment Remediation Action Team Meeting:
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Ground Water-Surface Water Workshop

Overview of the Hydrogeology of GW/SW Interactions

Brewster Conant Jr., Ph.D.
Waterloo, Ontario, Canada
bconant@sympatico.ca

Outline

1. Definitions
2. Factors controlling interactions
3. Conceptualizing GW/SW interactions
4. Implications for transport and fate of plumes
5. Monitoring and Remediation Issues

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Definitions

- Hyporheic Zone
  - Areas beneath and adjacent to a stream that contain some portion of channel water or has been altered by surface water (White 1993).
- Groundwater/Surface-water Interface
  - The boundary (i.e. surface) in the subsurface between groundwater and surface water.
- Transition Zone
  - The general area beneath and near surface water bodies where conditions go from a groundwater dominated system to a surface water system.

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Important and Unique Features of Transition Zone

- Complex and dynamic hydrological, geological, and biogeochemical zone.
- Spatial and temporal variability make it difficult to determine exact GW flow paths.
- Transition zone has potential to change shape, size, and composition of plumes.

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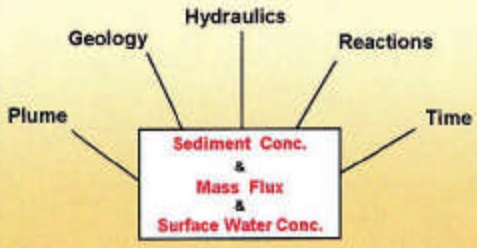
Factors Affecting Transport and Fate



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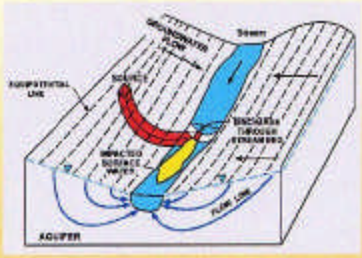
Idealized Discharge of a Plume to a River



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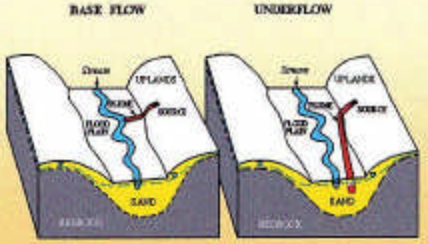
Regional Flow



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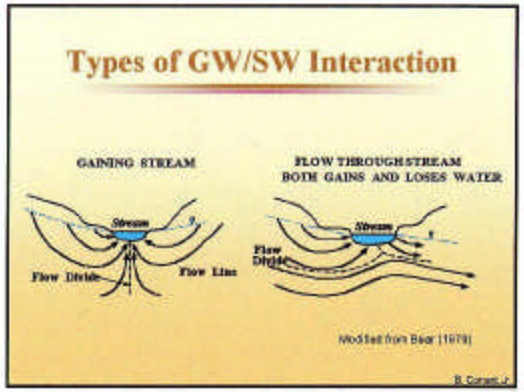
Types of GW/SW Interaction
GAINING STREAM
FLOW THROUGH STREAM
BOTH GAINS AND LOSES WATER
Stream
Flow Divide
Flow Line
Modified from Bear (1979)
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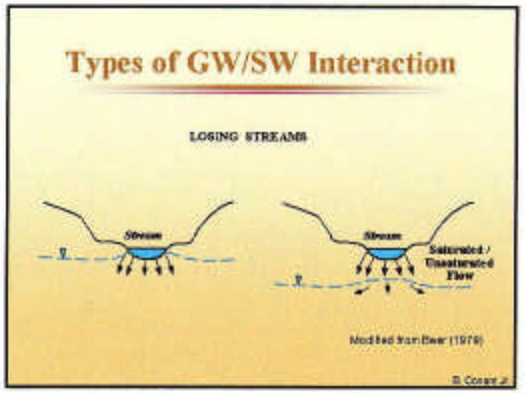
Types of GW/SW Interaction
LOSING STREAMS
Stream
Saturated / Unsaturated Flow
Modified from Bear (1979)
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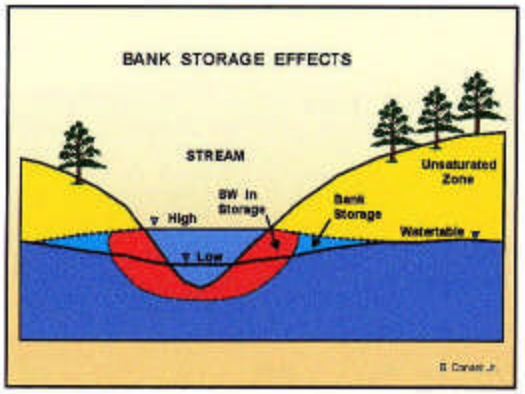
BANK STORAGE EFFECTS
STREAM
Unsaturated Zone
BW in Storage
Bank Storage
High
Low
Watertable
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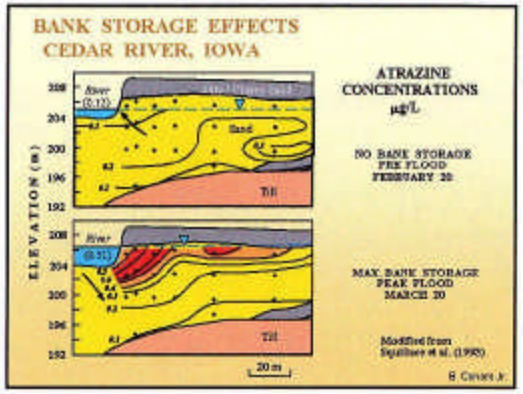
BANK STORAGE EFFECTS
CEDAR RIVER, IOWA
ATRAZINE CONCENTRATIONS µg/L
NO BANK STORAGE PRE FLOOD FEBRUARY 20
MAX BANK STORAGE PEAK FLOOD MARCH 20
ELEVATION (m)
River
Sand
Till
20 m
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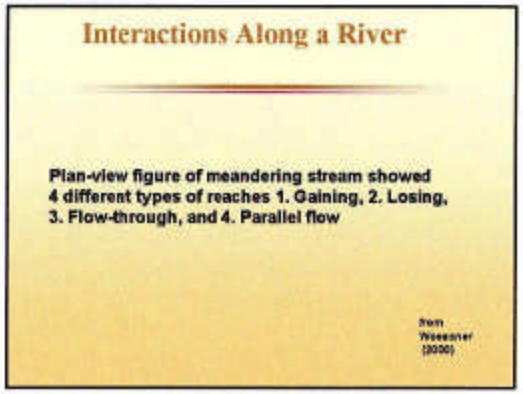
Interactions Along a River
Plan-view figure of meandering stream showed 4 different types of reaches 1. Gaining, 2. Losing, 3. Flow-through, and 4. Parallel flow
from Woessner (2000)

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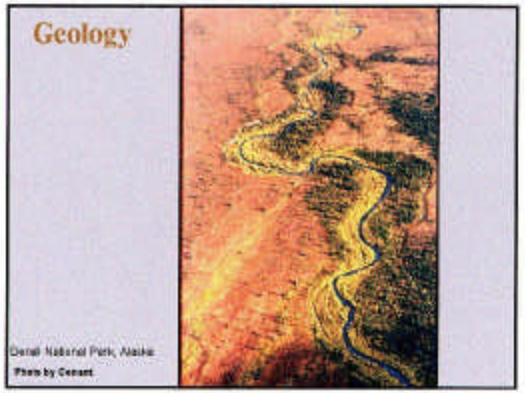
Geology
Denali National Park, Alaska
Photo by Conant

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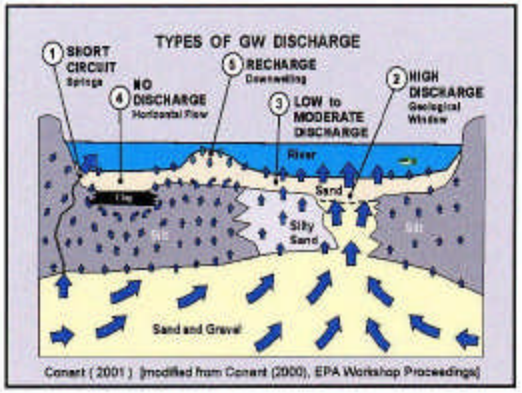

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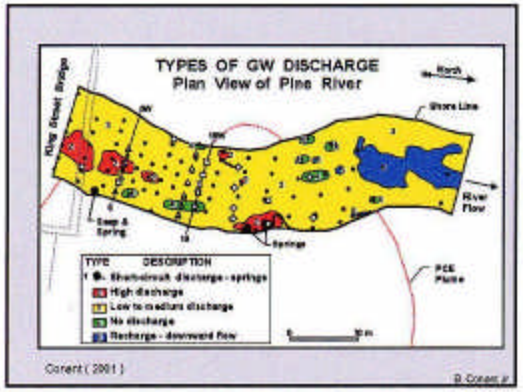

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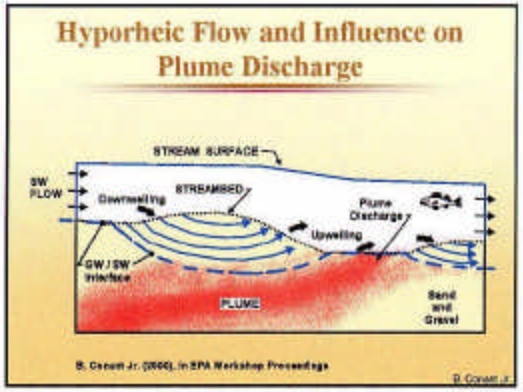

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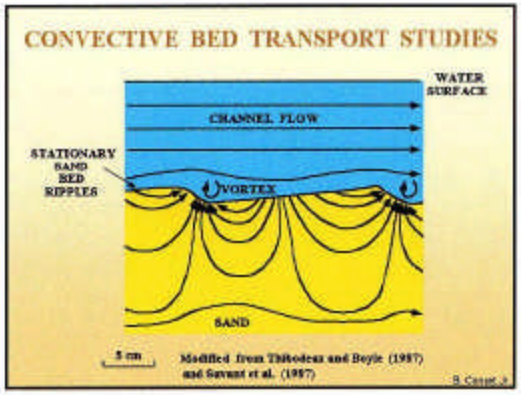

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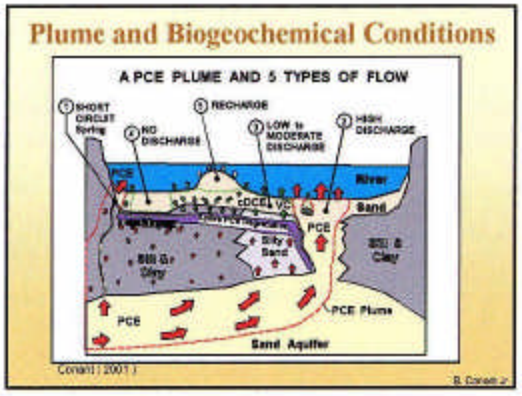

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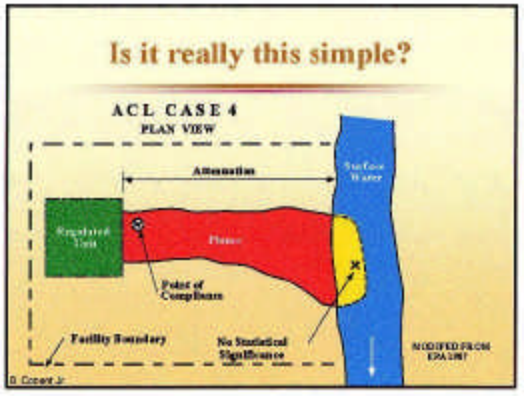

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Monitoring of Natural Attenuation

Figures of recommended monitoring for a GW plume discharging to SW do not appear to include any investigation of or in the streambed

?

Sediments ?
Interstitial Water ?

Modified from
Wiedemeier and Haas (2002)

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Flow to and From Lakes

Figure illustrated local and regional flow effects, flow lines, areas of capture, stagnation points and how flow-through conditions can occur

Modified From
Winter (1999)

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GW Plume Discharging to Pond

- vapor diffusion samplers
- Discovered previously unknown higher concentration TCE plume !
- TCE plume had gone under an adjacent pond to get there !

Diagram from Savoie et al.
(2000) USGS WRIR 00-4017

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Redox Zonation of GW/SW Interface, Lake Michigan

Figure showed how redox conditions vary both laterally with depth, and in proximity of the lake and shoreline

From Landwey et al. (1998)

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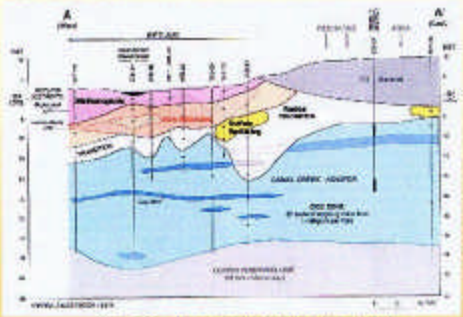
Redox Conditions for Freshwater Wetland



Modified from Lorah et al. (1997) (USGS WRIR 97-4171)

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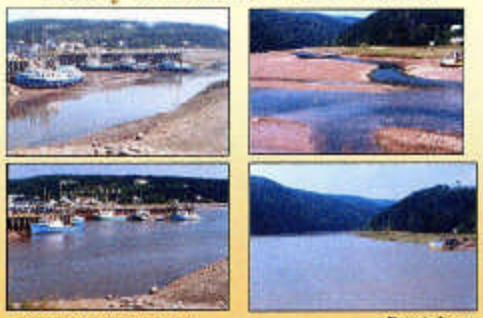
Tidally Influenced Water Bodies



Bay Of Fundy, New Brunswick

Photos by Conant

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Tidally Influenced Systems and an Ultrasonic Seepage Meter

Figure showed how specific discharge varies inversely with tidal stage over time

From Paulsen et al. (2001)

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Monitoring Goals and Objectives

1. Representative samples
2. Understand fate and transport of contaminants
3. Concentrations (exposures) & fluxes (loading)
4. A predictive conceptual model
5. Provide information for Eco Risk Assessment

How much monitoring is enough ?

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Investigations - Typical Questions To Ask

1. Distribution of contaminants in streambed
2. Delineating and quantifying GW discharge
3. Determining total mass discharge
4. Quantifying mass losses in streambed

Increasing Difficulty

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Implications for Remediation

- Initial characterization
- Remedial design
- Performance monitoring

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