Geomorphology along an incised channel

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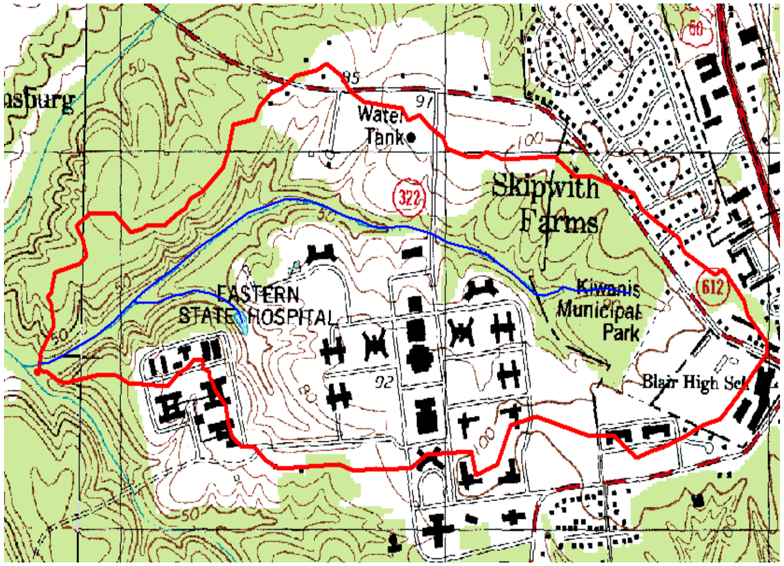
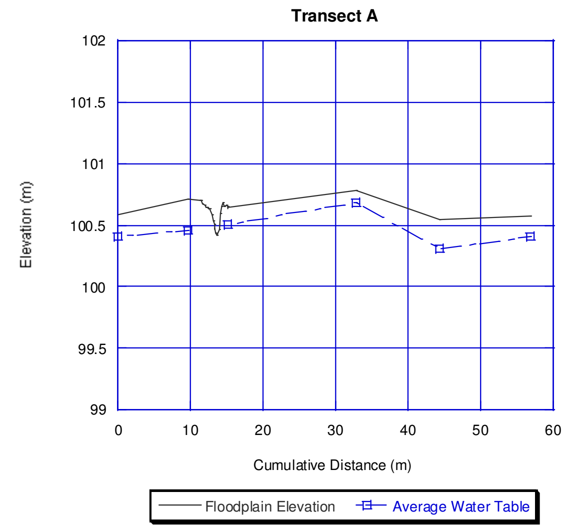
Background

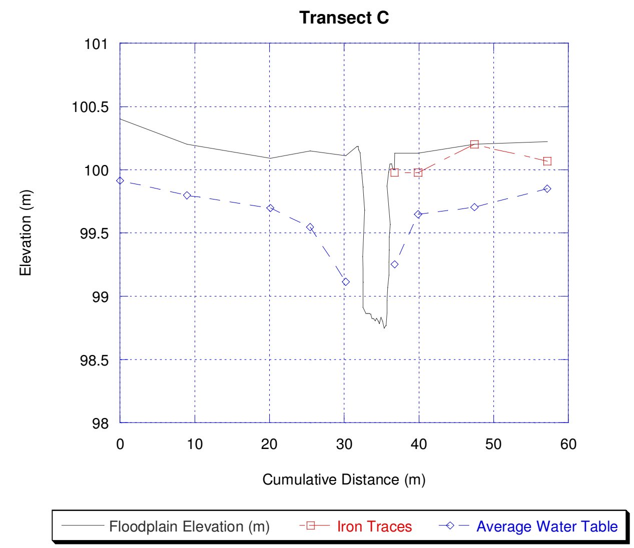
- Site: Eastern State, a moderately developed hospital with a wooded area
- Contains a perennial stream and several intermittent tributaries
- Stream and some tributaries have incised, presumably due to urbanization



Incision

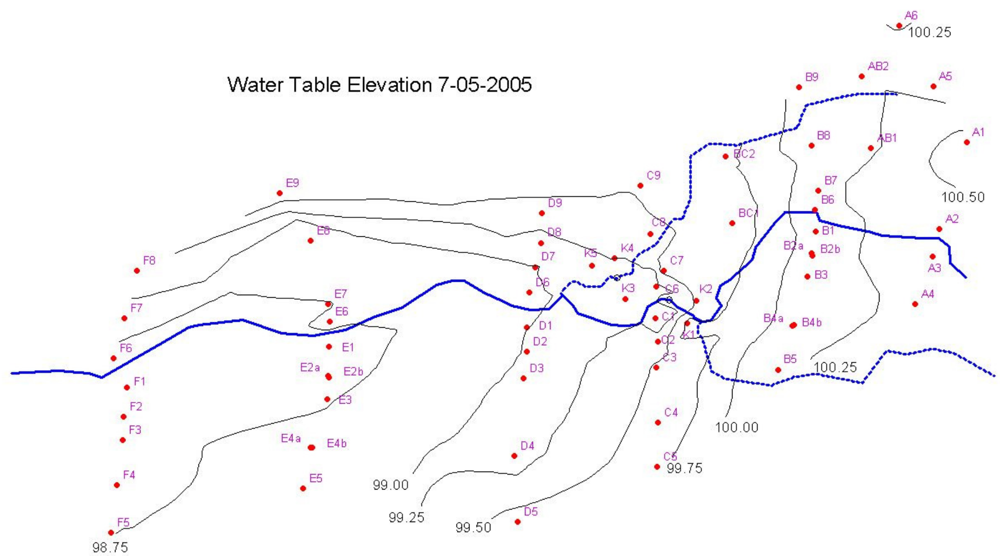
- Occurs as runoff from urbanization increases flows through a channel
- Cuts into the streambed, deepening the channel and altering its shape and the bank shape
- Changes the flow patterns of the water table
  - Water table drops at knickpoint
  - Groundwater flow direction changes to flow into the stream
  - Increase in hydraulic head can lead to bank failure





The Knickpoint

- A point upstream of which the channel and floodplain maintain natural condition
  - Large, well developed floodplain
  - Storm recovery
  - Fine grained, highly organic floodplain and streambed
- Downstream the channel is incised
  - Small or no floodplain
  - High erosion rates, little recovery after storms
  - Coarser grained, often soil has been eroded away entirely



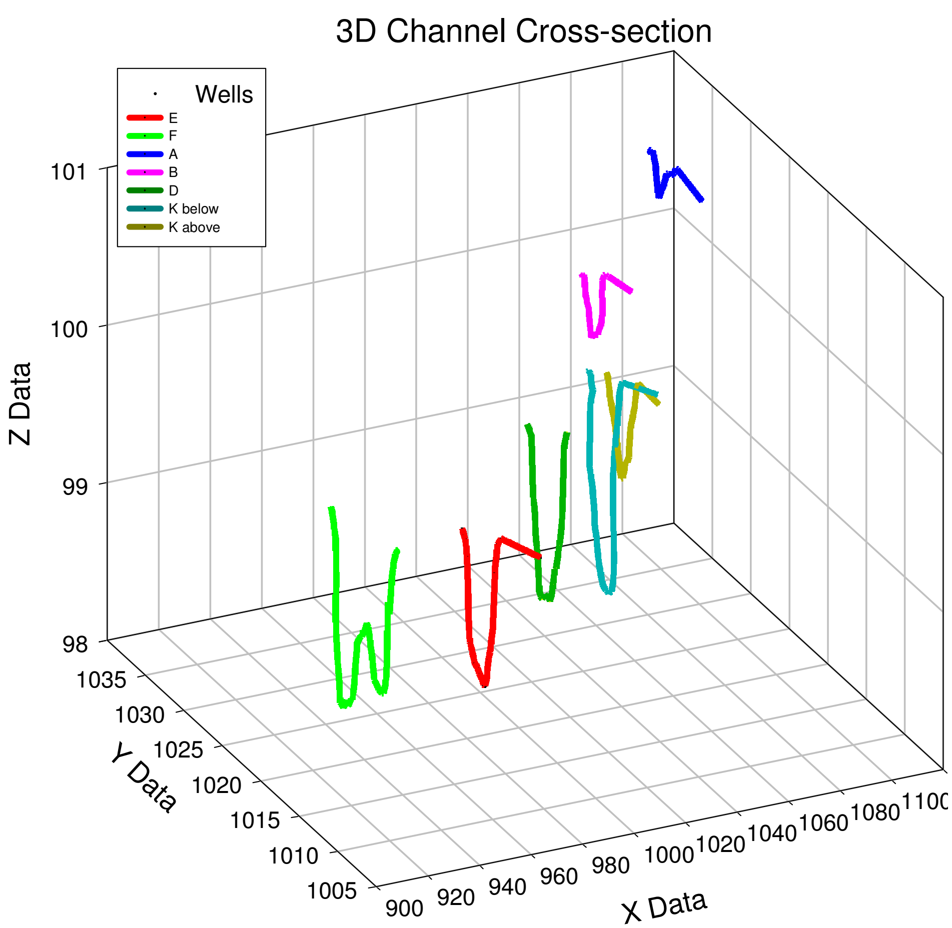
Hypotheses

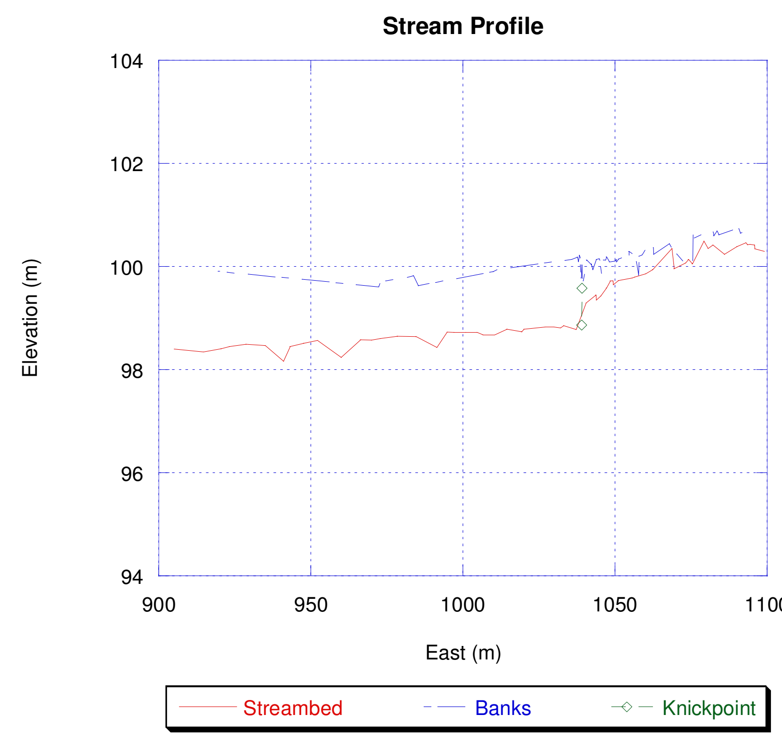
- The knickpoint is eroding at a rate of about 1.5 meters per year; floodplain recovery occurs at a slower rate
- The stream channel will reach a geomorphic equilibrium with the “new” discharge cycle downstream of the knickpoint
- Significant differences will exist between the newly built floodplain deposits downstream of the knickpoint and the floodplain upstream of the knickpoint

Methods

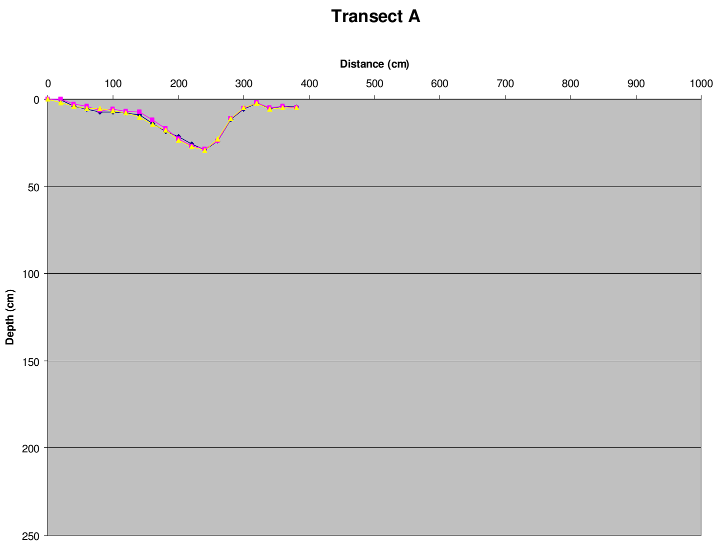
- Wells
  - Water table monitoring
  - Stratigraphy sections
- Channel cross-sections
  - June, July, and August 2005
  - October 2001
- Erosion pins
  - Across transects
  - At knickpoint
- Survey Data

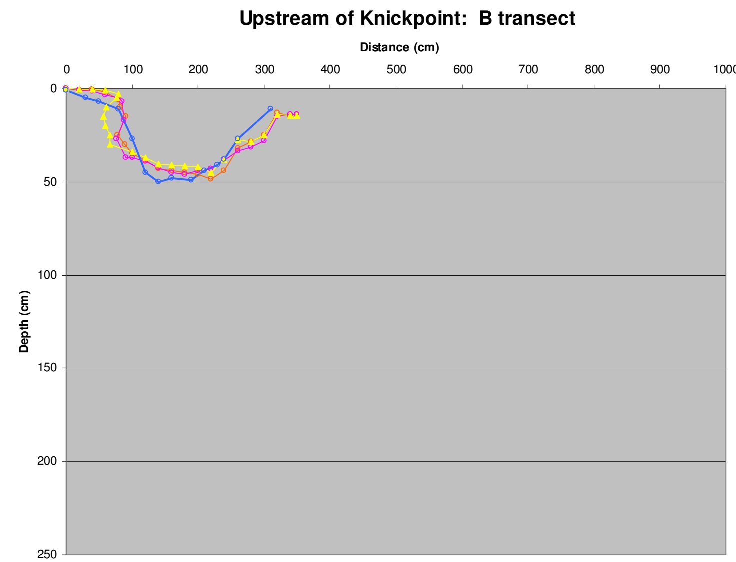
Channel profile

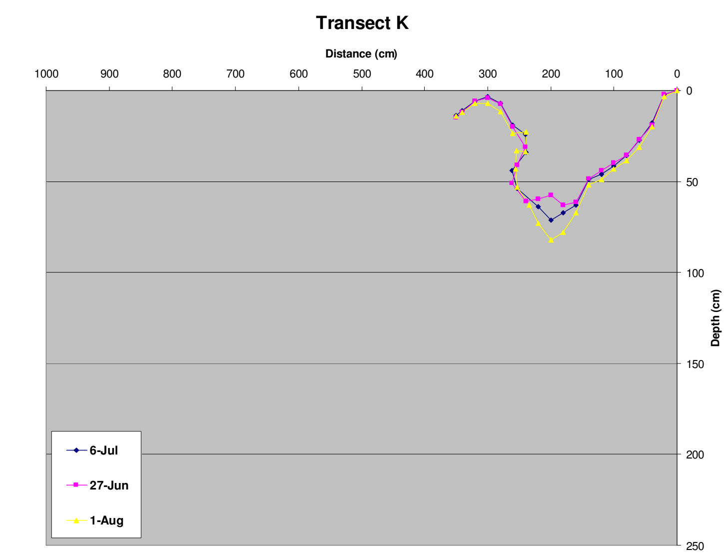


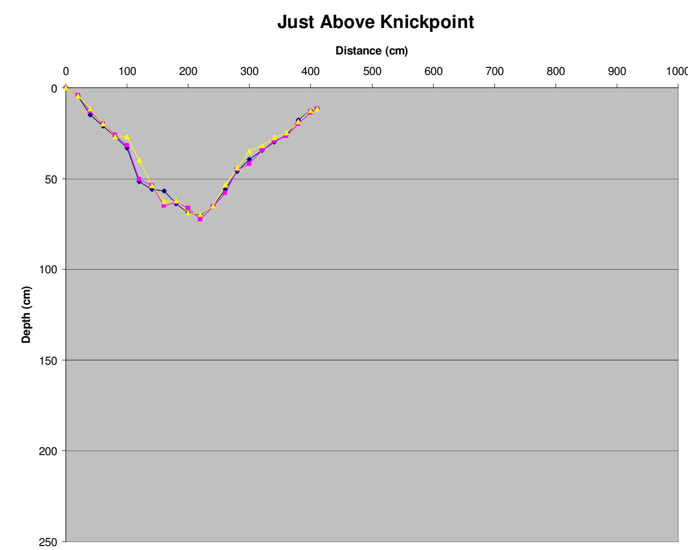


Channel modification and equilibrium above the knickpoint

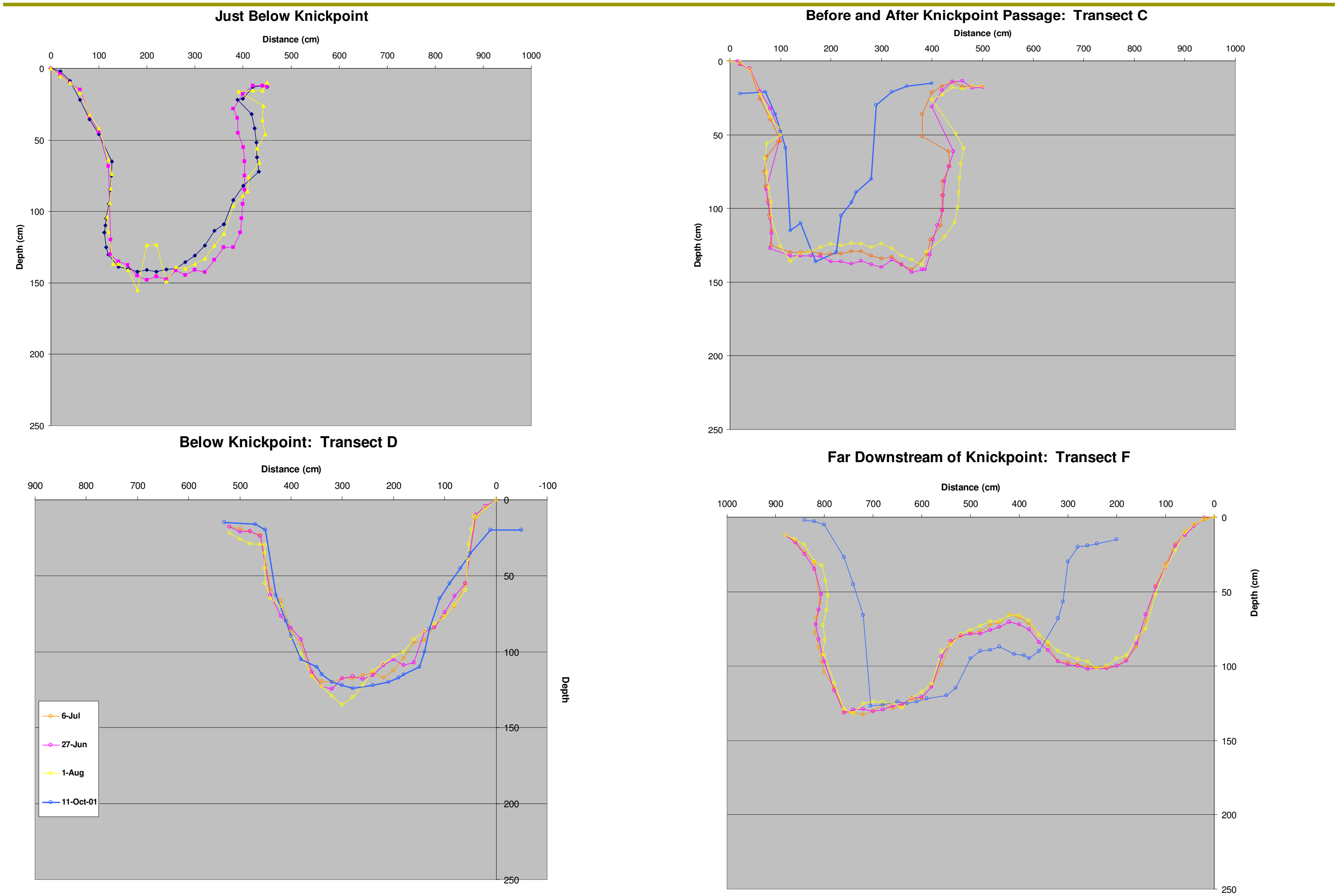








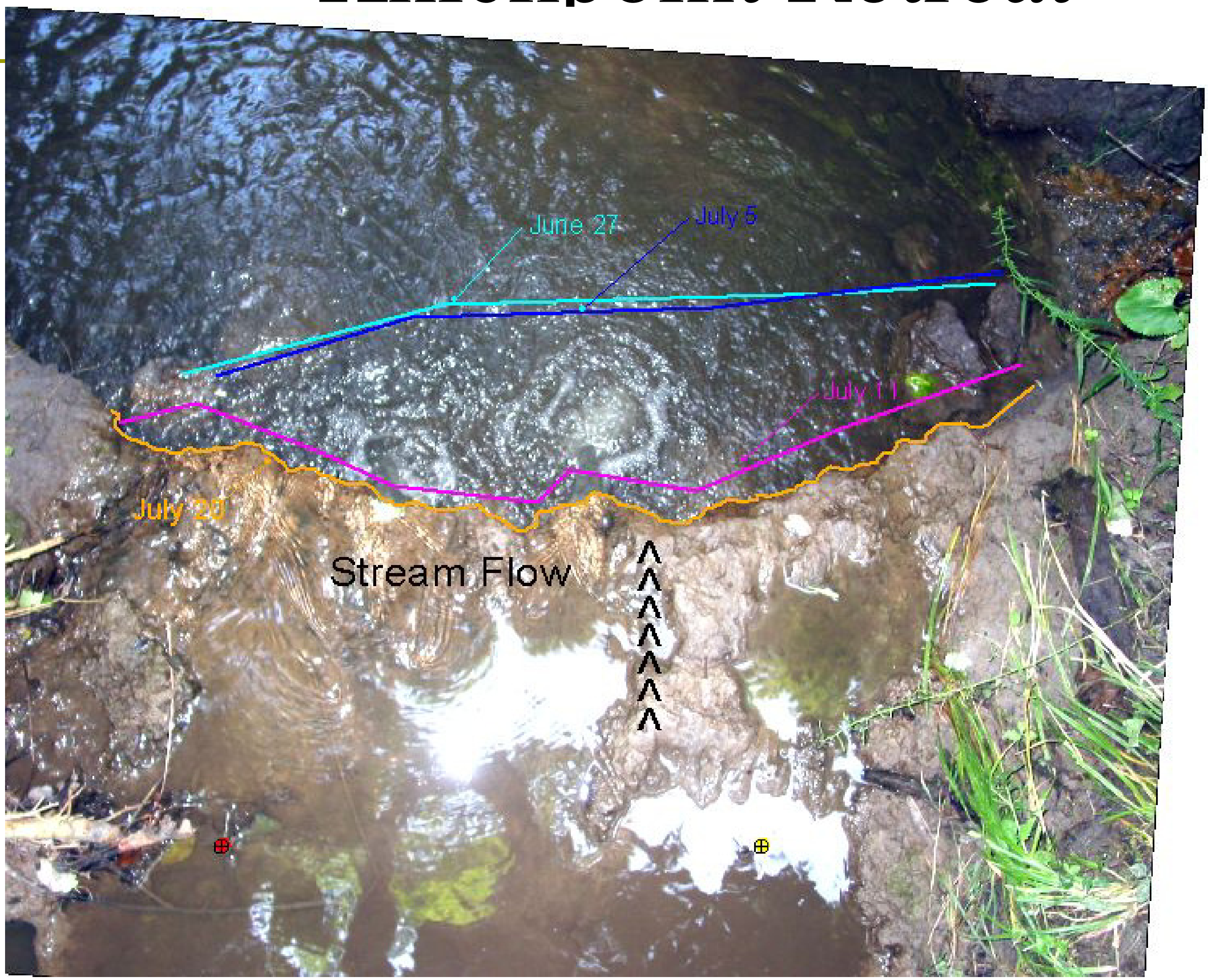
Channel modification and equilibrium below the knickpoint



Cross section area analysis

	Average size from summer 2005 x-sections	Average change between measurements	% change total 2005	% Growth since 2001
Transect A	4082 cm	145 cm	7%	
B	9471	72	2	8%
K	12099	851	14	
Just above k.p.	15707	407	5	
Just below k.p	41457	109	1	
C	47167	185	1	49
D	40828	492	2	-3
E	32340	235	1	
F	70468	1502	4	32

Knickpoint Retreat

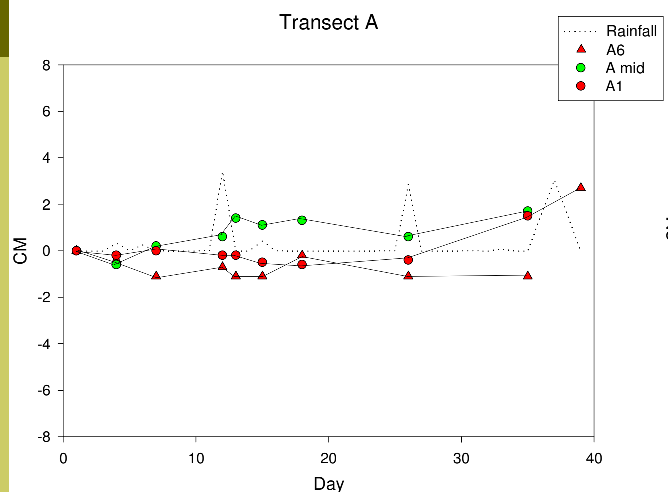


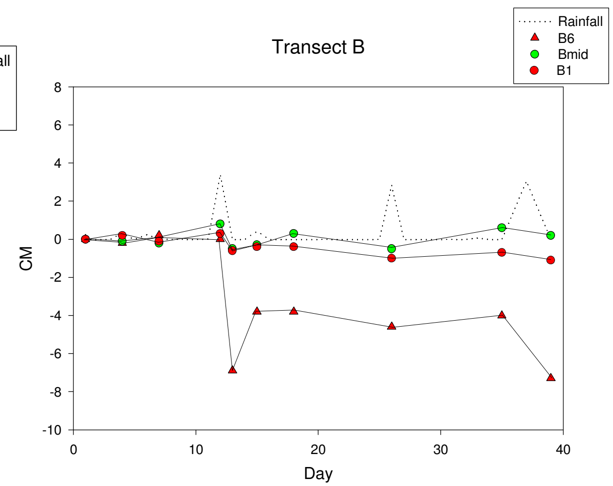
Retreats (cm):
27 June – 5 July: 1.2
5 July – 11 July: 16
11 July – 20 July: 3.6
Total: 20.8 cm

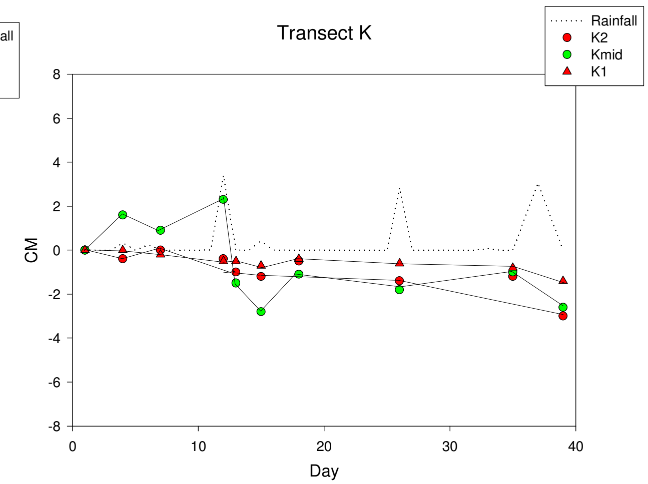
Rates of Change

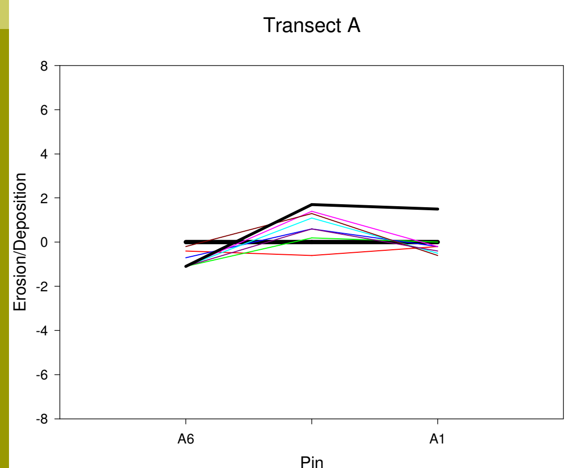
- Knickpoint
  - Summer: 20.8 cm; extended to one year = about 1 m per year (close)
  - **3.75 years: 595 cm, about 1.6 m per year**
    - Since 1950 (Eastern State development): 88 m, 10 m beyond transect E
    - If it started at F: 40 m more = 25 more years (1925)
  - If the knickpoint started at F, what does this mean?
- Banks and floodplain
  - Rapid drop in elevation following knickpoint passage
  - Some immediate deposition in channel, relatively stable channel
  - Deposits of coarse grains in banks following storm events leads to a slowly building floodplain
  - Unclear rate of new floodplain development; still no total recovery

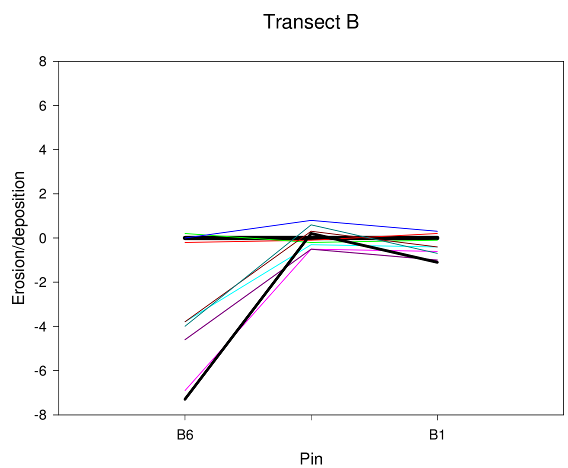
Erosion and deposition above the knickpoint

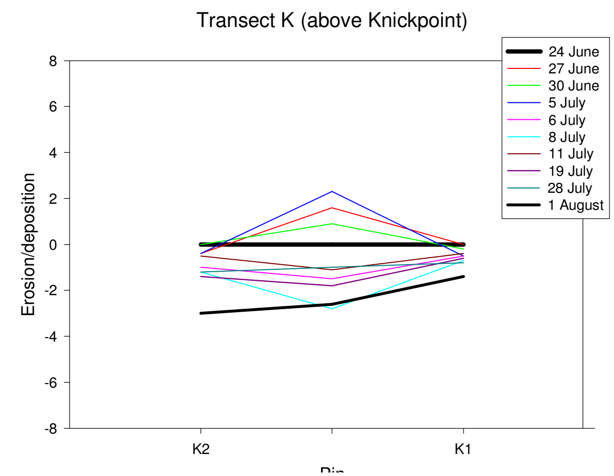




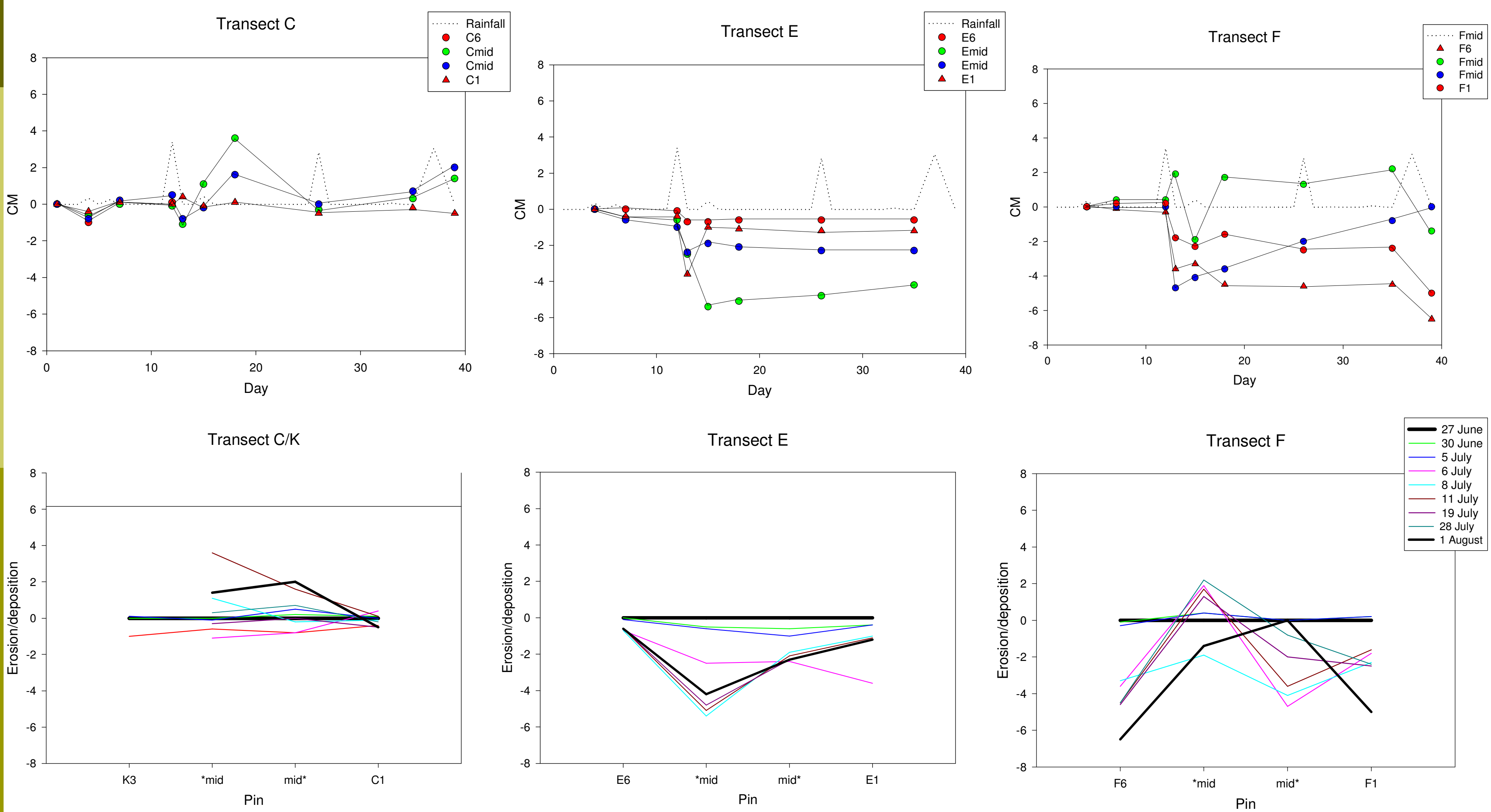








Erosion and deposition below the knickpoint



Erosion and storm recovery

Upstream of knickpoint

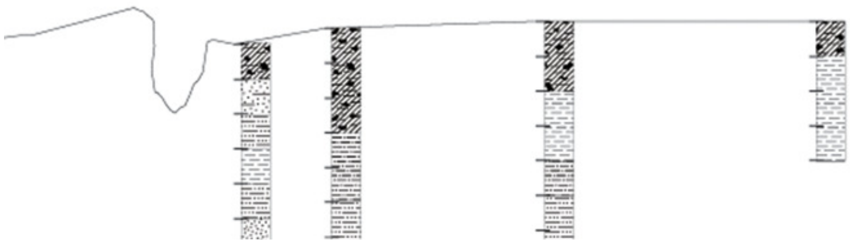
- Erosion
  - Less variation in erosion and deposition; net deposition following most storms
  - Deposition in channel
  - Closer to knickpoint incision begins
- Storm reaction
  - Storm response less extreme
  - Banks erode more than channel far upstream
  - Nearing the knickpoint channel bottom is more variable

Downstream of knickpoint

- Erosion
  - Close to knickpoint erratic deposition and erosion
  - Farther incision still is present
  - Farthest downstream deposition along channel bottom occurs less consistently
- Storm reaction
  - Channel deposition near knickpoint
  - At incision banks erode less quickly than channel
  - At newly building floodplain instability is still high

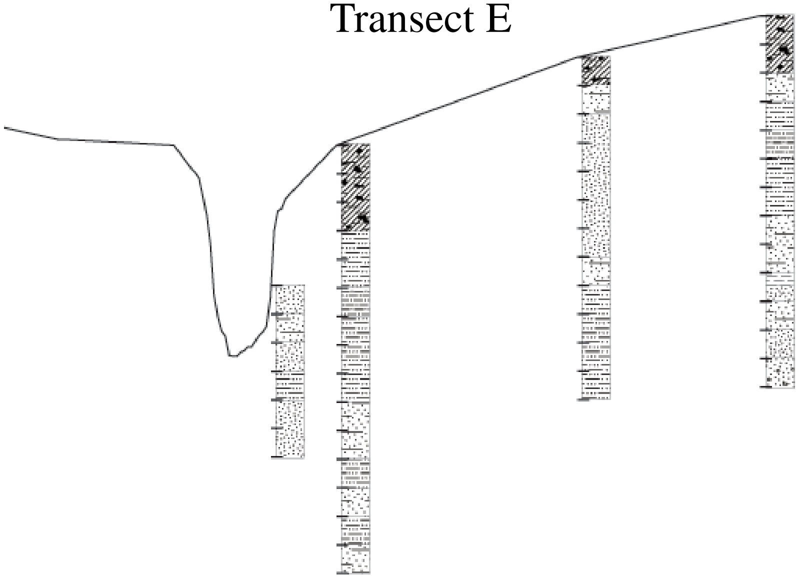
Floodplain Stratigraphy

Transect B

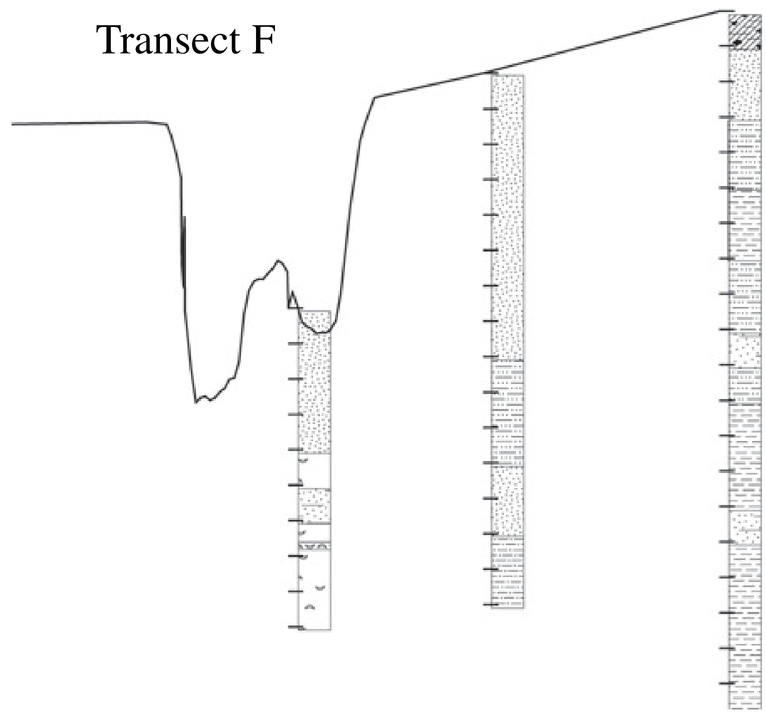


Transect C

Transect E



Transect F



Implications

- Knickpoint past
  - Could have started around transect E in response to incision, assuming a linear rate of about 1.6 m/year
  - Could have started at transect F given a nonlinear rate or other development conditions
- Knickpoint future
  - 71.5 m to transect A, about 44.5 years assuming linear rate
  - What then?
- Bank/floodplain recovery rate
  - Upwards of 50 years for current state
  - Still less stable than A; water table recovery has not fully occurred
- Recovered floodplain
  - Larger grain size
  - Less organic content
  - Total recovery?

Future Directions

- More on recovery rates
- Permanent changes to the stream channel and ecosystem?
- Grain size and stratigraphy analyses in the channel and floodplain
- Pore water pressure and bank failure measurements
- Remediation and prevention techniques

Acknowledgements

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