Measuring bedload transport on large rivers: A case study from the Missouri River, USA

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Columbia Environmental
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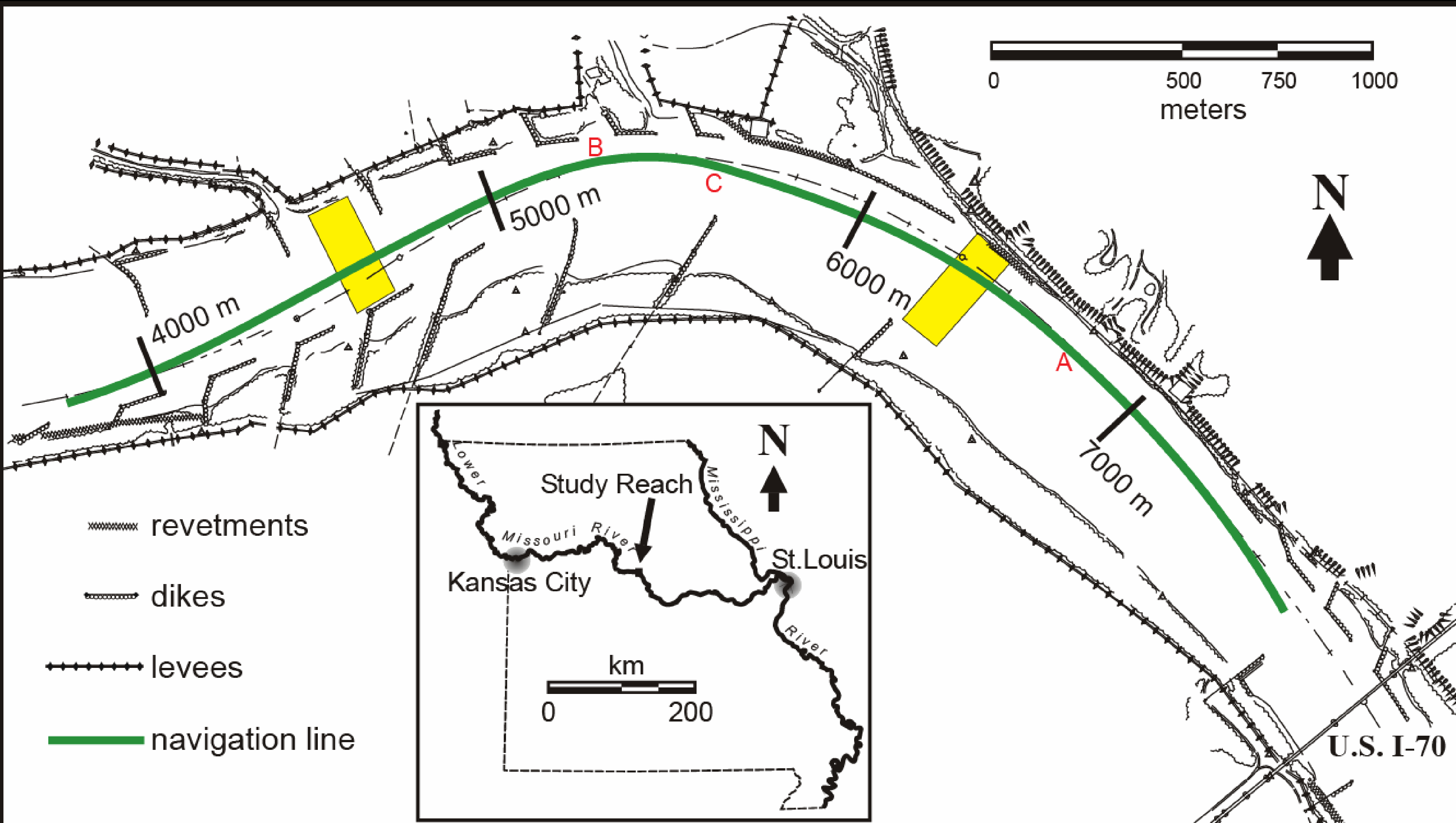
River Corridor Habitat Dynamics

Methods to estimate bedload transport

Conventional physical sampling

Dune tracking

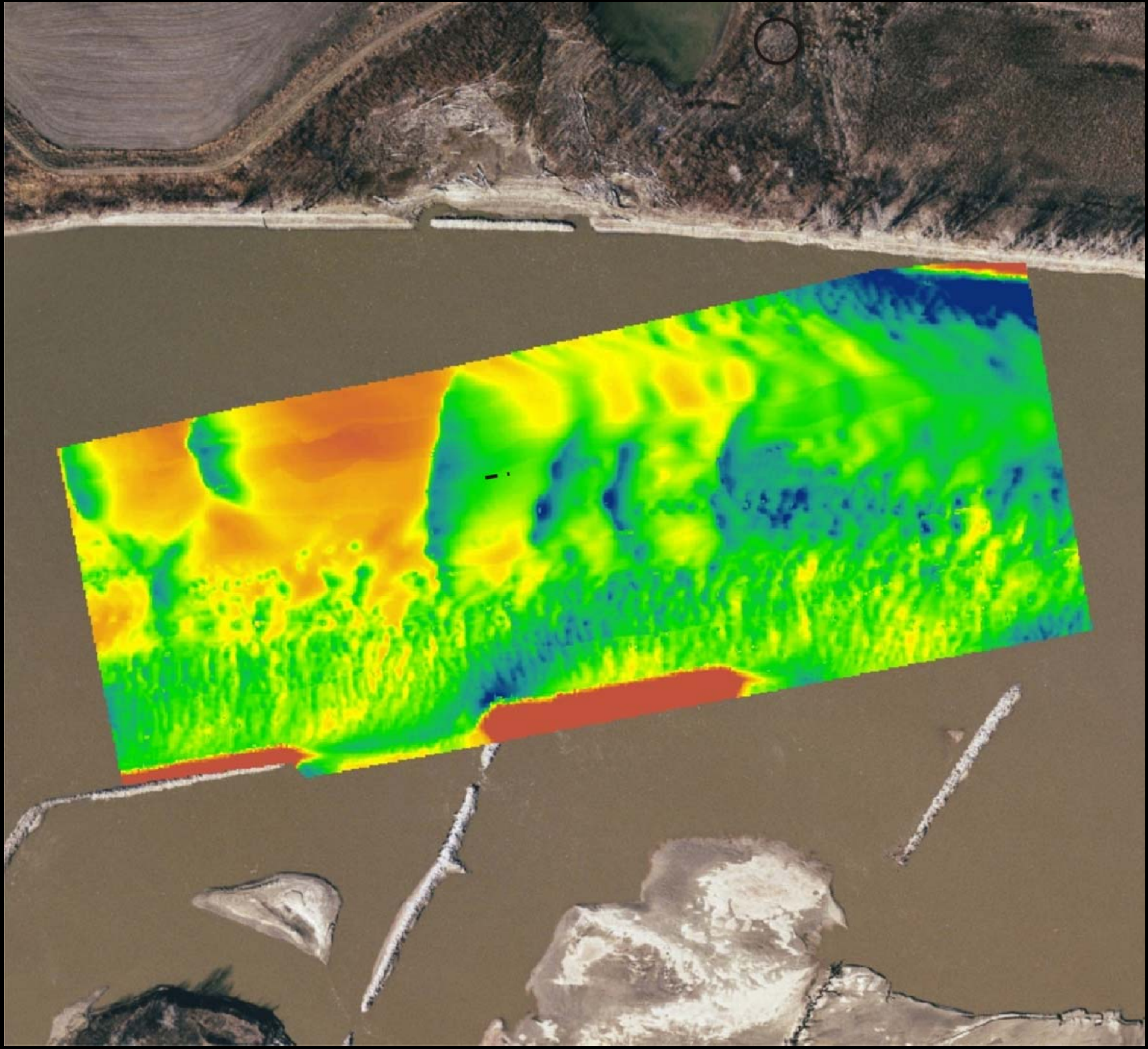
Acoustic bed velocity (ADCP)

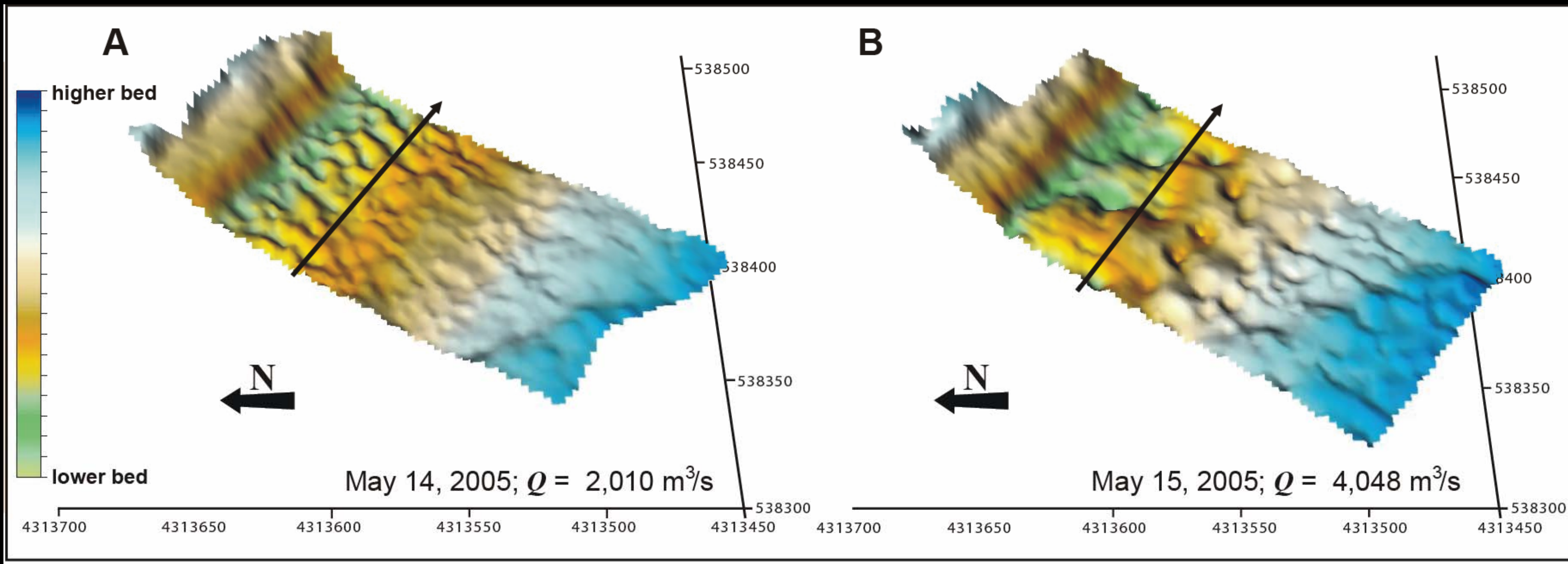


0
500
750
1000
meters
N
B
C
A
4000 m
5000 m
6000 m
7000 m
U.S. I-70
revetments
dikes
levees
navigation line
Lower Missouri River
Mississippi River
Study Reach
St.Louis
Kansas City
km
0
200


USGS
MERCURY

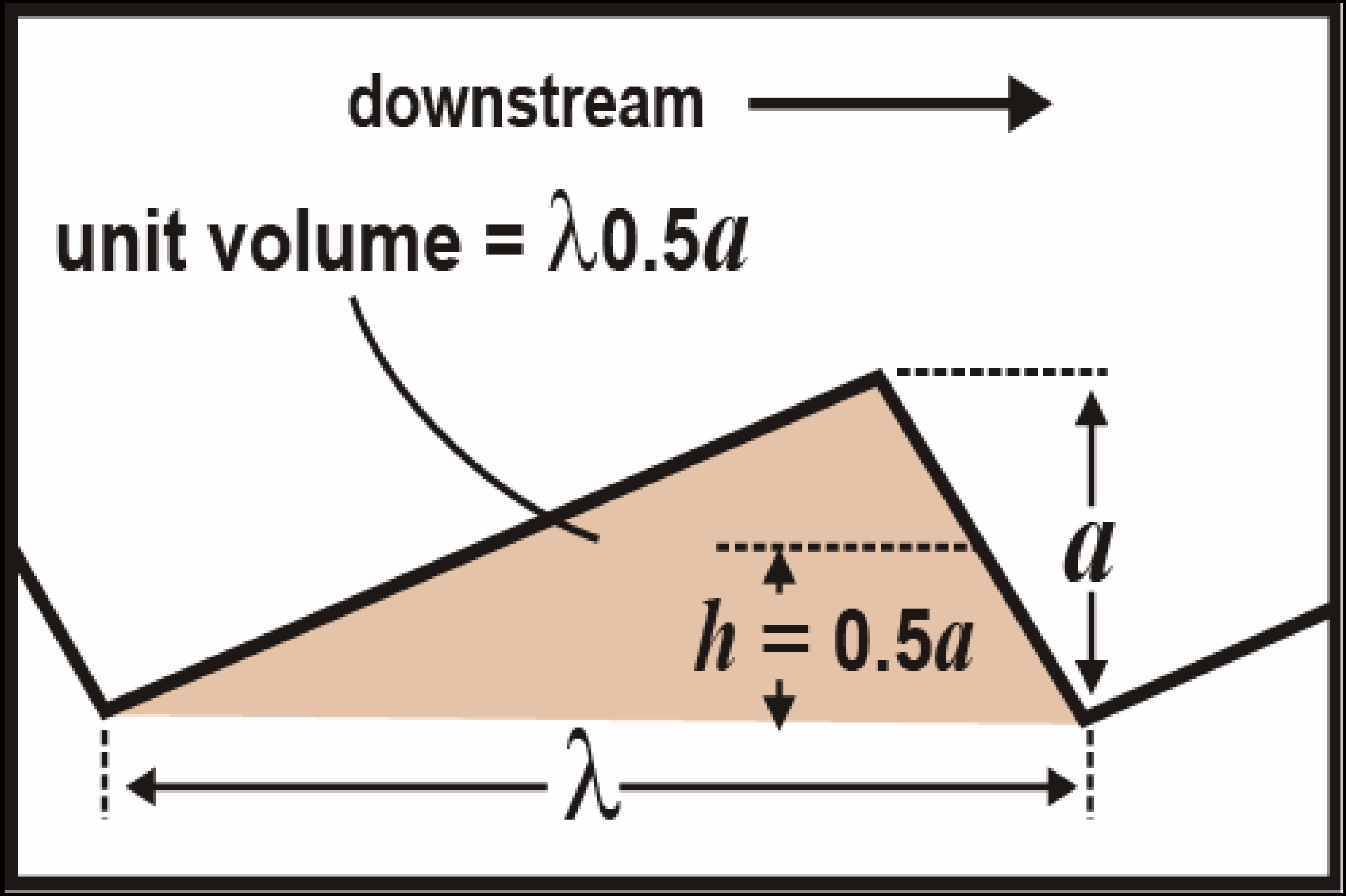
Navigation



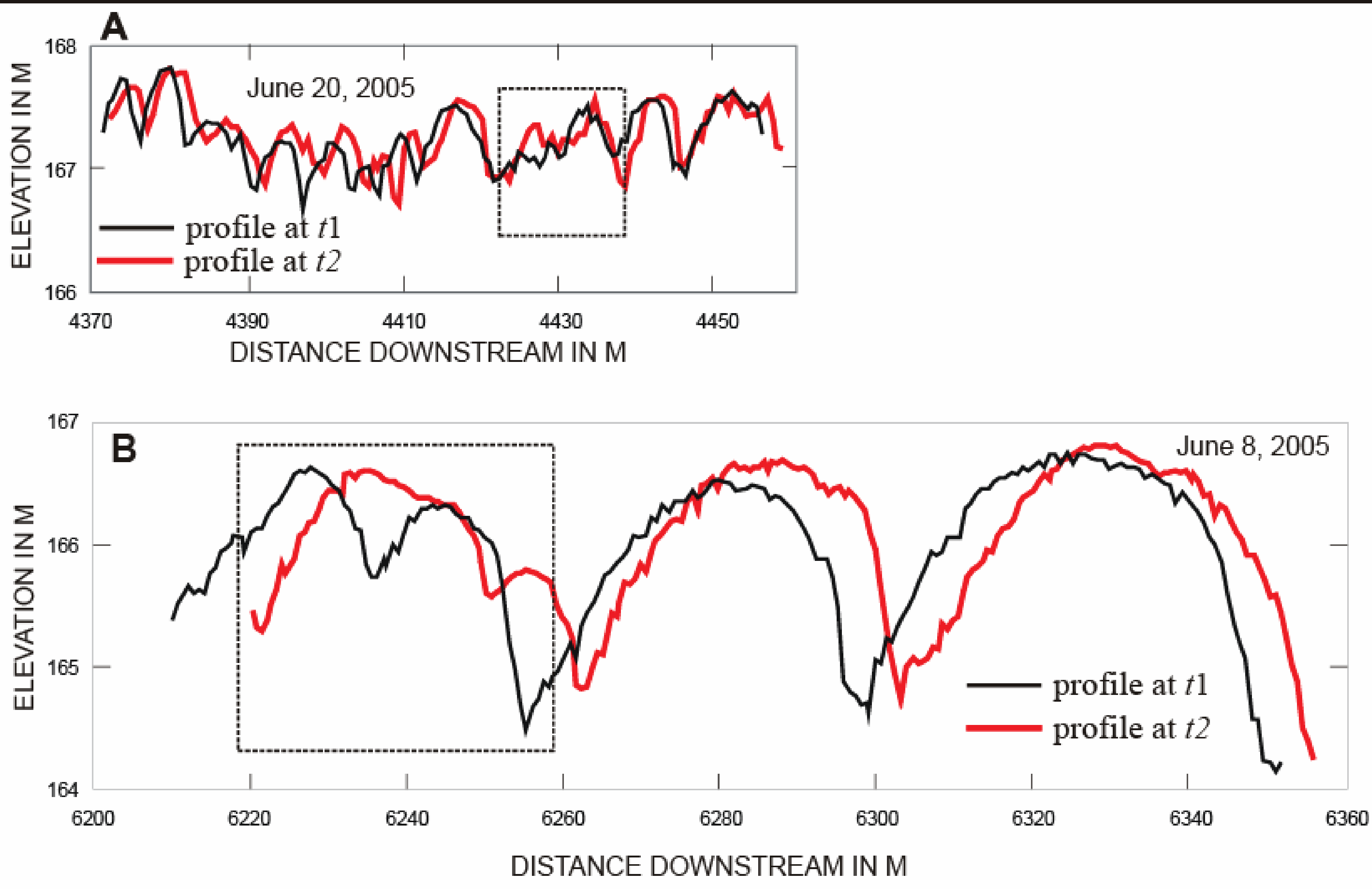


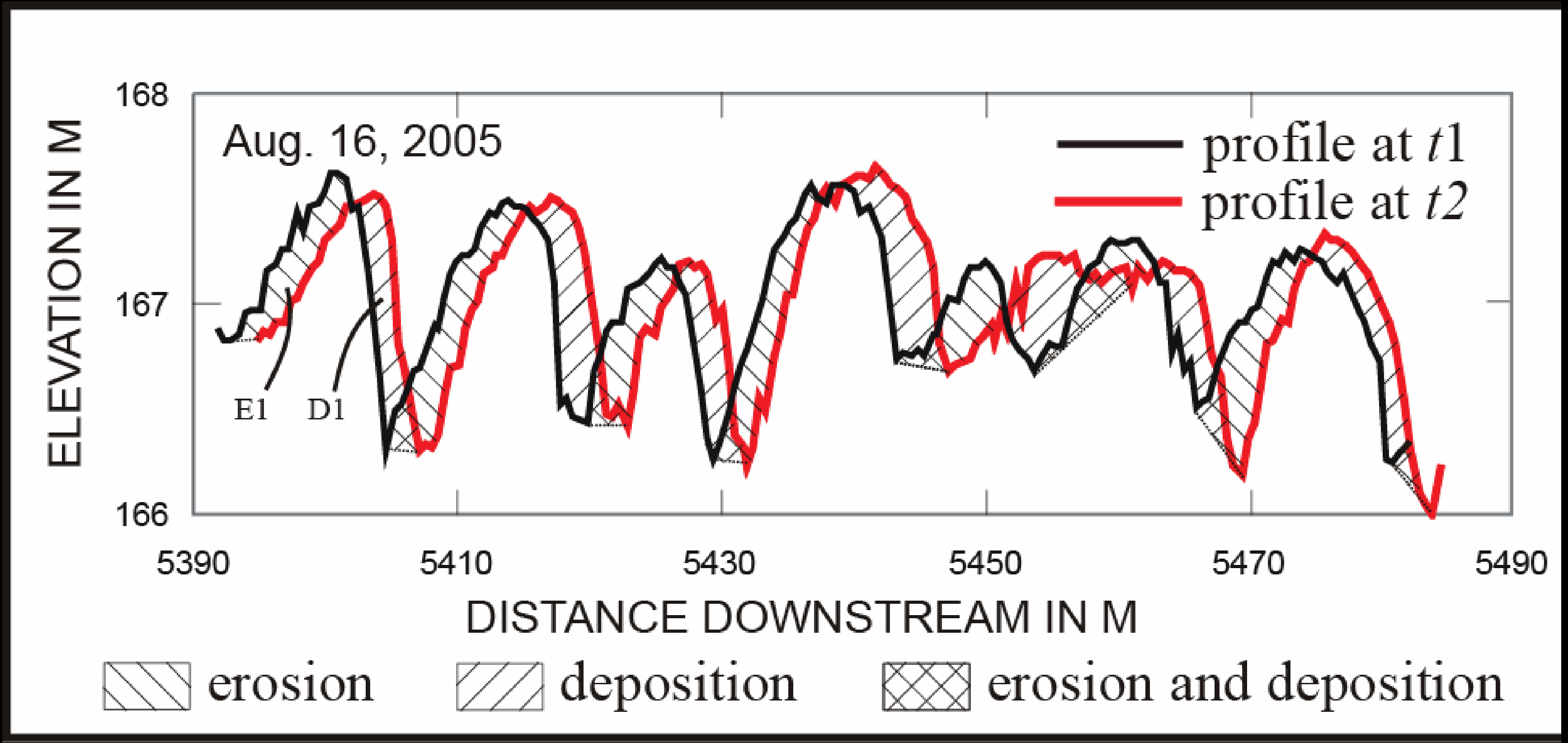
A
higher bed
lower bed
May 14, 2005; Q = 2,010 m3/s
N
538500
538450
538400
538350
538300
4313700
4313650
4313600
4313550
4313500
4313450
B
May 15, 2005; Q = 4,048 m3/s
N
538500
538450
8400
538350
538300
4313700
4313650
4313600
4313550
4313500
4313450


R/V LUCIEN M. BRUSH



$$q_b = \beta(1-\varepsilon)a\frac{dx}{dt} + C_1$$


A
June 20, 2005
ELEVATION IN M
168
167
166
4370
4390
4410
4430
4450
DISTANCE DOWNSTREAM IN M
profile at t1
profile at t2
B
June 8, 2005
ELEVATION IN M
167
166
165
164
6200
6220
6240
6260
6280
6300
6320
6340
6360
DISTANCE DOWNSTREAM IN M
profile at t1
profile at t2



Aug. 16, 2005
profile at t1
profile at t2
168
167
166
ELEVATION IN M
E1
D1
5390
5410
5430
5450
5470
5490
DISTANCE DOWNSTREAM IN M
erosion
deposition
erosion and deposition

BED ELEVATION IN M
169.5
169
168.5
168
167.5
167
166.5
0
10
20
30
40
50
60
70
8
DISTANCE IN M
Type 1 bedforms, July 27, Q= 2,490 m 3/s
Type 2 bedforms, June 18, Q = 3,960 m 3/s

Acoustic Dopper Current Profiler

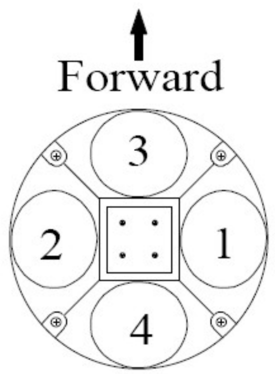
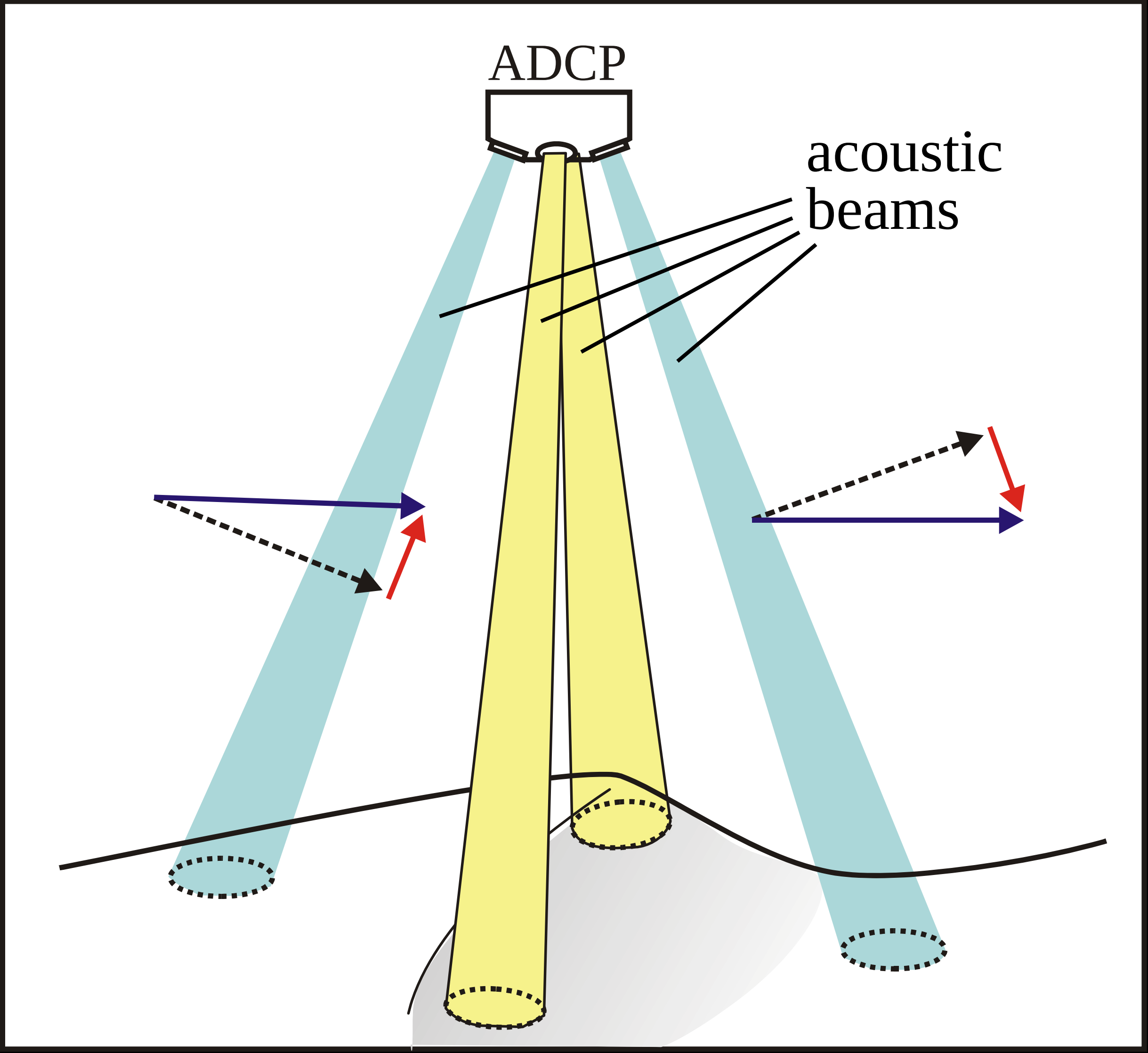


Figure 18. View facing an ADCP transducer.

Source: RD Instruments, Inc. 1996



Bottom-Track Bed Velocity

Bottom-track pings (BT):

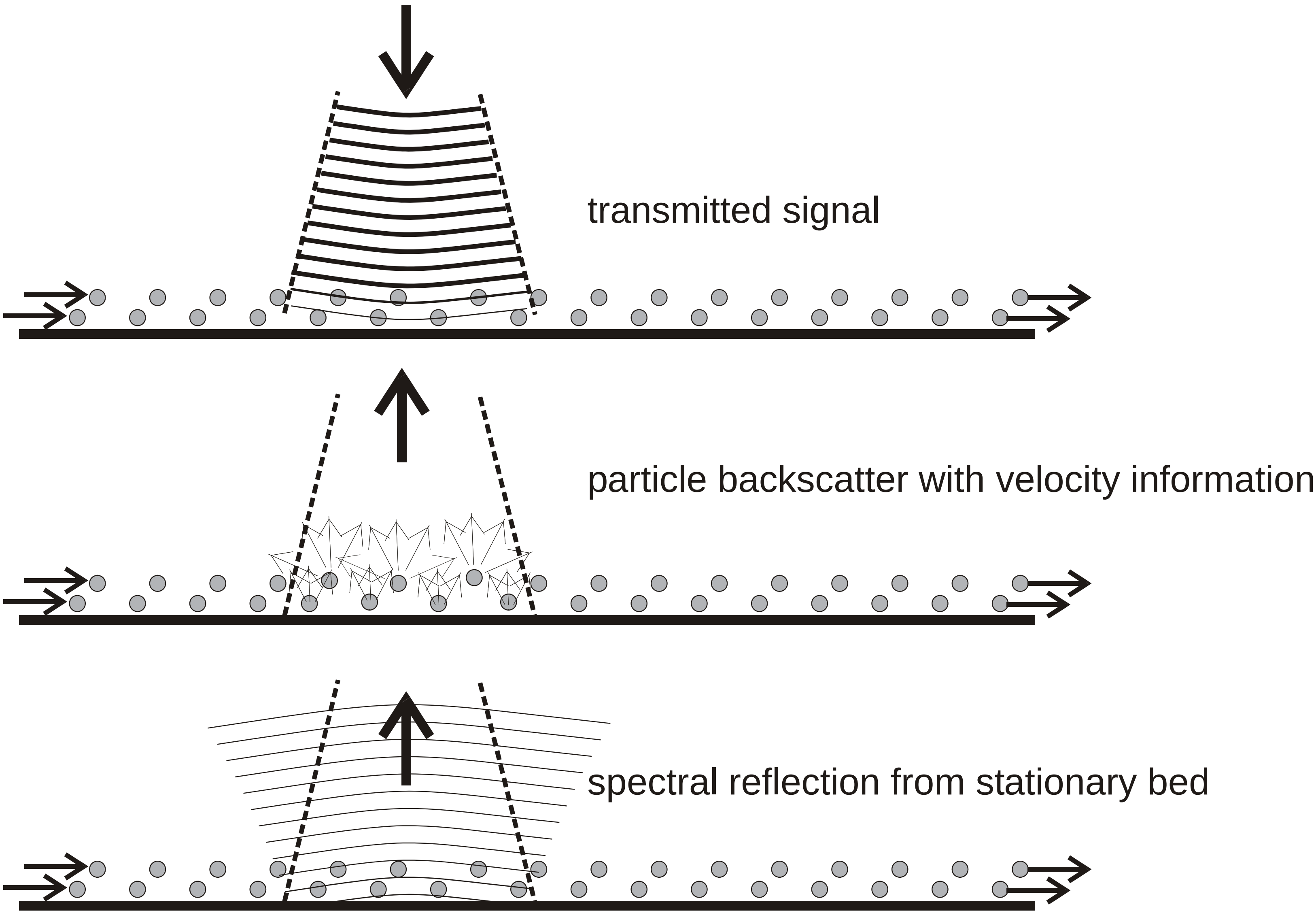
Measure ADCP velocity relative to bed

RTK GPS:

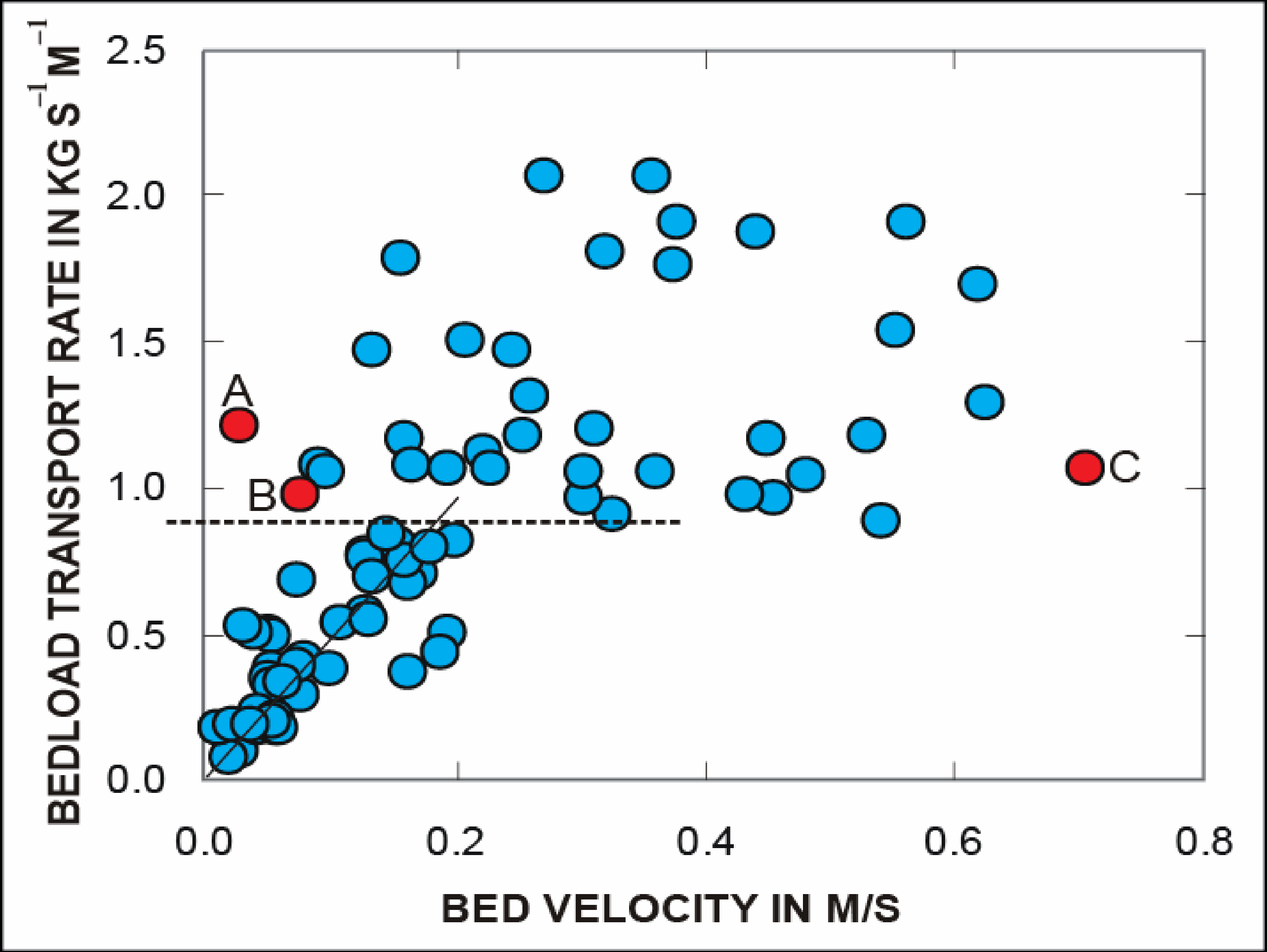
Measure actual ADCP velocity

BT– GPS = Bed Velocity

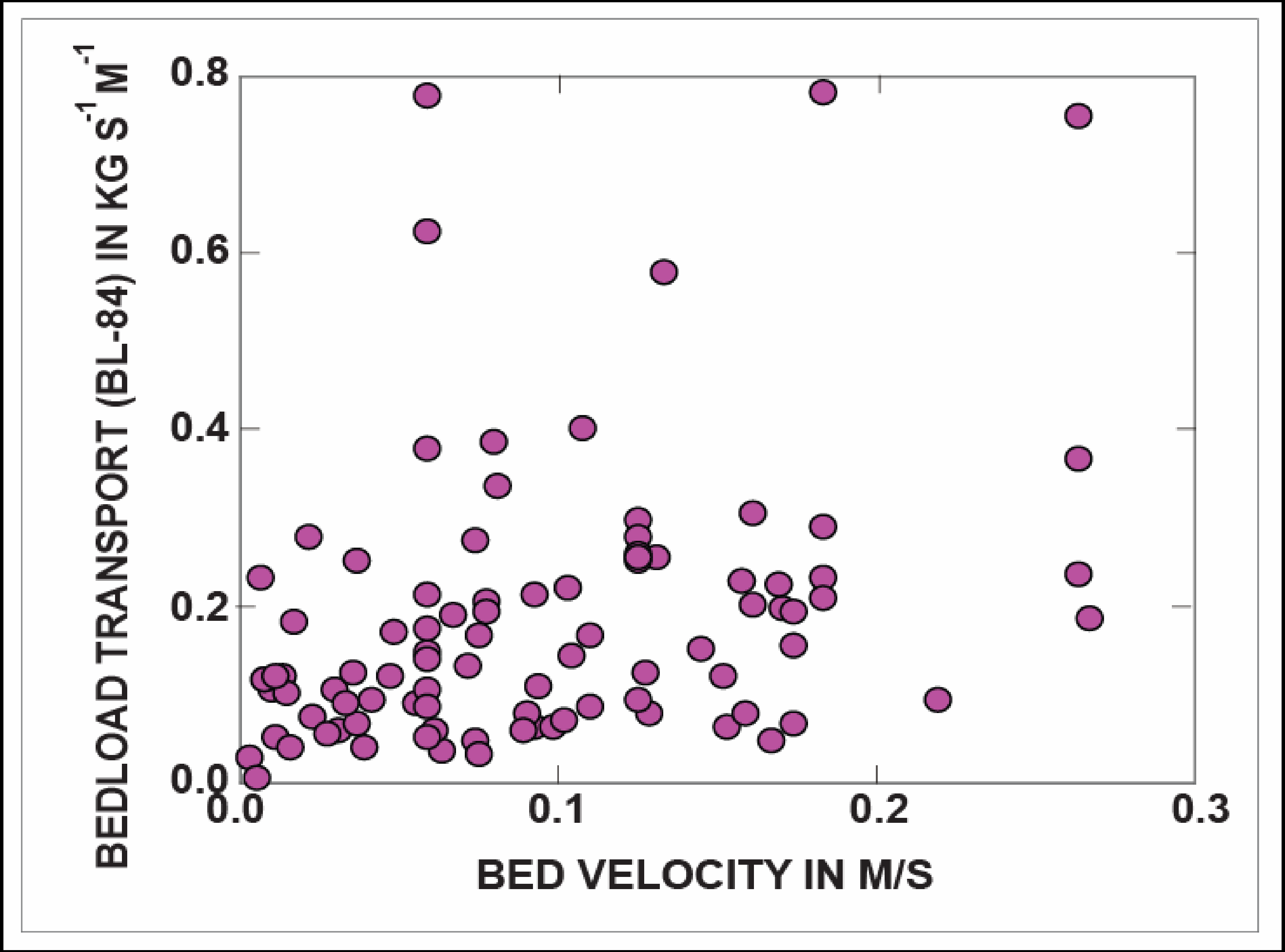
(i.e., velocity of sediment moving at the bed)



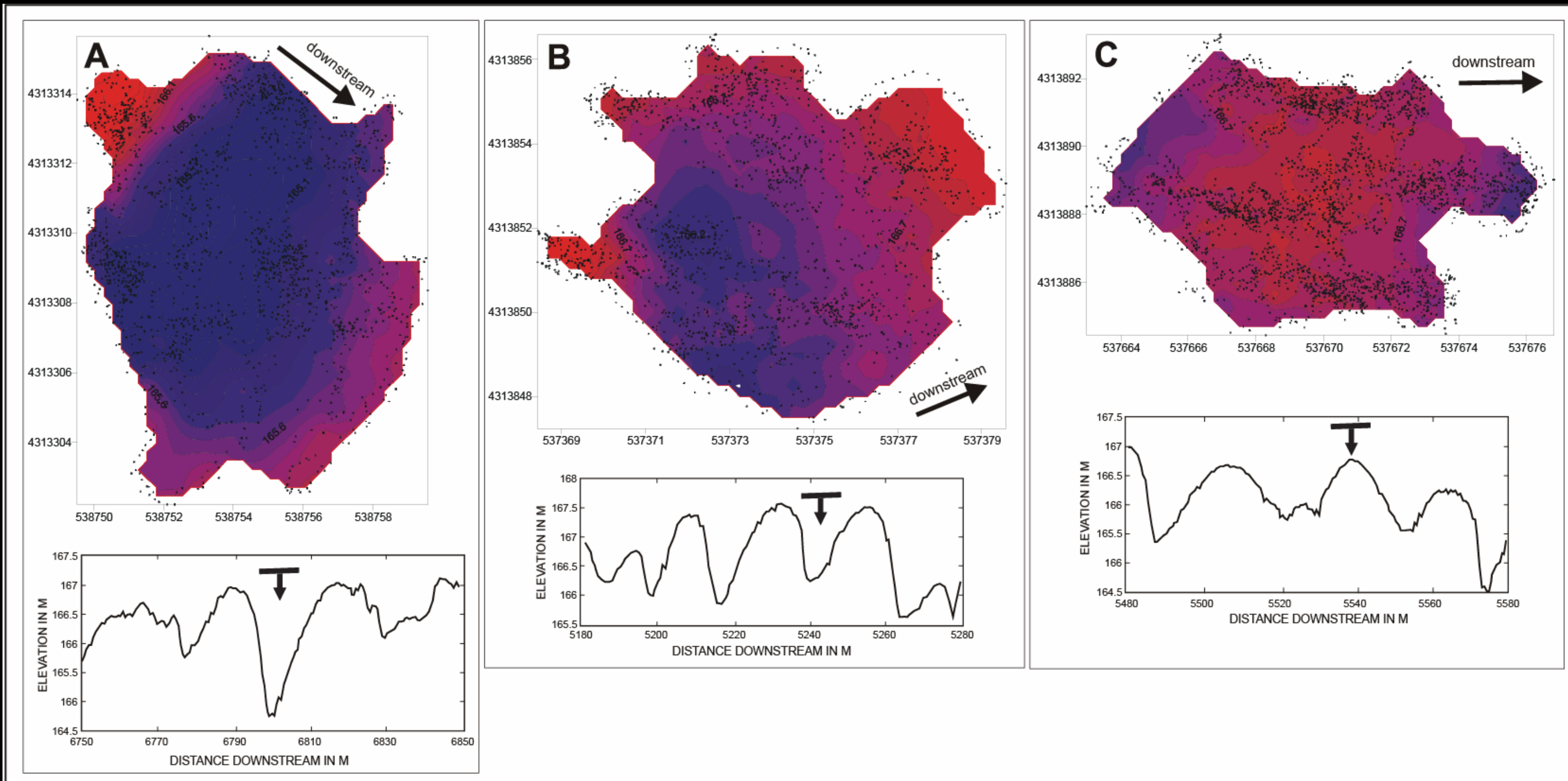
Rennie and Villard **[2004] put it this way:** $g_b = \sum_i \nu_{pi} \left[\delta_i (1 - \lambda_i) \frac{A_i}{A} \rho_s \right]$



Dune tracking to validate/calibrate



Physical sampling to validate/calibrate



A
downstream
4313314
4313312
4313310
4313308
4313306
4313304
538750
538752
538754
538756
538758
ELEVATION IN M
DISTANCE DOWNSTREAM IN M
B
downstream
4313856
4313854
4313852
4313850
4313848
537369
537371
537373
537375
537377
537379
C
downstream
4313892
4313890
4313888
4313886
537664
537666
537668
537670
537672
537674
537676

Summary

Good correlation between dune tracking results and ADCP bed velocity measurements suggest both methods are effective when transport stage is less than about 17.

Dune tracking probably underestimates transport at higher transport stages

Bed velocity *may* be robust at higher transport stages

The relation between bed velocity and bedload transport rate cannot be described by a single stable calibration

A Suggested Bedload Sampling Strategy

Dune-tracking along multiple longitudinal profiles distributed laterally across the active channel
(length of each profile is sufficient to encompass several complete dunes; suggest 1 channel width)

Coupled ADCP bed velocity measurements obtained along profiles between first and second dune-tracking pass
(boat is slowly drifted upstream and downstream a distance sufficient to sample a complete dune)

Look for stable calibrations at specific verticals or consistent spatial patterns in calibration to reduce future dune-track effort

Why measure bedload transport?

A significant fraction of all bed-material load is transported as bedload

Bed-material budgets identify sources/sinks at the segment/catchment scales

Bed-material fluxes are boundary conditions for predictive modeling at the reach scale.

Knowledge of local-scale bedload dynamics is useful in the design of self-maintaining channel and aquatic habitat features