Sediment Transport in Gravel-Bed Rivers
with implications for channel change

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Lecture 1. Overview & General Principles

Begins with an overview discussing types of transport and transport problems, the problems of variability and sparse information in predicting transport, units and dimensionless variables describing flow and transport, and sediment rating curves. We then consider a classic transport model for coarse-bedded streams. The model demonstrates that the main problems associated with accurately estimating transport rate arise because transport is highly sensitivity to uncertainties in the flow driving the transport (the flow problem) and to uncertainties in the composition of the sediment bed (the sediment problem).

Lecture 2. The Flow Problem

We examine what determines the distribution of boundary shear stress producing transport. We demonstrate why one cannot develop a general transport model in terms of water discharge (as convenient as that would be).

Tuesday 27 January

Lecture 3. The Sediment Problem

The effect of sediment grain size shows up in transport models through the critical shear stress for incipient grain motion. We define standard relations for critical shear stress and discuss its different personalities and applications.

Lecture 4. Topics in Mixed-Size Sediment Transport

Gravel-bed rivers are invariably characterized by a very wide range of grain sizes. We consider three problems of mixed-size sediment transport (partial transport, armoring, and the effect of sand supply on transport rates) and in the process build two transport models. There is a focus in several lectures on building transport models—not that you would necessarily want to build your own—but knowing how they the models are built helps you to understand how they work and how to use them responsibly.

Wednesday 28 January

Lecture 5. Estimating Transport Rates

Finally, we get to the very basic (and difficult) problem of estimating transport rates, considering whether the balance of effort and accuracy is better served with a formula prediction, with many transport observations in the field, or a hybrid. We consider the very difficult problem of sampling bed material transport and present a calibrated approach that appears to address the "flow" and "sediment" problems and to optimize the tradeoff between effort and accuracy.

Lecture 6. Sediment Transport and Channel Change

In the last lecture, we combine a transport relation with governing equations for the flow to develop approximate relations that can be used to estimate whether a stream channel is likely to store or evacuate sediment, which is the first step is evaluating possible channel change.

These lecture notes, along with a few spreadsheets and journal papers, can be downloaded from a URL to be announced in class.

A (very) few readings

Middleton, G.V. & Southard, J.B., 1984, Mechanics of Sediment Movement, SEPM Short Course #3, 401 p.

20 years old, but the best and most accessible coverage of the physics of sediment transport (little on transport of coarse sediment, however). Out of print; must be found on the black market or through interlibrary loan.

Engelund, F. and Hansen, E., 1972, A Monograph on Sediment Transport in Alluvial Streams, Teknisk Forlag, Copenhagen. 62p.

A gem of a monograph, giving the clearest presentation of the classical engineering approach to sediment transport (all about sand, however). Again, out of print; must be found on the black market or through interlibrary loan.

Henderson, F.M., 1966. Open Channel Flow, Macmillan, 522 p.

THE book on open channel flow. So good and so clear, the absence of material on modern computing can be overlooked.

Yalin, M.S., 1977, Mechanics of Sediment Transport, 2nd ed., Pergamon, 298 p.

Yalin, M.S., 1991. River Mechanics, Pergamon, 219 p.

If you are truly serious about sediment transport, you must, at some point, wrestle with the unique and creative perspective offered by Yalin.

Tritton, D.J., 1988. Physical Fluid Dynamics, Oxford, Clarendon Press, 2nd ed., 519 p.

A very nice, very clear presentation of the physics of fluid flow.

White, F.M., 1998. Fluid Mechanics, 4th ed., McGraw-Hill, 752 pp.

The best basic engineering fluid mechanics book.

Wiberg, P.L. and J.D. Smith, A theoretical model for saltating grains in water, J. Geophys. Res. 90(C4):7341-7354, 1985.

The clearest and most comprehensive discussion of theoretical transport models.

Garcia, M. and G. Parker, 1991. Entrainment of bed sediment into suspension, J. Hydr. Eng., 117(4):414-435.

A very good introduction to the transport of sediment in suspension.

Parker, G., and P. C. Klingeman, On why gravel bed streams are paved, Water Res. Res., 18, 1409-1423, 1982.

Good introduction to the modern perspective transport in gravel-bed streams.