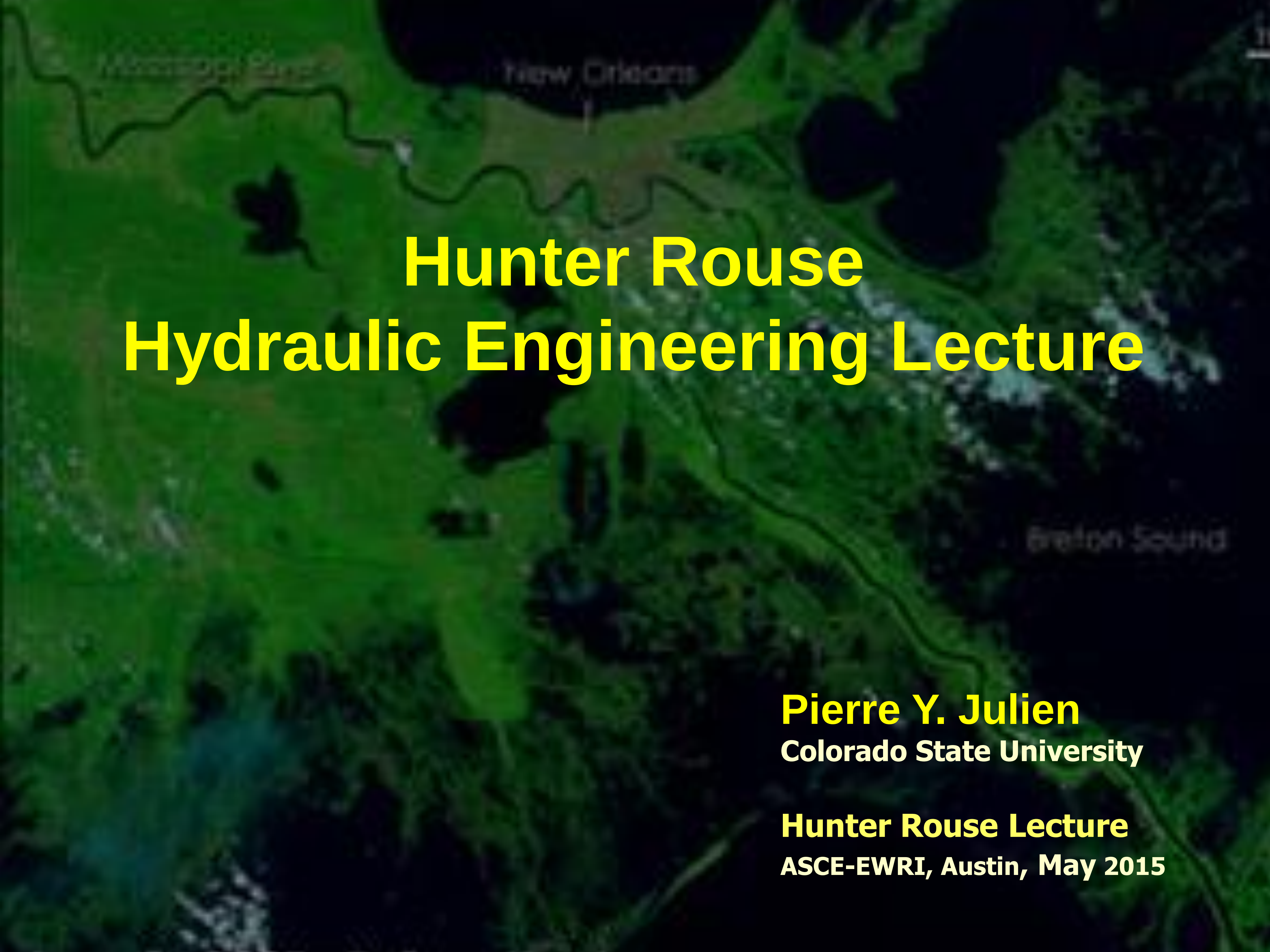


Hunter Rouse
Hydraulic Engineering Lecture

Pierre Y. Julien
Colorado State University

Hunter Rouse Lecture
ASCE-EWRI, Austin, May 2015

1) My H&H dream

2) By year 2000, …

3) We all know …

4) Hunter Rouse and CSU …

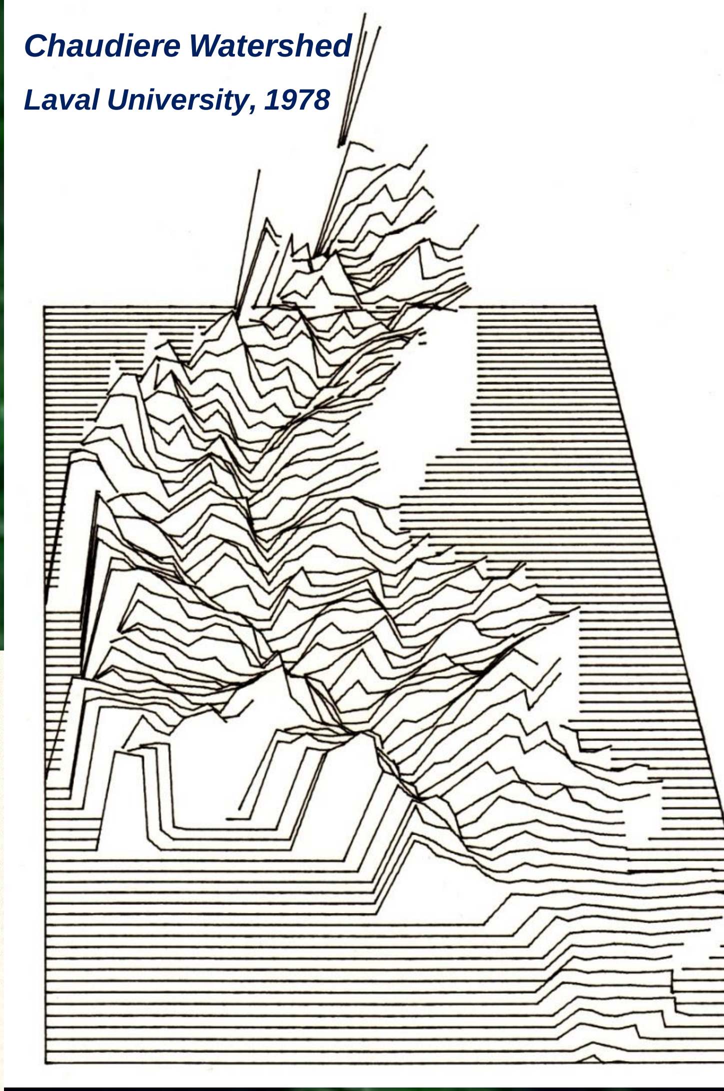
1) My H&H dream

"…every sediment particle which passes a cross-section must:

(1) have been eroded on the watershed; and

(2) must be transported by the flow to the cross-section…"

Hans Albert Einstein, 1964

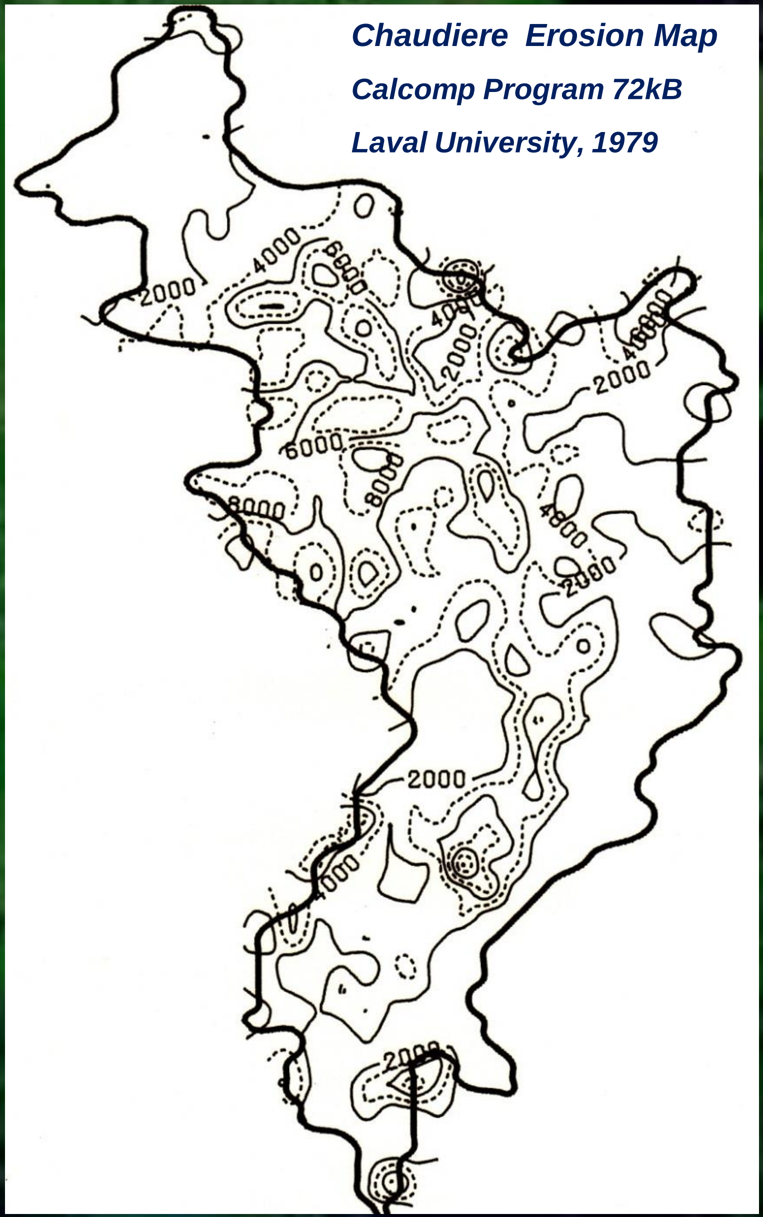


1462	3529	36	66	1680	250	3	FMF	1	1479	3583	55	4
1463	3530	35	66	1575	375	2	FFM	1	1464	3531	115	4
1464	3531	34	66	1460	375	3	AFC	1	1481	3585	0	16
1465	3532	33	66	1600	325	3	FMM	1	1482	3586	160	4
1466	3533	32	66	1510	175	3	CMA	1	1483	3587	35	16
1467	3534	31	66	1550	250	3	CAF	2	1484	3588	175	4
1468	3535	30	66	1290	475	2	FMA	2	1469	3536	0	12
1469	3536	29	66	1290	275	2	HAA	2	1470	3537	10	768
1470	3537	28	66	1280	225	2	UAH	4	1471	3538	5	784
1471	3538	27	66	1275	250	1	FAA	2	1453	3484	15	796
1472	3539	26	66	1475	125	4	FMA	2	1471	3538	200	4
1473	3540	25	66	1245	300	1	AFF	2	1455	3486	15	64
1474	3541	24	66	1250	425	4	FAM	1	1473	3540	5	48
1475	3542	23	66	1375	400	1	FFM	1	1457	3488	50	20
1476	3543	22	66	1475	425	4	FMC	1	1475	3542	100	16
1477	3544	21	66	1515	500	4	FCM	1	1476	3543	40	12
1478	3545	20	66	1625	700	4	FCM	1	1477	3544	110	4
1479	3583	36	67	1625	250	3	AMF	1	1495	3637	45	8
1480	3584	35	67	1550	300	3	AMF	1	1496	3638	50	4
1481	3585	34	67	1460	375	2	MHF	1	1482	3586	20	20
1482	3586	33	67	1440	375	3	MFC	1	1498	3640	15	28
1483	3587	32	67	1475	250	2	CAF	1	1484	3588	100	20
1484	3588	31	67	1375	275	3	CMF	1	1500	3642	75	28
1485	3589	30	67	1290	400	2	MFA	2	1486	3590	0	4
1486	3590	29	67	1290	125	1	HHF	1	1469	3536	0	752
1487	3591	28	67	1390	350	1	AMU	3	1470	3537	110	4
1488	3592	27	67	1425	375	1	FAM	1	1471	3538	150	4
1489	3593	26	67	1370	350	2	AFA	2	1490	3594	30	4
1490	3594	25	67	1340	300	1	FMC	1	1473	3540	95	12
1491	3595	24	67	1270	425	1	FFM	1	1474	3541	20	44
1492	3596	23	67	1300	475	4	FMM	1	1491	3595	30	40
1493	3597	22	67	1450	475	4	FMC	1	1492	3596	150	16
1494	3598	21	67	1625	625	4	MCC	1	1493	3597	175	4
1495	3637	36	68	1580	275	2	CMA	1	1496	3638	80	12
1496	3638	35	68	1500	175	2	MFC	1	1497	3639	25	20
1497	3639	34	68	1475	325	3	FMM	1	1513	3693	35	24
1498	3640	33	68	1425	375	2	MFC	1	1499	3641	100	32

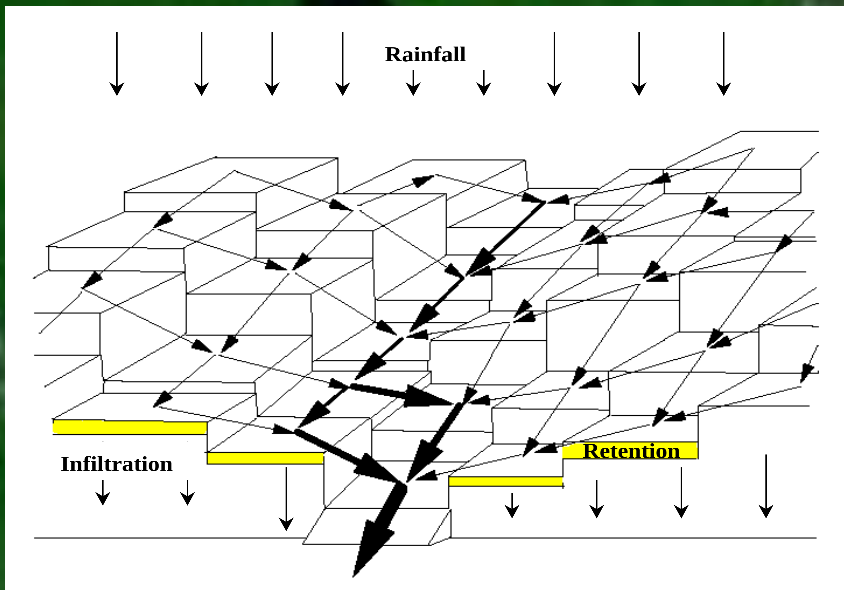
Lets remember:

The IBM 360 needed the library basement to process 72kB of data.

Today, 72GB of data fits in your pocket.



From Julien, MS thesis, 1979



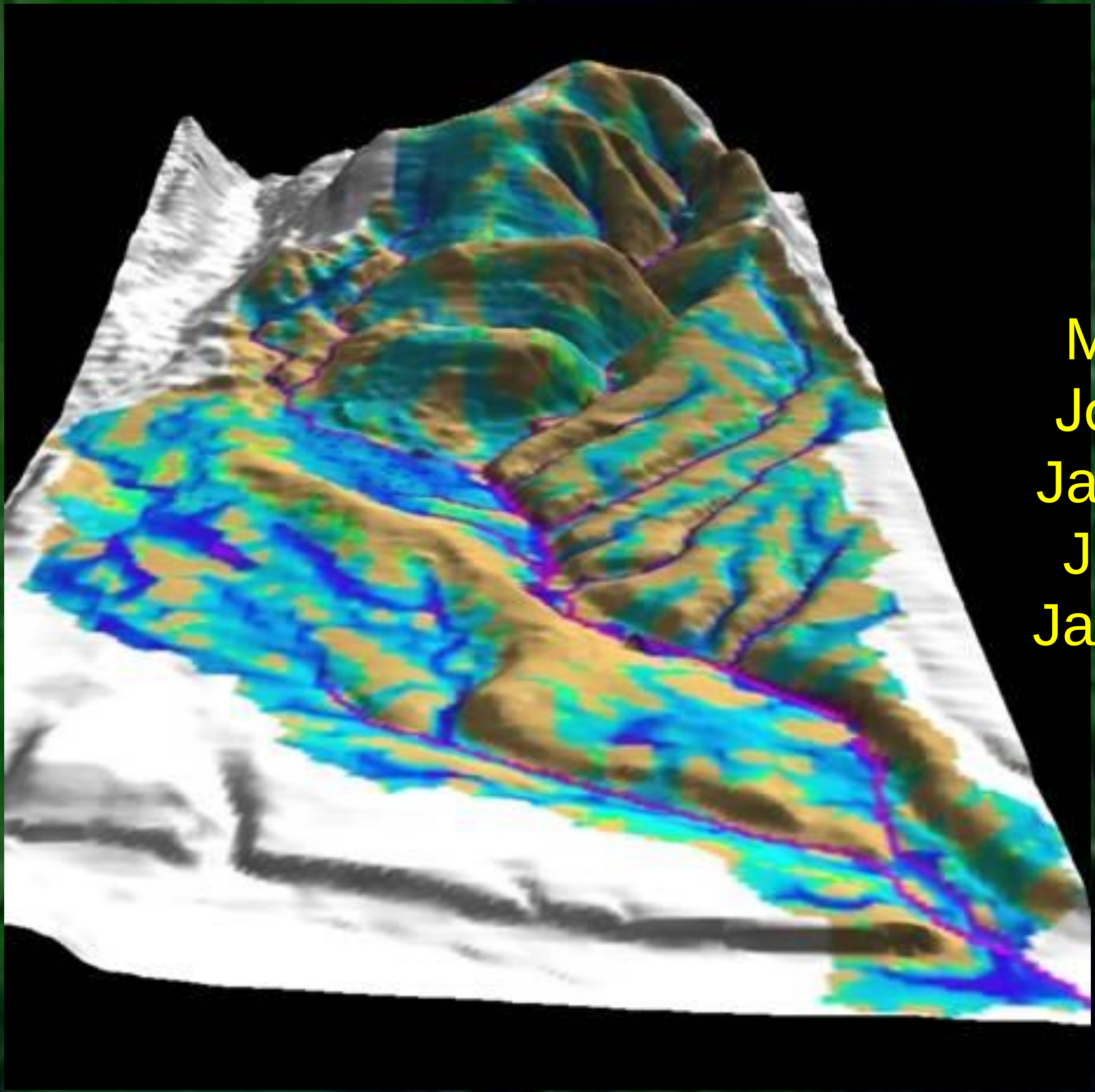
CASC2D- Julien et al. (1995)

Jerry Richardson, PhD ‘89
Bahram Saghafian, PhD ‘92
Fred Ogden, PhD ‘92
William Doe III, PhD ‘92
Don May, PhD ‘93
Darcy Molnar, PhD ‘97

CASC2D-SED – Johnson et al. (2000)

Billy Johnson, PhD ‘97
Jeff Jorgeson, PhD ’99
Amit Sharma, PhD ‘00
Rosalia Rojas, PhD ‘02

Aug. 9, 2005: Before Katrina



TREX Model

Mark Velleux, PhD ‘05

John England, PhD ‘06

James Halgren, PhD ‘12

Jaehoon Kim, PhD ‘12

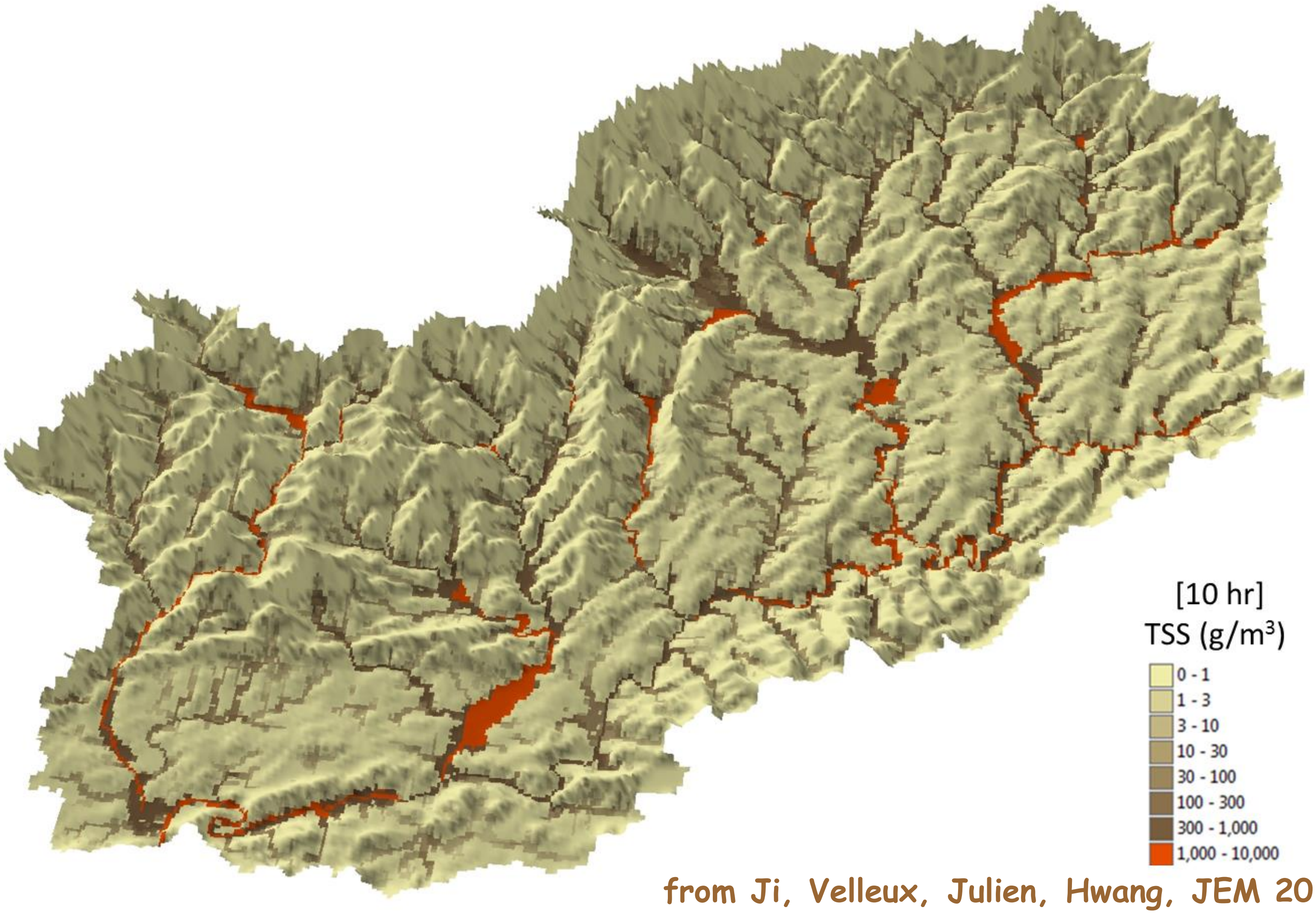
Jazuri Abdullah, PhD ‘13

CSU Watershed Model TREX

Surface Water Depth [ft]

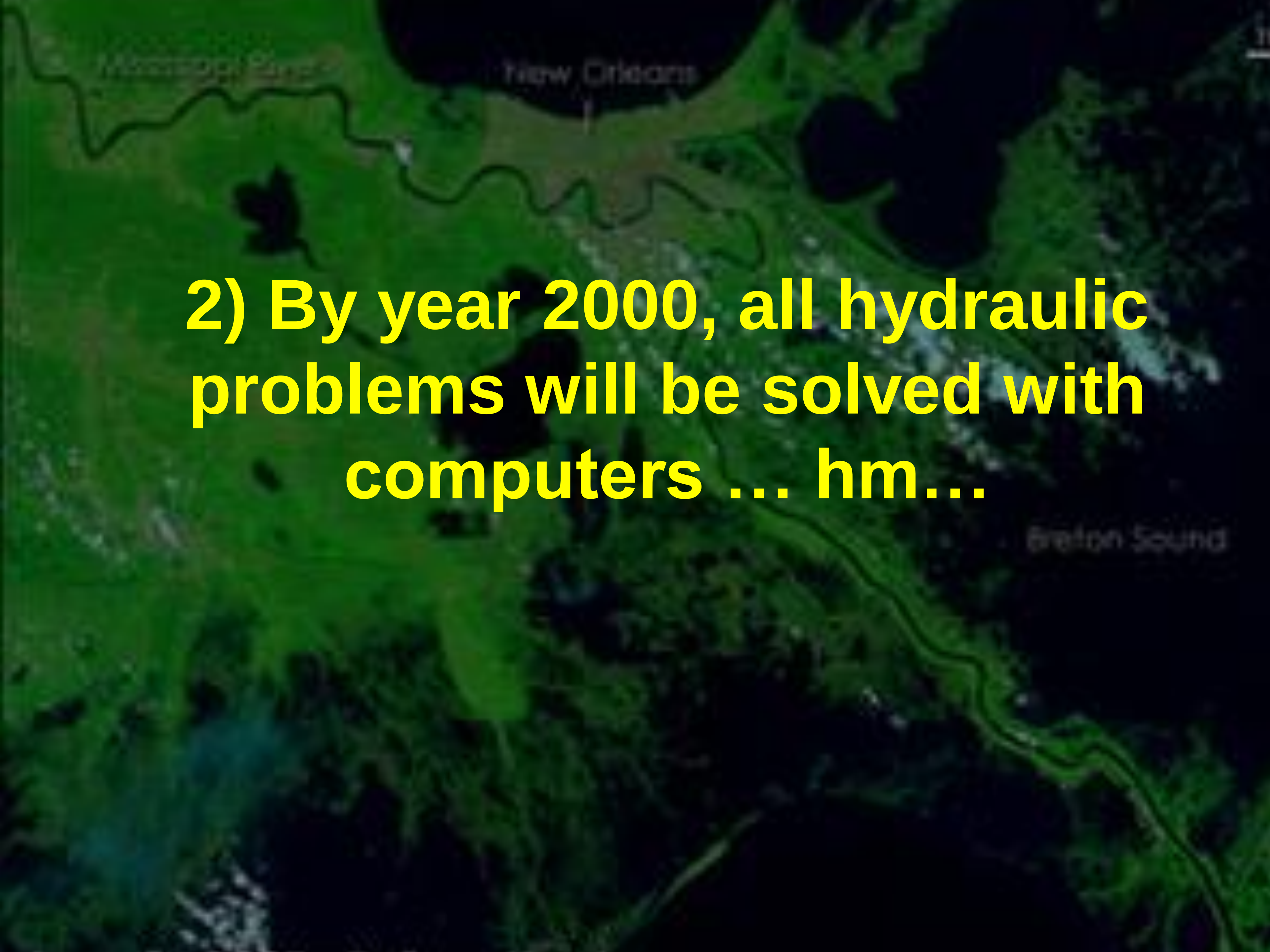
From J. Halgren, 2009

Total Suspended Solids



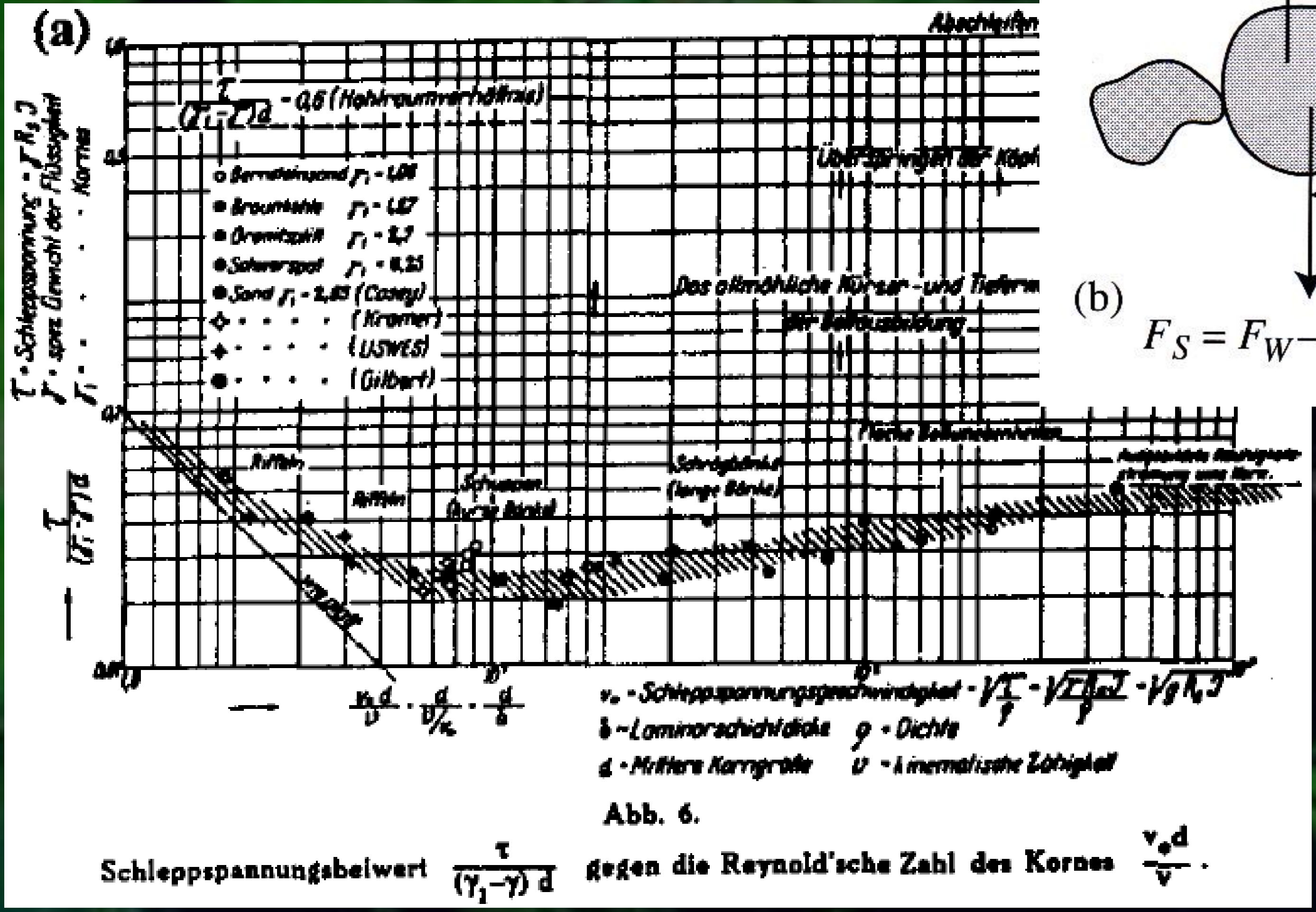
from Ji, Velleux, Julien, Hwang, JEM 2014

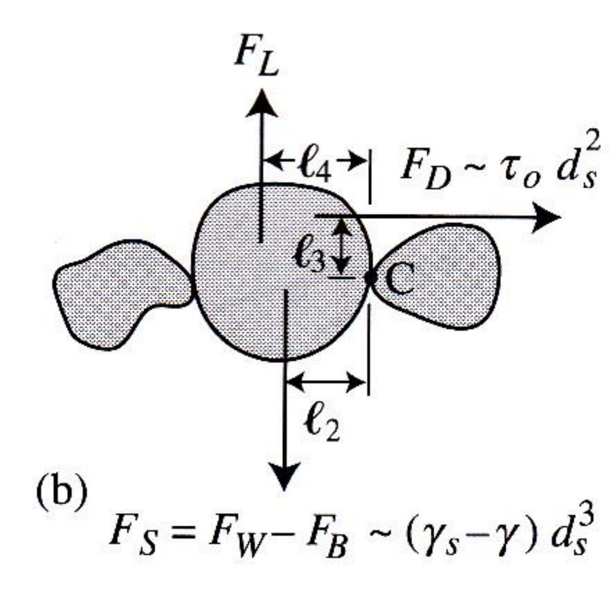
Today, we can simulate the PMP and PMF on large watersheds



2) By year 2000, all hydraulic problems will be solved with computers … hm…

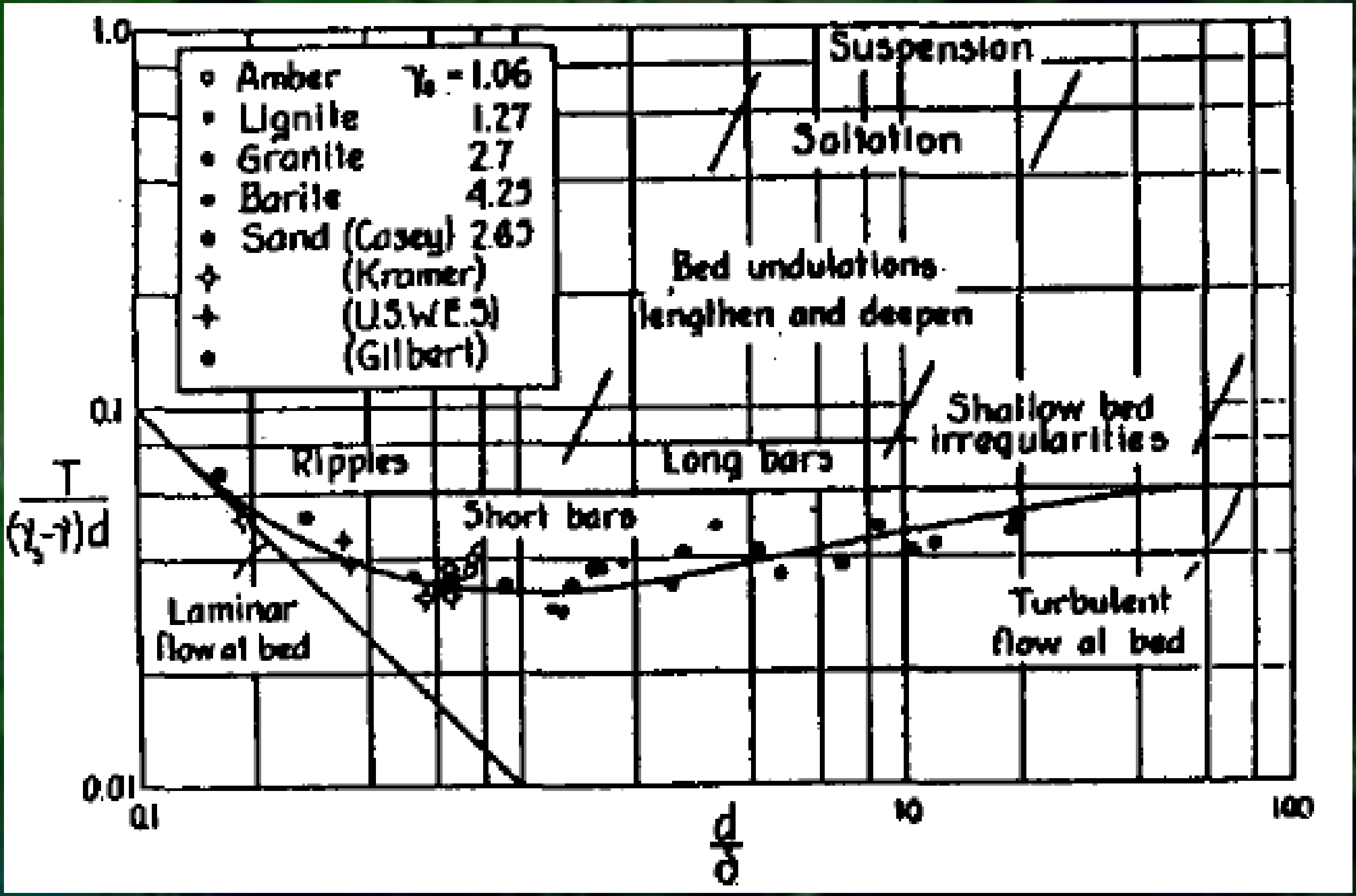
The original Shields Diagram, 1936,
It is based on the sum of forces.





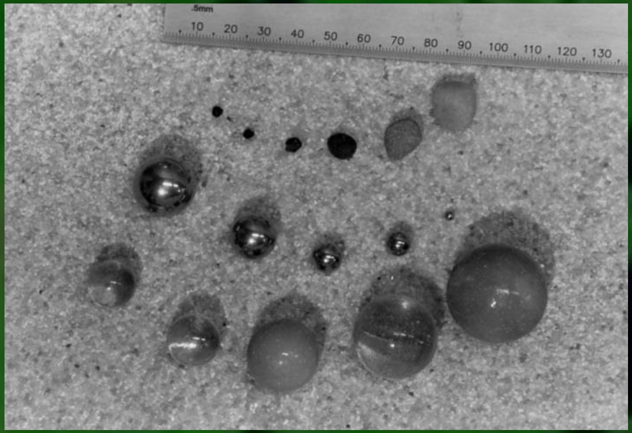
From A. Shields, 1936

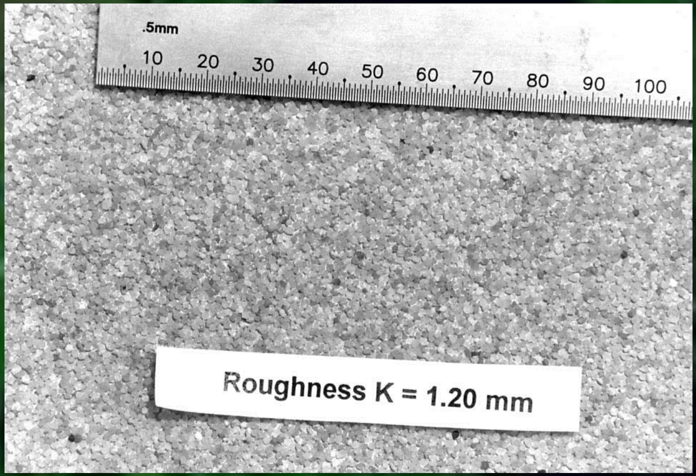
Hunter Rouse's version of the Shields Diagram, 1939 - what is the difference?



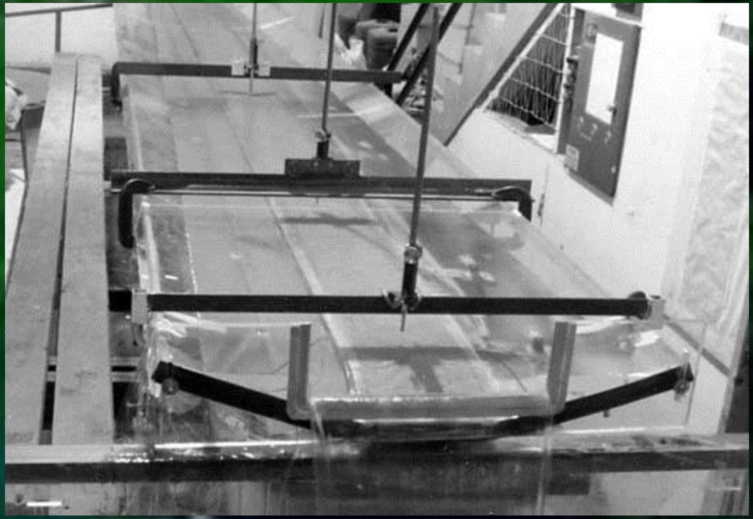
From Rouse, 1939

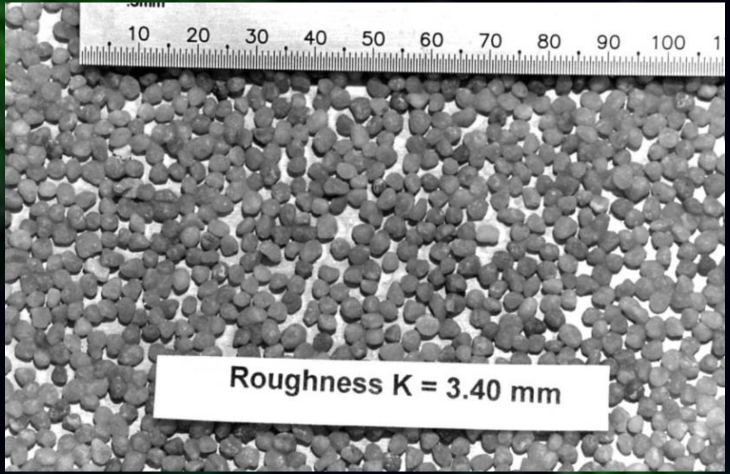
Laboratory experiments at CSU





~10,000 particle velocity measurements





Bounvilay and Julien, ASCE-JHE (2013)

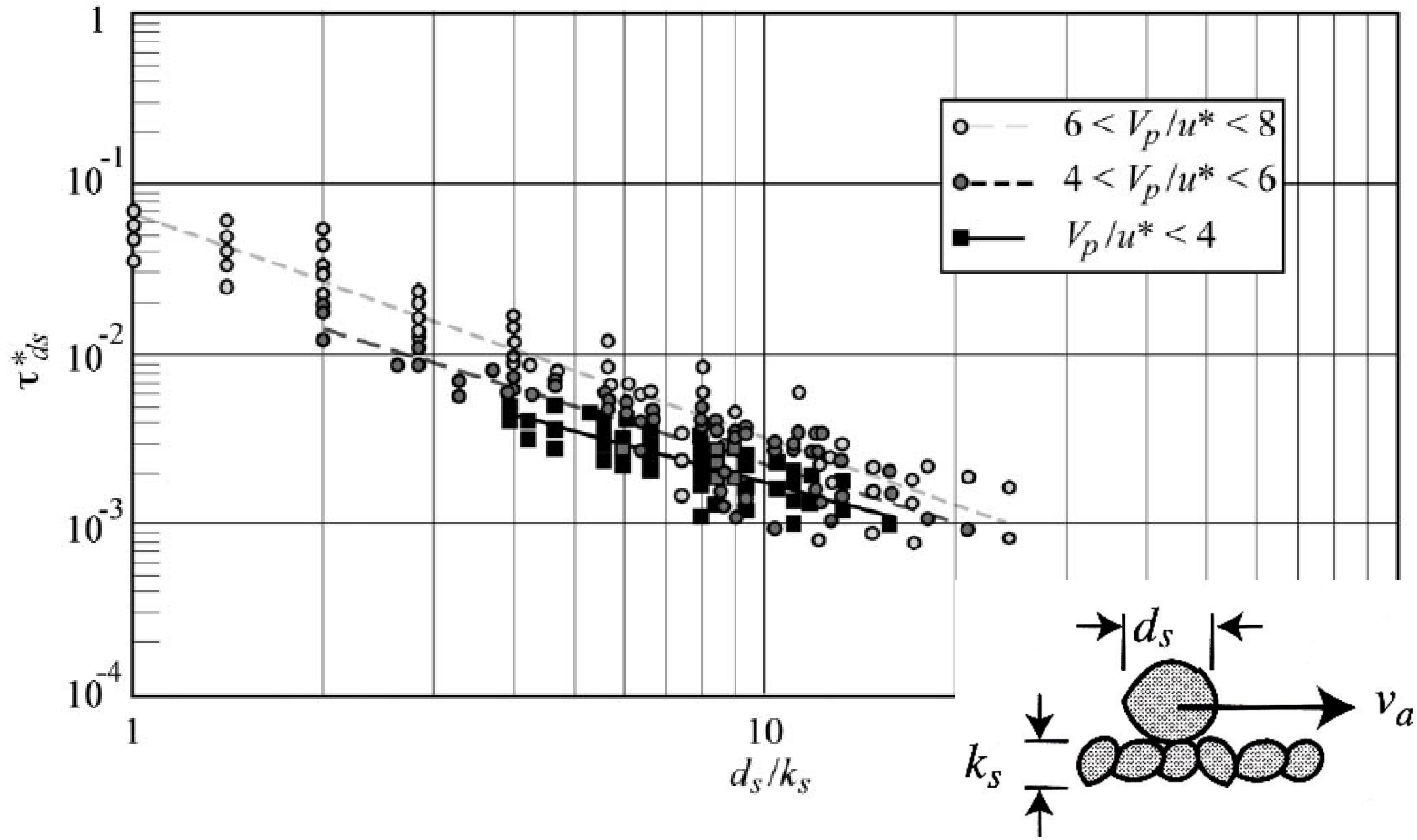
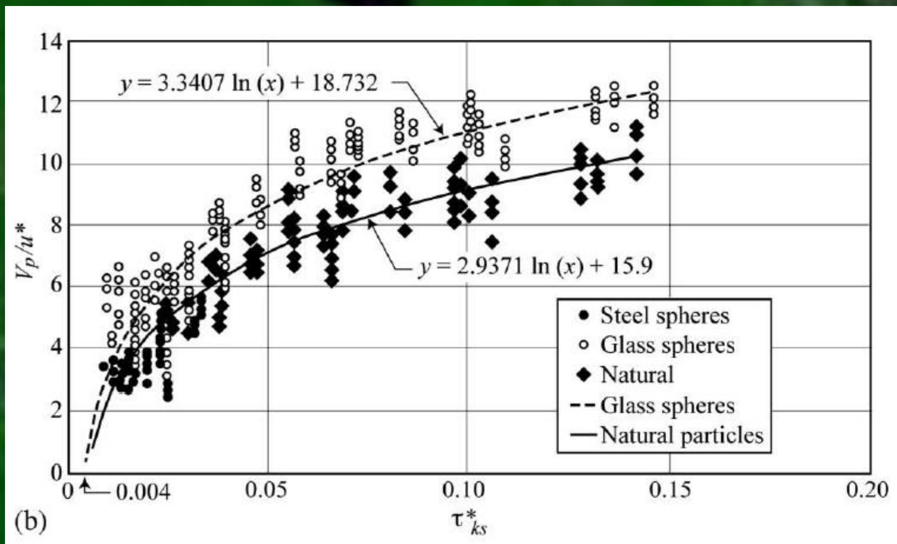


Fig. 9. Shields parameter τ^*_{ds} vs d_s/k_s for different values of ratio V_p/u_*

Lets remember:

Incipient motion depends on the sum of moments, not forces.

The Shields approach can only be a rough approximation.



Bounvilay and Julien, ASCE-JHE (2013)

Sediment, rainfall …

Adbulhakim Dawod, PhD ‘86
Jimmy O’Brien, PhD ‘86
David Hartley, PhD ’90
Khalid Marcus, PhD ‘91
Yasser Raslan, PhD ‘94
Junke Guo, PhD ‘98
Bounthanh Bounvilay, PhD ’02
Boubacar Kane, PhD ’03
Seema Shah-Fairbank, PhD ’08
Sangdo An, PhD ’11
Shazwani Nur Muhammad, PhD ’13

Lets remember:
Hydraulic laboratories help us gain new knowledge
that would not be possible with computers alone.

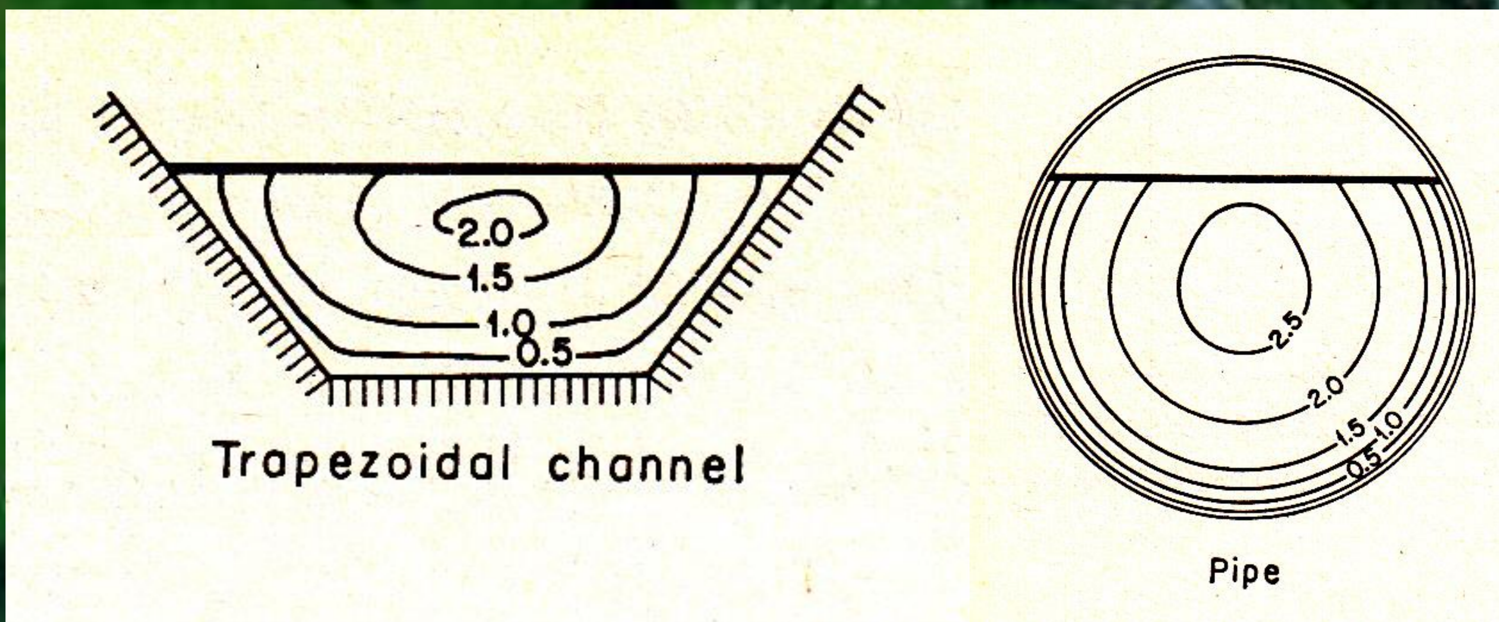
3) We all know

a)Velocity profiles

b) Sediment plugs

We all know …

that the maximum flow velocity is often observed below the free surface.



From ven te Chow (1959)

Theory - Modified Log-Wake Law

- *The modified log-wake law*
  - In 2003 and 2005, Guo and Julien proposed a modified log-wake law for turbulent *pipe and boundary layer* flows.

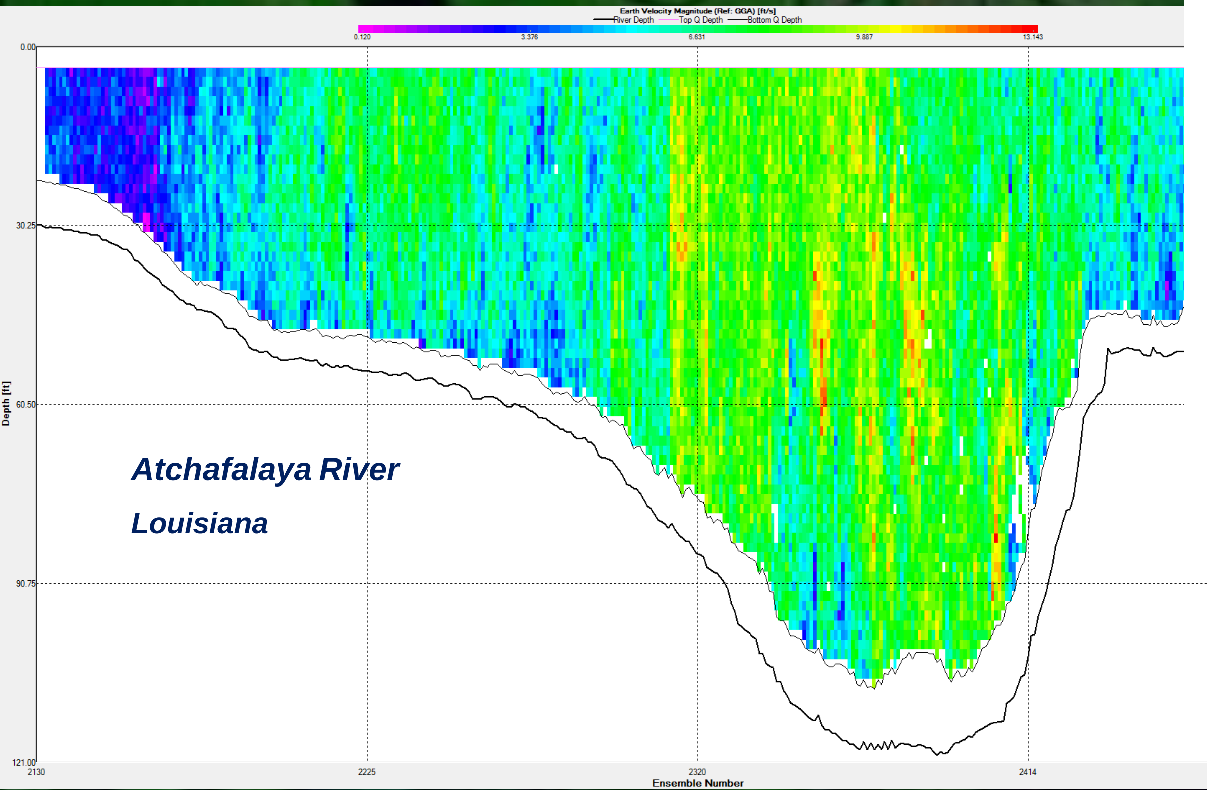
$$\frac{u}{u_*} = \left(\frac{1}{\kappa} \ln \frac{y u_*}{\nu} + B \right) + \frac{2\Pi}{\kappa} \sin^2 \frac{\pi \xi}{2} - \frac{\xi^3}{3\kappa}$$

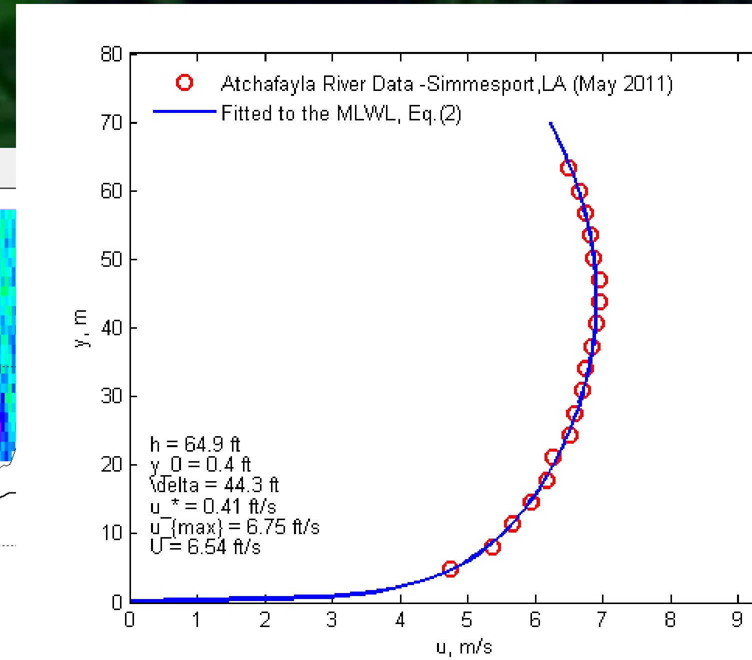
  - *The wake strength Π:* the effects of pressure-gradient in pipes or convective inertia in boundary layers.
  - The last term corrects the log law velocity gradient to be zero at the maximum velocity.

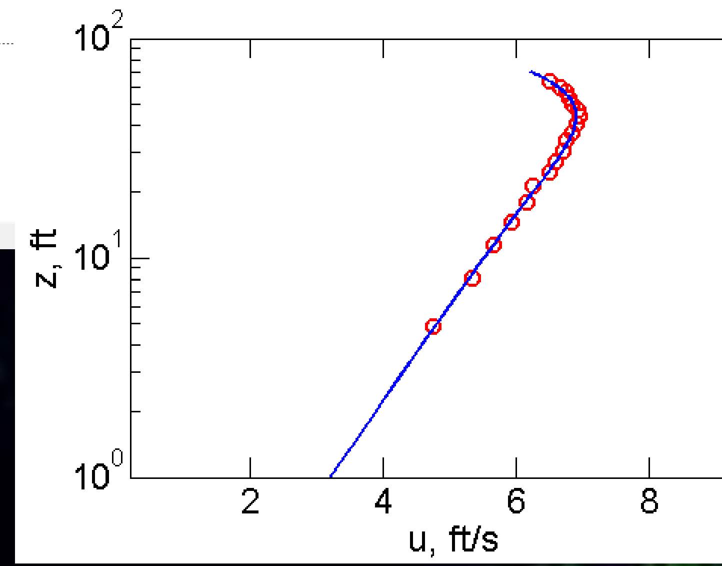
Lets remember:

We were all excited to solve sin and cos on an HP 35.
Today spreadsheets solve erfc, gamma and Bessel functions.

… and practice







Lets remember:

Can we theoretically solve the practical problems that have been waiting for so long?

Do we know how sediment plugs form?

Photo from Baird, USBR

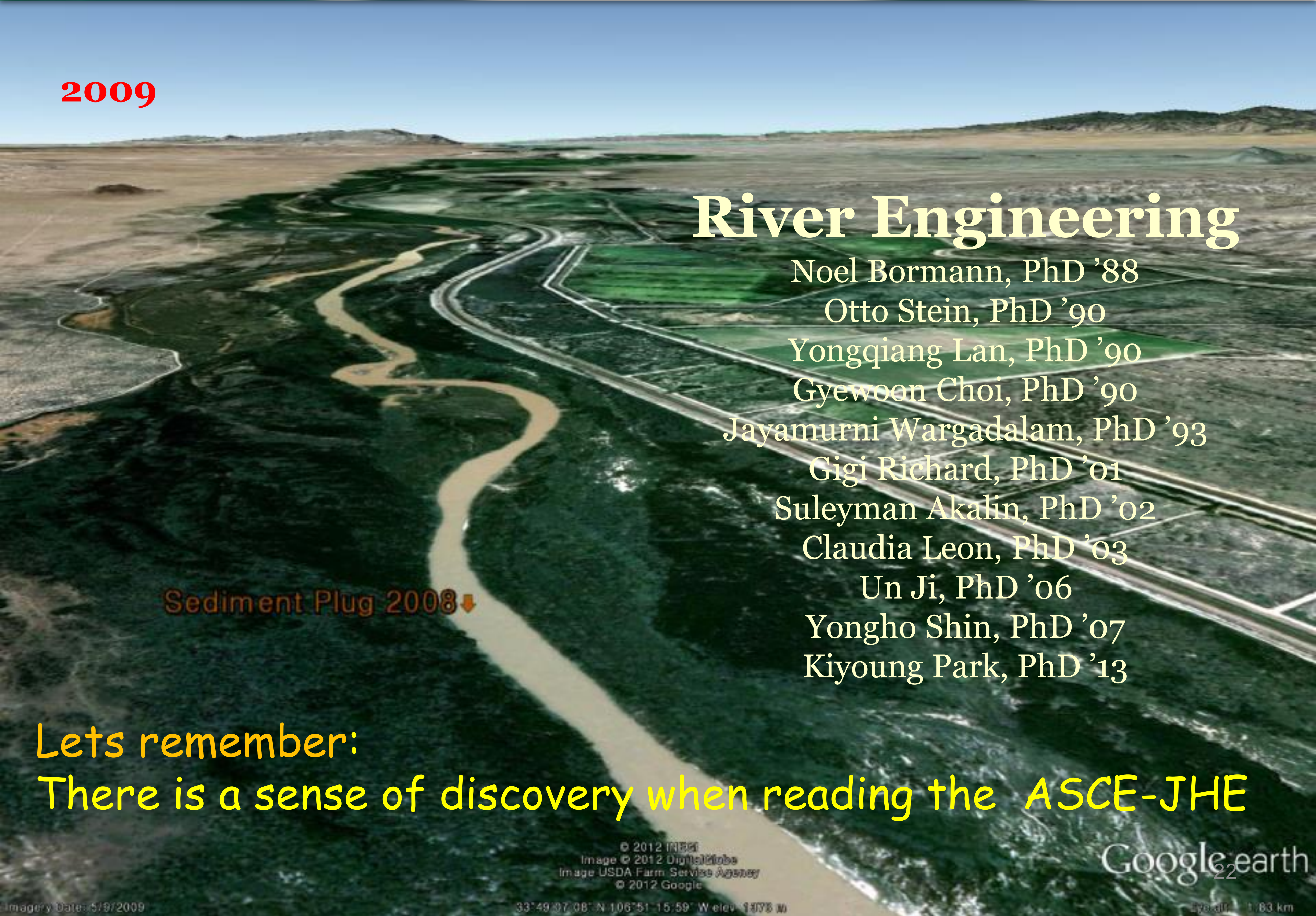
Rio Grande – note the channel width changes 1996-2009

Rio Grande


2006
Sediment Plug 2008
Image USDA Farm Service Agency
Image © 2012 DigitalGlobe
Image NMRGIS
© 2012 Google
Google earth

Rio Grande

2009

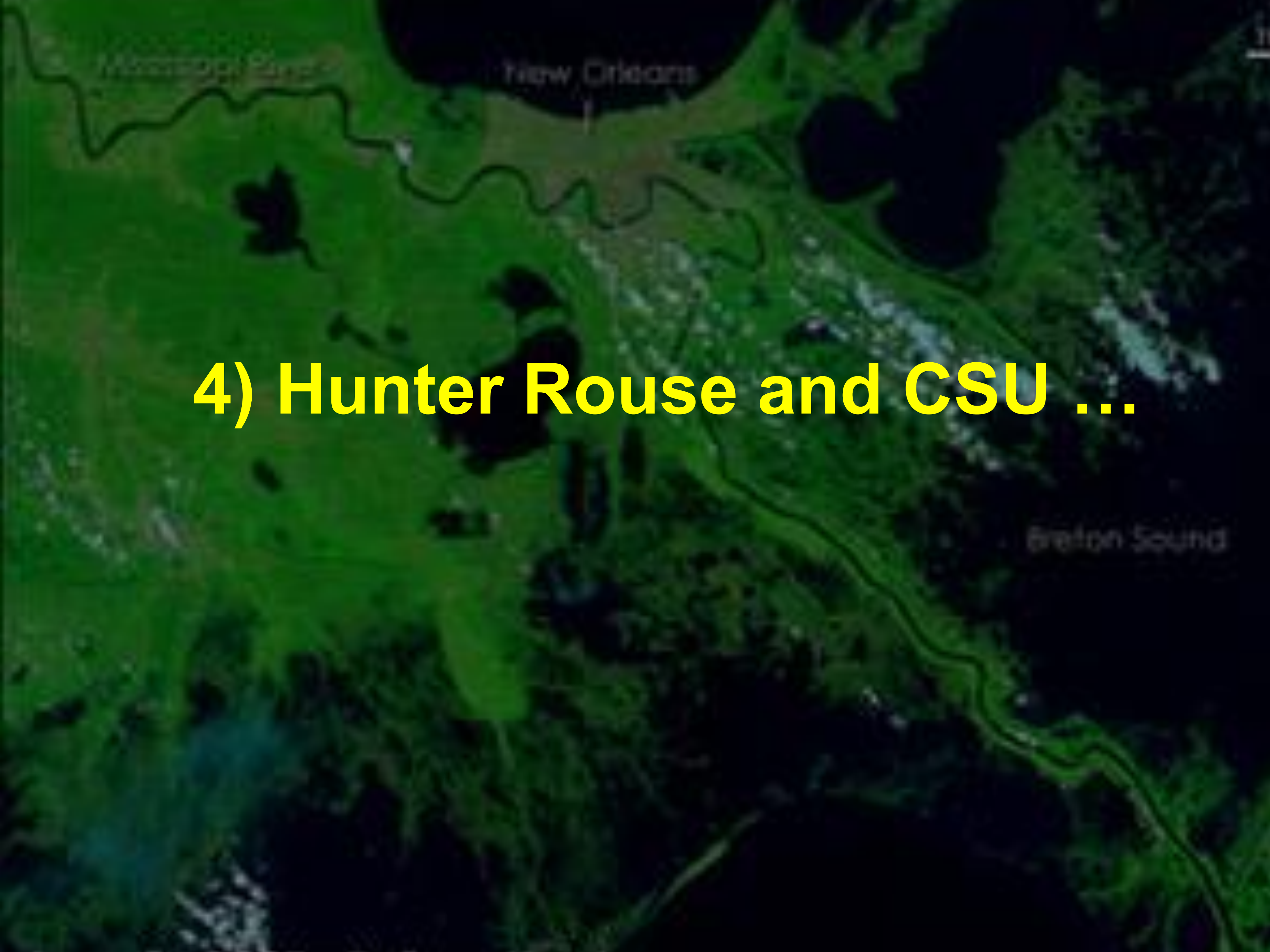


River Engineering

Noel Bormann, PhD '88
Otto Stein, PhD '90
Yongqiang Lan, PhD '90
Gyewoon Choi, PhD '90
Jayamurni Wargadalam, PhD '93
Gigi Richard, PhD '01
Suleyman Akalin, PhD '02
Claudia Leon, PhD '03
Un Ji, PhD '06
Yongho Shin, PhD '07
Kiyoung Park, PhD '13

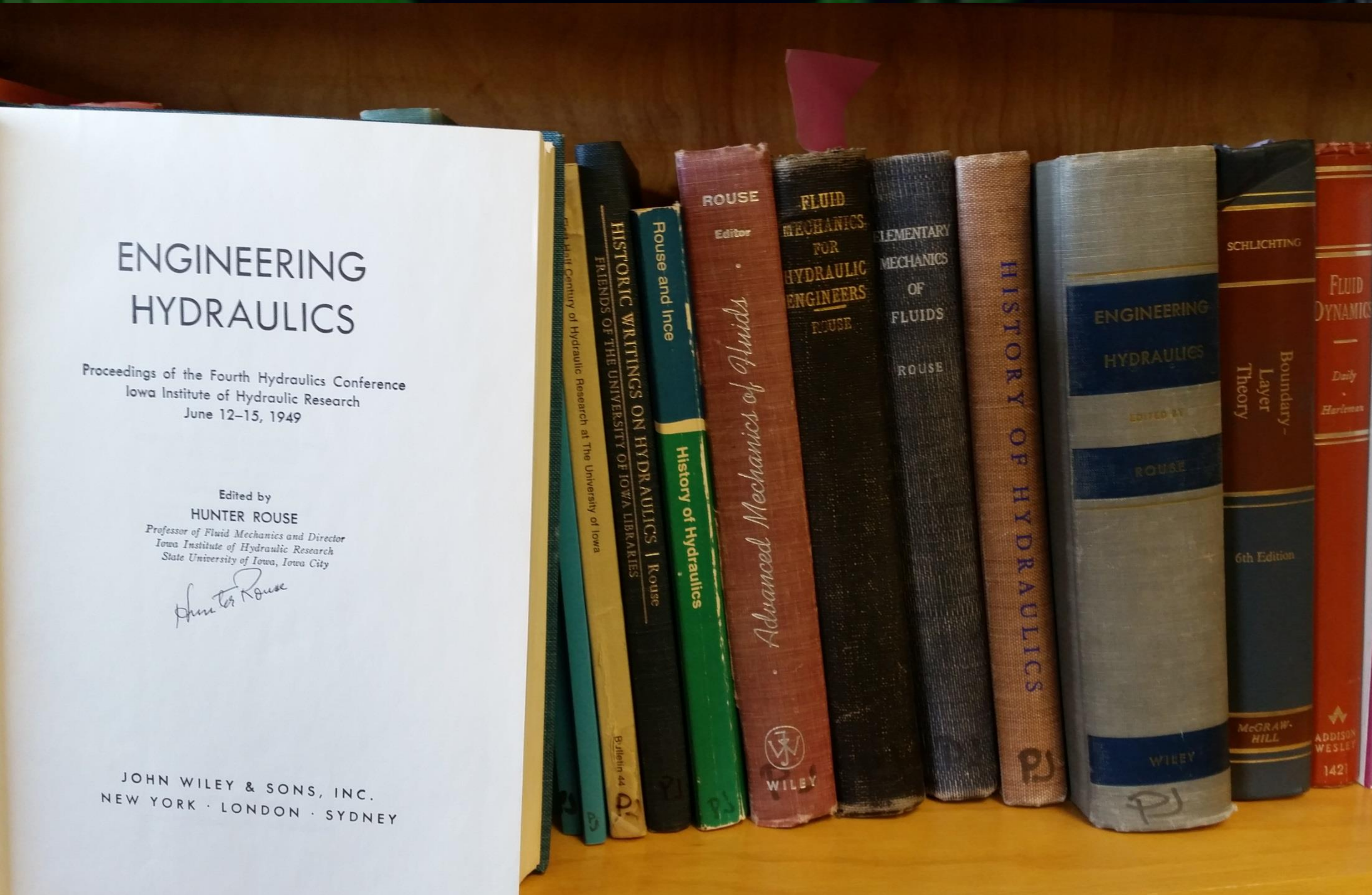
Lets remember:
There is a sense of discovery when reading the ASCE-JHE

4) Hunter Rouse and CSU …



1902 – pass or fail exam at CSU: can you walk on water?

1940 Hunter Rouse Summer Class in Fort Collins


ENGINEERING
HYDRAULICS
Proceedings of the Fourth Hydraulics Conference
Iowa Institute of Hydraulic Research
June 12–15, 1949
Edited by
HUNTER ROUSE
Professor of Fluid Mechanics and Director
Iowa Institute of Hydraulic Research
State University of Iowa, Iowa City
JOHN WILEY & SONS, INC.
NEW YORK · LONDON · SYDNEY
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McGRAW-HILL
FLUID DYNAMICS
Daily
Harleman
ADDISON WESLEY

Monday Morning oral exam questions from the Hunter Rouse Class at CSU

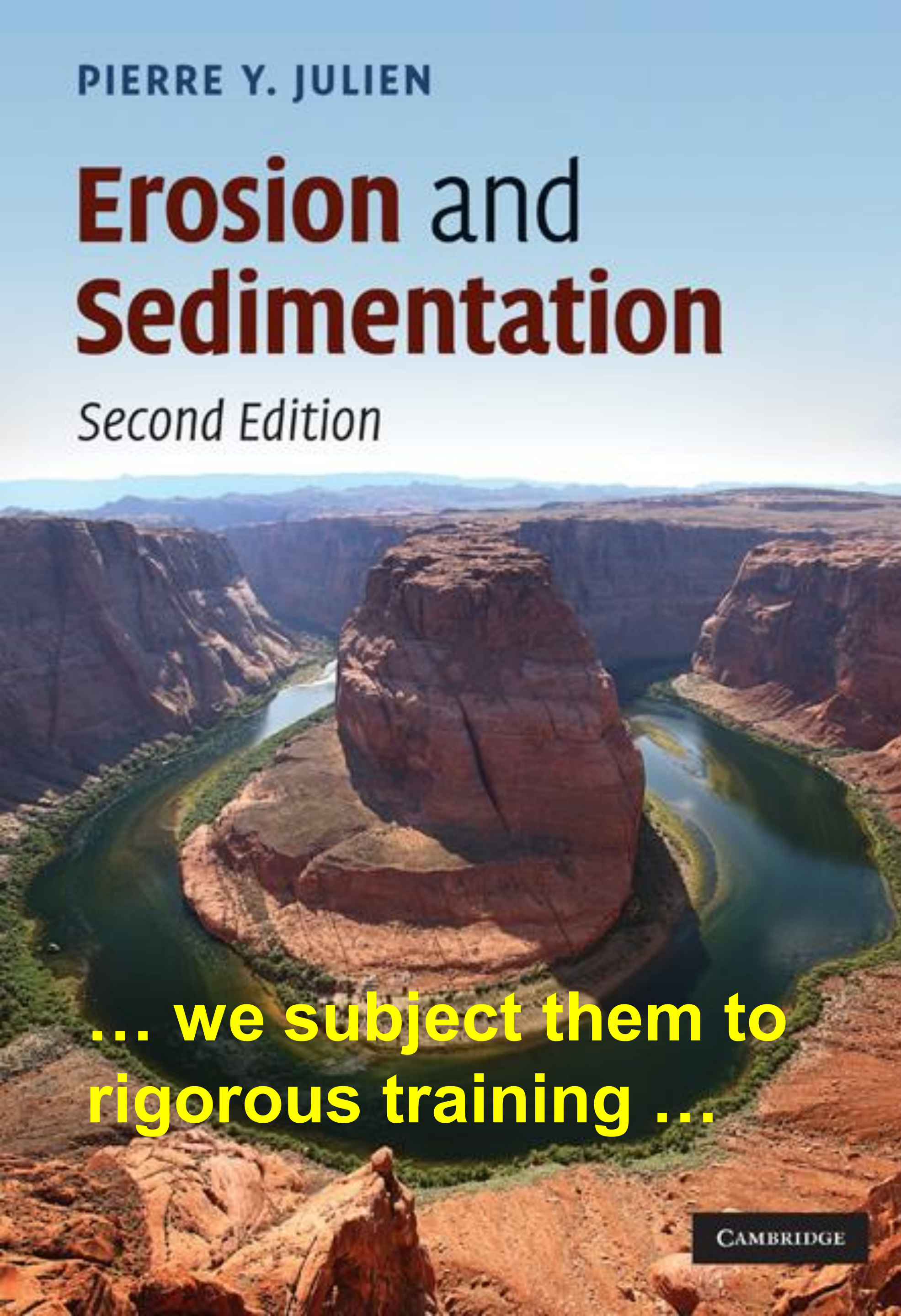
2. Compare Euler, St Venant, Nav-Stokes, & Reynolds eqs.
3. What is a newtonian fluid?
4. What is principle of viscous lubrication?
5.  show continuity relationship graphically
6. What is dissipation mechanism?
7. What changes does a turbulent eddy undergo with time?
8. What is result of vortex stretching?
9. How can one change time scale of turb & length scale?
10. What is diff in turb between flow through grid and along wall

In response to a student at a weekly oral exam:

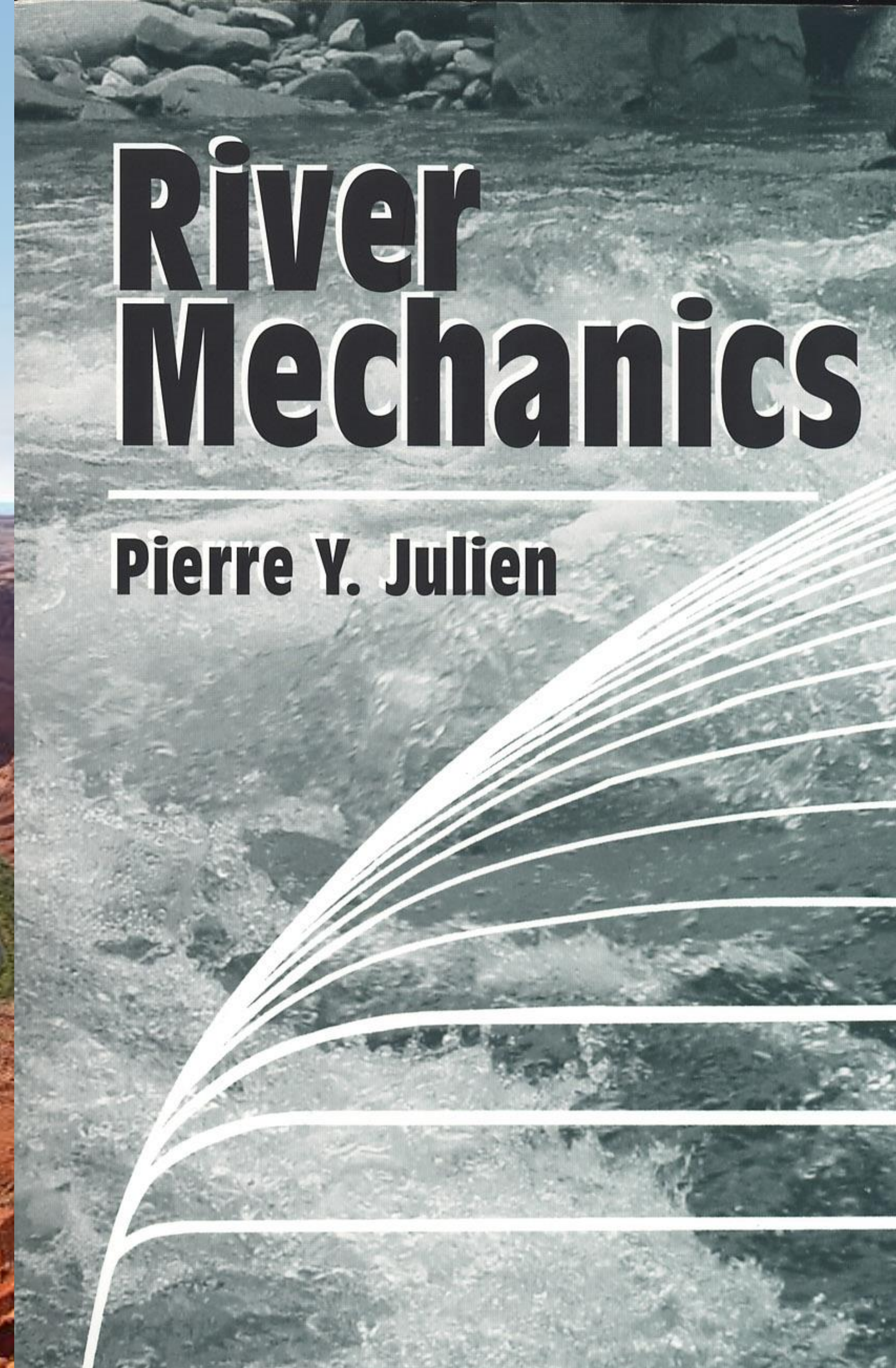
"…I have been teaching Fluid Mechanics for 50 years and this is the worst answer I ever heard…"

Hunter Rouse, 1986


Today CSU recruits the
most talented students



… we subject them to rigorous training …




… and recognize when they are ready to graduate.


Rising Stars!

Thank You!

pierre@engr.colostate.edu