NC STATE UNIVERSITY

15- yrs (2002 – 2018) 3-D Stream Design, Monitoring and Beyond

David Bidelspach, PE

Greg Jennings, PE

Barbara Doll, PE

Dan Clinton, PE

Jan Patterson, PE

Mike Geenen, PE

AND MANY OTHERS

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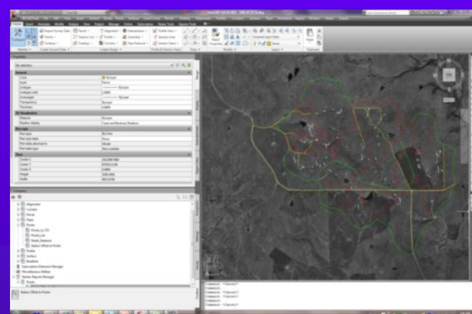
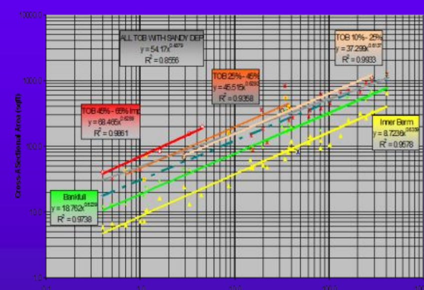
S.H.A.R.E.D Philosophy

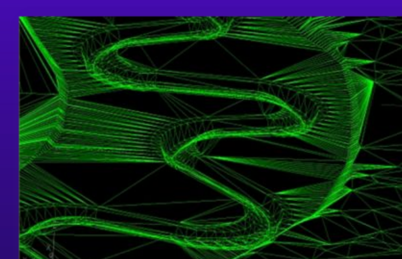
- **S**hare knowledge with humility.
- **H**ave patience and discernment for innovation.
- **A**dvocate excellence.
- **R**espect the risk and uncertainty in river systems.
- **E**mpower, challenge and question.
- **D**ocument and learn from unexpected results.

Share knowledge with humility

- Trade secrets are not good for maturing an industry, our understanding of river processes have come as a result of many other's sharing their knowledge and not keeping trade secrets.

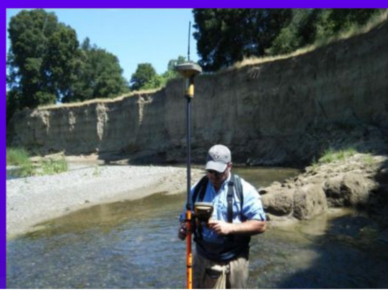


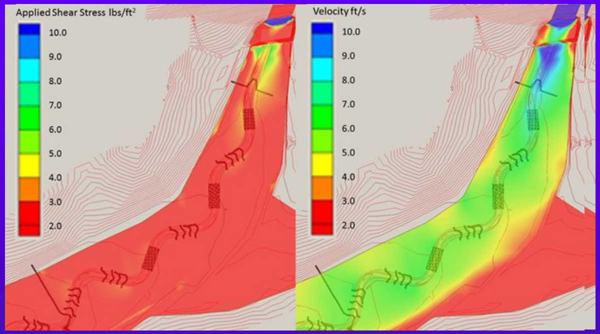




Have patience and discernment for innovation

♦ **Innovation is great but, we must not rush innovation or lose sight of the established processes that have led to the innovation.**





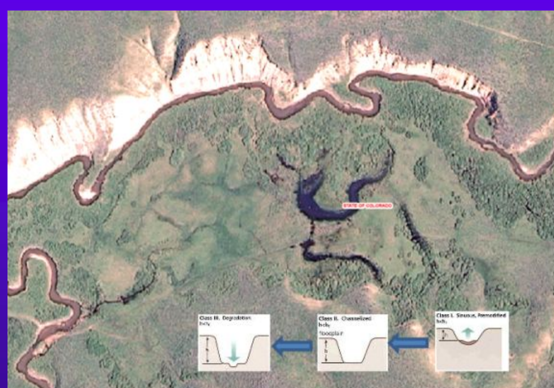
Advocate excellence

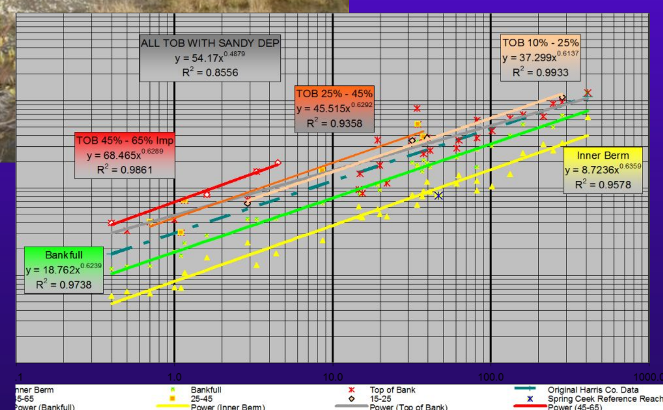
- Stay commitment to excellence and define excellence on all project. Strive to promote excellence throughout the profession

		Stream Stability GOAL			Water Quality GOAL				Buffer GOAL								
	Concept Option Description	[illegible] 2	[illegible] 1	[illegible] 2	[illegible] 1	[illegible] 1	[illegible] 1	[illegible] 1	[illegible] 1	[illegible] 1	Linear Feet of Proposed Project	Required Fill (yd3)	Fill cost ($10/yd3)	Preliminary Cost Estimate of Proposed Project	UNIT COST	MCDA Matrix Score	MCDA RANKING
Option #1	Tie into wetland floodplain as long as possible step down channel gradually; Higher slope at top, lower slope at bottom	1	1	3	1	1	1	0	1	1	1170	6000	$60,000	$ 1,330,000.00	$ 1,136.75	12	3
Option #2	Tie into wetland floodplain as long as possible step down channel gradually; More-or-less consistent slope	1	1	2	1	1	1	0	1	1	1170	7000	$70,000	$ 1,340,000.00	$ 1,145.30	10	1
Option #3	Stay very high and flat coming out of the wetland	1	1	2	1	1	1	0	1	1	1170	10000	$100,000	$ 1,320,000.00	$ 1,128.21	10	1
Option #4	Lower in Wetland and then inbetween 1 and 2	2	1	2	1	1	1	0	1	1	1170	6500	$65,000	$ 1,335,000.00	$ 1,141.03	12	3
Option #5	60% Design as drafted	2	3	4	1	1	1	0	2	1	1170	500	$5,000	$ 1,270,000.00	$ 1,085.47	19	6
Option #6	30% Design as drafted	2	2	3	1	1	2	0	2	1	1170	6000	$60,000	$ 1,330,000.00	$ 1,136.75	16	5

Respect the risk and uncertainty in river systems

- Rivers are complex, the more learned about riverine/riparian systems the more that is appreciated about the complexity of these systems. Innovation and modeling can be great tools, but the answers are still in the science and observation of the river.





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Empower, challenge and question

- Empower others by encouraging them to question and challenge the design and geomorphic assumptions as well as conclusions. Others include, clients, design team, reviewers, regulators, grandmothers and others.

Document and learn from unexpected results

- Rivers are complex systems that have a high degree of uncertainty and sometimes our remedial alternatives produce unexpected results. Sometimes our results are very unexpected. Document uncertainty and learn from unexpected results so that we may have a better understanding of why the unexpected result has occurred.

The Beginning of 3-D Stream Restoration Design at NCSU

- A Desire - Greg Jennings, Barbara Doll and Dan Clinton pre- 2002
  - Simulation Stream Design
- A Lie – "Yes I can do that" 2002
- The Cover up - "Breakline Theory" 2003
- Training Courses 2003-2018
- Hec-RAS Modeling Improved with AutoCAD 2004
- Implementation North State Environmental and NCEEP 2006 Mill Branch Demo Project

We are living in a 3-D World

- DESIGN
- MODELING
- RE-DESIGN
- CONSTRUCTION
- MONITORING

3D- Design

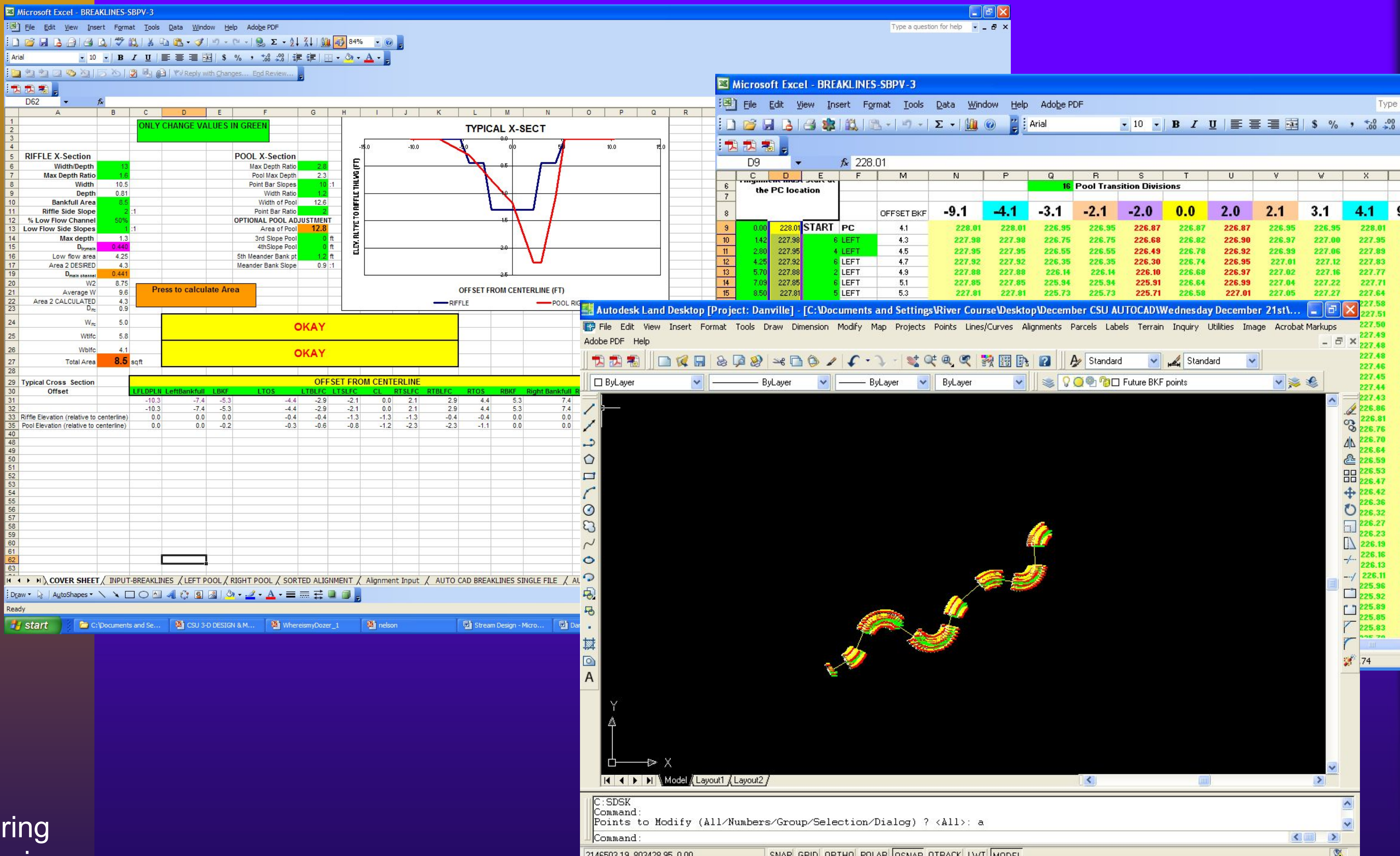
- Assist in Construction
- Easier to Create Design Revisions
- Modeling
- Better Estimate of Cost
- Good Check for On-site Stupidity During Construction

- Eagle Point, Surv-CAD, Geo-Pak, Land Desktop, Autodesk Civil Series
- RiverMorph

40 Steps to a Stable Stream…

- Step 1. Regional Curve Data
- Step 2. Hydraulic Geometry
- Step 3. Dimensionless Ratio Hydraulic Geometry
- Step 4. Flow Duration Curves
- Step 5. Dimensionless Flow Duration Curves
- Step 6. Identify Valley Type
- *Step 7. Reference Reach Data*
- Step 8. Stability Analysis for Reference Reach
- Step 9: Scenario of Successional Stages
- Step 10: Drainage Area

3D – Breaklines for Surface



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Past, present and Future Design,

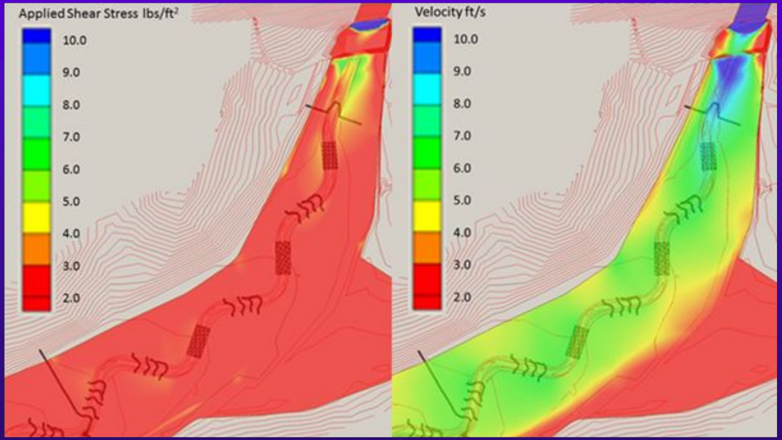
- Limited to Design Philosophy
- Limits Creativity
- Optimization based on Grading and not goals and objectives
- Rapid revisions
- Only a Tool
- PC and PT usage on alignments
- OTHER IDEAS?

3D - Modeling Summary

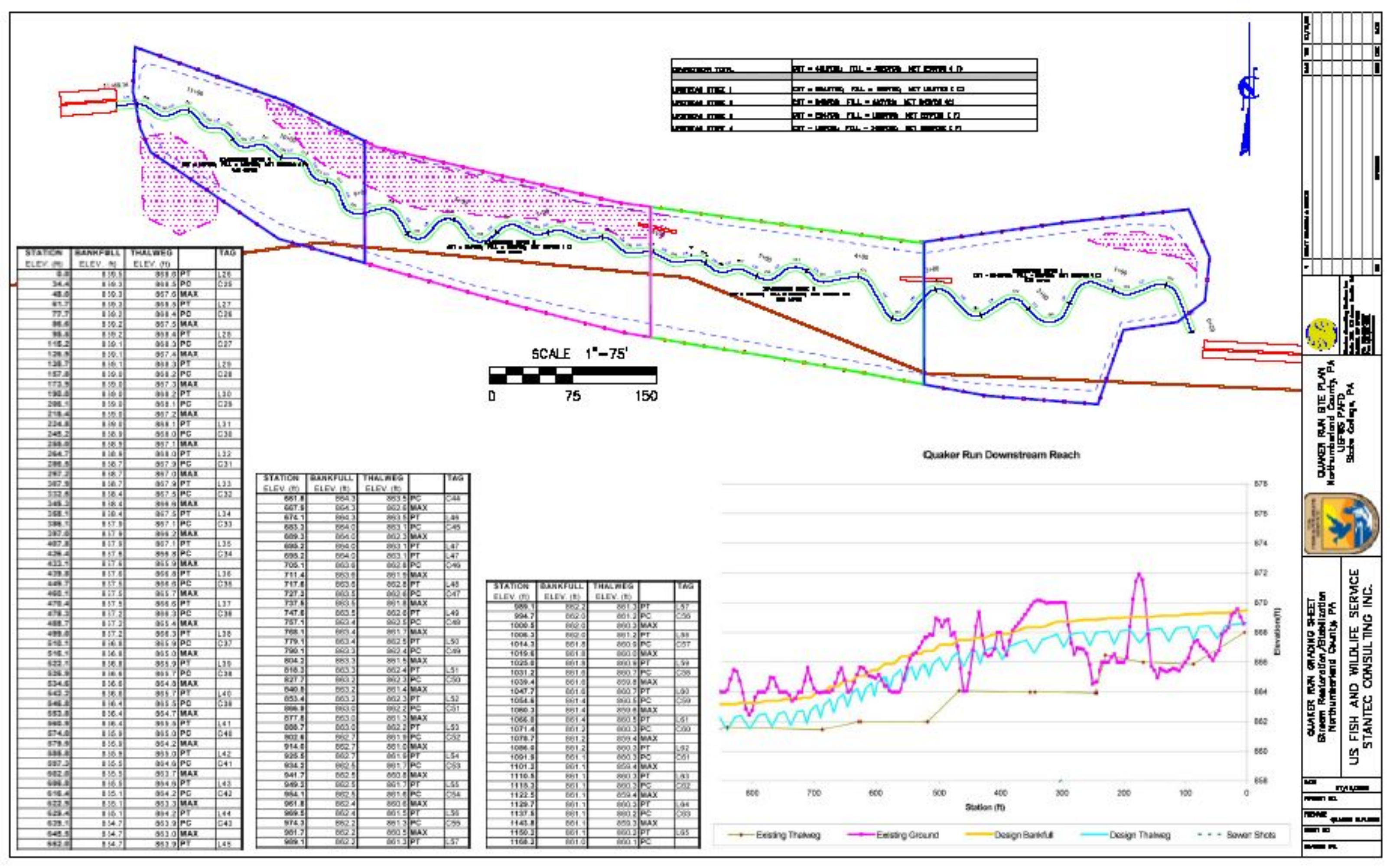
- Engineering to check and Design
  - Sediment, Backwater, Velocity, & Shear Stress
- HEC-RAS Limitations
  - 1-D only
    - cannot model actual flow around bends, in constrictions, or other 2-D, 3-D flows
    - cannot model channel-floodplain interactions
  - Average shear only for each floodplain and main channel
    - average shear not always indicator of sediment movement
    - max shear can be several times greater than average

Past, present and Future Modeling

- Paper verses Digital
- 2-D and 3-D Modeling with Monitoring and Construction
- Modeling During Construction
- Drones, GPS Units
- Only a Tool
- HEC-RAS 2D
- OTHER IDEAS?



Re-Design, Constructability



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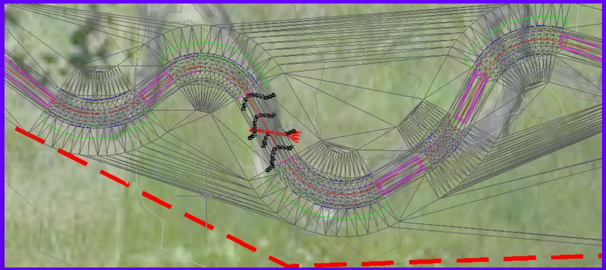
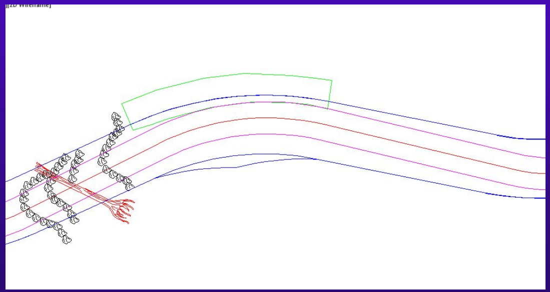
Re-Design

- Rapid Adjustment
- During Construction
- Construction Optimization
- Datum and projection
- OTHER IDEAS?





GPS Construction

3-D Construction

3-D Construction

3-D Monitoring
Data Analysis

- Shows current condition of the project
- Compares current condition to previous years
- Shows how the stream is functioning
- Shows trends and direction

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3D - Monitoring

- Photo Documentation
- Profile Analysis - 3D Surveys
- Cross-sectional Analysis - 3D Surveys
- Planform Analysis - CAD

3D – Surveys vs. 1-D Surveys

Total Station Equipment Cost	$ 7,500.00	
Expected Life	5	years
Annual Maintenance	$ 150.00	
Hourly Employee Rate	$ 25.00	
Daily Reimbursement Food	$ 30.00	
Daily Reimbursement Hotel	$ 60.00	
Total Number of Employees Onsite	3	(Enter Based on a 2 or 3 Person Crew)
Total Man Hours Needed	366.0	
Total Travel Reimbursement (not mileage)	$ 3,330.00	
Total Man Hours Cost	$ 9,150.00	
Total Cost (including Data Entry)	**$14,130.00**	

	STONE MTN	KATO	PAYNE	PRICE	SF MIT	VET	PVCC1	SM & AU	BNT CRK	ZCK FRK	
Site	Stream 1	Stream 2	Stream 3	Stream 4	Stream 5	Stream 6	Stream 7	Stream 8	Stream 9	Stream 10	To
Breaklines	6	5	5	6	5	5	5	5	15	2	
Stream Projects Year (ft)	5000	1800	1200	1600	1900	1400	800	14000	800	1400	
Average Stream Width W_{bkf} (ft)	60	10	15	15	30	10	10	25	25	5	
Number of Cross Sections (#)	11	5	8	4	4	4	5	12	0	2	
Approximate Total Points Need	1481	1166	838	859	554	913	666	3494	480	663	
Vegatation (1-10)	4	3	6	3	2	2	4	3	5	1	
Walking Time Factor	1.3	1.0	2.0	1.0	0.7	0.7	1.3	1.0	1.7	0.3	
Shooting Time (Points Per Hour 100)	14.8	11.7	8.4	8.6	5.5	9.1	6.7	34.9	4.8	6.6	
Man-Hours	54.3	35.0	41.9	25.8	12.9	21.3	24.4	104.8	20.8	11.1	
Total Crew-Hours	19	12	14	9	5	8	9	35	7	4	
Points per hour Average	78.0	97.1	59.8	95.4	110.8	114.1	74.0	99.8	68.6	165.8	

Laser Level/Sight Level Equipment Cost	$ 500	
Expected Life	5	years
Annual Maintenance	$ 50.00	
Hourly Employee Rate	$ 25.00	
Daily Reimbursement Food	$ 30.00	
Daily Reimbursement Hotel	$ 60.00	
Total Number of Employees Onsite	3	(Enter Based on a 2 or 3 Person Crew)
Total Man Hours Needed	777.0	
Total Travel Reimbursement (not mileage)	$ 6,840.00	
Total Man Hours Cost	$ 19,425.00	
Total Cost (including Data Entry)	**$ 26,415.00**	

	STONE MTN	KATO	PAYNE	PRICE	SFMit	VET	PVCC1	SM & AU			
Site	Stream 1	Stream 2	Stream 3	Stream 4	Stream 5	Stream 6	Stream 7	Stream 8	Stream 9	Stream 10	T
Breaklines	6	5	5	6	5	5	5	5			
Stream Projects Year (ft)	5000	1800	1200	1600	1900	1400	800	14000			
Average Stream Width W_{bkf} (ft)	60	10	15	15	30	10	10	25			
Number of Cross Sections (#)	11	5	8	4	4	4	5	12			
Approximate Total Points Need	1481	1166	838	859	554	913	541	3194	0	0	
Vegatation (1-10)	4	3	6	3	2	2	4	3	3	3	
Walking Time Factor	1.3	1.0	2.0	1.0	0.7	0.7	1.3	1.0	0.0	0.0	
Shooting Time (Points Per Hour 40)	37.0	29.1	20.9	21.5	13.9	22.8	13.5	79.8	0.0	0.0	
Man-Hours	135.8	87.4	104.7	64.4	32.3	53.2	49.6	239.5	0.0	0.0	
Total Crew-Hours	46	30	35	22	11	18	17	80	0	0	
Points per hour Average	32.2	38.9	23.9	39.0	50.4	50.7	31.8	39.9	#DIV/0!	#DIV/0!	

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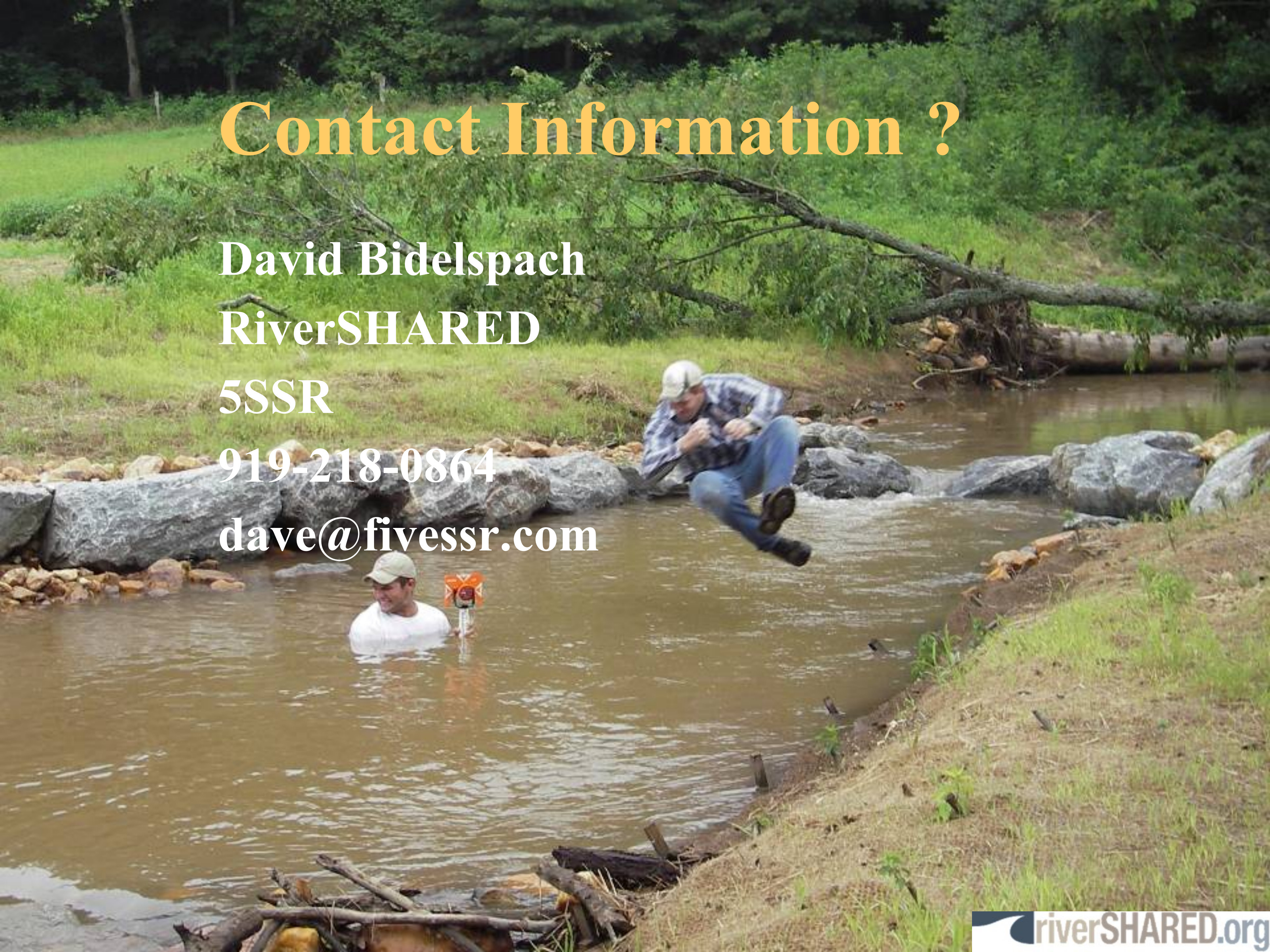
Past, present and Future Monitoring

- Paper verses Digital
- Regulators limit data transfer protocols
- 2-D and 3-D Modeling with Monitoring
- Monitoring During Construction
- Only a Tool
- OTHER IDEAS?

Questions ?

- Empowerment of Others
- Sharing Knowledge with Kindness
- Be a part of the solution don't just Go to Conferences
- Mentorship and Apprenticeship
- Courage to share to build the industry

Contact Information ?



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