Construction, Application, and Discussion of a Homemade Bridge-Based Stream Sediment and Discharge Sampling System

A Capstone Project

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Bachelor of Science

by Wright Cole

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Preface

This is an under-graduate student report. The opinions and conclusions presented do not necessarily reflect the final material to be presented as the outcome of the Salinas Sediment Study (2000-1 contract). Nor do they necessarily reflect the opinions or conclusions of the Central Coast Regional Water Quality Control Board, who funded the work, or any of its staff.

Having said that, I hope you enjoy the report. It is the product of an extra-ordinary level student dedication to the science of bettering the environment of the Central Coast while recognizing the social and economic importance of its agriculture and industry.

Dr. Fred Watson
Project leader.
Student Capstone Advisor

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Abstract

Clean water has become a precious resource, and in response water quality has become a growing concern. The Salinas River Watershed is home to one of the largest agricultural zones in California. Soil loss to the Salinas River due to agricultural runoff is a common and expensive problem. The Salinas River and its tributaries provide habitat and spawning grounds for the steelhead trout and other important species. Steelhead trout are particularly sensitive to fine sediment and sand. Recently, the Central Coast Regional Water Quality Control Board has become responsible for defining and allowable Total Maximum Daily Loads (TMDLs) of sediment for the Salinas River. This report describes the design, building and implementation of a safe, practical, accurate and economical bridge based sediment and discharge sampling system. The final project will include safe use instructions, component descriptions, availability and instructions for possible future replication. A cost benefit analysis will be conducted to assess the differences between building this sediment and discharge monitoring system and purchasing commercially available equipment. To accurately estimate the amount of sediment and water moving through the watershed, sampling teams collect suspended sediment and bed-load sediment as well as take velocity readings with a clear understanding of the limitations of the sampling equipment. A propeller style velocity meter was chosen for the bridge-based sampling system, and an experimental accuracy assessment of this method was performed. This was completed utilizing a known length of a local swimming pool and a stopwatch. Accuracy was assessed by plotting the average velocity of the propeller readings versus the actual velocity calculated from known distance and time. The propeller style velocity meter consisting of a model boat propeller, PVC tee, magnet, and sensor combination that is connected to a bicycle computer has many benefits over USGS style vertical axis velocity meters. In the most basic application of the propeller style meter such as a staff-mounted velocity meter, the propeller style meter is lightweight, durable, accurate, and relatively inexpensive. I believe this style of meter for measuring stream velocity will become widespread in its use and acceptance.

1 Introduction

1.1 Background

The Salinas River Watershed is a relatively large and unique watershed. According to the 1999 Monterey County Agricultural Report, agricultural production exceeded 2.4 billion dollars. The Salinas River meanders through natural and agricultural lands, and is home to several important species including the steelhead trout. This is important because Fish and Game Code section 5937 states that provisions must be made to secure adequate habitat to ensure the survival of the population. The steelhead trout is particularly sensitive to fine sediment and sand. These smaller particles collect in the pore spaces in-between cobbles where the female steelhead trout deposits her eggs. As the sediment dynamics of the Salinas River are largely unknown, the Central Coast Regional Water Quality Control Board (CCRWQCB) has become responsible for determining and implementing allowable Total Maximum Daily Loads (TMDLs) of sediment for the Salinas River.

The Salinas Sediment Study team was hence formed at the Watershed Institute at CSUMB and is currently working on the technical background for the development of a sediment TMDL for the Salinas River. This task requires extensive and continuous monitoring of sediment loads. The primary concern of this report is to provide sufficient equipment to perform that monitoring, such as the bridge based sampling system and staff-mounted flow meters. A bridge-based sampling system was designed to lower a thirty-pound fish-shaped lead weight into the river, to which either a sediment sampler or flow velocity meter will be attached. Because of the high cost of vertical shaft velocity meters, such as the Pygmy (U.S.G.S. website), and the risks of suspending thousand dollar meters into the debris-laden current, a less expensive plastic propeller style velocity meter was deemed most practical for the project's needs.

A key part of the technical background for a Salinas River TMDL is determining the sediment budget of the watershed. In a fluvial system there does not exist a linear relationship between discharge and sediment load. Much of the sediment transported during an entire year can happen in just a few hours. The sampling strategy is to capture sediment and record flow velocity during periods of high discharge, especially after the first large sediment-mobilizing storm event of the year. The data and samples collected from the bridge-based sampling system will be crucial to the understanding of the sediment dynamics of the Salinas River Watershed.

At the outset, it is impossible to predict with any degree of certainty whether the bulk of the sediment in the Salinas River comes from natural lands or agricultural lands. Similarly the extent of steelhead trout populations in the Salinas River and how they are affected by agricultural practices is unknown. The Salinas Sediment Study team is working to answer these questions. If the results indicate an excess of agricultural source sediment in relation to important environmental considerations such as steelhead trout populations, then policy implements may be put in place to encourage landowners to modernize their farming practices.

The ethical ramifications of the Salinas Sediment Study are profound. It is important to be very clear about our objectives, which are to obtain a solid understanding of the Salinas River sediment dynamics and report our findings to the CCRWQCB. If landowners make costly changes in their agricultural practices, then it is possible that field workers would bear a significant amount of this cost. Stewardship of the land could come with a high price tag.

1.2 Goal

The goal of this project was to:

1. Construct discharge and sediment measuring equipment necessary to support the activities of a small storm event monitoring team

2. Assess the relative merits of this endeavor as compared to purchasing commercially available equipment

3. Provide clear instructions for construction of homemade discharge and sediment measuring equipment

4. Provide a set of safe use instructions for future users

2 Design of Monitoring Equipment

2.1 Methods

The design of the homemade sediment and discharge measuring equipment is similar to some commercially available equipment. There is great uniformity of design when it comes to certain pieces of hydrological equipment. For example, there are several companies that incorporate a radio-controlled model boat propeller mounted inside a PVC tee into the design of their staff mounted velocity meters. This is not coincidence; this method of sampling velocity has proven to be inexpensive and reliable. The design of the bridge-based discharge and sediment sampling system is modeled after a simple one-piece aluminum platform with a sheave at one end and a winch platform on the other. This piece of equipment was the first step in the design of the bridge-based discharge and sediment measuring system. The goal of monitoring equipment design was to feasibly construct similar equipment at a lesser cost, using widely available raw materials.

2.2 Results

The above design guidelines resulted in sediment and discharge monitoring equipment that puts function before aesthetic considerations. The bridge-based unit is a hodge-podge of components easily identifiable to those who know their way around their local hardware store.

2.3 Bridge-Board Design

Aluminum was the logical frame material choice. Its resistance to corrosion, high strength, light weight, and relatively low cost make it ideal. An aluminum hand truck purchased from an industrial supply catalog became the frame choice for the bridge-board. Mobility would be practical considering the lead we would be hauling around. By altering an accessory available for the hand truck called a stair climber set, designed to allow the hand truck to negotiate stairs, a 180-degree pivoting platform was created and then attached to the axle of the hand truck. To this platform a two speed, free-spooling boat winch with a hand brake was later secured. The pivoting platform positions the winch platform above the hand truck's wheels to preserve their function in the mobile position, as well as reduce the overall bulkiness of the bridge-board. The platform is securely locked in place with a steel rod in its operating position and hooks onto the bridge-board frame in the mobile position. Eighty feet of 3/32 inch vinyl-coated wire rope was wound around the winch spool and over a sheave mounted on a steel rod near the hand truck's handle. The base or noseplate of the hand truck was removed, elevated, then reattached to the frame. In the bridge-board's operating position the noseplate now contacts the top and inside face of the bridge railing. It was relocated to the balance point of the bridge-board, with the winch is in the operating position and the fish-shaped lead weight attached. The stability of the bridge-board is increased with an additional accessory called a nose extension. The nose extension attaches to the noseplate and lies flat against the bridge-board's frame in the mobile position. The nose extension, as its name implies, extends the noseplate an additional 24 inches. It was designed to allow the hand truck user to support large bulky objects such as a large cardboard box. The nose extension pivots 90-degrees and locks in place in the same manner as the winch platform, with a steel rod. The nose extension lies flush against the inside face of the bridge railing when the bridge-board is in the operating position. The bridge-board is secured to the bridge railing via two bar clamps and two ratchet tie downs. This design works well for the more common square or rectangular steel tubing type railings, and is less effective on the less common guardrail style bridge railings. An adapter is in the process of being developed which will match the profile of the guardrail and provide a flat mounting surface. This would be easily constructed out of rigid insulation and plywood. A device consisting of a counter and wheel of known diameter designed to measure distance called a measure master was mounted on the bridge-board frame so as the wheel lies tangent to the winch cable. This device accurately measures depth. An AVOCET brand bicycle computer is mounted to the axle of the bridge-board, adjacent to a plastic spool of 1/4 inch phono cable. This phone cable parallels the vinyl-coated steel cable through eyelets and connects to the velocity meter mounted on the fish-shaped lead weight.

2.4 Staff Mounted Velocity Meter Design

The propeller-style velocity meter that attaches to the fish-shaped lead weight and is suspended from the bridge-board is the same velocity meter that can be attached to a staff to take velocity readings in small streams, reclamation ditches, and from low bridges. PVC pipe and aluminum tubing are non-corrosive, lightweight and relatively inexpensive materials. They were the logical choice for the staff portions of the staff mounted velocity meters. At this point work has begun on four staff-mounted velocity meters. Two of these flow probes triple extend to around 5 meters and are approximately half completed. Two that are one piece and do not extend are in their final stages of completion. All staff mounted velocity meters in construction at this point utilize a replacement parts package from a company called Global Water. It consists of a two bladed radio controlled model boat propeller with a very small half disc of rare earth magnet attached with epoxy to one of the blades. The propeller then mounts inside a 2" PVC tee. To complete the staff mounted velocity meter a magnetic sensor from an AVOCET brand bicycle computer is imbedded in a PVC plug and is glued into the PVC tee. A section of PVC pipe is attached to the propeller tee and two wires from the imbedded magnet are fed up through the pipe to the computer. A depth scale in centimeters is attached to the staff and the meter is nearly complete. All that remains is the calibration and accuracy analysis.

2.5 Sounding Weight Mounted Velocity Meter Design

The velocity meter that is suspended from the bridge-board attaches to the fish-shaped lead weight in a slightly different manner. A section of steel stock 1/8th inch thick 1 inch wide and approximately 24 inches long penetrates the balance point of the fish-shaped lead weight and is secured with an aluminum pin and two steel clips. The 2 inch PVC tee housing the propeller and magnet assembly mounts on one side of the steel stock with two screws. This velocity meter needs to be disconnected from the bridge-board periodically. This is accomplished using 1/4 inch coiled phono cable. Since the connection of this cable to the velocity meter will be submerged, duct tape is wrapped around the connection to prevent water from affecting the signal.

2.6 Safety Considerations

Due to the nature of the bridge-board's use, several important safety considerations have been incorporated into its design. I chose a free-spooling winch for this reason. A free-spooling winch will allow cable to spool out without the handle spinning around. Should a fast moving submerged log or other debris snag the submerged sampling package a ring-pin can be pulled releasing the brake and allowing the cable to spool off until empty. The fish-shaped lead weight and its instrument package would most likely be lost to the current, but the bridge-board, winch, computer and person sampling would remain on the bridge. There are bridge-boards on the market that are designed for smaller non free-spooling winches that utilize a T bar under the feet of the person sampling to balance the weight of the fish-shaped lead weight. Both this style of bridge-board and the one I've been building are designed to use the bridge's railing as a fulcrum. The concern I have with this commercially available bridge-board, is that should a large log or other debris snag the lead weight and instrument package, it seems possible to actually catapult the person sampling over the railing while being beaten by a spinning winch handle. Since it is likely that the bridge-board will be used at night during heavy rain, reflective stickers have been placed in key locations on the bridge-board. Since the bridge-board has many moving parts and weighs over 70 pounds when in use, following the steps for proper and safe use becomes crucial. Training and safe-use of the bridge-board pamphlets will be providing to all expected users.

3 Construction

3.1 Methods

Construction of the bridge-based sampling system and staff mounted velocity meters was completed with a basic set of hand tools, including a bench-mounted vise and cordless drill. Due to concurrent design and construction, the bridge-board's design influenced construction and vise versa.

3.2 Results

Because the bridge-board was constructed and designed concurrently and all work was done by hand, the bridge-boards many components were attached in a somewhat less than exact manner. This result was expected, as the bridge-board is the first of its kind, a prototype.

3.3 Instructions for Future Construction (see Appendix B)

4 Operational Testing

4.1 Methods

Comparisons were made between the homemade bridge-based sampling system and the USGS bridge sampling system in the categories of ease of use, speed of use, accuracy, maintenance and safety.

4.2 Ease of Use

Both the homemade and USGS bridge-based sampling systems were designed with ease of use in mind. The USGS bridge-based system utilizes a large rolling crane to support the sampling package, which requires a pickup truck for transport. The homemade bridge-based sampling system is significantly smaller and can be easily transported in the backseat of a midsize car. The homemade bridge-based sampling system requires a longer sequence of steps, than the USGS bridge-based system, as it must be removed and reattached at each railing location. However, neither system is overly complicated.

4.3 Speed of Use

Both the homemade and USGS bridge-based sampling systems are bulky and as a result, cross sections are tedious and time consuming. The USGS bridge-based sampling system utilizes a crane that rolls from railing location to railing location without having to be removed and reattached to the bridge-railing at each step as the homemade system requires. As a result, the USGS system is to some degree a speedier system.

4.4 Accuracy

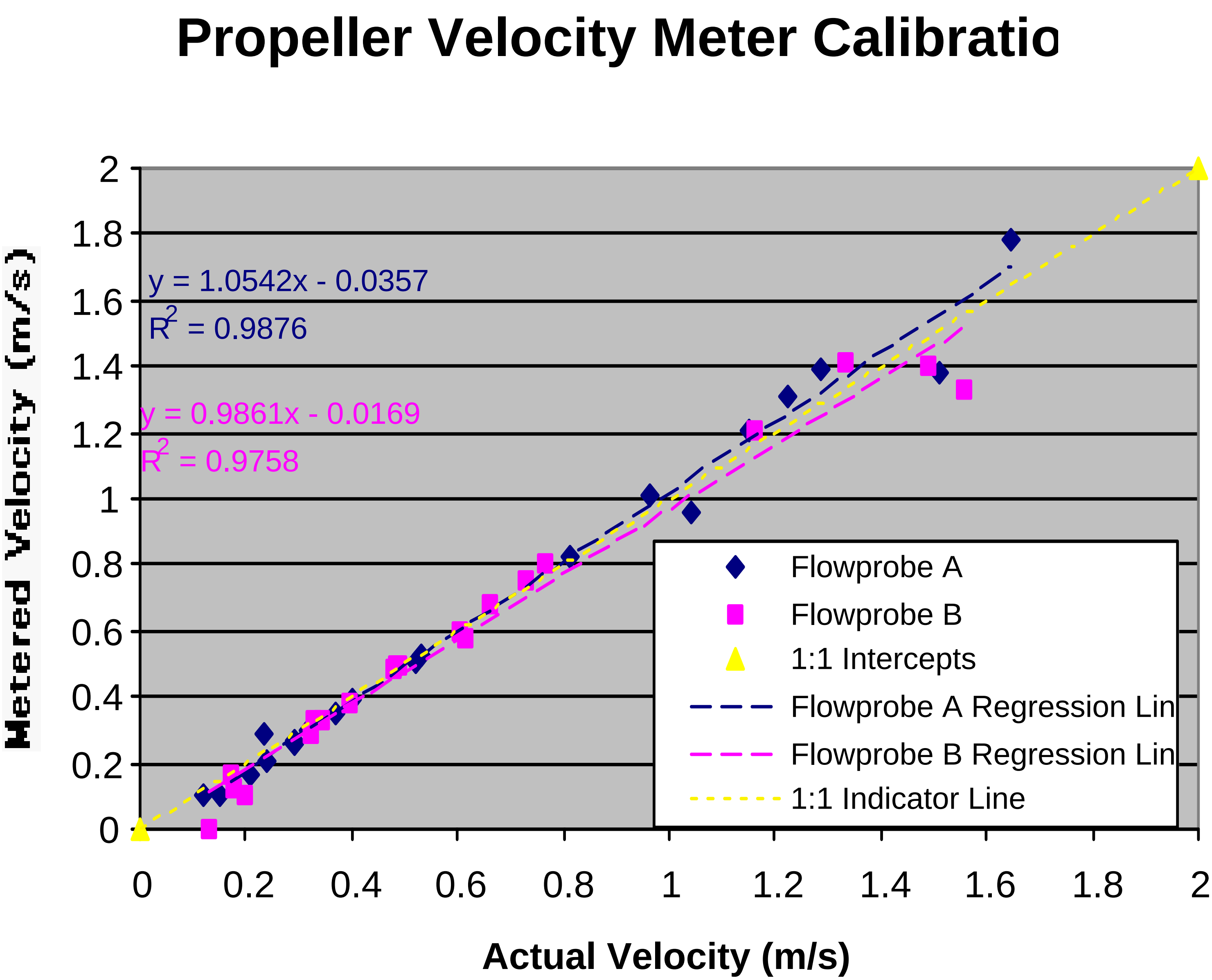
The homemade bridge-based sampling system and the USGS bridge-based sampling system were compared for accuracy in two areas, velocity meter accuracy and depth meter accuracy.

4.4.1 Velocity Meter Accuracy

4.4.1.1 Homemade system velocity meter accuracy (propeller)

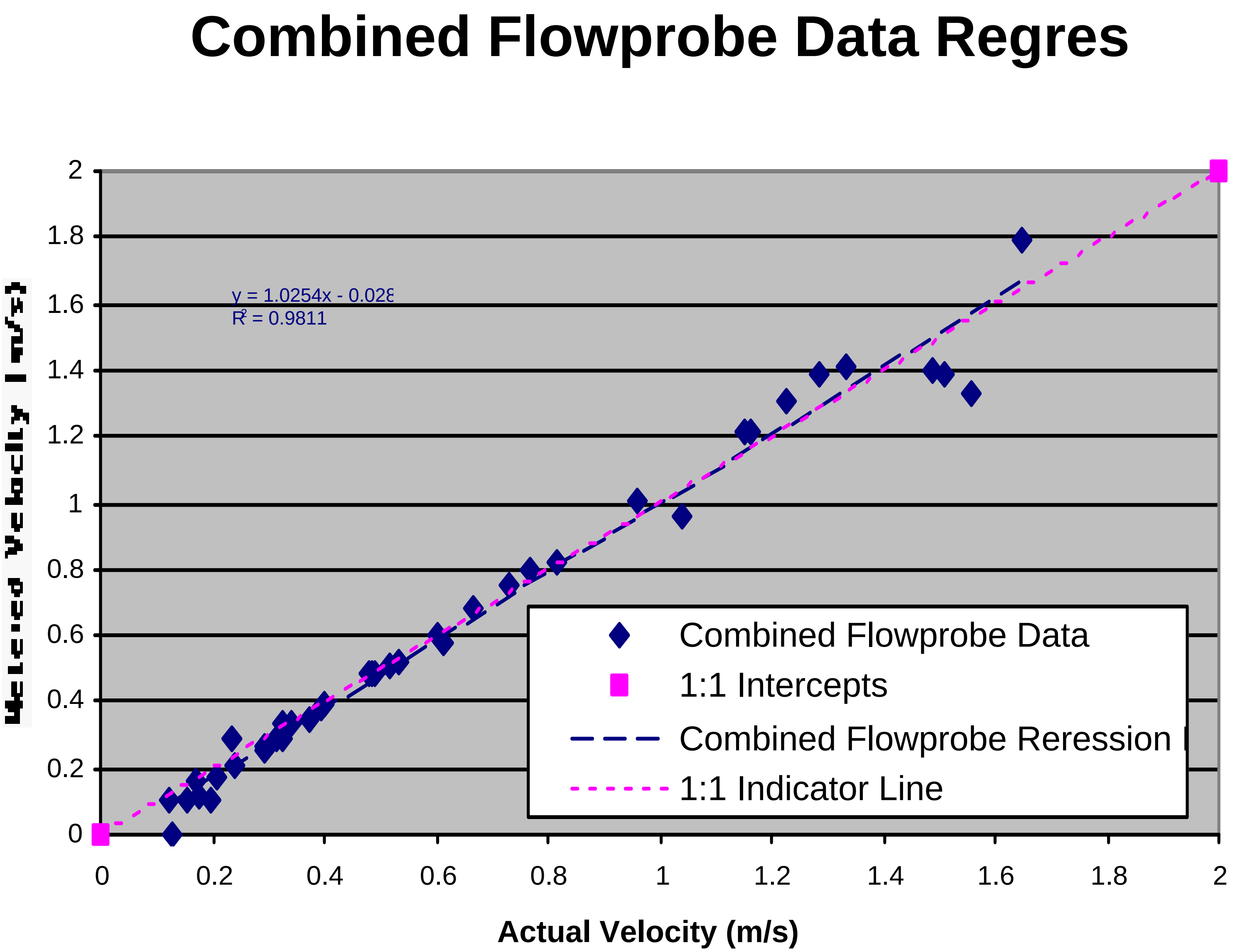
The propeller style velocity meter, in conjunction with the computer, produce water current velocities within plus or minus about 3 percent of true velocity. This result is according to experimental testing conducted in controlled conditions. The computer readings have been compared to true velocity by pulling a staff-mounted velocity meter along a known distance of poolside over a known period of time. The results of this experimental analysis follow.

Figure 1.



Propeller Velocity Meter Calibratio
Metered Velocity (m/s)
Actual Velocity (m/s)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
y = 1.0542x - 0.0357
R2 = 0.9876
y = 0.9861x - 0.0169
R2 = 0.9758
Flowprobe A
Flowprobe B
1:1 Intercepts
Flowprobe A Regression Lin
Flowprobe B Regression Lin
1:1 Indicator Line

Figure 2.



Combined Flowprobe Data Regres
y = 1.0254x - 0.028
R2 = 0.9811
Combined Flowprobe Data
1:1 Intercepts
Combined Flowprobe Reression
1:1 Indicator Line
Actual Velocity (m/s)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2

The accuracy of the propeller style meter chosen for the homemade system is shown to lie within plus or minus 3 percent of true velocity according to the regression analysis above. There are several conditions however, that are required to produce consistent and accurate readings. These conditions are as follows.

1. The computer calibration number must be (1603)…default is 2086.

2. The computer display reading is a factor of 10 too great and in incorrect units.

   (A 10.7 km/hour reading is really 1.07 meters/sec)

3. The stream flow must be between 0.1 and 2.0 meters/sec.

4. The computer battery is not weak.

   (a weak battery may revert computer to default settings)

4.4.1.2 USGS system velocity meter accuracy (vertical-axis Type AA model 6200)

The vertical-axis style water current meter is the standard used by USGS technicians and independent consultants for the most accurate estimates of discharge. The USGS Type AA model 6200 is a vertical-axis water current meter. Different sized meters are designed for different current velocities. There is ample discussion of experimental results designed to test the accuracy of these meters through the USGS website. These meters, when properly calibrated, produce velocity readings within about plus or minus 2 percent. The accuracy of horizontal and vertical axis style water current meters are comparable for the purposes of this report. It should be noted that calibration of USGS type vertical-axis water current velocity meters is a complicated process best left to those qualified for the task.

4.4.2 Depth Meter Accuracy

4.4.2.1 Homemade system depth meter accuracy

The depth meter component of the homemade system is derived from a hand-held rolling wheel with a metric counter attached. This distance meter is available through rolatape.com. The depth of the water column from the surface water to the bed is assessed in a manner similar to a sounding reel. The sampling package supporting cable runs tangent to the metric counting wheel. This method of assessing depth has proven to be as accurate as its USGS counterpart, the sounding reel.

4.4.2.2 USGS system depth meter accuracy

The depth of the water column from the surface water to the bed is assessed using a sounding-reel. Since the cable never overlaps itself, each rotation of the spindle corresponds to a known measure of depth. This USGS standard method is simple and effective.

4.5 Maintenance

All scientific monitoring equipment requires maintenance. Good design translates into reduced maintenance.

4.5.1 Homemade System Maintenance

The maintenance the homemade system may require is somewhat difficult to predict. The system is complete and has been tested, but has not been in use long enough to reveal points of wear. The system was designed for a minimum of maintenance. The components likely to require maintenance are as follows.

1. Ratchet Cord (due to wear)
2. Vinyl Coated Cable (due to wear)
3. Computer Battery (due to wear)

4.5.2 USGS System Maintenance

The maintenance this system requires is also difficult to predict. The vertical-axis water current meter requires periodic examination and calibration by a trained professional.

Calibration costs vary somewhat, but one can expect to pay a few hundred dollars and be without a meter for a little while.

4.6 Safety Considerations

Bridge-based sediment and discharge monitoring has several inherent dangers. Traffic crossing the bridge during sampling is inevitable, and its threat is clear. In addition to traffic, the possibility of floating debris snagging the sampling package is a real safety concern.

4.6.1 Homemade System

Safety is a primary concern. Sampling sediment and velocity during periods of high discharge presents several dangers. A major concern is the snagging of the sampling package by floating debris. The homemade bridge-based system utilizes a free-spooling two-speed winch to suspend the sampling package. A hand brake is engaged when the sampling package is at the desired depth in the water column. If floating debris becomes entangled, the hand brake can be quickly disengaged allowing the cable to completely feed off of the reel and be swept away preserving the main unit and the person sampling. For increased visibility to passing traffic, the frame has reflective stickers strategically placed in the event of nighttime use. In addition a complete set of user safety instructions has been developed. (See Appendix B)

4.6.2 USGS System

The USGS system operates in very much the same manner as the homemade system. The main difference is the USGS system provides no method of disengaging the sampling package short of cutting the cable with a pair of wire- cutters. Jeff West (USGS technician) relayed a true account of a debris snag that pulled the entire system over the railing to be lost. He mentioned that had he tried to cut the cable with his wire-cutters, he might have been pulled over with it

4.7 Comparison of Results from Operational Testing

The USGS system is generally easier to use than the homemade system provided one has access to a pickup truck. The USGS system is a speedier system, as it doesn't have to be disconnected from the railing after each measurement. The accuracy of the homemade and USGS systems depth and velocity meters is comparable. The maintenance the homemade system may require is difficult to predict, however, it does not require a trained professional to calibrate the velocity meter as the USGS system does. The homemade velocity meter has only one moving part, a nylon model boat propeller which rotates on a stainless steel axle. I believe the homemade system is somewhat safer to use as it allows for a quick disconnection of the sampling package.

5 Overall Assessment

5.1 Introduction

This section of the report is an overall assessment of the similarities and differences between two separate methods of obtaining a bridge-based sampling system. The Salinas Sediment Study has chosen a method that consists of designing and building a largely homemade system with an inexpensive, horizontal-axis, propeller style meter. The alternative method consists of purchasing commercially available equipment, mainly USGS, and utilizes a more costly vertical-axis Price type meter. This section looks at the dollar costs of these two alternatives. It contains a component cost breakdown; sampling package loss cost breakdown, as well as comparing the benefits of both methods

5.2 Methods

The methods of the overall assessment are to add up the costs of the two alternatives, list their separate benefits and provide a detailed comparison.

5.3 Costs

The following section contains a cost breakdown for both bridge-based sampling systems, the homemade system and the USGS system.

5.3.1 Homemade System

The total cost of the homemade bridge-based sampling system is calculated by summing the component costs and the labor costs. The amount of hours spent exclusively on the design or construction of the homemade system is difficult to accurately calculate. Time spent working on the system was often spent equally between construction and pondering the next practical step. I would often find myself designing and building the system inside my head at random times. According to my records I have spent approximately 160 paid hours designing and building this system. This time was spent equally between design and construction.

Homemade Bridge-Based Sampling System Total Cost

	Components	
FRAME		
	Aluminum Hand Truck (McMaster-Carr part # 2611T71)	$ 108.00
	Stair Climber Set (McMaster-Carr part # 2611T88)	$ 26.00
REEL		
	Two Speed Free-Spooling Boat Winch (McMaster-Carr part # 3736T3)	$ 148.00
	80 Feet 3/32" Vinyl Coated Wire Rope (Orchard Supply Hardware)	$ 50.00
BRIDGE INTERFACE		
	(Hand Truck) Nose Extension (McMaster-Carr part # 9969T68)	$ 54.00
	Pair Craftsman 16" Adjustable Bar Clamps (Orchard Supply Hardware)	$ 35.00
	Pair Werner Ratchet Cords (Orchard Supply Hardware)	$ 15.00
DEPTH METER		
	Rolatape Measuring Wheel (rolatape.com)	$ 55.00
VELOCITY METER		
	Bicycle Mounted Velocity Computer AVOCET model 35 (Bicycle Shop)	$ 45.00
	25' 1/4" Coiled Phono Cable, 25' 1/4" Phono Cable (Radio Shack)	$ 15.00
	1 3/4" Two Blade Model Boat Propeller in 2" PVC Tee (Global Water)	$ 30.00
SOUNDING WEIGHT		
	USGS 30 Lb. Lead Sounding Weight (benmeadows.com)	$ 335.00
SUSPENDED SEDIMENT SAMPLER		
	USGS DH48 (Advanced Measurements and Controls Inc.)	$ 210.00
MISCELLANEOUS HARDWARE		
	Nuts and Bolts (Approximate Cost)	$ 200.00
	Labor	
LABOR (DESIGN)		
	Hours X $9/Hour (80)	$ 720.00
LABOR (CONSTRUCTION)		
	Hours X $9/Hour (80)	$ 720.00
	Total Cost	$ 2,766.00

5.3.2 USGS System

The cost of the USGS bridge-based system contains component costs and purchasing time costs only, as there are no relevant design or construction costs. A reasonable estimate of the time it would require to order the all the components of the USGS bridge-based sampling system is 10 hours. This dollar cost is subjective.

USGS Bridge-Based Sampling System Total Cost		
	Components	
CRANE		
	USGS Model 4300 (Advanced Measurements and Controls Inc.)	$ 1,155.00
REEL		
	USGS A-55 Sounding Reel Model 3220 (Adv. Meas. And Controls Inc.)	$ 1,275.00
HEADPHONE SYSTEM		
	USGS Compatible Headphones (Adv. Meas. And Controls Inc.)	$ 65.00
SOUNDING WEIGHT		
	USGS 30 Lb. Lead Sounding Weight (benmeadows.com)	$ 335.00
VERTICAL AXIS VELOCITY METER		
	USGS Type AA Model 6200 (Adv. Meas. And Controls Inc.)	$ 745.00
SUSPENDED SEDIMENT SAMPLER		
	USGS DH48 Susp. Sed. Sampler (Adv. Meas. And Controls Inc.)	$ 210.00
	Labor	
PURCHASING TIME		
	Hours X $9/Hour (10)	$ 90.00
	Total Cost	$ 3,875.00

5.4 Sampling Package Replacement Cost

The following sections reflect the component costs of each system susceptible to debris loss.

5.4.1 Homemade System Sampling Package

This section itemizes the cost of replacing the portion of the homemade bridge-based sampling system that is suspended from the bridge into the flowing stream.

Homemade System Sampling Package Replacement Cost			
VELOCITY METER			
	25' 1/4" Coiled Phono Cable, 25' 1/4" Phono Cable (Radio Shack)	$	15.00
	1 3/4" Two Blade Model Boat Propeller in 2" PVC Tee (Global Water)	$	30.00
	80Ft. 3/32" Vinyl Coated Wire Rope (Orchard Supply Hardware)	$	50.00
SOUNDING WEIGHT			
	USGS 30 Lb. Lead Sounding Weight (benmeadows.com)	$	335.00
SUSPENDED SEDIMENT SAMPLER			
	USGS DH48 (Advanced Measurements and Controls Inc.)	$	210.00
	Total Cost	**$**	**640.00**

5.4.2 USGS System Sampling Package

This section itemizes the cost of replacing the portion of the USGS bridge-based sampling system that is suspended from the bridge into the flowing stream.

USGS System Sampling Package Replacement Cost		
SOUNDING WEIGHT		
	USGS 30 Lb. Lead Sounding Weight (benmeadows.com)	$ 335.00
VERTICAL AXIS VELOCITY METER		
	USGS Type AA Model 6200 (Adv. Meas. And Controls Inc.)	$ 745.00
SUSPENDED SEDIMENT SAMPLER		
	USGS DH48 Susp. Sed. Sampler (Adv. Meas. And Controls Inc.)	$ 210.00
	Total Cost	**$ 1,290.00**

5.5 Relative Benefits

This section of the report identifies the relative benefits of both the homemade and USGS systems based on operational testing and dollar cost criteria.

5.5.1 Homemade System

The accuracy of the homemade and USGS systems depth and velocity meters is comparable. The maintenance the homemade system may require is difficult to predict, but unlike the USGS system, it does not require a trained professional to calibrate the velocity meter. The homemade system is safer to use as it allows for a quick disconnection of the sampling package. The homemade system has a lesser total cost of $ 2,766.00, which is approximately 75% of the USGS system total cost of $ 3,875.00. The homemade system has a lesser sampling package replacement cost of $ 640.00, which is approximately 50% of the USGS system sampling package replacement cost of $ 1,290.00.

5.5.2 USGS System

The results of operational testing revealed that The USGS system is easier to use than the homemade system provided one has access to a pickup truck. The USGS system, because of it rolling crane design, is also the speedier system. The accuracy of the homemade and USGS systems depth and velocity meters is comparable

5.6 Analysis / Discussion / Conclusions

[Fred notes: Make sure this section is where you compare costs versus benefits of each system]

Interpretation of relative dollar costs of the two systems is important. The $ 2,766.00 cost of the homemade system incorporates the design cost. If this system were to be reproduced the cost would be significantly less due to experience gained. $ 2,000.00 is a good estimate of the reproduction cost. The homemade system sampling package replacement cost is $ 640.00. The USGS system sampling package replacement cost is $

1,290.00. This is the replacement cost for each system should the sampling package be lost to floating debris. The USGS system sampling package cost assumes the cable is cut and the crane and sounding reel are preserved. As shown by the results, the homemade method is somewhat less inexpensive to produce, somewhat less expensive to maintain, and perhaps somewhat safer to operate. The USGS system however, is speedier and easier to use. To say which method is better is open to interpretation.

6 Conclusions

This project originated when the Salinas Sediment Study team made a choice between purchasing commercially available equipment, or attempting to design and construct similar equipment at a lesser cost. The ramifications of choosing commercially available equipment are clear. The cost is known, the accuracy is known, the design has been through testing and modification, and last but not least the delivery time is known. The second choice holds a great deal more risk. It could have well cost more than a USGS system and completely failed at it desired function. To state which system is more appropriate depends on several factors. The homemade system is more mobile and less costly to maintain and repair, but compromises speed, ease of use and the ability to support sounding weights of greater than fifty pounds. Instead of comparing these two alternatives as equals, they may each find their own niche.

The good value of the propeller style velocity meter was somewhat surprising and deserves mention. Several companies marketing staff mounted velocity meters use the same basic components and the same basic design. A plastic radio control model boat propeller mounted on a stainless steel axle centered in a PVC tee. The propeller then has a small but powerful rare earth magnet glued to one or more of the blades. A sensor from a bicycle computer mounted inside the PVC tee detects each pass of the magnet and records this data as a velocity. This style of velocity meter is extremely accurate, durable, and inexpensive. I predict their widespread use and acceptance.

The fact that either system chosen had a relatively similar cost is worth noting. The homemade system is approximately 75% of the USGS system cost. There was not a large cash savings afforded the Salinas Sediment Study for opting to go the design and construction route. There were other benefits worth noting. Designing and building the homemade system provided me with valuable experience, a paycheck, a chance to create, and the backbone of this report.

7 Acknowledgements

No one works alone. There are several individuals that made this project and report possible. Without their assistance the bridge-board could not have been built and this report could not have been written.

Fred Watson

Thank you for the opportunity to work on an important ESSP project, and for your suggestions for the structure of this paper.

Thor Anderson

Thank you for all of your help with the research, design, and testing of the bridgeboard.

Joel Casagrande and *Donald Kozlowski*

Thank you for your time spent collecting the data necessary to calculate the accuracy of the velocity meter.

Salinas Sediment Team

I'd like to thank the rest of the Salinas Sediment Study team for providing a positive work environment

The Watershed Institute at CSUMB

I'd like to thank the Watershed Institute at CSUMB for providing the location and utilities necessary to fulfill my goals.

8 References

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   Water Measurement Manual

   Second Edition-Revised Reprint Denver, Colorado 1974

2. McMaster-Carr Supply Company

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Appendix A: Instructions for Construction of the Bridge-Board

THESE INSTRUCTIONS WILL FACILITATE EASY CONSTRUCTION SHOULD ONE WISH TO REPRODUCE THE BRDIGE-BOARD

1. The frame of the bridge-board consists of the aluminum hand truck.

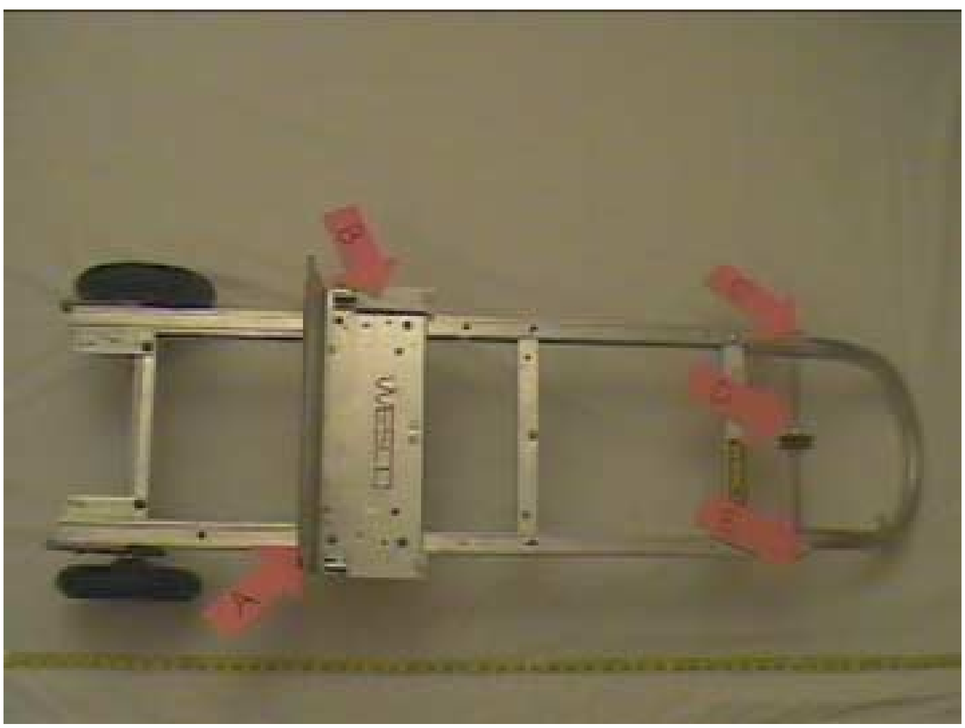
2. The hand truck noseplate is attached 13 1/4" above its normal position and acts as the fulcrum of the system. Observe Point "A"

3. The nose extension brackets are secured to the noseplate with the provided hardware, and covered with a durabl e plastic to protect the bridge railing. Observe Point "B"

4. Two 3/8" diameter holes are drilled near the handle to allow for the 3/8" diameter 12 1/4" sheave axle. Observe Point "C"

5. Two 3/8" locking collars hold the aluminum sheave in the center position. Observe Point "D"

6. Two 1" roll pins seated perpendicular through the ends of the sheave axle lock it in place. Observe Point "E"



1. The two-speed, free spooling boat winch is bolted to a 7 1/2” X 12” aluminum plate 1/8” thick. Observe Point “A”

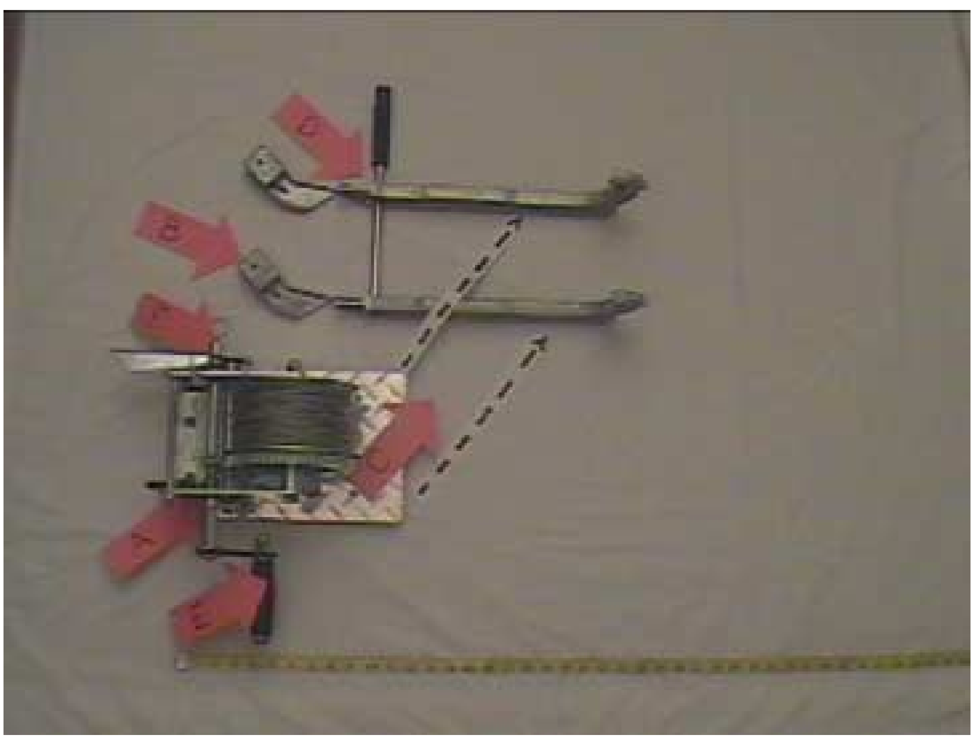
2. The ends of the stair climber set are cut to create a level brace for the winch platform. Observe Point “B”

3. The winch platform is attached to the level surface of the stair climber set with 3/4” aluminum angle iron and machine screws.   Observe Point “C”

4. 3/4” holes are drilled in the ends of the stair climber set to accommodate a 3/4” diameter steel rod with a plastic handle. The steel rod is secured to the stair climber set with 1” roll pins. Observe Point “D”

5. The original winch handle is removed and a handle is manufactured of shorter length. The 4” long handle is constructed from 1” steel stock and a 1/2” coupling nut. It is secured with 3/4” roll pins. Observe Point “E”

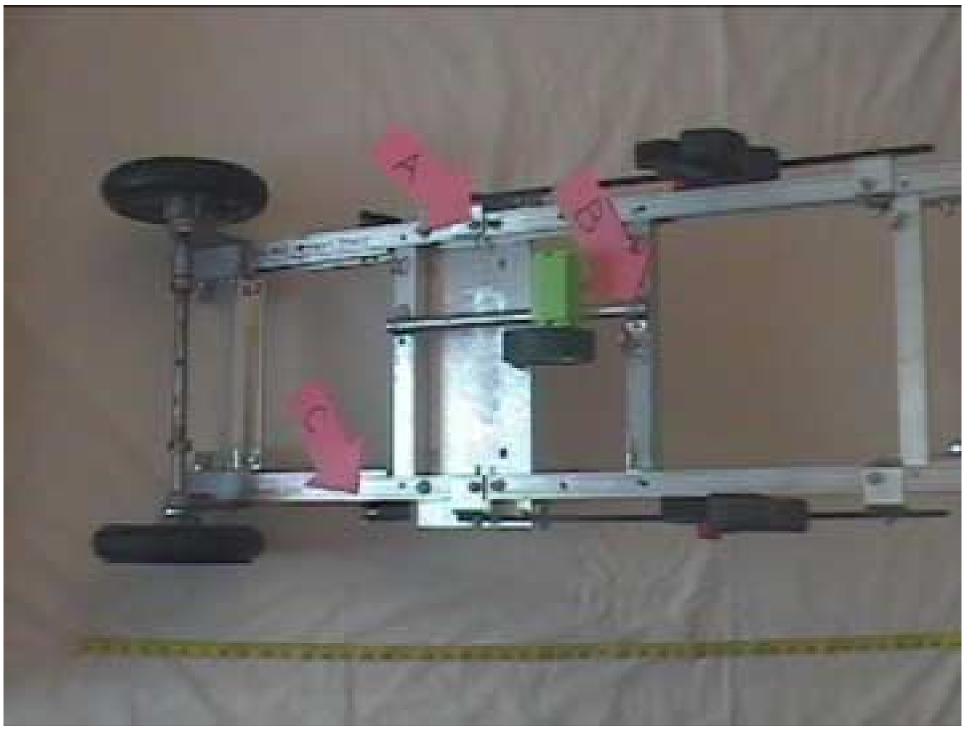
6. A 3/16” hole is drilled through the hand brake and winch frame, while the hand brake is in the locked position. A ring pin is used to allow hands free locking of the spool. Observe Point "F”



1. Two 16” bar clamps are bolted to the bridge-board frame using 1/8” galvanized steel angle iron. Observe Point “A”

2. The depth meter handle is cut to a length of 12” and attached 4 1/2” from the left side of the bridge-board (top of picture) using 1/2” pipe straps and self tapping screws. Observe Point “B”

3. The ratchet cord units are bolted to the bridge-board frame 2” below the first cross-member. Observe Point “C”

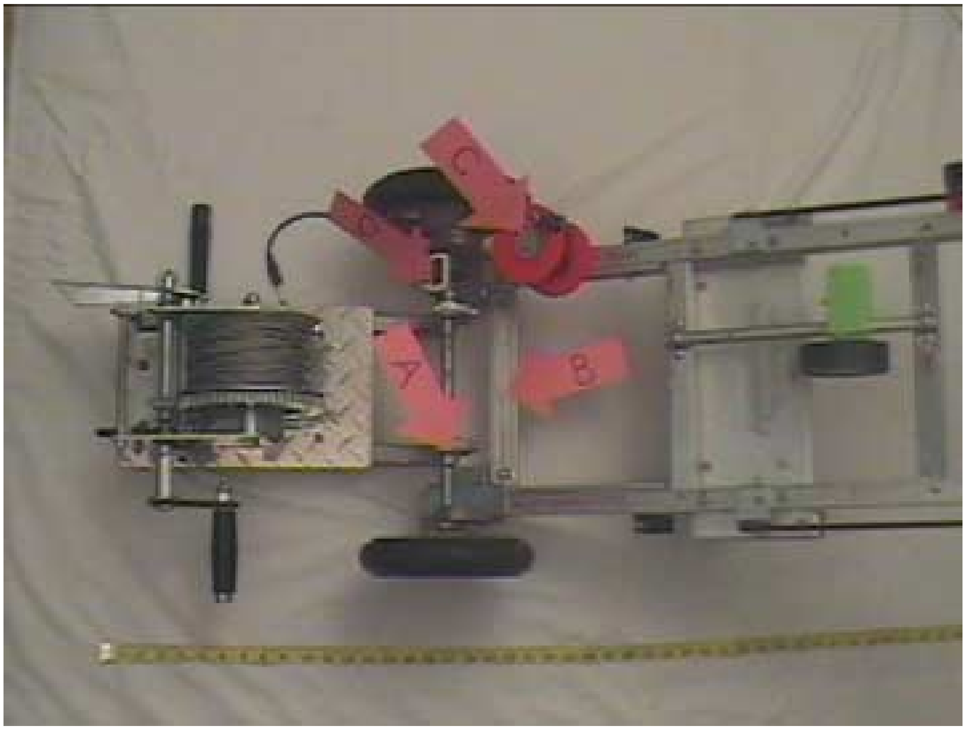


1. The assembled winch platform is connected to the bridge-board axle, and secured in place with 5/8” locking collars. Observe Point “A”

2. A 9” length of 1/4” thick 1” X 1” aluminum angle iron is bolted 8” below the first cross-member to act as a stop for the winch platform once the platform pivots to a point parallel to the bridge-board frame. Observer Point “B”

3. A small plastic spool is bolted to the bridge-board to hold the electrical cable used to transmit the velocity meter signal to the computer. Observe Point “C”

4. The computer lead is cut and replaced with a short section of 1/4” phono cable. The male lead will connect to the female lead of the spooled cable. The computer is then mounted to the bridge-board axle with the supplied bracket. Observe Point “D”

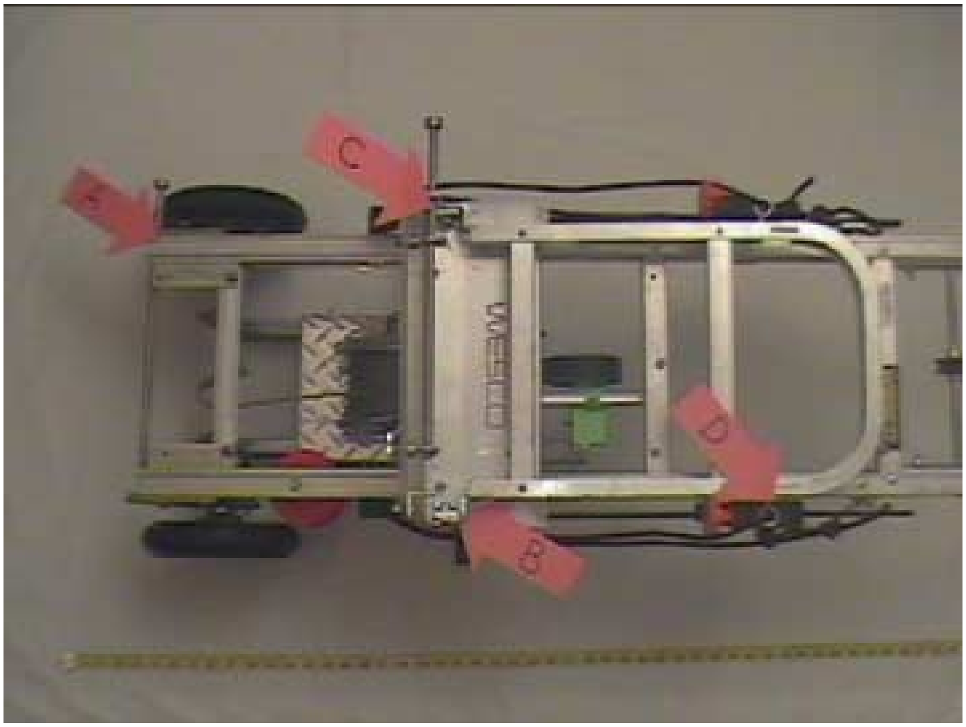


1. 3/8” diameter holes were drilled through the base of the bridge-board frame as well as through the stair climber set portion of the winch platform. These holes allow for a 14” long 3/8” diameter steel rod, which locks the winch platform in the operating position. Observe Point “A”

2. The nose extension is bolted to noseplate via the provided brackets. Observe Point “B”

3. 3/8” holes were drilled through the nose extension and two short sections of 1 1/4” X 1 1/4” aluminum angle iron. These sections and two eye-hooks are bolted to the noseplate and act as guides for the 14” long 3/8” diameter steel rod, which locks the nose extension in the operating position. Observe Point “C”

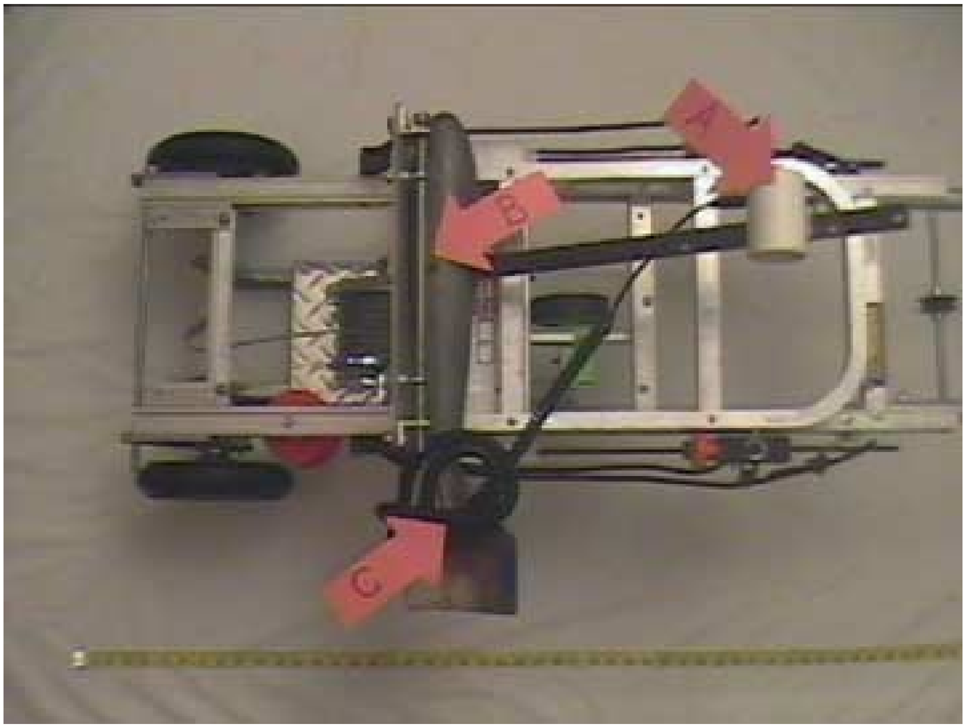
4. Two eye-hooks are bolted to the nose extension 1 1/2” above the second cross-member to provide routing for the ratchet cords. Observe Point “D



1. The computer magnetic sensor lead is cut and replaced with a 4” length of phono cable with a female lead. The magnetic sensor is glued into a PVC cap and set into the PVC tee in a position so that the magnet attached to the propeller blade passes over it on each rotation. Observe Point “A”

2. The PVC tee with propeller and magnetic sensor is screwed to a 22” long 1’”wide 1/8” thick piece of steel stock. 3/8” holes are drilled on each end of the steel stock, to allow winch cable and sounding weight attachment. The sounding weight is attached with a 3” section of 3/8” diameter aluminum rod and cotter pins. Observe Point “B”

3. The 25’ section of coiled phono cable connects between the velocity meter and the straight phono cable coiled on the spool. Observe Point “C”


A
B
C

Appendix B: Safe Use Instructions

8.1 Lowering the Sounding Weight and Velocity Meter

1. Wheel bridge-board to desired railing location

2. Open and lock nose extension with steel rod

3. Carefully tilt bridge-board onto railing and secure by squeezing bar clamp handles

4. Pull ratchet cords snug to complete the interface
5. Unhook and pivot winch platform 180 degrees and lock into position using steel rod
6. Engage winch hand brake

7. Attach sounding weight to winch cable and plug coiled cable into the velocity meter

8. Place (SHIFT LOCK) lever into the 3rd position from the left

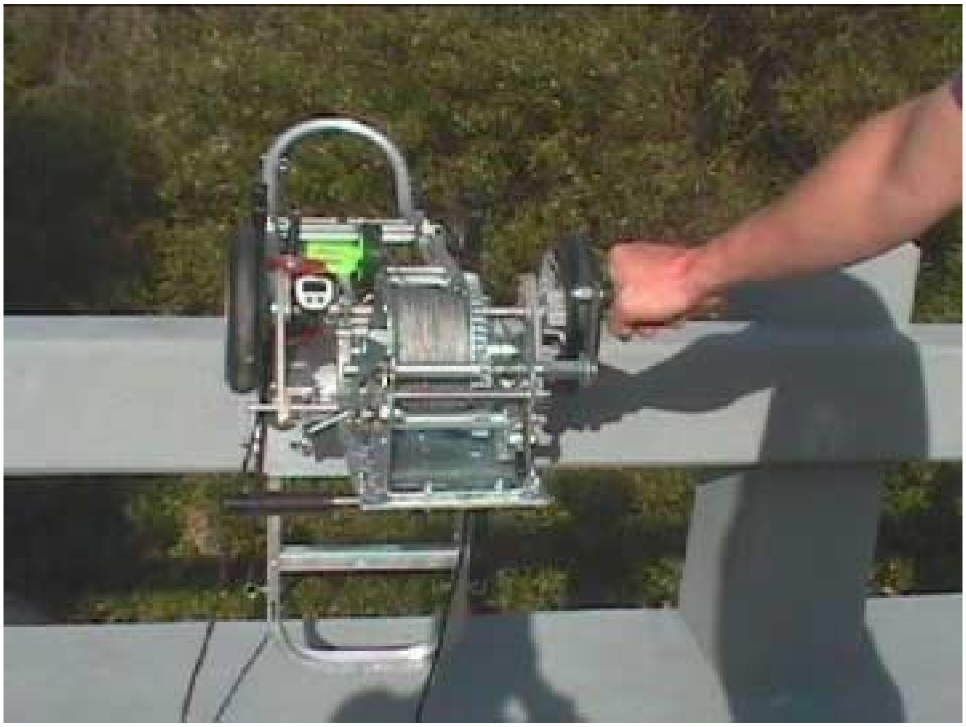
9. Place black handled ratchet lever in top position

10. Have helper lower sounding weight w/ meter over railing while holding winch platform handle

11. Place ratchet lever in middle position

12. Grasp winch handle and hand brake

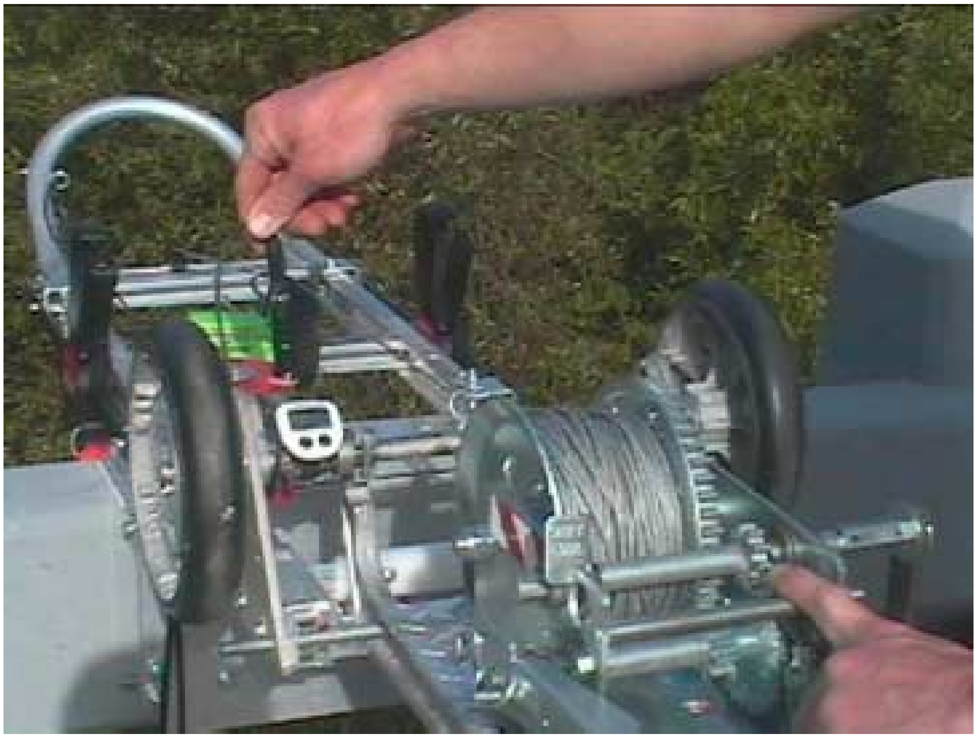
13. Release hand brake and lower meter to desired depth by turning winch handle



14. Engage hand brake

15. Place (SHIFT LOCK) lever into middle position

16. Connect computer to velocity meter cable



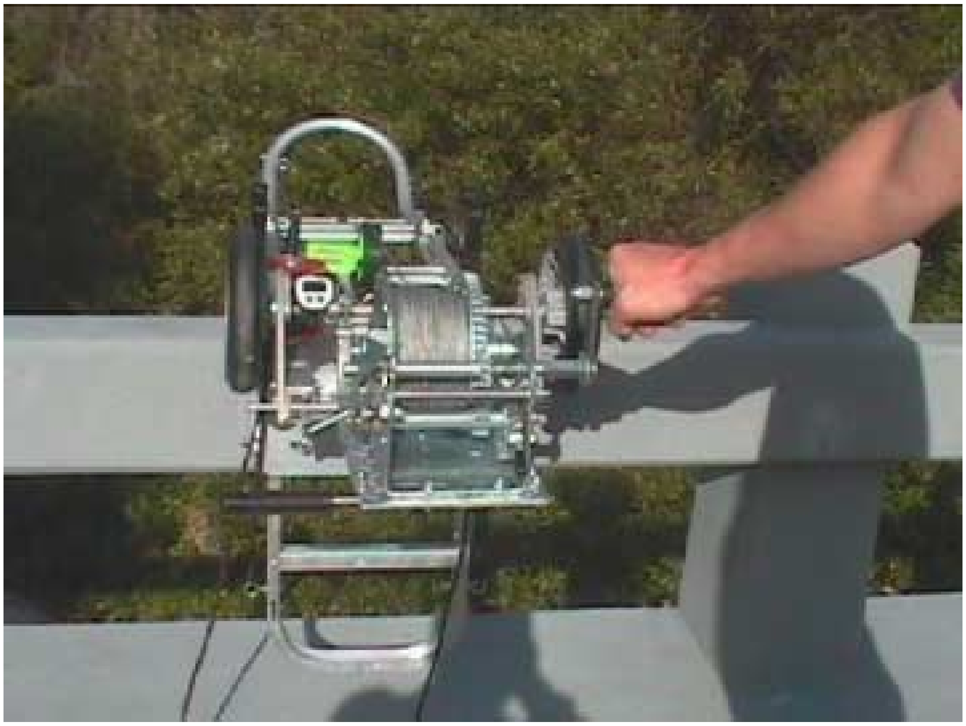
8.2 Retrieving the Sounding Weight and Velocity Meter

1. Place (SHIFT LOCK) in 3rd position from left

2. Place ratchet lever into top position

3. Grasp winch handle and hand brake

4. Release brake and raise sounding weight w/ meter by turning winch handle



5. Have helper retrieve the sampling package and disconnect it from the bridge-board

6. Engage hand brake

7. Remove steel rod from winch platform and pivot platform to mobile position

8. Hook winch platform to bridge-board frame and replace steel rod in frame ends

9. Release ratchet cords and bar clamps while holding bridge-board stable

10. Carefully tilt bridge-board back down

11. Remove steel rod from nose extension, pivot closed and replace steel rod in nose-plate

12. Roll bridge-board to new location