NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

NCHRP Report 397B

Magnetic Sliding Collar Scour Monitor

Installation, Operation, and Fabrication Manual

Transportation Research Board
National Research Council

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Magnetic Sliding Collar Scour Monitor

Installation, Operation, and Fabrication Manual

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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

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FOREWORD

By Staff
Transportation Research Board

This report consists of separate manuals that provide specific fabrication, installation, and operation guidance for two scour monitoring devices. The findings of the study in which these fixed devices for measuring maximum scour depth were developed, tested, and evaluated are reported in a companion document. These reports will be of immediate interest to hydraulics engineers, bridge management engineers, and bridge maintenance engineers.

Scour is the primary cause of bridge failure in the United States. Because scour holes generally fill in as streamflows diminish, post-flood inspections are not adequate to determine fully the extent of scour damage. Methods of measuring the maximum scour depth are needed in the management of scour-susceptible bridges and unknown-foundation bridges.

These manuals and the companion report, published as *NCHRP Report 396*, are the culmination of NCHRP Project 21-3, which consisted of three phases. Phase I, which was reported in *NCHRP Research Result Digest 189*, developed four mandatory and eight desirable characteristics for scour monitoring devices and identified four classes of instruments—sounding rod, sonic fathometer, buried/driven rod, and other buried devices—likely to provide these characteristics.

In Phase II, the most promising devices were evaluated under field conditions. The objective of these evaluations was to determine accuracy, dependability, and durability under a broad range of stream types, flow conditions, and bridge geometries. On the basis of these evaluations, the magnetic sliding collar and the sonar-based devices were identified as appropriate for further refinement. These two monitors meet all of the mandatory requirements and most of the desirable characteristics established for scour monitoring devices. There was no report on the Phase II research.

These manuals, which are the product of Phase III, provide guidance for selecting the device most suitable for a bridge and its location. Detailed instructions, including fabrication drawings and parts lists, are included to permit the fabrication of the monitors in most machine shops. Instructions for operation and maintenance are also given.

CONTENTS

PART I INSTALLATION AND OPERATION

CHAPTER 1

SYSTEM DESCRIPTION

1.1 DESCRIPTION

The magnetic sliding collar scour monitor is a simple, mechanical device for measuring maximum scour depth. The device is the result of research that was conducted under NCHRP Project 21-3, *Instrumentation for Measuring Scour at Bridge Piers and Abutments*. Refer to *NCHRP Report 396* for detailed findings from this research project, and for interpretation and appraisal of information derived from laboratory and field testing of bridge scour instrumentation.

The device consists of a stainless steel pipe that is placed vertically into the streambed with a sliding collar that drops as the scour progresses. The location of the collar is determined by sensing the magnetic field created by magnets attached to the collar. The device measures the *maximum* scour that occurs during a given flood; if the scour hole refills, the collar becomes buried. This is not a limitation of the instrument, because the maximum scour that occurs during a flood is what is important from a bridge safety and bridge integrity perspective. Both manual and automated-readout devices are described in this manual.

1.2 MAJOR COMPONENTS—MANUAL-READOUT DEVICE

For the low-cost, manual-readout device, the sliding collar is located by sending a probe down the center of the stainless steel pipe (see Figure 1). When the probe encounters the magnetic field created by the magnets on the collar, a buzzer sounds. As with a well sounding measurement, the collar is then located by measuring the length of cable dropped into the pipe.

This device is particularly well suited to small bridges that are close to the water surface. It can be used to measure scour at piers and vertical wall abutments; however, it is not generally adaptable for use at spill-through (sloping) abutments.

The major components of the manual-readout, magnetic sliding collar scour monitor include

1. **Sliding Collar Pipe**. A 50-mm (2-in.) diameter, Schedule 40, stainless steel pipe that is placed vertically in the streambed by vibrator driving, jetting, or predrilling. For most small bridges that are close to the water surface, the pipe can be installed as deep as necessary by driving. Driving requires a hardened driving point on the bottom of the pipe.
2. **Connection Pipe**. A stainless steel pipe that can be used as a connecting pipe from the streambed to the bridge deck; however, to reduce cost, it is acceptable to terminate the stainless steel pipe above the water surface and use galvanized or black pipe to make the connection to the bridge deck.
3. **Sliding Collar**. A stainless steel collar, 165 mm (6.5 in.) in diameter and 178 mm (7.0 in.) high, with magnets. The collar slides freely on the pipe and is designed to minimize potential binding.
4. **Measurement Probe**. A probe that is dropped down the center of the pipe from the bridge deck to determine the distance to the sliding collar.

1.3 MAJOR COMPONENTS—AUTOMATED-READOUT DEVICE

A refinement to the manual-readout device is an automated-readout device that eliminates the need for a manual probe, and, perhaps more importantly, for having the pipe extend to the bridge deck. A pipe extending from the streambed to the bridge deck can be impractical for bridges that are over deep channels or are elevated well above the water surface. Additionally, the pipe is vulnerable to damage from debris and ice impact.

The automated-readout insert consists of a series of magnetic switches spaced at equal intervals inside the pipe below the streambed. The location of the collar is determined by which switch is activated. The wiring for the switches is typically routed in a flexible, waterproof conduit from the streambed to the instrument shelter along a path that is not vulnerable to ice and debris impact (see Figure 2).

This device is well suited to measure scour at piers and vertical wall abutments. Additionally, without the need for a pipe extending to the bridge deck, this device can be used at spill-through abutments.

The major components of the automated-readout magnetic sliding collar scour monitor include

1. **Sliding Collar Pipe**. A 50-mm (2-in.) diameter, Schedule 40, stainless steel pipe that is placed vertically in the streambed by vibratory driving, jetting, or predrilling. For most small bridges that are close to the water sur-

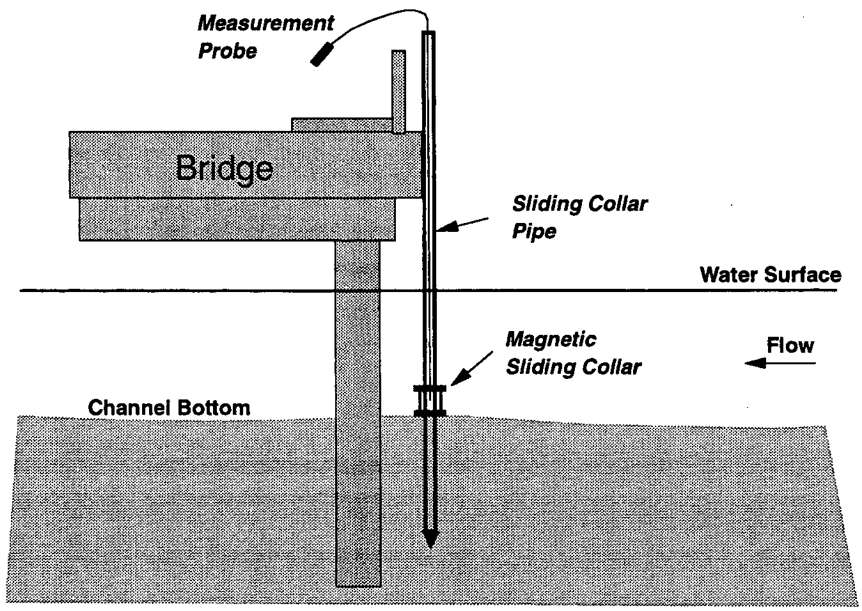


Figure 1. Manual-readout, magnetic sliding collar scour monitor.

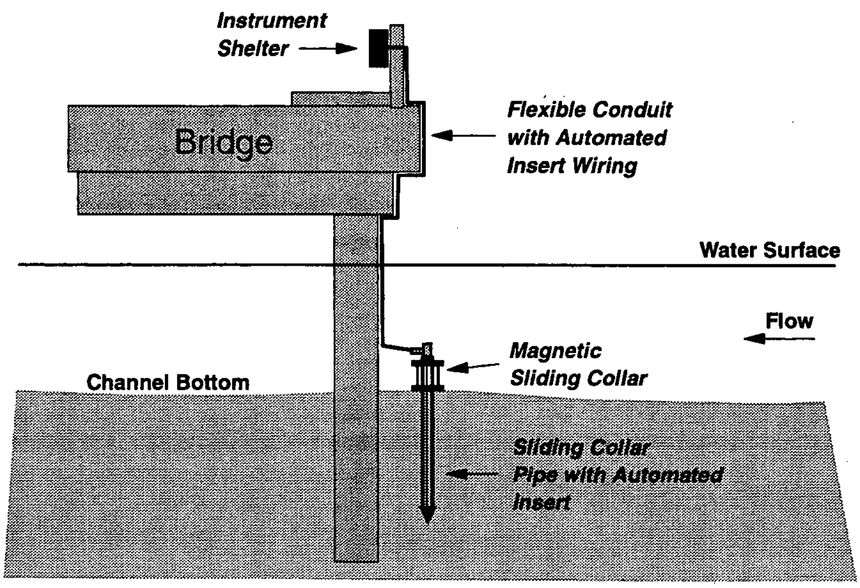


Figure 2. Automated-readout, magnetic sliding collar scour monitor.

face, the pipe can be installed as deep as necessary by driving. Driving requires a hardened driving point on the bottom of the pipe.

2. **T-fitting**. At the top of the stainless steel pipe is a T-fitting that provides a connection through the horizontal leg of the T for wiring going to the bridge deck, and a driving location off the vertical leg of the T. If the installation is in a predrilled hole, and does not require driving, a standard pipe elbow can be used instead of the T-fitting.
3. **Sliding Collar**. A stainless steel collar, 165 mm (6.5 in.) in diameter and 178 mm (7.0 in.) high, with magnets. The collar slides freely on the pipe and is designed to minimize potential binding.
4. **Automated Insert**. A switch array, with switches at equal 152-mm (6-in.) intervals. The switch array is placed inside the stainless steel pipe prior to installation, and the wiring for the switches is routed through the T-fitting in a flexible, waterproof conduit to the bridge deck.
5. **Instrument Shelter**. With the automated insert in place, the collar location is indicated automatically by an LED light when a push button in the instrument shelter is activated.

CHAPTER 2

APPLICATION GUIDELINES

2.1 ANALYSIS OF THE ENVIRONMENT

Most streams that highways cross are alluvial; that is, the streams are formed in materials that have been and can be transported by the stream. In alluvial stream systems, it is the rule rather than the exception that banks will erode; sediments will be deposited; and floodplains, islands and side channels will undergo modification with time. Alluvial channels continually change position and shape as a consequence of hydraulic forces exerted on the bed and banks. These changes may be gradual or rapid and may be the result of natural causes or human activities. As a result, the deepest portion of the channel (called the thalweg) or the location of greatest scour at a bridge crossing can change from one flood to the next, or even during a given flood (see Figure 3).

Scour is the result of the erosive action of flowing water, excavating and carrying away material from the bed and banks of streams. *Local scour* involves the removal of a small portion of the channel near piers, abutments, spurs and embankments. *Contraction scour* involves the removal of material from the bed across all or most of the width of the channel and is caused by the contraction of flow by bridges or approaches. *Degradation* is the long-term lowering of the streambed over relatively long distances. Scour is generally thought of in terms of vertical change; however, horizontal changes in the bank line also occur as a result of scour processes.

Different materials scour at different rates. Loose granular soils are quickly eroded by flowing water, while cohesive or cemented soils are more scour-resistant. Scour generally occurs on the rising limb of a flood and is at maximum near peak flow. The local scour hole at a bridge pier, or the cross section undergoing contraction scour, can refill on the receding limb of the flood (see Figure 4).

The magnetic sliding collar instrument is a *maximum scour depth instrument*; if the scour hole refills the collar becomes buried at the maximum depth of scour. The magnetic sliding collar instrument cannot track the typical refilling of a scour on the recession limb of the flood, but should deeper scour occur during another flood event, the collar will track the additional scour.

The inherent instability of alluvial channels complicates the placement of fixed scour instrumentation. Initially, the location of maximum scour needs to be determined, and then the potential for shifting of the maximum scour location should be considered. Even if the location of maximum scour is not expected to change, the angle of attack of the flow may be different from one flood to the next, or may change during a given flood. For example, in a meandering stream channel the low-flow thalweg is typically different from the high-flow thalweg (see Figure 5).

Consequently, the location of maximum scour can change (e.g., Bridge 2 in Figure 5), as can the angle of attack (Bridge 1 in Figure 5). If the meander pattern changes over time, as often occurs, this change can further impact the scour conditions at the bridge. Therefore, evaluating the location of maximum scour and the preferred location to install fixed instrumentation at a given bridge is difficult and can be very subjective. Complex situations could require the use of specialized expertise.

As a general rule, the maximum scour typically occurs in the deepest portion of the channel. Comparative cross sections from bridge inspection files can be useful in locating the deepest portion of the channel and potential changes in this location over time. At a given pier, the maximum scour generally occurs at the upstream face. However, if the skew angle of the attacking flow is large, the location of maximum scour may shift from the upstream face of the pier to the side of a pier or even to the downstream face. Furthermore, a high-skew angle at a pier in the overbank (for example where flow is turning the corner around an abutment) may cause greater scour than that occurring at a main channel pier where the flow is deep and fast, but well aligned with the pier. Field observation of skew angles during high flow conditions can be useful in evaluating the location of maximum scour. Alternatively, evaluation of cross-channel flow patterns with a two-dimensional (2-D) computer model can be useful in predicting the location of maximum scour. Without specialized information, the best approach is to locate the instrumentation based on field observations, and be prepared to relocate the instrumentation if the maximum scour does not occur where expected during a significant flood event.

For bridges located in bends, the greatest scour generally occurs at the outside of the bend; although the location of maximum scour may shift toward the inside during large floods as the high-flow path shifts. Again, field observation of flow patterns and currents under relatively high-flow conditions can provide insight, as can use of comparative cross

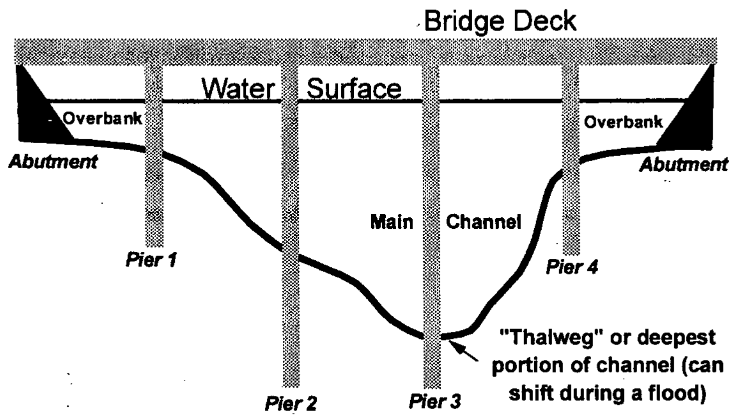


Figure 3. Typical channel cross section.

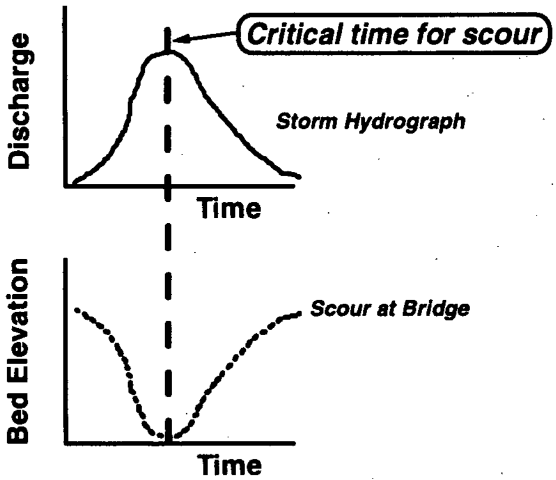


Figure 4. Sketch of the changes in scour depth during a flood.

sections or analysis with 2-D models. Without this information, it is generally best to locate the instrumentation near the outside of the bend.

The effect of debris can also be very significant in influencing the location of greatest scour. Debris accumulation has the effect of increasing the effective width of a pier, which increases the scour depth (see Figure 6). Therefore, if debris tends to accumulate more along one side of a channel than the other, expect greater scour depths at the piers on the debris-laden side of the channel. The presence of debris does complicate instrument installation, and may affect instrument operation.

Additional information on instrument application factors is provided in *NCHRP Report 396.* Detailed information on scour is provided in FHWA's "Evaluating Scour at Bridges" (*Hydraulic Engineering Circular No. 18*, Richardson and Davis [1995]). Detailed information on stream stability is provided in FHWA's "Stream Stability and Scour at Highway Structures" (*Hydraulic Engineering Circular No. 20*, Lagasse et al. [1995]).

2.2 ANALYSIS OF THE STRUCTURE

Generally speaking, magnetic sliding collar instruments were designed and developed to provide a low-cost instrument that could be widely implemented on smaller bridges where more sophisticated or expensive instruments are not justified. "Smaller" in this case generally refers to the height of the bridge off the streambed, given that the initial instrument development was a manual-readout device that required extending the sliding collar pipe up to the bridge deck.

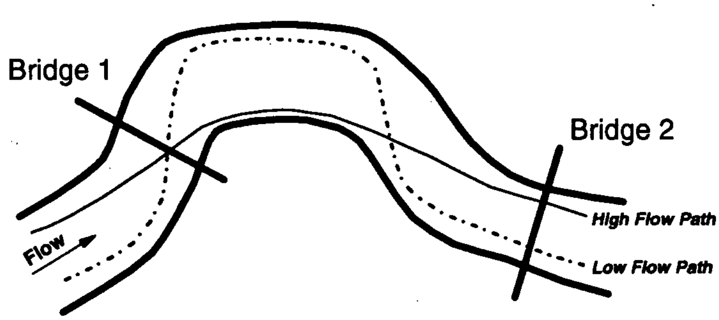


Figure 5. Sketch of changing flow paths during flooding.

Figure 6. Debris collection on a pier.

However, the automated-readout version of the magnetic sliding collar, without a pipe extending to the bridge deck, can be installed on higher bridges. As a general recommendation, the manual-readout instrument is best used on bridges less than 10 m (32 ft) off the stream bottom; there is no height limitation on the automated-readout device. A significant improvement of the automated-readout device is that it can be used at spill-through (sloping) abutments.

Another important consideration is the scour depth that can be reasonably monitored with a magnetic sliding collar instrument. Practical considerations with either version of this instrument include how far the pipe can be driven or otherwise installed in the streambed, and concerns for unsupported length of the pipe as a scour hole develops. These factors suggest that the instrument is best applied to bridges with less severe scour problems.

For example, the achievable installation depth of the pipe may limit the effectiveness of a magnetic sliding collar device at a given bridge. It may be possible to drive the pipe only 3 m (10 ft) before refusal is obtained. Alternatively, a large rock might be encountered 4.5 m (15 ft) below the bed during either a driving or predrilling installation. However, if the anticipated scour condition for the given bridge is, for example, 6 m (20 ft) based on procedures described by FHWA's *Hydraulic Engineering Circular 18* (Richardson and Davis [1995]), the instrument would fail before the anticipated scour is reached.

The concern for unsupported length of pipe, which is the length from the last support bracket to the bottom of the scour hole, relates to problems with vibration, vortex shedding, and bending as the unsupported length gets larger. The unsupported length gets larger as the scour hole develops, and, at some point, the length of the pipe will become too great for the hydrodynamic loading and the instrument will fail.

Given these considerations, a magnetic sliding collar device has a suggested maximum scour depth that can be monitored of about 5 m (16 ft). Note that the bottom of the instrument will still have to be deeper than this to provide the necessary structural support for the bottom of the pipe. The required penetration will depend in part on how consolidated the streambed material is, however, a minimum penetration of about 1 m (3 ft) below the anticipated scour is recommended. Therefore, the suggested maximum total length of stainless steel pipe in the streambed is 6 m (20 ft). If the anticipated scour depth is greater than 5 m (16 ft), the instrument can still provide valuable information on the development of the scour hole, but will likely fail prior to reaching the maximum scour depth.

The depth and velocity of the water at the bridge at the time of installation must also be considered. Without diver support, the maximum practical water depth is about 3 m (10 ft); otherwise, it is difficult to accurately position the instrument prior to driving, particularly with the current and turbulence that typically exist.

Another consideration when driving the pipe is the overall length of the stainless steel pipe and driving pipe. If the total length becomes too long, driving may become difficult because of potential bending or buckling of the pipe. If a predrilled hole is used, these factors would not be a concern, although diver support would still be required in deep water.

On bridges with battered piles, the instrument must be installed far enough ahead of the pile so that the bottom of the stainless steel pipe does not intersect with the pile. Alternatively, it generally would be acceptable to install the pipe to one side or the other of a battered pile.

CHAPTER 3

INSTALLATION AND STARTUP—MANUAL READOUT

Sections 3.1 and 3.2 outline the necessary steps for site preparation and assembly.

3.1 SITE PREPARATION

1. After selecting the pier or abutment for installation, remove any existing debris that might interfere with placement of the stainless steel pipe.
2. If the stainless steel pipe for the instrument is going to be driven, it is recommended that a test drive with an expendable solid rod or black steel pipe be completed first to ensure that the instrument can be installed at the selected location. Buried debris or previously placed revetment can interfere with the driving process.
3. After driving the test rod, remove it so it does not interfere with the instrument operation after installation.

3.2 ASSEMBLY

1. Stainless steel pipe is available in 6-m (20-ft) lengths. The length of the stainless steel pipe used should be based on the maximum scour depth to be monitored and the anticipated depth of the water. Above the water, black pipe or galvanized pipe is typically used to reach the bridge deck, although stainless steel pipe could be continued.
2. Typically, a lightweight pneumatic driver (e.g., Rhino brand model PD-40 or equal) can drive the pipe 3 to 5 m (10 to 15 ft) into a sandy bottom. If the potential driving depth is not known, estimate the likely depth based on the test drive completed as described in Section 3.1. A longer section of pipe can be installed in a predrilled hole.
3. The stainless steel pipe can be field cut to length or precut prior to installation.
4. If the required length of stainless steel pipe is greater than 6 m (20 ft), a specially manufactured union (coupler) should be used to join adjacent sections of pipe. The union is made with o-rings to provide a watertight joint, and has an inside diameter large enough to allow the manual-readout probe to pass through. Note that the unions are expensive to manufacture and as a general rule, it may be more cost-effective to install an automated-readout device than to install a manual-readout device with more than 6 m (20 ft) of stainless steel pipe.
5. If the installation is by driving, a hardened driven point on the bottom of the pipe and a driving cap on the top are required. The driving point should be welded in place. The driving cap is placed in the top of the pipe during installation to prevent deforming the top of the pipe, and removed after the driving is completed.
6. Prior to installation, check the operation of the probe with the sliding collar. Drop the end of the probe into the center of the collar and evaluate the location of the probe end when the buzzer first sounds. Note that the buzzer will sound in two locations: there will be an initial location and then, as the probe is lowered into the collar, the buzzer will stop, and then will sound again as the probe is lowered further. The location that the buzzer first sounds is somewhat variable depending on the location of the probe's magnetic reed switch relative to the end of the probe assembly and the strength of the magnets on the collar. Typically, the position that the buzzer first sounds is used for measurement purpose. If there is an offset between the end of the probe and the centerline of the collar when the buzzer first sounds, record the distance for use in data reduction.

3.3 INSTALLATION AND SUPPORT EQUIPMENT

After site preparation and initial assembly are complete, the typical steps required for installation include

Step 1: Position the stainless steel pipe with driving point and driving cap in place.

Step 2: Place the pneumatic driver on the driving cap.

Step 3: Begin driving the pipe. CAUTION: It is best not to stop driving the pipe once started, as it can be difficult to restart downward movement. However, if additional sections of pipe are necessary, this may not be possible.

Step 4: After the pipe is driven to the desired depth, install the collar over the pipe.

Step 5: Attach the galvanized or black pipe from the top of the stainless steel pipe to the bridge deck. This connection can be made by threaded fittings or various commercially available unions and couplers.

Step 6: Route the pipe to minimize potential debris/ice damage, but avoid making sharp bends. Do not use any 90-deg elbows, as the probe will not

readily pass through the pipe. A 45-deg bend will work; however, it is preferable to make any directional changes through standard pipe sweeps that follow a larger radius of curvature.

Step 7: Attach the pipe to the bridge as required to provide a rigid installation.

Step 8: At the bridge deck, cut the pipe off at the desired level (typically just above the guard rail).

Step 9: Install the cap and locking chain.

On small bridges with little or no flow in the channel, a ladder can be used during installation. Otherwise, an under bridge inspection truck will be required. Attaching the necessary brackets to secure the above-water pipe up to the bridge deck typically requires concrete anchors, although on small piers stainless steel Band-it™ can be used effectively. A pipe cutter and threader will also facilitate installation as the above-water pipe can be field cut and fit. Otherwise, all necessary pieces must be precut based on bridge dimensions. The chain on the locking cap can be field-welded in place, or can be shop-welded on a short piece of pipe that is attached to the last section of pipe just below the bridge deck.

Figure 7 shows a completed installation of a manual-readout, magnetic sliding collar scour monitor. This installation was on Schoharie Creek in New York and was completed by inserting the stainless steel pipe into a predrilled hole. The instrument location was in front of a spread footing and sweeps were used to position the connecting pipe tightly along the pier to the bridge deck. The connecting pipe was galvanized pipe, and was terminated with a locking cap near the handrail along the sidewalk on the bridge deck.

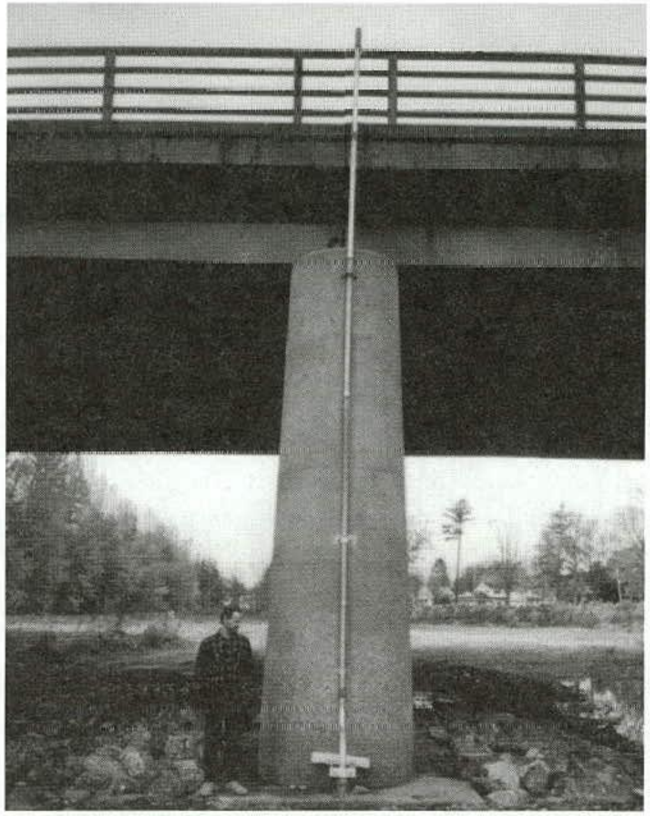


Figure 7. Completed manual-readout, magnetic sliding collar scour monitor.

3.4 STARTUP

After completing the installation, confirm the operation of the collar and the locating probe by checking the collar location. Make a sounding with a tape measure, leadline or a portable sonar to establish the known streambed elevation. If the collar is underwater on sand bed, some settlement of the collar may occur immediately after installation, but the measurements should be within 0.3 m (1 ft). Be sure to correct for any offset, as established in Section 3.2. Establish a measurement datum for future measurements, typically the top of the pipe after removing the cap.

CHAPTER **4**

OPERATION AND DATA ACQUISITION—MANUAL READOUT

4.1 THEORY OF OPERATION

The magnetic sliding collar instrument is a simple, mechanical device for monitoring scour. As scour develops, the collar drops into the scour hole. The location of the collar is determined by dropping a probe down the center of the pipe, which sounds a buzzer when the collar is reached. The amount of cable dropped down the pipe defines the distance to the collar.

4.2 OPERATOR FUNCTIONS

Step 1: To take a scour measurement, first remove the locking cap.

Step 2: Drop the probe down the pipe (see Figure 8). Depending on the alignment of the pipe, it may be necessary to work the probe up and down to pass bends and pipe unions.

Step 3: When the probe enters the magnetic field, the buzzer will sound. Note that if the probe is lowered slightly, the buzzer will stop and then will start again as the probe is lowered more. The offset established in Section 3.2 is based on the location that the buzzer first sounds, and this location should be used for all measurements. Make sure that all operators are aware of this characteristic to ensure consistency in the data.

Step 4: Measure the distance the probe was dropped relative to the top of the pipe at the bridge deck and record this amount (see Appendix D for sample data recording forms).

4.3 DATA ACQUISITION, ANALYSIS, AND INTERPRETATION

Data acquisition should occur according to the established schedule for that particular instrument. Typically, a measurement might be taken once per month, as well as during and after major floods. The measurements should be taken as described in Section 4.2. Any offset for the given probe, as established in Section 3.2, should be accounted for in data reduction. By surveying in the location of the top of the pipe, the elevation of the collar can be determined. Alternatively, the collar measurement can be used directly to indicate scour depth relative to the measurement when the instrument was first installed.

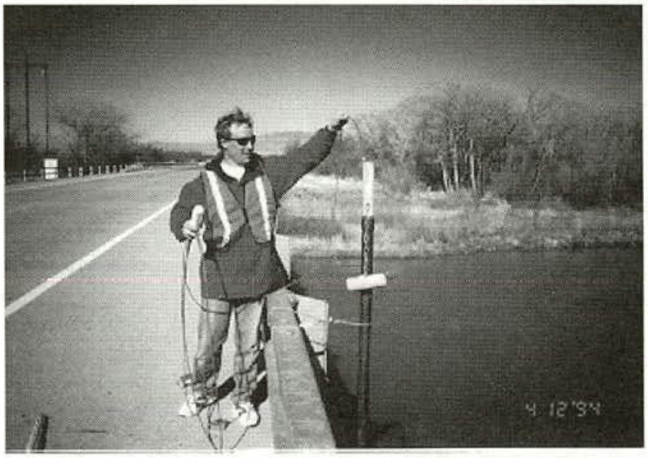


Figure 8. Taking a measurement at a manual-readout, magnetic sliding collar instrument.

To evaluate scour hole refilling, an independent sounding of the streambed elevation relative to the top of the pipe at the bridge deck can be made with a leadline or portable sonar device. If the collar is deeper than the depth indicated by the leadline or sonar measurement, refilling has occurred and the collar is buried. Scour during a subsequent event will re-expose the collar, and if deeper scour occurs the collar will then slide downward.

It is possible to track the scour after refill by installing a second collar based on a split-ring design, that is, a collar that opens like a clam shell and can be inserted without disrupting the bracketing and connections of an existing installation. As the refilled sediments are scoured away during a subsequent flood, this second collar will drop. With sufficient scour, the second collar will eventually come to rest on the first collar, after which both collars will move together. However, because the maximum scour that has occurred is of most interest, and this would be indicated by the location of the first collar, the use of a second collar would not be necessary from a bridge safety or bridge integrity perspective.

CHAPTER 5

INSTALLATION AND STARTUP—AUTOMATED READOUT

5.1 SITE PREPARATION

1. After selecting the pier or abutment for installation, remove any existing debris that might interfere with placement of the stainless steel pipe.
2. If the stainless steel pipe for the instrument is going to be driven, it is recommended that a test drive with an expendable solid rod or black pipe be completed first to ensure that the instrument can be installed at the selected location. Buried debris or previously placed revetment can interfere with the driving process.
3. After driving the test rod, remove it so it does not interfere with the instrument operation after installation.

5.2 ASSEMBLY

1. Stainless steel pipe is available in 6-m (20-ft) lengths. The length of the stainless steel pipe used should be based on the potential scour and the estimated driving depth.
2. Typically, a lightweight pneumatic driver (e.g., Rhino brand model PD-40 or equal) can drive the pipe 3 to 5 m (10 to 15 ft) in a sandy bottom. If the potential driving depth is not known, estimate the likely depth based on the test drive completed as described in Section 5.1.
3. While stainless steel pipe for the manual-readout sliding collar device can be field cut or shop-fabricated (see Section 3.2), the pipe for the automated-readout MUST be shop-fabricated, because the automated insert must be designed and built in advance, installed in the pipe, and the T-fitting attached prior to installation.
4. If the installation is by driving, a hardened driving point on the bottom of the pipe and a T-fitting on the top are required. The driving point and T-fitting should be attached and the entire assembly shipped to the job site for installation. If the instrument is going to be placed in a predrilled hole and not driven, the T-fitting can be replaced by a simple elbow.
5. With the automated-readout instrument, the stainless steel pipe terminates just above the streambed, and wiring from there to the bridge deck is routed in a flexible, waterproof conduit. While the instrument box wiring can be completed at the jobsite, it is typically easier to complete all wiring to the instrument box prior to arriving at the jobsite. This means that the distance from the streambed to the desired mounting location for the instrument box must be known in advance, since the flexible conduit must be cut to size and the wires routed through the conduit and to the instrument box.
6. Prior to installation, check the operation of the automated insert with the sliding collar. Make sure each switch in the automated insert is operational by monitoring the LED-lights in the instrument box.
7. Leave the collar on the pipe and install the black driving pipe in preparation for installation. If not already completed, attach the flexible conduit to the T-fitting (or elbow if not driving) and route the wiring from the automated insert through the flexible conduit.

Figure 9 shows a system ready for installation, with the black driving pipe to the left of the T-fitting, the stainless steel pipe and collar to the right of the T-fitting, and the flex conduit with the wiring for the automated insert at the base of the T-fitting.

5.3 INSTALLATION AND SUPPORT EQUIPMENT

After site preparation and initial assembly are completed, the typical steps required for installation include

Step 1: Position the completed stainless steel pipe with automated insert and collar in place. CAUTION: Be sure the sliding collar is in place before positioning and driving the pipe as the collar cannot be installed from the top over the T-fitting (or elbow) after the pipe is in the ground. The collar can be held in place during positioning and initial driving by holding onto both ends of a rope fed through the collar.

Step 2: Place the pneumatic driver on the black driving pipe.

Step 3: Begin driving the pipe. CAUTION: It is best not to stop driving the pipe once started, as it can be difficult to restart downward movement.

Step 4: Stop driving the pipe when the T-fitting and collar are near the streambed. CAUTION: Do not

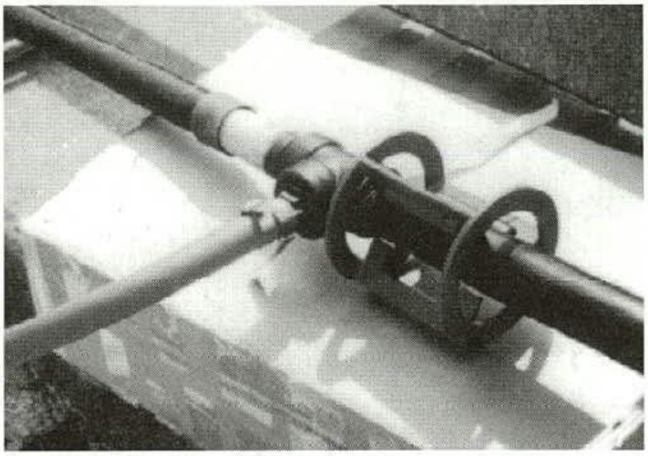


Figure 9. Automated-readout device ready for driving.

overdrive the pipe as the collar may become jammed or damaged.

Step 5: Install the flexible conduit with the wiring up to the bridge deck. Route the conduit to minimize potential debris/ice damage.

Step 6: Attach the instrument shelter at the selected location.

On small bridges with little or no flow in the channel, a ladder can be used during installation. Otherwise, an under bridge inspection truck will be required. Attaching the necessary brackets to secure the flexible conduit typically requires concrete anchors, although on small piers stainless steel Band-it™ can be used effectively.

If the instrument will be installed in a predrilled hole, disregard the instructions related to driving.

Figure 10 shows a completed installation of an automated-readout, magnetic sliding collar scour monitor. This installation was on Nassau Sound in Florida and was completed by driving the stainless steel pipe at slack low water. The flex conduit was connected to the pier using cable clamps. The instrument box was located near the guard rail.

Figure 10. Completed automated-readout, magnetic sliding collar instrument.

5.4 STARTUP

Step 1: After completing the installation, confirm the operation of the collar and the locating probe by measuring the collar location.

Step 2: Make a sounding with a leadline or a portable sonar to establish the known streambed elevation. This measurement can also be used to establish a datum for the instrument.

Step 3: Compare the two readings. If the collar is underwater on a sand bed, some settlement of the collar may occur, but the measurements should be within 0.3 m (1 ft).

CHAPTER 6

OPERATION AND DATA ACQUISITION—AUTOMATED READOUT

6.1 THEORY OF OPERATION

The magnetic sliding collar instrument is a simple, mechanical device for monitoring scour. As scour develops, the collar drops into the scour hole. The location of the collar is determined by the automated insert, which consists of a series of magnetic reed switches at a prescribed interval within the stainless steel pipe. Each switch is connected to an indicator light in the instrument shelter. As the collar drops, a different switch will be closed, indicating the location of the collar by the corresponding light in the instrument shelter.

6.2 OPERATOR FUNCTIONS

Step 1: To take a scour measurement, push the button in the instrument box and note which light activates.

Step 2: Record this measurement.

6.3 DATA ACQUISITION, ANALYSIS, AND INTERPRETATION

Data acquisition should occur according to the established schedule for that particular instrument. Typically, a measurement might be taken once per month, as well as during and after major floods. The measurements should be taken as described in Section 6.2. By surveying in the location of the collar or streambed at the time of installation, the elevation of the collar can be determined.

To evaluate scour hole refilling, an independent sounding of the streambed elevation can be made with a leadline or portable sonar device. If the collar is deeper than the depth indicated by the leadline or sonar measurement, refilling has occurred and the collar is buried. Scour during a subsequent event will re-expose the collar, and if deeper scour occurs, the collar will then slide downward.

It is possible to track the scour after refill by installing a second collar based on a split-ring design, that is, a collar that opens like a clam shell and can be inserted without disrupting the bracketing and connections of an existing installation. As the refilled sediments are scoured away during a subsequent flood, this second collar will drop. With sufficient scour the second collar will eventually come to rest on the first collar, after which both collars will move together. However, because the maximum scour that has occurred is of most interest, and this would be indicated by the location of the first collar, the use of a second collar would not be necessary from a bridge safety or bridge integrity perspective.

CHAPTER 7

TROUBLESHOOTING, MAINTENANCE, AND SERVICING

7.1 MANUAL-READOUT SLIDING COLLAR

Because of the simplicity of the manual-readout device, there is little that can go wrong, and only minimal maintenance and servicing are required. However, if the instrument is not operating properly, consider the following troubleshooting, maintenance, and servicing factors:

Troubleshooting

Problem

The probe cannot locate the collar.

Solution

Check and make sure that the battery for the buzzer is good. It is useful to glue a small magnet on the buzzer enclosure to use for a self-check on the buzzer circuit prior to taking a measurement (see Appendix A, Sheet 4 of 8).

Problem

The battery is good, but the buzzer will not operate during a self-check.

Solution

The wiring to the magnetic reed switch at the end of the probe may be the problem. Depending on probe construction and use, particularly the number of bends that the probe must pass, it is possible that the wiring at the switch may break after extensive use.

Problem

The self-check is okay, but the probe still cannot locate the sliding collar.

Solution

Confirm that the length of the probe you are using is long enough to reach the bottom of the stainless steel pipe at this location. If you have multiple installations and multiple probes, some probes may have been fabricated for shorter instruments.

Maintenance and Servicing

The primary maintenance concern with the manual-readout device is debris collecting on the pipe leading up to the bridge deck. If debris is bending or crushing the pipe, it will be necessary to remove the debris; replace the pipe if the probe cannot be inserted.

1. Submerged, waterlogged debris may also potentially snag the collar preventing downward movement. The only way to evaluate this potential concern is with a ground truth measurement or inspection by a diver. A ground truth measurement is simply a measurement of the scour condition by some alternate technique to evaluate instrument performance.
2. Ground truthing or dive inspection should be a regular part of the maintenance program for any scour instrument.

7.2 AUTOMATED-READOUT SLIDING COLLAR

Troubleshooting

Problem

The automated-readout device does not operate.

Solution

Check the condition of the battery.

Problem

The battery is good, but no LED lights come on.

Solution

Complete a visual check of the flexible conduit. If the conduit is pinched or damaged by debris or other factors, the wiring may have been damaged.

Problem

The battery is good and there is no sign of damage to the flexible conduit, but the device does not operate.

Solution

Check the wiring inside the instrument shelter. If the wiring in the instrument shelter is not damaged, there is little else that can be evaluated, short of removing the pipe, disassembling it and evaluating the automated insert.

Problem

A single automated-readout light is not working.

Solution

Because each switch in the automated insert has its own circuit; therefore, it is possible that one switch is defective and after the collar moves past this switch the instrument will begin to function again.

Maintenance

1. The primary maintenance concern with the automated-readout device is debris collecting on the flexible conduit leading up to the bridge deck. If debris is impacting the conduit, quickly remove it to minimize potential damage to the wiring.
2. Submerged, waterlogged debris may also potentially snag the collar preventing downward movement. The only way to evaluate this potential concern is with a ground truth measurement or inspection by a diver. A ground truth measurement is simply a measurement of the scour condition by some alternate technique to evaluate instrument performance.
3. Ground truthing or dive inspection should be a regular part of the maintenance program for any scour instrument.

Annual Servicing

1. Inspect the conduit and cable run for damage and repair or replace as necessary.
2. Inspect the instrument enclosure and clean out any spiders, mice nests, etc. Check the door gasket and/or seal.

CHAPTER 8

ENHANCEMENTS

8.1 MANUAL-READOUT SLIDING COLLAR

A manual-readout, magnetic sliding collar can be converted to an automated-readout device by installing the automated insert.

8.2 AUTOMATED-READOUT SLIDING COLLAR

An enhanced version of the basic automated-readout device has been developed by ETI Instruments, Inc. (see Appendix E), that allows connecting the instrument to a datalogger and also provides options such as telemetry and use as an early warning device.

Telemetry and early warning devices can be incorporated into an automated-readout, magnetic sliding collar scour monitor, based in part on the capability of the datalogger selected. Telemetry can be either local telemetry or long-distance telemetry.

Local telemetry is used to transmit data from an instrument enclosure on the bridge to a location at the edge of the bridge near the abutment. This might be advantageous if a lane closure is required to safely service the instrument enclosure, or if the instrument enclosure is located in the middle of a long bridge. In these situations, a local telemetry system could be used to download the instrument without going to the main instrument enclosure. Radio frequency (RF) receivers using conventional techniques or spread spectrum technology can be employed for local telemetry. Local telemetry can also be used when the cost of running cable and conduit becomes expensive.

Long-distance telemetry allows downloading data without visiting the bridge site. There are a number of telemetry methods available, including microwave networks, UHF/VHF networks, satellite systems, and cellular phone-based systems.

An early warning system can also be added to a sliding collar scour monitor by having some type of warning light or signal activated when scour reaches a certain depth. Effective use of this enhancement requires first defining the scour-critical elevation, and second, effectively communicating to all responsible parties the nature of the warning system and the action to be taken when it is activated.

Note: For more detail on enhancements such as telemetry or early warning possibilities, see *NCHRP Report 396.* While none of these enhancements was investigated in detail during NCHRP Project 21-3, demonstrations of feasibility for several enhancement options were completed.

PART II FABRICATION OF MANUAL-READOUT DEVICE

CHAPTER 9

SYSTEM SCHEMATICS AND SPECIFICATIONS FOR MANUAL-READOUT DEVICE

9.1 MAJOR COMPONENTS

The major components of a manual-readout, magnetic sliding collar scour monitor are

1. Stainless steel pipe placed vertically in the streambed,
2. Connecting pipe (stainless, galvanized or black pipe) to the bridge deck,
3. Magnetic sliding collar, and
4. Manual-readout measurement probe.

The following sections detail the fabrication of each of these major components. Detailed, scaled construction drawings are provided in Appendix A, and referenced by sheet number. *Sheet 1* is a conceptual sketch showing a typical installation of a manual-readout, magnetic sliding collar scour monitor.

9.2 STAINLESS STEEL PIPE

Pipe

1. The pipe placed vertically in the streambed is standard 50-mm (2-in.) Schedule 40 stainless steel pipe available from local suppliers. Schedule 40 stainless steel is used for strength and durability. Type 304 or 304L stainless steel is recommended for corrosion resistance, particularly at tidal bridge sites.
2. A hardened driving point, machined according to the dimensions on *Sheet 2*, should be welded to the bottom of the pipe when the installation will be by pneumatic driving. The driving point is oversized to reduce drag on the pipe during driving.
3. If a predrilled hole is used, the driving point may not be necessary; however, the bottom should be plugged to provide a watertight seal.

Coupler

The length of stainless steel pipe varies, as discussed in Part I, Section 2.2. Stainless steel pipe is available in standard 6-m (20-ft) lengths. A special union, or coupler, should be used whenever joining adjacent sections of stainless steel pipe. This might be necessary if the required stainless steel pipe length is longer than 6 m (20 ft). Alternatively, it may not be possible to install a long piece of pipe on a low bridge because of vertical clearance under the bridge deck or low chord elevation. In this case, shorter sections of pipe are installed one-at-a-time, with a field-installed coupler joining each section.

1. The coupler should be machined according to the dimensions on *Sheet 2*.
2. The o-rings provide a watertight fitting, necessary to prevent potential pipe rupture in freezing climates and to minimize sediment accumulation in the pipe for channels with significant sediment load.
3. The coupler should be shop-welded into the top of each section of pipe. The set screws are then used to connect the bottom of the next section of pipe during field installation. In order to ensure a square joint between pipe sections (which is particularly important in an installation requiring driving), cut 25 mm (1 in.) off the pipe, place the coupler in the pipe, reinstall the 25-mm (1-in.) piece and weld at the cut line (see detail on *Sheet 2*).

9.3 CONNECTING PIPE

Stainless steel pipe can be used from the water surface all the way to the bridge deck; however, above the anticipated water surface it is acceptable to switch to galvanized or black pipe.

1. Regardless of the pipe material, avoid sharp bends in the connecting pipe. The use of standard pipe sweeps will provide a more gradual change in alignment that will facilitate movement of the manual probe down the pipe.
2. The connecting pipe may be field-cut and fit, or prefabricated in the shop. Field-cut and fit will generally provide a better installation, and provide an installation less vulnerable to damage from debris and ice.
3. The interior surface of all joints should be as smooth as possible, again to facilitate the downward movement of the probe.
4. Anchor the connecting pipe to the bridge using standard pipe/conduit clamps. Alternatively, on small

columns the pipe can be secured with stainless steel Band-it™.

9.4 MAGNETIC SLIDING COLLAR

1. The magnetic sliding collar should be fabricated out of stainless steel according to *Sheet 3*.
2. The magnet is a round-bar magnet, 22 mm (0.875 in.) in diameter and 76 mm (3 in.) long. The magnet is fully enclosed in a stainless steel housing to prevent corrosion. Use silicone sealant during assembly of the magnet and the plugs located in each end of the housing.
3. To facilitate attachment (welding) of each magnet housing to the vertical support bracket of the sliding collar, two magnet housing attachment brackets are recommended, as shown on Sheet 3 of 8.

9.5 MANUAL PROBE

1. Fabricate the manual probe and annunciator (buzzer) according to *Sheet 4*.
2. The magnetic reed switch should be securely positioned in the flexible conduit to avoid changes in location that would affect measurement accuracy or repeatability.
3. A "bulb-shaped" end will facilitate downward movement of the probe and can be created by gluing an appropriate shape on the end, or by forming the shape with epoxy resin.
4. The flexible conduit can be made from a variety of locally available materials such as vinyl tubing, Quest™ tubing, or vinyl-covered bicycle brake housing. The selection of a conduit type depends on a variety of factors, including the probe length, connecting pipe alignment, climate, and so on.

   If the pipe is straight from top to bottom, the use of a stiff electrical wire alone, without a flexible conduit, may be adequate. For a pipe with minimal changes in alignment, the wire alone with a small weight may work well. If the pipe has several changes in alignment or is a long pipe, use of a flexible conduit that provides the rigidity necessary to "push" the probe down the pipe is recommended.

   When using a flexible conduit, provide adequate slack in the wiring so that when the conduit is coiled for transport, the wires are not stretched to the point of breaking or disconnection at the reed switch.
5. The annuciator housing should be fabricated to fit the selected buzzer and battery. The use of standard PVC pipe and fittings provides a low-cost, convenient way to fabricate the housing.

9.6 TYPICAL INSTALLATION FOR MANUAL-READOUT, MAGNETIC SLIDING COLLAR DEVICE

Installation photographs and a parts list for a typical manual-readout, magnetic sliding collar device are included as Appendix C. While no two installations of a magnetic sliding collar scour monitor will be identical (depending on bridge geometry and stream characteristics), the photographs of Appendix C provide guidance on a typical installation.

PART III FABRICATION OF AUTOMATED-READOUT DEVICE

CHAPTER **10**

SYSTEM SCHEMATICS AND SPECIFICATIONS FOR AUTOMATED-READOUT DEVICE

10.1 MAJOR COMPONENTS

The major components of an automated-readout, magnetic sliding collar scour monitor are

1. Stainless steel pipe placed vertically in the streambed,
2. T-fitting or elbow at the top of the stainless steel pipe,
3. Magnetic sliding collar,
4. Automated insert, and
5. Instrument enclosure.

The following sections detail the fabrication of each of these major components. Detailed, scaled construction drawings are provided in Appendix B, and referenced by sheet number. *Sheet 5* is a conceptual sketch showing a typical installation of an automated-readout, magnetic sliding collar scour monitor.

10.2 STAINLESS STEEL PIPE

1. The pipe placed vertically in the streambed is standard 50-mm (2-in.) Schedule 40 stainless steel pipe available from local suppliers. Schedule 40 stainless steel is used for strength and durability. Type 304 or 304L stainless steel is recommended for corrosion resistance, particularly at tidal bridge sites.
2. A hardened driving point, machined according to the dimensions on *Sheet 6*, should be welded to the bottom of the pipe when the installation will be by pneumatic driving. The driving point is oversized to reduce drag on the pipe during driving.
3. If a predrilled hole will be used, the driving point should not be necessary; however, the bottom should be plugged to provide a watertight seal.

10.3 T-FITTING OR ELBOW

A T-fitting is required when driving the stainless steel pipe to provide (1) a location for the wires from the automated insert to exit the pipe and (2) a location for driving. The T-fitting was also designed to allow an above-water installation at many locations; that is, an installation without diver support. The T-fitting allows the driving pipe to be attached at the time of assembly and the entire unit to be lowered over the bridge to be driven. When the driving process is complete, the design of the T-fitting allows the driving pipe to be readily disconnected and removed.

1. The T-fitting should be built according to the specifications on *Sheet 6*. After threading the top of the stainless steel pipe, the T-fitting can be screwed on. A pipe thread compound or thread tape should be used to provide a water-tight joint.
2. The pipe plug in top of the T-fitting is a standard pipe plug that has been machined according to the detail on *Sheet 6*. The modifications (1) allow a driving surface and (2) provide enough threads in the T-fitting to allow the driving pipe to be screwed on without tightening, which would inhibit easy removal of the driving pipe. Install the pipe plug using sealant after inserting the automated insert into the pipe.
3. The driving pipe arrangement is shown on *Sheet 7*. The driving pipe is black pipe with a coupler welded on the bottom. The coupler is welded on for strength during the driving process so that the threads do not have to sustain the driving forces.
4. A standard close pipe nipple that is cut even shorter is used to ensure that the pipe coupler on the driving pipe seats against the T-fitting, again so that the threads do not have to sustain the driving forces (see *Sheet 7*). The purpose of the close coupler is to keep the assembly together as it is lowered in place, and to maintain alignment during driving.
5. Since the pipe threads on the close nipple cannot tighten with the coupler seating on the T-fitting, the driving pipe should be readily removed after driving is complete.

10.4 MAGNETIC SLIDING COLLAR

The magnetic sliding collar is identical to that used for the manual-readout device. Fabricate the collar as described in Section 9.4 and as detailed on *Sheet 3*, Appendix A.

10.5 AUTOMATED INSERT

The automated insert is a series of magnetic reed switches in a waterproof enclosure with a cable leading to the instrument shelter on the bridge.

1. Fabricate and wire the automated insert as shown on *Sheet 8*. The reed switches should be located at 152-mm (6-in.) intervals. The total length of the insert will depend on the maximum scour depth to be monitored.
2. A pair of switches wired in parallel is necessary at each 152-mm (6-in.) interval to avoid any "dead spots." Similar to the evaluation of the offset for a manual-readout device, as described in Section 3.2, Step 6, there is a location in the middle of the collar where a single magnetic reed switch will not be actuated. By placing two switches wired in parallel and placed in close proximity at each 152-mm (6-in.) interval, this dead spot can be eliminated, as one or the other of the switches will be triggered when the center of the collar is near the switch locations.
3. Each reed switch will have a corresponding LED light in the instrument shelter. The color coding on the multiple conductor wiring from the insert should be used to identify each switch location so that each switch can be connected to the appropriate LED light in the instrument shelter.
4. After wiring the switch assembly, carefully lower the wiring and switches into a 12.5-mm (0.5-in.) diameter Schedule 40 PVC pipe. Fill the pipe with silicone sealant and glue an end cap on each end. A hole will be required on the upper end cap to pass the multi-conductor wire. Seal this hole with silicone.
5. Be sure to check that there are no dead spots by moving a sliding collar up and down along the automated insert. With 76-mm (3-in.) magnets in the sliding collar, and a 152-mm (6-in.) interval on the switch layout, as one light turns off, the next light should turn on. That way, one light will always be on and there will never be any question as to where the collar is located.

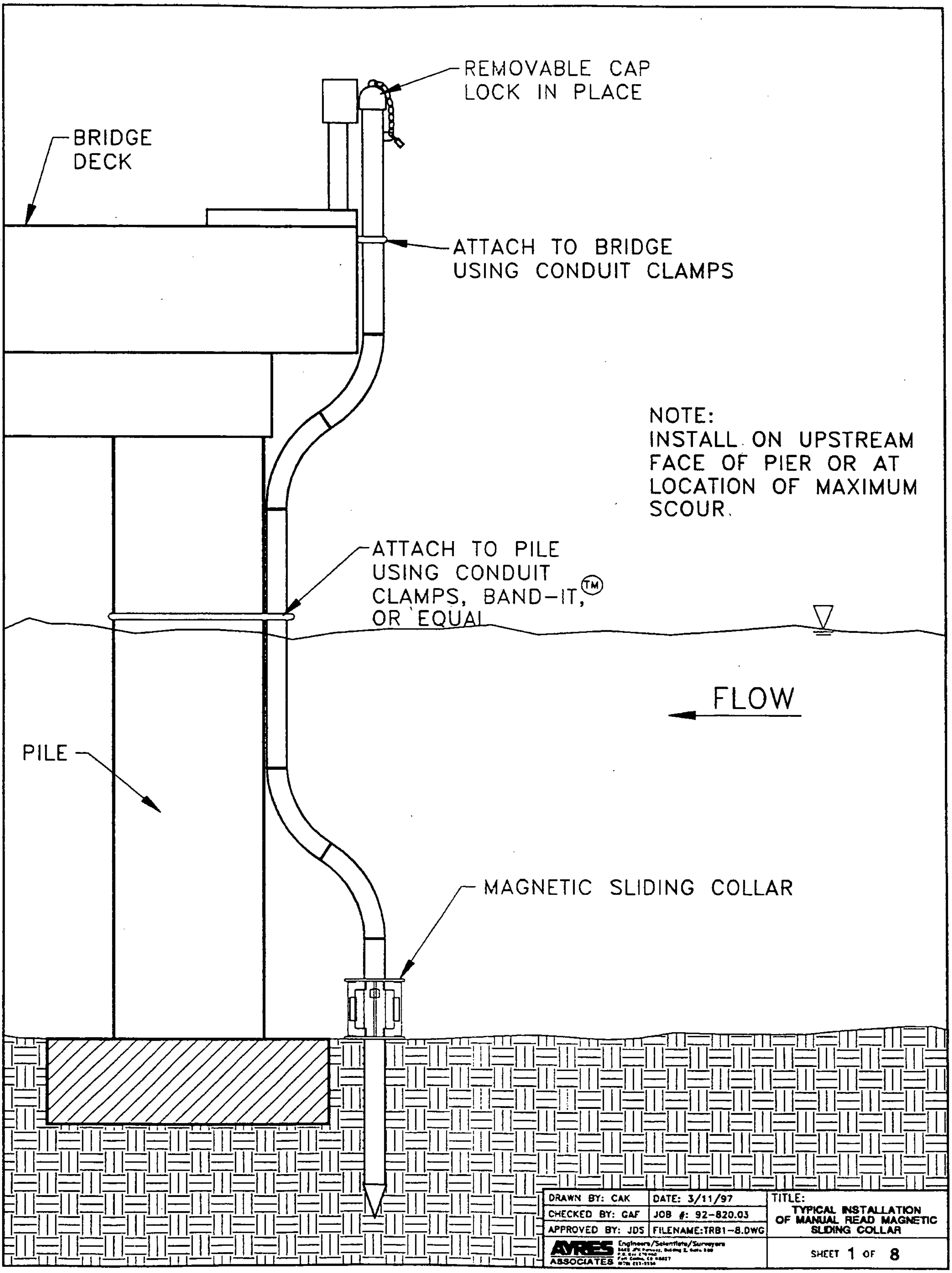
10.6 INSTRUMENT ENCLOSURE

The instrument enclosure houses the LED lights, the activation switch, and a 9-volt battery.

1. Fabricate the readout panel with the LED lights and switch in a fashion similar to that shown on *Sheet 8*. The LED lights and switch should be mounted on a board that can be bolted into the instrument enclosure.
2. The actual layout is not important, except that the LED lights should be arranged in descending order corresponding to the location of the reed switches in the automated insert. The LED lights should be labeled with the descending distance based on the 152-mm (6-in.) spacing so that direct readout of scour depth is possible.
3. Wire the LED lights, switch, and battery as shown on *Sheet 8*.
4. Mount the readout panel in the instrument enclosure. Elevate the backside of the panel as required to avoid an electrical short circuit with the instrument enclosure.
5. Mount an electrical compression fitting in the bottom of the instrument enclosure to route the multi-conductor cable through. Connect the wiring so that the each LED light corresponds with the correct reed switch location.

APPENDIX A

INSTALLATION AND FABRICATION DRAWINGS FOR MANUAL-READOUT, MAGNETIC SLIDING COLLAR SCOUR MONITOR


REMOVABLE CAP
LOCK IN PLACE
BRIDGE
DECK
ATTACH TO BRIDGE
USING CONDUIT CLAMPS
NOTE:
INSTALL ON UPSTREAM
FACE OF PIER OR AT
LOCATION OF MAXIMUM
SCOUR.
ATTACH TO PILE
USING CONDUIT
CLAMPS, BAND-IT,(TM)
OR EQUAL
FLOW
PILE
MAGNETIC SLIDING COLLAR
DRAWN BY: CAK
DATE: 3/11/97
CHECKED BY: GAF
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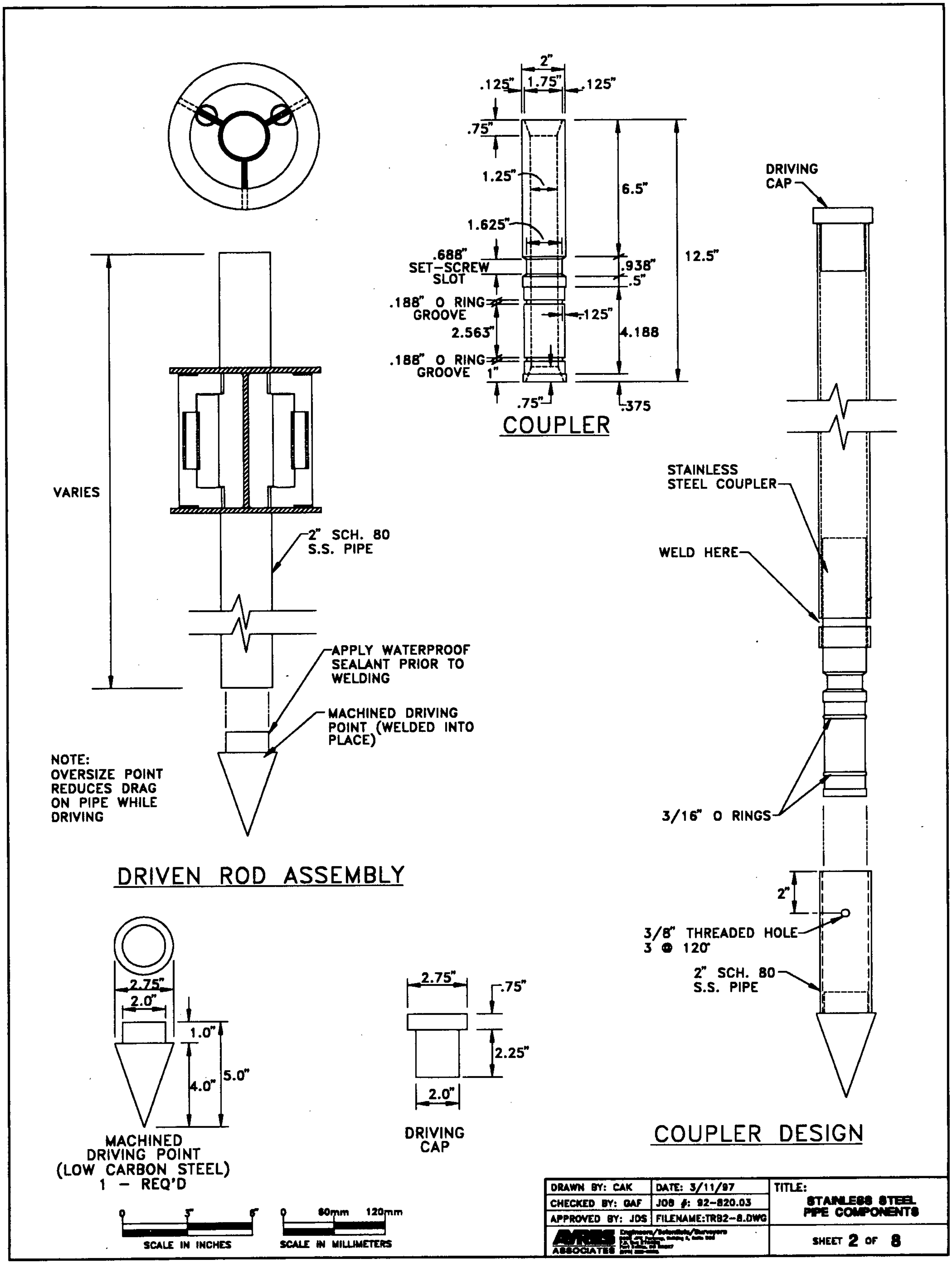
OF MANUAL READ MAGNETIC
SLIDING COLLAR
AYRES
ASSOCIATES
Engineers/Scientists/Surveyors
SHEET 1 OF 8



2"
.125"
1.75"
.125"
.75"
1.25"
6.5"
1.625"
12.5"
.688"
SET-SCREW SLOT
.938"
.5"
.188" O RING GROOVE
.125"
2.563"
4.188
.188" O RING GROOVE
1"
.75"
.375
COUPLER
DRIVING CAP
VARIES
2" SCH. 80 S.S. PIPE
STAINLESS STEEL COUPLER
WELD HERE
APPLY WATERPROOF SEALANT PRIOR TO WELDING
MACHINED DRIVING POINT (WELDED INTO PLACE)
NOTE:
OVERSIZE POINT REDUCES DRAG ON PIPE WHILE DRIVING
3/16" O RINGS
DRIVEN ROD ASSEMBLY
2"
3/8" THREADED HOLE 3 @ 120°
2" SCH. 80 S.S. PIPE
2.75"
2.0"
1.0"
5.0"
4.0"
2.75"
.75"
2.25"
2.0"
MACHINED DRIVING POINT (LOW CARBON STEEL) 1 - REQ'D
DRIVING CAP
COUPLER DESIGN
0
3"
6"
SCALE IN INCHES
0
60mm
120mm
SCALE IN MILLIMETERS
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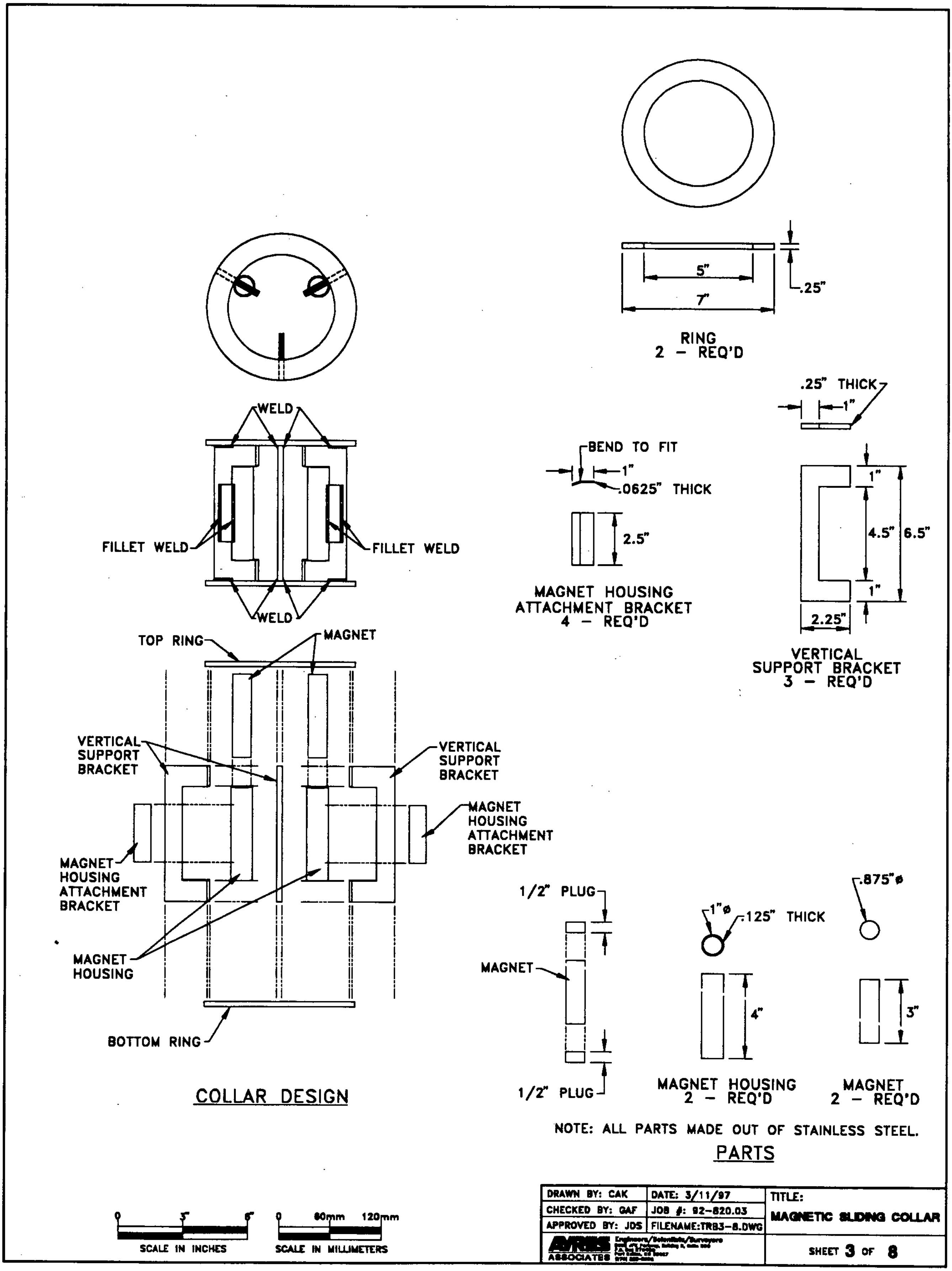
STAINLESS STEEL PIPE COMPONENTS
SHEET 2 OF 8



RING
2 – REQ'D
5"
7"
.25"
WELD
FILLET WELD
FILLET WELD
WELD
TOP RING
MAGNET
VERTICAL SUPPORT BRACKET
VERTICAL SUPPORT BRACKET
MAGNET HOUSING ATTACHMENT BRACKET
MAGNET HOUSING ATTACHMENT BRACKET
MAGNET HOUSING
BOTTOM RING
COLLAR DESIGN
BEND TO FIT
1"
.0625" THICK
2.5"
MAGNET HOUSING ATTACHMENT BRACKET
4 – REQ'D
.25" THICK
1"
1"
4.5"
6.5"
1"
2.25"
VERTICAL SUPPORT BRACKET
3 – REQ'D
1/2" PLUG
MAGNET
1/2" PLUG
1"ø
.125" THICK
4"
MAGNET HOUSING
2 – REQ'D
.875"ø
3"
MAGNET
2 – REQ'D
NOTE: ALL PARTS MADE OUT OF STAINLESS STEEL.
PARTS
0 3" 6"
SCALE IN INCHES
0 60mm 120mm
SCALE IN MILLIMETERS
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CHECKED BY: GAF
JOB #: 92-820.03
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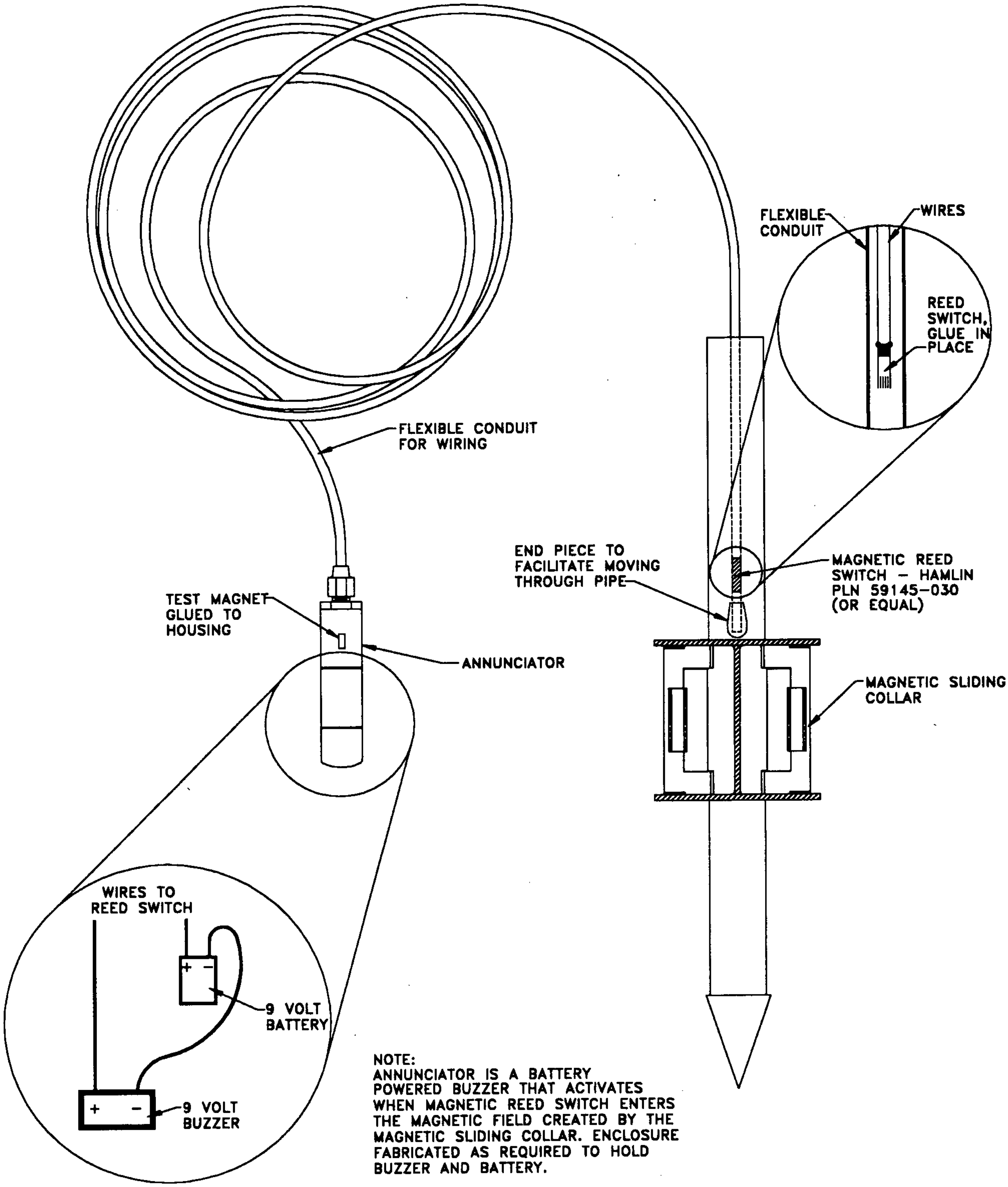
AYRES ASSOCIATES
TITLE:
MAGNETIC SLIDING COLLAR
SHEET 3 OF 8



NOTE:
ANNUNCIATOR IS A BATTERY POWERED BUZZER THAT ACTIVATES WHEN MAGNETIC REED SWITCH ENTERS THE MAGNETIC FIELD CREATED BY THE MAGNETIC SLIDING COLLAR. ENCLOSURE FABRICATED AS REQUIRED TO HOLD BUZZER AND BATTERY.

WIRING SCHEMATIC

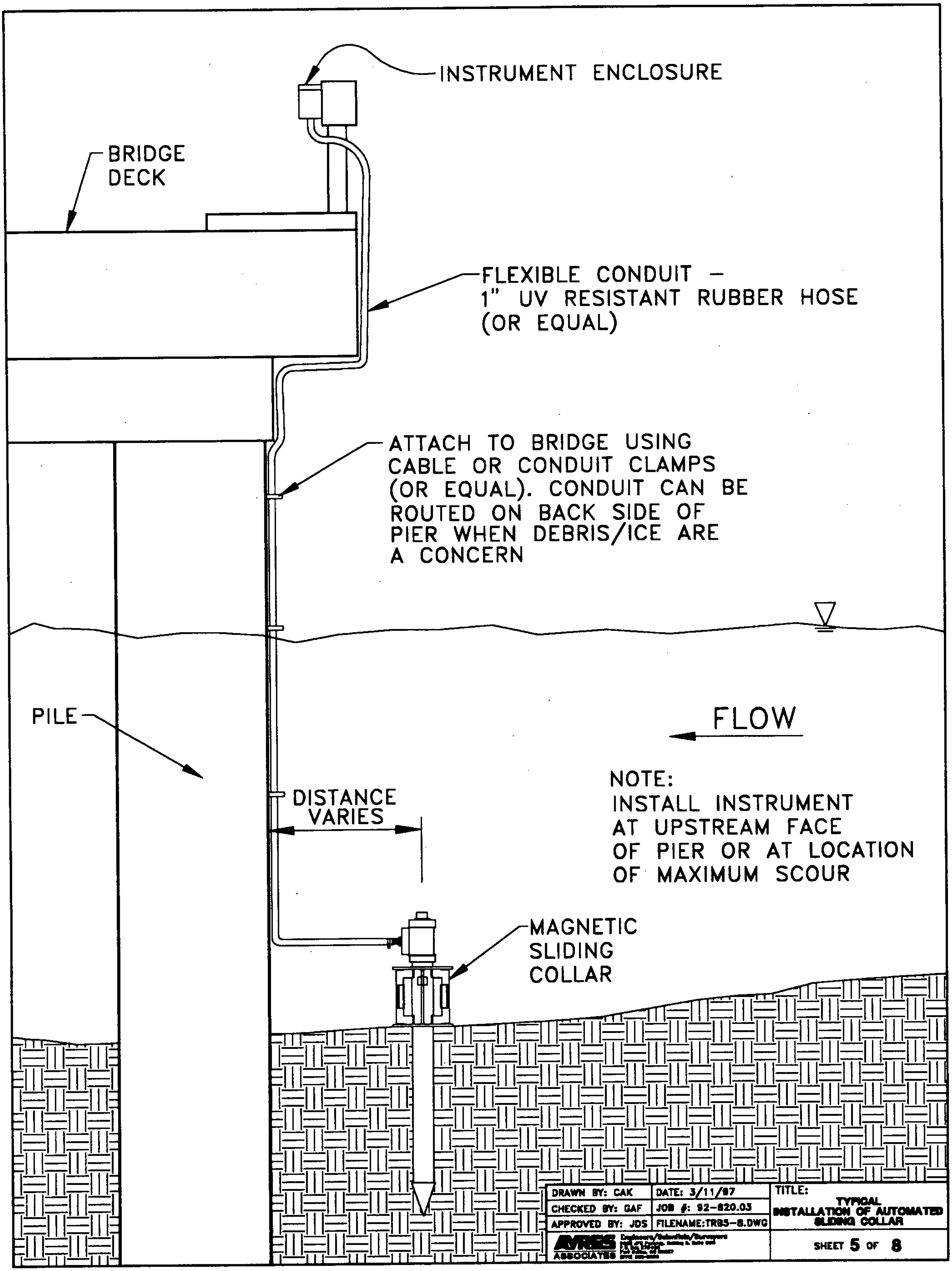
0 3" 6"
SCALE IN INCHES

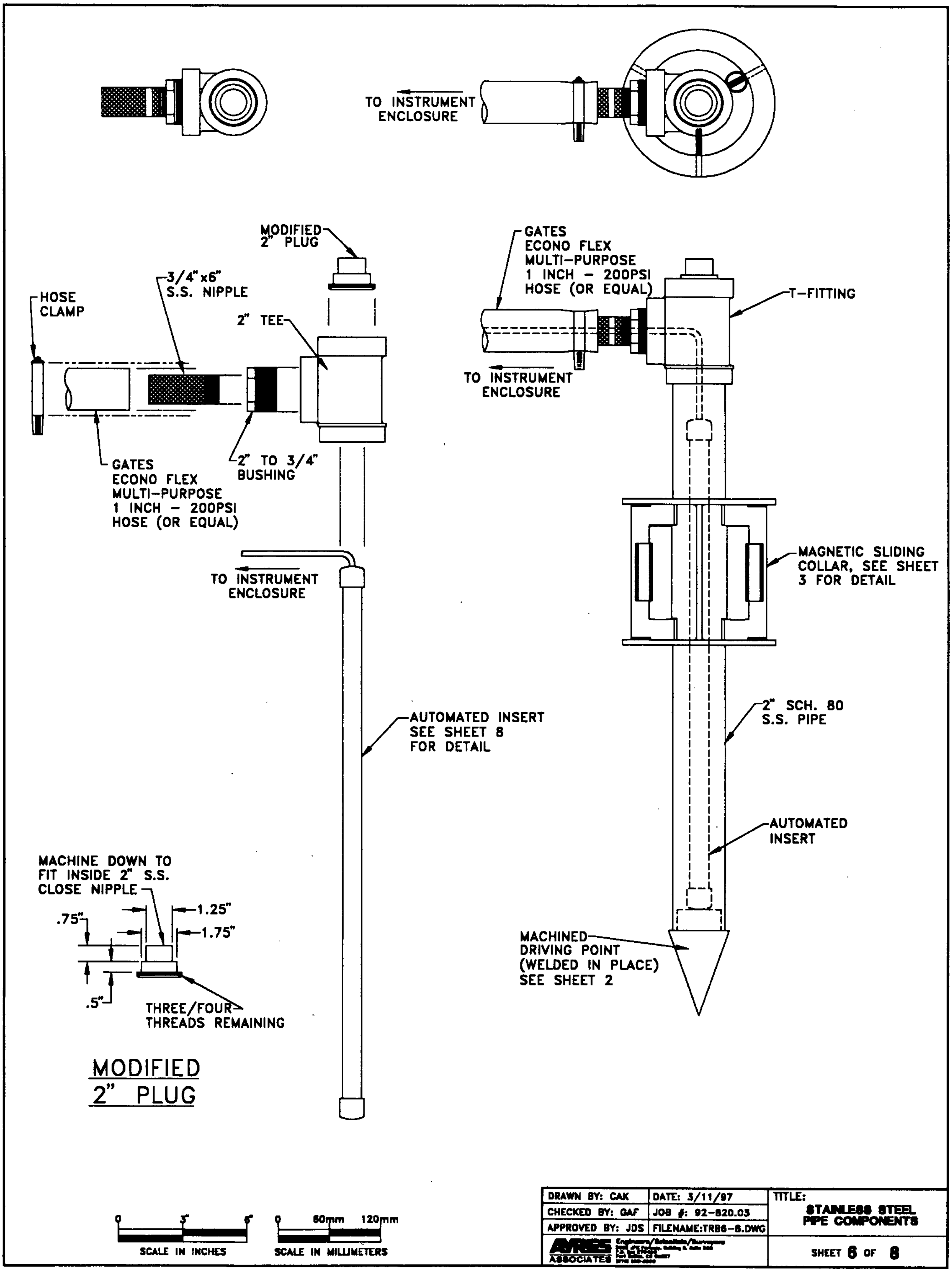
0 60mm 120mm
SCALE IN MILLIMETERS

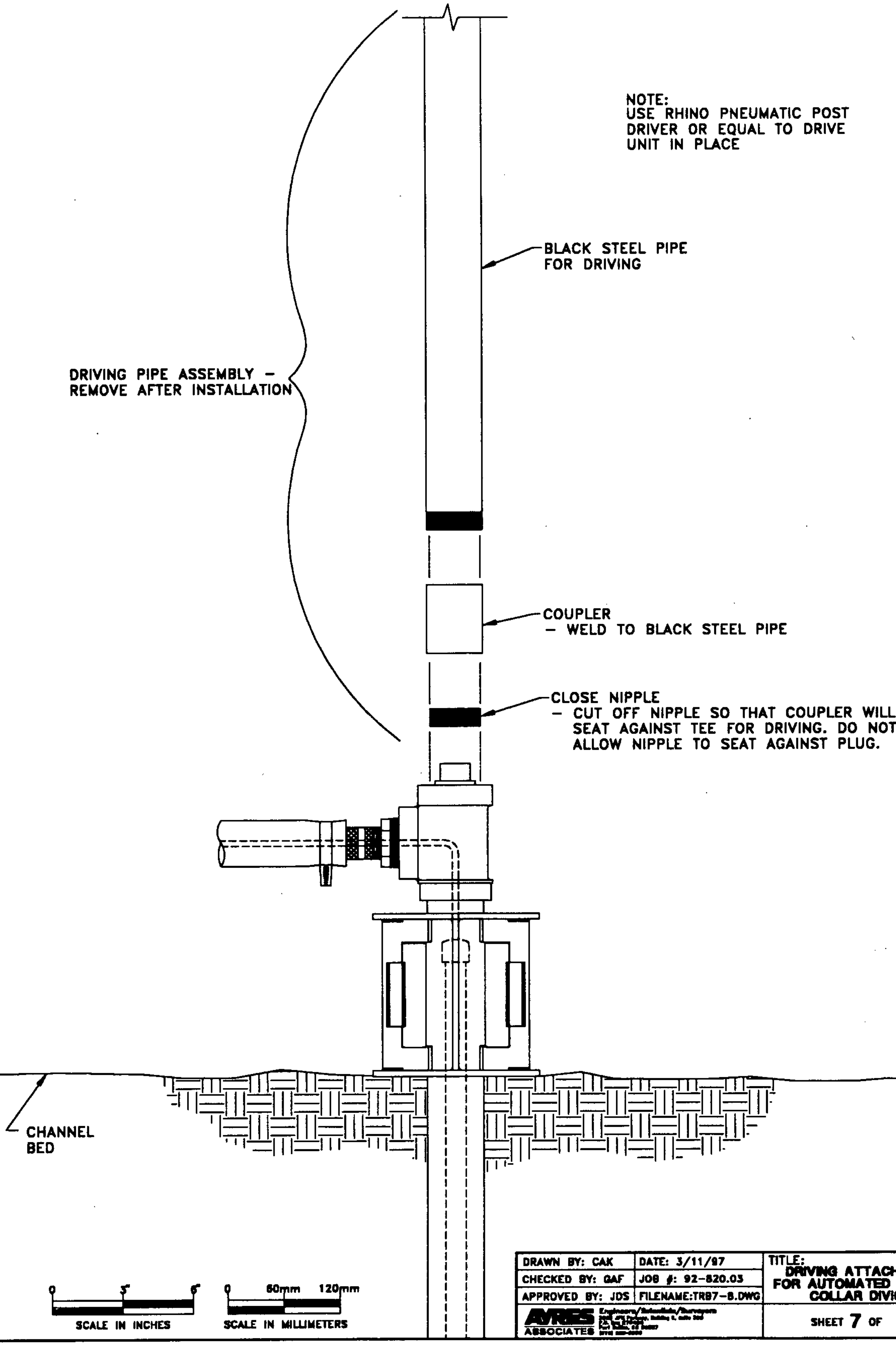
DRAWN BY: CAK	DATE: 3/11/97	TITLE: MANUAL PROBE READOUT
CHECKED BY: GAF	JOB #: 92-820.03	
APPROVED BY: JDS	FILENAME:TRB4-8.DWG	
ASSOCIATES Engineers/Scientists/Surveyors		SHEET 4 OF 8

APPENDIX B

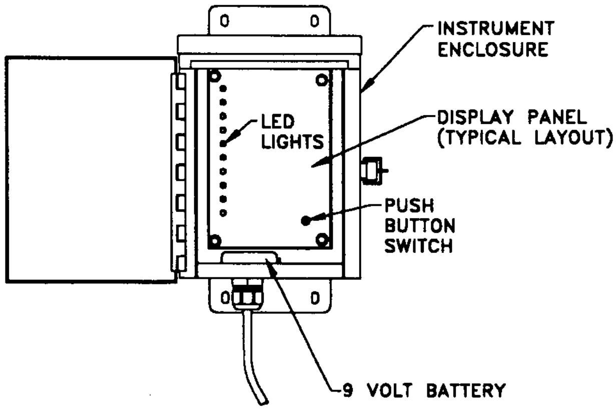
INSTALLATION AND FABRICATION DRAWINGS FOR AUTOMATED-READOUT, MAGNETIC SLIDING COLLAR SCOUR MONITOR

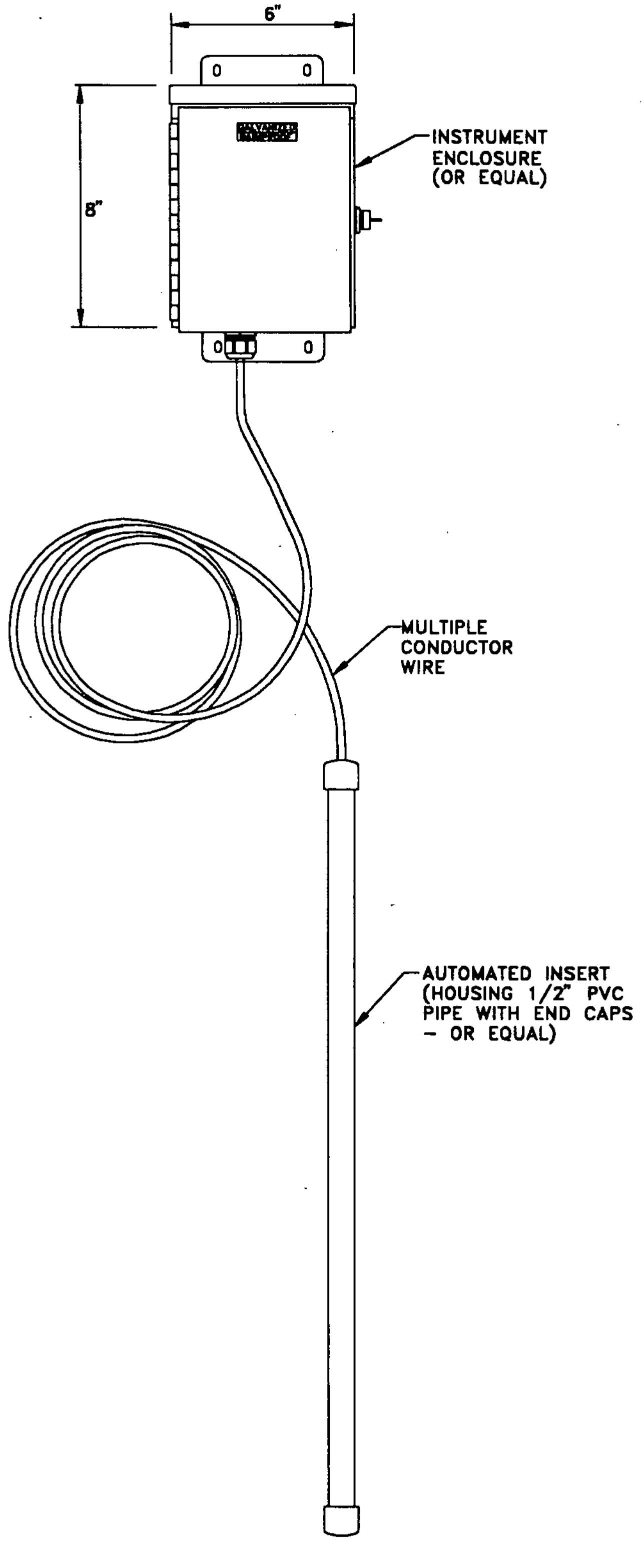

INSTRUMENT ENCLOSURE
BRIDGE DECK
FLEXIBLE CONDUIT – 1" UV RESISTANT RUBBER HOSE (OR EQUAL)
ATTACH TO BRIDGE USING CABLE OR CONDUIT CLAMPS (OR EQUAL). CONDUIT CAN BE ROUTED ON BACK SIDE OF PIER WHEN DEBRIS/ICE ARE A CONCERN
PILE
FLOW
DISTANCE VARIES
NOTE:
INSTALL INSTRUMENT AT UPSTREAM FACE OF PIER OR AT LOCATION OF MAXIMUM SCOUR
MAGNETIC SLIDING COLLAR
DRAWN BY: CAK
DATE: 3/11/97
CHECKED BY: GAF
JOB #: 92-820.03
APPROVED BY: JDS
FILENAME:TRB5-8.DWG
TITLE:
TYPICAL INSTALLATION OF AUTOMATED SLIDING COLLAR
AYRES ASSOCIATES
Engineers/Scientists/Surveyors
SHEET 5 OF 8

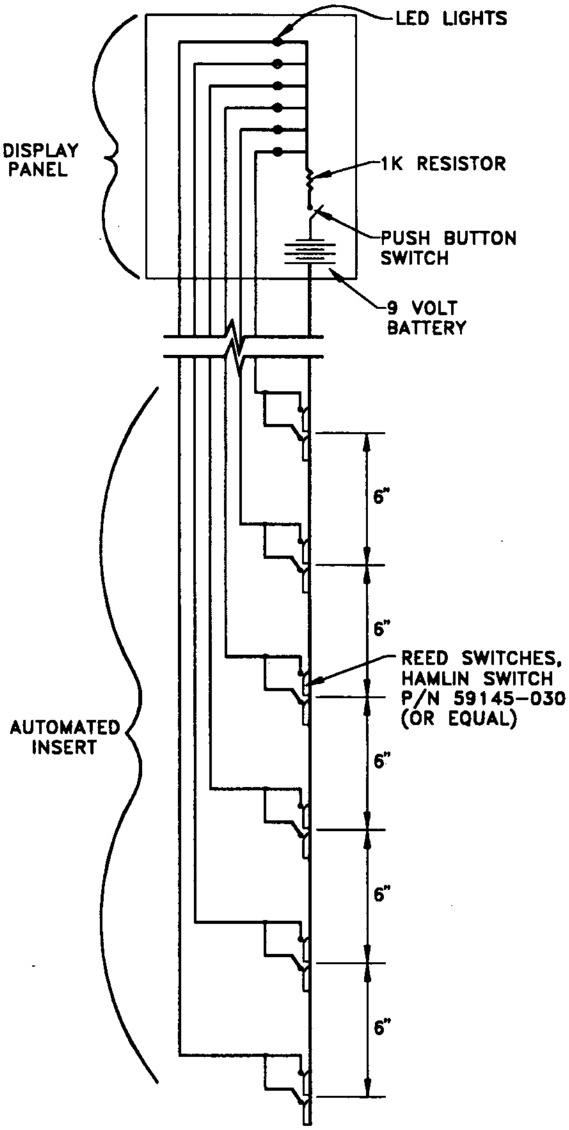

TO INSTRUMENT ENCLOSURE
MODIFIED 2" PLUG
3/4"x6" S.S. NIPPLE
HOSE CLAMP
2" TEE
GATES ECONO FLEX MULTI-PURPOSE 1 INCH - 200PSI HOSE (OR EQUAL)
2" TO 3/4" BUSHING
TO INSTRUMENT ENCLOSURE
GATES ECONO FLEX MULTI-PURPOSE 1 INCH - 200PSI HOSE (OR EQUAL)
T-FITTING
TO INSTRUMENT ENCLOSURE
MAGNETIC SLIDING COLLAR, SEE SHEET 3 FOR DETAIL
AUTOMATED INSERT SEE SHEET 8 FOR DETAIL
2" SCH. 80 S.S. PIPE
AUTOMATED INSERT
MACHINE DOWN TO FIT INSIDE 2" S.S. CLOSE NIPPLE
1.25"
.75"
1.75"
.5"
THREE/FOUR THREADS REMAINING
MACHINED DRIVING POINT (WELDED IN PLACE) SEE SHEET 2
MODIFIED 2" PLUG
0 3" 6"
SCALE IN INCHES
0 60mm 120mm
SCALE IN MILLIMETERS
DRAWN BY: CAK
DATE: 3/11/97
CHECKED BY: GAF
JOB #: 92-820.03
APPROVED BY: JDS
FILENAME:TRB6-8.DWG
AYRES ASSOCIATES
TITLE: STAINLESS STEEL PIPE COMPONENTS
SHEET 6 OF 8

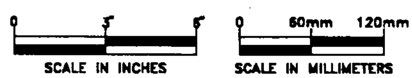


DRAWN BY: CAK	DATE: 3/11/97	TITLE: DRIVING ATTACHMENT FOR AUTOMATED SLIDING COLLAR DIVICE
CHECKED BY: GAF	JOB #: 92-820.03	
APPROVED BY: JDS	FILENAME:TRB7-8.DWG	
AYRES ASSOCIATES Engineers/Scientists/Surveyors		SHEET 7 OF 8









ALL PARTS AVAILBLE FROM RADIO SHACK

WIRING SCHEMATIC
N.T.S.

DRAWN BY: CAK	DATE: 3/11/97	TITLE: AUTOMATED INSERT AND DISPLAY PANEL
CHECKED BY: GAF	JOB #: 92-820.03	
APPROVED BY: JDS	FILENAME:TR86-8.DWG	
AYRES ASSOCIATES		SHEET 8 OF 8

APPENDIX C

TYPICAL INSTALLATION FOR MANUAL-READOUT, MAGNETIC SLIDING COLLAR SCOUR MONITOR

Purpose

This appendix illustrates a typical installation of a manual-readout, magnetic sliding collar scour monitor. A series of photographs illustrates site characteristics, major system components, and installation details. While no two installations of a magnetic sliding collar instrument will be identical (depending on bridge geometry and stream characteristics), the photographs provide guidance on a typical installation. A detailed parts list for this installation is also included.

Site Description

The site selected to illustrate a typical installation of a magnetic sliding collar device is the U.S. 60 Rio Grande bridge near Bernardo, New Mexico. The Bernardo crossing (NM1 on Figure C-1) is in a rural area and classified as a minor arterial. The bridge is a steel pile supported structure relatively low to the water. Guide banks facilitate flow through the bridge opening, which occurs in a single channel. The bridge has two traffic lanes with a narrow shoulder or emergency lane along each side. The ADT loading in 1988 was 630, but occurs at highway speeds (>80 km/h [>50 mph]) and includes truck traffic. Instrument installation was facilitated by the relatively small-diameter, round piles and limited bridge overhang. A U.S. Geological Survey (USGS) stream gage is located just downstream of the bridges. Note: A description of the sonic scour monitor installed at site NM2 (Figure C-1) is provided in *NCHRP Report 396.*

The Bernardo Bridge has pile bents consisting of a concrete pile cap and circular steel piles. The water depth at the time of installation was about 1 m (3.5 ft) with a mean flow velocity of about 1 m/s (3.5 ft/s). Fluctuating scour in the sand bed of the Rio Grande at this bridge had been noted by the USGS. The bridge deck was approximately 4 m (13.5 ft) above the water surface and the pile cap was 1,067 mm (42 in.) high and 914 mm (36 in.) wide. The 406-mm (16-in.) circular steel piles are vertical and inset approximately 660 mm (26 in.) from the face of the pile cap. The bridge is shown on Figures C-2 and C-3.

Installation

The installation of the magnetic sliding collar scour monitor is shown in Figures C-4 and C-5. The basic installation of the device went smoothly, requiring about 1 day for installation by a three-person crew. One problem encountered during installation at the Bernardo site was debris that had collected around many of the piers, limiting the locations where instrument installation was feasible. At some piers, debris piles were not evident from the water surface, and were only detected by probing around the piers.

Figures C-4 and C-5 show installation support equipment including the air compressor and the pneumatic post driver. The vertical piles at this bridge allowed the driven rod of the sliding collar to be driven vertically. The driven rod was 6 m (20 ft) of 50-mm (2-in.) diameter, Schedule 40 stainless steel pipe with a coupler (see Appendix A, *Sheet 2*) to join the black steel connecting pipe (see Section 9.3) to the stainless steel pipe. The stainless steel pipe for this installation consisted of four 1.5-m (5-ft) sections of pipe joined with couplers; however, when possible a single length of pipe is recommended to minimize cost and increase strength and durability. The stainless steel pipe was driven into the sandy streambed with a Rhino air-operated post driver (Model PD-40) to a depth of about 3.7 m (12 ft) as shown in Figure C-5.

The pipe was then attached along the front edge of the pile cap and at the bridge deck. A mounting bracket fabricated to clamp around the pile cap was used to secure the pipe rather than anchoring into the concrete of the pile cap (Figure C-6). Figure C-6 also shows the completed installation, looking from the bridge deck down to the water surface; note the offset in the pipe that was necessary to allow for the overhang of the bridge deck over the pile cap. The section of pipe above the pile cap, including the offset, was constructed of 50-mm (2-in.) Schedule 40 black steel pipe. For this installation, 45 elbows were used for the offset; however, where possible, standard pipe sweeps are preferred to facilitate insertion of the manual-readout probe to locate the collar position.

The sliding collar used is shown in Figure C-7. For the Bernardo Bridge, the pipe extended above the guard rail with a locking cap that could be removed to take measurements of the collar location (Figures C-8 and C-9).

Figure C-8 shows the locking cap removed and the manual-readout probe (see Appendix A, *Sheet 4*) and Figure C-10 shows the procedure for taking a reading at the completed installation.

Parts List

A complete parts list for the manual-readout, magnetic sliding collar scour monitor installed on the Bernardo Bridge over the Rio Grande is shown in Figure C-11.

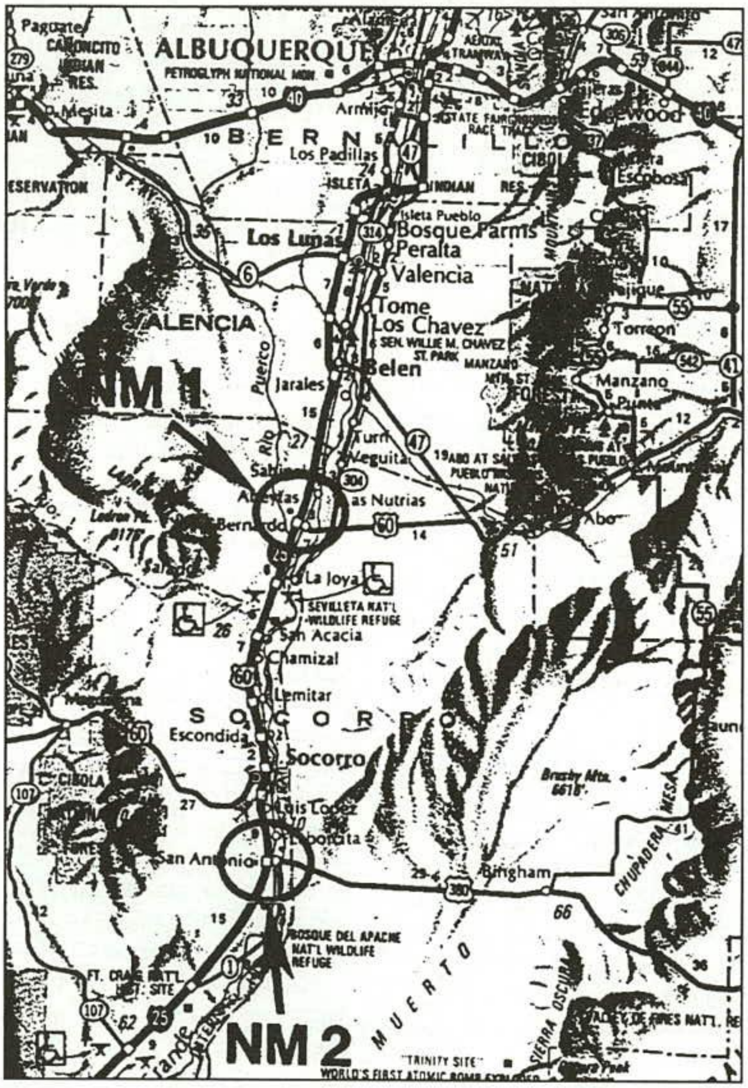


Figure C-1. Bridge at Rio Grande test sights in New Mexico.

Figure C-2. Bernardo Bridge over the Rio Grande.

Figure C-3. Upstream side of bridge.

Figure C-4. Arriving on-site with equipment.

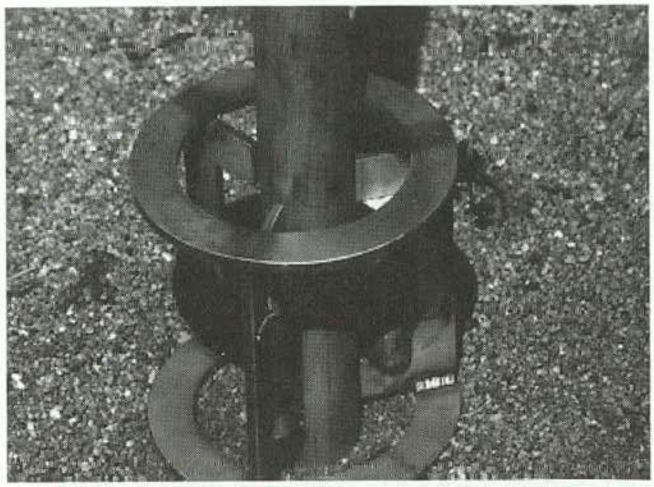


Figure C-7. Magnetic sliding collar.

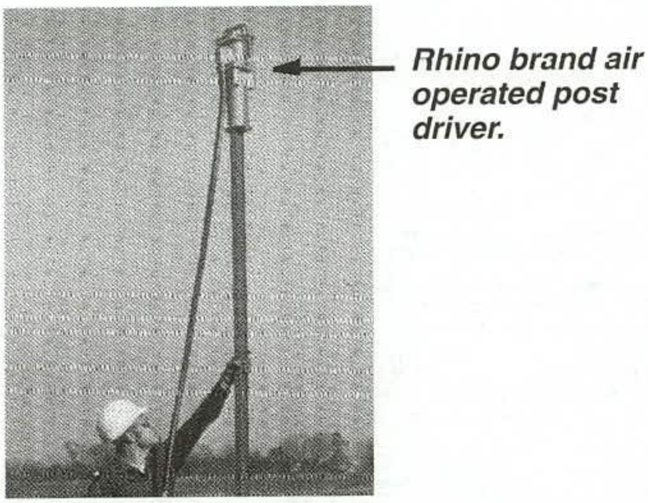


Figure C-5. Driving stainless steel pipe.

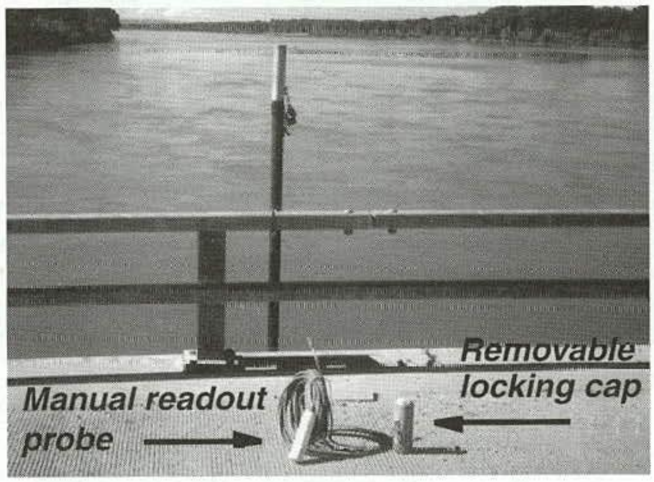


Figure C-8. Completed installation.

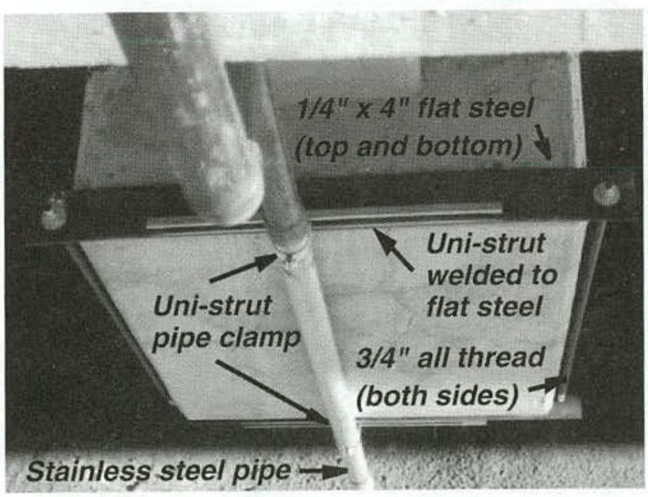


Figure C-6. Adjustable mounting bracket for pile cap.

Figure C-9. Close-up of removable locking cap.

Figure C-10. Making a scour measurement.

MANUAL-READOUT, MAGNETIC SLIDING COLLAR SCOUR MONITOR Typical Parts List - Example: Rio Grande near Bernardo, New Mexico	
Description	Quantity
1. Sliding Collar Pipe	
2-inch Schedule 40 stainless steel pipe (four 5-foot sections with couplers)	20 ft
Hardened driving point	1
Driving cap	1
2. Connector Pipe	
Black steel pipe fabricated with a 4-foot offset to compensate for bridge deck overhang. Ten foot overall length top to bottom with 45° elbows to create offset.	1
Two-inch pipe coupler (one to join connector pipe to stainless steel pipe and one to join locking cap assembly to connector pipe)	2
Locking cap and chain assembly	1
Padlock	1
3. Adjustable Mounting Bracket for Pile Cap	
1/4 in. x 4 in. x 3 ft flat steel with 3/4 in. holes at each end	2
2 ft of Unistrut™ (to be welded to flat steel)	2
2 in. Unistrut™ pipe clamps)	2
3/4 in. x 4 ft all tread™ (or steel rod threaded at ends)	2
3/4 in. coarse thread nuts	4
3/4 in. flat washers	4
3/4 in. lock washers	4
4. Magnetic Sliding Collar and Manual Readout Probe	
Fabricated collar with magnets (per design drawings)	1
Fabricated manual readout probe (per design drawings)	1

Figure C-11. Typical parts list.

APPENDIX D

DATA RECORDING FORM—MANUAL-READOUT, MAGNETIC SLIDING COLLAR SCOUR MONITOR

MANUAL READOUT
MAGNETIC SLIDING COLLAR SCOUR MONITOR
DATA RECORDING FORM

Agency: ____________________
River: ____________________
Location: ____________________

Structure ID: ____________________
Datum: ____________________
Datum Elevation: ____________________

Date	Time	Probe* Reading (ft)	Flow Rate (cfs)	Water Surface Elev./ Stage	Comments (Debris, Ice, Condition of Instrument, Past Flows, Problems)

*Reading taken at (first) (second) sound of buzzer (choose one - see Section 4.2, Step 3)

APPENDIX E

EQUIPMENT SUPPLIERS

Supplier	Equipment
Rhino Sales Corporation P.O. Box 367 620 Andrews Avenue Kewanee, Illinois 61443	Model PD-40 Pneumatic Driver
ETI Instruments Systems, Inc. 1317 Webster Avenue Fort Collins, Colorado 80524	Automated Insert with Instrument Enclosure
Hoffman A Pentair Company 900 Ehlen Drive Anoka, Minnesota 55303-7504	Equipment Enclosure

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Abbreviations used without definitions in TRB publications:

AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
IEEE	Institute of Electrical and Electronics Engineers
ITE	Institute of Transportation Engineers
NCHRP	National Cooperative Highway Research Program
NCTRP	National Cooperative Transit Research and Development Program
NHTSA	National Highway Traffic Safety Administration
SAE	Society of Automotive Engineers
TCRP	Transit Cooperative Research Program
TRB	Transportation Research Board
U.S.DOT	United States Department of Transportation

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