Engineering

Technical Guideline TG0640

General Technical Information for Geotechnical Design - Survey Pillars

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Only the current revision of this Guideline should be used which is available for download from the SA Water website.

Significant/Major Changes Incorporated in This Edition

This is the first issue of this Technical Guideline under the new numbering format. The original version of the document was last published in 2007 with the name of General Technical Information for Geotechnical Design Part M – Survey Pillars (TG 10m). A full version history of this document is given in Document Controls. The major changes in this revision are listed in the following table:

Section No. in TG 0640	Section No. in TG 10m	Changes
TG0640 – 3	New Section	Section 3 is added to provide an introductory discussion.
TG0640 – 4	TG 10m – 2	Minor Revision
TG0640 – 5	TG 10m – 5	Minor Revision
TG0640 – 6 & Appendix A	TG 10m – 4	Major Revision
TG0640 – 7 & Appendix B	TG 10m – 6	Major Revision
TG0640 – 8 & Appendix C	TG 10m – 3	Major Revision
TG0640 – 9 & Appendices D and E	TG 10m – 7	Major Revision

Document Controls

Revision History

Revision	Date	Author	Comments
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1	10/1/2007		Nil
2	20/05/2020	Moji Kan	Major Revision, Reformatting to TG 0640

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1 Introduction

SA Water is responsible for operation and maintenance of an extensive amount of engineering infrastructure.

This guideline has been developed to assist in the design, maintenance, construction, and management of this infrastructure.

1.1 Purpose

The purpose of this guideline is to detail minimum requirements to ensure that assets covered by the scope of this guideline are constructed and maintained to consistent standards and attain the required asset life.

1.2 Glossary

The following glossary items are used in this document:

Term	Description
SA Water	South Australian Water Corporation
TG	SA Water Technical Guideline
TS	SA Water Technical Standard

1.3 References

1.3.1 Australian and International

The following table identifies Australian and International standards and other similar documents referenced in this document:

Number	Title
AS 1725.1 – 2010	Chain link fabric fencing - Security fences and gates - General requirements
AS 2423 – 2002	Coated steel wire fencing products for terrestrial, aquatic and general use

1.3.2 SA Water Documents

The following table identifies the SA Water standards and other similar documents referenced in this document:

Number	Title

1.4 Definitions

The following definitions are applicable to this document:

Term	Description
SA Water's Representative	The SA Water representative with delegated authority under a Contract or engagement, including (as applicable): • Superintendent's Representative (e.g. AS 4300 & AS 2124 etc.) • SA Water Project Manager • SA Water nominated contact person
Responsible Discipline Lead	The engineering discipline expert responsible for TG 0640 defined on page 3 (via SA Water's Representative)

2 Scope

The scope of this document is to provide guidelines on geotechnical aspects of design of survey pillars as part of survey monitoring systems for SA Water infrastructure.

3 Introduction

Design and construction of survey pillars is often required as part of monitoring systems of large infrastructure such as concrete and earthfill dams, large tanks, and earth bank storages. The present guideline covers the geotechnical aspects of design and construction of survey pillars, based on experiences and past performance that were observed in SA Water assets.

4 Survey Pillars – Site Selection Criteria

The criteria for the selection of survey pillar sites (e.g. for the monitoring of a dam) are:

- Lines of sight and angles to other survey pillars,
- Lines of sight and angles to targets (e.g. on a dam wall),
- Ease and safety of access for construction,
- Ease and safety of access for ongoing observations,
- Likely cost of construction,
- Geotechnical stability

The best compromise between the various criteria is probably arrived at most quickly and efficiently by having the person responsible for setting up the monitoring of the structure, the surveyor, and the geotechnical specialist on site simultaneously.

A high degree of stability is required for survey pillars and so, from the geotechnical point of view, it is almost essential to found them on stable "bedrock" – not in soil or on a rock floater.

However, even so-called "stable" bedrock is, at some scale or another, broken up into blocks by "defects" (joints or faults). Movement would have occurred on these defects in the past and is likely to occur on them again in the future.

Joints can be spaced as close as a few tens or hundreds of millimetres apart (the typical "jointed rock" with which most people will be familiar), and most such joints may have historically only had displacements of a few micrometres on them. Nevertheless, even such small displacements can still add up to significant total displacements on the scale of, say, a valley side.

On the other hand, *faults* can be spaced many tens or hundreds of metres apart (typical "regional" scale faulting, generally less obvious to the lay person), but may have had displacements on them of up to several kilometres. It is movements like these that build mountain ranges such as the Mount Lofty Ranges.

What this means for survey pillars is that there is no such thing as a truly stable site:

- Valley sides will creep (out and/or down) in response to a whole range of subtle drivers (lunar tides, thermal strains, chemical forces, internal stress relief, erosion, etc.), and will take the survey pillars with them.
- Larger and more sudden movements of bedrock may occur anywhere during earthquakes – even to the extent that a survey pillar might become part of a rockslide. The movement of a survey pillar during an earthquake is a particularly unfortunate occurrence because it is usually after an earthquake that we would most like to know whether and by how much a structure (such as a dam) has moved.

Despite these reservations, survey pillars are often essential (e.g. for dam surveillance) and so geotechnically “acceptable” though inevitably “imperfect” sites will need to be found.

5 Standard Design for Shallow Rock Foundation

A standard design for survey pillars on rock foundation is presented in Figure 5-1. This typical standard design might be tailored to the project specific requirements by a qualified dams or geotechnical engineer. The original design was prepared in 2003.

Notes on Figure 5-1are as below:

1. The pillar is designed to be bushfire proof and vandal resistant.
2. The pillar is designed to be thermally stable. Extension = 0.75 mm for 43 °C rise.
3. The pillar unit (blue) is designed to be prefabricated. Total mass is about 80 kg.
4. The instrument-mounting socket will be installed separately by a surveyor.
5. If rock is shallower than 500 mm, extend the concrete footing above the surface.
6. If rock is deeper than 1000 mm and concrete volumes are a problem, consult a geotechnical specialist for a special design.
7. Pour a pad of concrete to the correct height for the base plate. Set the base plate on the pad and prop/guy the pillar dead vertical. Pour the remainder of the footing concrete against the excavation. Use formwork above ground level if necessary.
8. Use a class S25 or higher concrete. Alternatively, a concrete mix of 1 : 12 : 3 (cement : sand : aggregate) by volume might be adopted, whereby the compressive strength of the concrete after 28 days should be at least 25 MPa.
9. Coat with “cold galvanising” paint to paint manufacturer’s specifications after installation.
10. Over-paint with cosmetic finish as and only if directed.

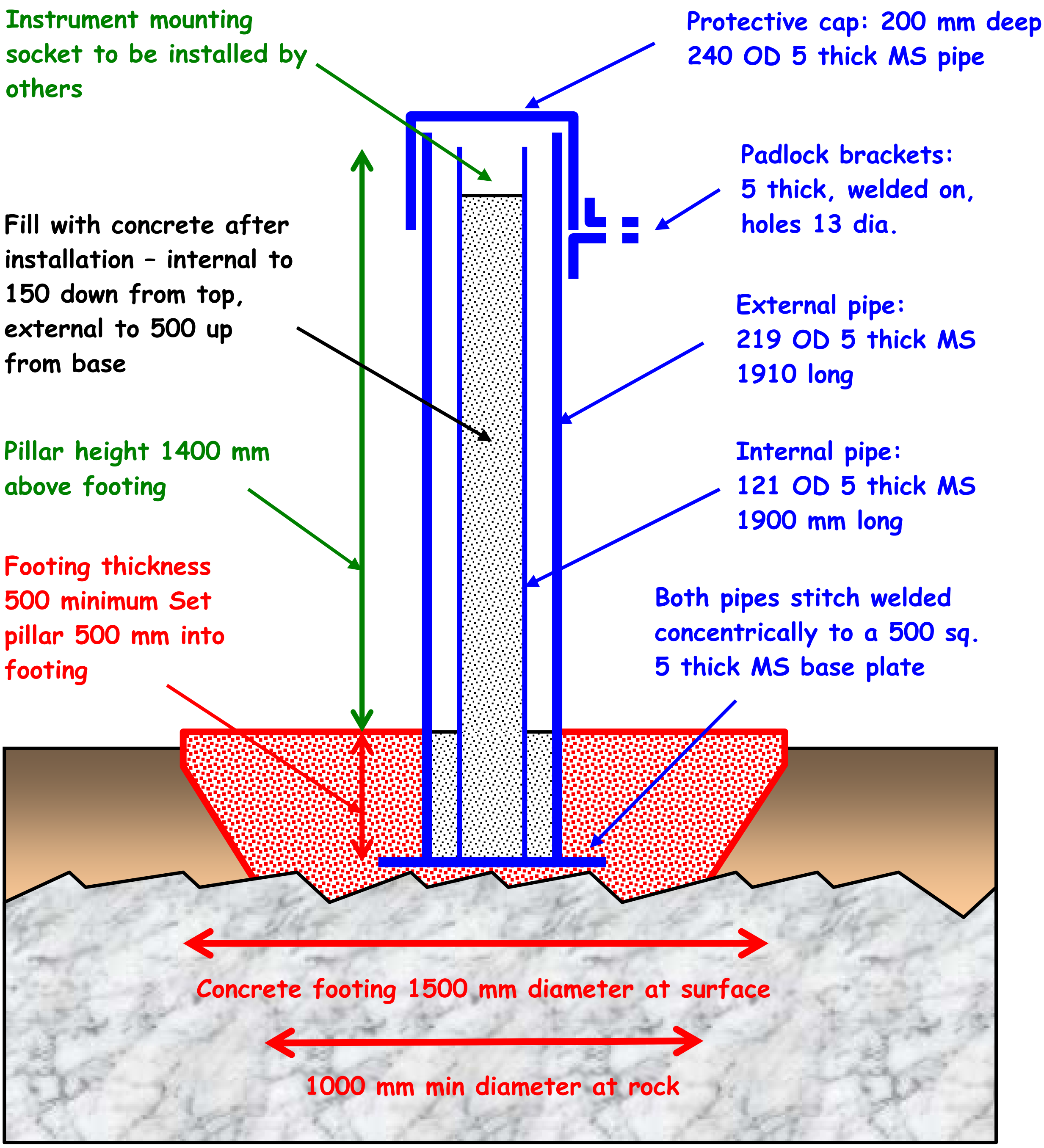


Figure 5-1: Standard Design for Shallow Rock Foundation

6 Design of Safety Railing

The design and construction of safety railing needs to be based on the following standards:

- AS 1725.1: Australian Standard for chain link fabric fencing - Security fences and gates.
- AS 2423: Australian standard for coated steel wire fencing products for terrestrial, aquatic and general use.

A typical design based on these standards that was originally prepared in 2003 is presented in Appendix A.

7 Access Track and Step Design and Construction

Access track to the survey pillars and required steps need to be designed and constructed based on all relevant Australian Standards for safe access to the sites. A typical design drawing which was prepared for Myponga and Sturt River Dams in 2003 is presented in Appendix B to provide a guideline.

8 Dam Target Installation Specification

Installation of targets on dam walls require detailed technical specifications which should be prepared and signed off by a qualified dams engineer. As a minimum requirement, a sample technical specification from SA Water concrete dams' projects is presented in Appendix C.

9 Construction of Survey Pillars

A project specific technical specification needs to be prepared for construction of survey pillars. A qualified dams or geotechnical engineer should be involved in preparation of the specifications. Two sample technical specifications that were used in SA Water projects are presented in Appendices D and E.

Appendix A Typical Design for Safety Railing

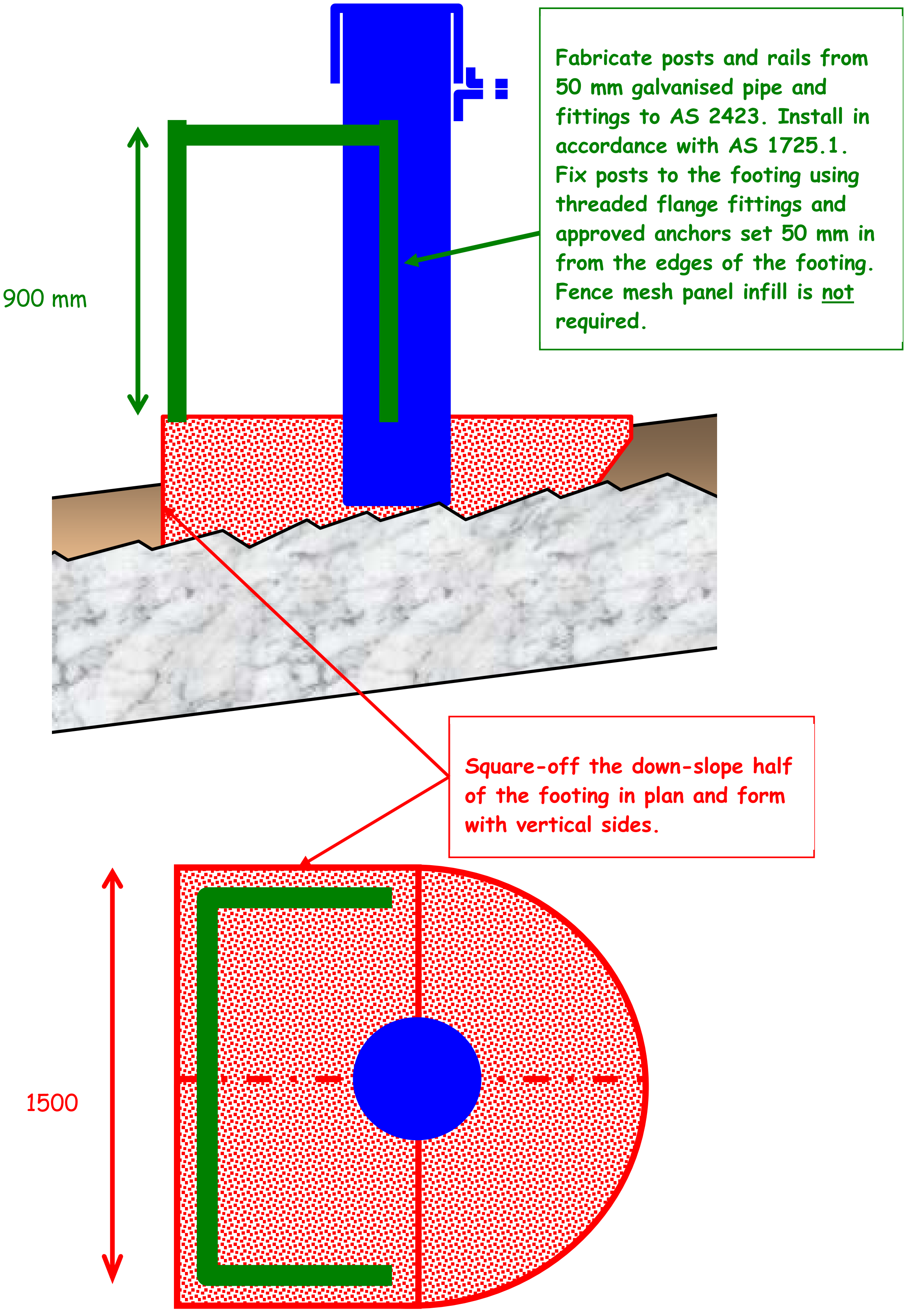
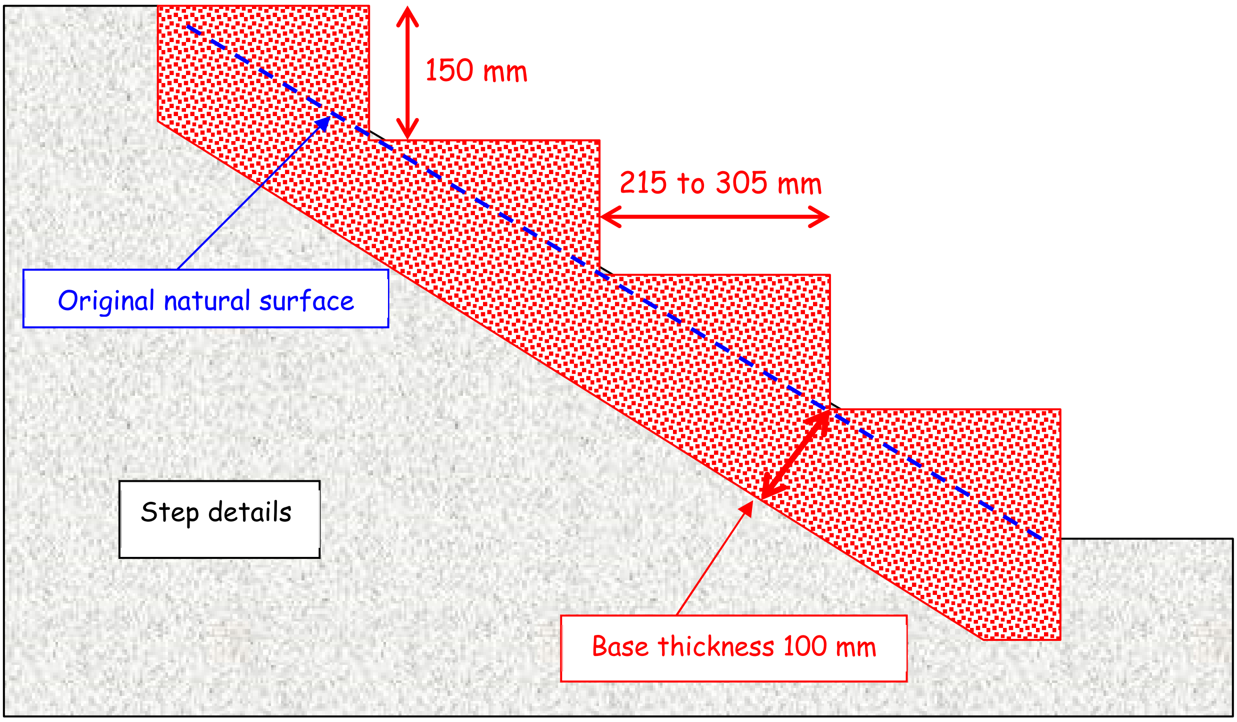


Figure A-1: Typical Design for Safety Railing

Appendix B Typical Design for Access Track and Steps

This is a typical design for access track and steps to the survey pillars. This was designed for Sturt River and Myponga Dams in 2003.



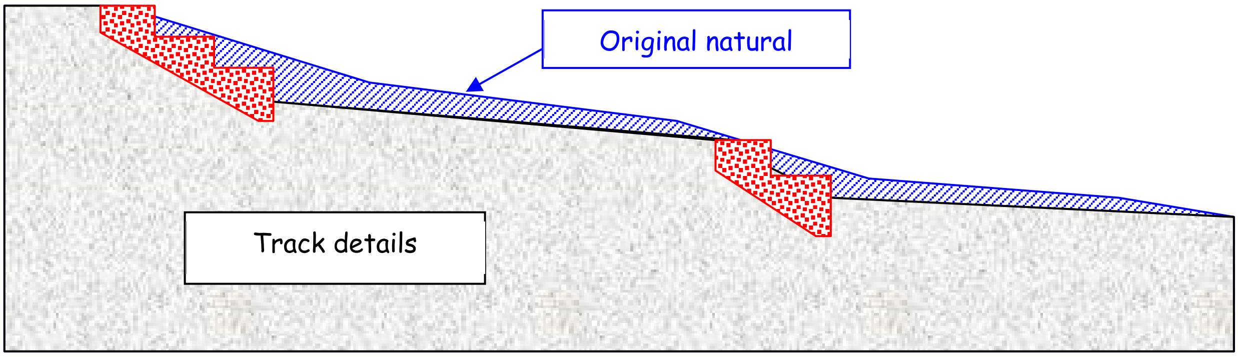
The "slope" of all flights of steps to be between 1:1.4 and 1:2 (35° and 26°) *.

All risers to be 150 mm high. Goings to be between 215 mm min and 305 mm max – but constant on each flight. Treads to be 800 mm wide and horizontal. The number of risers in any flight of steps should not exceed 18. Concrete to be N20 (normal grade 20 MPa) unreinforced*.

Strip topsoil and loose materials and found steps on firm natural soil foundation or compacted granular fill. Backfill all excavations around completed steps with well-compacted select fill. Regrade surrounding natural surface to neat fit using matching material (topsoil/rock/etc).

*: These aspects (slope of flights and reinforcement and grade of the concrete) needs to be designed based on project specific requirements.

Figure B-1: Illustration of Access Steps



Tracks to be 800 mm wide. Fit tracks to the natural lie of the ground as much as possible using the minimum of clearing, grading, or cut-and-fill necessary to give cross and longitudinal slopes of 1 on 6 or flatter. Avoid disturbing natural drainage patterns where this might lead to erosion, otherwise manage runoff as per the SA EPA code of practise for stormwater pollution prevention for the building and construction industry. Match the track surfacing to the surroundings (e.g. grass, rock rubble, etc.). Install flights of steps between stretches of “ramp” as necessary. Make use of natural rock outcrops as steps where possible.

Figure B-2: Illustration of Access Track

Appendix C Sample Technical Specification on Installation of Targets

This sample Technical Specification sets the minimum requirements for the installation of targets on dam walls. This was prepared as a SA Water technical note on 29/07/2003. A project specific specification needs to be prepared by a qualified Dams Engineer to specify the installation specifications in all dams' projects.

C1 General Requirements

Install all chemical and masonry anchors in accordance with the manufacturer's written instructions. Supply full details of proposed anchors (including manufacturer's literature) with tender.

After installation of the brackets, including tightening to the torque recommended by the manufacturer, burr all exposed threads to prevent removal of nuts from the anchors.

C2 Installation of Brackets

C2.1 Material & Work by Principal

The Principal will:

1. Supply the brackets and mark the position of each bracket on the Dam wall.
2. Supply the survey pillar tube assemblies ready for encasing in the pillar base.

C2.2 Type 1 Bracket

Fix to dam wall in the position indicated using 4 – 10 mm dia. 316 stainless steel masonry anchors (Ramset Dynabolt or an equivalent approved by the Superintendent's Representative), with an embedment length not less than 55 mm. Apply sufficient Epirez 8242 adhesive or equivalent (subject to approval) to the back of the bracket to fully bed the bracket in adhesive immediately prior to installation and remove surplus material immediately after tightening the anchors.

Design, supply and install a hot dip galvanised mild steel canopy over the bracket to protect it from stones and other objects dropped or thrown from the top of the dam. Fix the canopy to the dam wall with hot dip galvanised masonry anchors and provide a minimum clear distance of TBA mm from the bracket to the underside of the canopy.

C2.3 Type 2 Brackets

Fix to the top downstream edge of the downstream kerb at positions indicated. Fix using 2 – M10 316 stainless steel chemical anchors (Ramset Chemset Maxima capsules or equivalent approved by the Superintendent's Representative) vertically into the top horizontal surface with a minimum embedment length of 90 mm, and 2 – 10 mm 316 stainless steel masonry anchors (Ramset Dynabolt or an equivalent approved by the Superintendent's Representative), with an embedment length not less than 55 mm, horizontally into the vertical face.

Apply sufficient Epirez 8242 adhesive or equivalent (subject to approval) to the back of the bracket to fully bed the bracket in adhesive immediately prior to installation and remove surplus material immediately after tightening the anchors.

Note that it may be necessary to temporarily remove the bottom fence rail to facilitate the drilling of the vertical holes for the anchors.

Provide an opening 200 mm (to be confirmed) square in the fence chain wire mesh immediately above the bottom rail centred on each bracket, for the installation and removal of targets on the brackets. Twist together and turn back the cut ends of the chain wire mesh to provide a knuckled selvedge around the opening to prevent scratches and unravelling of the mesh. Lace with galvanised wire if necessary, as added precaution against unravelling.

Appendix D Typical Technical Specifications (River Murray)

The following technical specifications is a sample only. It was prepared on 26/09/2001, as a memo to River Murray Operations for construction of survey pillars in River Murray.

Table D-1: Recommended Survey Pillar Construction according to Geotechnical Conditions

Geotechnical Conditions at the Site of the Survey Pillar	**Recommended Survey Pillar Construction Details**
1. Shallow loose sandy soil over rock or strong sheet calcrete. 2. Shallow reactive clay over rock or strong sheet calcrete.	Excavate to the rock or strong sheet calcrete. Found a standard concrete pillar on the rock or sheet calcrete.
3. Shallow loose sandy soils over dense sandy soil or weathered rock. 4. Shallow reactive clay over dense sandy soil or weathered rock.	Excavate to dense sandy soil or weathered rock. Pour or place a footing slab (not less than 1 m diameter) on the dense sandy soil or weathered rock. Set a standard concrete pillar on the slab.
5. Deep loose sandy soils. 6. Deep loose sandy or carbonate soils with weak sheet calcrete or calcrete rubble. (The soil beneath calcrete is usually very loose, so calcrete should not be founded on unless it is strong.)	Drill a tight-fit pilot-hole to 1 m only. If weak sheet calcrete or calcrete rubble are present, drill through them also. Drive a suitable steel pile (not less than 100 mm diameter) to not less than 1.5 m AND to a set of not less than 10 kN (1 tonne). Leave 1.35 m standing above ground. Fill the pile with concrete to within 150 mm of the top. Set the instrument mount in mortar. Protect the pile from vehicle/cattle damage.
7. Deep reactive clays not on the floodplain. (e.g. Blanchetown Clay) 8. River Murray floodplain. (Typical profile: 1 to 6 m of reactive clay, over soft silts, over sand.) *Note: The depth of seasonal shrink and swell on reactive clay sites in SA is generally taken as 4 m.*	Drill a tight-fit pilot-hole to 1.5 m. Drive a suitable steel pile (minimum 100 mm diameter) to a depth of not less than 4 m AND to a set of not less than 10 kN (1 tonne). Leave 1.35 m standing above ground. Fill the pile with concrete to within 150 mm of the top. Set the instrument mount in mortar. Surround the pile with a 2 m diameter concrete slab, with a PVC sleeve around the pile shaft through the slab. Protect the pile from vehicle/cattle damage.

Note on Geotechnical Condition “8”:

The geotechnical conditions at a site govern the construction details necessary to achieve a sufficiently stable survey pillar at minimum cost. Stable rock sites (1 to 4) are the easiest and cheapest to build on. Loose sand sites (5 and 6) need deeper foundations. Reactive clay sites (7 and 8) require quite sophisticated designs to ensure that the pillar is not disturbed by the shrink and swell movements of the clay, which can be up to several hundred millimetres.

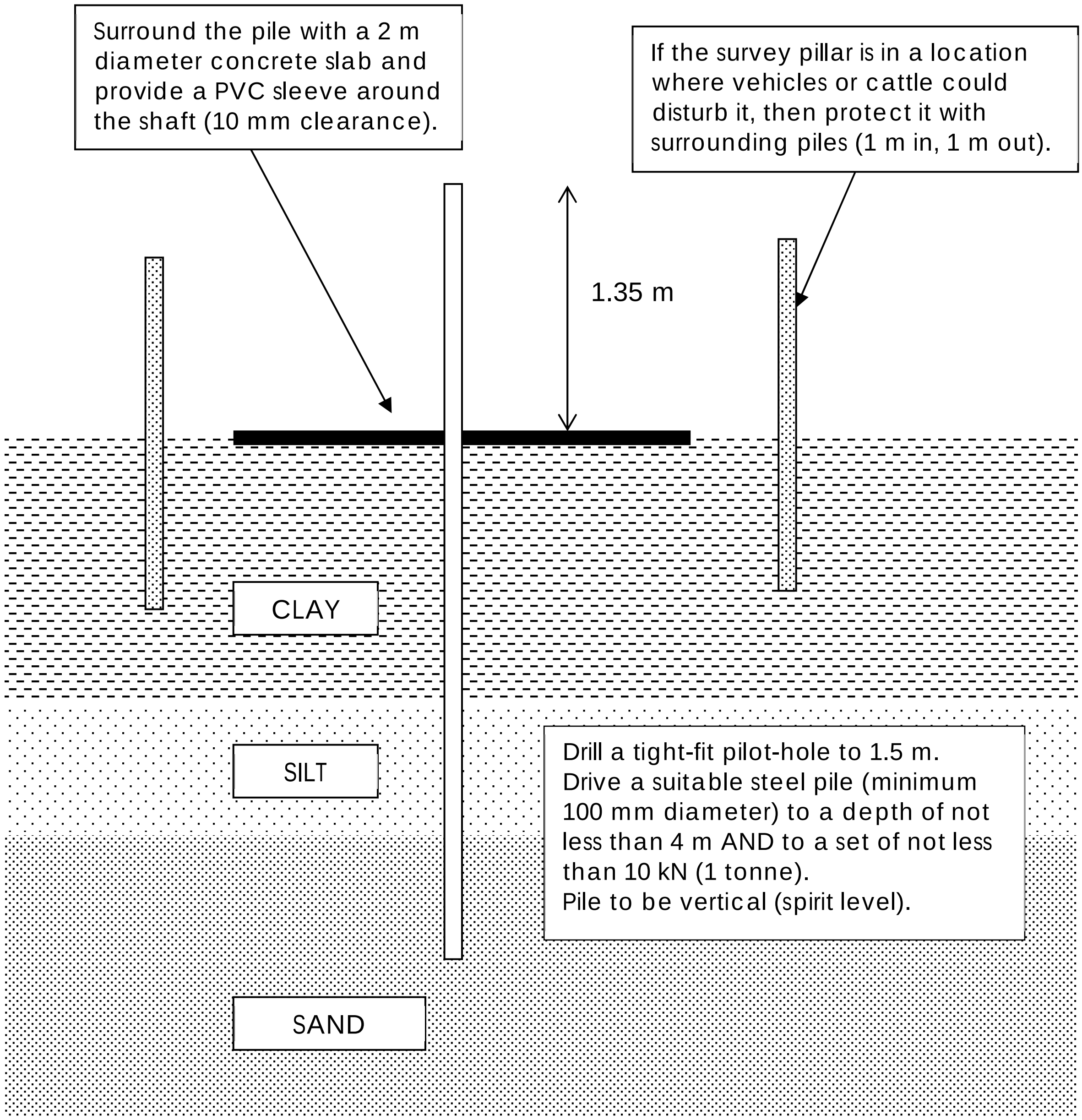


Figure D-1: Recommended Survey Pillar Construction for River Murray according to Geotechnical Conditions

Appendix E Typical Technical Specifications (Hope Valley Dam)

The following technical specifications is a sample only. It was prepared on 17/05/2002 on construction of the survey pillars in Hope Valley Dam.

E1 Survey Pillar Design Logic

a. **To ensure the required vertical stability** the pillar must be founded in the Tertiary "sandstone" below any reactive soils; isolated from reactive soils; resistant to changes in length with ambient temperature and/or direct exposure to the sun.

b. **To ensure the required lateral stability** the pillar must be of sufficient diameter; it must be socketed into the Tertiary sandstone; and it must be resistant to lateral deflection if exposed to sun from one side.

c. **The lower part of the soil profile** may be used to assist with the provision of lateral stability provided the pillar is socketed far enough into sandstone for it to be able to resist any tendency for the swelling reactive soils to pull it out of the socket.

d. **The most economical and effective way to achieve the requirements** in (a) and (b) and to take advantage of (c) appears to be to use a concrete-filled PVC pipe concreted into an auger hole.

E2 Survey Pillar Construction Sequence

a. **Auger the hole.** Use a 500 mm diameter auger. The auger hole should extend 1 m into the Tertiary sandstone (or equivalent strong non-reactive rock-like material) beneath the clay or other potentially reactive soil-like near-surface materials. Seek geotechnical confirmation that the soil profile is as assumed in this design.

b. **Install the "pillar casing".** Use 250- or 300-mm nominal diameter PVC pipe or approved alternative (DN 250 pipe has an outside diameter of 290 mm). Wedge the pipe in position vertical. Fill pipe and auger hole to 2 m above bottom of hole, i.e. to 1 m above the sandstone.

c. **Install the "hole support casing".** Use Ribloc or approved alternative. The diameter of the casing should be selected to fit comfortably inside the auger hole (e.g. 450 to 500 mm).

d. **Fill the "pillar casing".** Fill the rest of the pipe with concrete to within 150 mm of the required level of the top. Allow the concrete to cure. Trim the top back to its final level if necessary, ensuring that 150 mm of pipe extends above the concrete filling.

e. **Pour the surround slab.** Outside diameter about 2 m or about 2 m square. Minimum thickness 100 mm. Clearance around the pillar 50 mm. Lip around the pillar 50 mm high. No reinforcement. Minimum concrete strength 20 MPa. Formwork will be required – e.g. prefabricated annular "tray" left in place. Install approved flashing to cover the gap between the pillar and the surround slab.

f. **Install the instrument mount.** Allow three weeks between pouring and installing the instrument mount to allow the concrete to complete most of its curing shrinkage. The instrument mount will be installed by the surveyor.

g. **Paint the pillar white.** The top of the pillar will move vertically about 0.4 mm per 10 °C change in the overall temperature of the pillar, and laterally by a similar amount for a 10 °C differential in temperature between one side of the pillar and the other. Thermal stability was one of the reasons for recommending a large diameter for the pillar (the other was lateral stiffness) and for casting it inside thermally insulating PVC casing. Painting it white will help minimise all forms of temperature change.

h. **Protect the pillar from impact** – e.g. surround by four solid posts (timber or precast concrete).

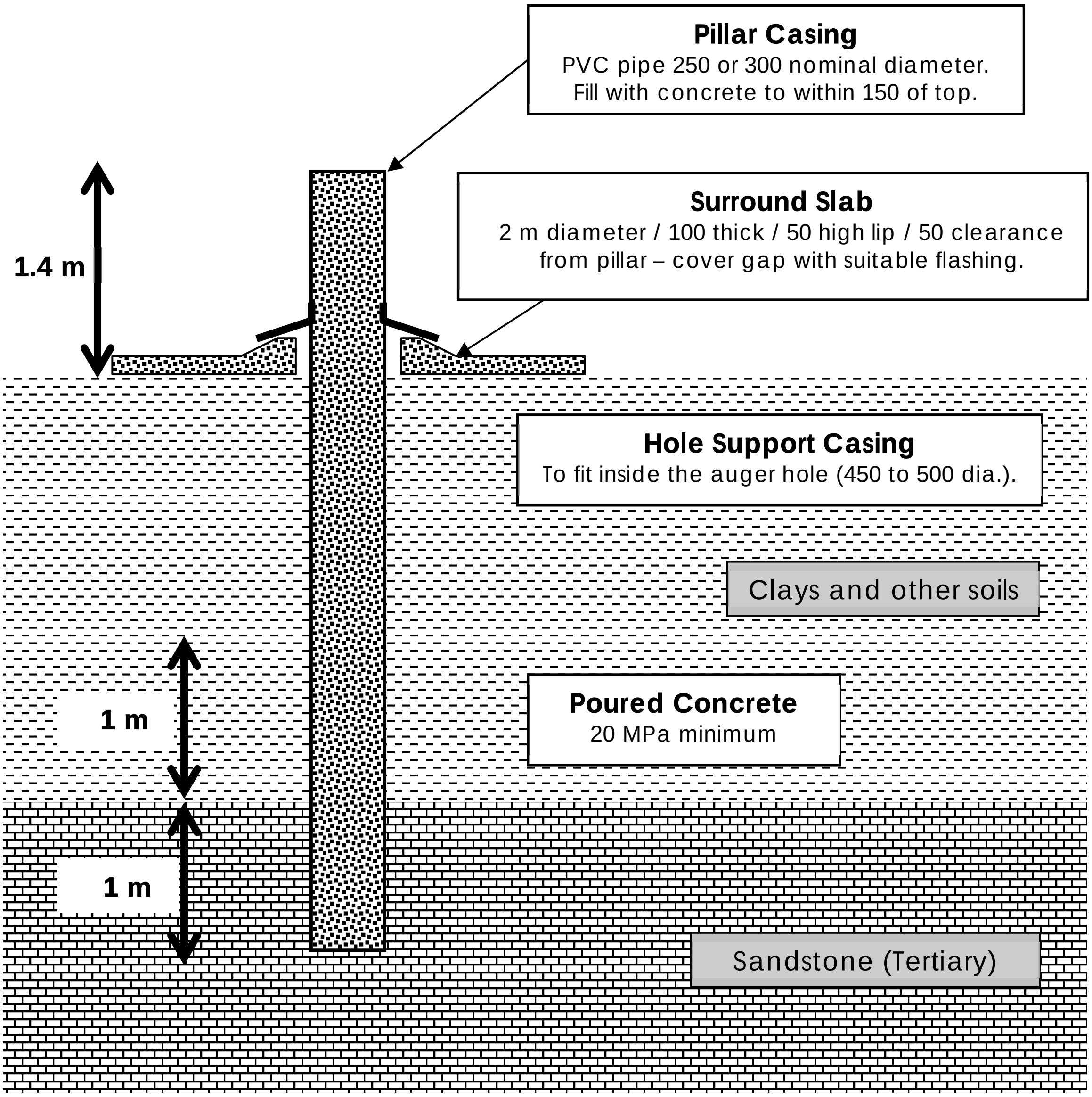


Figure E-1: Design example for Survey Pillars/ Permanent Benchmarks in Hope Valley Dam