17.0 MAIN CANAL CONVEYANCE STRUCTURES

17.1 General

Conveyance structures typically employed on main canal systems include inverted syphons, flumes, check structures, and drop structures.

17.2 Inverted Syphon

An inverted syphon may be used across a depression (coulee) where conditions such as the depth and length of the depression favour it over a high embankment canal or a flume. The syphon structure usually consists of an inlet structure, conduit, and outlet structure.

The inlet and outlet structures are ordinarily constructed of reinforced concrete, whereas the conduit generally consists of cast-in-place or precast concrete pressure pipe, or steel pipe. More recently, cast-in-place or precast concrete pressure pipes have been used, particularly for large syphons. Therefore, only concrete conduits are discussed in this section. The general arrangement of the large diameter reinforced concrete Pinepound Coulee Syphon is shown on Figure 17-1.

At the low point of the conduit, a pipe equipped with a gate valve to drain the conduit and an access port (Tee fitting with a blind flange) is usually provided for seasonal draining, inspection and maintenance purposes.

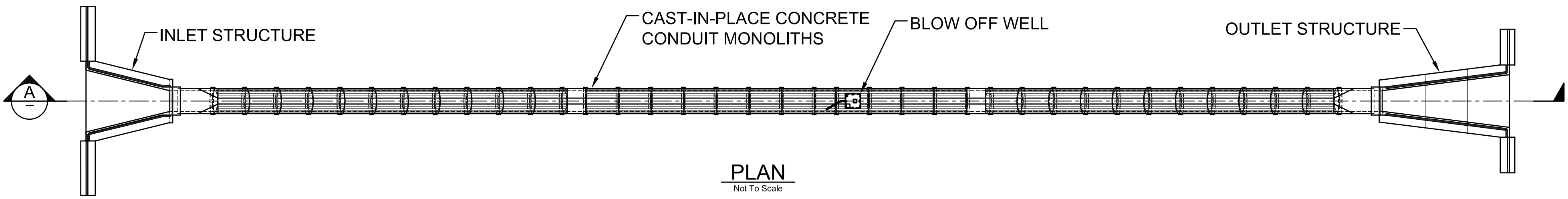
The design of the conduit should consider the governing loading combinations for both the operating condition (full internal hydrostatic pressure) and the completely dewatered condition.

For cast-in-place concrete, the conduit should be designed to minimize leakage; consequently, the resulting crack widths, particularly under Usual Conditions of loading, should be reviewed as discussed in Section 9.1.1.

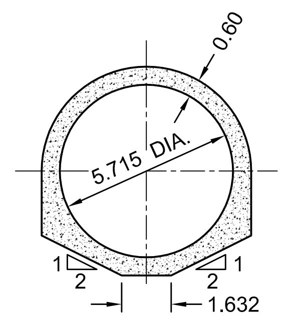
For a cast-in-place concrete conduit, transverse contraction joints are normally employed to accommodate temperature and shrinkage effects, accommodate minor differential movements, and facilitate construction. For the East Arrowwood (1999), West Arrowwood (1995), and Pinepound Coulee (1990) Syphons, a standard spacing of 9 m was used for the contraction joints. Typical contraction joint details are shown on Figure 17-2. Articulated transverse joints may be required at locations where greater differential movements may occur (e.g. due to poor foundation conditions). An example of an articulated joint used at the Pinepound Coulee Syphon is shown on Figure 17-3

It is preferred that the pipe slope be not steeper than 4H:1V. The conduit should be constructed starting from the lowest point and proceeding in an uphill direction. For precast concrete pressure pipe, the bell end of the pipe should be located on the uphill side.

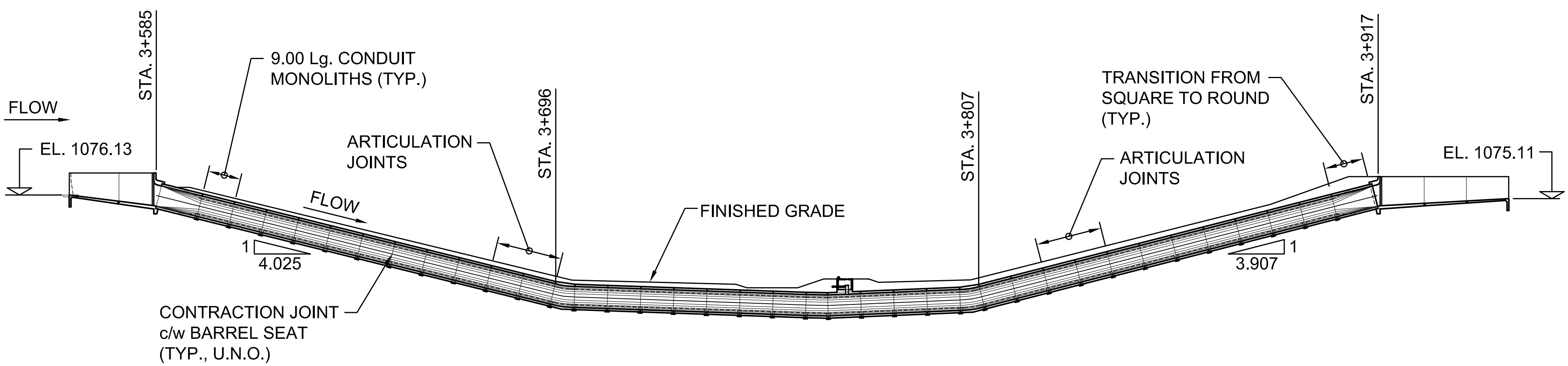
Normally, each joint of the precast concrete pressure pipe is internally tested using a low-pressure



PLAN
Not To Scale



SECTION - TYPICAL BARREL
Not To Scale



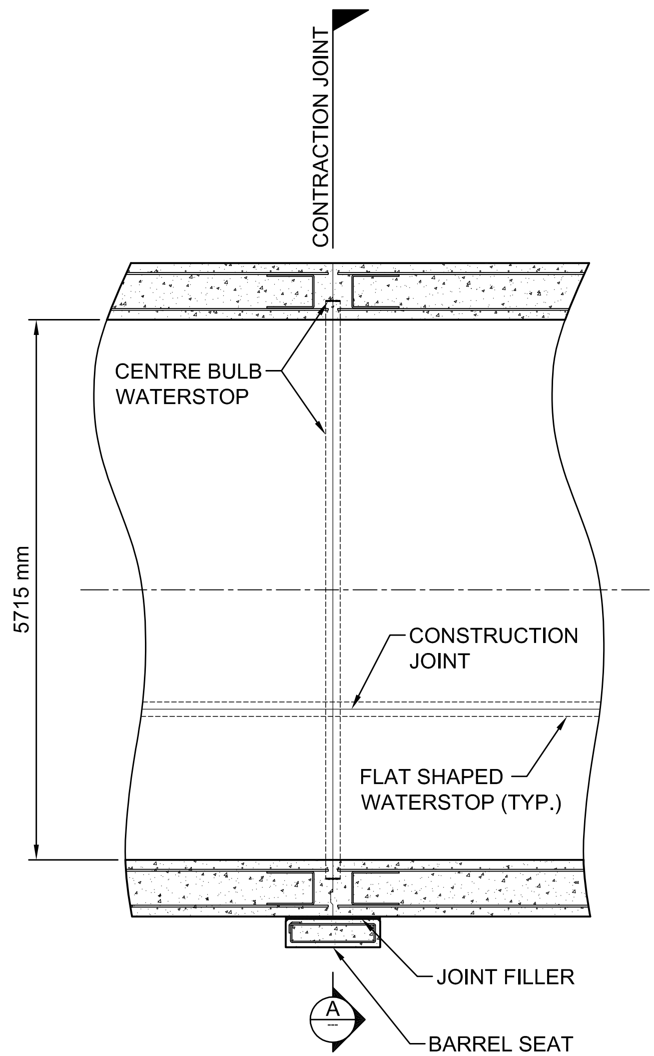
A SECTION
Not To Scale

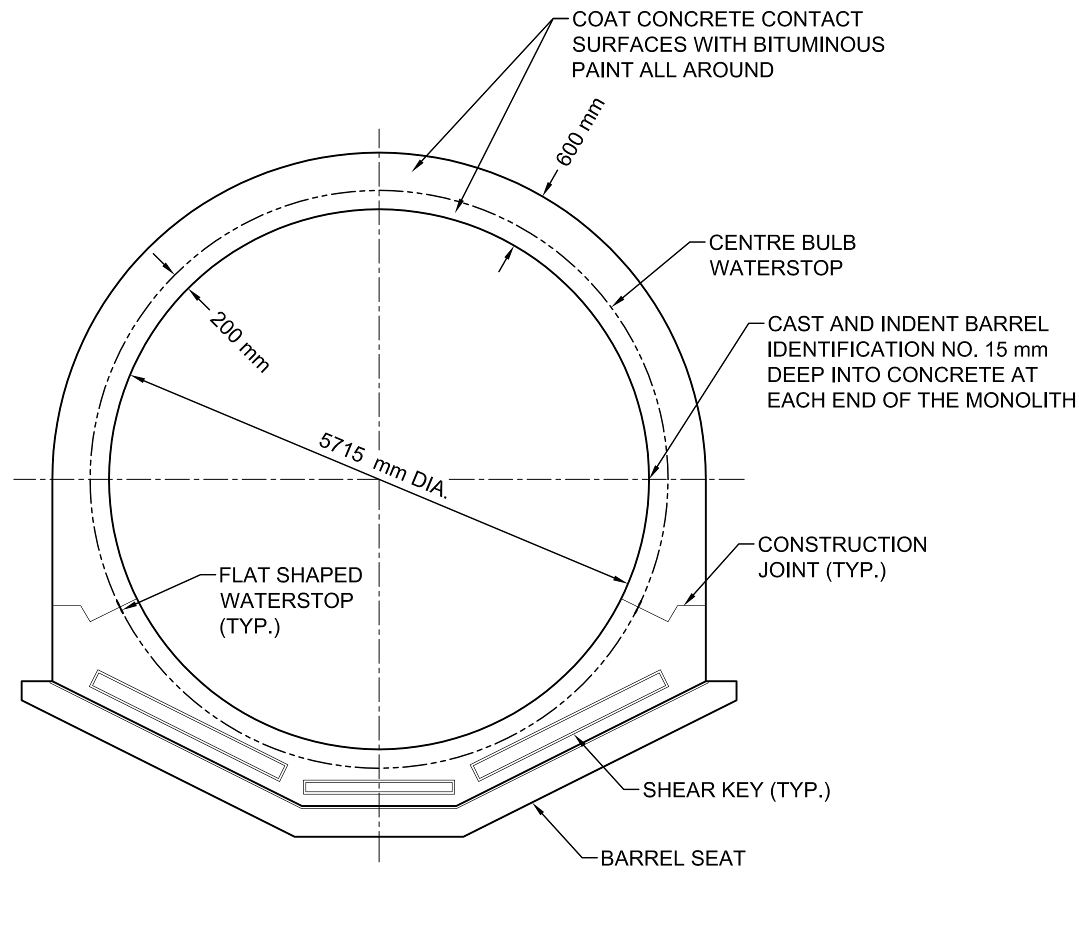
NOTE:

1. STATIONS, ELEVATIONS AND DIMENSIONS ARE IN METRES.

SOURCE: ALBERTA ENVIRONMENT, 1990.

ALBERTA TRANSPORTATION CIVIL PROJECTS BRANCH ALBERTA ENVIRONMENT WATER MANAGEMENT OPERATIONS	WATER CONTROL STRUCTURES - SELECTED DESIGN GUIDELINES **GENERAL ARRANGEMENT OF THE PINEPOUND COULEE SYPHON STRUCTURE** DATE: November 2004 · CAD FILE: 99008A17-1.dwg · FIGURE No.: 17-1

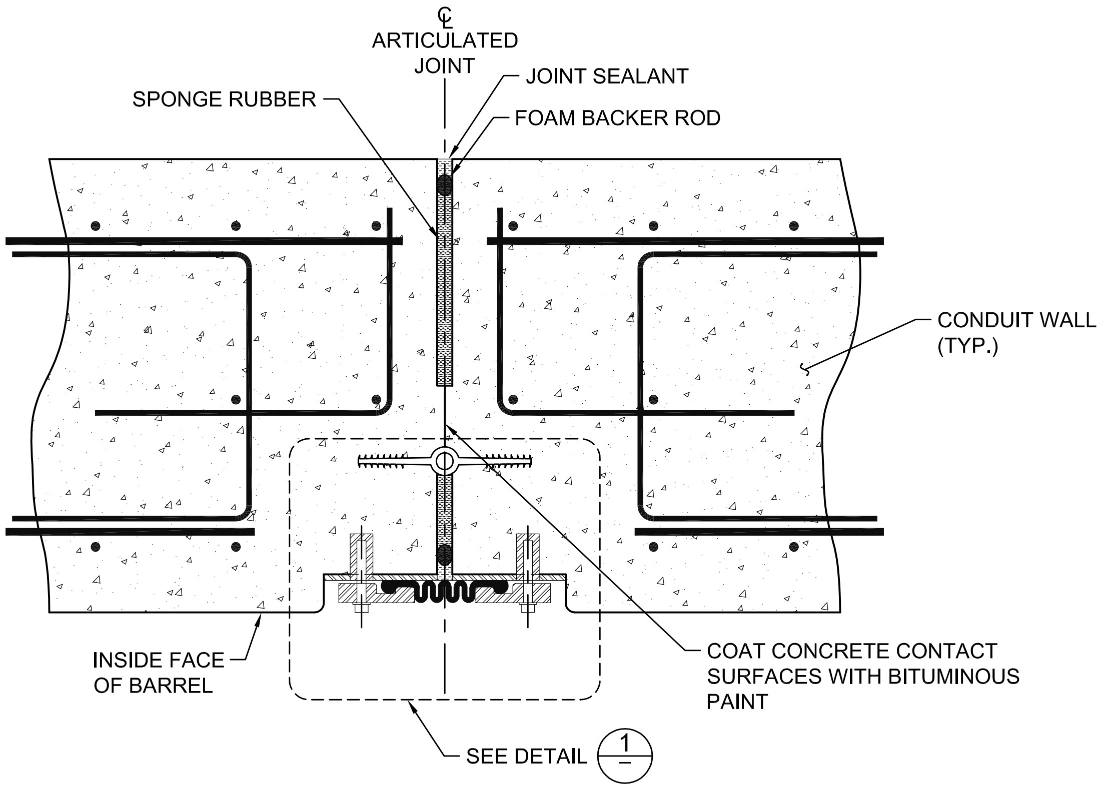




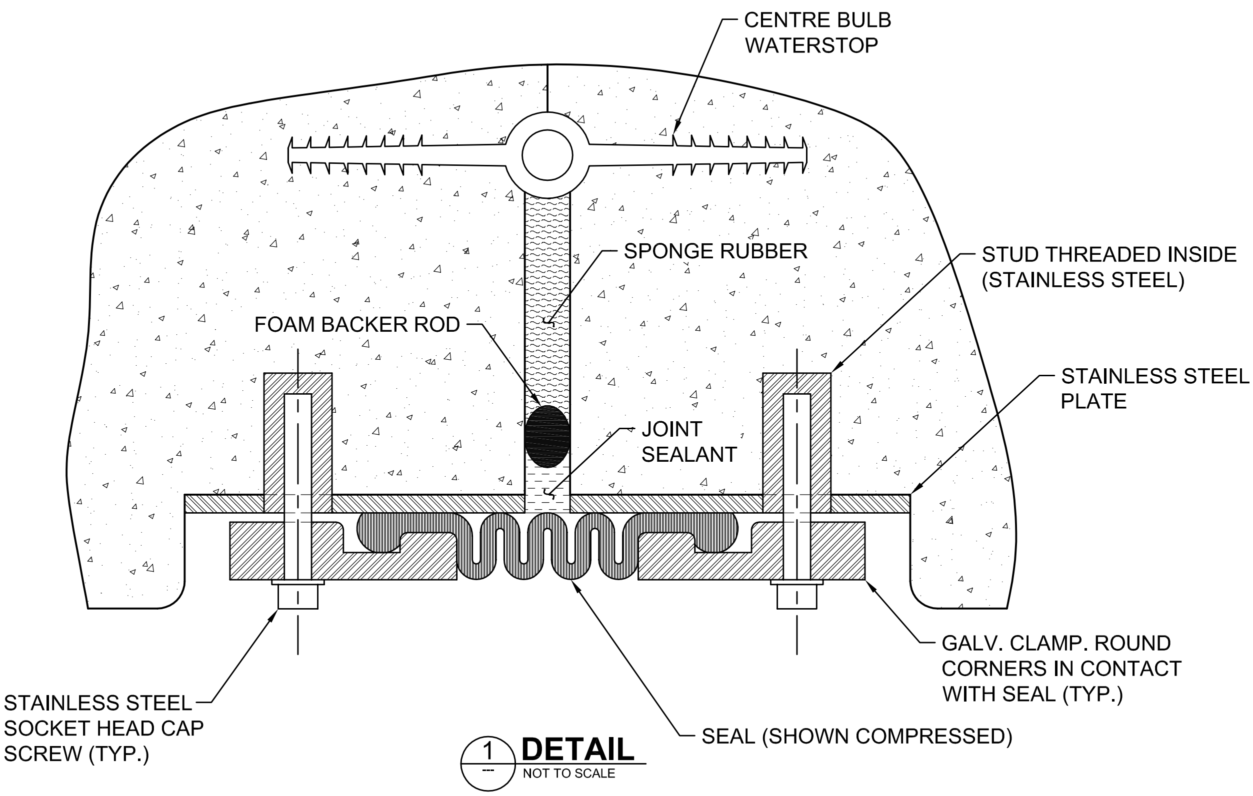
SOURCE: ALBERTA ENVIRONMENT, 1990.

ALBERTA TRANSPORTATION CIVIL PROJECTS BRANCH **ALBERTA ENVIRONMENT** WATER MANAGEMENT OPERATIONS	**WATER CONTROL STRUCTURES - SELECTED DESIGN GUIDELINES** **TYPICAL CONTRACTION JOINT FOR THE PINEPOUND COULEE SYPHON CONDUIT** DATE: November 2004 — CAD FILE: 99008A17-2.dwg — FIGURE No.: 17-2

17-2 Jan 07'2005 - 10:53am Jesse Llorca



CONCRETE CONDUIT - ARTICULATED JOINT DETAIL



1 **DETAIL**
NOT TO SCALE

SOURCE: ALBERTA ENVIRONMENT, 1990.

ALBERTA TRANSPORTATION CIVIL PROJECTS BRANCH **ALBERTA ENVIRONMENT** WATER MANAGEMENT OPERATIONS	**WATER CONTROL STRUCTURES - SELECTED DESIGN GUIDELINES** **ARTICULATED JOINT FOR THE PINEPOUND COULEE SYPHON CONDUIT** DATE: November 2004 / CAD FILE: 99008A17-3.dwg / FIGURE No.: 17-3

17-3 Jan 07 2005 - 10:53am Jesse Llorca

joint testing device. This test is used to verify that adjacent pipes have been properly joined and that the joint gasket is properly seated. Where steel bell and spigot joint rings are used, particular attention should be given to protecting the joint rings against corrosion (e.g. galvanizing, filling the joint gap with a rich mix of cement mortar, etc.) The resulting loss in joint flexibility and its ability to accommodate differential movements should be considered if cement mortar is used to infill the joint gap.

Once construction of the conduit has been completed, hydrostatic testing of the entire installation is normally performed to verify that the leakage rate does not exceed permissible values.

The conduit is normally buried to protect it against frost and other thermal effects and floatation. Where a natural drainage course crosses over the syphon conduit, riprap or other erosion protection is provided to protect it from scour.

17.3 Flume

In general, a flume is an open channel structure used to convey water over a depression (coulee) where conditions and costs favour it over a high embankment canal or a syphon.

A rectangular or semi-circular channel configuration is usually used for the flume. The flume is typically divided into a series of segments that are supported on piers. Watertight expansion joints are ordinarily provided between the segments to accommodate thermal expansion/contraction movements.

The flume may be constructed of steel or reinforced concrete. Where reinforced concrete is to be used, crack widths, particularly under Usual Conditions of loading, should be reviewed in order to minimize leakage as discussed in Section 9.1.1.

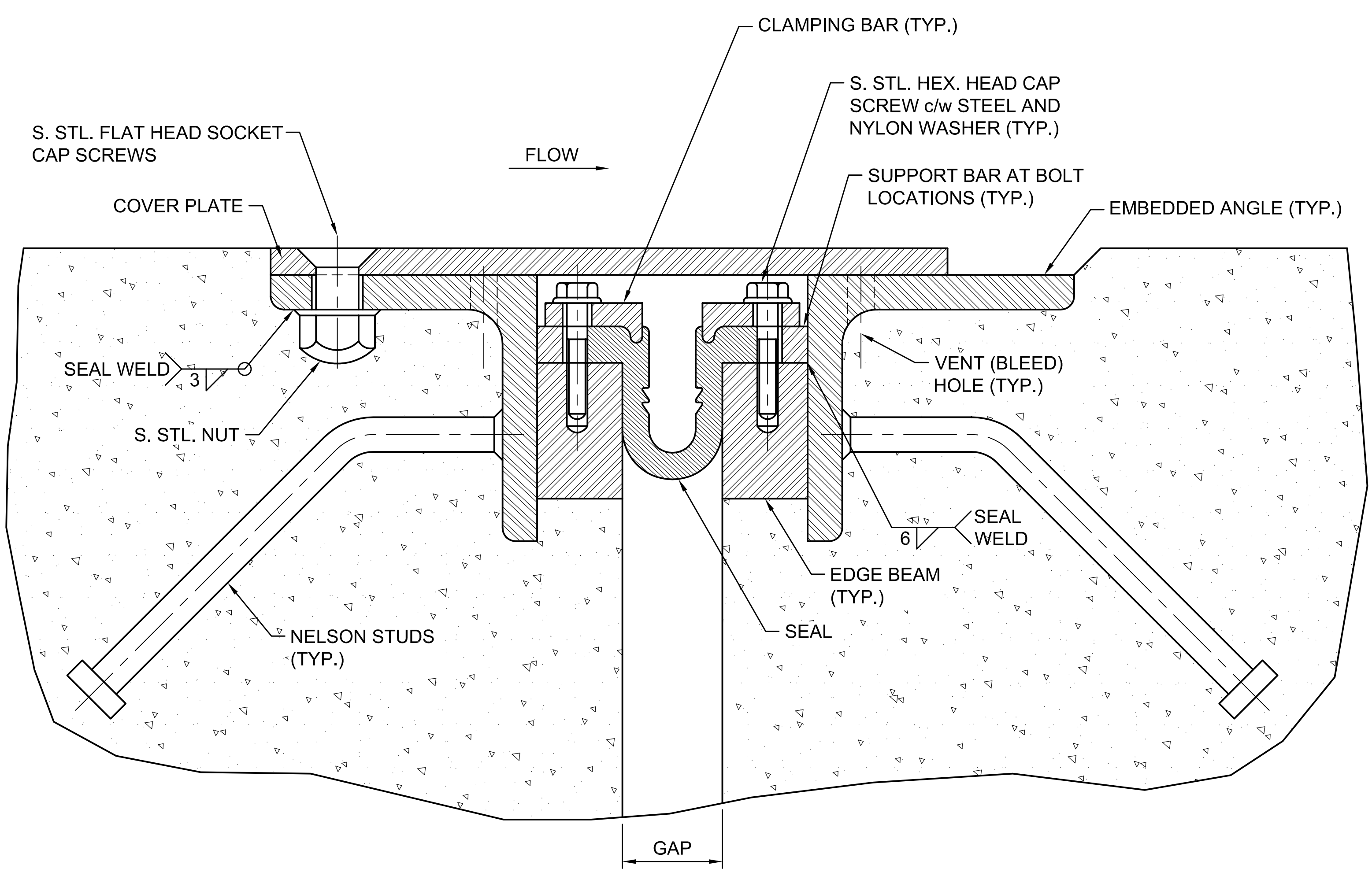
At the expansion joints, prefabricated joint systems, if required, may be used to provide a watertight seal. The advantage of this system is that the seal can be removed and replaced. An example of the system used on the Lethbridge Northern Irrigation District (LNID), Oldman River Flume is shown on Figure 17-4.

Neoprene and Teflon bridge-type bearing assemblies are typically incorporated at the supports to allow longitudinal movements to occur without inducing excessive stresses in the structure.

17.4 Check Structure

A check structure is used to raise the water level within a section of the main canal during periods when the flow is below its design discharge. The higher water level is required to provide adequate head to divert sufficient water at turnout structures.

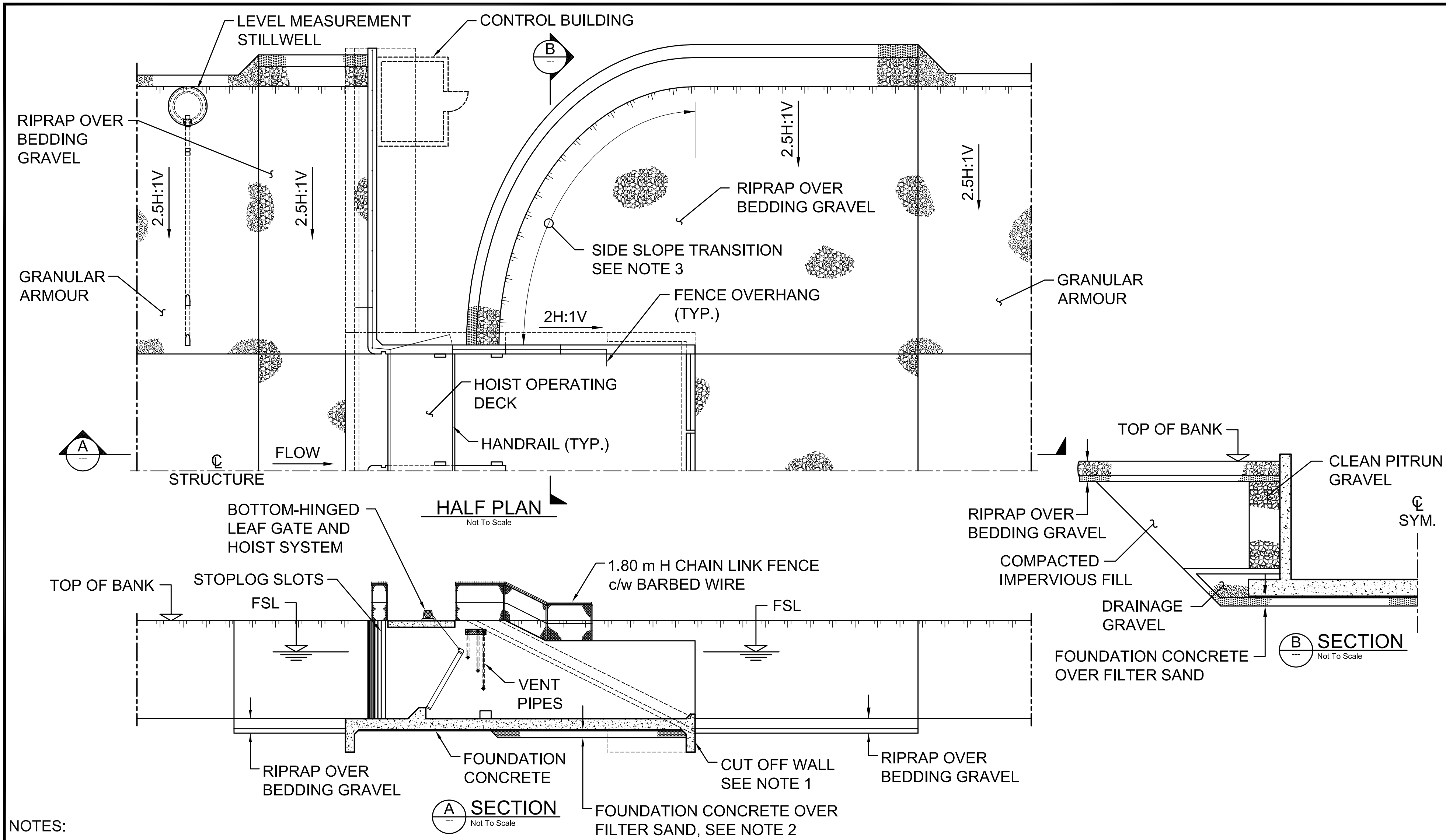
Overflow gates as described in Section 19.1.4, are typically provided for controlling water levels. A typical check structure equipped with bottom-hinged leaf gates is shown on Figure 17-5. For



SOURCE: ALBERTA ENVIRONMENT.

ALBERTA TRANSPORTATION CIVIL PROJECTS BRANCH ALBERTA ENVIRONMENT WATER MANAGEMENT OPERATIONS	WATER CONTROL STRUCTURES - SELECTED DESIGN GUIDELINES **L.N.I.D. FLUME EXPANSION JOINT WITH PREFABRICATED JOINT SEALING SYSTEM**

DATE:	CAD FILE:	FIGURE No.:
November 2004	99008A17-4.dwg	17-4



NOTES:

1. EXTEND THE CUTOFF WALL BACK SOME LENGTH ALONG THE HEEL OF THE WALL FOOTING WHERE TOE EROSION AND POTENTIAL UNDERCUTTING BENEATH THE SLAB IS A CONCERN.

2. EXTEND FILTER SAND OUT PAST SLAB AND PROPERLY TIE-IN WITH DRAINAGE MATERIALS ADJACENT TO THE WALLS AND THE RIPRAP BEDDING.

3. FOR BACKFILL IMMEDIATELY ADJACENT TO THE BASIN, A 2H:1V SLOPE IS USED TO AVOID HAVING TO INCREASE THE STRUCTURE LENGTH SOLELY TO ACCOMMODATE THE BACKFILL.

ALBERTA TRANSPORTATION CIVIL PROJECTS BRANCH **ALBERTA ENVIRONMENT** WATER MANAGEMENT OPERATIONS	**WATER CONTROL STRUCTURES - SELECTED DESIGN GUIDELINES** **TYPICAL CHECK STRUCTURE** DATE: November 2004 · CAD FILE: 99008A17-5.dwg · FIGURE No.: 17-5

installations where the overall length of the check structure is being governed by earthworks (i.e. top of bank widths, side slopes, etc.) and not hydraulic requirements, consideration may be given to incorporating downstream wingwalls, if found to be more cost effective. In cases where the structure is located at a change in the canal bed elevation, a combined check drop structure or a drop (vertical or chute) structure incorporating a fixed weir, as discussed in Sections 17.5 and 17.6, may be appropriate.

As part of the stability analyses, the sliding stability for the case of minimum discharge in the canal and the gates checked to provide FSL should be considered.

In general, the structure components should be designed for the governing loading combinations that may occur during construction, normal operation (gates fully down or checked, where applicable), flood, and rapid drawdown conditions (end of operating season). The invert of the basin should be set at the canal bed elevation so that it is drained when the canal is shutdown. As discussed in Section 17.5, the small unbalanced uplift pressures due to the plunging nappe, which occurs when the gate is raised high enough, are invariably less than the submerged weight of the structure basin.

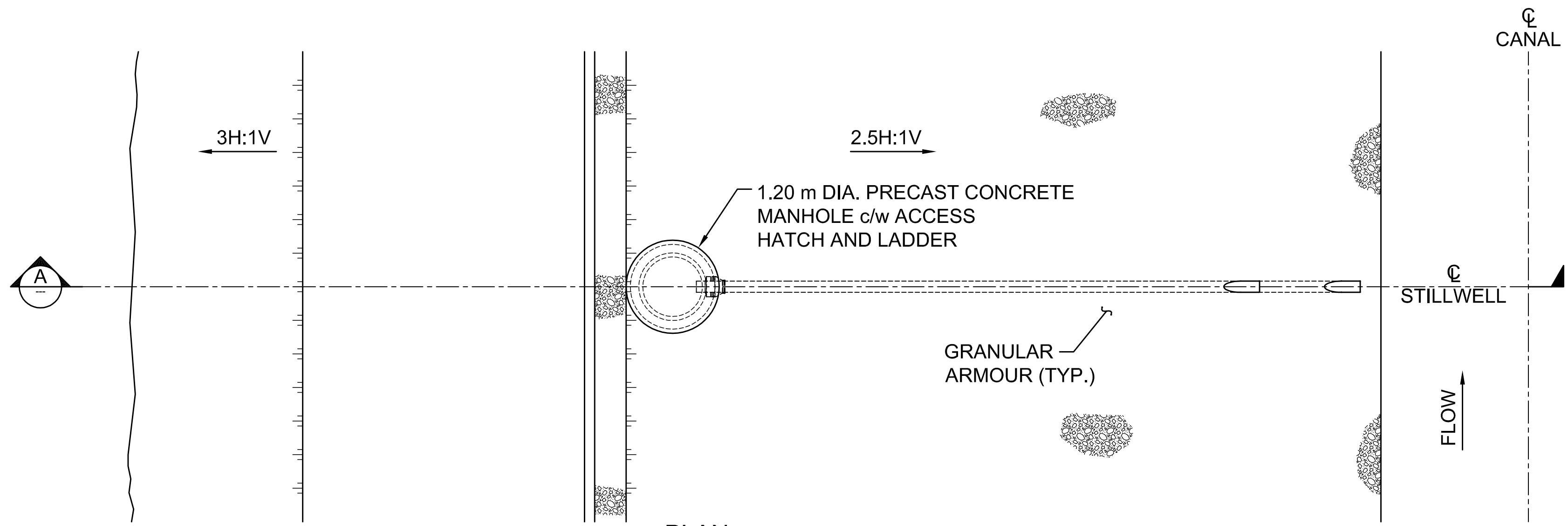
A stillwell is normally provided upstream of the check structure to measure the water level and establish the proper gate position. In situations where the tailwater would affect upstream water levels and flow measurements, two stillwells, one upstream and the second downstream of the check structure, may be needed. Details of a typical stillwell normally used in main canals are shown on Figure 17-6. The 1.2 m diameter stillwell provides room for installing equipment and for maintenance purposes. For a specific installation, guidelines for sizing the stillwell and inlet pipe is available from USBR (2001).

A control building, as discussed in Section 18.4.2 and shown on Figure 18-14, is usually provided to house the controls and electrical equipment.

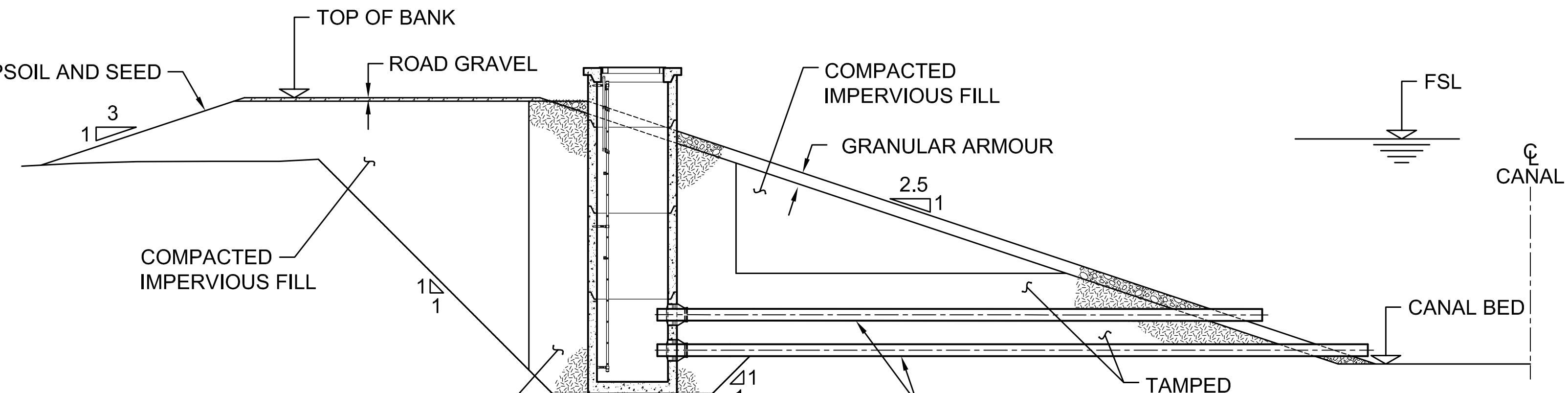
Downstream of the basin, riprap is normally provided as discussed in Section 12.7.1. However, the riprap may have to be extended further downstream to resist waves that may be formed during flow conditions which produce a supported jet.

17.5 Vertical Drop Structure

A vertical drop structure can be used to accommodate changes in the canal bed elevation. A typical vertical drop structure with an uncontrolled crest is shown on Figure 17-7. This type of structure is generally more economical than a chute drop structure particularly for drops of up to around 2.5 m, Smith (1995). For installations where the overall length of the drop structure is being governed by earthworks (i.e. top of bank widths, side slopes, etc.) and not hydraulic requirements, consideration may be given to incorporating downstream wingwalls, if found to be more cost effective. At locations where checking capabilities are also required, an overflow gate can be added to the crest as shown on Figure 17-8.

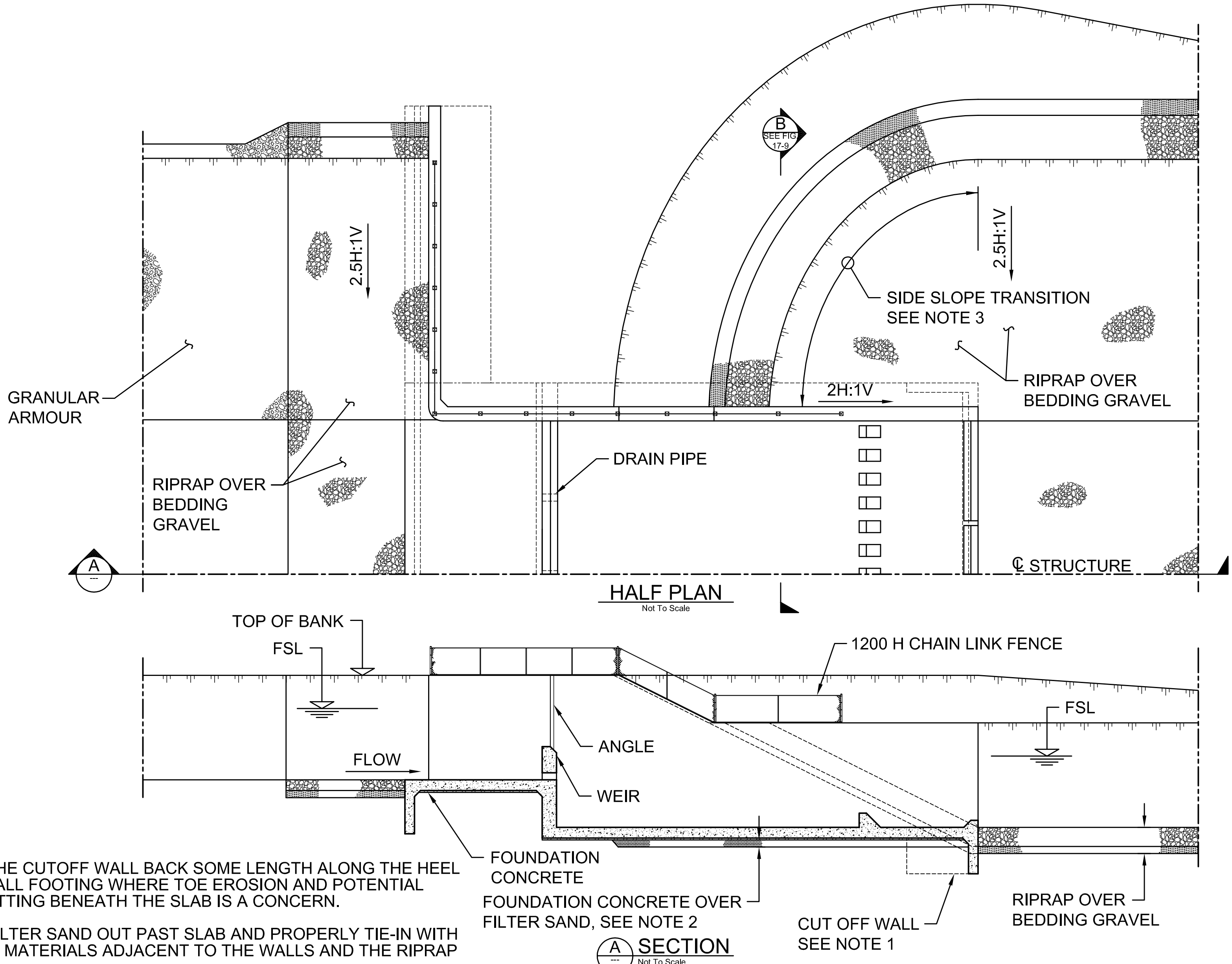


PLAN
Not To Scale



A SECTION
Not To Scale

ALBERTA TRANSPORTATION CIVIL PROJECTS BRANCH **ALBERTA ENVIRONMENT** WATER MANAGEMENT OPERATIONS	**WATER CONTROL STRUCTURES - SELECTED DESIGN GUIDELINES**		
	TYPICAL LEVEL MEASUREMENT STILLWELL		
	DATE: November 2004	CAD FILE: 99008A17-6.dwg	FIGURE No.: 17-6

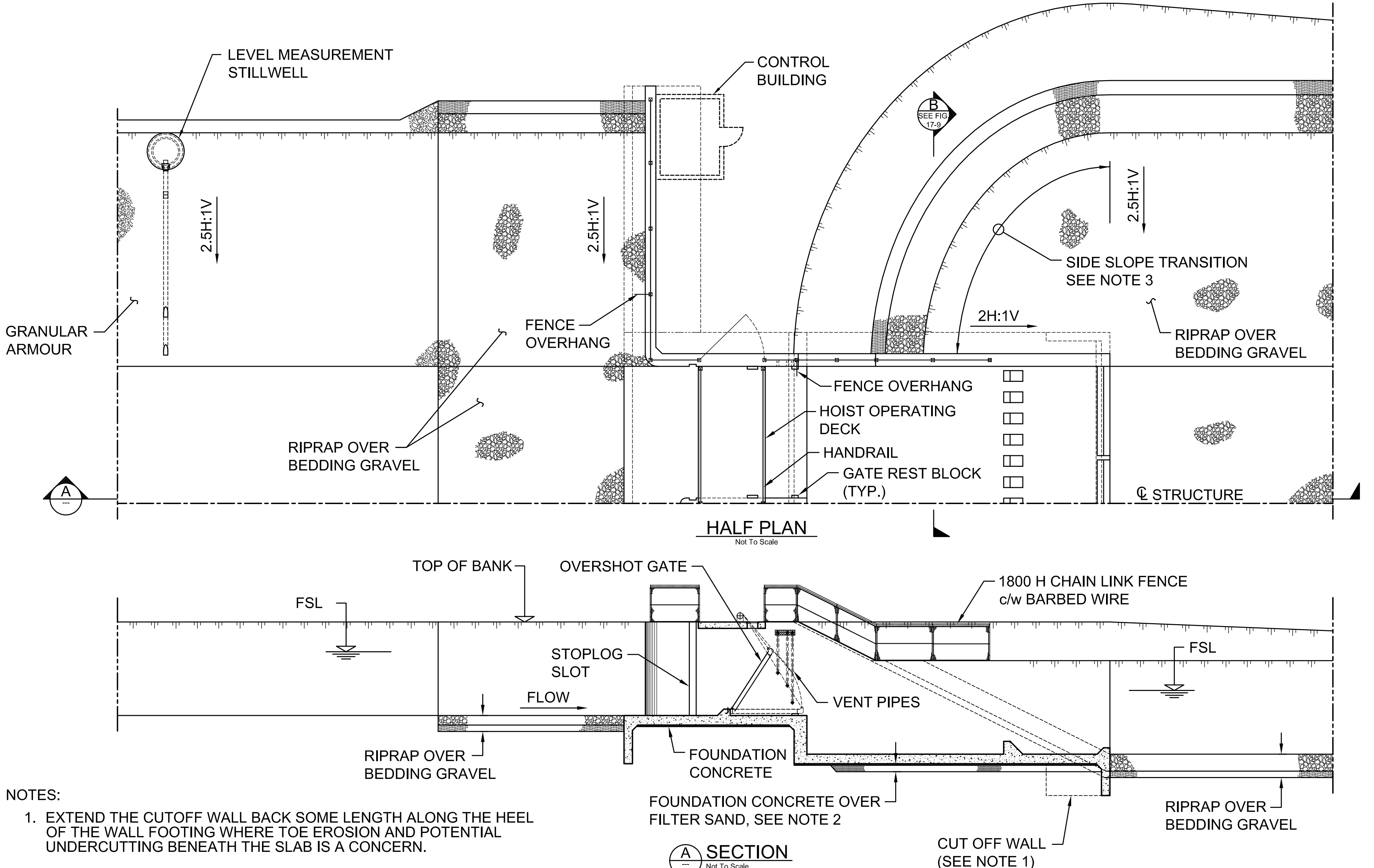


NOTES:

1. EXTEND THE CUTOFF WALL BACK SOME LENGTH ALONG THE HEEL OF THE WALL FOOTING WHERE TOE EROSION AND POTENTIAL UNDERCUTTING BENEATH THE SLAB IS A CONCERN.
2. EXTEND FILTER SAND OUT PAST SLAB AND PROPERLY TIE-IN WITH DRAINAGE MATERIALS ADJACENT TO THE WALLS AND THE RIPRAP BEDDING.
3. FOR BACKFILL IMMEDIATELY ADJACENT TO THE BASIN, A 2H:1V SLOPE IS USED TO AVOID HAVING TO INCREASE THE STRUCTURE LENGTH SOLELY TO ACCOMMODATE THE BACKFILL.
4. ALTHOUGH NOT PREFERRED, THE BASIN MAY HAVE TO BE SET BELOW THE CANAL BED ELEVATION FOR HYDRAULIC REASONS.

ALBERTA TRANSPORTATION CIVIL PROJECTS BRANCH **ALBERTA ENVIRONMENT** WATER MANAGEMENT OPERATIONS	**WATER CONTROL STRUCTURES - SELECTED DESIGN GUIDELINES** **TYPICAL VERTICAL DROP STRUCTURE** DATE: November 2004 / CAD FILE: 99008A17-7.dwg / FIGURE No.: 17-7

17-7 Jan 07'2005 - 10:55am Jesse Llorca



NOTES:

1. EXTEND THE CUTOFF WALL BACK SOME LENGTH ALONG THE HEEL OF THE WALL FOOTING WHERE TOE EROSION AND POTENTIAL UNDERCUTTING BENEATH THE SLAB IS A CONCERN.

2. EXTEND FILTER SAND OUT PAST SLAB AND PROPERLY TIE-IN WITH DRAINAGE MATERIALS ADJACENT TO THE WALLS AND THE RIPRAP BEDDING.

3. FOR BACKFILL IMMEDIATELY ADJACENT TO THE BASIN, A 2H:1V SLOPE IS USED TO AVOID HAVING TO INCREASE THE STRUCTURE LENGTH SOLELY TO ACCOMMODATE THE BACKFILL.

ALBERTA TRANSPORTATION
CIVIL PROJECTS BRANCH

ALBERTA ENVIRONMENT
WATER MANAGEMENT OPERATIONS

WATER CONTROL STRUCTURES - SELECTED DESIGN GUIDELINES

TYPICAL VERTICAL CHECK DROP STRUCTURE

DATE:	CAD FILE:	FIGURE No.:
November 2004	99008A17-8.dwg	17-8

As part of the stability analyses, the sliding stability for at least the following cases should be considered:

- Headwater level and tailwater level based on the canal operating at its design discharge.

- Headwater level at the crest elevation and no tailwater.

- Headwater level and tailwater level based on the canal operating at its design discharge plus the design flood.

In general, the structure components should be designed for the governing loading combinations that may occur during construction, normal operating, flood, and rapid drawdown conditions (end of operating season). Whenever possible, the invert of the basin should be set at the canal bed elevation so that it is drained when the canal is shutdown. Due to the relatively small drop and the energy loss that occurs within the basin, the nappe will be submerged by tailwater. Furthermore, the depth of the nappe roller which forms under the nappe (i.e. upstream side) is always greater than the depth on the downstream side. The combined effect of the deep nappe roller, downward jet impact, and tailwater submergence normally means that the unbalanced uplift force will be small and likely less than the submerged weight of the structure basin.

Downstream of the basin, riprap is normally provided as discussed in Section 12.7.1.

17.6 Chute Drop Structure

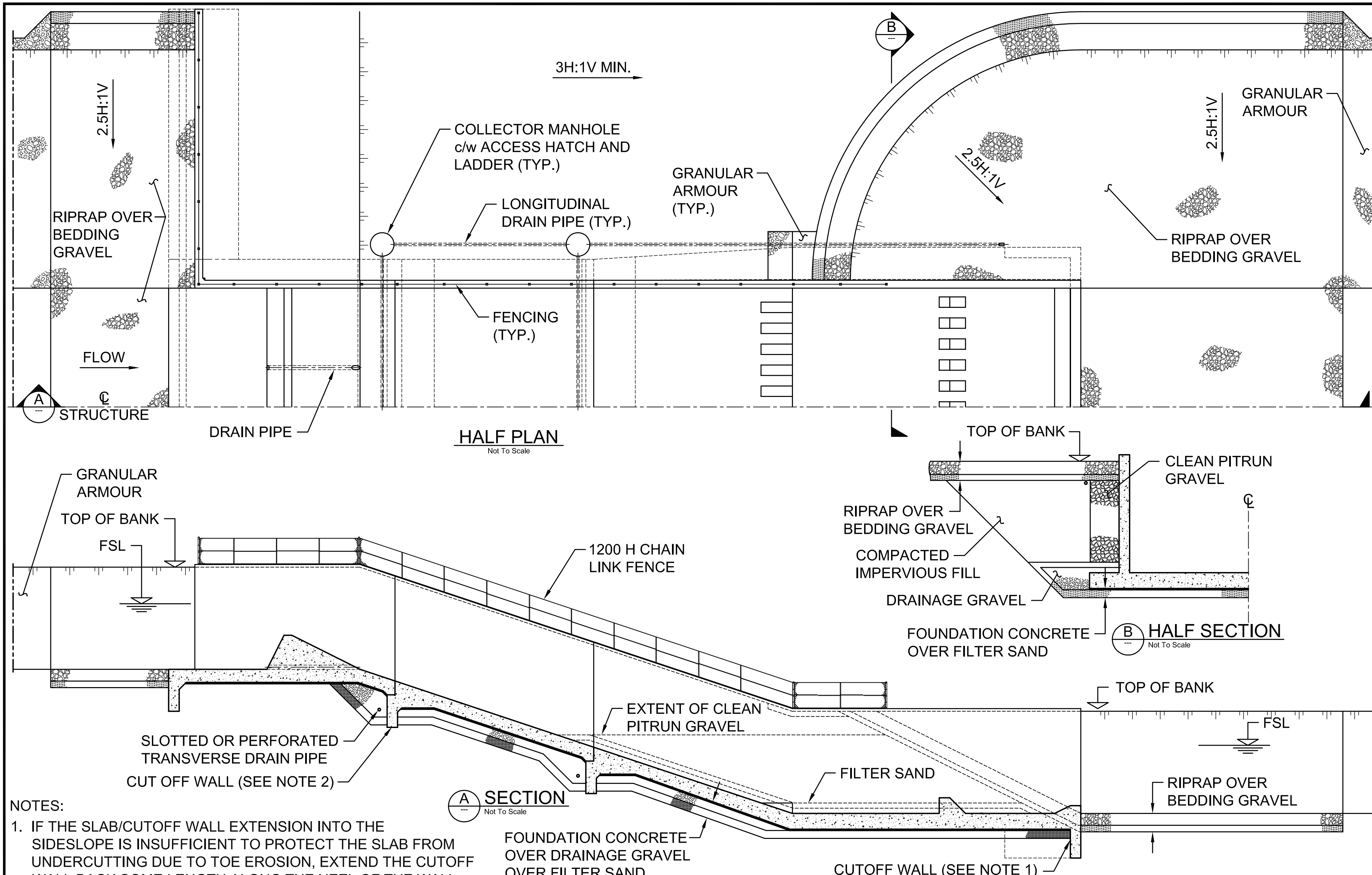
A chute drop structure is usually used to accommodate large changes in the canal bed elevation. It is also commonly used as a reservoir inlet or a wasteway structure.

The chute drop structure generally consists of a weir crest section, a sloping chute section, and a hydraulic jump stilling basin.

In general, ogee, trapezoidal or vertical weirs have been employed. The trapezoidal weir is commonly used instead of an ogee weir because it is much easier to form, and provides similar hydraulic characteristics. The vertical weir results in a much shorter crest section; however, the adverse effects of a plunging nappe on the performance of the stilling basin, particularly for a short structure, should be considered.

It is preferred that the sloped chute section not be steeper than 3H:1V. A typical chute drop structure with an uncontrolled crest is shown on Figure 17-9. At locations where checking capabilities are also required, overflow gates can be added to the crest.

Transverse contraction joints are usually incorporated to provide some differential movement capability between the components, and to reduce cracking due to thermal and shrinkage effects. Additional joints may be required along the sloping chute section depending on its length.



NOTES:

1. IF THE SLAB/CUTOFF WALL EXTENSION INTO THE SIDESLOPE IS INSUFFICIENT TO PROTECT THE SLAB FROM UNDERCUTTING DUE TO TOE EROSION, EXTEND THE CUTOFF WALL BACK SOME LENGTH ALONG THE HEEL OF THE WALL FOOTING.
2. AT THE MANHOLES, DESIGN THE BACKFILL DETAILS TO INCLUDE AN IMPERVIOUS BLOCK SO THAT WATER DOES NOT NORMALLY FLOW AROUND THE MANHOLES, BUT IS FORCED INTO THE DRAIN.

ALBERTA TRANSPORTATION
CIVIL PROJECTS BRANCH

ALBERTA ENVIRONMENT
WATER MANAGEMENT OPERATIONS

WATER CONTROL STRUCTURES - SELECTED DESIGN GUIDELINES

TYPICAL CHUTE DROP STRUCTURE (UNCONTROLLED CREST)

DATE:	CAD FILE:	FIGURE No.:
November 2004	99008A17-9.dwg	17-9

As part of the structure stability analyses, the sliding stability of the weir crest section with the canal operating at its design discharge and bank full discharge should be considered. Adequate factor of safety against a deep-seated foundation failure should also be provided.

In general, the structure components should be designed for the governing loading combinations that may occur during construction, normal operating, flood, and rapid drawdown conditions (end of operating season).

The design of the hydraulic jump stilling basin, including erosion protection requirements, is described in Section 12.7.1.

Wall overtopping at the start of the basin (i.e. at the chute blocks) by splash and spray that leads to bank erosion has been a common problem particularly for main canal chute drop structures, which operate on a continuous basis during the irrigation season. As a result, the provision of greater freeboard or erosion protection on the backfilled slope adjacent the walls at this location should be considered. Whenever possible, the invert of the basin should be set at the canal bed elevation so that it is drained when the canal is shutdown.

For reservoir inlet chutes, the sloping chute is normally extended and designed to accommodate the hydraulic jump, which could occur at various locations on the slope (due to fluctuations in the reservoir water level), rather than providing a horizontal hydraulic jump stilling basin. Extending the chute generally results in a simpler design and shorter overall structure length; however, the elevation at the downstream end of the structure will be lower.

17.7 Pipe Drop Structure

A pipe drop structure may be used to accommodate changes in elevation for smaller discharges. Structure components typically consist of an intake structure, conduit, and terminal structure. An impact basin is generally used for energy dissipation.

The design should also consider the potential for blockage to occur and the need to provide emergency overflow provisions at a suitable location upstream of the structure.

17.8 Baffled Chute Drop Structure

Baffled chute drop structures, as discussed in Section 13.7.4, have been employed at locations where reliable tailwater conditions did not exist. It has been found that these structures tend to trap debris and weeds, which results in a high degree of maintenance. Consequently, they should not be used in situations where significant amounts of debris and weeds occur.