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17 August 2006

Mr. Pieter Bekker
Deputy Comptroller of Water Rights
Ministry of Environment
PO Box 9340 Stn Prov Govt
Victoria, BC V8W 9M1

Re: Clayton Falls Project Water Use Plan
Construction Completion Report: Water Release and Measurement Device

In your letter approving the Clayton Falls Project Water Use Plan physical work terms of reference, dated 8 December 2005, BC Hydro was requested to submit the Clayton Falls Water Release and Measurement Device Construction Completion Report.

Please find enclosed the Clayton Falls Water Release and Measurement Device Construction Completion Report.

Should you have any questions please do not hesitate to contact me.

Regards,

Sue Foster

Enclosures (1)

CC Ian Dodd, BC Hydro
Brent Mossop, BC Hydro
Stephen Watson, BC Hydro
Ted Down, MOE
Ed Woo, DFO

Clayton Falls Project Water Use Plan

Construction Completion Report:

- **Water Release and Measurement Device**

July 2006

COMPLETION REPORT

Date: 13 July 2006
File: CGR06MTC CLA01

CLAYTON FALLS WATER USE PLAN PHYSICAL WORKS: WATER RELEASE AND MEASUREMENT DEVICE

1.0 PROJECT INFORMATION

Project name:	CGR06MTC CLA01	Initiator:	Ian Dodd
Project Title:	Clayton Falls Minimum Flow Discharge Device	Project Sponsor:	Graeme Matthews
Project Phase:	Implementation	Project Manager:	Kathy Groves
Authorization:	Request for Service: CGR06MTC CLA01	Originating Organization:	Generation

1.1 Project Team

Environmental	Ian Dodd
Structural Design	Cory Barker, Engineer-In-Training
Structural Design Review	R. Carter, P.Eng
Hydraulic Design	Kathy Groves, P.Eng
Hydraulic Design Review	D. Sakamoto, P.Eng
Clayton Falls Site Contact	Brant Underhill

2.0 PROJECT OBJECTIVES

2.1 Project Background

The Consultative Committee (CC) for the Clayton Falls Water Use Plan (WUP) expressed concern that the lack of a guaranteed base flow in the mainstem channel between Clayton Falls and the confluence of the tailrace channel might impact the over-winter survival of fish and their invertebrate prey. To address this concern, the CC recommended that the WUP include a 0.05 cms minimum continuous flow release from the Clayton Falls Dam. The 0.05 cms release will be provided via an engineered structure which will be designed to ensure passage of the minimum flow requirement.

2.2 Scope Objectives

Design, fabrication and installation of a water release/measurement device to be installed in Clayton Falls Dam in order to ensure a minimum flow of 0.05 cms from the dam.

3.0 DESIGN

The selected design for the water release/measurement device was a pipe inserted through the flashboards of the dam. The design basis for the selected device and review of other options considered are described in the following memo:

Title	Report No.	Date
Clayton Falls Minimum Flow Discharge Pipe – Design Basis Interoffice Memo: K. Groves to Ian Dodd	BC Hydro Engineering File: CGR06MTC CLA01	15 February 2006

4.0 IMPLEMENTATION

Design completion	February 2005
Fabrication and delivery to site completed	3 March 2005
Installation completed	8 March 2005

The installed works are a relatively simple device. Actual installation is in accordance with the design sketches provided in the Design Basis memo. The issue of as-built drawings is not considered to be required.

5.0 OPERATION AND MAINTENANCE

Operation

Flow through the device is uncontrolled and dependent on reservoir level. The device has been designed to deliver the required minimum flow under normal operating conditions. A discharge rating curve for the device is included in Figure 1.

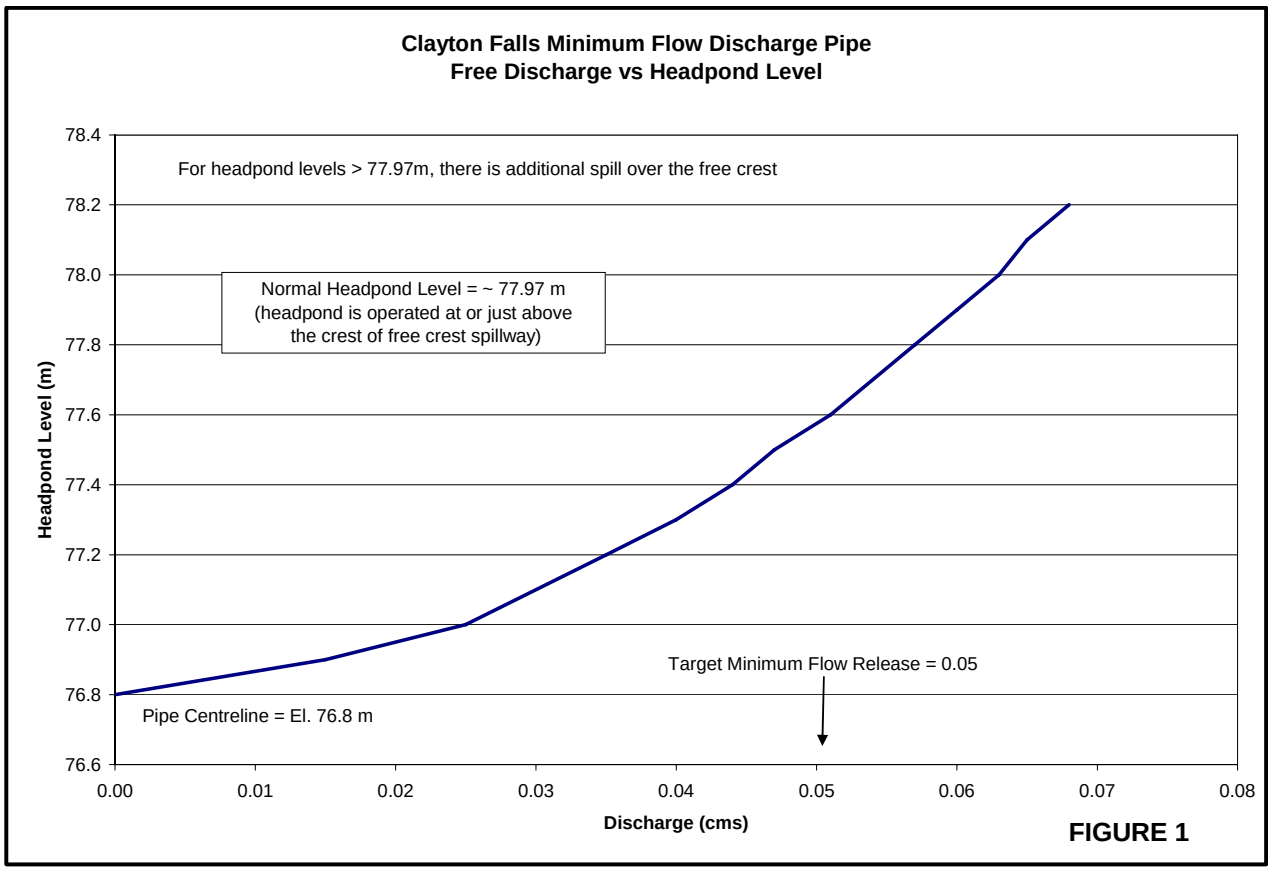


FIGURE 1

Note that during the annual maintenance period, the reservoir is drawn down below the crest of the spillway and the minimum flow release pipe will be dewatered. However, during this period of time the sluice gate is opened to pass the project inflow while the unit is out of service thus sustaining the minimum flow to the downstream channel. At the end of the maintenance period when the sluice gate is closed to allow the headpond to refill, there will be a short period of time (15 – 30 minutes) when there will be no minimum

flow release until the headpond fills to the elevation of the flow release pipe. This exception was noted in the Terms of Reference[1] submitted to the Water Comptroller and was considered to be acceptable variance.

Maintenance Considerations:
Little to no maintenance will be required. Based on discussions with site staff, this location experiences the least frequency of flashboard breakage and is an accessible location for periodic removal of debris from the pipe inlet if required.

6.0 RECOMMENDATIONS

- The design of the minimum flow device would have to be revisited prior to implementing changes to the current practice of maintaining the headpond at levels near the top of the flashboards.
- Based on discussions with site staff, passing the pipe under the walkway and allowing the free discharge to jet into the downstream channel is considered not to introduce any safety concerns for plant operators re: ice, spray, other. This assumption should be revisited after one winter of operation and modifications implemented if required.

7.0 FINANCIAL CLOSURE

Approved funds: $8,200

Actuals: $8,200

Project closed 24 March 2006

8.0 PROJECT COMPLETION

Clayton Falls Water Use Plan Physical Works: Water Release and Measurement Device has been successfully completed in accordance with the Project Management Procedures of BC Hydro and of Engineering Services.

Project Submitted by:	K. Graves Kathy Groves, BC Hydro Engineering	20 JUL 06 Date
Project Accepted by:	I. Dodd Ian Dodd, Initiator/Client, Organization	11 aug 06 Date

[1] Clayton Falls Project Water Use Plan, Physical Works Terms of Reference, Claworks #1, Water Release Measurement Device, 28 October 2006, prepared by Ian Dodd, BC Hydro.

Inter-office memo

TO:	Ian Dodd Brant Underhill	**DATE:**	15 February 2006
FROM:	Kathy Groves	**FILE:**	CGR06MTC CLA01
SUBJECT:	**Clayton Falls Minimum Flow Discharge Pipe Design Basis**		

Project Description

The Clayton Falls hydroelectric project is part of BC Hydro's Non-Integrated Electric System, which serves remote areas of British Columbia not connected to the provincial power grid. The facility is located about 4 km west of Bella Coola and is controlled remotely from Ah-Sin-Heek Diesel Generating Station.

The Clayton Falls hydroelectric project comprises:
- Clayton Falls Dam;
- Clayton Falls Headpond; and
- Clayton Falls Generating Station (GS), including its various appurtenances.

The Clayton Falls Project diverts water from the 93 km² drainage area above the dam through a 580 m long penstock to the Clayton Falls Powerhouse which is located approximately 100 m upstream from the creek mouth. Clayton Falls Dam is a concrete gravity dam with a total length of 41 m and a maximum height of 7 m above its foundation. Clayton Falls Dam impounds a small headpond, which has negligible storage capacity – 2500 m^3 at the normal maximum headpond level. Thus the project operates as a run-of-river facility year round passing daily inflows through the turbine and/or over the dam with little to no regulation of the total inflow pattern observed downstream of the plant.

Discharge facilities at Clayton Falls Dam include:
- Sluiceway (1 gate) – sill elevation 73.85 m, maximum discharge capacity of 12cms at headpond elevation 77.97m. Under current operations, the sluiceway is only used when the headpond is drawn down for inspections or other maintenance procedures and otherwise normally remains closed.
- Free Overflow Spillway – 30.1m long, concrete crest elevation at 76.465 m with removable flashboards which increase the crest elevation to 77.97m. Under current operations, the flashboards are left in place year round.
- Power Intake – single power intake with centreline at elevation 75.08 m.

Current Operation

Normal operating levels for Clayton Falls headpond are between 77.97 m (top of flashboards) and 76.4 m (generation curtailed). During the period from April through November, daily inflows to the Clayton Falls headpond typically exceed the maximum discharge capability of the turbines. Under these conditions, both units operate at near maximum load with hourly output varying within the day in accordance with demand. Spill occurs almost continually and fluctuates naturally in response to runoff conditions. For the remainder of the year (December – March), daily inflows fluctuate in response to changing climate conditions but are frequently less than the maximum turbine discharge capability.

On low inflow days, generation is adjusted such that turbine discharge does not exceed the real time project inflow and the headpond level is maintained at the top of the spillway flashboards or

just above the flashboard crest. Plant operators prefer to implement a small, voluntary spill over the top of the spillway flashboards to utilize the natural flow ramping effect provided by use of the overflow spillway in order to provide additional response time to changes in hourly inflow. Thus even during these low inflow periods there is typically a spill of ~ 0.8 cms or more going over the flashboards as the headpond controller maintains the headpond level just above the top of the flashboards.

However, there are occasional short periods of time (i.e. a total of 50 hours recorded in 2002) when the headpond level may drop to just below the crest of the flashboards. As a result, flows to Reach 2 can be limited to the minimal leakage from the dam and any local inflows (estimated at approximately 0.05 cms).

Minimum Flow Requirements

During the recent Clayton Falls Water Use Planning process, the Consultative Committee (CC) expressed concern that the lack of a guaranteed base flow in the mainstem channel between Clayton Falls and the confluence of the tailrace channel might impact the over-winter survival of fish and their invertebrate prey.

To address this concern, the CC recommended that the WUP include a 0.05 cms minimum continuous flow release from the Clayton Falls Dam. The 0.05 cms release will be provided via an engineered structure which will be designed to ensure passage of the minimum flow requirement.

Options reviewed

Several options were considered for delivery of the 0.05cms minimum flow release.

a) Small opening of the sluice gate
   This could be a feasible and simple method of delivering the minimum flow and could deliver flow under all envisioned operating conditions. However, the Clayton Falls headpond accumulates significant deposits of bedload to the extent that it is typically dredged each year to remove the material. There were concerns that the gate opening could become partially blocked with debris over the course of the year. In addition, it would be difficult to verify the delivery of the minimum flow.
b) Wedging open a small gap between two of the spillway flashboards
   The flashboards are approximately 1.9 m long and wedging open a small gap between two of the flashboards could be a simple means of providing the flow release. However, there were concerns that the very small gap required to deliver a 0.05cms flow may be prone to clogging with the leaf litter and other debris that are commonly present in the forebay area. In addition, it would be difficult to prepare an accurate rating curve for such an opening and it would also be difficult to verify the delivery of the minimum flow.
c) Pipe inserted through the spillway flashboards
   A properly sized pipe inserted through the flashboards can deliver the 0.05 cms flow. The device is relatively inexpensive to fabricate, easy to install, and will require little to no maintenance or calibration. An accurate rating curve can be developed for the pipe flow and it would be easy to visually confirm the delivery of the minimum flow.

Selected Option

The selected design for the water release/measurement device will consist of a pipe inserted through the lower flashboards along the spillway.

Note that during the annual maintenance period, the reservoir is drawn down below the crest of the spillway and the minimum flow release pipe will be dewatered. However, during this period of time the sluice gate is opened to pass the project inflow while the unit is out of service thus sustaining the minimum flow to the downstream channel. At the end of the maintenance period when the

sluice gate is closed to allow the headpond to refill, there will be a short period of time (15 – 30 minutes) when there will be no minimum flow release until the headpond fills to the elevation of the flow release pipe. This exception was noted in the Terms of Reference[1] submitted to the Water Comptroller and was considered to be acceptable variance.

Design Details

General description: As per sketches 1 and 2 attached.

- Straight length of pipe
- Centred on the connection between the two lowest flashboards
- Passing through the flashboards and under the walkway on the downstream side of the flashboards.
- Installed in the fourth flashboard section nearest the sluiceway.

Hydraulics

Pipe length = 2.2 m (or shorter would also be acceptable)
Inlet elevation = centerline 76.77 m (or lower would also be acceptable)
Available Head = (77.97m – 76.77 m) = 1.20 m
Inlet loss coefficient = 0.8 (pipe protrudes into approaching flow)
Friction factor = 0.02 (Galvanized steel pipe)
Exit Loss coefficient = 1.0 (free flow)
Minimum Diameter required to deliver 0.05 cms = 0.14 m
Recommended diameter = 0.154 m (standard pipe size)

Debris screen: not required
Based on discussions with site staff, it was considered that the majority of the debris material capable of entering the pipe would pass right through. A debris basket would be more likely to accumulate leaf litter and block the entrance.

Control valve: not required
During the period from April through November spill over the top of the entire spillway flashboard section would negate the benefits of any control valve. During periods of lower flow, the headpond can be drawn down if dewatering of the pipe is required.

Structural

As per sketches attached

SK1 = Flashboard assembly
SK2 = Downstream support details

Safety Considerations:
Based on discussions with site staff, passing the pipe under the walkway and allowing the free discharge to jet into the downstream channel is considered not to introduce any safety concerns for plant operators re: ice, spray, other.

Maintenance Considerations:
Little to no maintenance will be required. Based on discussions with site staff, this location experiences the least frequency of flashboard breakage and is an accessible location for periodic removal of debris from the pipe inlet if required.

[1] Clayton Falls Project Water Use Plan, Physical Works Terms of Reference, Claworks #1, Water Release Measurement Device, 28 October 2006, prepared by Ian Dodd, BC Hydro.

Recommendations

The design of the minimum flow device would have to be revisited prior to implementing changes to the current practice of maintaining the headpond at levels near the top of the flashboards.

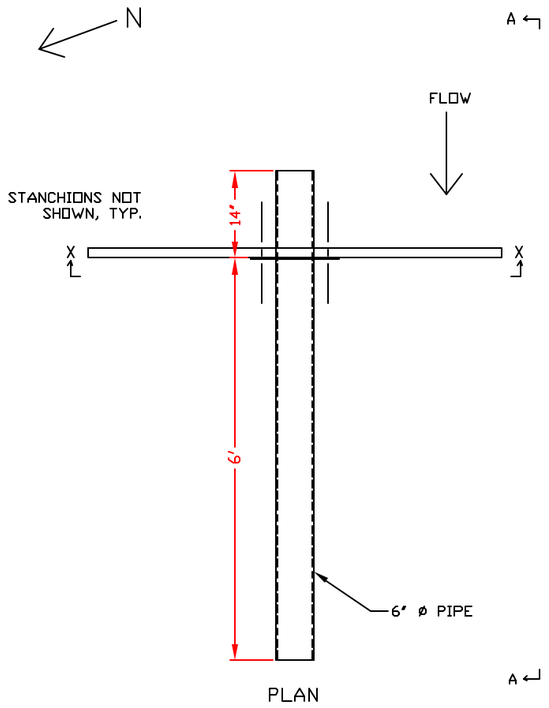
Structural design = Cory Barker, EIT; reviewed by R. Carter, P. Eng.
Hydraulic design = Kathy Groves, P. Eng, reviewed by D. Sakamoto, P. Eng.

K. Groves

Prepared by: K. Groves

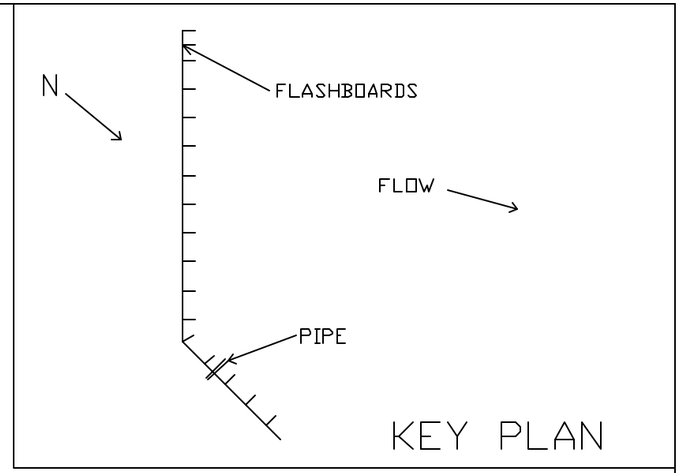
Attachments

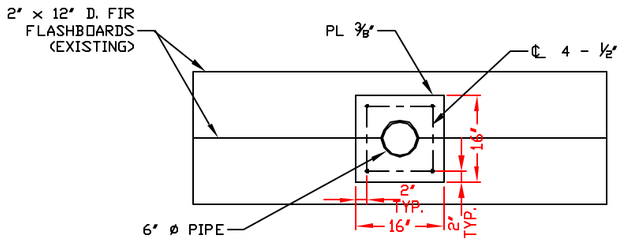
c:
Cory Barker
Rod Carter
Derek Sakamoto



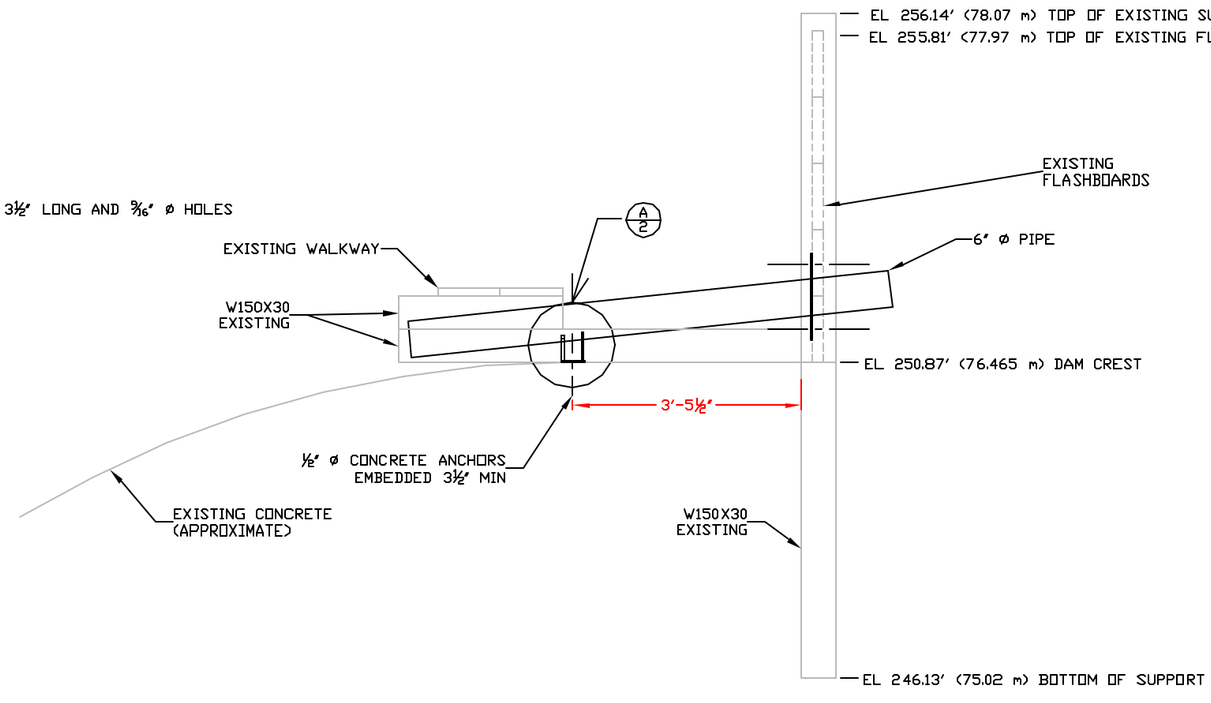
GENERAL NOTES:

1. THE DESIGN IS BASED ON THE WATER LEVEL TO THE TOP OF THE FLASHBOARDS.
2. THE DESIGN, FABRICATION AND ERECTION OF METALWORK SHALL BE IN ACCORDANCE WITH THE REQUIREMENTS OF CAN/CSA-S16.1.
3. ALL METALWORK SHALL BE HOT DIP GALVANIZED IN ACCORDANCE WITH CAN/CSA G164-M.
4. ALL BOLTS, NUTS AND WASHERS SHALL CONFORM TO ASTM A307, GRADE 60ksi (414 MPa).
5. METALWORK SHALL CONFORM TO CAN/CSA G40.21-M GR 44 ksi (300W) FOR PLATES.
6. STEEL PIPE SHALL CONFORM TO ASTM A53, GRADE B-35ksi (241 MPa).
7. ALL ASPECTS OF WELDING SHALL BE COMPLETED IN ACCORDANCE WITH CSA W59-M.
8. CONCRETE ANCHORS SHALL BE HILTI KWIK BOLT 3 ANCHORS.





SECTION X-X

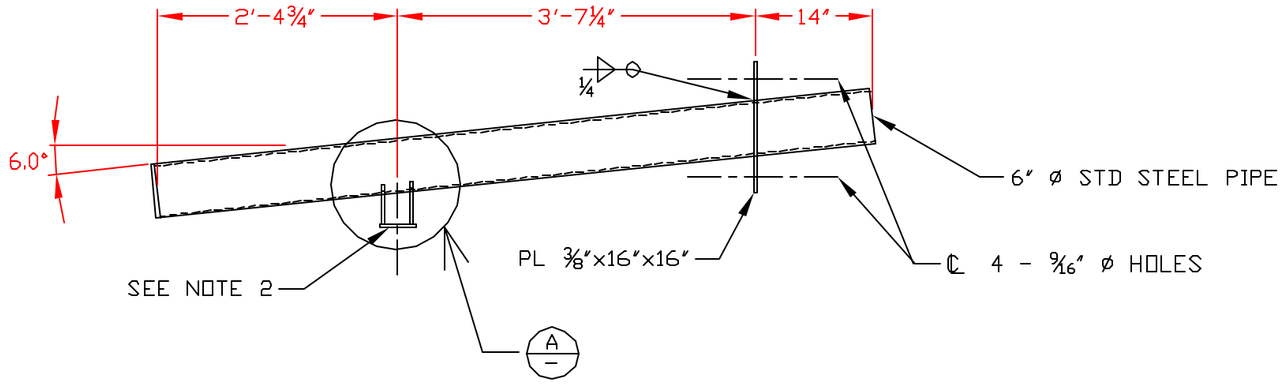


ELEVATION A-A

CLAYTON FALLS

SK 1 - FLASHBOARD ASSEMBLY

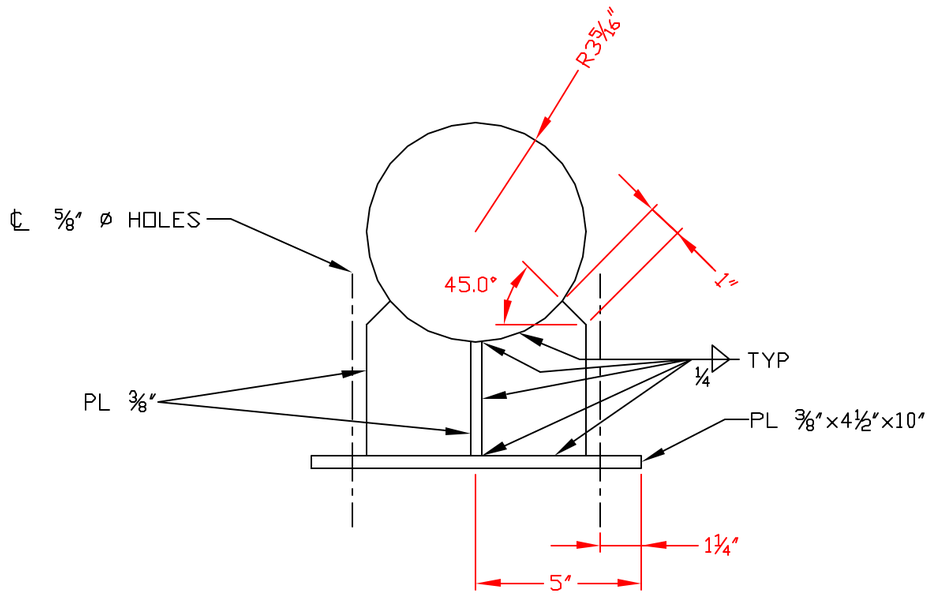
DATE: 25 JANUARY 2006



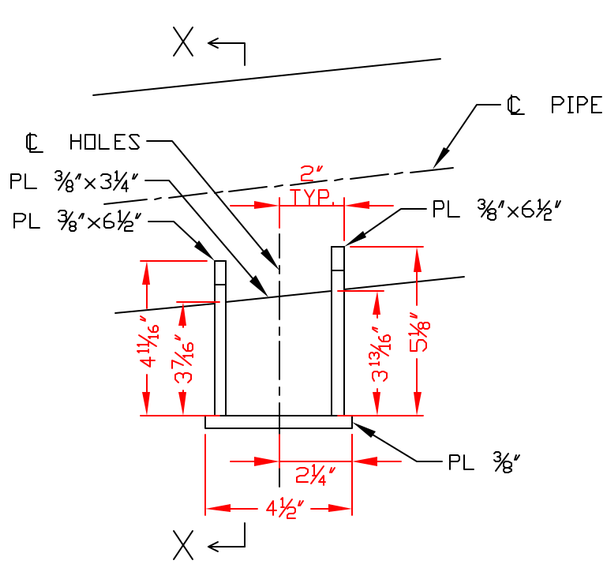
PIPE ELEVATION

NOTES:

1. SEE SK 1.
2. PROVIDE 1 - ⅜"×4½"×10" AND 1 - ½"×4½"×10" SHIM PLATES



SECTION X-X



DETAIL A

CLAYTON FALLS

SK 2 - DOWNSTREAM SUPPORT DETAILS

DATE: 25 JANUARY 2006