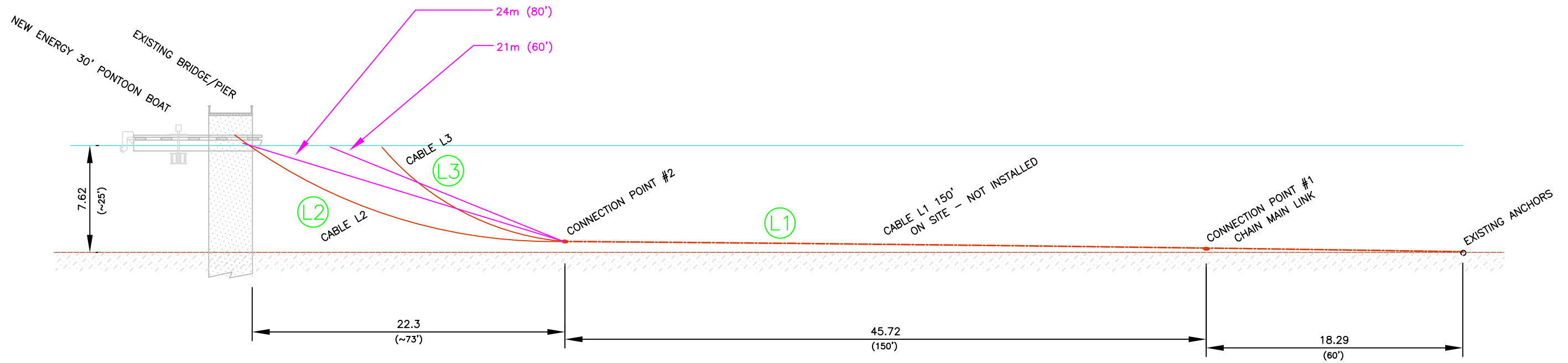
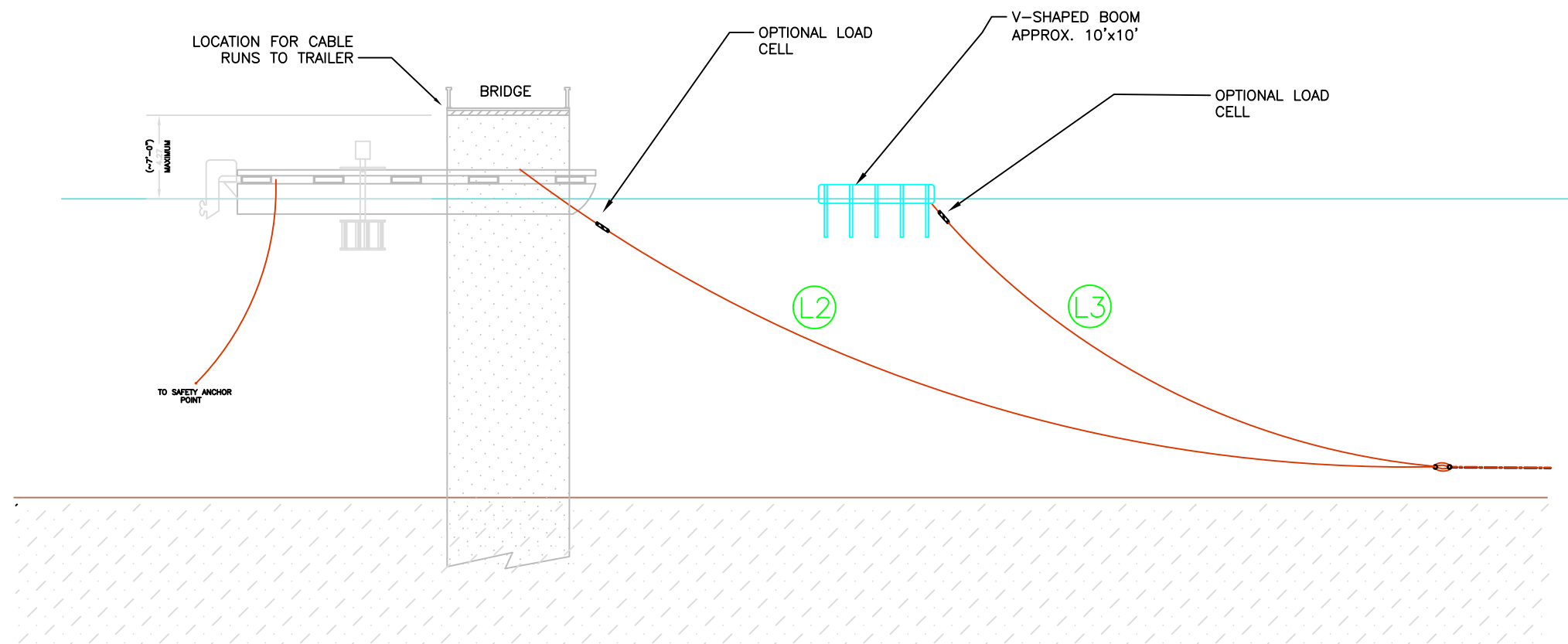


Appendix 1
Drawings and details

For:
PhD Thesis
John Woods
2017
University of Manitoba

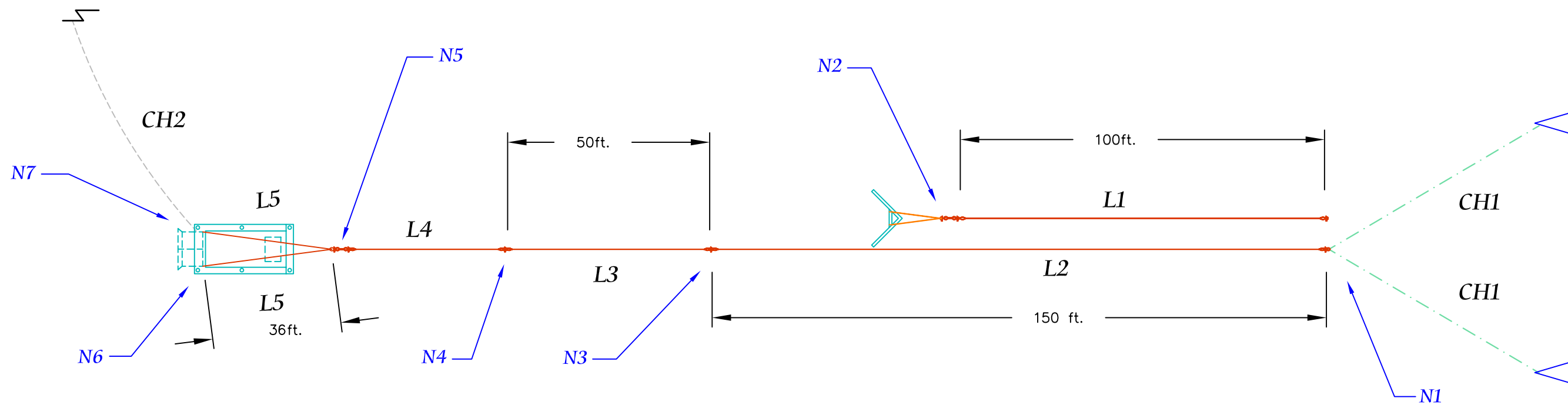


N-S SECTION THROUGH CHANNEL 10 meters 10 feet



N-S SECTION THROUGH CHANNEL 10 meters 10 feet

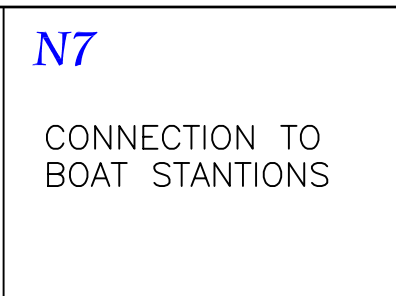
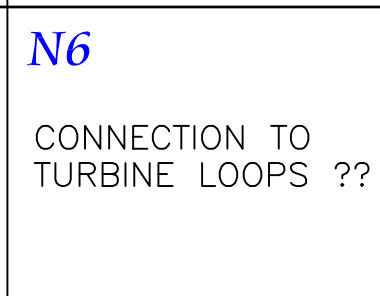
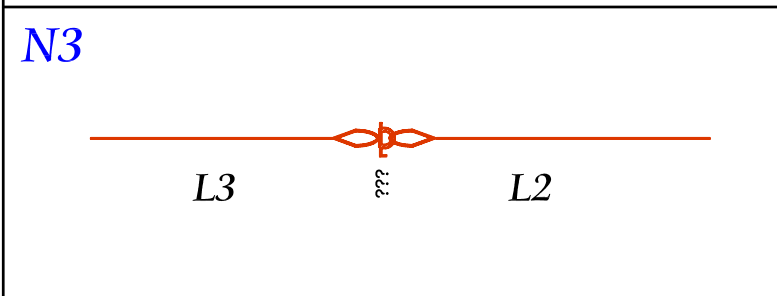
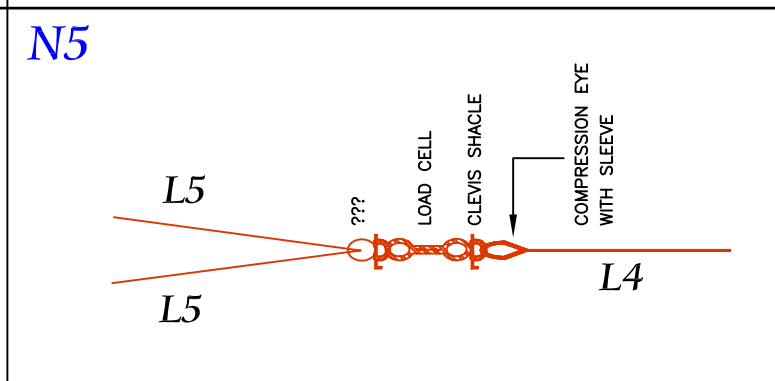
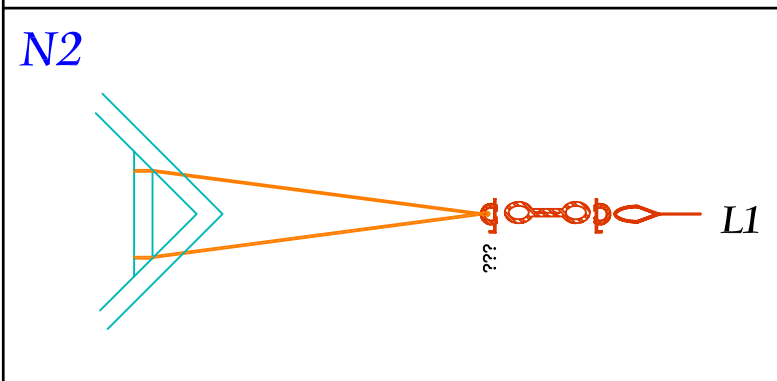
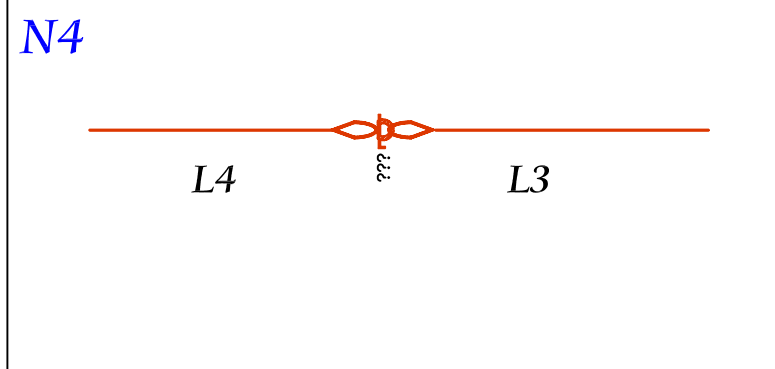
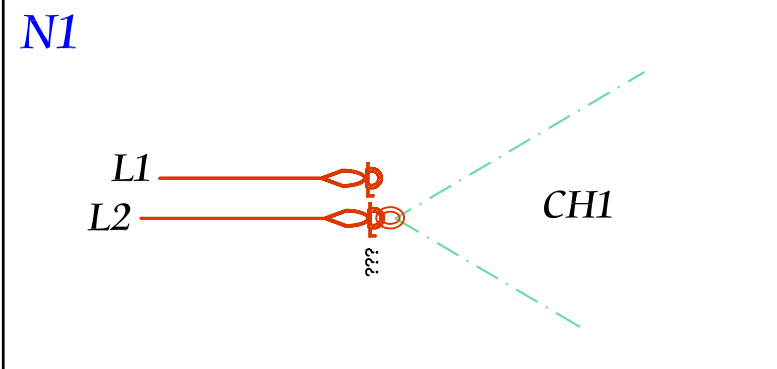
| | |
|---|-------------------------|
| e John Woods, U of M | |
| UNDERWATER KINETIC TURBINE PROJECT | |
| POINTE DUBOIS, MANITOBA | |
| UNIVERSITY OF MANITOBA | |
| SECTION DETAILS FOR ANCHOR CABLES NEW ENERGY CORP. | 1. INITIAL JCW 11/19/07 |
| | NE-2 |



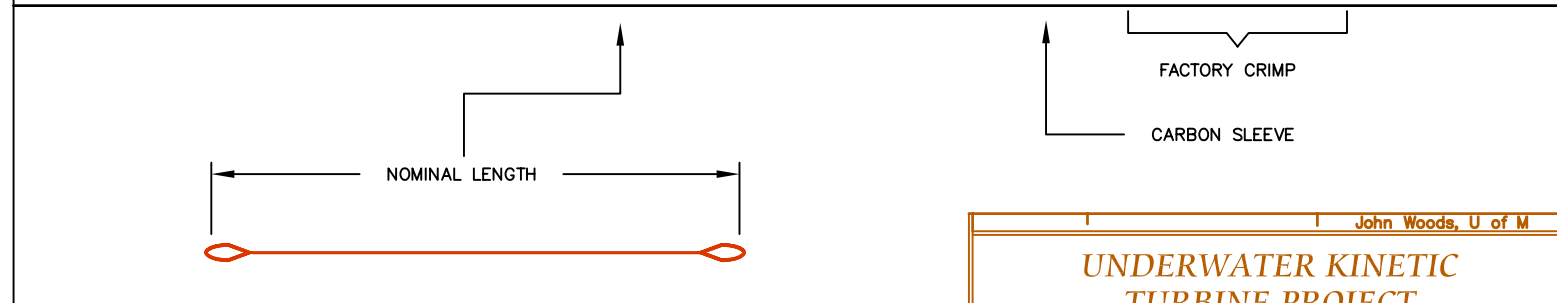
A Entire Assembly

B Node Details

C Cable Details



| # | CABLE USE | DIAM (in.) | LENGTH (ft.) | TYPE | SLEEVE | END1 | END 2 | QTY |
|----|-------------|------------|--------------|--------------|--------|------|--------|-----|
| L1 | BOOM CABLE | 1/2" | 100 | DY PAC6 H.P. | CS | EYE | EYE | 1 |
| L2 | MAIN CABLE | 1-1/4" | 150 | DY PAC6 H.P. | CS | EYE | EYE | 1 |
| L3 | INTERM. CBL | 1-1/4" | 50 | DY PAC6 H.P. | CS | EYE | EYE | 1 |
| L4 | VARIABLE | 1-1/4" | 80 | DY PAC6 H.P. | CS | EYE | CLAMPS | 1 |
| L5 | TURBINE CBL | 1-1/4" | 36 | DY PAC6 H.P. | CS | EYE | EYE | 2 |



John Woods, U of M

**UNDERWATER KINETIC
TURBINE PROJECT**

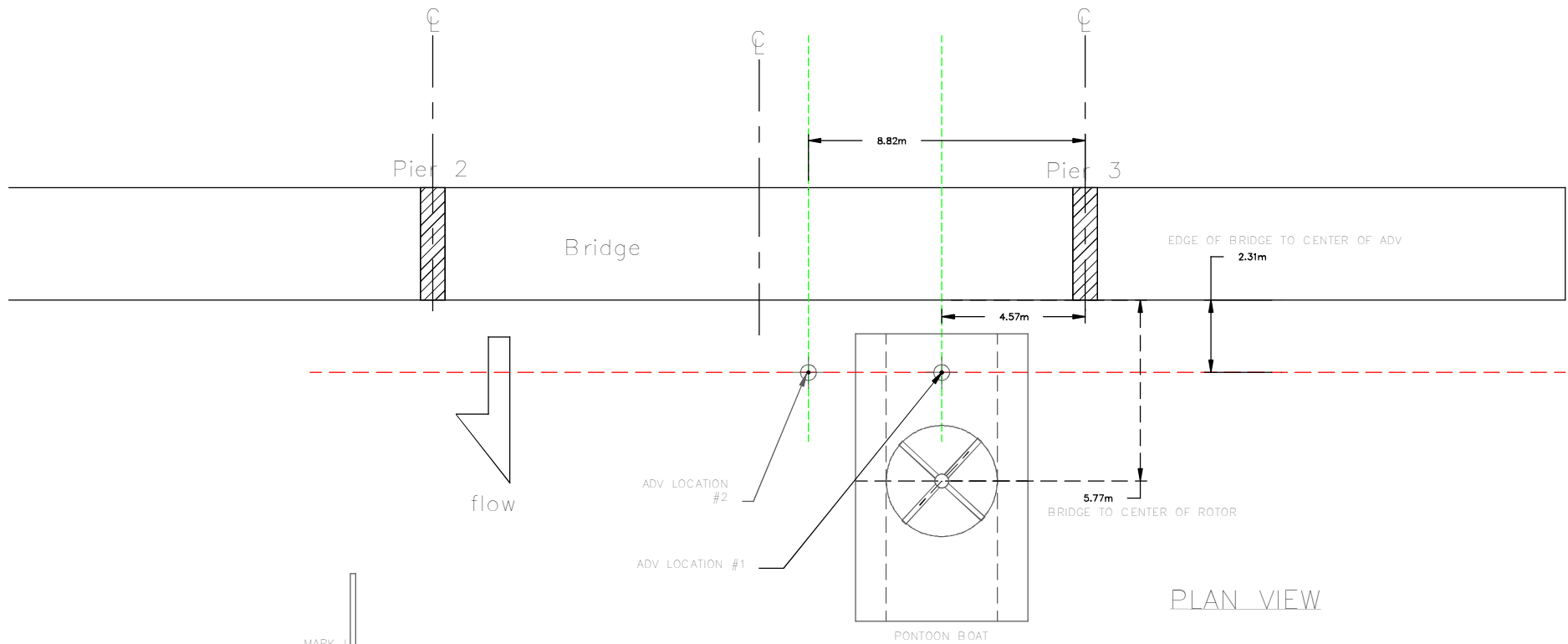
POINTE DUBOIS, MANITOBA

UNIVERSITY OF MANITOBA

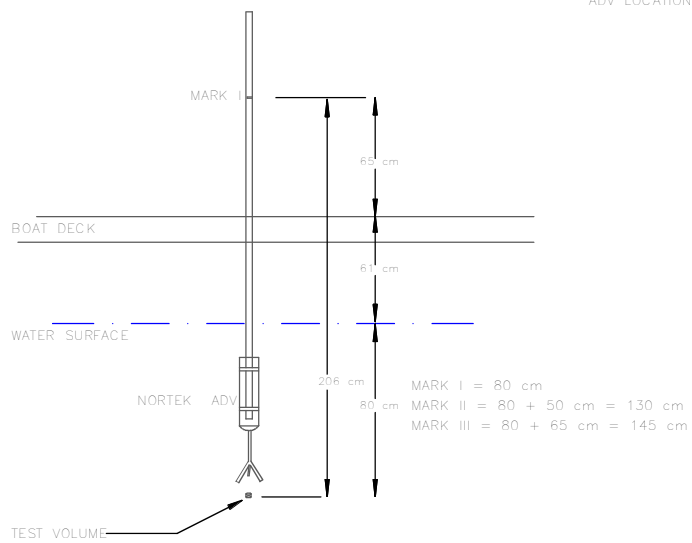
DETAILS FOR ANCHOR CABLES

I. INITIAL JCW 08/08/07

C - 2



PLAN VIEW



VERTICAL ALIGNMENT

| | |
|------------------------------------|-------------------------|
| 5m | John Woods, U of M 2010 |
| UNDERWATER KINETIC TURBINE PROJECT | |
| POINTE DUBOIS, MANITOBA | |
| UNIVERSITY OF MANITOBA | |
| ADV MEASUREMENT POINTS NE TURBINE | 1. INITIAL JCW 10/18/10 |
| | M - 1 |

PROCEDURE

PHASE 0

1. PLACE 'L1' ON BOW DECK OF "WIDE-LOAD" BOAT, WITH UPSTREAM SHACKLE READY, SECURE END TO BOAT.
2. PLACE L2 AND L3 MID-SHIPS ON "WIDE-LOAD" BOAT, SHACKLES READY.
3. SECURE 'F3' ON UPSTREAM AND DOWNSTREAM SIDES OF BRIDGE WITH REMOVABLE TIES, WITH SPARE CABLE LOOP AT TEST LOCATION 'F'. TIE LOOPS IN F3 FOR PULLING.
4. SECURE SAFETY ROPE 'S1' TO TEST PLATFORM AND TO BRIDGE 1/2 WAY POINT, THEN BACK TO PONTOON BOAT.
5. MOVE LEMON FLOAT TO BRIDGE TEST POSITION, HAVE ROPE TIED AT ONE END, LOOP ROPE AROUND HANDRAIL AT THE OTHER - SO LEMON CAN BE HEFTED OVER RAIL PARALLEL TO BRIDGE.
6. PLACE 3/8" CABLE CLAMPS ON BOARD (3) FOR 'LY2' SHORTENING IF NECESSARY.

PHASE 1

1. MAKE WINCH CONNECTION AT B FROM "WIDE LOAD" BOAT WINCH 'W3' TO 'R2' ANCHOR ROPE, WINCH/PULL UP 'LY1' END AND CONNECT 'L1'.
2. WINCH OUT TO BRIDGE POSITION 'C'
3. BRING WHITE FLOAT 'H2' ONTO BOAT AND PULL UP THE END OF 3/8" CABLE 'LY2' TO SURFACE. DEPENDING ON END LOCATION, SHORTEN CABLE IF REQUIRED FOR LEMON POSITION.
4. KEEP 'LY2' ON BOARD SO END IS AVAILABLE FOR LEMON CONNECTION.
5. WINCH BACK AND RECEIVE LEMON FROM BRIDGE, CONNECT TO 'LY2'
6. FEED DEPLOYMENT ROPE 'F3' FROM BRIDGE, THROUGH PULLEY ON 'WIDE LOAD' BOAT (TO BLOCK MOUNTED WINCH 'W5' POSITION).

PHASE 2

1. RELEASE PONTOON BOAT INTO THE FREE STREAM, PAYOUT 'S1' AS REQUIRED.
2. ONCE IN LINE WITH FLOW, BEGIN TO WINCH IN 'F3' USING 'W5'.
3. EVERY 60', SHACKLE ROPE TO BLOCK, RELEASE WINCH HOOK AND PULL BACK TO BRIDGE FOR NEXT LOOP CONNECTION.
4. WHEN TEST PLATFORM NEAR BRIDGE - MAKE CONNECTION FROM PULLEY ON WINCH LINES W1 AND W2 TO DOWNSTREAM END LEMON FLOAT.
5. TEST OPERATION AND MOTION OF TEST PLATFORM USING 'W1' AND 'W2', WINCH UPSTREAM TO SLACK 'F3' AND REMOVE.
6. PASS L2 AND L3 TO PONTOON BOAT, AND CONNECT TO SHACKLES ON TURBINE.
7. PAY OUT W1 AND W2, TO MOVE PONTOON BOAT AWAY FROM 'C'
8. WHEN SECURE, WINCH "WIDE LOAD" UPSTREAM TO 'C' AND TIE UP TO FLOAT ROPE, START ENGINE CUT WINCH CABLE WHEN CABLE IS SLACK.
9. MAKE SURE PROPELLER IS FREE OF CABLES, UNTIE FROM WHITE BUOY 'R2' AND CLEAR AREA.

PHASE 3

AT THIS POINT, NO ONE WILL BE ON THE TEST PLATFORM UNTIL PHASE 4

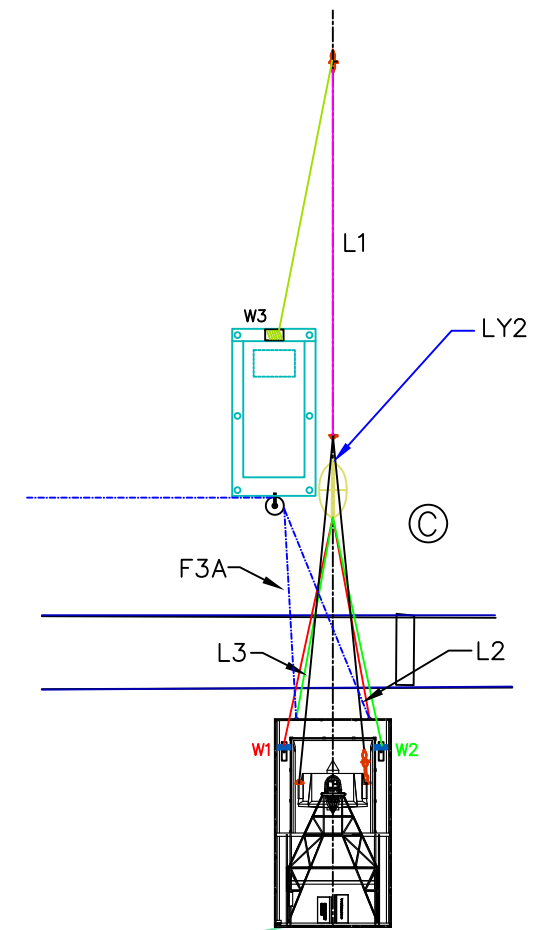
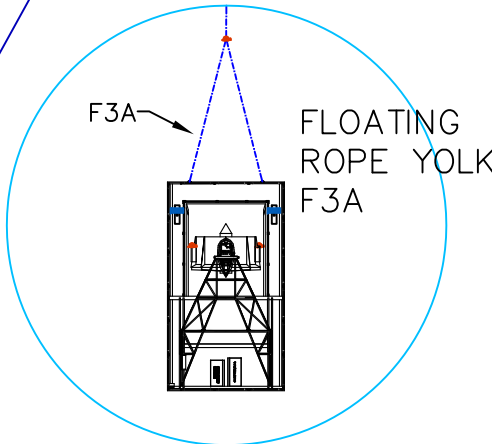
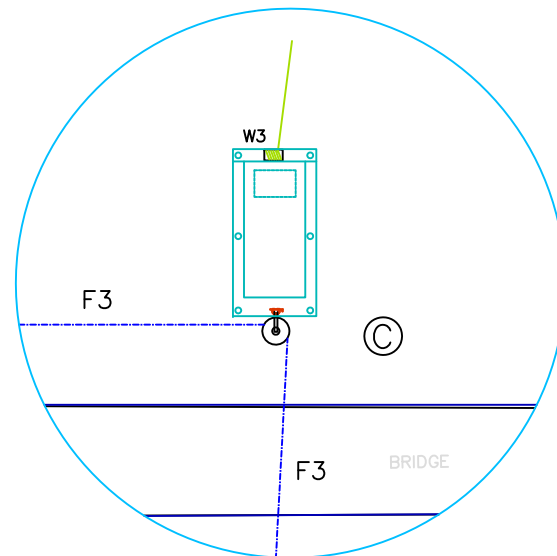
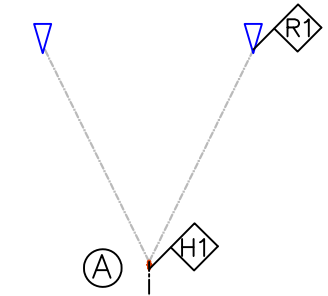
1. USE REMOTE WINCH CONTROLS FOR 'W1', 'W2' ON BRIDGE TO ADJUST TEST PLATFORM IN THE FLOW TO CORRECT LOCATION AND ANGLE.
2. USE REMOTE HYDRAULICS CONTROL ON DEPLOYMENT ARM TO LOWER TURBINE SLOWLY INTO STREAM, ADJUSTING 'W1' AND 'W2' TO SUIT.
3. STOP AT ANY TIME DURING LOWERING PROCEDURE IF ANYTHING LOOKS UNSTABLE AND LIFT TURBINE USING HYDRAULICS.

PHASE 4

1. WHEN TURBINE IS FULLY LOWERED INTO STREAM, AND STABLE, TEST SETUP ON THE TEST PLATFORM CAN BEGIN.
2. VIBRATION AND FLOW METERS TO BE LOWERED INTO THE WATER, AND MONITORED.
3. POWER CONVERTER IS TO BE SET FOR 'NO LOAD'.
4. MAIN BREAKER FOR GENERATOR OUTPUT CAN BE CLOSED.
5. ALL PERSONNEL EXIT THE TEST PLATFORM.
6. POWER CONVERTER CAN START TO LOAD UP THE UNIT, MONITOR VIBRATION AND TEST PLATFORM STABILITY. REMOVE LOAD IF INSTABILITIES ARE DETECTED.



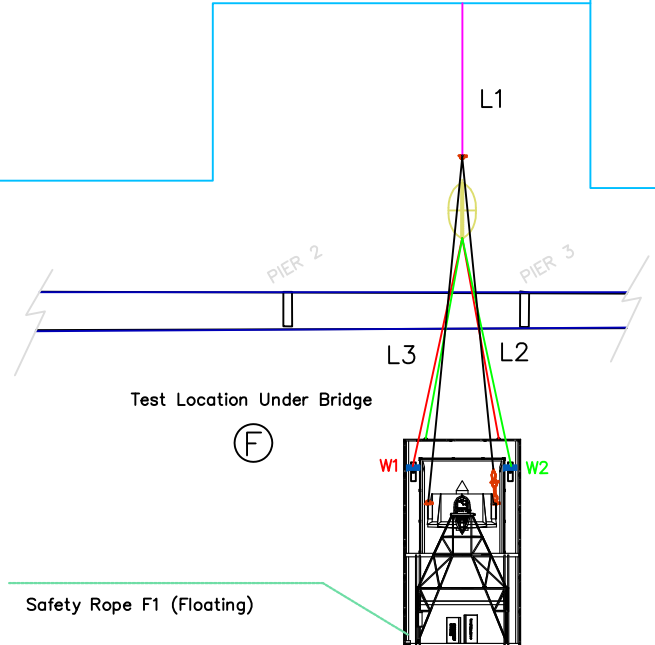
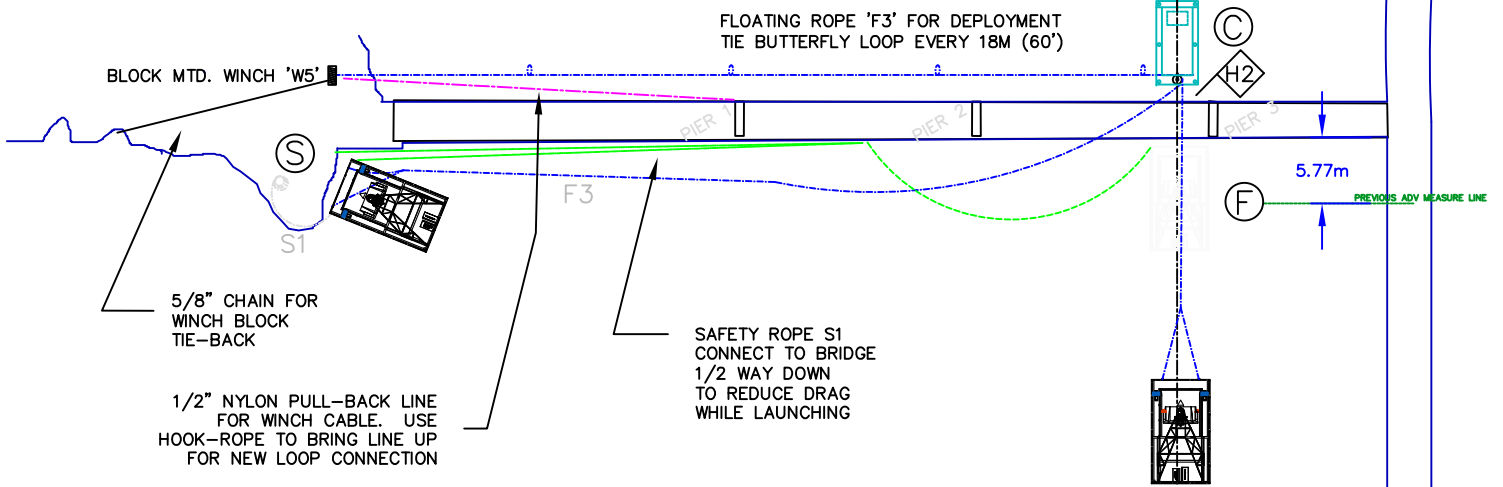
MAIN ANCHORS



AT POSITION 'C' BOTH UEK BOAT AND PONTOON BOAT WILL BE IN CLOSE PROXIMITY TO THE BRIDGE.

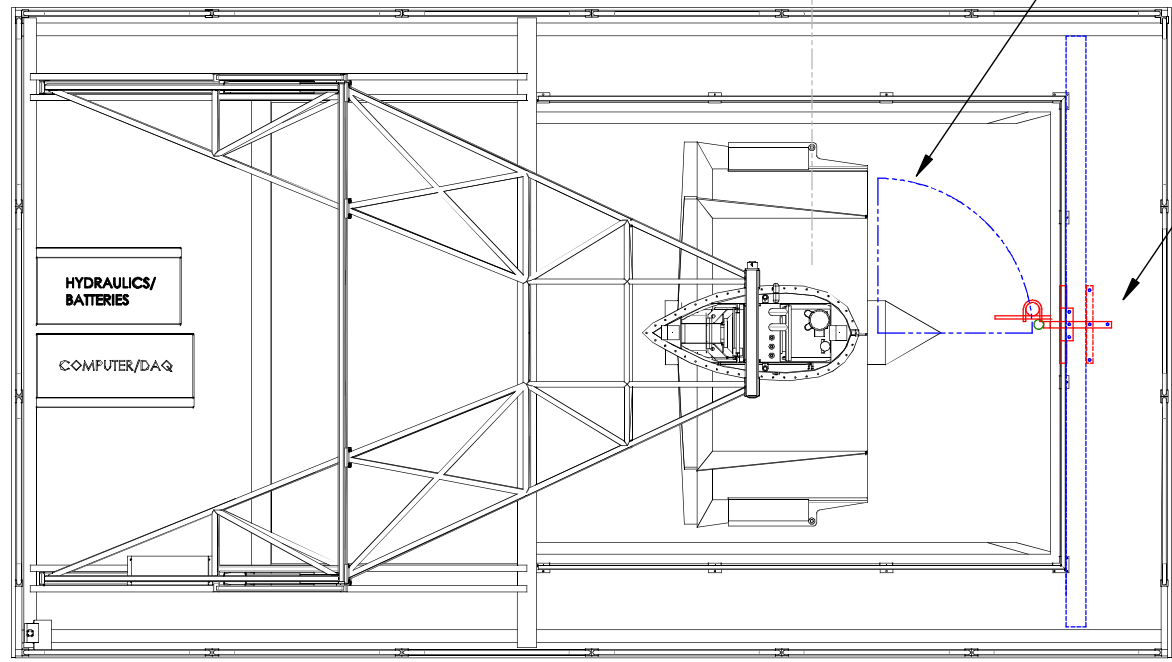
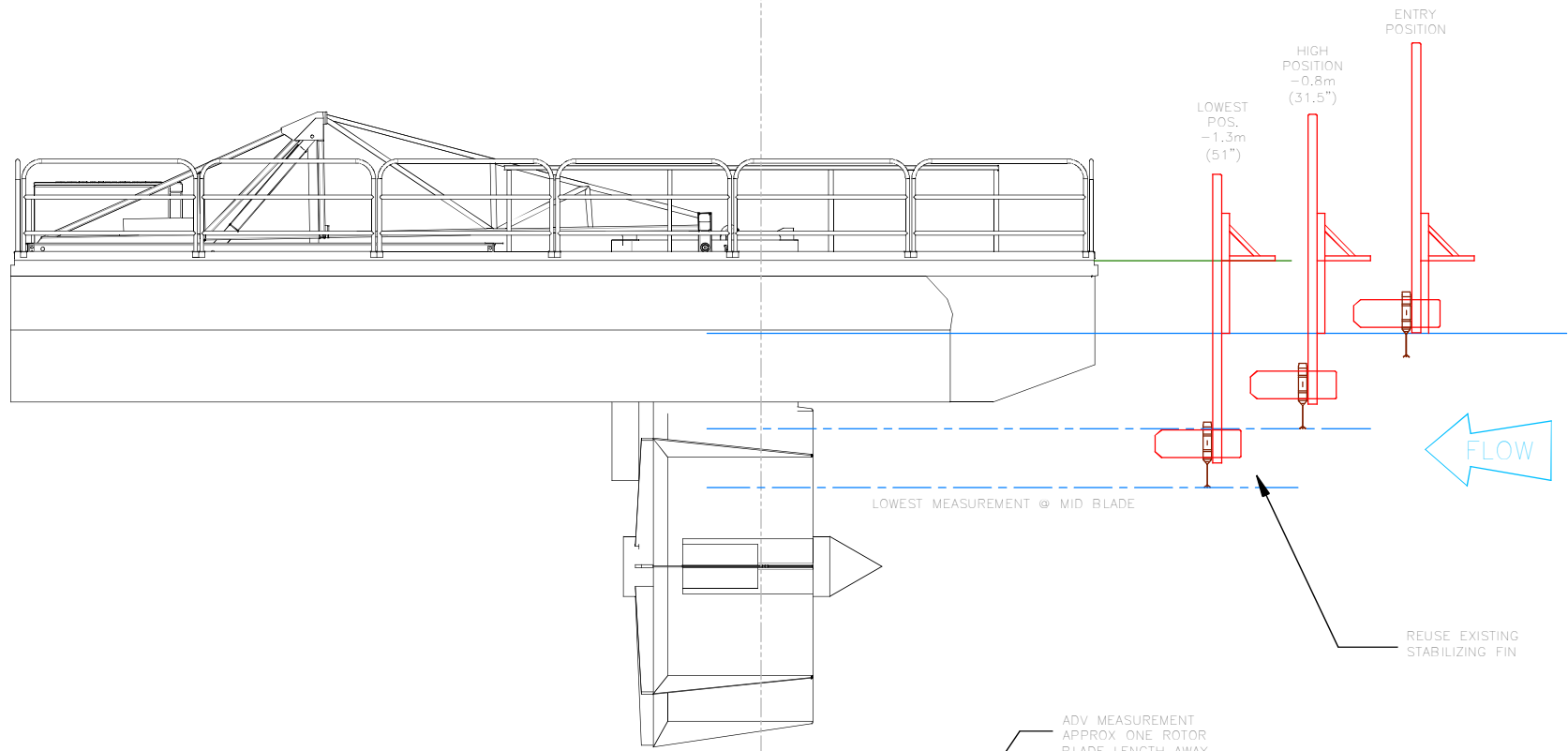
ONCE W1 AND W2 ARE CONNECTED TO (LEMON) FLOAT, F3 AND PULLEY WILL BE REMOVED AND FINAL CONNECTION TO MAIN LINE L1 WILL BE MADE TO L2 AND L3 ON THE DECK OF UEK BOAT.

- L = WIRE ROPE
- F = FLOATING ROPE
- W1 = WINCH, #1, #2, #3, AND #5
- S1 = FLOATING SAFETY ROPE
- R# = RED BUOY, #1 AND #2
- H# = WHITE BUOY, #1 AND #2



IN FINAL TEST LOCATION (F), AFTER MAIN CABLE L1 IS CONNECTED TO TURBINE HARNESS L2 AND L3, WINCHES W1 AND W2 CAN BE USED TO ADJUST LOCATION OF PONTOON BOAT RELATIVE TO TURBINE.

| | |
|---|-------------------------|
| John Woods, c U of M | |
| UNDERWATER KINETIC TURBINE PROJECT | |
| POINTE DUBOIS, MANITOBA | |
| UNIVERSITY OF MANITOBA | |
| 60kW TURBINE DEPLOYMENT PLAN | 4. FINAL JCW 09/28/2011 |
| | 3. FOR REVIEW |
| | 2. WITH DEPLOYMENT V1 |
| | 1. INITIAL JCW 05/12/10 |
| C20 R4 | |



5m John Woods, U of M 2011

**UNDERWATER KINETIC
TURBINE PROJECT**

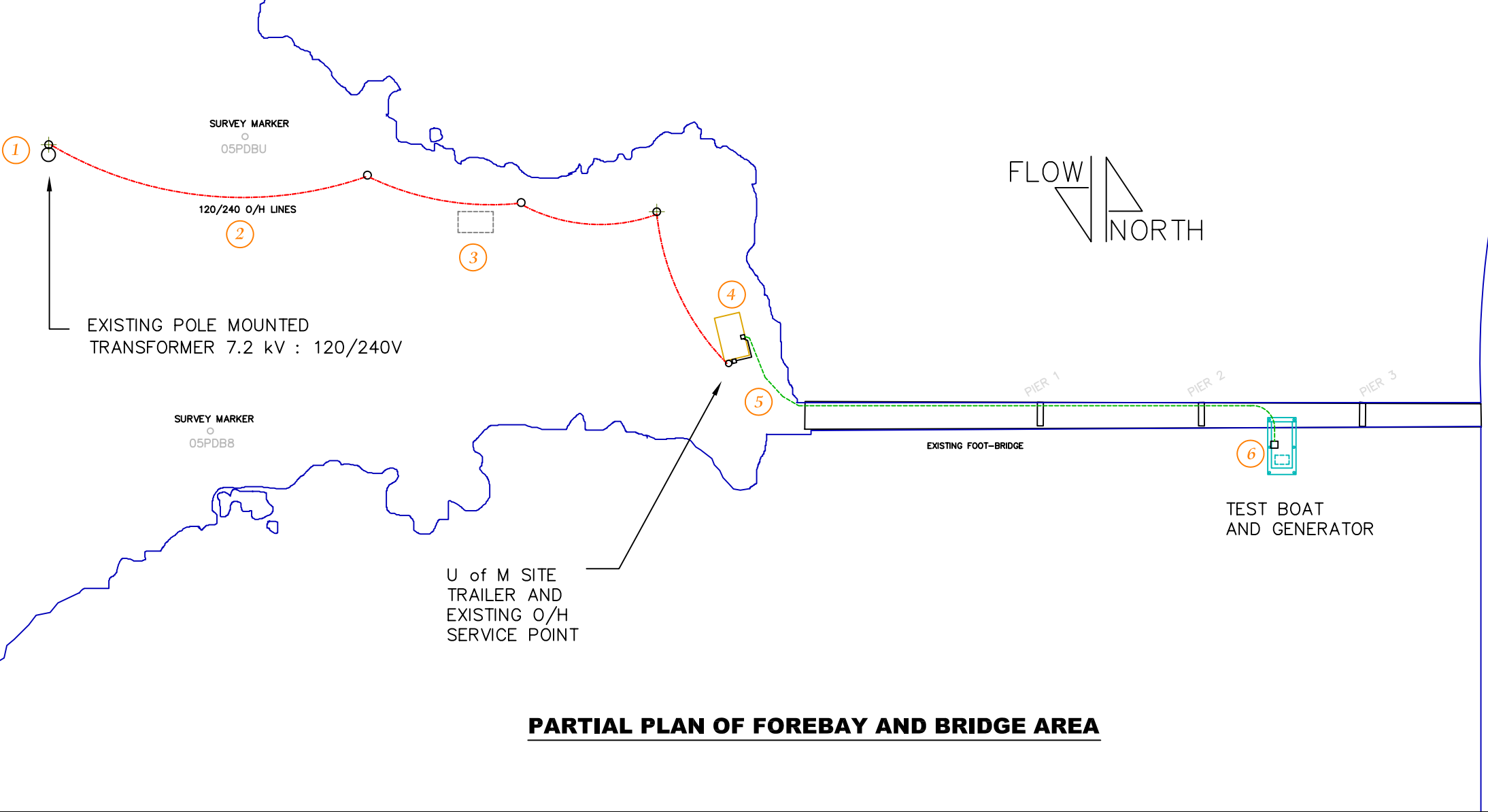
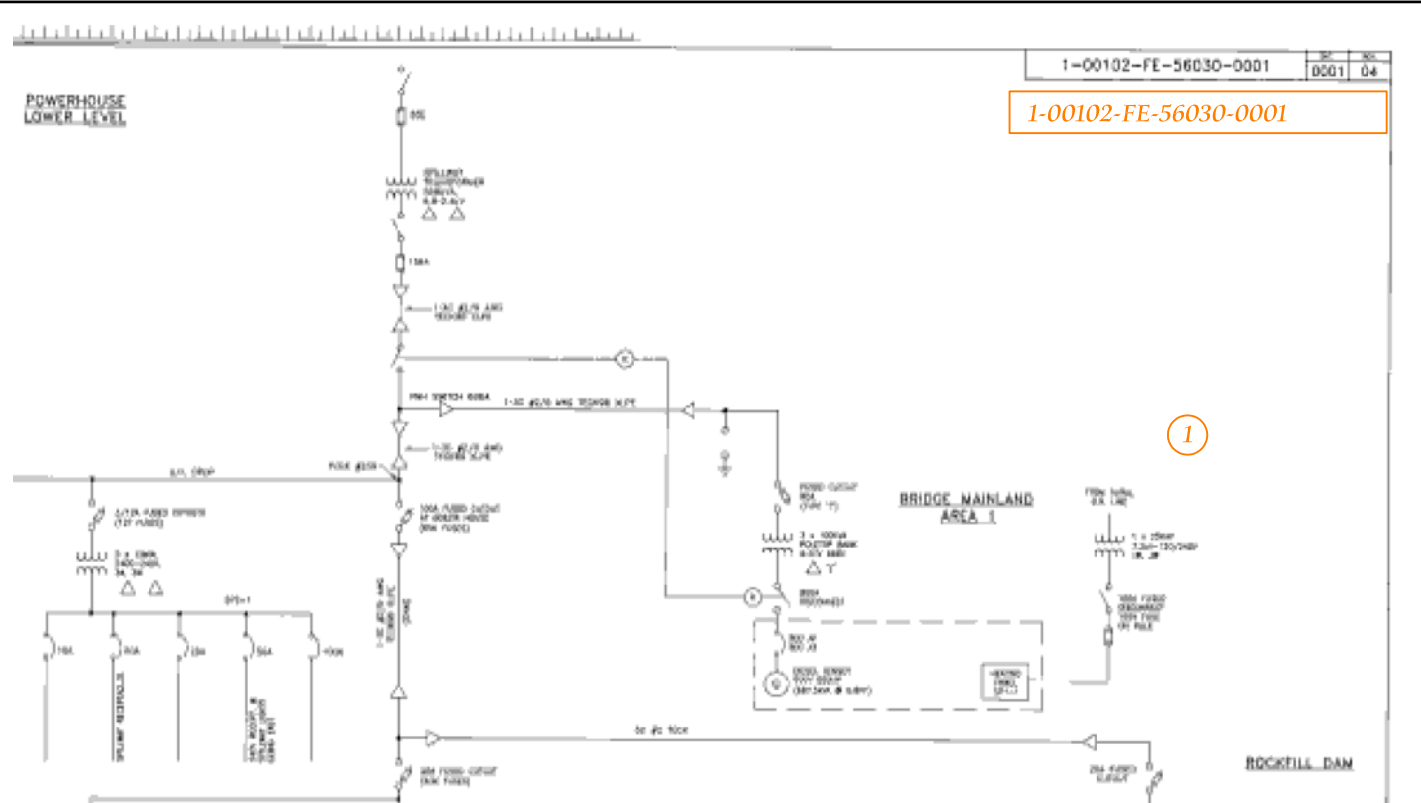
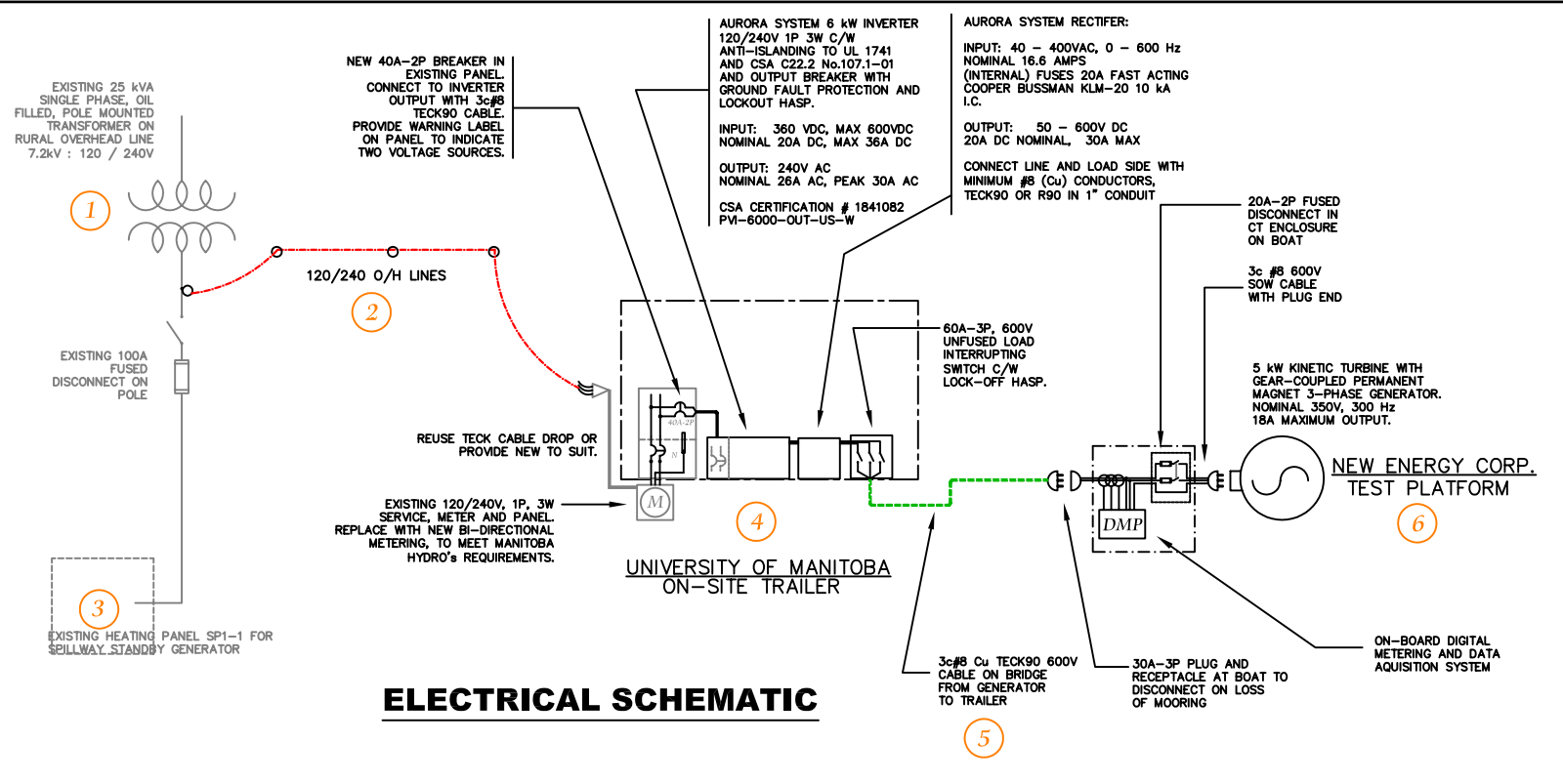
**POINTE DUBOIS, MANITOBA
UNIVERSITY OF MANITOBA**

ADV MEASUREMENT
POINTS UEK TURBINE

1. INITIAL JCW 09/26/11

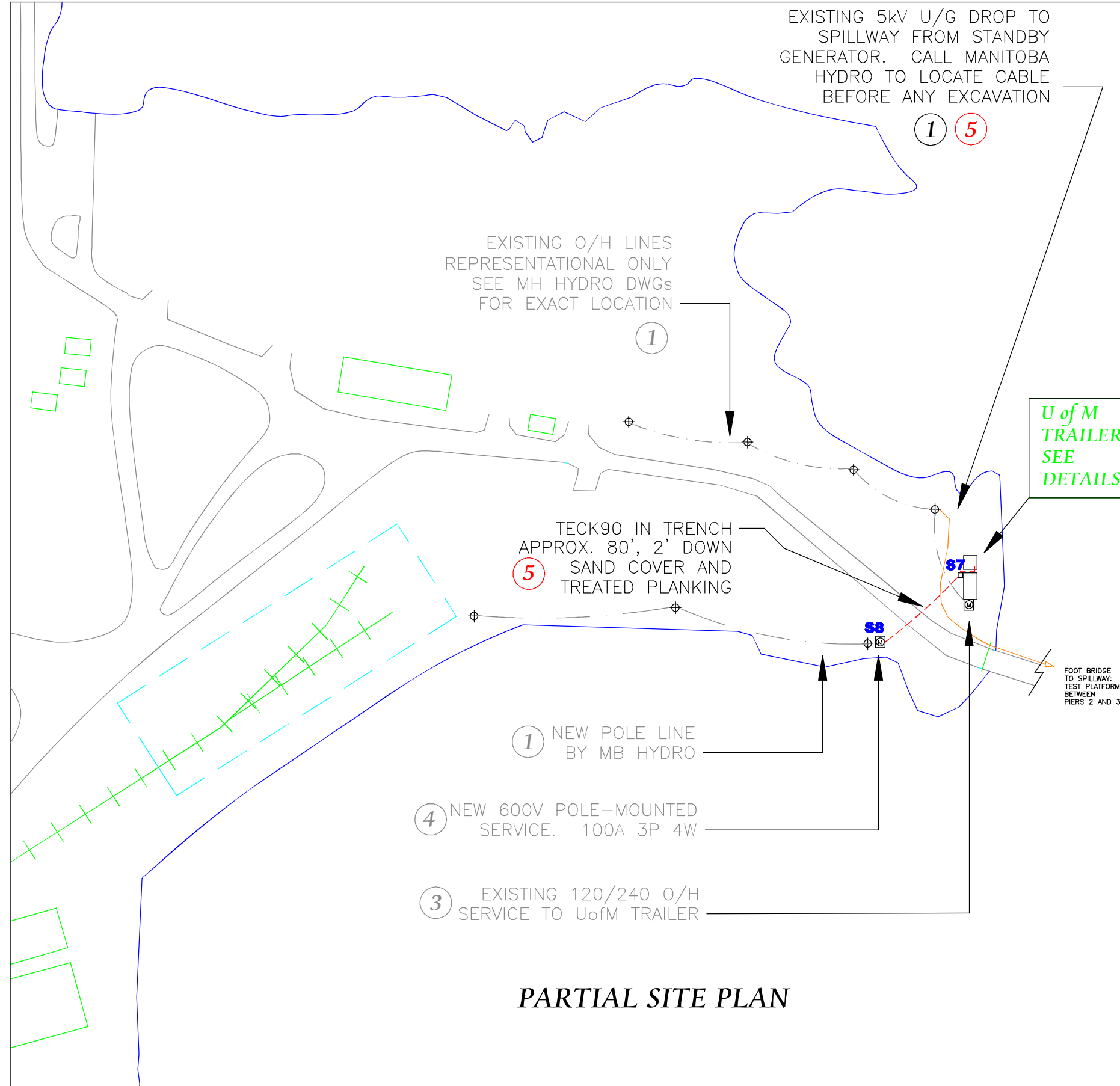
M - 2

Copyright John Woods, U of M, 2008

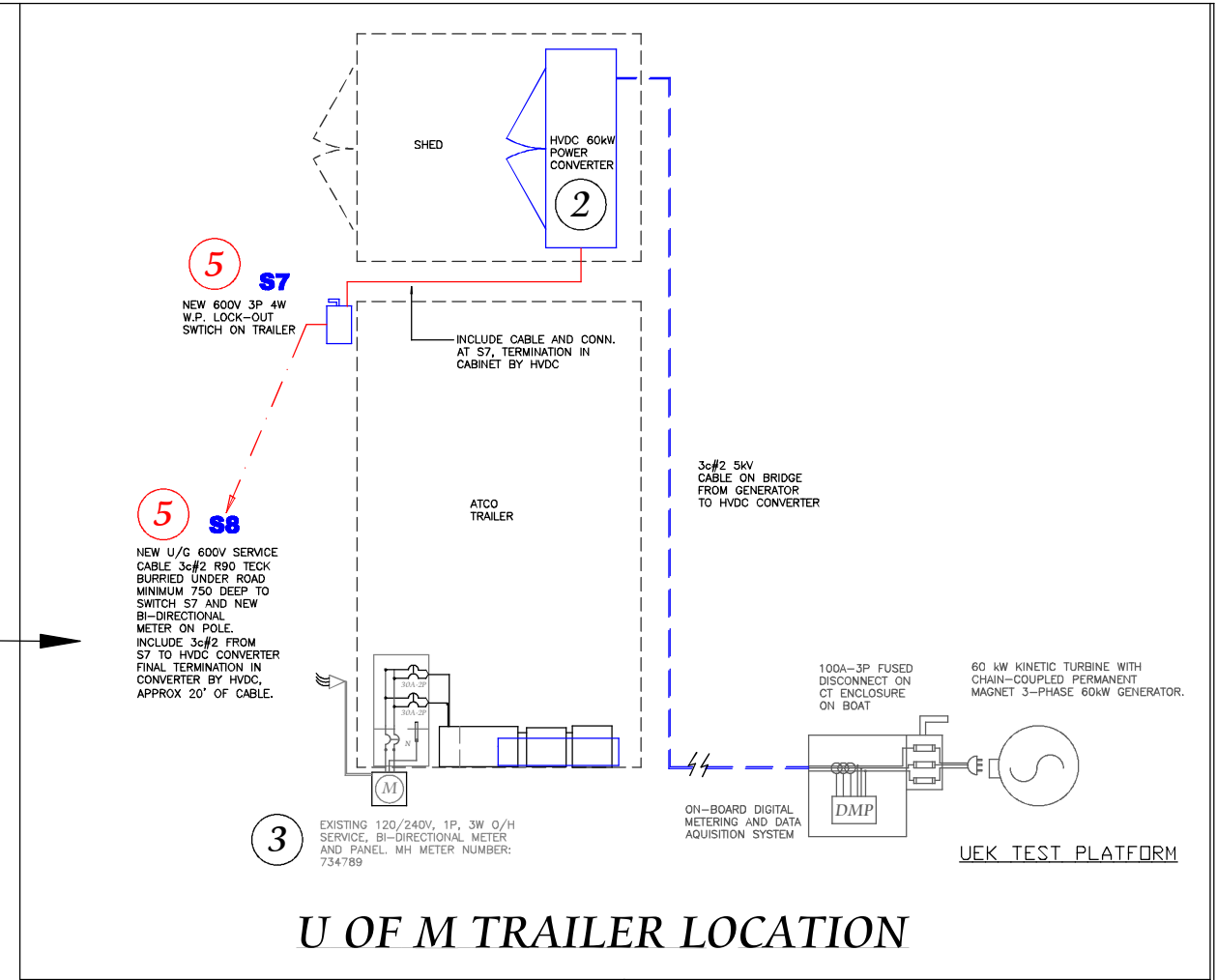
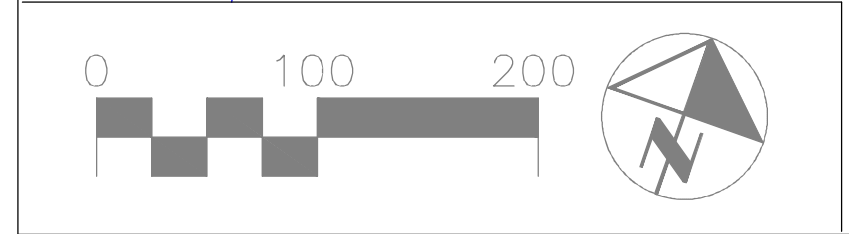


- GENERAL NOTES**
1. GENERATOR AND TEST RECTIFIER HAVE BEEN TESTED UNDER LOAD IN STAND-ALONE CONFIGURATION, AND HAVE BEEN IN (INTERMITTENT) OPERATION SINCE JANUARY 2008. PEAK VOLTAGE MEASURED IS 185V L-L, 256 Hz.
 2. NEW 'AURORA' RECTIFIER/INVERTER IS A PACKAGED SYSTEM AND HAS BEEN SIZED BY NEW ENERGY CORPORATION INC. TO MATCH THE PEAK TURBINE OUTPUT. THEY ARE CSA APPROVED AND INCLUDE ANTI-ISLANDING REQUIREMENTS OF UL 1741 AND CSA C22.2 No.107.1-01. CSA CERTIFICATION No.1841082 (LR56325).
 3. INTENT IS TO CREATE A 'CONNECTION TO THE GRID' VIA EXISTING OVERHEAD SERVICE DROP TO U of M SITE TRAILER.
 4. OVERHEAD LINES ARE SHOWN IN APPROXIMATE LOCATIONS ONLY. EXACT SERVICE LOCATION, AND CONNECTION TO MANITOBA HYDRO FACILITIES MUST BE CONFIRMED ON SITE BY QUALIFIED ELECTRICIAN.
 7. NO WORK WILL COMMENCE ON THIS PROJECT UNTIL APPROVAL IS OBTAINED FROM MANITOBA HYDRO.

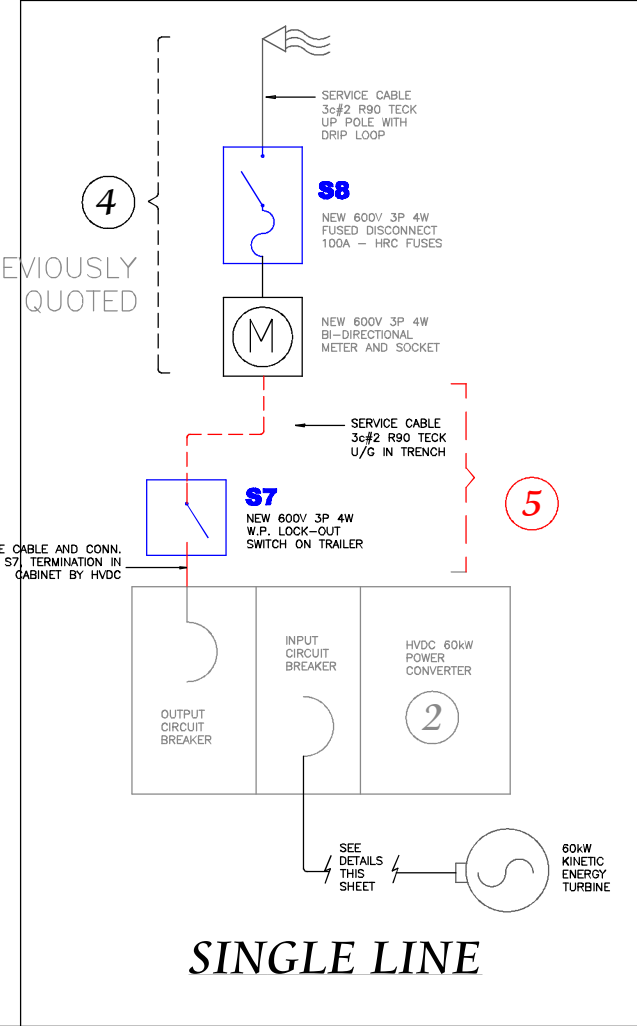
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|---|----------------------------|--------------------|
| 10m | 20m | John Woods, U of M |
| UNDERWATER KINETIC TURBINE PROJECT | | |
| POINTE DUBOIS, MANITOBA | | |
| UNIVERSITY OF MANITOBA | | |
| GRID-CONNECT DRAWING NEW ENERGY CORPORATION INC. | 3. REVISION 1 JCW 03/09/08 | |
| | 2. FOR REVIEW JCW 03/07/08 | |
| | 1. INITIAL JCW 03/05/08 | |
| G - 1 | | |



PARTIAL SITE PLAN



U OF M TRAILER LOCATION



SINGLE LINE

- NOTES**
- 1 PRELIMINARY LAYOUT DRAWING ONLY. ALL ELECTRICAL EQUIPMENT, POLES, LINES AND BUILDINGS ARE SHOWN FOR REFERENCE ONLY.
 - 2 SEE HVDC DRAWINGS FOR DETAILS ON CONVERTER DESIGN AND FEATURES. SHOWN HERE FOR INTERCONNECTION PURPOSES ONLY.
 - 3 EXISTING U of M SITE TRAILER, WITH EXISTING 120 / 240v 3W SERVICE TO REMAIN.
 - 4 NEW PROPOSED POLE-MOUNTED SERVICE SWITCH (S8) AND CONDUCTORS UP POLE.
 - 5 UNDERGROUND FEEDER TO DISCONNECT SWITCH (S7) AT TEST SITE. MUST BE CONFIRMED AND COORDINATED WITH EXISTING H.V. LINE TO SPILLWAY.

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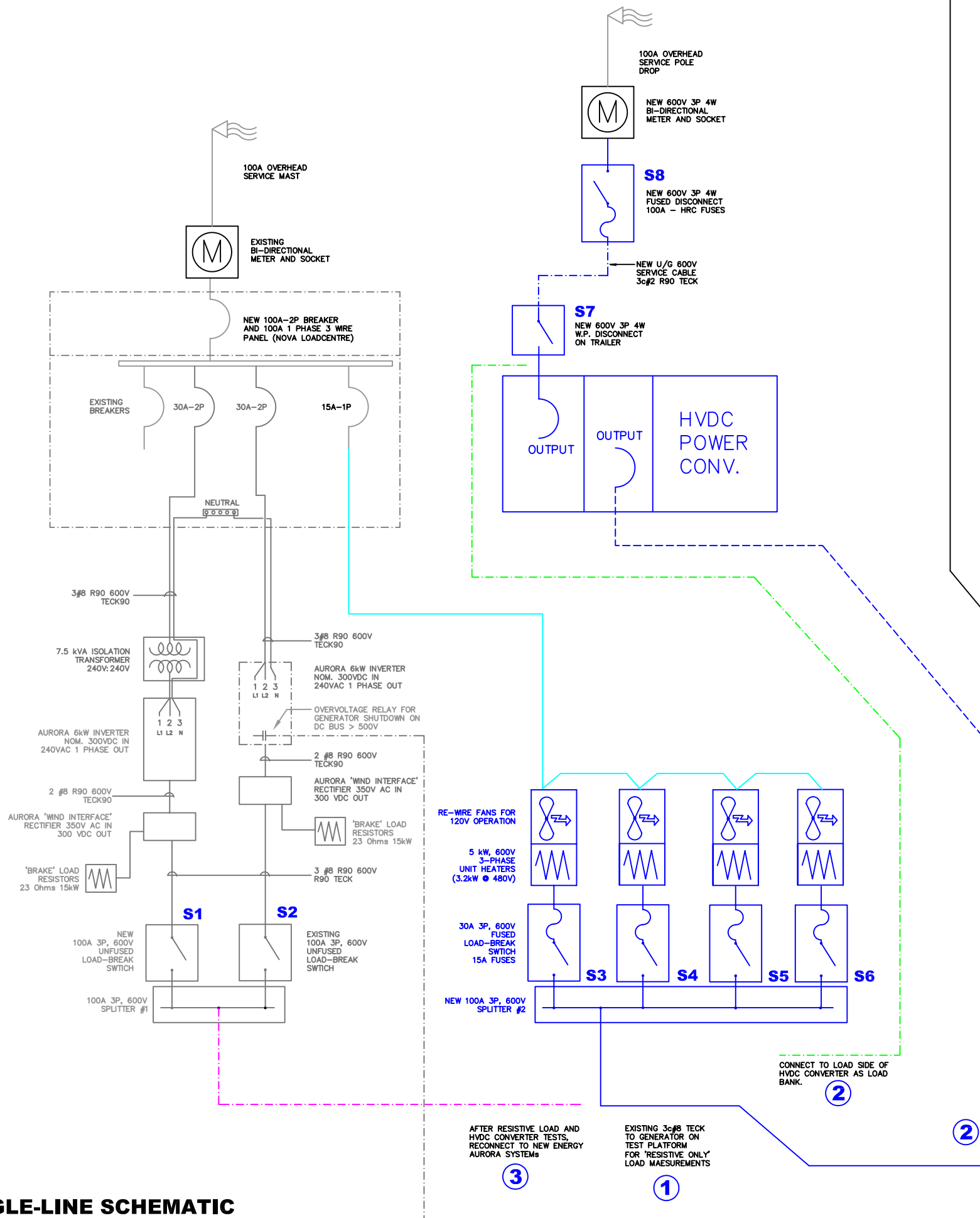
UNDERWATER KINETIC TURBINE PROJECT

POINTE DUBOIS, MANITOBA

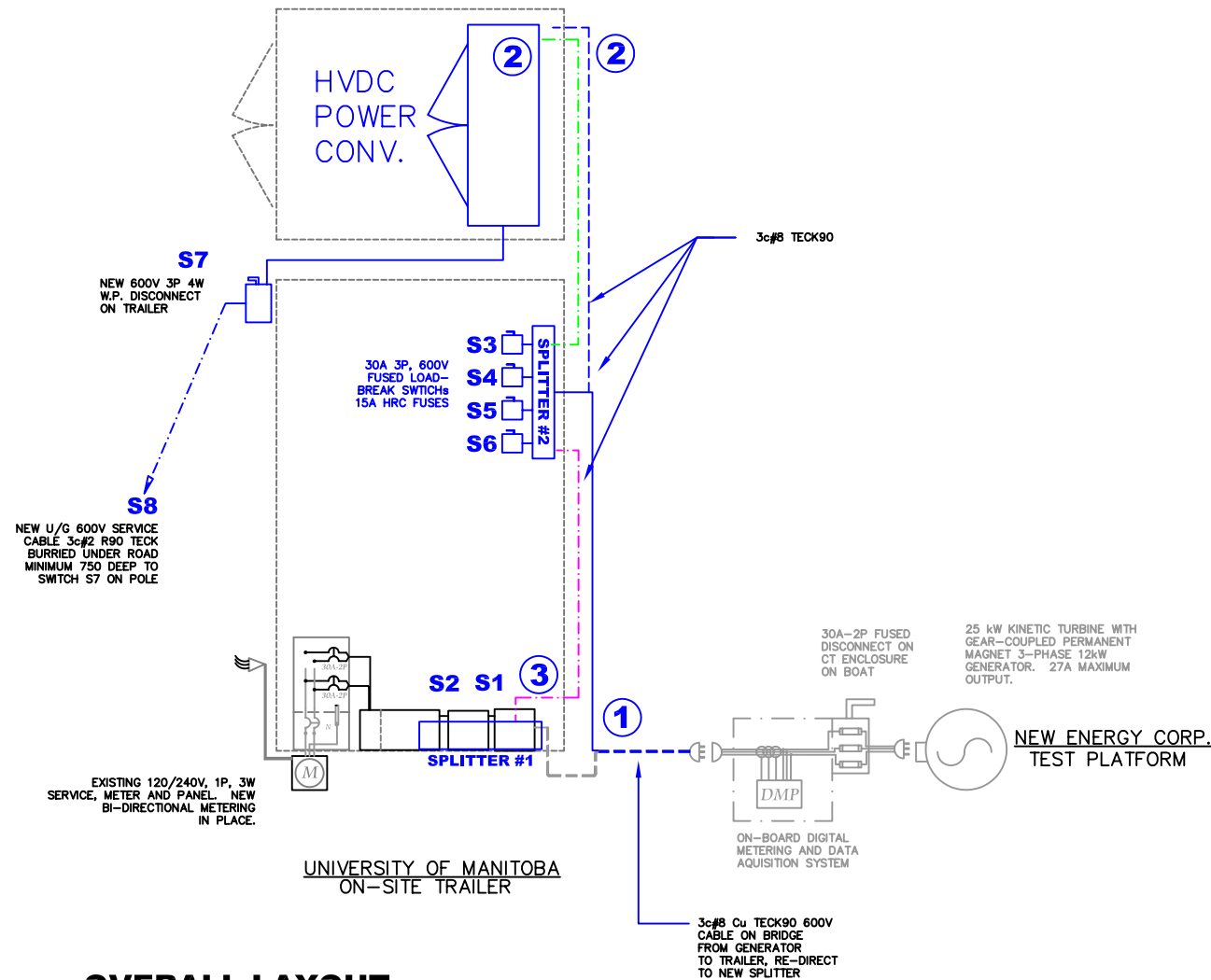
UNIVERSITY OF MANITOBA

| | |
|--|-----------------------------|
| GRID-CONNECT PHASE 2 600V SERVICE | 3. FOR PRICING 07/07/09 (5) |
| | 2. FOR MB HYDRO 5/5/09 |
| | 1. INITIAL JCW 10/26/08 |
| G - 6 | |

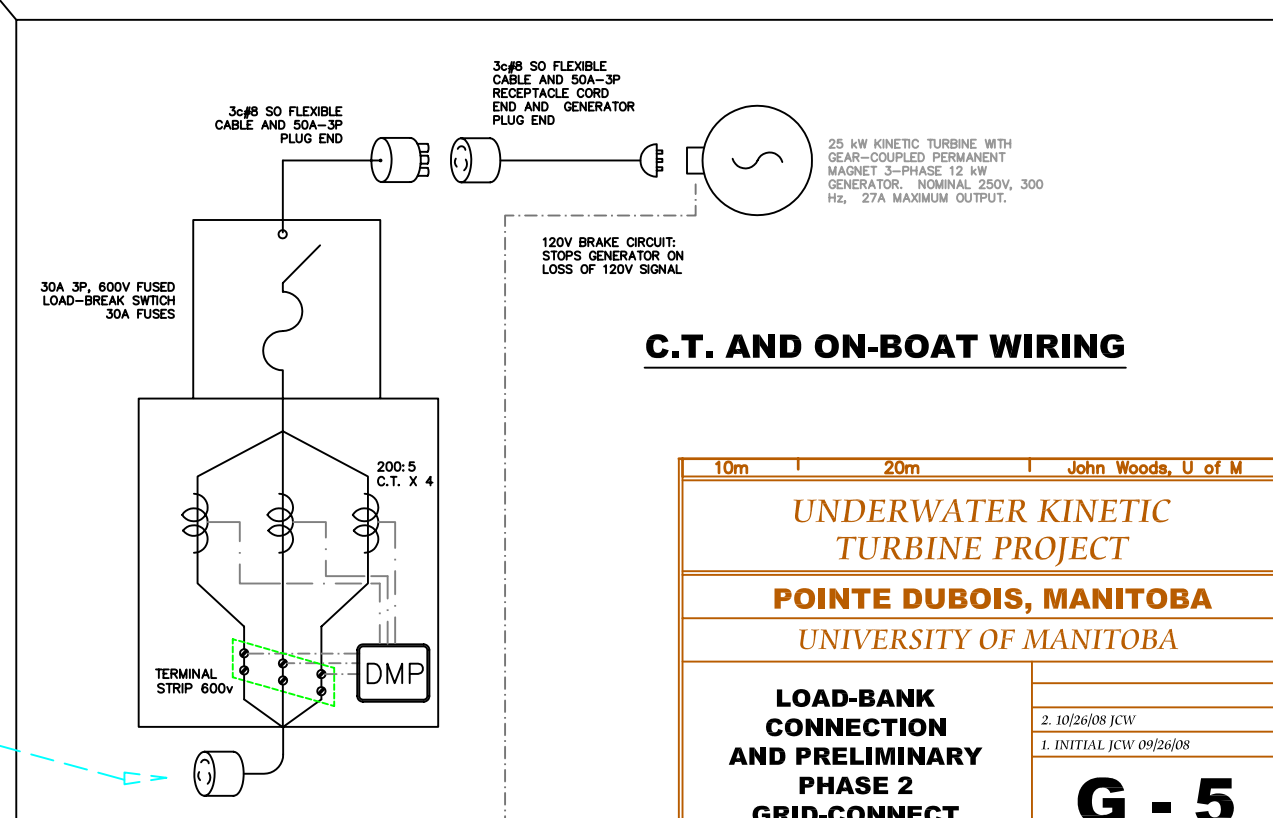
SINGLE-LINE SCHEMATIC

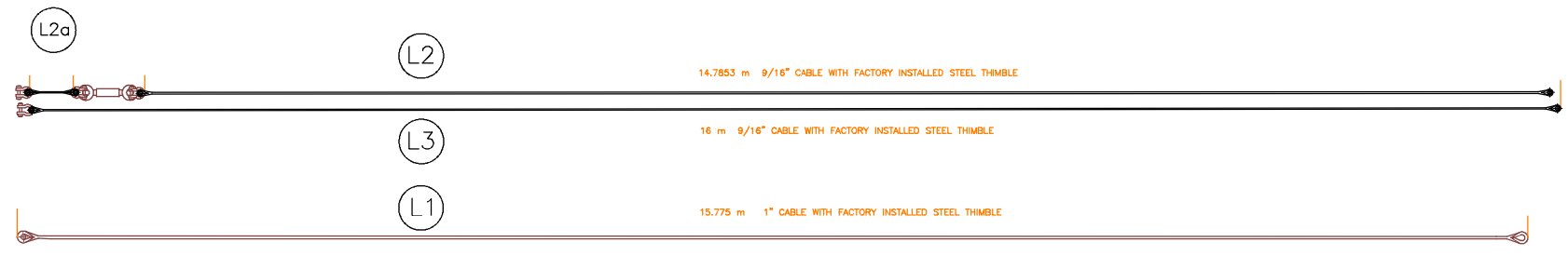


OVERALL LAYOUT



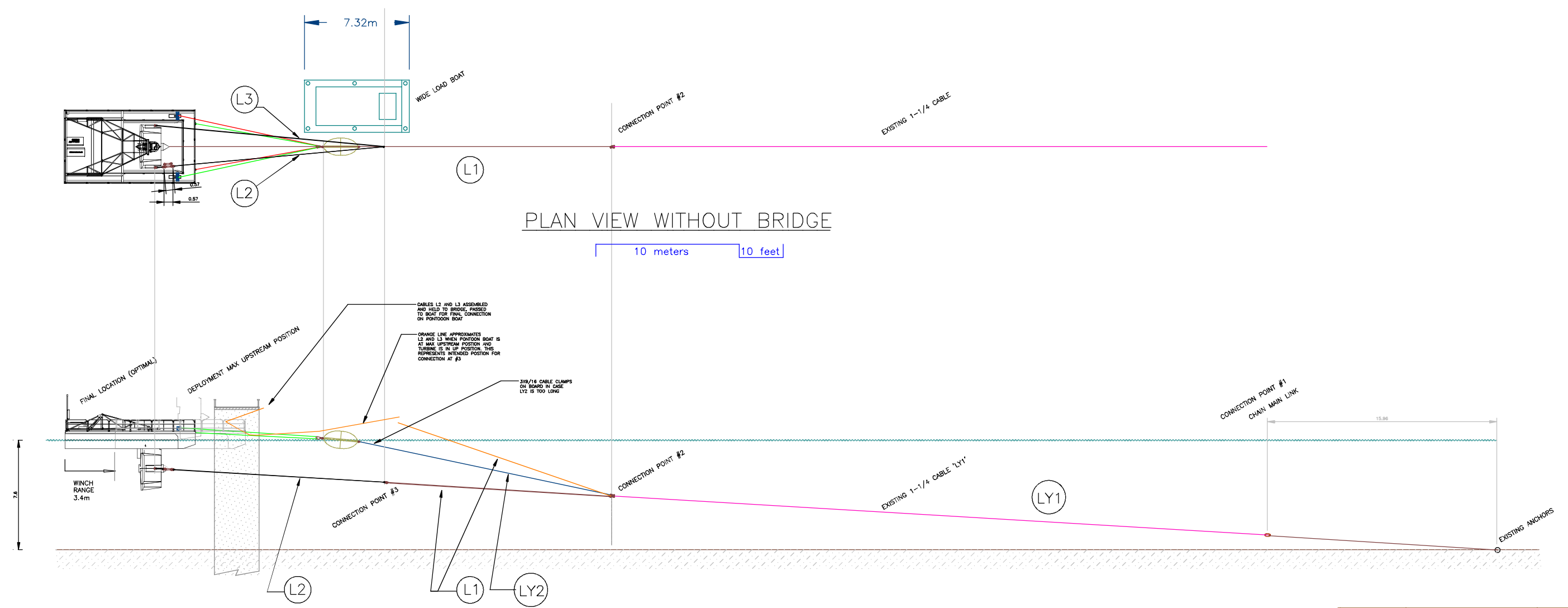
C.T. AND ON-BOAT WIRING





MAIN CABLES AND ASSEMBLIES

1 meter 10 feet



| | |
|---|---------------------------|
| c John Woods, U of M | |
| UNDERWATER KINETIC TURBINE PROJECT | |
| POINTE DUBOIS, MANITOBA | |
| UNIVERSITY OF MANITOBA | |
| DEPLOYMENT DETAILS FOR ANCHOR CABLES 60 kW UEK | 4. FINAL JCW 09-28-2011 |
| | 3. REVISED JCW 09-12-2011 |
| | 2. REVISED JCW 09-07-2011 |
| | 1. INITIAL JCW 08-30-2011 |
| C-21 | |

PROCEDURE

PHASE 0

1. PLACE 'L1' ON BOW DECK OF "WIDE-LOAD" BOAT, WITH UPSTREAM SHACKLE READY, SECURE END TO BOAT.
2. PLACE L2 AND L3 MID-SHIPS ON "WIDE-LOAD" BOAT, SHACKLES READY.
3. SECURE 'F3' ON UPSTREAM AND DOWNSTREAM SIDES OF BRIDGE WITH REMOVABLE TIES, WITH SPARE CABLE LOOP AT TEST LOCATION 'F'. TIE LOOPS IN F3 FOR PULLING.
4. SECURE SAFETY ROPE 'S1' TO TEST PLATFORM AND TO BRIDGE 1/2 WAY POINT, THEN BACK TO PONTOON BOAT.
5. MOVE LEMON FLOAT TO BRIDGE TEST POSITION, HAVE ROPE TIED AT ONE END, LOOP ROPE AROUND HANDRAIL AT THE OTHER - SO LEMON CAN BE HEFTED OVER RAIL PARALELL TO BRIDGE.
6. PLACE 3/16" CABLE CLAMPS ON BOARD (3) FOR 'LY2' SHORTENING IF NECESSARY.

PHASE 1

1. MAKE WINCH CONNECTION AT B FROM "WIDE LOAD" BOAT WINCH 'W3' TO 'R2' ANCHOR ROPE, WINCH/PULL UP 'LY1' END AND CONNECT 'L1'.
2. WINCH OUT TO BRIDGE POSITION 'C'
3. BRING WHITE FLOAT 'H2' ONTO BOAT AND PULL UP THE END OF 3/16" CABLE 'LY2' TO SURFACE. DEPENDING ON END LOCATION, SHORTEN CABLE IF REQUIRED FOR LEMON POSITION.
4. KEEP 'LY2' ON BOARD SO END IS AVAILABLE FOR LEMON CONNECTION.
5. WINCH BACK AND RECEIVE LEMON FROM BRIDGE, CONNECT TO 'LY2'
6. FEED DEPLOYMENT ROPE 'F3' FROM BRIDGE, THROUGH PULLEY ON 'WIDE LOAD' BOAT (TO BLOCK MOUNTED WINCH 'W5' POSITION).

PHASE 2

1. RELEASE PONTOON BOAT INTO THE FREE STREAM, PAYOUT 'S1' AS REQUIRED.
2. ONCE IN LINE WITH FLOW, BEGIN TO WINCH IN 'F3' USING 'W5'.
3. EVERY 60', SHACKLE ROPE TO BLOCK, RELEASE WINCH HOOK AND PULL BACK TO BRIDGE FOR NEXT LOOP CONNECTION.
4. WHEN TEST PLATFORM NEAR BRIDGE - MAKE CONNECTION FROM PULLEY ON WINCH LINES W1 AND W2 TO DOWNSTREAM END LEMON FLOAT.
5. TEST OPERATION AND MOTION OF TEST PLATFORM USING 'W1' AND 'W2', WINCH UPSTREAM TO SLACK 'F3' AND REMOVE.
6. PASS L2 AND L3 TO PONTOON BOAT, AND CONNECT TO SHACKLES ON TURBINE.
7. PAY OUT W1 AND W2, TO MOVE PNOTOON BOAT AWAY FROM 'C'
8. WHEN SECURE, WINCH "WIDE LOAD" UPSTREAM TO 'C' AND TIE UP TO FLOAT ROPE, START ENGINE CUT WINCH CABLE WHEN CABLE IS SLACK.
9. MAKE SURE PROPELLER IS FREE OF CABLES, UNTIE FROM WHITE BUOY 'R2' AND CLEAR AREA.

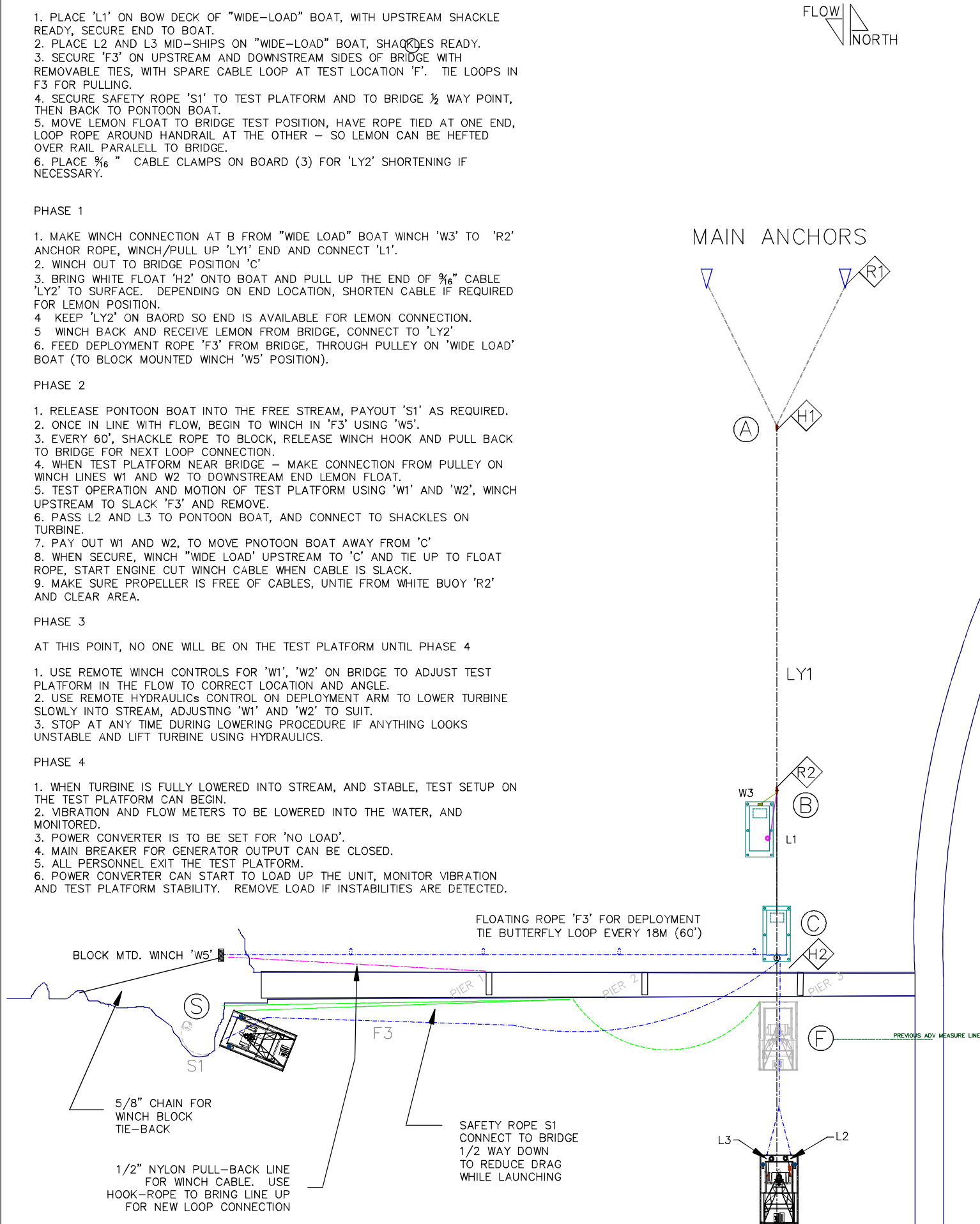
PHASE 3

AT THIS POINT, NO ONE WILL BE ON THE TEST PLATFORM UNTIL PHASE 4

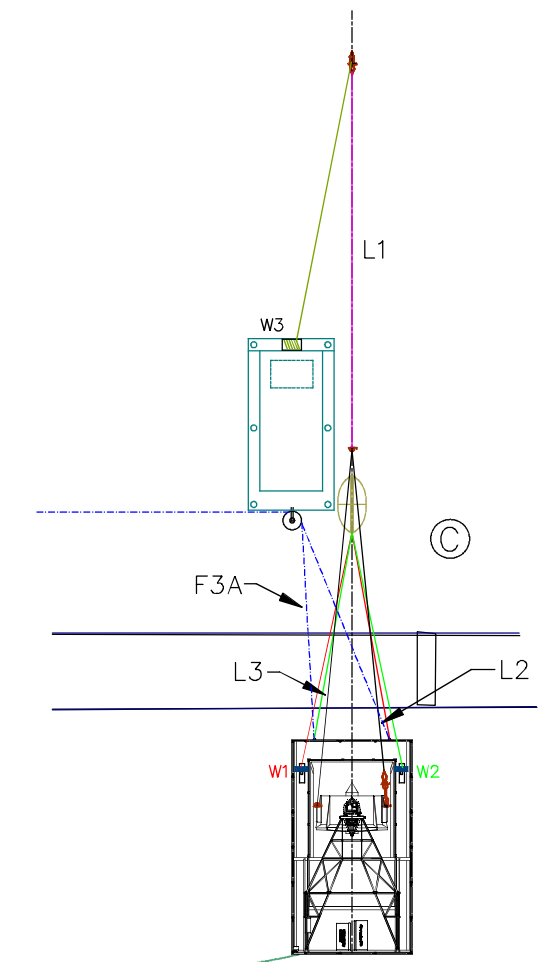
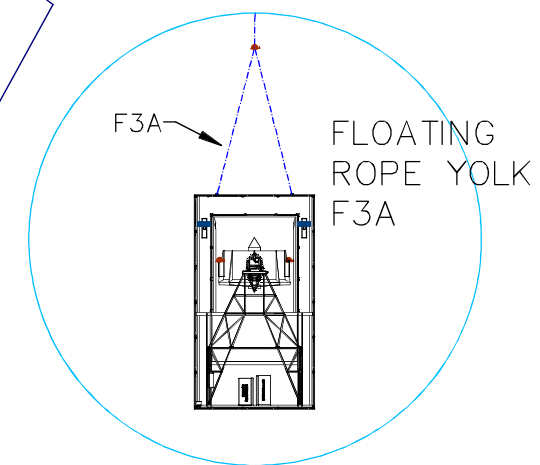
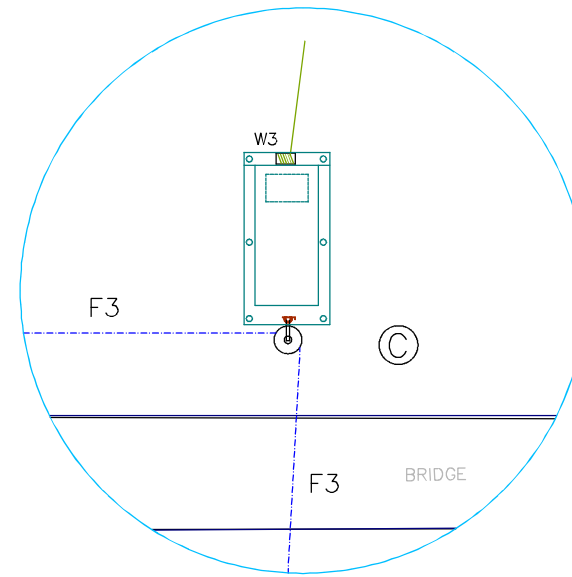
1. USE REMOTE WINCH CONTROLS FOR 'W1', 'W2' ON BRIDGE TO ADJUST TEST PLATFORM IN THE FLOW TO CORRECT LOCATION AND ANGLE.
2. USE REMOTE HYDRAULICS CONTROL ON DEPLOYMENT ARM TO LOWER TURBINE SLOWLY INTO STREAM, ADJUSTING 'W1' AND 'W2' TO SUIT.
3. STOP AT ANY TIME DURING LOWERING PROCEDURE IF ANYTHING LOOKS UNSTABLE AND LIFT TURBINE USING HYDRAULICS.

PHASE 4

1. WHEN TURBINE IS FULLY LOWERED INTO STREAM, AND STABLE, TEST SETUP ON THE TEST PLATFORM CAN BEGIN.
2. VIBRATION AND FLOW METERS TO BE LOWERED INTO THE WATER, AND MONITORED.
3. POWER CONVERTER IS TO BE SET FOR 'NO LOAD'.
4. MAIN BREAKER FOR GENERATOR OUTPUT CAN BE CLOSED.
5. ALL PERSONNEL EXIT THE TEST PLATFORM.
6. POWER CONVERTER CAN START TO LOAD UP THE UNIT, MONITOR VIBRATION AND TEST PLATFORM STABILITY. REMOVE LOAD IF INSTABILITIES ARE DETECTED.

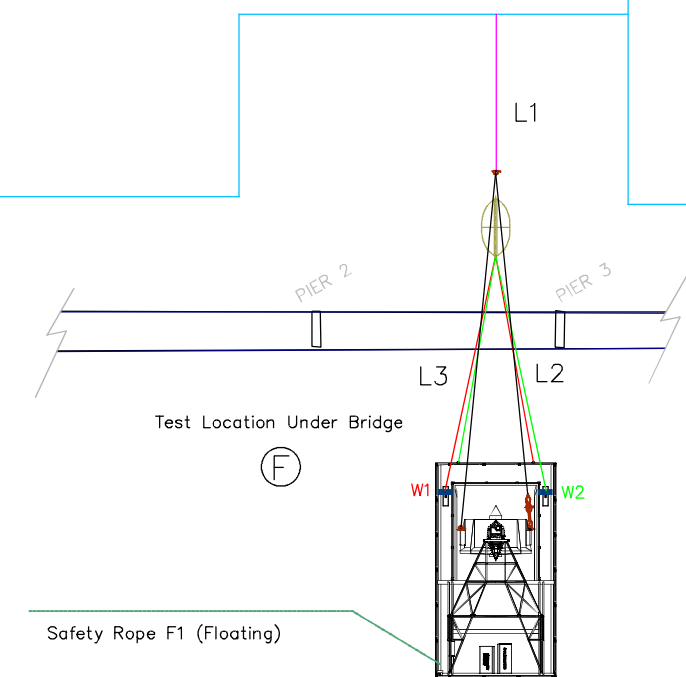


MAIN ANCHORS



AT POSITION 'C' BOTH UEK BOAT AND PONTOON BOAT WILL BE IN CLOSE PROXIMITY TO THE BRIDGE.

ONCE W1 AND W2 ARE CONNECTED TO (LEMON) FLOAT, F3 AND PULLEY WILL BE REMOVED AND FINAL CONNECTION TO MAIN LINE L1 WILL BE MADE TO L2 AND L3 ON THE DECK OF UEK BOAT.

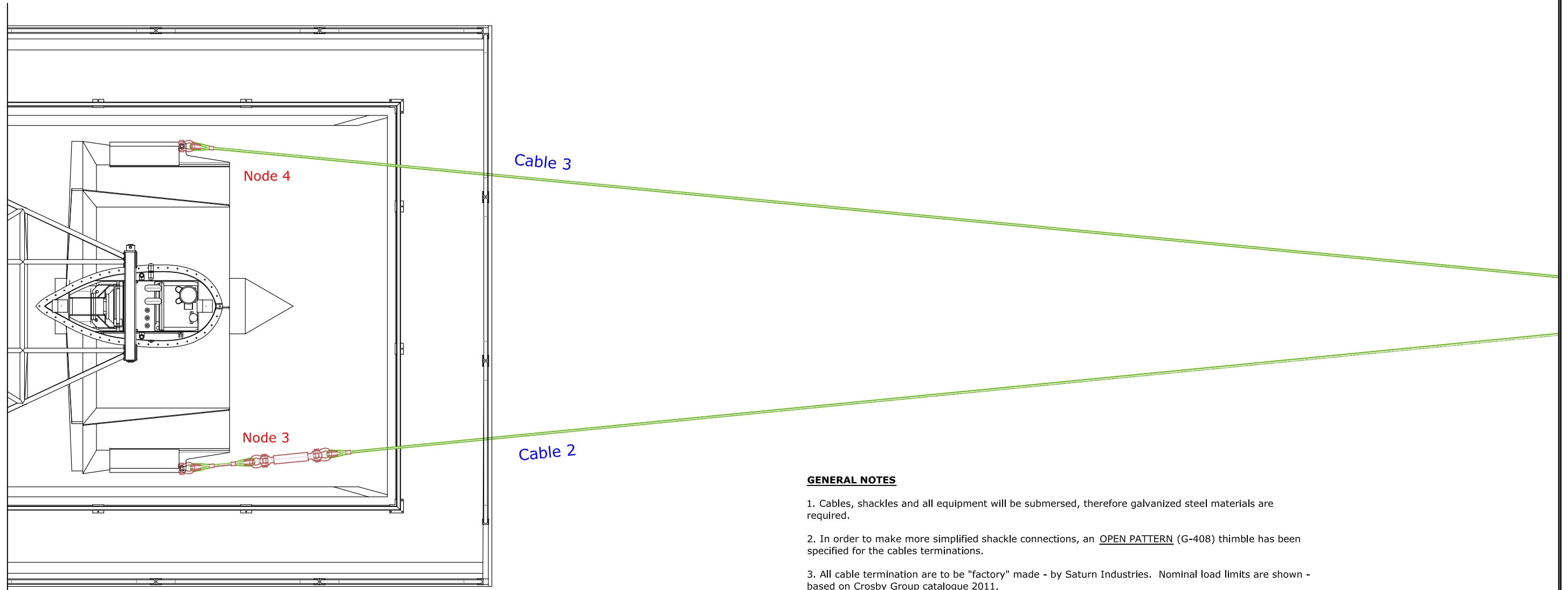


IN FINAL TEST LOCATION (F), AFTER MAIN CABLE L1 IS CONNECTED TO TURBINE HARNESS L2 AND L3, WINCHES W1 AND W2 CAN BE USED TO ADJUST LOCATION OF PONTOON BOAT RELATIVE TO TURBINE.

- L = WIRE ROPE
- F = FLOATING ROPE
- W1 = WINCH, #1, #2, #3, AND #5
- S1 = FLOATING SAFETY ROPE

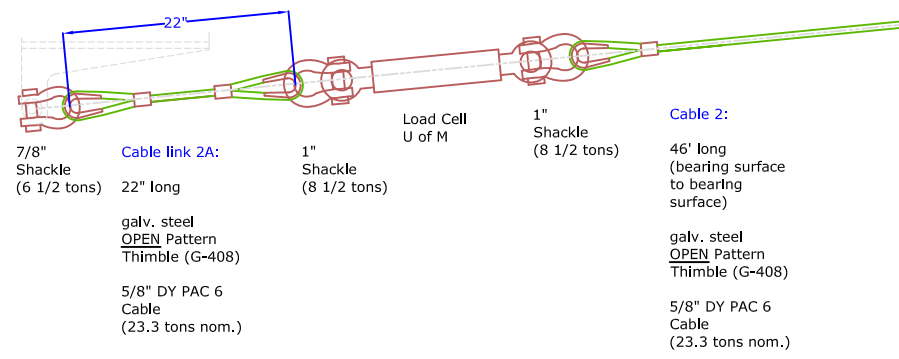
- R# = RED BUOY, #1 AND #2
- H# = WHITE BUOY, #1 AND #2

| | |
|---|-------------------------|
| John Woods, U of M | |
| UNDERWATER KINETIC TURBINE PROJECT | |
| POINTE DUBOIS, MANITOBA | |
| UNIVERSITY OF MANITOBA | |
| UEK TURBINE DEPLOYMENT PLAN | 3. FOR REVIEW |
| | 2. WITH DEPLOYMENT V1 |
| | 1. INITIAL JCW 05/12/10 |
| 100R3 | |

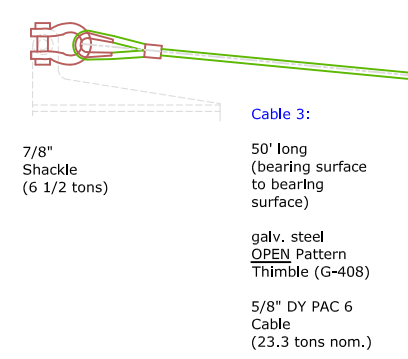


GENERAL NOTES

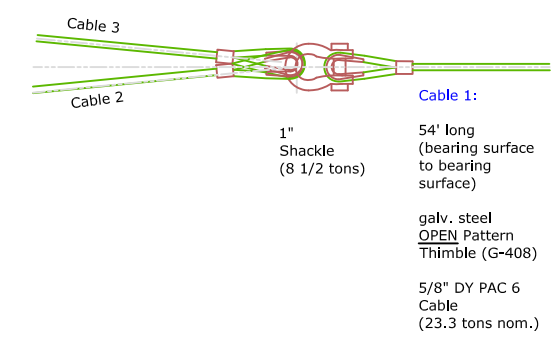
1. Cables, shackles and all equipment will be submersed, therefore galvanized steel materials are required.
2. In order to make more simplified shackle connections, an OPEN PATTERN (G-408) thimble has been specified for the cables terminations.
3. All cable termination are to be "factory" made - by Saturn Industries. Nominal load limits are shown - based on Crosby Group catalogue 2011.
4. Cables are specified as DY PAC 6 High Performance wire rope cables.
5. Entire system is estimated to have a downstream force of 10,000 pounds. However, the weakest known link - in the mooring system shown here are the 6½ ton shackles - right at the turbine connection points (Nodes 3 and 4). Shackles have maximum proof load of 2x, and ultimate strength of 6x.



Assembly at Node 3

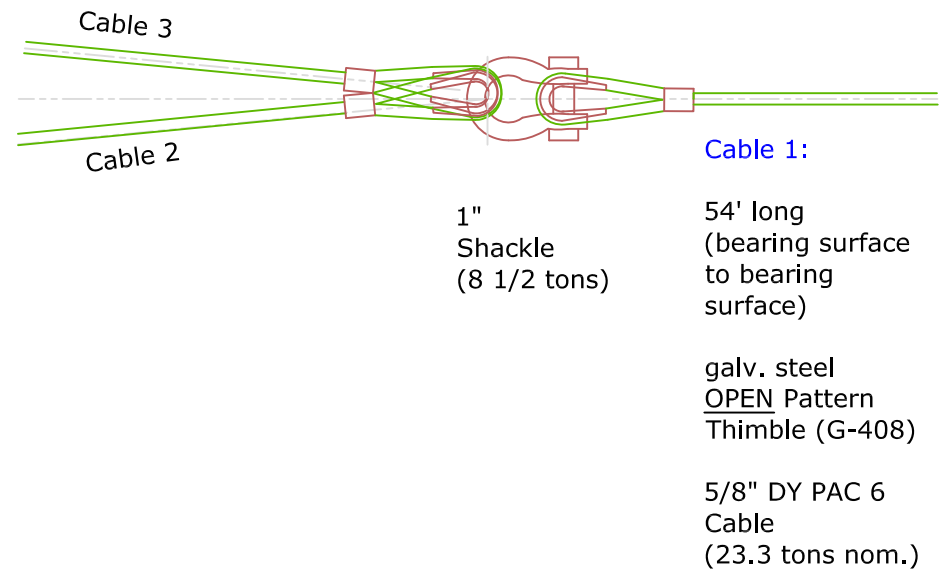


Assembly at Node 4

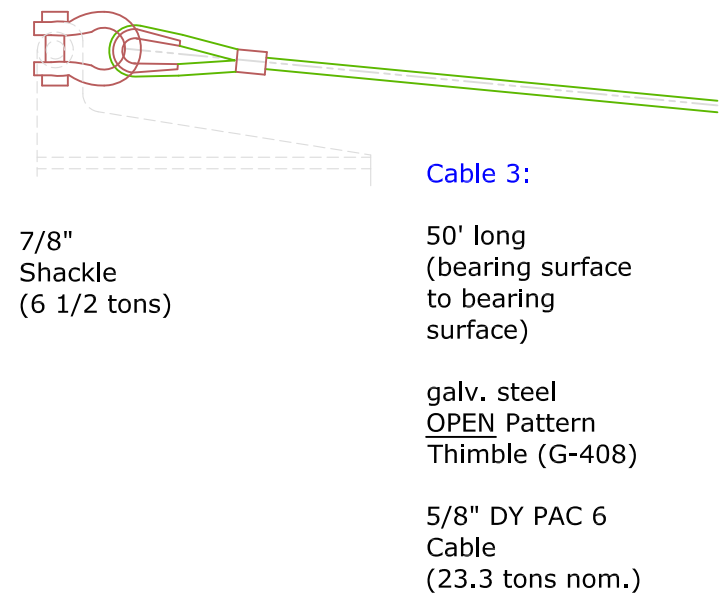


Assembly at Node 2

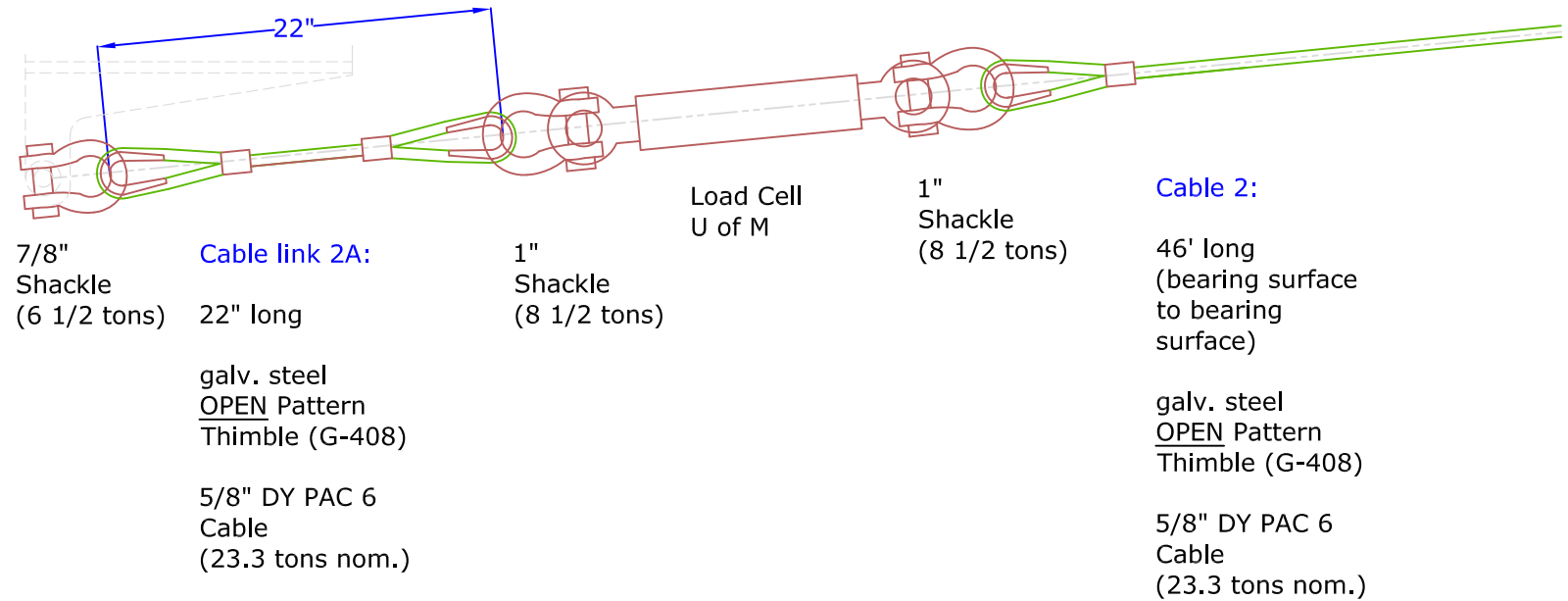
| | | |
|--|-----|---------------------------|
| 10m | 20m | John Woods, U of M |
| UNDERWATER KINETIC TURBINE PROJECT | | |
| POINTE DUBOIS, MANITOBA | | |
| UNIVERSITY OF MANITOBA | | |
| DETAILS FOR ANCHOR CABLING SEE C30 FOR REST OF LAYOUT | | 1. INITIAL JCW 2011-09-14 |
| C - 31 | | |



Assembly at Node 2



Assembly at Node 4



Assembly at Node 3

GENERAL NOTES

1. Cables, shackles and all equipment will be submersed, therefore galvanized steel materials are required.
2. In order to make more simplified shackle connections, an OPEN PATTERN (G-408) thimble has been specified for the cables terminations.
3. All cable termination are to be "factory" made - by Saturn Industries. Nominal load limits are shown - based on Crosby Group catalogue 2011.
4. Cables are specified as DY PAC 6 High Performance wire rope cables.
5. Entire system is estimated to have a downstream force of 10,000 pounds. However, the weakest known link - in the mooring system shown here are the 6½ ton shackles - right at the turbine connection points (Nodes 3 and 4). Shackles have maximum proof load of 2x, and ultimate strength of 6x.

| | | |
|---|-----|--------------------------|
| 10m | 20m | John Woods, U of M |
| UNDERWATER KINETIC TURBINE PROJECT | | |
| POINTE DUBOIS, MANITOBA | | |
| UNIVERSITY OF MANITOBA | | |
| DETAILS FOR ANCHOR CABLING (same as C31 with larger scale) | | L INITIAL JCW 2011-09-14 |
| C - 32 | | |

Appendix 2
Example Safety Plan

For:

PhD Thesis

John Woods

2017

University of Manitoba

Deployment Procedure
October 1, 2011
Version 2.0

University of Manitoba
Hydrokinetic Turbine
at
Manitoba Hydro Generating Station
Pointe du Bois, Manitoba

Version 2.0

**University of Manitoba
Hydrokinetic Turbine
Pointe du Bois Manitoba
Deployment Procedure
October 1, 2011**

1 Introduction

This document outlines the procedures to be used during the deployment of the Hydro-Kinetic turbine upstream of Manitoba Hydro's Pointe du Bois Generating Station in south-western Manitoba.

Having successfully deployed two smaller turbines, in association with New Energy Corporation, at the same site, with the same test platform, University of Manitoba researchers will deploy a 60kW hydro-kinetic turbine generator using similar methods.

Refer to Figure N-1 for a description of identified areas, terms and components. Following that is a graphic showing an aerial photo of the site and some relevant deployment elements.

2 Test Situation

- 2.1 The test site will be in a small area of the Winnipeg River, designated as the *Forebay* for the Point DuBois Generating Station. The specific location is approximately 100m upstream of the Power House, and between piers 2 and 3 of an existing walking bridge.

The attached diagram C20 R4 shows a partial site plan and a general arrangement of the test setup. Drawing C21 R4, also attached, shown a cross section of the deployment and mooring system.

We note that the walkway bridge itself is slated for demolition as part of Manitoba Hydro's Spillway replacement project, and is not suitable for any support of the test platform – or turbine. It will, however, be used by research personnel to gain access to the test platform after mooring – and also during the actual deployment – to ensure safety of researchers.

- 2.2 The NORMAL flow of the Winnipeg River is reasonably high in this area – in the order of 2.5 m/s, which is one of the reasons it was chosen as the

- test site. The turbine itself is rated for full output at 3 m/s. However, due to low water levels, the flow may be as little as 1.1 m/s during test.
- 2.3 In October 2006, an anchoring system was installed into the bottom of the river bed approximately 100m upstream of the walkway bridge / test site. It consists of two 30mm diameter 2.4m long rods, drilled into the rock, and grouted in place. To each of these a 20m long a 9.5mm (3/8") steel chain was connected, and at the free end, both were connected to a single 300mm connection ring. This continues to be the basis of the mooring system. See attached Canadian Engineering Design Network paper, July 2007 for details.
 - 2.4 A 30mm (1 1/4") diameter steel wire rope cable extends the mooring point downstream, towards the test site. The cable ends approximately 30m upstream of the bridge, and this is the point to which the pontoon boat test structure will be connected using similar wire ropes in a yolk-style two point connection. Refer again to Diagram C20 R4. Deployment of the pontoon boat is covered in the notes.
 - 2.5 The pontoon boat or test platform was used previously by the test group to test both a 5kW and a 25kW vertical axis kinetic turbine for New Energy Corporation. It is approximately 9.1m long and 5.5m wide (30' x 18'), supported by two full-length aluminum pontoons.
 - 2.6 A support arm, or A-arm has been constructed of welded web, tubular steel, and fitted with two hydraulic pistons designed to raise and lower the turbine and support structure (referred to as the "leg") into the flowing water. The design has taken into account a worst-case scenario – that being the entire leg being full of water.
 - 2.7 The leg itself supports the rotor and houses the generator and speed increaser (gear box) and is sealed from water ingress. A sump pump (with oil separator) has been installed in the leg to remove any water which may splash in (or minor leaking of seals etc.).

3 Safety

- 3.1 The system has been designed to allow for the rotor (leg) to be lowered into the water with the research personnel standing on the walkway bridge, such that no person will be on the test platform during deployment. Once the rotor is fully submerged and proven to be stable, personnel can board the platform using a ladder system and fall arrest equipment. Personnel have received formal fall arrest training.

- 3.2 Electrical safety is maintained by having break-away cordsets, for both generated power and ancillary (shore) power. A breaker with disconnecting handle has been installed between the generator and the measurement and control box on board the boat – for emergency disconnecting of the power.
- 3.3 Life jackets will be worn by all deployment personnel during deployment. Life rings will be onboard both boats, as well as a station at the west end of the foot bridge.

DEPLOYMENT 2012 – UEK Turbine on Pontoon Platform

In early October 2011, the test platform was prepared for a final test at the Manitoba Hydro Point du Bois Generating Station.

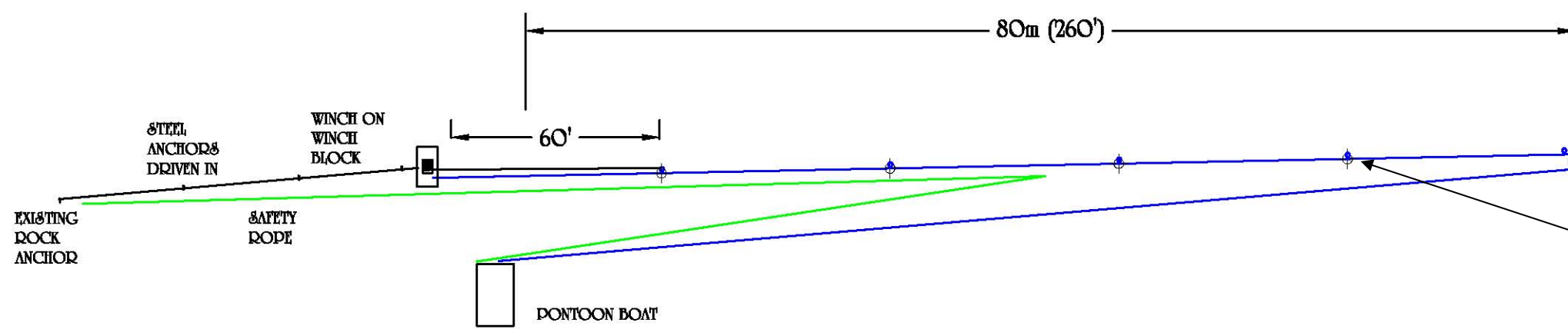
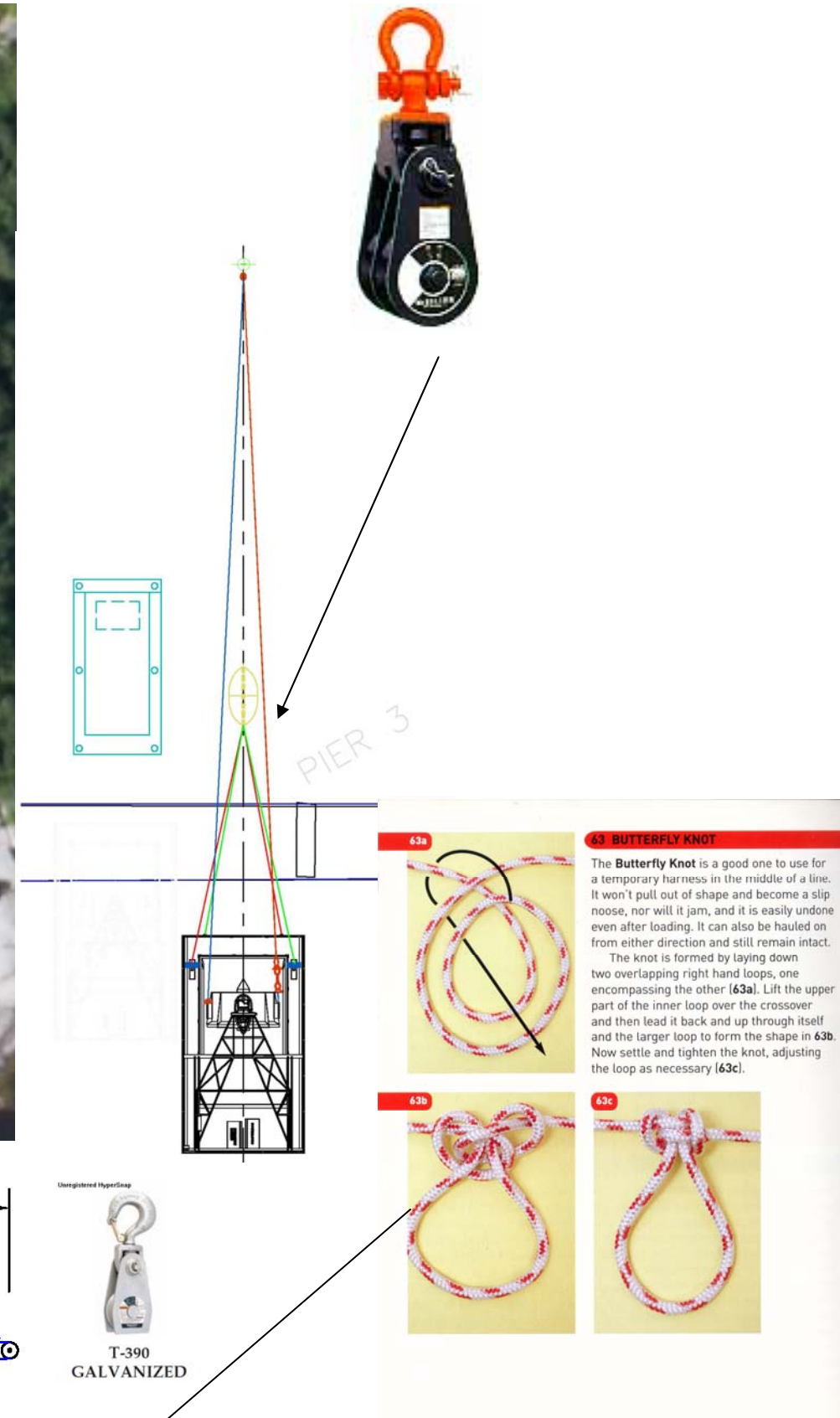
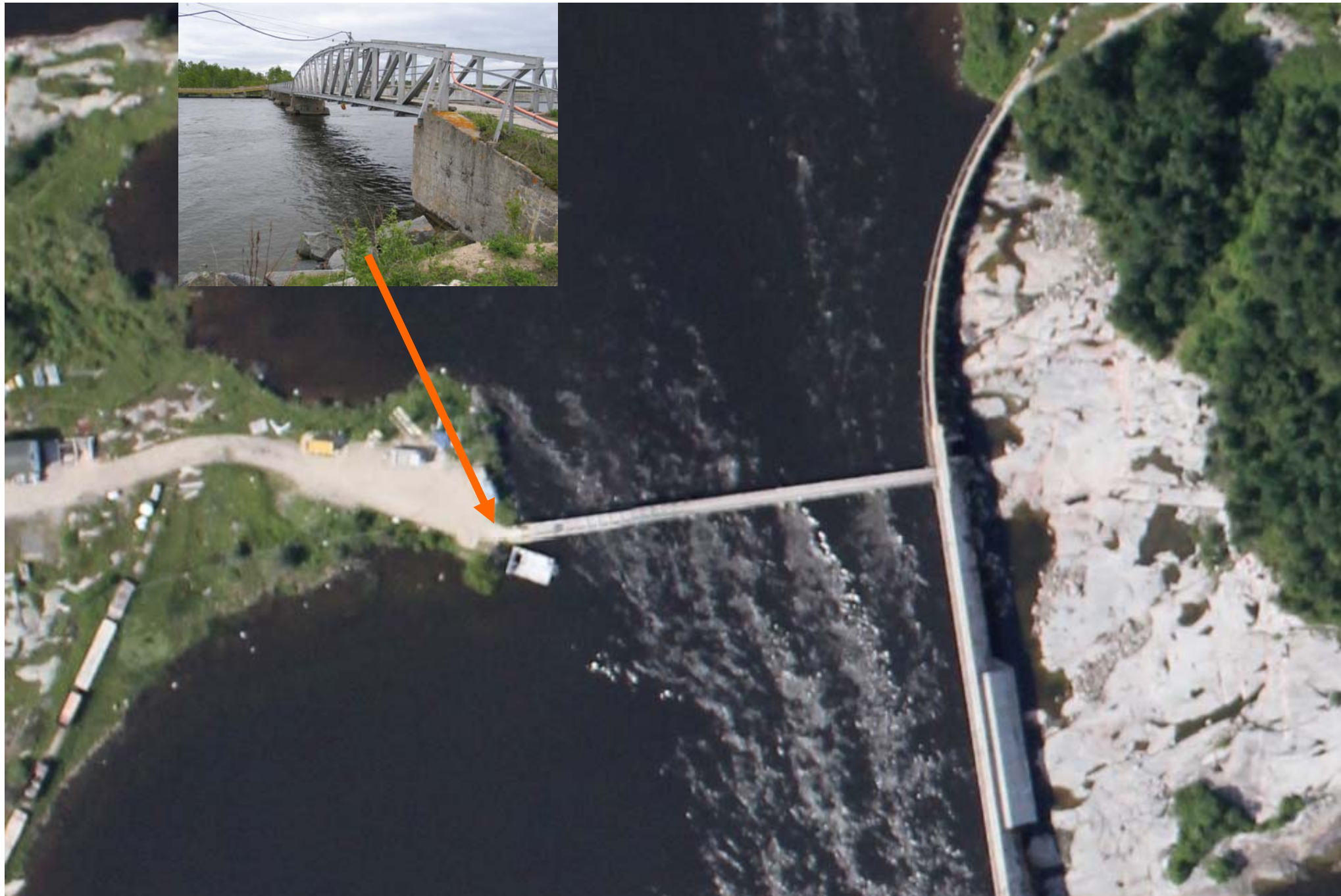
A Deployment and Safety manual was prepared and reviewed by the test group. The manual is attached for reference as it includes a list of identities (nomenclature) to ensure consistent terminology for the various components. This list is identified as Figure N-1. That document also shows the cables, winches and fitting required to safely deploy the pontoon boat with the turbine onboard, and so that will not be repeated here.

Before deployment, the final on-site fit up included the following work:

- Installation of the Turbine/Generator onto the support arm on the platform
- Connection of cooling pumps for gearbox cooling system
- Connection of bilge pump to oil/water separator system
- Connection of the generator output cables to the termination cabinet at the top of the generator support housing
- Installation of the safety disconnect switch on the support arm
- Main output cable from the safety disconnect switch to the data acquisition box at the stern of the platform
- Connection of current transformers, voltage transformers and power analyzer to main output cable
- Installation of output cable and outlet to on-shore Power Converter system
- Installation of the acoustic Doppler velocimeter (flow and turbulence measurement) on the platform ahead of the turbine
- Installation and connection of pressure transducers around the turbine shroud, and vibration sensors to the Data Acquisition device
- Connection of shore power – for the measurement devices and ancillary pumps

The cable list attached identifies the cables and accessory wiring, with reference to Figure N-1 for equipment descriptions.

Photo 1 shows the current transformers (one per phase), terminal blocks for phase voltages and a voltage transformer, which were used to measure the generator output at the test platform, ahead of the main connector (which is shown in Photo 2. This allowed the generator to be started and test run – before connecting the output to the Power Converter on shore.



Deployment Graphic – 60kW Turbine
 October 1, 2011 – Pointe du Bois Manitoba
 John Woods U of M

PROCEDURE

PHASE 0

1. PLACE 'L1' ON BOW DECK OF "WIDE-LOAD" BOAT, WITH UPSTREAM SHACKLE READY, SECURE END TO BOAT.
2. PLACE L2 AND L3 MID-SHIPS ON "WIDE-LOAD" BOAT, SHACKLES READY.
3. SECURE 'F3' ON UPSTREAM AND DOWNSTREAM SIDES OF BRIDGE WITH REMOVABLE TIES, WITH SPARE CABLE LOOP AT TEST LOCATION 'F'. TIE LOOPS IN F3 FOR PULLING.
4. SECURE SAFETY ROPE 'S1' TO TEST PLATFORM AND TO BRIDGE 1/2 WAY POINT, THEN BACK TO PONTOON BOAT.
5. MOVE LEMON FLOAT TO BRIDGE TEST POSITION, HAVE ROPE TIED AT ONE END, LOOP ROPE AROUND HANDRAIL AT THE OTHER - SO LEMON CAN BE HEFTED OVER RAIL PARALLEL TO BRIDGE.
6. PLACE 3/8" CABLE CLAMPS ON BOARD (3) FOR 'LY2' SHORTENING IF NECESSARY.

PHASE 1

1. MAKE WINCH CONNECTION AT B FROM "WIDE LOAD" BOAT WINCH 'W3' TO 'R2' ANCHOR ROPE, WINCH/PULL UP 'LY1' END AND CONNECT 'L1'.
2. WINCH OUT TO BRIDGE POSITION 'C'
3. BRING WHITE FLOAT 'H2' ONTO BOAT AND PULL UP THE END OF 3/8" CABLE 'LY2' TO SURFACE. DEPENDING ON END LOCATION, SHORTEN CABLE IF REQUIRED FOR LEMON POSITION.
4. KEEP 'LY2' ON BOARD SO END IS AVAILABLE FOR LEMON CONNECTION.
5. WINCH BACK AND RECEIVE LEMON FROM BRIDGE, CONNECT TO 'LY2'
6. FEED DEPLOYMENT ROPE 'F3' FROM BRIDGE, THROUGH PULLEY ON 'WIDE LOAD' BOAT (TO BLOCK MOUNTED WINCH 'W5' POSITION).

PHASE 2

1. RELEASE PONTOON BOAT INTO THE FREE STREAM, PAYOUT 'S1' AS REQUIRED.
2. ONCE IN LINE WITH FLOW, BEGIN TO WINCH IN 'F3' USING 'W5'.
3. EVERY 60', SHACKLE ROPE TO BLOCK, RELEASE WINCH HOOK AND PULL BACK TO BRIDGE FOR NEXT LOOP CONNECTION.
4. WHEN TEST PLATFORM NEAR BRIDGE - MAKE CONNECTION FROM PULLEY ON WINCH LINES W1 AND W2 TO DOWNSTREAM END LEMON FLOAT.
5. TEST OPERATION AND MOTION OF TEST PLATFORM USING 'W1' AND 'W2', WINCH UPSTREAM TO SLACK 'F3' AND REMOVE.
6. PASS L2 AND L3 TO PONTOON BOAT, AND CONNECT TO SHACKLES ON TURBINE.
7. PAY OUT W1 AND W2, TO MOVE PONTOON BOAT AWAY FROM 'C'
8. WHEN SECURE, WINCH "WIDE LOAD" UPSTREAM TO 'C' AND TIE UP TO FLOAT ROPE, START ENGINE CUT WINCH CABLE WHEN CABLE IS SLACK.
9. MAKE SURE PROPELLER IS FREE OF CABLES, UNTIE FROM WHITE BUOY 'R2' AND CLEAR AREA.

PHASE 3

AT THIS POINT, NO ONE WILL BE ON THE TEST PLATFORM UNTIL PHASE 4

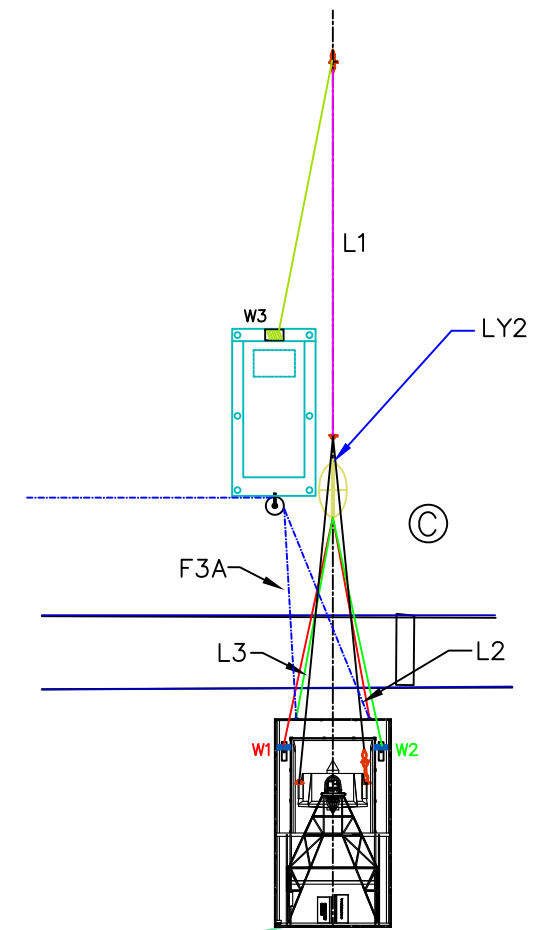
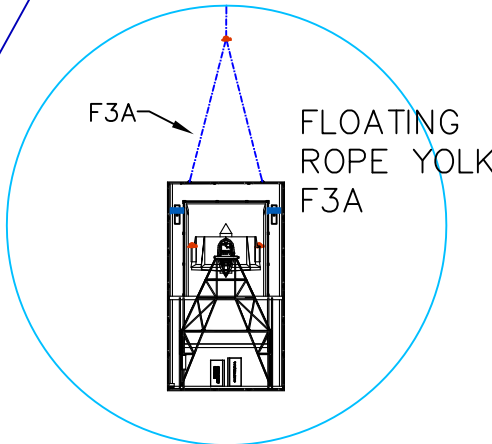
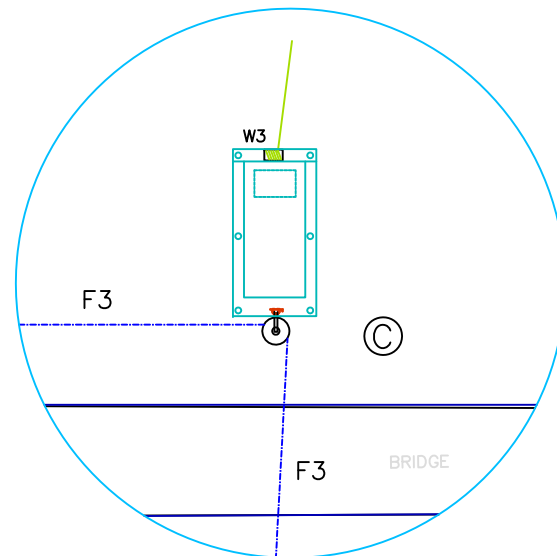
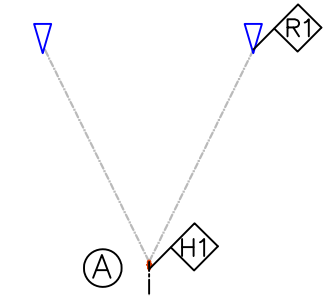
1. USE REMOTE WINCH CONTROLS FOR 'W1', 'W2' ON BRIDGE TO ADJUST TEST PLATFORM IN THE FLOW TO CORRECT LOCATION AND ANGLE.
2. USE REMOTE HYDRAULICS CONTROL ON DEPLOYMENT ARM TO LOWER TURBINE SLOWLY INTO STREAM, ADJUSTING 'W1' AND 'W2' TO SUIT.
3. STOP AT ANY TIME DURING LOWERING PROCEDURE IF ANYTHING LOOKS UNSTABLE AND LIFT TURBINE USING HYDRAULICS.

PHASE 4

1. WHEN TURBINE IS FULLY LOWERED INTO STREAM, AND STABLE, TEST SETUP ON THE TEST PLATFORM CAN BEGIN.
2. VIBRATION AND FLOW METERS TO BE LOWERED INTO THE WATER, AND MONITORED.
3. POWER CONVERTER IS TO BE SET FOR 'NO LOAD'.
4. MAIN BREAKER FOR GENERATOR OUTPUT CAN BE CLOSED.
5. ALL PERSONNEL EXIT THE TEST PLATFORM.
6. POWER CONVERTER CAN START TO LOAD UP THE UNIT, MONITOR VIBRATION AND TEST PLATFORM STABILITY. REMOVE LOAD IF INSTABILITIES ARE DETECTED.



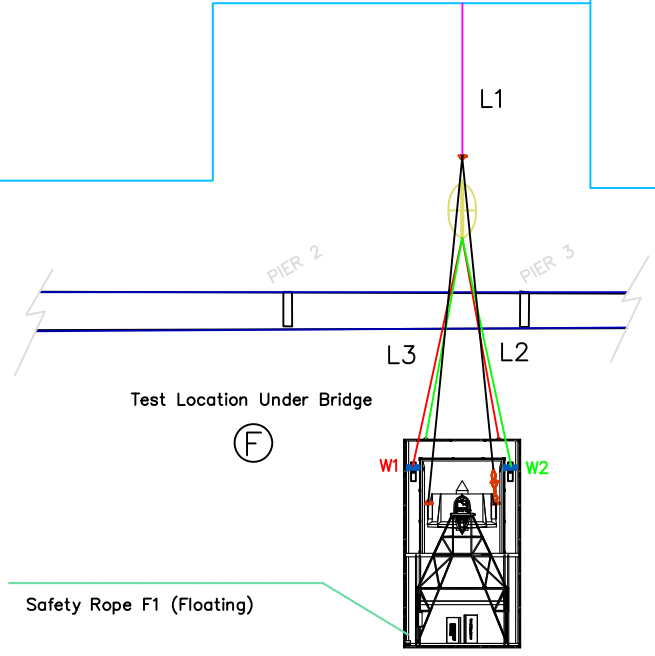
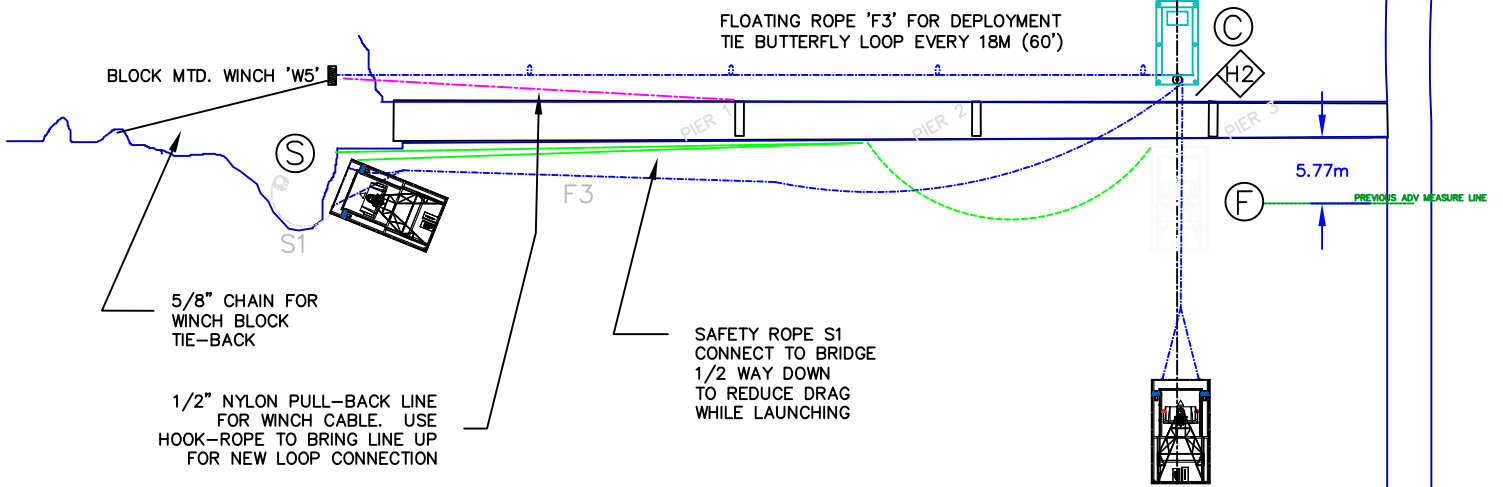
MAIN ANCHORS



AT POSITION 'C' BOTH UEK BOAT AND PONTOON BOAT WILL BE IN CLOSE PROXIMITY TO THE BRIDGE.

ONCE W1 AND W2 ARE CONNECTED TO (LEMON) FLOAT, F3 AND PULLEY WILL BE REMOVED AND FINAL CONNECTION TO MAIN LINE L1 WILL BE MADE TO L2 AND L3 ON THE DECK OF UEK BOAT.

- L = WIRE ROPE
- F = FLOATING ROPE
- W1 = WINCH, #1, #2, #3, AND #5
- S1 = FLOATING SAFETY ROPE
- R# = RED BUOY, #1 AND #2
- H# = WHITE BUOY, #1 AND #2



IN FINAL TEST LOCATION (F), AFTER MAIN CABLE L1 IS CONNECTED TO TURBINE HARNESS L2 AND L3, WINCHES W1 AND W2 CAN BE USED TO ADJUST LOCATION OF PONTOON BOAT RELATIVE TO TURBINE.

| | |
|---|-------------------------|
| John Woods, c U of M | |
| UNDERWATER KINETIC TURBINE PROJECT | |
| POINTE DUBOIS, MANITOBA | |
| UNIVERSITY OF MANITOBA | |
| 60kW TURBINE DEPLOYMENT PLAN | 4. FINAL JCW 09/28/2011 |
| | 3. FOR REVIEW |
| | 2. WITH DEPLOYMENT V1 |
| | 1. INITIAL JCW 05/12/10 |
| C20 R4 | |

PHASE 0

1. PLACE 'L1' ON BOW DECK OF "WIDE-LOAD" BOAT, WITH UPSTREAM SHACKLE READY, SECURE END TO BOAT.
2. PLACE L2 AND L3 MID-SHIPS ON "WIDE-LOAD" BOAT, SHACKLES READY.
3. SECURE 'F3' ON UPSTREAM AND DOWNSTREAM SIDES OF BRIDGE WITH REMOVABLE TIES, WITH SPARE CABLE LOOP AT TEST LOCATION 'F'. TIE LOOPS IN F3 FOR PULLING.
4. SECURE SAFETY ROPE 'S1' TO TEST PLATFORM AND TO BRIDGE ½ WAY POINT, THEN BACK TO PONTOON BOAT.
5. MOVE LEMON FLOAT TO BRIDGE TEST POSITION, HAVE ROPE TIED AT ONE END, LOOP ROPE AROUND HANDRAIL AT THE OTHER – SO LEMON CAN BE HEFTED OVER RAIL PARALELL TO BRIDGE.
6. PLACE ⅝" CABLE CLAMPS ON BOARD (3) FOR 'LY2' SHORTENING IF NECESSARY.

PHASE 1

1. MAKE WINCH CONNECTION AT B FROM "WIDE LOAD" BOAT WINCH 'W3' TO 'R2' ANCHOR ROPE, WINCH/PULL UP 'LY1' END AND CONNECT 'L1'.
2. WINCH OUT TO BRIDGE POSITION 'C'
3. BRING WHITE FLOAT 'H2' ONTO BOAT AND PULL UP THE END OF ⅝" CABLE 'LY2' TO SURFACE. DEPENDING ON END LOCATION, SHORTEN CABLE IF REQUIRED FOR LEMON POSITION.
4. KEEP 'LY2' ON BAORD SO END IS AVAILABLE FOR LEMON CONNECTION.
5. WINCH BACK AND RECEIVE LEMON FROM BRIDGE, CONNECT TO 'LY2'
6. FEED DEPLOYMENT ROPE 'F3' FROM BRIDGE, THROUGH PULLEY ON 'WIDE LOAD' BOAT (TO BLOCK MOUNTED WINCH 'W5' POSITION).

PHASE 2

1. RELEASE PONTOON BOAT INTO THE FREE STREAM, PAYOUT 'S1' AS REQUIRED.
2. ONCE IN LINE WITH FLOW, BEGIN TO WINCH IN 'F3' USING 'W5'.
3. EVERY 60', SHACKLE ROPE TO BLOCK, RELEASE WINCH HOOK AND PULL BACK TO BRIDGE FOR NEXT LOOP CONNECTION.
4. WHEN TEST PLATFORM NEAR BRIDGE – MAKE CONNECTION FROM PULLEY ON WINCH LINES W1 AND W2 TO DOWNSTREAM END LEMON FLOAT.
5. TEST OPERATION AND MOTION OF TEST PLATFORM USING 'W1' AND 'W2', WINCH UPSTREAM TO SLACK 'F3' AND REMOVE.
6. PASS L2 AND L3 TO PONTOON BOAT, AND CONNECT TO SHACKLES ON TURBINE.
7. PAY OUT W1 AND W2, TO MOVE PNOTOON BOAT AWAY FROM 'C'
8. WHEN SECURE, WINCH "WIDE LOAD' UPSTREAM TO 'C' AND TIE UP TO FLOAT ROPE, START ENGINE CUT WINCH CABLE WHEN CABLE IS SLACK.
9. MAKE SURE PROPELLER IS FREE OF CABLES, UNTIE FROM WHITE BUOY 'R2' AND CLEAR AREA.

PHASE 3

AT THIS POINT, NO ONE WILL BE ON THE TEST PLATFORM UNTIL PHASE 4

1. USE REMOTE WINCH CONTROLS FOR 'W1', 'W2' ON BRIDGE TO ADJUST TEST PLATFORM IN THE FLOW TO CORRECT LOCATION AND ANGLE.
2. USE REMOTE HYDRAULICS CONTROL ON DEPLOYMENT ARM TO LOWER TURBINE SLOWLY INTO STREAM, ADJUSTING 'W1' AND 'W2' TO SUIT.
3. STOP AT ANY TIME DURING LOWERING PROCEDURE IF ANYTHING LOOKS UNSTABLE AND LIFT TURBINE USING HYDRAULICS.

PHASE 4

1. WHEN TURBINE IS FULLY LOWERED INTO STREAM, AND STABLE, TEST SETUP ON THE TEST PLATFORM CAN BEGIN.
2. VIBRATION AND FLOW METERS TO BE LOWERED INTO THE WATER, AND MONITORED.
3. POWER CONVERTER IS TO BE SET FOR 'NO LOAD'.
4. MAIN BREAKER FOR GENERATOR OUTPUT CAN BE CLOSED.
5. ALL PERSONNEL EXIT THE TEST PLATFORM.
6. POWER CONVERTER CAN START TO LOAD UP THE UNIT, MONITOR VIBRATION AND TEST PLATFORM STABILITY. REMOVE LOAD IF INSTABILITIES ARE DETECTED.

TEST FACILITY [F]

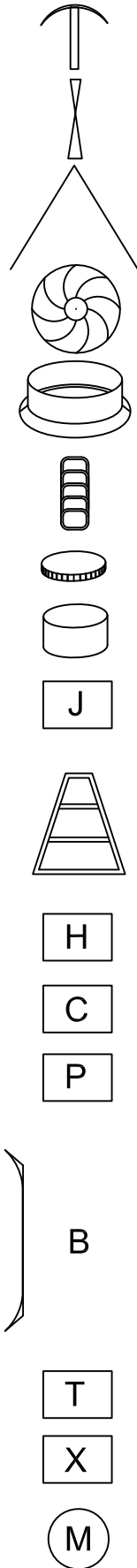
PONTOON BOAT [P]

BRIDGE [B]

TRAILER [T]

MOORING [M]

IN-WATER LEG [L]



- M MOORING
- W WIRE ROPE
- Y YOLK
- R ROTOR
- S SHROUD
- D DRIVE CHAIN
- E SPEED INCREASER (GEAR)
- G GENERATOR
- J JUNCTION BOX
- A A-ARM
(SUPPORT STRUCTURE)
- H HYDRAULIC CONTROL BOX
- C CONTROL BOX
- P POWER PANEL
- B BRIDGE
- T TRAILER (U of M)
- X POWER CONVERTER
(HVDC)
- M METERING AND GRID
(MB HYDRO)

WHEREVER POSSIBLE, REFER TO LOCATIONS, SYSTEMS, SUB-SYSTEMS ETC. BY WAY OF LETTERS SHOWN. START WITH LOCATION, THEN SYSTEM.

IN SOME CASES, IDENTITIES ARE USED FOR LOCATION AND SYSTEM.

Cable List

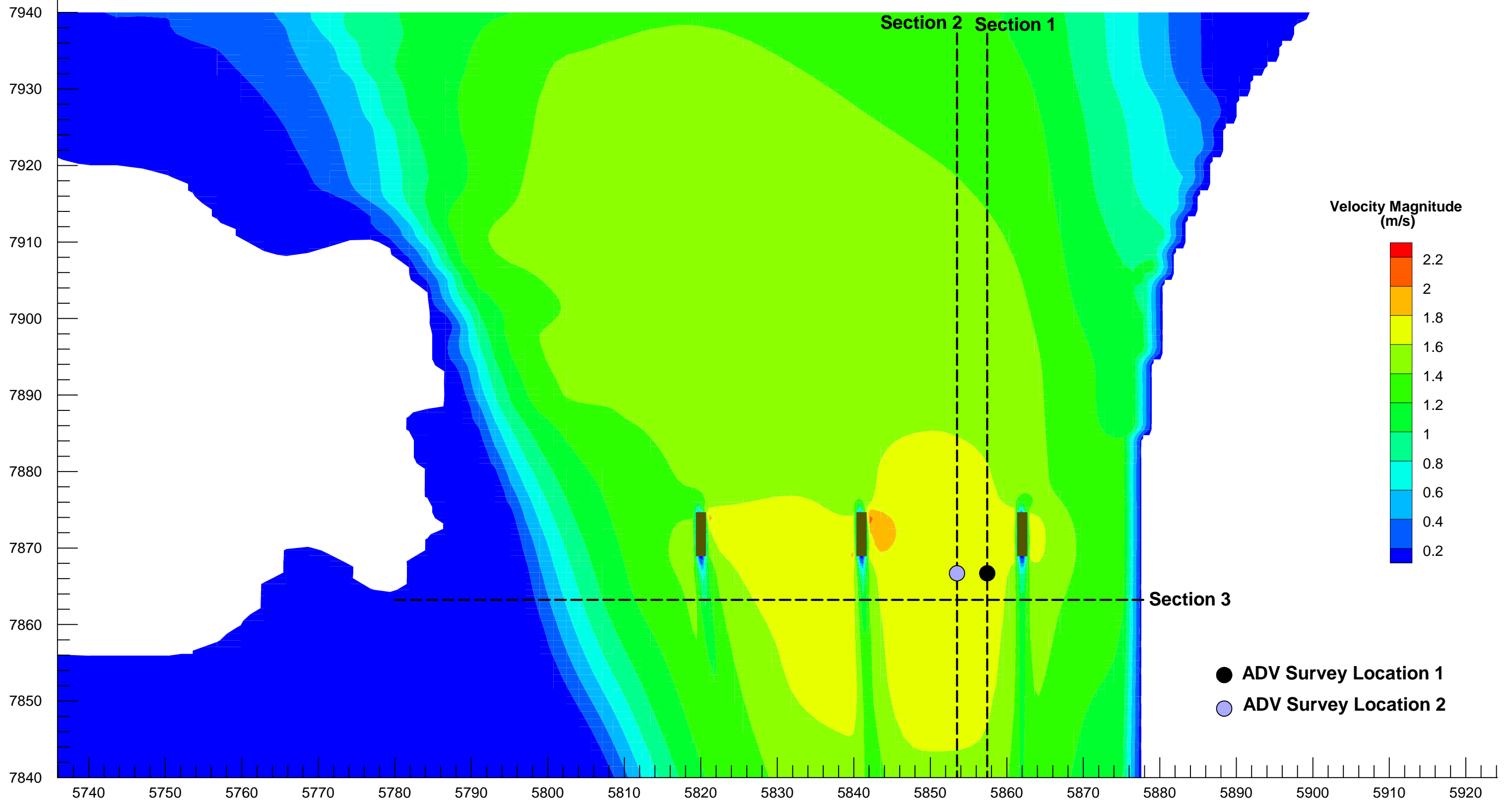
Refer to Identifies Legend N-1 for further naming conventions

Cable Reference Number

| Ref Num | Short Tag | Location | System | Sub-System | Component | Mode | Length | Number | End | Outlet |
|---------|-----------|--------------|-------------------------|-----------------|----------------------------|----------------|--------|--------|-----|--------|
| 1 | F1 | Yolk | Y | Load Cell | N Load Cell | F A | A | 1 | C | |
| 2 | P1 | Leg | L Shroud | S Monitoring | N Pressure Trans | P Analoge | A | 1 | C | |
| 3 | P2 | Leg | L Shroud | S Monitoring | N Pressure Trans | P Analoge | A | 2 | C | |
| 4 | P3 | Leg | L Shroud | S Monitoring | N Pressure Trans | P Analoge | A | 3 | C | |
| 5 | P4 | Leg | L Shroud | S Monitoring | N Pressure Trans | P Analoge | A | 4 | C | |
| 6 | A1 | Leg | L Shroud | S Monitoring | N Accelerometer (in-strear | A Analoge | A | 1 | C | |
| 7 | A2 | Leg | L Shroud | S Monitoring | N Accelerpmeter (cross-st | A Analoge | A | 2 | C | |
| 8 | T1 | Leg | L Gear Box | E Monitoring | N Thermocouple | T Thermocouple | C | 1 | C | |
| 9 | T2 | Leg | L Generator | G Monitoring | N Thermocouple | T Thermocouple | C | 2 | C | |
| 10 | T3 | Leg | L Generator | G Monitoring | N Thermocouple | T Thermocouple | C | 3 | C | |
| 11 | T4 | Leg | L Leg Ambient | L Monitoring | N Thermocouple | T Thermocouple | C | 4 | C | |
| 12 | U1 | Leg | L Video | V Monitoring | N CAT 5 video | U TCP/IP | T | 1 | C | |
| 13 | M1 | Leg | L Audio | A Monitoring | N Shielded Cable | M Mic | H | 1 | C | |
| 14 | HV1 | Leg | L Power | P generator pov | A generated power | HV 4c | HV | 1 | J | |
| 15 | S1 | Pontoon Boat | P Panel | P 120V Power | A Fan (cooling) | S 2 cond #12 | S | 1 | J | |
| 16 | S2 | Pontoon Boat | P Panel | P 120V Power | A Gear pump (cooling) | S 2 cond #12 | S | 2 | J | |
| 17 | S3 | Pontoon Boat | P Panel | P 120V Power | A Blige pump | S 2 cond #12 | S | 3 | J | |
| 18 | S4 | Pontoon Boat | P Panel | P 120V Power | A Light in Leg | S 2 cond #12 | S | 4 | J | |
| 19 | S5 | Pontoon Boat | P Panel | P 120V Power | A Hydraulic Control Box | S 2 cond #12 | S | 5 | H | |
| 20 | S6 | Pontoon Boat | P Panel | P 120V Power | A Control Box | S 2 cond #12 | S | 6 | C | |
| 21 | D1 | Pontoon Boat | P Hydraulic Control Box | H 12V winch | D Port & Starboard | D 2 cond #2 | W | 1 | W | |
| 22 | U2 | Pontoon Boat | P TCP/IP | D Data | E Ethernet link to trailer | U TCP/IP | T | 2 | T | |
| 23 | U3 | Bridge | B Video | V Monitoring | N CAT 5 video | U TCP/IP | T | 3 | T | |
| 24 | W1 | Bridge | B Winch | W winch control | D Port winch | W 3c | R | 1 | W | |
| 25 | W2 | Bridge | B Winch | W winch control | D Starboard winch | W 3c | R | 2 | W | |
| 26 | S7 | Bridge | B Shore Power | P 120/240V pov | A shore power from Hydro | S 3c | S | 7 | P | Male |
| 27 | HV2 | Bridge | B Generator Power | P 400V power | A generated power | HV 4c | HV | 2 | C | Female |
| 28 | HV3 | Bridge | B Generator Power | P 400V power | A bridge to converter | HV 4c | HV | 3 | X | Male |

Appendix 3
Flow 3D model output for
Manitoba Hydro
prepared by KGS Group

For:
PhD Thesis
John Woods
2017
University of Manitoba



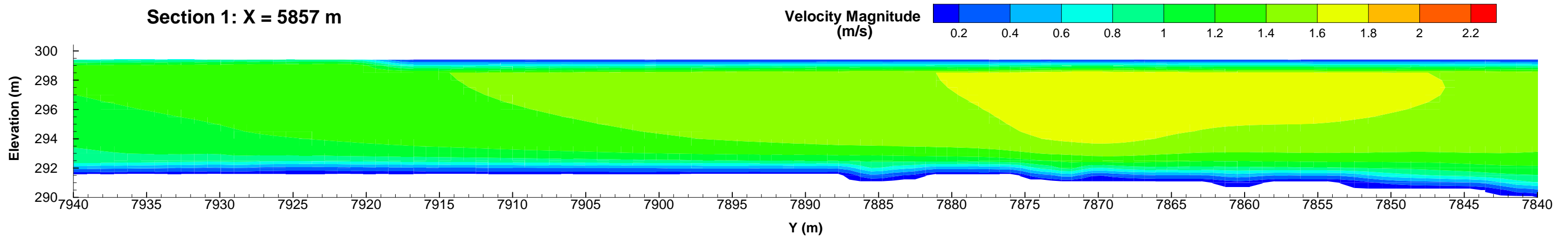
Flow Conditions:
 Discharge: 615 m³/s
 Forebay Level: 299.1 m

Velocity Magnitude
 at 1 m below Water Surface

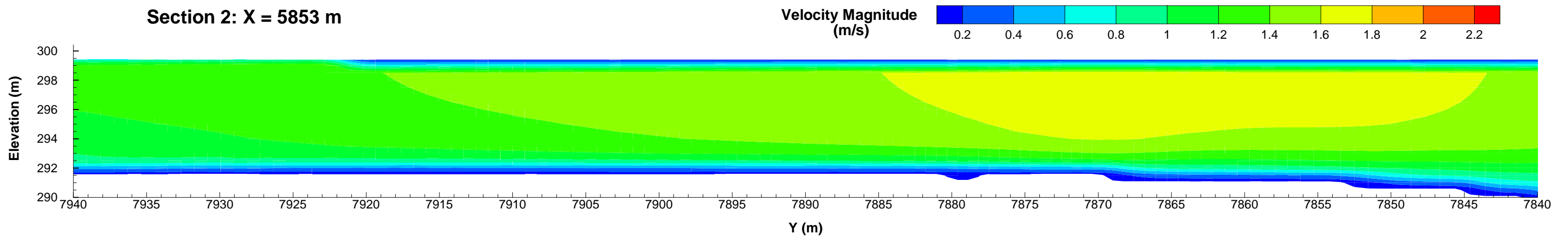
Plots Based on Preliminary FLOW 3D Simulation Results

Plate 1 12/18/2013

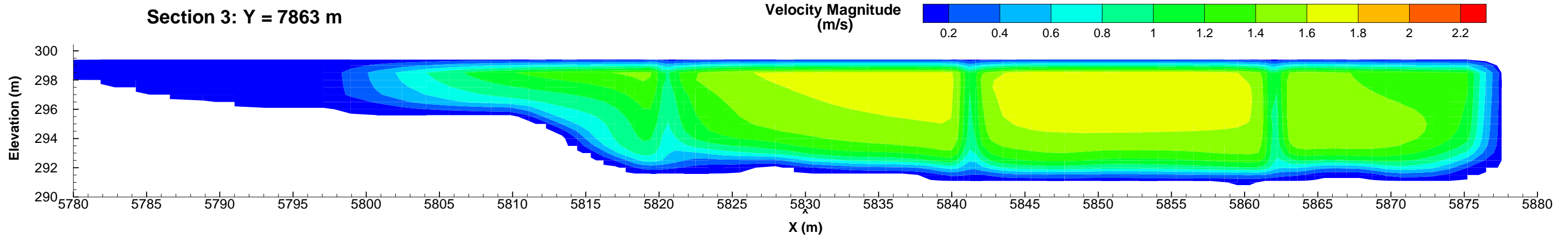
Section 1: X = 5857 m



Section 2: X = 5853 m



Section 3: Y = 7863 m

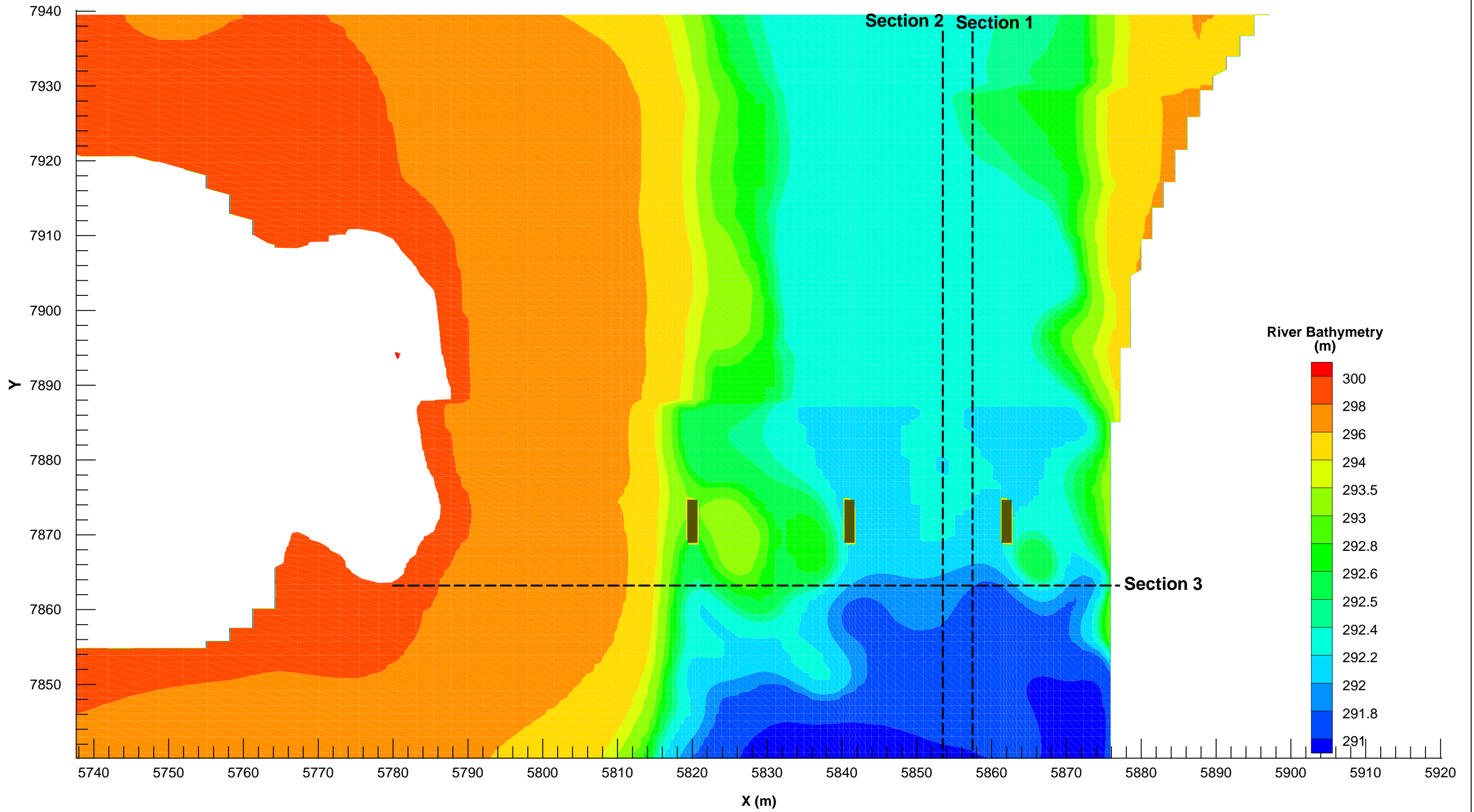


Flow Conditions:
Discharge: 615 m³/s
Forebay Level: 299.1 m

The locations of the sections were defined in Plate 1.
Plots Based on Preliminary FLOW 3D Simulation Results.

Cross Section Velocity

Plate 2 12/18/2013



Flow Conditions:
 Discharge: 615 m³/s
 Forebay Level: 299.1 m

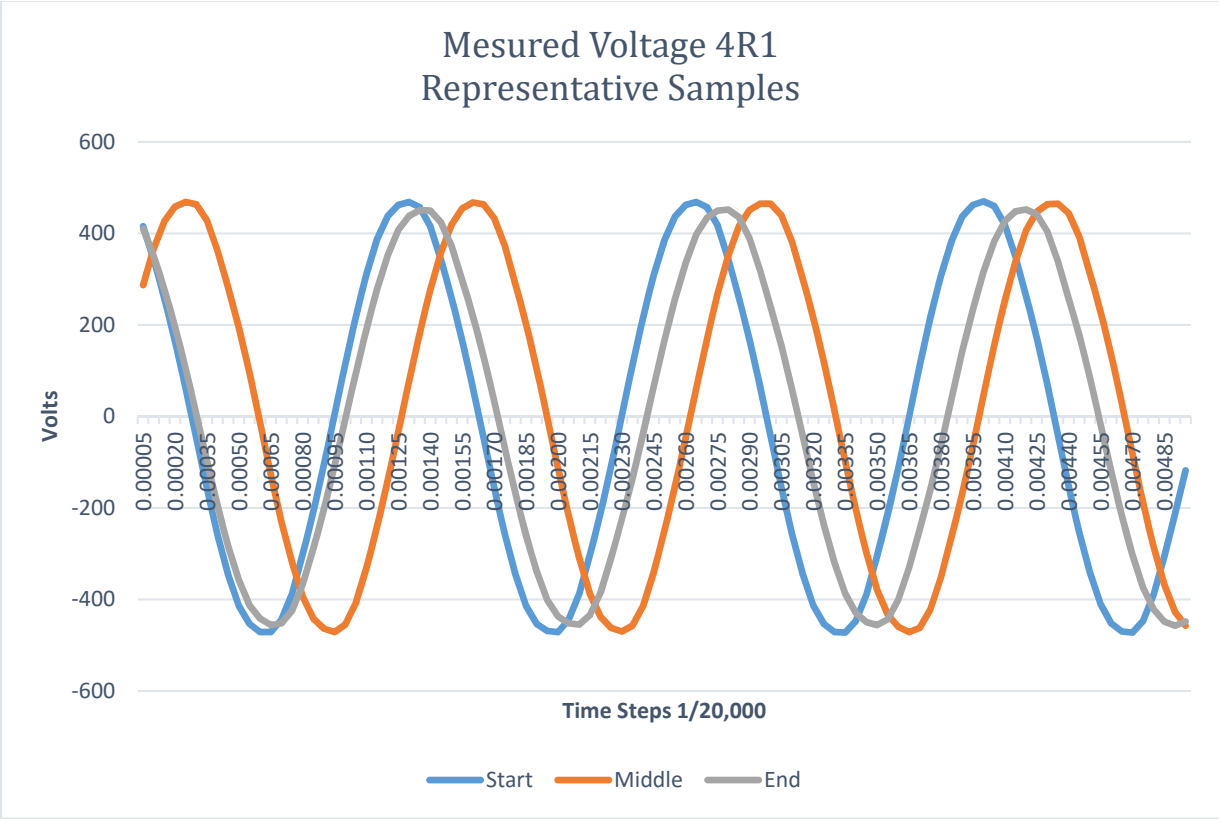
Plots Based on Preliminary FLOW 3D Simulation Results

River Bathymetry

Plate 5 12/19/2013

Appendix 4
Example Waveform
Voltage from sample set 4R1

For:
PhD Thesis
John Woods
2017
University of Manitoba



This is an example of high resolution measurements taken for voltage and current generated by the 12 kW axial flux, permanent magnet generator as driven by a 25 kW vertical axis 4-blade rotor, manufactured by New Energy Corporation. Note time steps of 0.00005 seconds representing a 1/20,000 sampling rate.

A short sample from the start, middle and end of the complete 4R1 sample set demonstrates reasonable voltage stability, with some fluctuation of frequency – as expected with the water velocity varying with time and highly turbulent.