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4321 Still Creek Drive
Burnaby BC V5C 6S7
Canada

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www.advisian.com

P: +1 604 298 1616

19 October 2017

Callum Campbell
Manager, Marine Branch
Ministry of Transportation and Infrastructure
5D - 940 Blanshard Street
Victoria, BC V8W 3E6

Dear Mr. Campbell,

RE: VESSEL DATA WATER DEPTH ANALYSIS IN KOOTENAY LAKE WEST ARM

Thank you for the opportunity to review the depth data provided by the Ministry of Transportation and Infrastructure (MoTI) from the MV Osprey 2000. Please find herein our water depth analysis summary as related to the underkeel clearance of the vessel in the West Arm of Kootenay Lake, traveling to and from the Balfour Ferry Terminal.

In general, the results of our analysis indicate that the vessel underkeel clearance was less than 1 m in two areas of the West Arm during the low lake level period in March 2017.

Given Information (by MoTI)

- Depth data from VDR Explorer 3.10 Software, data files in .NAS, extracted to .csv file.
- Data was collected from the MV Osprey 2000 from February 8 to May 9, 2017. The data logger was mounted to the underside of the vessel, and recorded the water depth from bottom of vessel to lake bed surface (underkeel clearance).
- The lowest recorded water level was noted to be from March 11–13, 2017.
- Underkeel clearances less than 1 m are to be highlighted.
- Vessel was loaded approximately 24% on average during the data collection period, corresponding to a draught of approximately 2.74 m based on the 'Deadweight Scale' (see Attachment 1).
- FortisBC provides lake level data and posts to the website:
<http://webapp.fortisbc.com/lakelevel/lakes.jsp#KootenayLakeLevel31Days>

Assumptions

- FortisBC lake level data is from the Queens Bay station and is reasonably representative of the conditions along the ferry route.
- The MoTI recording device was mounted on the lowest point of the vessel, including consideration of trim, such that the device records the minimum underkeel clearance at each data point.
- Vessel draught will have varied throughout the data collection period based on vessel loading, but this analysis considers only the average loaded draught provided (approximately 2.74 m).



Other Information Considered

- Conceptual design parameters for the navigation route in the West Arm (Advisian, 2017)¹:
 - Water depths of 4.1 m (13.5 ft.) to 4.7 m (15.4 ft.) for the MV Osprey 2000 vessel, depending on the channel conditions.
 - Maximum loaded draught of the MV Osprey is 3.174 m + 0.085 m trim/heel = 3.259 m
 - Allowable underkeel clearance would be 0.841 m to 1.441 m, depending on channel conditions, for maximum loaded draught of the MV Osprey. This analysis considers 1 m underkeel clearance as requested by MoTI.
 - Conversion from Geodetic Datum (GD) to Chart Datum (CD) is 529.44 m GD = 0.0 CD in the West Arm.
 - 'Design' water depth for the Navigation Study is considered to be at 529.71 m GD (0.27 m CD).
- Terminology herein is depicted in Figure 1.

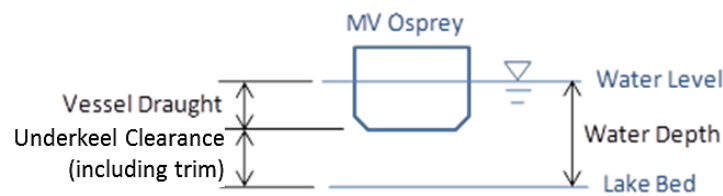


Figure 1 **Dimension References**

Depth Analysis Summary

- Data was analysed from March 9 to 15, 2017 and are shown graphically in sketches 307071-01156-00-CX-SK-0001 to 0007, provided in Attachment 2.
- The data on March 11, 2017 (SK-0003) show two areas (Area A and Area B) where underkeel clearance was less than 1 m, a snapshot of SK-0003, as shown in Figure 2.
- The worst case underkeel clearances (minimum underkeel depth recordings) from March 9 to 15, 2017 that occurred in Areas A and B are shown on sketch 307071-01156-00-CX-SK-0008, provided in Attachment 3.
- The water levels to Geodetic Datum (GD) from March 9–15, 2017 according to Fortis BC's website are shown in Table 1 (the conversion to CD is by Advisian and is based on 529.44 m GD = 0.0 CD in the West Arm).

¹ Advisian, 2017. *Improvements to Navigation – Study Report Draft – Balfour Terminal. Burnaby, BC.*

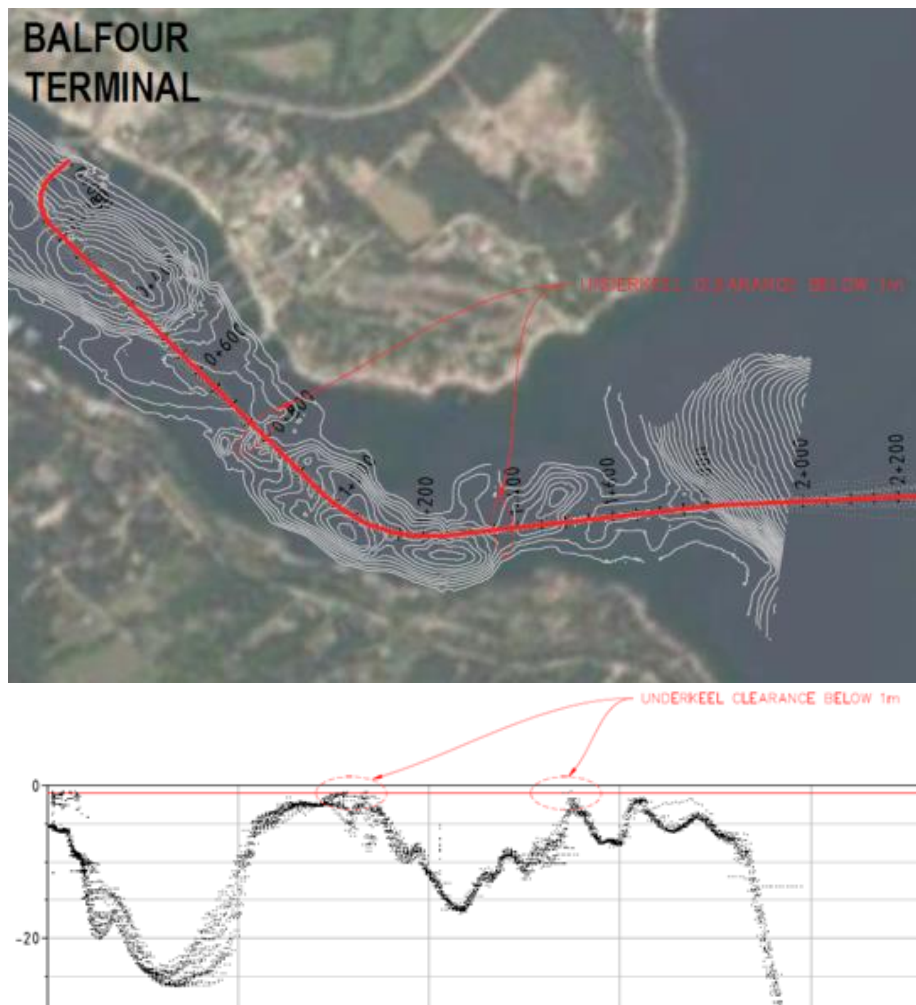


Figure 2 Underkeel Clearance Data from March 11, 2017 (see SK-0003 for more details)

Table 1 Lowest Water Level Elevations during Data Collection Period

Date	Water Level Elevation (m, GD) – Fortis BC	Water Level Elevation (m, CD) – Calculated
09-Mar-2017	530.11	0.67
10-Mar-2017	530.08	0.64
11-Mar-2017	530.05	0.61
12-Mar-2017	530.02	0.58
13-Mar-2017	530.02	0.58
14-Mar-2017	530.02	0.58
15-Mar-2017	530.05	0.61

Note: Water levels above are approximately 0.3m higher than the 'design' water depth considered in the Navigation Study.



- To approximately back check the depth data provided, an estimated contour was developed from the 2017 vessel data. The contour was calculated by taking the Fortis BC water level elevation for each day and subtracting the 24% loaded vessel draught (2.74 m) and subtracting the recorded underkeel clearance. The result provides the approximate elevation of the lake bed at each data point (estimated contour). The resulting estimated contour was compared to the 2016 bathymetric contour data as shown in sketches 307071-01156-00-CX-SK-0010 to SK-0013 provided in Attachment 4. Figure 3 shows a snapshot of SK-0010.

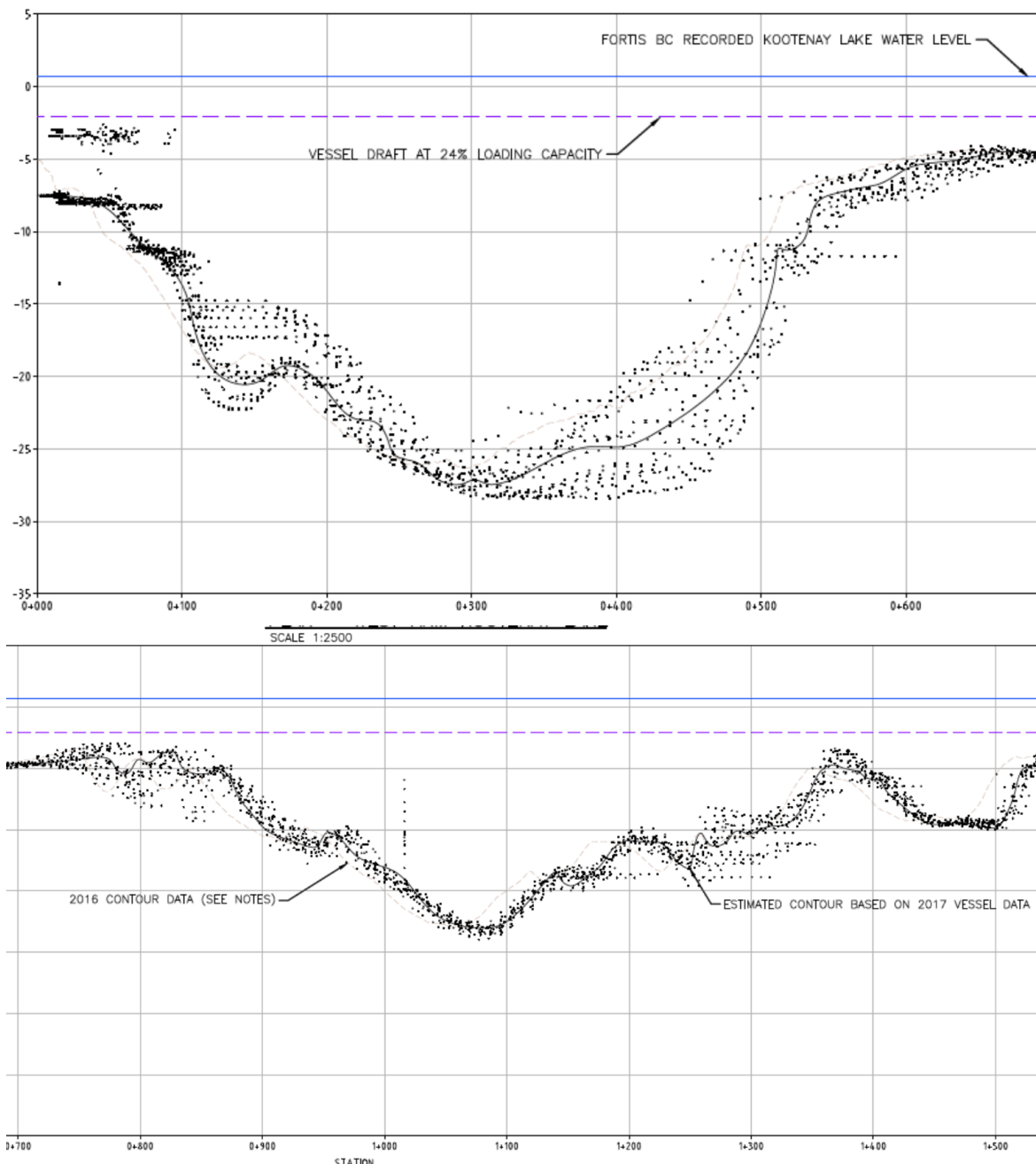


Figure 3 Snapshots of Sketch No. 307071-01156-00-CX-SK-0010



- The contours are in reasonable alignment to validate the recorded underkeel clearance and water level data. It is noted that the estimated contour is offset from the 2016 sounding contour, which is likely due to vessel speed at the time of the GPS coordinate recording.

Further Considerations

- Vessel draught is affected by the loading. As stated in the assumptions, the analysis herein is based on a constant draught of 2.74 m based on an average vessel load of 24%. Additional loading information would help to refine the analysis.
- Vessel draught will have varied throughout the data collection period.
- Vessel loading during seasons of higher or lower water level would help to refine the analysis.
- Water level at Queens Bay is not perfectly representative of the water levels in the West Arm.
- Location of recorder may not have been at the location of worst trim.
- Additional dates could be investigated / analyzed.

Conclusion

Based on the review herein of the MV Osprey vessel data provided by MoTI, underkeel clearances less than 1 m occurred in Areas A and B during the noted period of low lake levels. Thus, water depths are considered insufficient in Areas A and B for the safe navigation of the MV Osprey, especially if the vessel were to be fully loaded.

Closing

Thank you for this opportunity to provide MoTI with continued support in improving navigational conditions in the West Arm. Please do not hesitate to contact me with any questions, either by email at daiva.seavey@advisian.com or by phone at 604-298-1616.

Yours sincerely,

Daiva Seavey, P.Eng.
Manager of Projects
Transportation Service Line
Advisian Americas, WorleyParsons Group

DAS/clc

Colleen Ackermann, P.Eng.
Technical Director, Ports and Marine Terminals

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Attachment 1 Deadweight Scale



Deadweight Scale

MCT-1 CM [Tonne-m/cm]	TPC [Tonnes/cm]	Draft [m]	Displacement [Tonnes FW]	Deadweight [Tonnes]	
46.0	9.7		1700	500	Subdivision Draft = 3.174 m [Displacement = 1633.8 Tonnes]
		3.20	1600		
	9.6	3.10			
44.0	9.4		1500	400	
		3.00			
			1400	300	
42.0	9.2	2.90			
	9.0		1300	200	
		2.80			
40.0		2.70	1200	100	
	8.8				
	8.6	2.60	1100		Lightship Draft = 2.606 m [Displacement = 1109.9 Tonnes]
		2.50	1000		
	8.4				

Drafts are measured from bottom of RAD units, located 1.03 metres below top side of keel (Moulded baseline).



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Attachment 2 Echo Sounder Data Sketches

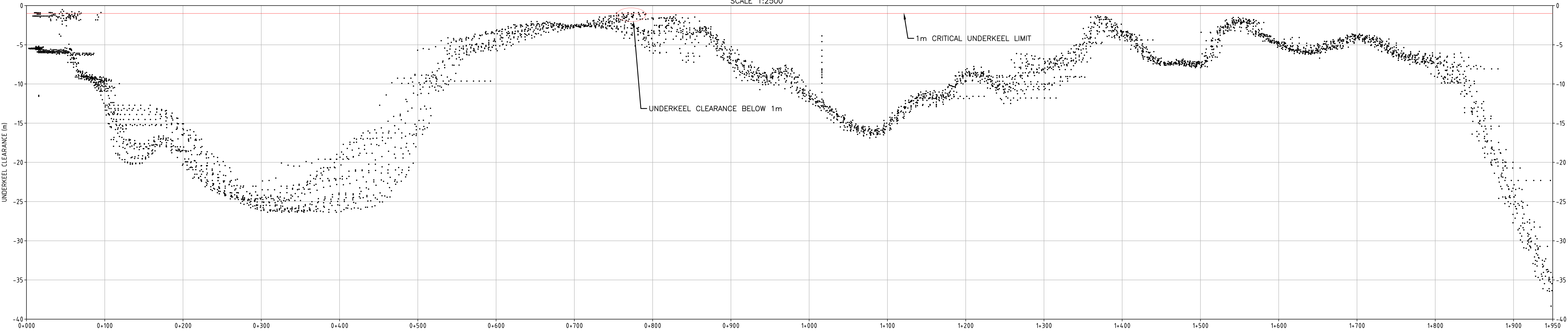


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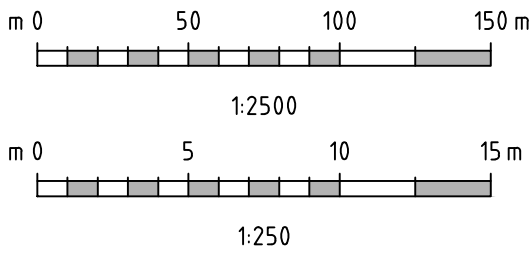


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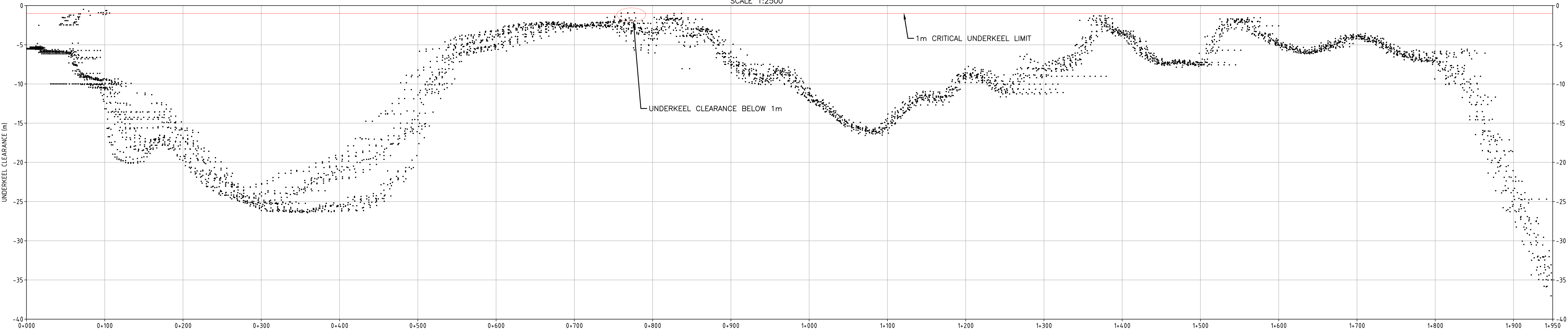
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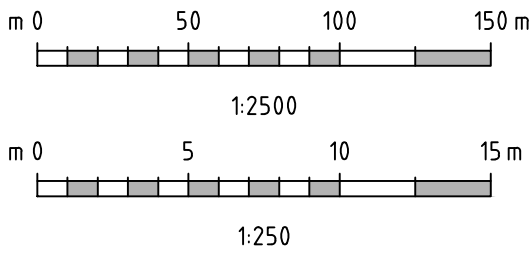


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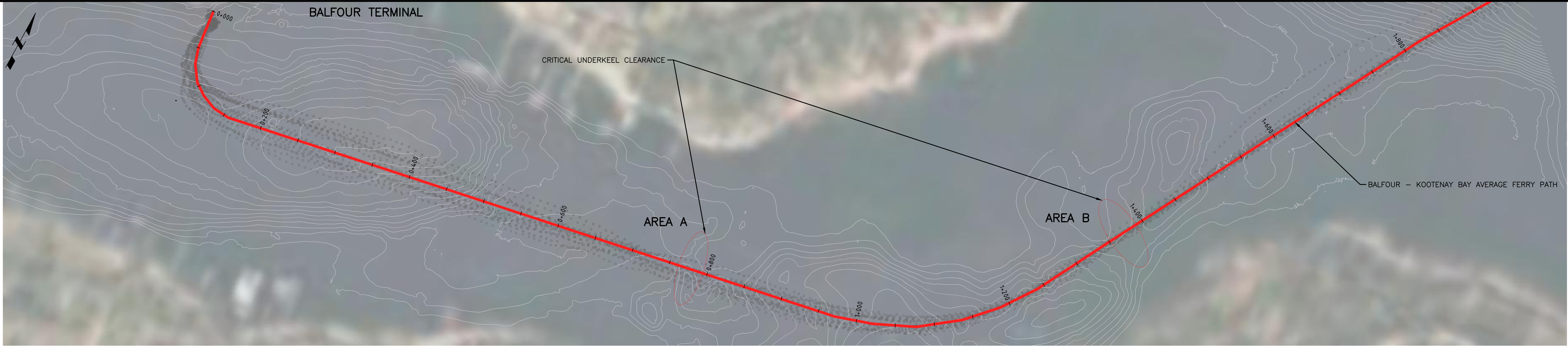
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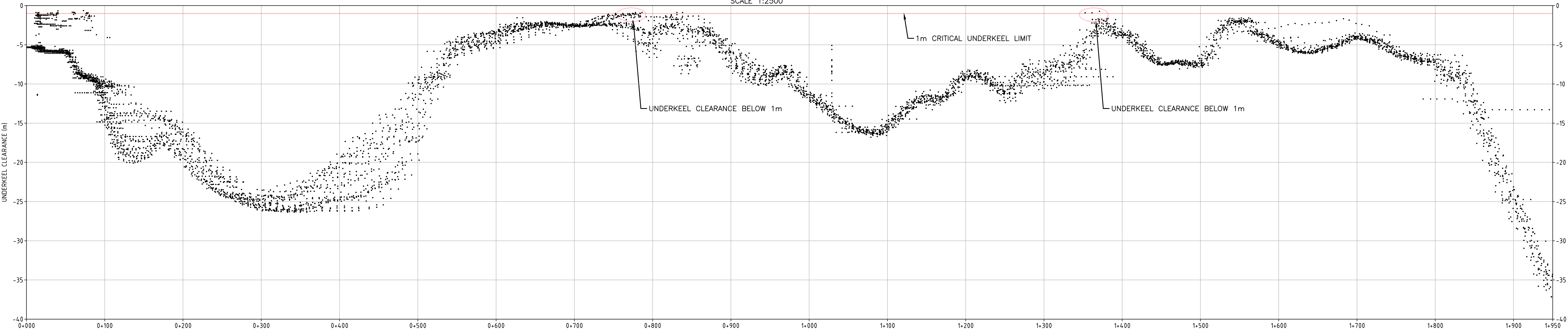
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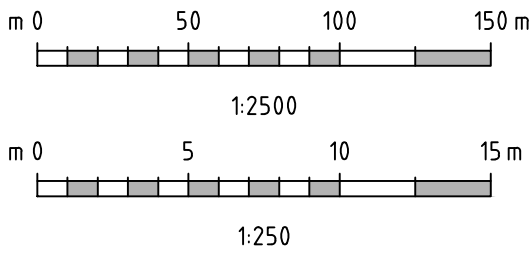



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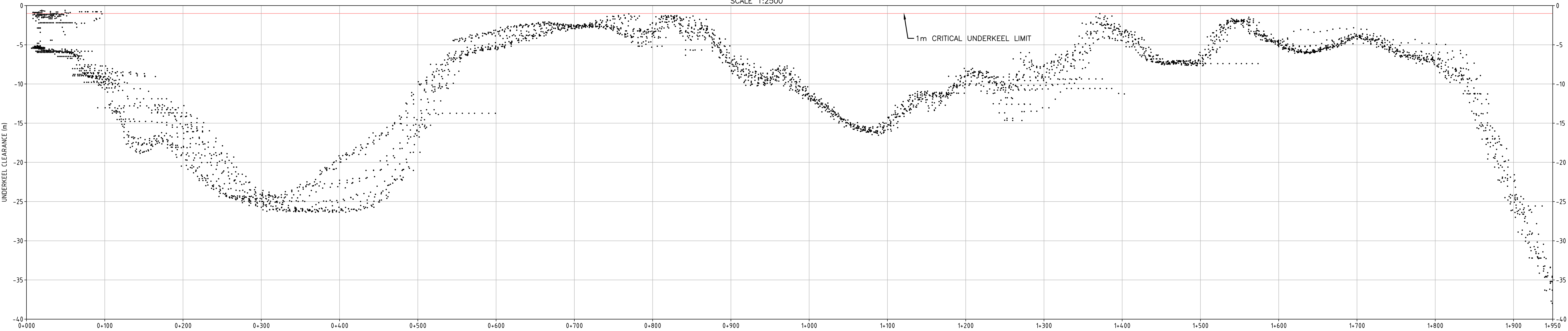
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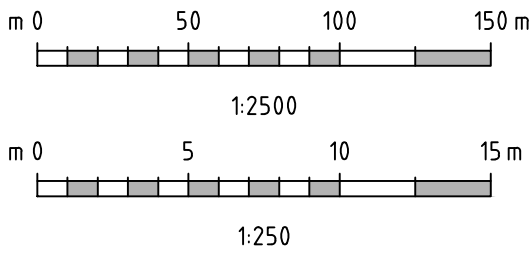



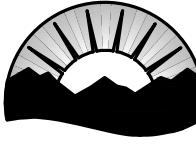
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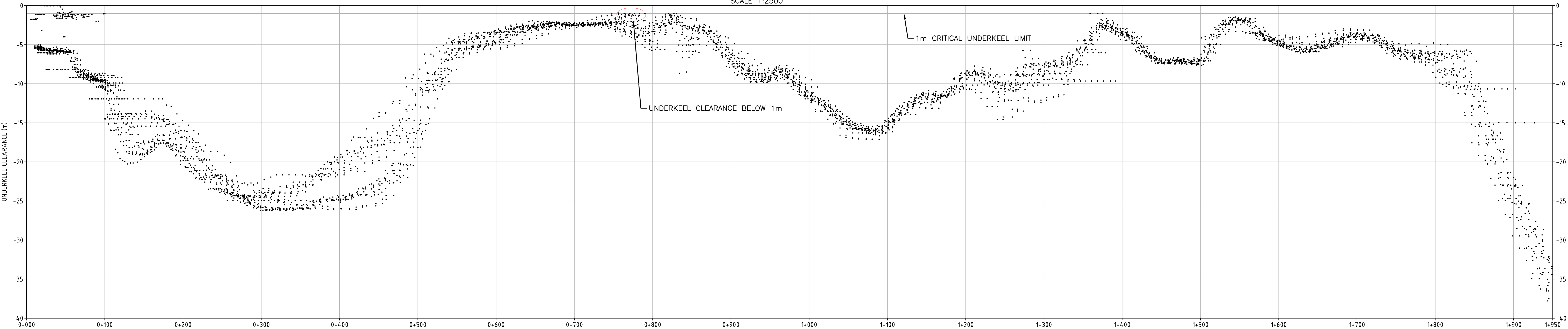
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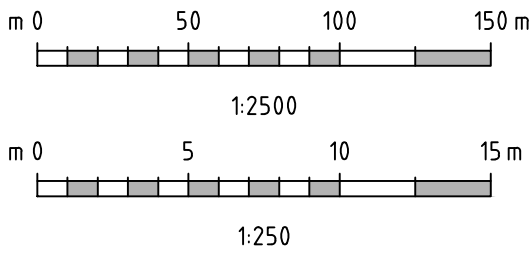




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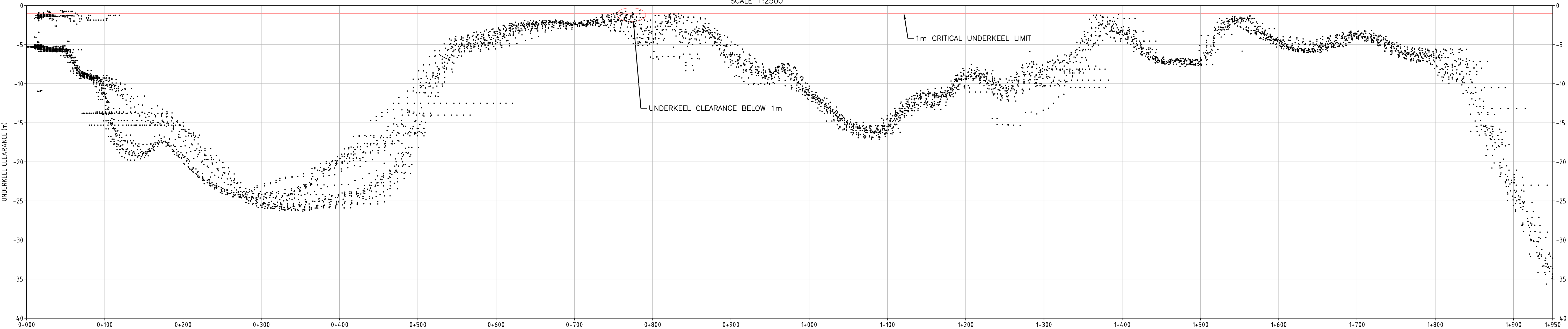
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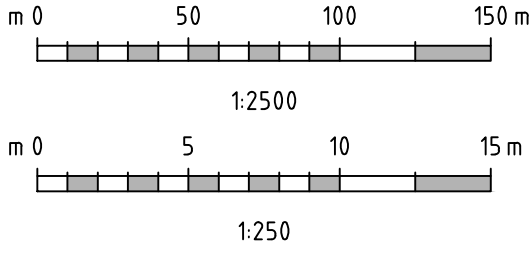


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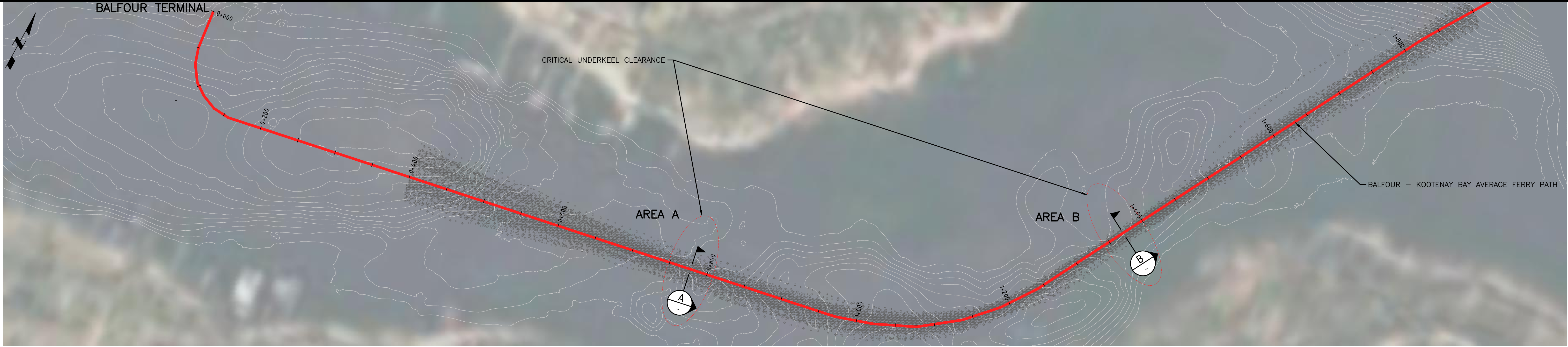
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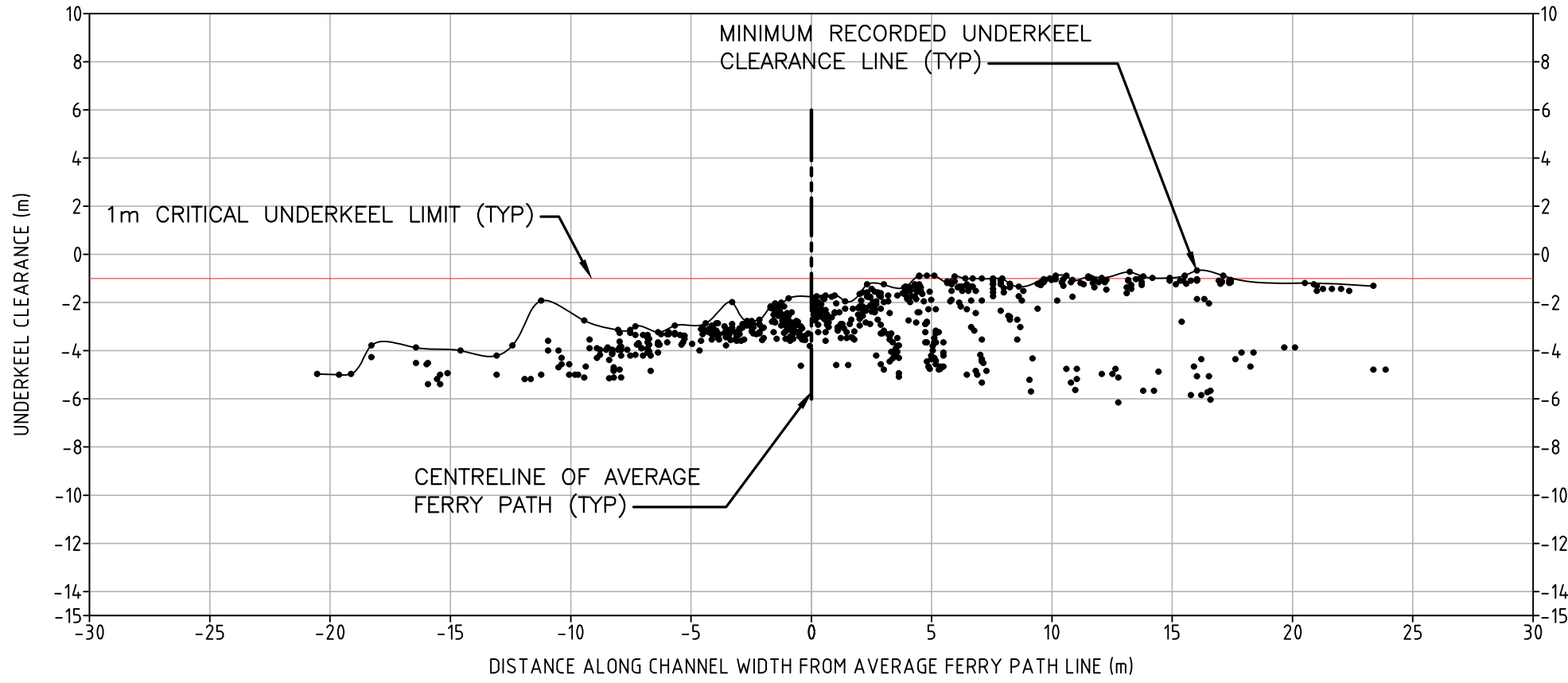
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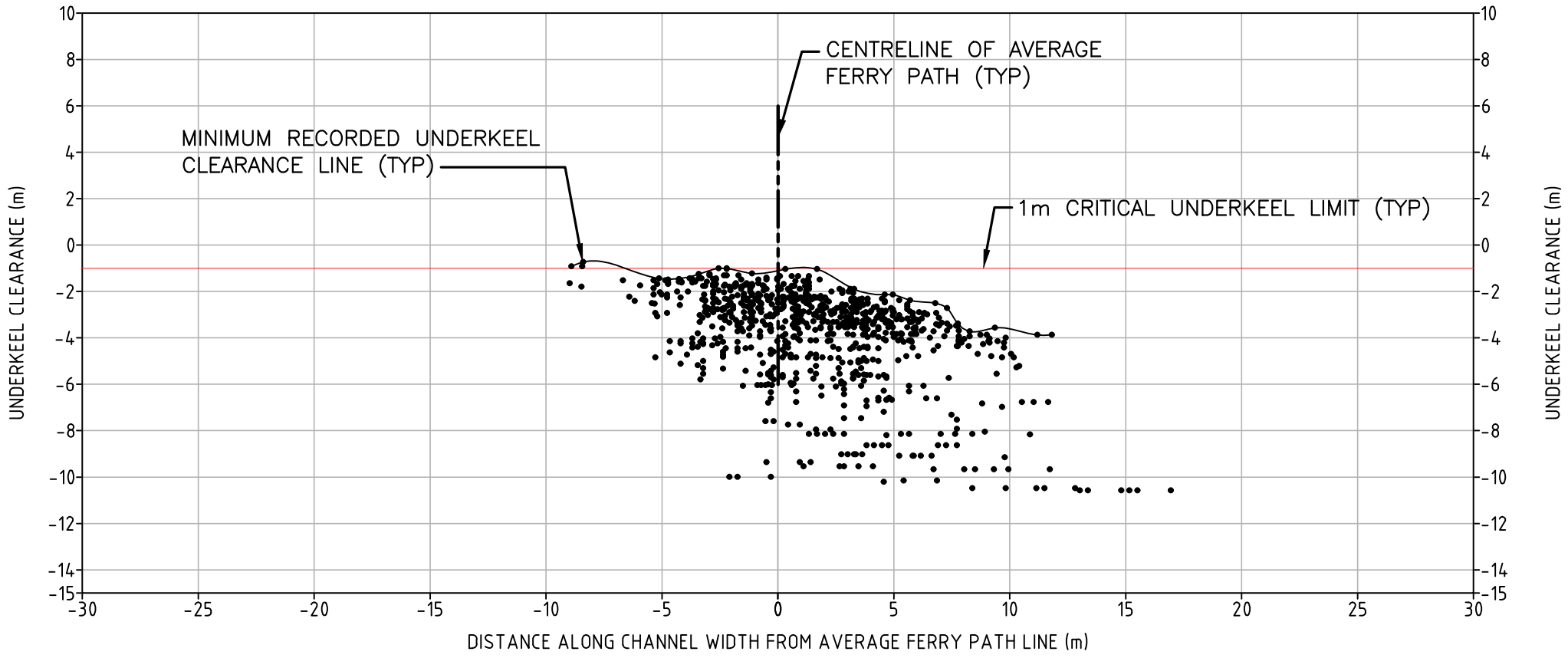
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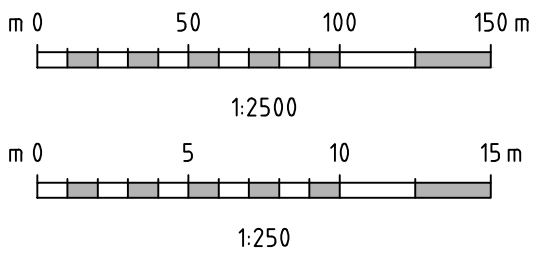
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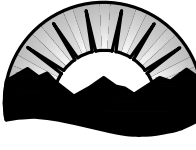


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	AVERAGE FERRY PATH FROM GPS LOCATION DATA POINTS
	WORST-CASE MINIMUM UNDERKEEL FROM MARCH 09 TO 15, 2017

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		Ministry of Transportation & Infrastructure Southern Interior Region		
KOOTENAY LAKE				
BALFOUR TERMINAL TO KOOTENAY BAY TERMINAL ECHO SOUNDER DATA CRITICAL DEPTH AREAS				
PREPARED UNDER THE DIRECTION OF		DESIGNED _____ DATE _____		
DAIVA SEAVEY		CHECKED <u>DAS</u> DATE <u>OCT-17</u>		
ENGINEER OF RECORD		DRAWN <u>RYL</u> DATE <u>OCT-17</u>		
DATE		SCALE: AS SHOWN		
FILE No.	PROJECT No.	REG.	DRAWING No.	0
		2	SK-0008	
CANCEL PRINTS BEARING PREVIOUS LETTER				

H-30812-07-08



Advisian

WorleyParsons Group

Attachment 4 Bathymetric Contour Comparison Sketches

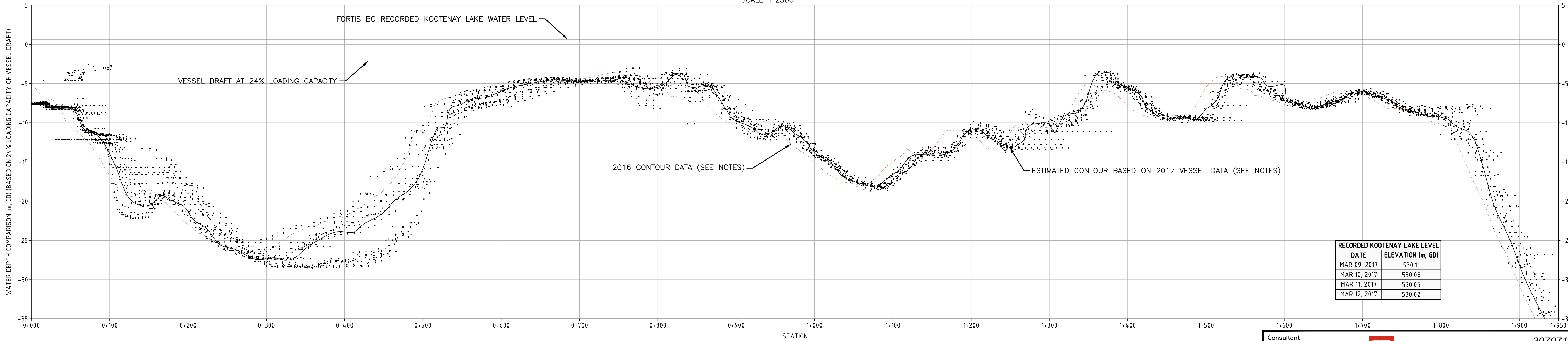


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Last Saved: Oct. 04/17 6:32pm Plotted: Oct. 18/17



PLAN — WEST ARM KOOTENAY LAKE

SCALE 1:2500

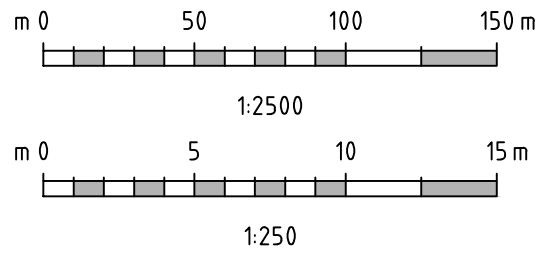


PROFILE — WEST ARM KOOTENAY LAKE

SCALE H=1:2500 V=1:250

LEGEND	
	DATA POINTS ON PROFILE OF UNDERKEEL CLEARANCE (FROM VDR EXPLORER 3.10 SOFTWARE)
	GPS LOCATION ON PLAN OF DATA POINTS (FROM VDR EXPLORER 3.10 SOFTWARE)
	AVERAGE FERRY PATH FROM GPS LOCATION DATA POINTS
	FORTIS BC RECORDED LAKE LEVEL
	VESSEL DRAFT AT 24% LOADING CAPACITY
	2016 CONTOUR DATA (SEE NOTES)
	ESTIMATED CONTOUR BASED ON 2017 VESSEL DATA (SEE NOTES) WITH BEST FIT LINE

PRELIMINARY
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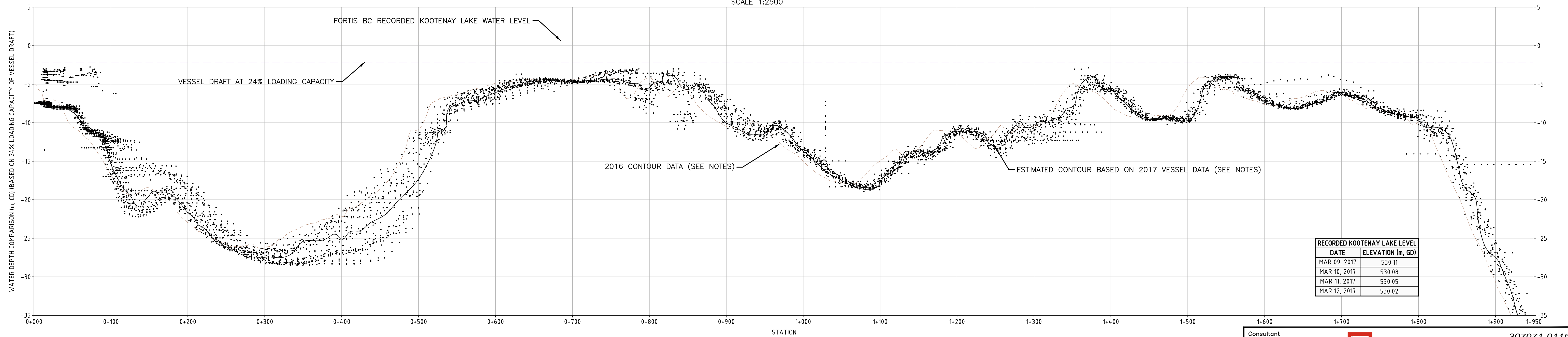
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



- 2016 CONTOUR DATA PROVIDED BY MOTI FROM CANADIAN COAST GUARD SOUNDING SURVEY.
- 2017 VESSEL DATA RECORDED FROM MV OSPREY 2000.
- KOOTENAY LAKE LEVEL RECORDED BY FORTIS BC.
- VESSEL DRAFT PROVIDED BY MOTI IS APPROXIMATELY 2.74m AT 24% VESSEL LOADING CAPACITY.
- ESTIMATED CONTOUR BASED ON 2017 VESSEL DATA CALCULATED AS FOLLOWS: LAKE LEVEL ON RELEVANT DATE — ESTIMATED VESSEL DRAFT — UNDERKEEL CLEARANCE DEPTH DATA

RECORDED KOOTENAY LAKE LEVEL	
DATE	ELEVATION (m, GD)
MAR 09, 2017	530.11
MAR 10, 2017	530.08
MAR 11, 2017	530.05
MAR 12, 2017	530.02

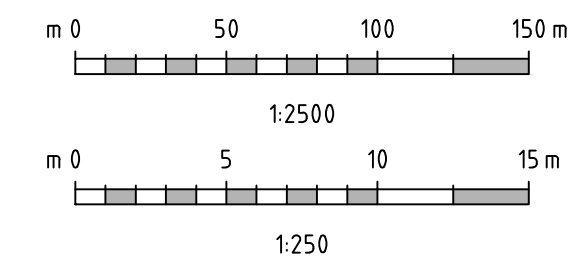
Consultant		WorleyParsons resources & energy		307071-01156	
THIS DRAWING IS PREPARED FOR THE USE OF THE CONTRACTUAL CUSTOMER OF WORLEYPARSONS CANADA SERVICES LTD. AND WORLEYPARSONS CANADA SERVICES LTD. ASSUMES NO LIABILITY TO ANY OTHER PARTY FOR ANY REPRESENTATIONS CONTAINED IN THIS DRAWING.					
Rev	Date	Description			Init
0	OCT18/17	ISSUED WITH LETTER			RYL
R E V I S I O N S					
		Ministry of Transportation & Infrastructure Southern Interior Region			
KOOTENAY LAKE					
BALFOUR TERMINAL TO KOOTENAY BAY TERMINAL LAKEBED ELEVATION COMPARISON (MARCH 10 2017)					
PREPARED UNDER THE DIRECTION OF			DESIGNED _____ DATE _____		
DAIVA SEAVEY			CHECKED <u>DAS</u> DATE <u>OCT-17</u>		
ENGINEER OF RECORD			DRAWN <u>RYL</u> DATE <u>OCT-17</u>		
DATE			SCALE: AS SHOWN		
FILE No.		PROJECT No.		NEGATIVE No.	
				2	
				SK-0010	
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CANCEL PRINTS BEARING PREVIOUS LETTER					

H-30812-e(07-08)





LEGEND	
	DATA POINTS ON PROFILE OF UNDERKEEL CLEARANCE (FROM VDR EXPLORER 3.10 SOFTWARE)
	GPS LOCATION ON PLAN OF DATA POINTS (FROM VDR EXPLORER 3.10 SOFTWARE)
	AVERAGE FERRY PATH FROM GPS LOCATION DATA POINTS
	FORTIS BC RECORDED LAKE LEVEL
	VESSEL DRAFT AT 24% LOADING CAPACITY
	2016 CONTOUR DATA (SEE NOTES)
	ESTIMATED CONTOUR BASED ON 2017 VESSEL DATA (SEE NOTES) WITH BEST FIT LINE

PRELIMINARY
DO NOT USE FOR CONSTRUCTION
Last Saved: Oct. 04/17 6:32pm



- NOTES:

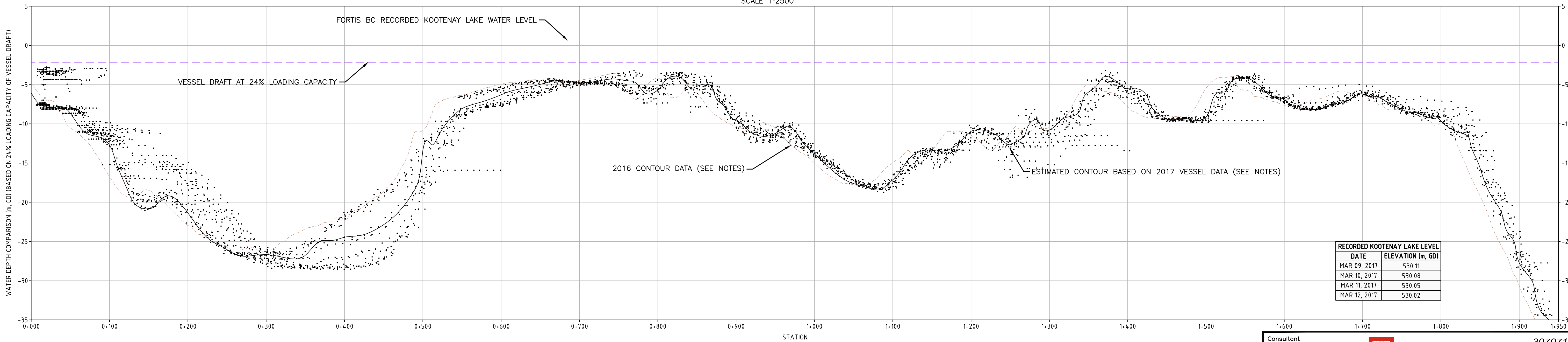
1. 2016 CONTOUR DATA PROVIDED BY MOTI FROM CANADIAN COAST GUARD SOUNDING SURVEY.
2. 2017 VESSEL DATA RECORDED FROM MV OSPREY 2000.
3. KOOTENAY LAKE LEVEL RECORDED BY FORTIS BC.
4. VESSEL DRAFT PROVIDED BY MOTI IS APPROXIMATELY 2.74m AT 24% VESSEL LOADING CAPACITY.
5. ESTIMATED CONTOUR BASED ON 2017 VESSEL DATA CALCULATED AS FOLLOWS: LAKE LEVEL ON RELEVANT DATE - ESTIMATED VESSEL DRAFT = UNDERKEEL CLEARANCE DEPTH DATA

Consultant		<b style="font-size: 1.2em;">WorleyParsons resources & energy	307071-01156
THIS DRAWING IS PREPARED FOR THE USE OF THE CONTRACTUAL CUSTOMER OF WORLEYPARSONS CANADA SERVICES LTD. AND WORLEYPARSONS CANADA SERVICES LTD. ASSUMES NO LIABILITY TO ANY OTHER PARTY FOR ANY REPRESENTATIONS CONTAINED IN THIS DRAWING.			
Rev	Date	Description	Init
0	OCT18/17	ISSUED WITH LETTER	RYL
R E V I S I O N S			
<div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;">  <p>BRITISH COLUMBIA</p> </div> <div style="text-align: center;"> <p>Ministry of Transportation & Infrastructure</p> <p>Southern Interior Region</p> </div> </div>			
KOOTENAY LAKE			
BALFOUR TERMINAL TO KOOTENAY BAY TERMINAL LAKEBED ELEVATION COMPARISON (MARCH 11 2017)			
PREPARED UNDER THE DIRECTION OF <div style="border-bottom: 1px solid black; margin-top: 10px;">DAIVA SEAVEY</div>			DESIGNED _____ DATE _____ CHECKED <u> DAS </u> DATE <u> OCT-17 </u> DRAWN <u> RYL </u> DATE <u> OCT-17 </u> SCALE: AS SHOWN NEGATIVE No.
ENGINEER OF RECORD	SCALE: AS SHOWN		
DATE	NEGATIVE No.		
FILE No.	PROJECT No.	REG.	DRAWING No.
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Last Saved: Oct. 04/17 6:32pm Plotted: Oct. 18/17



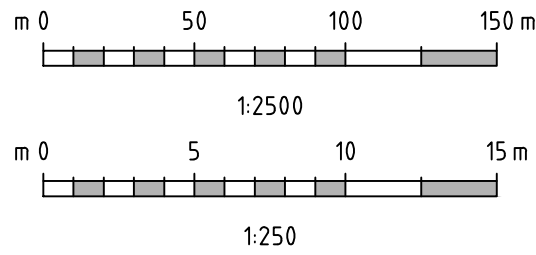
PLAN — WEST ARM KOOTENAY LAKE
SCALE 1:2500



PROFILE — WEST ARM KOOTENAY LAKE
SCALE H=1:2500 V=1:250

LEGEND	
	DATA POINTS ON PROFILE OF UNDERKEEL CLEARANCE (FROM VDR EXPLORER 3.10 SOFTWARE)
	GPS LOCATION ON PLAN OF DATA POINTS (FROM VDR EXPLORER 3.10 SOFTWARE)
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	FORTIS BC RECORDED LAKE LEVEL
	VESSEL DRAFT AT 24% LOADING CAPACITY
	2016 CONTOUR DATA (SEE NOTES)
	ESTIMATED CONTOUR BASED ON 2017 VESSEL DATA (SEE NOTES) WITH BEST FIT LINE

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NOTES:

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- 2017 VESSEL DATA RECORDED FROM MV OSPREY 2000.
- KOOTENAY LAKE LEVEL RECORDED BY FORTIS BC.
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- ESTIMATED CONTOUR BASED ON 2017 VESSEL DATA CALCULATED AS FOLLOWS: LAKE LEVEL ON RELEVANT DATE — ESTIMATED VESSEL DRAFT — UNDERKEEL CLEARANCE DEPTH DATA

Consultant		WorleyParsons resources & energy		307071-01156	
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Rev	Date	Description			Init
0	OCT18/17	ISSUED WITH LETTER			RYL
REVISIONS					
		Ministry of Transportation & Infrastructure Southern Interior Region			
KOOTENAY LAKE					
BALFOUR TERMINAL TO KOOTENAY BAY TERMINAL LAKEBED ELEVATION COMPARISON (MARCH 12 2017)					
PREPARED UNDER THE DIRECTION OF		DESIGNED		DATE	
DAIVA SEAVEY		CHECKED		DATE	
ENGINEER OF RECORD		DRAWN		DATE	
DATE		REG.		DRAWING No.	
FILE No.		PROJECT No.		2 SK-0012	
				0	
CANCEL PRINTS BEARING PREVIOUS LETTER					

H-30812-c(07-08)