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G. Comfort Ice
Engineering Ltd.

Ice

2 Conacher Gate, Kanata, Ontario, Canada K2K 3H1
Tel: 613 702 5950
Email: comfortga@gmail.com

INVESTIGATION FOR MESO-SCALE MARINE OIL SIMULATOR

Final Report

October 30, 2015

Submitted to:

Attn.: Dr. Bruce Hollebone
Chemist, Emergencies Science & Technology Section,
Science & Technology Branch
Environment Canada
335 River Road, Ottawa, Ont., K1A 0H3

Submitted by:

George Comfort, P. Eng.,
G. Comfort Ice Engineering Ltd.
2 Conacher Gate
Kanata, Ontario
K2K 3H1

Report No:
G. Comfort Ice Engineering Ltd. Report: FR 135

REVISION HISTORY RECORD

Revision No.	Date of Issue	Description of Change
Draft Final Report	October 17, 2015	Initial submission for Client review and comment
Final Report	October 30, 2015	Report expanded & Client comments addressed

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The project monitor at Environment Canada was Dr. Bruce Hollebone. He is thanked for the technical information and direction that he provided in a timely manner, as well as for his efforts to expedite the project.

Several other people at Environment Canada also provided useful information and input, including Dr. Ben Fieldhouse, Dr. Carl Brown, William Duffett and Adam Kurz.

Many other people also provided useful inputs, including the following:

(a) CCORE – Dr. Bing Chen and Chris Fowler

(b) CEDRE – Dr. Stefan LeFloch and Dr. Julien Guyomarch

(c) CRREL – Dr. Steve Daly and Leonard Zabilansky

(d) NWRI – Dr. Ian Droppo

(e) OCRE of the NRC – Anne Barker, Dr. Mohammed Sayed and James Millan

(f) Joe Mullin

(g) OHMSETT – Dave Devitis

(h) Richard Softye

(i) SINTEF – Dr. Per Daling and Frode Liervik

(j) SL Ross Environmental Research Ltd. – David Cooper

(k) University of Manitoba – Dr. David Barber

(l) USCG R&D Center – Kurt Hansen

EXECUTIVE SUMMARY

The Emergencies Science and Technology Section (ESTS) of Environment Canada is at the development and design stage for a meso-scale marine oil exposure simulator. ESTS is initiating the process of designing and constructing a mid-size facility (with about 3-10 m^3 of water) facility to simulate the exposure and examine changes in oil behavior and fate over periods of weeks to months in a marine environment.

This project was carried out to gather information and specifications on existing and planned systems which are broadly similar, as well as facilities that conduct related research and testing. The information-gathering process included reviews of the literature as well as contacts with the organizations operating these facilities. The work was focussed on issues such as the engineering challenges and the lessons learned; and whether or not these designs would meet the technical needs of Environment Canada's Science Plan. As well, this project was carried out to provide input to the consultants retained by PWGSC for overall technical design for items such as: (a) structural and mechanical design; (b) HVAC; (c) safety and ventilation, etc.

Recommendations were developed for design parameters and specifications for a test tank design, in keeping with the requirements imposed by Environment Canada's Science Plan; and the technical constraints for it (e.g., due to the available laboratory space). These are summarized in Table 1.

Table 1: Summary of Recommendations

Item	Summary Recommendations
Overall Configuration and Capabilities	The ESTS tank should be similar in size and capabilities to those of the existing tanks, provided that this is sufficient to meet the needs of the Science Plan established by ESTS for its facility.
Tank Material	The tank should be made from stainless steel. It should also be insulated to retard ice growth on the tank walls for tests in freezing conditions.
Coatings for Tank Walls	The tank should have an oleophilic coating on its walls. Further investigation should be made to select the coating to be used, starting with the three coatings identified by SINTEF.
Viewing windows	The capability to "see" what is happening in a test is believed to be very important. The tank should be built with viewing windows but they should not be the only means for underwater viewing. Underwater cameras should be included too.
Cover for the Air Chase	The most appropriate selection depends on the degree to which the ESTS tank will be moved, e.g., in and out of the cold room. The ability to view experiments and conditions from above is considered to be a very significant advantage. Unless the ESTS tank will be moved often, it is believed that a plexiglass top is preferred, as this allows for viewing from above. Other options may be considered in detailed design if a stainless steel top is desired. It is recommended that these options be considered in that case.
Wave-maker	The ESTS tank should have a wave-making apparatus that is similar to those the existing race-track flumes, provided that this will have enough capacity to meet the needs of the Science Plan.
UV Radiation	The tank should have flexibility so that different simulation methods can be investigated. As a starting point, the ESTS tank should a UV system that is similar in capabilities to those at the CEDRE and SINTEF tanks.

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1 INTRODUCTION AND OBJECTIVES

1.1 Background

The Emergencies Science and Technology Section (ESTS) of Environment Canada (EC) is at the development and design stage for a meso-scale marine oil exposure simulator. ESTS is initiating the process of designing and constructing a mid-size facility (with about 3-10 m^3 of water) facility to simulate the exposure and examine changes in oil behavior and fate over periods of weeks to months in a marine environment. It is generally termed "test tank" here.

1.2 Scope of Work

G. Comfort Ice Engineering Ltd. was contracted to:

(a) gather information and specifications on existing and planned systems which are broadly similar, as well as those facilities that conduct related research and testing. The information gathering process was intended to include reviews of the literature as well as contacts with the organizations operating these facilities.

(b) consult with ESTS staff on the science plan for the simulator activities.

(c) develop recommendations for design parameters and specifications for a test tank design, in keeping with the requirements imposed by Environment Canada's Science Plan.

G. Comfort Ice Engineering Ltd. reviewed other oil-test facilities presently in place around the world, focusing on "nuts-and-bolts" issues such as the engineering challenges and the lessons learned; and whether or not these designs would meet the technical needs of Environment Canada's Science Plan.

This summary report was prepared:

(a) to document the information-gathering that was done and;

(b) to provide recommendations regarding design parameters and facility specifications, in relation to the scientific requirements of ESTS; and the technical constraints for it (e.g., due to the available laboratory space).

1.3 Context

PWGSC has hired consultants to assist with the overall technical design of key engineering items such as: (a) structural and mechanical design; (b) HVAC; (c) safety and ventilation requirements, etc. This design work is ongoing. This report was prepared to help provide guidance at the initial design stage.

2 CLIENT CONSULTATIONS AND FACILITY CONSTRAINTS

2.1 Kickoff Meetings and Initial Consultations

The project commenced with a kick-off meeting held by teleconference on July 7, 2015 which was attended by Bruce Hollebone, Ben Fieldhouse, and Patrick Lambert of Environment Canada; and George Comfort. This was followed up with personal meetings at Environment Canada's laboratories on River Road: (a) on July 10th, attended by Ben Fieldhouse and George Comfort; and (b) on July 13th, attended by William Duffett, Adam Kurz, Ben Fieldhouse, and George Comfort. The kickoff meetings were followed up with various telephone calls and emails.

Key points arising from the meetings are summarized below:

(a) Overall objectives for the test tank – it is to provide a means for conducting meso-scale tests of short-term to long-term oil behavior in marine (open sea) environments in temperate and freezing conditions. It is intended to provide a means for bridging the knowledge gap between oil behavior in bench-scale tests and in the field. Bruce Hollebone is working on a Science Plan which will be sent to George Comfort soon for information.

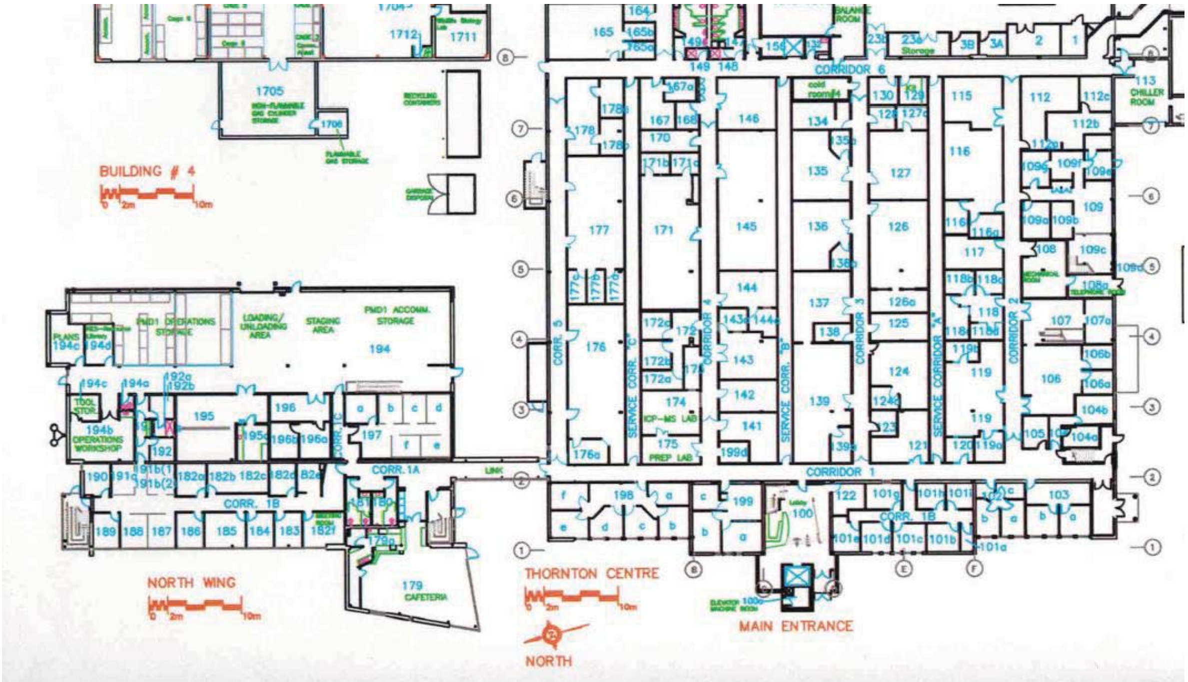
(b) General Layout for the Tank – EC is thinking about building a race-track type elliptical flume, generally similar to the ones presently in existence. The tank will be housed in a temperature-controlled cold room to allow tests at freezing temperatures. It may be useful to make the tank portable so that it could be rolled in and out of the cold room.

(c) Capabilities – the test tank must have capabilities to produce waves, winds, currents, and Ultra-Violet (UV) radiation. Consideration must be given to other critical support facilities and issues such as: (i) the ancillary facilities required (control room for the laboratory, mechanical room for equipment such as refrigeration units, power supplies, etc.); (ii) the ability to clean and re-use water from a test; (iii) means to observe the tests underwater; (iv) temperature control for the water; (v) humidity control; and (vi) systems handling such as equipment for mounting test fixtures, lifting oil barrels, etc.

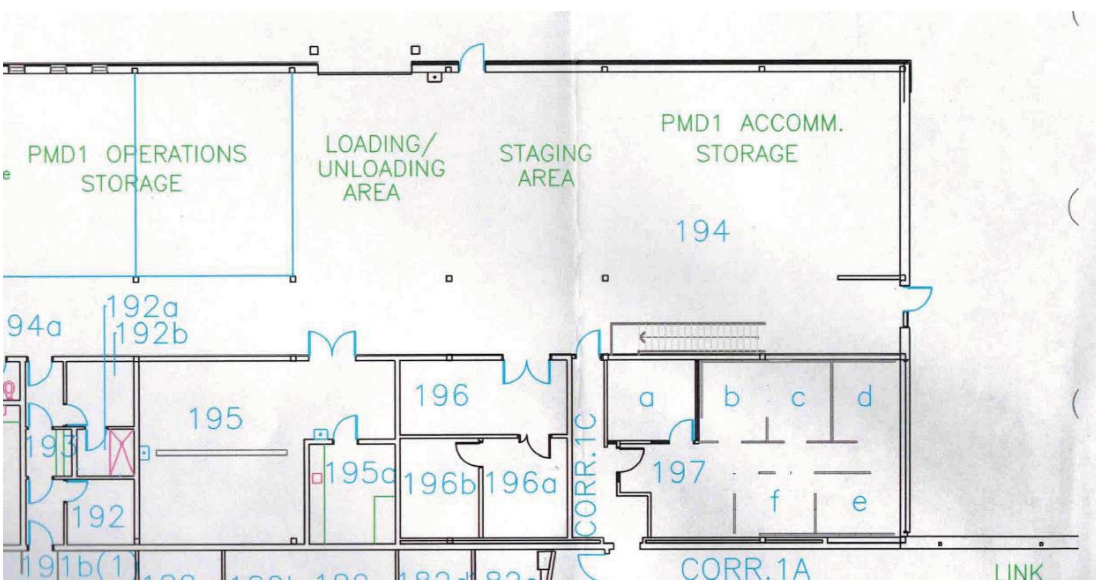
(d) Other Efforts – G. Comfort Ice Engineering Ltd. is expected to define key features and requirements of the test facility in a way that is useful to the consultants hired by PWGSC for overall technical design.

2.2 Constraints

The facility must fit within an area that is about 9m x 18m (30ft by 60ft) in Environment Canada's laboratories at 335 River Road, Ottawa. This location is shown as Area 194 on the floor plan (Figure 2.1). Access is available through a roll-up door near the available test area. It may be possible to locate buildings or trailers outside the walls of the building with some equipment such as refrigeration compressors. Figure 2.2 shows the available location inside the building, as well as the exterior of the building near the location for the facility.



Overview



Detailed View

Figure 2-1: Available Space and Location for the Facility at the EC Building
(From Ground Floor Plan – Dwg BB-1 provided by William Duffett, Environment Canada)

Available Location Inside the Building (Generally Denoted by Yellow lines)

Exterior Space along the Building

Figure 2-2: Photos of Available Location

3 INFORMATION-GATHERING

3.1 Purpose and Sources

Information was sought regarding other test facilities in the world to assist the design process. Information-gathering was focussed on obtaining practical information in an effort to allow Environment Canada to benefit from the "lessons learned" from the facilities to date.

Information was gathered from two main sources:

(a) References and written material – Appendix B provides a bibliography of references with information related to meso-scale oil test facilities. While these were useful as background material, they generally lacked the detail necessary to define "nuts-and bolts" items related to the planned tank. Consequently, information-gathering was focused on personal contacts.

(b) Personal contacts by email and telephone – these contacts were identified through the personal knowledge and experience of the project personnel.

3.2 General Summary of Personal Contacts

Table 3.1 summarizes the contacts made. Contact reports are provided in Appendix A for the contacts listed below.

(a) CCORE – Dr. Bing Chen and Chris Fowler

(b) CRREL – Dr. Steve Daly and Leonard Zabilansky

(c) NWRI – Dr. Ian Droppo

(d) OCRE of the NRC – Anne Barker, Dr. Mohammed Sayed and James Millan

(e) Joe Mullin

(f) OHMSETT – Dave Devitis

(g) SL Ross Environmental Research Ltd. – David Cooper

(h) USCG R&D Center – Kurt Hansen

More detailed information regarding the existing CEDRE, SINTEF and SL Ross race-track meso-scale oil flumes is presented separately in the sections that follow.

Table 3-1: Summary of Contacts Made

Person & Organization	Reason for Contact	Status
Julien Guyomarch , Stephane LeFloch & Ronan Jezequel, CEDRE	Get information about CEDRE's Polludrome	- Useful information received from multiple contacts in response to questions by email - Detailed section prepared regarding the CEDRE tank and facility
SINTEF	Get information about their elliptical flume	- Useful information received from multiple contacts in response to questions by email - Detailed section prepared regarding the SINTEF tank and facility
David Devitis, Mar (contractor for OHMSETT)	Request information re water filtration at OHMSETT	- Referral from original contact made to Bill Schmidt of Mar - Useful information received by telephone, as well as report by SL Ross re Evaluation of Wastewater Treatment from OHMSETT - Contact report prepared (Appendix A)
Dr. Ian Droppo, NWRI, Burlington	NWRI has test carousels which may provide useful experience for ESTD	- Useful information obtained during telephone call. This was followed up with papers from Ian. - Contact report prepared (Appendix A)
BIO (Dartmouth, NS) – Tom King	Get information about their Sea Carousel & wave flume	- Contact unsuccessful as Tom King was on holidays - Contact dropped due to time constraints
Steve Daly (US Army CRREL, Hanover, NH)	CRREL has extensive experience with test tanks in cold chambers	- Useful teleconference held with Dr. Steve Daly and Leonard Zabilansky (Facilities Mgr.) - Contact report prepared (Appendix A)
OCRE/NRC: Anne Barker, Ottawa M. Sayed, Ottawa J. Millan, St. John's	CHC has experience with test tanks in ice in cold chambers, and has done oil-ice tests in the past	- Useful information received through telephone contacts with Anne Barker, Mohammed Sayed and James Millan. Papers and reports were received. - Contact report prepared (Appendix A)
David Barber, University of Manitoba (UM)	UM just received funding for multi-million dollar facility for oil-in-ice in Churchill, Man.	- Preliminary information received from Dr. Barber - Facility still at the development stage, so not much detailed information is available – contact dropped
CCORE/Memorial: Bing Chen, Chris Fowler, Freeman Ralph	CCORE/Memorial developing designs for oil spill test facilities	- Useful information received by telephone and email - Contact report prepared (Appendix A)
Joe Mullin, Now Head Liaison Officer for Arctic Response Technology JIP	Extensive experience	- Useful information received by telephone – later expanded by Joe Mullin - Contact report prepared (Appendix A)
David Cooper, SL Ross Environmental Research Ltd.	Get info about their elliptical flume	- Useful information received by telephone and brief description provided - Detailed report section & Contact report prepared (App. A)
Rich Softye, Consultant	General experience in oil spills and hazardous materials	- Suggested that Kurt Hansen (USCG, R&D Ctr.) and Bill Lehr of NOAA should be contacted
Kurt Hansen, USCG R&D Centre	Active in oil spill research, mainly countermeasures	- Useful information and feedback received - Contact report prepared (Appendix A)
Bill Lehr, NOAA Emerg. Response Div'n, Seattle	Referral by Rich Softye	- Left voicemail but no callback received - Contact dropped

3.3 Detailed Information for Existing Race-Track Flumes

3.3.1 Overview

Three meso-scale race-track flumes are presently in existence that are designed and used for testing oil fate and behaviour, as follows:

(a) SINTEF, located in Trondheim, Norway

(b) CEDRE, located in Brest, France

(c) SL Ross Environmental Research Ltd., located in Ottawa, Canada

Table 3.1 provides an overall comparison between the SINTEF, SL Ross and CEDRE tanks. The SL Ross tank is patterned on the SINTEF one, and has similar dimensions and capabilities.

Table 3-2: General Specifications for the SINTEF and CEDRE Tanks (Faksness, 2013)

Table 2.2 Key figures for the flumes

	SINTEF and SL Ross	Cedre
Flume (circulation) length inner wall	10,2 m	16,4 m
Flume (circulation) length outer wall	16,6 m	20,2 m
Flume height	1,5 m	1,4 m
Flume width	0,5 m	0,6 m
Seawater depth	1 m	0,9 m
Seawater volume	4,8 m^3	7,2 m^3
Seawater temperature	13 °C	13 °C
Dispersant applicator	Wagner 450	Wagner 450
Nozzle size applicator	0,8 mm	0,8 mm
Oil volume	1 L	1 L
Containment ring for oil and dispersant application	0,25 m^2	0,25 m^2
Oil film thickness (1 L oil) in containment ring	4 mm	4 mm
Dispersant to oil ratio (DOR)	1:25	1:25
Particle size analyzer	LISST*	Malvern
Position of particle size analyzer	Vertically, 37 cm depth, 25 cm from wall	40 cm depth, 30 cm from wall

**LISST: Laser In-Situ Scattering and Transmissiometry (Sequoia Scientific, Inc.)*

3.3.2 CEDRE

The CEDRE "Polludrome" is illustrated in Figures 3.1 to 3.3. Table 3.3 summarizes detailed information provided by CEDRE personnel, in response to questions that were sent to them. Table 3.4 summarizes information published by Guyomarch, 2012 with respect to the re-design that was carried out for CEDRE's Polludrome.

Structural drawings were also provided by CEDRE for its second-generation tank. Because these have already been provided to Environment Canada under separate cover, only a General Arrangement drawing is included in Appendix C.

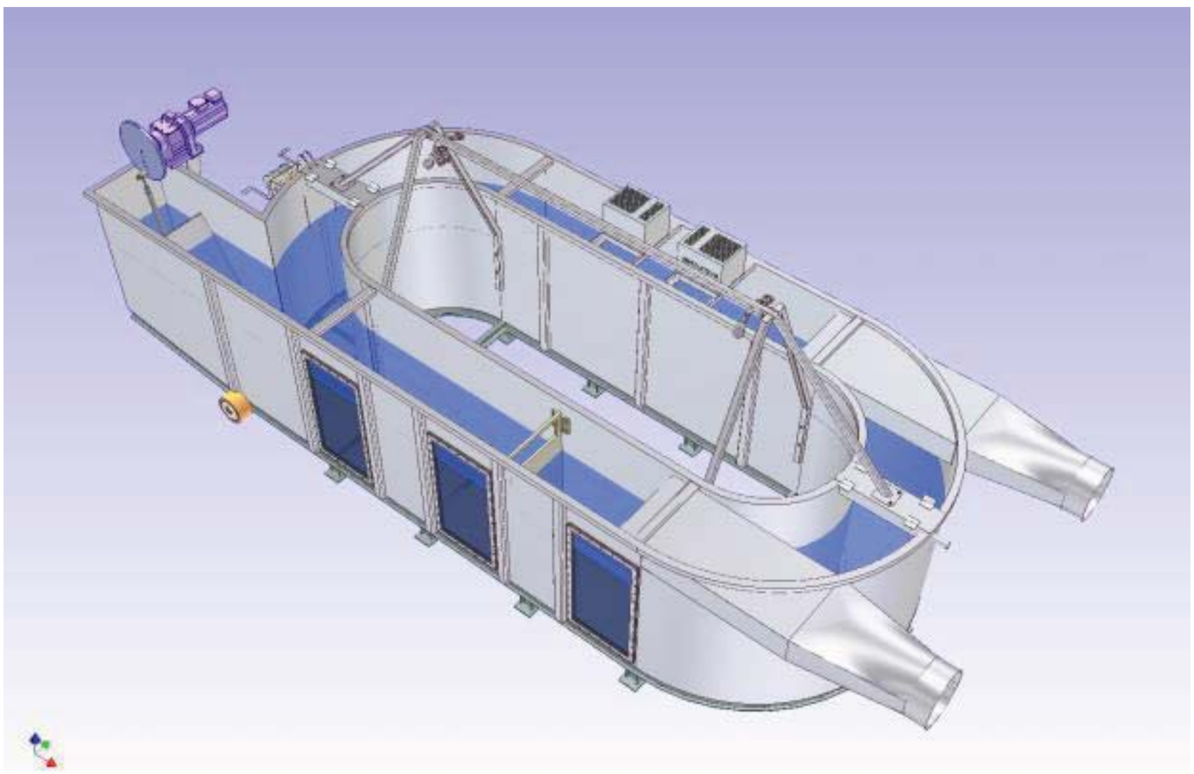


Figure 3-1: CEDRE Flume Tank (J. Guyomarch, CEDRE, pers. comm'n)

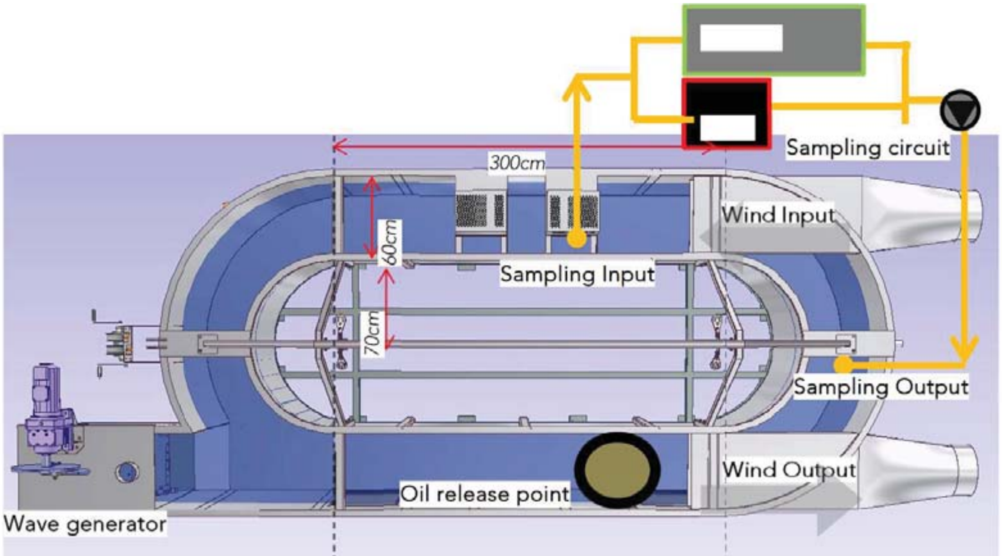


Figure 2 Experimental design

Figure 3-2: CEDRE Flume (Faksness, 2013)

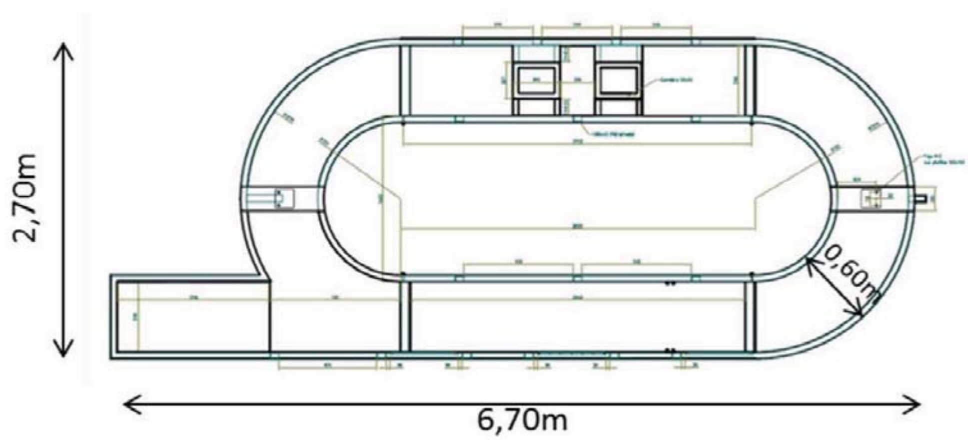


Figure 2.4 Meso scale flume tank at Cedre

Figure 3-3: CEDRE Flume Tank (Faksness, 2013)

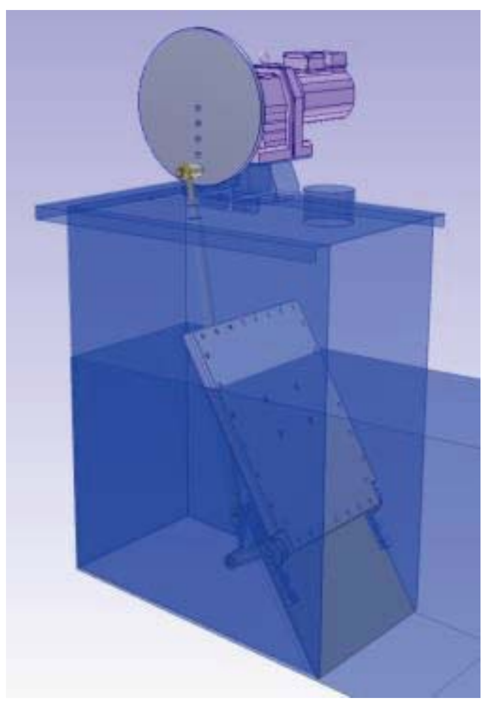
Table 3-3: Detailed Information Received from CEDRE
(taken from emails by Dr. Stephan Lefloch and Dr. Julien Guyomarch)

Question	Response
Treatment of oily water– How do you handle the oily/dispersant wastewater from a test? Do you filter water for reuse or treat for disposal? Is a fresh water supply used for each test?	For each test, fresh sea water or fresh "fresh water" (Salinity = 0). After each test, the water is filtered on sorbent pads and the water is collected in a specific basin for decantation (at the end, this water is polled with the water of our artificial beach).
Oiling of surfaces– Has collection of oil on the tank surfaces caused issues with for example, mass balance evaluations?	Not always done. This step depends of the contract / the project.
Water temperature control – How is the temperature of the water in the tank controlled? What is the variation in temperature? Are both heaters and coolers installed in the tank? Have you found it necessary to include equipment to prevent stratification of the water temperature (e.g., air bubblers) to achieve a uniform temperature profile? Also, do you have any comments about the precision of the water temperature control that has been achieved in your tank?	In fact, the easy way is to work in a thermos-regulated room! In fact, our tank is placed in a thermostatically controlled room. Schedule of a test: we fill the tank with water, we fix the temperature of the room, and the test start really the following day. It is clear that the water is at the appropriate temperature and there is no temperature profile (homogeneous water column). We work at + or - 1°C.
Tests at freezing temperatures – We are considering arrangements to allow us to conduct tests at freezing temperatures. Have you ever done tests at freezing temperatures at CEDRE? If so, have you had any issues in doing tests in these conditions (e.g., ice forming along the sides of the tank, equipment icing up, etc.)?	Yes, we have a project funded by a JIP. In fact, we are a bit lucky: Cedre is the neighbour of Oceanopolis and this institute has a "polar building" (simulated ice pack). Therefore, they have specific equipments for ice production, we can used them. In addition, we have purchased specific equipment for cooling the temperature of the sea water (storage tank into which sea water can be maintained at 2-3 °C).
Currents – How are currents generated? How do you avoid irregularities in the current field caused by, for example, the shape of the tank and the natural tendency for currents to disperse from a source? Do you use multiple current generators spaced around the circumference of the tank? Have you found it necessary to install baffles as flow straighteners in the tank?	We have a current generator made of a propeller. Our system has to be replaced and we are looking for another solution, or we have to improve this option with additional device in order to make the current more regular (with a propeller, we have an area close to the generator characterized by a very low current)
As a follow-on question about currents, have you had any issues with emulsions being produced by the current generators?	Up to now, we had no problems of oil being dispersed by the generator, but maybe because it is located at the opposite side of the waves.
Waves – Does the wavemaker produce regular waves in your tank; or can it make irregular ones too? How uniform is the wave field? Have you had issues with the wave field being affected by the geometry of the tank (e.g., due to reflections off the tank walls, etc.)?	Wavemaker produces only regular waves. But it is possible to adapt the frequency. We have quite regular waves but not very regular, and this is due to the reflection off the tank walls. I have questioned an institute which is working on big modelling projects, including protection of harbours by dikes they have designed, and I was told that it was not possible to modelled waves with such equipment due to that reflection.
Winds – How uniform is the wind field? Do you have equipment (e.g., baffles in the air chase above the tank) to straighten the wind field?	We have not designed our system to get a uniform wind field, particularly when we have not uniform waves...
UV radiation sources – how are these powered? Have there been any issues with them?	Important parameter, specific light and filters. http://www.hoenle.de/en/product/uv-systems/sun-simulation/

Powering the various components of the tank – how are the various components (i.e., wavemaker, fans, current generators, solar radiation, etc.) powered? Are they powered individually or do you have a central power supply?	Each equipment is independent with its own energy. Each system is individually powered. Our installation is checked by telemonitoring.
As a follow-on question, do you have auxiliary power supplies to keep the tank operating in the event of a power failure? We are thinking about this as some of our planned experiments may last for about a month in duration.	
Safety – what safety equipment is included in your tank (e.g., air extraction to remove vapors, protection against UV, etc.)?	Very important to have an extractor (many oils have light components). For the light, not possible to be exposed... In addition, we have specific "safety recommendations" when a test is running. Vapors are directly extracted in the tank which is closed. Careful attention has to be paid when creating low temperatures (the important renewal of air should not compromise the temperature stability). Systems with heat exchange could be a solution (double-flow ventilation?)
Duty cycle for testing – How much time is generally required for non-testing activities (e.g., cleaning, maintenance, mobilization and demobilization for a test, etc.); versus the actual conduct of a test?	Link to the project. But, for a "normal test" to study the oil weathering, 2 days of logistic (preparation and cleaning) and 4, 5 or 6 days for the experiment in itself.
Maintenance – do you have maintenance issues, other than cleaning which is to be expected? Have you experienced any incompatibilities to tank materials or equipment with either salt water or oil exposure?	Yes, but not with oil... We performed some experiments with phosphoric acid and... too much corrosion!
Systems Handling – we note from your pictures that you have installed a gantry crane above your tank. What capacity does it have; and have you found that it has any limitations for your work? We are thinking about installing a similar system. Do you have any recommendations for us?	In fact, this equipment is used for operating the lid of the tank. We have a lid which covers all the tank, a bit heavy... but very important for safety reason and not only...
Any other comments or suggestions? Are there any revisions you would make to the next generation of tank?	Consider a system that could generate simultaneously waves and currents (a plate push the water in on direction to create waves, but when it goes back to its position, valves open not to suck up the water that has been pushed). Consider a system that could generate simultaneously waves and currents (a plate push the water in on direction to create waves, but when it goes back to its position, valves open not to suck up the water that has been pushed).

Table 3-4: Relevant Information in Guyomarch, 2012

- *Mobility of Test Tank*: "The tank had to be mobile in the case of the entire climate room should be necessary for a specific experiment".
- *Material for Tank*: "Equipment made of 4mm stainless steel (3mm for the cover) instead of aluminum"
- *Viewing Windows*: "Reduction of the size of the windows and withdrawal of the small ones previously located just above the bottom"
- *Cover for Tank*: "The cover was made of two parts instead of around ten different pieces and operated by using a winch"
- *Wind Generator*: "The wind generator was kept but the geometry of the diffusion in the canal was modified to generate less turbulences. The location of the fume extractor was also changed".
- *Key Specifications*:
  - Dimensions: "L = 12m, l = 0.6m, h = 1.4m"
  - Temperature: "1°C to 30°C"
- *Wave Generator*: Waves are generated by lifting and lowering a slanted metal plate into the water using an electric motor. See Figure below. Guyomarch, 2012 commented that this arrangement produced a "regular and reproducible wave" without the "jolts" given by their previous wavemaking apparatus, which consisted of a wedge-shaped section that was driven into the water using a hydraulic cylinder. Waves can be varied by various methods.
  - There are four bottom plate anchor plates positioned along the two oblique attachment rails.
  - The connecting rod can be attached at four different positions on the rotating disc.
  - The speed of the rotating disc can be adjusted using a rheostat.
- *UV Radiation*: CEDRE uses two lights at 2000 W each, "generating an intensity of 1000 W on the slick (manufacturer data)." Guyomarch, 2012 commented that "as the "area exposed to the radiation is about 1.5 metres long by 60 cm wide, the light intensity per surface unit is about 2000 W/m^2". Guyomarch, 2012 further commented that "as a slick drifting in the canal is only exposed to this radiation periodically, the average intensity is approximately 200 W/m^2".



3.3.3 SINTEF

Figures 3.4 to 3.6 show the SINTEF race-track flume.

Detailed information was provided by SINTEF personnel in response to questions sent to them by email (Table 3.5). As well, SINTEF prepared a report (Daling and Liervik 2015a) and a set of slides ((Daling and Liervik 2015b) in response to an email request from Environment Canada, from which the information in Table 3.6 has been extracted.

Structural drawings were also provided by SINTEF for its second-generation tank. Because these have already been provided to Environment Canada under separate cover, only a General Arrangement drawing is included in Appendix D.

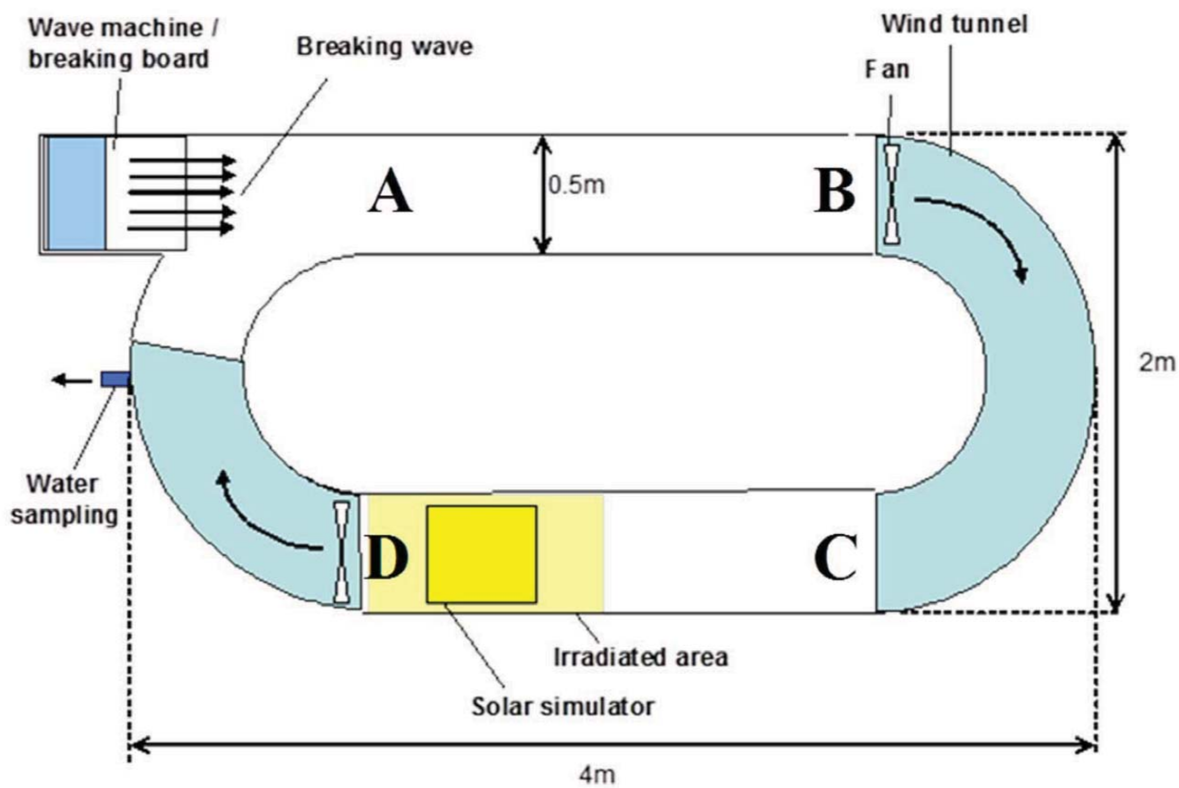


Figure 2.2 Meso scale flume tank at SINTEF and SL Ross with measuring points A, B, C and D.

Figure 3-4: SINTEF Flume (Faksness, 2013)

	**From Johnson, 2015**
4.2.5 Photo-documentation of the deliverables to the oil / ice test basin facility 	**From Daling and Liervik, 2015a**

Figure 3-5: SINTEF Flume

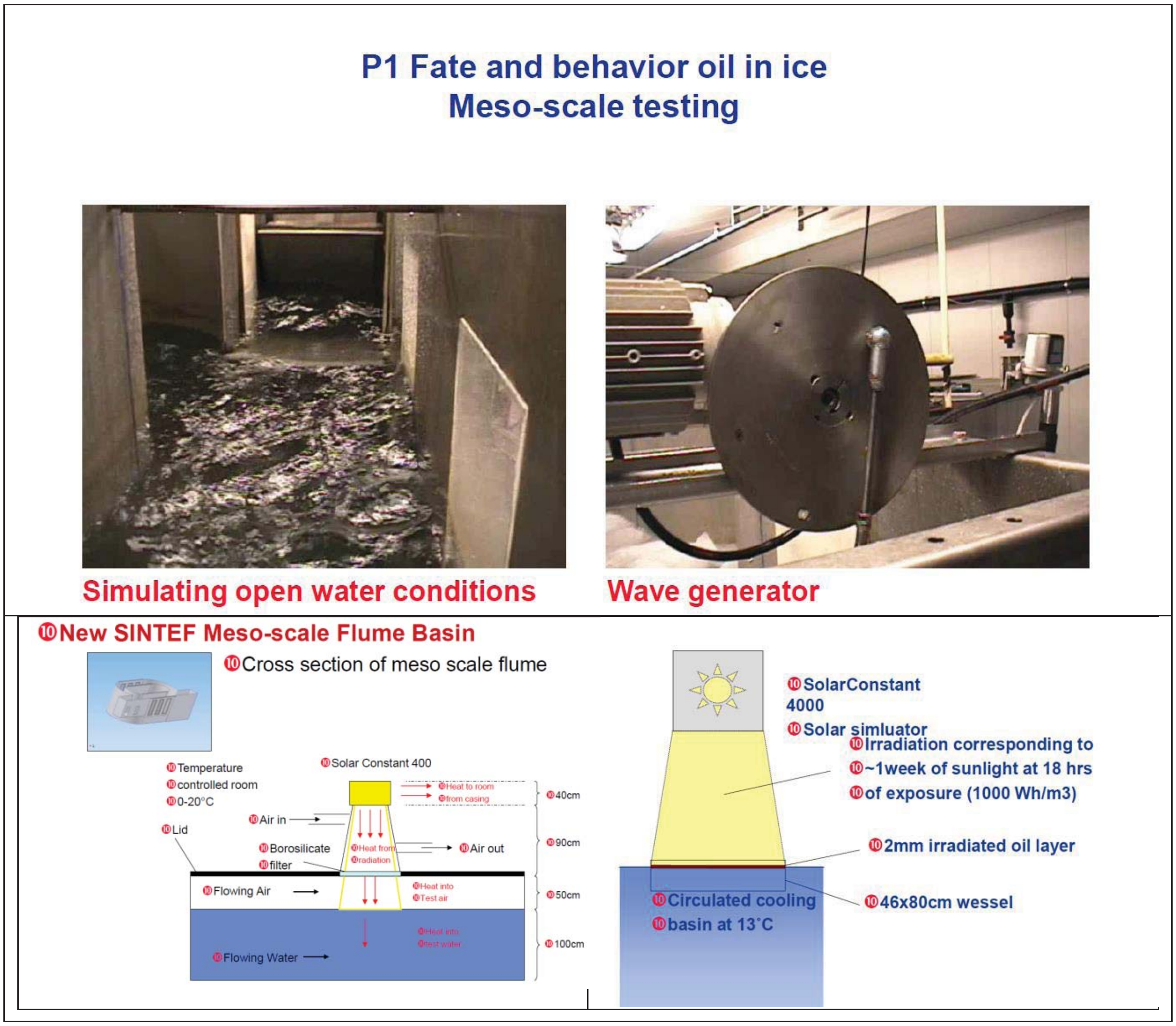


Figure 3-6: SINTEF Flume and Facilities (Daling and Liervik, 2015b)

Table 3-5: Detailed Information from SINTEF
(from email of Aug 31 by Dr. Per Daling, with contributions by F. Liervik)

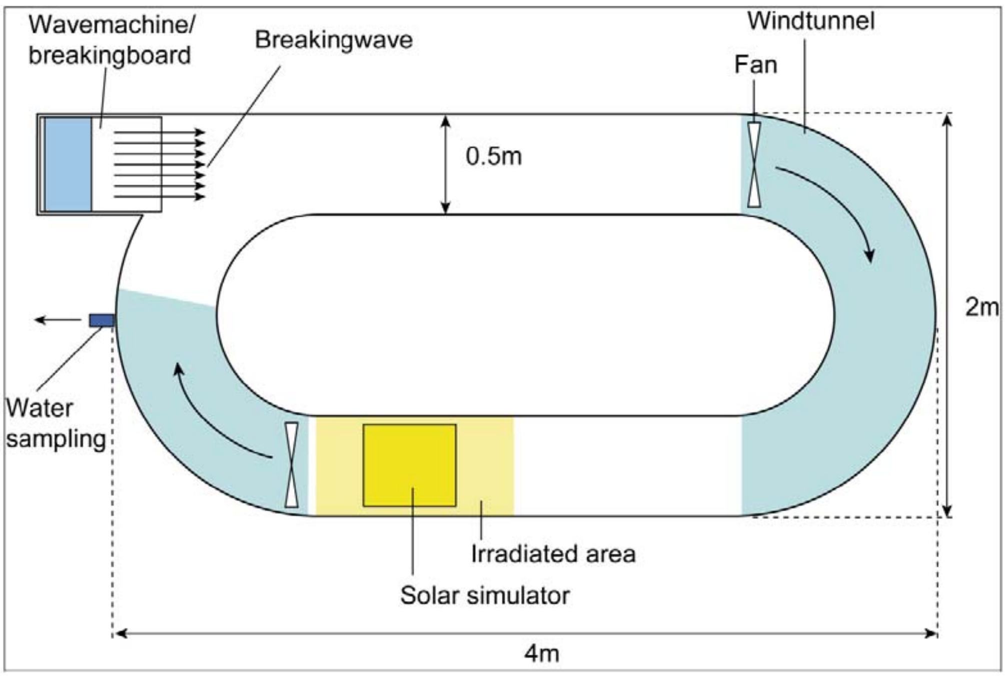
Question	Response
Treatment of oily water– How do you handle the oily/dispersant wastewater from a test? Do you filter water for reuse or treat for disposal? Is a fresh water supply used for each test?	We change water for every new experiment. We skim of most of the oil, and have a permit to dispose of the water to the municipal sewer system. We have an in-house seawater supply taken from 80 meters depth in the Trondheim fjord.
Oiling of surfaces– Has collection of oil on the tank surfaces caused issues with for example, mass balance evaluations?	Yes, especially for waxy crudes/and waxy condensates (see other comments under pkt 14.) Note by GComfort: SINTEF is referring to their comments in the last row in this table regarding oleophilic surfaces.
Water temperature control – How is the temperature of the water in the tank controlled? What is the variation in temperature? Are both heaters and coolers installed in the tank? Have you found it necessary to include equipment to prevent stratification of the water temperature (e.g., air bubblers) to achieve a uniform temperature profile? Also, do you have any comments about the precision of the water temperature control that has been achieved in your tank?	We have heating/cooling coils installed in the two long sections of the tank. There is a PLS system controlling the heater/cooler. The PLS makes the temperature oscillate around the set-point (0.5°C). The tank is also placed inside a temperature controlled room. At the standard wave conditions stratification is documented not to be an issue.
Tests at freezing temperatures – We are considering arrangements to allow us to conduct tests at freezing temperatures, similar to the SINTEF facility. Have you had any issues in doing tests in the cold room (e.g., ice forming along the sides of the tank, equipment icing up, etc.)?	We have had ice growth on the cooling coils when working around freezing point. The room temperature can go down to around -1 to 0 deg C. When we are doing weathering experiments with presence of ice on surface, we prepare the different type of ice outside the flume (in a freezing room)
Currents – Are currents generated only by wave action or are other methods used as well? How do you avoid irregularities in the current field caused by, for example, the shape of the tank and the natural tendency for currents to disperse from a source? Do you use multiple current generators spaced around the circumference of the tank? Have you found it necessary to install baffles as flow straighteners in the tank?	Current is generated by the wave action and two fans mounted above the surface. The currents in the flume are not at all laminar.
Have you had any issues with emulsions being produced by the current generators?	As the braking wave is our current generator, obviously it also makes emulsions (as it is meant to).
Waves – Does the paddle system produce regular waves in your tank; or can it make irregular ones too? How uniform is the wave field? Have you had issues with the wave field being affected by the geometry of the tank (e.g., due to reflections off the tank walls, etc.)?	We have had projects where we have made irregular waves in a modified setup of the flume tank. If we were to do this on a regular basis the wave maker would have been designed differently.
Winds – How uniform is the wind field? Do you have equipment (e.g., baffles in the air chase above the tank) to straighten the wind field?	The wind is probably as non-uniform as the currents. We have no equipment straightening the wind field,
UV radiation sources – how are these powered? Have there been any issues with them?	The UV source is a solar simulator from Steuernagel (now merged with Atlas). The system has its own control/power unit powered from our in house 400V. No issues.
Powering the various components of the tank – how are the various components (i.e., wavemaker, fans, current generators, solar radiation, etc.) powered? Are they powered individually or do you have a central power supply?	The wavemaker is powered through a frequency converter giving out 220V 3 phase. The two fans share a common Frequency controller (220V 3phase). The power for the sunlight is described above. We have no current generator in the standard setup.
As a follow-on question, do you have auxiliary power supplies to keep the tank operating in the event of a power	No.

failure? We are thinking about this as some of our planned experiments may last for about a month in duration.	
Safety – what safety equipment is included in your tank (e.g., air extraction to remove vapors, protection against UV, etc.)?	The continuous air extraction is limited by the capacity of the cooling system. We have gas detectors mounted. At 20% LEL the air extraction is opened at full throttle to dilute the gas. Alarms are off course also going off. We have reels of air supply hoses for active gas masks, but usually the passive ones are OK.
Duty cycle for testing – How much time is generally required for non-testing activities (e.g., cleaning, maintenance, mobilization and demobilization for a test, etc.); versus the actual conduct of a test?	Cleaning is usually quite fast. A turnaround time of 2 days is manageable.
Maintenance – do you have maintenance issues, other than cleaning which is to be expected? Have you experienced any incompatibilities to tank materials or equipment with either salt water or oil exposure?	Keeping windows tight with time has been an issue. We started out with lexane windows which were easy to replace and modify, but we never found glue that would stick with time. We are now trying out tempered glass that works promising.
Systems Handling – we note from your pictures that you have installed a gantry crane above your tank. What capacity does it have; and have you found that it has any limitations for your work? We are thinking about installing a similar system. Do you have any recommendations for us?	We do not have a gantry crane, but would not mind having one. Our room is too low, and the ceiling is to crowded to have one mounted now. The crane you see on the picture holding the "artificial shoreline frame" is only a small, moveable crane on the floor we are using occasionally.
Any other comments or suggestions? Are there any revisions you would make to the next generation of tank?	As mentioned in the 2nd row of this table: To minimize the adsorption of oil residue / emulsions to the walls is challenging, particularly in low- temperature experiments with waxy oils. It is primarily a 5 – 10 cm band of oil adsorbed to the wall around the water surface area that may be generated. We have been thinking on several approaches: from having tubes with air along the walls to avoid contact between oil and the wall, but this may lead to artificial emulsification along the tube. We have also been thinking on the possibility to have some heating elements connected to the flume in that limited area. We will also looking more into testing oleophobic coating to avoid oil adsorption to the wall in the flume. There are several companies: 1. SLIPS: http://wyss.harvard.edu/viewpage/370/ 2. ACULON: http://www.aculon.com/oleophobic-coatings.php 3. LIQUIGLIDE: http://liquiglide.com/

Table 3-6: Key Information Extracted from Daling and Liervik, 2015a

4.2.3 Specification and capacities with the meso-scale flume basin

- *The skate-rink formed flume (see sketch below) is 4 m long and 2 m wide, with a prolongation of one side for installation of a wave generator (plunger) and an artificial beach. The height will be approximately 1.5 m allowing for a water depth of 1 m.*
- *The flume is built in modules in stainless steel and can also be put together in different basin shape constructions (e.g. circular, straight channel etc).*



- *Air temperature: 0°C to 30°C+.*
- *Wave generator (plunger) and a wave breaking board.*
- *Fans for creating wind in a wind tunne:l up to 10m/s.*
- *Current generators (up to 1 knot current).*
- *Possibility for water exchange / dilution*
- *Cooling facilities for water: down to – 2°C.*
- *Ventilation facilities for safe operations by laboratory personnel in the room.*
- *Artificial beach (removable with tidal variations).*
- *Photo-oxidation panels: 2x Solar-lamps (4kW, Gmbh Steuernagel) removable. also for use in the oil/ice test basin*

Daling and Liervik, 2015 further commented that:

The old meso-scale oil weathering flume at SINTEF (in plexi-glass) has been extensively used over a period of 12 years and needed to be replaced by a new flume.

3.3.4 SL Ross Environmental Research Ltd.

The SL Ross meso-scale oil test flume is illustrated in Figures 3.7 and 3.8. Table 3.7 summarizes detailed information provided by SL Ross personnel.

MAY 06 2014

THE RECIRCULATING FLUME TANK

The flume tank, constructed primarily to perform weathering experiments, consists of a working channel 0.5 metres wide, 1.5 metres deep, with a total centre-line length of 8.7 metres. The overall footprint is 2.0 metres wide by 4.8 metres long including a wave generating section. Water temperature is controlled using a chiller and heat transfer coils mounted within the water column. A UV source is used to simulate solar radiation, while a ventilation fan is used to extract vapours. The tank enclosure is covered by clear polycarbonate sheets to prove an air chase above the water surface and block stray UV light. Water currents are created using fans mounted within the air chase or twin thrusters mounted vertically within the water column. A reciprocating wedge may also be used to generate small waves. The flume tank will be used for weathering & dispersant studies.

Figure 3-7: SL Ross Flume Tank (ref.: World Catalog of Oil Spill Products)

Figure 2. Air Space Fan.

Figure 5. Ultra Violet Light mounted above Access Port.

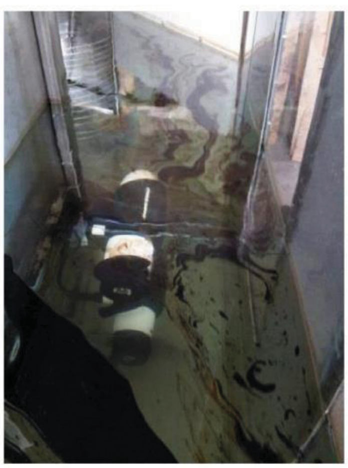


Figure 3. Water Current Thrusters

Water Chiller Heat Transfer Coil and Water Cascade Pump Location

Figure 3-8: SL Ross Flume Tank (SL Ross, 2012)

Table 3-7: SL Ross Flume Tank Description (D. Cooper, SL Ross, personal comm'n)

The meso-scale oil weathering flume consists of a channel 0.5 metres wide with a total centre-line length of 8.7 metres. The inner and outer radii of the tank ends are 0.5 and 1.0 metres and the tank straight sections are 2.0 metres long. The tank footprint is 2.0 m wide by 4.8 metres long (including a wave generating section). The tank enclosure is covered by clear Lexan sheets to create an air chase above the water surface. Wind is circulated above the water using fans. A flex hose is attached to a ventilation fan that extracts vapours from the air space above the floating oil. Water currents are created using dual thrusters, and a UV light source may be used in weathering experiments. The water temperature is controlled using a chiller and heat transfer coils.

3.4 Summary Conclusions from the Information-Gathering and Recommendations

The findings from the information-gathering are summarized in the sections that follow. The recommendations made are also summarized in Table 3.9.

As a starting point for this section, it is understood that Environment Canada has decided that its test tank should have an overall configuration that is similar to the existing race-track flumes at CEDRE, SINTEF and SL Ross Environmental Research Ltd. (Bruce Hollebone, ESTS, personal communication). Consequently, the information presented here, and the recommendations drawn from them, are primarily based on the experience for these three tanks. The experience at CRREL was also helpful as it has several decades of experience with operating test tanks in cold conditions; as well as having experience in conducting oil-in-ice tests.

3.4.1 Overall Test Tank Configuration and Capabilities

Summary: Table 3.8 compares key capabilities for the three existing race-track flumes.

Table 3-8: General Summary of the Capabilities of the Three Existing Face-Track Flumes

Parameter	CEDRE Tank	SINTEF Tank	SL Ross Tank
Waves	• Waves made with plunger driven by electric motor • Performance limits not known – Waves up to 20 cm high & 3s period in tests by Guyomarch, 2013	• Waves made with plunger driven by electric motor • Performance limits not known – breaking waves up to 11cm high in JIP tests (Faksness, 2013)	• Can produce waves • Performance limits not known – Produced waves up to 15 cm high in JIP tests (Faksness, 2013)
Currents	• Can produce currents independently • Performance limits not known – Currents up to 0.4 m/s (0.8 knots) in tests by Guyomarch, 2013	• Can produce currents independently • Performance limits – up to 0.5 m/s (1 knot); source: Daling and Liervik, 2015a	• Can produce currents independently using pump & thrusters • Performance limits not known – Produced currents of 0.25 m/s (0.5 knots) in tests by SL Ross, 2012
Winds	• Winds made using fans • Performance limits not known – Produced winds up to 5 m/s (10 knots) in tests by Guyomarch, 2013	• Winds made using fans • Performance limits – up to 10 m/s (20 knots): source: Daling and Liervik, 2015a	• Can produce winds using fans • Performance limits not known – Produced winds of 2.5 m/s (5 knots) in JIP tests by Faksness, 2013
UV Radiation	• Can produce UV radiation using 2 UV lights • Performance limits – 4 kW power; produced max. intensity of 2000 W/m^2 in tests by Guyomarch, 2013	• Can produce UV radiation using 2 UV lights • Performance limits – 4 kW power, lights from Gmbh Steuernagel (Daling and Liervik, 2015a)	• Can produce UV radiation • Performance limits not known – Produced avg. of 15 mW/cm^2 in tests by SL Ross, 2012
Temperature Control	• Tank in Thermo-regulated room; Range: 1 to 30°C • Can cool water separately in outside tank to 2-3°C	• Air Temp: 0° to 30°C • Water: down to -2°C	Has chiller and heat transfer coils in water

One contactee commented that there is nothing "really lacking" with respect to the capabilities of the CEDRE, SINTEF and SL Ross tanks; and that the capabilities of all three existing meso-scale race track flumes are considered to be acceptable.

Recommendation by GComfort: the ESTS tank should be similar in size and capabilities to those of the existing tanks, provided that this is sufficient to meet the needs of the Science Plan established by ESTS for its facility.

3.4.2 Tank Material

Summary: CRREL has standardized its designs such that the only materials in their ice tank are plexiglass and stainless steel. CRREL advised against using aluminum due to the fact that electrolytic currents tend to get set up with it, in a seawater environment.

The original SINTEF tank was made from plexiglass; but the second-generation one was made of stainless steel.

The second-generation CEDRE tank is made of stainless steel.

As a further consideration, it is important for the ESTS tank to minimize heat transfer through its walls, to reduce the amount of ice buildup that will occur on the tank walls during tests in freezing conditions. This is considered to be quite important for the ESTS tank as many tests are planned to be done in it in freezing conditions (B. Hollebone, ESTS, personal communication).

It is well known at "ice tanks" that horizontal ice growth will occur at the tank walls unless it is retarded by the heat transfer properties of the basin walls.

Recommendation by GComfort: the tank should be made from stainless steel.

The tank walls should also be insulated to retard ice growth on them. Because insulated tank walls may not be necessary for all tests, it may be useful to consider having removable insulated panels for the tank walls. It is recommended that this option be considered in detailed design.

3.4.3 Coatings for Tank Walls

Summary: These are important to minimize cleanup efforts associated with coating of the tank by oil. SINTEF provided information about three oleophilic coatings that are under consideration for its tank. CRREL reported that they have a "high-performance epoxy" coating on their basin walls (which are concrete); and that this coating greatly facilitates cleanup efforts.

Recommendation by GComfort: the tank should have an oleophilic coating on its walls. Further investigation should be made to select the coating to be used, starting with the three coatings identified by SINTEF.

3.4.4 Viewing Windows

Summary: The experience to date is mixed, which indicates that these need to be considered with care. CRREL has found that they leak, and relies on underwater cameras instead for viewing. This is also partly due to the fact that their tank is large; and as a result, the windows in the basin walls are often far away from the experiments, so visibility is limited in any case. CRREL relies on underwater cameras for viewing.

SINTEF reported that have had trouble keeping their Lexane windows "tight with time"; and that they are trying out alternatives.

CEDRE reduced the number of viewing windows in its second-generation tank.

Recommendation by GComfort: the capability to "see" what is happening in a test is believed to be very important. The tank should be built with viewing windows but they should not be the only means for underwater viewing. Underwater cameras should be included too.

3.4.5 Cover for the Air Chase

Summary: The air chase for the tanks at SINTEF and SL Ross Environmental Research Ltd. are made of plexiglass, which allows experiments and conditions to be viewed from above.

CEDRE has a stainless steel cover for the air chase in its tank. Of course, this does not allow experiments to be viewed from above. It is speculated that the stainless steel cover may have been selected by CEDRE to obtain added structural integrity for its tank, as CEDRE occasionally moves its tank on rollers out of the experimentation area when not in use.

Recommendation by GComfort: the most appropriate selection depends on the degree to which the ESTS tank will be moved, e.g., in and out of the cold room. Windows in the top and/or cover would provide the ability to view experiments and conditions from above, which is considered to be a very significant advantage. Unless the ESTS tank will be moved often, it is believed that a plexiglass top is preferred.

If a stainless steel tank top is selected in the design phase (e.g., to achieve greater structural rigidity), the option of having viewing windows in the tank top should be considered.

If it is decided in the design phase that the tank top is to be made of plexiglass, options to increase the structural rigidity when the tank is moved could be considered (e.g., by adding a metal "strongback" to the tank top; or by having a second tank top made of stainless steel for the purpose of moving the tank).

It is recommended that these issues and these options be assessed during the design phase.

3.4.6 Wave-Maker

Summary: The three existing race-track flumes only produce regular waves. Generally, the wave-maker is comprised of a plunger section connected to an electric motor. The wave height can be varied through the mechanical connecting arrangement; while the wave period can be varied by controlling the speed of the motor, e.g., using a rheostat.

Recommendation by GComfort: the ESTS tank should have a wave-making apparatus that is similar to those the existing race-track flumes, provided that this will have enough capacity to meet the needs of the Science Plan.

3.4.7 UV Radiation

Summary: CEDRE and SINTEF use commercially-available lights, with a total power of power of 4 kW. The SL Ross tank has similar capabilities.

It is understood that there is debate regarding the most appropriate method of simulating UV radiation; and that Environment Canada intends to investigate this as part of the Science Plan for its tank (B. Hollebone, ESTS, personal communication).

Recommendation by GComfort: the tank should have flexibility so that different simulation methods can be investigated. As a starting point, the ESTS tank should a UV system that is similar in capabilities to those at the CEDRE and SINTEF tanks.

3.4.8 Overall Summary of Recommendations

This is provided in Table 3.9.

Table 3-9: Summary of Recommendations

Item	Summary Recommendations
Overall Configuration and Capabilities	The ESTS tank should be similar in size and capabilities to those of the existing tanks, provided that this is sufficient to meet the needs of the Science Plan established by ESTS for its facility.
Tank Material	The tank should be made from stainless steel. It should also be insulated to retard ice growth on the tank walls for tests in freezing conditions.
Coatings for Tank Walls	The tank should have an oleophilic coating on its walls. Further investigation should be made to select the coating to be used, starting with the three coatings identified by SINTEF.
Viewing windows	The capability to "see" what is happening in a test is believed to be very important. The tank should be built with viewing windows but they should not be the only means for underwater viewing. Underwater cameras should be included too.
Cover for the Air Chase	The most appropriate selection depends on the degree to which the ESTS tank will be moved, e.g., in and out of the cold room. The ability to view experiments and conditions from above is considered to be a very significant advantage. Unless the ESTS tank will be moved often, it is believed that a plexiglass top is preferred, as this allows for viewing from above. Other options may be considered in detailed design if a stainless steel top is desired. It is recommended that these options be considered in that case.
Wave-maker	The ESTS tank should have a wave-making apparatus that is similar to those the existing race-track flumes, provided that this will have enough capacity to meet the needs of the Science Plan.
UV Radiation	The tank should have flexibility so that different simulation methods can be investigated. As a starting point, the ESTS tank should a UV system that is similar in capabilities to those at the CEDRE and SINTEF tanks.

4 REQUIREMENTS FOR THE ESTS MESO-SCALE OIL TEST FACILITY

4.1 Technical

As a starting point, it is useful to review the test parameters used for previous tests at the existing facilities. Table 4.1 summarizes key parameters for a weathering and dispersability study that was conducted at CEDRE's Polludrome for Fossekal crude oil (Guyomarch, 2013).

Table 4-1: Weathering and Dispersability Study at CEDRE (Guyomarch, 2013)

The general characteristics of the canal are:
- Canal dimensions: width: 0.6m; wall height: 1.4 m; average water depth: 0.9 m.
- Waves typical characteristics: period 3 seconds, amplitude ± 0.1 m.
- Climate room: from 1 to 30 °C.

All tests were run assuming a moderate situation (sea state 3. which corresponds to wave heights between 0.5 and 1.25 m). The corresponding parameters for the *Polludrome* were:
- wave height: 20 cm
- mean period: 3 s
- current speed (water): 40 cm/s
- wind velocity: 5 m/s
- volume of seawater : 7 m^3

The solar energy was recreated by two UV lights (up to 2000 W/m^2). Full salinity seawater (33 ppt) was used in tests.

Comparative dispersant efficiency tests were conducted at each of the three existing race-track flumes by Faksness, 2013, as part of an extensive Joint Industry Project. Environment Canada has expressed interest (B. Hollebone, ESTS, personal communication) in conducting trials in its tank that are comparable to the ones already conducted at the existing race-track flumes. Table 4.2 summarizes key test parameters for the comparative dispersant efficiency tests conducted at the SINTEF, SL Ross and CEDRE tanks (Faksness, 2013).

Of course, this affects many technical requirements for the ESTS tank.

In addition to being able to reproduce the test conditions used in the dispersant efficiency tests (by Faksness, 2013), the ESTS tank must be capable of creating test conditions that satisfy the demands of the ESTS Science Goals for the tank (Table 4.3). These requirements have been amalgamated to produce an overall set of technical criteria as summarized in Table 4.4.

Table 4-2: Parameters for Comparison Tests for Existing Flumes (Source: Faksness, 2013)

Parameter	CEDRE	SINTEF	SL Ross
Wind Speeds[1], m/s:			
Energy Level A	3 m/s	1.9 – 2.0	1.9 – 2.1
Energy Level B	for	2.1 – 2.3	1.8 – 1.9
Energy Level C	all	2.1 – 2.5	2.2 – 2.5
Energy Level D	tests	2.0 – 2.4	1.8 – 1.9
Currents, m/s:			
Energy Level A (300)[2]	0.02; 0.04[3,4]	0.1 – 0.11[5]	0.05 – 0.15[5]
Energy Level B (400)[2]	0.02; 0.05[3,4]	0.03 – 0.16[5]	0.05 – 0.15[5]
Energy Level C (500)[2]	0.09 (unstable); 0.04[3,4]	0.01 – 0.09[5]	0.04 – 0.08[5]
Energy Level D (600)[2]	unstable; 0.08[3,4]	0.02 – 0.10[5]	0.04 – 0.08[5]
Waves:			
Low Energy: Wave Type Wave Amplitude, cm Wave Gen. Spd., rpm	 No information 3 to 4 14.6 +/- 0.0	 Swells 1.9 – 2.0[6,7] 24	 Swells 0.8 – 1.2; 1.1 – 2.6[8,9] 24
Medium Energy: Wave Type Wave Amplitude, cm Wave Gen. Spd., rpm	 No information 4 to 7 17.4 +/- 0.1	 Non-breaking 6.0 – 8.1[6,7] 29	 Non-breaking 3.0 – 4.2; 4.8 – 6.9[8,9] 29
High Energy: Wave Type Wave Amplitude, cm Wave Gen. Spd., rpm	 No information 5 to 10 19.6 +/- 0.1	 Breaking 8.2 – 11.0[6,7] 49	 Breaking 5.6 – 7.4; 11 - 15[8,9] 49

Notes:

1. The wind in the test program was selected to simulate an evaporation rate corresponding to a wind speed of 5-10 m/s at the sea surface (Faksness, 2013).
2. The energy levels in Faksness, 2013 are described as 300, 400, 500 and 600 for the tests at CEDRE whereas they are referred to as A, B, C and D for the tests at SINTEF and SL Ross tanks.
3. The water currents at CEDRE are those induced from a 3 m/s wind at the water surface.
4. The water currents listed for the CEDRE tests are those "close to the surface" and "close to the bottom" respectively.
5. The range of water currents listed for the tests at the SINTEF and SL Ross tanks is the range measured for depths of 20 cm, 30 cm and 50 cm below the water surface.
6. SINTEF - The ranges given are those observed over the different measurement locations in the tank.
7. SINTEF - The values given are the average wave heights.
8. SL Ross - The ranges given are those observed over the different measurement locations in the tank.
9. SL Ross - The values given are the average wave heights; and the maximum wave heights respectively.

Table 4-3: ESTS Science Goals for Tank (B. Hollebone, ESTS, personal communication)

Goal: Develop an ocean simulator to study the long-term weathering and behaviours of oil and related products in a marine environment. • Must be capable of simulating and monitoring a range of behaviours of oil in water, including: evaporation, dispersion (including sedimentation and coalescence), dissolution, photolysis, and emulsification. These behaviours must be capable of being monitored simultaneously and in combination. The possibility of addition of suspended solid material should be considered. • Capable of containing oil (up to 1L), water (simulated seawater) and air in a controlled and monitored system. • Capable of simulating regular wave energies up to breaking waves (whitecaps) • Capable of simulating wind over the water of up to 5 m/s • Capable of generating a stable current in the tank. • Capable of simulating solar exposure under a range of conditions • Capable of continuous operation up to 4 weeks. • Capable of operating from -2C to 15C (with liquid seawater/ice combinations) • Sampling capabilities for water (via ports), and air. • Facility to view and record images/video of air and water phases (including from within water column looking upward at bottom surface of ice). • Facility to mount instruments in the water, and in the air chase over the water. • Must have instruments and measurement points capable of quantifying wave heights and speeds, wind speed, water currents and incident light spectrum and flux. • Capability to determine mass balances for hydrocarbons in air, oil and water phases. This will require managed compartments (air, water) of known dimensions and volume. • Must be adaptable to studies of non-petroleum substances, including some HNS materials.
Goal: Develop a simulator capable of static (no current) or dynamic (with current) simulations below freezing point. • Capable of containing oil, water, ice and air in controlled and monitored system. • Capable of examining oil/water/ice interactions and chemistry • Capable of examining effects of oil on ice growth in ice margin and continuous ice conditions with and without waves. • Capable of simulating oil under ice, oil in ice scenarios • Capable of simulating cooling (ice growth) and warming (ice melt & breakup) scenarios.
Goal: Develop simulator capable of countermeasures testing, specifically dispersants. • Demonstrated to produce results for dispersion studies compared to with existing facilities (e.g. Faksness, 2013). • Capable of simulating use of existing and foreseeable future chemical countermeasures considered for use in Canadian waters. • Possibility of adaptation to additional countermeasures (e.g. herders, solidifiers)

Table 4-4: Summary of Technical Requirements for the ESTS Test Tank

Parameter	Requirement
Size and Geometry of tank	Similar to those of the CEDRE, SINTEF and SL Ross tanks
Oil types	Must allow testing with all relevant oil types
Test water	Must allow testing in all relevant water types including freshwater and seawater
Waves	• Regular waves to be produced; irregular waves not required • Maximum wave height: 20 cm • Wavelength and wave type: must produce a range that includes swells, non-breaking and breaking waves
Winds	• Must simulate an evaporation rate corresponding to a wind speed of at least 5-10 m/s at the sea surface • Maximum wind speed: 5 m/s
Currents	• Must be capable of creating currents independently from the wind regime above the water surface • Maximum current speed: 0.2 m/s at the water surface
Ultra-violet radiation	• Must allow the needs of the ESTS Science Goals to be met • Tank must have mounting points as required for trials of multiple light sources
Air and water temperature	• Must be capable of controlling the air and water temperatures independently • Minimum air temperature: -20°C • Minimum water temperature: Must be capable of creating sustained freezing conditions (e.g., frazil) in the water, which requires super-cooling of the water

4.2 Logistical

The logistical requirements are generally summarized in Table 4.5.

Table 4-5: Summary of Logistical Requirements for the Test Tank and Facility

Parameter	Requirement
Overall facility	Must efficiently allow relevant activities to be carried out, including: • Test preparation, which includes preparation of the water used for testing, oil deposition, etc. • Test conduct, which includes simulating all relevant conditions (winds, waves, currents, UV, etc.); and long-term monitoring of the oil fate and behavior • Oil sampling and bench-scale testing of oil properties • Treatment of waste water, which may range from removing to cleaning it • Access through a large exterior door • Storage of ancillary equipment
Test tank	• Must be located in a temperature-controlled room (-20°C to 20°C) • Must be capable of being transported in and out of the cold room • Must meet the needs of the Science Plan
Cold room	• Must provide temperature control as required (-20°C to 20°C) • Must have at least two access doors. One of them must be a large door at least 3m wide. The other is a personnel-door, with a vestibule. • Must have a flat non-slip concrete working surface while still allowing cleanup (e.g., of spilled oil) to be done efficiently. • Must have equipment-handling gear, such as a gantry crane. The crane must have a capacity of 2.2 kN (500 lbs). • Must have a water supply into the cold room, with a ¾ inch “garden hose” fitting • The air chase above the water surface must be ventilated. • Electrical power for all equipment (wave-maker, fans, pumps for currents, ultra-violet lamps, instrumentation, etc.) • UPS required for the instrumentation
Storage and Data Acquisition	• Data acquisition and office facilities to be located in an office adjacent to the cold room • Space required immediately outside of cold room to allow equipment assembly and short-term storage • Space required outdoors in general vicinity of tank for long-term storage of ancillary equipment, flammable oil storage, test tank when idle, etc.

4.3 Recommendations for Layout of Facility

4.3.1 Overall Layout of Facility

Figure 4.1 shows a recommended layout for the overall facility, within the constraints of the available space at Environment Canada's laboratories at 335 River Road, Ottawa.

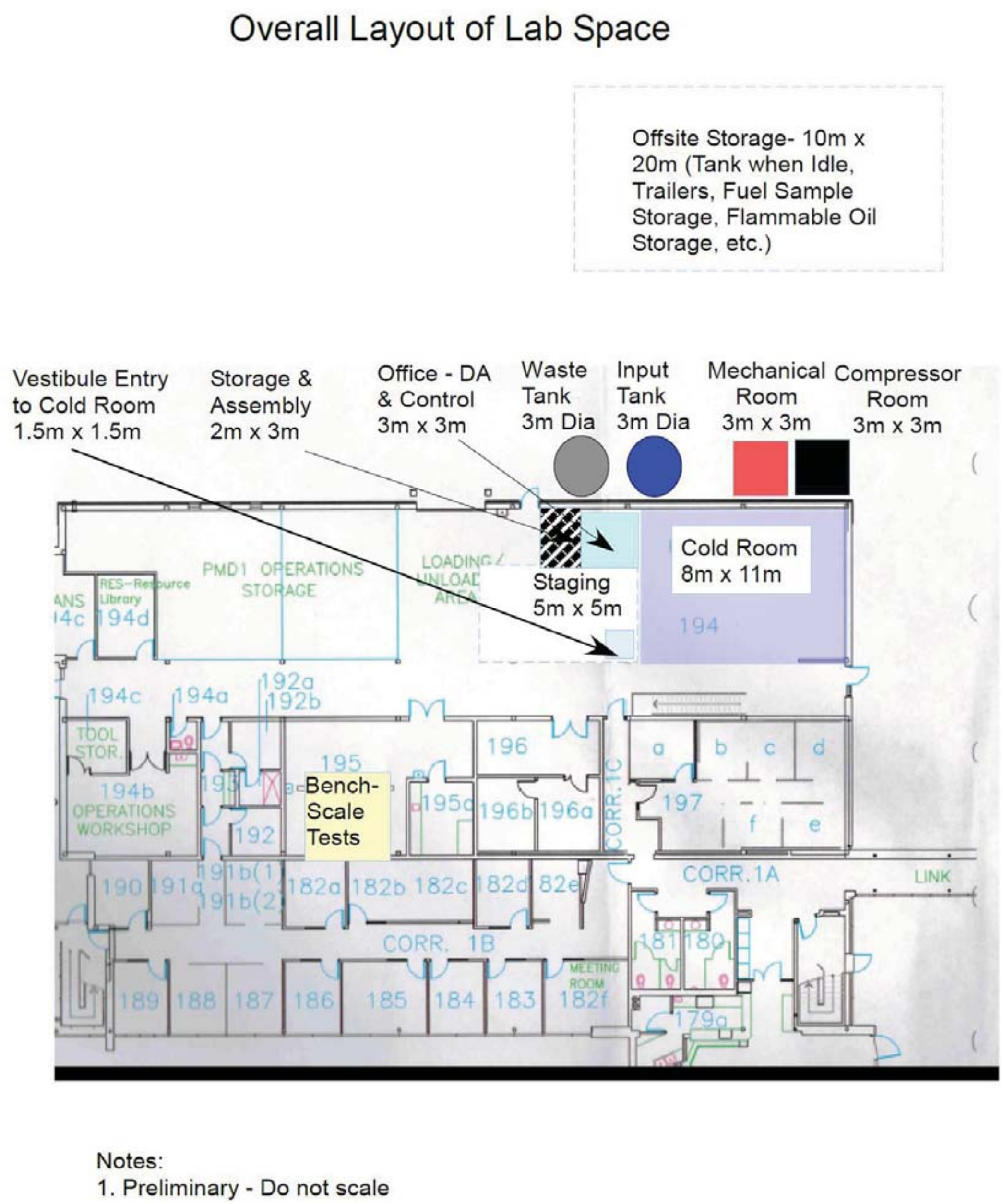


Figure 4-1: Recommendation for Overall Layout of Facility
(Base Drawing: Ground Floor Plan – Dwg BB-1 provided by William Duffett, Environment Canada)

4.3.2 Cold Room Layout

Figure 4.2 shows a recommended layout for the cold room within the overall facility, within the constraints of the available space at Environment Canada's laboratories at 335 River Rd, Ottawa.

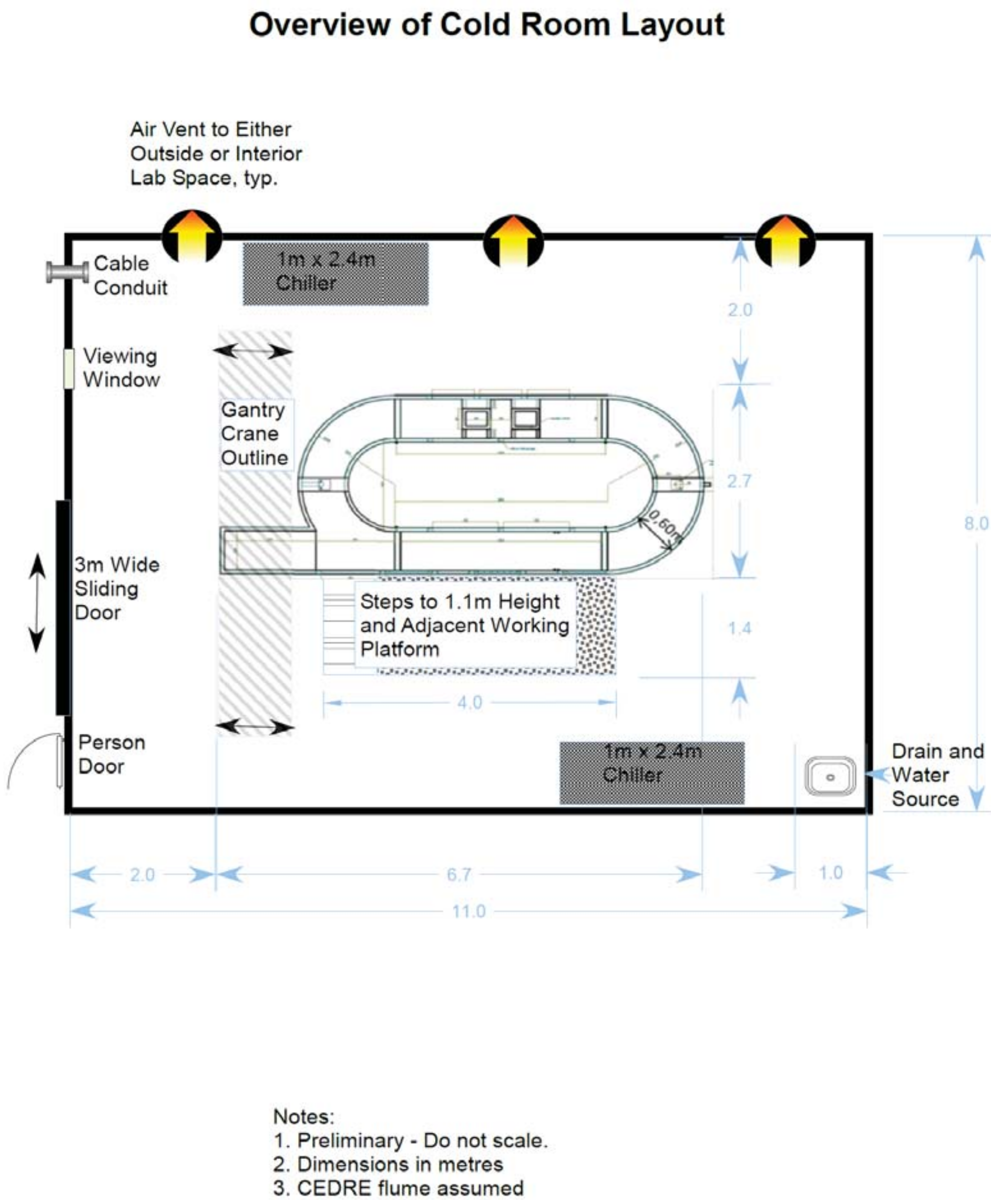


Figure 4-2: Recommendation for Layout of Cold Room

The cold room must have a capability for materials handling inside it. A gantry crane is proposed to meet this requirement (Figure 4.3).

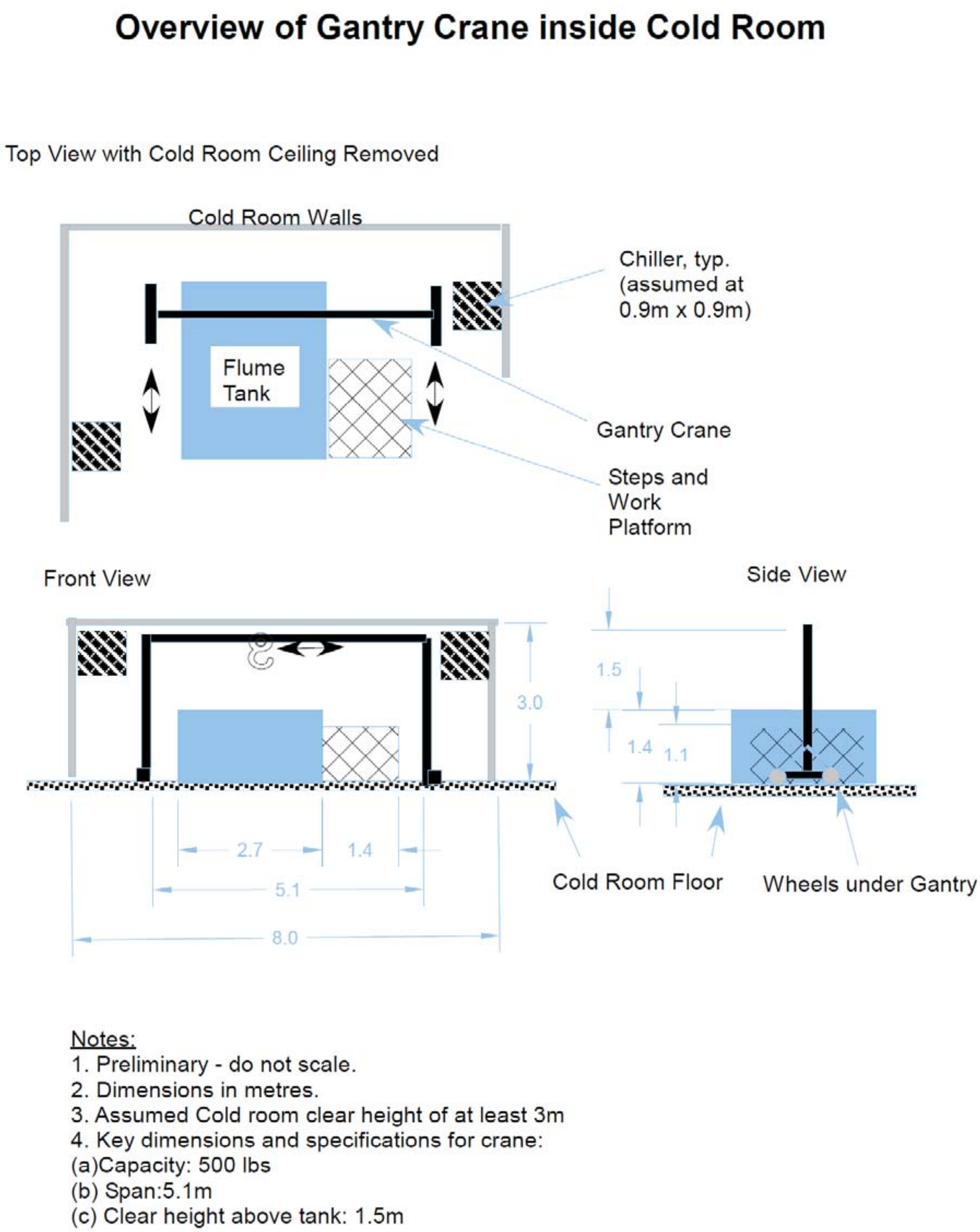


Figure 4-3: Proposed Gantry Crane inside the Cold Room

4.3.3 Requirements for Data Acquisition Room

Figure 4.4 shows a suggested layout for the data acquisition room, within the constraints of the available space at Environment Canada's laboratories at 335 River Road, Ottawa.

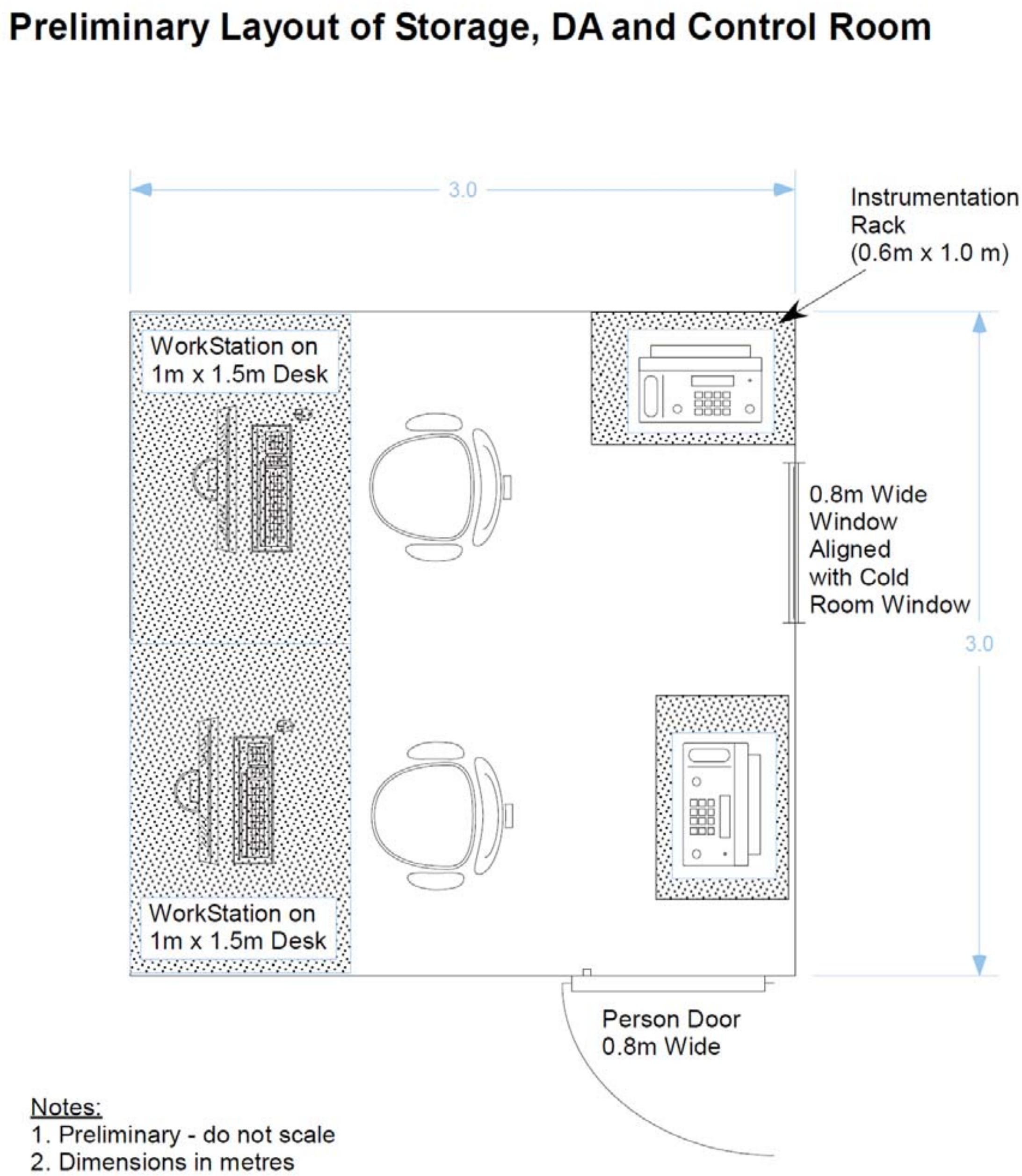


Figure 4-4: Suggested Layout for Data Acquisition Room

4.4 Power Requirements and Expected Instrumentation for Operational Monitoring

4.4.1 Preliminary Estimated Power Requirements

Table 4.6 provides a preliminary listing of the estimated power requirements. It should be recognized that design and analysis is required to establish the power requirements, which has not yet been carried out. Thus, the values listed in Table 4.6 are preliminary, and primarily based on judgement.

Table 4-6: Preliminary Estimated Power Requirements

Item	Likely Voltage, V	Rough Estimate of Power or Amperage[1]		Basis	UPS Required
Key Systems					
Compressors for Cold Room	575	2 compressors @ 10-15 hp each		Judgement	
Wavemaker Motor	220 (note 2)	1 motor @ 2-5 hp		Judgement	
Motors for Fans	220	4 motors @ 1 hp		Judgement	
Power for UV lights	?	2 units @ 2KW each = 4 kW total		SINTEF	
Motor for Pumps for currents	110-220	1 motor @ 2-3 hp		Judgement	
Ancillary Facilities					
Wastewater Cleanup (pumps)	110-220	1 motor @ 1-2 hp		Judgement	
Input tank (pumps to mix water)	110-220	1 motor @ 1-2 hp		Judgement	
Other (e.g., humidity control?)	110-220	1 motor @ 1-2 hp		Judgement	
General					
Instrumentation	110	4 circuits @ 15 amps each		Judgement	Yes
General lighting & supply in cold room	110	4 circuits @ 15 amps each		Judgement	
Supply to shop (e.g., hand tools)	110	4 circuits @ 15 amps each		Judgement	
Supply to office/control room	110	2 circuits @ 15 amps each		Judgement	
Bench-Scale Tests					
Common w Instrumentation Above					
Use of ancillary plug also					

Notes:
1. Analysis and design is needed to establish the power requirements. Because this has not been done, the above estimnates are preliminary and are mainly based on judgement.
2. Probably will be 3 phase but this requires design and analysis.

4.4.2 Expected Operational Instrumentation Complement

It is expected that the test tank will have instrumentation for:

(a) Operational monitoring – it is expected that a significant "operational" instrumentation complement will be included. These data would be collected routinely for a given test to provide quality assurance for the scientific tests that will be carried out. They would also be part of the safety and monitoring protocols for testing, such as for example, air quality monitoring within the air chase of the tank.

(b) Scientific test documentation and measurement – because these will be project-specific, they are not discussed here.

Table 4.7 provides a preliminary listing for a possible instrumentation complement for the tank, for the operational monitoring that will be required. It should be recognized that design and analysis is required to establish the instrumentation requirements, which has not yet been carried out. Thus, the information in Table 4.7 is preliminary and primarily based on judgement.

Table 4-7: Possible Instrumentation Complement for Operational Monitoring

Parameter	Possible Location	# of Channels
Air Temperature	Outside the Flume tank (in the annulus & outside?)	4
	Inside the air chase at 4 axes of tank	4
Wind Speed	At water surface at the four axes of tank	4
Water surface elev'n	At one axis of tank	1
	Could be combined with wave height measurement?	
Water Temperature	At four axes of tank; three depths at each loc'n	12
Wave Height	At four axes of tank	4
Wave Period	At four axes of tank	4
Currents	At four axes of tank; at three depths	12
UV radiation	Power level (Watts/m^2 ?)	TBD
Air quality	Inside the air chase at 4 axes of tank	TBD
(LEL; PID; others?)		
	Total Instrumentation Channels	45 or more
TBD: To Be Determined		

5 REFERENCES

[1] Daling, P. and Liervik, F., 2015a, Upgrading of SINTEF Oil/Ice/Shoreline Facilities for Oil Spill R&D Studies 2005/2006 Chapter 4: Meso-scale Oil Weathering Flume Facilities – info to Environment Canada, report from SINTEF to Environment Canada.

[2] Daling, P. and Liervik, F., 2015b, Input to Environment Canada building of flume basin: Some Figures/Pictures of the SINTEF Oil Weathering Flume at SINTEF SeaLab, slides prepared by SINTEF for Environment Canada.

[3] Faksness, L., Belore, R., and Merlin, F., 2013, Test Tank Inter-Calibration for Dispersant Efficiency, Report 2.2, Arctic Oil Spill Response Technology Joint Industry Program (JIP).

[4] Guyomarch, J., LeFloch, S., and Jezequel, R., 2012, Oil Weathering, Impact Assessment, and Response Options Studies at the Pilot Scale: Improved Methodology and Design of a New Dedicated Test Flume, proc. AMOP.

[5] Guyomarch, J., 2013, Weathering and Dispersability Study of the Fossekal Crude Oil from Skuld Field in Simulated Local Weather Conditions, report by CEDRE to Statoil, available on internet.

[6] Johnson, H., 2015, The Arctic Oil Spill Response Technology Program – Joint Industry Program, PowerPoint presentation available at www.arcticresponsetechnology.org.

[7] SL Ross, 2012, Meso-Scale Weathering of Cold Lake Bitumen/Condensate Blend, contractor report by SL Ross Environmental Research Ltd., part of Northern Gateway Pipelines Application to the National Energy Board (OH-4-2011; NEB File No.: OF-Fac-Oil-N304-2010-01 01).

APPENDIX A
CONTACT REPORTS

Contents:

- CCORE/Memorial Contact Report
- Joe Mullin Contact Report
- SL Ross Contact Report
- OCRE/NRC Contact Report
- OHMSETT Contact Report
- NWRI (IDroppo) Contact Report
- CRREL Contact Report
- K Hansen Contact Report

CCORE/Memorial University Contact Report

Person: Various contacts were made as follows.
Chris Fowler (C-CORE)
Dr. Bing Chen (Memorial University)

Points and Inputs:

1. The purpose of the contacts was to obtain information regarding facilities (planned or existing) at C-CORE.

2. Dr. Bing Chen – He was on travel. He has been involved in the consultation and design of a large scale testing facility for oil spill research in cold waters through a collaborative initiative of HMDC (particularly ExxonMobil), C-CORE and Memorial. He is also in the process of developing a multi-scale physical simulation & testing system in his Northern Region Persistent Organic Pollution Control (NRPOP) Lab at Memorial University. The system includes a set of bench-top wave tanks, a mesoscale circular spill tank, and a high-pressure stainless-steel vessel. The system itself has no capability of creating ice or cold conditions but the cold chambers (one existing and a couple to be built) in the Faculty of Engineering and Applied Science can be used. The system will be hosted in a new high-bay laboratory space which is currently under design and construction in the Faculty. His NRPOP Lab has established collaborations with other oil spill research programs/organizations in such as EST/EC, COOGER/DFO, C-CORE and SINTEF.

3. Chris Fowler – Chris provided information regarding a large-scale oil/ice test facility that is in the planning stage. He said that the tank is at a preliminary design stage. To date, they have conducted a scoping study to define the tank in broad terms, e.g., what facilities and capabilities would be useful. This included a meeting of Subject Matter Experts this past spring that was held in St. John's.

   C-CORE is in the final stages of preparing their report for the scoping study, and it will be submitted to the Client soon. The report is not public.

4. Presently, no information is available publicly regarding the planned tank, so Chris could not send anything to us. He promised to include us on the mailing list when something public is released.

5. Generally, they are thinking about a tank that would be about 110m long by 10m wide by 4.5m deep. The facility would include ice, waves and a towing carriage. It would be housed in a refrigerated building with the capability to bring the air temperature down to as low as -25°C. It might be located in St. John's. Nfld.

6. Other planned facilities: Chris mentioned that the following other oil spill test facilities are at the planning stage:
   a. David Barber's large scale facility being planned to be built in Churchill, Manitoba

b. CFER in Edmonton – they are planning a facility for spills in inland waters. Chris Fowler did not know who would be an appropriate contact person at CFER regarding this, but promised to let us know if possible.

7. Coordination with Environment Canada – Chris was happy to learn about Environment Canada's plans and welcomed the chance to coordinate efforts. Bing and his NRPOP Lab have been collaborating with and receiving support from EC in the past and would like to continue and enhance the collaboration in oil spill research. Chris said that C-CORE's CEO (Charles Randall) was in Ottawa on that day for a meeting with Environment Canada at the Director General level.

Joe Mullin Contact Report

Person: Joe Mullin
Position: Manager of Arctic Oil Spill Response Technology - JIP

Points and Inputs:

1. The JIP is in its 5th year, and all research will be completed by Dec 2016. Joe didn't expect that it would be a potential client for Environment Canada's (EC's) tank.

2. The JIP did an inter-tank comparison in 2013 among the CEDRE, SINTEF and SL Ross tanks. See the reference below. Joe recommended that this report be reviewed. Report is on JIP website www.arcticresponsetechnology.org.

3. CCORE is at the final design stage for a large tank for oil spill work. The CCORE contact for it is Chris Fowler (tel. 709 864 8373). **Newfoundland Labrador Northern OSR Center of Excellence**

- Phase 1 Focus on technology development (not oil fate & effects); OSR training; OSR drills; Possible Phase 2 fate & effects capabilities
- Ice capable wave tank modeled after Ohmsett located in St. John's, NL – 100 m x 10 m x 6.25 m indoor, ice-capable wave tank
- Dispersant testing in ice / waves
- Mechanical recovery testing in ice / waves
- Remote detection testing in ice
- Classrooms for training / large-scale drills
- Separate outdoor burn tank
- Scoping study completed in August 2015
- Major equipment specified
- Cost estimate $62M
- Funding model
- Industry provides 50% capital, 50% yearly O&M, and $2M-$4M / year in research grants; facility won't be self-sustainable from hire charges
- Hibernia project may commit $30M capital / $2M O&M/year
- Current status: attempting to secure funding partners within province / Canada
- Estimated 50% chance of success
- Possibility of working facility by 2018 – 2019
- **SINTEF proposing the Svea Arctic Research Infrastructure (SARI)**
    - Build on existing facilities in Svea on Svalbard – much broader than just oil spill research
    - Provide significant research capacity improvements, it will offer capabilities that are complementary to a wave basin facility, not direct competition.
    - Current status: preliminary design / scoping ongoing, no committed funding
- **University of Manitoba's Churchill Marine Observatory (CMO)**
    - Located near the Port of Churchill on the coast of Hudson Bay
    - Expected focus will be oil spill fate & effects with some technology testing capabilities

- Oil in Sea Ice Mesocosm (OSIM) (indoor tank) & the existing Sea-Ice Environmental Research Facility (SERF)

OSIM: Two tanks (20m x 20m x 3m) and a retractable roof overhead. There will be a burn capability with an instrumented fume for emission analysis.
Research focus on oil detection, impacts and mitigation using bioremediation and conventional methods
Current status: $31.8M in capital funding secured
Facility will be built; likely by 2017 – 2018

University of Alaska Fairbanks Center for Arctic Sustainable Development
Broad focus to support the sustainable development of energy resources in the Arctic
Initial focus will be related to preventing, monitoring, and responding to the accidental discharge of petroleum into the Arctic environment
Partners: UAF, Brigham Young U., Rensselaer Polytechnic Inst., and U. of Washington
Current status: In development; Attempting to build a 12 member advisory board ($100K yearly fee) to provide $1.2M yearly funding, $224K matching from universities
Likelihood of being built is unknown

- **Finnish Arctic Research Center (ArcMate)**

Focus is not OSR but rather maritime testing, training, consulting, and R&D (mainly search and rescue); concerned about not overlapping with other facilities
Current status: conduct a feasibility study to determine business need
Likelihood of being built is unknown

4. Need for a Business Plan – Joe stressed that the tank needs to meet the needs of customers and this should drive the design. A Business Plan should be prepared that identifies the clients for the tank, especially repeat ones.

5. Input for Design of EC Tank- Joe commented that:
   a. Flexibility is a very important requirement. The tank needs to have multiple capabilities or ability to adapt
   b. There is nothing "really lacking" with respect to the capabilities of the CEDRE, SINTEF and SL Ross tanks. They are all similar with respect to waves, currents, winds, etc. Joe felt that they would be a good template for the EC tank.
   c. Joe felt that it would be useful to have a spray bar assembly (like they had at OHMSETT) as a platform, e.g., for applying dispersants, herders, etc. during tests. This would avoid the manual approach at the SL Ross tank.
   d. Again, flexibility is very important. Joe gave the example of an outboard boat motor (very small) being used to add more mixing energy for dispersant tests in ice, as an attempt to simulate the added mixing provided by the prop wash of offshore ships.

6. Source of Ideas for Test Programs – In the past, Joe has used criticisms from WWF, Greenpeace and the Sierra Club as sources for developing test programs. Need to do a review (or continue to monitor) organizations conducting research to avoid duplication as much as possible

7. Filtration at OHMSETT – Joe said that it is important for the EC tank to be able to re-use water from one test to another BUT not to have contamination from one test to another. OHMSETT has two levels of filtration. The 1st level uses diatomaceous earth. The 2nd level uses activated carbon. In the past, they had a ConEx trailer in the tank with activated carbon and they directed flow through it. Later, they used thee offsite trucks with activated carbon, and directed flow through them. This was simpler and cheaper Decision on filtration system will be determined on types of oil/dispersants/other chemicals that could be released into the tank.

8. Joe encouraged us to contact him again should any further questions arise.

<u>References:</u>

- Faksness, L., Belore, R., and Merlin, F., 2013, Test Tank Inter-Calibration for Dispersant Efficiency, Report 2.2, Arctic Oil Spill Response Technology Joint Industry Program (JIP).

SL Ross Environmental Research Ltd. Contact Report

Person: David Cooper
Organization: SL Ross Environmental Research Ltd.

Points and Inputs:

1. SL Ross has a horizontal race track flume in its laboratory in Ottawa, Ontario. It is patterned after the SINTEF one and has the same dimensions as SINTEF. It is smaller than the CEDRE one. Its facilities include a wave paddle, fans in an air chase above the tank (for winds) and a pump for currents. They have temperature control for the water.

2. The tank is located in an “engineered” room which has insulation and refrigeration chillers for cooling.

3. David sent a brief description of the tank following the call. More information about it is contained in the 2013 World Catalog of Oil Spill Response Products (Reference below).

References:

- S.L. Ross, 2013, Two New Test Tanks Commissioned in 2013, Article in the World Catalog of Oil Spill Response Products.

OCRE/NRC Contact Report

Person: Various contacts were made as follows. All are at the OCRE of NRC.
Anne Barker, Ottawa
Dr. Mohammed Sayed, Ottawa
Jim Millan, St, John's

Points and Inputs:

1. Anne Barker was first contacted. She said that oil-in-ice tests have been conducted in the past at the CHC/NRC in Ottawa by: (a) Dr. Garry Timco; and (b) Dr. Mohammed Sayed.

2. Garry Timco – these tests investigated oil spreading in the presence of broken ice pieces. The tests were done in their ice tank in Ottawa, which does not have the capability for waves or currents. Thus, the tests were static in the sense that the only forces causing oil spreading were gravity, buoyancy, surface tension, and blockage/adsorption by ice pieces. Anne provided a test report as well as a technical paper (listed below in the References) describing these tests. Garry Timco has since retired from the NRC.

3. Mohammed Sayed – Mohammed conducted oil-in-ice tests in 1993-94 in a purpose-built elliptical race track flume that was placed in the NRC's cold room. Anne provided a test report as well as a technical paper (listed below in the References) describing these tests. Mohammed Sayed is still at the NRC and was contacted next.

   The test flume had currents but no waves. Currents were produced using a rotating horizontal-axis paddle generator driven by an electric motor. The paddles were located at the water surface and generated currents at the water surface up to about 20 cm/s. Baffles were placed in the water at each end of the flume to straighten the flow. Mohammed said that these were essential to achieve a uniform flow and to avoid turbulence caused by the shape of the tank.

   Ice cubes and brash were not grown in the tank. They were either grown elsewhere or purchased locally. (Mohammed did not remember which).

   Special safety procedures were not put inplace, e.g., to remove vapors, but Mohammed did remember wearing masks.

   These tests were conducted to investigate the physical processes involved with oil spreading in brash ice or small ice pieces. Each test was a "one-time" test, as oil was released upstream of the test area; and then driven through the control volume where the ice was located.

   Mohammed commented that for a continuous test (with oil going around a loop), the oil would get coated everywhere.

4. Further input from Jim Millan – Jim was primarily contacted to get information regarding their capabilities in St. John's Nfld. They have never had oil in their ice tank at St.

John's Nfld. The NRC does advertise the capability to do oil-in-ice tests; and would expect to do these in their ice tank in Ottawa if the requirement arose.

Jim said that there was not much that he could say beyond the information that Anne Barker and Mohammed Sayed had provided.

References (Reports and Papers):

- Sayed, M., and Loset, S., 1993, Laboratory Experiments of Oil Spreading Brash Ice, International Journal of Offshore and Polar Engineering, Vol. 3, No. 4, pp. 306-312.
- Sayed, M., Kotylar, L., and Sparks, D., 1994, Spreading of Crude Petroleum in Brash Ice: Effects of Oil's Physical Properties and Water Current, proc. Fourth International Offshore and Polar Engineering Conference, pp. 225-232.
- Timco. G., and Davies, M., 1995, Laboratory Tests of Oil Fate in Cold Water, Ice and Waves, NRC Report HYD-TR-002.
- Timco, G., and Davies, M., 1998, Laboratory Tests of Oil Fate in Cold Water, Ice and Waves, proc. IAHR Ice Symposium, pp. 411-417.

OHMSETT Contact Report

Person: Dave Devitis (referral from Bill Schmidt who was initially contacted)
Position: Operations, OHMSETT Tank

Points and Inputs:

1. Dave Devitis was contacted to get information about the methods used to filter water at OHMSETT, in Leonardo, New Jersey; and their potential applicability to the Environment Canada (EC) tank.

2. Dave said that they have only one stage of filtration, a diatomaceous earth filter. It is essentially a "large pool filter". It was originally obtained from US Filter, and is their Autojet 1000 model. The company has since been purchased by "Violia", based in California. . It filters out particles as small as 1.5-2.0 micron.

   Dave said that they use a "loop" system to put flow through the filter. They have a 12" inlet at one end of the tank and a 12" outlet at the other end. They can theoretically filter the entire tank volume through the filter in 24 hours.

   Dave said that they have had no issues with it, and they have had "years and years" of service from it. Maintenance is required to clean the filter. They do this when there is a high pressure differential (which they measure) across the filter. They prepare the backwash slurry mix for disposal by dewatering through a plate and frame filter which leaves the media dry. The spend media is taken to a landfill.

3. The overall system has three main components: (a) the diatomaceous earth filter; (b) a de-watering system for spend diatomaceous earth dewatering; and (c) a chlorinator. Overall, there are no major issues with the system.

4. Evaluation of the wastewater filtration capabilities at OHMSETT by SL Ross Environmental Research Ltd. - the reference below provides further information.

5. Dave encouraged us to contact him again should any further questions arise.

Report on SL Ross Website

- SL Ross, 2003, Research on Powdered Activated Carbon to Remove Dissolved Oil Dispersants from OHMSETT Basin Water, report by SL Ross to the United States Minerals Management Service.

NWRI Contact Report

Person: Dr. Ian Droppo
Position: Research Scientist, National Water Resources Institute

Points and Inputs:

1. Environment Canada has two rotating annular carousels in its facilities at Burlington, Ontario. They are both used to investigate sediment transport issues, such as the mobilization of sediments and the energy needed to keep sediments in suspension. As a result, these facilities are focused on accurately simulating bed shear and processes at the bed. Ian Droppo sent the references below which describe them.

2. One carousel is 2m in diameter. It creates currents at the water surface by having the top ring rotate while the bottom ring (containing the water and bed material) is stationary. These surface currents lead to shears at the bed.

3. The other carousel is 5m in diameter. It creates larger currents at the water surface and higher bed shears by having the top and bottom both ring rotate in opposite directions.

4. Their facilities only have the capability to create currents, which are generated to produce bed shears. Other controls, e.g., relative humidity in the room, temperatures) are not necessary as they are not issues for them.

5. Comment from Ian Droppo regarding testing in ice or cold – Ian felt that the rotating ring concepts they use would have difficulties for testing in ice or cold temperatures. He felt that icing and other cold-related problems would occur.

6. Ian encouraged us to contact him again should any further questions arise; or should we wish to visit their facilities.

References:

- Khrishnappan, B., Rotating Circular Flumes, Journal of Hydraulic Engineering, Vol. 119, no. 6, paper 3108, June 1993.
- Droppo, I., 2009, Biofilm Structure and Bed Stability of Five Contrasting Freshwater Sediments, Marine and Freshwater Research, 2009, 60, pp. 690-699.
- Garcia-Aragon, J., Droppo, I., Krishnappan, B., Trapp, B., and Jaskot, C., 2011, Experimental Assessment of Athabasca River Cohesive Sediment Deposition Dynamics, Water Quality Research Journal of Canada, 46.1, 2011.

US Army Cold Regions Research and Engineering Laboratory (CRREL) Contact Report

Persons: Dr. Steve Daly
Leonard Zabilansky

<u>Points and Inputs:</u>

1. CRREL has several decades of experience with conducting tests in ice. Recently, it has been conducting tests related to oil-in-ice problems. CRREL has never built a race-track type elliptical flume but it has made several designs for them. All their oil-in-ice tests have been done in their "ice" tank, which is a refrigerated room about 120 ft. long by 30 ft. wide.

2. Cleaning and Replacement of Test Water – Presently, CRREL does not re-use the water for testing. It runs tests until the water and facilities are unacceptable, and then it starts "fresh". They try to extend the testing period by procedures such as scheduling, such that the tests progress from the least-oiled case to the most-oiled case. They do recover the oil on the surface between tests and before running the bubblers or pumps, that would emulsify the oil.

   In the past, they tried to have secondary containment for the test water and to clean it, using technologies such as sand filters and cyclonic cleaners. This was not successful, especially for heavy oils, or for cases where emulsification occurred.

   CRREL commented that the tank walls are coated with high-performance epoxy which minimizes oil absorption, making cleaning easier. They can clean the walls using a high-pressure washer or steam cleaner.

3. Control of Test Conditions – The room (being originally built as an ice tank) has a refrigeration system to cool the air temperature of course.

   CRREL also has a submerged coil (Ice Builder Coil – IBC) in the water in the test basin to cool the water. The IBC is connected to the ammonia system. A photo is included showing the new IBC that CRREL will be installing, after 35 years of usage from the existing coil. A layer of ice forms on the outside of the pipes and the circulated water passes through the coil, thereby cooling the water. The coils are operated based on water temperature sensors in the water.

   CRREL uses air bubblers and low-flow pumps to provide mixing to prevent temperature stratification of the water in the tank.

   CRREL does not have heaters in the tank to warm the water.

   CRREL does not control the humidity on the room. This has never been an issue for the ice tests that CRREL carries out as the room is enclosed with a vapor barrier to minimize moisture infiltration.

New Ice Builder Coil that will be Installed at CRREL (photo: Leonard Zabilansky)

4. Salt water – saline water is produced by adding NaCl to the water. Urea ice is used to model testing where the engineering properties of the ice have to be scaled.

5. Currents – CRREL can only produce low currents (less than a few cm/s) in their tank. These are produced by low-flow pumps. They have considered systems to produce higher currents but it would be a major undertaking for their large tank. CRREL commented that the capability to produce higher currents would be beneficial for investigating issues such as oil being stripped out of the skeletal layer at the bottom of an ice sheet.

6. Waves – CRREL can't produce waves in their main tank. They commented that they inherited a tank from ACS which can produce waves.

7. Winds – winds are produced using an array of large fans.

8. UV radiation – CRREL can't produce UV radiation in their tank.

9. Powering – CRREL does not have backup power for their tank systems, although they do have an UPS for the tank instrumentation. Most of their tests are short-term but they can see the value in having backup power for long-term tests. CRREL gave the example of a test where they lost power while an ice sheet was being formed, which was a significant loss.

10. Safety – CRREL has large fans for ventilation. However, they commented that care has to be taken because significant ventilation would degrade the capability to grow ice.

Generally, ventilation is not an issue for CRREL as the oil is under ice or in broken ice. For recent OGP tests, 600 gallons of oil was spilled under water. For recent oil herder tests, the oil volume was only 5-6 gallons. They do monitor air quality if that is a concern and will ventilate if necessary.

11. Duty Cycle for Testing – Cleanup can be "intense", especially if the tests involved heavy oil or emulsification. As an example, recent OGP test for skimmers required 1 week of cleanup, after 3 months of testing. Generally, CRREL would try to schedule test programs so that major cleanups are minimized.

12. Maintenance and Compatibility of Materials – CRREL has never had compatibility issues related to oil. However, they have had major issues with salt. Now, they only have fiberglass and stainless steel in the tank as a result. For example, their underwater carriage is fiberglass. They strongly advised against using aluminum as it is susceptible to electrolytic currents.

13. Systems Handling – CRREL pointed out that the ice tank already had infrastructure, such as a robust main carriage (built to take ice forces), a work carriage, and a monorail with a crane on it that runs along the length of the tank. This was adequate as a base for systems handling for oil tests, although special-purpose fixtures are often necessary. For example, to handle an oil barrel, they would use a crane for on the carriage to get it onto the carriage, and then move the carriage to the desired location. For recent tests with oil detection sensors, the y had to get the sensor about 2m above the ice and about 5m from the carriage. They accomplished this using the existing infrastructure as a base. They do not have a special-purpose spray bar for tests involving dispersants or herders. These were applied manually using a syringe around the 17ft x 17 ft test area.

    CRREL strongly recommended that the EC tank include a warm area just outside the cold room where sensitive equipment (e.g. instruments) could be kept warm until deployment into the cold room. CRREL has a warm area, and it is very valuable.

14. Oil Recovery –CRREL uses a grooved drum skimmer the can be deployed within a containment hoop of for general clean-up of the tank Depending on the test requirements, the recovered oil maybe used for other test, This is valuable as it minimizes the amount of oil needed for testing. CRREL commented that often, it is difficult to obtain oil for testing, so this capability to re-use oil is useful.

15. Viewing Windows and Viewing Tests – CRREL advised against relying on using viewing windows. They tend to fog up and leak; and for the CRREL tank, the walls are too far away from the test to allow good observation of the test anyway. Instead, CRREL uses underwater cameras to observe tests. These are very useful and are essential in their view.

16. Instrumentation and Sampling – CRREL does not hang instruments in the water in their tank. Instead, they take samples and bring them to a nearby lab in their building. For example, this is the procedure they use for particle size analyses.

17. Comparisons with Other Facilities in the World – CRREL is generally familiar with the other test facilities around the world. CRREL commented that the recirculating current in the tank is too low to investigate the actions of currents to strip oil out of the ice skeletal layer, at the bottom of an ice sheet. Bruce Hollebone commented that EC's planned tank would complement the other race-track elliptical flumes (Sintef, CEDRE, SL Ross) by adding the capability to conduct parametric tests in freezing conditions.

18. Other Comments – CRREL commented that tests in currents in ice are an area where work is needed. They felt that only initial tests have been done so far. For their large tank, they commented that major work would be required to set up a system to reliably produce currents.

    CRREL further commented that the race-track elliptical flume has many advantages over a circular flume and they felt that it is preferable. For example, the straight section of the race-track flume (along its long axis) provides a section where flow and conditions can straighten out, allowing more reliable measurements and observations. They felt that this was especially true for simulations of frazil ice.

USCG R&D Center Contact Report

Person: Kurt Hansen
Organization: USCG R&D Center

Points and Inputs:

1. Kurt's focus is on oil spill countermeasures as opposed to oil behaviour. He said that for oil behaviour issues, they would probably go to BIO (at Environment Canada) or to the U.S. EPA. Nevertheless, Kurt was pleased about Environment Canada's initiative to develop a meso-scale oil spill test facility, saying the "more the merrier".

2. Kurt felt that there is a knowledge gap regarding how oil behaves in moving ice or slush; or in the presence of currents under ice. There is a lack of knowledge about how oil becomes trapped in slush or taken up into an ice sheet through its skeletal layer. As an example, he pointed to the January, 2015 oil spill in the Yellowstone River, Montana which occurred with dilbit in moving ice and slush. He encouraged that the tank be capable of investigating oil behaviour in these scenarios.

3. Kurt felt that the facility should be designed to be flexible regarding the oil types that it could handle. Its capabilities should range from light crudes to heavier materials such as dilbit. The oil type (and its stage of weathering) is important for assessing the appropriate oil spill countermeasure. This affects when it is necessary to switch from "normal" technologies to other equipment.

4. Kurt encouraged us to contact him again for any more feedback or comments.

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This write-up is prepared and published in author's personal individual capacity for informational/public service purposes only and do not reflect/should not be construed as professional/U.S. Government's instructions/view/advice. Furthermore, it does not constitutes any endorsement, recommendation, or favoring any private person/entity.

APPENDIX B
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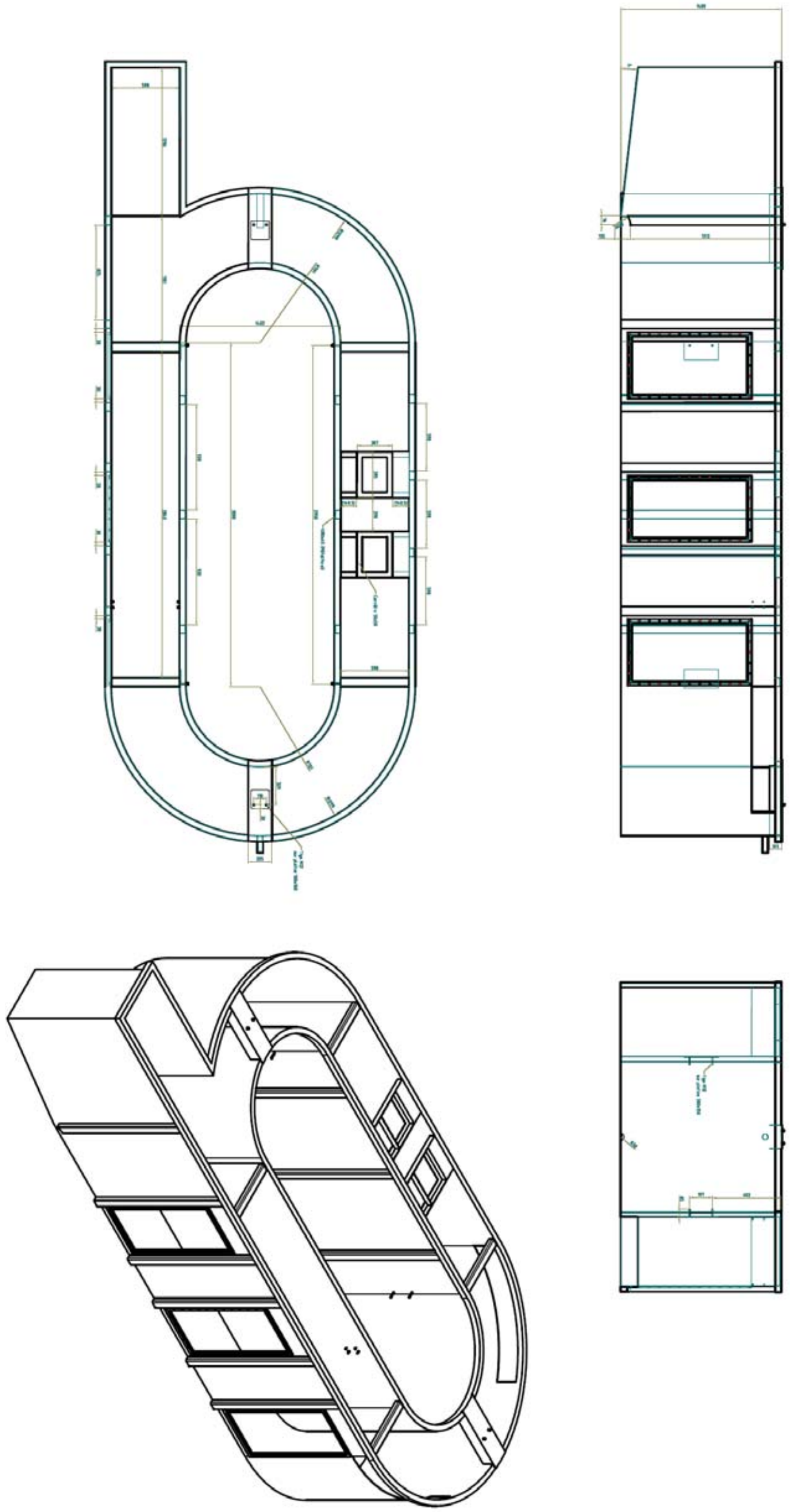
Appendix C – Detailed Information for the CEDRE Flume

Note:
Although detailed plans were received from CEDRE, only overview drawings are included here because:

(a) this minimizes the size of this report, and;

(b) detailed plans for CEDRE's flume have already been received by Environment Canada.

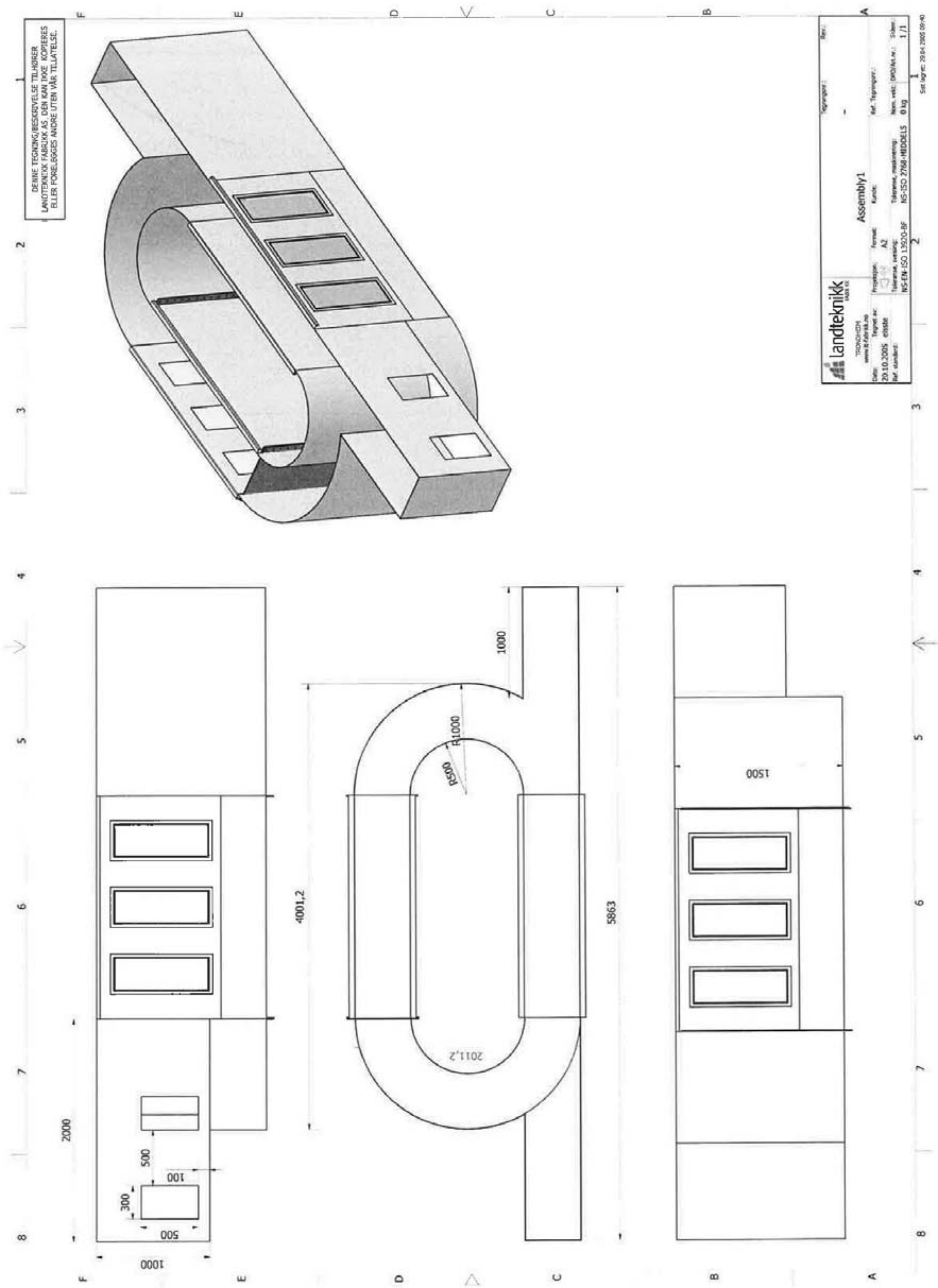


Appendix D – Detailed Information for the SINTEF Flume

Note:
Although detailed plans were received from SINTEF, only overview drawings are included here because:

(a) this minimizes the size of this report, and;

(b) detailed plans for SINTEF's flume have already been received by Environment Canada.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G. Comfort Ice
Engineering Ltd.

2 Conacher Gate, Kanata, Ontario, Canada K2K 3H1
Tel: 613 702 5950
Email: comfortga@gmail.com

La modification 001 vise à répondre aux questions suivantes :

Q1. Les dessins de fabrication numériques utilisés par CEDRE en 2011 pour construire leur nouveau polludrome à Brest, en France (par exemple, les figures 1 et 2 à la page 22 et 23 de la DP) sont-ils disponibles pour nous aider à préparer notre proposition?

R1. Les dessins provenant des communications avec CEDRE sont joints dans le fichier 170118-CEDRE.zip.

Q2. Les dessins architecturaux et techniques numériques préparés par Pageau-Morel et Associés Inc. pour la nouvelle chambre froide dans laquelle le Simulateur d'environnement de nouvelle génération doit être utilisé (p. ex., figure 3, page 30 de la DP) sont-ils disponibles pour que nous puissions les utiliser pour préparer notre proposition?

R2. Les dessins sont disponibles au lien suivant :

https://buyandsell.gc.ca/procurement-data/tender-notice/PW-FG-267-71638"

Q3. Peut-on avoir des copies numériques des deux rapports mentionnés dans la DP sur la page 39? à savoir :
[1] Comfort, G., 2015, Investigation for Meso-Scale Marine Oil Simulator, contractor rapport 135 présenté par G. Comfort Ice Engineering Ltd. aux SUST.
[2] GWA, 2016, 335 River Road Large-Scale Marine Oil Exposure Simulator – Location Feasibility Study, PWGSC Project #R.075351.001, rapport de l'Entrepreneur GWA 2015-448 présenté par Goodkey, Weedmark and Associates Ltd. à TPSGC, le 12 janvier 2016.

R3. Le rapport de Goodkey, Weedmark and Associates Ltd ne sera pas fourni, car toute information dans cette étude de faisabilité a été remplacée par la conception finale ultérieure pour le site de Pageau-Morel et Associés Inc.

Q4. Compte tenu de la demande d'un prix ferme tout compris pour la conception, la construction, l'installation, la formation, la garantie de 2 ans, les dessins, les manuels de formation et les pièces de rechange critiques, ainsi que trois années de garantie prolongée optionnelles, nous souhaitons demander que la date de clôture de la demande de proposition soit reportée du 8 septembre 2017 au 6 octobre 2017 pour nous permettre un temps suffisant pour préparer une proposition appropriée au coût raisonnable.

R4. Aucune prolongation ne sera accordée pour respecter l'échéancier du 31 mars.

TOUTES LES AUTRES CONDITIONS DE LA DP DEMEURENT INCHANGÉES