Responding to Submerged Oils in Freshwater Environments

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Premise and Overview: Non-Floating Oils

When spilled, many types of heavy and crude oils may sink or be suspended in the water column below the water's surface.

Oils classified under Group V, along with some Group IV oils, will tend to sink under certain conditions.

"If the ratio of the density of oil to the density of the receiving water is greater than 1.0, the oil will not float. If it is within a few % points of 1.0, oil is much more likely to become submerged due to wave action (and/or sedimentation or adherence – author's note) - *Spills of Non-Floating Oils -* National Academy Press

The Reasons Oil Will Sink

The oil's density is greater than receiving water density.

The oil picks up sediment or sand content, thereby increasing its relative density.

During low tides (or other low water periods) the oil strands on surfaces due to adhesion. When water level raises, the oil remains stranded on the now-submerged surfaces.

Submerged Oil and Water Current

Oil will be transported in currents in excess of 0.1 knot, and will only accumulate in low-flow points when almost no current is present.

Three Fundamental Operational Difficulties in Nonfloating Oil Response Activities:

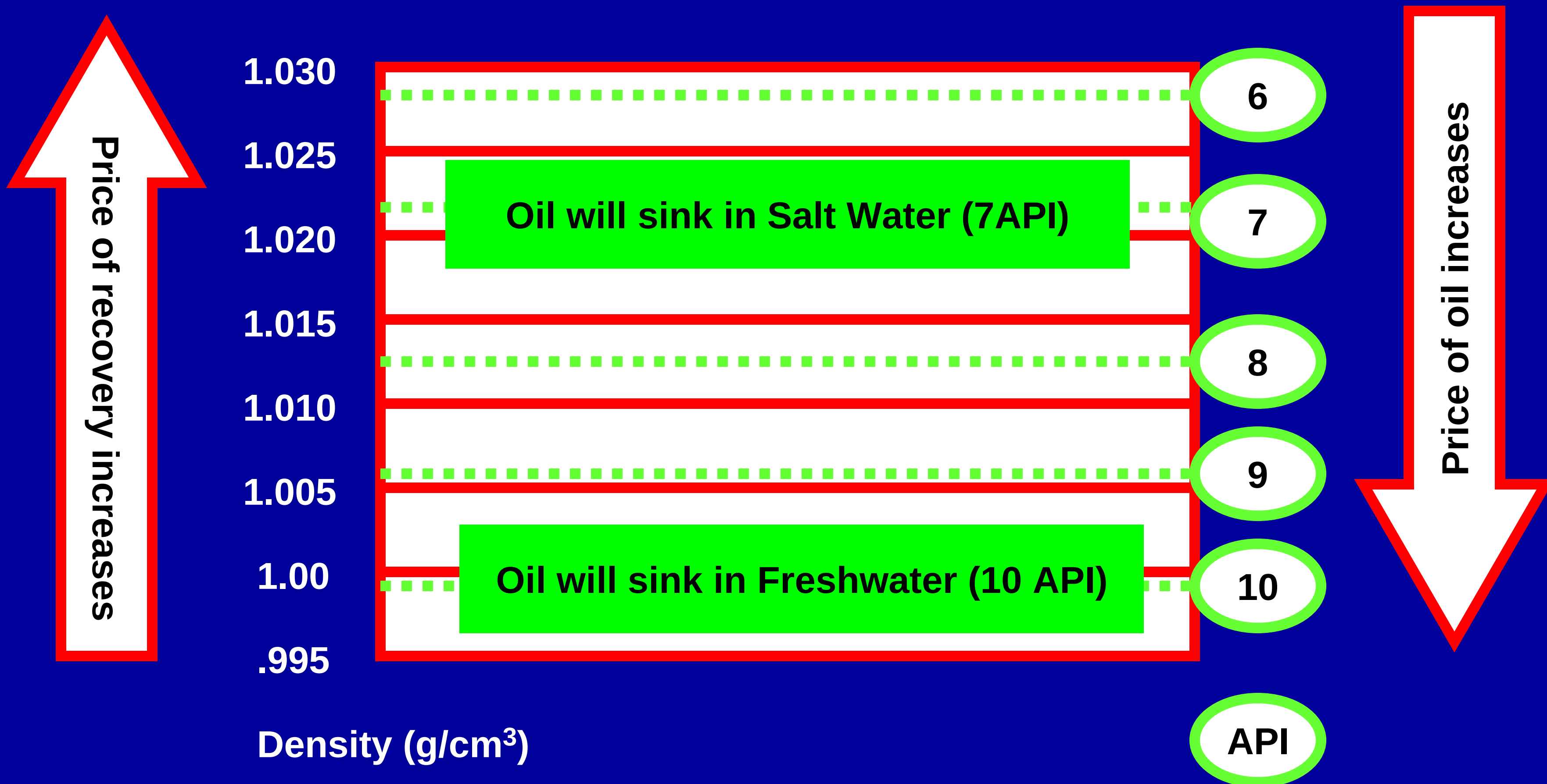
1. **Locating & Tracking:** It can be particularly difficult to locate, track and predict the behavior of non-floating oil; especially in the presence of currents.

2. **Containment:** Effective containment of submerged oil is usually next to impossible when currents are present.

3. **Recovery:** Accepted methods may be problematic due to a general lack of experience in the field, the requirement of specialized equipment, and the tendency to recover large quantities of water and/or sediments along with the oil, and cost and safety factors.

The Recovery Cost Versus Reclaim Value Paradigm

Relatively speaking, the price of an oil product can be judged by its API Density value. The higher the API value, the higher the price of the oil.



Case Study #1 – CSO Barge

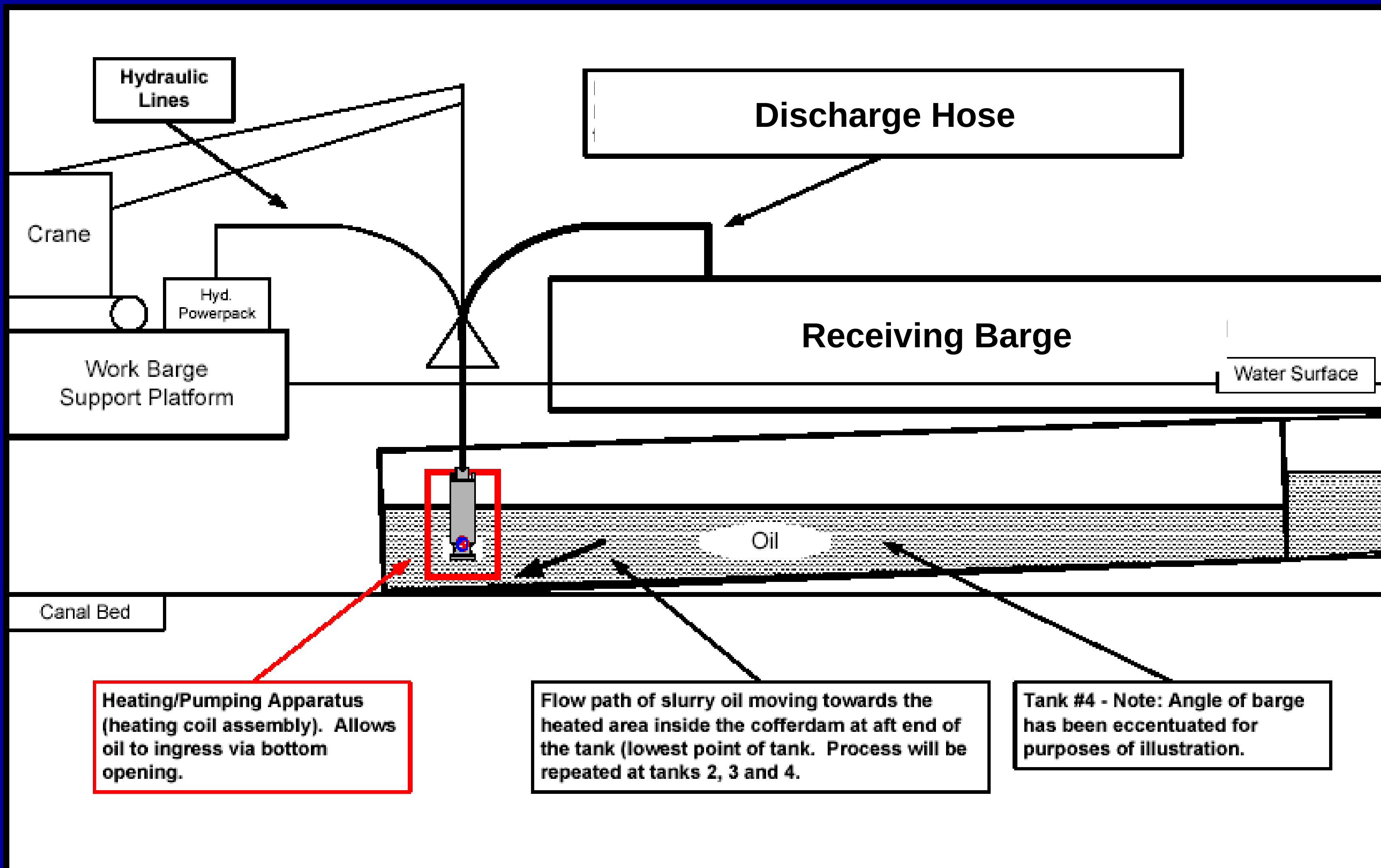
Chicago Ship & Sanitary Canal – January, 2005

Overview: Due to undetermined causes, barge carrying 600,000+ gallons of Clarified Slurry Oil (CSO) suffers explosion and fire in heavily populated area.

CSO is stored and transported in a heated condition to allow for pumping. When it cools, it quickly transitions into a semi-solid, "plastic" material, which cannot be pumped and which sinks in the presence of fresh water. Almost all of the oil contained in the barge when it suffered the explosion remained on the wreck and was eventually recovered using traditional and creative heating and pumping techniques. Some oil that leaked from the barge was removed from the bottom by dredge.

Photo taken from the exposed bow of the barge, with the stern ~295' to the rear and under ~20 feet of water. At this point, all oil is thought to remain on board.

Initial operations sought to remove the oil from within the barge's damaged tanks using pumps. Heat was applied to the oil using an oil-based heater employing a specialized heating apparatus, and by tying into the barge's remaining heating coils.

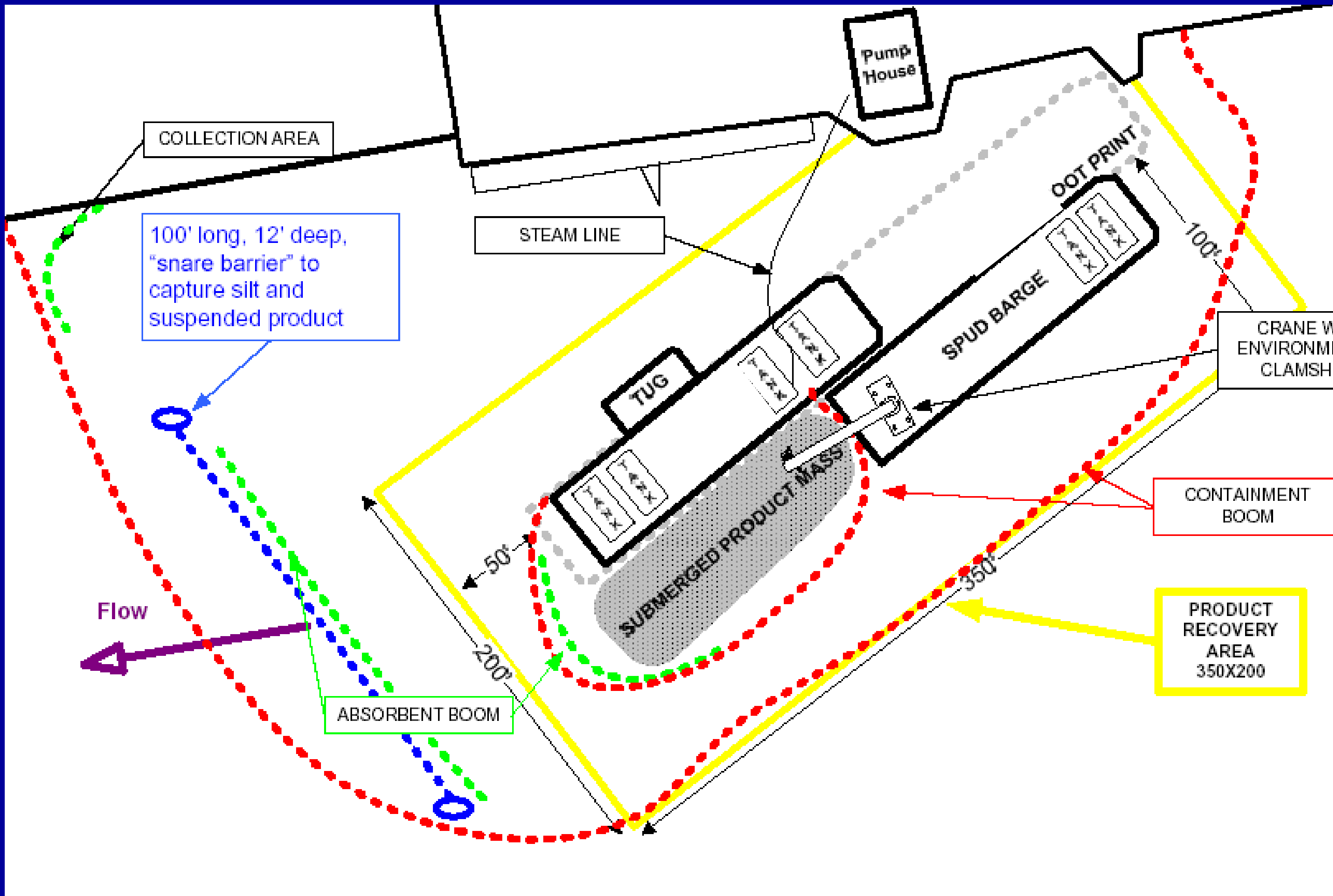


The strategy positioned a heating/pumping apparatus within the open tank space onboard the barge (tanks 2,3 & 4 were all missing top covers after the explosion and thus candidates for this process). The immediate area around a pump would be heated to promote the oil to flow in a controlled manner to the pump's intake.

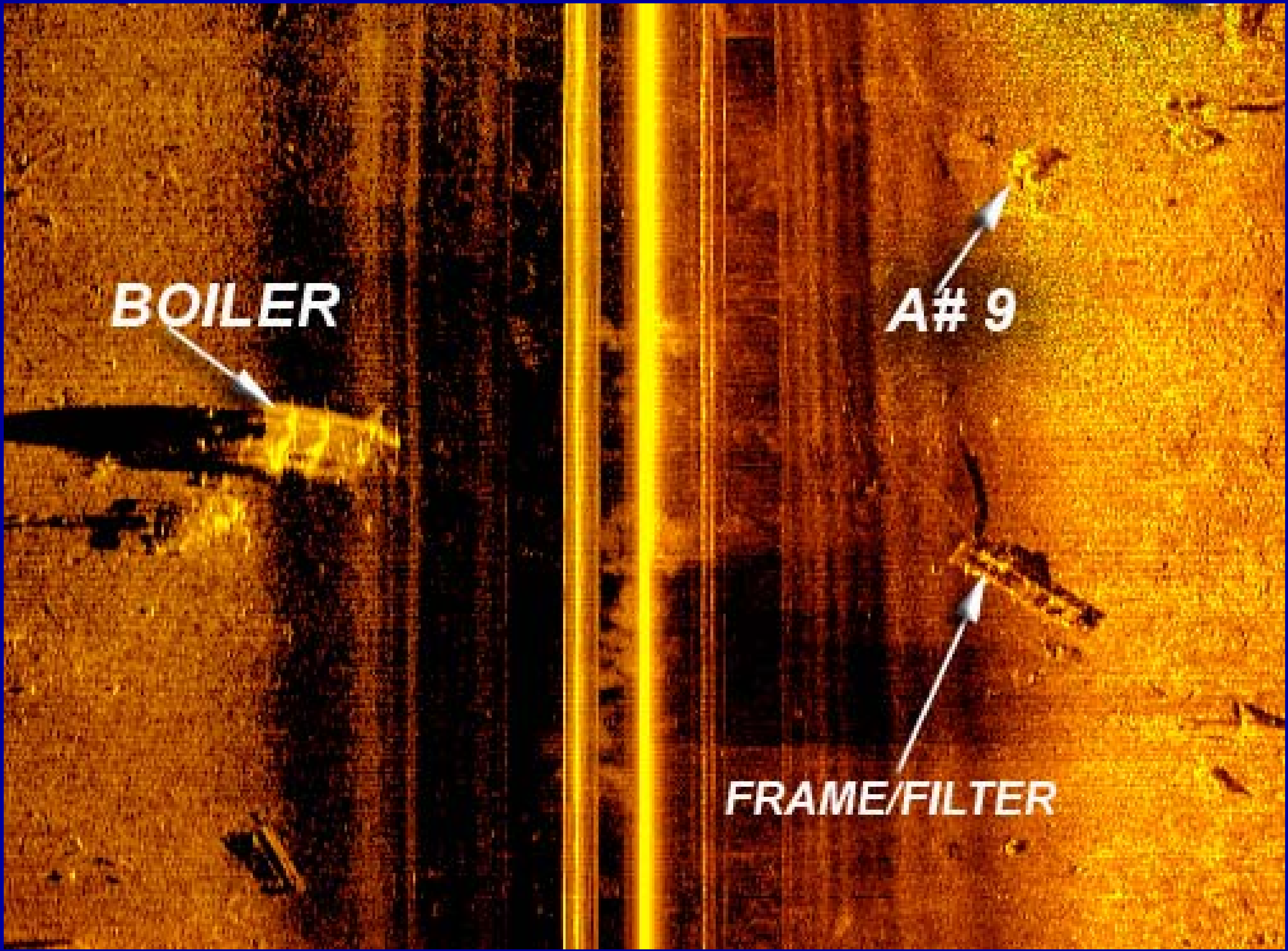
Initial attempts to pump the oil underwater (after heating) were abandoned when the heating process could not be limited to releasing oil in a controlled manner at the pump intake (i.e., the oil was refloated outside the control area).

When exposed to cold air (ambient temperatures were consistently below 20 degrees F) the CSO immediately solidified and could not be pumped unless heated again.

When heat could be maintained on the product and the oil was well contained (such as at the the #1 cargo tank which remained intact after the explosion), a hydraulic submersible pump (MPC model KMA 333) easily transferred the contents.



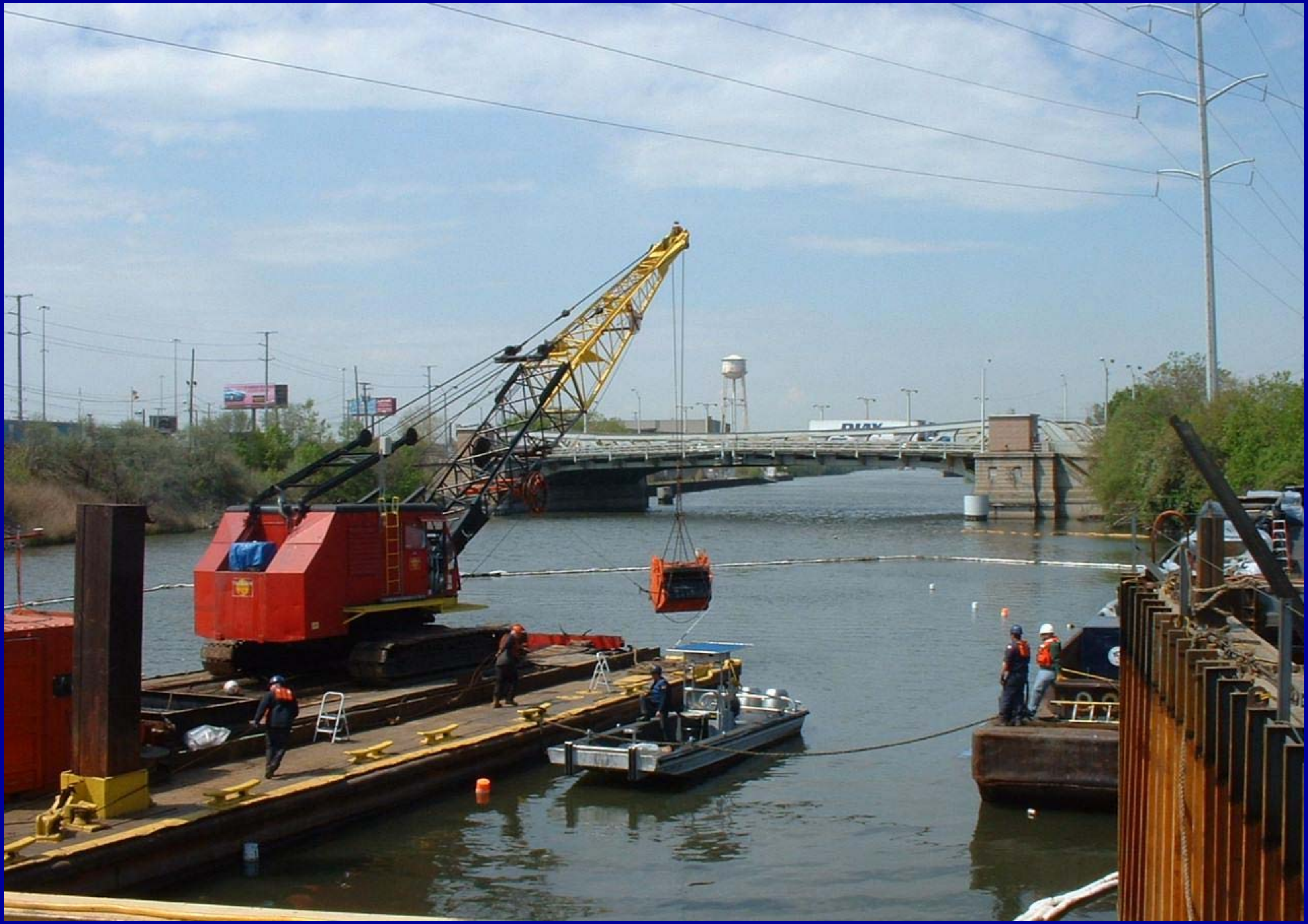
During the course of the operations, divers began reporting a mass of oil located adjacent to and under the barge. It was determined that this oil had migrated from the barge through cracks or had slopped over-the-top when she sank.



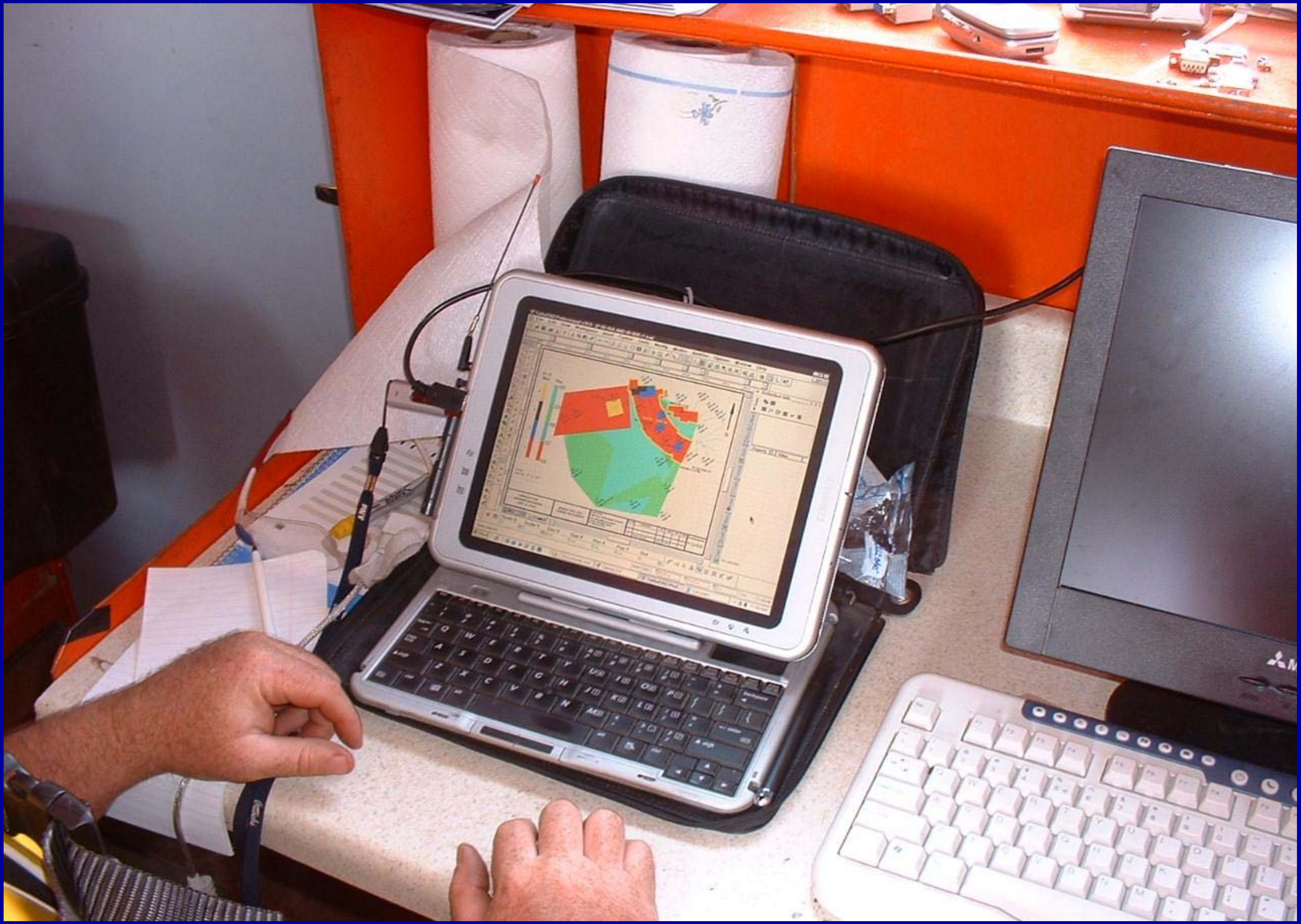
Side scan sonar proved very useful for debris recovery purposes. However, the planning team did not find this technology useful for locating oil on the bottom of the canal and instead relied on divers' visual observations.

After considering a number of different approaches, this environmentally-friendly clamshell dredge unit was mobilized to the site. The dredge minimizes the amount of contaminated water runoff associated with such operations.

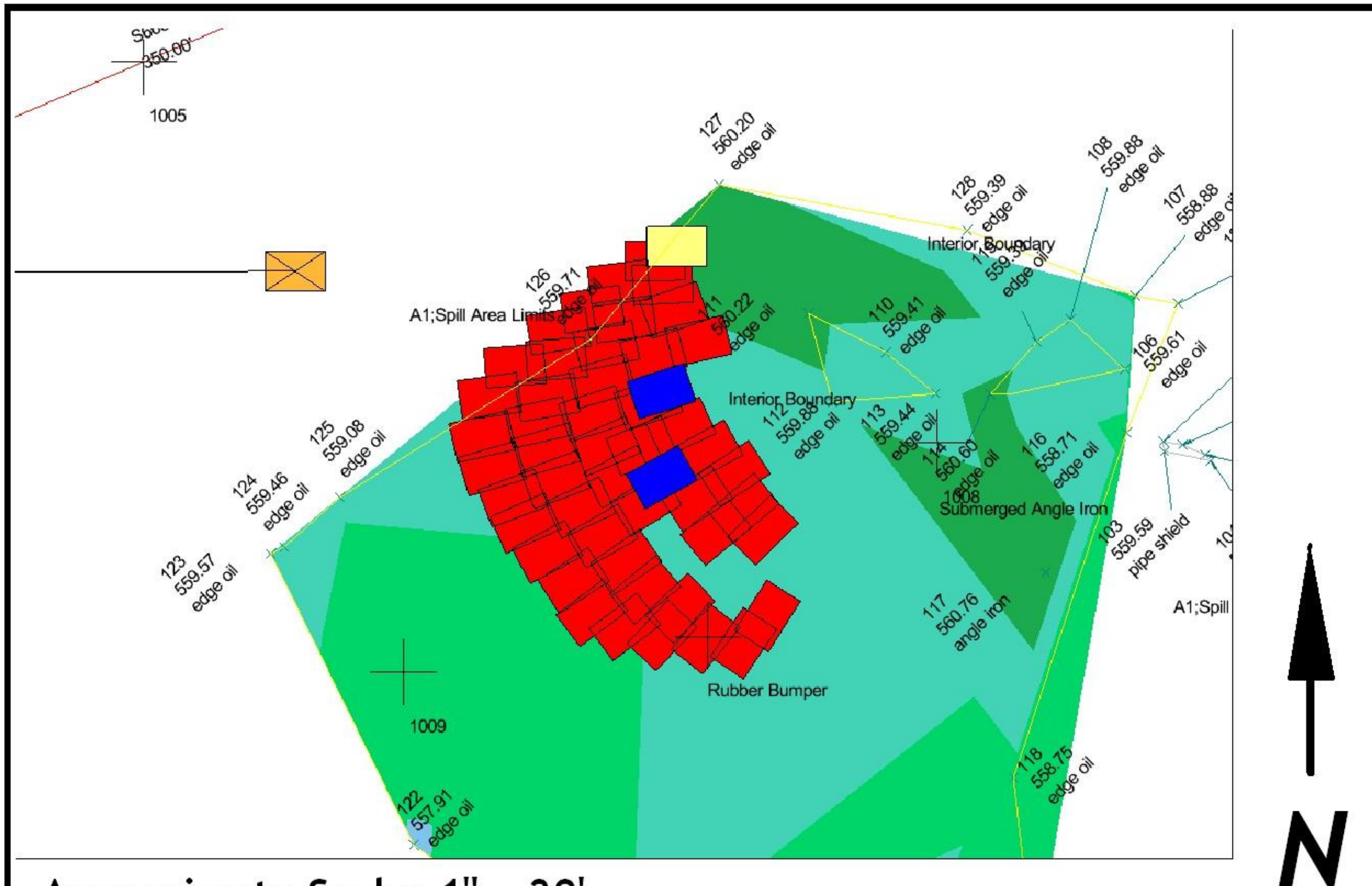
Two platform barges were sourced and obtained. One and was outfitted with a series of recovery boxes (20 cubic yard – DOT-approved). The boxes were sealed with waterproof foam at their doors.



The second barge housed the crane unit that was used to deploy the environmental clamshell bucket. The second barge also housed the GPS system, analytical processing center and computers.



Each “bite” taken by the crane was recorded in an electronic format, and a map representing daily progress was submitted at the close of each day’s operations.



Approximate Scale: 1" = 20'

DAILY AMOUNT REMOVED MAY 10, 2005	BARGE EMC 423 CARGO RECOVERY	prepared by: Cable Arm Professional Services 3452 West Jefferson Avenue Trenton, Michigan 48183 Ph: 734-676-6108	Rev. No.	Description	Dsr.	Date	Chk.	Date	Drawing No. P-5/10-A
			0	Issued to MMG	GWS	05/10/05			

A cofferdam was eventually outfitted around the stern of the barge and she was dewatered. This resulted in the refloating of the barge and her transport to a facility where the remaining oil was removed from the tanks.

Recovery Figures:

- Almost all the oil that remained in the barge (>570,000 gallons) was successfully recovered by standard heating and pumping methodologies (which hinged on the fact that the barge was refloated intact).
- ~22,450 gallons of oil (estimated) was recovered using the clamshell dredge. Over 600 yards of sediments was recovered during the process.

Lessons Learned:

- Availability of specialized equipment necessary to conduct subsurface containment/recovery operations is limited. This is especially true of remote sensing equipment capable of discerning oil below the surface.
- Oil containment proved problematic; both during the heating processes and during other times when prop wash was thought to be moving oil.
- Planning and Operations Groups must be PROACTIVE during submerged oil operations, and must be prepared to “switch gears” when conditions change or based on unsatisfactory field results.
- It was eventually concluded that traffic on the canal had a deleterious effect on the operation, causing oil that would otherwise have remaining recoverable to migrate beyond practical recovery points.
- Clamshell operation lacked precision due to antiquated crane apparatus.

Case Study #2 – Fuel Oil Barge

Gulf of Mexico *(Salt Water Environment)* – November 2005

Overview: November 10, 2005 - Barge DBL152 strikes a submerged object in the Gulf of Mexico (later determined to be a oil platform wrecked and displaced by the second Hurricane - Rita). On November 14, 2005, DBL 152 capsizes.

Amount of Spill: As a result of both the initial collision and the subsequent capsizing of the barge, over 2.7 million gallons of Slurry Oil is discharged into a salt water body. The density of the oil is 1.04 g/cm^3, and it immediately sinks upon contact with the water.

Freshwater vs. Saltwater

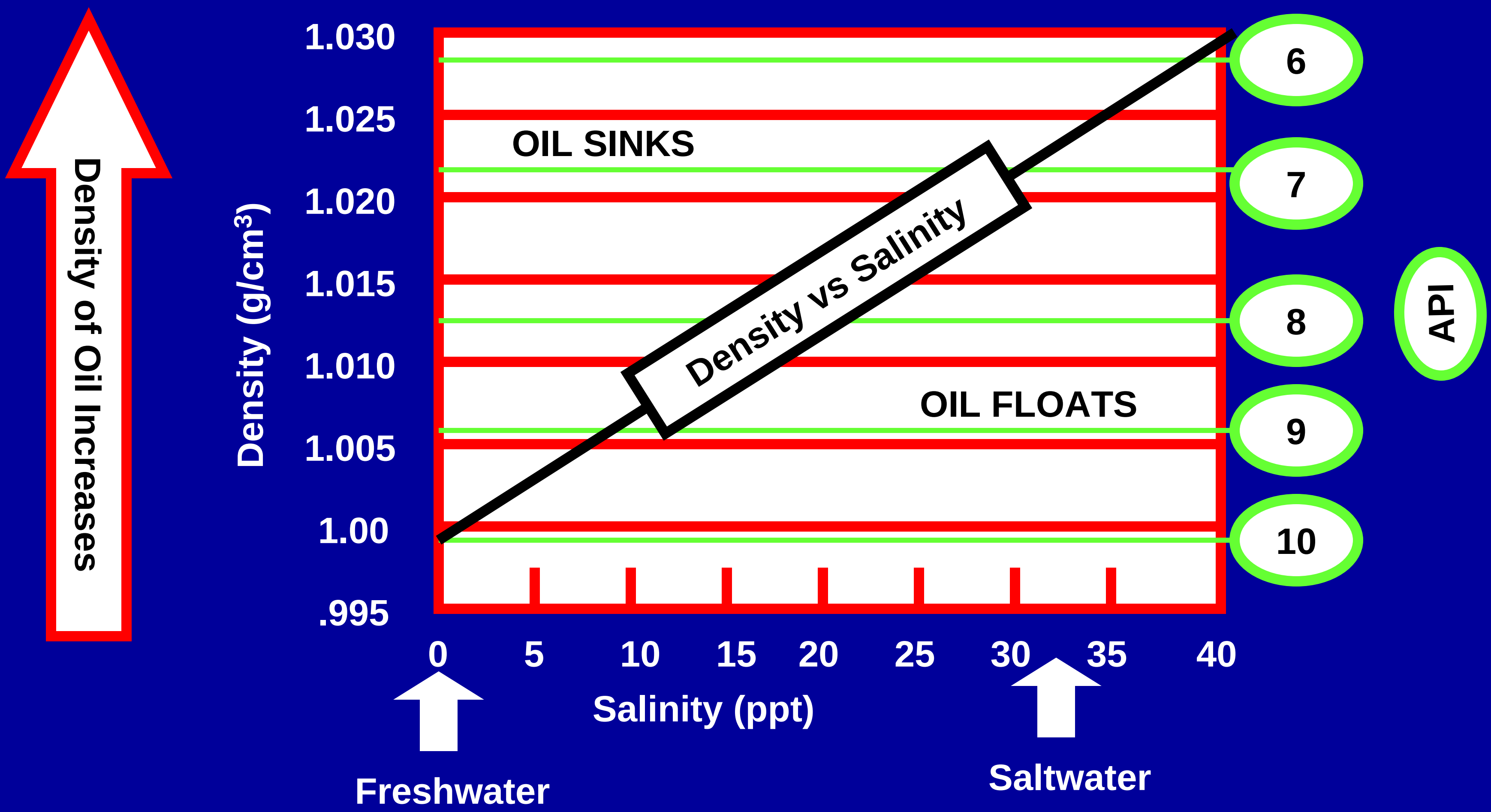
The densities of freshwater and salt water differ (salt water has a higher density than freshwater).

Oils with an API gravity of less than 10 may be denser than freshwater (and may sink); oils must have an API gravity less than about 7 to be denser than seawater. Thus an oil classified as API 8 could potentially sink if introduced into freshwater, but could float in saltwater.

Notwithstanding the general differences between Fresh and Saltwater environments, the general principles of responding to submerged oil spills remain the same for salt water environments as they do for freshwater environments.

Relationship between Water Density & Salinity

Note: This table applies to water at a temperature of 59 degrees F, changes in water temperature will alter this information (water density decreases as its temperature increases)

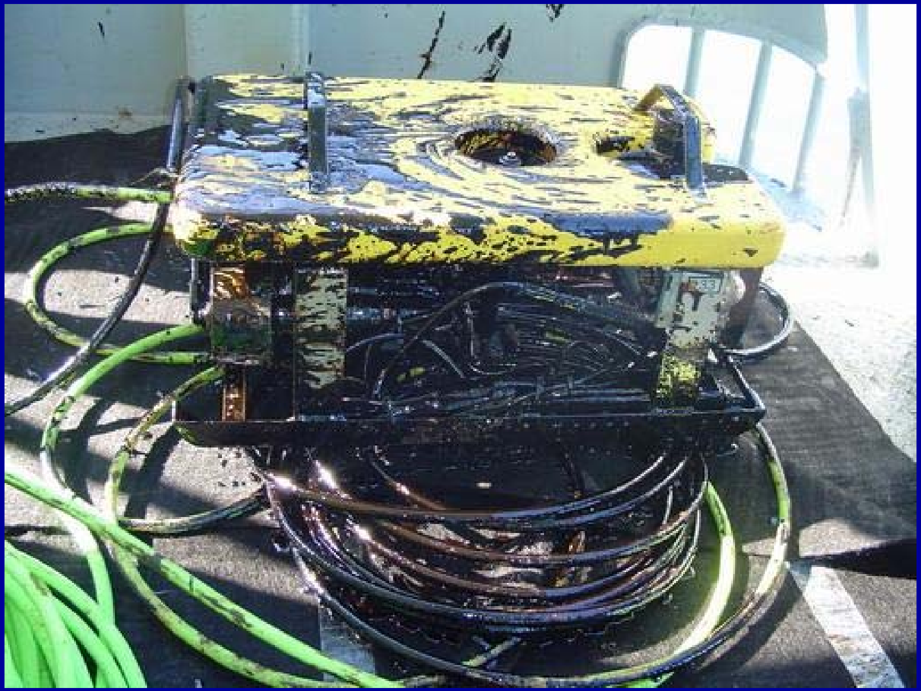


Traditional spill response resources were mobilized to the site but proved to be of little use during the spill due to the fact that the oil did not float in seawater.

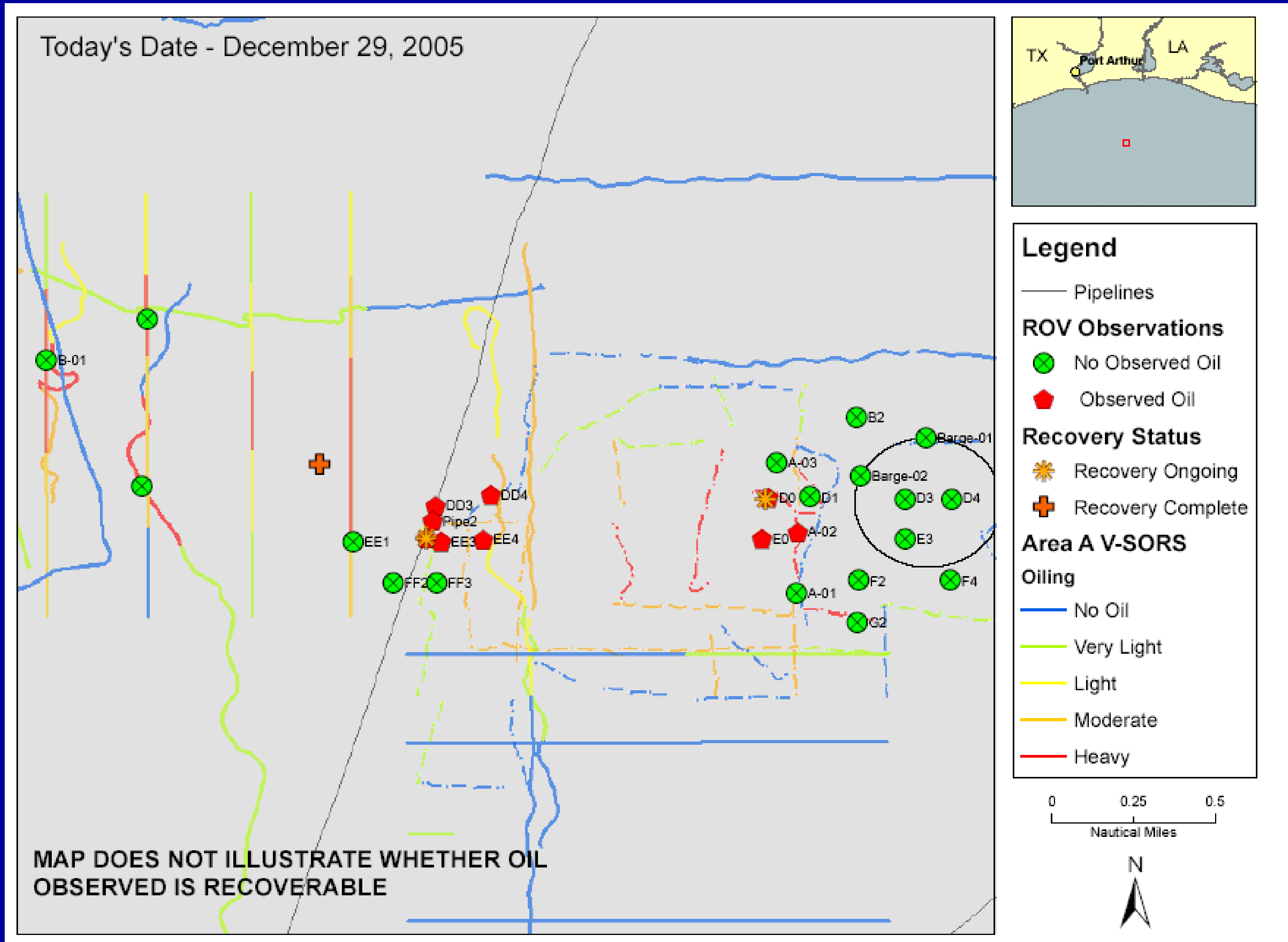
The DBL 152 after capsizing on November 14, 2005. Note that there are very few traces of oil on the surface despite the fact that millions of gallons have presumably spilled by this point.

A large gash in the hull of the now completely inverted DBL 152.

This absorbent trawling device was used to detect the presence of oil on the bottom of the Gulf. An area of approximately 100 square miles was covered by surveys.

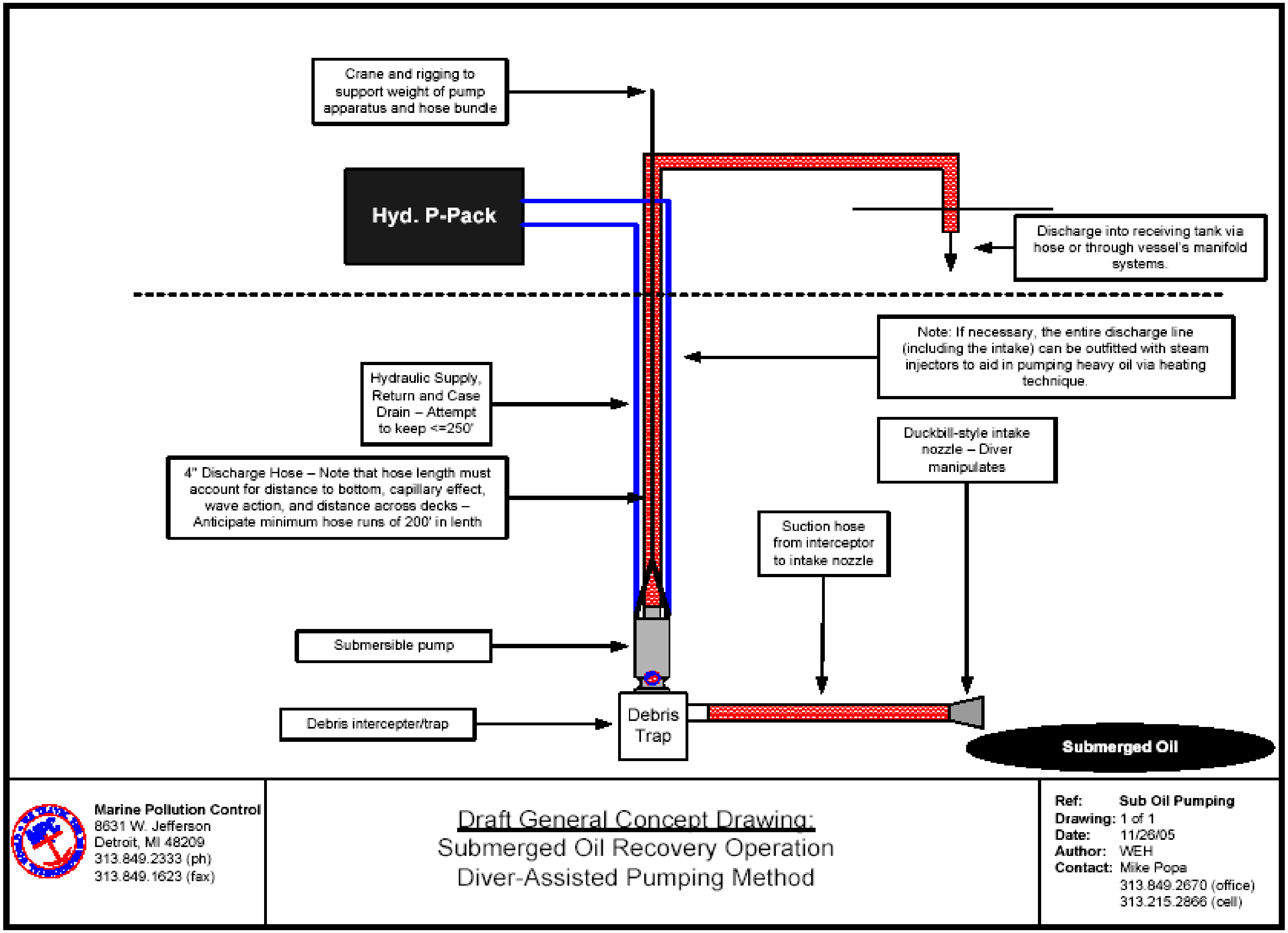


In addition to the trawling units, visual observations were acquired using an ROV-based platform. These photographs represent before and after a successful oil location sequence.



Based on the acquired data, the ICS Environmental Unit produced these oil location and project progress maps, and distributed this collected and processed data to the operations personnel to guide the recovery operations.

A 250’ x 50’ barge was secured, and the recovery and decanting equipment was positioned on board. Note that a receiving barge is positioned alongside (in front of) the recovery barge in this photo.



The team deduced, and subsequent visual operations confirmed, that the oil would remain within a pumpable viscosity range on the seabed. It was decided that the best method for recovery would entail diver-assisted pumping operations.

MPC utilized several types of pumps to recover the oil from the bottom. The best units for this application proved to be hydraulic submersibles that featured “open” impeller chambers, such as the MPC model KMA axial/centrifugal pump.

In this remarkable diver photo we see the oil being gently lifted from the seabed, with the vortex drawing almost exclusively oil/water mixture without drawing in excessive amounts of sediments.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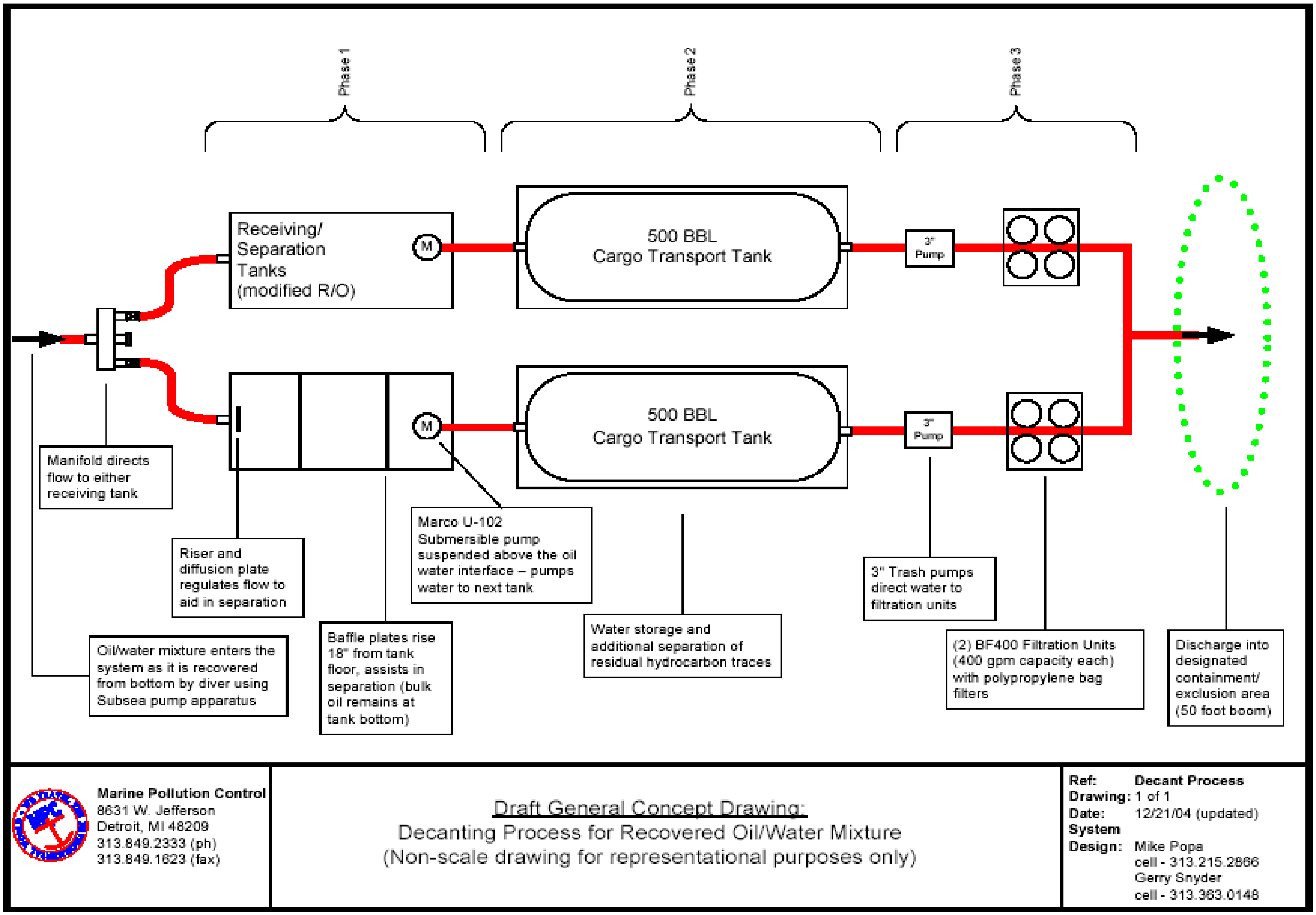
MAGNAVOX

This photo shows heavy concentrations of oil remaining in one of the storage tanks (after water decanting operations had taken place).



A critical component of the recovery process was the storage and decanting of the oil/water mixture that would be recovered. The system included holding tanks, absorbent based recovery components and a filtration package.

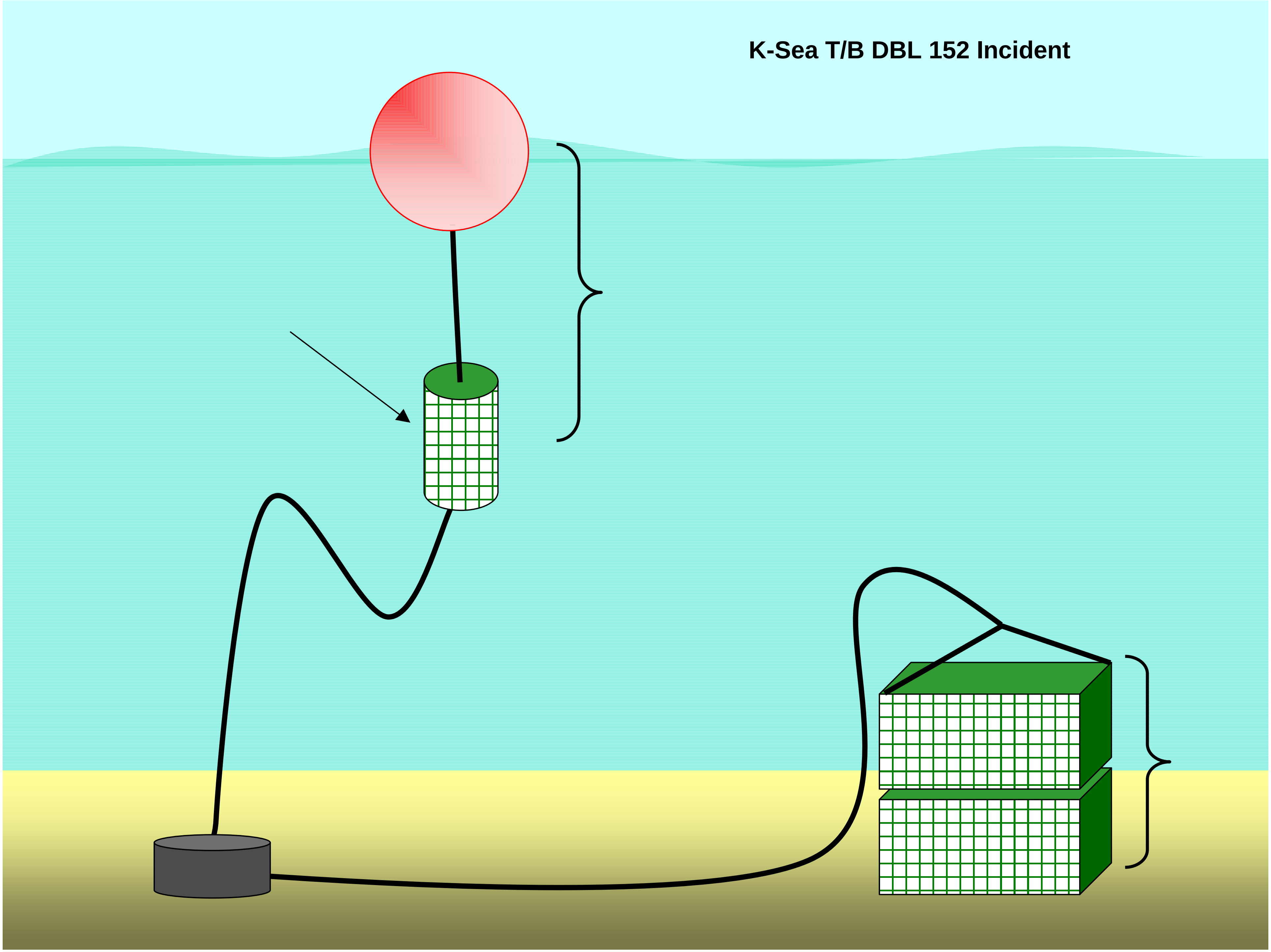
The final stage of the decanting operation included discharge of the filtered water through a chamber that contained absorbent recovery devices, into a contained area at the end of the barge.

The methodology selected required a team of 14 divers to support the operation on an around the clock basis.

To increase bottom time for each diver, a Nitrox mixture was used. A decompression chamber was maintained onboard in case of any emergencies. Due to the diligence of the entire crew, no reportable injuries occurred during the project.

Diver decontamination was an integral part of the operations process, and rapid and effective decontamination ensured that diver rotations remained efficient, thereby increasing the overall productivity rate.

These specially-designed “crab pot” submerged oil detection devices would be left in position after practical oil recovery operations had ceased, and would be monitored over time to ensure that masses of oil were remobilizing in the area.


K-Sea T/B DBL 152 Incident

Recovery Figures:

- Approximately 2,730,000 gallons of oil was reported to be missing from DBL 152. Approximately 30,450 gallons of oil was recovered from the seabed, along with approximately 400,000 gallons of oily water.

Lessons Learned:

- Weather in the Gulf of Mexico during this operation severely impacted operations. Since windows of opportunity were few and far between, the adaptation to a 24-hour operation proved fortuitous.
- The process of locating the oil in a 100 square mile area proved to be extremely complex. Differences in the GPS systems of various elements within the overall command further complicated this part of the mission.
- Several types of pumps were utilized to accomplish recovery. The best types, it was found, were those which had "open" impellers that would accept the oil/water mixture and sediments.
- The effects of the harsh hurricane season impacted the operation substantially, with resources drawn from around the country to accomplish the operation.
- Water decanting operations proved difficult in that wave conditions kept the oil in constant agitation, slowing the separation phase

Case Study #3 – Crude Oil Tanker Athos I

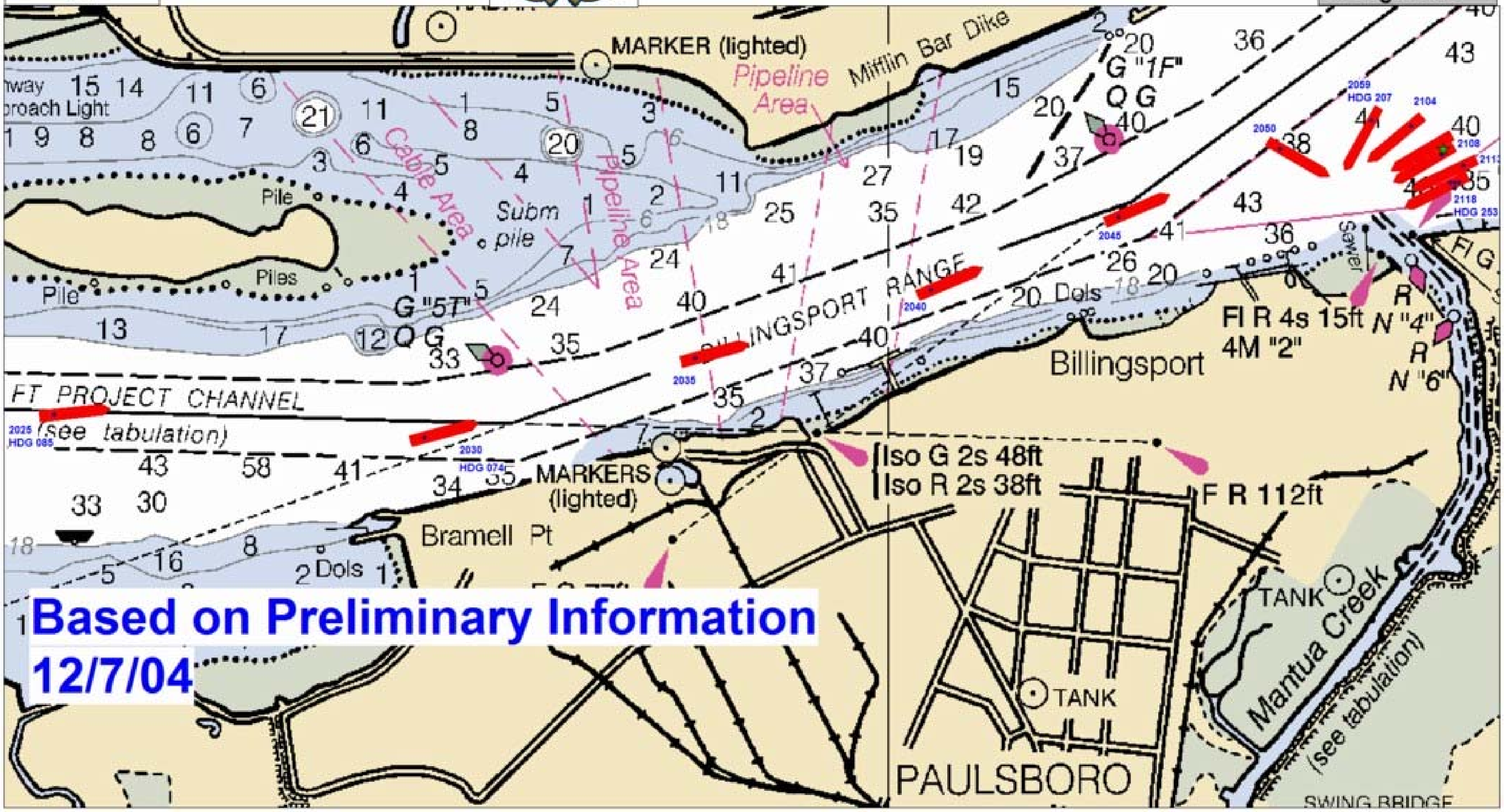
Delaware River (Philadelphia) Freshwater – November 2004

Overview: November 26, 2004 – 60,880 dwt Cyprus flagged crude oil tanker strikes submerged object when maneuvering to berth at Citgo Terminal in Paulsboro, NJ. Object breeches two tanks on the ship, which was carrying 14 million gallons of Venezuelan crude at the time (API 10-20).

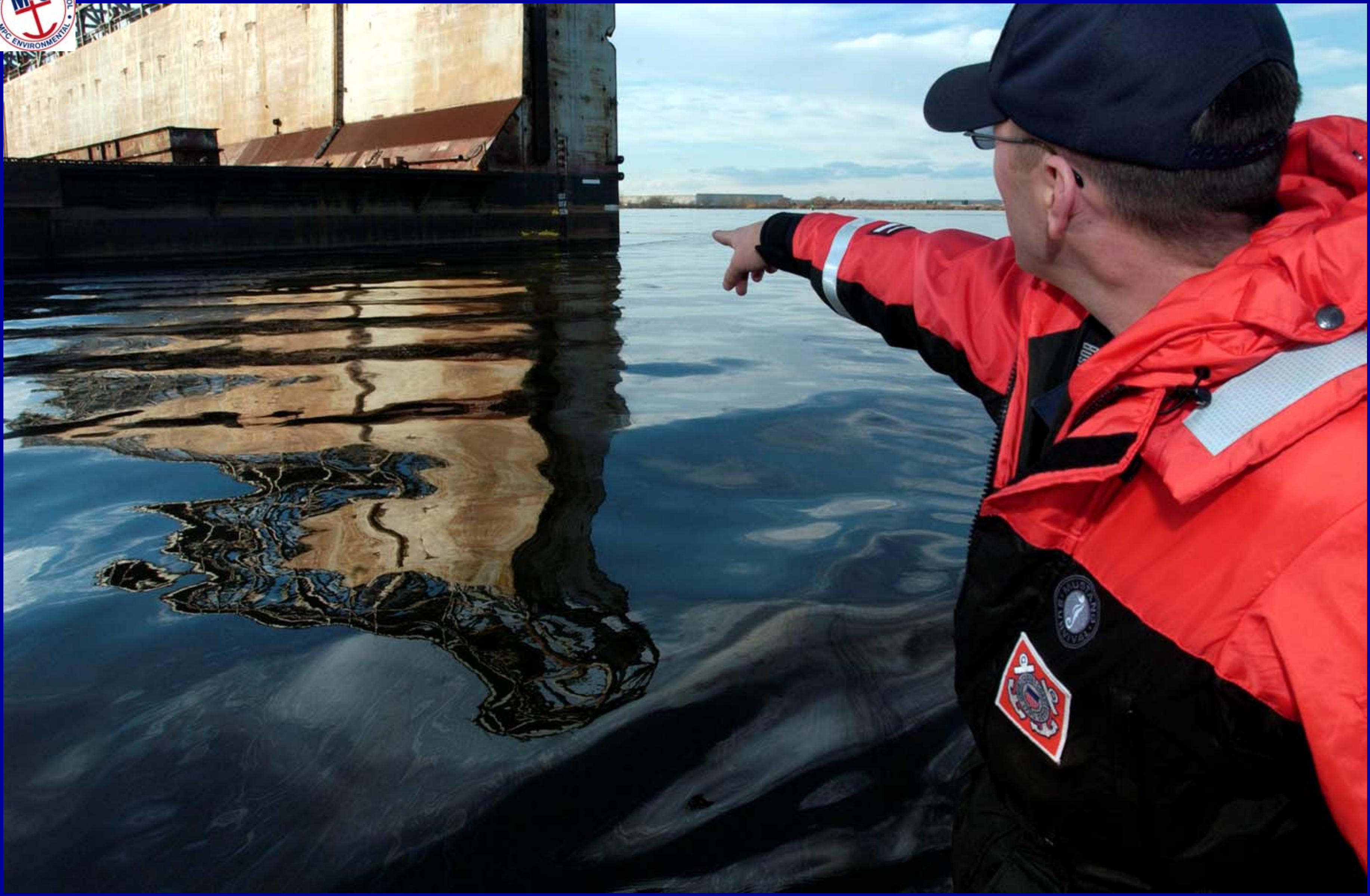
Amount of Spill: It was eventually determined that over 265,000 gallons spilled. By January 12, 2005 over 72,000 gallons of oil/oily water recovered, *1,812 gallons submerged oil recovered*, 7,227 tons of oily waste recovered.

USCG INVESTIGATION
MV ATHOS I OIL SPILL
Nov 26, 2004

US Army Corps of Engineers®



Vessel struck submerged object at 9:08 p.m. November 26 (Low Tide/Full Moon)



The spilled crude oil is extremely thick and heavy

Around December 2nd, submerged oil was discovered on the river. The presence of this threat, along with floating oil, resulted in closing 2 nuclear power plants.

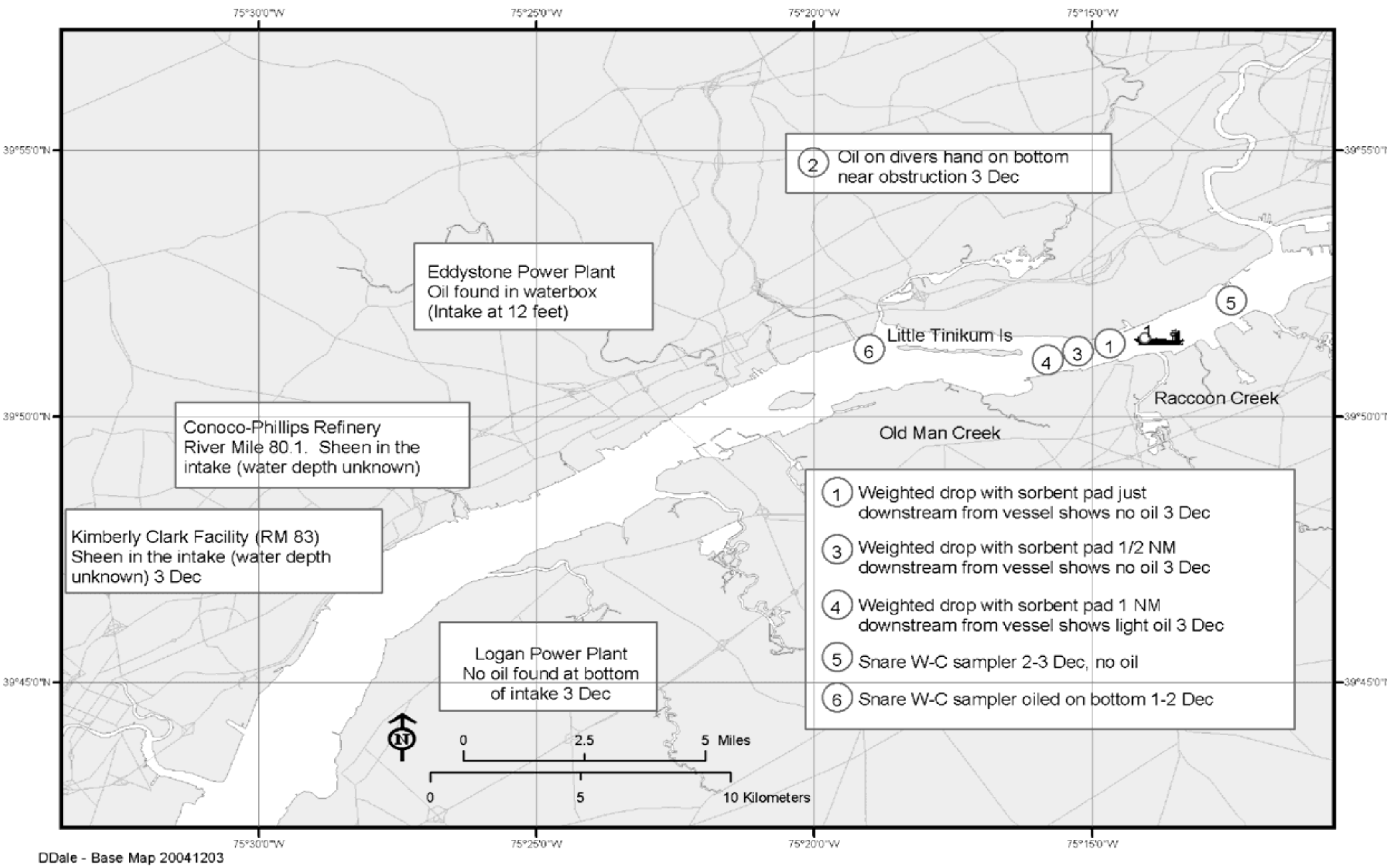
M/V Athos I, Delaware River, NJ/PA/DE

Location of Submerged Oil - map by NOAA

Date: 12/3/2004

USE ONLY AS A GENERAL REFERENCE

Graphic does not represent precise amounts or locations of oil

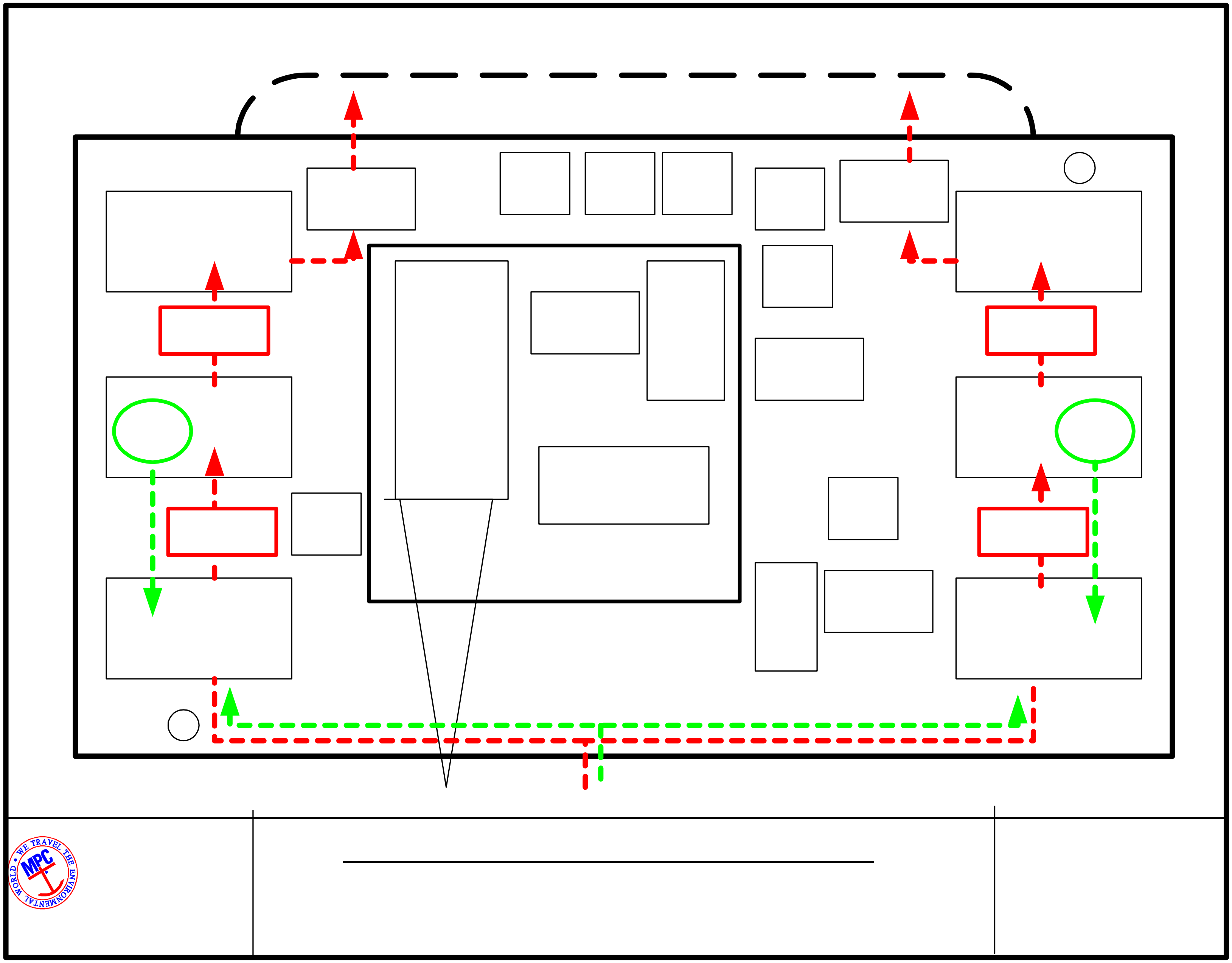


Eventually, several areas were identified as candidates for underwater recovery (and in one area underwater recovery was conducted).

To search for submerged oil in the murky waters, this snare trap was devised.

In operation, the unit was dragged by a support vessel in an area suspected to have subsurface contamination.

If, when retrieved, oil was present, the decision to mount a dive survey and/or recovery operation was made.



Diesel hydraulic powerpacks provide the necessary power for the submersible pumps to run. They are controlled at the surface by diver verbal commands.

A hydraulic submersible pump mounted on a steel debris box. The debris box decreases the likelihood that rock or other object will jam the pump.

Divers would use these steam-enabled duckbill nozzles to "vacuum" up the oil from the river bottom.

Divers could only operate under a small window of opportunity when tides and visibility were in their favor.

After each shift, the extensive decontamination procedure would ensue.

Recovery Figures:

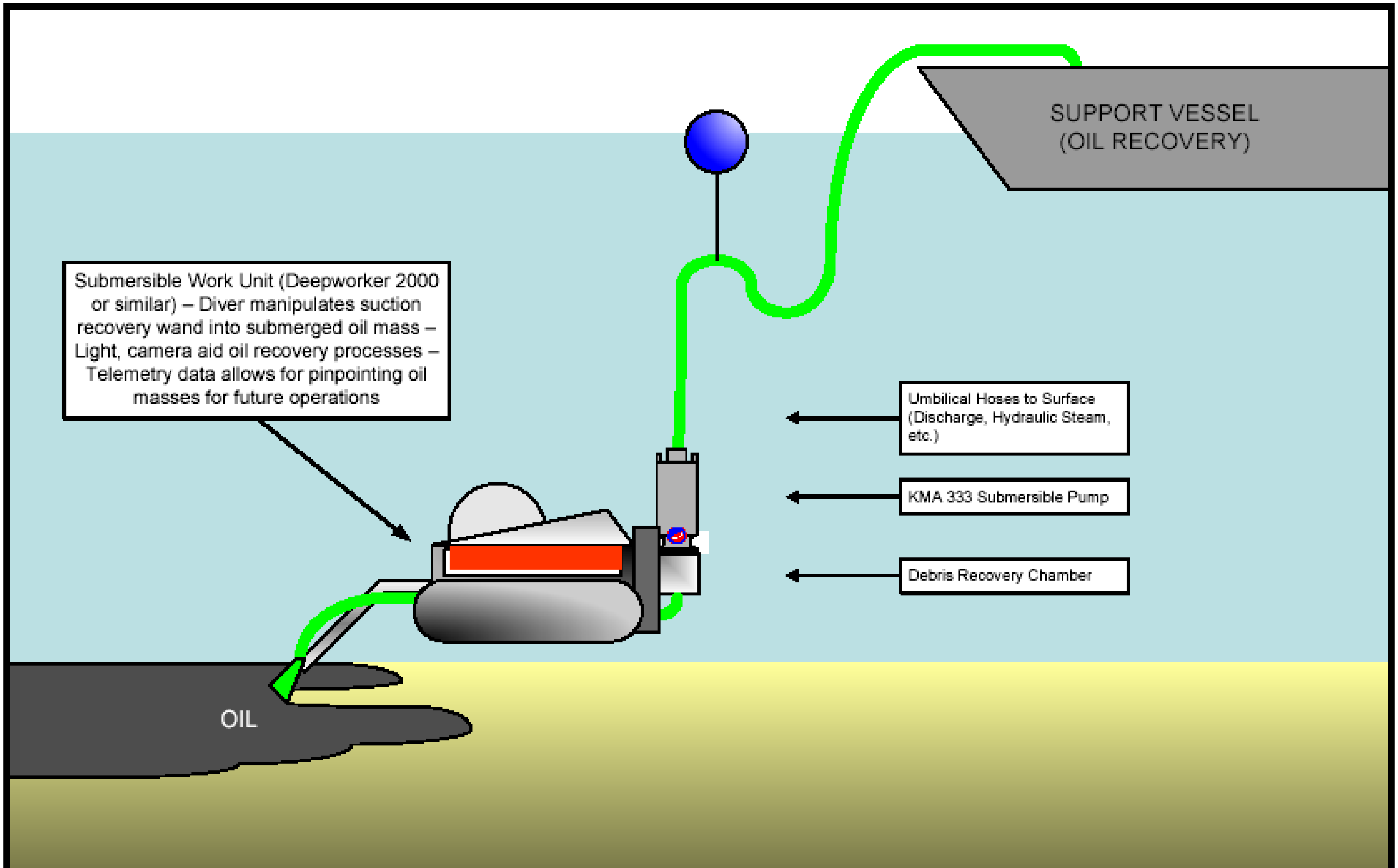
- Almost 2.5 million gallons of crude oil was lightered from the tanker prior to her being released to discharge her cargo and sail to Mobile, Alabama for repairs. Over 72,000 gallons of oil and oily water were recovered using traditional (surface) methods, along with 7,227 tons of oiled debris. 1,817 gallons of submerged oil were recovered during this phase of the operations.

Lessons Learned:

- It is thought that the submerged oil that was recovered was "injected" and adhered to the riverbed early on (due to the fact that it was recovered in a trench near the site of the accident). Venezuelan crude is a particularly heavy crude oil; the heaviest components of the oil may have tended to sink (although the majority of the oil floated).

- Visibility in the river was extremely low, and tidal actions also limited diver windows of opportunity. Spill impacts were witnessed almost 60 miles downstream of the spill site. Locating and recovering submerged oil would be extremely problematic for this event.

- A "Consortium" of businesses and municipal facilities was formed to ensure water quality after the cleanup. These organizations would report to a central body if and when oil turned up at their intakes. This program would stay in effect for long term monitoring purposes to ensure no submerged oil had refloated and migrated.



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<u>Draft General Concept Drawing:</u>
Subsurface Oil Recovery Utilizing Hybrid Manned Submersible Unit

Ref: **Sub Oil Recovery Sys.**
Drawing: 1 of 1
Date: 3/15/06
Author: David Usher
Contact: David Usher
313.849.2333 (office)

Thank You For Your Attention.

Questions?