

An interim analysis of the June 14, 2003 report by Independent Maritime Consulting on the volume of oil Spilled by the Bouchard Transportation Company tank barge *Bouchard No. 120* in Buzzards Bay

**by
Joseph E. Costa, PhD
Executive Director
Buzzards Bay Project National Estuary Program**

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Introduction

In October 2003, the Buzzards Bay Project National Estuary Program received the report titled “Investigation and reconciliation of cargo quantities for B 120 oil spill at Buzzards Bay, April 2003,” dated June 14, 2003¹. The report was funded by Bouchard Transportation Co. Inc., and prepared by David A. Hall, Marine Surveyor & Consultant for the firm Independent Maritime Consulting Ltd. This firm provides a wide range of services for their clients ranging from litigation support to cargo analysis. The report, which was presented to the US Coast Guard, Massachusetts Department of Environmental Protection, and other agencies involved with the spill, concluded that the amount of No. 6 fuel oil spilled by the *Bouchard No. 120* was between 22,000 and 52,000 gallons. These estimates were sharply lower than earlier estimates of 98,000 gallons.

In this report, we analyze Hall’s methodology and conclusions for estimating the volume of oil spilled by the *Bouchard No. 120* tank barge. The Buzzards Bay Project undertook this review because it is of interest to the NRDA Aquatic Injury Technical Work Group, particularly with respect to models that may be employed in assessing injuries caused by the spill. The volume of oil is also of interest to managers who want to better understand the costs and impacts associated with a specific quantity of No. 6 oil, and how those costs compare to other spills. The precise volume of oil spilled by the *Bouchard No. 120* does not directly affect fines or fees imposed by the Commonwealth of Massachusetts.

Overview of the accident and oil spill estimates

The rupture on the bottom of the Bouchard tank-barge *Bouchard No. 120* is reported to have occurred when the vessel struck bottom just north of marker G1 at the entrance of Buzzards Bay, sometime around 3:15 PM on April 27, 2003. This occurred approximately at low tide (see Figure 1). The *Bouchard No. 120* spill resulted from a 12’-by-2’ rupture of the number two starboard tank, which contained roughly 435,000 gallons² of oil, only a portion of which was released.

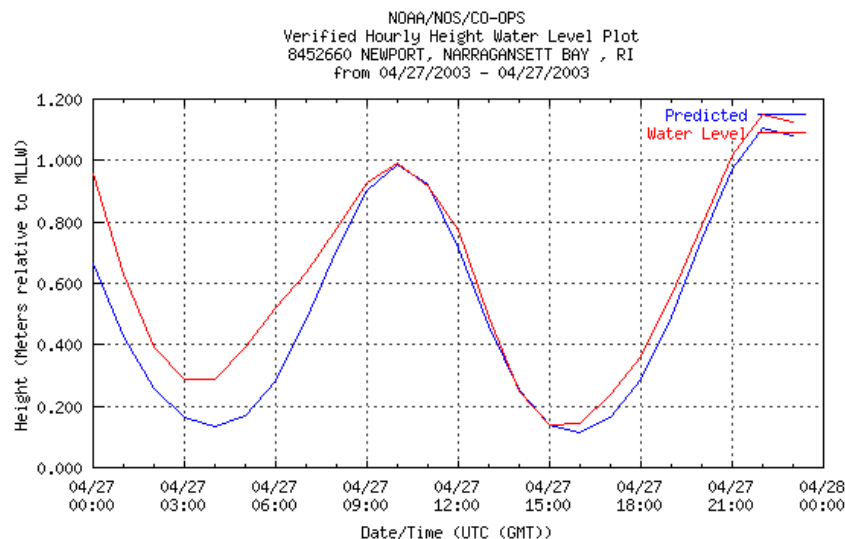


Figure 1. Time of low and high tides in southern Buzzards Bay the day of the accident. (NOAA website data, note that areas in the vicinity of the accident, such as Cuttyhunk Pond are the same time as Newport, and Penikese Island is 15 minutes before, as per Eldridge tables. Heights in meters.)

¹ Because of the varied audience copied for this correspondence, certain terms are explained in more detail either parenthetically, or in footnotes.

² There are 42 gallons in a barrel of oil. Barrels or gallons, or both units are used variably throughout the report to make comparisons to various ullage reports easier.

It has been reported that the operators of the barge towing the *Bouchard No. 120*³, the *Evening Tide*, may have been unaware that the *Bouchard No. 120* struck bottom, and proceeded well into Buzzards Bay at operating speed. The vessel first came to rest at marker BB, 11.5 miles from the accident site around 5:30 P.M.⁴, after radio calls of oil on the water were called in to the Coast Guard. The *Evening Tide* and *Bouchard No. 120* then proceeded to Anchorage Lima, an additional 4.5 miles to the northwest. The positions of the vessel, and approximate times are shown in Figure 2.

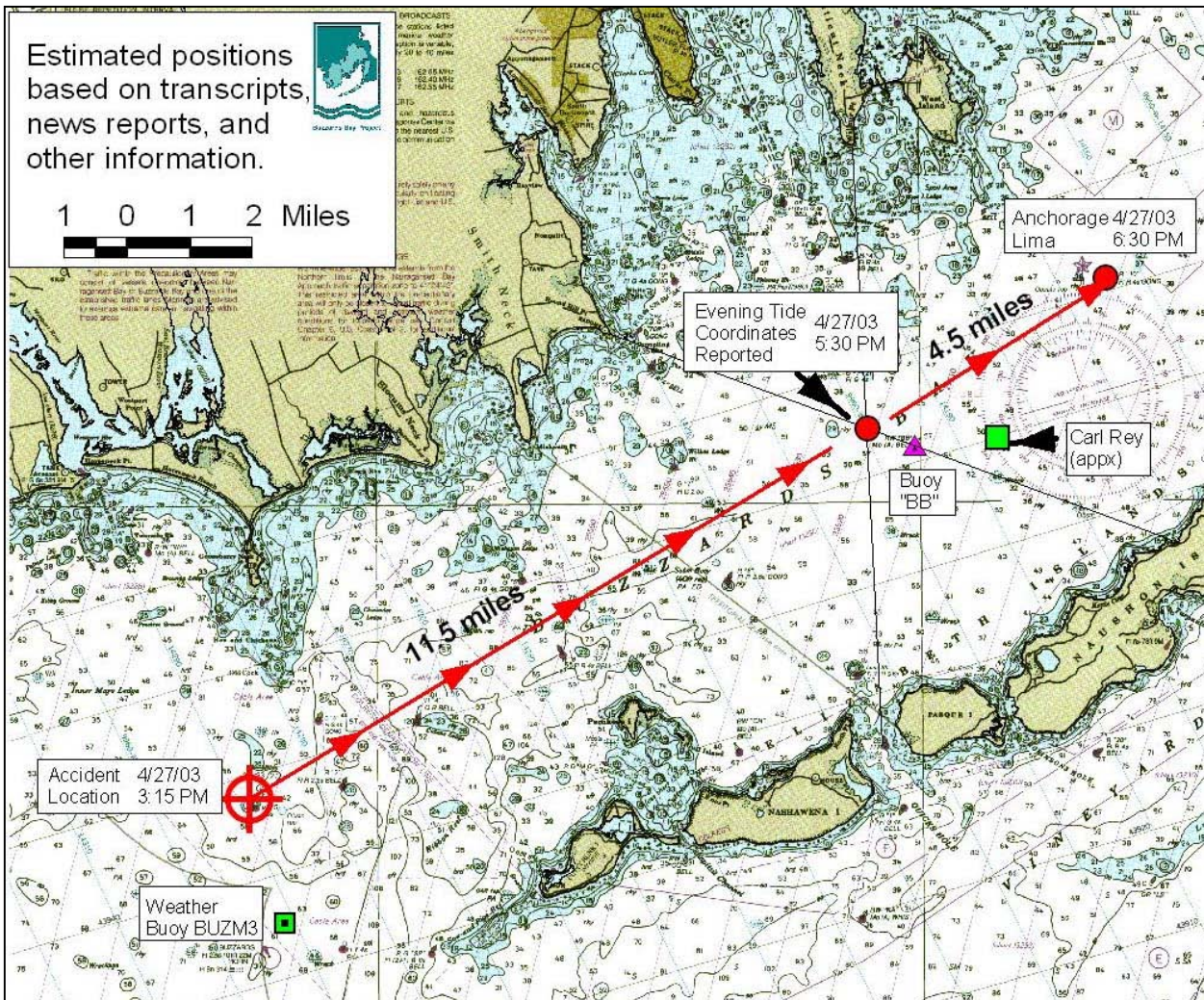


Figure 2. Map from Buzzards Bay website showing approximate positions and times relevant to the accident. The vessel was en route to the Mirant Canal Electric Plant in Sandwich.

Soon after the spill, it was estimated that 14,400 gallons of No. 6 oil was spilled. The basis of this estimate is unclear, but it may have been related to a drop in oil level observed, using a calculation similar to the “hydrostatic” method described in detail below.

³ The tank barge was towed on a 1000 foot cable.

⁴ This is based on published transcripts between the vessel *Carl Rey* and the USCG station Woods Hole Group.

The first definitive estimate of oil spilled from the *Bouchard No. 120*, was based on “Ullage Reports”⁵ prepared by inspectors from the company Caleb Brett, a division of Intertek Testing Services. Caleb Brett is an independent inspection and certification service used to ensure that the sellers, transporters, and buyers of petroleum products have reliable and precise estimates of oil transacted. In May, the Bouchard Transportation Company reported to the Coast Guard that they had estimated that approximately 98,000 gallons of oil was spilled. This estimate was apparently based on the difference in oil volumes calculated by Caleb Brett when the *Bouchard No. 120* was at its last port of call (Eagle Point, Staten Island) on April 24, and measurements taken in Buzzards Bay on April 28, the day after the spill, but before oil was offloaded.

The Bouchard Transportation Company contracted with Hall to evaluate the volume of oil spilled from the *Bouchard No. 120* based on the inspection reports from Caleb Brett, and other information. Hall did this by three lines of evidence. First, he identified potential flaws in the Caleb Brett analysis. Second, he did an evaluation of a minimum theoretical loss based on a “hydrostatic calculation.” Simply put, this is the amount of oil that would be lost as the oil reached nearly the same level as the surrounding sea. Finally, Hall compared what was loaded onto the vessel to what was offloaded at the Mirant power station and the oil water mixture offloaded in Buzzards Bay into another tank barge (the *Bouchard No. 10*), and oil-water mixtures and oil residuals removed from both boats at the Caddell Shipyard in New York. He performed this last analysis using two different sets of assumptions, for two separate estimates (so-called reconciliation methods 1, 2 and a modification of method 2 called reconciliation method 3).

Based on the aforementioned lines of analysis, Hall concluded that the hydrostatic calculation suggested that at the absolute minimum 21,301 gallons were lost. Reconciliation methods 1 and 2 resulted in estimates of 22,323 and 52,146 gallons, respectively. The author concludes the report by stating “the amount of oil lost was certainly not less than 22,000 gallons... [and] that it was most unlikely to have been more than 55,000 gallons.” In the absence of any compelling reason for choosing one method over another, Hall suggests using the mean of these two values, or 39,000 gallons as the amount lost. In the end, Hall concludes “there are bound to be inaccuracies in the measurements at all stages of the movement and transfer of the *B 120*’s cargo and the figure for the quantity of oil lost can never be known exactly.”

While Hall has extensive maritime experience as a marine surveyor, and he even managed Caleb Brett’s technical division from 1982 to 1987, there are some technical errors and confounding factors in his analysis that call into question whether his conclusion that the 98,000 gallon volume based on the Caleb Brett reports “appears to have been a significant over estimate.” In the sections below, we summarize the key elements of the oil spill analysis, and the problems that confound Hall’s analysis.

General note on volumes reported as TOV, GOV, GSV, and TCV

Number 6 oil is shipped heated (typically over 130° F), because this is the only way it can be pumped effectively. Warm oil has a greater volume than oil at ambient water or air temperatures. Oil in ullage reports include “Total Observed Volume” (TOV) which is the volume of the heated oil

⁵ Ullage is an archaic term used for measuring the volume in containers by measuring the headspace, rather than the depth of the liquid.

with any free water, Gross Observed Volume (GOV), which is the heated volume after subtracting out free water, and Gross Standard Volume (GSV) the volume of oil at 60° F (an agreed upon “room temperature”), and Total Calculated Volume (TCV) which is GSV plus free water on the Caleb Brett Ullage Reports.

No. 6 oil is about 2.6% greater in volume at its warmed shipping temperature, than the cooled volume. Given the fact that 4.2 million gallons of heated oil were on board, if heated and cooled oil volumes are mixed in calculations, this can result in misleading results. In his analysis, Hall correctly distinguishes between the measurements, and in this report we focus primarily on GSV volumes as an agreed upon standard for reporting spilled volumes.

In one of the Caleb Brett reports (post delivery reports on the *Bouchard No. 120* and *Bouchard No. 10*), only GOV volumes are provided. However, given the relatively small volume of oil (3,700 barrels), this introduces a relatively small error (tens of barrels), even if the oil was residually warm.

General note on volume of oil on *Bouchard No. 120* and No. 2 starboard tank.

The *Bouchard No. 120* received about 42% of one type of heavier No. 6 oil in New Jersey on April 23, then a lighter No. 6 oil in New York on April 24. The combined total of oil in all tanks (including more than 2000 barrels of oil residuals in the tanks), and tanks 1S on departure from New York were as shown in Table 1 below.

Table 1. Vessel and No. 2 starboard tank oil volumes approaching Buzzards Bay

Entire Vessel	
GOV (heated volume): 98,902.95 barrels	= 4,153,923 gallons
GSV (cooled volume): 95,958.69 barrels	= 4,030,326 gallons
No. 2 starboard Tank	
GOV (heated volume): 10,360.82 barrels	= 435,154 gallons
GSV (cooled volume): 10,051.03 barrels	= 422,143 gallons

Note on the May 2003 reported volume of oil spilled based on first Caleb Brett ullage reports

The firm Caleb Brett measured the volume of oil and water in each tank, the morning of April 28⁶, and the report is apparently signed 12:00 noon, approximately 21 hours after the spill⁷. The Caleb Brett inspector found that the 35-foot 5-inch tall⁸ No. 2 starboard tank had a 19 ft 10 in thick layer of oil on top of a 9 ft 1.2 in thick layer of water. Apparently, as part of emergency measures to minimize the loss of oil, the tank barge operators transferred oil out of the damaged No. 2 starboard to No. 1 starboard tank⁹. No. 1 starboard tank apparently received appreciable amounts of water in

⁶ This measurement occurred at Anchorage Lima in central Buzzards Bay. The time appears to be 12:00 on the Caleb sheet, but the photocopy is difficult to read.

⁷ The time of the accident on 4/27 has not been made public, but in this report is assumed to have been 3:15 PM April 27.

⁸ This height differs by 1 inch more than that used by Hall as explained in item 10.

⁹ Hall states that oil was transferred from Tank1S to 3S. However, the left edge on most of the ullage sheets in Hall’s report from Buzzards Bay and Mirant (e.g. Hall Report Appendix G) have been cut off by a fax machine, and the tank

this process, as suggested by the fact that the Caleb Brett inspector measured a 21 ft 11 inch thick layer of oil on a 5 ft. 8.9 inch thick layer of water in that tank.

Based on these measurements, the volumes in the other tanks, and subtracting out the water volume, the Caleb Brett inspector’s report show that the *Bouchard No. 120* contained these volumes of Number 6 oil (adjusted for water volumes measured) in Buzzards Bay, the day after the spill:

GOV (heated volume): 96,153.48 barrels = 4,038,446 gallons
 GSV (cooled volume): 93,634.26 barrels = 3,932,639 gallons

Using the Caleb Brett pre- and post- accident ullage reports (April 24 and April 28 respectively), it could be easily calculated that the *Bouchard No. 120* lost 115,477 gallons (2,749 barrels) of heated oil, which had a volume of 97,626 gallons (2,324 barrels GSV, or cooled volume). The latter figure appears to be the basis of the estimates the Bouchard Transportation Company reported to the Coast Guard in mid-May. These values are summarized in Table 2.

Table 2. Apparent basis of mid-May reports of volume of oil spilled
Bouchard No. 120 Ullage reports,
 Volumes GSV

	Barrels	Gallons
<i>Bouchard No. 120</i> Volume leaving Eagle Pt	95,958.69	4,030,265
<i>Bouchard No. 120</i> Volume in Buzzards Bay	93,634.26	3,932,639
Apparent Loss	2,324.43	97,626

Loss could be larger than 98,000 gallons.

While the apparent initial loss of nearly 98,000 gallons seemed large, subsequent ullage reports of the *Bouchard No. 10* and *Bouchard No. 120* at Mirant between April 30 and May 3, coupled with actual shore receipts at Mirant, implied a greater volume of oil could have been spilled. For example, Appendix R1 in the Hall report appears to be a May 6, 2003 memo from Caleb Brett to VITOL that calculated the volume of oil potentially lost *after* the initial 98,000 gallon estimated spill. Appendix R1 utilizes ullage reports and delivery information of the *Bouchard No. 120* and *Bouchard No. 10* at the Mirant facility. In these calculations, it appears that Caleb Brett uses as its starting point their volume of oil on the *Bouchard No. 120* in Buzzards Bay, and subtracts from this the volume of oil remaining on board the *Bouchard No. 10* and *Bouchard No. 120* after delivery, and the shore receipts. Using this method (summarized in Table 3), Caleb Brett analysts estimated the volume of additional oil not accounted for after the initial spill was an additional 1,607 barrels, or 67,494 gallons. This report noted that some oil was contained in the slop tanks.

numbers cannot be read. A close inspection of the number on the other sheets show that the numbering is from 1 to 5 port, then 1 to 5 starboard . This is a different order from the ullage reports from New York and New Jersey, which are ordered 1P, 1S, 2P, 2S, etc. It appears the unruptured tank with water is really 1S, but the actual identity of the tank does not affect the discussion here.

Table 3. Summary of Appendix R1 evaluation of potential additional oil loss after first release of oil.

	Barrels	Gallons
<i>Bouchard No. 120</i> Volume in Buzzards Bay	93,634.05	3,932,630
<i>Bouchard No. 120, Bouchard No. 10</i> ROB ex Mirant	-3,777.93	-158,673
Shore Receipts	-88,239.46	-3,706,057
Unaccounted:	1,616.66	67,900

Note: Most or all of this oil was likely contained in the *Bouchard No. 10* slop tanks

A better way to communicate potential losses by all the Caleb Brett Ullage reports is illustrated by the summary in Table 4 below. As shown, taken at face value, the April and early May ullage reports suggested that the loss of oil in Buzzards Bay could have been as great as 168,000 gallons. No doubt, these reports created uncertainty, which may have prompted Bouchard Transportation Company to initiate the review of the data by Hall.

Table 4. Estimates of unaccounted oil based on three sets of ullage reports

a) Anchorage Lima measurements (4/28/03)

	Barrels	Gallons
<i>Bouchard No. 120</i> in BB, May Announcement Basis		
GSV Oil Volume departing Eagle Point	95,958.69	
GSV Oil Volume in <i>Bouchard No. 120</i> 19hr after accident	93,634.26	
Unaccounted oil (presumed spill volume)	2,324.43	97,626

b) Mirant pre- unloading measurements (4/30/03-5/02/03)

GSV Oil Volume departing Eagle Point	95,958.69	
GSV oil <i>Bouchard No. 120</i> and <i>Bouchard No. 10</i> at Mirant, before unloading	92,727.67	
Unaccounted oil (not adjusted for <i>Bouchard No. 10</i> slop tanks)	3,231.02	135,703

c) Mirant post- unloading measurements (to 5/3/03)

GSV oil <i>Bouchard No. 120</i> and <i>Bouchard No. 10</i> at Mirant, ROB after unloading	3,708.30	
Mirant Shore Receipt	88,239.46	
Total	91,947.76	
Unaccounted oil (not adjusted for <i>Bouchard No. 10</i> slop tanks)	4,010.93	168,459

Of course, both calculations b) and c) are overestimates because they do not account for oil in the 3,535 barrels of “slop water” on the *Bouchard No. 10*, nor the smaller residual amount of oil in the water fraction of the ruptured *Bouchard No. 120* tank. The discrepancy between b) in c) are largely the result of mixing ullage report volumes which do not included a VEF correction and the “actual” volume measured on shore.

Hall correctly focuses on estimating oil in the *Bouchard No. 10* slop tanks, but he does this by dismissing or Caleb Brett inspector’s ullage reports in Buzzards Bay and using only measurement at the Caddell shipyards to estimate the volume of oil spilled in Buzzards Bay. In the sections below, the strengths and weaknesses of Hall’s assumptions and approaches, particularly in the Caddell shipyard data, are discussed.

The water content of Mirant delivery was not reconciled.

The one cautionary note Hall offers on his analysis is that he assumes no water was mixed with the oil delivered to Mirant. He states on page 4:

“Also at the time of writing this report we would expect that the oil delivered to Mirant, Sandwich was of a commercially acceptable quality and that it would have contained less than 1 percent water. We have not seen documents to support this but before a consumer will accept No. 6 fuel they normally require that the water content should not exceed 1 percent. We anticipate that tests to establish this fact were made. In the circumstances we would expect that these tests were given more attention than usual! If additional ITS/Caleb Brett documents detailing analysis of samples taken at Mirant, Sandwich later indicate that the water content of the material discharged to Mirant, Sandwich was actually in excess of 1% then it might possibly affect the conclusions in this report.”

This cautionary note is appropriate, because Mirant received 3.6 million gallons of oil. Thus, if only 1% of this delivery consisted of water, an additional 36,000 gallons of oil would be presumed spilled. The Coast Guard should obtain these records from Mirant.

The hydrostatic calculation has limited utility in predicting lower bounds of spilled volume

The hydrostatic calculation was meant to show the absolute minimum amount that must have been spilt based on the head difference between the oil level in the tank, and the water level outside the vessel. For the purposes of this calculation, Hall assumed that the oil had approximately the same density (specific gravity) of seawater, which for the purposes of this exercise, was an adequate assumption.

The basis of the calculation was that the oil level in starboard tank 2 was 15.75 inches higher than sea level, and that as the oil level dropped to sea level. This drop equaled 21,301 gallons (507 barrels). There are a couple of minor technical errors in Hall’s calculation, and a couple of larger conceptual ones.

With respect to the minor technical errors, Hall gives the height of the tank as 424 inches. Actually, this is the difference in the gauge level of the *Bouchard No. 120* before it took on any oil. At the start of the trip, Tank 2 starboard contained 29 barrels of oil, which, based on the oil to inch calculations in the first load, equals 0.91 inches of oil in the compartment. Thus the tank height (inner diameter) was actually 424.91 inches, or the oil was really 322.65 inches above the bottom of the tank. However, the tank likely has a thickness of at least .625 inches (5/8”). Thus, the oil was really at 323.3 inches above the bottom of the vessel. Given the reported draft of the vessel as 306 inches, the height of the oil in the tank was actually only 17.3 inches above the water line.

Hall then gives a barrels-per-inch conversion of 32.20 for the starboard tank. This is actually the approximate barrels per inch value for complete volume and height of oil in the tank. If one examines the barrels per inch rate between the first load and the second load of oil, for some of the tanks it is quite different (for example the number 1 tanks). This is probably due to slightly sloping sides at the bottom of some tanks. The actual barrels per inch for number 2 starboard tank for the upper tank was 32.34. This revised hydrostatic calculation is thus:

32.34 bbls per in x 17.3 inches = 559.4 barrels or 23,500 gallons.

While the exercise above shows only a modest increase over Hall’s estimate of 21,301 gallons, it illustrates a larger problem. This calculation is based on a mere 17-inch difference between oil level in the tank, and the surrounding ocean. This calculation would have meaning if the vessel were completely stationary with no seas. That is to say, if an opening were made on the bottom of the tank, the oil exited the vessel then stopped when it reached nearly the same level of water outside the hull. Under these idealized conditions, no water would enter the vessel. This led Hall to conclude:

“The initial spill would have consisted of the oil in 2 starboard , that resided above the water line of the barge at the time the tank was breached. A further quantity of oil might have leaked from the damaged location until such time as a temporary repair was made.... It seems likely therefore that the total quantity of oil spilled, on the basis of the hydrostatic condition of the 2 starboard tank, was 21,000 gallons plus some fractional percentage of this amount.”

In actuality, the *Bouchard No. 120* was not stationary. The vessel was likely traveling at 10 knots when the accident occurred, and was reported to have continued at the speed until approaching Buoy BB, 11.5 miles into Buzzards Bay. Average wave heights recorded on April 27 at 3:00 PM at NOAA’s Buzzards Bay Buoy (BUZM3) were 4.7 feet (see Figure 3). The shear and laminar forces across the bottom of the vessel across this opening would have been substantial while the vessel was moving at 10 knots. Swirling currents and eddies from this flow could have swept out large volumes of oil, not just a “fractional percentage” of the calculated 21,000 gallons.

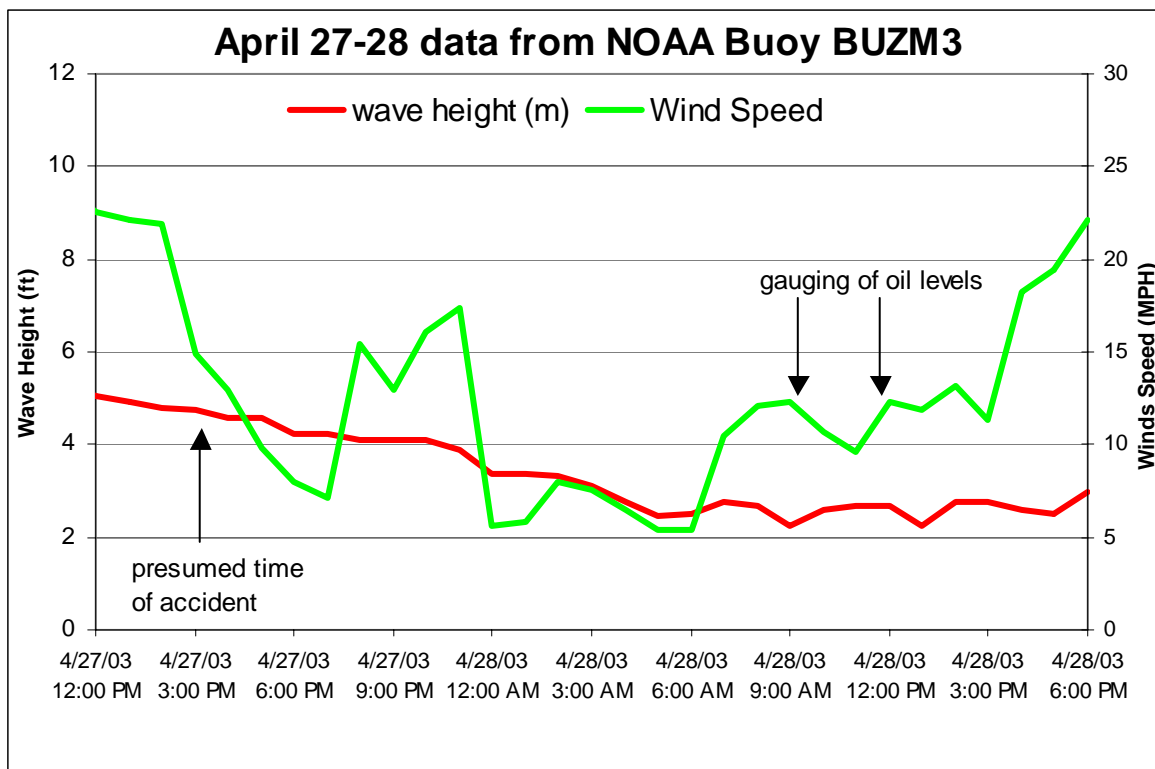


Figure 3. Wind speed and wave height at NOAA weather buoy BUZM3, near the entrance of Buzzards Bay and the accident site. Note that wave height could have been appreciably less in central Buzzards Bay at Anchorage Lima, the morning after the spill, when inspectors were on board. See locations in Figure 2 and Figure 4.

The fact that oil appeared to be released well into Buzzards Bay, perhaps 10 miles, is supported by the report of another tugboat operator approaching Buoy BB, as contained in transcripts released by the USCG Woods Hole Group. Another indication that the hydrostatic calculation has little relevance is the fact that so much water was observed in two tanks in the vessel, a far larger quantity of water than the replacement volume of oil transferred out of tank 2 starboard¹⁰.

The author acknowledges that he does not have the engineering or fluid dynamics expertise to evaluate the loss from the vessel while it traveled over 15 miles in Buzzards Bay to Anchorage Lima when he states: “The writer’s practical experience in handling and measuring heavy oil has more often been in non spill situations such as measuring slop oil resulting from tank cleaning, or when oil has become contaminated with water from leaking steam heating coils.” Given this acknowledgement, the statements that most of the oil would have been lost in the first half hour¹¹ (why not 10 minutes?), or that only a fractional amount was released over the hydrostatic volume seem problematic, and appear to have no basis. In a note in Appendix B, the author recognizes some of these issues, and even suggests some heavier oil may have sank, but no consideration seems to be given to the effect of a 10 knot force across the opening over 5 to 10 miles.

Water volumes and total volumes of the vessel seem to contradict the hydrostatic assumption. To minimize oil loss, the transporters pumped oil out of the ruptured tank (2S) and into tank 1S¹². As oil was transported out of 2S, seawater flooded the tank from below. When the Caleb Brett inspector measured oil and water depths the next day, the total volume of liquid on the tanker increased by 2,300 barrels (96,600 gallons GOV). Presumably, this volume can be assumed accurate because there is less uncertainty about the air/water interface gauge level measurements than the oil/water interface gauge levels. Altogether, Caleb Brett observed 5,056 barrels of water on the damaged vessel. If the hydrostatic loss was 507 barrels, at a minimum, 2,807 barrels of measured water, really had to be water. For the hydrostatic calculation to work, all the remaining observed water had to be really oil, which can be the case only if Caleb Brett’s measurements in Buzzards Bay were grossly in error.

The Caleb Brett calculations were too easily dismissed.

ITS-Caleb Brett is one of the leading independent petroleum cargo inspection companies. Hall too easily dismisses the ullage report calculations made by the firm Caleb Brett while the *Bouchard No. 120* was anchored in central Buzzards Bay, and does not even consider the consistency of the subsequent measurements made at the Mirant facility docks in the Cape Cod Canal. In contrast, Hall uses and accepts the Caleb Brett ullage reports in other situations, such as on the *Jay Bee VI* tanks at the Caddell shipyards. Key to Hall’s argument is the presumption that Caleb Brett incorrectly identified the oil water interface, or that the water contained “significant” amounts of oil, or that weather

¹⁰ After the accident, Number 2 starboard tank contained 3475 barrels (TOV) of oil according to Caleb Brett estimates, before the accident, it contained 10,361 barrels (TOV).

¹¹ If the vessel continued at 10 knots, oil would have been released over a distance of 5 miles during this period.

¹² In Hall’s report, he states the oil in the ruptured tank was transferred to tank 3S. Unfortunately, the copies of ullage report sheets often have the columns cut off that indicate tank number. Based on the order of tanks where this column was not cut off, it appears that Tank 1S received water from the ruptured tank, and this tank is used in this report. Whatever tank number is on the sheet does not affect the calculations because the volumes on the visible columns were used in the calculations in this report.

conditions were adverse for measuring oil levels, or that listing of the vessel was not accurately accounted for.

While it is true that the oil had a specific gravity close to seawater, it did float. This No. 6 oil was not observed to form a mousse with water, and oil globules were observed to coalesce into a single layer after a few hours in the water and oil samples collected by the Buzzards Bay Project the day after the spill. The tanker was anchored at Anchorage Lima for at least 19 to 21 hours when the Caleb Brett measurements were made, which would have provided some time for an oil-water boundary to form.

Hall notes, “It is difficult to detect water in the type of oil that was being carried on the *Bouchard No. 120*, especially when the cargo has cooled; similarly it is difficult to detect the oil in the cold water that has come into contact with cargo.” Elsewhere in the report, he states “It should be noted that the methods that cargo inspectors use to measure heavy fuel oil cargoes become less accurate when there is a lot of water present in the material. In addition, when the temperature of the oil becomes low, water is especially difficult to detect with water finding paste or electronic water/oil interface detectors.” But Hall does not indicate which method or whether Caleb Brett used both methods before discounting the methods out of hand.

On the issue of cooling, the oil leaving New York was at 140° F in tank 1 starboard and tank 2 starboard . The oil would have been kept warm by the heating coils up until the accident in Buzzards Bay, which ruptured the heating coils in the tank 2 starboard . Most of the other tanks appear to be still heated after the accident. Presumably, the heating coils kept the oil heated to at least 130 degrees up to or just after the accident based on Caleb Brett’s assessment after the accident in Buzzards Bay and the typical transport temperature for this oil.¹³ After the heating coils are turned off, this volume of oil has tremendous heat capacity, even when exposed to 44 degree Buzzards Bay water.¹⁴ This was demonstrated by the fact that when the *Bouchard No.120* was again sampled at the Mirant Power station 72 hours after the accident, the oil in tank 1 Starboard , which received 66,000 gallons of cold Buzzards Bay water was still at 99° F, and ruptured tank 2 starboard was at 60° F. Most of the other tanks were still warm, generally ranging between 100 and 121° F.

If both tanks started at 130° F at the time of the accident, if the first Caleb Brett measurements were completed 21 hours after the accident, and if the temperature drop were linear, then the oil might have been 111° F in tank 2 starboard and 121° F in tank 1 starboard ¹⁵ at the time of the completion of the ullage report at Anchorage Lima. Of course, the temperatures of the oil were probably not consistent throughout the oil, but this illustrates that the oil may not have been quite so cool when Caleb Brett made the measurements as suggested by Hall. The oil in the eight unaffected tanks was certainly warm as shown by their high temperatures three days later.

¹³ Actually, Caleb Brett uses 130° F as the temperature for all the tanks. More likely, this was either the typical transport temperature, or the temperature of just one of the tanks, applied to the ullage spreadsheet or software program.

¹⁴ NOAA Buoy BUZZM3 records Buzzards Bay water temperature at noon on April 27 as 6.5 ° C.

¹⁵ 130 - temperature change x 20/72.

Fundamentally, Hall dismisses Caleb Brett’s measurements of 9’ 8” and 5’ 9” depths of water in the 2S and 1S *Bouchard No. 120* tanks by asserting that “the barge was possibly moving in a sea and swell and was not on an even keel.” In fact, the 375 foot-long tank-barge was anchored in Buzzards Bay for 19 to 21 hours when the measurements were made. Weather Buoy (BuzzM3) shows light seas the morning of April 28, the time of the Caleb Brett measurements. At NOAA weather buoy BUZM3, 15 miles to the southwest at the entrance to Buzzards Bay, wind speed averaged 10 –12 miles per hour, with a wind bearing 261 degrees (slight south of West), and wave heights averaged 2 to 3 feet (see Figure 3). With a westerly wind, wave heights in central Buzzards Bay would have certainly been less than at the weather buoy at the mouth of the bay. In fact, aerial photographs of the barge the morning after the accident (on April 28, when oil levels were being gauged) show fairly calm seas. (Figure 4.)



Figure 4. The B. No. 120 at 7:18 AM April 28, 2004, the morning of oil level measurements, in relatively calm seas.

It is true that the Caleb Brett report did not list the Trim-List corrected ullage. The Caleb report shows the maximum list on the maximum trim and list was nearly a 4-foot difference between forward starboard and aft port. However, this was a 4-foot drop across a 376 foot long vessel, or a 2 foot drop across the width of a 76-foot wide vessel, slopes of the vessel were less than a degree and a degree and a half respectively. This would have introduced errors on the order of inches in sealed tanks, not the many feet needed to agree with Hall’s other calculation methods. Because the trim and list is presented, the ullage report could also easily be corrected by entering the information into the spreadsheet.

The fact that sea conditions or list and trim values did not have much effect on Caleb Brett’s measurements in central Buzzards Bay is demonstrated by comparing Caleb Brett’s ullage report for the *Bouchard No. 120* in Buzzards Bay to the ullage reports at the Mirant Dock before it offloaded oil.

As shown in Table 5 below, there is good consistency¹⁶ between Caleb Brett’s estimates of total oil volume on the *Bouchard No. 120* in Buzzards Bay and the sum of the *Bouchard No. 120* and *Bouchard No. 10* on arrival at the Mirant facility two days later. In fact, the difference was only 1%.

Table 5. Comparison between total oil volume of the *Bouchard No. 120* in Buzzards Bay versus the *Bouchard No. 120* and *Bouchard No. 10* arriving at Mirant days later. Note that discrepancy appears to equal apparent transfer to slop tanks suggested by Table 6.

Gauged Oil Levels	Oil GSV barrels	Oil GSV gallons
<i>Bouchard No. 120</i> in BB after spill	93,634.3	3,932,639
<i>Bouchard No. 120</i> at Mirant	85,818.8	3,604,390
<i>Bouchard No. 10</i> at Mirant	6,908.9	290,173
Total	92,727.7	3,894,562
Discrepancy	906.6	38,077
Discrepancy as percent	1.0%	

The 1% “discrepancy” in this case is the apparent additional loss of oil during transit of the damaged *Bouchard No. 10* from Buoy 10 to the Mirant station, not the volume of oil spilled. In reality, there was likely negligible additional loss of oil from the ruptured No. 2 starboard tank because nearly all the remaining oil was pumped out into the *Bouchard No. 10*. Rather this discrepancy is likely accounted for by oil transferred with water to two “slop tanks” on the *Bouchard No. 10*. These two tanks (3P and 5S) together contained 3,535 barrels of water with oil mixed in. In fact, the 906-barrel discrepancy can be fully explained by 919-barrel losses of oil in the two tanks pumped by the *Bouchard No. 10* (see section below), showing remarkable consistency of the initial Caleb Brett measurements in central Buzzards Bay.

The consistency of Caleb Brett measurements between the supposedly adverse conditions in Buzzards Bay and measurements at the Mirant dock are even more remarkable when the volumes of the individual tanks are examined, as shown in Table 6. Tanks that did not have transfers or offloads often differed by less than a few tenths of 1%.

Some of the larger percent differences in Table 6 probably represent transfer among tanks to keep the tank barge on a level keel. The transfers of oil among tanks are especially apparent when the volumes in each tank are compared to departure volumes at Eagle Point (not shown). However, once these transfers were made and Caleb Brett detected the large volumes of water in two tanks after the accident, it appears they stopped transfers of oil from these two tanks to the other tanks, possibly to prevent water from entering other tanks. In fact, when the two tanks with water are removed from the calculation, the volume of oil measured on the *Bouchard No. 120* in the remaining

¹⁶ There may have been some minor additional losses from the *Bouchard No. 120* after it was gauged 20 hours after the accident and when it arrived at the Mirant station days later.

tanks while anchored in Buzzards Bay is within two-hundredths of one percent of the volume of oil measured in those same tanks while the vessel was docked at Mirant (Table 6, last row).

Table 6. Volumes of oil in the *Bouchard No. 120* after the accident, and after transfers to the *Bouchard No. 10*.

Tank No.	After accident in Buzz Bay	Barrels After accident at Mirant	Comments	minimum oil to slop tanks (Barrels)
1P	9,043.25	9,153.57		1.22%
2P	10,116.85	10,141.45		0.24%
3P	11,272.98	11,290.77		0.16%
4P	7,464.08	7,835.20		4.97%
5P	9,701.69	9,782.82		0.84%
1S (received water)	7,921.01	7,309.85	water removed with some oil	611.16
2S (ruptured)	7,474.09	258.01	oil removed with some water	308.00
3S	10,730.23	10,177.24		-5.15%
4S	10,055.14	10,050.61		-0.05%
5S	9,854.73	9,819.08		-0.36%
Totals	93,634.05	85,818.60		919.16
Totals without 1S, 2S	78,238.95	78,250.74		0.02%

Taken together, these measurements and observations appear to contradict Hall’s statement that “The volumes calculated by ITS/Caleb Brett, taken before the transfer to the *Bouchard No. 10* at Buzzards Bay, were almost certainly not as accurate as those taken later at Mirant, Sandwich.”

***Bouchard No. 10* volumes matched volumes in serviced *Bouchard No. 120* tanks.**

Other evidence of consistency with the Caleb Brett measurements in central Buzzards Bay is found in comparisons between the contents of the *Bouchard No. 10* and the *Bouchard No. 120*. When the *Bouchard No. 10* serviced the damaged *Bouchard No. 120* in Buzzards Bay the day after the spill, it had two main objectives. The first objective was to offload the remaining oil in the damaged No. 2 starboard tank of the *Bouchard No. 120*. The second objective was to remove the water inadvertently pumped into No. 1 starboard Tank.

With respect to the removal of oil from the damaged No. 2 starboard tank, Caleb Brett’s inspectors calculated that the *Bouchard No. 120* 2S tank had 7,474 barrels of oil (GSV) after the accident, but before the *Bouchard No. 10* arrived. This tank had only 258 barrels of oil remaining after withdrawals by the *Bouchard No. 10*¹⁷. Thus, there was an apparent net removal of 7,216 barrels by the *Bouchard No. 10*. In fact, Caleb Brett ullage sheets for the *Bouchard No. 10*, when it arrived at the Mirant facility showed that it had collected 6,908 barrels from the *Bouchard No. 120*. The “miss-

¹⁷ See Appendix H in Hall report, for the ullage report when the *Bouchard No. 120* it arrived at Mirant on April 30. This assumes that there were no other internal transfers from this tank between the noon measurements by the Caleb Brett inspector and transfers to the *Bouchard No. 10* that began later that day.

ing” 308 barrels (Table 6) were likely discharged into one of the two slop water tanks. That is, as the oil was removed from the damaged *Bouchard No. 120* tank, the layer of oil floating on water became increasingly thin. At some point, flow was likely diverted into one of the slop tanks to prevent contamination of the offloaded cargo with water. Alternative movements of oil and water could have occurred on the *Bouchard No. 10* to explain these volumes, but the volume of oil on the *Bouchard No. 10* essentially matches the volume of oil remaining in the damaged *Bouchard No. 120* tank.

The other objective of the *Bouchard No. 10* was to remove the water transferred to the undamaged *Bouchard No. 120* tank (No. 1 starboard). This tank contained 1,581 barrels of water. This water was obviously pumped into one or both of the two *Bouchard No. 10* tanks containing slop water. The Caleb Brett inspector determined that one of these tanks with oily slop water (*Bouchard No. 10*, tank 3P) contained 1,844 barrels of oily water, the other (*Bouchard No. 10*, tank 5S) contained 1,691 barrels of oily slop water. It seems likely that the water at the bottom of the *Bouchard No. 120* 1S tank accounts for most of the contents of at least one of these two slop tanks on the *Bouchard No. 10*.

In the process of sucking out water at the base of *Bouchard No. 120* tank 1S, some oil was likely withdrawn as well (Hall Report Appendix G versus Appendix H). In fact, the Caleb Brett reports suggest, and *Bouchard No. 120* tank 1S appears to have lost 611 barrels after lightering by the *Bouchard No. 10* (Table 6). It is assumed there were no transfers out of *Bouchard No. 120* Tank 1S after the *Bouchard No. 10* pumped out the water. The volume of the water in the tank plus missing oil ($1581+611=2192$ barrels) does exceed the volume of either slop tank, but this likely reflects some balancing of volumes or diversion of flow while the *Bouchard No. 120* was pumped.

In the preceding discussion, it is assumed that oil in *Bouchard No. 120* tanks 1S and 2S was not transferred to any other *Bouchard No. 120* tanks after determination they contained substantial amounts of water. This would have been a reasonable action to prevent water contamination of the other oil containing tanks. If accurate, these calculations give a good minimum estimate of oil transferred to the slop tanks from *Bouchard No. 120* tanks 1S and 2S. That is to say, if the *Bouchard No. 10* withdrew only the water at the bottom of Tank 1S (with some oil) and withdrew the oil at the top of Tank 2S (with some water), any oil missing from those two tanks, and not ending up in the oil containing tanks must reside in the *Bouchard No. 10* slop tanks.

In fact, the 919 barrels missing from tanks 1S and 2S nearly precisely matches the 906 barrel decline observed between the total volume of oil in the *Bouchard No. 120* in Buzzards Bay, and the *Bouchard No. 120* and *Bouchard No. 10* arriving at Mirant as shown in Table 5. This strongly suggests that actual oil volume of the *Bouchard No. 10* slop water tanks 3P and 5S must have contained this minimum of 919 barrels of oil. Therefore, 26% of the 3,535 barrels of slop oil water mixture on the *Bouchard No. 10* was oil.

Total water and oil volumes may contradict Hall’s conclusions

Hall argues that the Caleb Brett inspector’s measurements in Buzzards Bay are unreliable, and he does not evaluate the *Bouchard No. 120* and *Bouchard No. 10* volumes on arrival to Mirant. His conclusion would suggest that considerably more of the 3,535 barrels in the *Bouchard No. 10* slop

tanks was oil, or that appreciable volumes remained in the water fraction of the ruptured *Bouchard No. 120* tank¹⁸. There are some important implications to this line of reasoning when one considers the total volume of liquid on the *Bouchard No. 120* when it was anchored in Buzzards Bay. For example, the total volume of liquid on the *Bouchard No. 120* after the accident increased in volume by 2,300 barrels (GOV). This occurred because as oil was pumped out of Tank 2S and placed into Tank 1S, water was filling in the tank from the hole below. This total liquid volume can be presumed to be accurate because there is less uncertainty about the air/water interface gauge levels than the oil/water interface gauge levels. By definition, this increase was the amount of water that had flooded the vessel. Thus, at least 2,300 barrels of the 5,056 barrels that Caleb Brett calculated on board the *Bouchard No. 10* was definitely water. The hydrostatic loss was another 507 barrels, so at a minimum 2,807 barrels of water must have been on board the vessel in the calculations made by the Caleb Brett inspector. For the hydrostatic calculation to work, all the remaining “water” had to be oil. In other words, 44% of the volume of “water” calculated by Caleb Brett had to be oil while the *Bouchard No. 120* sat anchored in Buzzards Bay, and that the inspectors misjudged the depth of water in the two tanks by nearly half.

On this topic, Hall suggests some form of miscalculation in the Caleb Brett report when he states: “The figures in Bouchard Transportation Company’s “overestimate” [the 98,000 gallons] apparently did not take account of the fact that tanks 2 starboard and 3 starboard [sic¹⁹] on the B 120 contained 5,056.52 bbls of ‘water.’ The oil recovered at Caddell explains the cause of the inadvertent over estimate of the amount of the spill referred to above.” Actually, Caleb Brett did appear to accurately account for the water in the vessel, and the meaning of this statement is unclear. However, Hall correctly notes that the amount of oil in the fractions and slop tanks must be accounted for.

Total volume of liquids on the *Bouchard No. 10* and *Bouchard No. 120* after lightering support the Caleb Brett calculations before lightering

When all the Caleb Brett measurements at the Mirant facility are combined, the amount of oil that appears to be spilled in Buzzards Bay is remarkably consistent with the initial estimate of 97,600 gallons lost when calculated using the difference in volumes measured on the *Bouchard No. 120* in New York and in Buzzards Bay before the *Bouchard No. 10* offloaded oil (Table 1). When the combined volume of oil on the *Bouchard No. 120* and *Bouchard No. 10* at Mirant (before offloaded to the power plant), is compared to the volume of oil on departure from New York, it appears the the barge spilled 97,105 gallons of oil. These calculations are summarized in Table 7 below.

In Table 7, the amount of oil in the two slop tanks (919 barrels) was based on the calculations and measurements of the apparent reduction of oil in the two tanks pumped out by the *Bouchard No. 10* as described in the previous section. The reason why the two estimates are so remarkably similar is that the total volumes of oil measured on the *Bouchard No. 120* and *Bouchard No. 10* measured at

¹⁸ The *Bouchard No. 120* tank 2S was open to the sea throughout its journey to Mirant, and for many days later when the vessel was patched. Weeks later, when leaving the Mirant station, and traveling down the Canal, the patch failed. After the *Bouchard No. 10* removed most of the oil from the tank on April 28, and during the patch failure, the Coast Guard stated in press reports that no additional loss of oil was observed. These observations appear to contradict the idea that sizeable amounts of oil remained in the water fraction of *Bouchard No. 120* tank 2S

¹⁹ Refer to footnote 9.

the Mirant facility on April 30 and May 1 respectively, are nearly identical and consistent with to the total amount of oil measured on the *Bouchard No. 120* in Buzzards Bay on April 28.

Table 7. Estimate of oil loss based on Caleb Brett ullage reports

	Barrels	Gallons
Volume departing Eagle Point	95,958.7	4,030,265
<i>Bouchard No. 120</i> Delivered Mirant	82,304.2	3,456,776
<i>Bouchard No. 10</i> Delivered Mirant	6,645.6	279,114
ROB <i>Bouchard No. 120</i> post Mirant*	3,514.6	147,614
ROB <i>Bouchard No. 10</i> post Mirant	263.3	11,059
<i>Bouchard No. 120</i> tank 2S oil loss to slop tank	308.0	12,936
<i>Bouchard No. 120</i> tank 1S oil loss to slop tank	611.0	25,662
Total=	93,646.7	3,933,160
Difference (presumed spilled)=	2,312.0	97,105

*The *Bouchard No. 120* ROB volume is GOV, not GSV, so this might be a slight overestimate.

Actual VEF differed slightly.

Hall correctly asserts that the actual volume of oil spilled should be adjusted for the vessel experience factor (VEF). The VEF is a minor adjustment between the volume the tank-barge operator believes he has on board based on depth gauges and ullage tables, and the actual volume measured in tanks or pumps at the receiving facility. The VEF is used by Hall in his Reconciliation Method 3. Hall states that the VEF for the *Bouchard No. 120* was given as 1.0047, or a typical error of less than one half of one percent. That is, there is one-half of one percent less oil on board the *Bouchard No. 120* than the ullage reports indicate. Presumably, the VEF corrects for residual oil stuck to the walls of tanks during offload, and other factors. There are actually two VEFs for a vessel, one for discharge (VDF), and one for loading of oil (VLF).

There is validity in considering a VEF, and it should be applied to estimates of volume spilled, like those in Table 7 above. For example, the “real” volume spilled in Table 7 is actually 96,650 gallons. However, there are two confounding issues in applying the VEF as Hall as done. Because of the large volumes of oil involved, a tiny difference in the VEF can appreciably alter the volumes. In fact, a comparison of the reported shore receipts to actual ullage reports shows that in this case, *Bouchard No. 120*, the VEF at discharge²⁰ was 1.0037 (Table 8). Though the discrepancy from Hall’s suggested factor is small, it still suggests the shipment contained an additional 95.2 barrels, or nearly 4,000 more gallons of oil would need to be added to the estimate of oil spilled. Note that the VEF for the *Bouchard No. 10* in Table 8 is considerably larger. Thus, the actual volume of oil spilled in Buzzards Bay based on the calculations in Table 7 is 96,747 gallons.

²⁰ VEF at discharge is also called the VDF. The vessel’s reported VEF is the weighted average of at least five shipments.

Table 8. VEF based on comparison of oil delivered versus oil received

Volumes GSV delivered to Mirant facility	from ullage	shore receipts*	Actual
<i>Bouchard No. 120</i>	82,304.18	81,998.06	1.0037
<i>Bouchard No. 10</i>	6,645.34	6,241.40	1.0647
Total	88,949.52	88,239.46	1.0080

* These values were not adjusted for water content

To some degree, a VEF correction accounts for the oil stuck to the sides of tanks (clingage), and various pipes, and interstices. Thus, if the *Bouchard No. 120* were to receive more than 4,000,000 gallons of oil in clean tanks, 14,800 gallons less may be discharged. If a VEF is used, some care must be used when comparing the volume of oil collected in a hot water wash cleaning, as occurred at the shipyards, because much of the oil collected on the walls and in the plumbing may have been already subtracted in the VEF calculation. That is, this clingage is likely present before and after receipt delivery of oils. Hall states “the clingage would be considerable on the B 120 as she was permanently in heavy oil service...” This is especially relevant because no shore tank calculations were made as to what the *Bouchard No. 120* contained before it entered Buzzards Bay.

Caddell Shipyard discrepancies in oil volumes recovered are not adequately addressed.

Except for the hydrostatic method, all of Hall’s estimates of oil spilled in Buzzards Bay include the estimated volume of oil collected when the *Bouchard No. 10* and *Bouchard No. 120* were hot water washed at the Caddell Dry Dock and Repair Co. shipyards. In Caddell’s May 23 letter to Bouchard they state “As accurately as we can tell, Caddell has received 3593 BBls of oil from the T/B No. 10 and 3515 BBls of oil from the T/B No. 120 for a total of 7108 BBls. The figures for the B. No. 10 were gauged from our barge Jay Bee VI, and the B. No. 120’s figures are taken directly from the barge and confirmed by Caddell’s...” Remarkably, the total quoted by Caddell for *Bouchard No. 120* oil content is precisely the GOV (heated) total volume of oil from Caleb Brett when the *Bouchard No. 120* left the Mirant Station. It does not include any assumed oil mixed in the water of tank 2S.

More importantly, the Caddell shipyard letter suggests that the *Jay Bee VI* contained only the contents of the *Bouchard No. 10*. When the *Bouchard No. 10* left Mirant, its cargo was 263.31 barrels of oil²¹, and 3,535 barrels of oil²² and water mix in two slop tanks, for a total of 3,797 gallons. This is nearly the same volume of “oil” that Caddell stated it received from the *Bouchard No. 10*.

Hall correctly concluded that the Caddell letter could not be accurate because it implies no oil was spilled in Buzzards Bay and more oil was collected than shipped as illustrated by the calculations in Table 9. Hall believed that the water was not accurately accounted for in the oil fractions.

²¹ GOV appendix K1, but presumed to be at a temperature equal to GSV, since temperature of the oil was roughly 80° F, see Hall Appendix K2

²² Hall Appendix K3 suggests that the volume of the slop tanks increased to 3,555 barrels after offloading oil at Mirant.

Table 9. Accounting of volume spilled based on Caddell correspondence.

	Barrels	gallons
Volume departing Eagle Point	95,958.7	4,030,265
<i>Bouchard No. 120</i> Delivered Mirant	82,304.2	3,456,776
<i>Bouchard No. 10</i> Delivered Mirant	6,645.6	279,114
oil to Caddell shipyard	7,108.0	298,536
Total	96,057.7	4,034,425
difference (negative=gain of oil)	-99.0	-4,160

Hall affirms that the Caddell summary letter is roughly correct, but shows an ullage report dated May 28, which showed the *Jay Bee* contained 6,998 gallons of oil and 807 barrels of water (Hall Report, Appendix Q). This report is problematic because the amount of oil recovered on the *Jay Bee VI* is greater than the entire volume delivered by the *Bouchard No. 10*. That is, there were 2,747 barrels (115,000 gallons) more of oil found on the *Bouchard No. 10* than the entire volume of liquid found on board the *Bouchard No. 10* when it left Buzzards Bay (Table 10 below).

Table 10. Volume of the *Bouchard No. 10* versus the volume of the *Jay Bee VI*

Barrels	GSV oil	slop water	total
<i>Bouchard No. 10</i> after Mirant	261.5	3535.1	3796.6
<i>Jay Bee VI</i>	7804.8	807.1	8611.9

Hall believes the likely explanation for the increase in volume was that the *Jay Bee VI* must have received additional oil and water from either the *Bouchard No. 120* or Caddell shore tanks in the five days after Caddell's May 23 letter (Hall, personal communication). Documentation or confirmation of these transfers should be provided by Caddell.

Because the Caddell shipyard still appeared to receive more oil that would be possible for even the hydrostatic method after adjusting for oil and water levels in the tank, Hall requested an analysis of the water content in the *Jay Bee VI* tanks and shore tanks to document how much water was in the oil fractions (Hall Report, Appendix Q). In fact, water and sediments in the "oil" layer of the various tanks ranged from 6.5 to 69.5% of the oil fraction among the tanks, with a weighted average of 30%. That is to say, on average, only 70% of the layer of "oil" in these tanks was really oil, the rest was water and sediments.

The percent water and sediments content in each tank has an appreciable effect on Hall's calculations of the total oil volume collected at Caddell. However, only single samples appear to have been taken from the tanks, with no replication. It is unclear if the sample was taken from the bottom, top, or middle of the oil layer in the tanks. Since water mixed in this heavy, viscous oil tends to separate, there is no reason to believe the water content of the oil layers was identical at all depths of the oil. Given the high variability in water and sediments among the tanks, errors in average total water content in each tank can profoundly affect the conclusions.

Another subtlety of the data in Appendix Q is that fact that water and sediments are combined in the assay. Before the *Bouchard No. 120* received its first volume of No. 6 oil in New Jersey, each tank contained 1 to several inches of oil, for a total volume of nearly 35,000 gallons. In a working vessel, this bottom layer may accumulate oily sediments. These oily sediments were part of the starting volume in Hall's calculations. However, in Hall's spill volume calculations, these oily sediments are treated the same as the water volume, and subtracted out of the total.

The potential importance that oily sediments may have on the calculations is illustrated in Appendix P1-3, the original data report for these water-sediment assays. Interestingly, only one of the ten different tanks tested was evaluated only for water content (method D95). All the others were tested for sediments and water combined (method D1796). The single tank tested for water had a water content of only 6.5%, the lowest correction factor. All the remaining tanks were tested for sediment and water combined, and ranged from 15.0 to 69.5 percent. Because water from Buzzards Bay entered the *Bouchard No. 120*, not sediments, the sediments should not be subtracted out of the calculation. To illustrate the importance of the percent water calculation, if 82% of the oil gathered at Caddell were really oil, instead of the observed 70%, then the conclusion would have been there was no oil spilled in Buzzards Bay.²³ Also, for this calculation to make sense, method D1796 should have been applied to oil from one of the tanks uncontaminated with water on board the *Bouchard No. 120*, or the oil delivered to Mirant. Given that Mirant received more than 3,000,000 gallons of oil, even a small value for sediment and water in this delivered cargo would have profound effects on the Caddell shipyard calculations and estimated losses.

These are not the only difficulties with the Caddell data. Other issues and questions arise with the Caddell data. These include:

- In his report Hall notes "The oil recovered at Caddell is not sold commercially so the three shore tanks are not formally calibrated however calibration tables exist for the *Jaybee VI*." Dimensions of the tanks should be provided so that the calculated volumes can be corroborated.
- A statement should be provided from Caddell as to whether the shore tanks or the *Jay Bee VI* contained any waste oil before they received oil from the *Bouchard No. 10* and *Bouchard No. 120*.
- The "*Jey Bee IV*" is referenced in two documents (see Appendix P1). Was the *Jey Bee IV* another vessel handling oil at Caddell, or was this a typographical error? If this is an actual vessel, do ullage reports exist for this vessel? The terms SMP and SI in this ullage report should be explained.
- Caddell shipped out some oil and water because it was clogging their equipment, and Caddell also burned some of the oil for heating the water used in washes (Hall, personal communication). These volumes were not accounted for in the calculations, and estimates of these losses need to be provided.
- Elsewhere in the report, Hall assumes the water fraction of the Caleb Brett ullage reports actually contain appreciable amounts of oil, but the water fraction in the Caddell shore tanks and *Jay Bee VI* tanks are presumed to contain only water. This line of reasoning should be justified.

²³ The difference between Eagle Point volume and Mirant receipts was 7,719 barrels. Oil at Caddell before the percent water and sediments adjustment was 9,435 barrels

- The Caddell shipyard hot washes the tanks. This residual oil stuck to the sides of the tanks collected and included in the calculations would seem to be already included in the Vessel Experience Factor correction described earlier. This volume in any case was not added to the starting volume because Hall uses only the Caleb Brett ullage reports of measured tank volumes. This issue should be addressed.
- Any assays made of the water, or water and sediment content of oil on the *Bouchard No. 120*, *Bouchard No. 10*, or oil received at the Mirant facility need to be provided.

Conclusions

The Caleb Brett inspector ullage reports represent the industry standard for calculating and reporting the volume of oil transported and delivered. The ullage report for the *Bouchard No. 120* in Buzzards Bay the morning after the accident suggests that 97,600 gallons of oil was spilled. Subsequent ullage reports for the *Bouchard No. 120* and *Bouchard No. 10* (which lightered oil and water from the *No. 120*) at the Mirant electric generating facility in Sandwich appear to suggest that even greater volumes of oil were spilled. However, these calculations must be adjusted for oil contained in two “slop” tanks of oil and water on the *Bouchard No. 10*, which totaled more than 148,000 gallons. These tanks of slop water were never evaluated to determine their precise oil content.

Hall attempts to conduct a comprehensive analysis of the volume of oil spilled by the *Bouchard No. 120* given these facts. However, Hall dismisses the ullage reports as unreliable, and instead relies heavily on his calculation that the Caddell shipyards received 6,478 barrels of oil from the *Bouchard No. 10* and *Bouchard No. 120* after they returned from Buzzards Bay. The measurements at the shipyard were made after the contents of the slop tanks were combined with 155,000 gallons of residual No. 6 oil from undamaged tanks on the *No. 120* and oil on the *No. 10*, and after the inclusion of sediments and residuals on tank walls and plumbing after weeks of hot water washes, and after apparent multiple undocumented transfers between shore slop tanks, and tanks on the *Bouchard No. 120*, *Bouchard No. 10*, the *Jay Bee VI*, and possibly one other vessel.

Numerous issues arise from the data collected at the shipyards. No documentation was provided as to whether the shore slop tanks or the *Jay Bee VI* contained any residual oil from other shipyard activities. The oil quantities include residual volumes of oil stuck to the tanks and plumbing in the *Bouchard No. 120*, and may have may already been accounted for in Hall’s application of a Vessel Experience Factor, and that no similar adjustment was made for that undocumented volume at the start of the voyage. Because the Caddell facility does not sell oil, detailed documentation of the transfers at the facility may be lacking, and the volume of oil collected by the facility was partly based on uncalibrated tanks.

The biggest issue confronting Hall with the Caddell shipyard data was that the volume of oil measured at the facility was so great, that it would be necessary to conclude that no oil could have been spilled in Buzzards Bay. This volume was even greater than reported because Hall acknowledged that some of the oil was burned at Caddell to heat water for the hot water washes, and some oil was even transferred out of the shipyard because it was clogging pumps. Estimates of these volumes were not included in his report.

Hall correctly surmised that after the oil was subjected to hot water washes and multiple transfers and mixing of oil and water, the measured oil volume must contain some water. To document this, Hall had a sample assayed from 10 separate tanks (3 shore tanks and 7 barge tanks) and found the “oil” layer contained anywhere from 6.5% to 69.5% water and sediments. Hall applied these coefficients to conclude the shipyard received more than 272,000 gallons of oil, which, when compared to oil deliveries volumes and volumes on the *Bouchard No. 120* leaving New York, and led to his lower estimated volumes spilled.

Hall’s calculations are very sensitive to the actual percent water and sediment coefficients for the 10 tanks sampled. However, his calculations and conclusions appear to have been based on single samples measurements of sediment and water content, with no replication or sense of data integrity, and were collected at what appear to be indeterminate depths within the oil fraction. Since oil and water tend to separate, there is no reason to believe the water content of the oil was identical at all depths. Even more problematic is that 9 of 10 assays were sediment and water content, and only one was water content alone. The sample with the water only assay coincidentally had the lowest contamination (6.5%), and was less than half the lowest value for the combined sediment and water assays. The sediment content of the oil should not have been included in his calculations and subtracted from the total to calculate the spill volume, only water content. This is because the residual several inches of oil in the undamaged *Bouchard No. 120* tanks delivered to the shipyard appear to have contained appreciable sediments. These sediments and volumes are actually part of the starting cargo volume, and not part estimating water contamination of the oil. Furthermore, for Hall’s approach to be consistent, water content, and the water and sediment content of oil delivered to Mirant must also be provided and addressed.

These issues undermine any conclusions about the volume of oil retrieved by the Caddell shipyard. The high reliance on the Caddell data, with its questionable integrity, and other uncertainties identified in this report, call in to question the reliability of Hall’s conclusion that the volume of oil was “considerably less” than 55,000 gallons.

Perhaps more important than the weaknesses in the Caddell data is the fact that the Caleb Brett inspector’s ullage reports for the *Bouchard No 120* in Buzzards Bay and *Bouchard No 120* and the *Bouchard No 10* arriving at Mirant are remarkably consistent. The volume of oil offloaded from the *Bouchard No. 120* at Mirant also precisely matches recorded by shore receipts within the expected Vessel Experience Factor. Combined volumes of unaffected tanks in Buzzards Bay, match those volumes at the Mirant facility within 2 hundredths of one percent.

These ullage reports suggest that 919 gallons of oil were transferred to *Bouchard No. 10* slop oil and water tanks (tanks 3P and 5S). Based on this volume, the volume of oil received by Mirant, and oil remaining on board on the *Bouchard No. 120* and the *Bouchard No. 10* (in the tanks without tanks without water), it appears that 97,105 gallons of oil was spilled in Buzzards Bay. This estimate is highly consistent with the 97,600 gallon spill volume first measured while the *Bouchard No. 120* was anchored in Buzzards Bay the day after the accident. Adjusting the Caleb Brett inspector reports in Buzzards Bay and at Mirant by a Vessel Experience Factor of 1.0037 suggests that the volume of oil spilled was between 96,742 and 97,240 gallons. This volume could be larger if the Mirant facility documented a water content in the oil delivered by more than a few tenths of one percent.

These Caleb Brett inspector data alone do not negate the possibility of a lower calculated spill volume spilled based on the Caddell shipyard data gathered by Hall, nor is Hall's approach necessarily inappropriate. Rather, better documentation of the Caddell data is needed, as well as data for oil and sediment content of the deliveries to Mirant, water only content of the Caddell collected oil, and a better defense of the methods used. This documentation needs to be provided in order to dismiss the Caleb Brett inspector reports in Buzzards Bay and at the Mirant facility as Hall has done. Until this information is provided, a 97,000 gallon loss (VEF corrected) based on the Caleb Brett inspector's reports, seems to be the most conservative estimate of oil spilled in Buzzards Bay by the *Bou-chard No. 120*.