BP Deepwater Horizon Oil Budget: What Happened To the Oil?

The National Incident Command (NIC) assembled a number of interagency expert scientific teams to estimate the quantity of BP Deepwater Horizon oil that has been released from the well and the fate of that oil. The expertise of government scientists serving on these teams is complemented by nongovernmental and governmental specialists reviewing the calculations and conclusions. One team calculated the flow rate and total oil released. Led by Energy Secretary Steven Chu and United States Geological Survey (USGS) Director Marcia McNutt, this team announced on August 2, 2010, that it estimates that a total of 4.9 million barrels of oil has been released from the BP Deepwater Horizon well. A second interagency team, led by the Department of the Interior (DOI) and the National Oceanic and Atmospheric Administration (NOAA) developed a tool called the Oil Budget Calculator to determine what happened to the oil. The calculator uses the 4.9 million barrel estimate as its input and uses both direct measurements and the best scientific estimates available to date, to determine what has happened to the oil. The interagency scientific report below builds upon the calculator and summarizes the disposition of the oil to date.

In summary, it is estimated that burning, skimming and direct recovery from the wellhead removed one quarter (25%) of the oil released from the wellhead. One quarter (25%) of the total oil naturally evaporated or dissolved, and just less than one quarter (24%) was dispersed (either naturally or as a result of operations) as microscopic droplets into Gulf waters. The residual amount — just over one quarter (26%) — is either on or just below the surface as light sheen and weathered tar balls, has washed ashore or been collected from the shore, or is buried in sand and sediments. Oil in the residual and dispersed categories is in the process of being degraded. The report below describes each of these categories and calculations. These estimates will continue to be refined as additional information becomes available.

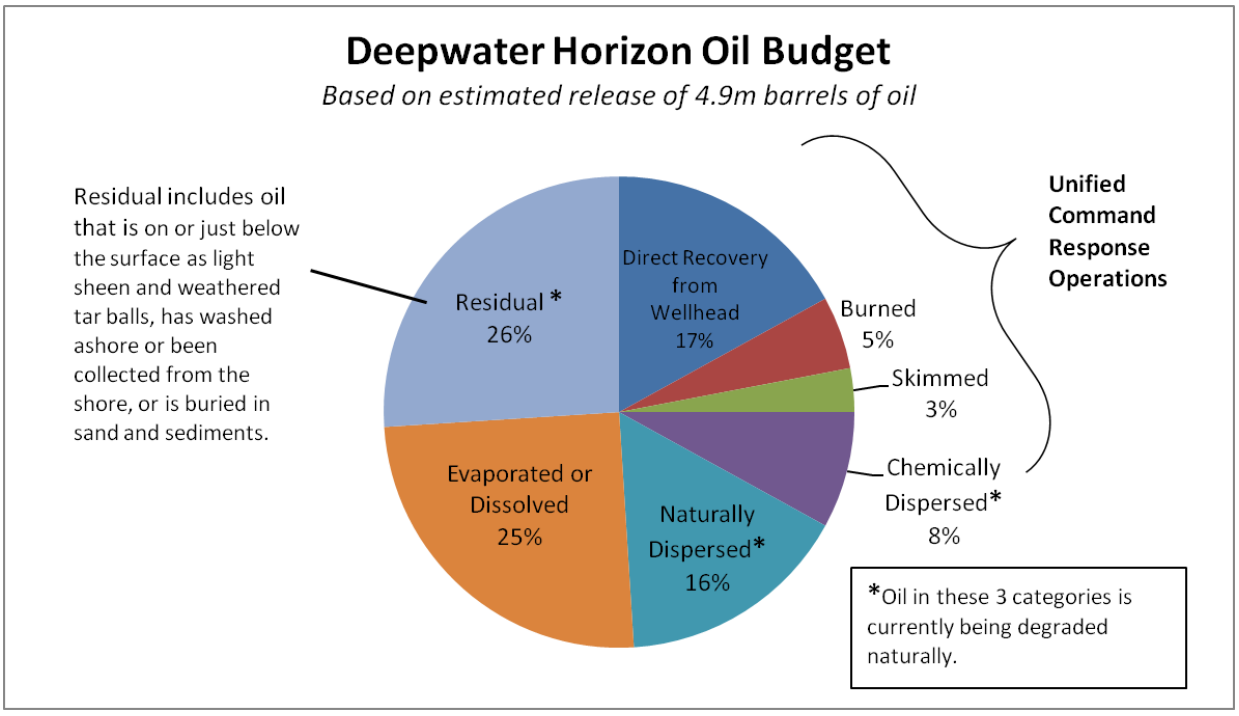

Figure 1: Oil Budget - Shows current best estimates of what happened to the oil.

Explanation of Findings

Unified Command Response Efforts: Response efforts to deal with the oil have been aggressive. As shown in the pie chart (Figure 1), response efforts were successful in addressing 33% of the spilled oil. This includes oil that was captured directly from the wellhead by the riser pipe insertion tube and top hat systems (17%), burning (5%), skimming (3%) and chemical dispersion (8%). Direct capture, burning and skimming remove the oil from the water entirely, while chemically dispersed oil remains in the water until it is biodegraded, as discussed below.

Dispersion: Based on estimates, 16% of the oil dispersed naturally into the water column and 8% was dispersed by the application of chemical dispersants on and below the surface. Natural dispersion occurs as a result of the oil coming out of the riser pipe at high speed into the water column, which caused some of the oil to spray off in small droplets. For the purpose of this analysis, 'dispersed oil' is defined as droplets that are less than 100 microns — about the diameter of a human hair. Oil droplets that are this small are neutrally buoyant and thus remain in the water column where they then begin to biodegrade. Chemical dispersion also breaks the oil up into small droplets to keep it from coming ashore in large surface slicks and makes it more readily available for biodegradation. Chemical dispersants were applied at the surface and below the surface; therefore, the chemically dispersed oil ended up both deep in the water column and just below the surface. Dispersion increases the likelihood that the oil will be biodegraded, both in the water column and at the surface. Until it is biodegraded, naturally or chemically dispersed oil, even in dilute amounts, can be toxic to vulnerable species.

All of the naturally dispersed oil and some of the oil that was chemically dispersed remained well-below the surface in diffuse clouds where it began to dissipate further and biodegrade. Previous analyses have shown evidence of diffuse clouds of dispersed oil between 3,300 and 4,300 feet in very low concentrations (parts per million or less), moving in the direction of known ocean currents and decreasing with distance from the wellhead. (citation: Federal Joint Analysis Group Report 1 and 2, http://ecowatch.ncddc.noaa.gov/JAG/reports.html). Oil that was chemically dispersed at the surface moved into the top 20 feet of the water column where it mixed with surrounding waters and began to biodegrade.

Evaporation and Dissolution: It is estimated that 25% of the oil volume quickly and naturally evaporated or dissolved into the water column. The evaporation and dissolution rate estimate is based on scientific research and observations conducted during the Deepwater Horizon incident.

Dissolution is different from dispersion. Dissolution is the process by which individual hydrocarbon molecules from the oil separate and dissolve into the water just as sugar can be dissolved in water. Dispersion is the process by which larger volumes of oil are broken down into smaller droplets of oil.

Residual: After accounting for the categories that can be measured directly or estimated (i.e., recovery operations, dispersion, and evaporation and dissolution), an estimated 26% remains. This figure is a combination of categories all of which are difficult to measure or estimate. It includes oil still on or just below the surface in the form of light sheen or tar balls, oil that has washed ashore or been collected from the shore, and some that is buried in sand and sediments and may resurface through time. This oil has also begun to degrade through natural processes.

Biodegradation: Dispersed oil in the water column and oil on the surface of the water biodegrade naturally. While there is more analysis to be done to quantify the rate of biodegradation in the Gulf, early observations and preliminary research results from a number of scientists show that the oil from the BP Deepwater Horizon spill is biodegrading quickly. Scientists from NOAA, EPA, DOE and academia are working to calculate more precise estimates of this rate. It is well known that bacteria that break down the dispersed and weathered surface oil are abundant in the Gulf of Mexico in large part because of the warm water, the favorable nutrient and oxygen levels, and the fact that oil regularly enters the Gulf of Mexico through natural seeps.

Explanation of Methods and Assumptions

Flow Rate: The Oil Budget Calculator starts with an estimate of the cumulative amount of oil released over the course of the spill. The newest estimates reflect the collaborative work and discussions of the National Incident Command's Flow Rate Technical Group (FRTG) led by United States Geological Survey (USGS) Director Marcia McNutt, and a team of Department of Energy (DOE) scientists and engineers, led by Energy Secretary Steven Chu. This group estimates that approximately 4.9 million barrels of oil flowed from the BP Deepwater Horizon wellhead between April 22 and July 15, 2010, at which time the flow of oil was suspended. The uncertainty of this estimate is $\pm$ 10%. The pie chart above is based on this group's estimate of 4.9 million barrels of oil.

Direct Measures and Best Estimates: The oil budget calculations are based on direct measurements wherever possible and the best available scientific estimates where measurements were not possible. The numbers for direct recovery and burns were measured directly and reported in daily operational reports. The skimming numbers were also based on daily reported estimates. The rest of the numbers were based on previous scientific analyses, best available information and a broad range of scientific expertise. These numbers will continue to be refined based on additional information and further analysis. Further information on these calculation methods is available in the Deepwater Horizon Gulf Incident Budget Tool Report from Aug 1, 2010 (available online). The tool was created by the US Geological Survey in collaboration with US Coast Guard, NOAA and NIST.

Continued monitoring and research:

Our knowledge of the oil, dispersants, ecosystem impacts and human impacts will continue to evolve. Federal agencies and many academic and independent scientists are actively pursuing better understanding of the fate, transport and impact of the oil. The federal government will continue to report activities, results and data to the public on a regular basis. Updates and information can be found at www.restorethegulf.gov, and data from the response and monitoring can be found at www.geoplatform.gov.

DOI, NASA and NOAA continue to refine understanding of amounts of remaining surface oil. NOAA responders are working with the Unified Command on monitoring strategies for tar balls and near shore submerged oil, and researchers continue subsurface scanning and sampling to monitor the concentration, distribution and impact of oil there. EPA and NOAA have carefully monitored BP's use of dispersant in the Gulf and continues to monitor the air, water and sediments near the shoreline for the presence of dispersant and crude oil components with special attention to human health impacts. Numerous NOAA- and NSF-funded academic researchers and NOAA scientists are investigating rates of biodegradation, ecosystem and wildlife impacts. DOI and DOE responders are working to ensure control of the well and

accurate measurement of oil released and oil remaining in the environment. DOI is leading efforts to mitigate impacts of oil to terrestrial wildlife, natural resources, and public lands.

Even though the threat to shorelines, fish and wildlife, and ecosystems has decreased since the capping of the BP wellhead, federal scientists remain extremely concerned about the impact of the spill to the Gulf ecosystem. Fully understanding the impacts of this spill on wildlife, habitats, and natural resources in the Gulf region will take time and continued monitoring and research.

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Acknowledgements

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Credits

The following scientists were involved in developing the Oil Budget Calculator tool:

LT(jg) Charity Drew (USCG) – Original Excel spreadsheet and application inspiration
David Mack and Jeff Allen (USGS) – Application development and engineering
Rebecca Uribe (USGS) – Graphic design
Bill Lehr (NOAA) – Lead mass balance and oil budget scientist
Antonio Possolo and Pedro Espina (NIST) – Statistical oil budget model encoded as an R program
LCDR Lance Lindgren, CDR Peter Hoffman, CDR Sean O'Brien, and LT Amy McElroy (USCG) – Application requirements and user stories
Sky Bristol and Tim Kern (USGS) – Project vision and management
Kevin Gallagher, Martha Garcia, and Stephen Hammond (USGS) – Executive sponsors

The following experts were consulted on the oil budget calculations, contributed field data, suggested formulas, analysis methods, or reviewed the algorithms used in the calculator. The team continues to refine the analysis and this document will be updated as appropriate.

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