**CENTRE OF DOCUMENTATION, RESEARCH AND EXPERIMENTATION ON ACCIDENTAL WATER POLLUTION**

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# Inland Waters Technical Newsletter *n°17*

**LTEI 2011 - 2**

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## • Main oil spills worldwide

### PIPELINE SPILLS

**Crude oil leak from a pipeline into Yellowstone River (Silvertip Pipeline, Montana, US)**

On the evening of 1st July 2011, a drop in pressure was detected in a pipeline owned by ExxonMobil Pipeline Company (EMPCo). The line (30 cm in diameter) transports light crude oil (sweet crude, with low sulphur content) 110 km from the Silvertip pump station near Elk Basin in Wyoming to the Billings refinery in Montana.

A Unified Command (UC) was established with the US Environmental Protection Agency (EPA), which coordinated response in collaboration with representatives of the relevant federal agencies (in particular the U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration (PHMSA); the U.S. Department of the Interior; the U.S. Fish & Wildlife Service (USFWS)), State agencies (Montana Department of Environmental Quality (MDEQ); Montana Fish, Wildlife & Parks (MFWP), etc.) and local services (Yellowstone County Disaster and Emergency Services), with the participation of EMPCo and the support of non-governmental organisations (e.g. International Bird Rescue). Furthermore, 4 technical experts from the Pacific Strike Team, one of the teams of the US Coast Guard's National Strike Force, provided support to EPA, at least during the initial stages of the response.

On 6$^{th}$ July, the EPA officially ordered ExxonMobil – actively involved in the response from the onset of the spill – in compliance with the provisions of the Clean Water Act, to present an action plan and to technically and financially ensure the implementation of clean-up and restoration operations for the affected sites, according to the recommendations and under the supervision of the federal agency.

In total, around 1,000 people were involved in assessment, monitoring and clean-up operations on the banks, including EMPCo personnel (North America Regional Response Team) and specialised companies contracted by ExxonMobil.

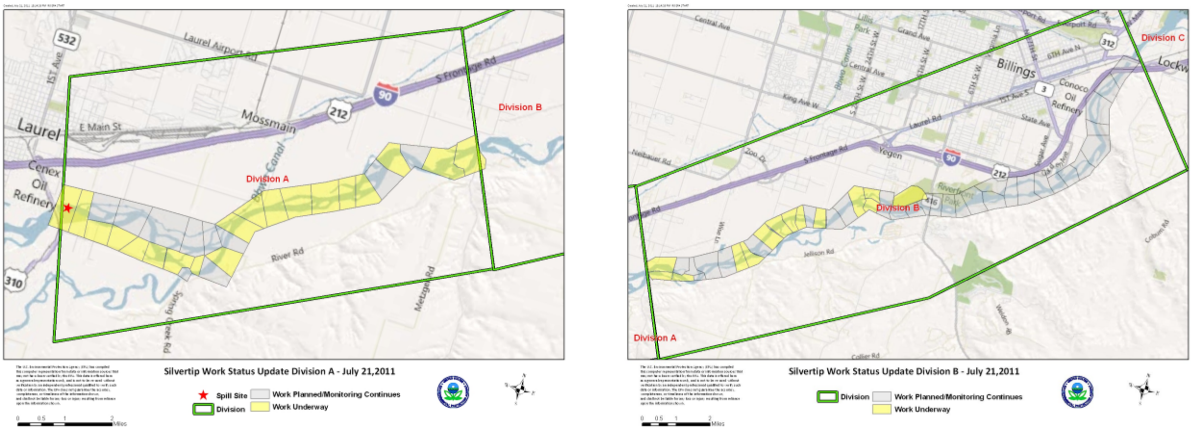
From the first days of the response, SCAT (Shoreline Cleanup Assessment Technique) surveys conducted on foot or from boats and supplemented by daily observations from helicopters, aimed to cover over 400 km of banks of the Yellowstone River. This distance was split into 4 operational divisions according to the level of oiling and the priorities and clean-up techniques required:

- two priority divisions, the most heavily oiled, immediately downstream and close to the spill location, were defined for immediate implementation of clean-up operations; they included respectively the first 16 kilometres (division A) downstream of the spill location and the following 29 km (division B). Around thirty clean-up sites were defined in these sections;
- further downstream, two other divisions, covering more extensive distances and believed to be less liable to be affected, were controlled by land-based surveys, again by teams trained in SCAT procedures, and aerial surveys. They covered 231 km (from Johnson Lane to Miles City) and 125 km (from Miles City to Glendive) respectively.

The survey results (Cf. table below) showed a decrease in the level of oiling with distance from the spill location, and enabled clean-up sites to be defined – mainly on the south bank of the watercourse and the islets.

| | **Distance (km)** | **Area covered by SCAT survey (km$^2$)** | **Proportion of banks by oiling categories/levels** | | | | |
|---|---|---|---|---|---|---|---|
| | | | None | Very light | Light | Moderate | High |
| **Division A** | 16 | 2.27 | 39.8 % | 7.9 % | 15.8 % | 33.8 % | 2.7 % |
| **Division B** | 29 | 5.53 | 39.2 % | 22.4 % | 32.4 % | 5.8 % | 0.1 % |

*Summary of systematic surveying, using the SCAT procedure, of the 2 most heavily oiled divisions (from US EPA data)*




*Operational sections within the 2 most heavily oiled divisions (A and B), immediately downstream of the spill site ( ★) (Source: US EPA).*

Meanwhile, to assess the environmental impact and health risks for local inhabitants and response personnel, the EPA immediately implemented monitoring, until the end of operations:

- in real time of atmospheric concentrations of hydrogen sulphide and volatile organic compounds (VOCs) including BTEX[1], with a particular focus on residential areas (e.g. Laurel and Billings) and the scenes of response operations. On 6th July, the EPA indicated that no contamination had been detected since the beginning of monitoring, 3 days earlier;
- of contamination by oil-related compounds in the water (river[2], intakes and drinking water supply), ground and sediment. The results (published on the EPA's public website) showed no values above the standards in force.

*Polluted site (division A): difficult access and sensitivity to response (low load-bearing capacity of ground + vegetation) (Source: EPA)*

Implementation of the response was rapidly confronted with difficulties related to the inaccessibility and sensitivity of many oiled areas which, in the meanders and islets of the Yellowstone River (the longest free-flowing river in the United States), were characterised by heavily vegetated banks and a low load-bearing capacity.

In addition to these difficulties, (i) a high level of plant debris was found in areas of calm currents and (ii) the lateral spread of the pollution was promoted by flood conditions (due to late snow melt). In relation to this last point, the water level began to drop 10 days after the incident, giving SCAT teams better access; these teams were gradually increased from 4 to 7, in order to implement optimised monitoring of the situation through repeated visits.

On the water, the possibility of recovery operations (or even surveys) from boats was hindered as navigation was made difficult by the high flow rate and flood conditions in the river at the time of the incident.

*Containment using sorbent booms along flooded banks (left) and in trenches along the south bank (right) (Source: USFWS)*

Nevertheless, daily aerial surveys by helicopter helped to locate the main accumulations of free oil, general found in calm areas with low hydrodynamics, along banks or in adjacent trenches.

This floating pollution was contained using sorbent booms, deployed from light, shallow-draught

[1] Benzene, Toluene, Ethylbenzene and Xylene.
[2] Except, it seems, during the first 2 days following the spill, due to difficulties related to the flood conditions.

boats, before being recovered, mainly manually (using shovels, bailers, etc.) or other conditioned sorbents or, when access was possible, by vacuum trucks.

Accumulations at the water surface were located and treated during the first week, at the end of which a last significant slick, weathered and emulsified, was detected around 130 km downstream of the leak

Alongside recovery, large sections of sorbent booms were also deployed on the water, as is common practice in the US, to protect sensitive sites, in particular islets.

In terms of bank clean-up, the inaccessibility of sites – exacerbated by the high water level – caused alternative transport means such as air boats and amphibious vehicles to be mobilised, to transport personnel and response equipment as well as to evacuate waste. With the gradual decrease in water level and flow rate in the Yellowstone River, transport by small flat-bottomed, shallow-draught boats (jonboats) was useful to maintain survey and clean-up operations as well as for site monitoring.

*Maintaining sorbent booms using a jonboat (Source: USFWS)*

The oil, deposited on the ground or floating on a layer of water along many of the flooded banks, was mainly collected manually, in some cases using light-weight tools (such as rakes, shovels, scoop nets, bailers, etc.) or often using conditioned sorbents (booms, mats and pads). A few rinsing operations using low pressure hoses were implemented locally, as well as pumping operations where possible.

*Manually collecting oil and debris on banks (Source: USCG)*

Vegetation was treated differently according to the form and degree of oiling:

- in the case of heavily oiled plants and shrubs, clean-up was carried out using sorbent pads or by scything and collecting the most affected vegetation,
- in the case of dead vegetation and mobile debris, removal was prioritised, except for very large elements (e.g. thick trunks). These elements were cleaned by low pressure rinsing, manual scraping and/or using sorbents, and left on site,
- in the case of levels of oiling below the standards requiring response actions, the vegetation was left to be self-cleaned (as with residual pollution).

*Lightly oiled vegetation (trunks/stalks at the flood level) in division A (Source: EPA)*

On remote, inaccessible sites, particularly in the case of islets, the removal of accumulations of all sizes of oiled dead wood, sometimes very large, in locally very high quantities, led to a number of logistical difficulties. To treat these areas, a helicopter with a large airlift capacity (*Sikorsky S-61*) was mobilised towards the end of July, to transport the necessary equipment: mini caterpillar loaders (Bobcat), chipper-shredders (to optimise the volumes of waste to be evacuated), containers, etc.

In terms of recovery, the EPA announced on 12th July the collection of over 100 m$^3$ of oily liquids, which were then processed at an ExxonMobil refinery located nearby (near Laurel), and 90 m$^3$ of oily solids, transferred to approved landfill sites in Bennett (Colorado) for non-hazardous waste and in Clive (Utah) for hazardous waste.

*Equipment decontamination area (Source: EPA)*

*Temporary storage of solid waste (Source: EPA).*

The impact of the pollution on wildlife proved minor: the USFWS reported (i) the observation, at the end of daily surveys conducted during the first weeks, of a total of 19 birds whose low level of oiling did not require them to be captured for subsequent treatment and (ii) the cleaning of 5 animals (reptile, batrachians and sparrows, released after cleaning).

According to the EPA, around ten dead specimens (unspecified animals) were collected during response operations, but no link with the accident was determined.

The PHMSA enquiry is in progress and, consequently, the exact causes of the incident have not yet been officially established. Nevertheless, one of the hypotheses put forward is that the flooding and increased flow of the Yellowstone, due to a major snow melt, may have eroded the soil of the banks at the pipeline section, exposing the pipe to floating debris and causing it to be damaged by physical impact.

The cost of clean-up has been estimated at $135 million, covered by EMPCo, which was also fined $1.6 million following legal proceedings by the State of Montana. The company is also being sued by landowners claiming a total of $10 million in damages.

For further information:
http://www.epa.gov/yellowstoneriverspill/
http://yellowstoneriveroilspill.mt.gov/
http://news.exxonmobil.com/

## OIL FACILITY SPILLS

**Heavy fuel oil spill in Mobile River (Mobile Ship Channel, Alabama, US).**

On 1st September 2011, at an asphalt production facility (Gulf Coast Asphalt Co., LLC) on Blakely Island (Alabama), an incident occurred as a barge was being unloaded, causing a fuel oil tank to overflow: the excess oil (fuel n°6) spread across the retention basin, before overflowing and escaping through a storm drain into the trenches next to the facility. The volume involved was estimated at 500 to 700 m$^3$, part of which flowed into the Mobile Ship Channel below.

*Site overview (Source: USCG)*

The firm immediately alerted the US Coast Guard as to the spill, as well as the Alabama Department of Environmental Management (ADEM) and contracted 4 service providers to begin clean-up.

The USCG, which at one point estimated the volume spilt into the water at 160 m$^3$ (no subsequent estimations are to be found in our information sources), coordinated the response by leading the Unified Command, which included representatives of the ADEM and the industrial facility. The imminence of tropical storm Lee accentuated the urgency of the need to implement the response, which was later interrupted by severe weather between 4th and 6th September.

A safety zone was set up on each side of the spill point (and maintained for 1 week), and the area where response operations were being carried out on the water (from McDuffie Coal Terminal to Cochran Bridge) was closed to traffic on the first day of the response. The response involved containing the oil (with floating and sorbent booms) and pumping it using vacuum trucks and skimmers.

The USCG called upon the National Oceanic and Atmospheric Administration (NOAA) for oil drift forecasts under the effects of the tides and currents, as well as an environmental risk assessment.

*Containing the fuel oil on the water in front of the spill point using floating and sorbent booms (Source: USCG)*

By 7th September, almost 10 km of booms had been deployed, as well as 13 drum skimmers, 1 barge fitted with a Marco Filterbelt system, and no less than 15 vacuum trucks and 68 vessels. On 22nd September, the USCG announced that a total of 600 $m^3$ of an oil/water mixture had been recovered.

**Spill in a bayou from an ageing platform (Cedyco Corp., US)**

On 11th September 2011, a crude oil spill occurred in the waters of Bayou Dupont, in the Manila Village oil field (north Barataria Bay, Jefferson Parish, Louisiana), from 2 leaks in 3 internal pipes on a disused platform that had not yet been dismantled, classified as "orphaned" by the Louisiana Department of Natural Resources.

This relatively small spill (see below) nevertheless provoked the implementation of response operations under the leadership of a Unified Command, supervised by Coast Guard Sector New Orleans, with support from 2 technical experts from the Gulf Strike Team (one of the teams that make up the USCG National Strike Force, a unit specifically trained to respond to national scale spills). The Unified Command gathered the relevant agencies of the State of Louisiana: Louisiana Oil Spill Coordinator's Office (LOSCO), Louisiana State Police, Louisiana Department of Environmental Quality (LADEQ), Louisiana Department of Wildlife and Fisheries (LAWLF), Louisiana Department of Natural Resources (LDNR) and Jefferson Parish Department of Environmental Affairs. The NOAA (National Oceanic and Atmospheric Administration) also took part, providing slick drift forecasts and a risk assessment of environmental impact.

In compliance with the Federal Water Pollution Control Act, the USCG issued an administrative order to the last documented owner of the facility at fault (Cedyco Corporation) to secure the source of the discharge and to conduct clean-up operations. Initially, the Oil Spill Liability Trust Fund covered the costs of federal clean-up operations.

*15th September 2011: Containing the oil and protecting the banks with booms (Source: USCG)*

The emergency measures consisted, for Wild Well Control Inc., contracted by the owner, of plugging the leaks (3 in total, including the 2 initially discovered) and rinsing the leaking pipes, before securing the 10 ageing wells associated with the facility. Recovery on the water involved a total of around 40 USCG staff and 80 responders from specialised contractors (in particular OMI Environmental Solutions Inc.). Almost 4,000 metres of boom – floating and sorbent – were deployed on the water, as well as a few skimmers and no less than 7 oil spill response vessels.

Following visual inspections jointly conducted by the NOAA, USCG and the environment authorities for the State and Parish, no environmental impact due to the spill was reported according to the LAWLF.

According to the USCG, the clean-up operations resulted in the recovery of over 8 $m^3$ of crude oil in Bayou Dupont on 20th February. This estimation came after the announcement, 6 day earlier, by the same agency of the recovery of 940 $m^3$ of fluid pollutant, 380 $m^3$ of oiled solids and 40 $m^3$ of floating oil.

**Ground and water pollution due to a light oil spill from a refinery (Suncor, US)**

On 28th November, a leak, whose cause remains unknown, from a pipe within the Suncor refinery in Commerce City (Colorado, US) caused a spill of between 10 and 20 $m^3$ of gasoline into Sand Creek, upstream of its confluence with the South Platte River.

The presence of sheen and petroleum odours on the watercourse were reported to the US EPA by a fisherman, and experts from the federal agency sent on site identified a leak of gasoline in front of the refinery the same day. The industrial firm, immediately contacted, was ordered by the authorities to stop the leak and implement the response (under the supervision of the EPA).

Alongside the investigation, by Suncor and the Colorado Department of Public Health and Environment (CDPHE), into the origin of the leak and the route taken by the gasoline[3], the refinery staff – and that of the service provider contracted by Suncor – contained the pollutant, notably by digging a trench around 70 m long between the refinery and the watercourse, to collect the gasoline that had infiltrated into the ground and to prevent it from flowing into Sand Creek.

At the spill point on the bank, an earthen dam (reinforced with sand bags) was built as an emergency measure and successive rows of floating and sorbent booms were also deployed on the water.

*Containment, at the edge of the bank, of gasoline seepage with an earthen dam and booms (Source: US EPA)*

The accumulations of gasoline contained were pumped using vacuum trucks, mainly from within the earthen dam at the bank edge. This set-up proved to be very effective for capturing seepage of fluid pollutant that had infiltrated into the ground. Eight days after the incident was reported, the volume of gasoline recovered was estimated at more than 13 $m^3$.

The type of product justified the implementation by Suncor of air and water quality monitoring. In this respect, the EPA observed that the winter temperatures significantly contributed to reducing evaporation of the gasoline, whose content in the water indicated, over and above a general trend of decreasing contamination over time, fluctuating BTEX concentrations (Benzene, Toluene, Ethyl-benzene and Xylenes), explained according to the EPA by reworking of the soil caused by response operations during this period.

No visible impact was reported in the watercourse downstream of the spill.

## • Main spills of other hazardous substances worldwide

**Xylene leak from a chemical tanker (*Chembulk New Orleans*, Lake Charles, US)**

On 16th November, a leak, whose cause remains unknown, from the *Chembulk New Orleans* chemical tanker while in dock at the Citgo Lake Charles refinery (Louisiana, US) resulted in a spill of xylene into the Calcasieu Ship Channel.

The spill, whose source and nature were unknown at the time of occurrence, provoked a sort of bubbling effect near the ship and required the rapid deployment of USCG teams to identify the nature and origin of the spill, which were established the following day.

According to the USCG Marine Safety Unit Lake Charles, after having set up a safety zone (with a radius of around 500 m around the leak point), containment of the xylene around the vessel was prioritised, in theory with a view to recovering it. Nevertheless, the chemical – which did not form visible accumulations according to the USCG – proved to be particularly volatile in the prevailing conditions (sunshine), which promoted rapid evaporation

[3] The flow of pollutant in the soil turned out to pass under the neighbouring Metro Wastewater Treatment Facility.

While no estimation of volume was given, atmospheric contamination monitoring, performed by Citgo using sensors deployed on the dock and on the vessel, enabled the hypothesis of risks for human health to be rejected. No consequences of the incident were reported, except on river traffic which was temporarily disturbed during response operations.

**Train derailment and copper concentrate spill in the Edith River (Northern Territory, Australia)**

On 27th December, heavy rainfall (385 mm in one evening) caused by Cyclone Grant destroyed part of the railway line between Alice Springs and Darwin at the Edith River, near the town of Katherine (Northern Territory). A train travelling on this line loaded with copper concentrate from Oz Minerals' Prominent Hill mine (Southern Australia) and headed for the port of Darwin (North Territory) derailed on Edith River Bridge, releasing part of its load into the Edith River.

Due to severe weather, aerial surveillance of the site was carried out initially, as the land was too flooded for teams to be sent on site. The quantity of copper concentrate spilt into the river was estimated by Oz Minerals at between 1,000 and 1,200 tonnes. The company was ordered by NT WorkSafe to clean up the Edith River.

The high degree of dilution of the copper concentrate meant, according to NT WorkSafe, that it was not a health risk. However, that same evening, a second spill occurred, from a retention basin at the Mount Todd mining site, affecting the Edith River 55 km north of Katherine. Environmental monitoring was organised following these 2 events, with the monitoring of metal concentrations in the water and sediment by the North Territory Environment Protection Agency (NTEPA). No concentrations exceeding the standards in force in Australia were recorded for either of these two compartments.

**Pollution of the Hunter River by arsenic-contaminated effluent (Kooragang Island, Australia)**

On 19th August 2011, a leak of effluent occurred from a chemical plant near Newcastle, in New South Wales (Australia). The spill, estimated at 1,200 $m^3$, contained traces of arsenic at a concentration (0.067 $mg.L^{-1}$) which exceeded the environmental protection licence cap (0.05 $mg.L^{-1}$). However, the Office of Environment and Heritage stated that it "does not expect the increase in the concentration of arsenic to have an impact on the health of the Hunter River".

The authorities were notified of the spill, in particular NSW Health and the Department of Primary Industries. Although arsenic had not been used at the plant for 18 years, this incident was caused by cleaning operations, the previous week, following a spill of hexavalent chromium, resulting in old deposits of arsenic leaking into a storage pond and then into the Hunter River. The spill occurred 11 days after a spill of hexavalent chromium that attracted a great deal of media attention, as the authorities and local residents near the plant had not been immediately notified.

## • Main spills of other substances in France

**Spill of black liquor into the Vienne River from a ruptured tank at a paper mill (Haute-Vienne, France)**

On the morning of 8th July 2011, a black liquor storage tank with a capacity of 600 $m^3$ ruptured at a paper mill in Haute-Vienne, France. The tank, filled with 500 $m^3$ at the time of the spill, released its contents into the retention tank. A wave effect caused the retention tank to overflow and part of the content escaped through the unprotected rainwater drainage network into the Vienne River. The operator, after activating its contingency plan, deflected the remains of the spill into the plant's aerated treatment lagoon. The French authorities (DREAL) estimated that 100 to 120 $m^3$ had been retained by the retention tank, around 300 $m^3$ deflected into the lagoon and around 80 to 100 $m^3$ released into the Vienne River via the rainwater drainage network. Inspection of the tank by the French authorities (DREAL) revealed progressive wear by corrosion/erosion of the tank's cone double bottom, with undetectable infiltration between the bottom of the outer tank and its double bottom, thus accelerating corrosion.

Black liquor, spent cooking liquor from the papermaking process, i.e. organic matter mixed with caustic soda and sodium sulphide, is considered to be a corrosive substance (pH 13). In response to this spill into the Vienne River, the emergency measures consisted of firemen laying floating booms at Pilas Bridge, around 2.5 km downstream.

The authorities advised against bathing, fishing, water intakes for farming and traffic downstream of the plant.

At the paper mill, operations were implemented to clean up the site using vacuum trucks. The black liquor recovered was then re-injected into the production chain following in situ pre-treatment.

On the banks of the Vienne, no clean-up was necessary. A few hours after the incident, foam could be seen on the water, due to saponification products still present after treatment. However, no fish mortality was detected either in the Vienne or the Charente. Certain physical and chemical characteristics of the water, in particular pH, were monitored at 3 points downstream of the spill into the Vienne. The relatively deep water at the plant outfall, combined with the high flow rate of the Vienne at this time of year, promoted the substance's dilution and the pH only increased by 0.5.

Operations at the mill were stopped at the time of the spill and resumed a few days later. The operator estimated its losses at €2 million.

*State of the site following the black liquor spill (Source: Synergi)*

## • Review of significant spills having occurred worldwide in 2011

This review is based on an inventory of incidents in 2011 recorded by *Cedre* having led to a spill of over an estimated 10 tonnes, for which sufficient information was available. We remind readers that, for a certain number of incidents, the volumes spilt are not known or divulged by our information sources, although they clearly exceed the 10-tonne mark; these missing data should therefore be born in mind and could affect the balance of the results presented below.

### Spill sources

In 2011, 41 significant incidents resulting in a spill were identified worldwide by *Cedre*, giving an estimated cumulated total of around 11,200 tonnes of oil and other hazardous substances spilt in inland waters – minimum estimation due to a lack of detailed data for several incidents.

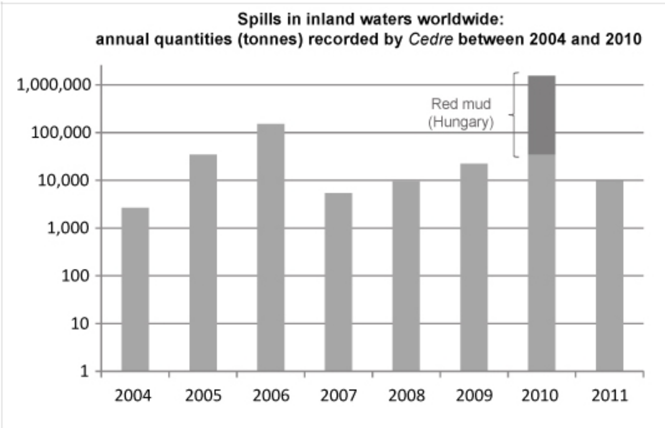



***Figure 1***

This value is lower than those obtained by the same approach for 2009 and 2010 (Figure 1).

Among the most major spills in 2011 (over 1,000 m$^3$), we note in particular a spill in wetlands in the Canadian province of Alberta[4], but also those in the Hunter and Edith Rivers following two separate incidents in Australia (Cf. above, LTEI n°17).

In terms of occurrence, in the same way as in past years, **pipelines** were clearly the most frequent source (27 %) of spills in 2011 (Figure 2).

[4] Spill, in April, of around 4,500 m$^3$ of light crude oil not far from the village of Little Buffalo (Cf. LTEI n°16).

**Tanker trucks** and different types of **storage capacities** were involved in spills to a similar extent, respectively around 17 % and 15 % of cases (Fig. 2).
Ships caused 12 % of spills in 2011, the same share as **internal pipes** within different types of facilities.
With the exception of **basins and trenches** (various facilities: refineries, mines, farming facilities), involved in 7 % of cases, the other sources identified each concerned less than 5 % of the spills recorded in 2011 (Fig. 2).

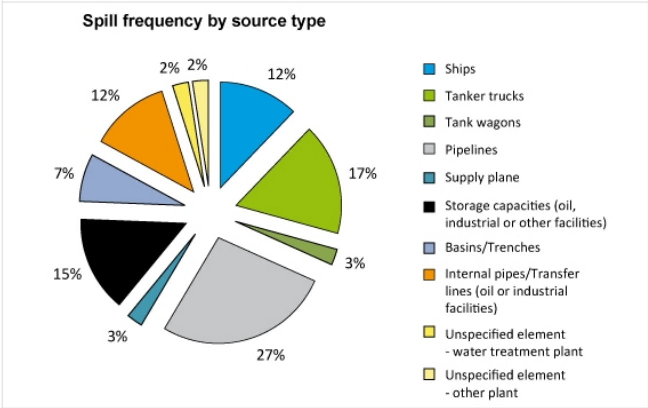



***Figure 2***

In terms of quantities, and in line with the observations in previous years, we note the major share (around 53 %) of **pipelines** in the 2011 total (Figure 3). The most significant spills (for which sufficient information was available) from pipelines occurred in North America, in particular in April, June and July in Canada[5], in April[6] and July (Cf. above, LTEI n°17) in the United States, and in December in Mexico[7].

The other main contributors to the cumulated total were **basins and trenches** at various facilities – in this case oil, mining and farming facilities – which represented 12 % of the total volume (Fig. 3).

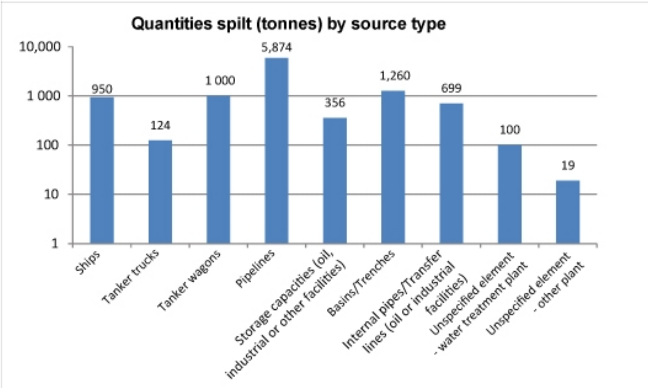



***Figure 3***

Then came **tank wagons** and **ships**, at a similar level with around 10 % and 9 % respectively of the total volume for 2011 (Fig. 3). With relatively low frequency in 2011, these mainly consisted of two contributing events: the derailment of a train carrying copper concentrate, in December in Australia (Cf. above, LTEI n°17) and the capsizing of the chemical barge *Waldhof*, carrying 2,400 tonnes of sulphuric acid, on the Rhine in January (Cf. LTEI n°16[8]).
The other structures identified were each responsible for less than 10 % of the total quantity spilt; among these spills we note that, while they appear in 2nd and 3rd position in terms of frequency, **tanker trucks** and **storage capacities** only constituted a small proportion (1 % and 3 % respectively) of the total quantity spilt, suggesting that spills from these structures were small in 2011.

## Types of substances spilt

The analysis of the quantities spilt by type of substance shows that in 2011 the majority of spills were of **oil** in general, which represented 60 % of the estimated total quantity for the year (Figure 4). Within this category, **crude oils** were very dominant (>80 % of oil).

[5] On 29th April: leak from Rainbow Pipeline, belonging to Plains Midstream Canada (Cf. LTEI n°16); on 26th June: spill of approximately 160 $m^3$ of salt water containing around 5 % light crude oil near Swan Hills (Alberta), following the rupture of a 1.5 km pipe between a well and a process site operated by Pengrowth Energy Corporation; on 19th July, leak of just over 200 tonnes of crude oil due to a crack in the Pembina Moosehorn 8" pipeline near Swan Hills Terminal and Pump Station (Swan Hills, Alberta).
[6] Gasoline spill from a leaking pipeline belonging to Marathon Pipeline LLC (Cf. LTEI n°16).
[7] On 31st December, spill of around 240 tonnes of crude oil into the Coatzacoalcos River (State of Veracruz), following illegal attempts to tap into a PeMex (Petroleos Mexicanos) pipeline.
[8] N.B. This only includes the share of the volume of sulphuric acid that was *accidentally* spilt, i.e. due to the accident itself and not the (just as significant) share *deliberately* released in a controlled manner as part of the response (Cf. LTEI n°16).

With over 5,000 tonnes, they are also responsible for half of the volume spilt in 2011 (Figure 4), due to 8 incidents, the largest of which (> 1,000 tonnes) was unquestionably the Rainbow Pipeline spill in April (Canada, Cf. LTEI n°16), responsible for over 80 % of the crude oil total in 2011.

More than half of the remaining 20 % of the oil spilt consisted of **white oils** – mainly due to one incident (gasoline spill from a Marathon pipeline at an oil depot, Cf. LTEI n°16), together with relatively minor incidents (volumes of less than 50 m$^3$).

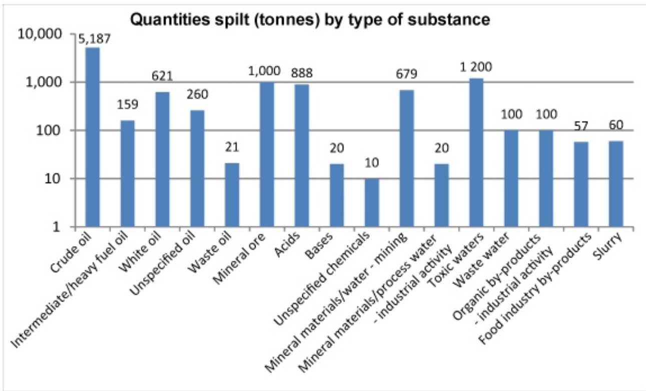



***Figure 4***

With cumulated quantities of nearly 1,000 tonnes – i.e. contributions of around 10 % of the annual total – we note the respective shares of **toxic waters** (12 % due to the Hunter River spill, in Australia, of arsenic-contaminated water; Cf. above, LTEI n°17), **mineral ore** (10 % due to a spill of copper concentrate into the Edith River in Australia; Cf. above, LTEI n°17), and finally **acids** (9 % of the annual total, following the sulphuric acid spill caused by the *Waldhof* chemical barge incident on the Rhine; Cf. LTEI n°16).

The other categories of pollutants recorded contributed marginally to the 2011 total, with estimations of a few dozen tonnes – possibly reaching a hundred tonnes as in the case of **organic by-products from industrial activity** (here represented by the black liquor spill from a paper mill into the Vienne River in July; Cf. above, LTEI n°17).

## Causes

First we note that the cause – or event – responsible for the spill was not indicated or unknown in our information sources in around 20 % of the cases recorded in 2011 (Figure 5), a sufficiently high proportion to jeopardise the accuracy of the following analysis.

Where the causes were identified, the analysis of their distribution by frequency suggests a high prevalence in 2011 of leaks caused by ageing structures (**wear**, **crack**, **corrosion**) (17 %), mainly pipelines, but also internal pipes and industrial storage capacities.

**Road accidents**, involving tanker trucks, caused 15 % of spills into inland waters, while incidents caused by **rupture/disintegration** (e.g. storage facility walls, or lines) represented around 12 % of cases.

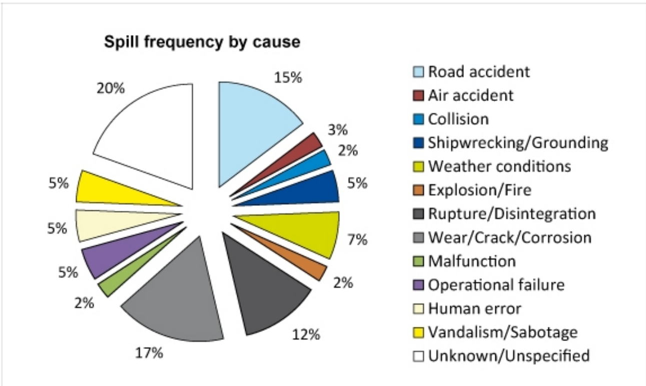



***Figure 5***

The other causes recorded, with the exception of **weather conditions** (7 %)[9], were reported in at least 5 % of events.

[9] On 13th February, pollution of the Teaone and Esmeraldas Rivers (province of Esmeraldas) following the flooding and overflow of a reception basin within a Petroecuador refinery, caused by heavy rainfall; on 27th December, in Australia, spill into the Edith River following a train derailment, due to destruction of a section of railway line by flooding (Cf. above, LTEI n°17).

In terms of the quantities spilt, the ageing of structures (**wear**, **crack**, **corrosion**) is at the top of the list of causes in 2011 (57 %; Figure 6), relating to 7 incidents and more specifically (75 %) to the spill in April in Canada (following cracks at the welds on the 44-year-old Rainbow Pipeline; Cf. LTEI n°16). **Weather conditions**, although responsible for few spills (Cf. above), appear to be the 2nd cause in terms of quantity (around 10 %).

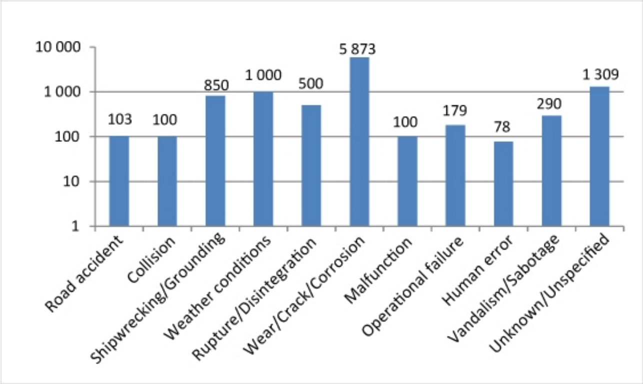



***Figure 6***

**Ship accidents** contributed to around 8 % of the total volume spilt, ahead of the other causes which did not exceed 5 %, among which we note that the low proportion of **road accidents** (around 1 % of the total quantity) indicates, in relation to their position in terms of frequency, the small volumes involved.