



NATIONAL PROTECTION AND PROGRAMS DIRECTORATE

## OFFICE OF CYBER AND INFRASTRUCTURE ANALYSIS

# *Analysis – Hazardous Liquid Pipeline and Rail Incidents (1985-2014)*

April 6, 2015



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# Data Uncertainty Disclaimer

- This analysis combines U.S. Department of Transportation data from different time periods with different reporting, collection, and data quality standards. Trends and findings from this analysis that compare data from 1985 through 2014 should be used for expository purposes only. Care should be taken when fully comparing data from before 2002 with more recent information.

# A note about the pipeline data used in this analysis

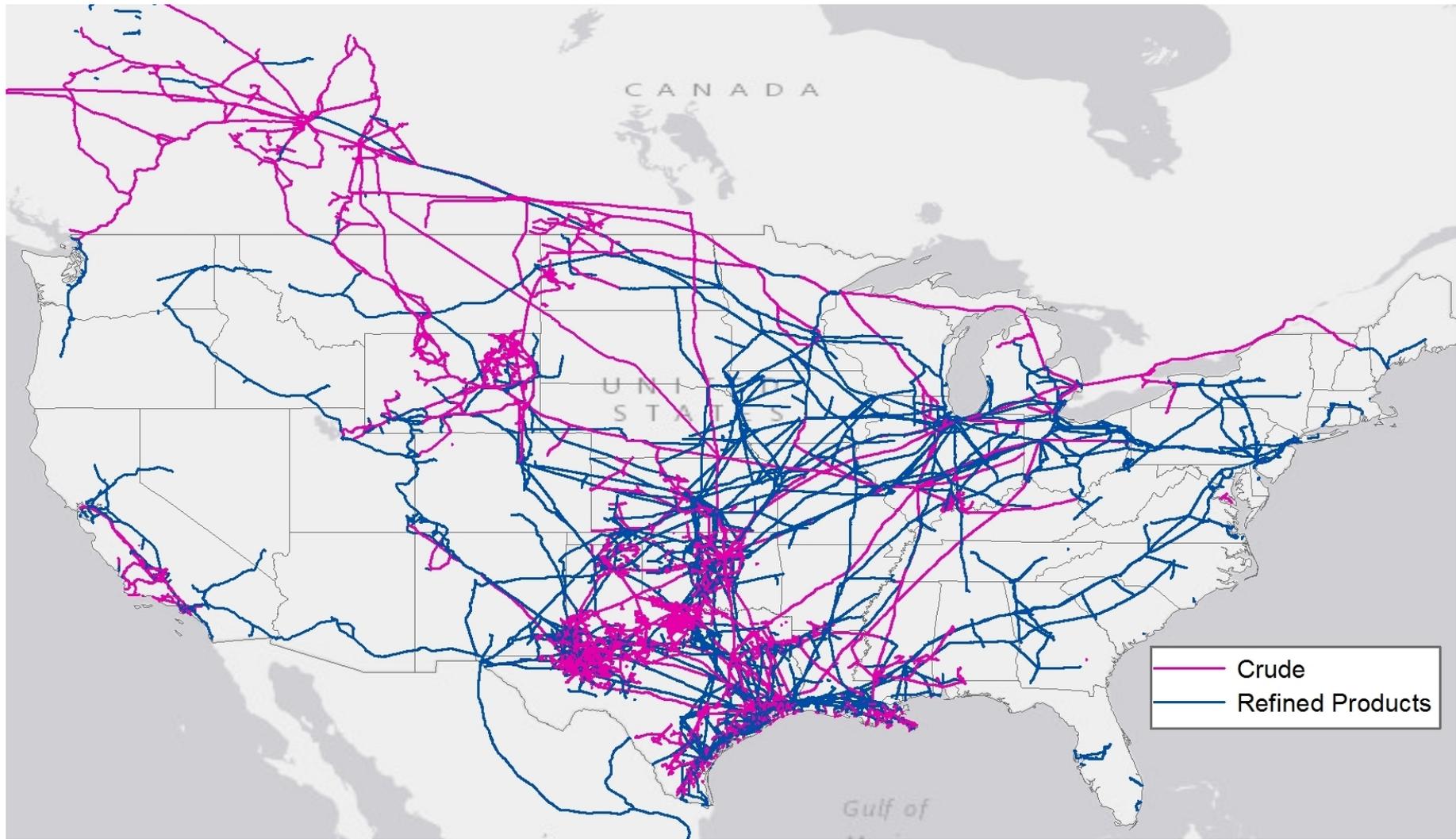
- Information was drawn primarily from DOT/PHMSA's Liquid Accident and Incident Data, while information on total volumes of hazardous liquids moved by pipeline came from the Association of Oil Pipe Lines' 2015 Annual Liquids Pipeline Safety Performance Report & Strategic Plan.
- PHMSA incident data was drawn from reporting contained in three separate databases that cover the periods 1985-2001, 2002-2009, and 2010-Present. The consistency of the data between reporting periods was uneven, particularly for the 1985-2001 period. OCIA analysts consolidated these periods using PHMSA's latest reporting. Where that was not possible (e.g., disaggregating specific causes of failure previously lumped under "Other" categories), the data was left as is.

## ...And a note about the railroad data...

- Rail information was drawn primarily from DOT/PHMSA's Hazmat Incident Reports for Rail, while information on total volumes moved by rail came from DOT's Surface Transportation Board Freight Commodity Statistics.
- PHMSA rail incident data contains numerous examples of multiple reports with the same incident ID. In some cases this was due to updating quantities or other information about a spill. OCIA analysts averaged the quantities of the commodity because the final was not evident. In other cases, where there was a release of multiple commodities, separate reports with the same incident number were generated for each commodity. OCIA analysts treated those spills as separately for calculating total barrels released, but treated the injuries, fatalities, and cost on a per incident basis.
- PHMSA regulations have changed over the period of analysis and affected the timing and the information reported by industry. In 1990, 1991, 1997 and 2005, reporting requirements changed the time to report, expanded requirements to intrastate transportation, and clarified exemption criteria for reporting.
- PHMSA rail incident data is not normalized or weighted for annual changes in the amount of commodity shipped.
- In order to make its analysis comparable between the pipeline and rail data, OCIA restricted its analysis of rail incidents to those involving liquid releases of any commodity type, except where noted. In addition, to improve comparability, rail data captured in gallons was converted to barrels (42 gallons = 1 barrel).



# U.S. transmission pipeline infrastructure, a visual...



*NOTE: Does not include any natural gas pipelines.*

...U.S. transmission hazardous liquid pipeline infrastructure, by the numbers...

Year	Total Liquids Pipeline (miles)	Annual Increase	Crude Oil (miles)	Refined Products (miles)	Highly Volatile Liquids (HVL) (miles)
2008	173,789	2.3%	50,963	61,599	57,024
2009	175,965	1.3%	52,737	61,803	57,233
2010	181,974	3.4%	54,737	64,787	57,980
2011	183,568	0.9%	56,100	64,117	58,599
2012	186,209	1.4%	57,463	64,029	59,861
2013	192,396	3.3%	60,911	63,532	62,742

***Liquids pipeline mileage has increased 9.3% (16,431 miles) within 5 years, with the largest increases in crude oil and HVLs.***

*NOTE: Does not include any natural gas pipelines.*



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...The spill rate of these pipelines remains extremely small...

	Total Volume Transported by Pipeline (barrels)*	Total Unintentional Releases (barrels)*	Release Rate
2009	13,600,000,000	53,937	0.000397%
2010	13,500,000,000	100,229	0.000742%
2011	13,500,000,000	86,570	0.000641%
2012	14,100,000,000	45,861	0.000325%
2013	14,900,000,000	119,225	0.000800%

***Pipelines have been on average 99.9994% reliable from 2009-2013.***

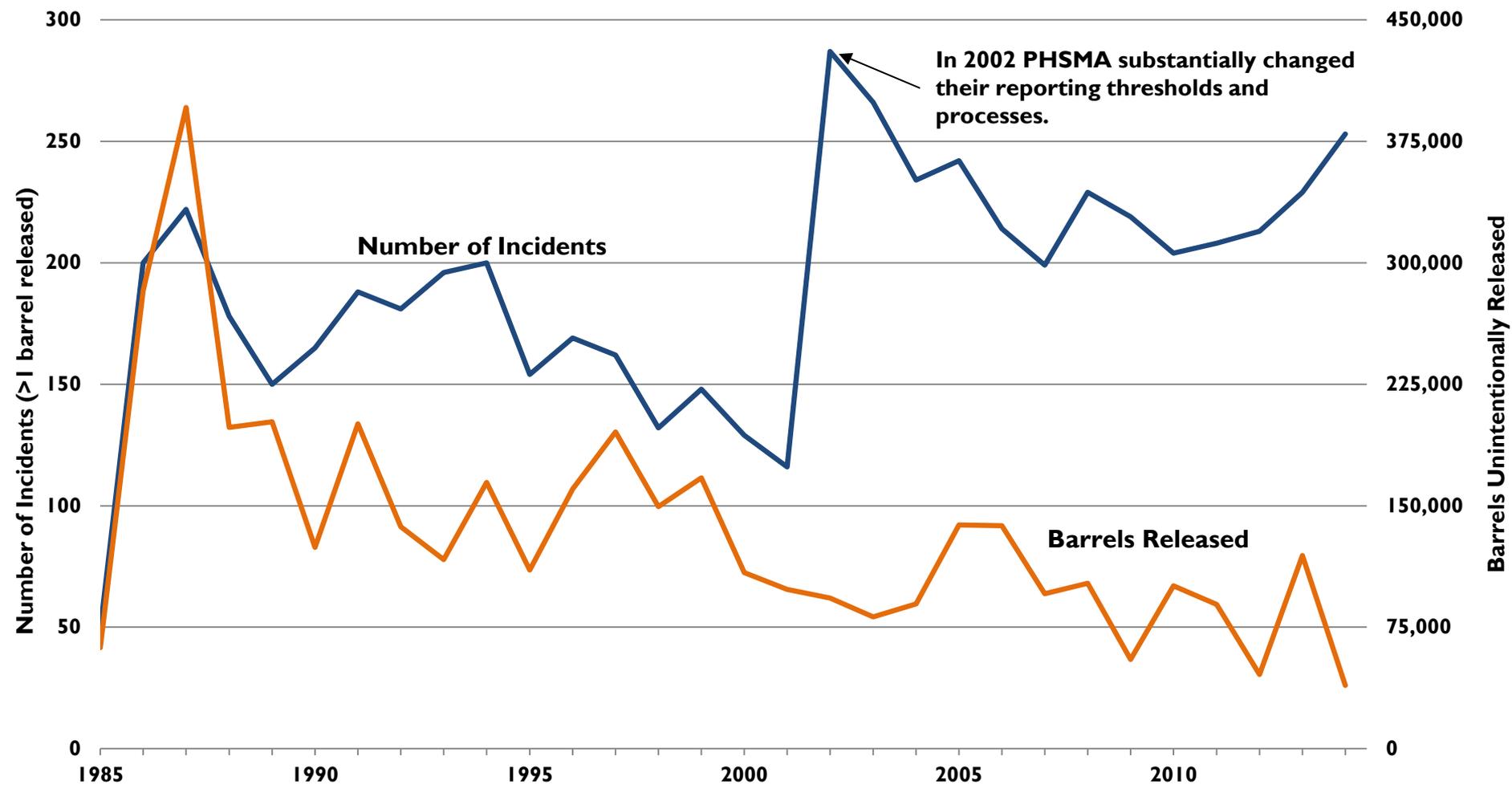
***That means, between 2009-2013, for every 172,000 barrels of product moved by pipeline, on average, 1 barrel spilled.‡***

*\* Only includes crude and refined products, including HVLs, but not CO2, which are captured in the remaining pipeline slides.  
 ‡ While this captures aggregate information, the likelihood and impact of a spill are based on numerous factors associated with an incident and not capable of being captured in a single metric.*



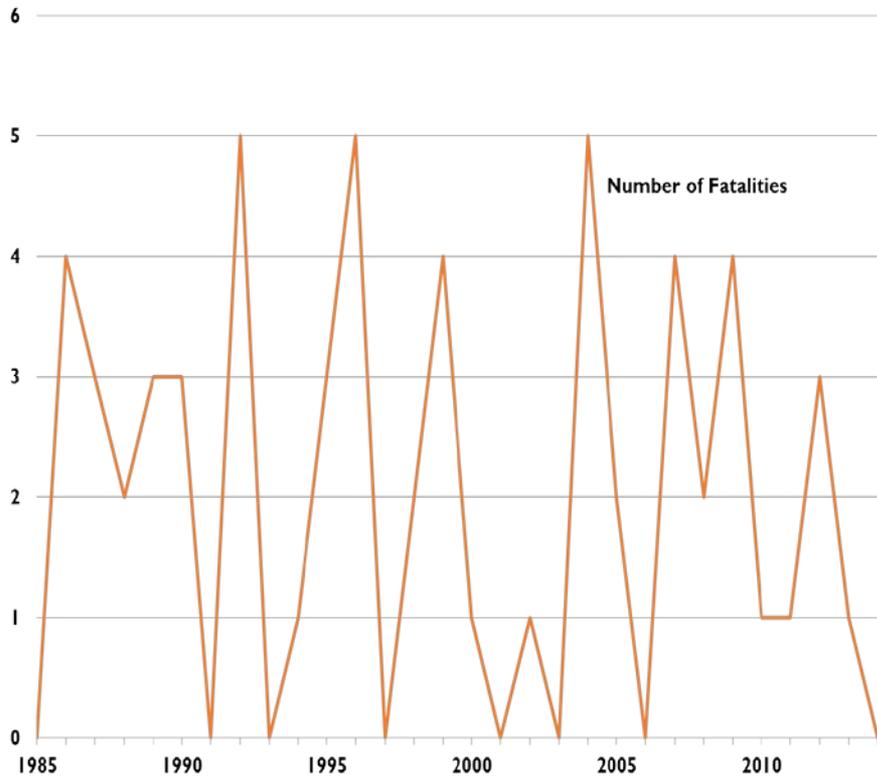
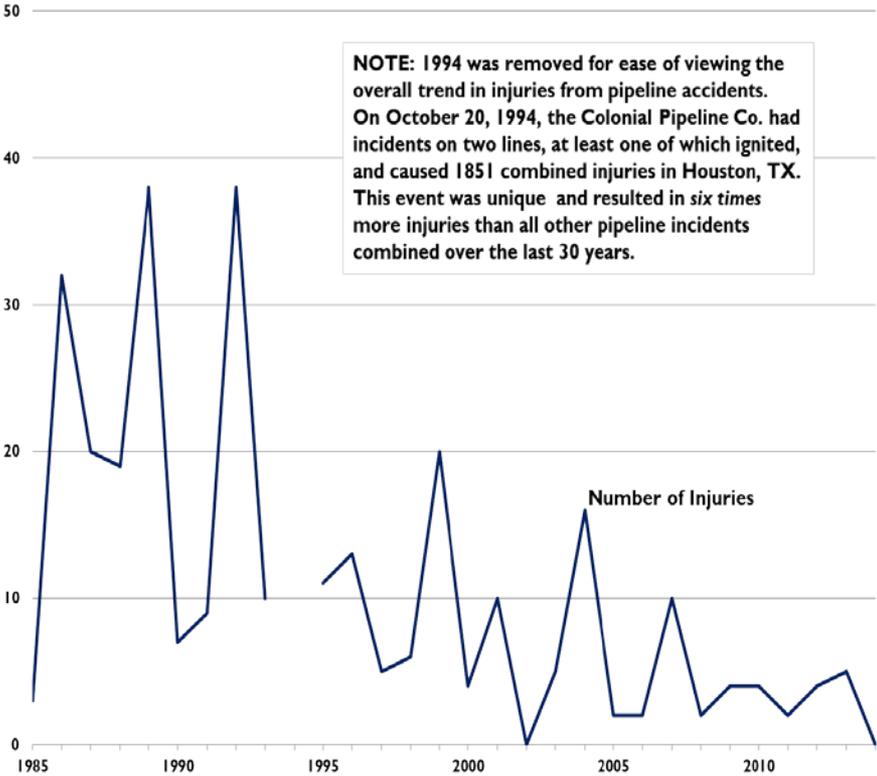
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... While the number of spills has been increasing, the volume of all hazardous liquids spilled is at historic lows. Operators have also recovered over 40% of barrels spilled since 1985...

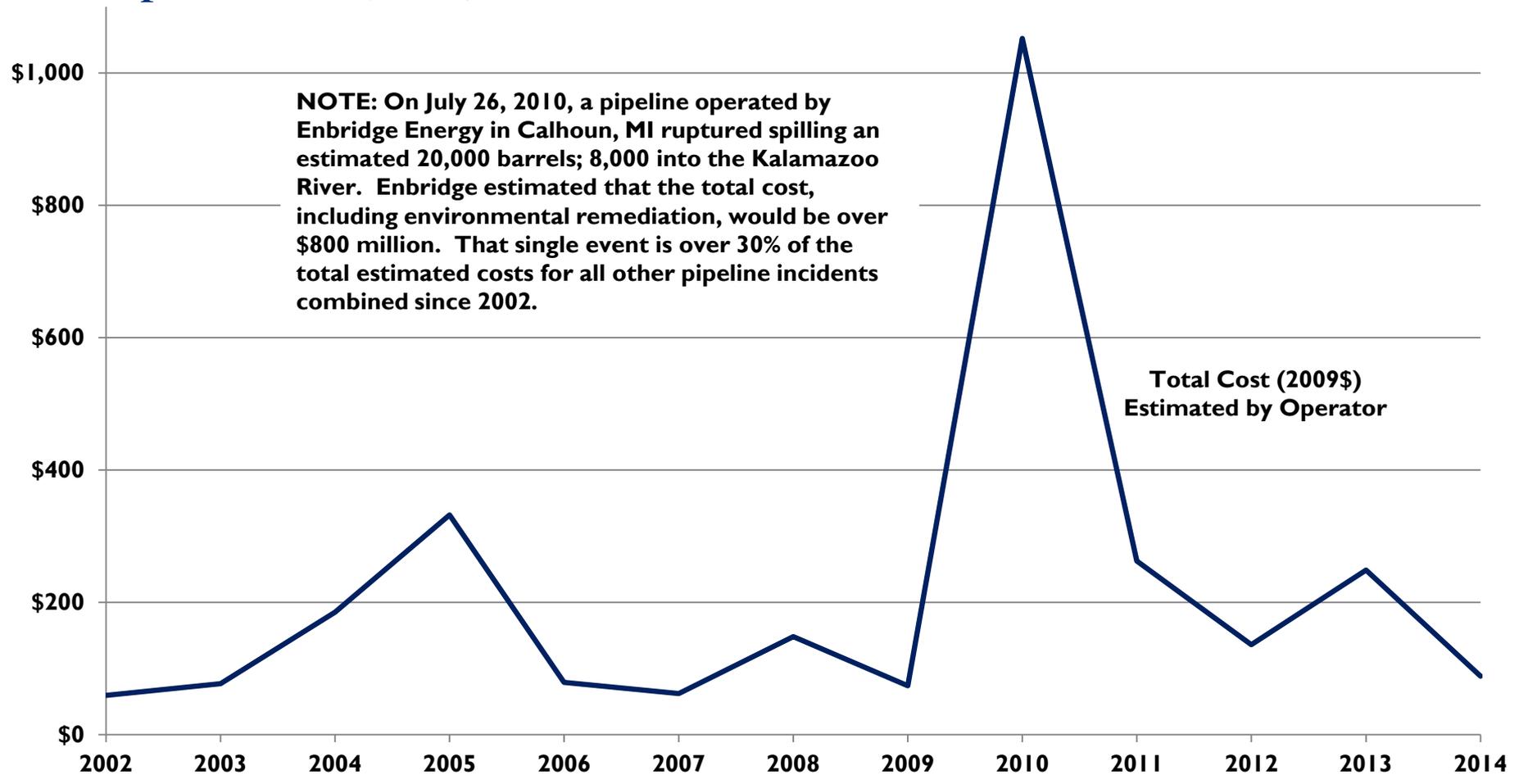


...With one exception (see note), injuries have been declining in a similar fashion to the amount of product spilled, however, fatalities have been uncommon and highly variable...

**NOTE:** 1994 was removed for ease of viewing the overall trend in injuries from pipeline accidents. On October 20, 1994, the Colonial Pipeline Co. had incidents on two lines, at least one of which ignited, and caused 1851 combined injuries in Houston, TX. This event was unique and resulted in six times more injuries than all other pipeline incidents combined over the last 30 years.



...The overall costs of spills, as estimated by the operators, have generally remained between \$50-\$300 million nationwide per year, with one exception, since reporting began in 2002. Environmental remediation costs make up the bulk (37%) of total estimated costs since 2002....



**NOTE: On July 26, 2010, a pipeline operated by Enbridge Energy in Calhoun, MI ruptured spilling an estimated 20,000 barrels; 8,000 into the Kalamazoo River. Enbridge estimated that the total cost, including environmental remediation, would be over \$800 million. That single event is over 30% of the total estimated costs for all other pipeline incidents combined since 2002.**

**Total Cost (2009\$)  
Estimated by Operator**



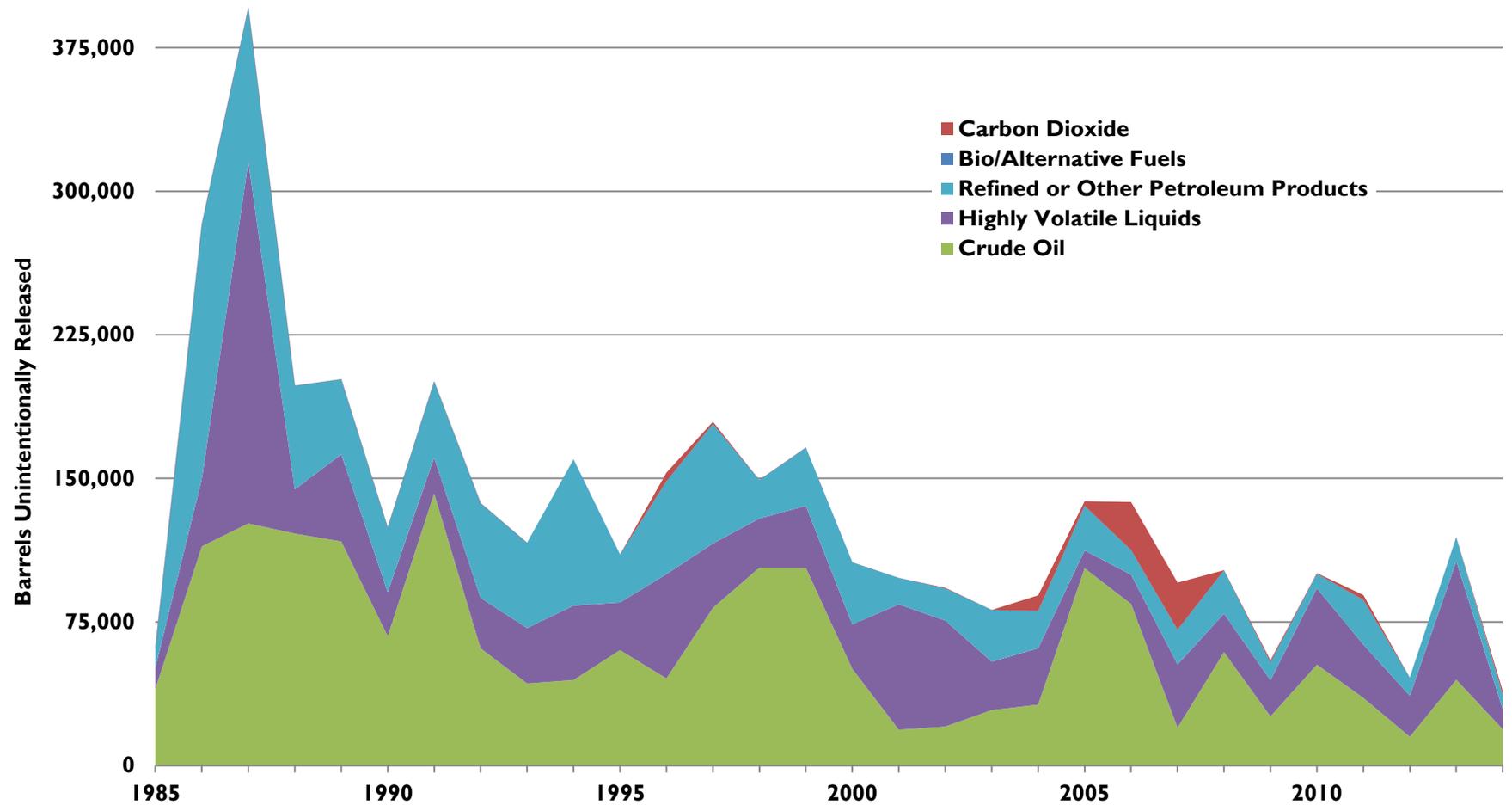
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# ...Examples of the types of hazardous and other liquid commodities carried by U.S. pipelines, categorized based on PHMSA reporting guidelines...

- Crude Oil
- Refined and/or Petroleum Product which is a Liquid at Ambient Conditions
  - Gasoline (non-Ethanol)
  - Diesel, Fuel Oil, Kerosene, Jet Fuel
  - Mixture of Refined Products (transmix)
- Highly Volatile Liquid (HVL) or Other Flammable or Toxic Fluid which is a Gas at Ambient Conditions
  - Anhydrous Ammonia
  - Liquefied Petroleum Gas, Natural Gas Liquid
- Carbon Dioxide
- Biofuel/Alternative Fuel
  - Fuel Grade Ethanol
  - Ethanol Blend
  - Biodiesel

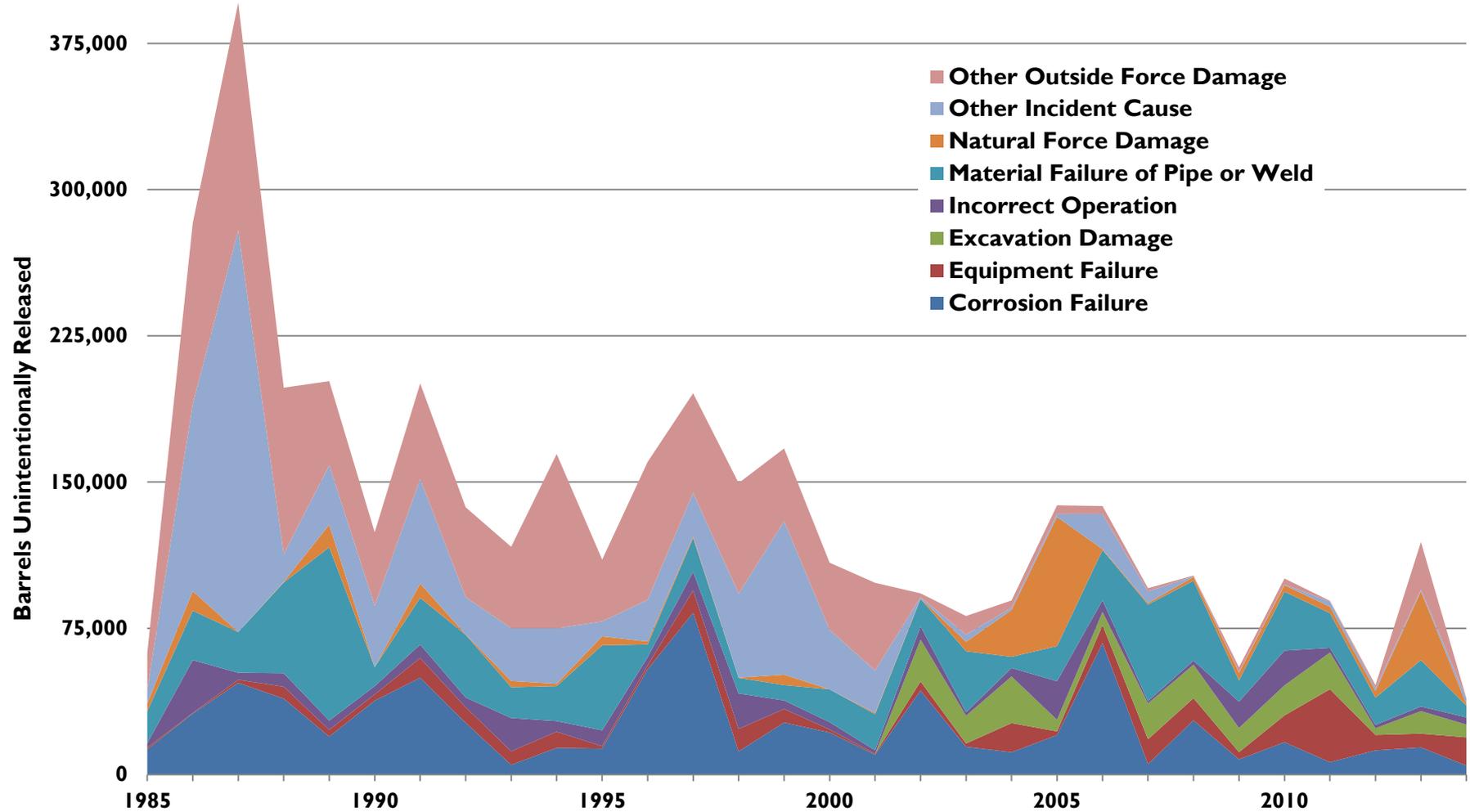
...The barrels of unintentionally released products has generally trended down, with the reduction in refined product spills being most pronounced...



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...The causes of pipeline spills have seen more changes over the past 30 years...



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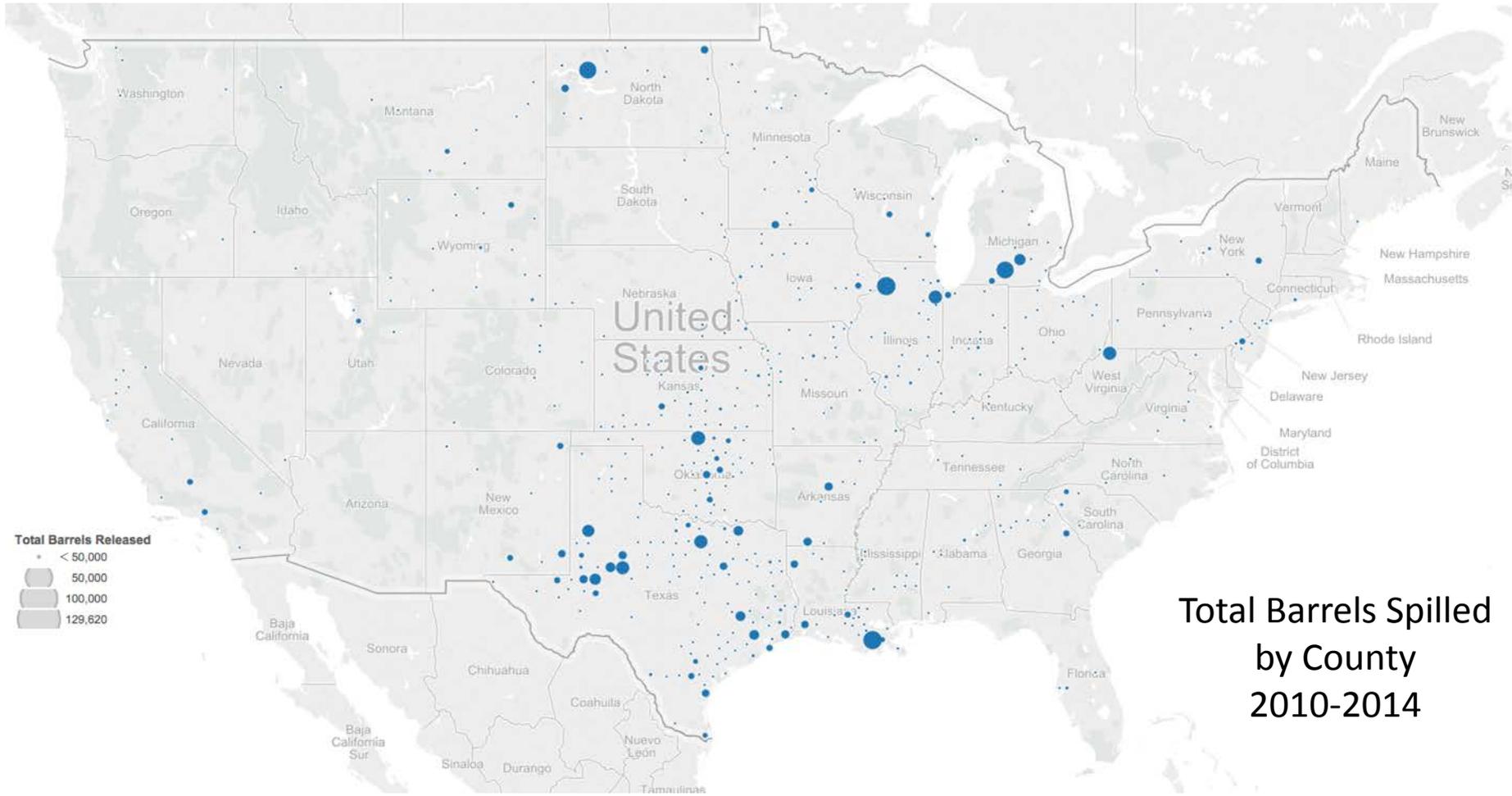
# ...Examining the causes of spills over various time horizons highlights potential infrastructure resilience challenges...

Cause of Spill	30 Years	10 Years	5 Years
Incorrect Operation	5%	8%	7%
Equipment Failure	6%	13%	20%
Material Failure of Pipe or Weld	17%	26%	23%
Corrosion Failure	19%	20%	14%
Excavation Damage	4%	13%	14%
Natural Force Damage	5%	13%	12%
Other Outside Force Damage	25%	5%	8%
Other Incident Cause	19%	4%	2%

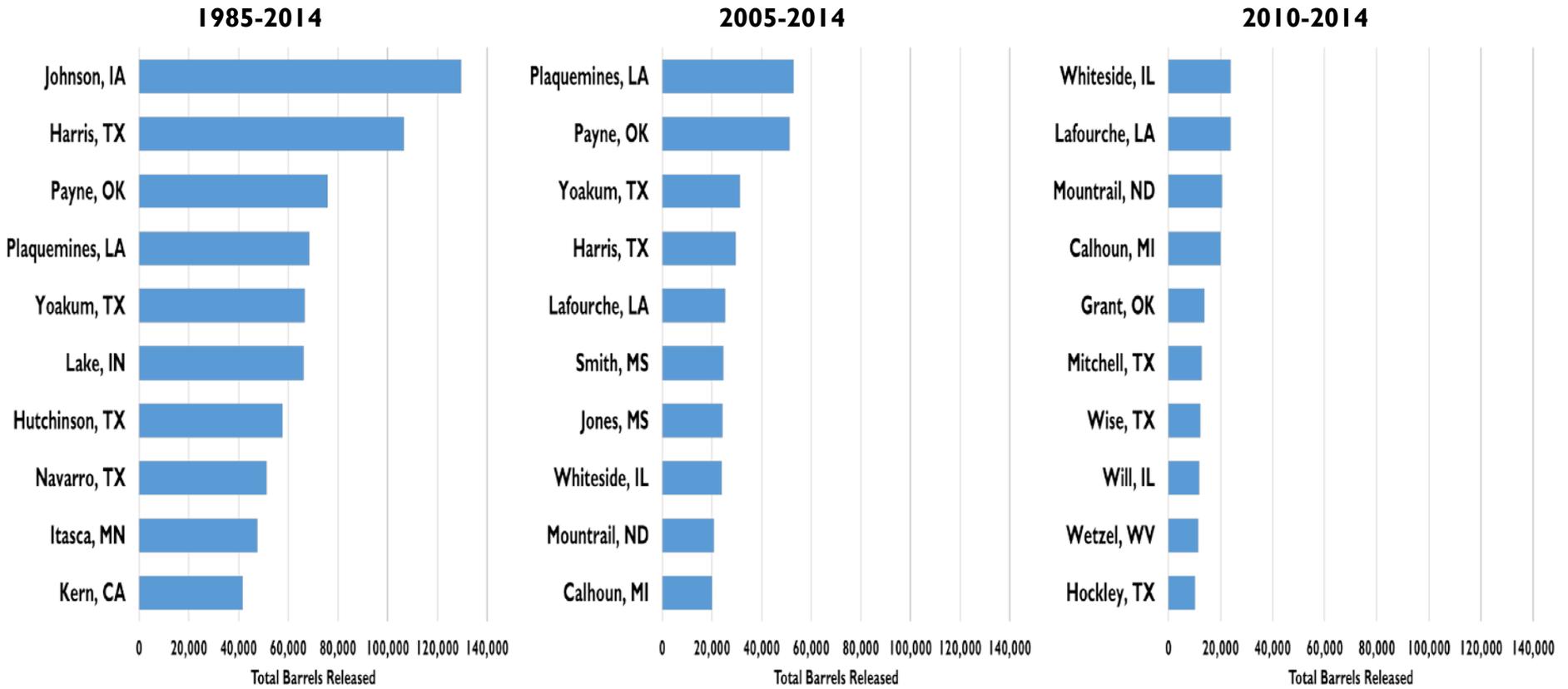
- Material and Equipment Failures have seen the most sizeable increases, possibly due to aging pipeline systems
- Increases in Natural Force and Excavation Damage are more likely associated with reporting changes, as they were previously lumped under Other Outside Force Damage prior to 2002



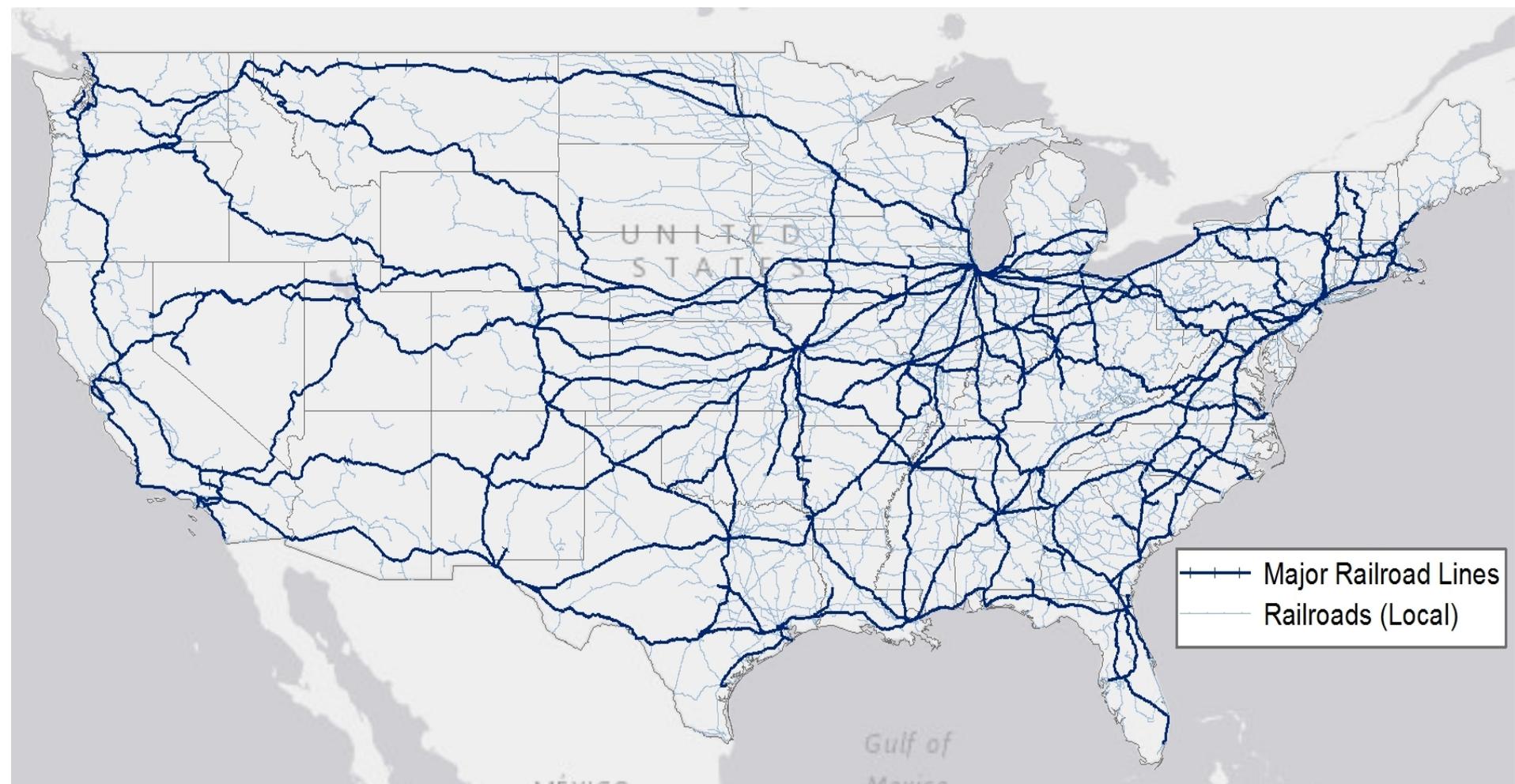
...but, since 2010, the Midwest has seen an increasing share of much smaller pipeline spills...



...The counties with the largest spills reflect subtle geographic changes, and the overall reduction in amount of product spilled.



# U.S. railroad infrastructure, a visual...



# ...U.S. rail infrastructure, by the numbers...

Year	Class 1 Freight (miles)	Regional (miles)	Total (miles)	Car Loads Liquid HAZMAT
2008	118,859	19,511	169,389	1,320,226
2009	118,649	15,048	169,082	1,280,755
2010	95,573	10,407	168,803	1,306,993
2011	95,387	10,355	168,755	1,255,709
2012	N/A	N/A	N/A	1,726,558
2013	N/A	N/A	N/A	1,942,525

***Railroad track miles have slightly decreased. However, car loads of hazardous material has increased by 47%.***



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N/A = Not available at this time

...The spill rate of liquid HAZMAT on railroads is extremely small, but not as small as pipelines...

Year	Total Volume Liquid HAZMAT Transported by Rail (Tons)	Estimated Total Volume Liquid HAZMAT Transported by Rail (Barrels)*		Barrels Released	Release Rate	
		LOW	HIGH		LOW	HIGH
2009	112,039,947	28,009,986.75	12,448,883.00	3,192	0.00011%	0.00026%
2010	113,888,068	28,472,017.00	12,654,229.78	6,104	0.00021%	0.00048%
2011	108,921,380	27,230,345.00	12,102,375.56	9,255	0.00034%	0.00076%
2012	150,967,705	37,741,926.25	16,774,189.44	7,084	0.00019%	0.00042%
2013	170,175,432	42,543,858.00	18,908,381.33	14,335	0.00034%	0.00076%

***Railroads have been on average between 99.946% and 99.976% reliable from 2009-2013 in the movement of liquid HAZMAT.***

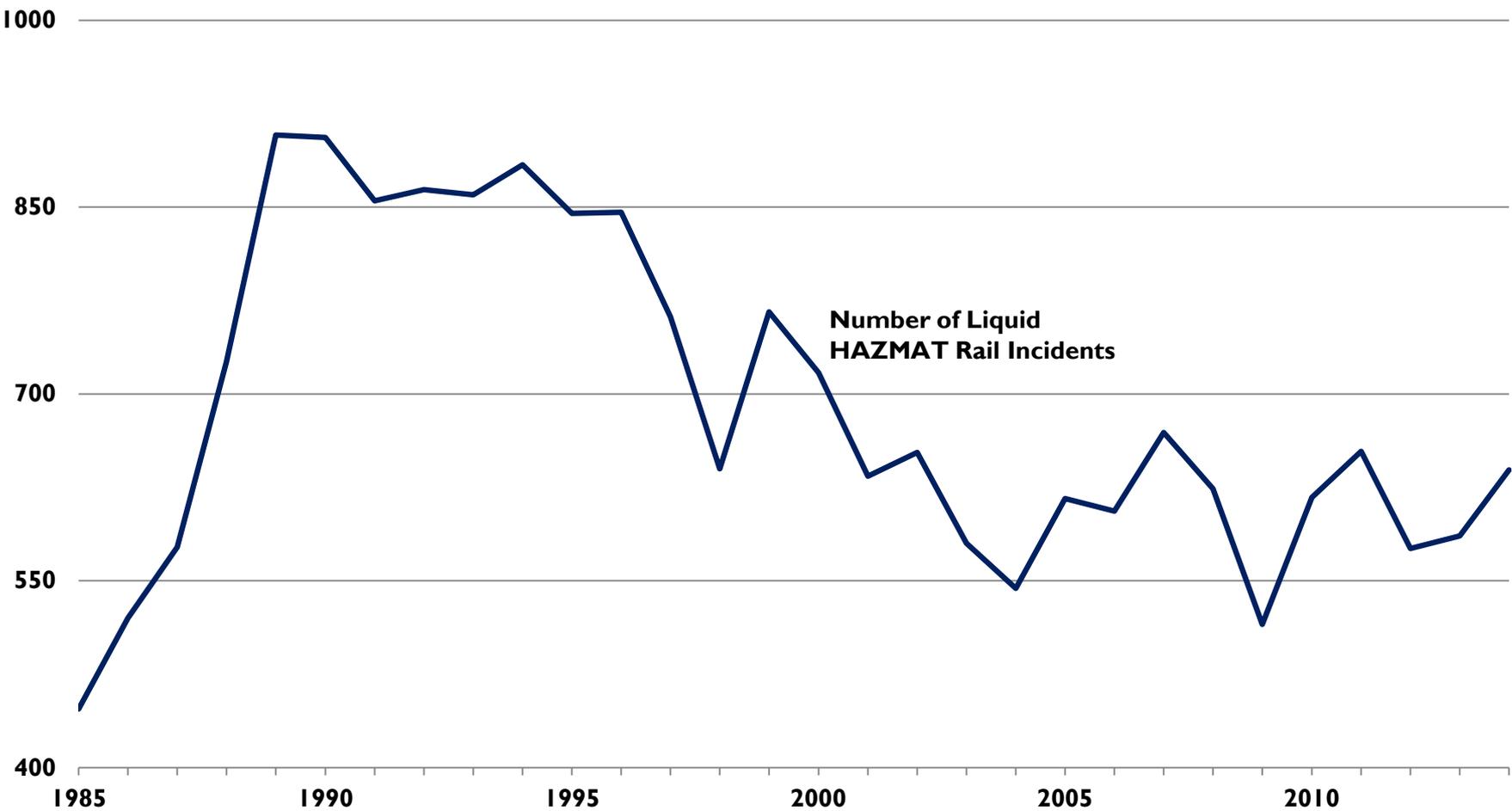
***That means, between 2009-2013, for every 1860 and 4200 barrels of liquid HAZMAT moved by rail (depending on the commodity weight), on average, 1 barrel spilled.‡***

\* Barrels are estimated for a range of possible commodity weights ranging from 4 barrels per ton (LOW) to 9 barrels per ton (HIGH).  
 ‡ While this captures aggregate information, the likelihood and impact of a spill are based on numerous factors associated with a incident and not capable of being captured in a single metric

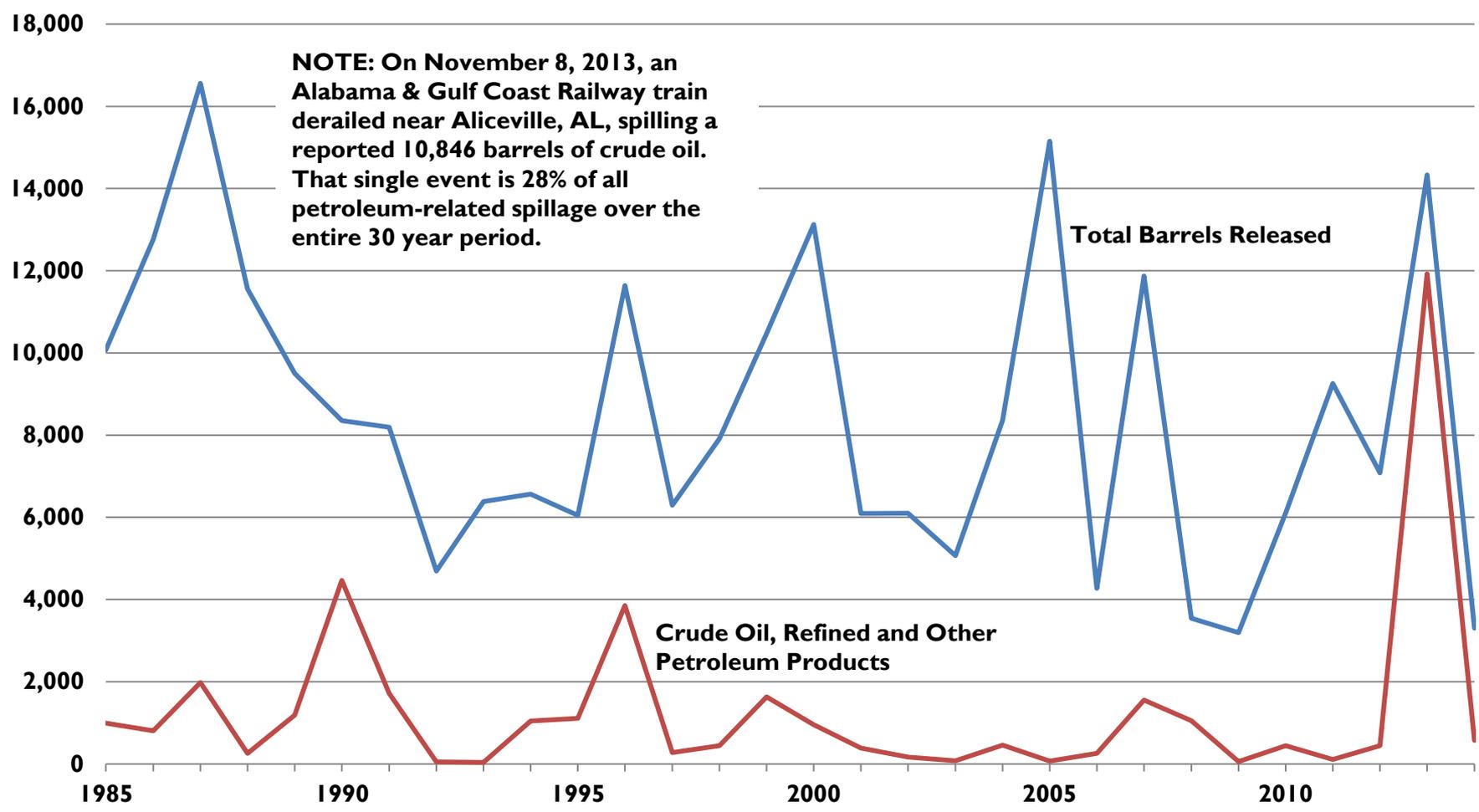


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...The number of incidents within the scope of our analysis declined substantially since the late 1980s and early 1990s, but since 2001 the overall trend has been more stable, despite year to year fluctuations...



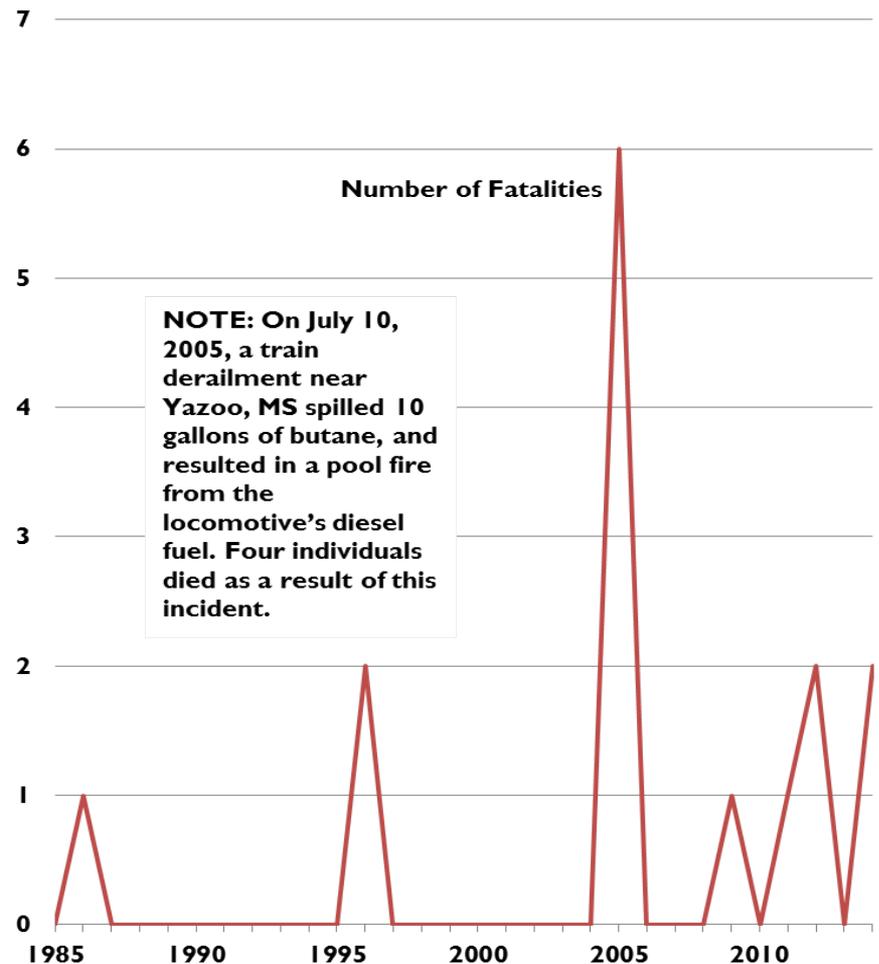
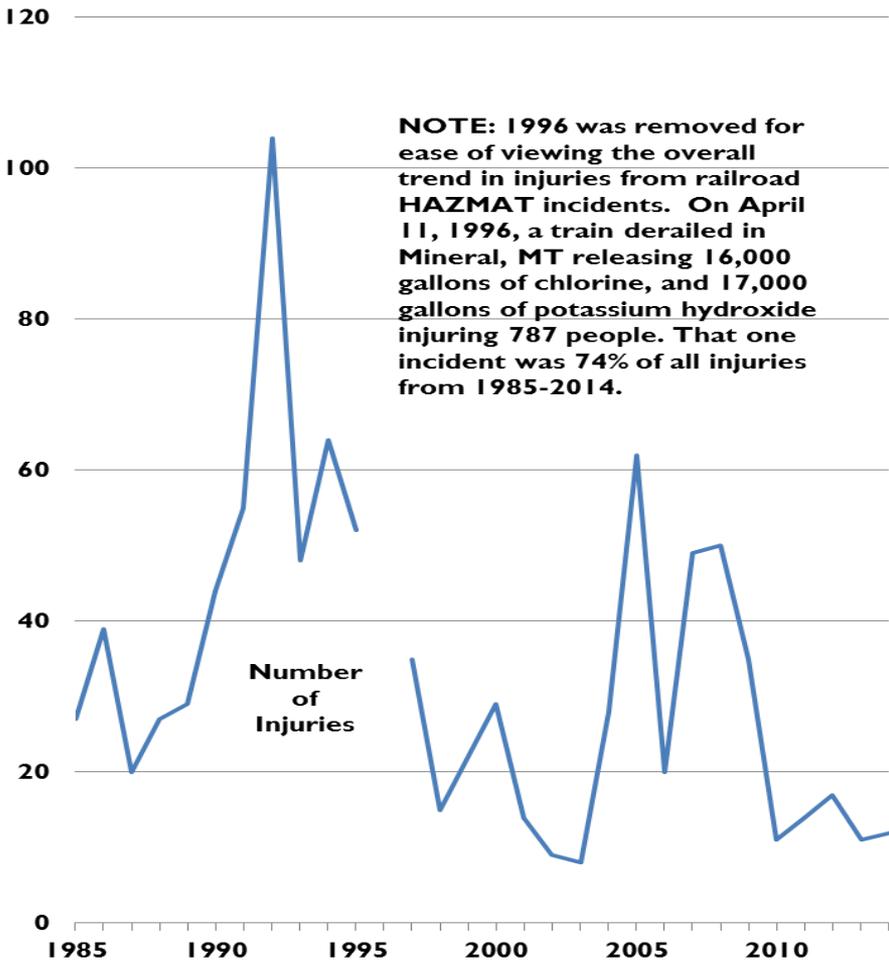
...The volume of HAZMAT spills has fluctuated substantially, but has been dominated by non-petroleum related products with the exception of a large spill in Alabama in 2013...



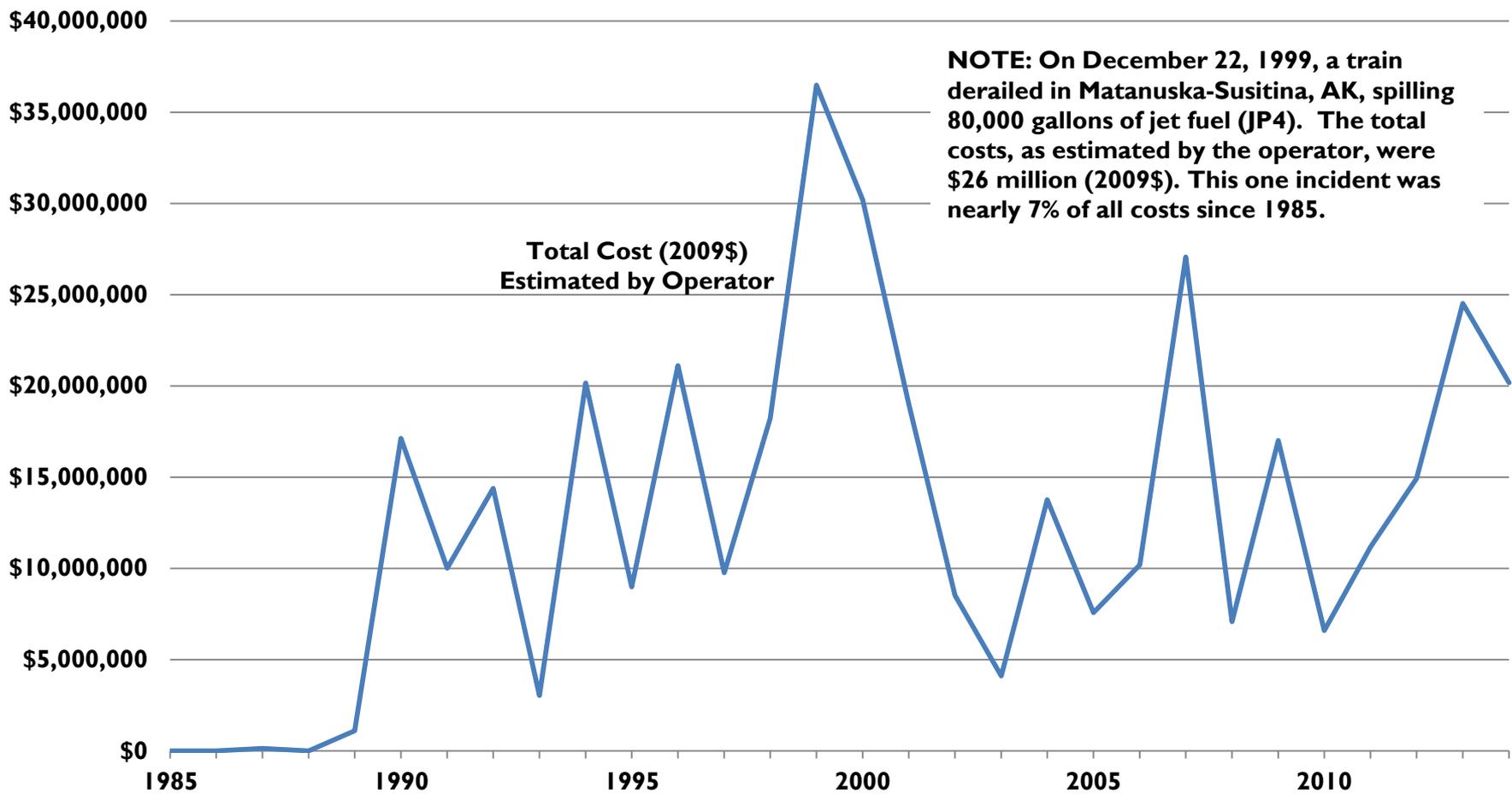
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...With one exception (see note), injuries have been generally declining, and fatalities have been uncommon and highly variable...



...The overall costs of spills, as estimated by the operators, have generally remained between \$7-\$20 million per year, with one exception (see note). Environmental remediation costs make up the bulk (40%) of total estimated costs since 1985....

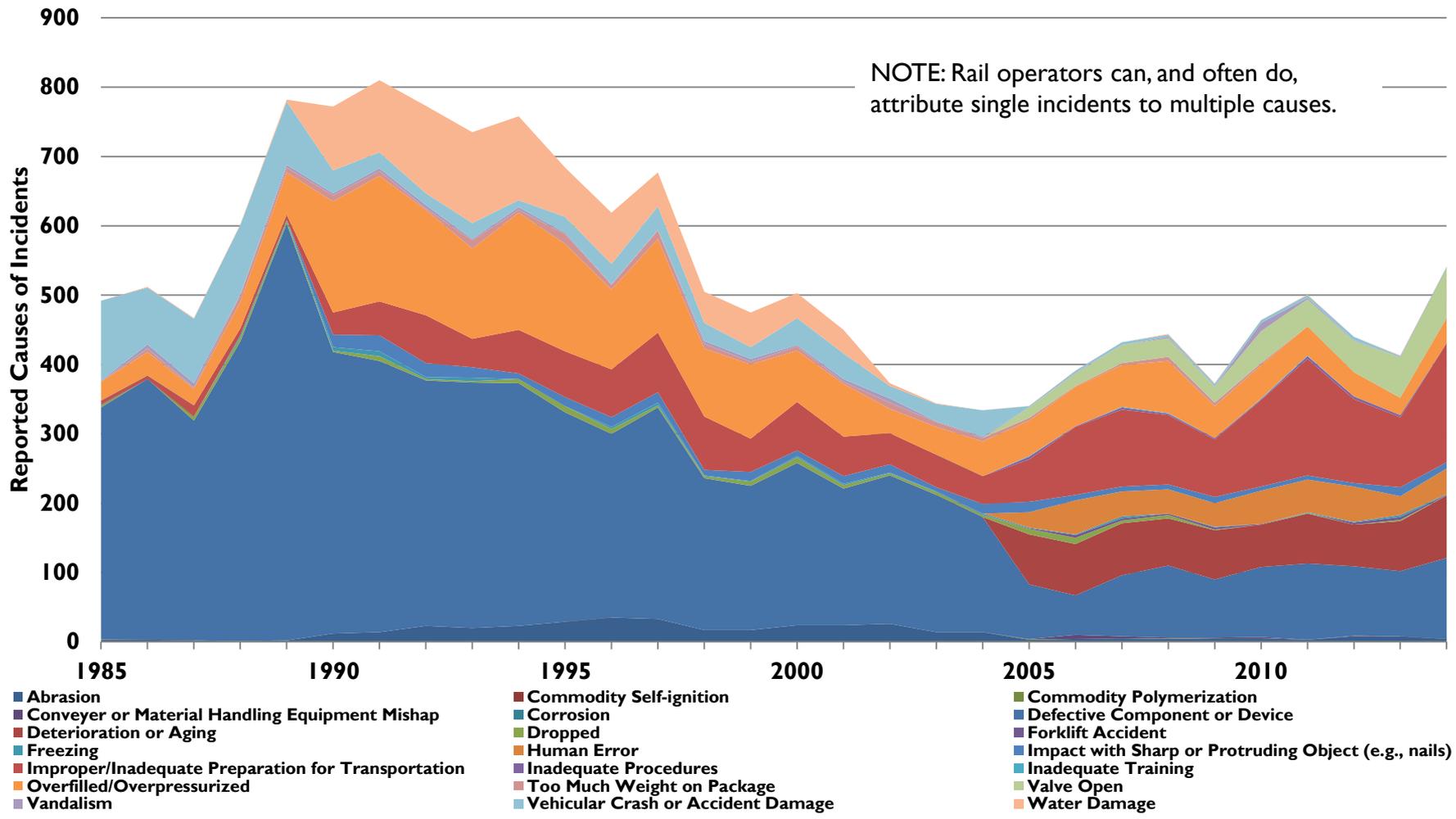


**NOTE: On December 22, 1999, a train derailed in Matanuska-Susitina, AK, spilling 80,000 gallons of jet fuel (JP4). The total costs, as estimated by the operator, were \$26 million (2009\$). This one incident was nearly 7% of all costs since 1985.**



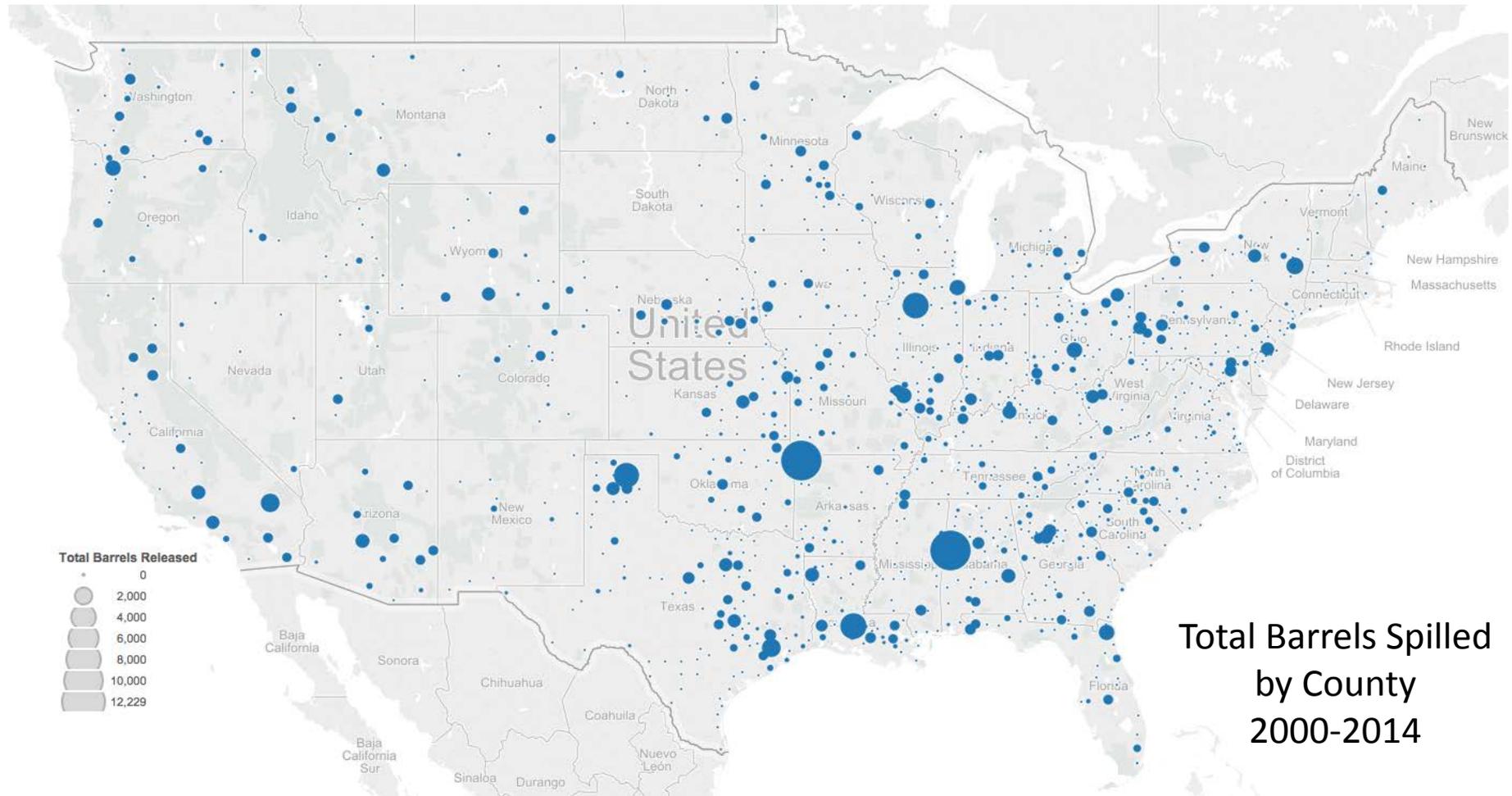
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...The reported causes of rail HAZMAT incidents have largely shifted because of increasing reporting standards, but inadequate preparation for transportation now makes up the largest share of reported causes...



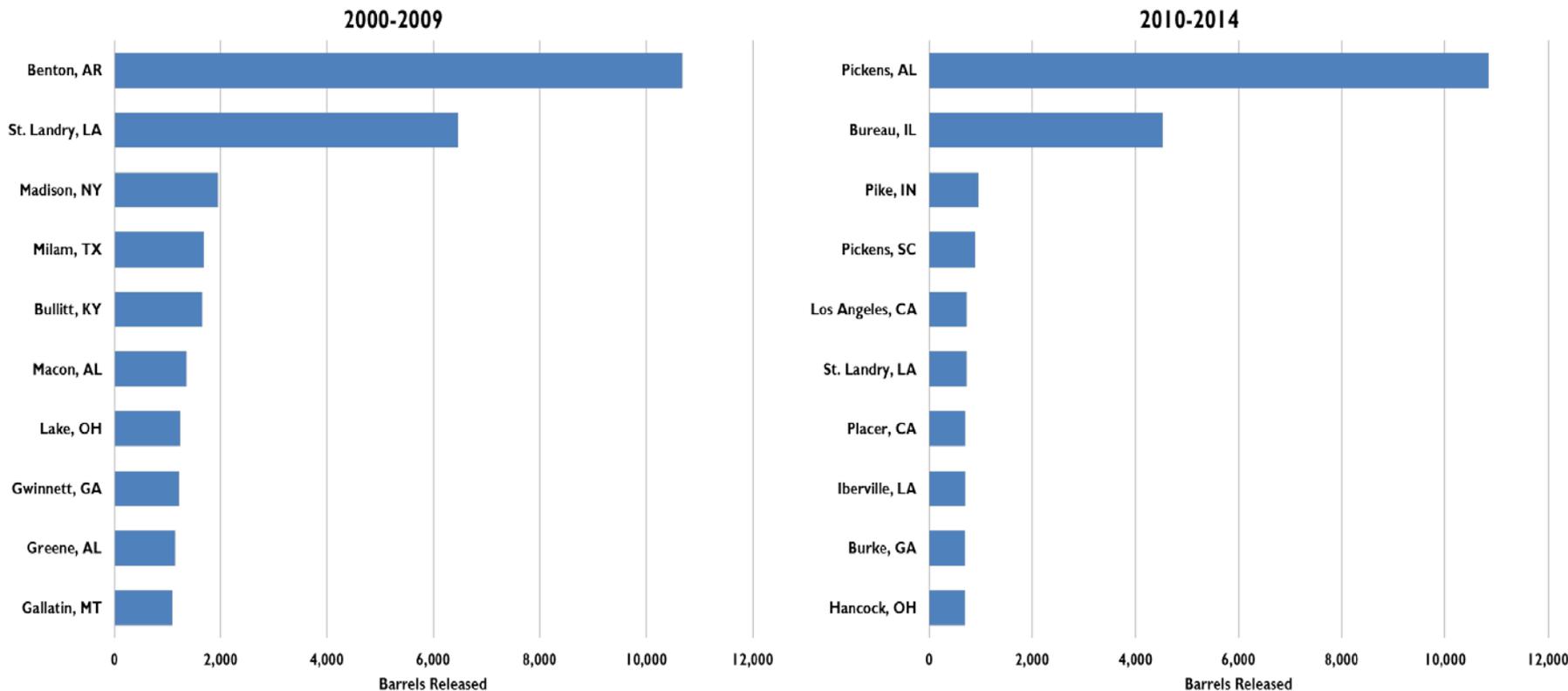
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...Since 2000, rail incidents resulting in HAZMAT spills have been concentrated in the Midwest and are dominated by a small number of larger spills...

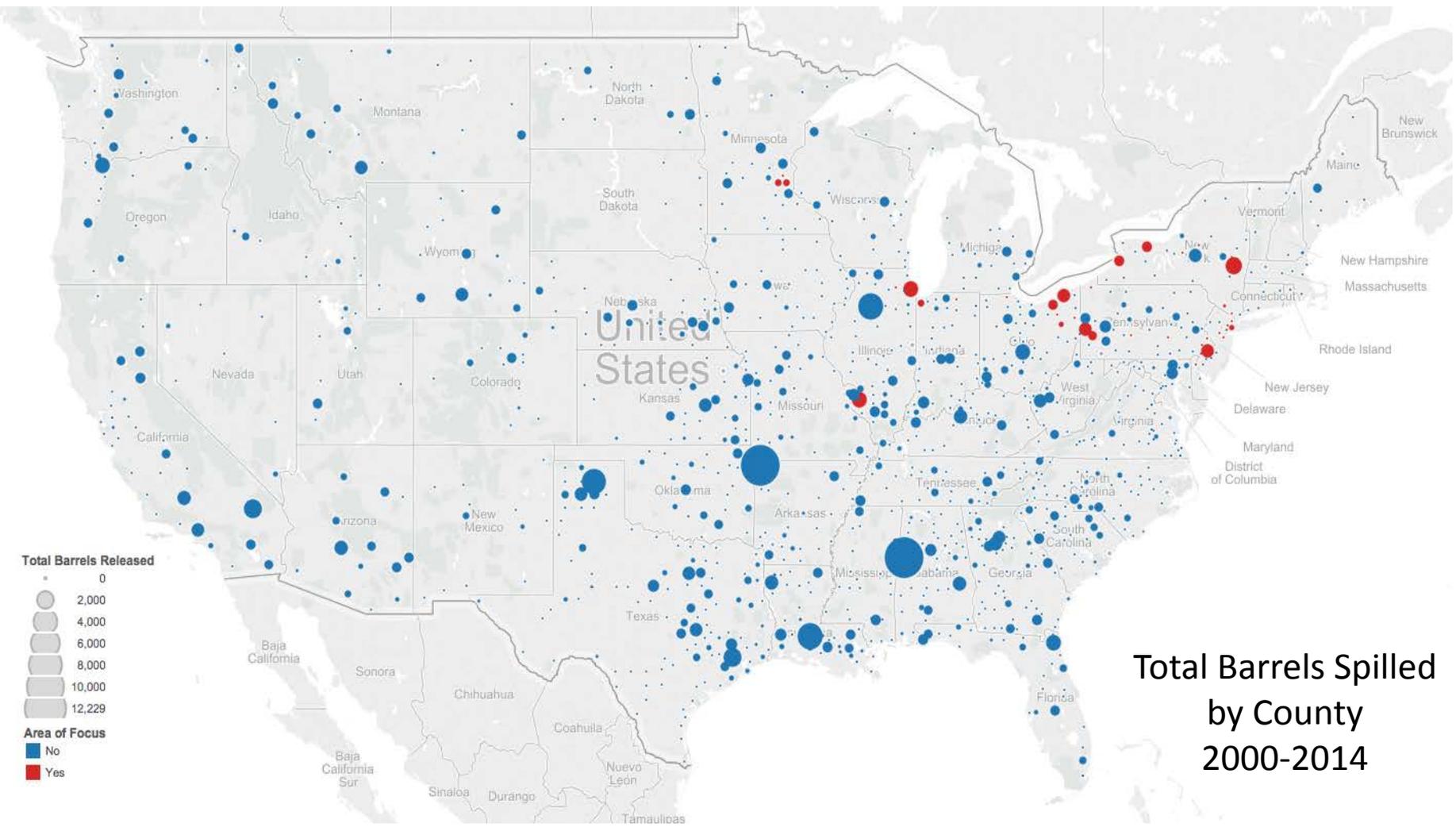


Total Barrels Spilled by County 2000-2014

...While the geospatial information in data collected prior to 2000 made it not well suited to analyze here, since 2000 the scale of incidents has remained similar and only a single county, St. Landry, LA appears in the top 10 counties during the two analyzed periods...



...The areas of focus (see next slide for a fuller explanation) identified by OCIA's July 2014 analysis of industry data provided under DOT's Emergency Order do not feature prominently in liquid HAZMAT spills since 2000...



Total Barrels Spilled by County 2000-2014

...These areas of focus\* were compared to all other counties by total barrels released by rail incidents during two time periods. Lake County, OH was the only one in the top 10 of counties (and only during the 2000-2009 period), and the vast majority of focus areas were below the top 100 or had no spills...

Area of Focus	Rank (2000-2009)
Lake, OH	7
St. Clair, IL	16
Monroe, NY	19
Cuyahoga, OH	42
Philadelphia, PA	47
Albany, NY	49
Cook, IL	51
Allegheny, PA	68
Beaver, PA	72
Hennepin, MN	89
Hudson, NJ	100

Area of Focus	Rank (2010-2014)
Allegheny, PA	50
Cook, IL	57
Albany, NY	66
Philadelphia, PA	70
Hennepin, MN	82
Ramsey, MN	97

\* The areas of focus identified by OCIA in July 2014 were based on counties with population density over 1,000 people/sq. mile within a half a mile of a route with more than fourteen trains per week moving more than one million gallons of shale crude oil.



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