Review of the
US Department of Transportation Report
The State of the National Pipeline Infrastructure

Analysis by
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The US Department of Transportation runs the Pipeline and Hazardous Materials Safety Administration (PHMSA). Among other tasks, PHMSA tracks pipeline incidents in the United States. The records of all reported incidents is available via the PHMSA website, and the records include data from 1986 to 2013. The PHMSA files include over 13,700 reported incidents as of June, 2013. Nearly 8000 incidents are designated as significant by PHMSA. Only the significant events are considered here. Quoting from the PHMSA website:

> *PHMSA defines Significant Incidents as those incidents reported by pipeline operators when any of the following specifically defined consequences occur:*
>
> *1. fatality or injury requiring in-patient hospitalization,*
> *2. $50,000 or more in total costs, measured in 1984 dollars,*
> *3. highly volatile liquid releases of 5 barrels or more or other liquid releases of 50 barrels or more,*
> *4. liquid releases resulting in an unintentional fire or explosion.*

In 2011 PHMSA produced a report for the Department of Transportation entitled *The State of the National Pipeline Infrastructure*. We will refer to this as the DOT/PHMSA report. This report uses the significant incident records to describe the state of the national pipeline infrastructure at the time of the report. The report was originally open for review and public comment in 2011. As far as we know a revised or updated report has not been released.

The author conducted an independent study of the PHMSA significant incident records in July, 2013. To help understand the very large body of data contained in the PHMSA records, the initial goal of the study was to produce a video showing the significant incidents both geographically in the US and in proper time sequence. After that study was completed, the DOT/PHMSA report was discovered on the PHMSA website. Initially the author thought the results given in the report could be used to cross-check and verify the accuracy of our own analysis. However, we quickly found what we believe to be significant errors and omissions in the DOT/PHMSA report. This review describes some of those errors and omissions.

The pipeline incidents are divided into three categories by PHMSA: gas transmission, gas distribution, and hazardous liquids. The DOT/PHMSA report describes these incidents with a series of pie charts which show the seven standardized causes of any incident, with the number of incidents for each cause and the percent of the total for each cause. An example, extracted from the report, is shown below. Quoting from the report:

> *Figures 1 and 2 below show the number and percentage of significant onshore hazardous liquid and gas transmission pipeline incidents attributable to different cause categories during 2006-2010. Only incidents involving line pipe are included (pipeline facilities such as*

pump or compressor stations or tank facilities are not included).

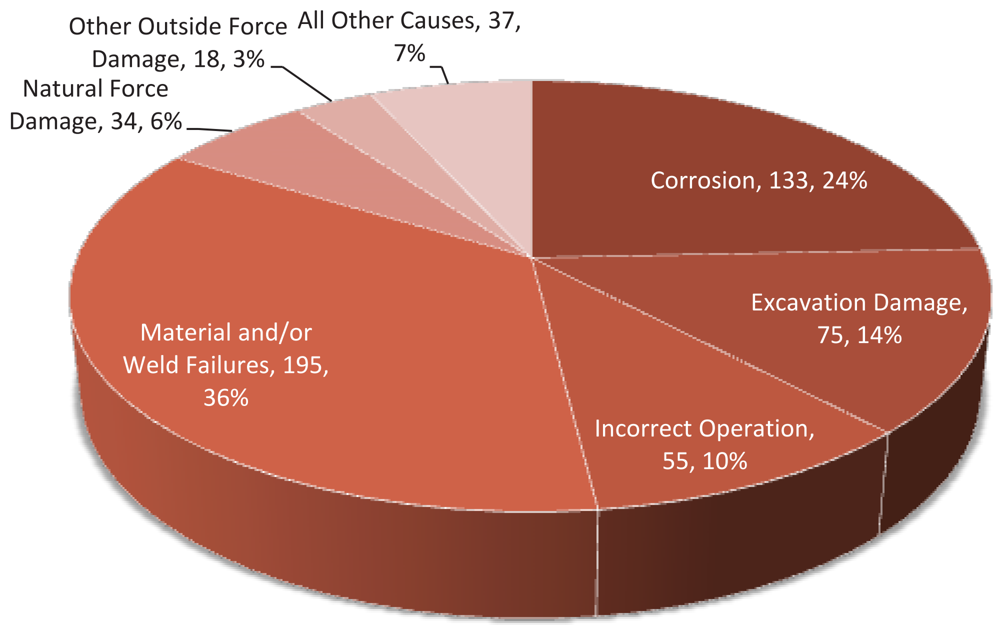

Figure 1 Causes of Significant Onshore Hazardous Liquid Pipeline Incidents

The above figure was extracted from the PHMSA report.

When the author tried to reproduce this figure, he found that he could not if he used the description quoted above. He found significantly fewer events than reported in the pie chart, and the percentages were different. A lengthy analysis ensued to identify the source of the discrepancy between our result and the PHMSA analysis. It turns that it is easy to show that the DOT/PHMSA report description of the data cannot possibly be correct. Take, for instance, the largest cause of pipeline failures, Material and/or Weld Failures. The pie chart shows 195 such failures. If one counts ALL of the Material and/or Weld Failures between 2006 and 2010 there are exactly 195 in the records, but this total includes 30 incidents involving pumps, compressor stations or tank facilities, the very facilities the report claims to exclude from the analysis. The results are similar for all of the other causes. The error also carries over into the report's description of gas transmission pipeline incidents. All incidents were counted, not just the set of incidents restricted to pipelines as the report claims.

Thus, it appears that the description in the text and the charts to which the text refers do not match. It is unknown whether this is deliberate or accidental. But it does lead one to wonder if the reports's analysis and discussion that follows from these faulty data are also in error. Assuming the misrepresentation of fundamental data is accidental, it does suggest that the person writing the report did not have personal, intimate knowledge of the data set.

Even if one actually restricts the analysis to just pipelines as the report claims, the appearance of the pie chart does not change much because the percentages change only modestly. The number of incidents is decreased, so the statistical significance is reduced a little, but probably not enough to make a difference. So does the misrepresentation of the data in the text really matter? That depends on whether the person writing the report continues to make errors because of a limited or possibly faulty understanding of the true data. We believe such errors do exist.

The section of the DOT/PHMSA report titled Pipeline Condition shows a graph with the following description:

> *By some measures, the overall trend in pipeline safety has shown steady improvement over the past two decades. Figure 4 shows pipeline incidents involving death or injury to people have dropped by more than half over the past 20 years.*

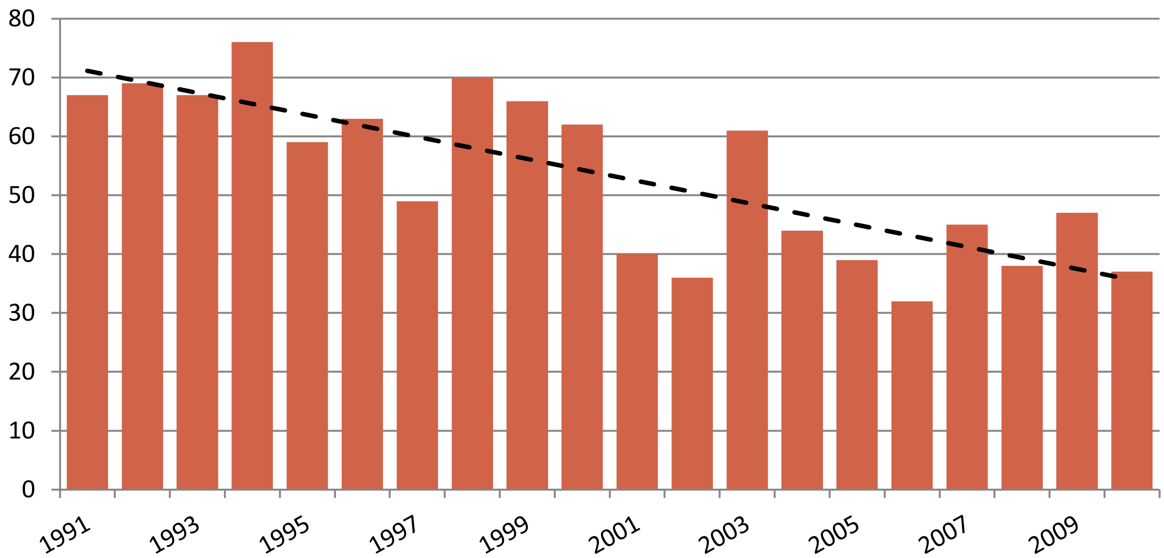

Figure 4 Trends in Pipeline Incidents Involving Death or Injury

The above figure was extracted from the PHMSA report.

There are at least two errors in this presentation. First, the graph seems to misrepresent the true year-to-year variation in the rate as shown in Figure A below. It may be that only some subset of the data are represented by PHMSA. But then one has to ask why some of the injuries (all serious enough to require hospitalization) are not worthy of reporting. Pipeline safety can't be honestly evaluated if many of the injuries are misrepresented.

As one can see from the injury rates shown in Figure A, rates vary greatly from year to year. The simple straight line used by PHMSA does not represent the data properly. While there may have been a downward trend in the early years it has certainly stopped during the last 13 years when so much emphasis has reportedly been placed on improving pipeline safety. The yellow line in Figure A shows the recent average of 43.9 injuries per year. The claimed continuing improvement made by PHMSA is not reflected in the data since 2001. As DOT/PHMSA Figure 4 and our Figure A show, there has been NO significant reduction in injuries since at least 2001. This is the period when the pipeline industry has reportedly spent hundreds of millions of dollars on pipeline safety improvements. Note that 2001 corresponds to the beginning of the George Bush administration. Historians will need to evaluate the significance of that coincidence.

The second serious problem with this graph is that injuries and deaths are lumped together. The separate injury and death rates are shown in the Figure A below. Lumping deaths and injuries together as

PHMSA has done hides the important fact that the death rate has not declined since 1986. It is simply false to claim any improvement in this most important safety measure.

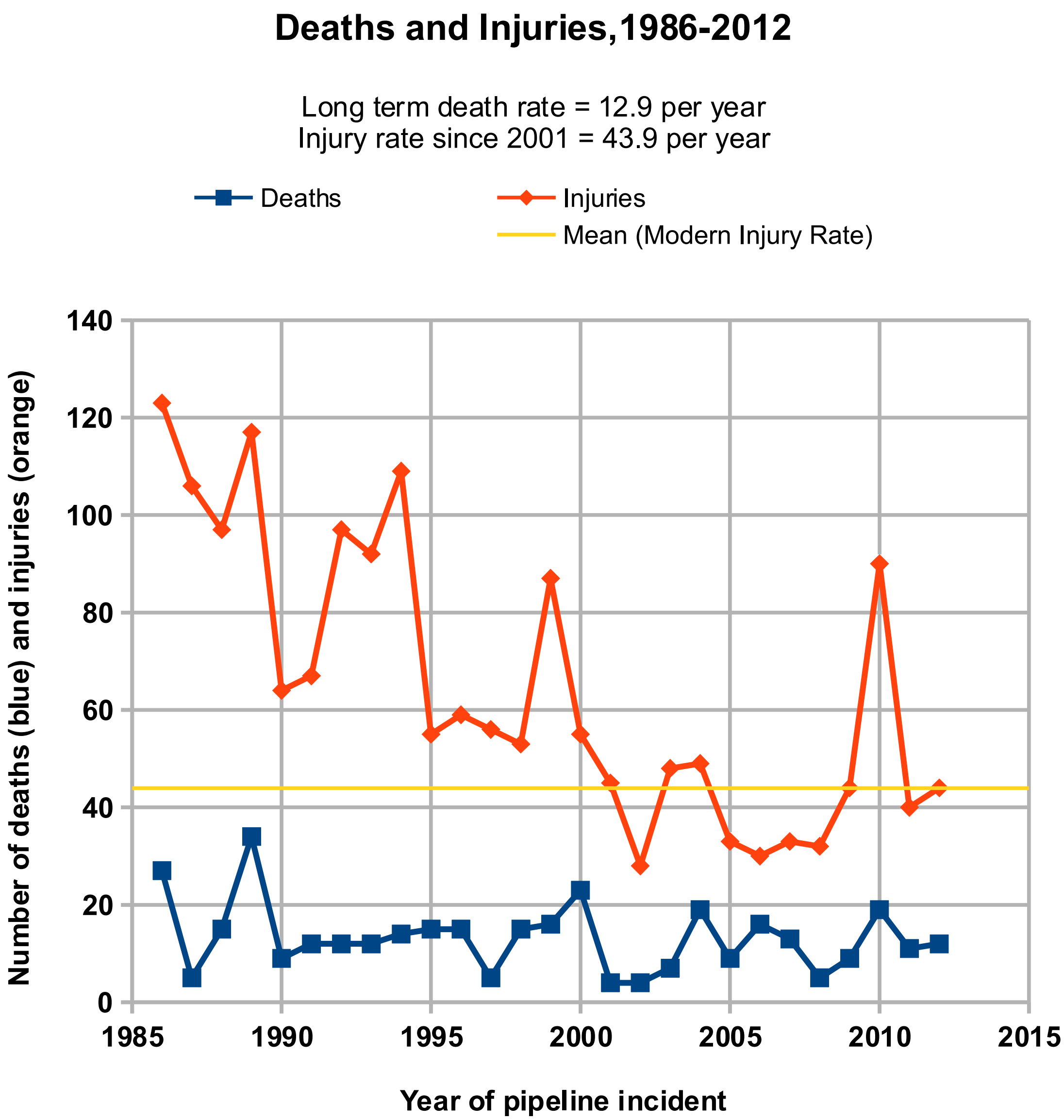

Figure A. Injury and death rates counting all significant incidents.

The author does not believe a straight line fit to the data is appropriate, but if PHMSA were to do that for the period from 2001 to the present they would find an upward sloping line indicating worsening safety rather than improving safety.

Another measure of the safety of the nation's pipelines can be obtained by examining the number of incidents plotted against the age of the failed component. The cleanest measure is produced by looking at incidents involving corrosion, since the extent of corrosion is likely related in many cases to the age of the pipeline. Figure B shows the data.

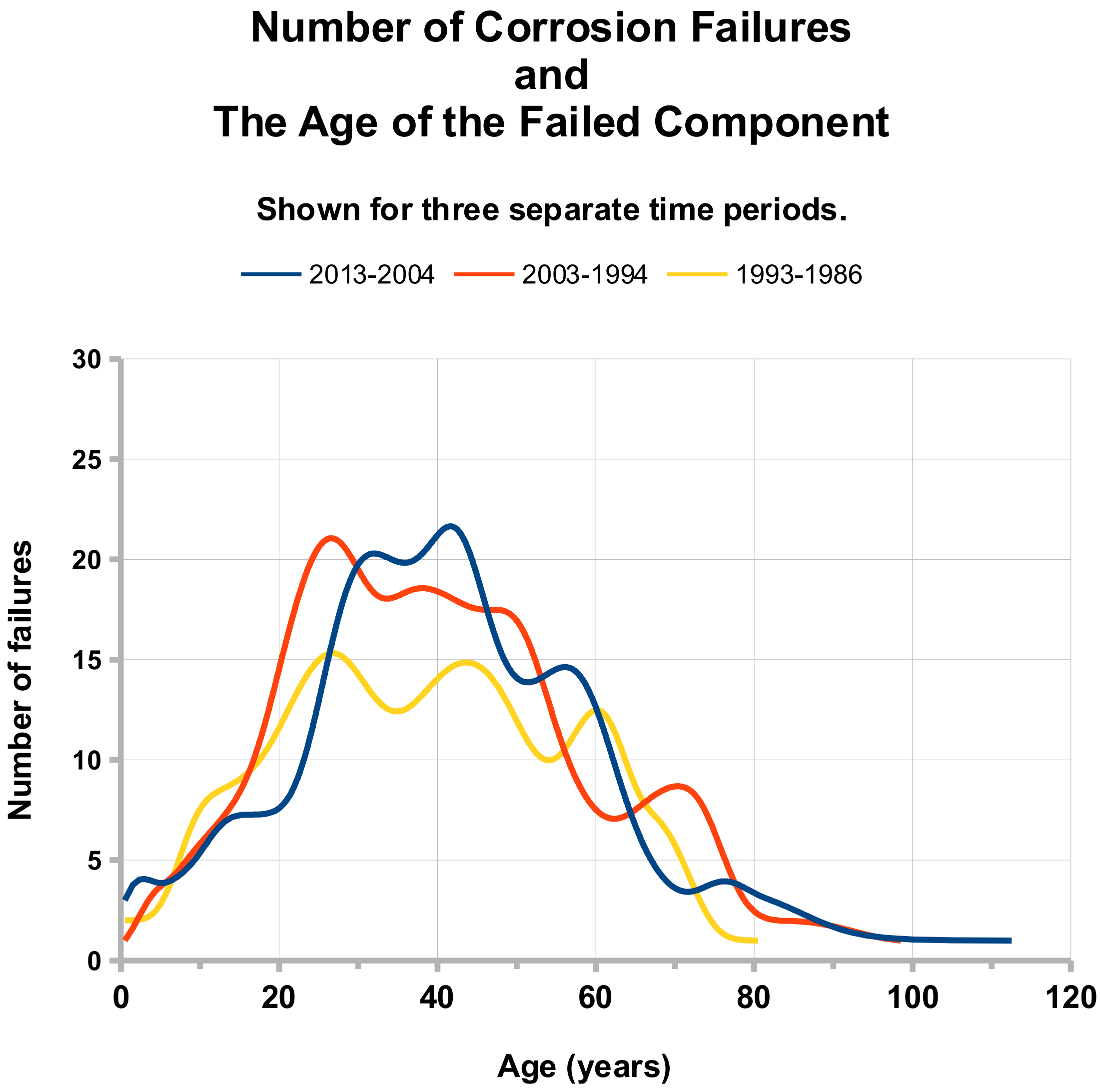

Figure B. Corrosion related pipeline failures for three time periods.

Figure B shows that as pipeline facilities age they fail at a much higher rate and since corrosion accounts for at least ¼ of all failures, these results matter. We divided the data into three time periods to demonstrate an important point. We initially had plotted all corrosion incidents together and then hypothesized that the number of incidents went up because there were a large number of 30 to 40 year old pipes. But Figure B shows that is not the case. Take, for instance, the 2013-2004 decade. If the numbers for that decade reach a maximum at around 40 years just because there are many 40 year old pipes, then the prior decade, 2003-1994, should have had a peak shifted to an age of 30 years since the supposed large number of pipes would be 10 years younger. The peak rate for the period before that, 1993-1986, should have been shifted to an even younger age. Instead we see that all three curves have approximately the same shape and the same age for the peak. The median age for each group is shown in Table 1.

Period	Median Age
1986 through 1993	39.0
1994 through 2003	38.0
2004 through 2013	40.5

Table 1: The median age for each of the three time periods shown in Figure B. There is no significant difference in the three periods.

Figure B and Table 1 demonstrate that the nation's pipeline facilities really have a lifetime of not more than 30 years before corrosion failures increase dramatically. Also note that the number of events has remained relatively constant. These PHMSA data facts contradict pipeline industry claims of dramatic reductions due to corrosion[1].

A few comments about Figure B are worth mentioning. First, the careful reader might wonder why the incident rate starts to drop after about age 50. To answer that question we would need to know much more about the age of all existing pipelines, not just those that have failed and are therefore in the PHMSA incident records. Our hypothesis is that the number of really old pipelines still in use starts to decline and thus the number of incidents goes down as well. PHMSA may have these pipeline age data but the data do not appear to be publicly available. PHMSA should undertake a thorough analysis with all of the data they do have in order to model the observed pipeline failures with age and to better understand the magnitude of the problem with the aging US pipeline infrastructure. Also, they should make publicly available all of the data so that independent analysis can be performed.

Finally, we want to comment on the curves shown in Figure B. Figure B is a complex plot with three sets of data drawn on top of one other. In order to make a less confusing graph we chose to show three smoothed spline curves fitted to the original data points. For those who are concerned that this may hide important features of the data, we include a figure in the Appendix to this report showing the original data points instead of the smoothed curves.

The PHMSA report briefly discusses the replacement of some of the failing old pipelines, and the report cites difficulty and inconvenience (in reconfiguring the pipeline network and in digging up urban corridors) for reasons why aging pipelines may not be replaced. In addition it should be noted that new replacement pipelines are also dangerous. The PHMSA records show that there are more injuries in the first two years of a pipeline's existence than in the next seven years combined. This is a remarkable finding since the number of pipeline facilities in the 0-to-2 year age group is just a fraction of the number in the 0-to-9 year age group. This should be sobering news for anyone advocating new pipelines, including Keystone XL.

PHMSA tries to use total human deaths and injuries to measure pipeline safety. Deaths and injuries, while critical, is just one measure of safety. Another measure is safety for the environment. To assess that we show Figure C. This Figure shows the net oil spilled each year from oil pipeline failures per PHMSA records. While we see that the amount spilled varies from year to year around the mean of about 32,000 barrels (1,344,000 gallons at 42 gallons per barrel) it is obvious that no improvement has occurred in the last 25 years. 2013 may be one of the worst years, with over 50,000 net barrels of oil spilled so far, especially considering that the PHMSA records which we analyzed include data only through June, 2013.

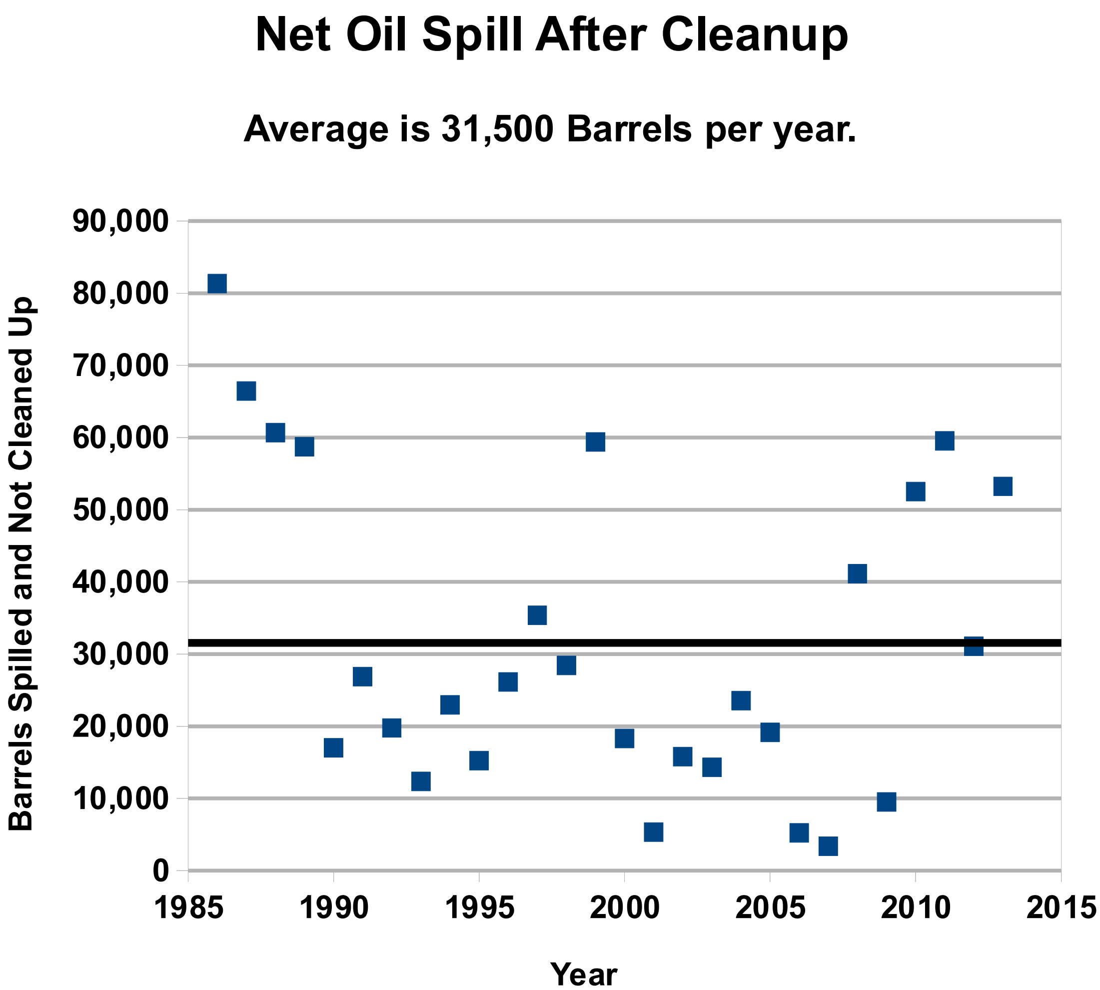

Figure C. The number of barrels of oil spilled in each year from oil pipeline incidents. This is the net spilled, after cleanup is attempted. The gross loss, before cleanup, is of course greater

The PHMSA records do not have sufficient information for us to directly measure environmental damage from this spilled oil not cleaned up. We don't know how much of it entered streams, rivers, and other bodies of water, for instance. Environmental damage can happen due to spilled oil before clean-up efforts begin. Figure C is a conservative indication of potential environmental damage. Gross losses, before cleanup, are even worse, averaging 76,000 barrels per year.

Conclusions

We have shown that the DOT/PHMSA report entitled *The State of the National Pipeline Infrastructure* contains several errors and important omissions. The description of the data presented in the report's Figures 1, 2, and 3 is incorrect. Combining death and injury rates as shown in the report's Figure 4 obscures the fact that death rates have not improved at all in 25 years and that injury rates have not improved since 2001. We have shown that pipeline corrosion failures are related to the aging infrastructure and that the rate of such failures has not decreased in the last 25 years, a fact of which PHMSA seems to be unaware and which the pipeline industry tries to deny altogether.

Our analysis of oil spills shows that safety for the environment from these spills has not improved in the last 25 years. Given the early data for 2013, this year may turn out to have one of the worst net oil spill totals in the entire PHMSA record. The DOT/PHMSA report makes no assessment of damage to the environment from pipeline incidents. When the US government agency charged with guaranteeing pipeline safety ignores the environment, it is not surprising that environmental stewardship has not improved in the last 25 years.

The DOT/PHMSA report does not evaluate the high cost of pipeline failures. The PHMSA records document a total damage for significant pipeline incidents since 1986 of over $6.8B. This is the direct cost incurred by the pipeline operators (and no doubt passed through to consumers). It does not include the external costs including lost productivity and economic activity resulting from 2320 hospitalizations and 512 deaths since 1986 or the costs of long term environmental damage that can result from leaks, spills and fires.

In summary this report finds:

- The DOT/PHMSA report descriptions of their own graphs are inaccurate,
- The DOT/PHMSA use of a straight line to represent the death plus injury rate is a poor representation of the data, and is misleading,
- The injury rate has not improved since 2001,
- **The death rate has never improved since 1986**,
- The injury rate in the first two years of new pipeline facilities averages more than the next seven years combined,
- Pipeline facilities 30 years old and older have much higher rates of failure due to corrosion than younger facilities.
- The rate of pipeline incidents caused by corrosion in older facilities has not decreased in 25 years,
- Safety for the environment as judged by oil spilled has not improved in 25 years.

The problem with the DOT/PHMSA report is a failure to produce sound interpretation and accurate presentation of the data along with a failure to include important and relevant data which the PHMSA pipeline records clearly contain. This does a disservice to the American people and puts everyone and the environment at heighten risk.

About the Author

Richard Stover is a retired research astronomer from the University of California with a PhD in Astronomy from the University of Texas. Much of his career has involved the development of state-of-the-art astronomical camera systems. He has had decades of experience generating and analyzing many large, complex data sets. He is now free to devote his time to family, home, and working for a better environment. He can be reached at, oildrop@icogitate.com

About the PHMSA Data

The data upon which this report is based is publicly available from the PHMSA website[1]. Finding it on the website can be a little challenging, but it is there. Contact the author if you have trouble finding it. The basic data set consists of 9 spreadsheet-style files, one supporting file, and some documentation files. The data recorded in these files is all self-reported by the pipeline industry and PHMSA appears to do little to verify the accuracy of the records. There are some reporting errors. For that reason it is a mistake to dwell too much on any particular incident. Instead the value in these files is to be gained from consideration

1 http://phmsa.dot.gov

of the entire data set because, with nearly 8000 significant pipeline incidents in the record, individual reporting errors become insignificant.

PHMSA occasionally changes the details of the data recorded in the incident files. Records of recent incidents are occasionally added as well. For that reason future versions of the data files may not be identical to those obtained in July, 2013 and used in this analysis.

This project began when the author saw an online plot of the locations of some of the pipeline incidents on a map of the US and thought this might be an interesting set of data to visualize with a video. The results of that effort can be seen online[2]. Having developed the software to extract the geographic coordinates for the pipeline incidents to make the video it was an easy extension of the computer code to extract many other items of information stored in the records. That effort led to the graphs presented with the video and to this report.

None of the computer analysis for this report is difficult and it requires only simple arithmetic. All three of the Figures in this report (and the DOT/PHMSA report Figures reproduced here) involve adding up various quantities. Whether it is number of injuries, number of incidents, number of barrels of oil, or number of weld failures, the computer analysis just involves sorting the data and summing the quantities in question.

2 http://www.biologicaldiversity.org/campaigns/americas_dangerous_pipelines

Appendix

Here we present a graph similar to Figure B with the original data points instead of the smoothed curves.