OCS Study MMS 2008-035

FINAL TASK 4A.1 REPORT

VOLUME I

Alternative Oil Spill Occurrence Estimators and their Variability for the Beaufort Sea – Fault Tree Method

MMS Contract Number 1435-01-05-CT-39348

March 2008

By

Bercha International Inc.
Calgary, Alberta, Canada

U.S. Department of the Interior
Minerals Management Service
Alaska Outer Continental Shelf Region

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ABSTRACT

Oil spill occurrence estimates were generated for high and low case estimated future oil and gas development scenarios (including exploration, production, and abandonment) in the Beaufort Sea Outer Continental Shelf (OCS) lease sale region. Because sufficient historical data on offshore oil spills for this region do not exist, an oil spill occurrence model based on fault tree methodology was developed and applied. Using the fault trees, base data from the Gulf of Mexico including the variability of the data, were modified and augmented to represent expected Arctic offshore oil spillage frequencies. Three principal spill occurrence indicators, as follows, were quantified for each year of each scenario, as well as scenario life of field averages:

- Spill frequency
- Spill frequency per barrel produced
- Spill index, the product of spill size and spill frequency

These indicators were quantified for the following spill sizes:

- Small (S): 50 - 99 bbl
- Medium (M): 100 - 999 bbl
- Large (L): 1,000 - 9,999 bbl
- Huge (H): >= 10,000 bbl
- Significant (SG): >=1,000 bbl

Quantification was carried out for each future year for a high and low principal Beaufort Sea development scenario, with a range of development parameters, in duration up to 36 years. In addition, a comparative scenario for non-Arctic locations was formulated and analyzed for oil spill occurrence. Generally, it was found that the non-Arctic spill indicators were likely to be significantly higher than those for similar scenarios in the Arctic. The computations were carried out using a Monte Carlo process to permit the inclusion of estimated uncertainties in the base and scenario data and Arctic effects. A wide range of details for each scenario was generated, including the following:

- Expected time history of spill occurrences over the scenario life.
- Spill occurrence variations by spill volumes in the above spill size ranges.
- Spill occurrence variation by spill cause such as boat anchoring or ice gouging.
- Spill occurrence contribution from each main facility type, including pipelines, platforms, and wells.
- Comparison of spill occurrence predictions between Arctic and non-Arctic scenarios.
- Life of field averages of spill occurrence estimators.
- The variability in the results due to uncertainties in the inputs was expressed as cumulative distribution functions and statistical measures.

In the final report, a detailed description of the methodology, results, and conclusions and recommendations is given, as well as a section on limitations of the study.

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- Caryn Smith, Oil-Spill-Risk-Analysis Coordinator
- Cheryl Anderson, MMS Spill Database Coordinator
- Debra Bridge, Contracting Officer
- Dr. Warren Horowitz, Oceanographer

This work was carried out by Bercha International Inc. Key Bercha personnel on the project team were as follows:

- Dr. Frank G. Bercha, Project Manager and Principal Engineer
- Milan Cerovšek, Reliability Engineering Specialist
- Edmund A. Yasinko, Offshore Pipeline Specialist
- Wesley Abel, Offshore Engineering Specialist
- Susan Charlton, Editorial and Word Processing Manager

EXECUTIVE SUMMARY

A. Summary of Work Done

Oil spill occurrence estimators were generated for high and low production estimated future oil and gas development scenarios (including exploration, production, and abandonment) in the Beaufort Sea Outer Continental Shelf (OCS) lease sale region. Because sufficient historical data on offshore oil spills for these regions do not exist, an oil spill occurrence model based on fault tree methodology was developed and applied. Using the fault trees, base data from the Gulf of Mexico, including their variability, were modified and augmented to represent expected Arctic offshore oil spillage frequencies for the Beaufort Sea region under study. Three principal spill occurrence indicators, as follows, were quantified for each year of each scenario, as well as scenario life of field averages:

- Spill frequency
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These indicators were quantified for the following spill sizes:

- Small (S): 50 - 99 bbl
- Medium (M): 100 - 999 bbl
- Large (L): 1,000 - 9,999 bbl
- Huge (H): >=10,000 bbl
- Signficant (SG): >=1,000 bbl

Fractional spill sizes were rounded up or down to the nearest whole number, with rounding up for any decimal ending in 5.

Quantification was carried out for each future year for estimated Beaufort Sea exploration and development scenarios, extending up to 30 years from 2010 to 2039. In addition, a comparative high production case scenario for non-Arctic locations was formulated and analyzed for oil spill occurrence. Generally, it was found that the non-Arctic spill indicators were likely to be higher than those for a similar scenario in the Arctic. The computations were carried out using a Monte Carlo process to permit the inclusion of estimated uncertainties in the input data. A wide range of details for each scenario was generated, including the following:

- Expected time history of spill occurrences over the scenario life.
- Spill occurrence variations by spill volumes in the above spill size ranges.

- Spill occurrence variation by spill cause such as boat anchoring or ice gouging.
- Spill occurrence contribution from each main facility type, including pipelines, platforms, and wells.
- Comparison of spill occurrence predictions between Arctic and non-Arctic scenarios.
- The variability in the results due to uncertainties in the input data expressed as cumulative distribution functions and statistical measures.

In the final report, a detailed description of the methodology, results, and conclusions and recommendations is given, as well as a section on limitations of the study.

B. Conclusions

B.1 General Conclusions

Oil spill occurrence indicators were quantified for future offshore development scenarios in the Beaufort Sea in the area of MMS jurisdiction. The quantification included the consideration of the variability of historical and future scenario data, as well as that of Arctic effects in predicting oil spill occurrence indicators. Consideration of the variability of all input data yields both higher variability and a higher expected value of the spill occurrence indicators. The three types of spill occurrence indicators were: annual oil spill frequency, annual oil spill frequency per billion barrels produced, and annual spill index – and, additionally, the life of field averages for each of these three oil spill indicators were assessed.

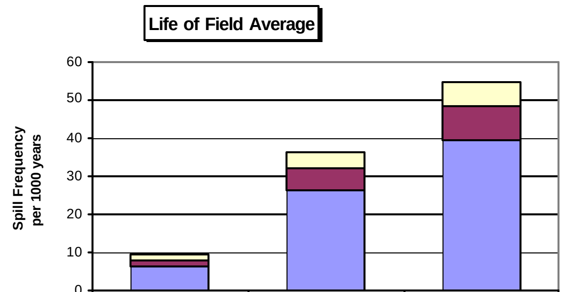
B.2 Oil Spill Occurrence Indicators by Spill Size

How do spill indicators for the Beaufort scenario and for its non-Arctic counterpart vary by spill size and location? Table 1 and Figures 1 and 2 summarize the Life of Field average spill indicator values by spill source and size for the Low and High Cases and Non-Arctic High Case scenarios. The following can be observed from Table 1.

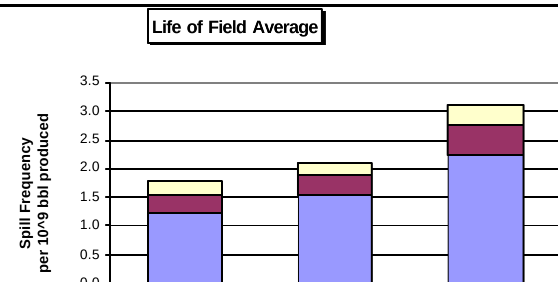
- Spill frequency per year and per barrel-year decreases significantly with increasing spill size for all scenarios.
- The spill index increases significantly with spill size for all scenarios.
- All non-Arctic scenario spill indicators are greater than their Arctic counterparts.

Table 1
Summary of Life of Field Average Spill Indicators by Spill Source and Size
(Appendix Table 5.1)

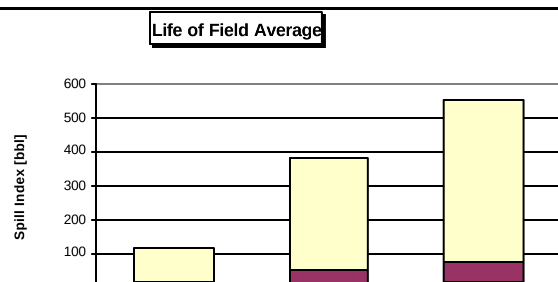
Spill Indicators LOF Average	Low Case			High Case			High Case Non-Arctic		
	Spill Frequency per 10^3 years	Spill Frequency per 10^9 bbl produced	Spill Index [bbl]	Spill Frequency per 10^3 years	Spill Frequency per 10^9 bbl produced	Spill Index [bbl]	Spill Frequency per 10^3 years	Spill Frequency per 10^9 bbl produced	Spill Index [bbl]
Small and Medium Spills 50-999 bbl	6.431	1.232	3	26.468	1.534	11	39.306	2.233	14
	69%	**69%**	**2%**	**73%**	**73%**	**3%**	**72%**	**72%**	**3%**
Large Spills 1000-9999 bbl	1.623	0.311	12	5.773	0.335	40	9.029	0.511	60
	17%	**17%**	**11%**	**16%**	**16%**	**12%**	**17%**	**16%**	**12%**
Huge Spills =>10000 bbl	1.256	0.241	93	4.222	0.245	293	6.312	0.361	417
	13%	**13%**	**87%**	**12%**	**12%**	**85%**	**12%**	**12%**	**85%**
Significant Spills =>1000 bbl	2.879	0.551	104	9.995	0.579	332	15.341	0.871	477
	31%	**31%**	**98%**	**27%**	**27%**	**97%**	**28%**	**28%**	**97%**
All Spills	9.310	1.783	107	36.463	2.113	343	54.647	3.104	492
	100%	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
Pipeline Spills	4.414	0.845	12	18.402	1.066	44	31.209	1.746	76
	47%	**47%**	**11%**	**50%**	**50%**	**13%**	**57%**	**56%**	**15%**
Platform Spills	3.615	0.692	4	14.085	0.816	14	17.873	1.036	17
	39%	**39%**	**4%**	**39%**	**39%**	**4%**	**33%**	**33%**	**3%**
Well Spills	1.281	0.245	92	3.977	0.230	285	5.565	0.322	399
	14%	**14%**	**86%**	**11%**	**11%**	**83%**	**10%**	**10%**	**81%**
Platform and Well Spills	4.896	0.938	95	18.062	1.047	299	23.438	1.358	416
	53%	**53%**	**89%**	**50%**	**50%**	**87%**	**43%**	**44%**	**85%**
All Spills	9.310	1.783	107	36.463	2.113	343	54.647	3.104	492
	100%	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**



	Low Case	High Case	High Case non Arctic
Huge Spills =>10000 bbl	1.256	4.222	6.312
Large Spills 1000-9999 bbl	1.623	5.773	9.029
Small and Medium Spills 50-999 bbl	6.431	26.468	39.306

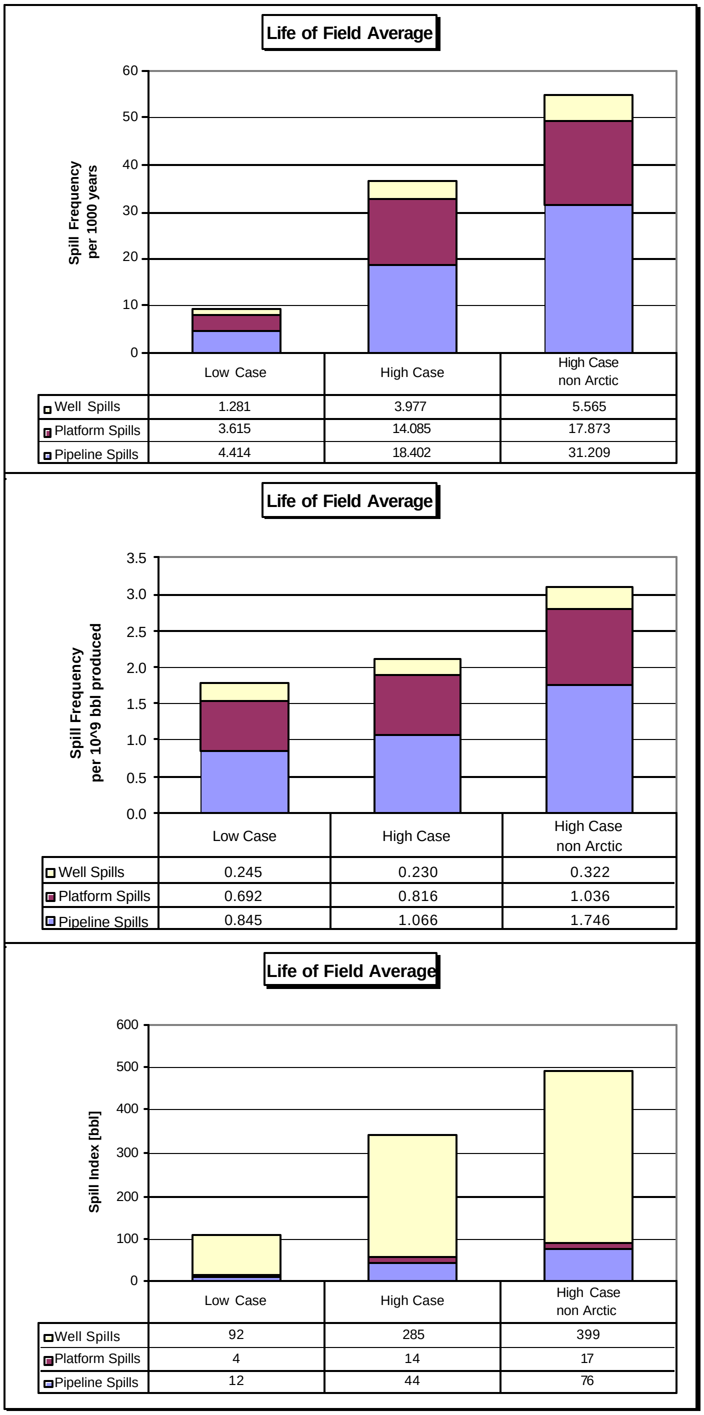


	Low Case	High Case	High Case non Arctic
Huge Spills =>10000 bbl	0.241	0.245	0.361
Large Spills 1000-9999 bbl	0.311	0.335	0.511
Small and Medium Spills 50-999 bb	1.232	1.534	2.233



	Low Case	High Case	High Case non Arctic
Huge Spills =>10000 bbl	104	332	477
Large Spills 1000-9999 bbl	12	40	60
Small and Medium Spills 50-999 bbl	3	11	14

Figure 1
Life of Field Spill Indicators – By Spill Size
Appendix Figure 5.1



	Low Case	High Case	High Case non Arctic
Well Spills	1.281	3.977	5.565
Platform Spills	3.615	14.085	17.873
Pipeline Spills	4.414	18.402	31.209

	Low Case	High Case	High Case non Arctic
Well Spills	0.245	0.230	0.322
Platform Spills	0.692	0.816	1.036
Pipeline Spills	0.845	1.066	1.746

	Low Case	High Case	High Case non Arctic
Well Spills	92	285	399
Platform Spills	4	14	17
Pipeline Spills	12	44	76

Figure 2
Life of Field Spill Indicators – By Source Composition
(Appendix Figure 5.2)

B.3 Oil Spill Occurrence Indicators by Spill Source

How do the spill indicators vary by facility type for representative scenarios? The contributions of spill indicators by facility have been summarized in Table 1 and also in Figure 2. Table 1 and Figure 2 give the component contributions, in absolute value and percent, for each of the main facility types; namely, pipelines (P/L), platforms, and wells. The following may be noted from these for the High Case:

- Pipelines contribute the most (50%) to the spill frequency indicators.
- Platforms are next in relative contribution to spill frequencies (39%) and least in contribution to spill index (4%).
- Wells are by far (at 83%) the highest contributors to spill index.
- It can be concluded that pipelines are likely to have the most, but smaller spills, while wells will have the least number, but largest spills.

Figures 3 and 4 show relative contributions by facility and spill size to the maximum production year 2030 and Life of Field average spill indicators, respectively. Although Life of Field average absolute values are significantly smaller than the maximum production year values, the proportional contributions by spill facility source and spill size are almost identical. In Figures 3 and 4, "TOTAL" designates the sum of the spill indicators for all spill sizes and facility types.

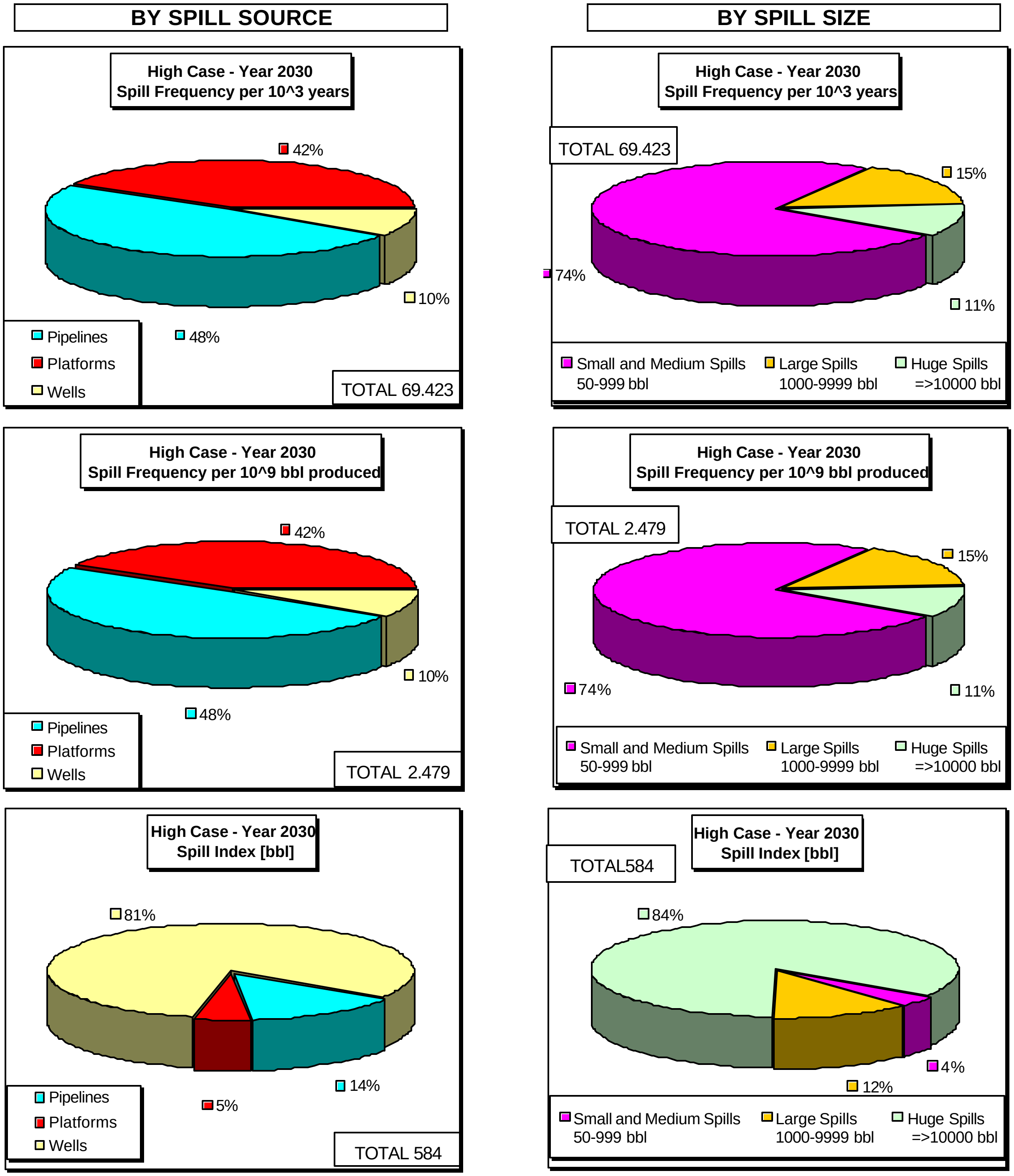


Figure 3
Beaufort Sea High Case – Year 2030 – Spill Indicator Composition by Source and Spill Size
(Appendix Figure 4.2.17)

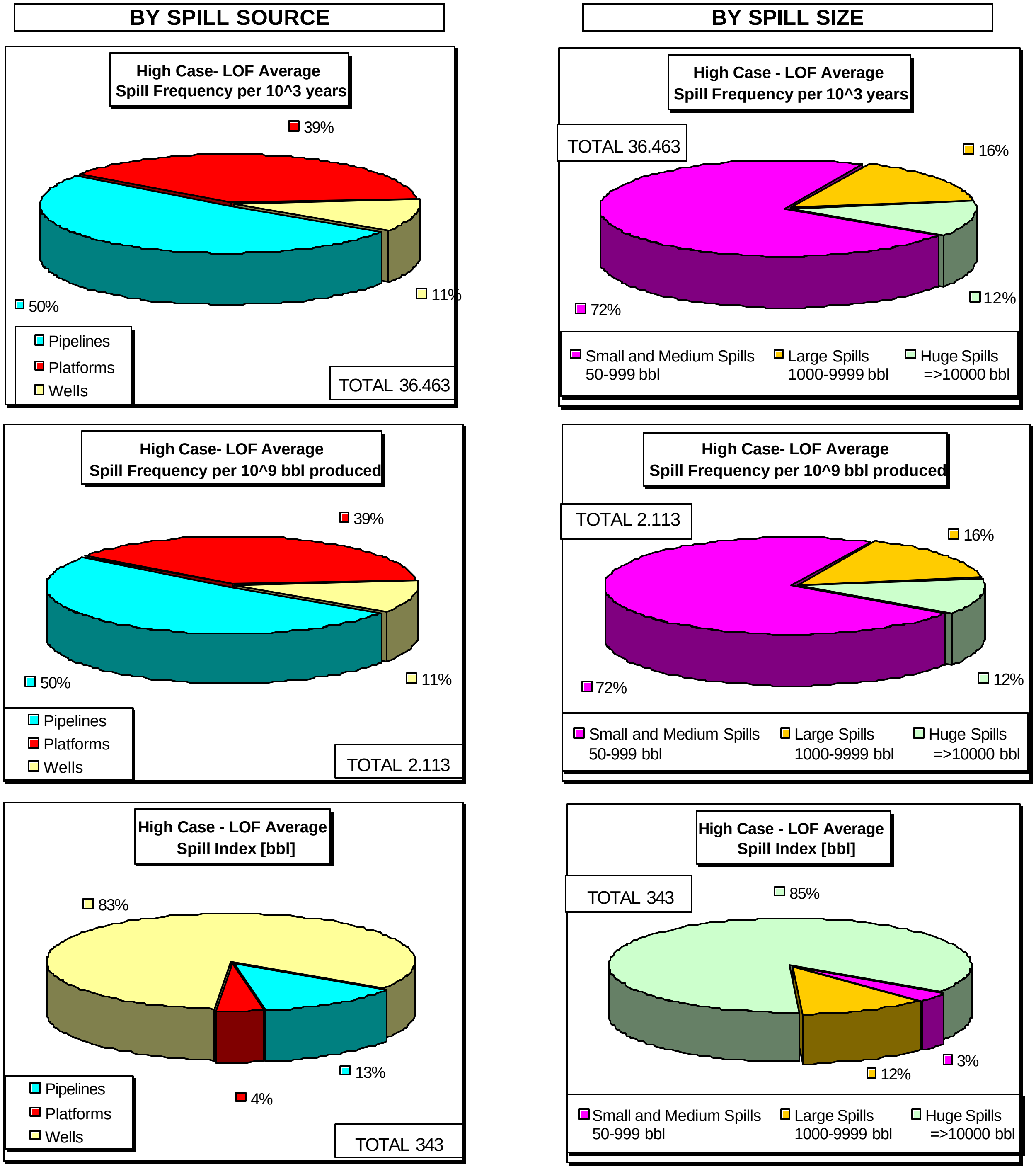


Figure 4
Beaufort Sea High Case– Life of Field Average Spill Indicator Composition by Source and Spill Size
(Appendix Figure 4.2.18)

B.4 Variability of Oil Spill Occurrence Indicators

Figures 5, 6, and 7 show the Cumulative Distribution Functions (CDF) for the Beaufort Sea Life of Field average spill indicators. The variability of these indicators is fairly representative of the trends in variability for spill indicators for the Low Case as well. Generally, the following can be observed from the figures:

- The variance of the frequency spill indicators (Figures 5 and 6) decreases as spill size increases for pipelines and platforms. In other words, small and medium spills illustrate the largest variability; huge spills show the least variability for pipelines and platforms.

- For wells, the frequency variability for different spill sizes does not change as much as that for platforms and pipelines.

- The variability of the spill index (Figure 7) shows an increasing variability with increasing spill size.

The Cumulative Distribution Functions contain extensive information on the statistical properties of the spill indicators. For example, from Figure 5 (bottom right-hand graph), it can be seen, for all significant spills, that the Life of Field average mean (50%) value of 10 (spills per 1,000 years) ranges between about 5 and 15 at the lower and 5% to 95% confidence intervals. A similar percentage variation is shown for the Life of Field average spill frequency per barrel produced in Figure 6. The spill index variability shown in Figure 7 is proportionally higher. For example, in Figure 7 (bottom right-hand corner graph), the mean value of the significant spills index of 325 per billion barrels produced ranges from 200 to 500 over the 5% to 95% confidence interval.

Figure 5
Beaufort Sea High Case Life of Field Average Spill Frequency
(Appendix Figure 4.2.14)

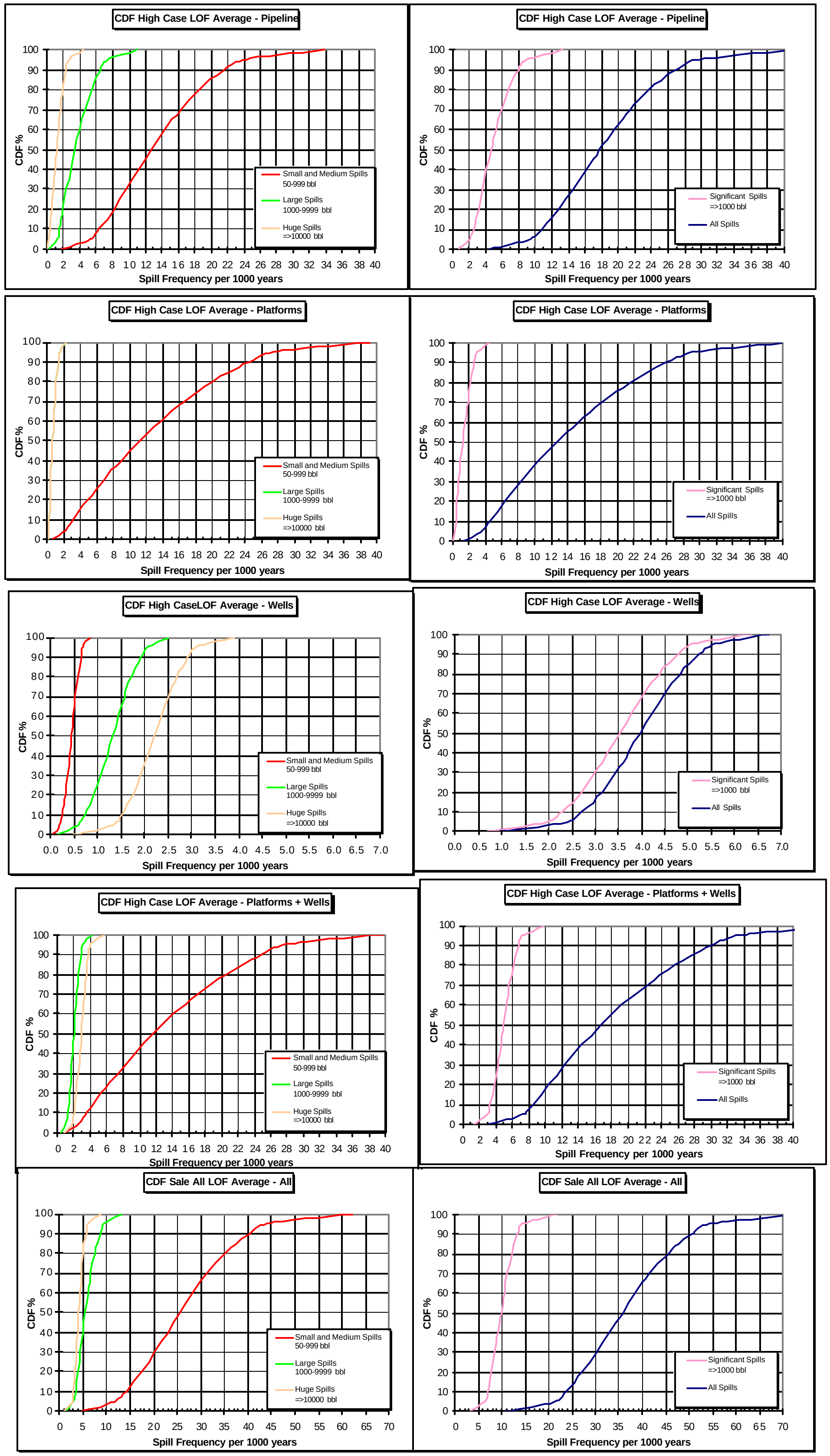


Figure 6
Beaufort Sea High Case Life of Field Average Spills per Barrel Produced
(Appendix Figure 4.2.15)

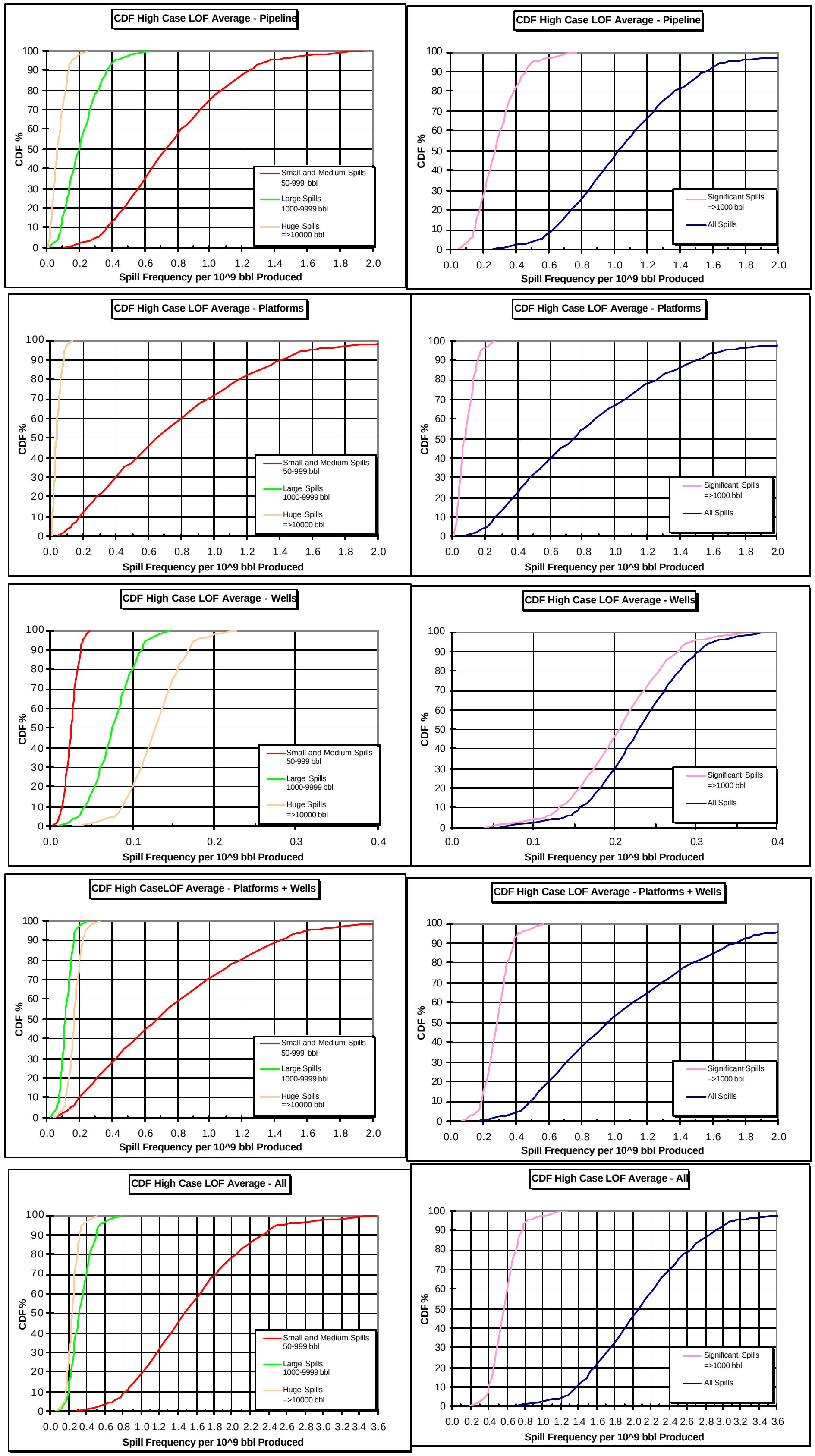
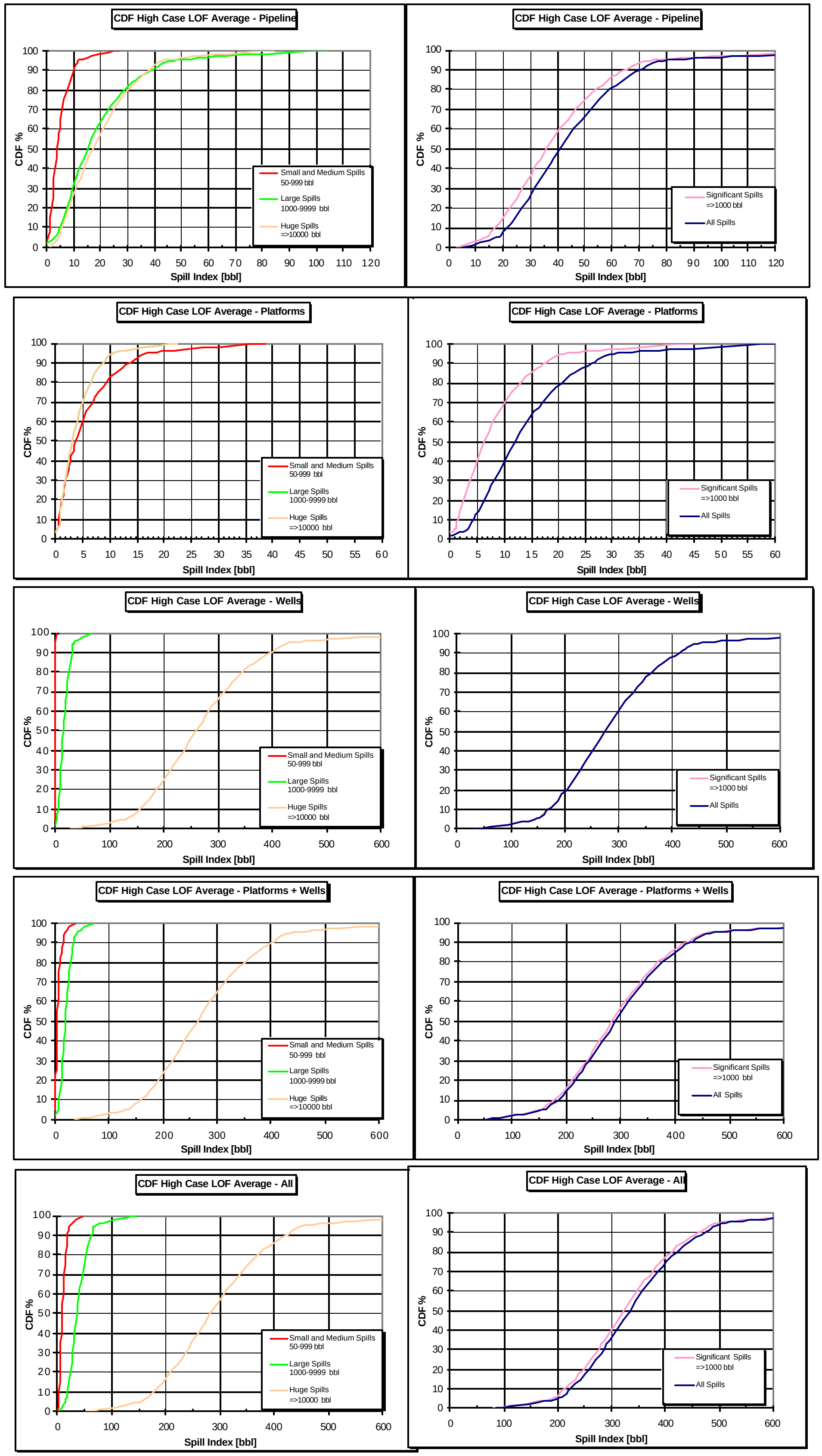


Figure 7
Beaufort Sea
High Case
Life of Field
Average Spill
Index (bbl) – CDF
(Appendix
Figure 4.2.16)



C. Conclusions on the Methodology and its Applicability

An analytical tool for the prediction of oil spill occurrence indicators for systems without history, such as future offshore oil production developments in the Beaufort Sea, has been developed based on the utilization of fault tree methodology. Although the results generated are voluminous, they are essentially transparent, simple, and easy to understand. The analytical tool developed is also quite transparent, very efficient in terms of computer time and input-output capability. In addition, the predictive model is setup so that any input variables can be entered as distributions.

A wealth of information that can be utilized for the optimal planning and regulation of future developments is generated by the analytical tool. Key aspects of the analytical tool capability may be summarized as follows:

- Ability to generate expected and mean values as well as their variability in rigorous numerical statistical format.
- Use of verifiable input data based on MMS or other historical spill data and statistics.
- Ability to independently vary the impacts of different causes on the spill occurrences as well as add new causes such as some of those that may be expected for the Arctic or other new environments.
- Ability to generate spill occurrence indicator characteristics such as annual variations, facility contributions, spill size distributions, and life of field (Life of Field) averages.
- Ability to generate comparative spill occurrence indicators such as those of comparable scenarios in more temperate regions. The model developed provides a basis for estimating each Arctic effect's importance through sensitivity analysis as well as propagation of uncertainties.
- Capability to quantify uncertainties rigorously, together with their measures of variability.

D. Limitations of the Methodology and Results

During the work, a number of limitations in the input data, the scenarios, the application of the fault tree methodology, and finally the oil spill occurrence indicators themselves have been identified. These shortcomings are summarized in the following paragraphs.

Two categories of input data were used; namely the historical spill data and the Arctic effect data. Although a verifiable and optimal historical spill data set has been used, the following shortcomings may be noted:

- Gulf of Mexico (OCS) historical data bases were provided by MMS for pipelines and facilities, and were used as a starting point for the fault tree analysis. Although these data are adequate, a broader population base would be expected to give more robust statistics. Unfortunately, data from a broader population base, such as the North Sea, do not contain the level of detail provided in the GOM data.
- The Arctic effects include modifications in causes associated with the historical data set as well as additions of spill causes unique to the Arctic environment. Quantification of existing causes for Arctic effects was done in a systematic manner dependent on engineering judgment.
- A reproducible but relatively elementary analysis of gouging and scour effects was carried out.
- Upheaval buckling effect assessments were included on the basis of an educated guess; no engineering analysis was carried out for the assessment of frequencies to be expected for these effects, as they are highly variable for different locations and pipeline characteristics.

The scenarios are those developed for use in the MMS Alaska OCS Region Environmental Impact Statements for Oil and Gas Lease Sales. As estimated they appear reasonable and were incorporated in the form provided. The only shortcoming appears to be that the facility abandonment rate is significantly lower than the rate of decline in production.

The following comments can be made on limitations associated with the indicators that have been generated:

- The indicators have inherited the deficiencies of the input and scenario data noted above.
- The model generating the indicators is fundamentally a linear model which ignores the effects of scale, of time variations such as the learning and wear-out curves (Bathtub curve), global warming, and production volume non-linear effects.

E. Recommendations

The following recommendations based on the work may be made:

- Continue to utilize the Monte Carlo spill occurrence indicator model for new scenarios to support MMS needs, as it is currently the best predictive spill occurrence model available.
- Utilize this oil spill occurrence indicator model to generate additional model validation information, including direct application to specific non-Arctic scenarios, such as GOM projects, which have an oil spill statistical history.
- Utilize the oil spill occurrence indicator model in a sensitivity mode to identify the importance of different Arctic effect variables introduced to provide a prioritized list of those items having the highest potential impact on Arctic oil spills.
- Generalize the model so that it can be run both in an adjusted expected value and a distributed value (Monte Carlo) form with the intent that expected value form can be utilized without the Monte Carlo add-in for preliminary estimates and sensitivity analyses, while for more comprehensive rigorous studies, the Monte Carlo version can be used.

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GLOSSARY OF TERMS AND ACRONYMS

Bbbl	**B**illion Barrels
CDF	**C**umulative **D**istribution **F**unction
Consequence	The direct effect of an accidental event.
GOM	**G**ulf **o**f **M**exico
Hazard	A condition with a potential to create risks such as accidental leakage of natural gas from a pressurized vessel.
KBpd	Thousand Barrels per day
LOF	**L**ife of **F**ield
MMbbl	Million Barrels
MMS	**M**inerals **M**anagement **S**ervice, Department of the Interior
Monte Carlo	A numerical method for evaluating algebraic combinations of statistical distributions.
OCS	**O**uter **C**ontinental **S**helf
QRA	**Q**uantitative **R**isk **A**ssessment
Risk	A compound measure of the probability and magnitude of adverse effect.
RLS	Release
SINTEF	The Foundation of Scientific and Industrial Research at the Norwegian Institute of Technology
Spill Frequency	The number of spills of a given spill size range per year. Usually expressed as spills per 1,000 years (and so indicated).
Spill Frequency per Barrel Produced	The number of spills of a given spill size range per barrel produced. Usually expressed as spills per billion barrels produced (and so indicated).
Spill Index	The product of spill frequency for a given spill size range and the mean spill size for that spill size range.
Spill Occurrence	Characterization of an oil spill as an annual frequency and associated spill size or spill size range.
Spill Occurrence Indicator	Any of the oil spill occurrence characteristics; namely, spill frequency, spill frequency per barrel produced, or spill index (defined above).
Spill Sizes	Small (S): 50 - 99 bbl Medium (M): 100 - 999 bbl Large (L): 1,000 - 9,999 bbl Huge (H): >=10,000 bbl Significant (SG): >=1,000 bbl

CHAPTER 1

INTRODUCTION

1.1 General Introduction

The MMS Alaska Outer Continental Shelf (OCS) Region uses oil spill occurrence estimates for National Environmental Policy Act assessments for all parts of their area of jurisdiction, ranging from near shore through shallow water, to deeper water. Although land to 3 nautical miles is not within MMS jurisdiction, it is included in the MMS environmental impact analysis; hence it is also included in the study area here. In 2002 and early 2006, studies were carried out by Bercha International Inc. [11, 12] * to assess and quantify oil spill occurrence indicators for the Beaufort and Chukchi Seas. In this study, methodologies based on fault tree analysis were developed for the assessment of oil spill rates associated with exploration and production facilities and operations in in the Beaufort Sea.

The prediction of the reliability (or failure) of systems without history can be approached through a variety of mathematical techniques, with one of the most preferable and accepted being fault trees [7, 10, 23, 26, 45, 51, 65], and their combination with numerical distribution methods such as Monte Carlo simulation [9, 45]. In the previous study [12, 13], fault tree methodology was applied to the prediction of oil spill rates for oil and gas developments such as those now operational or contemplated for the Beaufort Sea in the Alaska OCS, and used to generate predictions of oil spill occurrence indicators.

As there is a paucity of offshore Arctic oil spill occurrences, associated data worldwide and from the Gulf of Mexico (GOM) were used as a starting point to develop a simulation model of oil spill occurrence probabilities. The model for non-Arctic occurrence probabilities was then modified to include Arctic effects and their variabilities. In the preceding Beaufort Sea study [12], variability in the non-Arctic input data was considered; but variability of the future development scenario physical facility parameters, such as miles of sub-sea pipeline, was not considered. However, these scenario variabilities have been included in the recent Chukchi Sea Study [13], and are included herein. Thus, in the present study, both the historical data variability and that of the future development scenario characteristics is included in calculation of oil spill occurrence probabilities.

1.2 Study Objectives

The objectives of this study are as follows:

* Numbers in square brackets refer to citations listed in the "References" section of this report.

- Assimilate and analyze world-wide and US OCS oil spill statistics and evaluate their applicability to lease tracts which could be offered in the upcoming Beaufort Sea sales.
- Develop the fault tree method for estimating oil spill occurrences from Beaufort Sea developments associated with spills of different size categories.
- Using the fault tree approach, develop alternative oil spill indicators and assess their variability, including effect of variability of both the historical data and the future development scenario parameters.
- Provide statistical support to MMS in evaluation of statistical issues in estimation of oil spill rates.
- One of the specific objectives of this study was to add the variability of the non-Arctic factors.

1.3 Study Area Definition

The geographical study area is the offshore continental shelf in the U.S. Beaufort Sea, as generally illustrated in Figure 1.1. Of interest is the offshore area from landfall to approximately the 60-meter isobath. This area is selected due to the possibility of future oil and gas development within it, based on potential leases. Although a depth greater than 60 meters was originally contemplated as part of the study area, the analysis of development scenarios has indicated that it is highly unlikely that any oil and gas developments will take place in depths greater than 60 meters. More details on the leases and the geology of the study area are described in several MMS publications [35, 36, 37, 38, 39].

Temporally, the study scenarios investigated span into the future from the present to Year 2039.

1.4 General Background

The final reports – dated August 2002 [11], January 2006 [12], and October 2006 [13] – described the methodology and results of the fault tree method for the evaluation of oil spill occurrence estimators for the Beaufort and Chukchi Seas. The focus of the first report [11] was on the initial development of a fault tree method to model both non-Arctic GOM spill causes as well as Arctic causes and effects that would be encountered in the Beaufort and Chukchi Seas OCS Regions. The variability of the parameters associated with Arctic effects was developed in order to provide an estimate of the variance in the spill occurrence predictions resulting directly from variances in the Arctic effects. In addition, in 2006 [12], variance in the Gulf of Mexico (GOM) historical data was incorporated. In the most recent report [13], the variability of the future development scenario parameters is also considered. In the present study, all variances are considered in a manner analogous to that of the October 2006 [13] study. These variances were numerically incorporated through the use of Monte Carlo simulation for the fault tree model numerical predictions.

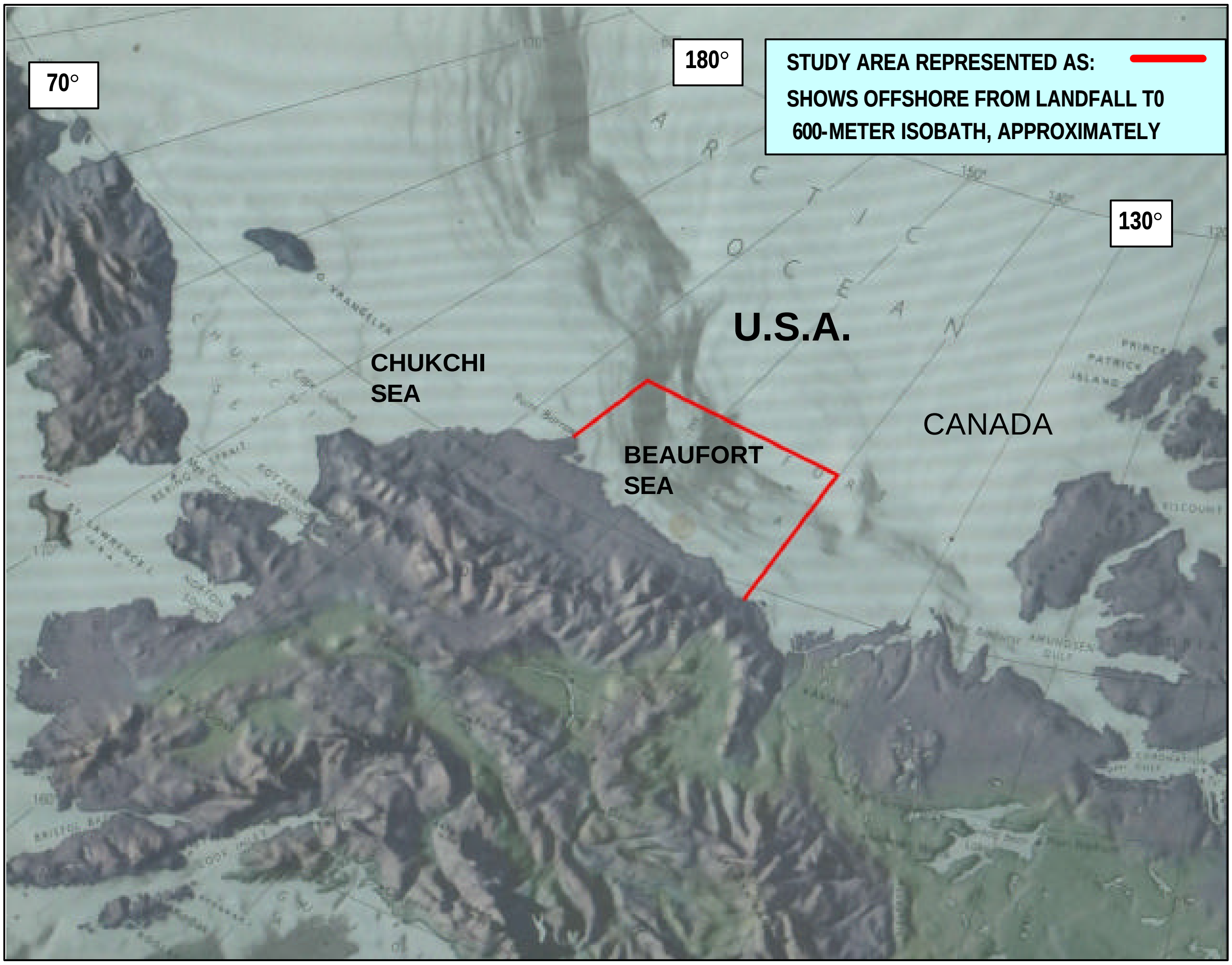


Figure 1.1
Study Area Map

1.5 Technical Approaches

Uncertainties in the results of oil spill occurrence predictions generated in this study can be attributed to uncertainties in input data, scenario characterization, and the occurrence model. In the original 2002 study [11], uncertainties in input data were quantified for the Arctic effects only. Uncertainties in the scenario were included through the choice of scenarios representing the expected and maximum development levels. In the 2006 study [13], uncertainties in the non-Arctic input data were also included. Thus the principal source of uncertainty in the occurrence results was that caused by uncertainties in the Arctic and non-Arctic input parameters themselves.

The non-Arctic input parameters fall under two principal categories as follows:

- Spill frequencies
- Spill volumes

These spill frequencies and volumes as used in the study were derived from the following principal sources:

- Pipeline spills – GOM data
- Platform spills – GOM data
- Well (drilling and production) blowout spills – Worldwide data

The specific sources of the data are described in detail in Chapter 2 of this report.

In the October 2006 [13] and the current study, in addition to the above data uncertainties, those of the following main facility parameters were also considered:

- Number of wells drilled
- Number of platforms and sub-sea production wells
- Sub-sea pipeline length
    - For pipelines less than nominal 10” diameter
    - For pipelines greater than or equal to 10” nominal diameter.

The inclusion of all of these types of variability – Arctic effects, non-Arctic data, and facility parameters – is intended to provide a realistic estimate of the spill occurrence indicators and their resultant variability.

1.6 Scope of Work

<u>*Task 1:*</u> *Data Assimilation*

a) Update of GOM pipeline and platform spill data [14].

b) Identification of alternative data sources including the Foundation of Scientific and Industrial Research at the Norwegian Institute of Technology (SINTEF), United Kingdom Health & Safety Executive (HSE), and others.

c) Assimilation and analysis of additional blowout data (SINTEF).

d) Beaufort Sea scenario development from MMS information.

<u>*Task 2:*</u> *Development of Non-Arctic Total Annual Spill Frequency and Volume Probability Distributions*

a) Development of non-Arctic total annual spill frequency and volume distribution for pipelines.

b) Development of non-Arctic total annual spill frequency and volume distribution for platforms.

c) Development of non-Arctic total annual spill frequency and volume distribution for well drilling and production wells.

<u>*Task 3:*</u> *Development of Arctic Spill Frequency Causal Event and Total Probability Distributions*

a) Development of Arctic spill frequency causal event probability distributions associated with pipeline spills.

b) Development of Arctic spill frequency causal event probability distributions associated with platform spills.

c) Development of Arctic spill frequency causal event probability distributions associated with well drilling and production well blowouts.

<u>*Task 4:*</u> *Generation of Oil Spill Occurrence Estimator Probability Distributions*

a) Variability in future development scenario parameters.

b) Model runs for variable Beaufort Sea high and low scenarios.

c) Model runs for comparative non-Arctic scenario.

<u>*Task 5:*</u> *Reporting*

a) Preliminary results following completion of Tasks 1, 2, 3, and 4.

b) Draft Final Report and Final Report.

1.7 Work Organization

The present study consisted of statistical and engineering investigations, followed by numerical simulation. Although the assimilation of historical and future scenario data is of key significance to the work, the salient contribution consisted primarily of the analytical work involving fault trees and oil spill occurrence indicator generation. Although the individual calculations are relatively simple, the subdivision of the calculations into realistic representative categories of facilities, spill sizes, and water depth for different variable development scenarios resulted in a relatively complex mix of computations, generally illustrated in the flow chart in Figure 1.2.

The flow chart in Figure 1.2, of course, does not show all the different combinations and permutations; rather, it indicates the typical calculations for one case, and suggests the balance by dotted lines. Moving from left to right; initially historical data were obtained for each of three principal facility categories, pipelines, platforms, and wells. Pipelines were further subdivided among < 10 inch and >=10 inch diameter lines. Wells were categorized in two ways: according to producing (production) wells and the drilling (D) of exploration and development wells. For each of the above facility subcategories, spill causes were analyzed for small, medium, large, huge, and significant spills, defined as follows:

- Small (S) - 50 to 99 bbl
- Medium (M) - 100 to 999 bbl
- Large (L) - 1,000 to 9,999 bbl
- Huge (H) - >= 10,000 bbl
- Significant (SG) - >= 1,000 bbl

Significant spills, which are spills of 1,000 bbl or more (Large and Huge) are also identified. Fractional spill sizes were rounded up or down to the nearest whole number, with rounding up for any decimal ending in 5. For example, a spill of 99.5 bbl is taken as 100 bbl; 99.42 is taken as 99 bbl.

In the interests of conciseness and clarity, the above main categories of spill sizes will generally be designated by either their name (small, medium, large, huge, significant) or, when space is limited, by their acronym (S, M, L, H, SG), in the balance of this report.

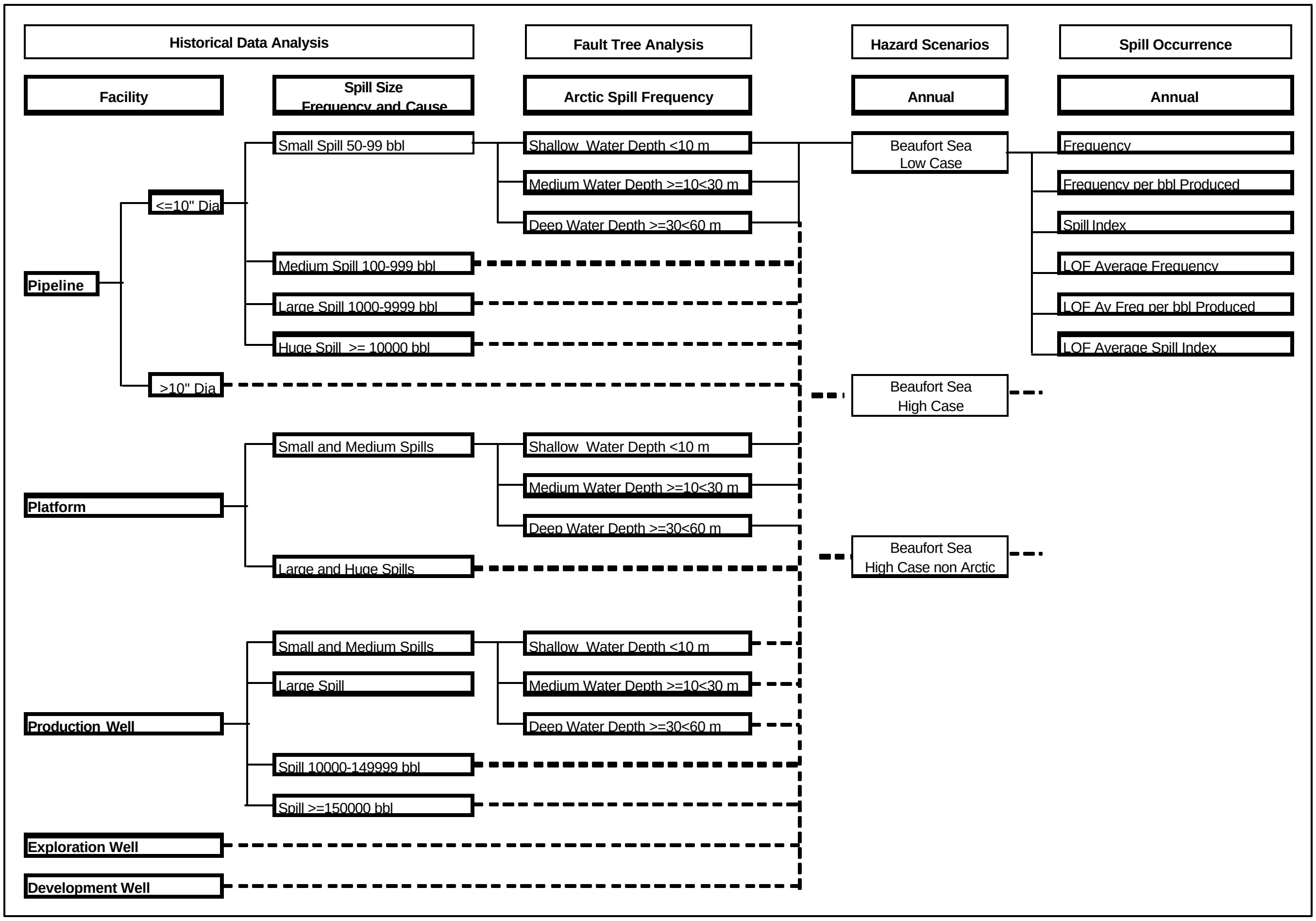


Figure 1.2
Calculation Flow Chart

Next, in the frequency analysis utilizing fault trees, each of three representative water depth ranges was assessed as follows:

- Shallow - < 10 meters
- Medium - 10 to 29 meters
- Deep - 30 to 60 meters

Although originally it was anticipated that 'very deep' water would be considered, it was found that none of the development scenarios anticipated by MMS for the Beaufort Sea extended beyond the 60-meter isobath.

Two principal future development scenarios were defined for the Beaufort Sea, as well as a compatible non-Arctic (hypothetical) scenario. Each scenario was described for each year in its development history, from the year 2010 to the year 2039 (High) and 2034 (Low). The hypothetical non-Arctic scenario was developed for comparative purposes on the assumption that it was located with the same facility distribution in a non-Arctic area. This permitted the comparison of the spill indicator results with and without the application of the fault tree analysis to account for Arctic effects.

Finally, for each of the scenarios considered, four oil spill occurrence indicators were generated, as follows:

- Oil spill frequency
- Oil spill frequency per barrel produced
- Spill index, which is the product of the oil spill frequency and the mean spill size (for the particular category under consideration)
- Life of Field Indices

1.8 Outline of Report

Following this brief introductory chapter, Volume I of the final report addresses each of the principal tasks and subtasks in its logical sequence. Accordingly, Chapter 2 summarizes the historical data assimilation and analysis detailed in [14], Chapter 3 defines the future development scenario used, Chapter 4 discusses the fault tree analysis to obtain Arctic oil spill frequencies, while Chapter 5 summarizes the results of the oil spill occurrence indicator computations and their distributions. Chapter 6 summarizes conclusions and recommendations including a section on the benefits and shortcomings of the present study. Extensive references and bibliography are given in the References.

The appendices given in Volume II form an integral part of the work for the reader who wishes to learn about background and calculation details. Accordingly, Appendix 1 summarizes the historical data assimilated and analyzed. Appendix 2 gives details of the fault tree analysis. Appendix 3 gives details on the future development scenario utilized as a basis for the study. Appendix 4 gives a printout of all the calculation steps, including results, utilized in the development of the Arctic oil spill occurrence indicators using the Monte Carlo approach. Appendix 5 gives general conclusions and results.

CHAPTER 2

HISTORICAL DATA

2.1 Approaches to Historical Data

Historical data on offshore oil spills were utilized as a numerical starting point for predicting Arctic offshore oil spill characteristics. Because a statistical history on Arctic offshore oil spills does not exist, oil spill histories for temperate offshore locations were utilized. Although Arctic offshore exploration and production was started in the early 1970s, operations have been sporadic, with very few spills, so that a statistical history cannot be generated.

The following data sets or databases were utilized:

(a) GOM OCS Pipeline Spills (1972-2006)
(b) GOM OCS Platform Spills (1972-2006)
(c) Oil Blowouts, Worldwide (1955-1995)

The GOM categories of data are discussed in detail in the GOM update report [14], while the blowout data are given in this chapter as before [13]. The contents of the balance of this chapter are restricted to the presentation of only those data sets utilized in the present study.

2.2 Pipeline Spills

The pipeline spill statistics generated in this update are basic spill statistics. First, the number of spills by size occurring for each causal category is given. Next, spill causes by two principal spill size categories are given, and transformed to spill frequencies per kilometer-year by dividing the number of kilometer-years exposure. And finally, the spill frequency distribution for spills of different size categories, by pipe diameter is determined. Table 2.1 summarizes the spill occurrences by size for each of the principal causes. These causes are those that are reported in the MMS database*. Both the exact spill size in barrels and the spill size distribution by each of the spill size categories are given in Table 2.1.

Table 2.2 gives the pipeline hydrocarbon spill statistics by cause. These statistics are given as the probability of occurrence per kilometer-year of operating pipeline. Thus, for example, approximately 12.78 spills per 100,000 km-yrs in the small and medium size category are projected. Of these, it is expected that approximately 1.1 per 100,000 km-yrs can be attributed to pipe corrosion.

* MMS Website, www.mms.gov/incidents/spills

Table 2.1
Analysis of GOM OCS Pipeline Spill Data for Causal Distribution and Spill Size
(App. Table 1.1)

CAUSE CLASSIFICATION	# OF SPILLS	SPILL SIZE (BBL)																	NUMBER OF SPILLS					
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	S	M	L	H	SM	LH
CORROSION	**4**																		**1**	**2**	**1**		**3**	**1**
External	1	80																	1				**1**	
Internal	3	100	5000	414																2	1		**2**	**1**
THIRD PARTY IMPACT	**18**																		**2**	**6**	**7**	**3**	**8**	**10**
Anchor Impact	12	19833	65	50	300	900	323	15576	2000	800	1211	2240	600						2	5	3	2	**7**	**5**
Jackup Rig or Spud Barge	1	3200																			1			**1**
Trawl/Fishing Net	5	4000	100	14423	4569	4533														1	3	1	**1**	**4**
OPERATION IMPACT	**4**																		**3**		**1**		**3**	**1**
Rig Anchoring	1	50																	1				**1**	
Work Boat Anchoring	3	50	5100	50															2		1		**2**	**1**
MECHANICAL	**2**																			**2**			**2**	
Connection Failure	1	135																		1			**1**	
Material Failure	1	210																		1			**1**	
NATURAL HAZARD	**20**																		**6**	**11**	**3**		**17**	**3**
Mud Slide	3	250	80	8212															1	1	1		**2**	**1**
Storm/ Hurricane	17	3500	671	126	200	260	250	1720	95	123	960	50	50	100	75	862	66	108	5	10	2		**15**	**2**
ARCTIC																								
Ice Gouging																								
Strudel Scour																								
Upheaval Buckling																								
Thaw Settlement																								
Other																								
UNKNOWN	**2**	119	190																	**2**			**2**	
TOTALS	**50**																		**12**	**23**	**12**	**3**	**35**	**15**

Table 2.2
Distribution and Frequency of Historical Spills – Pipeline
(App. Table 1.2)

CAUSE CLASSIFICATION	Small and Medium Spills 50-999 bbl				Large and Huge Spills >=1000 bbl			
	HISTORICAL DISTRI-BUTION %	NUMBER OF SPILLS	EXPOSURE [km-years]	FREQUENCY spill per 10^5km-year	HISTORICAL DISTRI-BUTION %	NUMBER OF SPILLS	EXPOSURE [km-years]	FREQUENCY spill per 10^5 km-year
CORROSION	**8.57**	**3**		**1.0955**	**6.67**	**1**		**0.3652**
External	2.86	1		0.3652				
Internal	5.71	2		0.7303	6.67	1		0.3652
THIRD PARTY IMPACT	**22.86**	**8**		**2.9213**	**66.67**	**10**		**3.6517**
Anchor Impact	20.00	7		2.5562	33.33	5		1.8258
Jackup Rig or Spud Barge					6.67	1		0.3652
Trawl/Fishing Net	2.86	1		0.0365	26.67	4		1.4607
OPERATION IMPACT	**8.57**	**3**		**1.0955**	**6.67**	**1**		**0.3652**
Rig Anchoring	2.86	1		0.3652				
Work Boat Anchoring	5.71	2		0.7303	6.67	1		0.3652
MECHANICAL	**5.71**	**2**		**0.7303**				
Connection Failure	2.86	1	**273847**	0.3652			**273847**	
Material Failure	2.86	1		0.3652				
NATURAL HAZARD	**48.57**	**17**		**6.2078**	**20.00**	**3**		**1.0955**
Mud Slide	5.71	2		0.7303	6.67	1		0.3652
Storm/ Hurricane	42.86	15		5.4775	13.33	2		0.7303
ARCTIC								
Ice Gouging								
Strudel Scour								
Upheaval Buckling								
Thaw Settlement								
Other								
UNKNOWN	**5.71**	**2**		**0.7303**				
TOTALS	**100.00**	**35**		**12.7809**	**100.00**	**15**		**5.4775**

Finally, Table 2.3 summarizes the pipeline hydrocarbon spill statistics by spill size and pipe diameter; while Table 2.4 gives the derived values for the present study. For example, if there were 30 data points, the upper 90% (or high value) was the third highest, while the lower 90% (or low value) was selected as the third lowest, which was invariably zero, as numerous years had no spills. Next, the third highest value was divided by the historical value to get the high factor. Finally, the high factor was used to obtain the high value by multiplying the applicable historical frequency by this high factor. The mode was then calculated from the triangular distribution relationship [13], as follows:

$$\textit{Mode} = 3 \times \textit{Historical} - \textit{High} - \textit{Low} \qquad \textbf{(2.1)}$$

2.3 Platform Spills

The primary platform spill statistical information required is the spill frequency distribution by different causes and spill sizes, and the spill rate per well year. Table 2.5 summarizes the spill size distribution among the principal reported causes. As can be seen, the major cause attributable to almost 50% of the spills – at 35 out of 74 spills – is equipment failure. However, although hurricanes have only caused a relatively small number of spills, their total spill volumes are the largest, giving the largest spill volume total. The largest single spill, however, is the tank failure which caused a spill of nearly 10,000 barrels. From a review of the platform spill data [14], it can be seen that platform spills are limited to those caused from process, storage, or transfer equipment losses of containment, so that they do not include blowouts, which are dealt with subsequently here in Section 2.4.

The spill rate data, given per production well-year, is shown in Table 2.6, again, by causal distribution as well as two broad spill size categories of small and medium spills and large and huge spills. Here, it becomes immediately evident that the largest spill potential in terms of volume is attributable to hurricanes, which are responsible for roughly 43% of the large and huge spills.

Finally, Table 2.7 gives the input data derived from Table 2.6.

Table 2.3
GOM OCS Pipeline Spills Statistics Summary (1972-2006)
(App. Table 1.3)

GOM OCS Pipeline Spills, Categorized 1972-2006			Spill Statistics	Exposure	Frequency
			Number of Spills	km-years	spills per 10^5 km-years
By Pipe Diameter		<= 10"	30	187,984	15.9588
		> 10"	20	85,863	23.2929
By Spill Size		Small <100 bbl	12	273,847	4.3820
		Medium 100 - 999 bbl	23	273,847	8.3989
		Large 1000 - 9999 bbl	12	273,847	4.3820
		Huge >=10000 bbl	3	273,847	1.0955
By Diameter, By Spill Size	**<=10"**	Small <100 bbl	8	187,984	4.2557
		Medium 100 - 999 bbl	14	187,984	7.4474
		Large 1000 - 9999 bbl	7	187,984	3.7237
		Huge >=10000 bbl	1	187,984	0.5320
	> 10"	Small <100 bbl	4	85,863	4.6586
		Medium 100 - 999 bbl	9	85,863	10.4818
		Large 1000 - 9999 bbl	5	85,863	5.8232
		Huge >=10000 bbl	2	85,863	2.3293

Table 2.4
Pipeline Historical Spill Frequency Variability
(App. Table 1.4 Modified)

GOM OCS Pipeline Spills, Categorized 1972-2006		Low Factor	High Factor	Frequency spill per 10^5 km-years			
				Historical	Low	Mode	High
By Diameter, By Spill Size							
<=10"	**Small**	0	2.81	4.2557	0	0.8086	11.9585
	Medium	0	2.81	7.4474	0	1.4150	20.9273
	Large	0	2.81	3.7237	0	0.7075	10.4637
	Huge	0	2.81	0.5320	0	0.1011	1.4948
>10"	**Small**	0	2.81	4.6586	0	0.8851	13.0906
	Medium	0	2.81	10.4818	0	1.9915	29.4539
	Large	0	2.81	5.8232	0	1.1064	16.3633
	Huge	0	2.81	2.3293	0	0.4426	6.5453

Table 2.5
Analysis of GOM OCS Platform Spill Data for Causal Distribution and Spill Size (1972-2006)
(App. Table 1.5)

CAUSE CLASSIFICATION	NUMBER OF SPILLS	SPILL SIZE BBL														NUMBER OF SPILLS					
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	S	M	L	H	SM	LH
EQUIPMENT FAILURE	35															**17**	**18**			**35**	
Process Equipment	14	130	50	104	60	95	107	50	643	60	50	400	75	125	127	7	7			**14**	
Transfer Hose	12	321	118	50	400	228	214	540	125	77	200	77	58			4	8			**12**	
Incorrect Operation	9	300	70	83	58	60	50	280	436	60						6	3			**9**	
HUMAN ERROR	12	239	95	120	286	100	64	600	170	200	262	429	60			**3**	**9**			**12**	
TANK FAILURE	3	9935	150	50												**1**	**1**	**1**		**2**	**1**
SHIP COLLISION	6	166	100	1500	320	95	119									**1**	**4**	**1**		**5**	**1**
WEATHER	10	7000	165	258	80	1456	66	89	105	100	105					**3**	**5**	**2**		**8**	**2**
HURRICANE	6	75	200	1536	954	3093	6897									**1**	**2**	**3**		**3**	**3**
OTHER	2	64	100													**1**	**1**			**2**	
TOTALS	**74**															**27**	**40**	**7**		**67**	**7**

Table 2.6
Causal and Spill Size Distribution of GOM OCS Platform Spills (1972-2006)
(App. Table 1.6)

CAUSE CLASSIFICATION	Small and Medium Spills 50-999 bbl				Large and Huge Spills >=1000 bbl			
	HIST. DISTRI-BUTION %	NUMBER OF SPILLS	EXPOSURE [well-years]	FREQUENCY spill per 10^4 well-year	HIST. DISTRI-BUTION %	NUMBER OF SPILLS	EXPOSURE [well-years]	FREQUENCY spill per 10^4 well-year
EQUIPMENT FAILURE	**52.24**	**35**		**1.6434**				
Process Equipment	20.90	14		0.6574				
Transfer Hose	17.91	12		0.5635				
Incorrect Operation	13.43	9		0.4226				
HUMAN ERROR	**17.91**	**12**		**0.5635**				
TANK FAILURE	**2.99**	**2**	**212971**	**0.0939**	**14.29**	**1**	**212971**	**0.0470**
SHIP COLLISION	**7.46**	**5**		**0.2348**	**14.29**	**1**		**0.0470**
WEATHER	**11.94**	**8**		**0.3756**	**28.57**	**2**		**0.0939**
HURRICANE	**4.48**	**3**		**0.1409**	**42.86**	**3**		**0.1409**
OTHER	**2.99**	**2**		**0.0939**				
TOTALS	**100.00**	**67**		**3.1460**	**100.00**	**7**		**0.3287**

Table 2.7
Platform Historical Spill Frequency Variability
(App. Table 1.7 Modified)

Spill Size	Frequency Unit	Low Factor	High Factor	Historical	Low	Mode	High
Small and Medium Spills (50-999 bbl)	Spill per 10^4 well-year	0	3	3.1460	0.0000	0.0000	9.4379
Large and Huge Spills (>= 1000 bbl)	Spill per 10^4 well-year	0	3	0.3287	0.0000	0.0000	0.9860

2.4 Oil Well Blowout Data

The development scenarios considered under this study include both the drilling of exploratory and development wells, and the production wells producing oil. To identify a basis for the non-Arctic historical oil well blowout statistics, a number of sources were reviewed including the Northstar and Liberty oil development project reports [52], a study by ScanPower giving the cumulative distribution function for oil blowout releases [59], as well as the book by Per Holand entitled "Offshore Blowouts", which gives risk analysis data from the SINTEF worldwide offshore blowout database [25]. The most comprehensive historical information was found in the latter reference [25], which not only gives the results of database analyses for the North Sea and the Gulf of Mexico, but also provides confidence intervals calculated from these databases. Table 2.8 gives a summary of the historical data analysis by Per Holland [25] for production wells and the drilling of exploratory and development wells. The combination of these statistics together with the cumulative distribution function for oil blowout release volumes given in [59], generated in support of the Northstar project, permits the blowout spill volume frequency distribution as summarized in Table 2.9. Finally, combining the population parameters of oil well blowouts from Table 2.8 with the size distribution factors – which can be derived from Table 2.9 – one arrives at the historical oil spill blowout distribution characteristics by spill size and well type, summarized in Table 2.10.

Table 2.8
Summary of North Sea and Gulf of Mexico Blowout Rates
(Holand, 1997)

Well Type	Unit	Low 90% CI	Average	High 90% CI
Production Well	Spills per 10^4 well-year	0.86	1.91	2.95
Exploration Well Drilling	Spills per 10^4 wells	11.00	25.05	51.00
Development Well Drilling		4.00	9.15	16.10

Table 2.9
Well Blowout Historical Spill Size Distribution
(ScanPower, 2001) *(App. Table 1.8)*

EVENT	FREQUENCY UNIT	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Small, Medium, and Large Spills 50-9999 bbl	Spills 10000-149999 bbl	Spills >=150000 bbl	All spills
		HISTORICAL FREQUENCY					
PRODUCTION WELL	**spills per 10^4 well-year**	0.15	1.03	1.18	0.44	0.29	1.91
EXPLORATION WELL DRILLING	**spills per 10^4 wells**	1.97	13.75	15.72	5.91	3.42	25.05
DEVELOPMENT WELL DRILLING	**spills per 10^4 wells**	0.65	4.57	5.22	1.96	1.96	9.15

Table 2.10
Well Blowout Historical Spill Probability and Size Variability
(App. Table 1.9)

EVENT	FREQUENCY UNIT	Low Factor	High Factor	Frequencies			
				Historical	Low	Mode	High
				Small and Medium Spills 50-999 bbl			
PRODUCTION WELL	spill per 10^4 well-year	0.448	1.545	0.147	0.066	0.148	0.227
EXPLORATION WELL DRILLING	spill per 10^4 wells	0.439	2.036	1.966	0.863	1.032	4.002
DEVELOPMENT WELL DRILLING	spill per 10^4 wells	0.437	1.760	0.654	0.286	0.526	1.151
				Large Spills 1000-9999 bbl			
PRODUCTION WELL	spill per 10^4 well-year	0.448	1.545	1.028	0.460	1.037	1.588
EXPLORATION WELL DRILLING	spill per 10^4 wells	0.439	2.036	13.754	6.039	7.220	28.001
DEVELOPMENT WELL DRILLING	spill per 10^4 wells	0.437	1.760	4.570	1.998	3.671	8.041
				Small, Medium and Large Spills 50-9999 bbl			
PRODUCTION WELL	spill per 10^4 well-year	0.448	1.545	1.175	0.526	1.185	1.815
EXPLORATION WELL DRILLING	spill per 10^4 wells	0.439	2.036	15.719	6.903	8.252	32.003
DEVELOPMENT WELL DRILLING	spill per 10^4 wells	0.437	1.760	5.224	2.284	4.197	9.192
				Spill 10000-149999 bbl			
PRODUCTION WELL	spill per 10^4 well-year	0.448	1.545	0.441	0.197	0.444	0.681
EXPLORATION WELL DRILLING	spill per 10^4 wells	0.439	2.036	5.909	2.595	3.102	12.031
DEVELOPMENT WELL DRILLING	spill per 10^4 wells	0.437	1.760	1.963	0.858	1.577	3.454
				Spill >=150000 bbl			
PRODUCTION WELL	spill per 10^4 well-year	0.448	1.545	0.294	0.132	0.296	0.454
EXPLORATION WELL DRILLING	spill per 10^4 wells	0.439	2.036	3.421	1.502	1.796	6.965
DEVELOPMENT WELL DRILLING	spill per 10^4 wells	0.437	1.760	1.963	0.858	1.577	3.454

2.5 Arctic Effects Historical Data

2.5.1 General Approaches to the Quantification of Arctic Effects

There are essentially two main categories of Arctic effects; namely, those that are unique to the Arctic, such as marine ice effects, and those that are the same types of effects as those in temperate areas, but occurring with a different frequency, such as anchor impacts on subsea pipelines. The first will be termed "unique" effects; the second, "modified" effects. Modified Arctic effects are dealt with in conjunction with the fault tree analysis described in Chapter 4. Only those Arctic effects or hazards unique to the Arctic, and potentially having a historical occurrence database, such as ice gouging, are discussed in the balance of this section.

2.5.2 Ice Gouging

Ice gouging occurs when a moving ice feature contacts the sea bottom and penetrates into it, generally as it moves against a positive sea bottom slope. The ice feature can be a multiyear ridge, a hummock, or ice rafting formation. Various studies have been conducted on the frequency and depth distribution of ice gouges [8, 27, 29, 30, 46, 67, 68], and a number of assessments of the likelihood of resultant subsea pipeline failure [8, 29] have also been carried out. Pipeline failure frequencies at different water depth regimes as a result of ice gouging in this study have been estimated on the basis of the historical ice gouge characteristics [29] together with an analytical assessment [8, 68] of their likelihood to damage a pipeline.

According to Weeks [67, 68], a relationship between the expected probability of pipeline failure from ice gouging and ice gouging local characteristics may be expressed as follows:

$$N = e^{-kx} H_S \; ? \; F \; ? \; T \; ? \; L_P \; ? \; \sin ? \qquad \textbf{(2.2)}$$

Where:

N	=	Number of pipeline failures at burial depth of cover x (meters)
k	=	Inverse of mean scour depth (m^{-1})
x	=	Depth of cover (m)
H_S	=	Probability of pipeline failure given ice gouge impact or hit
F	=	Scour flux per km-yr
T	=	Exposure time (years)
L_P	=	Length of pipeline (km)
$?$	=	Gouge orientation (degrees) from pipeline centerline

For the Northstar project, according to [30], the mean scour depth is 0.2 m giving a ***k*** factor of 5.0. In addition, a good estimate of scour flux for shallow water is 2 gouges/km-yr. Using an average pipeline depth of cover of 2.5 m, an average directional angle of 45°, a conditional failure probability (H_S) of 0.83, gives a frequency of 5.26 x 10^{-6}/km-yr. For the purposes of the analysis, this frequency must be distributed among different spill size consequences. Due to the difficulty of detecting spills under ice, one can expect that the majority of spills would be in the large and huge categories. However, huge spills would be limited by segment length. Thus, a conditional probability (given a spill) of 50% has been assigned to large spills, and one of 14% to huge spills. Least likely are small spills, and accordingly they have been given a probability of 13%. The remaining probability of 23% has been assigned to medium sized spills. The resultant distribution of expected frequencies of spill sizes associated with ice gouging is given in Table 2.11.

Also, high and low values have been assigned in order to permit an analysis of the likely distribution of the effects. Essentially, these variations in effect probability were obtained through a parametric sensitivity analysis using Equation 2.1 for a range of likely values of depth of cover from 2.0 m to 3.0 m (with an expected value of 2.5 m). These resultant low and high values are also summarized in Table 2.11. For medium water depth (10 to 29 m), an analogous process was carried out with a reduced gouge flux of 1.5 gouges/km-yr. For deep water (>= 30 m) no gouging is expected.

2.5.3 Strudel Scour

When water collects on top of the landfast ice, generally from rivers running into the Arctic seas, and drains through a hole in the ice, its hydrodynamic effect on the ocean floor below forms a depression which is called a strudel scour. Numerous studies have been conducted on strudel scour [29, 30], so that a prediction on the number of strudel scours per unit area can be made on the basis of historical data. Strudel scours are restricted to shallow water. With an average strudel scour frequency of 4 scours/mi^2 (1.5 scours/km^2) [30], the methodology in [30] can be utilized to predict a possible failure rate of subsea pipelines in shallow waters due to strudel scour of approximately 8.9 x 10^{-8}/km-yr. Using reasoning similar to that for the distribution of spill sizes for ice gouging, and assigning limits based on parametric sensitivity studies, the distribution of strudel scour frequencies for shallow water as shown in Table 2.11 can be derived. Strudel scours are not expected in water depths greater than 10 m.

Table 2.11
Summary of Pipeline Unique Arctic Effect Inputs
(App. Table 2.2 Modified)

Cause Classification	Spill Size	Water Depth: Shallow (Frequency Increment per 10^5 km-year)			Medium			Deep		
		Min	Mode	Max	Min	Mode	Max	Min	Mode	Max
Ice Gouging	S	0.0087	0.1054	1.2841	0.0108	0.1318	1.6051			
	M	0.0087	0.1054	1.2841	0.0108	0.1318	1.6051			
	L	0.0216	0.2635	3.2103	0.0270	0.3294	4.0128			
	H	0.0043	0.0527	0.6421	0.0054	0.0659	0.8026			
Strudel Scour	S	0.0110	0.0235	0.1381						
	M	0.0110	0.0235	0.1381						
	L	0.0276	0.0587	0.3452						
	H	0.0055	0.0117	0.0690						
Upheaval Buckling	S	0.00221	0.00469	0.02761	0.00221	0.00469	0.02761	0.00221	0.00469	0.02761
	M	0.00221	0.00469	0.02761	0.00221	0.00469	0.02761	0.00221	0.00469	0.02761
	L	0.00552	0.01174	0.06904	0.00552	0.01174	0.06904	0.00552	0.01174	0.06904
	H	0.00110	0.00235	0.01381	0.00110	0.00235	0.01381	0.00110	0.00235	0.01381
Thaw Settlement	S	0.00110	0.00235	0.01381	0.00110	0.00235	0.01381	0.00110	0.00235	0.01381
	M	0.00110	0.00235	0.01381	0.00110	0.00235	0.01381	0.00110	0.00235	0.01381
	L	0.00276	0.00587	0.03452	0.00276	0.00587	0.03452	0.00276	0.00587	0.03452
	H	0.00055	0.00117	0.00690	0.00055	0.00117	0.00690	0.00055	0.00117	0.00690
Other Arctic	S	0.00230	0.01359	0.14636	0.00141	0.01388	0.16466	0.00033	0.00070	0.00414
	M	0.00230	0.01359	0.14636	0.00141	0.01388	0.16466	0.00033	0.00070	0.00414
	L	0.00575	0.03398	0.36590	0.00353	0.03470	0.41164	0.00083	0.00176	0.01036
	H	0.00115	0.00680	0.07318	0.00071	0.00694	0.08233	0.00017	0.00035	0.00207

2.5.4 Upheaval Buckling

Upheaval buckling occurs in a pipeline as a result of its thermal expansion which causes it to buckle upwards to accommodate the extra length generated from thermal effects. Unfortunately, there appears to be no defensible analytical method for calculating the probability of upheaval buckling of Arctic subsea pipelines in general. Accordingly, upheaval buckling has been taken simply as a percentage of the strudel scour effects. Assuming that an upheaval buckling occurs 20% as often as strudel scour, the distribution shown in Table 2.11 can be derived. Upheaval buckling is expected to be independent of water depth; accordingly, the same values have been used for each water depth range.

2.5.5 Thaw Settlement

Thaw settlement occurs when a permafrost lens or formation over which the pipeline was installed melts as a result of the heat generated by the pipeline and ceases to support the pipeline so that the pipeline overburden loads the pipeline and causes it to deflect downwards.

2.5.6 Platform Arctic Unique Effects

Potential causes of platform spills (other than blowouts, which are included under wells) that are uniquely associated with the Arctic are ice forces and low temperature effects. Although the possibility that ice forces will cause spills varies greatly from facility to facility, some broad assumptions have been made in regards to the likelihood of spills being caused by ice force effects. Specifically, it was assumed that the platforms are designed for a 10,000 year return period with a reliability level of 96%, in accordance with the Draft ISO WG8 Arctic Structures Reliability Section 7.2.2.3 [28]. That is, 4% of the time, the 10,000 year return period ice force can cause a spill. Further, it was assumed that 85% of spills so caused are small and medium, with large and huge spills associated with the other 15%. In regards to facility low temperature, a percentage of historical facility releases was taken. Specifically, it was assumed that the facility low temperature effects will cause medium spills at a rate of 6% of that of total historical small and medium spills, and large and huge spills at a rate of 3% of that associated with large and huge historical spills. Finally, other Arctic unique causes were assumed to constitute another 10% of the sum of the above spill rates in each of the spill categories. Table 2.12 summarizes the resultant Arctic unique effect frequencies derived for platforms on a per-well year basis.

2.6 Historical Spill Size Distribution

Table 2.13 gives the historical spill size distributions obtained from the available historical data. Here, the mode was taken as the historical average spill size in each spill size category, while the high and low values were taken to be the upper and lower bounds of each spill size category. The Huge spill high values were chosen on the basis of the upper 90% confidence interval spill volumes in the databases.

Table 2.12
Summary of Platform Unique Arctic Effect Inputs
(App. Table 2.7 Modified)

CAUSE	SPILL SIZE	Shallow	Medium	Deep	REASON
		Water Depth: Frequency Increment per 10^4 well-year			
		Expected	Expected	Expected	
		Mode	*Mode*	*Mode*	
Ice Force	SM	0.1447	0.2170	0.3256	Assumed 10,000 year return period ice force causes spill 4% of occurrences (96% reliability). 85% of the spills are SM.
		0.0340	*0.0510*	*0.0765*	
	LH	0.0255	0.0383	0.0575	
		0.0060	*0.0090*	*0.0135*	
Facility Low Temperature	SM	0.0986	0.0986	0.0986	Assumed fraction of Historical Equipment Failure release frequency with 6% for SM and 1% for LH spill sizes.
		0.0986	*0.0986*	*0.0986*	
	LH	0.0164	0.0164	0.0164	
		0.0164	*0.0164*	*0.0164*	
Other Arctic	SM	0.0242	0.0315	0.0423	10% of sum of above.
		0.0133	*0.0150*	*0.0175*	
	LH	0.0042	0.0055	0.0074	
		0.0022	*0.0025*	*0.0030*	

Table 2.13
Summary of Historical Spill Size Distribution Parameters

PIPELINE SPILL VOLUMES	Spill Size:	Small Spills (50-99 bbl)				Medium Spills (100-999 bbl)				Large Spills (1000-9999 bbl)				Huge Spills (=>10000 bbl)			
	Spill Expectation	Low	Mode	High	Expected	Low	Mode	High	Expected	Low	Mode	High	Expected	Low	Mode	High	Expected
	Pipeline (Diameter <10") Spill	50	58	99	71	100	226	999	485	1000	4436	9999	5279	10000	14423	20000	14880
	Pipeline (Diameter > 10") Spill	50	58	99	71	100	387	999	516	1000	3932	9999	5176	10000	17705	20000	15552
PLATFORM SPILL VOLUMES	Spill Size:	Small and Medium Spills (50-999 bbl)				Large and Huge Spills (=>1000 bbl)											
	Spill Expectation	Low	Mode	High	Expected	Low	Mode	High	Expected								
	Platform Spill	50	158	999	452	1000	6130	10000	5631								
WELL SPILL VOLUMES	Spill Size:	Small and Medium Spills (50-999 bbl)				Large Spills (1000-9999 bbl)				Spills (10000-149999 bbl)				Spills (=>150000 bbl)			
	Spill Expectation	Low	Mode	High	Expected	Low	Mode	High	Expected	Low	Mode	High	Expected	Low	Mode	High	Expected
	Well Spill	50	500	999	519	1000	4500	9999	5292	10000	20000	150000	68349	150000	200000	250000	200000

CHAPTER 3

FUTURE DEVELOPMENT SCENARIOS

3.1 Approaches to Future Development Scenarios

For the purposes of the fault tree analysis utilized in this study, future Beaufort Sea offshore oil and gas development scenarios need to include the following characteristics for each year of the development scenario:

- Water depth range for pipelines
- Physical quantities of individual facilities (e.g., production wells, pipelines) on an annual basis in correspondence with the baseline data exposure factors (e.g., per well year or per km-yr)
- Associated oil production volumes
- Other characteristics such as pipeline diameter or type of well drilled

Table 3.1 shows the classification of development Scenarios by water depth range and operation type. The salient aspect of this classification is subdivision into water depth ranges among which Arctic hazard characteristics (such as ice gouging rates) may change. The following water depth categories are used:

- Shallow - < 10 meters
- Medium - 10 to 29 meters
- Deep - 30 to 60 meters
- Very Deep - > 60 meters

In Table 3.1, an indication is given of the types of facilities that might be utilized in each of the principal types of oil and gas activities, exploration, production, or transportation. As will be seen in this chapter, current forecasts for development scenarios over the next 40 years exclude very deep locations, in excess of 60 m. Accordingly, any suggestions for facilities under the very deep scenario would be speculative and will not be used in the current study.

In general, the scenarios described in this chapter were developed to an appropriate level and type of detail to match the type of unit spill data and statistics available as a basis for the oil spill occurrence indicator quantification.

The principal regions of interest within the study area are the Beaufort Sea lease areas.

Table 3.1
Classification of Development Scenarios

PRINCIPAL ACTIVITY	WATER DEPTH (m)			
	SHALLOW (< 10)	MEDIUM (10 to 29)	DEEP (30 to 60)	VERY DEEP (> 60)
EXPLORATION	▪ Artificial island ▪ Drill barge ▪ Ice island	▪ Artificial island ▪ Drill ship (summer) ▪ Caisson	▪ Drill ship (summer) ▪ Semisubmersible (summer)	▪ Drill ship (summer) ▪ Semisubmersible (summer)
PRODUCTION	▪ Artificial island ▪ Caisson island	▪ Caisson island ▪ Gravity Base Structure (GBS)	▪ Caisson island ▪ Gravity Base Structure (GBS)	▪ New design structure ▪ Submarine habitat
TRANSPORT	▪ Subsea pipeline	▪ Subsea pipeline	▪ Subsea pipeline ▪ Storage & tankers	▪ Subsea pipeline ▪ Submarine storage ▪ Icebreaking tankers ▪ Submarine tankers

3.2 Beaufort Sea Development Scenarios

As a basis for the current analysis, the geographic and water depth distribution of the facilities and its variation over the life of the development is required in order to effectively incorporate the effects of Arctic operations on the oil spill occurrences. Two Beaufort Sea scenarios were considered; namely, the Low and High Cases. Table 3.2 summarizes the key quantity parameters of each possible Beaufort scenario. The facility quantities are hypothetical, and not based on any operator's plan. No facilities are predicted in the very deep region. Facilities onshore were not considered in the analysis, but were included in Table 3.2 for completeness.

Tables 3.3 and 3.4 summarize the complete development scenario including the temporal development to the year forecast to cease production. Table 3.3 summarizes the High scenario and Table 3.4 Low scenario. Both start activity in 2010, while the Low Case is assumed to cease in 2033 and the High Case to cease in 2038.For items such as exploration and field delineation well drilling, the actual number of wells drilled in a given year were needed, since the statistics of well spill (blowouts) are on a per well drilled exposure unit. For items that continue from year to year, such as production wells or subsea pipelines, both the annual incremental and the cumulative total are needed. Specifically, the following facility quantities were estimated and distributed as shown in Tables 3.3 and 3.4:

- Exploration wells drilled – annual
- Delineation wells drilled – annual
- Production platforms – only one platform was assumed in the low case, and three in the high case
- Production/service wells – annual increment and cumulative number
- Pipeline lengths for < 10", and >=10", and total – annual increment and cumulative number of pipeline length in service
- Oil production volumes – annual

As noted above, these quantities match the type of unit spill data that is available through the historical analysis. For example, we have spill data by pipeline diameter only for lines < and >=10", so a full spectrum of pipeline diameters would be redundant. An important aspect of the information in Table 3.3, however, is the distribution of the facilities by water depth, as there is a significant variation in pipeline Arctic hazards by water depth.

The low (Table 3.4) and high (Table 3.3) quantities were used in the balance of the calculations for the low and high case, respectively.

Table 3.2
Summary of Exploration and Development Scenario, Beaufort Sea OCS

Scenario Element	Range		Comments
	Low	High	
Maximum oil production (Bbbl/year)	16	55	Development from first 5-year plan sale only
Natural gas production	0	0	Delayed for North Slope gas line; initially reinjected
Exploration wells	4	9	2-5 wells are dry holes or sub-commercial shows
Delineation wells	4	13	Confirm and define the commercial discovery
Production platforms	1	3	Several platforms with processing facility; support several subsea satellite templates
Platform production wells	18	60	
Subsea wells	0	12	-
Offshore sales pipeline (mi)	15	90	Possible distance to landfall
Onshore sales pipeline (mi)	50	50	n/a
Landfall	1	1	n/a
Support shorebase	1	1	n/a
New processing facility	1	1	n/a
New waste facility	1	1	Co-located with shorebase (n/a)
Years of activity	20-30	20-30	Period from lease sale to end of oil production

Table 3.3
Beaufort Sea High Case Development Scenario (2010-2039)
(App. Table 3.3)

Year	Water Depth	Exploration Wells	Delineation Wells	Expl. / Del. Rigs	Production							In-Use Pipeline Length (miles)						Production (MMbbl).
					Platforms		Platform Wells		Subsea Wells		Rigs	Sum <= 10"		Sum > 10"		Sum All		
					Incr.	Cum.	Incr.	Cum.	Incr.	Cum.		Incr.	Cum.	Incr.	Cum.	Incr.	Cum.	
2010	Shallow	1		1														
	Medium																	
	Deep																	
	Total	**1**		**1**														
2011	Shallow	1	2	1														
	Medium																	
	Deep																	
	Total	**1**	**2**	**1**														
2012	Shallow		2	1														
	Medium																	
	Deep	1		1														
	Total	**1**	**2**	**2**														
2013	Shallow	1		1														
	Medium																	
	Deep	1	2	1														
	Total	**2**	**2**	**2**														
2014	Shallow	1		1														
	Medium																	
	Deep		3	1														
	Total	**1**	**3**	**2**														
2015	Shallow																	
	Medium	1	2	1														
	Deep																	
	Total	**1**	**2**	**1**														
2016	Shallow																	
	Medium	1	2	2														
	Deep																	
	Total	**1**	**2**	**2**														
2017	Shallow													10	10	10	10	
	Medium	1		1														
	Deep																	
	Total	**1**		**1**										**10**	**10**	10	10	
2018	Shallow													5	15	5	15	
	Medium																	
	Deep																	
	Total													**5**	**15**	5	15	
2019	Shallow				1	1	6	6			1				15		15	8.8
	Medium																	
	Deep																	
	Total				**1**	**1**	**6**	**6**			**1**				**15**		15	**8.8**
2020	Shallow					1	6	12			1				15		15	16.3
	Medium																	
	Deep													10	10	10	10	
	Total					**1**	**6**	**12**			**1**			**10**	**25**	10	25	**16.3**
2021	Shallow					1	6	18			1				15		15	16.3
	Medium																	
	Deep													10	20	10	20	
	Total					**1**	**6**	**18**			**1**			**10**	**35**	10	35	**16.3**

Table 3.3 ~ *Continued* ~
Beaufort Sea High Case Development Scenario (2010-2039)

Year	Water Depth	Exploration Wells	Delineation Wells	Expl. / Del. Rigs	Production: Platforms Incr.	Production: Platforms Cum.	Production: Platform Wells Incr.	Production: Platform Wells Cum.	Production: Subsea Wells Incr.	Production: Subsea Wells Cum.	Production: Rigs	In-Use Pipeline Length (miles): Sum <= 10" Incr.	Sum <= 10" Cum.	Sum > 10" Incr.	Sum > 10" Cum.	Sum All Incr.	Sum All Cum.	Production (MMbbl)
2022	Shallow					1		18							15		15	16.3
	Medium																	
	Deep				1	1	6	6			1			15	35	15	35	13.5
	Total				**1**	**2**	**6**	**24**			**1**			**15**	**50**	15	50	**29.8**
2023	Shallow					1		18							15		15	13.4
	Medium																	
	Deep					1	6	12	4	4	1	5	5		35	5	40	16.9
	Total					**2**	**6**	**30**	**4**	**4**	**1**	**5**	**5**		**50**	5	55	**30.3**
2024	Shallow					1		18							15		15	11.1
	Medium				1	1	6	6			1			10	10	10	10	8.8
	Deep					1	6	18	4	8	1	5	10		35	5	45	22.5
	Total				**1**	**3**	**12**	**42**	**4**	**8**	**2**	**5**	**10**	**10**	**60**	15	70	**42.4**
2025	Shallow					1		18							15		15	9.1
	Medium					1	6	12			1			15	25	15	25	16.3
	Deep					1	6	24	4	12	1	5	15		35	5	50	30.0
	Total					**3**	**12**	**54**	**4**	**12**	**2**	**5**	**15**	**15**	**75**	20	90	**55.4**
2026	Shallow					1		18							15		15	7.5
	Medium					1	6	18			1				25		25	16.3
	Deep					1		24		12			15		35		50	30.0
	Total					**3**	**6**	**60**		**12**	**1**		**15**		**75**		90	**53.8**
2027	Shallow					1		18							15		15	6.2
	Medium					1		18							25		25	16.3
	Deep					1		24		12			15		35		50	30.0
	Total					**3**		**60**		**12**			**15**		**75**		90	**52.5**
2028	Shallow					1		18							15		15	5.1
	Medium					1		18							25		25	13.4
	Deep					1		24		12			15		35		50	24.0
	Total					**3**		**60**		**12**			**15**		**75**		90	**42.5**
2029	Shallow					1		18							15		15	4.2
	Medium					1		18							25		25	11.1
	Deep					1		24		12			15		35		50	19.2
	Total					**3**		**60**		**12**			**15**		**75**		90	**34.5**
2030	Shallow					1		18							15		15	3.5
	Medium					1		18							25		25	9.1
	Deep					1		24		12			15		35		50	15.4
	Total					**3**		**60**		**12**			**15**		**75**		90	**28.0**
2031	Shallow					1		18							15		15	2.9
	Medium					1		18							25		25	7.5
	Deep					1		24		12			15		35		50	12.3
	Total					**3**		**60**		**12**			**15**		**75**		90	**22.7**
2032	Shallow					1		18							15		15	2.5
	Medium					1		18							25		25	6.2
	Deep					1		24		12			15		35		50	9.8
	Total					**3**		**60**		**12**			**15**		**75**		90	**18.5**
2033	Shallow					1		18							15		15	2.1
	Medium					1		18							25		25	5.1
	Deep					1		24		12			15		35		50	7.9
	Total					**3**		**60**		**12**			**15**		**75**		90	**15.1**

Table 3.3 ~ *Continued* ~
Beaufort Sea High Case Development Scenario (2010-2039)

Year	Water Depth	Exploration Wells	Delineation Wells	Expl. / Del. Rigs	Production							In-Use Pipeline Length (miles)						Production (MMbbl)
					Platforms		Platform Wells		Subsea Wells		Rigs	Sum <= 10"		Sum > 10"		Sum All		
					Incr.	Cum.	Incr.	Cum.	Incr.	Cum.		Incr.	Cum.	Incr.	Cum.	Incr.	Cum.	
2034	Shallow				-1		-18							-15		-15		
	Medium					1		18							25		25	4.2
	Deep					1		24		12			15		35		50	6.3
	Total				**-1**	**2**	**-18**	**42**		**12**			**15**	**-15**	**60**	-15	75	**10.5**
2035	Shallow																	
	Medium					1		18							25		25	3.5
	Deep					1		24		12			15		35		50	5.0
	Total					**2**		**42**		**12**			**15**		**60**		75	**8.5**
2036	Shallow																	
	Medium					1		18							25		25	2.9
	Deep					1		24		12			15		35		50	4.0
	Total					**2**		**42**		**12**			**15**		**60**		75	**6.9**
2037	Shallow																	
	Medium					1		18							25		25	2.6
	Deep					1		24		12			15		35		50	3.0
	Total					**2**		**42**		**12**			**15**		**60**		75	**5.6**
2038	Shallow																	
	Medium					1		18							25		25	2.1
	Deep				-1		-24		-12			-15		-35		-50		
	Total				**-1**	**1**	**-24**	**18**	**-12**			**-15**		**-35**	**25**	-50	25	**2.1**
2039	Shallow																	
	Medium				-1		-18							-25		-25		
	Deep																	
	Total				**-1**		**-18**							**-25**		-25		

Table 3.4
Beaufort Sea Low Case Development Scenario (2010-2034)
(App. Table 3.1)

Year	Water Depth	Exploration Wells	Delineation Wells	Expl. / Del. Rigs	Production							In-Use Pipeline Length (miles)						Production (Bbbl)
					Platforms		Platform Wells		Subsea Wells		Rigs	Sum <= 10"		Sum > 10"		Sum All		
					Incr.	Cum.	Incr.	Cum.	Incr.	Cum.		Incr.	Cum.	Incr.	Cum.	Incr.	Cum.	
2010	Shallow	1		1														
	Medium																	
	Deep																	
	Total	**1**		**1**														
2011	Shallow	1	2	1														
	Medium																	
	Deep																	
	Total	**1**	**2**	**1**														
2012	Shallow		2	1														
	Medium																	
	Deep																	
	Total		**2**	**1**														
2013	Shallow	1		1														
	Medium																	
	Deep																	
	Total	**1**		**1**														
2014	Shallow	1		1														
	Medium																	
	Deep																	
	Total	**1**		**1**														
2015	Shallow																	
	Medium																	
	Deep																	
	Total																	
2016	Shallow																	
	Medium																	
	Deep																	
	Total																	
2017	Shallow													10	10	10	10	
	Medium																	
	Deep																	
	Total													**10**	**10**	10	10	
2018	Shallow													5	15	5	15	
	Medium																	
	Deep																	
	Total													**5**	**15**	5	15	
2019	Shallow				1	1	6	6			1				15		15	8.8
	Medium																	
	Deep																	
	Total				**1**	**1**	**6**	**6**			**1**				**15**		15	**8.8**
2020	Shallow					1	6	12			1				15		15	16.3
	Medium																	
	Deep																	
	Total					**1**	**6**	**12**			**1**				**15**		15	**16.3**
2021	Shallow					1	6	18			1				15		15	16.3
	Medium																	
	Deep																	
	Total					**1**	**6**	**18**			**1**				**15**		15	**16.3**

Table 3.4 ~ *Continued* ~
Beaufort Sea Low Case Development Scenario (2010-2034)

Year	Water Depth	Exploration Wells	Delineation Wells	Expl. / Del. Rigs	Production: Platforms		Production: Platform Wells		Production: Subsea Wells		Production: Rigs	In-Use Pipeline Length (miles): Sum <= 10"		Sum > 10"		Sum All		Production (Bbbl)
					Incr.	Cum.	Incr.	Cum.	Incr.	Cum.		Incr.	Cum.	Incr.	Cum.	Incr.	Cum.	
2022	Shallow					1		18							15		15	16.3
	Medium																	
	Deep																	
	Total					**1**		**18**							**15**		15	**16.3**
2023	Shallow					1		18							15		15	13.4
	Medium																	
	Deep																	
	Total					**1**		**18**							**15**		15	**13.4**
2024	Shallow					1		18							15		15	11.1
	Medium																	
	Deep																	
	Total					**1**		**18**							**15**		15	**11.1**
2025	Shallow					1		18							15		15	9.1
	Medium																	
	Deep																	
	Total					**1**		**18**							**15**		15	**9.1**
2026	Shallow					1		18							15		15	7.5
	Medium																	
	Deep																	
	Total					**1**		**18**							**15**		15	**7.5**
2027	Shallow					1		18							15		15	6.2
	Medium																	
	Deep																	
	Total					**1**		**18**							**15**		15	**6.2**
2028	Shallow					1		18							15		15	5.1
	Medium																	
	Deep																	
	Total					**1**		**18**							**15**		15	**5.1**
2029	Shallow					1		18							15		15	4.2
	Medium																	
	Deep																	
	Total					**1**		**18**							**15**		15	**4.2**
2030	Shallow					1		18							15		15	3.5
	Medium																	
	Deep																	
	Total					**1**		**18**							**15**		15	**3.5**
2031	Shallow					1		18							15		15	2.9
	Medium																	
	Deep																	
	Total					**1**		**18**							**15**		15	**2.9**
2032	Shallow					1		18							15		15	2.5
	Medium																	
	Deep																	
	Total					**1**		**18**							**15**		15	**2.5**
2033	Shallow					1		18							15		15	2.1
	Medium																	
	Deep																	
	Total					**1**		**18**							**15**		15	**2.1**
2034	Shallow				-1		-18							-15		-15		
	Medium																	
	Deep																	
	Total				**-1**		**-18**							**-15**		-15		

CHAPTER 4

FAULT TREE ANALYSIS FOR ARCTIC OIL SPILL FREQUENCIES

4.1 General Description of Fault Tree Analysis

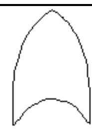
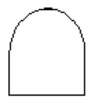
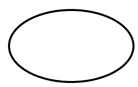
Fault trees are a method for modeling the occurrence of failures. They are used when an adequate history to provide failure statistics is not available. Developed initially by Rasmussen for the US Nuclear Regulatory Commission in the early 1970s [65, 51], fault trees have become a popular risk analytic tool for predicting risks, assessing relative risks, and quantifying comparative risks [7, 9, 15, 18, 23, 26, 45]. In 1976, we first used fault trees to quantify oil spill probabilities in the Canadian Beaufort Sea for the Canadian Department of the Environment [10, 11]. In the present study they are used for the transformation of historical oil spill statistics for non-Arctic regions to predictive oil spill statistics for Arctic regions in the study area.

4.2 Fault Tree Methodology

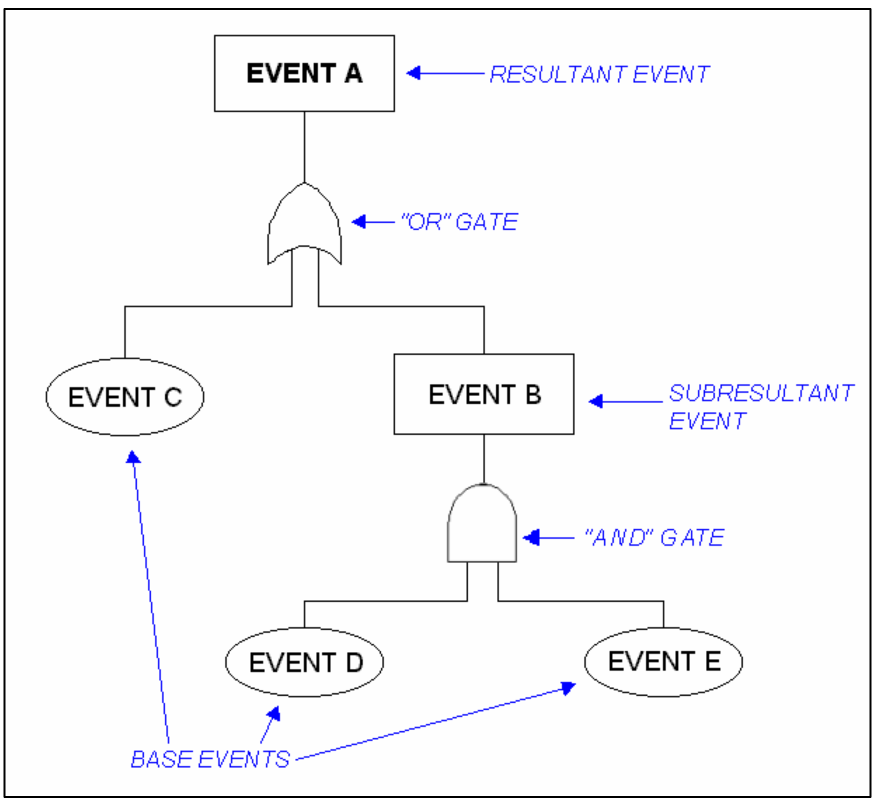
4.2.1 Fault Tree Analysis Basics

The basic symbols used in the graphic depiction of simple (as used here) fault tree networks are illustrated in Figure 4.1(a). As may be seen, the two types of symbols designate logic gates and event types. The basic fault tree building blocks are the events and associated sub-events, which form a causal network. The elements linking events are the AND and OR gates, which define the logical relationship among events in the network. The output event from an OR gate occurs if any one or more of the input events to the gate occurs. The output event from an AND gate occurs only if all the input events occur simultaneously.

The basic structure of a fault tree is illustrated in Figure 4.1(b). Because of their connection through an AND gate, Event D and Event E must both occur for the resultant Event B to occur. An OR gate connects Events B and C; therefore, the occurrence of either one or both of Events B and C results in the occurrence of the resultant Event A. As may be seen, the principal fault tree structures are easy to apply; however, the representation of complex problems often requires very large fault trees, which become more difficult to analyze and require more advanced techniques such as minimal cut-set analysis [2, 18, 23, 51]. For the present application, a simple system connected through OR gates only will used.

SYMBOL	DESCRIPTION
A. LOGIC	
	EITHER / OR GATE
	AND GATE
B. EVENT	
	RESULTANT EVENT
	BASIC EVENT

(a) Basic Fault Tree Symbols



(b) Basic Fault Tree Structure

Figure 4.1
Fault Tree Basics

Computationally, the probability of input events joined through an AND gate are multiplied to calculate the probabilities of the output event. The probabilities of input events joined through an OR gate are added to calculate the probability of the output event. The relevant equations and associated assumptions may be summarized as follows:

For AND Gate:

$$P = \prod_{n}^{i=1} P_i \tag{4.1a}$$

Example: Output Event Probability = P_x
Input Events failure probabilities, P_1, P_2, ….

$$P_x = P_1(P_2)(P_3) \tag{4.1b}$$

For OR Gate:

$$P = 1 - \prod_{n}^{i=1}(1 - P_i) \tag{4.2a}$$

Example: Output Event Probability = P_y
Input Event failure probabilities, P_1, P_2, …

$$P_y = 1 - \prod_{n}(1 - P_1)(1 - P_2)(1 - P_3)$$

$$P_y = P_1 + P_2 + P_3;\ \textit{for}\ P_i \le 0.1 \tag{4.2b}$$

In more complex fault trees, it is necessary to assure that base events which affect more than one fault tree branch are not numerically duplicated. This is done through the use of minimal cut-set theory [14, 18, 23, 51]. However, as indicated earlier, the fault trees used in this study are sufficiently simple in structure and level of detail to exclude the requirement of using minimal cut-set theory in their computation algorithms.

4.2.2 Current Application of Fault Trees

Figure 4.2 illustrates a two-tier fault tree that can be used to develop pipeline large spill frequencies for the Arctic study area from the historical frequencies. Note that this example is illustrative of the process only, and does not correspond to the same numerical values used in computations later. The type of fault tree shown, to be used extensively later, is a relatively simple fault tree showing the resultant event, the spill, generated from a series of subresultant events corresponding to the pipeline spill causal classification, such as that shown in Table 2.3. The upper tier of numbers (marked "H") below each of the events in the fault tree represents the historical frequency (per 100,000 km-yr) while the lower one (marked "A") represents the modified frequency for Arctic operations. As these fault trees are composed entirely of OR gates, the computation of resultant events is quite simple – consisting of the addition of the probabilities of events at each level of the fault tree to obtain the resultant probability at the next higher value.

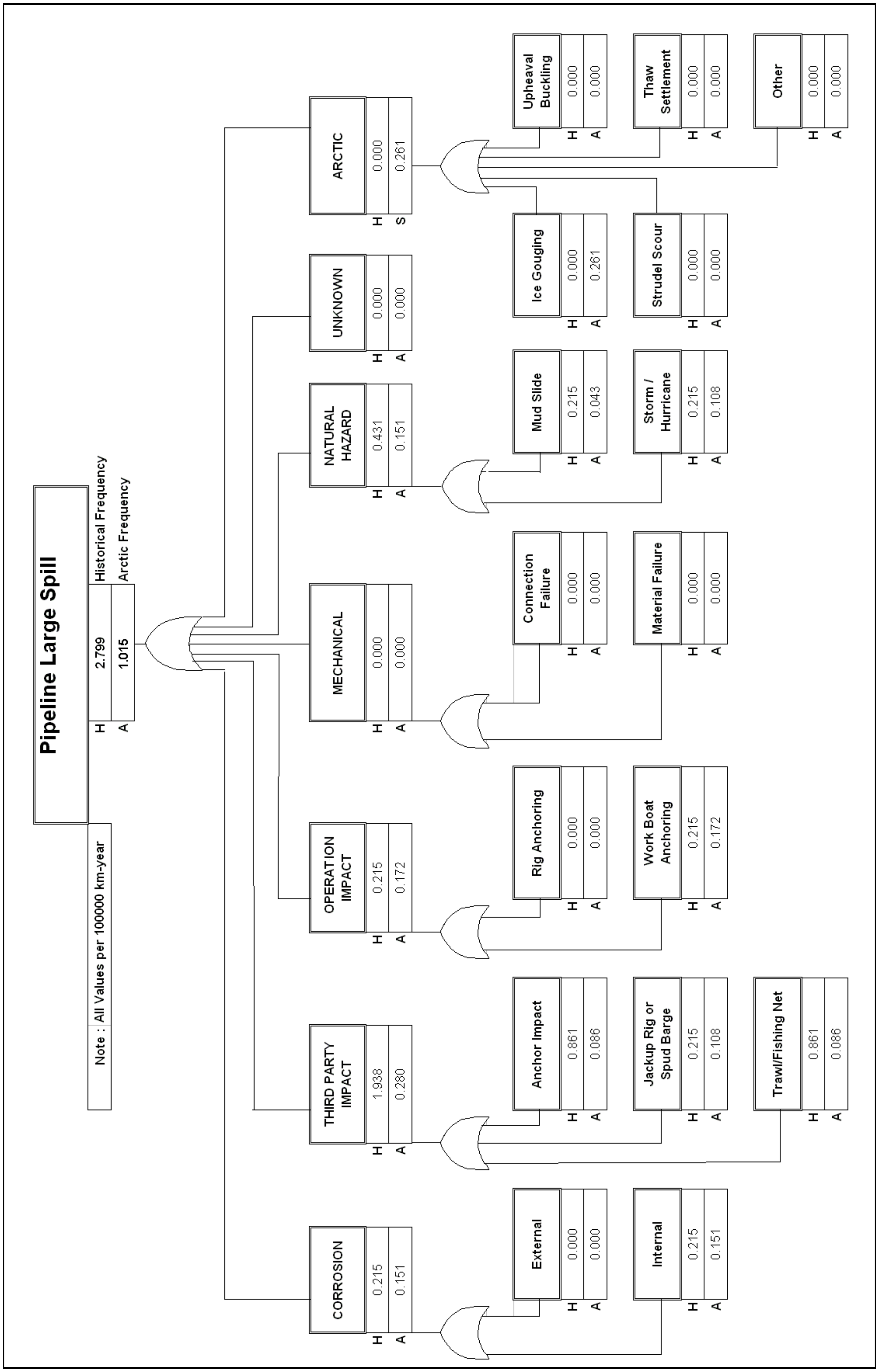


Figure 4.2
Example of Fault Tree to Transform Historical (GOM) to Arctic Spill Frequencies[1]

[1] The input data used here are only illustrative and do not represent the inputs used later in this study.

For example, to obtain the "Natural Hazard" Arctic ("A") probability of 0.151, add 0.043 and 0.108. Essentially, the fault tree resultant (top event) shows that the Arctic frequency of spills (for the example pipeline category, location, and spill size) is approximately 1 in 100,000 km-yr or 1.015 x 10^{-5}/km-yr. The non-Arctic historical frequency for this spill size, by comparison, is 2.799 x 10^{-5}/km-yr, or approximately 2.8 times higher. Both frequencies are for illustrative purposes only.

4.2.3 Monte Carlo Simulation

A type of numerical simulation, called Monte Carlo simulation [9] can be used to obtain the outcome of a set of interactions for equations in which the independent variables are described by distributions of any arbitrary form. The Monte Carlo simulation is a systematic method for selecting values from each of the independent variable distributions and computing all valid combinations of these values to obtain the distribution of the dependent variable. Naturally, this is done utilizing a computer, so that thousands of combinations can be rapidly computed and assembled to give the output distribution.

Consider the example of the following equation:

$$X = X_1 + X_2 \tag{4.3}$$

Where X is the dependent variable (such as the resultant spill frequency) and X_1 and X_2 are base event probabilities joined through an "and" gate. Suppose now that X_1 and X_2 are some arbitrary distributions that can be described by a collection of values x_1 and x_2. What we do in the Monte Carlo process, figuratively, is to put the collection of the X_1 values into one hat, the X_1 hat, and the same for the X_2 values – into an X_2 hat. We then randomly draw one value from each of the hats and compute the resultant value of the dependent variable, X, using equation 4.3. This is done several thousand times. Thus, a resultant or dependent variable distribution, X, is estimated from the computations of all valid combinations of the independent variables (X_1 and X_2).

Generally, the resultant can be viewed as a cumulative distribution function as illustrated in Figure 4.3. Such a cumulative distribution function (CDF) is also a measure of the accuracy or, conversely, the variance of the distribution. As can be seen from this figure, if the distribution is a vertical line, no matter where one draws on the vertical axis, the same value of the variable will result – that is, the variable is a constant. At the other extreme, if the variable is completely random then the distribution will be represented as a diagonal straight line between the minimum and maximum value. Intermediate qualitative descriptions of the randomness of the variable follow from inspection of the CDF in Figure 4.3.

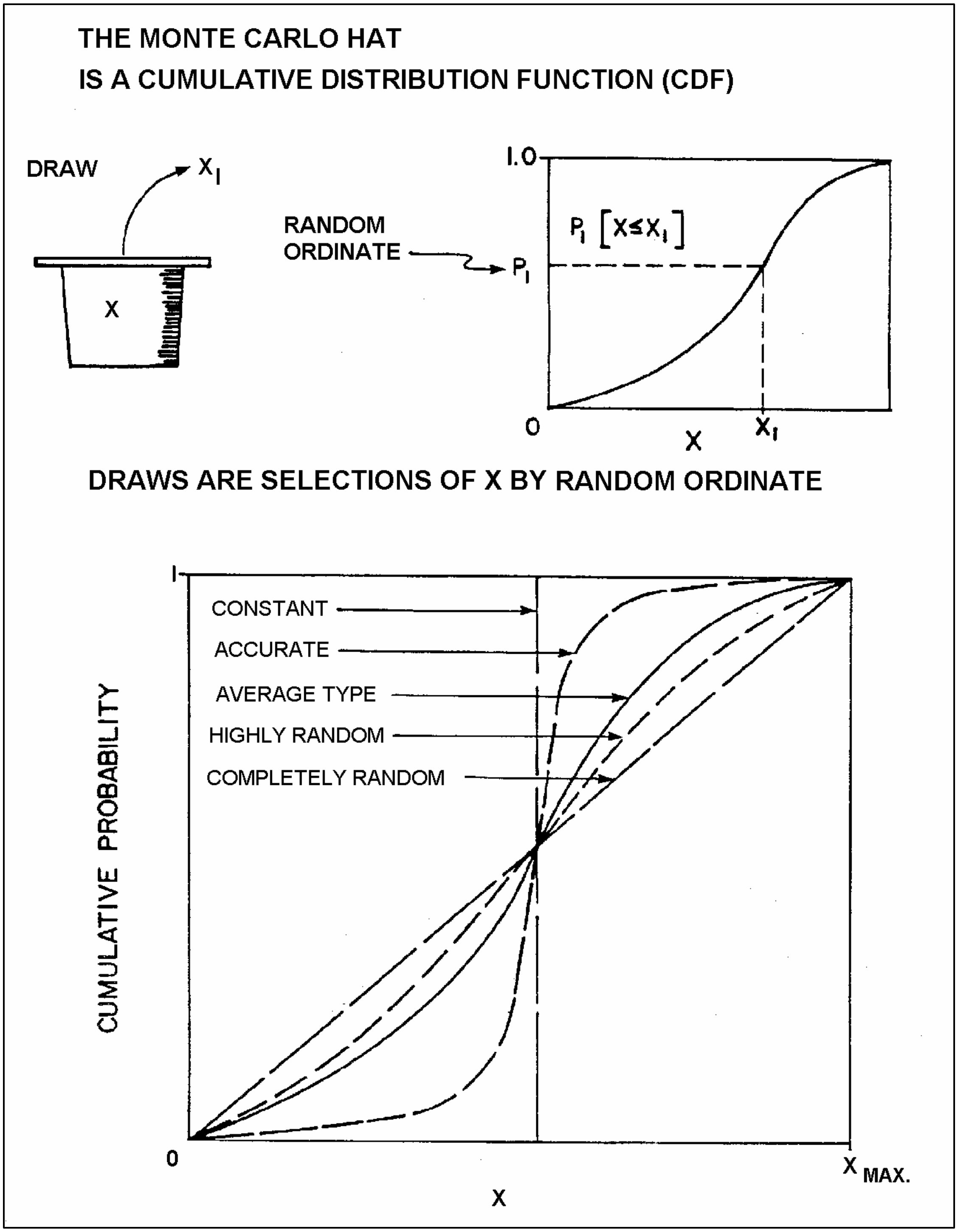


Figure 4.3
Monte Carlo Technique Schematic

There are two other important concepts related to the CDF enter into Monte Carlo modeling: auto-correlation and cross-correlation. Suppose the variables X_1 can vary only within a specified interval over the simulation time increment. Then, after the first random draw, the next draw would be restricted within certain limits of the initial draw simply as a result of the physical restrictions of the problem. Such a restriction is represented as an auto-correlation coefficient. Now, suppose that not only are the X_1 restricted, but also the X_2. Suppose further, however, that given a certain X_1, a restriction were placed on the range of X_2 associated with that X_1. Say, only small X_1 could associate with the full range of X_2, while large X_1 could only be associated with certain lower X_2. Then, such a relationship would be expressed as a cross-correlation factor and certain limits would be imposed for the drawing on both X_1 and associated X_2. In the present analysis, all distributed variables are considered to be independent – so that auto and cross-correlations need not be invoked.

4.2.4 Distribution Derived from Historical Data for Monte Carlo Analysis

In order to model the variability of the base data and its distribution through the Arctic effects, using the Monte Carlo approach, an appropriate distribution needs to be derived. As in the previous studies [12, 13], a Triangular Distribution was selected.

The Triangular Distribution is typically used as a descriptor of a population for which there is only limited sample data, as is the current case. The distribution is based on a knowledge of a minimum and maximum, which was derived from the historical data here, and an educated guess as to what the modal value might be. Here, the modal value was chosen to be a function of the average historical value, as given in Equation 2.1. Despite being a simplistic description of a population, the Triangular Distribution is a very useful one for modeling processes where the relationship between variables is understood, but data are scarce.

Also, when combining several variables in a functional relationship utilizing numerical methods, as is done in Monte Carlo Simulation, the Triangular Distribution is a preferred one due to its simplicity and relatively accurate probabilistic resultant when evaluated by a large number of random draws, as occurs in the Monte Carlo process. The data used here typifies sparse data with a preferred or modal value and an easily identifiable maximum and minimum. Then, for the case of the simple upper and lower 100% confidence interval (called High and Low), the expected value ***E*** (or mean value) of the Triangular Distribution can be expressed as:

$$\boldsymbol{E = (High + Mode + Low) / 3} \qquad \textbf{(4.4)}$$

For maximum and minimum which are not at the 100% confidence interval level – such as those at 90% confidence levels – a Monte Carlo computation is used to evaluate the expected value of each distribution, giving results somewhat different from Equation 4.4. Based on the historical data earlier presented in Tables 2.4, 2.7, and 2.10, the Triangular Distribution expected values computed from the low, mode, and high values at 90% confidence intervals are given in Tables 4.1, 4.2, and 4.3, for pipelines, platforms, and wells respectively. The high and low values were calculated as described in Section 2.2.

Table 4.1
Pipeline Spill Frequency Triangular Distribution Properties
(App. Table 1.4)

GOM OCS Pipeline Spills, Categorized 1972-2006		Low Factor	High Factor	Frequency spill per 10^5 km-years				
By Diameter	*By Spill Size*			Historical	Low	Mode	High	Expected
<10”	Small	0	2.81	4.2557	0	0.8086	11.9585	6.0361
	Medium	0	2.81	7.4474	0	1.4150	20.9273	10.5632
	Large	0	2.81	3.7237	0	0.7075	10.4637	5.2816
	Huge	0	2.81	0.5320	0	0.1011	1.4948	0.7545
=>10"	Small	0	2.81	4.6586	0	0.8851	13.0906	6.6076
	Medium	0	2.81	10.4818	0	1.9915	29.4539	14.8670
	Large	0	2.81	5.8232	0	1.1064	16.3633	8.2595
	Huge	0	2.81	2.3293	0	0.4426	6.5453	3.3038

Table 4.2
Platform Spill Frequency Triangular Distribution Properties
(App. Table 1.7)

Spill Size	Frequency Unit	Low Factor	High Factor	Historical	Low	Mode	High	Expected
Small and Medium Spills (50-999 bbl)	Spill per 10^4 well-year	0	3	3.1460	0.0000	0.0000	9.4379	4.6009
Large and Huge Spills (=>1000 bbl)	Spill per 10^4 well-year	0	3	0.3287	0.0000	0.0000	0.9860	0.4807

Table 4.3
Well Blowout Frequency Triangular Distribution Properties
(App. Table 1.9)

EVENT	FREQUENCY UNIT	Low Factor	High Factor	Frequencies				
				Historical	Low	Mode	High	Expected
				Small and Medium Spills 50-999 bbl				
PRODUCTION WELL	spill per 10^4 well-year	0.448	1.545	0.147	0.066	0.148	0.227	0.147
EXPLORATION WELL DRILLING	spill per 10^4 wells	0.439	2.036	1.966	0.863	1.032	4.002	2.262
DEVELOPMENT WELL DRILLING	spill per 10^4 wells	0.437	1.760	0.654	0.286	0.526	1.151	0.692
				Large Spills 1000-9999 bbl				
PRODUCTION WELL	spill per 10^4 well-year	0.448	1.545	1.028	0.460	1.037	1.588	1.026
EXPLORATION WELL DRILLING	spill per 10^4 wells	0.439	2.036	13.754	6.039	7.220	28.001	15.824
DEVELOPMENT WELL DRILLING	spill per 10^4 wells	0.437	1.760	4.570	1.998	3.671	8.041	4.833
				Small, Medium and Large Spills 50-9999 bbl				
PRODUCTION WELL	spill per 10^4 well-year	0.448	1.545	1.175	0.526	1.185	1.815	1.173
EXPLORATION WELL DRILLING	spill per 10^4 wells	0.439	2.036	15.719	6.903	8.252	32.003	18.086
DEVELOPMENT WELL DRILLING	spill per 10^4 wells	0.437	1.760	5.224	2.284	4.197	9.192	5.525
				Spill 10000-149999 bbl				
PRODUCTION WELL	spill per 10^4 well-year	0.448	1.545	0.441	0.197	0.444	0.681	0.440
EXPLORATION WELL DRILLING	spill per 10^4 wells	0.439	2.036	5.909	2.595	3.102	12.031	6.799
DEVELOPMENT WELL DRILLING	spill per 10^4 wells	0.437	1.760	1.963	0.858	1.577	3.454	2.076
				Spill =>150000 bbl				
PRODUCTION WELL	spill per 10^4 well-year	0.448	1.545	0.294	0.132	0.296	0.454	0.293
EXPLORATION WELL DRILLING	spill per 10^4 wells	0.439	2.036	3.421	1.502	1.796	6.965	3.936
DEVELOPMENT WELL DRILLING	spill per 10^4 wells	0.437	1.760	1.963	0.858	1.577	3.454	2.076

4.2.5 Approaches to Assessment of Arctic Spill Frequency Variability

The method for assessment of Arctic spill frequency variability consists of systematically perturbing the variability of all the causal events, plus that of the Arctic unique effects. In this approach, the non-Arctic variable distribution is multiplied by an adjustment or correction distribution to obtain the Arctic variable distribution.

4.3 Pipeline Fault Tree Analysis

4.3.1 Arctic Pipeline Spill Causal Frequency Distributions

The effects of the Arctic environment and operations are reflected in the effect on facility failure rates in two ways; namely, through "Modified Effects", those changing the frequency component of certain fault contributions such as anchor impacts which are common to both Arctic and temperate zones, and through "Unique Effects" or additive elements such as ice gouging which are unique to the Arctic offshore environment. Table 4.4 shows the frequency modifications (in %) and frequency increment additions (per 10^5 km-yr) developed for Arctic pipelines for different spill sizes throughout the three relevant water depth ranges. The right hand column of the table gives a summary of the reasoning behind the effects. For the Arctic unique effects, both the expected value (from Table 2.9) and the median value, determined through the Monte Carlo analysis, are given. The median values differ from the expected values due to skewness of the distributions introduced through the assigned values of the upper and lower bounds (Table 2.9). The following comments can be made for each of the causes described:

- *External corrosion* – Due to the low temperature, limited biological and lowered chemical effects are expected. Coatings will be state of art and high level of quality control will be used during pipeline installation resulting in high integrity levels of coating to prevent external corrosion.
- *Internal corrosion* – Additional (above historical levels) inspection or smart pigging is anticipated.
- *Anchor impact* – The very low traffic densities of third party shipping in the area justify a 50% reduction in anchor impact expectations on the pipeline.
- *Jack-up rig or spud barges* – Associated or other operations are going to be substantially more limited than they are in the historical data population in the Gulf of Mexico.
- *Trawl/Fishing net* – Very limited fishing is expected in the Chukchi Sea.

Table 4.4
Pipeline Arctic Effect Derivation Summary
(App. Table 2.1)

CAUSE CLASSIFICATION	Spill Size	Shallow	Medium	Deep	Reason
		Historical Expected Frequency Change %			
CORROSION					
External	**All**	(30)	(30)	(30)	Low temperature and bio effects. Extra smart pigging.
Internal	**All**	(30)	(30)	(30)	Extra smart pigging.
THIRD PARTY IMPACT					
Anchor Impact	**All**	(50)	(50)	(50)	Low traffic.
Jackup Rig or Spud Barge	**All**	(50)	(50)	(50)	Low facility density.
Trawl/Fishing Net	**All**	(50)	(60)	(70)	Low fishing activity. Less bottom fishing in deeper water.
OPERATION IMPACT					
Rig Anchoring	**All**	(20)	(20)	(20)	Low marine traffic during ice season (8 months).
Work Boat Anchoring	**All**	(20)	(20)	(20)	Low work boat traffic during ice season (8 months).
MECHANICAL					
Connection Failure	**All**				
Material Failure	**All**				
NATURAL HAZARD					
Mud Slide	**All**	(60)	(50)	(40)	Gradient low. Mud slide potential (gradient) increases with water depth.
Storm/ Hurricane	**All**	(80)	(80)	(70)	Fewer severe storms.
		Freq. Increment per 10^5 km-year			
		Expected Mode	**Expected Mode**	**Expected Mode**	
ARCTIC					
Ice Gouging	**S**	0.511	0.6763		Ice gouge failure rate calculated using exponential failure distribution for 2.5-m cover, 0.2-m average gouge depth, 4 gouges per km-yr flux. Spill size Distribution explained in text Section 2.5.2. Medium depth has 0.8 as many gouges as shallow.
		0.1054	0.1318		
	M	0.5411	0.6763		
		0.1054	0.1318		
	L	1.3527	0.6908		
		0.2635	0.3294		
	H	0.2705	0.3382		
		0.0527	0.0659		
Strudel Scour	**S**	0.0645			Only in shallow water. Average frequency of 4 scours/mile² and 100 ft of bridge length with 10% conditional Pipelines failure probability. The same spill size distribution as above.
		0.0235			
	M	0.0645			
		0.0235			
	L	0.1613			
		0.0587			
	H	0.0323			
		0.0117			
Upheaval Buckling	**S**	0.0129	0.0129	0.0129	All water depth. The failure frequency is 20% of that of Strudel Scour.
		0.0047	0.0047	0.0047	
	M	0.0129	0.0129	0.0129	
		0.0047	0.0047	0.0047	
	L	0.0323	0.0323	0.0323	
		0.0117	0.0117	0.0117	
	H	0.0065	0.0065	0.0065	
		0.0023	0.0023	0.0023	
Thaw Settlement	**S**	0.0065	0.0065	0.0065	All water depth. The failure frequency is 10% of that of Strudel Scour.
		0.0023	0.0023	0.0023	
	M	0.0065	0.0065	0.0065	
		0.0023	0.0023	0.0023	
	L	0.0161	0.0161	0.0161	
		0.0059	0.0059	0.0059	
	H	0.0032	0.0032	0.0032	
		0.0012	0.0012	0.0012	
Other Arctic	**S**	0.0625	0.0696	0.0019	10% of all Arctic effects.
		0.0136	0.0139	0.0007	
	M	0.0625	0.0696	0.0019	
		0.0136	0.0139	0.0007	
	L	0.1562	0.1739	0.0048	
		0.0340	0.0347	0.0018	
	H	0.0312	0.0348	0.0010	
		0.0068	0.0069	0.0004	

- *Rig anchoring* – Although it is anticipated that no marine traffic except possibly icebreakers will occur during the ice season, an increased traffic density during the four month open water season to resupply the platforms is expected, justifying only a 20% decrease in this failure cause.
- *Workboat anchoring* – The same applies to workboat anchoring as to rig anchoring.
- *Mechanical connection failure or material failure* – No change was made to account for Arctic effects.
- *Mudslide* – A relatively low gradient resulting in limited mudslide potential is anticipated. A gradual increase in the mudslide potential (reflected by smaller decreases in failure frequency) ranging from 60% for shallow water to only 40% in deep water was included to account for the anticipated increase in gradient as deeper waters are encountered.
- *Storms* – Considerably fewer severe storms are anticipated on an annual basis in the Arctic than in GOM, due to damping of the ocean surface by ice cover.
- *Arctic effects* – Arctic effects are effects which are unique to the Arctic and are not reflected in the historical fault tree itself. Arctic effects were discussed in detail in Chapter 2, Section 2.5. The discussion in that section is summarized in the right hand column of Table 4.4. The frequency increments in this table are given as both the "mode" values and the "expected" values. The mode values are the mode values given in Table 2.11. The expected values, however, are those calculated using the Monte Carlo method with the low, mode, and high values from Table 2.11, as inputs to the Monte Carlo. The expected or mean values are clearly considerably higher than the mode or most likely values. This lack of coincidence between expected and mode values is due to the skewness of the distribution.

Derivation of the Arctic effect distributions is accomplished through the construction of a secondary triangular distribution by which the historical causal frequency distributions are multiplied to provide the resultant Arctic effect distribution. This secondary distribution utilizes the value of mode adjustments from Table 4.4, with appropriate second order perturbations for the upper and lower 90% confidence interval bounds. Table 4.5 summarizes these Arctic effect distributions. For the Arctic modified effects, given in the top of the table, the secondary distribution is simply the frequency change used as the mode of the distribution, and 90% upper and lower confidence interval changes given under the Min and Max columns. For the Arctic unique effects, total frequency increments are given, with the upper confidence interval value at approximately 12 times the mode, and the lower bound value at approximately $^{1}/_{12}$ of the modal value.

Table 4.5
Pipeline Arctic Effect Distribution Derivation Summary
(App. Table 2.2)

Cause Classification	Spill Size	Water Depth								
		Shallow			Medium			Deep		
		Frequency Increment per 10^5 km-year								
		Min	Mode	Max	Min	Mode	Max	Min	Mode	Max
CORROSION										
External	**All**	(90)	(30)	(10)	(90)	(30)	(10)	(90)	(30)	(10)
Internal	**All**	(90)	(30)	(10)	(90)	(30)	(10)	(90)	(30)	(10)
THIRD PARTY IMPACT										
Anchor Impact	**All**	(90)	(50)	(10)	(90)	(50)	(10)	(90)	(50)	(10)
Jackup Rig or	**All**	(90)	(50)	(10)	(90)	(50)	(10)	(90)	(50)	(10)
Trawl/Fishing	**All**	(90)	(50)	(10)	(90)	(60)	(10)	(90)	(70)	(10)
OPERATION IMPACT										
Rig Anchoring	**All**	(50)	(20)	(10)	(50)	(20)	(10)	(50)	(20)	(10)
Work Boat	**All**	(50)	(20)	(10)	(50)	(20)	(10)	(50)	(20)	(10)
MECHANICAL										
Connection Failure	**All**									
Material Failure	**All**									
NATURAL HAZARD										
Mud Slide	**All**	(90)	(60)	(10)	(90)	(50)	(10)	(90)	(40)	(10)
Storm/ Hurricane	**All**	(90)	(80)	(10)	(90)	(80)	(10)	(90)	(70)	(10)

Cause Classification	Spill Size	Water Depth								
		Shallow			Medium			Deep		
		Frequency Increment per 10^5 km-year								
		Min	Mode	Max	Min	Mode	Max	Min	Mode	Max
Ice Gouging	**S**	0.0087	0.1054	1.2841	0.0108	0.1318	1.6051			
	M	0.0087	0.1054	1.2841	0.0108	0.1318	1.6051			
	L	0.0216	0.2635	3.2103	0.0270	0.3294	4.0128			
	H	0.0043	0.0527	0.6421	0.0054	0.0659	0.8026			
Strudel Scour	**S**	0.0110	0.0235	0.1381						
	M	0.0110	0.0235	0.1381						
	L	0.0276	0.0587	0.3452						
	H	0.0055	0.0117	0.0690						
Upheaval Buckling	**S**	0.00221	0.00469	0.02761	0.00221	0.00469	0.02761	0.00221	0.00469	0.02761
	M	0.00221	0.00469	0.02761	0.00221	0.00469	0.02761	0.00221	0.00469	0.02761
	L	0.00552	0.01174	0.06904	0.00552	0.01174	0.06904	0.00552	0.01174	0.06904
	H	0.00110	0.00235	0.01381	0.00110	0.00235	0.01381	0.00110	0.00235	0.01381
Thaw Settlement	**S**	0.00110	0.00235	0.01381	0.00110	0.00235	0.01381	0.00110	0.00235	0.01381
	M	0.00110	0.00235	0.01381	0.00110	0.00235	0.01381	0.00110	0.00235	0.01381
	L	0.00276	0.00587	0.03452	0.00276	0.00587	0.03452	0.00276	0.00587	0.03452
	H	0.00055	0.00117	0.00690	0.00055	0.00117	0.00690	0.00055	0.00117	0.00690
Other Arctic	**S**	0.00230	0.01359	0.14636	0.00141	0.01388	0.16466	0.00033	0.00070	0.00414
	M	0.00230	0.01359	0.14636	0.00141	0.01388	0.16466	0.00033	0.00070	0.00414
	L	0.00575	0.03398	0.36590	0.00353	0.03470	0.41164	0.00083	0.00176	0.01036
	H	0.00115	0.00680	0.07318	0.00071	0.00694	0.08233	0.00017	0.00035	0.00207

4.3.2 Arctic Pipeline Fault Tree Frequency Calculations

Incorporation of the frequency effects as variations in and additions to the historical frequencies can be represented in a fault tree, as shown for the large spill size for Arctic pipelines in Figure 4.4. In this figure, the historical frequency as well as that associated with small, medium, and deep-water zones are shown under each of the event boxes. Each box is further split into two, for pipelines less than or at least 10" diameter as represented in the historical database. Such fault trees were developed for all of the pipeline spill sizes, and these additional spill size fault trees, for small, medium, large, and huge spills are presented in Appendix 2, where the complete calculations are given.

Of greatest importance, however, are the pipeline failure frequencies or failure rates per km-yr calculated from the first and second order input distributions using Monte Carlo simulation. These failure rates for the entire range of pipeline spill sizes, small, medium, large, and huge, are given in Tables 4.6, 4.7, 4.8, and 4.9, respectively.

Indeed, a huge array of numbers is shown in these tables. Consider Table 4.8, which is the frequency calculation corresponding to the large spill size fault tree shown in Figure 4.4. Consider the bottom line opposite totals. What the table tells us is that the total spill frequency for pipelines < 10" diameter was 5.282 (per 10^5 km-yr) historically. With the first and second order frequency changes attributable to Arctic effects, this frequency is reduced to 4.402 for shallow water, to 4.575 for medium depth water, and to 2.707 for deep water. A similar trend in the reduction of failure frequencies with increasing water depth for pipelines >= 10" is manifested in the right hand side of the table. Because the frequencies per unit pipeline length and operating year are the key drivers in the balance of the analysis, they have been given in the body of the report (in Tables 4.6 to 4.9) for each of the spill sizes for pipelines. Finally, Table 4.10 summarizes the expected values of the pipeline spill frequencies.

Note : All Values per 100000 km-year

Pipeline Large Spill 1000-9999 bbl

	Dia<=10"	Dia>10"	P/L Size
H	5.282	8.259	Historical Frequency
S	4.402	5.915	Shallow Water Depth Frequency
M	4.575	6.075	Medium Water Depth Frequency
D	2.707	4.203	Deep Water Depth Frequency

CORROSION

	Dia<=10"	Dia>10"
H	0.352	0.551
S	0.190	0.298
M	0.190	0.298
D	0.190	0.298

External

	Dia<=10"	Dia>10"
H	0.000	0.000
S	0.000	0.000
M	0.000	0.000
D	0.000	0.000

Internal

	Dia<=10"	Dia>10"
H	0.352	0.551
S	0.190	0.298
M	0.190	0.298
D	0.190	0.298

THIRD PARTY IMPACT

	Dia<=10"	Dia>10"
H	3.521	5.506
S	1.761	2.753
M	1.731	2.707
D	1.703	2.663

Anchor Impact

	Dia<=10"	Dia>10"
H	1.761	2.753
S	0.880	1.377
M	0.880	1.377
D	0.880	1.377

Jackup Rig or Spud Barge

	Dia<=10"	Dia>10"
H	0.352	0.551
S	0.176	0.275
M	0.176	0.275
D	0.176	0.275

Trawl/Fishing Net

	Dia<=10"	Dia>10"
H	1.408	2.203
S	0.704	1.101
M	0.675	1.056
D	0.647	1.011

OPERATION IMPACT

	Dia<=10"	Dia>10"
H	0.352	0.551
S	0.254	0.397
M	0.254	0.397
D	0.254	0.397

Rig Anchoring

	Dia<=10"	Dia>10"
H	0.000	0.000
S	0.000	0.000
M	0.000	0.000
D	0.000	0.000

Work Boat Anchoring

	Dia<=10"	Dia>10"
H	0.352	0.551
S	0.254	0.397
M	0.254	0.397
D	0.254	0.397

MECHANICAL

	Dia<=10"	Dia>10"
H	0.000	0.000
S	0.000	0.000
M	0.000	0.000
D	0.000	0.000

Connection Failure

	Dia<=10"	Dia>10"
H	0.000	0.000
S	0.000	0.000
M	0.000	0.000
D	0.000	0.000

Material Failure

	Dia<=10"	Dia>10"
H	0.000	0.000
S	0.000	0.000
M	0.000	0.000
D	0.000	0.000

NATURAL HAZARD

	Dia<=10"	Dia>10"
H	1.056	1.652
S	0.479	0.749
M	0.486	0.760
D	0.507	0.792

Mud Slide

	Dia<=10"	Dia>10"
H	0.352	0.551
S	0.169	0.264
M	0.176	0.275
D	0.183	0.287

Storm/ Hurricane

	Dia<=10"	Dia>10"
H	0.704	1.101
S	0.310	0.485
M	0.310	0.485
D	0.323	0.506

UNKNOWN

	Dia<=10"	Dia>10"
H	0.000	0.000
S	0.000	0.000
M	0.000	0.000
D	0.000	0.000

ARCTIC

	Dia<=10"	Dia>10"
H	0.000	0.000
S	1.719	1.719
M	1.913	1.913
D	0.053	0.053

Ice Gouging

	Dia<=10"	Dia>10"
H	0.000	0.000
S	1.353	1.353
M	1.691	1.691
D	0.000	0.000

Strudel Scour

	Dia<=10"	Dia>10"
H	0.000	0.000
S	0.161	0.161
M	0.000	0.000
D	0.000	0.000

Upheaval Buckling

	Dia<=10"	Dia>10"
H	0.000	0.000
S	0.032	0.032
M	0.032	0.032
D	0.032	0.032

Thaw Settlement

	Dia<=10"	Dia>10"
H	0.000	0.000
S	0.016	0.016
M	0.016	0.016
D	0.016	0.016

Other Arctic

	Dia<=10"	Dia>10"
H	0.000	0.000
S	0.156	0.156
M	0.174	0.174
D	0.005	0.005

Figure 4.4
Large Spill Frequencies Fault Tree for Pipeline
(Appendix Figure 2.3)

Table 4.6
Arctic Pipeline Small Spill (50-99 bbl) Frequencies
(App. Table 2.3)

CAUSE CLASSIFICATION	HIST. DISTRIBUTION %	Pipeline Diameter <=10"										Pipeline Diameter > 10"									
			Shallow			Medium			Deep				Shallow			Medium			Deep		
		FREQUENCY spills per 10^5km-year	Frequency Change	New Frequency	New Distribution %	Frequency Change	New Frequency	New Distribution %	Frequency Change	New Frequency	New Distribution %	FREQUENCY spills per 10^5km-year	Frequency Change	New Frequency	New Distribution %	Frequency Change	New Frequency	New Distribution %	Frequency Change	New Frequency	New Distribution %
CORROSION	**8.57**	**0.517**	**(0.238)**	**0.280**	**5.11**	**(0.238)**	**0.280**	**5.04**	**(0.238)**	**0.280**	**5.81**	**0.566**	**(0.260)**	**0.306**	**5.17**	**(0.260)**	**0.306**	**5.10**	**(0.260)**	**0.306**	**5.82**
External	2.86	0.172	(0.079)	0.093	1.70	(0.079)	0.093	1.68	(0.079)	0.093	1.94	0.189	(0.087)	0.102	1.72	(0.087)	0.102	1.70	(0.087)	0.102	1.94
Internal	5.71	0.345	(0.158)	0.187	3.41	(0.158)	0.187	3.36	(0.158)	0.187	3.88	0.378	(0.173)	0.204	3.45	(0.173)	0.204	3.40	(0.173)	0.204	3.88
THIRD PARTY IMPACT	**22.86**	**1.380**	**(0.690)**	**0.690**	**12.61**	**(0.693)**	**0.686**	**12.36**	**(0.697)**	**0.683**	**14.19**	**1.510**	**(0.755)**	**0.755**	**12.75**	**(0.759)**	**0.751**	**12.51**	**(0.763)**	**0.747**	**14.19**
Anchor Impact	20.00	1.207	(0.604)	0.604	11.03	(0.604)	0.604	10.87	(0.604)	0.604	12.54	1.322	(0.661)	0.661	11.15	(0.661)	0.661	11.00	(0.661)	0.661	12.55
Jackup Rig or Spud Barge																					
Trawl/Fishing Net	2.86	0.172	(0.086)	0.086	1.58	(0.090)	0.083	1.49	(0.093)	0.079	1.64	0.189	(0.094)	0.094	1.59	(0.098)	0.090	1.51	(0.102)	0.087	1.65
OPERATION IMPACT	**8.57**	**0.517**	**(0.145)**	**0.373**	**6.81**	**(0.145)**	**0.373**	**6.71**	**(0.145)**	**0.373**	**7.74**	**0.566**	**(0.158)**	**0.408**	**6.89**	**(0.158)**	**0.408**	**6.79**	**(0.158)**	**0.408**	**7.75**
Rig Anchoring	2.86	0.172	(0.048)	0.124	2.27	(0.048)	0.124	2.24	(0.048)	0.124	2.58	0.189	(0.053)	0.136	2.30	(0.053)	0.136	2.26	(0.053)	0.136	2.58
Work Boat Anchoring	5.71	0.345	(0.096)	0.249	4.54	(0.096)	0.249	4.47	(0.096)	0.249	5.16	0.378	(0.106)	0.272	4.59	(0.106)	0.272	4.53	(0.106)	0.272	5.17
MECHANICAL	**5.71**	**0.345**		**0.345**	**6.30**		**0.345**	**6.21**		**0.345**	**7.17**	**0.378**		**0.378**	**6.37**		**0.378**	**6.29**		**0.378**	**7.17**
Connection Failure	2.86	0.172		0.172	3.15		0.172	3.11		0.172	3.58	0.189		0.189	3.19		0.189	3.14		0.189	3.58
Material Failure	2.86	0.172		0.172	3.15		0.172	3.11		0.172	3.58	0.189		0.189	3.19		0.189	3.14		0.189	3.58
NATURAL HAZARD	**48.57**	**2.932**	**(0.180)**	**2.752**	**50.30**	**(0.172)**	**2.759**	**49.69**	**(0.165)**	**2.767**	**57.48**	**3.209**	**(0.197)**	**3.013**	**50.85**	**(0.189)**	**3.021**	**50.29**	**(0.181)**	**3.028**	**57.50**
Mud Slide	5.71	0.345	(0.180)	0.165	3.02	(0.172)	0.172	3.11	(0.165)	0.180	3.73	0.378	(0.197)	0.181	3.05	(0.189)	0.189	3.14	(0.181)	0.197	3.73
Storm/ Hurricane	42.86	2.587		2.587	47.28		2.587	46.58		2.587	53.75	2.832		2.832	47.80		2.832	47.14		2.832	53.77
ARCTIC			**0.687**	**0.687**	**12.56**	**0.765**	**0.765**	**13.78**	**0.021**	**0.021**	**0.44**		**0.687**	**0.687**	**11.60**	**0.765**	**0.765**	**12.74**	**0.021**	**0.021**	**0.40**
Ice Gouging			0.5411	0.5411	9.89	0.6763	0.6763	12.18					0.5411	0.5411	9.13	0.6763	0.6763	11.26			
Strudel Scour			0.0645	0.0645	1.18								0.0645	0.0645	1.09						
Upheaval Buckling			0.0129	0.0129	0.24	0.0129	0.0129	0.23	0.0129	0.0129	0.27		0.0129	0.0129	0.22	0.0129	0.0129	0.21	0.0129	0.0129	0.24
Thaw Settlement			0.0065	0.0065	0.12	0.0065	0.0065	0.12	0.0065	0.0065	0.13		0.0065	0.0065	0.11	0.0065	0.0065	0.11	0.0065	0.0065	0.12
Other			0.0625	0.0625	1.14	0.0696	0.0696	1.25	0.0019	0.0019	0.04		0.0625	0.0625	1.05	0.0696	0.0696	1.16	0.0019	0.0019	0.04
UNKNOWN	**5.71**	**0.345**		**0.345**	**6.30**		**0.345**	**6.21**		**0.345**	**7.17**	**0.378**		**0.378**	**6.37**		**0.378**	**6.29**		**0.378**	**7.17**
TOTALS	**100.00**	**6.036**	**(0.564)**	**5.472**	**100.00**	**(0.483)**	**5.553**	**100.00**	**(1.223)**	**4.813**	**100.00**	**6.608**	**(0.683)**	**5.925**	**100.00**	**(0.601)**	**6.007**	**100.00**	**(1.341)**	**5.267**	**100.00**

Table 4.7
Arctic Pipeline Medium Spill (100-999 bbl) Frequencies
(App. Table 2.4)

CAUSE CLASSIFICATION	HIST. DISTRIBUTION %	*Pipeline Diameter <= 10"*										*Pipeline Diameter > 10"*									
			Shallow			Medium			Deep				Shallow			Medium			Deep		
		FREQUENCY spills per 10⁵km-year	Frequency Change	New Frequency	New Distribution %	Frequency Change	New Frequency	New Distribution %	Frequency Change	New Frequency	New Distribution %	FREQUENCY spills per 10⁵km-year	Frequency Change	New Frequency	New Distribution %	Frequency Change	New Frequency	New Distribution %	Frequency Change	New Frequency	New Distribution %
CORROSION	**8.57**	**0.517**	**(0.238)**	**0.280**	**5.11**	**(0.238)**	**0.280**	**5.04**	**(0.238)**	**0.280**	**5.81**	**0.566**	**(0.260)**	**0.306**	**5.17**	**(0.260)**	**0.306**	**5.10**	**(0.260)**	**0.306**	**5.82**
External	2.86	0.172	(0.079)	0.093	1.70	(0.079)	0.093	1.68	(0.079)	0.093	1.94	0.189	(0.087)	0.102	1.72	(0.087)	0.102	1.70	(0.087)	0.102	1.94
Internal	5.71	0.345	(0.158)	0.187	3.41	(0.158)	0.187	3.36	(0.158)	0.187	3.88	0.378	(0.173)	0.204	3.45	(0.173)	0.204	3.40	(0.173)	0.204	3.88
THIRD PARTY IMPACT	**22.86**	**1.380**	**(0.690)**	**0.690**	**12.61**	**(0.693)**	**0.686**	**12.36**	**(0.697)**	**0.683**	**14.19**	**1.510**	**(0.755)**	**0.755**	**12.75**	**(0.759)**	**0.751**	**12.51**	**(0.763)**	**0.747**	**14.19**
Anchor Impact	20.00	1.207	(0.604)	0.604	11.03	(0.604)	0.604	10.87	(0.604)	0.604	12.54	1.322	(0.661)	0.661	11.15	(0.661)	0.661	11.00	(0.661)	0.661	12.55
Jackup Rig or Spud Barge																					
Trawl/Fishing Net	2.86	0.172	(0.086)	0.086	1.58	(0.090)	0.083	1.49	(0.093)	0.079	1.64	0.189	(0.094)	0.094	1.59	(0.098)	0.090	1.51	(0.102)	0.087	1.65
OPERATION IMPACT	**8.57**	**0.517**	**(0.145)**	**0.373**	**6.81**	**(0.145)**	**0.373**	**6.71**	**(0.145)**	**0.373**	**7.74**	**0.566**	**(0.158)**	**0.408**	**6.89**	**(0.158)**	**0.408**	**6.79**	**(0.158)**	**0.408**	**7.75**
Rig Anchoring	2.86	0.172	(0.048)	0.124	2.27	(0.048)	0.124	2.24	(0.048)	0.124	2.58	0.189	(0.053)	0.136	2.30	(0.053)	0.136	2.26	(0.053)	0.136	2.58
Work Boat Anchoring	5.71	0.345	(0.096)	0.249	4.54	(0.096)	0.249	4.47	(0.096)	0.249	5.16	0.378	(0.106)	0.272	4.59	(0.106)	0.272	4.53	(0.106)	0.272	5.17
MECHANICAL	**5.71**	**0.345**		**0.345**	**6.30**		**0.345**	**6.21**		**0.345**	**7.17**	**0.378**		**0.378**	**6.37**		**0.378**	**6.29**		**0.378**	**7.17**
Connection Failure	2.86	0.172		0.172	3.15		0.172	3.11		0.172	3.58	0.189		0.189	3.19		0.189	3.14		0.189	3.58
Material Failure	2.86	0.172		0.172	3.15		0.172	3.11		0.172	3.58	0.189		0.189	3.19		0.189	3.14		0.189	3.58
NATURAL HAZARD	**48.57**	**2.932**	**(0.180)**	**2.752**	**50.30**	**(0.172)**	**2.759**	**49.69**	**(0.165)**	**2.767**	**57.48**	**3.209**	**(0.197)**	**3.013**	**50.85**	**(0.189)**	**3.021**	**50.29**	**(0.181)**	**3.028**	**57.50**
Mud Slide	5.71	0.345	(0.180)	0.165	3.02	(0.172)	0.172	3.11	(0.165)	0.180	3.73	0.378	(0.197)	0.181	3.05	(0.189)	0.189	3.14	(0.181)	0.197	3.73
Storm/ Hurricane	42.86	2.587		2.587	47.28		2.587	46.58		2.587	53.75	2.832		2.832	47.80		2.832	47.14		2.832	53.77
ARCTIC			**0.687**	**0.687**	**12.56**	**0.765**	**0.765**	**13.78**	**0.021**	**0.021**	**0.44**		**0.687**	**0.687**	**11.60**	**0.765**	**0.765**	**12.74**	**0.021**	**0.021**	**0.40**
Ice Gouging			0.5411	0.5411	9.89	0.6763	0.6763	12.18					0.5411	0.5411	9.13	0.6763	0.6763	11.26			
Strudel Scour			0.0645	0.0645	1.18								0.0645	0.0645	1.09						
Upheaval Buckling			0.0129	0.0129	0.24	0.0129	0.0129	0.23	0.0129	0.0129	0.27		0.0129	0.0129	0.22	0.0129	0.0129	0.21	0.0129	0.0129	0.24
Thaw Settlement			0.0065	0.0065	0.12	0.0065	0.0065	0.12	0.0065	0.0065	0.13		0.0065	0.0065	0.11	0.0065	0.0065	0.11	0.0065	0.0065	0.12
Other			0.0625	0.0625	1.14	0.0696	0.0696	1.25	0.0019	0.0019	0.04		0.0625	0.0625	1.05	0.0696	0.0696	1.16	0.0019	0.0019	0.04
UNKNOWN	**5.71**	**0.345**		**0.345**	**6.30**		**0.345**	**6.21**		**0.345**	**7.17**	**0.378**		**0.378**	**6.37**		**0.378**	**6.29**		**0.378**	**7.17**
TOTALS	**100.00**	**6.036**	**(0.564)**	**5.472**	**100.00**	**(0.483)**	**5.553**	**100.00**	**(1.223)**	**4.813**	**100.00**	**6.608**	**(0.683)**	**5.925**	**100.00**	**(0.601)**	**6.007**	**100.00**	**(1.341)**	**5.267**	**100.00**

Table 4.8
Arctic Pipeline Large Spill (1,000-9,999 bbl) Frequencies

(App. Table 2.5)

CAUSE CLASSIFICATION	HIST. DISTRIBUTION %	*Pipeline Diameter <= 10"*										*Pipeline Diameter > 10"*									
			Shallow			Medium			Deep				Shallow			Medium			Deep		
		FREQUENCY spills per 10^5km-year	Frequency Change	New Frequency	New Distribution %	Frequency Change	New Frequency	New Distribution %	Frequency Change	New Frequency	New Distribution %	FREQUENCY spills per 10^5km-year	Frequency Change	New Frequency	New Distribution %	Frequency Change	New Frequency	New Distribution %	Frequency Change	New Frequency	New Distribution %
CORROSION	**6.67**	**0.352**	**(0.162)**	**0.190**	**4.33**	**(0.162)**	**0.190**	**4.16**	**(0.162)**	**0.190**	**7.04**	**0.551**	**(0.253)**	**0.298**	**5.04**	**(0.253)**	**0.298**	**4.90**	**(0.253)**	**0.298**	**7.09**
External																					
Internal	6.67	0.352	(0.162)	0.190	4.33	(0.162)	0.190	4.16	(0.162)	0.190	7.04	0.551	(0.253)	0.298	5.04	(0.253)	0.298	4.90	(0.253)	0.298	7.09
THIRD PARTY IMPACT	**66.67**	**3.521**	**(1.761)**	**1.761**	**39.99**	**(1.790)**	**1.731**	**37.85**	**(1.818)**	**1.703**	**62.91**	**5.506**	**(2.753)**	**2.753**	**46.54**	**(2.799)**	**2.707**	**44.56**	**(2.843)**	**2.663**	**63.36**
Anchor Impact	33.33	1.761	(0.880)	0.880	20.00	(0.880)	0.880	19.24	(0.880)	0.880	32.52	2.753	(1.377)	1.377	23.27	(1.377)	1.377	22.66	(1.377)	1.377	32.75
Jackup Rig or Spud Barge	6.67	0.352	(0.176)	0.176	4.00	(0.176)	0.176	3.85	(0.176)	0.176	6.50	0.551	(0.275)	0.275	4.65	(0.275)	0.275	4.53	(0.275)	0.275	6.55
Trawl/Fishing Net	26.67	1.408	(0.704)	0.704	16.00	(0.733)	0.675	14.76	(0.762)	0.647	23.89	2.203	(1.101)	1.101	18.62	(1.147)	1.056	17.37	(1.191)	1.011	24.06
OPERATION IMPACT	**6.67**	**0.352**	**(0.098)**	**0.254**	**5.76**	**(0.098)**	**0.254**	**5.55**	**(0.098)**	**0.254**	**9.37**	**0.551**	**(0.154)**	**0.397**	**6.71**	**(0.154)**	**0.397**	**6.53**	**(0.154)**	**0.397**	**9.44**
Rig Anchoring																					
Work Boat Anchoring	6.67	0.352	(0.098)	0.254	5.76	(0.098)	0.254	5.55	(0.098)	0.254	9.37	0.551	(0.154)	0.397	6.71	(0.154)	0.397	6.53	(0.154)	0.397	9.44
MECHANICAL																					
Connection Failure																					
Material Failure																					
NATURAL HAZARD	**20.00**	**1.056**	**(0.577)**	**0.479**	**10.88**	**(0.570)**	**0.486**	**10.63**	**(0.550)**	**0.507**	**18.72**	**1.652**	**(0.903)**	**0.749**	**12.66**	**(0.892)**	**0.760**	**12.51**	**(0.860)**	**0.792**	**18.85**
Mud Slide	6.67	0.352	(0.183)	0.169	3.83	(0.176)	0.176	3.85	(0.169)	0.183	6.77	0.551	(0.287)	0.264	4.46	(0.275)	0.275	4.53	(0.264)	0.287	6.82
Storm/ Hurricane	13.33	0.704	(0.394)	0.310	7.04	(0.394)	0.310	6.78	(0.381)	0.323	11.94	1.101	(0.616)	0.485	8.20	(0.616)	0.485	7.98	(0.596)	0.506	12.03
ARCTIC			**1.719**	**1.719**	**39.04**	**1.913**	**1.913**	**41.82**	**0.053**	**0.053**	**1.97**		**1.719**	**1.719**	**29.05**	**1.913**	**1.913**	**31.49**	**0.053**	**0.053**	**1.27**
Ice Gouging			1.3527	1.3527	30.73	1.6908	1.6908	36.96					1.3527	1.3527	22.87	1.6908	1.6908	27.83			
Strudel Scour			0.1613	0.1613	3.66								0.1613	0.1613	2.73						
Upheaval Buckling			0.0323	0.0323	0.73	0.0323	0.0323	0.71	0.0323	0.0323	1.19		0.0323	0.0323	0.55	0.0323	0.0323	0.53	0.0323	0.0323	0.77
Thaw Settlement			0.0161	0.0161	0.37	0.0161	0.0161	0.35	0.0161	0.0161	0.60		0.0161	0.0161	0.27	0.0161	0.0161	0.27	0.0161	0.0161	0.38
Other			0.1562	0.1562	3.55	0.1739	0.1739	3.80	0.0048	0.0048	0.18		0.1562	0.1562	2.64	0.1739	0.1739	2.86	0.0048	0.0048	0.12
UNKNOWN																					
TOTALS	**100.00**	**5.282**	**(0.880)**	**4.402**	**100.00**	**(0.707)**	**4.575**	**100.00**	**(2.575)**	**2.707**	**100.00**	**8.259**	**(2.344)**	**5.915**	**100.00**	**(2.184)**	**6.075**	**100.00**	**(4.056)**	**4.203**	**100.00**

Table 4.9
Arctic Pipeline Huge Spill (>= 10,000 bbl) Frequencies
(App. Table 2.6)

CAUSE CLASSIFICATION	HIST. DISTRIBUTION %	Pipeline Diameter <= 10"										Pipeline Diameter > 10"									
			Shallow			Medium			Deep				Shallow			Medium			Deep		
		FREQUENCY spills per 10^5km-year	Frequency Change	New Frequency	New Distribution %	Frequency Change	New Frequency	New Distribution %	Frequency Change	New Frequency	New Distribution %	FREQUENCY spills per 10^5km-year	Frequency Change	New Frequency	New Distribution %	Frequency Change	New Frequency	New Distribution %	Frequency Change	New Frequency	New Distribution %
CORROSION	**6.67**	**0.050**	**(0.023)**	**0.027**	**3.74**	**(0.023)**	**0.027**	**3.57**	**(0.023)**	**0.027**	**6.98**	**0.220**	**(0.101)**	**0.119**	**5.89**	**(0.101)**	**0.119**	**5.82**	**(0.101)**	**0.119**	**7.13**
External																					
Internal	6.67	0.050	(0.023)	0.027	3.74	(0.023)	0.027	3.57	(0.023)	0.027	6.98	0.220	(0.101)	0.119	5.89	(0.101)	0.119	5.82	(0.101)	0.119	7.13
THIRD PARTY IMPACT	**66.67**	**0.503**	**(0.252)**	**0.252**	**34.59**	**(0.256)**	**0.247**	**32.42**	**(0.260)**	**0.243**	**62.42**	**2.203**	**(1.101)**	**1.101**	**54.45**	**(1.120)**	**1.083**	**52.89**	**(1.137)**	**1.065**	**63.76**
Anchor Impact	33.33	0.252	(0.126)	0.126	17.30	(0.126)	0.126	16.48	(0.126)	0.126	32.27	1.101	(0.551)	0.551	27.23	(0.551)	0.551	26.89	(0.551)	0.551	32.96
Jackup Rig or Spud Barge	6.67	0.050	(0.025)	0.025	3.46	(0.025)	0.025	3.30	(0.025)	0.025	6.45	0.220	(0.110)	0.110	5.45	(0.110)	0.110	5.38	(0.110)	0.110	6.59
Trawl/Fishing Net	26.67	0.201	(0.101)	0.101	13.84	(0.105)	0.096	12.64	(0.109)	0.092	23.70	0.881	(0.441)	0.441	21.78	(0.459)	0.422	20.62	(0.477)	0.404	24.21
OPERATION IMPACT	**6.67**	**0.050**	**(0.014)**	**0.036**	**4.98**	**(0.014)**	**0.036**	**4.75**	**(0.014)**	**0.036**	**9.30**	**0.220**	**(0.062)**	**0.159**	**7.85**	**(0.062)**	**0.159**	**7.75**	**(0.062)**	**0.159**	**9.50**
Rig Anchoring																					
Work Boat Anchoring	6.67	0.050	(0.014)	0.036	4.98	(0.014)	0.036	4.75	(0.014)	0.036	9.30	0.220	(0.062)	0.159	7.85	(0.062)	0.159	7.75	(0.062)	0.159	9.50
MECHANICAL																					
Connection Failure																					
Material Failure																					
NATURAL HAZARD	**20.00**	**0.151**	**(0.082)**	**0.068**	**9.41**	**(0.081)**	**0.069**	**9.10**	**(0.079)**	**0.072**	**18.57**	**0.661**	**(0.361)**	**0.300**	**14.81**	**(0.357)**	**0.304**	**14.85**	**(0.344)**	**0.317**	**18.97**
Mud Slide	6.67	0.050	(0.026)	0.024	3.32	(0.025)	0.025	3.30	(0.024)	0.026	6.72	0.220	(0.115)	0.106	5.22	(0.110)	0.110	5.38	(0.106)	0.115	6.87
Storm/ Hurricane	13.33	0.101	(0.056)	0.044	6.09	(0.056)	0.044	5.81	(0.054)	0.046	11.85	0.441	(0.247)	0.194	9.59	(0.247)	0.194	9.47	(0.238)	0.202	12.10
ARCTIC			**0.344**	**0.344**	**47.27**	**0.383**	**0.383**	**50.16**	**0.011**	**0.011**	**2.73**		**0.344**	**0.344**	**17.00**	**0.383**	**0.383**	**18.69**	**0.011**	**0.011**	**0.64**
Ice Gouging			0.2705	0.2705	37.21	0.3382	0.3382	44.33					0.2705	0.2705	13.38	0.3382	0.3382	16.52			
Strudel Scour			0.0323	0.0323	4.44								0.0323	0.0323	1.59						
Upheaval Buckling			0.0065	0.0065	0.89	0.0065	0.0065	0.85	0.0065	0.0065	1.66		0.0065	0.0065	0.32	0.0065	0.0065	0.32	0.0065	0.0065	0.39
Thaw Settlement			0.0032	0.0032	0.44	0.0032	0.0032	0.42	0.0032	0.0032	0.83		0.0032	0.0032	0.16	0.0032	0.0032	0.16	0.0032	0.0032	0.19
Other			0.0312	0.0312	4.30	0.0348	0.0348	4.56	0.0010	0.0010	0.25		0.0312	0.0312	1.55	0.0348	0.0348	1.70	0.0010	0.0010	0.06
UNKNOWN																					
TOTALS	**100.00**	**0.755**	**(0.027)**	**0.727**	**100.00**	**0.008**	**0.763**	**100.00**	**(0.365)**	**0.390**	**100.00**	**3.304**	**(1.281)**	**2.022**	**100.00**	**(1.256)**	**2.048**	**100.00**	**(1.633)**	**1.671**	**100.00**

Table 4.10
Arctic Pipeline Spill Frequencies Expected Value Summary
(App. Table 2.2A)

Pipeline Spill Size	Pipeline Diameter <=10"				Pipeline Diameter >10"			
	Historical Frequency spills per 10^5km-year	Arctic Frequency			Historical Frequency spills per 10^5km-year	Arctic Frequency		
		Shallow	Medium	Deep		Shallow	Medium	Deep
SMALL SPILLS 50-99 bbl	**6.036**	5.472	5.553	4.813	**6.608**	5.925	6.007	5.267
MEDIUM SPILLS 100-999 bbl	**10.563**	9.060	9.144	8.407	**14.867**	12.472	12.558	11.823
LARGE SPILLS 1000-9999 bbl	**5.282**	4.402	4.575	2.707	**8.259**	5.915	6.075	4.203
HUGE SPILLS >=10000 bbl	**0.755**	0.727	0.763	0.390	**3.304**	2.022	2.048	1.671

4.4 Platform Fault Tree Analysis

4.4.1 Arctic Platform Spill Causal Frequency Distributions

Table 4.11 summarizes the variations in the modified and unique Arctic effect inputs for platforms. As for pipeline unique effects, both the Triangular Distribution expected and modal values are given.

The first three modified cause classifications – equipment failure, human error, and tank failure – were reduced by 20 to 30% primarily as a result of the state-of-the-art engineering, construction, and operational standards and practices expected. Due to the extremely low traffic density, as for the case of pipelines, the ship collision cause has been reduced by 50%. As before, storms tend to be less severe in the Arctic, and certainly during the ice season would have limited impact on the facility. And hurricanes are so far not known to occur in the Beaufort, so a validation of 80% was used.

Unique effects are also included. Increments in facility spills were attributed to ice force, low temperature effects, and unknown effects which were taken as a percentage of the other unique Arctic effects. Ice force effect calculations were based on the 1/10,000 year ice force causing spills, predominantly small and medium. Ice forces are also considered to increase as a contributor to oil spill occurrences with water depth, due to the increasing severity of ice loads as one moves towards the edge of the landfast ice zone with increasing water depth. Increase of low temperature effects with water depth was estimated as 10% of historical process facility spill rates.

Changes in frequency distribution attributable to Arctic effects were calculated using the secondary effect probability distribution, as was done for pipelines. Table 4.12 summarizes the principal distribution parameters for both the Arctic modified and Arctic unique effect distributions.

4.4.2 Arctic Platform Fault Tree Spill Frequency Calculations

Figure 4.5 shows the fault tree developed for Arctic platform spills for the different water depth zones for large and huge spill sizes, which were grouped together as described for platforms in Chapter 2. Again, the fault tree gives the historical value, together with the calculated values for shallow, medium, and deep water. In the case of this particular fault tree, there was room to represent both the small and medium or less than 1,000 bbl and the large and huge or at least 1,000 bbl spills. Like pipelines, it is evident that platforms manifest a somewhat lower frequency for both spill size categories for the Arctic conditions. Tables 4.13 and 4.14 show the frequency calculations for platforms for small and medium and large and huge spill sizes, respectively. Table 4.15 summarizes the historical and derived Arctic expected values of platform spill frequencies.

Table 4.11
Platform Arctic Effect Derivation Summary
(App. Table 2.7)

CAUSE CLASSIFICATION	Spill Size	Historical Expected Frequency Change %			Reason
		Shallow	Medium	Deep	
EQUIPMENT FAILURE	**All**				
Process Equipment	**All**	(30)	(30)	(30)	State of the art now, High QC, High Inspection and Maintenance Requirements
Transfer Hose	**All**	(30)	(30)	(30)	State of the art now, High QC, High Inspection and Maintenance Requirements
Incorrect Operation	**All**	(30)	(30)	(30)	State of the art now, High QC, High Inspection and Maintenance Requirements
HUMAN ERROR	**All**	(20)	(20)	(20)	More qualified personnel - training, education, but colder
TANK FAILURE	**All**	(30)	(30)	(30)	State of the art now, High QC, High Inspection and Maintenance Requirements
SHIP COLLISION	**All**	(50)	(50)	(50)	Very low traffic density.
WEATHER	**All**	20	20	20	Cold Temperatures, cycling
HURRICANE	**All**	(80)	(80)	(70)	Less severe storms. More intensity in deep water.
OTHER	**All**				
		Freq. Increment per 10^4 well-year			
		Expected / **Mode**	**Expected** / **Mode**	**Expected** / **Mode**	
ARCTIC					
Ice Force	**SM**	0.1447 / 0.0340	0.2170 / 0.0510	0.3256 / 0.0765	Assumed 10,000 year return period ice force causes spill 4% of occurrences (96% reliability). 85% of the spills are SM.
	LH	0.0255 / 0.0060	0.0383 / 0.0090	0.0575 / 0.0135	
Facility Low Temperature	**SM**	0.0986 / 0.0986	0.0986 / 0.0986	0.0986 / 0.0986	Assumed fraction of Historical Equipment Failure release frequency with 6% for SM and 1% for LH spill sizes.
	LH	0.0164 / 0.0164	0.0164 / 0.0164	0.0164 / 0.0164	
Other Arctic	**SM**	0.0242 / 0.0133	0.0315 / 0.0150	0.0423 / 0.0175	10% of sum of above.
	LH	0.0042 / 0.0022	0.0055 / 0.0025	0.0074 / 0.0030	

Table 4.12
Platform Arctic Effect Distribution Derivation Summary
(App. Table 2.8)

CAUSE CLASSIFICATION	Spill Size	Shallow			Medium			Deep		
		Frequency Change %								
		Min	Mode	Max	Min	Mode	Max	Min	Mode	Max
EQUIPMENT FAILURE	**All**									
~ Process Equipment	**All**	(60)	(30)	(10)	(60)	(30)	(10)	(60)	(30)	(10)
~ Transfer Hose	**All**	(60)	(30)	(10)	(60)	(30)	(10)	(60)	(30)	(10)
~ Incorrect Operation	**All**	(60)	(30)	(10)	(60)	(30)	(10)	(60)	(30)	(10)
HUMAN ERROR	**All**	(60)	(20)	(10)	(60)	(20)	(10)	(60)	(20)	(10)
TANK FAILURE	**All**	(60)	(30)	(10)	(60)	(30)	(10)	(60)	(30)	(10)
SHIP COLLISION	**All**	(60)	(50)	(10)	(60)	(50)	(10)	(60)	(50)	(10)
WEATHER	**All**	10	20	30	10	20	30	10	20	30
HURRICANE	**All**	(90)	(80)	(10)	(90)	(80)	(10)	(90)	(70)	(10)
OTHER	**All**									
Frequency Increment per 10^4 well-year										
ARCTIC										
Ice Force	**SM**	0.003	0.034	0.340	0.005	0.051	0.510	0.008	0.077	0.765
	LH	0.001	0.006	0.060	0.001	0.009	0.090	0.001	0.014	0.135
Facility Low Temperature	**SM**	0.049	0.099	0.148	0.049	0.099	0.148	0.049	0.099	0.148
	LH	0.008	0.016	0.025	0.008	0.016	0.025	0.008	0.016	0.025
Other Arctic	**SM**	0.005	0.013	0.049	0.005	0.015	0.066	0.006	0.018	0.091
	LH	0.001	0.002	0.008	0.001	0.003	0.011	0.001	0.003	0.016

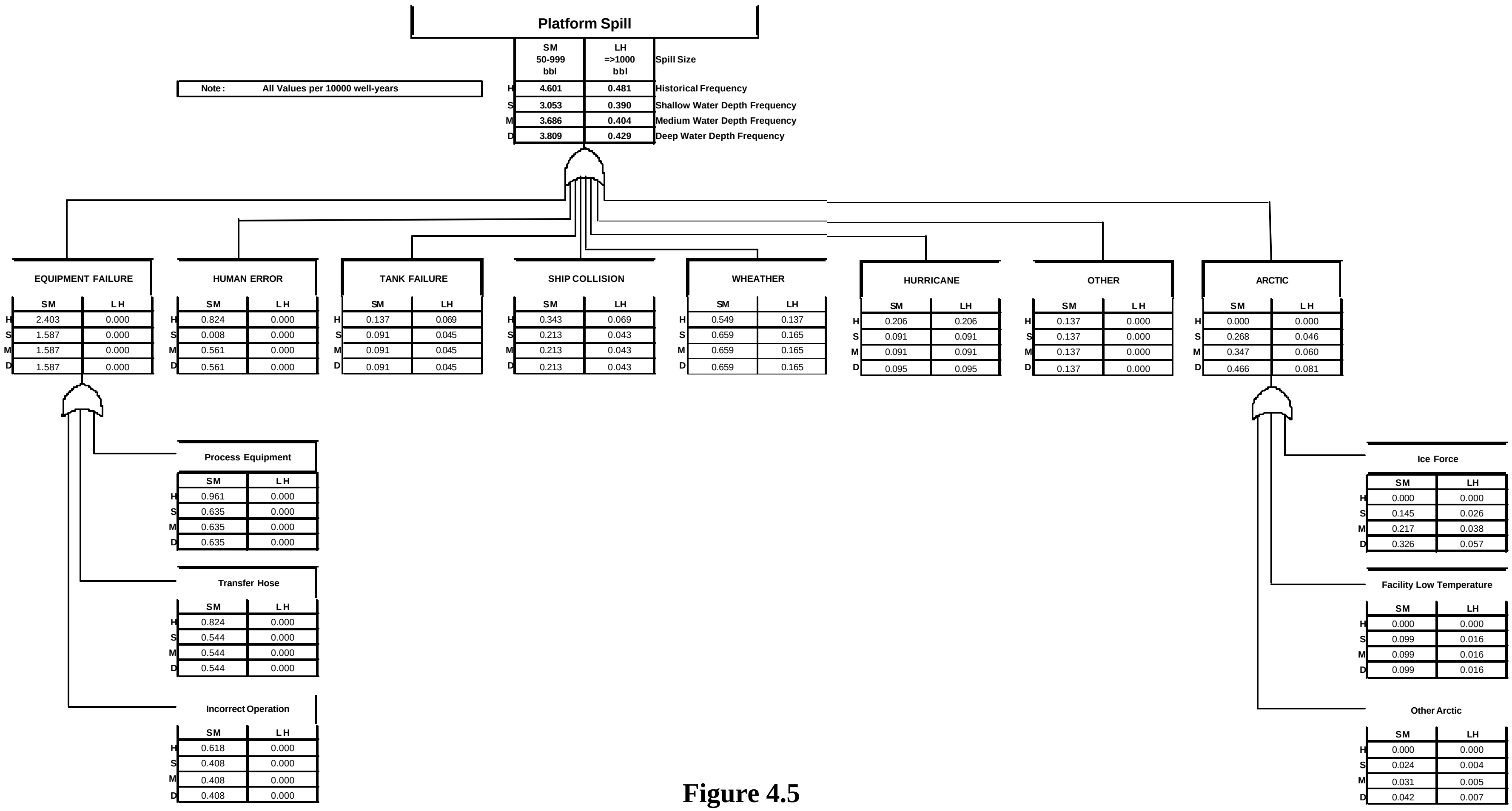


Figure 4.5
Spill Frequencies Platform Fault Tree
(Appendix Figure 2.5)

Table 4.13
Arctic Platform Small and Medium Spill Frequencies
(App. Table 2.9)

CAUSE CLASSIFICATION	HIST. DISTRIBUTION %	SMALL AND MEDIUM SPILLS 50-999 bbl									
			Shallow			Medium			Deep		
		FREQUENCY spills per 10^4well-year	Frequency Change	New Frequency	New Distribution %	Frequency Change	New Frequency	New Distribution %	Frequency Change	New Frequency	New Distribution %
EQUIPMENT FAILURE	**52.24**	**2.403**	**(0.816)**	**1.587**	**51.98**	**(0.816)**	**1.587**	**43.06**	**(0.816)**	**1.587**	**41.67**
Process Equipment	**20.90**	**0.961**	**(0.327)**	**0.635**	**20.79**	**(0.327)**	**0.635**	**17.23**	**(0.327)**	**0.635**	**16.67**
Transfer Hose	**17.91**	**0.824**	**(0.280)**	**0.544**	**17.82**	**(0.280)**	**0.544**	**14.76**	**(0.280)**	**0.544**	**14.29**
Incorrect Operation	**13.43**	**0.618**	**(0.210)**	**0.408**	**13.37**	**(0.210)**	**0.408**	**11.07**	**(0.210)**	**0.408**	**10.72**
HUMAN ERROR	**17.91**	**0.824**	**(0.816)**	**0.008**	**0.25**	**(0.263)**	**0.561**	**15.21**	**(0.263)**	**0.561**	**14.72**
TANK FAILURE	**2.99**	**0.137**	**(0.047)**	**0.091**	**2.97**	**(0.047)**	**0.091**	**2.46**	**(0.047)**	**0.091**	**2.38**
SHIP COLLISION	**7.46**	**0.343**	**(0.131)**	**0.213**	**6.97**	**(0.131)**	**0.213**	**5.77**	**(0.131)**	**0.213**	**5.58**
WEATHER	**11.94**	**0.549**	**0.110**	**0.659**	**21.59**	**0.110**	**0.659**	**17.89**	**0.110**	**0.659**	**17.31**
HURRICANE	**4.48**	**0.206**	**(0.115)**	**0.091**	**2.97**	**(0.115)**	**0.091**	**2.46**	**(0.111)**	**0.095**	**2.48**
OTHER	**2.99**	**0.137**		**0.137**	**4.50**		**0.137**	**3.73**		**0.137**	**3.61**
ARCTIC			**0.268**	**0.268**	**8.76**	**0.347**	**0.347**	**9.42**	**0.466**	**0.466**	**12.25**
Ice Force			0.145	0.145	4.74	0.217	0.217	5.89	0.326	0.326	8.55
Facility Low Temperature			0.099	0.099	3.23	0.099	0.099	2.68	0.099	0.099	2.59
Other Arctic			0.024	0.024	0.79	0.031	0.031	0.85	0.042	0.042	1.11
TOTALS	**100.00**	**4.601**	**(1.548)**	**3.053**	**100.00**	**(0.915)**	**3.686**	**100.00**	**(0.792)**	**3.809**	**100.00**

Table 4.14
Arctic Platform Large and Huge Spill Frequencies
(App. Table 2.10)

CAUSE CLASSIFICATION	HIST. DISTRIBUTION %	SMALL AND MEDIUM SPILLS 50-999 bbl									
			Shallow			Medium			Deep		
		FREQUENCY spills per 10^4well-year	Frequency Change	New Frequency	New Distribution %	Frequency Change	New Frequency	New Distribution %	Frequency Change	New Frequency	New Distribution %
EQUIPMENT FAILURE											
Process Equipment											
Transfer Hose											
Incorrect Operation											
HUMAN ERROR											
TANK FAILURE	**14.29**	**0.069**	**(0.023)**	**0.045**	**11.64**	**(0.023)**	**0.045**	**11.24**	**(0.023)**	**0.045**	**10.58**
SHIP COLLISION	**14.29**	**0.069**	**(0.026)**	**0.043**	**10.92**	**(0.026)**	**0.043**	**10.54**	**(0.026)**	**0.043**	**9.93**
WEATHER	**28.57**	**0.137**	**0.027**	**0.165**	**42.31**	**0.027**	**0.165**	**40.83**	**0.027**	**0.165**	**38.46**
HURRICANE	**42.86**	**0.206**	**(0.115)**	**0.091**	**23.29**	**(0.115)**	**0.091**	**22.48**	**(0.111)**	**0.095**	**22.07**
OTHER											
ARCTIC			**0.046**	**0.046**	**11.85**	**0.060**	**0.060**	**14.91**	**0.081**	**0.081**	**18.96**
Ice Force			0.026	0.026	6.55	0.038	0.038	9.49	0.057	0.057	13.41
Facility Low Temperature			0.016	0.016	4.22	0.016	0.016	4.07	0.016	0.016	3.84
Other Arctic			0.004	0.004	1.07	0.005	0.005	1.35	0.007	0.007	1.72
TOTALS	**100.00**	**0.481**	**(0.091)**	**0.390**	**100.00**	**(0.077)**	**0.404**	**100.00**	**(0.052)**	**0.429**	**100.00**

Table 4.15
Arctic Platforms Spill Frequency Expected Value Summary
(App. Table 2.8A)

Platform Spill Size	Historical Frequency spills per 10^4 well-year	Arctic Frequency		
		Shallow	Medium	Deep
SMALL AND MEDIUM SPILLS 50-999 bbl	**4.601**	3.053	3.686	3.809
LARGE AND HUGE SPILLS >=1,000 bbl	**0.481**	0.390	0.404	0.429

4.5 Blowout Frequency Analysis

4.5.1 Well Blowout First Order Arctic Effects

The historical data, as described in Chapter 2, was modified for each well type, spill size, and water depth range, as described in Table 4.16. No Arctic unique effects were introduced for well blowouts.

4.5.2 Arctic Well Blowout Spill Frequency Calculation

Table 4.17 gives the details of the frequency calculation for well blowouts. No fault tree was required here, as only base events with no causal distributions were modeled for each case. The modifications given in Table 4.16 were applied to all three values (minimum, mode, maximum) to yield the values summarized in Table 4.17.

4.6 Spill Volume Distributions

Table 4.18 summarizes the spill volume distribution parameters for each facility type, including the expected value that was calculated utilizing a Monte Carlo calculation. The spill volume parameters were derived from the historical data as described in Section 2.7.

Table 4.16
Well Fault Tree Analysis Arctic Effect Summary
(App. Table 2.11)

SPILL SIZE	EVENT	FREQUENCY UNIT	Historical Expected Frequency Change %			Reason
			Shallow	Medium	Deep	
Small and Medium Spills 50-999 bbl	PRODUCTION WELL	spill per 10^4 well-year	(30)	(30)	(30)	State of the art now, High QC, High Inspection and Maintenance Requirements
	EXPLORATION WELL DRILLING	spill per 10^4 wells	(30)	(20)	(10)	Highly qualified drilling contractor. Better logistics support in shallow water.
	DEVELOPMENT WELL DRILLING	spill per 10^4 wells	(30)	(20)	(10)	Highly qualified drilling contractor. Better logistics support in shallow water.
Large Spills 1000-9999 bbl	PRODUCTION WELL	spill per 10^4 well-year	(30)	(30)	(30)	State of the art now, High QC, High Inspection and Maintenance Requirements
	EXPLORATION WELL DRILLING	spill per 10^4 wells	(30)	(20)	(10)	Highly qualified drilling contractor. Better logistics support in shallow water.
	DEVELOPMENT WELL DRILLING	spill per 10^4 wells	(30)	(20)	(10)	Highly qualified drilling contractor. Better logistics support in shallow water.
Spill 10000 - 149999 bbl	PRODUCTION WELL	spill per 10^4 well-year	(30)	(30)	(30)	State of the art now, High QC, High Inspection and Maintenance Requirements
	EXPLORATION WELL DRILLING	spill per 10^4 wells	(30)	(20)	(10)	Highly qualified drilling contractor. Better logistics support in shallow water.
	DEVELOPMENT WELL DRILLING	spill per 10^4 wells	(30)	(20)	(10)	Highly qualified drilling contractor. Better logistics support in shallow water.
Spill >=150000 bbl	PRODUCTION WELL	spill per 10^4 well-year	(30)	(30)	(30)	State of the art now, High QC, High Inspection and Maintenance Requirements
	EXPLORATION WELL DRILLING	spill per 10^4 wells	(30)	(20)	(10)	Highly qualified drilling contractor. Better logistics support in shallow water.
	DEVELOPMENT WELL DRILLING	spill per 10^4 wells	(30)	(20)	(10)	Highly qualified drilling contractor. Better logistics support in shallow water.

Table 4.17
Arctic Well Blowout Frequencies
(App. Table 2.12)

EVENT	FREQUENCY UNIT	HISTORICAL FREQUENCY	Shallow		Medium		Deep	
			Frequency Change	New Frequency	Frequency Change	New Frequency	Frequency Change	New Frequency
		Small and Medium Spills 50-999 bbl						
PRODUCTION WELL	spill per 10^4 well-year	0.147	-0.044	0.103	-0.044	0.103	-0.044	0.103
EXPLORATION WELL DRILLING	spill per 10^4 wells	2.262	-0.678	1.583	-0.452	1.809	-0.226	2.035
DEVELOPMENT WELL DRILLING	spill per 10^4 wells	0.692	-0.208	0.484	-0.138	0.554	-0.069	0.623
		Large Spills 1000-9999 bbl						
PRODUCTION WELL	spill per 10^4 well-year	1.026	-0.308	0.718	-0.308	0.718	-0.308	0.718
EXPLORATION WELL DRILLING	spill per 10^4 wells	15.824	-4.747	11.077	-3.165	12.659	-1.582	14.242
DEVELOPMENT WELL DRILLING	spill per 10^4 wells	4.833	-1.450	3.383	-0.967	3.867	-0.483	4.350
		Spills 10000-149999 bbl						
PRODUCTION WELL	spill per 10^4 well-year	0.440	-0.132	0.308	-0.132	0.308	-0.132	0.308
EXPLORATION WELL DRILLING	spill per 10^4 wells	6.799	-2.040	4.759	-1.360	5.439	-0.680	6.119
DEVELOPMENT WELL DRILLING	spill per 10^4 wells	2.076	-0.623	1.453	-0.415	1.661	-0.208	1.868
		Spills >=150000 bbl						
PRODUCTION WELL	spill per 10^4 well-year	0.293	-0.088	0.205	-0.088	0.205	-0.088	0.205
EXPLORATION WELL DRILLING	spill per 10^4 wells	3.936	-1.181	2.755	-0.787	3.149	-0.394	3.543
DEVELOPMENT WELL DRILLING	spill per 10^4 wells	2.076	-0.623	1.453	-0.415	1.661	-0.208	1.868

Table 4.18
Summary of Spill Size Distribution Parameters
(App. Table 2.13)

	PIPELINE SPILL VOLUMES															
Spill Size	Small Spills 50-99 bbl				Medium Spills 100-999 bbl				Large Spills 1000-9999 bbl				Huge Spills >=10000 bbl			
Spill Expectation	Low	Mode	High	Expected	Low	Mode	High	Expected	Low	Mode	High	Expected	Low	Mode	High	Expected
Pipelines Diameter 10" Spill	50	58	99	71	100	226	999	485	1000	4436	9999	5279	10000	14423	20000	14880
Pipelines Diameter 10" Spill	50	58	99	71	100	387	999	516	1000	3932	9999	5176	10000	17705	20000	15552

	PLATFORM SPILL VOLUMES							
Spill Size	Small and Medium Spills 50-999 bbl				Large and Huge Spills >=1000 bbl			
Spill Expectation	Low	Mode	High	Expected	Low	Mode	High	Expected
Platform Spill	50	158	999	452	1000	6130	10000	5631

	WELL SPILL VOLUMES															
Spill Size	Small and Medium Spills 50-999 bbl				Large Spills 1000-9999 bbl				Spills 10000-149999 bbl				Spills >=150000 bbl			
Spill Expectation	Low	Mode	High	Expected	Low	Mode	High	Expected	Low	Mode	High	Expected	Low	Mode	High	Expected
Well Spill	50	500	999	519	1000	4500	9999	5292	10000	20000	149999	68349	150000	200000	250000	200000

CHAPTER 5

OIL SPILL OCCURRENCE INDICATOR QUANTIFICATION

5.1 Definition of Oil Spill Occurrence Indicators

Four primary oil spill occurrence indicators (generally referred to as "spill indicators" after this) were quantified in this study. These are as follows:

- Frequency in spills per year.
- Frequency in spills per barrel produced in each year.
- Spill index, the product of spill frequency and associated average spill size.
- Life of field indicators.

The spill indicators defined above are subdivided as follows for this study:

- By scenario (three scenarios)
- By water depth (three ranges)
- By facility type (six types)
- By spill size (four sizes)
- By year for three cases:
    - High Case: 30 years (2010-2039)
    - Low Case: 25 years (2010-2034)
    - Non-Arctic High Case: 30 years (2010-2039)

For the High Case and the Non-Arctic High Case, this results in 2,160 combinations each. For the Low Case, there are 1,800 sets of spill indicators. This totals 6,120 spill indicators. In this chapter, we will summarize only the salient results of the indicators; Appendix 4 gives a full calculation printout for the Monte Carlo results used in the body of this report for each of the three cases. Further, in this chapter, results from the principal calculation steps are given only for the High Case, while the Low Case and the Non-Arctic High Case reporting is restricted to a summary of the results.

5.2 Oil Spill Occurrence Indicator Calculation Process

The oil spill occurrence indicator calculation process is shown in the flow chart originally given in Figure 1.2, and again presented as Figure 5.1. This chapter discusses the spill occurrence indicator calculations as shown in the shaded rectangle in Figure 5.1. Previous chapters covered the balance of the items in that figure.

Essentially, this chapter addresses the combining of the development scenarios described in Chapter 3 with the unit-spill frequency distributions presented in Chapter 4 to provide measures of oil spill occurrence, the oil spill indicators. Although the calculation is complex because of the many combinations considered (approximately 6,000), in principle, it is a simple process of accounting. Essentially, the quantities of potential oil spill sources are multiplied by their appropriate unit oil spill frequency to give the total expected spill distributions. To develop the probability distributions by the Monte Carlo process, each of the 6,000 combinations needs to be sampled, in this case a sampling of 6,000 iterations was carried out for each combination studied. This translates into roughly 30 million arithmetic operations to generate the Monte Carlo results.

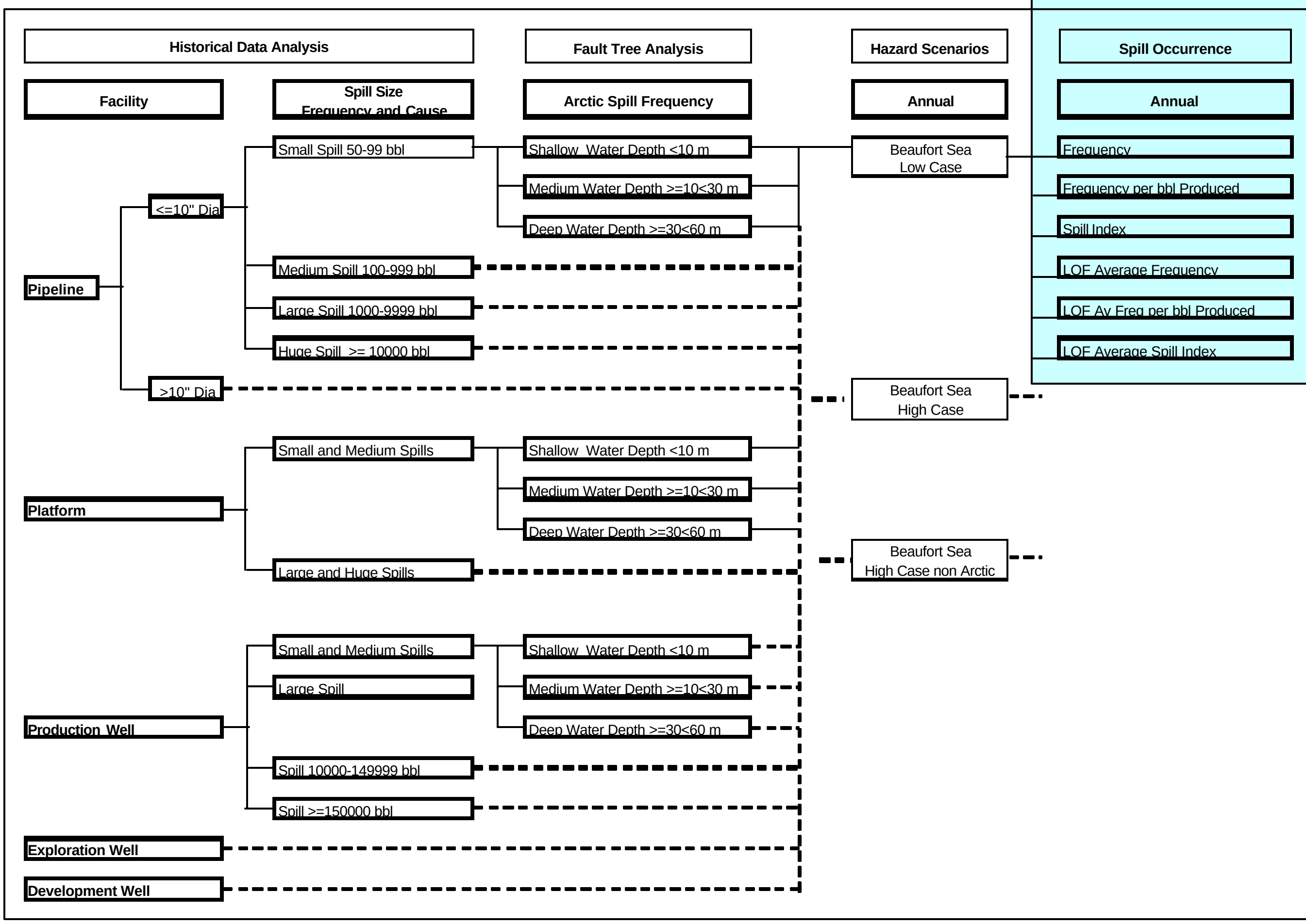


Figure 5.1
Calculation Flow Chart

5.3 Summary of Beaufort Sea Oil Spill Occurrence Indicators

5.3.1 Beaufort Sea High Case Oil Spill Occurrence Indicators

Each of the principal oil spill occurrence indicators calculated for the pipelines, platforms, and wells for the High Case for each year is given in Figures 5.2, 5.3, and 5.4.

As can be seen, each of these figures spans the development scenario to year 2039 as described in Table 3.3. Further, each of the indicators has been subdivided into three segments for each year, those corresponding to spills 50-999 bbl (small and medium), spills 1,000-9,999 bbl (large), and spills >=10,000 bbl (huge). It should be noted that the spill frequency associated with each spill size is only the shaded increment shown in each of the bars. Thus, for example, for the year 2030, small and medium spills are approximately 52.0 per thousand years. Next, in that year, large spills are approximately 10.0 per thousand years, as shown in the second bar increment (i.e., 58.0 – 48.0 = 10.0). Finally, the top increment corresponds to huge spills, and is approximately 8.0 per thousand years. The same form of presentation applies for spills per barrel produced and for the spill index shown in Figures 5.3 and 5.4. For years in which no production exists, the spills per barrel produced are not applicable. Clearly, the spill index is dominated by the huge spills. The spills per barrel produced continue to rise to the second final production years (2037), because the facility quantities (and hence spill rate) remain relatively high, while production volumes decrease significantly each year. The reader should note that following this detailed presentation of the spill indicators in separate figures, all three spill indicators will be given in one figure in order to conserve space and make the report a little more concise.

Spill indicators by facility type were also quantified. All three spill indicators for pipelines are shown in Figure 5.5. Figure 5.6 shows the spill indicators for platforms and Figure 5.7 shows the spill indicators for drilling of wells and producing wells. The graph ordinate axes have intentionally been kept the same to facilitate comparison. Numerous conclusions can be drawn from the comparison of these spill indicators. For example, it can be seen that the major contributors to spill frequency are platforms. The largest of the facility spill expectations, as represented by spill index, are the wells, simply because they have the potential to release the largest amounts of oil in blowouts.

Finally, as part of the assessment of the Beaufort Sea development scenario, a Monte Carlo analysis was carried out for each year, with the distributed inputs described earlier. The tabular results of the Monte Carlo simulation of 5,000 iterations, is summarized in Table 5.1. This table gives the statistical characteristics of the calculated indicators for each of three spill size ranges, as well as a tabular summary of their cumulative distribution curves for a representative production year (2030). Figure 5.8 shows graphs of the calculated cumulative distribution functions. Basically, the vertical axis gives the probability in percent that the corresponding value on the horizontal axis will not be exceeded. Thus, for example, referring to the right side central graph, for significant spills >= 1,000 bbl (large and huge), there is a 50% probability that a spill frequency will be no more than 0.65 per billion barrels produced in year 2030. This is the same as the mean value in Table 5.1

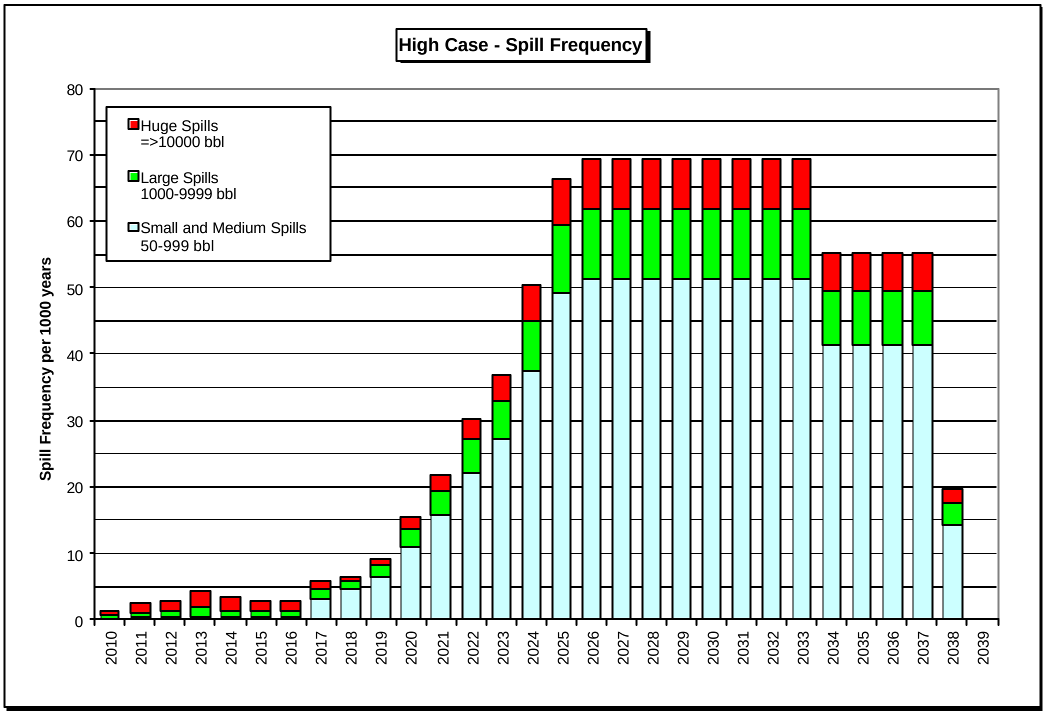


Figure 5.2
Beaufort Sea High Case Spill Frequency per 1,000 Years

(Appendix Figure 4.2.01)

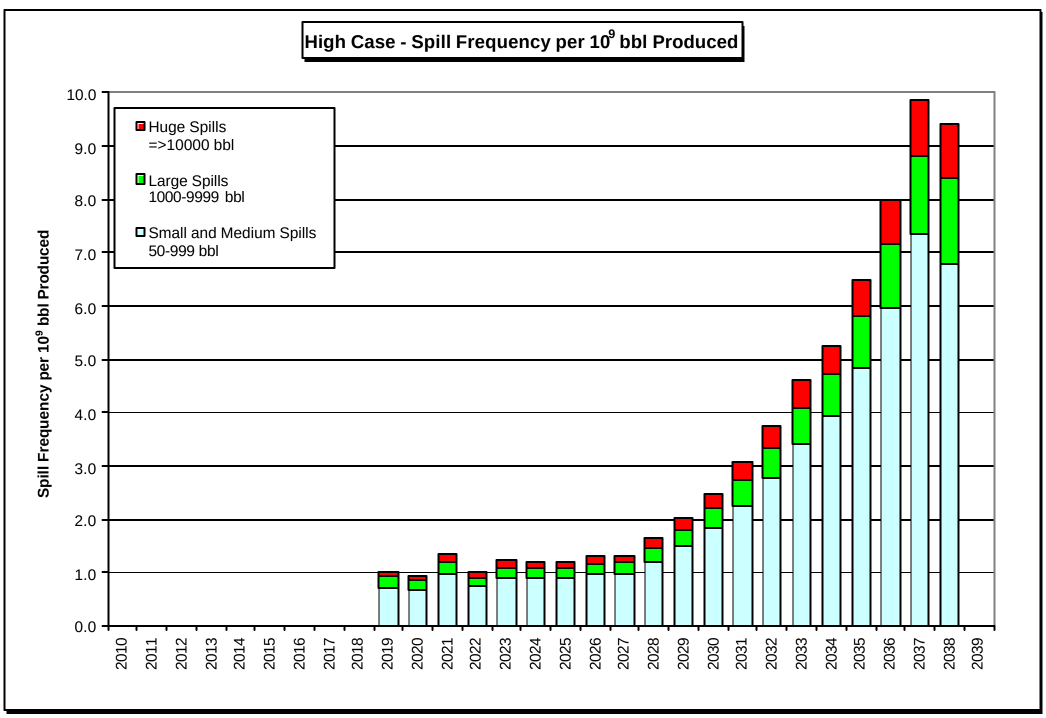


Figure 5.3
Beaufort Sea High Case Spill Frequency per 10^9 Barrels Produced
(Appendix Figure 4.2.02)

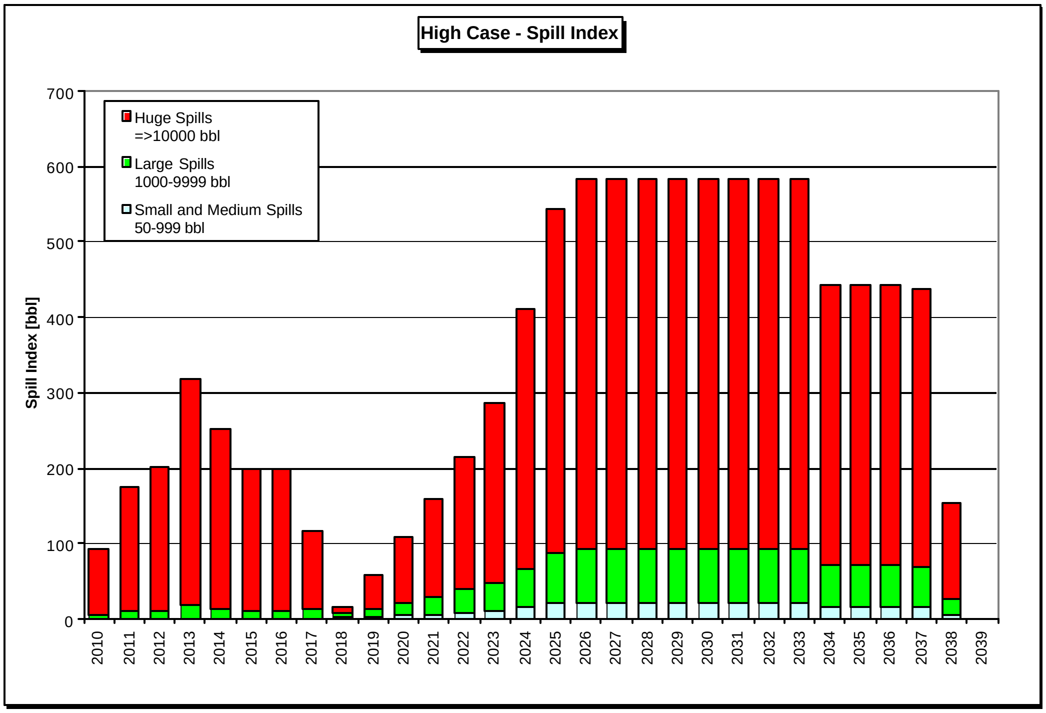


Figure 5.4
Beaufort Sea High Case Spill Index

(Appendix Figure 4.2.03)

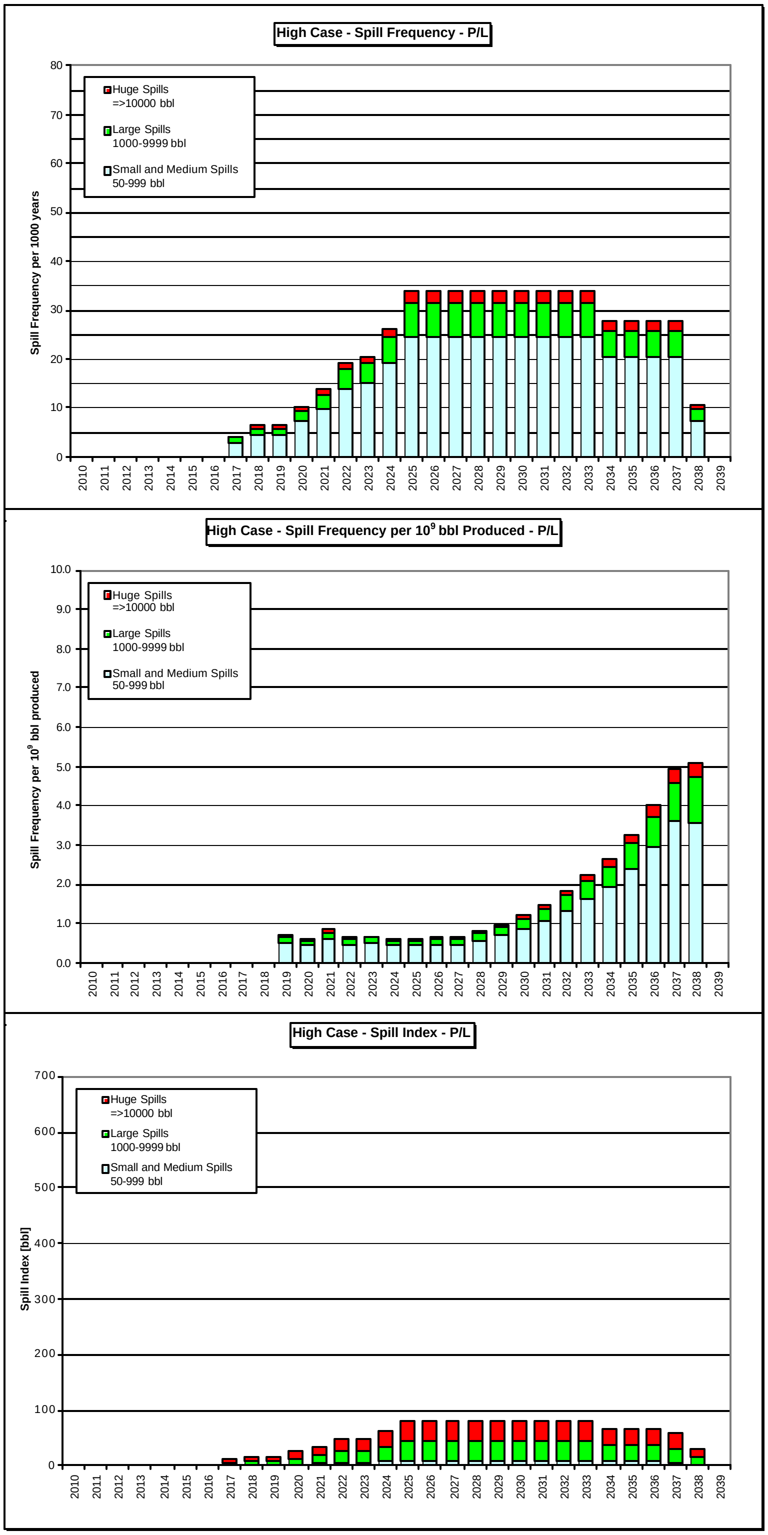


Figure 5.5
Beaufort Sea High Case Spill Indicators – Pipeline
(Appendix Figures 4.2.04, 4.2.05, 4.2.06)

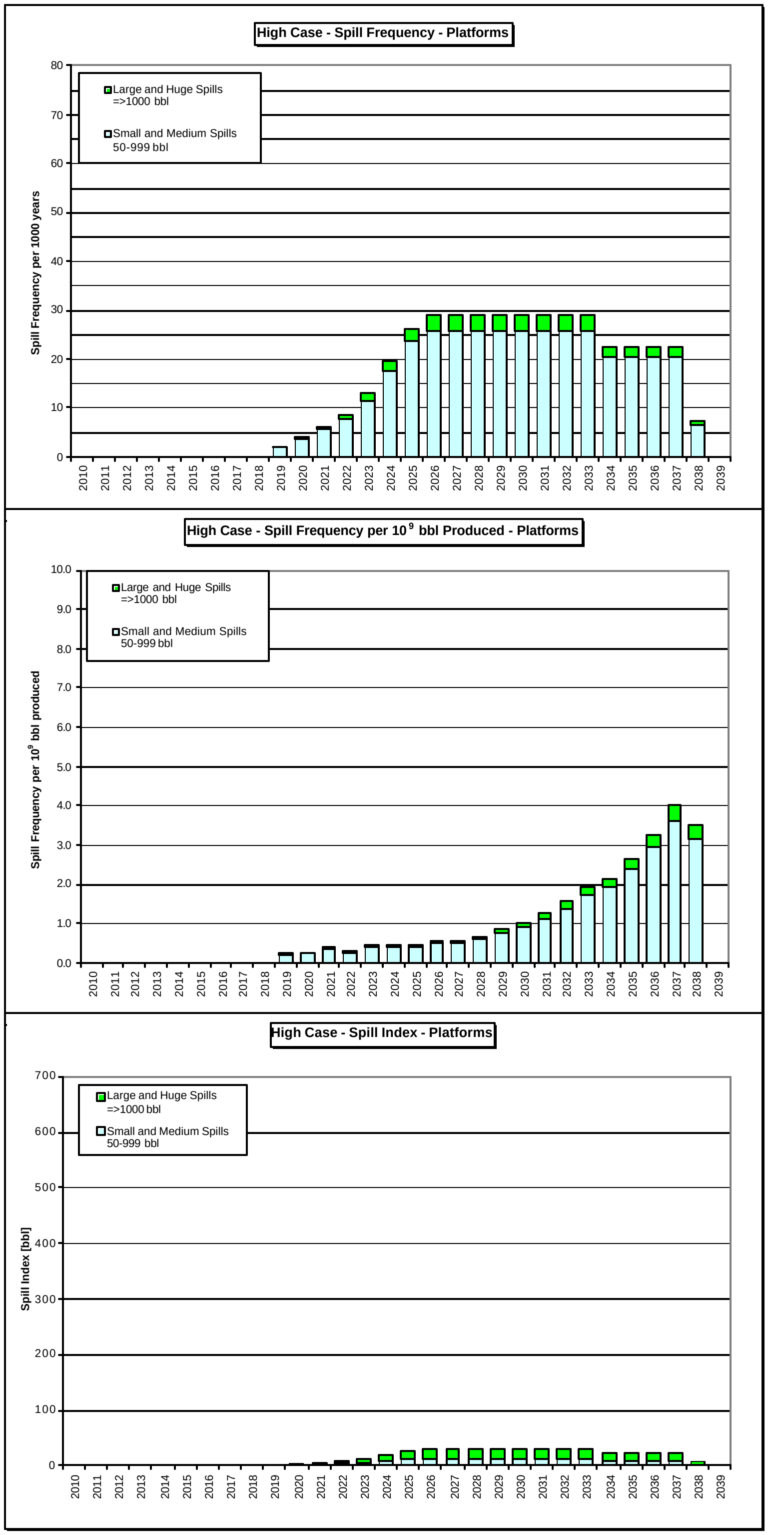


Figure 5.6
Beaufort Sea High Case Spill Indicators – Platforms
(Appendix Figures 4.2.07, 4.2.08, 4.2.09)

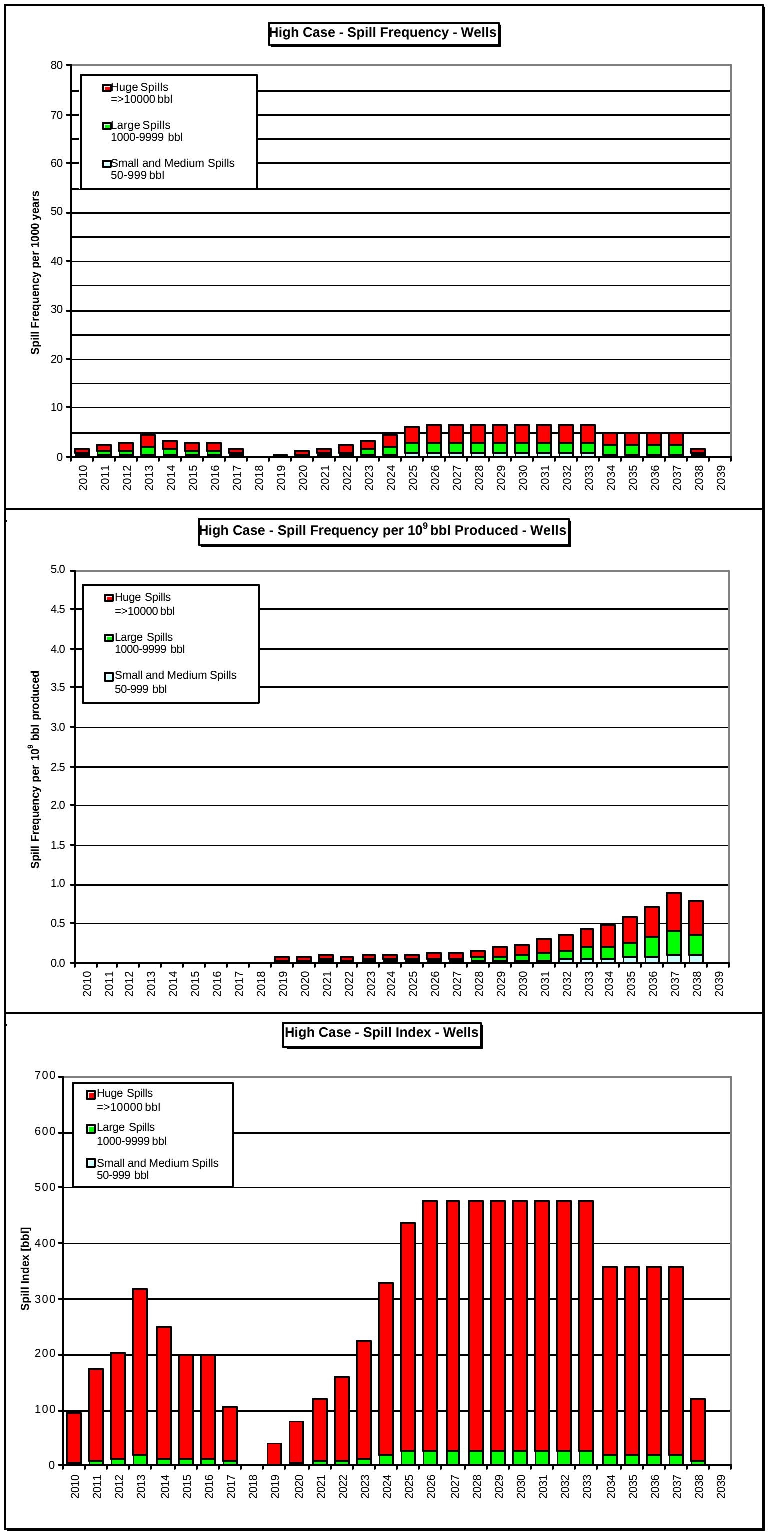


Figure 5.7
Beaufort Sea High Case Spill Indicators – Wells
(Appendix Figures 4.2.10, 4.2.11, 4.2.12)

Table 5.1
Beaufort Sea High Case Year 2030 – Monte Carlo Results
(App. Table 4.2.14)

High Case Year 2030	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills
	Frequency Spills per 10^3 years					Frequency Spills per 10^9 bbl Produced					Spill Index [bbl]				
Mean =	51.28	10.60	7.52	18.13	69.41	1.83	0.38	0.27	0.65	2.48	21.21	71.33	491.71	563.04	584.25
Std Deviation =	19.44	3.74	1.97	4.58	19.96	0.69	0.13	0.07	0.16	0.71	13.56	33.17	178.32	181.51	182.11
Variance =	377.998	13.989	3.877	20.966	398.438	0.482	0.018	0.005	0.027	0.508	183.771	1100.468	31797.980	32946.170	33164.640
Skewness =	0.42	0.54	0.30	0.34	0.40	0.42	0.54	0.30	0.34	0.40	1.30	0.92	0.45	0.42	0.42
Kurtosis =	2.66	2.77	2.96	2.85	2.72	2.66	2.77	2.96	2.85	2.72	5.14	4.13	3.09	3.08	3.08
Mode =	71.07	6.97	5.34	16.17	46.94	1.54	0.48	0.19	0.58	1.68	8.75	40.22	325.16	458.45	476.20
Minimum =	8.187	2.032	1.482	4.991	22.983	0.292	0.073	0.053	0.178	0.821	0.064	3.197	60.101	100.742	130.353
5% Perc =	22.719	5.389	4.482	11.124	39.524	0.811	0.192	0.160	0.397	1.412	5.312	26.808	222.457	286.804	307.398
10% Perc =	27.384	6.180	5.078	12.493	44.751	0.978	0.221	0.181	0.446	1.598	7.098	33.459	271.545	339.492	358.193
15% Perc =	30.674	6.760	5.460	13.426	48.541	1.096	0.241	0.195	0.480	1.734	8.632	38.793	308.502	376.638	396.569
20% Perc =	33.600	7.250	5.818	14.162	51.569	1.200	0.259	0.208	0.506	1.842	9.952	43.164	337.495	405.394	427.285
25% Perc =	36.507	7.731	6.124	14.801	54.458	1.304	0.276	0.219	0.529	1.945	11.144	47.115	363.157	433.984	454.829
30% Perc =	39.133	8.203	6.410	15.451	56.917	1.398	0.293	0.229	0.552	2.033	12.461	51.085	387.827	458.453	479.775
35% Perc =	41.590	8.631	6.677	16.047	59.601	1.485	0.308	0.238	0.573	2.129	13.758	54.667	410.997	482.887	504.145
40% Perc =	44.149	9.086	6.916	16.611	62.153	1.577	0.325	0.247	0.593	2.220	15.080	58.848	432.732	506.134	526.888
45% Perc =	46.551	9.548	7.170	17.195	65.034	1.663	0.341	0.256	0.614	2.323	16.489	62.366	454.688	526.781	547.199
50% Perc =	49.191	10.034	7.417	17.804	67.702	1.757	0.358	0.265	0.636	2.418	18.076	66.063	476.169	547.416	569.974
55% Perc =	51.891	10.573	7.663	18.375	70.304	1.853	0.378	0.274	0.656	2.511	19.621	69.916	500.021	570.307	592.075
60% Perc =	54.883	11.136	7.911	18.944	73.117	1.960	0.398	0.283	0.677	2.611	21.483	74.260	523.610	595.026	615.860
65% Perc =	57.797	11.730	8.171	19.581	76.114	2.064	0.419	0.292	0.699	2.718	23.400	79.144	548.968	621.246	641.803
70% Perc =	61.119	12.383	8.482	20.325	79.330	2.183	0.442	0.303	0.726	2.833	25.646	84.259	576.143	648.377	670.750
75% Perc =	64.529	13.067	8.811	21.157	82.938	2.305	0.467	0.315	0.756	2.962	28.080	90.096	605.128	677.459	700.516
80% Perc =	68.465	13.822	9.176	22.033	86.727	2.445	0.494	0.328	0.787	3.097	31.062	96.521	636.941	712.308	732.494
85% Perc =	72.799	14.788	9.614	23.033	91.498	2.600	0.528	0.343	0.823	3.268	34.475	104.665	677.985	753.098	776.324
90% Perc =	78.323	16.002	10.166	24.402	96.995	2.797	0.572	0.363	0.871	3.464	39.295	115.142	730.956	807.119	828.041
95% Perc =	86.487	17.543	10.948	26.319	105.045	3.089	0.627	0.391	0.940	3.752	48.128	134.545	810.522	884.107	904.597
Maximum =	124.637	26.607	15.232	36.664	143.184	4.451	0.950	0.544	1.309	5.114	97.373	249.105	1203.819	1297.845	1331.919

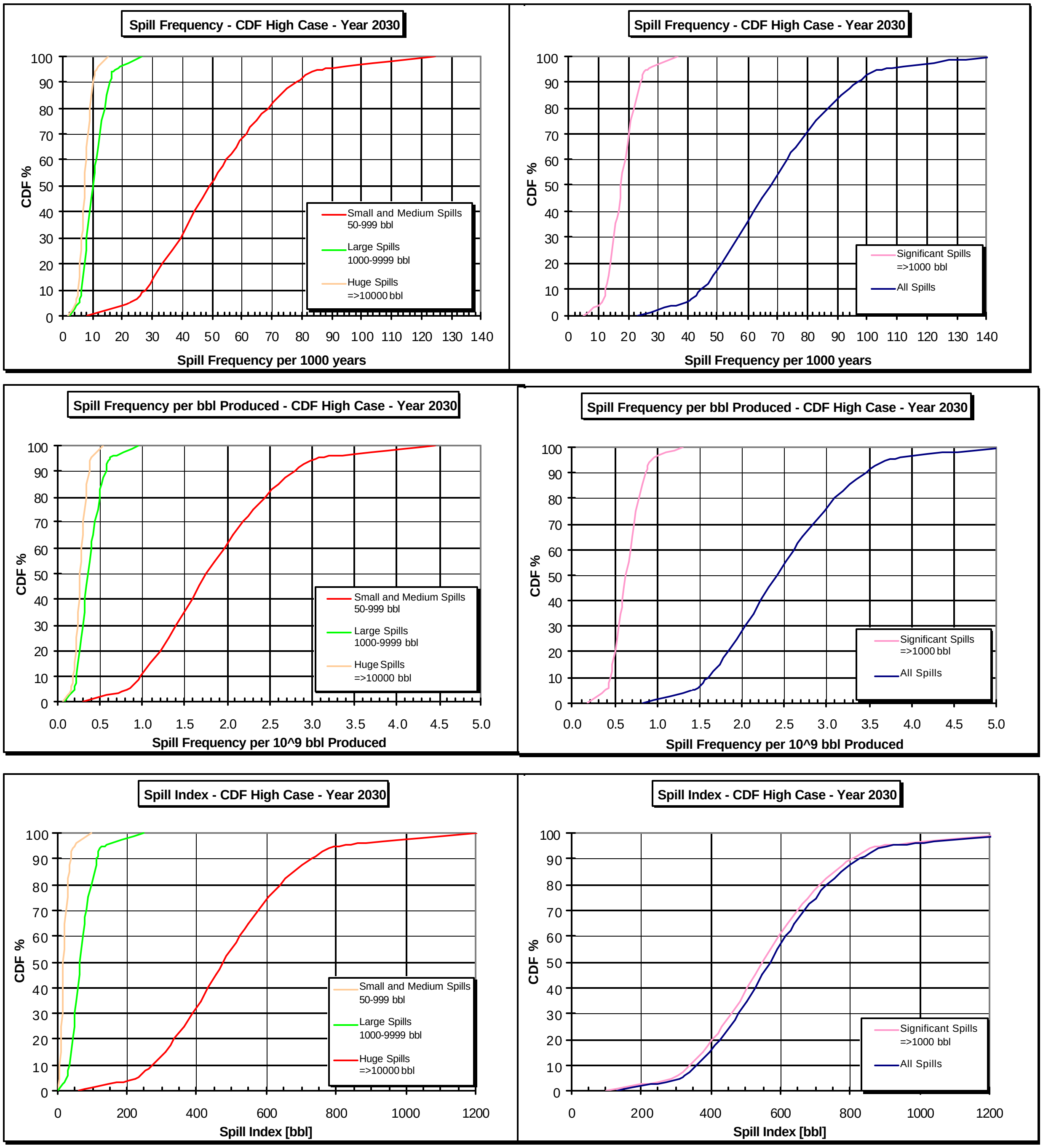


Figure 5.8
Beaufort Sea High Case Spill Indicator Distributions – Year 2030
(Appendix Figure 4.2.13)

In other words, there is a 50% chance that large and huge spills will occur at a rate of 0.65 per billion bbl or less.

The flattening or decrease in slope of the CDFs above 90% and below 10% can be attributed to the use of the triangular distribution with designated limits at corresponding (± 10%) levels.

In addition, since the Life of Field (LOF) averages were calculated, results from these are available for each scenario. Only selected ones are given in the text, with the balance given in the appendix. Table 5.2 shows the composition of the spill indicators for the High Case Life of Field average. The composition both by spill size (on the left hand side of the table) and by facility contribution (on the right hand side of the table). The variability of the spill frequencies Life of Field averages is shown in the following figures: Figure 5.9 illustrates the variability of the spill frequency, while Figure 5.10 shows variability of frequency per billion barrels produced.

5.3.2 Comparative Non-Arctic Indicator Assessment

To give an idea of the effect of the frequency variations introduced in Chapter 4, the Beaufort Sea scenario was also modeled utilizing unaltered historical frequencies. That is, no changes to incorporate the Arctic effects were introduced in the spill indicator calculations. Put yet another way, it was assumed that the facilities of the scenario would behave as if they were designed for and located in the Gulf of Mexico environment rather than in the Arctic environment, with the same facility quantities and production rates as their Arctic counterparts. Figures 5.11, 5.12, and 5.13 show the total values calculated for each of the three spill indicators. The dark histogram bar on the right side corresponds to the Arctic spill indicator, while that, on the left, corresponds to the computation based on historical frequencies only. Spill frequency in an absolute sense is significantly reduced for the Arctic situation roughly by 30%. The spills per barrel produced are also significantly reduced, as can be seen in Figure 5.12. The spill index (Figure 5.13) also shows a reduction of approximately 30%. What the comparison shows is that the Arctic development scenarios can be expected to have a lower oil spill occurrence rate than similar development scenarios would have in the GOM.

Table 5.2
Composition of Spill Indicators –Life of Field Average *(App. Table 4.2.21)*

Spill Size	Spill Source									
	P/L		Platforms		Wells		Platforms and Wells		All	
	LOF Average - Spill Frequency per 10^3 years									
Small and Medium Spills 50-999 bbl	13.395	73%	12.633	90%	0.441	11%	13.074	72%	26.468	73%
Large Spills 1000-9999 bbl	3.725	20%	0.726	5%	1.322	33%	2.048	11%	5.773	16%
Huge Spills =>10000 bbl	1.282	7%	0.726	5%	2.214	56%	2.940	16%	4.222	12%
Significant Spills =>1000 bbl	5.007	27%	1.452	10%	3.536	89%	4.988	28%	9.995	27%
All Spills	**18.402**	**100%**	**14.085**	**100%**	**3.977**	**100%**	**18.062**	**100%**	**36.463**	**100%**
	LOF Average - Spill Frequency per 10^9 bbl produced									
Small and Medium Spills 50-999 bbl	0.776	73%	0.732	90%	0.026	11%	0.758	72%	1.534	73%
Large Spills 1000-9999 bbl	0.216	20%	0.042	5%	0.077	33%	0.119	11%	0.335	16%
Huge Spills =>10000 bbl	0.074	7%	0.042	5%	0.128	56%	0.170	16%	0.245	12%
Significant Spills =>1000 bbl	0.290	27%	0.084	10%	0.205	89%	0.289	28%	0.579	27%
All Spills	**1.066**	**100%**	**0.816**	**100%**	**0.230**	**100%**	**1.047**	**100%**	**2.113**	**100%**
	LOF Average - Spill Index [bbl]									
Small and Medium Spills 50-999 bbl	5	11%	6	41%	0	0%	6	2%	11	3%
Large Spills 1000-9999 bbl	19	44%	4	29%	16	6%	20	7%	40	12%
Huge Spills =>10000 bbl	20	45%	4	29%	269	94%	273	91%	293	85%
Significant Spills =>1000 bbl	39	89%	8	59%	285	100%	293	98%	332	97%
All Spills	**44**	**100%**	**14**	**100%**	**285**	**100%**	**299**	**100%**	**343**	**100%**

Spill Source	Spill Size									
	S+M 50-999 bbl		Large 1000-9999 bbl		Huge =>10000 bbl		Significant =>1000 bbl		All Spills	
	LOF Average - Spill Frequency per 10^3 years									
Pipelines	13.395	51%	3.725	65%	1.282	30%	5.007	50%	18.402	13.395
Platforms	12.633	48%	0.726	13%	0.726	17%	1.452	15%	14.085	12.633
Wells	0.441	2%	1.322	23%	2.214	52%	3.536	35%	3.977	0.441
Platforms and Wells	13.074	49%	2.048	35%	2.940	70%	4.988	50%	18.062	13.074
All	**26.468**	**100%**	**5.773**	**100%**	**4.222**	**100%**	**9.995**	**100%**	**36.463**	**26.468**
	LOF Average - Spill Frequency per 10^9 bbl produced									
Pipelines	0.776	51%	0.216	65%	0.074	30%	0.290	50%	1.066	0.776
Platforms	0.732	48%	0.042	13%	0.042	17%	0.084	15%	0.816	0.732
Wells	0.026	2%	0.077	23%	0.128	52%	0.205	35%	0.230	0.026
Platforms and Wells	0.758	49%	0.119	35%	0.170	70%	0.289	50%	1.047	0.758
All	**1.534**	**100%**	**0.335**	**100%**	**0.245**	**100%**	**0.579**	**100%**	**2.113**	**1.534**
	LOF Average - Spill Index [bbl]									
Pipelines	5	45%	19	48%	20	7%	39	12%	44	5
Platforms	6	53%	4	10%	4	1%	8	2%	14	6
Wells	0	2%	16	41%	269	92%	285	86%	285	0
Platforms and Wells	6	55%	20	52%	273	93%	293	88%	299	6
All	**11**	**100%**	**40**	**100%**	**293**	**100%**	**332**	**100%**	**343**	**11**

Figure 5.9
Beaufort Sea
High Case
Life of Field
Average Spill
Frequency
(Appendix
Figure 4.2.14)

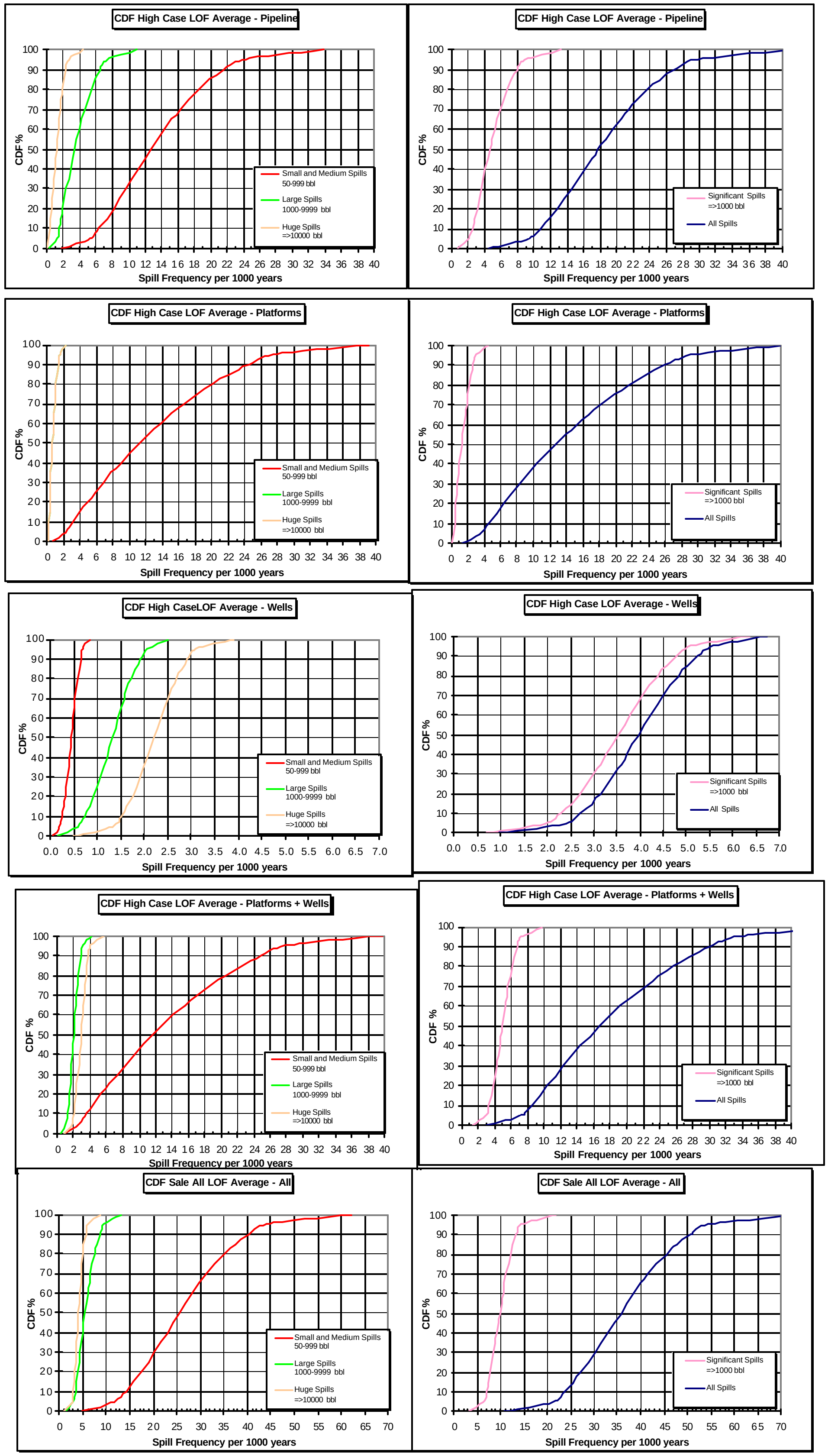
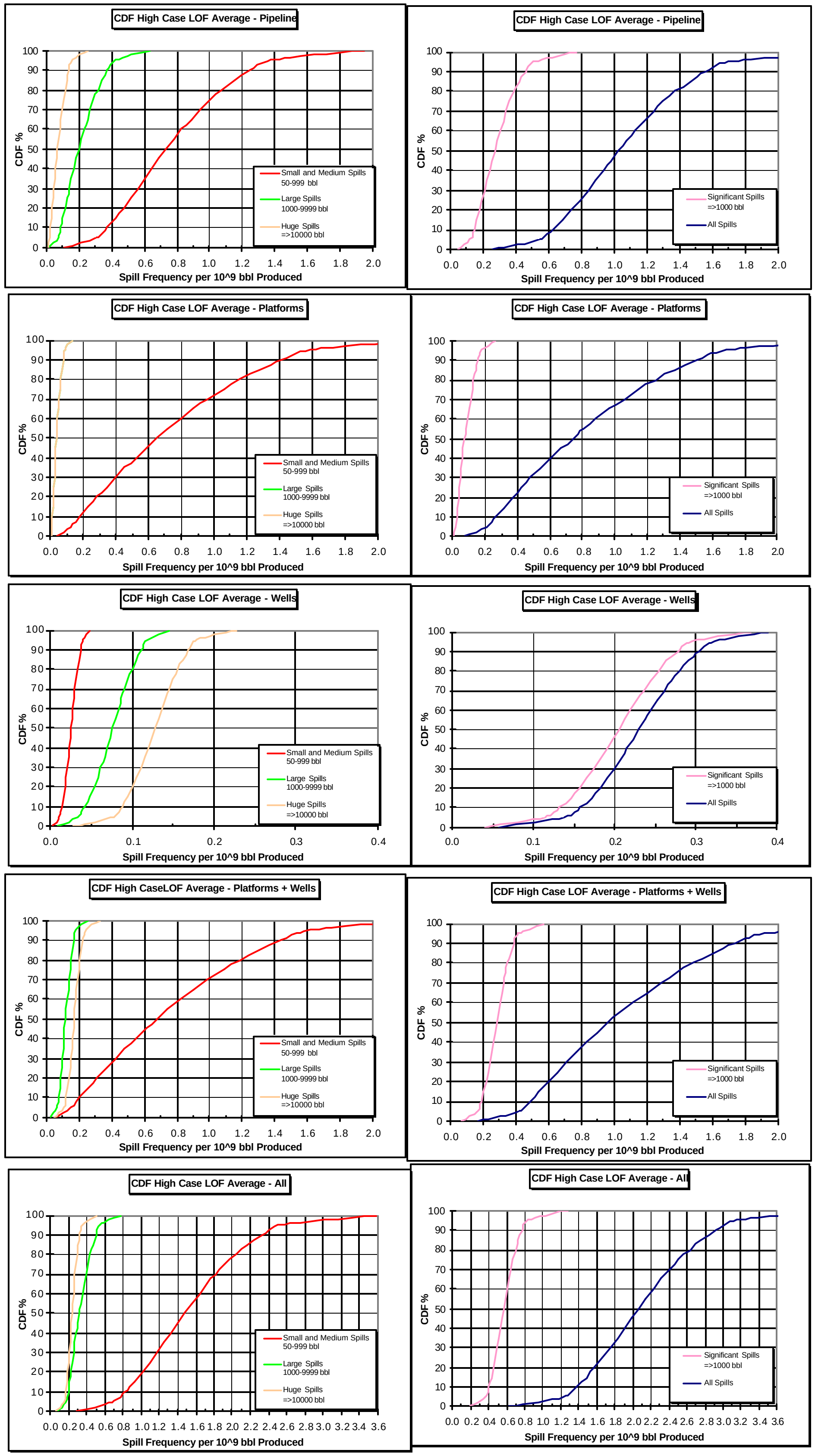


Figure 5.10 Beaufort Sea High Case Life of Field Average Spills per Barrel Produced
(Appendix Figure 4.2.15)



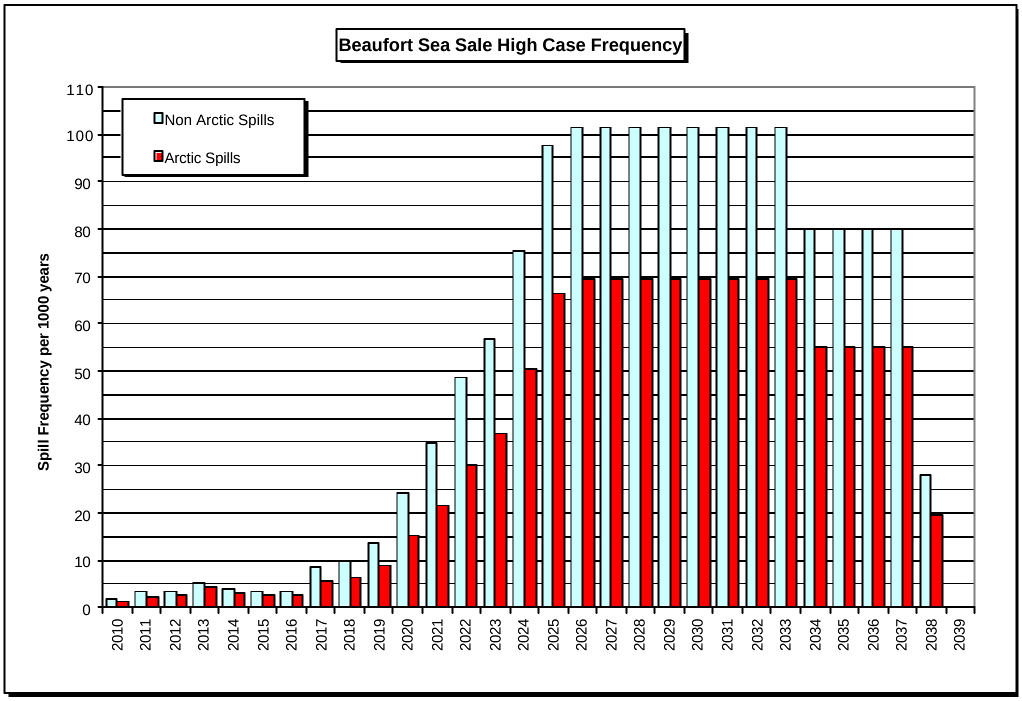


Figure 5.11
Beaufort Sea High Case Spill Frequency – Arctic and Non-Arctic
(Appendix Figure 5.3)

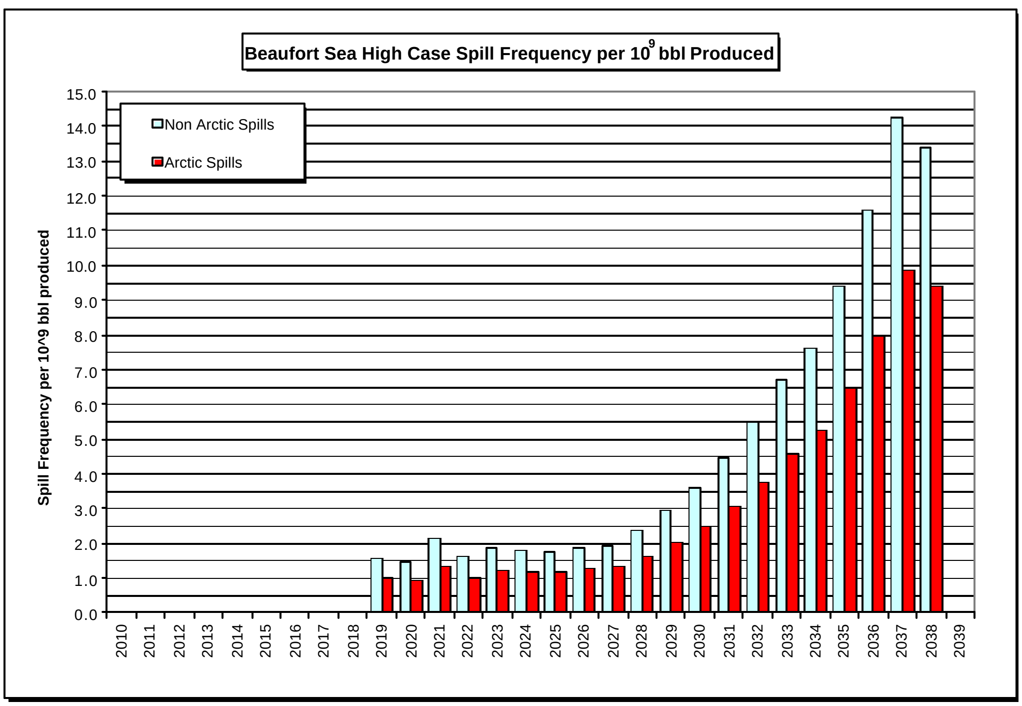


Figure 5.12
Beaufort Sea High Case Spill Frequency per 10^9 Barrels Produced – Arctic and Non-Arctic
(Appendix Figure 5.4)

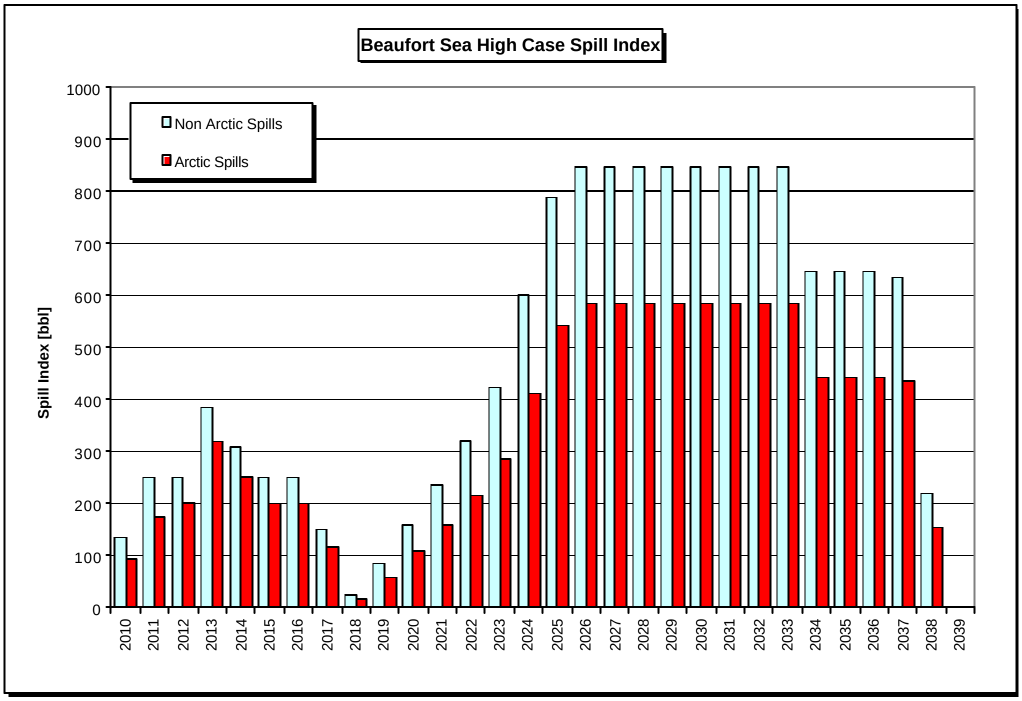


Figure 5.13
Beaufort Sea High Case Spill Index – Arctic and Non-Arctic
(Appendix Figure 5.5)

5.4 Summary of Representative Oil Spill Occurrence Indicator Results

How do spill indicators for the Beaufort scenario and for its non-Arctic counterpart vary by spill size and location? Table 5.3 and Figures 5.14 and 5.15 summarize the Life of Field average spill indicator values by spill source and size for the Low and High Cases and Non-Arctic High Case scenarios. The following can be observed from Table 5.3.

- Spill frequency per year and per barrel-year decreases significantly with increasing spill size for all three scenarios.
- The spill index increases significantly with spill size for all scenarios.
- All non-Arctic scenario spill indicators are greater than their Arctic counterparts.

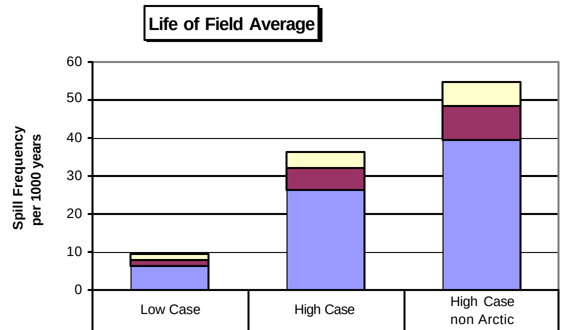
How do the spill indicators vary by facility type for representative scenarios? The contributions of spill indicators by facility have been summarized in Table 5.3 and also in Figure 5.15. Table 5.3 and Figure 5.15 give the component contributions, in absolute value and percent, for each of the main facility types; namely, pipelines (P/L), platforms, and wells. The following may be noted from these for the High Case:

- Pipelines contribute the most (50%) to the spill frequency indicators.
- Platforms are next in relative contribution to spill frequencies (39%) and least in contribution to spill index (4%).
- Wells are by far (at 83%) the highest contributors to spill index.
- It can be concluded that pipelines are likely to have the most, but smaller spills, while wells will have the least number, but largest spills.

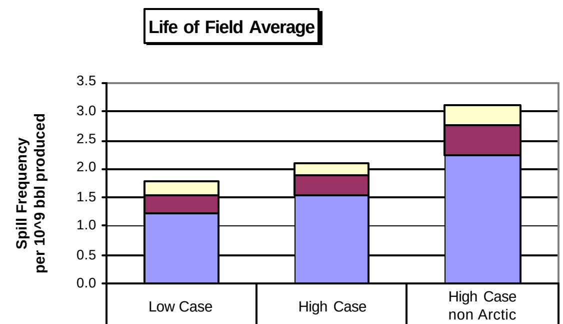
Figures 5.16 and 5.17 show relative contributions by facility and spill size to the maximum production year 2030 and Life of Field average spill indicators, respectively. Although Life of Field average absolute values are significantly smaller than the maximum production year values, the proportional contributions by spill facility source and spill size are almost identical. In Figures 5.16 and 5.17, "TOTAL" designates the sum of the spill indicators for all spill sizes and facility types.

Table 5.3
Summary of Life of Field Average Spill Indicators by Spill Source and Size
(App Table 5.1)

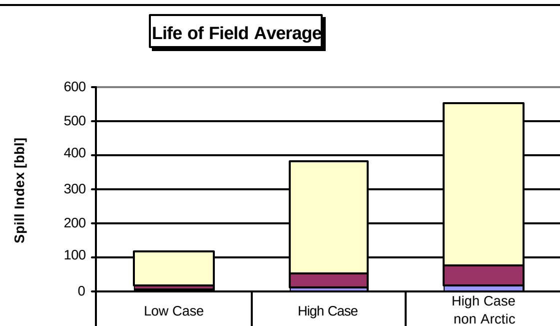
Spill Indicators LOF Average	Low Case			High Case			High Case Non-Arctic		
	Spill Frequency per 10^3 years	Spill Frequency per 10^9 bbl produced	Spill Index [bbl]	Spill Frequency per 10^3 years	Spill Frequency per 10^9 bbl produced	Spill Index [bbl]	Spill Frequency per 10^3 years	Spill Frequency per 10^9 bbl produced	Spill Index [bbl]
Small and Medium Spills 50-999 bbl	6.431	1.232	3	26.468	1.534	11	39.306	2.233	14
	69%	**69%**	**2%**	**73%**	**73%**	**3%**	**72%**	**72%**	**3%**
Large Spills 1000-9999 bbl	1.623	0.311	12	5.773	0.335	40	9.029	0.511	60
	17%	**17%**	**11%**	**16%**	**16%**	**12%**	**17%**	**16%**	**12%**
Huge Spills =>10000 bbl	1.256	0.241	93	4.222	0.245	293	6.312	0.361	417
	13%	**13%**	**87%**	**12%**	**12%**	**85%**	**12%**	**12%**	**85%**
Significant Spills =>1000 bbl	2.879	0.551	104	9.995	0.579	332	15.341	0.871	477
	31%	**31%**	**98%**	**27%**	**27%**	**97%**	**28%**	**28%**	**97%**
All Spills	9.310	1.783	107	36.463	2.113	343	54.647	3.104	492
	100%	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
Pipeline Spills	4.414	0.845	12	18.402	1.066	44	31.209	1.746	76
	47%	**47%**	**11%**	**50%**	**50%**	**13%**	**57%**	**56%**	**15%**
Platform Spills	3.615	0.692	4	14.085	0.816	14	17.873	1.036	17
	39%	**39%**	**4%**	**39%**	**39%**	**4%**	**33%**	**33%**	**3%**
Well Spills	1.281	0.245	92	3.977	0.230	285	5.565	0.322	399
	14%	**14%**	**86%**	**11%**	**11%**	**83%**	**10%**	**10%**	**81%**
Platform and Well Spills	4.896	0.938	95	18.062	1.047	299	23.438	1.358	416
	53%	**53%**	**89%**	**50%**	**50%**	**87%**	**43%**	**44%**	**85%**
All Spills	9.310	1.783	107	36.463	2.113	343	54.647	3.104	492
	100%	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**



	Low Case	High Case	High Case non Arctic
Huge Spills =>10000 bbl	1.256	4.222	6.312
Large Spills 1000-9999 bbl	1.623	5.773	9.029
Small and Medium Spills 50-999 bbl	6.431	26.468	39.306

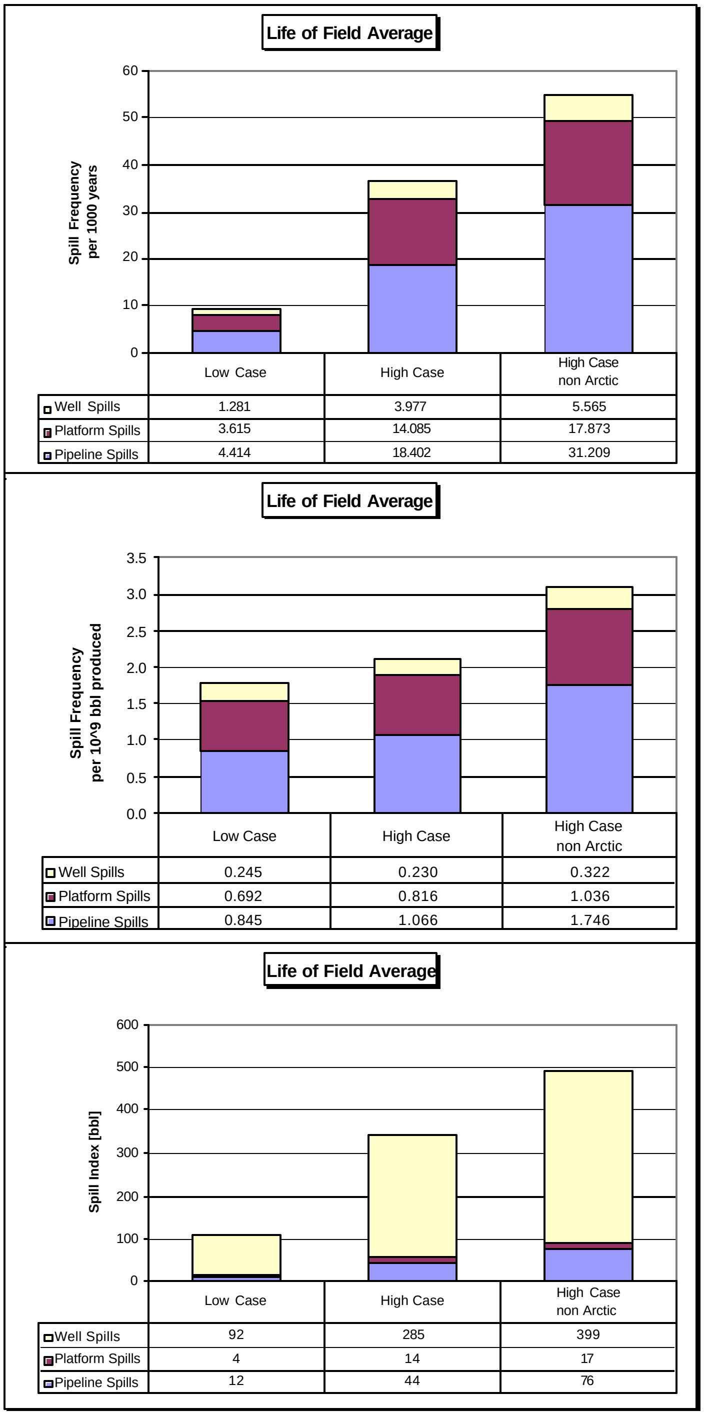


	Low Case	High Case	High Case non Arctic
Huge Spills =>10000 bbl	0.241	0.245	0.361
Large Spills 1000-9999 bbl	0.311	0.335	0.511
Small and Medium Spills 50-999 bb	1.232	1.534	2.233



	Low Case	High Case	High Case non Arctic
Huge Spills =>10000 bbl	104	332	477
Large Spills 1000-9999 bbl	12	40	60
Small and Medium Spills 50-999 bbl	3	11	14

Figure 5.14
Life of Field Spill Indicators – By Spill Size
(Appendix Figure 5.1)



	Low Case	High Case	High Case non Arctic
Well Spills	1.281	3.977	5.565
Platform Spills	3.615	14.085	17.873
Pipeline Spills	4.414	18.402	31.209

	Low Case	High Case	High Case non Arctic
Well Spills	0.245	0.230	0.322
Platform Spills	0.692	0.816	1.036
Pipeline Spills	0.845	1.066	1.746

	Low Case	High Case	High Case non Arctic
Well Spills	92	285	399
Platform Spills	4	14	17
Pipeline Spills	12	44	76

Figure 5.15
Life of Field Spill Indicators – By Source Composition
(Appendix Figure 5.2)

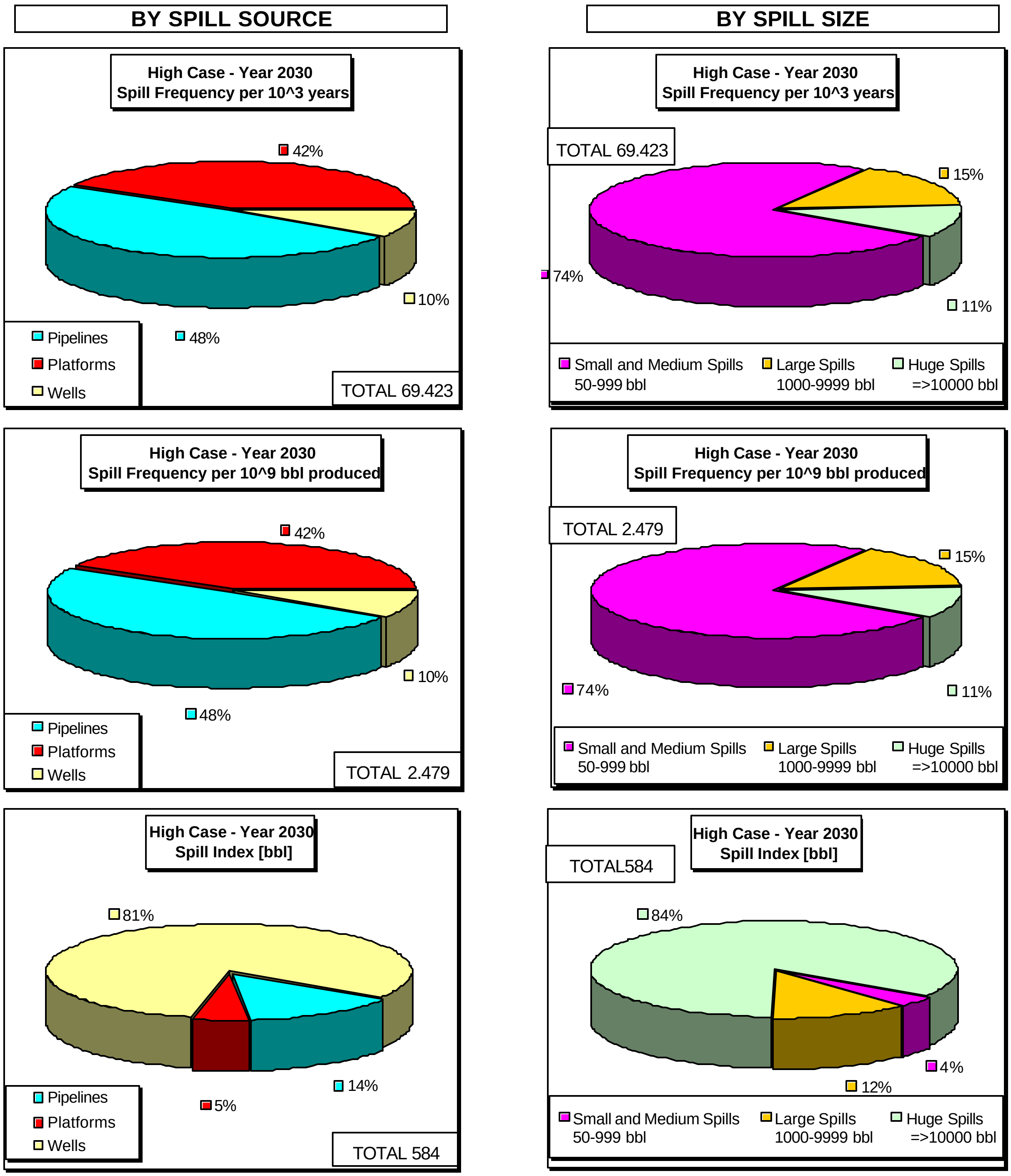


Figure 5.16
Beaufort Sea High Case – Year 2030 – Spill Indicator Composition by Source and Spill Size
(Appendix Figure 4.2.17)

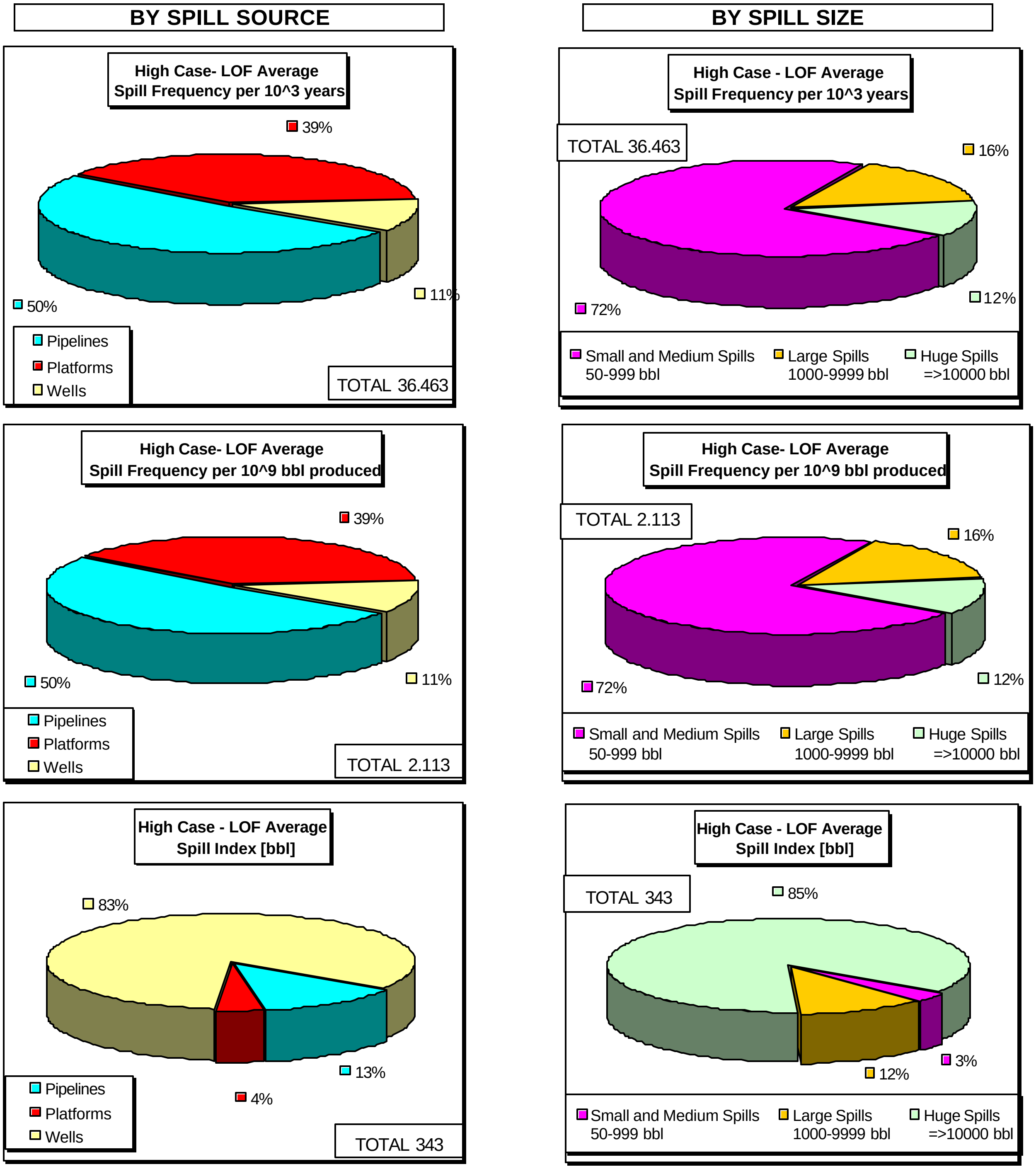


Figure 5.17
Beaufort Sea High Case – Life of Field Average Spill Indicator Composition by Source and Spill Size
(Appendix Figure 4.2.18)

Figures 5.18, 5.19, and 5.20 show the Cumulative Distribution Functions (CDF) for the Beaufort Sea Life of Field average spill indicators. (Figures 5.18 and 5.19 previously appeared as Figures 5.9 and 5.10, and are repeated here for convenience). The variability of these indicators is fairly representative of the trends in variability for spill indicators for the Low Case as well. Generally, the following can be observed from the figures:

- The variance of the frequency spill indicators (Figures 5.18 and 5.19) decreases as spill size increases for pipelines and platforms. In other words, small and medium spills illustrate the largest variability; huge spills show the least variability for pipelines and platforms.
- For wells, the frequency variability for different spill sizes does not change as much as that for platforms and pipelines.
- The variability of the spill index (Figure 5.20) shows an increasing variability with increasing spill size.

The Cumulative Distribution Functions contain extensive information on the statistical properties of the spill indicators. For example, from Figure 5.18, it can be seen, for all significant spills, that the Life of Field average mean (50%) value of 10 (spills per 1,000 years) ranges between 15 and 5 at the upper and lower 95% confidence intervals. A similar percentage variation is shown for the Life of Field average spill frequency per barrel produced in Figure 5.19. The spill index variability shown in Figure 5.20 is proportionally higher. For example, in Figure 5.20, the mean value of the significant spills index of 325 per billion barrels produced ranges from 200 to 500 over the 5% to 95% confidence interval.

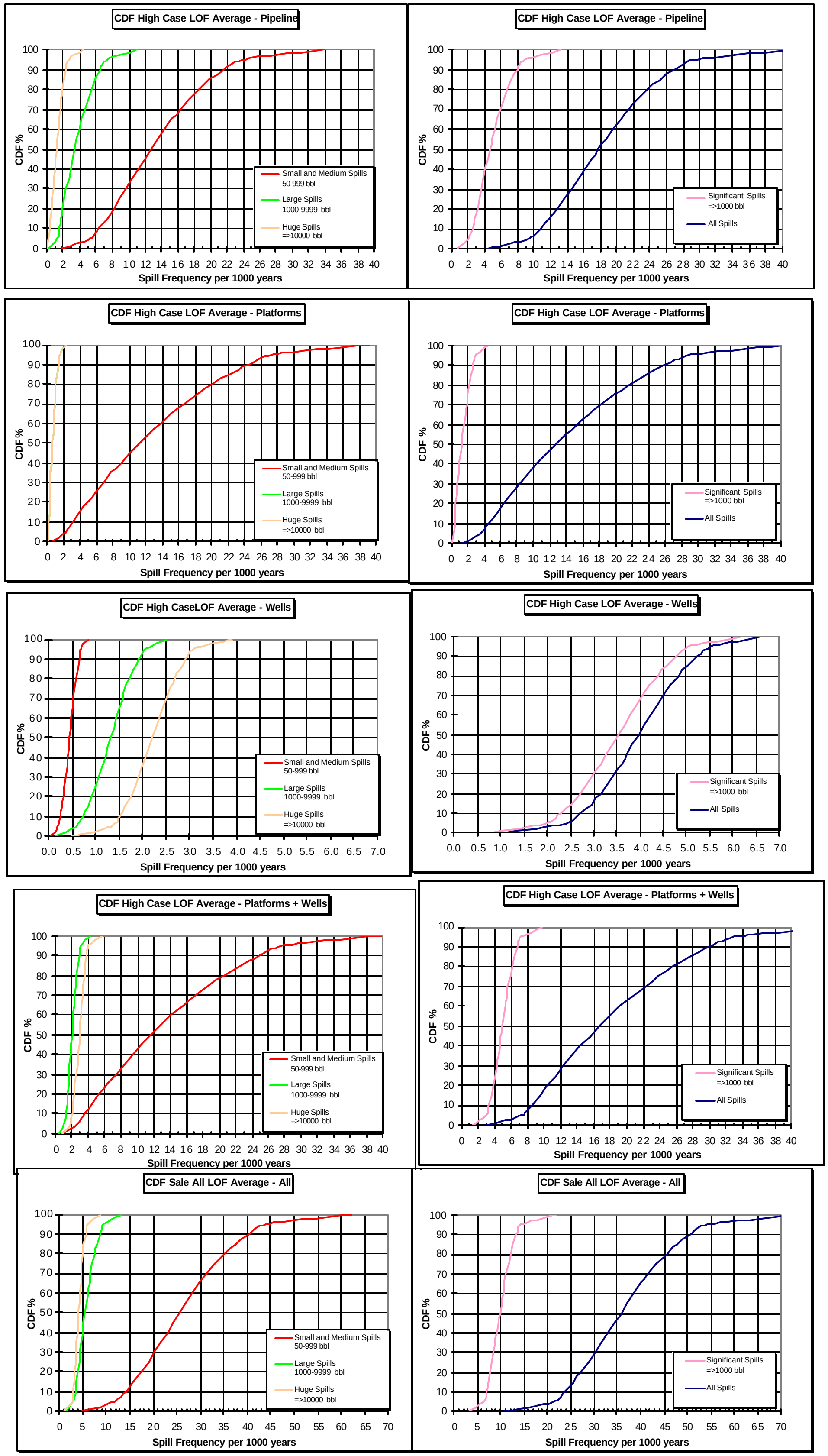
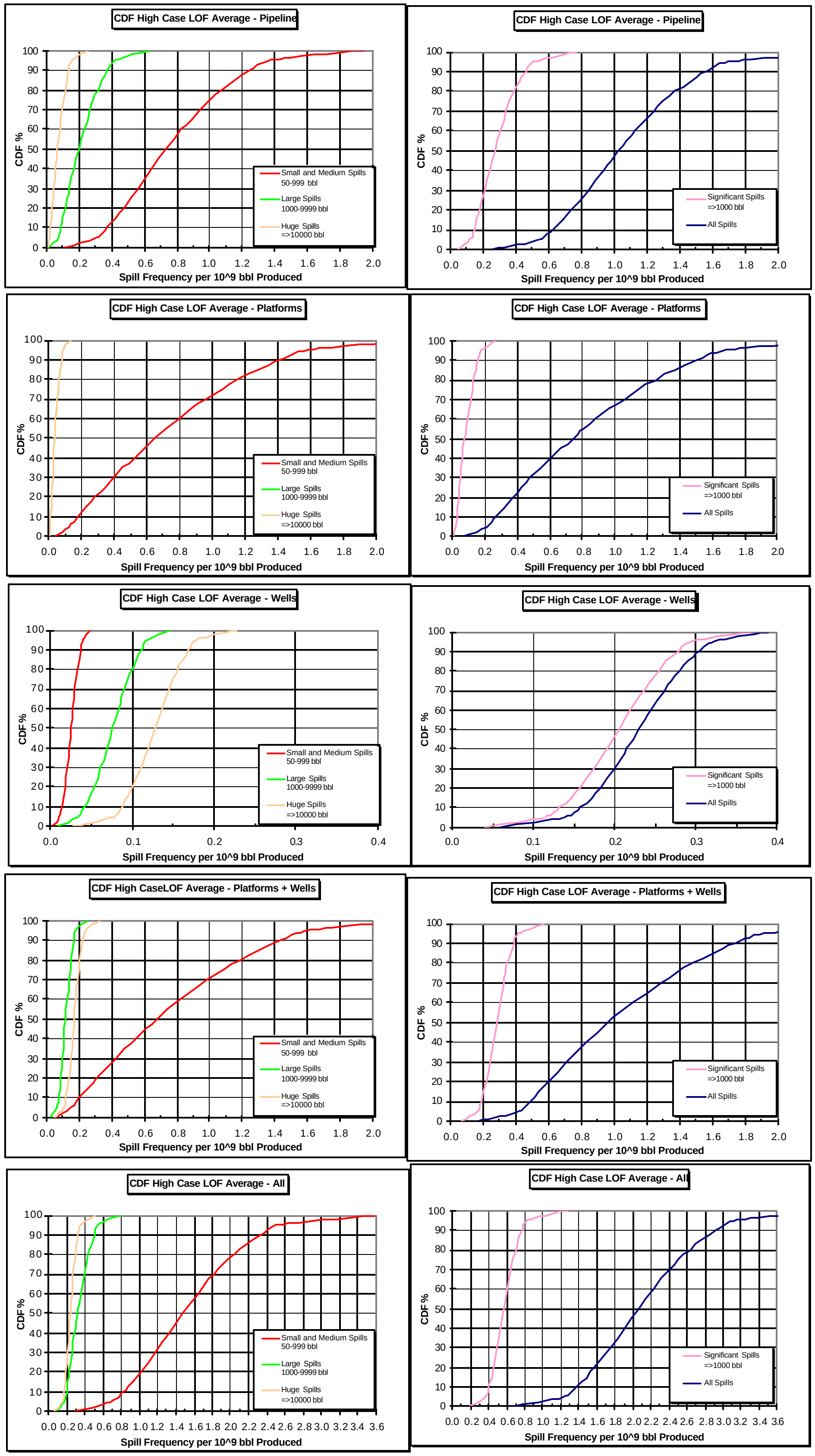


Figure 5.18 Beaufort Sea High Case Life of Field Average Spill Frequency *(Appendix Figure 4.2.14)*

Figure 5.19 Beaufort Sea High Case Life of Field Average Spills per Barrel Produced
(Appendix Figure 4.2.15)



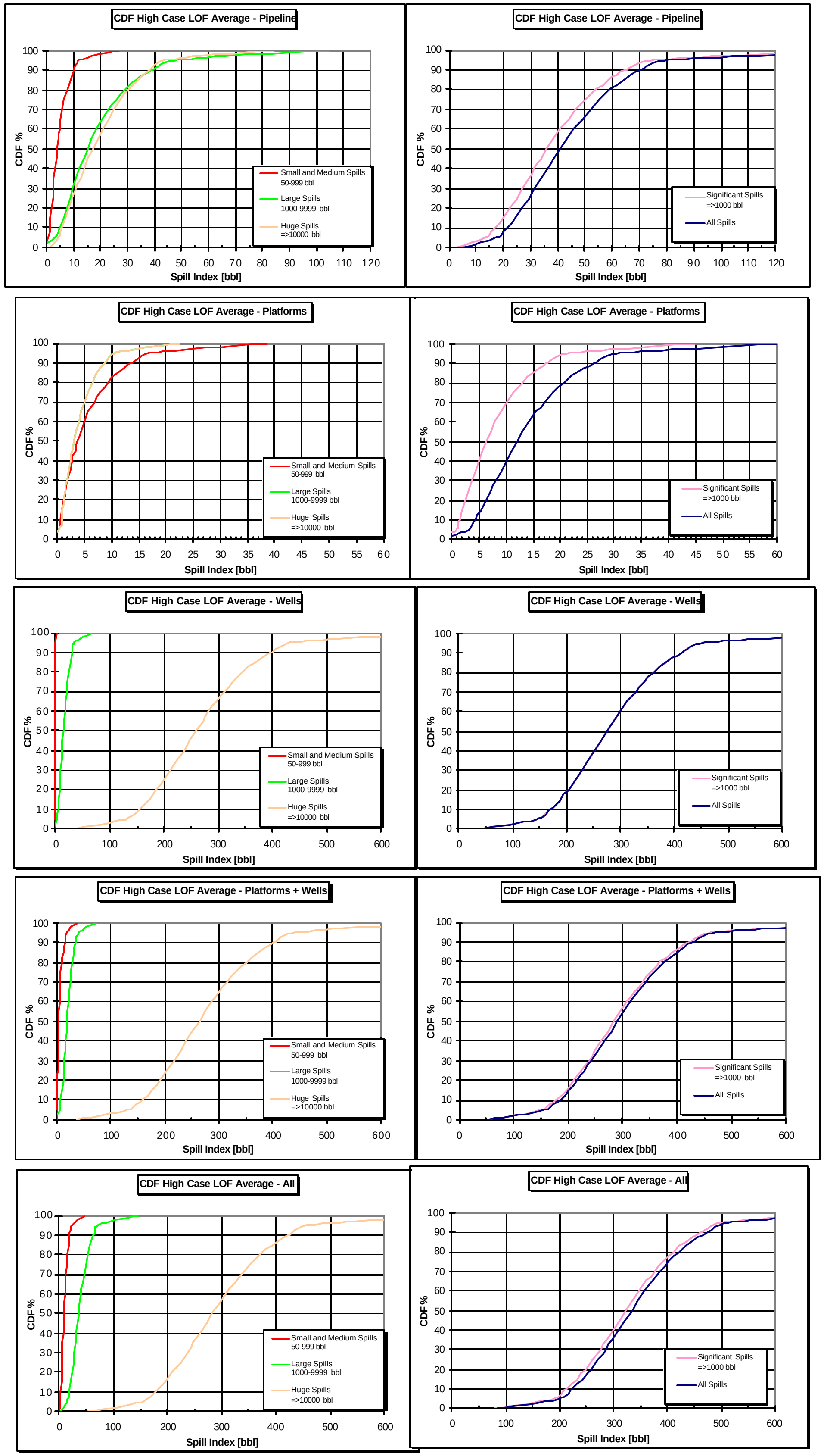


Figure 5.20 Beaufort Sea High Case Life of Field Average Spill Index (bbl) – CDF *(Appendix Figure 4.2.16)*

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

6.1.1 General Conclusions

Oil spill occurrence indicators were quantified for future offshore development scenarios in the Beaufort Sea in the area of MMS jurisdiction. The quantification included the consideration of the variability of historical and future scenario data, as well as that of Arctic effects in predicting oil spill occurrence indicators. Consideration of the variability of all input data yields both higher variability and a higher expected value of the spill occurrence indicators. The three types of spill occurrence indicators were: annual oil spill frequency, annual oil spill frequency per billion barrels produced, and annual spill index – and, additionally, the life of field averages for each of these three oil spill indicators were assessed.

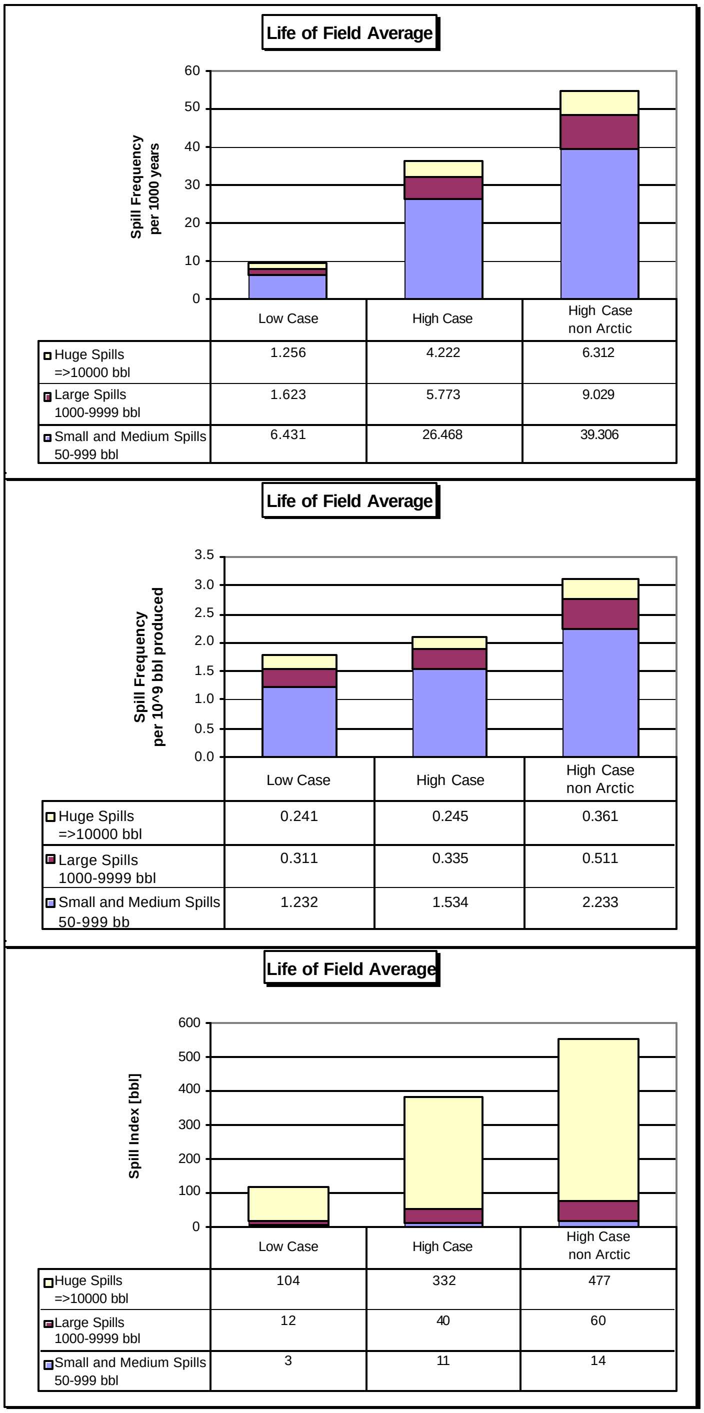
6.1.2 Oil Spill Occurrence Indicators by Spill Size

How do spill indicators for the Beaufort scenario and for its non-Arctic counterpart vary by spill size and location? Table 6.1 and Figures 6.1 and 6.2 summarize the Life of Field average spill indicator values by spill source and size for the Low and High Cases and Non-Arctic High Case scenarios. The following can be observed from Table 6.1.

- Spill frequency per year and per barrel-year decreases significantly with increasing spill size for all scenarios.
- The spill index increases significantly with spill size for all scenarios.
- All non-Arctic scenario spill indicators are greater than their Arctic counterparts.

Table 6.1
Summary of Life of Field Average Spill Indicators by Spill Source and Size
(Appendix Table 5.1)

Spill Indicators LOF Average	Low Case			High Case			High Case Non-Arctic		
	Spill Frequency per 10^3 years	Spill Frequency per 10^9 bbl produced	Spill Index [bbl]	Spill Frequency per 10^3 years	Spill Frequency per 10^9 bbl produced	Spill Index [bbl]	Spill Frequency per 10^3 years	Spill Frequency per 10^9 bbl produced	Spill Index [bbl]
Small and Medium Spills 50-999 bbl	6.431	1.232	3	26.468	1.534	11	39.306	2.233	14
	69%	**69%**	**2%**	**73%**	**73%**	**3%**	**72%**	**72%**	**3%**
Large Spills 1000-9999 bbl	1.623	0.311	12	5.773	0.335	40	9.029	0.511	60
	17%	**17%**	**11%**	**16%**	**16%**	**12%**	**17%**	**16%**	**12%**
Huge Spills =>10000 bbl	1.256	0.241	93	4.222	0.245	293	6.312	0.361	417
	13%	**13%**	**87%**	**12%**	**12%**	**85%**	**12%**	**12%**	**85%**
Significant Spills =>1000 bbl	2.879	0.551	104	9.995	0.579	332	15.341	0.871	477
	31%	**31%**	**98%**	**27%**	**27%**	**97%**	**28%**	**28%**	**97%**
All Spills	9.310	1.783	107	36.463	2.113	343	54.647	3.104	492
	100%	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
Pipeline Spills	4.414	0.845	12	18.402	1.066	44	31.209	1.746	76
	47%	**47%**	**11%**	**50%**	**50%**	**13%**	**57%**	**56%**	**15%**
Platform Spills	3.615	0.692	4	14.085	0.816	14	17.873	1.036	17
	39%	**39%**	**4%**	**39%**	**39%**	**4%**	**33%**	**33%**	**3%**
Well Spills	1.281	0.245	92	3.977	0.230	285	5.565	0.322	399
	14%	**14%**	**86%**	**11%**	**11%**	**83%**	**10%**	**10%**	**81%**
Platform and Well Spills	4.896	0.938	95	18.062	1.047	299	23.438	1.358	416
	53%	**53%**	**89%**	**50%**	**50%**	**87%**	**43%**	**44%**	**85%**
All Spills	9.310	1.783	107	36.463	2.113	343	54.647	3.104	492
	100%	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

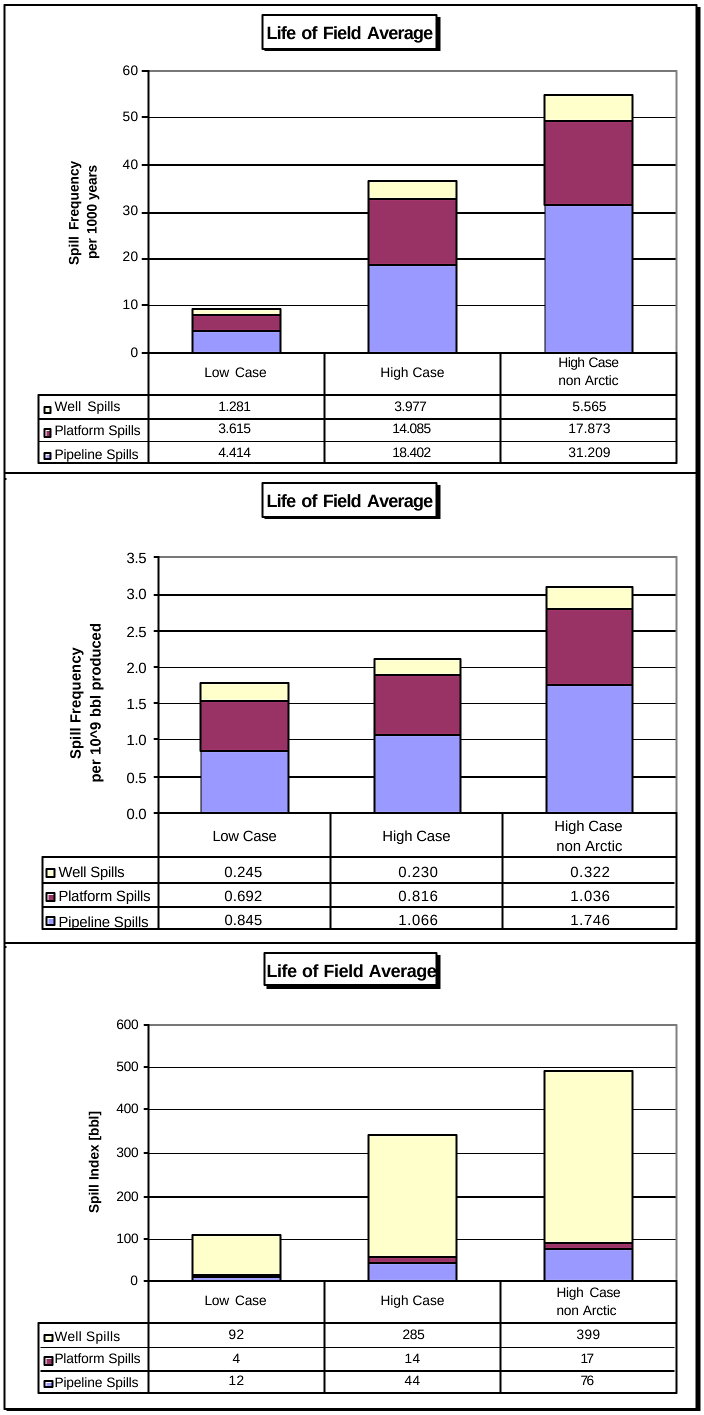


	Low Case	High Case	High Case non Arctic
Huge Spills =>10000 bbl	1.256	4.222	6.312
Large Spills 1000-9999 bbl	1.623	5.773	9.029
Small and Medium Spills 50-999 bbl	6.431	26.468	39.306

	Low Case	High Case	High Case non Arctic
Huge Spills =>10000 bbl	0.241	0.245	0.361
Large Spills 1000-9999 bbl	0.311	0.335	0.511
Small and Medium Spills 50-999 bb	1.232	1.534	2.233

	Low Case	High Case	High Case non Arctic
Huge Spills =>10000 bbl	104	332	477
Large Spills 1000-9999 bbl	12	40	60
Small and Medium Spills 50-999 bbl	3	11	14

Figure 6.1
Life of Field Spill Indicators – By Spill Size
Appendix Figure 5.1



	Low Case	High Case	High Case non Arctic
Well Spills	1.281	3.977	5.565
Platform Spills	3.615	14.085	17.873
Pipeline Spills	4.414	18.402	31.209

	Low Case	High Case	High Case non Arctic
Well Spills	0.245	0.230	0.322
Platform Spills	0.692	0.816	1.036
Pipeline Spills	0.845	1.066	1.746

	Low Case	High Case	High Case non Arctic
Well Spills	92	285	399
Platform Spills	4	14	17
Pipeline Spills	12	44	76

Figure 6.2
Life of Field Spill Indicators – By Source Composition
(Appendix Figure 5.2)

6.1.3 Oil Spill Occurrence Indicators by Spill Source

How do the spill indicators vary by facility type for representative scenarios? The contributions of spill indicators by facility have been summarized in Table 6.1 and also in Figure 6.2. Table 6.1 and Figure 6.2 give the component contributions, in absolute value and percent, for each of the main facility types; namely, pipelines (P/L), platforms, and wells. The following may be noted from these for the High Case:

- Pipelines contribute the most (50%) to the spill frequency indicators.
- Platforms are next in relative contribution to spill frequencies (39%) and least in contribution to spill index (4%).
- Wells are by far (at 83%) the highest contributors to spill index.
- It can be concluded that pipelines are likely to have the most, but smaller spills, while wells will have the least number, but largest spills.

Figures 6.3 and 6.4 show relative contributions by facility and spill size to the maximum production year 2030 and Life of Field average spill indicators, respectively. Although Life of Field average absolute values are significantly smaller than the maximum production year values, the proportional contributions by spill facility source and spill size are almost identical. In Figures 6.3 and 6.4, "TOTAL" designates the sum of the spill indicators for all spill sizes and facility types.

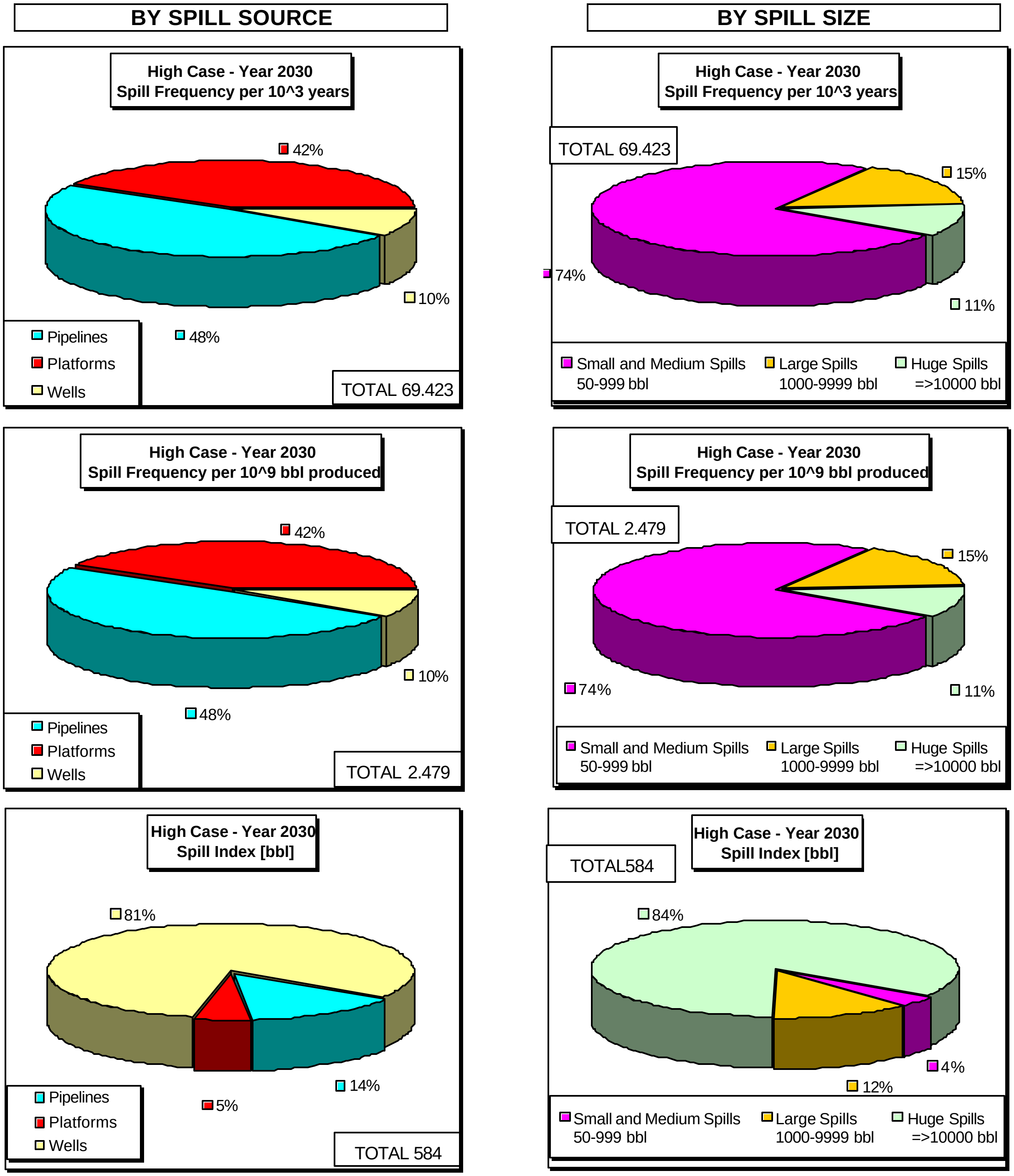


Figure 6.3
Beaufort Sea High Case – Year 2030 – Spill Indicator Composition by Source and Spill Size
(Appendix Figure 4.2.17)

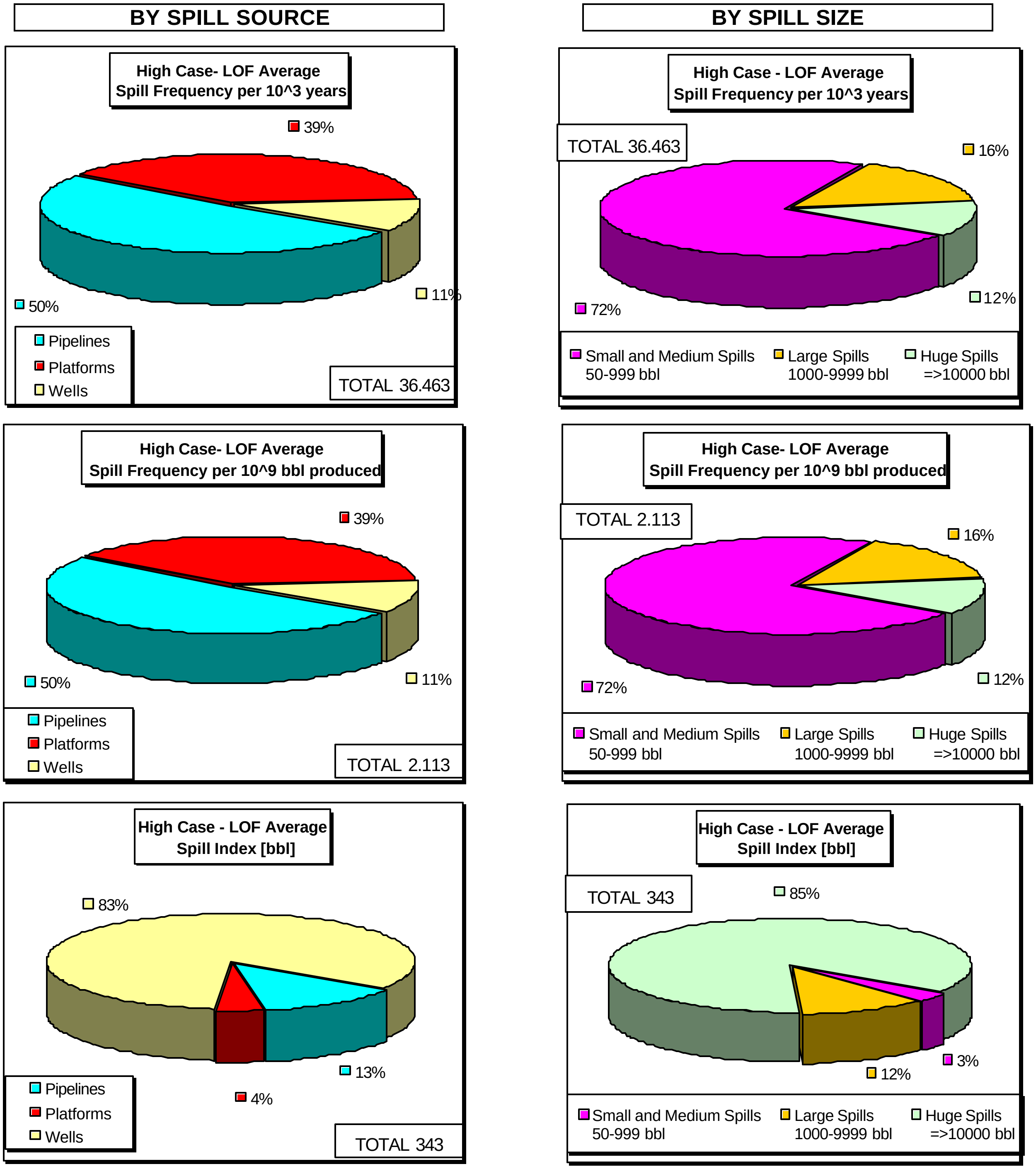


Figure 6.4
Beaufort Sea High Case – Life of Field Average Spill Indicator Composition by Source and Spill Size
(Appendix Figure 4.2.18)

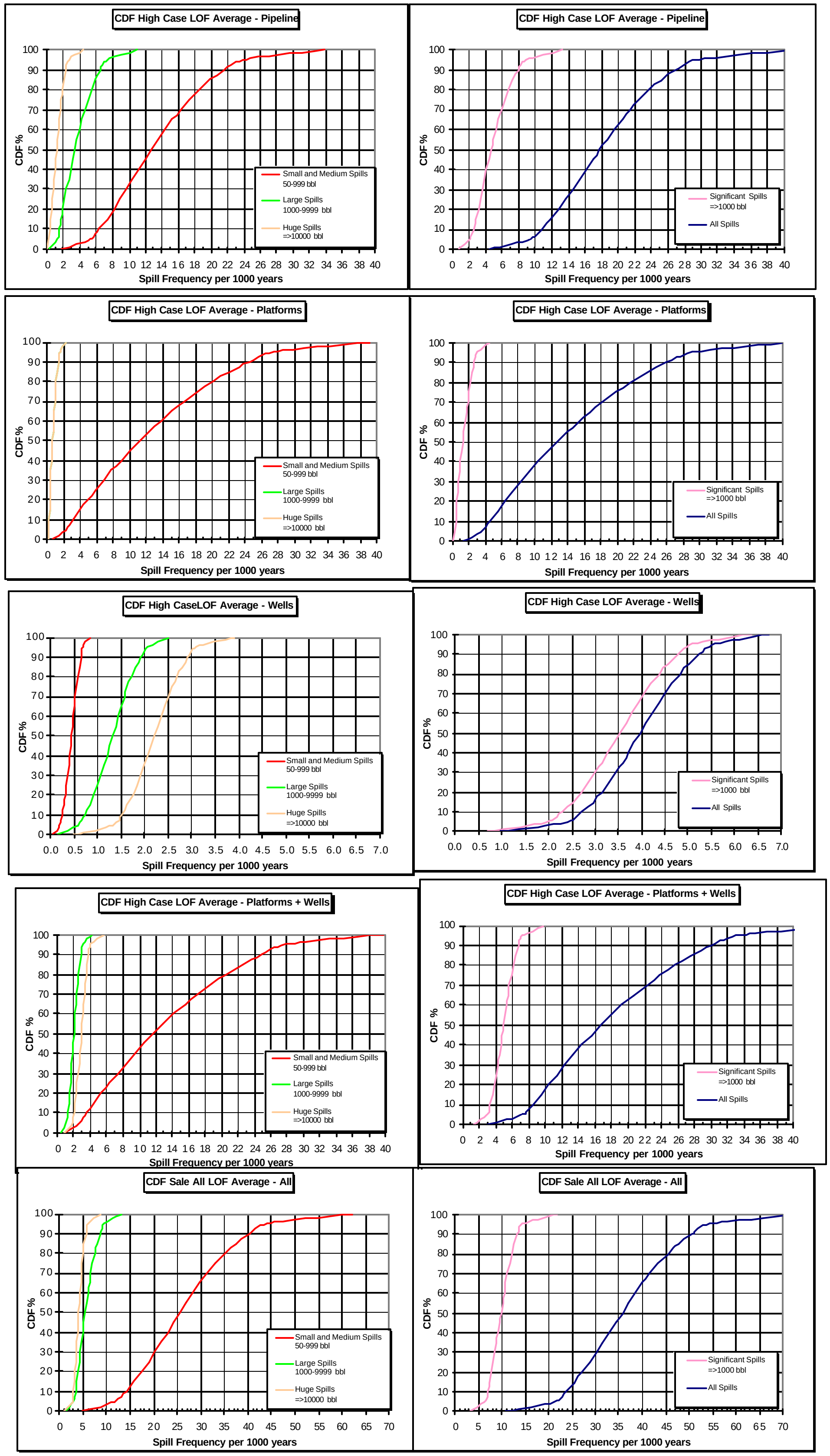
6.1.4 Variability of Oil Spill Occurrence Indicators

Figures 6.5, 6.6, and 6.7 show the Cumulative Distribution Functions (CDF) for the Beaufort Sea Life of Field average spill indicators. The variability of these indicators is fairly representative of the trends in variability for spill indicators for the Low Case as well. Generally, the following can be observed from the figures:

- The variance of the frequency spill indicators (Figures 6.5 and 6.6) decreases as spill size increases for pipelines and platforms. In other words, small and medium spills illustrate the largest variability; huge spills show the least variability for pipelines and platforms.
- For wells, the frequency variability for different spill sizes does not change as much as that for platforms and pipelines.
- The variability of the spill index (Figure 6.7) shows an increasing variability with increasing spill size.

The Cumulative Distribution Functions contain extensive information on the statistical properties of the spill indicators. For example, from Figure 6.5 (bottom right-hand graph), it can be seen, for all significant spills, that the Life of Field average mean (50%) value of 10 (spills per 1,000 years) ranges between about 5 and 15 at the lower and 5% to 95% confidence intervals. A similar percentage variation is shown for the Life of Field average spill frequency per barrel produced in Figure 6.6. The spill index variability shown in Figure 6.7 is proportionally higher. For example, in Figure 6.7 (bottom right-hand corner graph), the mean value of the significant spills index of 325 per billion barrels produced ranges from 200 to 500 over the 5% to 95% confidence interval.

Figure 6.5 Beaufort Sea High Case Life of Field Average Spill Frequency
(Appendix Figure 4.2.14)



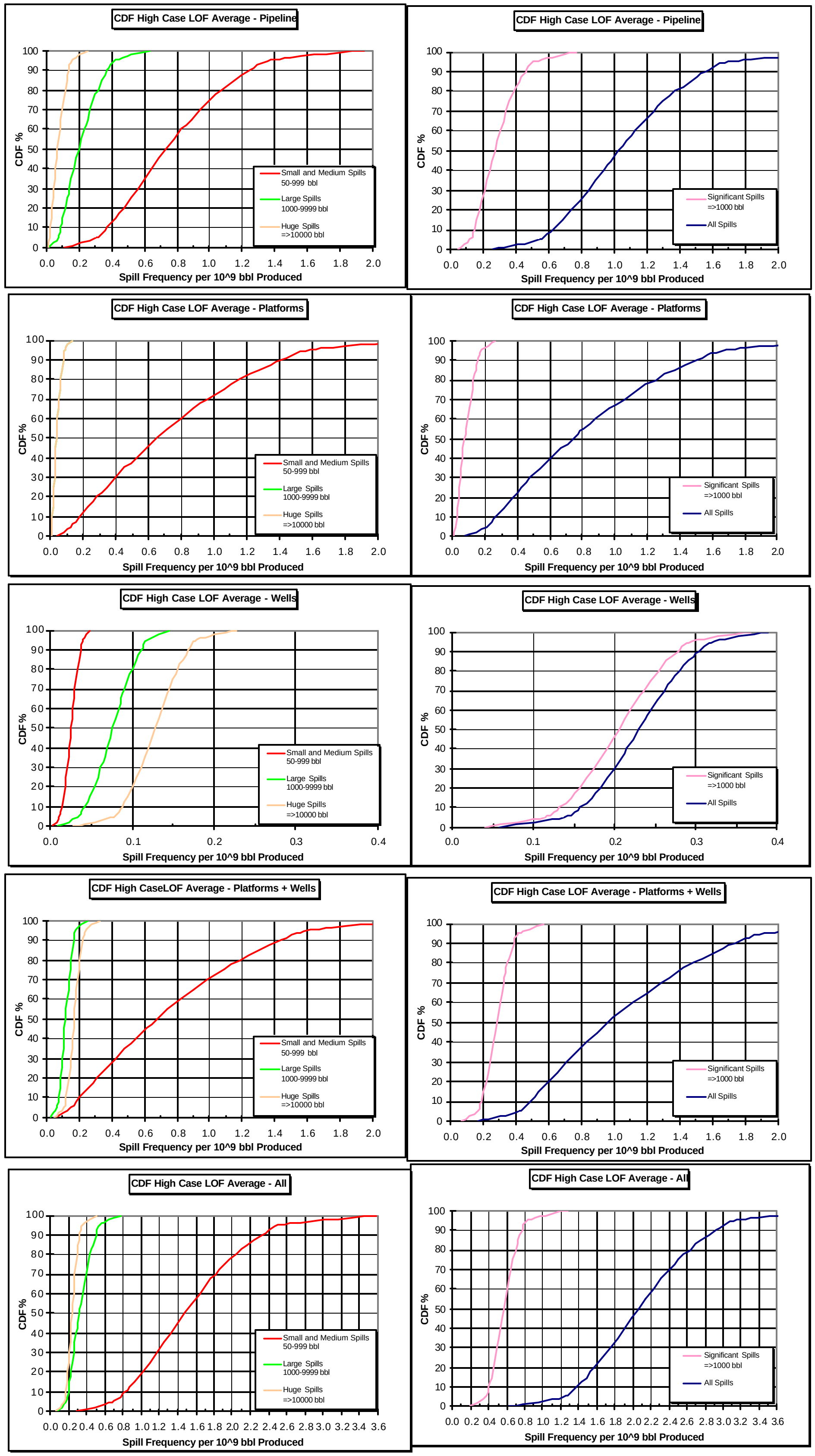
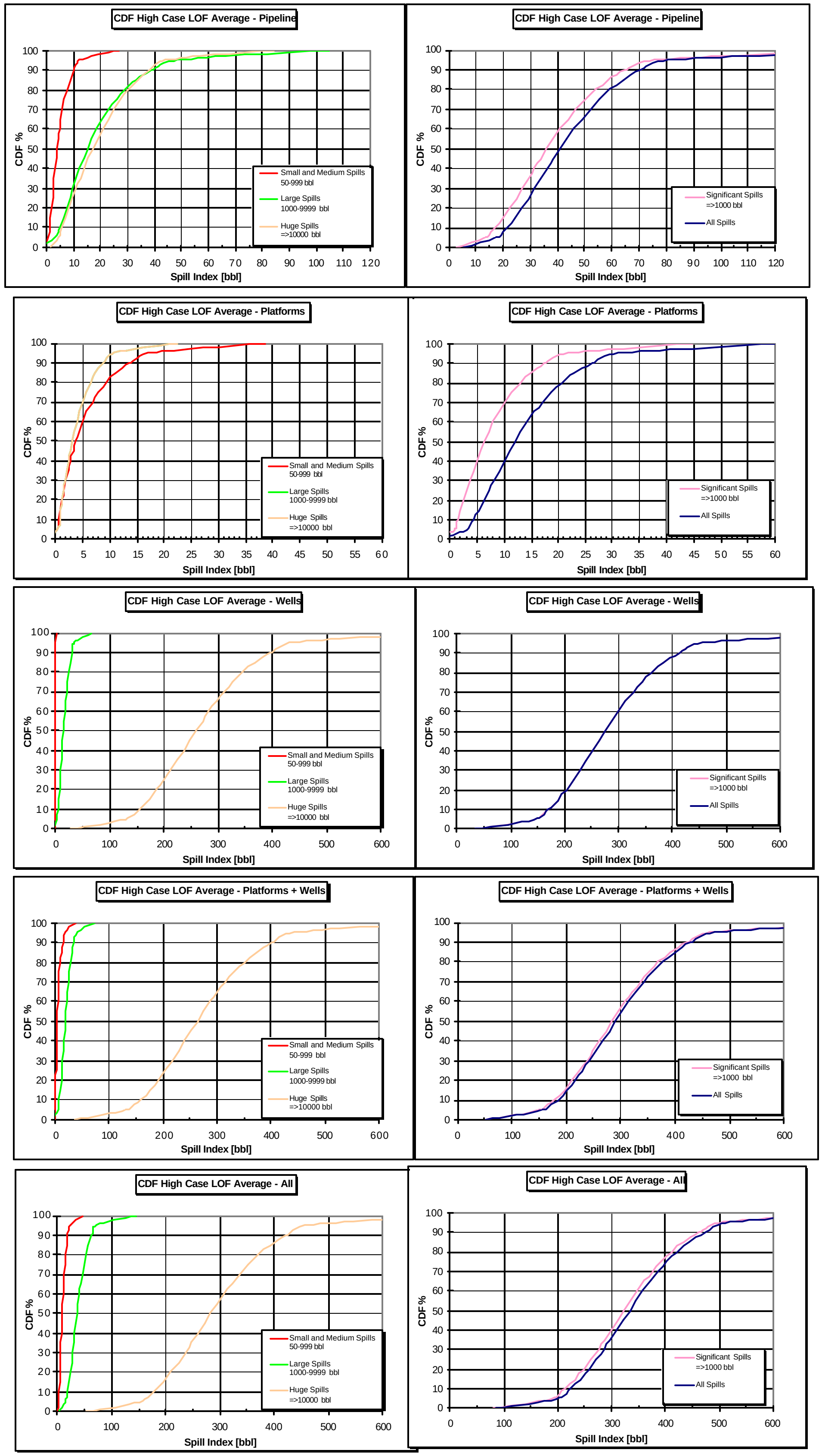


Figure 6.6
Beaufort Sea High Case Life of Field Average Spills per Barrel Produced
(Appendix Figure 4.2.15)

Figure 6.7 Beaufort Sea High Case Life of Field Average Spill Index (bbl) – CDF *(Appendix Figure 4.2.16)*



6.2 Conclusions on the Methodology and its Applicability

An analytical tool for the prediction of oil spill occurrence indicators for systems without history, such as future offshore oil production developments in the Beaufort Sea, has been developed based on the utilization of fault tree methodology. Although the results generated are voluminous, they are essentially transparent, simple, and easy to understand. The analytical tool developed is also quite transparent, very efficient in terms of computer time and input-output capability. In addition, the predictive model is setup so that any input variables can be entered as distributions.

A wealth of information that can be utilized for the optimal planning and regulation of future developments is generated by the analytical tool. Key aspects of the analytical tool capability may be summarized as follows:

- Ability to generate expected and mean values as well as their variability in rigorous numerical statistical format.
- Use of verifiable input data based on MMS or other historical spill data and statistics.
- Ability to independently vary the impacts of different causes on the spill occurrences as well as add new causes such as some of those that may be expected for the Arctic or other new environments.
- Ability to generate spill occurrence indicator characteristics such as annual variations, facility contributions, spill size distributions, and life of field (Life of Field) averages.
- Ability to generate comparative spill occurrence indicators such as those of comparable scenarios in more temperate regions. The model developed provides a basis for estimating each Arctic effect's importance through sensitivity analysis as well as propagation of uncertainties.
- Capability to quantify uncertainties rigorously, together with their measures of variability.

6.3 Limitations of the Methodology and Results

During the work, a number of limitations in the input data, the scenarios, the application of the fault tree methodology, and finally the oil spill occurrence indicators themselves have been identified. These shortcomings are summarized in the following paragraphs.

Two categories of input data were used; namely the historical spill data and the Arctic effect data. Although a verifiable and optimal historical spill data set has been used, the following shortcomings may be noted:

- Gulf of Mexico (OCS) historical data bases were provided by MMS for pipelines and facilities, and were used as a starting point for the fault tree analysis. Although these data are adequate, a broader population base would be expected to give more robust statistics. Unfortunately, data from a broader population base, such as the North Sea, do not contain the level of detail provided in the GOM data.

- The Arctic effects include modifications in causes associated with the historical data set as well as additions of spill causes unique to the Arctic environment. Quantification of existing causes for Arctic effects was done in a systematic manner dependent on engineering judgment.

- A reproducible but relatively elementary analysis of gouging and scour effects was carried out.
- Upheaval buckling effect assessments were included on the basis of an educated guess; no engineering analysis was carried out for the assessment of frequencies to be expected for these effects, as they are highly variable for different locations and pipeline characteristics.

The scenarios are those developed for use in the MMS Alaska OCS Region Environmental Impact Statements for Oil and Gas Lease Sales. As estimated they appear reasonable and were incorporated in the form provided. The only shortcoming appears to be that the facility abandonment rate is significantly lower than the rate of decline in production.

The following comments can be made on limitations associated with the indicators that have been generated:

- The indicators have inherited the deficiencies of the input and scenario data noted above.

- The model generating the indicators is fundamentally a linear model which ignores the effects of scale, of time variations such as the learning and wear-out curves (Bathtub curve), global warming, and production volume non-linear effects.

6.4 Recommendations

The following recommendations based on the work may be made:

- Continue to utilize the Monte Carlo spill occurrence indicator model for new scenarios to support MMS needs, as it is currently the best predictive spill occurrence model available.

- Utilize this oil spill occurrence indicator model to generate additional model validation information, including direct application to specific non-Arctic scenarios, such as GOM projects, which have an oil spill statistical history.

- Utilize the oil spill occurrence indicator model in a sensitivity mode to identify the importance of different Arctic effect variables introduced to provide a prioritized list of those items having the highest potential impact on Arctic oil spills.

- Generalize the model so that it can be run both in an adjusted expected value and a distributed value (Monte Carlo) form with the intent that expected value form can be utilized without the Monte Carlo add-in for preliminary estimates and sensitivity analyses, while for more comprehensive rigorous studies, the Monte Carlo version can be used.

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The Department of the Interior Mission

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

The Minerals Management Service Mission

As a bureau of the Department of the Interior, the Minerals Management Service's (MMS) primary responsibilities are to manage the mineral resources located on the Nation's Outer Continental Shelf (OCS), collect revenue from the Federal OCS and onshore Federal and Indian lands, and distribute those revenues.

Moreover, in working to meet its responsibilities, the **Offshore Minerals Management Program** administers the OCS competitive leasing program and oversees the safe and environmentally sound exploration and production of our Nation's offshore natural gas, oil and other mineral resources. The MMS **Royalty Management Program** meets its responsibilities by ensuring the efficient, timely and accurate collection and disbursement of revenue from mineral leasing and production due to Indian tribes and allottees, States and the U.S. Treasury.

The MMS strives to fulfill its responsibilities through the general guiding principles of: (1) being responsive to the public's concerns and interests by maintaining a dialogue with all potentially affected parties and (2) carrying out its programs with an emphasis on working to enhance the quality of life for all Americans by lending MMS assistance and expertise to economic development and environmental protection.

OCS Study MMS 2008-035

FINAL TASK 4A.1 REPORT

VOLUME II – APPENDICES

Alternative Oil Spill Occurrence Estimators and their Variability for the Beaufort Sea – Fault Tree Method

MMS Contract Number 1435-01-05-CT-39348

March 2008

By

Bercha International Inc.
Calgary, Alberta, Canada

U.S. Department of the Interior
Minerals Management Service
Alaska Outer Continental Shelf Region

OCS Study MMS 2008-035

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Alternative Oil Spill Occurrence Estimators and their Variability for the Beaufort Sea – Fault Tree Method

March 2008

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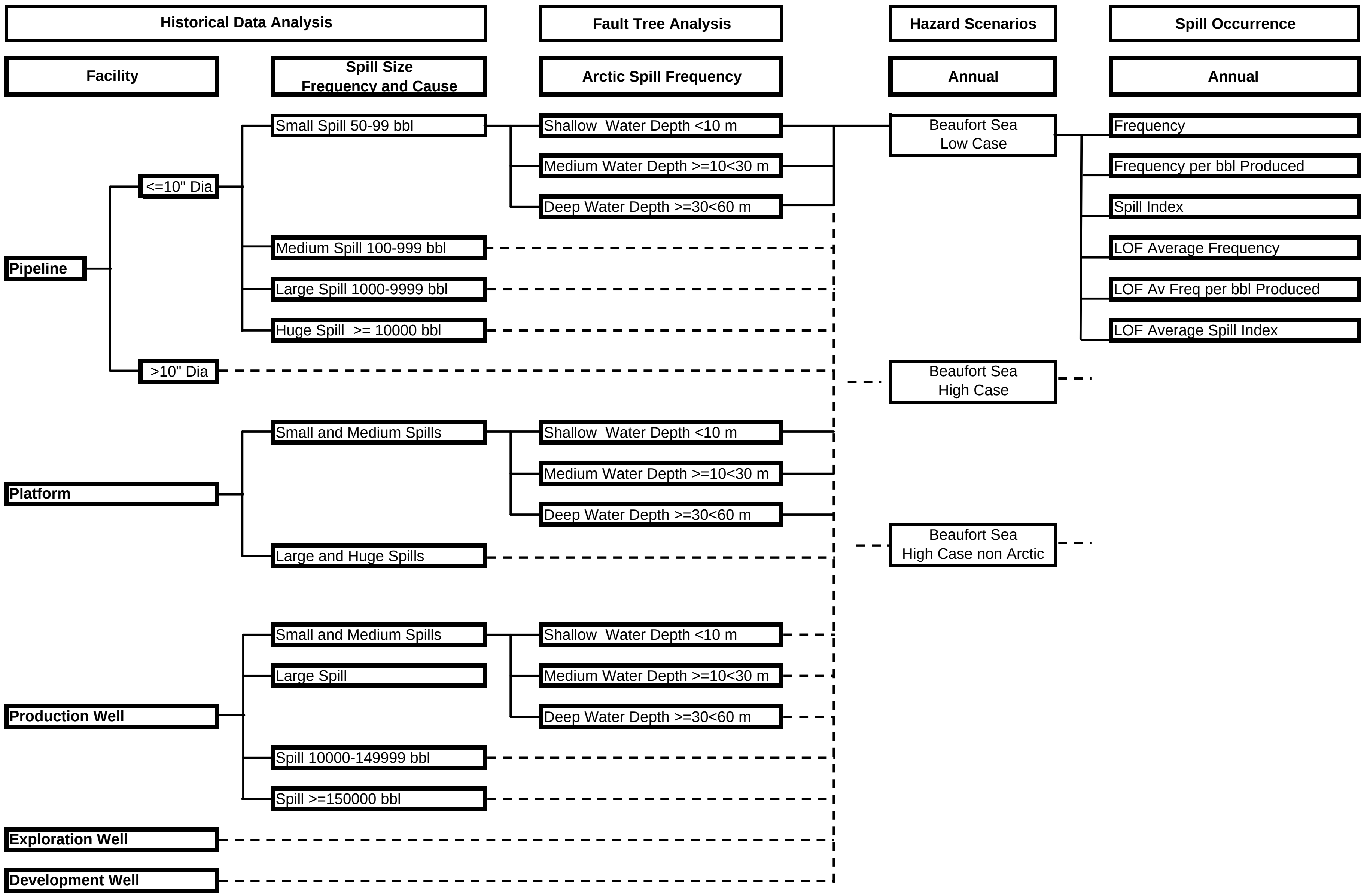


Table 1.1
Analysis of Historical Spills - Pipeline

CAUSE CLASSIFICATION	NUMBER OF SPILLS	SPILL SIZE BBL																	NUMBER OF SPILLS					
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**S**	**M**	**L**	**H**	**SM**	**LH**
CORROSION	**4**																		**1**	**2**	**1**		**3**	**1**
External	1	80																	1				**1**	
Internal	3	100	5000	414																2	1		**2**	**1**
THIRD PARTY IMPACT	**18**																		**2**	**6**	**7**	**3**	**8**	**10**
Anchor Impact	12	19833	65	50	300	900	323	15576	2000	800	1211	2240	600						2	5	3	2	**7**	**5**
Jackup Rig or Spud Barge	1	3200																			1			**1**
Trawl/Fishing Net	5	4000	100	14423	4569	4533														1	3	1	**1**	**4**
OPERATION IMPACT	**4**																		**3**		**1**		**3**	**1**
Rig Anchoring	1	50																	1				**1**	
Work Boat Anchoring	3	50	5100	50															2		1		**2**	**1**
MECHANICAL	**2**																			**2**			**2**	
Connection Failure	1	135																		1			**1**	
Material Failure	1	210																		1			**1**	
NATURAL HAZARD	**20**																		**6**	**11**	**3**		**17**	**3**
Mud Slide	3	250	80	8212															1	1	1		**2**	**1**
Storm/ Hurricane	17	3500	671	126	200	260	250	1720	95	123	960	50	50	100	75	862	66	108	5	10	2		**15**	**2**
ARCTIC																								
Ice Gouging																								
Strudel Scour																								
Upheaval Buckling																								
Thaw Settlement																								
Other Arctic																								
UNKNOWN	**2**	119	190																	**2**			**2**	
TOTALS	**50**																		**12**	**23**	**12**	**3**	**35**	**15**

Table 1.2
Distribution and Frequency of Historical Spills - Pipeline

CAUSE CLASSIFICATION	Small and Medium Spills 50-999 bbl				Large and Huge Spills >=1000 bbl			
	HIST. DISTRIBUTION %	NUMBER OF SPILLS	EXPOSURE [km-years]	FREQUENCY spill per 10^5km-year	HIST. DISTRIBUTION %	NUMBER OF SPILLS	EXPOSURE [km-years]	FREQUENCY spill per 10^5km-year
CORROSION	**8.57**	**3**	**273847**	**1.0955**	**6.67**	**1**	**273847**	**0.3652**
External	2.86	1		0.3652				
Internal	5.71	2		0.7303	6.67	1		0.3652
THIRD PARTY IMPACT	**22.86**	**8**		**2.9213**	**66.67**	**10**		**3.6517**
Anchor Impact	20.00	7		2.5562	33.33	5		1.8258
Jackup Rig or Spud Barge					6.67	1		0.3652
Trawl/Fishing Net	2.86	1		0.0365	26.67	4		1.4607
OPERATION IMPACT	**8.57**	**3**		**1.0955**	**6.67**	**1**		**0.3652**
Rig Anchoring	2.86	1		0.3652				
Work Boat Anchoring	5.71	2		0.7303	6.67	1		0.3652
MECHANICAL	**5.71**	**2**		**0.7303**				
Connection Failure	2.86	1		0.3652				
Material Failure	2.86	1		0.3652				
NATURAL HAZARD	**48.57**	**17**		**6.2078**	**20.00**	**3**		**1.0955**
Mud Slide	5.71	2		0.7303	6.67	1		0.3652
Storm/ Hurricane	42.86	15		5.4775	13.33	2		0.7303
ARCTIC								
Ice Gouging								
Strudel Scour								
Upheaval Buckling								
Thaw Settlement								
Other Arctic								
UNKNOWN	**5.71**	**2**		**0.7303**				
TOTALS	**100.00**	**35**		**12.7809**	**100.00**	**15**		**5.4775**

Table 1.3
Historical Spills Data - Pipeline

GOM OCS Pipeline Spills, Categorized 1972-2006		Spill Statistics Number of Spills	Exposure km-years	Frequency spills per 10^5 km-years
By Pipe Diameter				
	< = 10"	30	187,984	15.9588
	> 10"	20	85,863	23.2929
By Spill Size				
	Small <100 bbl	12	273,847	4.3820
	Medium 100 - 999 bbl	23	273,847	8.3989
	Large 1000 - 9999 bbl	12	273,847	4.3820
	Huge >=10000 bbl	3	273,847	1.0955
By Diameter, By Spill Size				
<=10"	Small <100 bbl	8	187,984	4.2557
	Medium 100 - 999 bbl	14	187,984	7.4474
	Large 1000 - 9999 bbl	7	187,984	3.7237
	Huge >=10000 bbl	1	187,984	0.5320
> 10"	Small <100 bbl	4	85,863	4.6586
	Medium 100 - 999 bbl	9	85,863	10.4818
	Large 1000 - 9999 bbl	5	85,863	5.8232
	Huge >=10000 bbl	2	85,863	2.3293

Table 1.4
Historical Spills Data - Pipeline - Variability

GOM OCS Pipeline Spills, Categorized 1972-2006		Low Factor	High Factor	Frequency spill per 10^5 km-years				
				Historical	Low	Mode	High	Expected
By Diameter, By Spill Size								
<=10"	**Small**	0	2.81	4.2557	0	0.8086	11.9585	6.0361
	Medium	0	2.81	7.4474	0	1.4150	20.9273	10.5632
	Large	0	2.81	3.7237	0	0.7075	10.4637	5.2816
	Huge	0	2.81	0.5320	0	0.1011	1.4948	0.7545
>10"	**Small**	0	2.81	4.6586	0	0.8851	13.0906	6.6076
	Medium	0	2.81	10.4818	0	1.9915	29.4539	14.8670
	Large	0	2.81	5.8232	0	1.1064	16.3633	8.2595
	Huge	0	2.81	2.3293	0	0.4426	6.5453	3.3038

Table 1.5
Analysis of Historical Spills - Platforms

CAUSE CLASSIFICATION	NUMBER OF SPILLS	SPILL SIZE BBL														NUMBER OF SPILLS					
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	S	M	L	H	SM	LH
EQUIPMENT FAILURE	**35**															**17**	**18**			**35**	
Process Equipment	14	130	50	104	60	95	107	50	643	60	50	400	75	125	127	7	7			**14**	
Transfer Hose	12	321	118	50	400	228	214	540	125	77	200	77	58			4	8			**12**	
Incorrect Operation	9	300	70	83	58	60	50	280	436	60						6	3			**9**	
HUMAN ERROR	**12**	239	95	120	286	100	64	600	170	200	262	429	60			**3**	**9**			**12**	
TANK FAILURE	**3**	9935	150	50												**1**	**1**	**1**		**2**	**1**
SHIP COLLISION	**6**	166	100	1500	320	95	119									**1**	**4**	**1**		**5**	**1**
WEATHER	**10**	7000	165	258	80	1456	66	89	105	100	105					3	5	2		8	2
HURRICANE	**6**	75	200	1536	954	3093	6897									**1**	**2**	**3**		**3**	**3**
OTHER	**2**	64	100													**1**	**1**			**2**	
ARCTIC																					
Ice Force																					
Facility Low Temperature																					
Other Arctic																					
TOTALS	**74**															**27**	**40**	**7**		**67**	**7**

Table 1.6
Distribution and Frequency of Historical Spills - Platforms

CAUSE CLASSIFICATION	Small and Medium Spills 50-999 bbl				Large and Huge Spills >=1000 bbl			
	HIST. DISTRIBUTION %	NUMBER OF SPILLS	EXPOSURE [well-years]	FREQUENCY spill per 10^4well-year	HIST. DISTRIBUTION %	NUMBER OF SPILLS	EXPOSURE [well-years]	FREQUENCY spill per 10^4well-year
EQUIPMENT FAILURE	**52.24**	**35**		**1.6434**				
Process Equipment	20.90	14		0.6574				
Transfer Hose	17.91	12		0.5635				
Incorrect Operation	13.43	9		0.4226				
HUMAN ERROR	**17.91**	**12**		**0.5635**				
TANK FAILURE	**2.99**	**2**		**0.0939**	**14.29**	**1**		**0.0470**
SHIP COLLISION	**7.46**	**5**		**0.2348**	**14.29**	**1**		**0.0470**
WEATHER	**11.94**	**8**	**212971**	**0.3756**	**28.57**	**2**	**212971**	**0.0939**
HURRICANE	**4.48**	**3**		**0.1409**	**42.86**	**3**		**0.1409**
OTHER	**2.99**	**2**		**0.0939**				
ARCTIC								
Ice Force								
Facility Low Temperature								
Other Arctic								
TOTALS	**100.00**	**67**		**3.1460**	**100.00**	**7**		**0.3287**

Table 1.7
Historical Spills Data - Platforms - Variability

Frequency Unit	Low Factor	High Factor	Historical	Low	Mode	High	Expected
			Small and Medium Spills 50-999 bbl				
spill per 10^4well-year	0	3	3.1460	0.0000	0.0000	9.4379	4.6009
			Large and Huge Spills >=1000 bbl				
spill per 10^4well-year	0	3	0.3287	0.0000	0.0000	0.9860	0.4807

Table 1.8
Frequency of Historical Spills - Wells

EVENT	FREQUENCY UNIT	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Small, Medium, and Large Spills 50-9999 bbl	Spills 10000-149999 bbl	Spills >=150000 bbl	All spills
		HISTORICAL FREQUENCY					
PRODUCTION WELL	**spills per 10^4 well-year**	0.15	1.03	1.18	0.44	0.29	1.91
EXPLORATION WELL DRILLING	**spills per 10^4 wells**	1.97	13.75	15.72	5.91	3.42	25.05
DEVELOPMENT WELL DRILLING	**spills per 10^4 wells**	0.65	4.57	5.22	1.96	1.96	9.15

Table 1.9
Frequency of Historical Spills - Wells - Variability

EVENT	FREQUENCY UNIT	Low Factor	High Factor	Frequencies: Historical	Low	Mode	High	Expected
				Small and Medium Spills 50-999 bbl				
PRODUCTION WELL	spill per 10^4 well-year	0.448	1.545	0.147	0.066	0.148	0.227	0.147
EXPLORATION WELL DRILLING	spill per 10^4 wells	0.439	2.036	1.966	0.863	1.032	4.002	2.262
DEVELOPMENT WELL DRILLING	spill per 10^4 wells	0.437	1.760	0.654	0.286	0.526	1.151	0.692
				Large Spills 1000-9999 bbl				
PRODUCTION WELL	spill per 10^4 well-year	0.448	1.545	1.028	0.460	1.037	1.588	1.026
EXPLORATION WELL DRILLING	spill per 10^4 wells	0.439	2.036	13.754	6.039	7.220	28.001	15.824
DEVELOPMENT WELL DRILLING	spill per 10^4 wells	0.437	1.760	4.570	1.998	3.671	8.041	4.833
				Small, Medium and Large Spills 50-9999 bbl				
PRODUCTION WELL	spill per 10^4 well-year	0.448	1.545	1.175	0.526	1.185	1.815	1.173
EXPLORATION WELL DRILLING	spill per 10^4 wells	0.439	2.036	15.719	6.903	8.252	32.003	18.086
DEVELOPMENT WELL DRILLING	spill per 10^4 wells	0.437	1.760	5.224	2.284	4.197	9.192	5.525
				Spill 10000-149999 bbl				
PRODUCTION WELL	spill per 10^4 well-year	0.448	1.545	0.441	0.197	0.444	0.681	0.440
EXPLORATION WELL DRILLING	spill per 10^4 wells	0.439	2.036	5.909	2.595	3.102	12.031	6.799
DEVELOPMENT WELL DRILLING	spill per 10^4 wells	0.437	1.760	1.963	0.858	1.577	3.454	2.076
				Spill >=150000 bbl				
PRODUCTION WELL	spill per 10^4 well-year	0.448	1.545	0.294	0.132	0.296	0.454	0.293
EXPLORATION WELL DRILLING	spill per 10^4 wells	0.439	2.036	3.421	1.502	1.796	6.965	3.936
DEVELOPMENT WELL DRILLING	spill per 10^4 wells	0.437	1.760	1.963	0.858	1.577	3.454	2.076

Table 2.1
Fault Tree Analysis Input Rationalization - Pipeline

CAUSE CLASSIFICATION	Spill Size	Shallow	Medium	Deep	Reason
		Historical Expected Frequency Change %			
CORROSION					
External	**All**	(30)	(30)	(30)	Low temperature and bio effects. Extra smart pigging.
Internal	**All**	(30)	(30)	(30)	Extra smart pigging.
THIRD PARTY IMPACT					
Anchor Impact	**All**	(50)	(50)	(50)	Low traffic.
Jackup Rig or Spud Barge	**All**	(50)	(50)	(50)	Low facility density.
Trawl/Fishing Net	**All**	(50)	(60)	(70)	Low fishing activity. Less bottom fishing in deep water.
OPERATION IMPACT					
Rig Anchoring	**All**	(20)	(20)	(20)	Low marine traffic during ice season (8 months).
Work Boat Anchoring	**All**	(20)	(20)	(20)	Low work boat traffic during ice season (8 months).
MECHANICAL					
Connection Failure	**All**				
Material Failure	**All**				
NATURAL HAZARD					
Mud Slide	**All**	(60)	(50)	(40)	Gradient low. Mud slide potential (gradient) increases with water depth.
Storm/ Hurricane	**All**	(80)	(80)	(70)	Fewer severe storms.
		Freq. Increment per 10^5 km-year			
		Expected	**Expected**	**Expected**	
		Mode	**Mode**	**Mode**	
ARCTIC					
Ice Gouging	**S**	0.5411	0.6763		Ice gouge failure rate calculated using exponential failure distribution for 2.5-m cover, 0.2-m average gouge depth, 4 gouges per km-yr flux. Spill size Distribution explained in text Section 2.5.2. Medium depth has 0.8 as many gouges as shallow.
		0.1054	0.1318		
	M	0.5411	0.6763		
		0.1054	0.1318		
	L	1.3527	1.6908		
		0.2635	0.3294		
	H	0.2705	0.3382		
		0.0527	0.0659		
Strudel Scour	**S**	0.0645			Only in shallow water. Average frequency of 4 scours/mile^2 and 100 ft of bridge length with 10% conditional P/L failure probability. The same spill size distribution as above.
		0.0235			
	M	0.0645			
		0.0235			
	L	0.1613			
		0.0587			
	H	0.0323			
		0.0117			
Upheaval Buckling	**S**	0.0129	0.0129	0.0129	All water depth. The failure frequency is 20% of that of Strudel Scour.
		0.0047	0.0047	0.0047	
	M	0.0129	0.0129	0.0129	
		0.0047	0.0047	0.0047	
	L	0.0323	0.0323	0.0323	
		0.0117	0.0117	0.0117	
	H	0.0065	0.0065	0.0065	
		0.0023	0.0023	0.0023	
Thaw Settlement	**S**	0.0065	0.0065	0.0065	All water depth. The failure frequency is 10% of that of Strudel Scour.
		0.0023	0.0023	0.0023	
	M	0.0065	0.0065	0.0065	
		0.0023	0.0023	0.0023	
	L	0.0161	0.0161	0.0161	
		0.0059	0.0059	0.0059	
	H	0.0032	0.0032	0.0032	
		0.0012	0.0012	0.0012	
Other Arctic	**S**	0.0625	0.0696	0.0019	To be assessed as 10% of all arctic effects.
		0.0136	0.0139	0.0007	
	M	0.0625	0.0696	0.0019	
		0.0136	0.0139	0.0007	
	L	0.1562	0.1739	0.0048	
		0.0340	0.0347	0.0018	
	H	0.0312	0.0348	0.0010	
		0.0068	0.0069	0.0004	

Table 2.2
Monte Carlo Input - Pipeline

CAUSE CLASSIFICATION	Spill Size	Shallow			Medium			Deep		
		Frequency Change %								
		Min	Mode	Max	Min	Mode	Max	Min	Mode	Max
CORROSION										
External	**All**	(90)	(30)	(10)	(90)	(30)	(10)	(90)	(30)	(10)
Internal	**All**	(90)	(30)	(10)	(90)	(30)	(10)	(90)	(30)	(10)
THIRD PARTY IMPACT										
Anchor Impact	**All**	(90)	(50)	(10)	(90)	(50)	(10)	(90)	(50)	(10)
Jackup Rig or Spud Barge	**All**	(90)	(50)	(10)	(90)	(50)	(10)	(90)	(50)	(10)
Trawl/Fishing Net	**All**	(90)	(50)	(10)	(90)	(60)	(10)	(90)	(70)	(10)
OPERATION IMPACT										
Rig Anchoring	**All**	(50)	(20)	(10)	(50)	(20)	(10)	(50)	(20)	(10)
Work Boat Anchoring	**All**	(50)	(20)	(10)	(50)	(20)	(10)	(50)	(20)	(10)
MECHANICAL										
Connection Failure	**All**									
Material Failure	**All**									
NATURAL HAZARD										
Mud Slide	**All**	(90)	(60)	(10)	(90)	(50)	(10)	(90)	(40)	(10)
Storm/ Hurricane	**All**	(90)	(80)	(10)	(90)	(80)	(10)	(90)	(70)	(10)
		Frequency Increment per 10^5 km-year								
ARCTIC										
Ice Gouging	**S**	0.0087	0.1054	1.2841	0.0108	0.1318	1.6051			
	M	0.0087	0.1054	1.2841	0.0108	0.1318	1.6051			
	L	0.0216	0.2635	3.2103	0.0270	0.3294	4.0128			
	H	0.0043	0.0527	0.6421	0.0054	0.0659	0.8026			
Strudel Scour	**S**	0.0110	0.0235	0.1381						
	M	0.0110	0.0235	0.1381						
	L	0.0276	0.0587	0.3452						
	H	0.0055	0.0117	0.0690						
Upheaval Buckling	**S**	0.00221	0.00469	0.02761	0.00221	0.00469	0.02761	0.00221	0.00469	0.02761
	M	0.00221	0.00469	0.02761	0.00221	0.00469	0.02761	0.00221	0.00469	0.02761
	L	0.00552	0.01174	0.06904	0.00552	0.01174	0.06904	0.00552	0.01174	0.06904
	H	0.00110	0.00235	0.01381	0.00110	0.00235	0.01381	0.00110	0.00235	0.01381
Thaw Settlement	**S**	0.00110	0.00235	0.01381	0.00110	0.00235	0.01381	0.00110	0.00235	0.01381
	M	0.00110	0.00235	0.01381	0.00110	0.00235	0.01381	0.00110	0.00235	0.01381
	L	0.00276	0.00587	0.03452	0.00276	0.00587	0.03452	0.00276	0.00587	0.03452
	H	0.00055	0.00117	0.00690	0.00055	0.00117	0.00690	0.00055	0.00117	0.00690
Other Arctic	**S**	0.00230	0.01359	0.14636	0.00141	0.01388	0.16466	0.00033	0.00070	0.00414
	M	0.00230	0.01359	0.14636	0.00141	0.01388	0.16466	0.00033	0.00070	0.00414
	L	0.00575	0.03398	0.36590	0.00353	0.03470	0.41164	0.00083	0.00176	0.01036
	H	0.00115	0.00680	0.07318	0.00071	0.00694	0.08233	0.00017	0.00035	0.00207

Table 2.2A
Pipeline Arctic Spills Summary

Pipeline Spill Size	P/L Dia <=10"				P/L Dia >10"			
	Historical Frequency spills per 10^5km-year	Arctic Frequency			Historical Frequency spills per 10^5km-year	Arctic Frequency		
		Shallow	Medium	Deep		Shallow	Medium	Deep
SMALL SPILLS 50-99 bbl	**6.036**	5.472	5.553	4.813	**6.608**	5.925	6.007	5.267
MEDIUM SPILLS 100-999 bbl	**10.563**	9.060	9.144	8.407	**14.867**	12.472	12.558	11.823
LARGE SPILLS 1000-9999 bbl	**5.282**	4.402	4.575	2.707	**8.259**	5.915	6.075	4.203
HUGE SPILLS =>10000 bbl	**0.755**	0.727	0.763	0.390	**3.304**	2.022	2.048	1.671

Table 2.2B
Gouging Calculation

		Depth of cover [m]	Inverse of Scour depth [/m]	Probability	Scour flux [/km-year]	Gauge Orientation [deg]	Number of P/L Failures [per 10^5 km-year]	Small Spills	Medium Spills	Large Spills	Huge Spills
		X	**k**	**Hs**	**F**	**alfa**	**N**	**20%**	**20%**	**50%**	**10%**
Shallow Depth	**MODE**	2.5	5	0.5	4	45	**0.5270**	0.1054	0.1054	0.2635	0.0527
	MIN	3	5	0.5	4	45	**0.0433**	0.0087	0.0087	0.0216	0.0043
	MAX	2	5	0.5	4	45	**6.4205**	1.2841	1.2841	3.2103	0.6421
Medium Depth	**MODE**	2.5	5	0.5	5	45	**0.6588**	0.1318	0.1318	0.3294	0.0659
	MIN	3	5	0.5	5	45	**0.0541**	0.0108	0.0108	0.0270	0.0054
	MAX	2	5	0.5	5	45	**8.0256**	1.6051	1.6051	4.0128	0.8026

N = EXP(-X x k) x Hs x F x sin(alfa)

Table 2.2C
Strudel Scours Calculation

		Number of Critical Scours [per 10^5 year]*	Number Scoures [per 10^5 km-year]	Pipeline Failure Probability	Number of P/L Failures [per 10^5 km-year]	Small Spills	Medium Spills	Large Spills	Huge Spills
						20%	**20%**	**50%**	**10%**
Shallow Depth	**MODE**	**3.40**	1.1736	0.10	0.1174	0.0235	0.0235	0.0587	0.0117
	MIN	**1.60**	0.5523	0.10	0.0552	0.0110	0.0110	0.0276	0.0055
	MAX	**20.00**	6.9037	0.10	0.6904	0.1381	0.1381	0.3452	0.0690

* Reference T5.9, page 120, Analysis of Strudel Scours and Ice Gouges for the Liberty Development Peline (Final Draft)
(Results for for 1.8 mile - Base Case)

Table 2.3
Arctic Spill Distribution and Frequency - P/L - Small Spills

CAUSE CLASSIFICATION	HIST. DISTRIBUTION %	SMALL SPILLS 50-99 bbl																			
		P/L Dia <=10"										P/L Dia >10"									
			Shallow			Medium			Deep				Shallow			Medium			Deep		
		FREQUENCY spills per 10^5km-year	Frequency Change	New Frequency	New Distribution %	Frequency Change	New Frequency	New Distribution %	Frequency Change	New Frequency	New Distribution %	FREQUENCY spills per 10^5km-year	Frequency Change	New Frequency	New Distribution %	Frequency Change	New Frequency	New Distribution %	Frequency Change	New Frequency	New Distribution %
CORROSION	**8.57**	**0.517**	**(0.238)**	**0.280**	**5.11**	**(0.238)**	**0.280**	**5.04**	**(0.238)**	**0.280**	**5.81**	**0.566**	**(0.260)**	**0.306**	**5.17**	**(0.260)**	**0.306**	**5.10**	**(0.260)**	**0.306**	**5.82**
External	2.86	0.172	(0.079)	0.093	1.70	(0.079)	0.093	1.68	(0.079)	0.093	1.94	0.189	(0.087)	0.102	1.72	(0.087)	0.102	1.70	(0.087)	0.102	1.94
Internal	5.71	0.345	(0.158)	0.187	3.41	(0.158)	0.187	3.36	(0.158)	0.187	3.88	0.378	(0.173)	0.204	3.45	(0.173)	0.204	3.40	(0.173)	0.204	3.88
THIRD PARTY IMPACT	**22.86**	**1.380**	**(0.690)**	**0.690**	**12.61**	**(0.693)**	**0.686**	**12.36**	**(0.697)**	**0.683**	**14.19**	**1.510**	**(0.755)**	**0.755**	**12.75**	**(0.759)**	**0.751**	**12.51**	**(0.763)**	**0.747**	**14.19**
Anchor Impact	20.00	1.207	(0.604)	0.604	11.03	(0.604)	0.604	10.87	(0.604)	0.604	12.54	1.322	(0.661)	0.661	11.15	(0.661)	0.661	11.00	(0.661)	0.661	12.55
Jackup Rig or Spud Barge																					
Trawl/Fishing Net	2.86	0.172	(0.086)	0.086	1.58	(0.090)	0.083	1.49	(0.093)	0.079	1.64	0.189	(0.094)	0.094	1.59	(0.098)	0.090	1.51	(0.102)	0.087	1.65
OPERATION IMPACT	**8.57**	**0.517**	**(0.145)**	**0.373**	**6.81**	**(0.145)**	**0.373**	**6.71**	**(0.145)**	**0.373**	**7.74**	**0.566**	**(0.158)**	**0.408**	**6.89**	**(0.158)**	**0.408**	**6.79**	**(0.158)**	**0.408**	**7.75**
Rig Anchoring	2.86	0.172	(0.048)	0.124	2.27	(0.048)	0.124	2.24	(0.048)	0.124	2.58	0.189	(0.053)	0.136	2.30	(0.053)	0.136	2.26	(0.053)	0.136	2.58
Work Boat Anchoring	5.71	0.345	(0.096)	0.249	4.54	(0.096)	0.249	4.47	(0.096)	0.249	5.16	0.378	(0.106)	0.272	4.59	(0.106)	0.272	4.53	(0.106)	0.272	5.17
MECHANICAL	**5.71**	**0.345**		**0.345**	**6.30**		**0.345**	**6.21**		**0.345**	**7.17**	**0.378**		**0.378**	**6.37**		**0.378**	**6.29**		**0.378**	**7.17**
Connection Failure	2.86	0.172		0.172	3.15		0.172	3.11		0.172	3.58	0.189		0.189	3.19		0.189	3.14		0.189	3.58
Material Failure	2.86	0.172		0.172	3.15		0.172	3.11		0.172	3.58	0.189		0.189	3.19		0.189	3.14		0.189	3.58
NATURAL HAZARD	**48.57**	**2.932**	**(0.180)**	**2.752**	**50.30**	**(0.172)**	**2.759**	**49.69**	**(0.165)**	**2.767**	**57.48**	**3.209**	**(0.197)**	**3.013**	**50.85**	**(0.189)**	**3.021**	**50.29**	**(0.181)**	**3.028**	**57.50**
Mud Slide	5.71	0.345	(0.180)	0.165	3.02	(0.172)	0.172	3.11	(0.165)	0.180	3.73	0.378	(0.197)	0.181	3.05	(0.189)	0.189	3.14	(0.181)	0.197	3.73
Storm/ Hurricane	42.86	2.587		2.587	47.28		2.587	46.58		2.587	53.75	2.832		2.832	47.80		2.832	47.14		2.832	53.77
ARCTIC			**0.687**	**0.687**	**12.56**	**0.765**	**0.765**	**13.78**	**0.021**	**0.021**	**0.44**		**0.687**	**0.687**	**11.60**	**0.765**	**0.765**	**12.74**	**0.021**	**0.021**	**0.40**
Ice Gouging			0.5411	0.5411	9.89	0.6763	0.6763	12.18					0.5411	0.5411	9.13	0.6763	0.6763	11.26			
Strudel Scour			0.0645	0.0645	1.18								0.0645	0.0645	1.09						
Upheaval Buckling			0.0129	0.0129	0.24	0.0129	0.0129	0.23	0.0129	0.0129	0.27		0.0129	0.0129	0.22	0.0129	0.0129	0.21	0.0129	0.0129	0.24
Thaw Settlement			0.0065	0.0065	0.12	0.0065	0.0065	0.12	0.0065	0.0065	0.13		0.0065	0.0065	0.11	0.0065	0.0065	0.11	0.0065	0.0065	0.12
Other Arctic			0.0625	0.0625	1.14	0.0696	0.0696	1.25	0.0019	0.0019	0.04		0.0625	0.0625	1.05	0.0696	0.0696	1.16	0.0019	0.0019	0.04
UNKNOWN	**5.71**	**0.345**		**0.345**	**6.30**		**0.345**	**6.21**		**0.345**	**7.17**	**0.378**		**0.378**	**6.37**		**0.378**	**6.29**		**0.378**	**7.17**
TOTALS	**100.00**	**6.036**	**(0.564)**	**5.472**	**100.00**	**(0.483)**	**5.553**	**100.00**	**(1.223)**	**4.813**	**100.00**	**6.608**	**(0.683)**	**5.925**	**100.00**	**(0.601)**	**6.007**	**100.00**	**(1.341)**	**5.267**	**100.00**

Table 2.4
Arctic Spill Distribution and Frequency - P/L - Medium Spills

CAUSE CLASSIFICATION	HIST. DISTRIBUTION %	MEDIUM SPILLS 100-999 bbl																		
		P/L Dia <=10"										P/L Dia >10"								
			Shallow			Medium			Deep				Shallow			Medium			Deep	
		FREQUENCY spills per 10^5km-year	Frequency Change	New Frequency	New Distribution %	Frequency Change	New Frequency	New Distribution %	Frequency Change	New Frequency	New Distribution %	FREQUENCY spills per 10^5km-year	Frequency Change	New Frequency	New Distribution %	Frequency Change	New Frequency	New Distribution %	Frequency Change	New Frequency	New Distribution %
CORROSION	**8.57**	**0.905**	**(0.416)**	**0.490**	**5.41**	**(0.416)**	**0.490**	**5.36**	**(0.416)**	**0.490**	**5.83**	**1.274**	**(0.585)**	**0.689**	**5.53**	**(0.585)**	**0.689**	**5.49**	**(0.585)**	**0.689**	**5.83**
External	2.86	0.302	(0.139)	0.163	1.80	(0.139)	0.163	1.79	(0.139)	0.163	1.94	0.425	(0.195)	0.230	1.84	(0.195)	0.230	1.83	(0.195)	0.230	1.94
Internal	5.71	0.604	(0.277)	0.327	3.60	(0.277)	0.327	3.57	(0.277)	0.327	3.88	0.850	(0.390)	0.460	3.68	(0.390)	0.460	3.66	(0.390)	0.460	3.89
THIRD PARTY IMPACT	**22.86**	**2.414**	**(1.207)**	**1.207**	**13.32**	**(1.213)**	**1.201**	**13.13**	**(1.220)**	**1.195**	**14.21**	**3.398**	**(1.699)**	**1.699**	**13.62**	**(1.708)**	**1.690**	**13.46**	**(1.716)**	**1.682**	**14.22**
Anchor Impact	20.00	2.113	(1.056)	1.056	11.66	(1.056)	1.056	11.55	(1.056)	1.056	12.56	2.973	(1.487)	1.487	11.92	(1.487)	1.487	11.84	(1.487)	1.487	12.57
Jackup Rig or Spud Barge																					
Trawl/Fishing Net	2.86	0.302	(0.151)	0.151	1.67	(0.157)	0.145	1.58	(0.163)	0.139	1.65	0.425	(0.212)	0.212	1.70	(0.221)	0.204	1.62	(0.230)	0.195	1.65
OPERATION IMPACT	**8.57**	**0.905**	**(0.253)**	**0.652**	**7.20**	**(0.253)**	**0.652**	**7.13**	**(0.253)**	**0.652**	**7.76**	**1.274**	**(0.356)**	**0.918**	**7.36**	**(0.356)**	**0.918**	**7.31**	**(0.356)**	**0.918**	**7.77**
Rig Anchoring	2.86	0.302	(0.084)	0.217	2.40	(0.084)	0.217	2.38	(0.084)	0.217	2.59	0.425	(0.119)	0.306	2.45	(0.119)	0.306	2.44	(0.119)	0.306	2.59
Work Boat Anchoring	5.71	0.604	(0.169)	0.435	4.80	(0.169)	0.435	4.76	(0.169)	0.435	5.17	0.850	(0.237)	0.612	4.91	(0.237)	0.612	4.87	(0.237)	0.612	5.18
MECHANICAL	**5.71**	**0.604**		**0.604**	**6.66**		**0.604**	**6.60**		**0.604**	**7.18**	**0.850**		**0.850**	**6.81**		**0.850**	**6.76**		**0.850**	**7.19**
Connection Failure	2.86	0.302		0.302	3.33		0.302	3.30		0.302	3.59	0.425		0.425	3.41		0.425	3.38		0.425	3.59
Material Failure	2.86	0.302		0.302	3.33		0.302	3.30		0.302	3.59	0.425		0.425	3.41		0.425	3.38		0.425	3.59
NATURAL HAZARD	**48.57**	**5.131**	**(0.314)**	**4.816**	**53.16**	**(0.302)**	**4.829**	**52.81**	**(0.289)**	**4.841**	**57.59**	**7.221**	**(0.442)**	**6.779**	**54.35**	**(0.425)**	**6.796**	**54.12**	**(0.407)**	**6.814**	**57.63**
Mud Slide	5.71	0.604	(0.314)	0.289	3.19	(0.302)	0.302	3.30	(0.289)	0.314	3.74	0.850	(0.442)	0.407	3.26	(0.425)	0.425	3.38	(0.407)	0.442	3.74
Storm/ Hurricane	42.86	4.527		4.527	49.97		4.527	49.51		4.527	53.85	6.372		6.372	51.09		6.372	50.74		6.372	53.89
ARCTIC			**0.687**	**0.687**	**7.59**	**0.765**	**0.765**	**8.37**	**0.021**	**0.021**	**0.25**		**0.687**	**0.687**	**5.51**	**0.765**	**0.765**	**6.09**	**0.021**	**0.021**	**0.18**
Ice Gouging			0.5411	0.5411	5.97	0.6763	0.6763	7.40					0.5411	0.5411	4.34	0.6763	0.6763	5.39			
Strudel Scour			0.0645	0.0645	0.71								0.0645	0.0645	0.52						
Upheaval Buckling			0.0129	0.0129	0.14	0.0129	0.0129	0.14	0.0129	0.0129	0.15		0.0129	0.0129	0.10	0.0129	0.0129	0.10	0.0129	0.0129	0.11
Thaw Settlement			0.0065	0.0065	0.07	0.0065	0.0065	0.07	0.0065	0.0065	0.08		0.0065	0.0065	0.05	0.0065	0.0065	0.05	0.0065	0.0065	0.05
Other Arctic			0.0625	0.0625	0.69	0.0696	0.0696	0.76	0.0019	0.0019	0.02		0.0625	0.0625	0.50	0.0696	0.0696	0.55	0.0019	0.0019	0.02
UNKNOWN	**5.71**	**0.604**		**0.604**	**6.66**		**0.604**	**6.60**		**0.604**	**7.18**	**0.850**		**0.850**	**6.81**		**0.850**	**6.76**		**0.850**	**7.19**
TOTALS	**100.00**	**10.563**	**(1.503)**	**9.060**	**100.00**	**(1.419)**	**9.144**	**100.00**	**(2.156)**	**8.407**	**100.00**	**14.867**	**(2.395)**	**12.472**	**100.00**	**(2.309)**	**12.558**	**100.00**	**(3.044)**	**11.823**	**100.00**

Table 2.5
Arctic Spill Distribution and Frequency - P/L - Large Spills

CAUSE CLASSIFICATION	HIST. DISTRIBUTION %	LARGE SPILLS 1000-9999 bbl																			
		P/L Dia <=10"										P/L Dia >10"									
			Shallow			Medium			Deep				Shallow			Medium			Deep		
		FREQUENCY spills per 10^5km-year	Frequency Change	New Frequency	New Distribution %	Frequency Change	New Frequency	New Distribution %	Frequency Change	New Frequency	New Distribution %	FREQUENCY spills per 10^5km-year	Frequency Change	New Frequency	New Distribution %	Frequency Change	New Frequency	New Distribution %	Frequency Change	New Frequency	New Distribution %
CORROSION	**6.67**	**0.352**	**(0.162)**	**0.190**	**4.33**	**(0.162)**	**0.190**	**4.16**	**(0.162)**	**0.190**	**7.04**	**0.551**	**(0.253)**	**0.298**	**5.04**	**(0.253)**	**0.298**	**4.90**	**(0.253)**	**0.298**	**7.09**
External																					
Internal	6.67	0.352	(0.162)	0.190	4.33	(0.162)	0.190	4.16	(0.162)	0.190	7.04	0.551	(0.253)	0.298	5.04	(0.253)	0.298	4.90	(0.253)	0.298	7.09
THIRD PARTY IMPACT	**66.67**	**3.521**	**(1.761)**	**1.761**	**39.99**	**(1.790)**	**1.731**	**37.85**	**(1.818)**	**1.703**	**62.91**	**5.506**	**(2.753)**	**2.753**	**46.54**	**(2.799)**	**2.707**	**44.56**	**(2.843)**	**2.663**	**63.36**
Anchor Impact	33.33	1.761	(0.880)	0.880	20.00	(0.880)	0.880	19.24	(0.880)	0.880	32.52	2.753	(1.377)	1.377	23.27	(1.377)	1.377	22.66	(1.377)	1.377	32.75
Jackup Rig or Spud Barge	6.67	0.352	(0.176)	0.176	4.00	(0.176)	0.176	3.85	(0.176)	0.176	6.50	0.551	(0.275)	0.275	4.65	(0.275)	0.275	4.53	(0.275)	0.275	6.55
Trawl/Fishing Net	26.67	1.408	(0.704)	0.704	16.00	(0.733)	0.675	14.76	(0.762)	0.647	23.89	2.203	(1.101)	1.101	18.62	(1.147)	1.056	17.37	(1.191)	1.011	24.06
OPERATION IMPACT	**6.67**	**0.352**	**(0.098)**	**0.254**	**5.76**	**(0.098)**	**0.254**	**5.55**	**(0.098)**	**0.254**	**9.37**	**0.551**	**(0.154)**	**0.397**	**6.71**	**(0.154)**	**0.397**	**6.53**	**(0.154)**	**0.397**	**9.44**
Rig Anchoring																					
Work Boat Anchoring	6.67	0.352	(0.098)	0.254	5.76	(0.098)	0.254	5.55	(0.098)	0.254	9.37	0.551	(0.154)	0.397	6.71	(0.154)	0.397	6.53	(0.154)	0.397	9.44
MECHANICAL																					
Connection Failure																					
Material Failure																					
NATURAL HAZARD	**20.00**	**1.056**	**(0.577)**	**0.479**	**10.88**	**(0.570)**	**0.486**	**10.63**	**(0.550)**	**0.507**	**18.72**	**1.652**	**(0.903)**	**0.749**	**12.66**	**(0.892)**	**0.760**	**12.51**	**(0.860)**	**0.792**	**18.85**
Mud Slide	6.67	0.352	(0.183)	0.169	3.83	(0.176)	0.176	3.85	(0.169)	0.183	6.77	0.551	(0.287)	0.264	4.46	(0.275)	0.275	4.53	(0.264)	0.287	6.82
Storm/ Hurricane	13.33	0.704	(0.394)	0.310	7.04	(0.394)	0.310	6.78	(0.381)	0.323	11.94	1.101	(0.616)	0.485	8.20	(0.616)	0.485	7.98	(0.596)	0.506	12.03
ARCTIC			**1.719**	**1.719**	**39.04**	**1.913**	**1.913**	**41.82**	**0.053**	**0.053**	**1.97**		**1.719**	**1.719**	**29.05**	**1.913**	**1.913**	**31.49**	**0.053**	**0.053**	**1.27**
Ice Gouging			1.3527	1.3527	30.73	1.6908	1.6908	36.96					1.3527	1.3527	22.87	1.6908	1.6908	27.83			
Strudel Scour			0.1613	0.1613	3.66								0.1613	0.1613	2.73						
Upheaval Buckling			0.0323	0.0323	0.73	0.0323	0.0323	0.71	0.0323	0.0323	1.19		0.0323	0.0323	0.55	0.0323	0.0323	0.53	0.0323	0.0323	0.77
Thaw Settlement			0.0161	0.0161	0.37	0.0161	0.0161	0.35	0.0161	0.0161	0.60		0.0161	0.0161	0.27	0.0161	0.0161	0.27	0.0161	0.0161	0.38
Other Arctic			0.1562	0.1562	3.55	0.1739	0.1739	3.80	0.0048	0.0048	0.18		0.1562	0.1562	2.64	0.1739	0.1739	2.86	0.0048	0.0048	0.12
UNKNOWN																					
TOTALS	**100.00**	**5.282**	**(0.880)**	**4.402**	**100.00**	**(0.707)**	**4.575**	**100.00**	**(2.575)**	**2.707**	**100.00**	**8.259**	**(2.344)**	**5.915**	**100.00**	**(2.184)**	**6.075**	**100.00**	**(4.056)**	**4.203**	**100.00**

Table 2.6
Arctic Spill Distribution and Frequency - P/L - Huge Spills

CAUSE CLASSIFICATION	HIST. DISTRIBUTION %	HUGE SPILLS =>10000 bbl																			
		P/L Dia <=10"										P/L Dia >10"									
			Shallow			Medium			Deep				Shallow			Medium			Deep		
		FREQUENCY spills per 10^5km-year	Frequency Change	New Frequency	New Distribution %	Frequency Change	New Frequency	New Distribution %	Frequency Change	New Frequency	New Distribution %	FREQUENCY spills per 10^5km-year	Frequency Change	New Frequency	New Distribution %	Frequency Change	New Frequency	New Distribution %	Frequency Change	New Frequency	New Distribution %
CORROSION	**6.67**	**0.050**	**(0.023)**	**0.027**	**3.74**	**(0.023)**	**0.027**	**3.57**	**(0.023)**	**0.027**	**6.98**	**0.220**	**(0.101)**	**0.119**	**5.89**	**(0.101)**	**0.119**	**5.82**	**(0.101)**	**0.119**	**7.13**
External																					
Internal	6.67	0.050	(0.023)	0.027	3.74	(0.023)	0.027	3.57	(0.023)	0.027	6.98	0.220	(0.101)	0.119	5.89	(0.101)	0.119	5.82	(0.101)	0.119	7.13
THIRD PARTY IMPACT	**66.67**	**0.503**	**(0.252)**	**0.252**	**34.59**	**(0.256)**	**0.247**	**32.42**	**(0.260)**	**0.243**	**62.42**	**2.203**	**(1.101)**	**1.101**	**54.45**	**(1.120)**	**1.083**	**52.89**	**(1.137)**	**1.065**	**63.76**
Anchor Impact	33.33	0.252	(0.126)	0.126	17.30	(0.126)	0.126	16.48	(0.126)	0.126	32.27	1.101	(0.551)	0.551	27.23	(0.551)	0.551	26.89	(0.551)	0.551	32.96
Jackup Rig or Spud Barge	6.67	0.050	(0.025)	0.025	3.46	(0.025)	0.025	3.30	(0.025)	0.025	6.45	0.220	(0.110)	0.110	5.45	(0.110)	0.110	5.38	(0.110)	0.110	6.59
Trawl/Fishing Net	26.67	0.201	(0.101)	0.101	13.84	(0.105)	0.096	12.64	(0.109)	0.092	23.70	0.881	(0.441)	0.441	21.78	(0.459)	0.422	20.62	(0.477)	0.404	24.21
OPERATION IMPACT	**6.67**	**0.050**	**(0.014)**	**0.036**	**4.98**	**(0.014)**	**0.036**	**4.75**	**(0.014)**	**0.036**	**9.30**	**0.220**	**(0.062)**	**0.159**	**7.85**	**(0.062)**	**0.159**	**7.75**	**(0.062)**	**0.159**	**9.50**
Rig Anchoring																					
Work Boat Anchoring	6.67	0.050	(0.014)	0.036	4.98	(0.014)	0.036	4.75	(0.014)	0.036	9.30	0.220	(0.062)	0.159	7.85	(0.062)	0.159	7.75	(0.062)	0.159	9.50
MECHANICAL																					
Connection Failure																					
Material Failure																					
NATURAL HAZARD	**20.00**	**0.151**	**(0.082)**	**0.068**	**9.41**	**(0.081)**	**0.069**	**9.10**	**(0.079)**	**0.072**	**18.57**	**0.661**	**(0.361)**	**0.300**	**14.81**	**(0.357)**	**0.304**	**14.85**	**(0.344)**	**0.317**	**18.97**
Mud Slide	6.67	0.050	(0.026)	0.024	3.32	(0.025)	0.025	3.30	(0.024)	0.026	6.72	0.220	(0.115)	0.106	5.22	(0.110)	0.110	5.38	(0.106)	0.115	6.87
Storm/ Hurricane	13.33	0.101	(0.056)	0.044	6.09	(0.056)	0.044	5.81	(0.054)	0.046	11.85	0.441	(0.247)	0.194	9.59	(0.247)	0.194	9.47	(0.238)	0.202	12.10
ARCTIC			**0.344**	**0.344**	**47.27**	**0.383**	**0.383**	**50.16**	**0.011**	**0.011**	**2.73**		**0.344**	**0.344**	**17.00**	**0.383**	**0.383**	**18.69**	**0.011**	**0.011**	**0.64**
Ice Gouging			0.2705	0.2705	37.21	0.3382	0.3382	44.33					0.2705	0.2705	13.38	0.3382	0.3382	16.52			
Strudel Scour			0.0323	0.0323	4.44								0.0323	0.0323	1.59						
Upheaval Buckling			0.0065	0.0065	0.89	0.0065	0.0065	0.85	0.0065	0.0065	1.66		0.0065	0.0065	0.32	0.0065	0.0065	0.32	0.0065	0.0065	0.39
Thaw Settlement			0.0032	0.0032	0.44	0.0032	0.0032	0.42	0.0032	0.0032	0.83		0.0032	0.0032	0.16	0.0032	0.0032	0.16	0.0032	0.0032	0.19
Other Arctic			0.0312	0.0312	4.30	0.0348	0.0348	4.56	0.0010	0.0010	0.25		0.0312	0.0312	1.55	0.0348	0.0348	1.70	0.0010	0.0010	0.06
UNKNOWN																					
TOTALS	**100.00**	**0.755**	**(0.027)**	**0.727**	**100.00**	**0.008**	**0.763**	**100.00**	**(0.365)**	**0.390**	**100.00**	**3.304**	**(1.281)**	**2.022**	**100.00**	**(1.256)**	**2.048**	**100.00**	**(1.633)**	**1.671**	**100.00**

Table 2.7
FTA Input Rationalization - Platforms

CAUSE CLASSIFICATION	Spill Size	Historical Expected Frequency Change %			Reason
		Shallow	Medium	Deep	
EQUIPMENT FAILURE	**All**				
Process Equipment	**All**	(30)	(30)	(30)	State of the art now, High QC, High Inspection and Maintenance Requirements
Transfer Hose	**All**	(30)	(30)	(30)	State of the art now, High QC, High Inspection and Maintenance Requirements
Incorrect Operation	**All**	(30)	(30)	(30)	State of the art now, High QC, High Inspection and Maintenance Requirements
HUMAN ERROR	**All**	(20)	(20)	(20)	More qualified personnel - training, education, but colder
TANK FAILURE	**All**	(30)	(30)	(30)	State of the art now, High QC, High Inspection and Maintenance Requirements
SHIP COLLISION	**All**	(50)	(50)	(50)	Very low traffic density.
WEATHER	**All**	20	20	20	Cold Teperatures, cycling
HURRICANE	**All**	(80)	(80)	(70)	Less severe storms. More intensity in deep water.
OTHER	**All**				
		Freq. Increment per 10^4 well-year			
		Expected	**Expected**	**Expected**	
		Mode	**Mode**	**Mode**	
ARCTIC					
Ice Force	**SM**	0.1447	0.2170	0.3256	Assumed 10,000 year return period ice force causes spill 4% of occurences (96% reliability). 85% of the spills are SM.
		0.0340	0.0510	0.0765	
	LH	0.0255	0.0383	0.0575	
		0.0060	0.0090	0.0135	
Facility Low Temperature	**SM**	0.0986	0.0986	0.0986	Assumed fraction of Historical Equipment Failure release frequency with 6% for SM anfd 1% for LH spill sizes.
		0.0986	0.0986	0.0986	
	LH	0.0164	0.0164	0.0164	
		0.0164	0.0164	0.0164	
Other Arctic	**SM**	0.0242	0.0315	0.0423	10% of sum of above.
		0.0133	0.0150	0.0175	
	LH	0.0042	0.0055	0.0074	
		0.0022	0.0025	0.0030	

Table 2.8
Monte Carlo Input - Platforms

CAUSE CLASSIFICATION	Spill Size	Shallow			Medium			Deep		
		Frequency Change %								
		Min	Mode	Max	Min	Mode	Max	Min	Mode	Max
EQUIPMENT FAILURE	**All**									
Process Equipment	**All**	(60)	(30)	(10)	(60)	(30)	(10)	(60)	(30)	(10)
Transfer Hose	**All**	(60)	(30)	(10)	(60)	(30)	(10)	(60)	(30)	(10)
Incorrect Operation	**All**	(60)	(30)	(10)	(60)	(30)	(10)	(60)	(30)	(10)
HUMAN ERROR	**All**	(60)	(20)	(10)	(60)	(20)	(10)	(60)	(20)	(10)
TANK FAILURE	**All**	(60)	(30)	(10)	(60)	(30)	(10)	(60)	(30)	(10)
SHIP COLLISION	**All**	(60)	(50)	(10)	(60)	(50)	(10)	(60)	(50)	(10)
WEATHER	**All**	10	20	30	10	20	30	10	20	30
HURRICANE	**All**	(90)	(80)	(10)	(90)	(80)	(10)	(90)	(70)	(10)
OTHER	**All**									
		Frequency Increment per 10^4 well-year								
ARCTIC										
Ice Force	**SM**	0.003	0.034	0.340	0.005	0.051	0.510	0.008	0.077	0.765
	LH	0.001	0.006	0.060	0.001	0.009	0.090	0.001	0.014	0.135
Facility Low Temperature	**SM**	0.049	0.099	0.148	0.049	0.099	0.148	0.049	0.099	0.148
	LH	0.008	0.016	0.025	0.008	0.016	0.025	0.008	0.016	0.025
Other Arctic	**SM**	0.005	0.013	0.049	0.005	0.015	0.066	0.006	0.018	0.091
	LH	0.001	0.002	0.008	0.001	0.003	0.011	0.001	0.003	0.016

Table 2.8A
Platforms Arctic Spill Summary

Platform Spill Size	Historical Frequency spills per 10^4km-year	Arctic Frequency		
		Shallow	Medium	Deep
SMALL AND MEDIUM SPILLS 50-999 bbl	**4.601**	3.053	3.686	3.809
LARGE AND HUGE SPILLS =>1000 bbl	**0.481**	0.390	0.404	0.429

Table 2.9
Arctic Spill Distribution and Frequency - Platforms - Small and Medium Spills

CAUSE CLASSIFICATION	HIST. DISTRIBUTION %	SMALL AND MEDIUM SPILLS 50-999 bbl									
		FREQUENCY spills per 10^4 well-year	Shallow			Medium			Deep		
			Frequency Change	New Frequency	New Distribution %	Frequency Change	New Frequency	New Distribution %	Frequency Change	New Frequency	New Distribution %
EQUIPMENT FAILURE	52.24	2.403	(0.816)	1.587	51.98	(0.816)	1.587	43.06	(0.816)	1.587	41.67
Process Equipment	20.90	0.961	(0.327)	0.635	20.79	(0.327)	0.635	17.23	(0.327)	0.635	16.67
Transfer Hose	17.91	0.824	(0.280)	0.544	17.82	(0.280)	0.544	14.76	(0.280)	0.544	14.29
Incorrect Operation	13.43	0.618	(0.210)	0.408	13.37	(0.210)	0.408	11.07	(0.210)	0.408	10.72
HUMAN ERROR	17.91	0.824	(0.816)	0.008	0.25	(0.263)	0.561	15.21	(0.263)	0.561	14.72
TANK FAILURE	2.99	0.137	(0.047)	0.091	2.97	(0.047)	0.091	2.46	(0.047)	0.091	2.38
SHIP COLLISION	7.46	0.343	(0.131)	0.213	6.97	(0.131)	0.213	5.77	(0.131)	0.213	5.58
WEATHER	11.94	0.549	0.110	0.659	21.59	0.110	0.659	17.89	0.110	0.659	17.31
HURRICANE	4.48	0.206	(0.115)	0.091	2.97	(0.115)	0.091	2.46	(0.111)	0.095	2.48
OTHER	2.99	0.137		0.137	4.50		0.137	3.73		0.137	3.61
ARCTIC			0.268	0.268	8.76	0.347	0.347	9.42	0.466	0.466	12.25
Ice Force			0.145	0.145	4.74	0.217	0.217	5.89	0.326	0.326	8.55
Facility Low Temperature			0.099	0.099	3.23	0.099	0.099	2.68	0.099	0.099	2.59
Other Arctic			0.024	0.024	0.79	0.031	0.031	0.85	0.042	0.042	1.11
TOTALS	100.00	4.601	(1.548)	3.053	100.00	(0.915)	3.686	100.00	(0.792)	3.809	100.00

Table 2.10
Arctic Spill Distribution and Frequency - Platforms - Large and Huge Spills

CAUSE CLASSIFICATION	HIST. DISTRIBUTION %	LARGE AND HUGE SPILLS =>1000 bbl									
			Shallow			Medium			Deep		
		FREQUENCY spills per 10^4well-year	Frequency Change	New Frequency	New Distribution %	Frequency Change	New Frequency	New Distribution %	Frequency Change	New Frequency	New Distribution %
EQUIPMENT FAILURE											
Process Equipment											
Transfer Hose											
Incorrect Operation											
HUMAN ERROR											
TANK FAILURE	**14.29**	**0.069**	**(0.023)**	**0.045**	**11.64**	**(0.023)**	**0.045**	**11.24**	**(0.023)**	**0.045**	**10.58**
SHIP COLLISION	**14.29**	**0.069**	**(0.026)**	**0.043**	**10.92**	**(0.026)**	**0.043**	**10.54**	**(0.026)**	**0.043**	**9.93**
WEATHER	**28.57**	**0.137**	**0.027**	**0.165**	**42.31**	**0.027**	**0.165**	**40.83**	**0.027**	**0.165**	**38.46**
HURRICANE	**42.86**	**0.206**	**(0.115)**	**0.091**	**23.29**	**(0.115)**	**0.091**	**22.48**	**(0.111)**	**0.095**	**22.07**
OTHER											
ARCTIC			**0.046**	**0.046**	**11.85**	**0.060**	**0.060**	**14.91**	**0.081**	**0.081**	**18.96**
Ice Force			0.026	0.026	6.55	0.038	0.038	9.49	0.057	0.057	13.41
Facility Low Temperature			0.016	0.016	4.22	0.016	0.016	4.07	0.016	0.016	3.84
Other Arctic			0.004	0.004	1.07	0.005	0.005	1.35	0.007	0.007	1.72
TOTALS	**100.00**	**0.481**	**(0.091)**	**0.390**	**100.00**	**(0.077)**	**0.404**	**100.00**	**(0.052)**	**0.429**	**100.00**

Table 2.11
Monte Carlo Input - Wells

EVENT	FREQUENCY UNIT	Historical Expected Frequency Change %			Reason
		Shallow	Medium	Deep	
		Small and Medium Spills 50-999 bbl			
PRODUCTION WELL	spill per 10^4 well-year	(30)	(30)	(30)	State of the art now, High QC, High Inspection and Maintenance Requirements
EXPLORATION WELL DRILLING	spill per 10^4 wells	(30)	(20)	(10)	Highly qualified drilling contractor. Better logistics support in shallow water.
DEVELOPMENT WELL DRILLING	spill per 10^4 wells	(30)	(20)	(10)	Highly qualified drilling contractor. Better logistics support in shallow water.
		Large Spills 1000-9999 bbl			
PRODUCTION WELL	spill per 10^4 well-year	(30)	(30)	(30)	
EXPLORATION WELL DRILLING	spill per 10^4 wells	(30)	(20)	(10)	
DEVELOPMENT WELL DRILLING	spill per 10^4 wells	(30)	(20)	(10)	
		Spill 10000-149999 bbl			
PRODUCTION WELL	spill per 10^4 well-year	(30)	(30)	(30)	
EXPLORATION WELL DRILLING	spill per 10^4 wells	(30)	(20)	(10)	
DEVELOPMENT WELL DRILLING	spill per 10^4 wells	(30)	(20)	(10)	
		Spill >=150000 bbl			
PRODUCTION WELL	spill per 10^4 well-year	(30)	(30)	(30)	
EXPLORATION WELL DRILLING	spill per 10^4 wells	(30)	(20)	(10)	
DEVELOPMENT WELL DRILLING	spill per 10^4 wells	(30)	(20)	(10)	

Table 2.12
Arctic Spill Distribution and Frequency - Wells

EVENT	FREQUENCY UNIT	HISTORICAL FREQUENCY	Shallow		Medium		Deep	
			Frequency Change	New Frequency	Frequency Change	New Frequency	Frequency Change	New Frequency
		Small and Medium Spills 50-999 bbl						
PRODUCTION WELL	spill per 10^4 well-year	0.147	-0.044	0.103	-0.044	0.103	-0.044	0.103
EXPLORATION WELL DRILLING	spill per 10^4 wells	2.262	-0.678	1.583	-0.452	1.809	-0.226	2.035
DEVELOPMENT WELL DRILLING	spill per 10^4 wells	0.692	-0.208	0.484	-0.138	0.554	-0.069	0.623
		Large Spills 1000-9999 bbl						
PRODUCTION WELL	spill per 10^4 well-year	1.026	-0.308	0.718	-0.308	0.718	-0.308	0.718
EXPLORATION WELL DRILLING	spill per 10^4 wells	15.824	-4.747	11.077	-3.165	12.659	-1.582	14.242
DEVELOPMENT WELL DRILLING	spill per 10^4 wells	4.833	-1.450	3.383	-0.967	3.867	-0.483	4.350
		Spills 10000-149999 bbl						
PRODUCTION WELL	spill per 10^4 well-year	0.440	-0.132	0.308	-0.132	0.308	-0.132	0.308
EXPLORATION WELL DRILLING	spill per 10^4 wells	6.799	-2.040	4.759	-1.360	5.439	-0.680	6.119
DEVELOPMENT WELL DRILLING	spill per 10^4 wells	2.076	-0.623	1.453	-0.415	1.661	-0.208	1.868
		Spills >=150000 bbl						
PRODUCTION WELL	spill per 10^4 well-year	0.293	-0.088	0.205	-0.088	0.205	-0.088	0.205
EXPLORATION WELL DRILLING	spill per 10^4 wells	3.936	-1.181	2.755	-0.787	3.149	-0.394	3.543
DEVELOPMENT WELL DRILLING	spill per 10^4 wells	2.076	-0.623	1.453	-0.415	1.661	-0.208	1.868

Table 2.13
Spill Volume Distributions

	PIPELINE SPILL VOLUMES															
Spill Size	Small Spills 50-99 bbl				Medium Spills 100-999 bbl				Large Spills 1000-9999 bbl				Huge Spills =>10000 bbl			
Spill Expectation	Low	Mode	High	Expected	Low	Mode	High	Expected	Low	Mode	High	Expected	Low	Mode	High	Expected
P/L Dia <10" Spill	50	58	99	71	100	226	999	485	1000	4436	9999	5279	10000	14423	20000	14880
P/L Dia > 10" Spill	50	58	99	71	100	387	999	516	1000	3932	9999	5176	10000	17705	20000	15552

	PLATFORM SPILL VOLUMES							
Spill Size	Small and Medium Spills 50-999 bbl				Large and Huge Spills =>1000 bbl			
Spill Expectation	Low	Mode	High	Expected	Low	Mode	High	Expected
Platform Spill	50	158	999	452	1000	6130	10000	5631

	WELL SPILL VOLUMES															
Spill Size	Small and Medium Spills 50-999 bbl				Large Spills 1000-9999 bbl				Spills 10000-149999 bbl				Spills =>150000 bbl			
Spill Expectation	Low	Mode	High	Expected	Low	Mode	High	Expected	Low	Mode	High	Expected	Low	Mode	High	Expected
Well Spill	50	500	999	519	1000	4500	9999	5292	10000	20000	150000	68349	150000	200000	250000	200000

Pipeline Small Spill 50-99 bbl

Note : All Values per 100000 km-year

	Dia<=10"	Dia>10"	P/L Size
H	6.036	6.608	Historical Frequency
S	5.472	5.925	Shallow Water Depth Frequency
M	5.553	6.007	Medium Water Depth Frequency
D	4.813	5.267	Deep Water Depth Frequency

CORROSION

	Dia<=10"	Dia>10"
H	0.517	0.566
S	0.280	0.306
M	0.280	0.306
D	0.280	0.306

External

	Dia<=10"	Dia>10"
H	0.172	0.189
S	0.093	0.102
M	0.093	0.102
D	0.093	0.102

Internal

	Dia<=10"	Dia>10"
H	0.345	0.378
S	0.187	0.204
M	0.187	0.204
D	0.187	0.204

THIRD PARTY IMPACT

	Dia<=10"	Dia>10"
H	1.380	1.510
S	0.690	0.755
M	0.686	0.751
D	0.683	0.747

Anchor Impact

	Dia<=10"	Dia>10"
H	1.207	1.322
S	0.604	0.661
M	0.604	0.661
D	0.604	0.661

Jackup Rig or Spud Barge

	Dia<=10"	Dia>10"
H	0.000	0.000
S	0.000	0.000
M	0.000	0.000
D	0.000	0.000

Trawl/Fishing Net

	Dia<=10"	Dia>10"
H	0.172	0.189
S	0.086	0.094
M	0.083	0.090
D	0.079	0.087

OPERATION IMPACT

	Dia<=10"	Dia>10"
H	0.517	0.566
S	0.373	0.408
M	0.373	0.408
D	0.373	0.408

Rig Anchoring

	Dia<=10"	Dia>10"
H	0.172	0.189
S	0.124	0.136
M	0.124	0.136
D	0.124	0.136

Work Boat Anchoring

	Dia<=10"	Dia>10"
H	0.345	0.378
S	0.249	0.272
M	0.249	0.272
D	0.249	0.272

MECHANICAL

	Dia<=10"	Dia>10"
H	0.345	0.378
S	0.345	0.378
M	0.345	0.378
D	0.345	0.378

Connection Failure

	Dia<=10"	Dia>10"
H	0.172	0.189
S	0.172	0.189
M	0.172	0.189
D	0.172	0.189

Material Failure

	Dia<=10"	Dia>10"
H	0.172	0.189
S	0.172	0.189
M	0.172	0.189
D	0.172	0.189

NATURAL HAZARD

	Dia<=10"	Dia>10"
H	2.932	3.209
S	2.752	3.013
M	2.759	3.021
D	2.767	3.028

Mud Slide

	Dia<=10"	Dia>10"
H	0.345	0.378
S	0.165	0.181
M	0.172	0.189
D	0.180	0.197

Storm/ Hurricane

	Dia<=10"	Dia>10"
H	2.587	2.832
S	2.587	2.832
M	2.587	2.832
D	2.587	2.832

UNKNOWN

	Dia<=10"	Dia>10"
H	0.345	0.378
S	0.345	0.378
M	0.345	0.378
D	0.345	0.378

ARCTIC

	Dia<=10"	Dia>10"
H	0.000	0.000
S	0.687	0.687
M	0.765	0.765
D	0.021	0.021

Ice Gouging

	Dia<=10"	Dia>10"
H	0.000	0.000
S	0.541	0.541
M	0.676	0.676
D	0.000	0.000

Strudel Scour

	Dia<=10"	Dia>10"
H	0.000	0.000
S	0.065	0.065
M	0.000	0.000
D	0.000	0.000

Upheaval Buckling

	Dia<=10"	Dia>10"
H	0.000	0.000
S	0.013	0.013
M	0.013	0.013
D	0.013	0.013

Thaw Settlement

	Dia<=10"	Dia>10"
H	0.000	0.000
S	0.006	0.006
M	0.006	0.006
D	0.006	0.006

Other Arctic

	Dia<=10"	Dia>10"
H	0.000	0.000
S	0.062	0.062
M	0.070	0.070
D	0.002	0.002

Figure 2.1 Fault Tree - Pipeline - Small Spills

Note : All Values per 100000 km-year

Pipeline Medium Spill 100 - 999 bbl

	Dia<=10"	Dia>10"	P/L Size
H	10.563	14.867	Historical Frequency
S	9.060	12.472	Shallow Water Depth Frequency
M	9.144	12.558	Medium Water Depth Frequency
D	8.407	11.823	Deep Water Depth Frequency

CORROSION

	Dia<=10"	Dia>10"
H	0.905	1.274
S	0.490	0.689
M	0.490	0.689
D	0.490	0.689

External

	Dia<=10"	Dia>10"
H	0.302	0.425
S	0.163	0.230
M	0.163	0.230
D	0.163	0.230

Internal

	Dia<=10"	Dia>10"
H	0.604	0.850
S	0.327	0.460
M	0.327	0.460
D	0.327	0.460

THIRD PARTY IMPACT

	Dia<=10"	Dia>10"
H	2.414	3.398
S	1.207	1.699
M	1.201	1.690
D	1.195	1.682

Anchor Impact

	Dia<=10"	Dia>10"
H	2.113	2.973
S	1.056	1.487
M	1.056	1.487
D	1.056	1.487

Jackup Rig or Spud Barge

	Dia<=10"	Dia>10"
H	0.000	0.000
S	0.000	0.000
M	0.000	0.000
D	0.000	0.000

Trawl/Fishing Net

	Dia<=10"	Dia>10"
H	0.302	0.425
S	0.151	0.212
M	0.145	0.204
D	0.139	0.195

OPERATION IMPACT

	Dia<=10"	Dia>10"
H	0.905	1.274
S	0.652	0.918
M	0.652	0.918
D	0.652	0.918

Rig Anchoring

	Dia<=10"	Dia>10"
H	0.302	0.425
S	0.217	0.306
M	0.217	0.306
D	0.217	0.306

Work Boat Anchoring

	Dia<=10"	Dia>10"
H	0.604	0.850
S	0.435	0.612
M	0.435	0.612
D	0.435	0.612

MECHANICAL

	Dia<=10"	Dia>10"
H	0.604	0.850
S	0.604	0.850
M	0.604	0.850
D	0.604	0.850

Connection Failure

	Dia<=10"	Dia>10"
H	0.302	0.425
S	0.302	0.425
M	0.302	0.425
D	0.302	0.425

Material Failure

	Dia<=10"	Dia>10"
H	0.302	0.425
S	0.302	0.425
M	0.302	0.425
D	0.302	0.425

NATURAL HAZARD

	Dia<=10"	Dia>10"
H	5.131	7.221
S	4.816	6.779
M	4.829	6.796
D	4.841	6.814

Mud Slide

	Dia<=10"	Dia>10"
H	0.604	0.850
S	0.289	0.407
M	0.302	0.425
D	0.314	0.442

Storm/ Hurricane

	Dia<=10"	Dia>10"
H	4.527	6.372
S	4.527	6.372
M	4.527	6.372
D	4.527	6.372

UNKNOWN

	Dia<=10"	Dia>10"
H	0.604	0.850
S	0.604	0.850
M	0.604	0.850
D	0.604	0.850

ARCTIC

	Dia<=10"	Dia>10"
H	0.000	0.000
S	0.687	0.687
M	0.765	0.765
D	0.021	0.021

Ice Gouging

	Dia<=10"	Dia>10"
H	0.000	0.000
S	0.541	0.541
M	0.676	0.676
D	0.000	0.000

Strudel Scour

	Dia<=10"	Dia>10"
H	0.000	0.000
S	0.065	0.065
M	0.000	0.000
D	0.000	0.000

Upheaval Buckling

	Dia<=10"	Dia>10"
H	0.000	0.000
S	0.013	0.013
M	0.013	0.013
D	0.013	0.013

Thaw Settlement

	Dia<=10"	Dia>10"
H	0.000	0.000
S	0.006	0.006
M	0.006	0.006
D	0.006	0.006

Other Arctic

	Dia<=10"	Dia>10"
H	0.000	0.000
S	0.062	0.062
M	0.070	0.070
D	0.002	0.002

Figure 2.2 Fault Tree - Pipeline - Medium Spills

Pipeline Large Spill 1000-9999 bbl

Note : All Values per 100000 km-year

	Dia<=10"	Dia>10"	P/L Size
H	5.282	8.259	Historical Frequency
S	4.402	5.915	Shallow Water Depth Frequency
M	4.575	6.075	Medium Water Depth Frequency
D	2.707	4.203	Deep Water Depth Frequency

CORROSION

	Dia<=10"	Dia>10"
H	0.352	0.551
S	0.190	0.298
M	0.190	0.298
D	0.190	0.298

External

	Dia<=10"	Dia>10"
H	0.000	0.000
S	0.000	0.000
M	0.000	0.000
D	0.000	0.000

Internal

	Dia<=10"	Dia>10"
H	0.352	0.551
S	0.190	0.298
M	0.190	0.298
D	0.190	0.298

THIRD PARTY IMPACT

	Dia<=10"	Dia>10"
H	3.521	5.506
S	1.761	2.753
M	1.731	2.707
D	1.703	2.663

Anchor Impact

	Dia<=10"	Dia>10"
H	1.761	2.753
S	0.880	1.377
M	0.880	1.377
D	0.880	1.377

Jackup Rig or Spud Barge

	Dia<=10"	Dia>10"
H	0.352	0.551
S	0.176	0.275
M	0.176	0.275
D	0.176	0.275

Trawl/Fishing Net

	Dia<=10"	Dia>10"
H	1.408	2.203
S	0.704	1.101
M	0.675	1.056
D	0.647	1.011

OPERATION IMPACT

	Dia<=10"	Dia>10"
H	0.352	0.551
S	0.254	0.397
M	0.254	0.397
D	0.254	0.397

Rig Anchoring

	Dia<=10"	Dia>10"
H	0.000	0.000
S	0.000	0.000
M	0.000	0.000
D	0.000	0.000

Work Boat Anchoring

	Dia<=10"	Dia>10"
H	0.352	0.551
S	0.254	0.397
M	0.254	0.397
D	0.254	0.397

MECHANICAL

	Dia<=10"	Dia>10"
H	0.000	0.000
S	0.000	0.000
M	0.000	0.000
D	0.000	0.000

Connection Failure

	Dia<=10"	Dia>10"
H	0.000	0.000
S	0.000	0.000
M	0.000	0.000
D	0.000	0.000

Material Failure

	Dia<=10"	Dia>10"
H	0.000	0.000
S	0.000	0.000
M	0.000	0.000
D	0.000	0.000

NATURAL HAZARD

	Dia<=10"	Dia>10"
H	1.056	1.652
S	0.479	0.749
M	0.486	0.760
D	0.507	0.792

Mud Slide

	Dia<=10"	Dia>10"
H	0.352	0.551
S	0.169	0.264
M	0.176	0.275
D	0.183	0.287

Storm/ Hurricane

	Dia<=10"	Dia>10"
H	0.704	1.101
S	0.310	0.485
M	0.310	0.485
D	0.323	0.506

UNKNOWN

	Dia<=10"	Dia>10"
H	0.000	0.000
S	0.000	0.000
M	0.000	0.000
D	0.000	0.000

ARCTIC

	Dia<=10"	Dia>10"
H	0.000	0.000
S	1.719	1.719
M	1.913	1.913
D	0.053	0.053

Ice Gouging

	Dia<=10"	Dia>10"
H	0.000	0.000
S	1.353	1.353
M	1.691	1.691
D	0.000	0.000

Strudel Scour

	Dia<=10"	Dia>10"
H	0.000	0.000
S	0.161	0.161
M	0.000	0.000
D	0.000	0.000

Upheaval Buckling

	Dia<=10"	Dia>10"
H	0.000	0.000
S	0.032	0.032
M	0.032	0.032
D	0.032	0.032

Thaw Settlement

	Dia<=10"	Dia>10"
H	0.000	0.000
S	0.016	0.016
M	0.016	0.016
D	0.016	0.016

Other Arctic

	Dia<=10"	Dia>10"
H	0.000	0.000
S	0.156	0.156
M	0.174	0.174
D	0.005	0.005

Figure 2.3 Fault Tree - Pipeline - Large Spills

Pipeline Huge Spill =>10000 bbl

Note : All Values per 100000 km-year

	Dia<=10"	Dia>10"	P/L Size
H	0.755	3.304	Historical Frequency
S	0.727	2.022	Shallow Water Depth Frequency
M	0.763	2.048	Medium Water Depth Frequency
D	0.390	1.671	Deep Water Depth Frequency

CORROSION

	Dia<=10"	Dia>10"
H	0.050	0.220
S	0.027	0.119
M	0.027	0.119
D	0.027	0.119

External

	Dia<=10"	Dia>10"
H	0.000	0.000
S	0.000	0.000
M	0.000	0.000
D	0.000	0.000

Internal

	Dia<=10"	Dia>10"
H	0.050	0.220
S	0.027	0.119
M	0.027	0.119
D	0.027	0.119

THIRD PARTY IMPACT

	Dia<=10"	Dia>10"
H	0.503	2.203
S	0.252	1.101
M	0.247	1.083
D	0.243	1.065

Anchor Impact

	Dia<=10"	Dia>10"
H	0.252	1.101
S	0.126	0.551
M	0.126	0.551
D	0.126	0.551

Jackup Rig or Spud Barge

	Dia<=10"	Dia>10"
H	0.050	0.220
S	0.025	0.110
M	0.025	0.110
D	0.025	0.110

Trawl/Fishing Net

	Dia<=10"	Dia>10"
H	0.201	0.881
S	0.101	0.441
M	0.096	0.422
D	0.092	0.404

OPERATION IMPACT

	Dia<=10"	Dia>10"
H	0.050	0.220
S	0.036	0.159
M	0.036	0.159
D	0.036	0.159

Rig Anchoring

	Dia<=10"	Dia>10"
H	0.000	0.000
S	0.000	0.000
M	0.000	0.000
D	0.000	0.000

Work Boat Anchoring

	Dia<=10"	Dia>10"
H	0.050	0.220
S	0.036	0.159
M	0.036	0.159
D	0.036	0.159

MECHANICAL

	Dia<=10"	Dia>10"
H	0.000	0.000
S	0.000	0.000
M	0.000	0.000
D	0.000	0.000

Connection Failure

	Dia<=10"	Dia>10"
H	0.000	0.000
S	0.000	0.000
M	0.000	0.000
D	0.000	0.000

Material Failure

	Dia<=10"	Dia>10"
H	0.000	0.000
S	0.000	0.000
M	0.000	0.000
D	0.000	0.000

NATURAL HAZARD

	Dia<=10"	Dia>10"
H	0.151	0.661
S	0.068	0.300
M	0.069	0.304
D	0.072	0.317

Mud Slide

	Dia<=10"	Dia>10"
H	0.050	0.220
S	0.024	0.106
M	0.025	0.110
D	0.026	0.115

Storm/ Hurricane

	Dia<=10"	Dia>10"
H	0.101	0.441
S	0.044	0.194
M	0.044	0.194
D	0.046	0.202

UNKNOWN

	Dia<=10"	Dia>10"
H	0.000	0.000
S	0.000	0.000
M	0.000	0.000
D	0.000	0.000

ARCTIC

	Dia<=10"	Dia>10"
H	0.000	0.000
S	0.344	0.344
M	0.383	0.383
D	0.011	0.011

Ice Gouging

	Dia<=10"	Dia>10"
H	0.000	0.000
S	0.271	0.271
M	0.338	0.338
D	0.000	0.000

Strudel Scour

	Dia<=10"	Dia>10"
H	0.000	0.000
S	0.032	0.032
M	0.000	0.000
D	0.000	0.000

Upheaval Buckling

	Dia<=10"	Dia>10"
H	0.000	0.000
S	0.006	0.006
M	0.006	0.006
D	0.006	0.006

Thaw Settlement

	Dia<=10"	Dia>10"
H	0.000	0.000
S	0.003	0.003
M	0.003	0.003
D	0.003	0.003

Other Arctic

	Dia<=10"	Dia>10"
H	0.000	0.000
S	0.031	0.031
M	0.035	0.035
D	0.001	0.001

Figure 2.4 Fault Tree - Pipeline - Huge Spills

Platform Spill

	SM 50-999 bbl	LH =>1000 bbl	Spill Size
H	**4.601**	**0.481**	**Historical Frequency**
S	**3.053**	**0.390**	**Shallow Water Depth Frequency**
M	**3.686**	**0.404**	**Medium Water Depth Frequency**
D	**3.809**	**0.429**	**Deep Water Depth Frequency**

Note : All Values per 10000 well-years

EQUIPMENT FAILURE

	SM	LH
H	2.403	0.000
S	1.587	0.000
M	1.587	0.000
D	1.587	0.000

HUMAN ERROR

	SM	LH
H	0.824	0.000
S	0.008	0.000
M	0.561	0.000
D	0.561	0.000

TANK FAILURE

	SM	LH
H	0.137	0.069
S	0.091	0.045
M	0.091	0.045
D	0.091	0.045

SHIP COLLISION

	SM	LH
H	0.343	0.069
S	0.213	0.043
M	0.213	0.043
D	0.213	0.043

WHEATHER

	SM	LH
H	0.549	0.137
S	0.659	0.165
M	0.659	0.165
D	0.659	0.165

HURRICANE

	SM	LH
H	0.206	0.206
S	0.091	0.091
M	0.091	0.091
D	0.095	0.095

OTHER

	SM	LH
H	0.137	0.000
S	0.137	0.000
M	0.137	0.000
D	0.137	0.000

ARCTIC

	SM	LH
H	0.000	0.000
S	0.268	0.046
M	0.347	0.060
D	0.466	0.081

Process Equipment

	SM	LH
H	0.961	0.000
S	0.635	0.000
M	0.635	0.000
D	0.635	0.000

Transfer Hose

	SM	LH
H	0.824	0.000
S	0.544	0.000
M	0.544	0.000
D	0.544	0.000

Incorrect Operation

	SM	LH
H	0.618	0.000
S	0.408	0.000
M	0.408	0.000
D	0.408	0.000

Ice Force

	SM	LH
H	0.000	0.000
S	0.145	0.026
M	0.217	0.038
D	0.326	0.057

Facility Low Temperature

	SM	LH
H	0.000	0.000
S	0.099	0.016
M	0.099	0.016
D	0.099	0.016

Other Arctic

	SM	LH
H	0.000	0.000
S	0.024	0.004
M	0.031	0.005
D	0.042	0.007

Figure 2.5 Fault Tree - Platform Spills

Table 3.1
Beaufort Sea Low Case 2010 - 2039

Year	Water Depth	Exploration Wells	Delineation Wells	Expl./Del. Rigs	Production							In-use Pipeline Length [miles]						Production MMbbl
					Platforms		Platform Wells		Subsea Wells		Rigs	Sum<=10"		Sum >10"		Sum All		
					Incr.	Cum.	Incr.	Cum.	Incr.	Cum.		Incr.	Cum.	Incr.	Cum.	Incr.	Cum.	
2010	Shallow	1		1														
	Medium																	
	Deep																	
	Total	**1**		**1**														
2011	Shallow	1	2	1														
	Medium																	
	Deep																	
	Total	**1**	**2**	**1**														
2012	Shallow		2	1														
	Medium																	
	Deep																	
	Total		**2**	**1**														
2013	Shallow	1		1														
	Medium																	
	Deep																	
	Total	**1**		**1**														
2014	Shallow	1		1														
	Medium																	
	Deep																	
	Total	**1**		**1**														
2015	Shallow																	
	Medium																	
	Deep																	
	Total																	
2016	Shallow																	
	Medium																	
	Deep																	
	Total																	
2017	Shallow													10	10	10	10	
	Medium																	
	Deep																	
	Total													**10**	**10**	10	10	
2018	Shallow													5	15	5	15	
	Medium																	
	Deep																	
	Total													**5**	**15**	5	15	
2019	Shallow				1	1	6	6			1				15		15	8.8
	Medium																	
	Deep																	
	Total				**1**	**1**	**6**	**6**			**1**				**15**		15	**8.8**
2020	Shallow					1	6	12			1				15		15	16.3
	Medium																	
	Deep																	
	Total					**1**	**6**	**12**			**1**				**15**		15	**16.3**
2021	Shallow					1	6	18			1				15		15	16.3
	Medium																	
	Deep																	
	Total					**1**	**6**	**18**			**1**				**15**		15	**16.3**
2022	Shallow					1		18							15		15	16.3
	Medium																	
	Deep																	
	Total					**1**		**18**							**15**		15	**16.3**
2023	Shallow					1		18							15		15	13.4
	Medium																	
	Deep																	
	Total					**1**		**18**							**15**		15	**13.4**
2024	Shallow					1		18							15		15	11.1
	Medium																	
	Deep																	
	Total					**1**		**18**							**15**		15	**11.1**
2025	Shallow					1		18							15		15	9.1
	Medium																	
	Deep																	
	Total					**1**		**18**							**15**		15	**9.1**
2026	Shallow					1		18							15		15	7.5
	Medium																	
	Deep																	
	Total					**1**		**18**							**15**		15	**7.5**
2027	Shallow					1		18							15		15	6.2
	Medium																	
	Deep																	
	Total					**1**		**18**							**15**		15	**6.2**
2028	Shallow					1		18							15		15	5.1
	Medium																	
	Deep																	
	Total					**1**		**18**							**15**		15	**5.1**
2029	Shallow					1		18							15		15	4.2
	Medium																	
	Deep																	
	Total					**1**		**18**							**15**		15	**4.2**
2030	Shallow					1		18							15		15	3.5
	Medium																	
	Deep																	
	Total					**1**		**18**							**15**		15	**3.5**

Table 3.1
Beaufort Sea Low Case 2010 - 2039

Year	Water Depth	Exploration Wells	Delineation Wells	Expl./Del. Rigs	Production							In-use Pipeline Length [miles]						Production MMbbl
					Platforms		Platform Wells		Subsea Wells		Rigs	Sum<=10"		Sum >10"		Sum All		
					Incr.	Cum.	Incr.	Cum.	Incr.	Cum.		Incr.	Cum.	Incr.	Cum.	Incr.	Cum.	
2031	Shallow					1		18							15		15	2.9
	Medium																	
	Deep																	
	Total					**1**		**18**							**15**		15	**2.9**
2032	Shallow					1		18							15		15	2.5
	Medium																	
	Deep																	
	Total					**1**		**18**							**15**		15	**2.5**
2033	Shallow					1		18							15		15	2.1
	Medium																	
	Deep																	
	Total					**1**		**18**							**15**		15	**2.1**
2034	Shallow				-1		-18							-15		-15		
	Medium																	
	Deep																	
	Total				**-1**		**-18**							**-15**		-15		
2035	Shallow																	
	Medium																	
	Deep																	
	Total																	
2036	Shallow																	
	Medium																	
	Deep																	
	Total																	
2037	Shallow																	
	Medium																	
	Deep																	
	Total																	
2038	Shallow																	
	Medium																	
	Deep																	
	Total																	
2039	Shallow																	
	Medium																	
	Deep																	
	Total																	

Table 3.3
Beaufort Sea High Case 2010 - 2039

Year	Water Depth	Exploration Wells	Delineation Wells	Expl./Del. Rigs	Production							In-use Pipeline Length [miles]						Production MMbbl
					Platforms		Platform Wells		Subsea Wells		Rigs	Sum<=10"		Sum >10"		Sum All		
					Incr.	Cum.	Incr.	Cum.	Incr.	Cum.		Incr.	Cum.	Incr.	Cum.	Incr.	Cum.	
2010	Shallow	1		1														
	Medium																	
	Deep																	
	Total	**1**		**1**														
2011	Shallow	1	2	1														
	Medium																	
	Deep																	
	Total	**1**	**2**	**1**														
2012	Shallow		2	1														
	Medium																	
	Deep	1		1														
	Total	**1**	**2**	**2**														
2013	Shallow	1		1														
	Medium																	
	Deep	1	2	1														
	Total	**2**	**2**	**2**														
2014	Shallow	1		1														
	Medium																	
	Deep		3	1														
	Total	**1**	**3**	**2**														
2015	Shallow																	
	Medium	1	2	1														
	Deep																	
	Total	**1**	**2**	**1**														
2016	Shallow																	
	Medium	1	2	2														
	Deep																	
	Total	**1**	**2**	**2**														
2017	Shallow													10	10	10	10	
	Medium	1		1														
	Deep																	
	Total	**1**		**1**										**10**	**10**	10	10	
2018	Shallow													5	15	5	15	
	Medium																	
	Deep																	
	Total													**5**	**15**	5	15	
2019	Shallow				1	1	6	6			1				15		15	8.8
	Medium																	
	Deep																	
	Total				**1**	**1**	**6**	**6**			**1**				**15**		15	**8.8**
2020	Shallow					1	6	12			1				15		15	16.3
	Medium																	
	Deep													10	10	10	10	
	Total					**1**	**6**	**12**			**1**			**10**	**25**	10	25	**16.3**
2021	Shallow					1	6	18			1				15		15	16.3
	Medium																	
	Deep													10	20	10	20	
	Total					**1**	**6**	**18**			**1**			**10**	**35**	10	35	**16.3**
2022	Shallow					1		18							15		15	16.3
	Medium																	
	Deep				1	1	6	6			1			15	35	15	35	13.5
	Total				**1**	**2**	**6**	**24**			**1**			**15**	**50**	15	50	**29.8**
2023	Shallow					1		18							15		15	13.4
	Medium																	
	Deep					1	6	12	4	4	1	5	5		35	5	40	16.9
	Total					**2**	**6**	**30**	**4**	**4**	**1**	**5**	**5**		**50**	5	55	**30.3**
2024	Shallow					1		18							15		15	11.1
	Medium				1	1	6	6			1			10	10	10	10	8.8
	Deep					1	6	18	4	8	1	5	10		35	5	45	22.5
	Total				**1**	**3**	**12**	**42**	**4**	**8**	**2**	**5**	**10**	**10**	**60**	15	70	**42.4**
2025	Shallow					1		18							15		15	9.1
	Medium					1	6	12			1			15	25	15	25	16.3
	Deep					1	6	24	4	12	1	5	15		35	5	50	30.0
	Total					**3**	**12**	**54**	**4**	**12**	**2**	**5**	**15**	**15**	**75**	20	90	**55.4**
2026	Shallow					1		18							15		15	7.5
	Medium					1	6	18			1				25		25	16.3
	Deep					1		24		12			15		35		50	30.0
	Total					**3**	**6**	**60**		**12**	**1**		**15**		**75**		90	**53.8**
2027	Shallow					1		18							15		15	6.2
	Medium					1		18							25		25	16.3
	Deep					1		24		12			15		35		50	30.0
	Total					**3**		**60**		**12**			**15**		**75**		90	**52.5**
2028	Shallow					1		18							15		15	5.1
	Medium					1		18							25		25	13.4
	Deep					1		24		12			15		35		50	24.0
	Total					**3**		**60**		**12**			**15**		**75**		90	**42.5**
2029	Shallow					1		18							15		15	4.2
	Medium					1		18							25		25	11.1
	Deep					1		24		12			15		35		50	19.2
	Total					**3**		**60**		**12**			**15**		**75**		90	**34.5**

Table 3.3
Beaufort Sea High Case 2010 - 2039

Year	Water Depth	Exploration Wells	Delineation Wells	Expl./Del. Rigs	Production: Platforms		Production: Platform Wells		Production: Subsea Wells		Production: Rigs	In-use Pipeline Length [miles]: Sum<=10"		In-use Pipeline Length [miles]: Sum >10"		In-use Pipeline Length [miles]: Sum All		Production MMbbl
					Incr.	Cum.	Incr.	Cum.	Incr.	Cum.		Incr.	Cum.	Incr.	Cum.	Incr.	Cum.	
2030	Shallow					1		18							15		15	3.5
	Medium					1		18							25		25	9.1
	Deep					1		24		12			15		35		50	15.4
	Total					**3**		**60**		**12**			**15**		**75**		90	**28.0**
2031	Shallow					1		18							15		15	2.9
	Medium					1		18							25		25	7.5
	Deep					1		24		12			15		35		50	12.3
	Total					**3**		**60**		**12**			**15**		**75**		90	**22.7**
2032	Shallow					1		18							15		15	2.5
	Medium					1		18							25		25	6.2
	Deep					1		24		12			15		35		50	9.8
	Total					**3**		**60**		**12**			**15**		**75**		90	**18.5**
2033	Shallow					1		18							15		15	2.1
	Medium					1		18							25		25	5.1
	Deep					1		24		12			15		35		50	7.9
	Total					**3**		**60**		**12**			**15**		**75**		90	**15.1**
2034	Shallow				-1		-18							-15		-15		
	Medium					1		18							25		25	4.2
	Deep					1		24		12			15		35		50	6.3
	Total				**-1**	**2**	**-18**	**42**		**12**			**15**	**-15**	**60**	-15	75	**10.5**
2035	Shallow																	
	Medium					1		18							25		25	3.5
	Deep					1		24		12			15		35		50	5.0
	Total					**2**		**42**		**12**			**15**		**60**		75	**8.5**
2036	Shallow																	
	Medium					1		18							25		25	2.9
	Deep					1		24		12			15		35		50	4.0
	Total					**2**		**42**		**12**			**15**		**60**		75	**6.9**
2037	Shallow																	
	Medium					1		18							25		25	2.6
	Deep					1		24		12			15		35		50	3.0
	Total					**2**		**42**		**12**			**15**		**60**		75	**5.6**
2038	Shallow																	
	Medium					1		18							25		25	2.1
	Deep				-1		-24		-12			-15		-35		-50		
	Total				**-1**	**1**	**-24**	**18**	**-12**			**-15**		**-35**	**25**	-50	25	**2.1**
2039	Shallow																	
	Medium				-1		-18							-25		-25		
	Deep																	
	Total				**-1**		**-18**							**-25**		-25		

Table 4.1.1
Arctic Spill Occurrence Beaufort Sea Low Case P/L Spills

Year	Water Depth	P/L Dia <=10"													P/L Dia >=10"												
		P/L [miles]	Small Spills 50-99 bbl			Medium Spills 100-999 bbl			Large Spills 1000-9999 bbl			Huge Spills =>10000 bbl			P/L [miles]	Small Spills 50-99 bbl			Medium Spills 100-999 bbl			Large Spills 1000-9999 bbl			Huge Spills =>10000 bbl		
			Expected Spill [bbl] =		71	Expected Spill [bbl] =		485	Expected Spill [bbl] =		5279	Expected Spill [bbl] =		14880		Expected Spill [bbl] =		71	Expected Spill [bbl] =		516	Expected Spill [bbl] =		5176	Expected Spill [bbl] =		15552
		Cumm.	Frequency spills per 10^5km-year	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^5km-year	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^5km-year	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^5km-year	Frequency spills per 10^3years	Spill Index bbl	Cumm.	Frequency spills per 10^5km-year	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^5km-year	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^5km-year	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^5km-year	Frequency spills per 10^3years	Spill Index bbl
2010	Shallow		5.472			9.060			4.402			0.727				5.925			12.472			5.915			2.022		
	Medium		5.553			9.144			4.575			0.763				6.007			12.558			6.075			2.048		
	Deep		4.813			8.407			2.707			0.390				5.267			11.823			4.203			1.671		
	Total																										
2011	Shallow		5.472			9.060			4.402			0.727				5.925			12.472			5.915			2.022		
	Medium		5.553			9.144			4.575			0.763				6.007			12.558			6.075			2.048		
	Deep		4.813			8.407			2.707			0.390				5.267			11.823			4.203			1.671		
	Total																										
2012	Shallow		5.472			9.060			4.402			0.727				5.925			12.472			5.915			2.022		
	Medium		5.553			9.144			4.575			0.763				6.007			12.558			6.075			2.048		
	Deep		4.813			8.407			2.707			0.390				5.267			11.823			4.203			1.671		
	Total																										
2013	Shallow		5.472			9.060			4.402			0.727				5.925			12.472			5.915			2.022		
	Medium		5.553			9.144			4.575			0.763				6.007			12.558			6.075			2.048		
	Deep		4.813			8.407			2.707			0.390				5.267			11.823			4.203			1.671		
	Total																										
2014	Shallow		5.472			9.060			4.402			0.727				5.925			12.472			5.915			2.022		
	Medium		5.553			9.144			4.575			0.763				6.007			12.558			6.075			2.048		
	Deep		4.813			8.407			2.707			0.390				5.267			11.823			4.203			1.671		
	Total																										
2015	Shallow		5.472			9.060			4.402			0.727				5.925			12.472			5.915			2.022		
	Medium		5.553			9.144			4.575			0.763				6.007			12.558			6.075			2.048		
	Deep		4.813			8.407			2.707			0.390				5.267			11.823			4.203			1.671		
	Total																										
2016	Shallow		5.472			9.060			4.402			0.727				5.925			12.472			5.915			2.022		
	Medium		5.553			9.144			4.575			0.763				6.007			12.558			6.075			2.048		
	Deep		4.813			8.407			2.707			0.390				5.267			11.823			4.203			1.671		
	Total																										
2017	Shallow		5.472			9.060			4.402			0.727			10	5.925	0.953	0.07	12.472	2.007	1.04	5.915	0.952	4.93	2.022	0.325	5.06
	Medium		5.553			9.144			4.575			0.763				6.007			12.558			6.075			2.048		
	Deep		4.813			8.407			2.707			0.390				5.267			11.823			4.203			1.671		
	Total														10		0.953	0.07		2.007	1.04		0.952	4.93		0.325	5.06
2018	Shallow		5.472			9.060			4.402			0.727			15	5.925	1.430	0.10	12.472	3.010	1.55	5.915	1.428	7.39	2.022	0.488	7.59
	Medium		5.553			9.144			4.575			0.763				6.007			12.558			6.075			2.048		
	Deep		4.813			8.407			2.707			0.390				5.267			11.823			4.203			1.671		
	Total														15		1.430	0.10		3.010	1.55		1.428	7.39		0.488	7.59
2019	Shallow		5.472			9.060			4.402			0.727			15	5.925	1.430	0.10	12.472	3.010	1.55	5.915	1.428	7.39	2.022	0.488	7.59
	Medium		5.553			9.144			4.575			0.763				6.007			12.558			6.075			2.048		
	Deep		4.813			8.407			2.707			0.390				5.267			11.823			4.203			1.671		
	Total														15		1.430	0.10		3.010	1.55		1.428	7.39		0.488	7.59
2020	Shallow		5.472			9.060			4.402			0.727			15	5.925	1.430	0.10	12.472	3.010	1.55	5.915	1.428	7.39	2.022	0.488	7.59
	Medium		5.553			9.144			4.575			0.763				6.007			12.558			6.075			2.048		
	Deep		4.813			8.407			2.707			0.390				5.267			11.823			4.203			1.671		
	Total														15		1.430	0.10		3.010	1.55		1.428	7.39		0.488	7.59
2021	Shallow		5.472			9.060			4.402			0.727			15	5.925	1.430	0.10	12.472	3.010	1.55	5.915	1.428	7.39	2.022	0.488	7.59
	Medium		5.553			9.144			4.575			0.763				6.007			12.558			6.075			2.048		
	Deep		4.813			8.407			2.707			0.390				5.267			11.823			4.203			1.671		
	Total														15		1.430	0.10		3.010	1.55		1.428	7.39		0.488	7.59
2022	Shallow		5.472			9.060			4.402			0.727			15	5.925	1.430	0.10	12.472	3.010	1.55	5.915	1.428	7.39	2.022	0.488	7.59
	Medium		5.553			9.144			4.575			0.763				6.007			12.558			6.075			2.048		
	Deep		4.813			8.407			2.707			0.390				5.267			11.823			4.203			1.671		
	Total														15		1.430	0.10		3.010	1.55		1.428	7.39		0.488	7.59
2023	Shallow		5.472			9.060			4.402			0.727			15	5.925	1.430	0.10	12.472	3.010	1.55	5.915	1.428	7.39	2.022	0.488	7.59
	Medium		5.553			9.144			4.575			0.763				6.007			12.558			6.075			2.048		
	Deep		4.813			8.407			2.707			0.390				5.267			11.823			4.203			1.671		
	Total														15		1.430	0.10		3.010	1.55		1.428	7.39		0.488	7.59
2024	Shallow		5.472			9.060			4.402			0.727			15	5.925	1.430	0.10	12.472	3.010	1.55	5.915	1.428	7.39	2.022	0.488	7.59
	Medium		5.553			9.144			4.575			0.763				6.007			12.558			6.075			2.048		
	Deep		4.813			8.407			2.707			0.390				5.267			11.823			4.203			1.671		
	Total														15		1.430	0.10		3.010	1.55		1.428	7.39		0.488	7.59
2025	Shallow		5.472			9.060			4.402			0.727			15	5.925	1.430	0.10	12.472	3.010	1.55	5.915	1.428	7.39	2.022	0.488	7.59
	Medium		5.553			9.144			4.575			0.763				6.007			12.558			6.075			2.048		
	Deep		4.813			8.407			2.707			0.390				5.267			11.823			4.203			1.671		
	Total														15		1.430	0.10		3.010	1.55		1.428	7.39		0.488	7.59
2026	Shallow		5.472			9.060			4.402			0.727			15	5.925	1.430	0.10	12.472	3.010	1.55	5.915	1.428	7.39	2.022	0.488	7.59
	Medium		5.553			9.144			4.575			0.763				6.007			12.558			6.075			2.048		
	Deep		4.813			8.407			2.707			0.390				5.267			11.823			4.203			1.671		
	Total														15		1.430	0.10		3.010	1.55		1.428	7.39		0.488	7.59
2027	Shallow		5.472			9.060			4.402			0.727			15	5.925	1.430	0.10	12.472	3.010	1.55	5.915	1.428	7.39	2.022	0.488	7.59
	Medium		5.553			9.144			4.575			0.763				6.007			12.558			6.075			2.048		
	Deep		4.813			8.407			2.707			0.390				5.267			11.823			4.203			1.671		
	Total														15		1.430	0.10		3.010	1.55		1.428	7.39		0.488	7.59
2028	Shallow		5.472			9.060			4.402			0.727			15	5.925	1.430	0.10	12.472	3.010	1.55	5.915	1.428	7.39	2.022	0.488	7.59
	Medium		5.553			9.144			4.575			0.763				6.007			12.558			6.075			2.048		
	Deep		4.813			8.407			2.707			0.390				5.267			11.823			4.203			1.671		
	Total														15		1.430	0.10		3.010	1.55		1.428	7.39		0.488	7.59
2029	Shallow		5.472			9.060			4.402			0.727			15	5.925	1.430	0.10	12.472	3.010	1.55	5.915	1.428	7.39	2.022	0.488	7.59
	Medium		5.553			9.144			4.575			0.763				6.007			12.558			6.075			2.048		
	Deep		4.813			8.407			2.707			0.390				5.267			11.823			4.203			1.671		

Table 4.1.1
Arctic Spill Occurrence Beaufort Sea Low Case P/L Spills

Year	Water Depth	P/L Dia <=10"													P/L Dia >=10"												
		P/L [miles]	Small Spills 50-99 bbl			Medium Spills 100-999 bbl			Large Spills 1000-9999 bbl			Huge Spills =>10000 bbl			P/L [miles]	Small Spills 50-99 bbl			Medium Spills 100-999 bbl			Large Spills 1000-9999 bbl			Huge Spills =>10000 bbl		
			Expected Spill [bbl] =		71	Expected Spill [bbl] =		485	Expected Spill [bbl] =		5279	Expected Spill [bbl] =		14880		Expected Spill [bbl] =		71	Expected Spill [bbl] =		516	Expected Spill [bbl] =		5176	Expected Spill [bbl] =		15552
		Cumm.	Frequency spills per 10^5km-year	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^5km-year	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^5km-year	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^5km-year	Frequency spills per 10^3years	Spill Index bbl	Cumm.	Frequency spills per 10^5km-year	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^5km-year	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^5km-year	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^5km-year	Frequency spills per 10^3years	Spill Index bbl
	Total														**15**		**1.430**	**0.10**		**3.010**	**1.55**		**1.428**	**7.39**		**0.488**	**7.59**
2030	Shallow		5.472			9.060			4.402			0.727			15	5.925	1.430	0.10	12.472	3.010	1.55	5.915	1.428	7.39	2.022	0.488	7.59
	Medium		5.553			9.144			4.575			0.763				6.007			12.558			6.075			2.048		
	Deep		4.813			8.407			2.707			0.390				5.267			11.823			4.203			1.671		
	Total														**15**		**1.430**	**0.10**		**3.010**	**1.55**		**1.428**	**7.39**		**0.488**	**7.59**
2031	Shallow		5.472			9.060			4.402			0.727			15	5.925	1.430	0.10	12.472	3.010	1.55	5.915	1.428	7.39	2.022	0.488	7.59
	Medium		5.553			9.144			4.575			0.763				6.007			12.558			6.075			2.048		
	Deep		4.813			8.407			2.707			0.390				5.267			11.823			4.203			1.671		
	Total														**15**		**1.430**	**0.10**		**3.010**	**1.55**		**1.428**	**7.39**		**0.488**	**7.59**
2032	Shallow		5.472			9.060			4.402			0.727			15	5.925	1.430	0.10	12.472	3.010	1.55	5.915	1.428	7.39	2.022	0.488	7.59
	Medium		5.553			9.144			4.575			0.763				6.007			12.558			6.075			2.048		
	Deep		4.813			8.407			2.707			0.390				5.267			11.823			4.203			1.671		
	Total														**15**		**1.430**	**0.10**		**3.010**	**1.55**		**1.428**	**7.39**		**0.488**	**7.59**
2033	Shallow		5.472			9.060			4.402			0.727			15	5.925	1.430	0.10	12.472	3.010	1.55	5.915	1.428	7.39	2.022	0.488	7.59
	Medium		5.553			9.144			4.575			0.763				6.007			12.558			6.075			2.048		
	Deep		4.813			8.407			2.707			0.390				5.267			11.823			4.203			1.671		
	Total														**15**		**1.430**	**0.10**		**3.010**	**1.55**		**1.428**	**7.39**		**0.488**	**7.59**
2034	Shallow		5.472			9.060			4.402			0.727				5.925			12.472			5.915			2.022		
	Medium		5.553			9.144			4.575			0.763				6.007			12.558			6.075			2.048		
	Deep		4.813			8.407			2.707			0.390				5.267			11.823			4.203			1.671		
	Total																										
2035	Shallow		5.472			9.060			4.402			0.727				5.925			12.472			5.915			2.022		
	Medium		5.553			9.144			4.575			0.763				6.007			12.558			6.075			2.048		
	Deep		4.813			8.407			2.707			0.390				5.267			11.823			4.203			1.671		
	Total																										
2036	Shallow		5.472			9.060			4.402			0.727				5.925			12.472			5.915			2.022		
	Medium		5.553			9.144			4.575			0.763				6.007			12.558			6.075			2.048		
	Deep		4.813			8.407			2.707			0.390				5.267			11.823			4.203			1.671		
	Total																										
2037	Shallow		5.472			9.060			4.402			0.727				5.925			12.472			5.915			2.022		
	Medium		5.553			9.144			4.575			0.763				6.007			12.558			6.075			2.048		
	Deep		4.813			8.407			2.707			0.390				5.267			11.823			4.203			1.671		
	Total																										
2038	Shallow		5.472			9.060			4.402			0.727				5.925			12.472			5.915			2.022		
	Medium		5.553			9.144			4.575			0.763				6.007			12.558			6.075			2.048		
	Deep		4.813			8.407			2.707			0.390				5.267			11.823			4.203			1.671		
	Total																										
2039	Shallow		5.472			9.060			4.402			0.727				5.925			12.472			5.915			2.022		
	Medium		5.553			9.144			4.575			0.763				6.007			12.558			6.075			2.048		
	Deep		4.813			8.407			2.707			0.390				5.267			11.823			4.203			1.671		
	Total																										

Table 4.1.2
Arctic Spill Occurrence - Low Case- P/L - Summary

Year	Production [MMbbl]	Small Spills 50-99 bbl			Medium Spills 100-999 bbl			Small and Medium Spills 50-999 bbl			Large Spills 1000-9999 bbl			Huge Spills =>10000 bbl			Significant Spills =>1000 bbl			All Spills		
		Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 103years	Frequency Spills per 109 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]
2010																						
2011																						
2012																						
2013																						
2014																						
2015																						
2016																						
2017		0.953		0.068	2.007		1.035	2.960		1.103	0.952		4.926	0.325		5.060	1.277		9.986	4.237		11.090
2018		1.430		0.102	3.010		1.553	4.440		1.655	1.428		7.389	0.488		7.591	1.916		14.980	6.356		16.634
2019	**8.8**	1.430	0.162	0.102	3.010	0.342	1.553	4.440	0.505	1.655	1.428	0.162	7.389	0.488	0.055	7.591	1.916	0.218	14.980	6.356	0.722	16.634
2020	**16.3**	1.430	0.088	0.102	3.010	0.185	1.553	4.440	0.272	1.655	1.428	0.088	7.389	0.488	0.030	7.591	1.916	0.118	14.980	6.356	0.390	16.634
2021	**16.3**	1.430	0.088	0.102	3.010	0.185	1.553	4.440	0.272	1.655	1.428	0.088	7.389	0.488	0.030	7.591	1.916	0.118	14.980	6.356	0.390	16.634
2022	**16.3**	1.430	0.088	0.102	3.010	0.185	1.553	4.440	0.272	1.655	1.428	0.088	7.389	0.488	0.030	7.591	1.916	0.118	14.980	6.356	0.390	16.634
2023	**13.4**	1.430	0.107	0.102	3.010	0.225	1.553	4.440	0.331	1.655	1.428	0.107	7.389	0.488	0.036	7.591	1.916	0.143	14.980	6.356	0.474	16.634
2024	**11.1**	1.430	0.129	0.102	3.010	0.271	1.553	4.440	0.400	1.655	1.428	0.129	7.389	0.488	0.044	7.591	1.916	0.173	14.980	6.356	0.573	16.634
2025	**9.1**	1.430	0.157	0.102	3.010	0.331	1.553	4.440	0.488	1.655	1.428	0.157	7.389	0.488	0.054	7.591	1.916	0.211	14.980	6.356	0.698	16.634
2026	**7.5**	1.430	0.191	0.102	3.010	0.401	1.553	4.440	0.592	1.655	1.428	0.190	7.389	0.488	0.065	7.591	1.916	0.255	14.980	6.356	0.847	16.634
2027	**6.2**	1.430	0.231	0.102	3.010	0.485	1.553	4.440	0.716	1.655	1.428	0.230	7.389	0.488	0.079	7.591	1.916	0.309	14.980	6.356	1.025	16.634
2028	**5.1**	1.430	0.280	0.102	3.010	0.590	1.553	4.440	0.871	1.655	1.428	0.280	7.389	0.488	0.096	7.591	1.916	0.376	14.980	6.356	1.246	16.634
2029	**4.2**	1.430	0.340	0.102	3.010	0.717	1.553	4.440	1.057	1.655	1.428	0.340	7.389	0.488	0.116	7.591	1.916	0.456	14.980	6.356	1.513	16.634
2030	**3.5**	1.430	0.409	0.102	3.010	0.860	1.553	4.440	1.269	1.655	1.428	0.408	7.389	0.488	0.139	7.591	1.916	0.547	14.980	6.356	1.816	16.634
2031	**2.9**	1.430	0.493	0.102	3.010	1.038	1.553	4.440	1.531	1.655	1.428	0.492	7.389	0.488	0.168	7.591	1.916	0.661	14.980	6.356	2.192	16.634
2032	**2.5**	1.430	0.572	0.102	3.010	1.204	1.553	4.440	1.776	1.655	1.428	0.571	7.389	0.488	0.195	7.591	1.916	0.766	14.980	6.356	2.542	16.634
2033	**2.1**	1.430	0.681	0.102	3.010	1.433	1.553	4.440	2.114	1.655	1.428	0.680	7.389	0.488	0.232	7.591	1.916	0.912	14.980	6.356	3.027	16.634
2034																						
2035																						
2036																						
2037																						
2038																						
2039																						
Total LOF	**125.3**	**23.833**		**2**	**50.168**		**26**	**74.001**		**28**	**23.794**		**123**	**8.135**		**127**	**31.928**		**250**	**105.929**		**277**
Average LOF		**0.993**	**0.190**	**0**	**2.090**	**0.400**	**1**	**3.083**	**0.591**	**1**	**0.991**	**0.190**	**5**	**0.339**	**0.065**	**5**	**1.330**	**0.255**	**10**	**4.414**	**0.845**	**12**

Table 4.1.3
Arctic Spill Occurrence - Low Case- Platforms

Year	Water Depth	N Platforms	N P Wells	Small and Medium Spills 50-999 bbl			Large and Huge Spills =>1000 bbl		
				Expected Spill [bbl] =		**452**	Expected Spill [bbl] =		**5631**
		Cum.	Cum.	Frequency spills per 10^4well-year	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^4well-year	Frequency spills per 10^3years	Spill Index bbl
2010	Shallow			3.053			0.390		
	Medium			3.686			0.404		
	Deep			3.809			0.429		
	Total								
2011	Shallow			3.053			0.390		
	Medium			3.686			0.404		
	Deep			3.809			0.429		
	Total								
2012	Shallow			3.053			0.390		
	Medium			3.686			0.404		
	Deep			3.809			0.429		
	Total								
2013	Shallow			3.053			0.390		
	Medium			3.686			0.404		
	Deep			3.809			0.429		
	Total								
2014	Shallow			3.053			0.390		
	Medium			3.686			0.404		
	Deep			3.809			0.429		
	Total								
2015	Shallow			3.053			0.390		
	Medium			3.686			0.404		
	Deep			3.809			0.429		
	Total								
2016	Shallow			3.053			0.390		
	Medium			3.686			0.404		
	Deep			3.809			0.429		
	Total								
2017	Shallow			3.053			0.390		
	Medium			3.686			0.404		
	Deep			3.809			0.429		
	Total								
2018	Shallow			3.053			0.390		
	Medium			3.686			0.404		
	Deep			3.809			0.429		
	Total								
2019	Shallow	1	6	3.053	1.832	0.83	0.390	0.234	1.32
	Medium			3.686			0.404		
	Deep			3.809			0.429		
	Total	**1**	**6**		**1.832**	**0.83**		**0.234**	**1.32**
2020	Shallow	1	12	3.053	3.664	1.66	0.390	0.467	2.63
	Medium			3.686			0.404		
	Deep			3.809			0.429		
	Total	**1**	**12**		**3.664**	**1.66**		**0.467**	**2.63**
2021	Shallow	1	18	3.053	5.496	2.48	0.390	0.701	3.95
	Medium			3.686			0.404		
	Deep			3.809			0.429		
	Total	**1**	**18**		**5.496**	**2.48**		**0.701**	**3.95**
2022	Shallow	1	18	3.053	5.496	2.48	0.390	0.701	3.95
	Medium			3.686			0.404		
	Deep			3.809			0.429		
	Total	**1**	**18**		**5.496**	**2.48**		**0.701**	**3.95**
2023	Shallow	1	18	3.053	5.496	2.48	0.390	0.701	3.95
	Medium			3.686			0.404		
	Deep			3.809			0.429		
	Total	**1**	**18**		**5.496**	**2.48**		**0.701**	**3.95**
2024	Shallow	1	18	3.053	5.496	2.48	0.390	0.701	3.95
	Medium			3.686			0.404		
	Deep			3.809			0.429		
	Total	**1**	**18**		**5.496**	**2.48**		**0.701**	**3.95**
2025	Shallow	1	18	3.053	5.496	2.48	0.390	0.701	3.95
	Medium			3.686			0.404		
	Deep			3.809			0.429		
	Total	**1**	**18**		**5.496**	**2.48**		**0.701**	**3.95**
2026	Shallow	1	18	3.053	5.496	2.48	0.390	0.701	3.95
	Medium			3.686			0.404		
	Deep			3.809			0.429		
	Total	**1**	**18**		**5.496**	**2.48**		**0.701**	**3.95**
2027	Shallow	1	18	3.053	5.496	2.48	0.390	0.701	3.95
	Medium			3.686			0.404		
	Deep			3.809			0.429		
	Total	**1**	**18**		**5.496**	**2.48**		**0.701**	**3.95**
2028	Shallow	1	18	3.053	5.496	2.48	0.390	0.701	3.95
	Medium			3.686			0.404		
	Deep			3.809			0.429		
	Total	**1**	**18**		**5.496**	**2.48**		**0.701**	**3.95**
2029	Shallow	1	18	3.053	5.496	2.48	0.390	0.701	3.95
	Medium			3.686			0.404		
	Deep			3.809			0.429		
	Total	**1**	**18**		**5.496**	**2.48**		**0.701**	**3.95**
2030	Shallow	1	18	3.053	5.496	2.48	0.390	0.701	3.95
	Medium			3.686			0.404		
	Deep			3.809			0.429		
	Total	**1**	**18**		**5.496**	**2.48**		**0.701**	**3.95**
	Shallow	1	18	3.053	5.496	2.48	0.390	0.701	3.95

Table 4.1.3
Arctic Spill Occurrence - Low Case- Platforms

Year	Water Depth	N Platforms	N P Wells	Small and Medium Spills 50-999 bbl			Large and Huge Spills =>1000 bbl		
				Expected Spill [bbl] =		452	Expected Spill [bbl] =		5631
		Cum.	Cum.	Frequency spills per 10^4well-year	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^4well-year	Frequency spills per 10^3years	Spill Index bbl
2031	Medium			3.686			0.404		
	Deep			3.809			0.429		
	Total	**1**	**18**		**5.496**	**2.48**		**0.701**	**3.95**
2032	Shallow	1	18	3.053	5.496	2.48	0.390	0.701	3.95
	Medium			3.686			0.404		
	Deep			3.809			0.429		
	Total	**1**	**18**		**5.496**	**2.48**		**0.701**	**3.95**
2033	Shallow	1	18	3.053	5.496	2.48	0.390	0.701	3.95
	Medium			3.686			0.404		
	Deep			3.809			0.429		
	Total	**1**	**18**		**5.496**	**2.48**		**0.701**	**3.95**
2034	Shallow			3.053			0.390		
	Medium			3.686			0.404		
	Deep			3.809			0.429		
	Total								
2035	Shallow			3.053			0.390		
	Medium			3.686			0.404		
	Deep			3.809			0.429		
	Total								
2036	Shallow			3.053			0.390		
	Medium			3.686			0.404		
	Deep			3.809			0.429		
	Total								
2037	Shallow			3.053			0.390		
	Medium			3.686			0.404		
	Deep			3.809			0.429		
	Total								
2038	Shallow			3.053			0.390		
	Medium			3.686			0.404		
	Deep			3.809			0.429		
	Total								
2039	Shallow			3.053			0.390		
	Medium			3.686			0.404		
	Deep			3.809			0.429		
	Total								

Table 4.1.4
Arctic Spill Occurrence - Low Case - Platforms - Summary

Year	Production [MMbbl]	Small and Medium Spills 50-999 bbl			Large and Huge Spills =>1000 bbl			Significant Spills =>1000 bbl			All Spills		
		Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 103years	Frequency Spills per 109 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]
2010													
2011													
2012													
2013													
2014													
2015													
2016													
2017													
2018													
2019	**8.8**	1.832	0.208	0.828	0.234	0.027	1.316	0.234	0.027	1.316	2.066	0.235	2.144
2020	**16.3**	3.664	0.225	1.656	0.467	0.029	2.632	0.467	0.029	2.632	4.131	0.253	4.288
2021	**16.3**	5.496	0.337	2.484	0.701	0.043	3.949	0.701	0.043	3.949	6.197	0.380	6.432
2022	**16.3**	5.496	0.337	2.484	0.701	0.043	3.949	0.701	0.043	3.949	6.197	0.380	6.432
2023	**13.4**	5.496	0.410	2.484	0.701	0.052	3.949	0.701	0.052	3.949	6.197	0.462	6.432
2024	**11.1**	5.496	0.495	2.484	0.701	0.063	3.949	0.701	0.063	3.949	6.197	0.558	6.432
2025	**9.1**	5.496	0.604	2.484	0.701	0.077	3.949	0.701	0.077	3.949	6.197	0.681	6.432
2026	**7.5**	5.496	0.733	2.484	0.701	0.093	3.949	0.701	0.093	3.949	6.197	0.826	6.432
2027	**6.2**	5.496	0.886	2.484	0.701	0.113	3.949	0.701	0.113	3.949	6.197	1.000	6.432
2028	**5.1**	5.496	1.078	2.484	0.701	0.137	3.949	0.701	0.137	3.949	6.197	1.215	6.432
2029	**4.2**	5.496	1.309	2.484	0.701	0.167	3.949	0.701	0.167	3.949	6.197	1.475	6.432
2030	**3.5**	5.496	1.570	2.484	0.701	0.200	3.949	0.701	0.200	3.949	6.197	1.771	6.432
2031	**2.9**	5.496	1.895	2.484	0.701	0.242	3.949	0.701	0.242	3.949	6.197	2.137	6.432
2032	**2.5**	5.496	2.198	2.484	0.701	0.280	3.949	0.701	0.280	3.949	6.197	2.479	6.432
2033	**2.1**	5.496	2.617	2.484	0.701	0.334	3.949	0.701	0.334	3.949	6.197	2.951	6.432
2034													
2035													
2036													
2037													
2038													
2039													
Total LOF	**125.3**	**76.942**		**35**	**9.817**		**55**	**9.817**		**55**	**86.759**		**90**
Average LOF		**3.206**	**0.614**	**1**	**0.409**	**0.078**	**2**	**0.409**	**0.078**	**2**	**3.615**	**0.692**	**4**

Table 4.1.5
Arctic Spill Occurrence - Low Case - Production Wells

Year	Water Depth	N Wells	Production Wells Blowout											
			Small and Medium Spills 50-999 bbl			Large Spills 1000-9999 bbl			Spills 10000-149999 bbl			Spills =>150000 bbl		
			Expected Spill [bbl] =		519	Expected Spill [bbl] =		5292	Expected Spill [bbl] =		68349	Expected Spill [bbl] =		200000
		Cum.	Frequency spills per 10^4well-year	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^4well-year	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^4well-year	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^4well-year	Frequency spills per 10^3years	Spill Index bbl
2010	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep		0.103			0.718			0.308			0.205		
	Total													
2011	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep		0.103			0.718			0.308			0.205		
	Total													
2012	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep		0.103			0.718			0.308			0.205		
	Total													
2013	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep		0.103			0.718			0.308			0.205		
	Total													
2014	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep		0.103			0.718			0.308			0.205		
	Total													
2015	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep		0.103			0.718			0.308			0.205		
	Total													
2016	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep		0.103			0.718			0.308			0.205		
	Total													
2017	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep		0.103			0.718			0.308			0.205		
	Total													
2018	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep		0.103			0.718			0.308			0.205		
	Total													
2019	Shallow	6	0.103	0.062	0.03	0.718	0.431	2.28	0.308	0.185	12.62	0.205	0.123	24.63
	Medium		0.103			0.718			0.308			0.205		
	Deep		0.103			0.718			0.308			0.205		
	Total	6		0.062	0.03		0.431	2.28		0.185	12.62		0.123	24.63
2020	Shallow	12	0.103	0.123	0.06	0.718	0.862	4.56	0.308	0.369	25.25	0.205	0.246	49.25
	Medium		0.103			0.718			0.308			0.205		
	Deep		0.103			0.718			0.308			0.205		
	Total	12		0.123	0.06		0.862	4.56		0.369	25.25		0.246	49.25
2021	Shallow	18	0.103	0.185	0.10	0.718	1.293	6.84	0.308	0.554	37.87	0.205	0.369	73.88
	Medium		0.103			0.718			0.308			0.205		
	Deep		0.103			0.718			0.308			0.205		
	Total	18		0.185	0.10		1.293	6.84		0.554	37.87		0.369	73.88
2022	Shallow	18	0.103	0.185	0.10	0.718	1.293	6.84	0.308	0.554	37.87	0.205	0.369	73.88
	Medium		0.103			0.718			0.308			0.205		
	Deep		0.103			0.718			0.308			0.205		
	Total	18		0.185	0.10		1.293	6.84		0.554	37.87		0.369	73.88
2023	Shallow	18	0.103	0.185	0.10	0.718	1.293	6.84	0.308	0.554	37.87	0.205	0.369	73.88
	Medium		0.103			0.718			0.308			0.205		
	Deep		0.103			0.718			0.308			0.205		
	Total	18		0.185	0.10		1.293	6.84		0.554	37.87		0.369	73.88
2024	Shallow	18	0.103	0.185	0.10	0.718	1.293	6.84	0.308	0.554	37.87	0.205	0.369	73.88
	Medium		0.103			0.718			0.308			0.205		
	Deep		0.103			0.718			0.308			0.205		
	Total	18		0.185	0.10		1.293	6.84		0.554	37.87		0.369	73.88
2025	Shallow	18	0.103	0.185	0.10	0.718	1.293	6.84	0.308	0.554	37.87	0.205	0.369	73.88
	Medium		0.103			0.718			0.308			0.205		
	Deep		0.103			0.718			0.308			0.205		
	Total	18		0.185	0.10		1.293	6.84		0.554	37.87		0.369	73.88
2026	Shallow	18	0.103	0.185	0.10	0.718	1.293	6.84	0.308	0.554	37.87	0.205	0.369	73.88
	Medium		0.103			0.718			0.308			0.205		
	Deep		0.103			0.718			0.308			0.205		
	Total	18		0.185	0.10		1.293	6.84		0.554	37.87		0.369	73.88
2027	Shallow	18	0.103	0.185	0.10	0.718	1.293	6.84	0.308	0.554	37.87	0.205	0.369	73.88
	Medium		0.103			0.718			0.308			0.205		
	Deep		0.103			0.718			0.308			0.205		
	Total	18		0.185	0.10		1.293	6.84		0.554	37.87		0.369	73.88
2028	Shallow	18	0.103	0.185	0.10	0.718	1.293	6.84	0.308	0.554	37.87	0.205	0.369	73.88
	Medium		0.103			0.718			0.308			0.205		
	Deep		0.103			0.718			0.308			0.205		
	Total	18		0.185	0.10		1.293	6.84		0.554	37.87		0.369	73.88

Table 4.1.5
Arctic Spill Occurrence - Low Case - Production Wells

Year	Water Depth	N Wells	Production Wells Blowout											
			Small and Medium Spills 50-999 bbl			Large Spills 1000-9999 bbl			Spills 10000-149999 bbl			Spills =>150000 bbl		
			Expected Spill [bbl] =		**519**	Expected Spill [bbl] =		**5292**	Expected Spill [bbl] =		**68349**	Expected Spill [bbl] =		**200000**
		Cum.	Frequency spills per 10^4 well-year	Frequency spills per 10^3 years	Spill Index bbl	Frequency spills per 10^4 well-year	Frequency spills per 10^3 years	Spill Index bbl	Frequency spills per 10^4 well-year	Frequency spills per 10^3 years	Spill Index bbl	Frequency spills per 10^4 well-year	Frequency spills per 10^3 years	Spill Index bbl
2029	Shallow	18	0.103	0.185	0.10	0.718	1.293	6.84	0.308	0.554	37.87	0.205	0.369	73.88
	Medium		0.103			0.718			0.308			0.205		
	Deep		0.103			0.718			0.308			0.205		
	Total	**18**		0.185	**0.10**		1.293	**6.84**		0.554	**37.87**		0.369	**73.88**
2030	Shallow	18	0.103	0.185	0.10	0.718	1.293	6.84	0.308	0.554	37.87	0.205	0.369	73.88
	Medium		0.103			0.718			0.308			0.205		
	Deep		0.103			0.718			0.308			0.205		
	Total	**18**		0.185	**0.10**		1.293	**6.84**		0.554	**37.87**		0.369	**73.88**
2031	Shallow	18	0.103	0.185	0.10	0.718	1.293	6.84	0.308	0.554	37.87	0.205	0.369	73.88
	Medium		0.103			0.718			0.308			0.205		
	Deep		0.103			0.718			0.308			0.205		
	Total	**18**		0.185	**0.10**		1.293	**6.84**		0.554	**37.87**		0.369	**73.88**
2032	Shallow	18	0.103	0.185	0.10	0.718	1.293	6.84	0.308	0.554	37.87	0.205	0.369	73.88
	Medium		0.103			0.718			0.308			0.205		
	Deep		0.103			0.718			0.308			0.205		
	Total	**18**		0.185	**0.10**		1.293	**6.84**		0.554	**37.87**		0.369	**73.88**
2033	Shallow	18	0.103	0.185	0.10	0.718	1.293	6.84	0.308	0.554	37.87	0.205	0.369	73.88
	Medium		0.103			0.718			0.308			0.205		
	Deep		0.103			0.718			0.308			0.205		
	Total	**18**		0.185	**0.10**		1.293	**6.84**		0.554	**37.87**		0.369	**73.88**
2034	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep		0.103			0.718			0.308			0.205		
	Total													
2035	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep		0.103			0.718			0.308			0.205		
	Total													
2036	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep		0.103			0.718			0.308			0.205		
	Total													
2037	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep		0.103			0.718			0.308			0.205		
	Total													
2038	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep		0.103			0.718			0.308			0.205		
	Total													
2039	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep		0.103			0.718			0.308			0.205		
	Total													

Table 4.1.6
Arctic Spill Occurrence - Low Case - Production Wells - Summary

Year	Production [MMbbl]	Small and Medium Spills 50-99 bbl			Large Spills 1000-9999 bbl			Huge Spills =>10000 bbl			All Spills		
		Frequency Spills per 10^3 years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3 years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3 years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3 years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]
2010													
2011													
2012													
2013													
2014													
2015													
2016													
2017													
2018													
2019	**8.8**	0.062	0.007	0.032	0.185	0.021	2.281	0.308	0.035	37.252	0.554	0.063	39.564
2020	**16.3**	0.123	0.008	0.064	0.369	0.023	4.562	0.616	0.038	74.503	1.108	0.068	79.129
2021	**16.3**	0.185	0.011	0.096	0.554	0.034	6.842	0.924	0.057	111.755	1.662	0.102	118.693
2022	**16.3**	0.185	0.011	0.096	0.554	0.034	6.842	0.924	0.057	111.755	1.662	0.102	118.693
2023	**13.4**	0.185	0.014	0.096	0.554	0.041	6.842	0.924	0.069	111.755	1.662	0.124	118.693
2024	**11.1**	0.185	0.017	0.096	0.554	0.050	6.842	0.924	0.083	111.755	1.662	0.150	118.693
2025	**9.1**	0.185	0.020	0.096	0.554	0.061	6.842	0.924	0.101	111.755	1.662	0.183	118.693
2026	**7.5**	0.185	0.025	0.096	0.554	0.074	6.842	0.924	0.123	111.755	1.662	0.222	118.693
2027	**6.2**	0.185	0.030	0.096	0.554	0.089	6.842	0.924	0.149	111.755	1.662	0.268	118.693
2028	**5.1**	0.185	0.036	0.096	0.554	0.109	6.842	0.924	0.181	111.755	1.662	0.326	118.693
2029	**4.2**	0.185	0.044	0.096	0.554	0.132	6.842	0.924	0.220	111.755	1.662	0.396	118.693
2030	**3.5**	0.185	0.053	0.096	0.554	0.158	6.842	0.924	0.264	111.755	1.662	0.475	118.693
2031	**2.9**	0.185	0.064	0.096	0.554	0.191	6.842	0.924	0.318	111.755	1.662	0.573	118.693
2032	**2.5**	0.185	0.074	0.096	0.554	0.222	6.842	0.924	0.369	111.755	1.662	0.665	118.693
2033	**2.1**	0.185	0.088	0.096	0.554	0.264	6.842	0.924	0.440	111.755	1.662	0.792	118.693
2034													
2035													
2036													
2037													
2038													
2039													

Table 4.1.7
Occurrence Spill Risks - Low Case - Exploration Wells

Year	Water Depth	Exploration Wells Blowout												
		N Wells	Small and Medium Spills 50-999 bbl			Large Spills 1000-9999 bbl			Spills 10000-149999 bbl			Spills =>150000 bbl		
			Expected Spill [bbl] =		519	Expected Spill [bbl] =		5292	Expected Spill [bbl] =		68349	Expected Spill [bbl] =		200000
		Cum.	Frequency spills per 10^4wells	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^4wells	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^4wells	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^4wells	Frequency spills per 10^3years	Spill Index bbl
2010	Shallow	1	1.583	0.158	0.08	11.077	1.108	5.86	4.759	0.476	32.53	2.755	0.276	55.11
	Medium		1.809			12.659			5.439			3.149		
	Deep		2.035			14.242			6.119			3.543		
	Total	**1**		0.158	**0.08**		1.108	**5.86**		0.476	**32.53**		0.276	**55.11**
2011	Shallow	1	1.583	0.158	0.08	11.077	1.108	5.86	4.759	0.476	32.53	2.755	0.276	55.11
	Medium		1.809			12.659			5.439			3.149		
	Deep		2.035			14.242			6.119			3.543		
	Total	**1**		0.158	**0.08**		1.108	**5.86**		0.476	**32.53**		0.276	**55.11**
2012	Shallow		1.583			11.077			4.759			2.755		
	Medium		1.809			12.659			5.439			3.149		
	Deep		2.035			14.242			6.119			3.543		
	Total													
2013	Shallow	1	1.583	0.158	0.08	11.077	1.108	5.86	4.759	0.476	32.53	2.755	0.276	55.11
	Medium		1.809			12.659			5.439			3.149		
	Deep		2.035			14.242			6.119			3.543		
	Total	**1**		0.158	**0.08**		1.108	**5.86**		0.476	**32.53**		0.276	**55.11**
2014	Shallow	1	1.583	0.158	0.08	11.077	1.108	5.86	4.759	0.476	32.53	2.755	0.276	55.11
	Medium		1.809			12.659			5.439			3.149		
	Deep		2.035			14.242			6.119			3.543		
	Total	**1**		0.158	**0.08**		1.108	**5.86**		0.476	**32.53**		0.276	**55.11**
2015	Shallow		1.583			11.077			4.759			2.755		
	Medium		1.809			12.659			5.439			3.149		
	Deep		2.035			14.242			6.119			3.543		
	Total													
2016	Shallow		1.583			11.077			4.759			2.755		
	Medium		1.809			12.659			5.439			3.149		
	Deep		2.035			14.242			6.119			3.543		
	Total													
2017	Shallow		1.583			11.077			4.759			2.755		
	Medium		1.809			12.659			5.439			3.149		
	Deep		2.035			14.242			6.119			3.543		
	Total													
2018	Shallow		1.583			11.077			4.759			2.755		
	Medium		1.809			12.659			5.439			3.149		
	Deep		2.035			14.242			6.119			3.543		
	Total													
2019	Shallow		1.583			11.077			4.759			2.755		
	Medium		1.809			12.659			5.439			3.149		
	Deep		2.035			14.242			6.119			3.543		
	Total													
2020	Shallow		1.583			11.077			4.759			2.755		
	Medium		1.809			12.659			5.439			3.149		
	Deep		2.035			14.242			6.119			3.543		
	Total													
2021	Shallow		1.583			11.077			4.759			2.755		
	Medium		1.809			12.659			5.439			3.149		
	Deep		2.035			14.242			6.119			3.543		
	Total													
2022	Shallow		1.583			11.077			4.759			2.755		
	Medium		1.809			12.659			5.439			3.149		
	Deep		2.035			14.242			6.119			3.543		
	Total													
2023	Shallow		1.583			11.077			4.759			2.755		
	Medium		1.809			12.659			5.439			3.149		
	Deep		2.035			14.242			6.119			3.543		
	Total													
2024	Shallow		1.583			11.077			4.759			2.755		
	Medium		1.809			12.659			5.439			3.149		
	Deep		2.035			14.242			6.119			3.543		
	Total													
2025	Shallow		1.583			11.077			4.759			2.755		
	Medium		1.809			12.659			5.439			3.149		
	Deep		2.035			14.242			6.119			3.543		
	Total													
2026	Shallow		1.583			11.077			4.759			2.755		
	Medium		1.809			12.659			5.439			3.149		
	Deep		2.035			14.242			6.119			3.543		
	Total													
2027	Shallow		1.583			11.077			4.759			2.755		
	Medium		1.809			12.659			5.439			3.149		
	Deep		2.035			14.242			6.119			3.543		
	Total													
2028	Shallow		1.583			11.077			4.759			2.755		
	Medium		1.809			12.659			5.439			3.149		
	Deep		2.035			14.242			6.119			3.543		
	Total													
2029	Shallow		1.583			11.077			4.759			2.755		
	Medium		1.809			12.659			5.439			3.149		
	Deep		2.035			14.242			6.119			3.543		
	Total													
2030	Shallow		1.583			11.077			4.759			2.755		
	Medium		1.809			12.659			5.439			3.149		
	Deep		2.035			14.242			6.119			3.543		
	Total													
2031	Shallow		1.583			11.077			4.759			2.755		
	Medium		1.809			12.659			5.439			3.149		
	Deep		2.035			14.242			6.119			3.543		
	Total													
2032	Shallow		1.583			11.077			4.759			2.755		
	Medium		1.809			12.659			5.439			3.149		
	Deep		2.035			14.242			6.119			3.543		
	Total													
2033	Shallow		1.583			11.077			4.759			2.755		
	Medium		1.809			12.659			5.439			3.149		
	Deep		2.035			14.242			6.119			3.543		
	Total													
2034	Shallow		1.583			11.077			4.759			2.755		
	Medium		1.809			12.659			5.439			3.149		
	Deep		2.035			14.242			6.119			3.543		
	Total													
2035	Shallow		1.583			11.077			4.759			2.755		
	Medium		1.809			12.659			5.439			3.149		
	Deep		2.035			14.242			6.119			3.543		
	Total													

Table 4.1.7
Occurrence Spill Risks - Low Case - Exploration Wells

Year	Water Depth	N Wells	Exploration Wells Blowout											
			Small and Medium Spills 50-999 bbl			Large Spills 1000-9999 bbl			Spills 10000-149999 bbl			Spills =>150000 bbl		
			Expected Spill [bbl] =		**519**	Expected Spill [bbl] =		**5292**	Expected Spill [bbl] =		**68349**	Expected Spill [bbl] =		**200000**
		Cum.	Frequency spills per 10^4wells	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^4wells	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^4wells	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^4wells	Frequency spills per 10^3years	Spill Index bbl
2036	Shallow		1.583			11.077			4.759			2.755		
	Medium		1.809			12.659			5.439			3.149		
	Deep		2.035			14.242			6.119			3.543		
	Total													
2037	Shallow		1.583			11.077			4.759			2.755		
	Medium		1.809			12.659			5.439			3.149		
	Deep		2.035			14.242			6.119			3.543		
	Total													
2038	Shallow		1.583			11.077			4.759			2.755		
	Medium		1.809			12.659			5.439			3.149		
	Deep		2.035			14.242			6.119			3.543		
	Total													
2039	Shallow		1.583			11.077			4.759			2.755		
	Medium		1.809			12.659			5.439			3.149		
	Deep		2.035			14.242			6.119			3.543		
	Total													

Table 4.1.8
Arctic Spill Occurrence - Low Case - Exploration Wells - Summary

Year	Production [MMbbl]	Small and Medium Spills 50-99 bbl			Large Spills 1000-9999 bbl			Huge Spills =>10000 bbl			All Spills		
		Frequency Spills per 10^3 years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3 years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3 years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3 years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]
2010		0.158		0.082	0.476		5.862	0.751		87.639	1.386		93.583
2011		0.158		0.082	0.476		5.862	0.751		87.639	1.386		93.583
2012													
2013		0.158		0.082	0.476		5.862	0.751		87.639	1.386		93.583
2014		0.158		0.082	0.476		5.862	0.751		87.639	1.386		93.583
2015													
2016													
2017													
2018													
2019	8.8												
2020	16.3												
2021	16.3												
2022	16.3												
2023	13.4												
2024	11.1												
2025	9.1												
2026	7.5												
2027	6.2												
2028	5.1												
2029	4.2												
2030	3.5												
2031	2.9												
2032	2.5												
2033	2.1												
2034													
2035													
2036													
2037													
2038													
2039													

Table 4.1.9
Arctic Spill Occurrence Beaufort Sea Low Case Development Wells

Year	Water Depth	N Wells	Development Wells Blowout											
			Small and Medium Spills 50-999 bbl			Large Spills 1000-9999 bbl			Spills 10000-149999 bbl			Spills =>150000 bbl		
			Expected Spill [bbl] =		519	Expected Spill [bbl] =		5292	Expected Spill [bbl] =		68349	Expected Spill [bbl] =		200000
		Cum.	Frequency spills per 10^4wells	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^4wells	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^4wells	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^4wells	Frequency spills per 10^3years	Spill Index bbl
2010	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total													
2011	Shallow	2	0.484	0.097	0.05	3.383	0.677	3.58	1.453	0.291	19.87	1.453	0.291	58.13
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total	**2**		0.097	**0.05**		0.677	**3.58**		0.291	**19.87**		0.291	**58.13**
2012	Shallow	2	0.484	0.097	0.05	3.383	0.677	3.58	1.453	0.291	19.87	1.453	0.291	58.13
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total	**2**		0.097	**0.05**		0.677	**3.58**		0.291	**19.87**		0.291	**58.13**
2013	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total													
2014	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total													
2015	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total													
2016	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total													
2017	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total													
2018	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total													
2019	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total													
2020	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total													
2021	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total													
2022	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total													
2023	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total													
2024	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total													
2025	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total													
2026	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total													
2027	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total													
2028	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total													
2029	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total													
2030	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total													
2031	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total													
2032	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total													
2033	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total													
2034	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total													
2035	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total													

Table 4.1.9
Arctic Spill Occurrence Beaufort Sea Low Case Development Wells

Year	Water Depth	N Wells	Development Wells Blowout											
			Small and Medium Spills 50-999 bbl			Large Spills 1000-9999 bbl			Spills 10000-149999 bbl			Spills =>150000 bbl		
			Expected Spill [bbl] =		519	Expected Spill [bbl] =		5292	Expected Spill [bbl] =		68349	Expected Spill [bbl] =		200000
		Cum.	Frequency spills per 10^4wells	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^4wells	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^4wells	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^4wells	Frequency spills per 10^3years	Spill Index bbl
2036	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total													
2037	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total													
2038	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total													
2039	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total													

Table 4.1.10
Arctic Spill Occurrence - Low Case - Development Wells - Summary

Year	Production [MMbbl]	Small and Medium Spills 50-99 bbl			Large Spills 1000-9999 bbl			Huge Spills =>10000 bbl			All Spills		
		Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]
2010													
2011		0.097		0.050	0.291		3.581	0.581		77.994	0.969		81.626
2012		0.097		0.050	0.291		3.581	0.581		77.994	0.969		81.626
2013													
2014													
2015													
2016													
2017													
2018													
2019	8.8												
2020	16.3												
2021	16.3												
2022	16.3												
2023	13.4												
2024	11.1												
2025	9.1												
2026	7.5												
2027	6.2												
2028	5.1												
2029	4.2												
2030	3.5												
2031	2.9												
2032	2.5												
2033	2.1												
2034													
2035													
2036													
2037													
2038													
2039													

Table 4.1.11
Arctic Spill Occurrence - Low Case - Wells - Summary

Year	Production [MMbbl]	Small and Medium Spills 50-999 bbl			Large Spills 1000-9999 bbl			Huge Spills =>10000 bbl			Significant Spills =>1000 bbl			All Spills		
		Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 103years	Frequency Spills per 109 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]
2010		0.158		0.082	0.476		5.862	0.751		87.639	1.227		93.501	1.386		93.583
2011		0.255		0.133	0.767		9.443	1.333		165.633	2.099		175.077	2.355		175.209
2012		0.097		0.050	0.291		3.581	0.581		77.994	0.872		81.575	0.969		81.626
2013		0.158		0.082	0.476		5.862	0.751		87.639	1.227		93.501	1.386		93.583
2014		0.158		0.082	0.476		5.862	0.751		87.639	1.227		93.501	1.386		93.583
2015																
2016																
2017																
2018																
2019	**8.8**	0.062	0.007	0.032	0.185	0.021	2.281	0.308	0.035	37.252	0.493	0.056	39.532	0.554	0.063	39.564
2020	**16.3**	0.123	0.008	0.064	0.369	0.023	4.562	0.616	0.038	74.503	0.985	0.060	79.065	1.108	0.068	79.129
2021	**16.3**	0.185	0.011	0.096	0.554	0.034	6.842	0.924	0.057	111.755	1.478	0.091	118.597	1.662	0.102	118.693
2022	**16.3**	0.185	0.011	0.096	0.554	0.034	6.842	0.924	0.057	111.755	1.478	0.091	118.597	1.662	0.102	118.693
2023	**13.4**	0.185	0.014	0.096	0.554	0.041	6.842	0.924	0.069	111.755	1.478	0.110	118.597	1.662	0.124	118.693
2024	**11.1**	0.185	0.017	0.096	0.554	0.050	6.842	0.924	0.083	111.755	1.478	0.133	118.597	1.662	0.150	118.693
2025	**9.1**	0.185	0.020	0.096	0.554	0.061	6.842	0.924	0.101	111.755	1.478	0.162	118.597	1.662	0.183	118.693
2026	**7.5**	0.185	0.025	0.096	0.554	0.074	6.842	0.924	0.123	111.755	1.478	0.197	118.597	1.662	0.222	118.693
2027	**6.2**	0.185	0.030	0.096	0.554	0.089	6.842	0.924	0.149	111.755	1.478	0.238	118.597	1.662	0.268	118.693
2028	**5.1**	0.185	0.036	0.096	0.554	0.109	6.842	0.924	0.181	111.755	1.478	0.290	118.597	1.662	0.326	118.693
2029	**4.2**	0.185	0.044	0.096	0.554	0.132	6.842	0.924	0.220	111.755	1.478	0.352	118.597	1.662	0.396	118.693
2030	**3.5**	0.185	0.053	0.096	0.554	0.158	6.842	0.924	0.264	111.755	1.478	0.422	118.597	1.662	0.475	118.693
2031	**2.9**	0.185	0.064	0.096	0.554	0.191	6.842	0.924	0.318	111.755	1.478	0.510	118.597	1.662	0.573	118.693
2032	**2.5**	0.185	0.074	0.096	0.554	0.222	6.842	0.924	0.369	111.755	1.478	0.591	118.597	1.662	0.665	118.693
2033	**2.1**	0.185	0.088	0.096	0.554	0.264	6.842	0.924	0.440	111.755	1.478	0.704	118.597	1.662	0.792	118.693
2034																
2035																
2036																
2037																
2038																
2039																
Total LOF	**125.3**	**3.413**		**2**	**10.243**		**126**	**17.098**		**2071**	**27.340**		**2198**	**30.753**		**2199**
Average LOF		**0.142**	**0.027**	**0**	**0.427**	**0.082**	**5**	**0.712**	**0.136**	**86**	**1.139**	**0.218**	**92**	**1.281**	**0.245**	**92**

Table 4.1.12
Arctic Spill Occurrence - Low Case - Summary

Year	Facility	Production [MMbbl]	Small and Medium Spills 50-999 bbl			Large Spills 1000-9999 bbl			Huge Spills =>10000 bbl			All Spills		
			Frequency Spills per 10^3 years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3 years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3 years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3 years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]
2010	Pipeline													
	Platforms													
	Production Wells													
	Exploration Wells		0.158		0.082	0.476		5.862	0.751		87.639	1.386		93.583
	Development Wells													
	Total		0.158		0.082	0.476		5.862	0.751		87.639	1.386		93.583
2011	Pipeline													
	Platforms													
	Production Wells													
	Exploration Wells		0.158		0.082	0.476		5.862	0.751		87.639	1.386		93.583
	Development Wells		0.097		0.050	0.291		3.581	0.581		77.994	0.969		81.626
	Total		0.255		0.133	0.767		9.443	1.333		165.633	2.355		175.209
2012	Pipeline													
	Platforms													
	Production Wells													
	Exploration Wells													
	Development Wells		0.097		0.050	0.291		3.581	0.581		77.994	0.969		81.626
	Total		0.097		0.050	0.291		3.581	0.581		77.994	0.969		81.626
2013	Pipeline													
	Platforms													
	Production Wells													
	Exploration Wells		0.158		0.082	0.476		5.862	0.751		87.639	1.386		93.583
	Development Wells													
	Total		0.158		0.082	0.476		5.862	0.751		87.639	1.386		93.583
2014	Pipeline													
	Platforms													
	Production Wells													
	Exploration Wells		0.158		0.082	0.476		5.862	0.751		87.639	1.386		93.583
	Development Wells													
	Total		0.158		0.082	0.476		5.862	0.751		87.639	1.386		93.583
2015	Pipeline													
	Platforms													
	Production Wells													
	Exploration Wells													
	Development Wells													
	Total													
2016	Pipeline													
	Platforms													
	Production Wells													
	Exploration Wells													
	Development Wells													
	Total													
2017	Pipeline		2.960		1.103	0.952		4.926	0.325		5.060	4.237		11.090
	Platforms													
	Production Wells													
	Exploration Wells													
	Development Wells													
	Total		2.960		1.103	0.952		4.926	0.325		5.060	4.237		11.090
2018	Pipeline		4.440		1.655	1.428		7.389	0.488		7.591	6.356		16.634
	Platforms													
	Production Wells													
	Exploration Wells													
	Development Wells													
	Total		4.440		1.655	1.428		7.389	0.488		7.591	6.356		16.634
2019	Pipeline	8.8	4.440	0.505	1.655	1.428	0.162	7.389	0.488	0.055	7.591	6.356	0.722	16.634
	Platforms		1.832	0.208	0.828	0.117	0.013	0.658	0.117	0.013	0.658	2.066	0.235	2.144
	Production Wells		0.062	0.007	0.032	0.185	0.021	2.281	0.308	0.035	37.252	0.554	0.063	39.564
	Exploration Wells													
	Development Wells													
	Total		6.334	0.720	2.515	1.729	0.196	10.328	0.913	0.104	45.500	8.976	1.020	58.343
2020	Pipeline	16.3	4.440	0.272	1.655	1.428	0.088	7.389	0.488	0.030	7.591	6.356	0.390	16.634
	Platforms		3.664	0.225	1.656	0.234	0.014	1.316	0.234	0.014	1.316	4.131	0.253	4.288
	Production Wells		0.123	0.008	0.064	0.369	0.023	4.562	0.616	0.038	74.503	1.108	0.068	79.129
	Exploration Wells													
	Development Wells													
	Total		8.227	0.505	3.375	2.031	0.125	13.267	1.338	0.082	83.410	11.595	0.711	100.051
2021	Pipeline	16.3	4.440	0.272	1.655	1.428	0.088	7.389	0.488	0.030	7.591	6.356	0.390	16.634
	Platforms		5.496	0.337	2.484	0.351	0.022	1.974	0.351	0.022	1.974	6.197	0.380	6.432
	Production Wells		0.185	0.011	0.096	0.554	0.034	6.842	0.924	0.057	111.755	1.662	0.102	118.693
	Exploration Wells													
	Development Wells													
	Total		10.121	0.621	4.234	2.332	0.143	16.206	1.762	0.108	121.320	14.215	0.872	141.760
2022	Pipeline	16.3	4.440	0.272	1.655	1.428	0.088	7.389	0.488	0.030	7.591	6.356	0.390	16.634
	Platforms		5.496	0.337	2.484	0.351	0.022	1.974	0.351	0.022	1.974	6.197	0.380	6.432
	Production Wells		0.185	0.011	0.096	0.554	0.034	6.842	0.924	0.057	111.755	1.662	0.102	118.693
	Exploration Wells													
	Development Wells													
	Total		10.121	0.621	4.234	2.332	0.143	16.206	1.762	0.108	121.320	14.215	0.872	141.760
2023	Pipeline	13.4	4.440	0.331	1.655	1.428	0.107	7.389	0.488	0.036	7.591	6.356	0.474	16.634
	Platforms		5.496	0.410	2.484	0.351	0.026	1.974	0.351	0.026	1.974	6.197	0.462	6.432
	Production Wells		0.185	0.014	0.096	0.554	0.041	6.842	0.924	0.069	111.755	1.662	0.124	118.693
	Exploration Wells													
	Development Wells													
	Total		10.121	0.755	4.234	2.332	0.174	16.206	1.762	0.132	121.320	14.215	1.061	141.760
2024	Pipeline	11.1	4.440	0.400	1.655	1.428	0.129	7.389	0.488	0.044	7.591	6.356	0.573	16.634
	Platforms		5.496	0.495	2.484	0.351	0.032	1.974	0.351	0.032	1.974	6.197	0.558	6.432
	Production Wells		0.185	0.017	0.096	0.554	0.050	6.842	0.924	0.083	111.755	1.662	0.150	118.693
	Exploration Wells													
	Development Wells													
	Total		10.121	0.912	4.234	2.332	0.210	16.206	1.762	0.159	121.320	14.215	1.281	141.760
2025	Pipeline	9.1	4.440	0.488	1.655	1.428	0.157	7.389	0.488	0.054	7.591	6.356	0.698	16.634
	Platforms		5.496	0.604	2.484	0.351	0.039	1.974	0.351	0.039	1.974	6.197	0.681	6.432
	Production Wells		0.185	0.020	0.096	0.554	0.061	6.842	0.924	0.101	111.755	1.662	0.183	118.693
	Exploration Wells													
	Development Wells													
	Total		10.121	1.112	4.234	2.332	0.256	16.206	1.762	0.194	121.320	14.215	1.562	141.760
2026	Pipeline	7.5	4.440	0.592	1.655	1.428	0.190	7.389	0.488	0.065	7.591	6.356	0.847	16.634
	Platforms		5.496	0.733	2.484	0.351	0.047	1.974	0.351	0.047	1.974	6.197	0.826	6.432
	Production Wells		0.185	0.025	0.096	0.554	0.074	6.842	0.924	0.123	111.755	1.662	0.222	118.693
	Exploration Wells													
	Development Wells													
	Total		10.121	1.349	4.234	2.332	0.311	16.206	1.762	0.235	121.320	14.215	1.895	141.760

Table 4.1.12
Arctic Spill Occurrence - Low Case - Summary

Year	Facility	Production [MMbbl]	Small and Medium Spills 50-999 bbl			Large Spills 1000-9999 bbl			Huge Spills =>10000 bbl			All Spills		
			Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]
2027	Pipeline	6.2	4.440	0.716	1.655	1.428	0.230	7.389	0.488	0.079	7.591	6.356	1.025	16.634
	Platforms		5.496	0.886	2.484	0.351	0.057	1.974	0.351	0.057	1.974	6.197	1.000	6.432
	Production Wells		0.185	0.030	0.096	0.554	0.089	6.842	0.924	0.149	111.755	1.662	0.268	118.693
	Exploration Wells													
	Development Wells													
	Total		10.121	1.632	4.234	2.332	0.376	16.206	1.762	0.284	121.320	14.215	2.293	141.760
2028	Pipeline	5.1	4.440	0.871	1.655	1.428	0.280	7.389	0.488	0.096	7.591	6.356	1.246	16.634
	Platforms		5.496	1.078	2.484	0.351	0.069	1.974	0.351	0.069	1.974	6.197	1.215	6.432
	Production Wells		0.185	0.036	0.096	0.554	0.109	6.842	0.924	0.181	111.755	1.662	0.326	118.693
	Exploration Wells													
	Development Wells													
	Total		10.121	1.984	4.234	2.332	0.457	16.206	1.762	0.346	121.320	14.215	2.787	141.760
2029	Pipeline	4.2	4.440	1.057	1.655	1.428	0.340	7.389	0.488	0.116	7.591	6.356	1.513	16.634
	Platforms		5.496	1.309	2.484	0.351	0.083	1.974	0.351	0.083	1.974	6.197	1.475	6.432
	Production Wells		0.185	0.044	0.096	0.554	0.132	6.842	0.924	0.220	111.755	1.662	0.396	118.693
	Exploration Wells													
	Development Wells													
	Total		10.121	2.410	4.234	2.332	0.555	16.206	1.762	0.420	121.320	14.215	3.385	141.760
2030	Pipeline	3.5	4.440	1.269	1.655	1.428	0.408	7.389	0.488	0.139	7.591	6.356	1.816	16.634
	Platforms		5.496	1.570	2.484	0.351	0.100	1.974	0.351	0.100	1.974	6.197	1.771	6.432
	Production Wells		0.185	0.053	0.096	0.554	0.158	6.842	0.924	0.264	111.755	1.662	0.475	118.693
	Exploration Wells													
	Development Wells													
	Total		10.121	2.892	4.234	2.332	0.666	16.206	1.762	0.503	121.320	14.215	4.061	141.760
2031	Pipeline	2.9	4.440	1.531	1.655	1.428	0.492	7.389	0.488	0.168	7.591	6.356	2.192	16.634
	Platforms		5.496	1.895	2.484	0.351	0.121	1.974	0.351	0.121	1.974	6.197	2.137	6.432
	Production Wells		0.185	0.064	0.096	0.554	0.191	6.842	0.924	0.318	111.755	1.662	0.573	118.693
	Exploration Wells													
	Development Wells													
	Total		10.121	3.490	4.234	2.332	0.804	16.206	1.762	0.608	121.320	14.215	4.902	141.760
2032	Pipeline	2.5	4.440	1.776	1.655	1.428	0.571	7.389	0.488	0.195	7.591	6.356	2.542	16.634
	Platforms		5.496	2.198	2.484	0.351	0.140	1.974	0.351	0.140	1.974	6.197	2.479	6.432
	Production Wells		0.185	0.074	0.096	0.554	0.222	6.842	0.924	0.369	111.755	1.662	0.665	118.693
	Exploration Wells													
	Development Wells													
	Total		10.121	4.048	4.234	2.332	0.933	16.206	1.762	0.705	121.320	14.215	5.686	141.760
2033	Pipeline	2.1	4.440	2.114	1.655	1.428	0.680	7.389	0.488	0.232	7.591	6.356	3.027	16.634
	Platforms		5.496	2.617	2.484	0.351	0.167	1.974	0.351	0.167	1.974	6.197	2.951	6.432
	Production Wells		0.185	0.088	0.096	0.554	0.264	6.842	0.924	0.440	111.755	1.662	0.792	118.693
	Exploration Wells													
	Development Wells													
	Total		10.121	4.819	4.234	2.332	1.111	16.206	1.762	0.839	121.320	14.215	6.769	141.760
2034	Pipeline													
	Platforms													
	Production Wells													
	Exploration Wells													
	Development Wells													
	Total													
2035	Pipeline													
	Platforms													
	Production Wells													
	Exploration Wells													
	Development Wells													
	Total													
2036	Pipeline													
	Platforms													
	Production Wells													
	Exploration Wells													
	Development Wells													
	Total													
2037	Pipeline													
	Platforms													
	Production Wells													
	Exploration Wells													
	Development Wells													
	Total													
2038	Pipeline													
	Platforms													
	Production Wells													
	Exploration Wells													
	Development Wells													
	Total													
2039	Pipeline													
	Platforms													
	Production Wells													
	Exploration Wells													
	Development Wells													
	Total													

Table 4.1.13
Arctic Spill Occurrence - Low Case - Annual Summary

Year	Production [MMbbl]	Small and Medium Spills 50-999 bbl			Large Spills 1000-9999 bbl			Huge Spills =>10000 bbl			Significant Spills =>1000 bbl			All Spills		
		Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 103years	Frequency Spills per 109 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]
2010		0.158		0.082	0.476		5.862	0.751		87.639	1.227		93.501	1.386		93.583
2011		0.255		0.133	0.767		9.443	1.333		165.633	2.099		175.077	2.355		175.209
2012		0.097		0.050	0.291		3.581	0.581		77.994	0.872		81.575	0.969		81.626
2013		0.158		0.082	0.476		5.862	0.751		87.639	1.227		93.501	1.386		93.583
2014		0.158		0.082	0.476		5.862	0.751		87.639	1.227		93.501	1.386		93.583
2015																
2016																
2017		2.960		1.103	0.952		4.926	0.325		5.060	1.277		9.986	4.237		11.090
2018		4.440		1.655	1.428		7.389	0.488		7.591	1.916		14.980	6.356		16.634
2019	**8.8**	6.334	0.720	2.515	1.729	0.196	10.328	0.913	0.104	45.500	2.642	0.300	55.828	8.976	1.020	58.343
2020	**16.3**	8.227	0.505	3.375	2.031	0.125	13.267	1.338	0.082	83.410	3.368	0.207	96.677	11.595	0.711	100.051
2021	**16.3**	10.121	0.621	4.234	2.332	0.143	16.206	1.762	0.108	121.320	4.095	0.251	137.525	14.215	0.872	141.760
2022	**16.3**	10.121	0.621	4.234	2.332	0.143	16.206	1.762	0.108	121.320	4.095	0.251	137.525	14.215	0.872	141.760
2023	**13.4**	10.121	0.755	4.234	2.332	0.174	16.206	1.762	0.132	121.320	4.095	0.306	137.525	14.215	1.061	141.760
2024	**11.1**	10.121	0.912	4.234	2.332	0.210	16.206	1.762	0.159	121.320	4.095	0.369	137.525	14.215	1.281	141.760
2025	**9.1**	10.121	1.112	4.234	2.332	0.256	16.206	1.762	0.194	121.320	4.095	0.450	137.525	14.215	1.562	141.760
2026	**7.5**	10.121	1.349	4.234	2.332	0.311	16.206	1.762	0.235	121.320	4.095	0.546	137.525	14.215	1.895	141.760
2027	**6.2**	10.121	1.632	4.234	2.332	0.376	16.206	1.762	0.284	121.320	4.095	0.660	137.525	14.215	2.293	141.760
2028	**5.1**	10.121	1.984	4.234	2.332	0.457	16.206	1.762	0.346	121.320	4.095	0.803	137.525	14.215	2.787	141.760
2029	**4.2**	10.121	2.410	4.234	2.332	0.555	16.206	1.762	0.420	121.320	4.095	0.975	137.525	14.215	3.385	141.760
2030	**3.5**	10.121	2.892	4.234	2.332	0.666	16.206	1.762	0.503	121.320	4.095	1.170	137.525	14.215	4.061	141.760
2031	**2.9**	10.121	3.490	4.234	2.332	0.804	16.206	1.762	0.608	121.320	4.095	1.412	137.525	14.215	4.902	141.760
2032	**2.5**	10.121	4.048	4.234	2.332	0.933	16.206	1.762	0.705	121.320	4.095	1.638	137.525	14.215	5.686	141.760
2033	**2.1**	10.121	4.819	4.234	2.332	1.111	16.206	1.762	0.839	121.320	4.095	1.950	137.525	14.215	6.769	141.760
2034																
2035																
2036																
2037																
2038																
2039																
Total LOF	**125.3**	**154.355**		**64**	**38.945**		**277**	**30.141**		**2225**	**69.086**		**2502**	**223.441**		**2567**
Average LOF		**6.431**	**1.232**	**3**	**1.623**	**0.311**	**12**	**1.256**	**0.241**	**93**	**2.879**	**0.551**	**104**	**9.310**	**1.783**	**107**

Table 4.1.14
Low Case - Year 2030 - Monte Carlo Results

Frequency – Spills per 10^3 years

Low Case Year 2030	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills
Mean =	10.13	2.33	1.76	4.09	14.22
Std Deviation =	4.26	0.83	0.46	1.05	4.38
Variance =	18.126	0.683	0.211	1.102	19.204
Skewness =	0.56	0.60	0.27	0.36	0.52
Kurtosis =	2.93	3.15	2.90	3.06	2.93
Mode =	3.98	1.03	1.02	4.33	12.13
Minimum =	1.135	0.387	0.334	1.060	3.798
5% Perc =	4.023	1.166	1.056	2.499	7.891
10% Perc =	4.964	1.348	1.181	2.798	8.905
15% Perc =	5.715	1.486	1.281	3.002	9.686
20% Perc =	6.317	1.603	1.358	3.182	10.365
25% Perc =	6.918	1.716	1.436	3.336	10.960
30% Perc =	7.477	1.823	1.503	3.483	11.546
35% Perc =	7.996	1.927	1.563	3.627	12.079
40% Perc =	8.499	2.024	1.621	3.766	12.604
45% Perc =	9.017	2.125	1.680	3.903	13.139
50% Perc =	9.557	2.229	1.739	4.039	13.678
55% Perc =	10.141	2.337	1.798	4.175	14.268
60% Perc =	10.761	2.441	1.859	4.312	14.871
65% Perc =	11.365	2.558	1.924	4.444	15.528
70% Perc =	12.115	2.697	1.997	4.598	16.302
75% Perc =	12.895	2.851	2.067	4.760	17.020
80% Perc =	13.784	3.032	2.148	4.949	17.931
85% Perc =	14.834	3.217	2.252	5.181	19.028
90% Perc =	16.100	3.466	2.374	5.476	20.317
95% Perc =	17.945	3.834	2.551	5.943	22.270
Maximum =	27.201	5.830	3.673	8.595	32.153

Frequency – Spills per 10^9 bbl Produced

Low Case Year 2030	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills
Mean =	2.89	0.67	0.50	1.17	4.06
Std Deviation =	1.22	0.24	0.13	0.30	1.25
Variance =	1.480	0.056	0.017	0.090	1.568
Skewness =	0.56	0.60	0.27	0.36	0.52
Kurtosis =	2.93	3.15	2.90	3.06	2.93
Mode =	1.14	0.46	0.29	1.01	2.72
Minimum =	0.324	0.111	0.095	0.303	1.085
5% Perc =	1.150	0.333	0.302	0.714	2.255
10% Perc =	1.418	0.385	0.337	0.799	2.544
15% Perc =	1.633	0.425	0.366	0.858	2.767
20% Perc =	1.805	0.458	0.388	0.909	2.961
25% Perc =	1.976	0.490	0.410	0.953	3.131
30% Perc =	2.136	0.521	0.429	0.995	3.299
35% Perc =	2.284	0.551	0.447	1.036	3.451
40% Perc =	2.428	0.578	0.463	1.076	3.601
45% Perc =	2.576	0.607	0.480	1.115	3.754
50% Perc =	2.731	0.637	0.497	1.154	3.908
55% Perc =	2.898	0.668	0.514	1.193	4.076
60% Perc =	3.075	0.697	0.531	1.232	4.249
65% Perc =	3.247	0.731	0.550	1.270	4.437
70% Perc =	3.461	0.771	0.570	1.314	4.658
75% Perc =	3.684	0.815	0.591	1.360	4.863
80% Perc =	3.938	0.866	0.614	1.414	5.123
85% Perc =	4.238	0.919	0.643	1.480	5.436
90% Perc =	4.600	0.990	0.678	1.565	5.805
95% Perc =	5.127	1.095	0.729	1.698	6.363
Maximum =	7.772	1.666	1.049	2.456	9.187

Spill Index [bbl]

Low Case Year 2030	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills
Mean =	4.22	16.19	121.48	137.67	141.89
Std Deviation =	2.89	7.65	44.85	45.57	45.65
Variance =	8.336	58.473	2011.889	2076.418	2084.285
Skewness =	1.41	0.85	0.50	0.48	0.48
Kurtosis =	5.66	3.98	3.28	3.25	3.25
Mode =	5.44	8.37	101.82	115.30	133.89
Minimum =	-0.293	-1.017	11.540	22.391	23.664
5% Perc =	0.917	5.820	54.033	69.235	73.114
10% Perc =	1.272	7.411	66.526	82.176	86.090
15% Perc =	1.572	8.683	75.463	91.280	95.110
20% Perc =	1.847	9.647	82.925	98.602	102.549
25% Perc =	2.125	10.535	89.417	104.946	109.037
30% Perc =	2.384	11.442	95.284	111.047	115.132
35% Perc =	2.638	12.393	100.979	116.819	121.176
40% Perc =	2.917	13.244	106.550	122.820	126.946
45% Perc =	3.218	14.144	112.338	128.403	132.799
50% Perc =	3.544	15.008	117.767	134.006	137.953
55% Perc =	3.876	16.010	123.567	139.704	143.764
60% Perc =	4.223	17.009	129.446	145.940	150.149
65% Perc =	4.608	18.123	135.796	152.226	156.183
70% Perc =	5.079	19.360	141.981	158.664	163.272
75% Perc =	5.581	20.637	148.923	166.283	170.733
80% Perc =	6.237	22.156	157.571	174.814	179.202
85% Perc =	7.003	23.872	168.125	184.680	188.934
90% Perc =	8.102	26.594	180.620	198.013	202.335
95% Perc =	9.967	30.191	200.713	217.877	222.213
Maximum =	24.368	62.031	321.285	347.610	355.904

Table 4.1.15
Low Case LOF Average - Pipeline - Monte Carlo Results

Low Case Pipeline	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills
All years Average LOF	Frequency Spills per 10^3years				
Mean =	3.08	0.99	0.34	1.33	4.41
Std Deviation =	1.44	0.52	0.20	0.56	1.55
Variance =	2.080	0.275	0.041	0.317	2.398
Skewness =	0.49	0.74	0.86	0.64	0.43
Kurtosis =	2.65	3.23	3.40	3.17	2.76
Mode =	2.62	0.89	0.23	1.22	2.12
Minimum =	0.234	0.013	0.014	0.142	0.647
5% Perc =	1.023	0.290	0.083	0.541	2.125
10% Perc =	1.320	0.375	0.110	0.658	2.514
15% Perc =	1.564	0.450	0.135	0.747	2.785
20% Perc =	1.768	0.518	0.157	0.823	3.029
25% Perc =	1.963	0.584	0.178	0.901	3.255
30% Perc =	2.149	0.646	0.201	0.975	3.446
35% Perc =	2.325	0.703	0.224	1.040	3.633
40% Perc =	2.514	0.769	0.245	1.113	3.832
45% Perc =	2.696	0.835	0.271	1.182	4.048
50% Perc =	2.894	0.904	0.297	1.254	4.261
55% Perc =	3.099	0.975	0.325	1.332	4.471
60% Perc =	3.334	1.056	0.358	1.412	4.691
65% Perc =	3.556	1.138	0.393	1.493	4.934
70% Perc =	3.788	1.225	0.427	1.588	5.184
75% Perc =	4.074	1.321	0.464	1.683	5.450
80% Perc =	4.359	1.433	0.507	1.792	5.763
85% Perc =	4.711	1.558	0.559	1.936	6.135
90% Perc =	5.149	1.716	0.628	2.106	6.565
95% Perc =	5.692	1.972	0.726	2.367	7.181
Maximum =	8.083	3.345	1.234	3.987	10.769

Low Case Pipeline	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills
All years Average LOF	Frequency Spills per 10^9 bbl Produced				
Mean =	0.59	0.19	0.06	0.25	0.85
Std Deviation =	0.28	0.10	0.04	0.11	0.30
Variance =	0.076	0.010	0.002	0.012	0.088
Skewness =	0.49	0.74	0.86	0.64	0.43
Kurtosis =	2.65	3.23	3.40	3.17	2.76
Mode =	0.27	0.18	0.03	0.17	0.41
Minimum =	0.045	0.002	0.003	0.027	0.124
5% Perc =	0.196	0.056	0.016	0.104	0.407
10% Perc =	0.253	0.072	0.021	0.126	0.481
15% Perc =	0.300	0.086	0.026	0.143	0.533
20% Perc =	0.339	0.099	0.030	0.158	0.580
25% Perc =	0.376	0.112	0.034	0.173	0.623
30% Perc =	0.412	0.124	0.038	0.187	0.660
35% Perc =	0.445	0.135	0.043	0.199	0.696
40% Perc =	0.481	0.147	0.047	0.213	0.734
45% Perc =	0.516	0.160	0.052	0.226	0.775
50% Perc =	0.554	0.173	0.057	0.240	0.816
55% Perc =	0.594	0.187	0.062	0.255	0.856
60% Perc =	0.639	0.202	0.069	0.270	0.899
65% Perc =	0.681	0.218	0.075	0.286	0.945
70% Perc =	0.726	0.235	0.082	0.304	0.993
75% Perc =	0.780	0.253	0.089	0.322	1.044
80% Perc =	0.835	0.275	0.097	0.343	1.104
85% Perc =	0.902	0.298	0.107	0.371	1.175
90% Perc =	0.986	0.329	0.120	0.403	1.257
95% Perc =	1.090	0.378	0.139	0.453	1.375
Maximum =	1.548	0.641	0.236	0.764	2.063

Low Case Pipeline	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills
All years Average LOF	Spill Index [bbl]				
Mean =	1.15	5.11	5.26	10.37	11.53
Std Deviation =	0.96	4.02	3.37	5.23	5.32
Variance =	0.924	16.196	11.343	27.388	28.277
Skewness =	1.50	1.42	1.05	0.91	0.88
Kurtosis =	5.57	5.58	3.98	4.02	3.98
Mode =	1.02	2.17	2.50	6.42	7.88
Minimum =	-0.123	-1.387	0.219	0.308	0.683
5% Perc =	0.153	0.596	1.215	3.466	4.426
10% Perc =	0.229	1.086	1.636	4.405	5.405
15% Perc =	0.299	1.447	1.988	5.166	6.182
20% Perc =	0.365	1.794	2.346	5.819	6.894
25% Perc =	0.438	2.186	2.669	6.465	7.546
30% Perc =	0.518	2.506	3.017	7.050	8.213
35% Perc =	0.595	2.865	3.349	7.682	8.813
40% Perc =	0.680	3.265	3.711	8.270	9.451
45% Perc =	0.778	3.632	4.073	8.926	10.074
50% Perc =	0.883	4.034	4.488	9.542	10.701
55% Perc =	0.984	4.518	4.939	10.199	11.384
60% Perc =	1.102	5.045	5.406	10.921	12.058
65% Perc =	1.244	5.594	5.928	11.656	12.885
70% Perc =	1.408	6.285	6.554	12.447	13.724
75% Perc =	1.588	7.089	7.192	13.348	14.605
80% Perc =	1.821	7.928	7.929	14.426	15.699
85% Perc =	2.092	9.085	8.815	15.741	16.959
90% Perc =	2.481	10.578	9.969	17.462	18.721
95% Perc =	3.111	13.111	11.864	20.137	21.427
Maximum =	6.332	32.735	22.827	38.795	41.700

Table 4.1.16
Low Case LOF Average - Platforms - Monte Carlo Results

Low Case Platforms	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills
All years Average LOF	**Frequency Spills per 10^3 years**					**Frequency Spills per 10^9 bbl Produced**					**Spill Index [bbl]**				
Mean =	3.21	0.20	0.20	0.41	3.62	0.61	0.04	0.04	0.08	0.69	1.44	1.15	1.15	2.30	3.74
Std Deviation =	2.15	0.13	0.13	0.27	2.17	0.41	0.03	0.03	0.05	0.41	1.49	1.00	1.00	2.00	2.50
Variance =	4.623	0.018	0.018	0.070	4.688	0.170	0.001	0.001	0.003	0.172	2.219	0.996	0.996	3.983	6.228
Skewness =	0.73	0.73	0.73	0.73	0.71	0.73	0.73	0.73	0.73	0.71	1.84	1.38	1.38	1.38	1.09
Kurtosis =	2.88	2.92	2.92	2.92	2.85	2.88	2.92	2.92	2.92	2.85	7.09	5.12	5.12	5.12	4.30
Mode =	3.19	0.14	0.14	0.29	1.54	0.55	0.02	0.02	0.03	0.30	0.53	0.92	0.92	1.83	4.00
Minimum =	0.069	0.006	0.006	0.012	0.171	0.013	0.001	0.001	0.002	0.033	-0.383	-0.419	-0.419	-0.838	-0.521
5% Perc =	0.488	0.037	0.037	0.074	0.841	0.094	0.007	0.007	0.014	0.161	0.072	0.091	0.091	0.182	0.718
10% Perc =	0.718	0.051	0.051	0.103	1.130	0.138	0.010	0.010	0.020	0.216	0.150	0.177	0.177	0.354	1.030
15% Perc =	0.958	0.066	0.066	0.131	1.370	0.184	0.013	0.013	0.025	0.262	0.219	0.251	0.251	0.502	1.315
20% Perc =	1.187	0.079	0.079	0.158	1.607	0.227	0.015	0.015	0.030	0.308	0.301	0.322	0.322	0.644	1.587
25% Perc =	1.438	0.095	0.095	0.191	1.834	0.275	0.018	0.018	0.037	0.351	0.386	0.396	0.396	0.791	1.832
30% Perc =	1.690	0.111	0.111	0.223	2.093	0.324	0.021	0.021	0.043	0.401	0.479	0.477	0.477	0.954	2.096
35% Perc =	1.939	0.127	0.127	0.253	2.370	0.371	0.024	0.024	0.048	0.454	0.585	0.559	0.559	1.118	2.366
40% Perc =	2.212	0.144	0.144	0.288	2.616	0.424	0.028	0.028	0.055	0.501	0.697	0.657	0.657	1.314	2.613
45% Perc =	2.490	0.162	0.162	0.323	2.897	0.477	0.031	0.031	0.062	0.555	0.815	0.754	0.754	1.509	2.897
50% Perc =	2.786	0.179	0.179	0.358	3.205	0.534	0.034	0.034	0.069	0.614	0.940	0.861	0.861	1.722	3.211
55% Perc =	3.100	0.199	0.199	0.399	3.513	0.594	0.038	0.038	0.076	0.673	1.083	0.981	0.981	1.961	3.530
60% Perc =	3.457	0.220	0.220	0.440	3.867	0.662	0.042	0.042	0.084	0.741	1.256	1.121	1.121	2.243	3.879
65% Perc =	3.811	0.242	0.242	0.485	4.233	0.730	0.046	0.046	0.093	0.811	1.468	1.274	1.274	2.548	4.252
70% Perc =	4.184	0.265	0.265	0.531	4.614	0.801	0.051	0.051	0.102	0.884	1.706	1.446	1.446	2.892	4.657
75% Perc =	4.641	0.294	0.294	0.587	5.070	0.889	0.056	0.056	0.112	0.971	1.994	1.645	1.645	3.289	5.136
80% Perc =	5.125	0.321	0.321	0.641	5.542	0.982	0.061	0.061	0.123	1.062	2.326	1.879	1.879	3.758	5.702
85% Perc =	5.621	0.353	0.353	0.707	6.063	1.077	0.068	0.068	0.135	1.161	2.815	2.171	2.171	4.341	6.326
90% Perc =	6.319	0.397	0.397	0.794	6.760	1.210	0.076	0.076	0.152	1.295	3.466	2.569	2.569	5.137	7.223
95% Perc =	7.306	0.456	0.456	0.913	7.721	1.399	0.087	0.087	0.175	1.479	4.523	3.152	3.152	6.304	8.556
Maximum =	11.886	0.736	0.736	1.472	12.022	2.277	0.141	0.141	0.282	2.303	11.608	7.478	7.478	14.956	16.749

Table 4.1.17
Low Case LOF Average - Wells - Monte Carlo Results

Low Case Wells	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills
All years Average LOF	Frequency Spills per 10^3years					Frequency Spills per 10^9 bbl Produced					Spill Index [bbl]				
Mean =	0.14	0.43	0.71	1.14	1.28	0.03	0.08	0.14	0.22	0.25	0.07	5.26	86.29	91.55	91.63
Std Deviation =	0.05	0.14	0.17	0.29	0.29	0.01	0.03	0.03	0.06	0.06	0.05	3.28	29.93	30.10	30.10
Variance =	0.002	0.019	0.027	0.084	0.086	0.000	0.001	0.001	0.003	0.003	0.002	10.790	896.061	905.798	905.797
Skewness =	0.01	-0.01	0.00	0.00	0.00	0.01	-0.01	0.00	0.00	0.00	0.70	0.78	0.50	0.49	0.49
Kurtosis =	2.52	2.50	2.71	2.58	2.61	2.52	2.50	2.71	2.58	2.61	3.37	3.46	3.17	3.17	3.17
Mode =	0.10	0.38	0.45	1.02	1.24	0.02	0.07	0.09	0.20	0.24	0.10	2.83	92.68	103.47	112.84
Minimum =	0.021	0.042	0.208	0.314	0.391	0.004	0.008	0.040	0.060	0.075	-0.036	-1.124	14.525	16.847	16.899
5% Perc =	0.065	0.196	0.440	0.659	0.795	0.013	0.037	0.084	0.126	0.152	0.006	0.815	41.983	47.037	47.059
10% Perc =	0.080	0.245	0.496	0.755	0.899	0.015	0.047	0.095	0.145	0.172	0.016	1.427	49.768	54.811	54.913
15% Perc =	0.092	0.276	0.537	0.829	0.969	0.018	0.053	0.103	0.159	0.186	0.024	1.932	55.246	60.482	60.548
20% Perc =	0.102	0.302	0.570	0.886	1.022	0.020	0.058	0.109	0.170	0.196	0.031	2.398	60.206	65.133	65.203
25% Perc =	0.110	0.329	0.597	0.933	1.076	0.021	0.063	0.114	0.179	0.206	0.038	2.797	64.283	69.611	69.684
30% Perc =	0.117	0.352	0.623	0.979	1.119	0.022	0.068	0.119	0.188	0.214	0.044	3.172	68.471	73.806	73.907
35% Perc =	0.124	0.371	0.647	1.024	1.163	0.024	0.071	0.124	0.196	0.223	0.050	3.612	72.305	77.733	77.782
40% Perc =	0.130	0.390	0.669	1.061	1.202	0.025	0.075	0.128	0.203	0.230	0.056	3.970	76.148	81.418	81.497
45% Perc =	0.136	0.408	0.691	1.100	1.241	0.026	0.078	0.132	0.211	0.238	0.062	4.362	79.827	85.205	85.313
50% Perc =	0.142	0.426	0.714	1.138	1.279	0.027	0.082	0.137	0.218	0.245	0.068	4.745	83.624	88.896	88.949
55% Perc =	0.148	0.445	0.735	1.177	1.319	0.028	0.085	0.141	0.226	0.253	0.074	5.167	87.510	92.600	92.684
60% Perc =	0.154	0.464	0.755	1.215	1.359	0.030	0.089	0.145	0.233	0.260	0.080	5.628	91.363	96.623	96.697
65% Perc =	0.160	0.482	0.777	1.257	1.399	0.031	0.092	0.149	0.241	0.268	0.087	6.093	95.622	100.954	101.034
70% Perc =	0.167	0.503	0.800	1.300	1.444	0.032	0.096	0.153	0.249	0.277	0.095	6.617	100.282	105.567	105.637
75% Perc =	0.175	0.525	0.827	1.343	1.489	0.033	0.101	0.158	0.257	0.285	0.103	7.227	105.286	110.379	110.452
80% Perc =	0.183	0.550	0.855	1.394	1.538	0.035	0.105	0.164	0.267	0.295	0.113	7.867	110.996	116.420	116.503
85% Perc =	0.192	0.578	0.888	1.451	1.596	0.037	0.111	0.170	0.278	0.306	0.125	8.729	117.570	122.953	123.051
90% Perc =	0.203	0.608	0.928	1.525	1.669	0.039	0.116	0.178	0.292	0.320	0.140	9.861	126.489	131.789	131.841
95% Perc =	0.219	0.655	0.985	1.617	1.765	0.042	0.125	0.189	0.310	0.338	0.164	11.476	139.783	145.525	145.575
Maximum =	0.270	0.821	1.216	1.979	2.163	0.052	0.157	0.233	0.379	0.414	0.295	20.953	221.107	230.858	230.863

Table 4.1.18
Low Case LOF Average Platforms + Wells - Monte Carlo Results

Low Case Platforms + Wells	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills
All years Average LOF	**Frequency Spills per 10^3 years**				
Mean =	3.35	0.63	0.92	1.55	4.90
Std Deviation =	2.15	0.19	0.21	0.39	2.19
Variance =	4.629	0.037	0.045	0.156	4.776
Skewness =	0.73	0.24	0.18	0.23	0.69
Kurtosis =	2.88	2.88	2.90	2.89	2.85
Mode =	3.01	0.47	0.72	1.11	2.52
Minimum =	0.126	0.104	0.281	0.443	1.033
5% Perc =	0.639	0.328	0.581	0.934	2.056
10% Perc =	0.858	0.387	0.647	1.043	2.386
15% Perc =	1.091	0.428	0.696	1.131	2.647
20% Perc =	1.329	0.463	0.734	1.205	2.887
25% Perc =	1.582	0.495	0.766	1.267	3.131
30% Perc =	1.829	0.523	0.798	1.326	3.388
35% Perc =	2.082	0.551	0.827	1.380	3.647
40% Perc =	2.356	0.576	0.859	1.435	3.914
45% Perc =	2.627	0.601	0.885	1.488	4.197
50% Perc =	2.936	0.624	0.908	1.534	4.485
55% Perc =	3.246	0.648	0.936	1.582	4.802
60% Perc =	3.606	0.673	0.966	1.635	5.140
65% Perc =	3.954	0.700	0.996	1.690	5.525
70% Perc =	4.340	0.729	1.027	1.749	5.932
75% Perc =	4.777	0.758	1.062	1.809	6.364
80% Perc =	5.271	0.793	1.096	1.883	6.818
85% Perc =	5.761	0.833	1.137	1.964	7.336
90% Perc =	6.454	0.884	1.193	2.062	8.044
95% Perc =	7.429	0.963	1.278	2.226	9.036
Maximum =	12.062	1.383	1.816	3.199	13.403

Low Case Platforms + Wells	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills
All years Average LOF	**Frequency Spills per 10^9 bbl Produced**				
Mean =	0.64	0.12	0.18	0.30	0.94
Std Deviation =	0.41	0.04	0.04	0.08	0.42
Variance =	0.170	0.001	0.002	0.006	0.175
Skewness =	0.73	0.24	0.18	0.23	0.69
Kurtosis =	2.88	2.88	2.90	2.89	2.85
Mode =	0.64	0.09	0.16	0.24	0.81
Minimum =	0.024	0.020	0.054	0.085	0.198
5% Perc =	0.122	0.063	0.111	0.179	0.394
10% Perc =	0.164	0.074	0.124	0.200	0.457
15% Perc =	0.209	0.082	0.133	0.217	0.507
20% Perc =	0.255	0.089	0.141	0.231	0.553
25% Perc =	0.303	0.095	0.147	0.243	0.600
30% Perc =	0.350	0.100	0.153	0.254	0.649
35% Perc =	0.399	0.106	0.158	0.264	0.698
40% Perc =	0.451	0.110	0.164	0.275	0.750
45% Perc =	0.503	0.115	0.169	0.285	0.804
50% Perc =	0.562	0.119	0.174	0.294	0.859
55% Perc =	0.622	0.124	0.179	0.303	0.920
60% Perc =	0.691	0.129	0.185	0.313	0.985
65% Perc =	0.757	0.134	0.191	0.324	1.058
70% Perc =	0.831	0.140	0.197	0.335	1.136
75% Perc =	0.915	0.145	0.203	0.346	1.219
80% Perc =	1.010	0.152	0.210	0.361	1.306
85% Perc =	1.103	0.160	0.218	0.376	1.405
90% Perc =	1.236	0.169	0.228	0.395	1.541
95% Perc =	1.423	0.184	0.245	0.426	1.731
Maximum =	2.310	0.265	0.348	0.613	2.567

Low Case Platforms + Wells	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills
All years Average LOF	**Spill Index [bbl]**				
Mean =	1.51	6.42	87.44	93.86	95.37
Std Deviation =	1.49	3.43	29.94	30.15	30.18
Variance =	2.222	11.778	896.560	908.771	910.660
Skewness =	1.84	0.72	0.50	0.49	0.49
Kurtosis =	7.08	3.39	3.17	3.17	3.17
Mode =	3.29	4.41	66.47	71.44	104.95
Minimum =	-0.319	-0.449	14.774	17.345	22.676
5% Perc =	0.139	1.636	43.049	49.441	51.128
10% Perc =	0.221	2.376	50.939	57.148	58.514
15% Perc =	0.295	2.924	56.467	62.818	64.287
20% Perc =	0.377	3.406	61.258	67.523	68.765
25% Perc =	0.461	3.888	65.515	71.954	73.433
30% Perc =	0.555	4.305	69.571	75.913	77.587
35% Perc =	0.660	4.705	73.531	79.787	81.203
40% Perc =	0.770	5.103	77.289	83.712	85.227
45% Perc =	0.890	5.511	81.040	87.655	89.004
50% Perc =	1.013	5.922	84.797	91.218	92.698
55% Perc =	1.155	6.364	88.657	94.925	96.590
60% Perc =	1.327	6.835	92.601	99.084	100.531
65% Perc =	1.542	7.328	96.729	103.156	104.808
70% Perc =	1.781	7.861	101.406	107.964	109.439
75% Perc =	2.069	8.437	106.501	112.817	114.494
80% Perc =	2.402	9.185	112.045	118.852	120.325
85% Perc =	2.884	10.058	118.749	125.305	126.819
90% Perc =	3.532	11.160	127.680	134.293	136.121
95% Perc =	4.594	12.868	140.846	147.425	149.076
Maximum =	11.643	23.433	225.273	239.190	240.213

Table 4.1.19
Low Case LOF Average - Monte Carlo Results

Low Case	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills
All years Average LOF	Frequency Spills per 10^3 years					Frequency Spills per 10^9 bbl Produced					Spill Index [bbl]				
Mean =	6.43	1.62	1.26	2.88	9.31	1.23	0.31	0.24	0.55	1.78	2.67	11.52	92.71	104.23	106.90
Std Deviation =	2.59	0.56	0.29	0.69	2.68	0.50	0.11	0.06	0.13	0.51	1.77	5.26	30.11	30.57	30.62
Variance =	6.687	0.312	0.086	0.473	7.172	0.245	0.011	0.003	0.017	0.263	3.125	27.713	906.887	934.462	937.334
Skewness =	0.50	0.61	0.35	0.36	0.46	0.50	0.61	0.35	0.36	0.46	1.31	0.79	0.49	0.47	0.47
Kurtosis =	2.89	3.19	3.16	3.01	2.88	2.89	3.19	3.16	3.01	2.88	5.13	3.83	3.17	3.16	3.16
Mode =	4.55	1.14	1.01	2.06	5.58	0.87	0.22	0.19	0.41	1.07	2.21	7.02	99.75	77.06	82.42
Minimum =	0.615	0.356	0.389	0.952	2.567	0.118	0.068	0.074	0.182	0.492	-0.080	0.118	20.832	28.859	29.761
5% Perc =	2.650	0.834	0.805	1.826	5.370	0.508	0.160	0.154	0.350	1.029	0.634	4.163	47.729	58.140	60.934
10% Perc =	3.253	0.951	0.896	2.024	6.007	0.623	0.182	0.172	0.388	1.151	0.829	5.332	56.129	66.831	69.573
15% Perc =	3.716	1.047	0.955	2.164	6.502	0.712	0.200	0.183	0.414	1.245	1.018	6.261	61.565	72.613	75.309
20% Perc =	4.117	1.130	1.005	2.275	6.926	0.789	0.216	0.192	0.436	1.327	1.190	7.020	66.377	77.790	80.412
25% Perc =	4.466	1.203	1.052	2.376	7.314	0.855	0.230	0.201	0.455	1.401	1.364	7.669	70.660	82.288	85.013
30% Perc =	4.830	1.270	1.094	2.479	7.679	0.925	0.243	0.209	0.475	1.471	1.528	8.362	74.852	86.304	88.911
35% Perc =	5.163	1.339	1.128	2.572	8.052	0.989	0.257	0.216	0.493	1.542	1.696	9.007	78.660	90.197	92.916
40% Perc =	5.514	1.409	1.165	2.658	8.373	1.056	0.270	0.223	0.509	1.604	1.864	9.613	82.655	94.163	96.807
45% Perc =	5.829	1.480	1.202	2.740	8.694	1.116	0.284	0.230	0.525	1.665	2.050	10.188	86.233	97.810	100.554
50% Perc =	6.162	1.547	1.238	2.828	9.043	1.180	0.296	0.237	0.542	1.732	2.253	10.797	89.897	101.552	104.214
55% Perc =	6.513	1.626	1.275	2.919	9.389	1.248	0.311	0.244	0.559	1.798	2.457	11.453	94.022	105.396	108.015
60% Perc =	6.885	1.706	1.311	3.014	9.760	1.319	0.327	0.251	0.577	1.869	2.682	12.132	97.900	109.600	112.383
65% Perc =	7.258	1.788	1.351	3.108	10.129	1.390	0.342	0.259	0.595	1.940	2.927	12.884	102.247	113.734	116.361
70% Perc =	7.686	1.881	1.397	3.215	10.598	1.472	0.360	0.268	0.616	2.030	3.220	13.741	107.010	118.330	120.938
75% Perc =	8.138	1.984	1.445	3.330	11.069	1.559	0.380	0.277	0.638	2.120	3.557	14.616	111.865	123.362	126.115
80% Perc =	8.623	2.088	1.498	3.457	11.596	1.652	0.400	0.287	0.662	2.221	3.934	15.621	117.300	129.327	131.998
85% Perc =	9.220	2.214	1.564	3.592	12.205	1.766	0.424	0.299	0.688	2.338	4.437	16.833	124.040	136.243	139.040
90% Perc =	10.012	2.378	1.642	3.783	13.015	1.918	0.455	0.315	0.725	2.493	5.085	18.564	133.164	145.347	148.001
95% Perc =	11.120	2.638	1.758	4.081	14.133	2.130	0.505	0.337	0.782	2.707	6.144	21.317	146.262	158.916	161.914
Maximum =	15.955	4.126	2.424	5.890	19.474	3.056	0.790	0.464	1.128	3.730	12.554	38.610	237.052	253.174	254.915

Table 4.1.20
Composition of Spill Indicators - Low Case - Year 2030

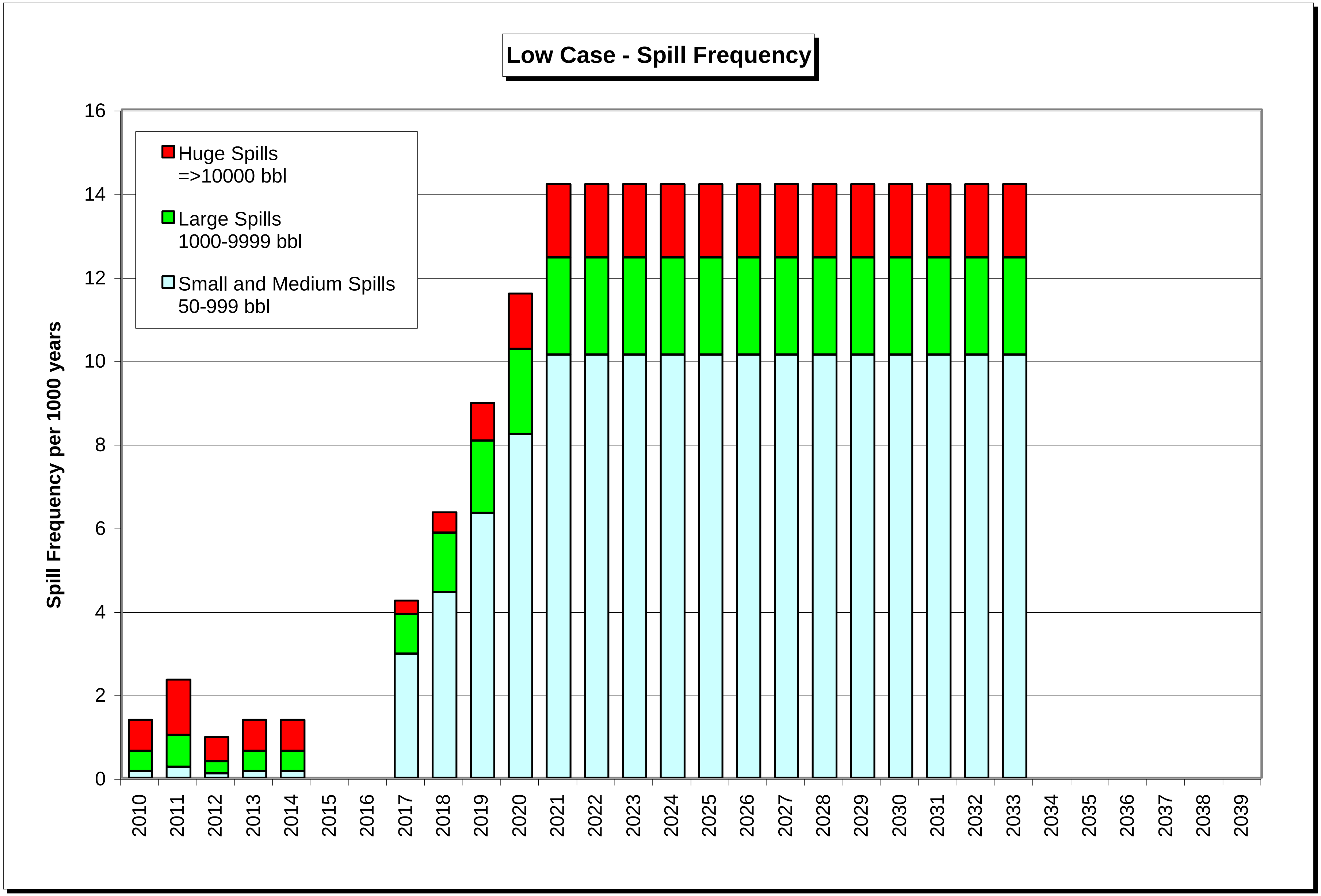
Spill Size	Spill Source									
	P/L		Platforms		Wells		Platforms and Wells		All	
	Low Case - Year 2030 Spill Frequency per 10^3 years									
Small and Medium Spills 50-999 bbl	4.440	70%	5.496	89%	0.185	11%	5.681	72%	10.121	71%
Large Spills 1000-9999 bbl	1.428	22%	0.351	6%	0.554	33%	0.905	12%	2.332	16%
Huge Spills =>10000 bbl	0.488	8%	0.351	6%	0.924	56%	1.274	16%	1.762	12%
Significant Spills =>1000 bbl	1.916	30%	0.701	11%	1.478	89%	2.179	28%	4.095	29%
All Spills	**6.356**	**100%**	**6.197**	**100%**	**1.662**	**100%**	**7.859**	**100%**	**14.215**	**100%**
	Low Case - Year 2030 Spill Frequency per 10^9 bbl produced									
Small and Medium Spills 50-999 bbl	1.269	70%	1.570	89%	0.053	11%	1.623	72%	2.892	71%
Large Spills 1000-9999 bbl	0.408	22%	0.100	6%	0.158	33%	0.258	12%	0.666	16%
Huge Spills =>10000 bbl	0.139	8%	0.100	6%	0.264	56%	0.364	16%	0.503	12%
Significant Spills =>1000 bbl	0.547	30%	0.200	11%	0.422	89%	0.623	28%	1.170	29%
All Spills	**1.816**	**100%**	**1.771**	**100%**	**0.475**	**100%**	**2.246**	**100%**	**4.061**	**100%**
	Low Case - Year 2030 Spill Index [bbl]									
Small and Medium Spills 50-999 bbl	2	10%	2	39%	0	0%	3	2%	4	3%
Large Spills 1000-9999 bbl	7	44%	2	31%	7	6%	9	7%	16	11%
Huge Spills =>10000 bbl	8	46%	2	31%	112	94%	114	91%	121	86%
Significant Spills =>1000 bbl	15	90%	4	61%	119	100%	123	98%	138	97%
All Spills	**17**	**100%**	**6**	**100%**	**119**	**100%**	**125**	**100%**	**142**	**100%**

Spill Source	Spill Size									
	S+M 50-999 bbl		Large 1000-9999 bbl		Huge =>10000 bbl		Significant =>1000 bbl		All Spills	
	Low Case - Year 2030 Spill Frequency per 10^3 years									
P/L	4.440	44%	1.428	61%	0.488	28%	1.916	47%	6.356	45%
Platforms	5.496	54%	0.351	15%	0.351	20%	0.701	17%	6.197	44%
Wells	0.185	2%	0.554	24%	0.924	52%	1.478	36%	1.662	12%
Platforms and Wells	5.681	56%	0.905	39%	1.274	72%	2.179	53%	7.859	55%
All	**10.121**	**100%**	**2.332**	**100%**	**1.762**	**100%**	**4.095**	**100%**	**14.215**	**100%**
	Low Case - Year 2030 Spill Frequency per 10^9 bbl produced									
P/L	1.269	44%	0.408	61%	0.139	28%	0.547	47%	1.816	45%
Platforms	1.570	54%	0.100	15%	0.100	20%	0.200	17%	1.771	44%
Wells	0.053	2%	0.158	24%	0.264	52%	0.422	36%	0.475	12%
Platforms and Wells	1.623	56%	0.258	39%	0.364	72%	0.623	53%	2.246	55%
All	**2.892**	**100%**	**0.666**	**100%**	**0.503**	**100%**	**1.170**	**100%**	**4.061**	**100%**
	Low Case - Year 2030 Spill Index [bbl]									
P/L	2	39%	7	46%	8	6%	15	11%	17	12%
Platforms	2	59%	2	12%	2	2%	4	3%	6	5%
Wells	0	2%	7	42%	112	92%	119	86%	119	84%
Platforms and Wells	3	61%	9	54%	114	94%	123	89%	125	88%
All	**4**	**100%**	**16**	**100%**	**121**	**100%**	**138**	**100%**	**142**	**100%**

Table 4.1.21
Composition of Spill Indicators - LOw Case - LOF Average

Spill Size	Spill Source									
	P/L		Platforms		Wells		Platforms and Wells		All	
	Low Case - LOF Average Spill Frequency per 10^3 years									
Small and Medium Spills 50-999 bbl	3.083	70%	3.206	89%	0.142	11%	3.348	68%	6.431	69%
Large Spills 1000-9999 bbl	0.991	22%	0.205	6%	0.427	33%	0.631	13%	1.623	17%
Huge Spills =>10000 bbl	0.339	8%	0.205	6%	0.712	56%	0.917	19%	1.256	13%
Significant Spills =>1000 bbl	1.330	30%	0.409	11%	1.139	89%	1.548	32%	2.879	31%
All Spills	**4.414**	**100%**	**3.615**	**100%**	**1.281**	**100%**	**4.896**	**100%**	**9.310**	**100%**
	Low Case - LOF Average Spill Frequency per 10^9 bbl produced									
Small and Medium Spills 50-999 bbl	0.591	70%	0.614	89%	0.027	11%	0.641	68%	1.232	69%
Large Spills 1000-9999 bbl	0.190	22%	0.039	6%	0.082	33%	0.121	13%	0.311	17%
Huge Spills =>10000 bbl	0.065	8%	0.039	6%	0.136	56%	0.176	19%	0.241	13%
Significant Spills =>1000 bbl	0.255	30%	0.078	11%	0.218	89%	0.297	32%	0.551	31%
All Spills	**0.845**	**100%**	**0.692**	**100%**	**0.245**	**100%**	**0.938**	**100%**	**1.783**	**100%**
	Low Case - LOF Average Spill Index [bbl]									
Small and Medium Spills 50-999 bbl	1	10%	1	39%	0	0%	2	2%	3	2%
Large Spills 1000-9999 bbl	5	44%	1	31%	5	6%	6	7%	12	11%
Huge Spills =>10000 bbl	5	46%	1	31%	86	94%	87	92%	93	87%
Significant Spills =>1000 bbl	10	90%	2	61%	92	100%	94	98%	104	98%
All Spills	**12**	**100%**	**4**	**100%**	**92**	**100%**	**95**	**100%**	**107**	**100%**

Spill Source	Spill Size									
	S+M 50-999 bbl		Large 1000-9999 bbl		Huge =>10000 bbl		Significant =>1000 bbl		All Spills	
	Low Case - LOF Average Spill Frequency per 10^3 years									
P/L	3.083	48%	0.991	61%	0.339	27%	1.330	46%	4.414	47%
Platforms	3.206	50%	0.205	13%	0.205	16%	0.409	14%	3.615	39%
Wells	0.142	2%	0.427	26%	0.712	57%	1.139	40%	1.281	14%
Platforms and Wells	3.348	52%	0.631	39%	0.917	73%	1.548	54%	4.896	53%
All	**6.431**	**100%**	**1.623**	**100%**	**1.256**	**100%**	**2.879**	**100%**	**9.310**	**100%**
	Low Case - LOF Average Spill Frequency per 10^9 bbl produced									
P/L	0.591	48%	0.190	61%	0.065	27%	0.255	46%	0.845	47%
Platforms	0.614	50%	0.039	13%	0.039	16%	0.078	14%	0.692	39%
Wells	0.027	2%	0.082	26%	0.136	57%	0.218	40%	0.245	14%
Platforms and Wells	0.641	52%	0.121	39%	0.176	73%	0.297	54%	0.938	53%
All	**1.232**	**100%**	**0.311**	**100%**	**0.241**	**100%**	**0.551**	**100%**	**1.783**	**100%**
	Low Case - LOF Average Spill Index [bbl]									
P/L	1	43%	5	44%	5	6%	10	10%	12	11%
Platforms	1	54%	1	10%	1	1%	2	2%	4	4%
Wells	0	3%	5	46%	86	93%	92	88%	92	86%
Platforms and Wells	2	57%	6	56%	87	94%	94	90%	95	89%
All	**3**	**100%**	**12**	**100%**	**93**	**100%**	**104**	**100%**	**107**	**100%**



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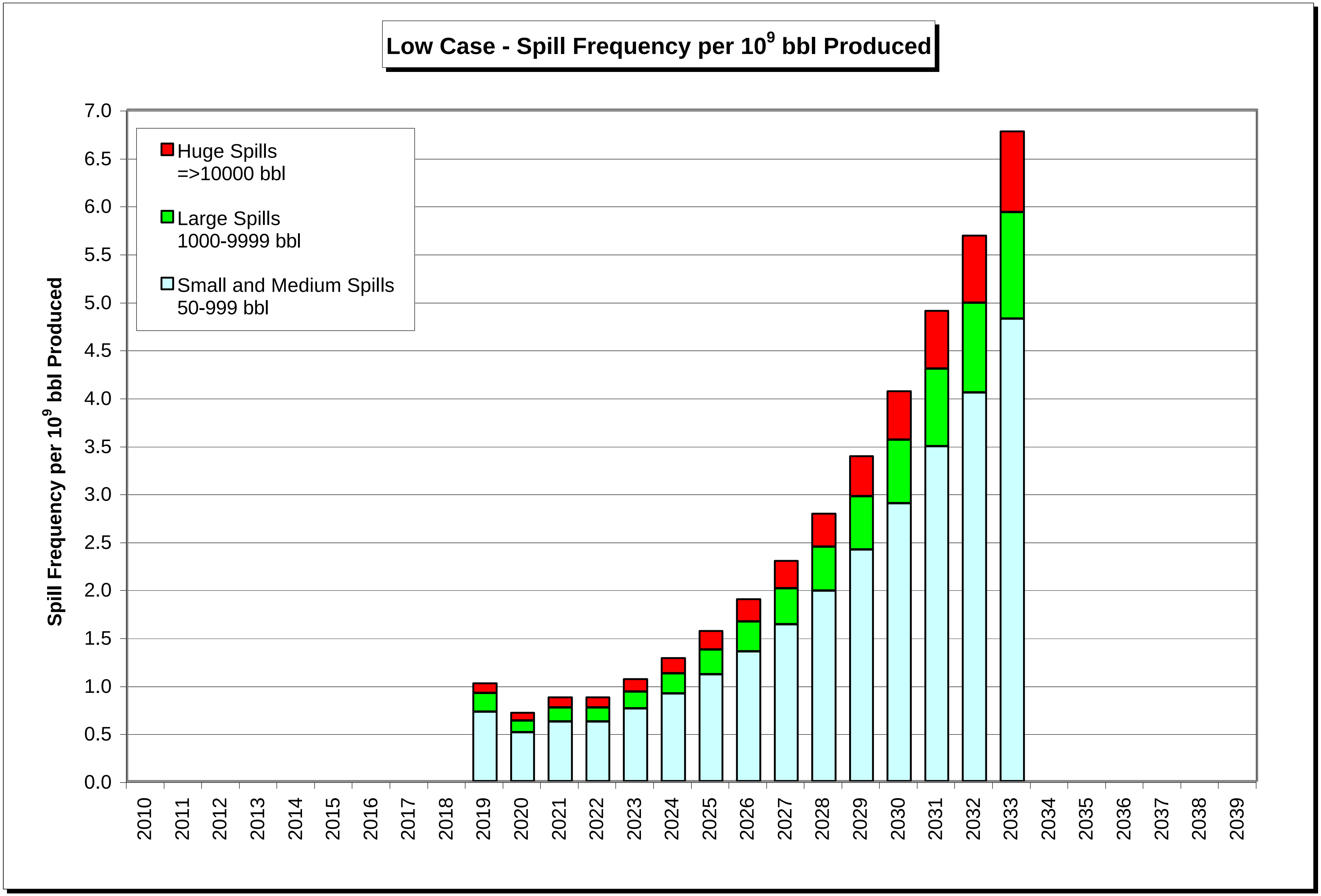

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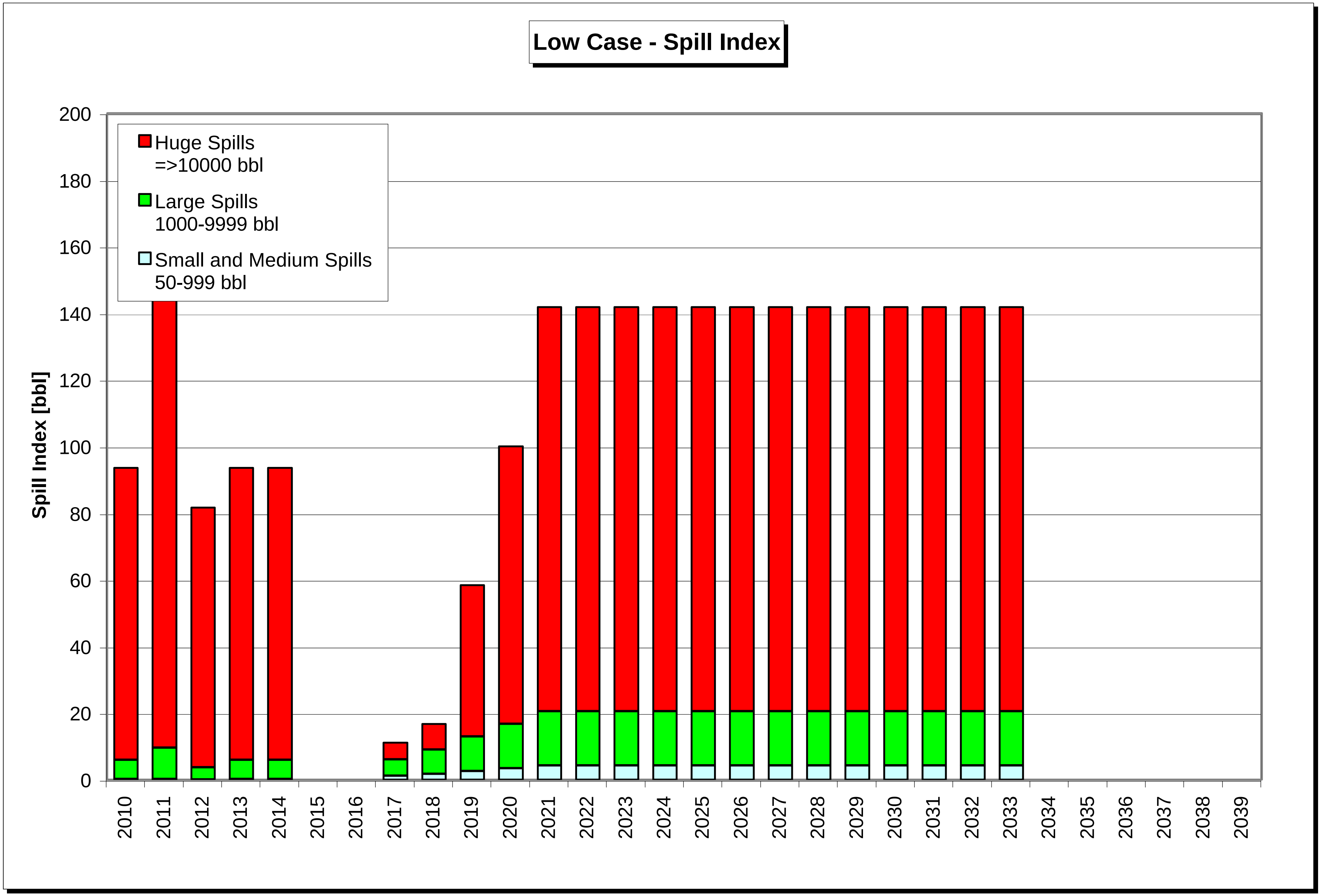

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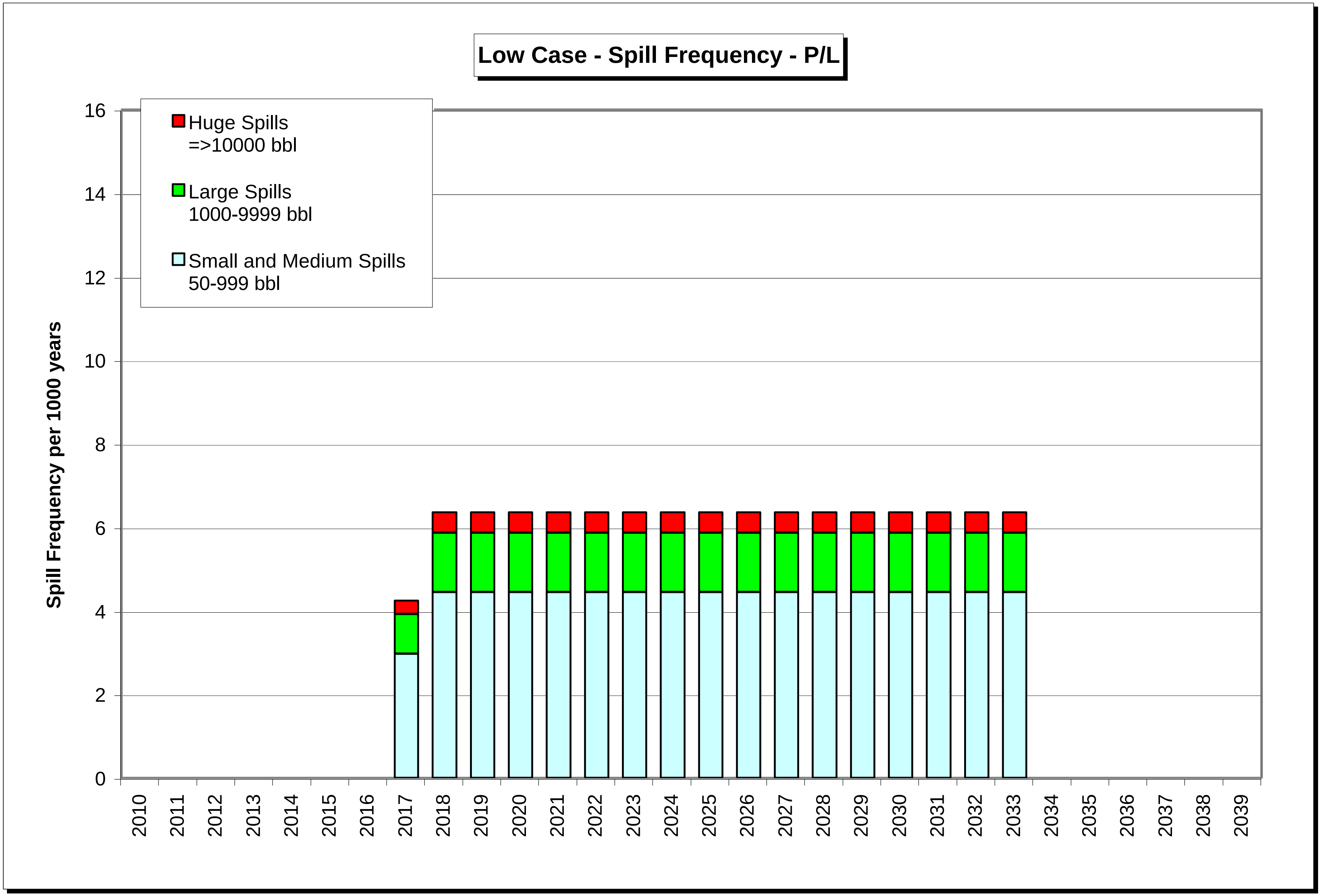

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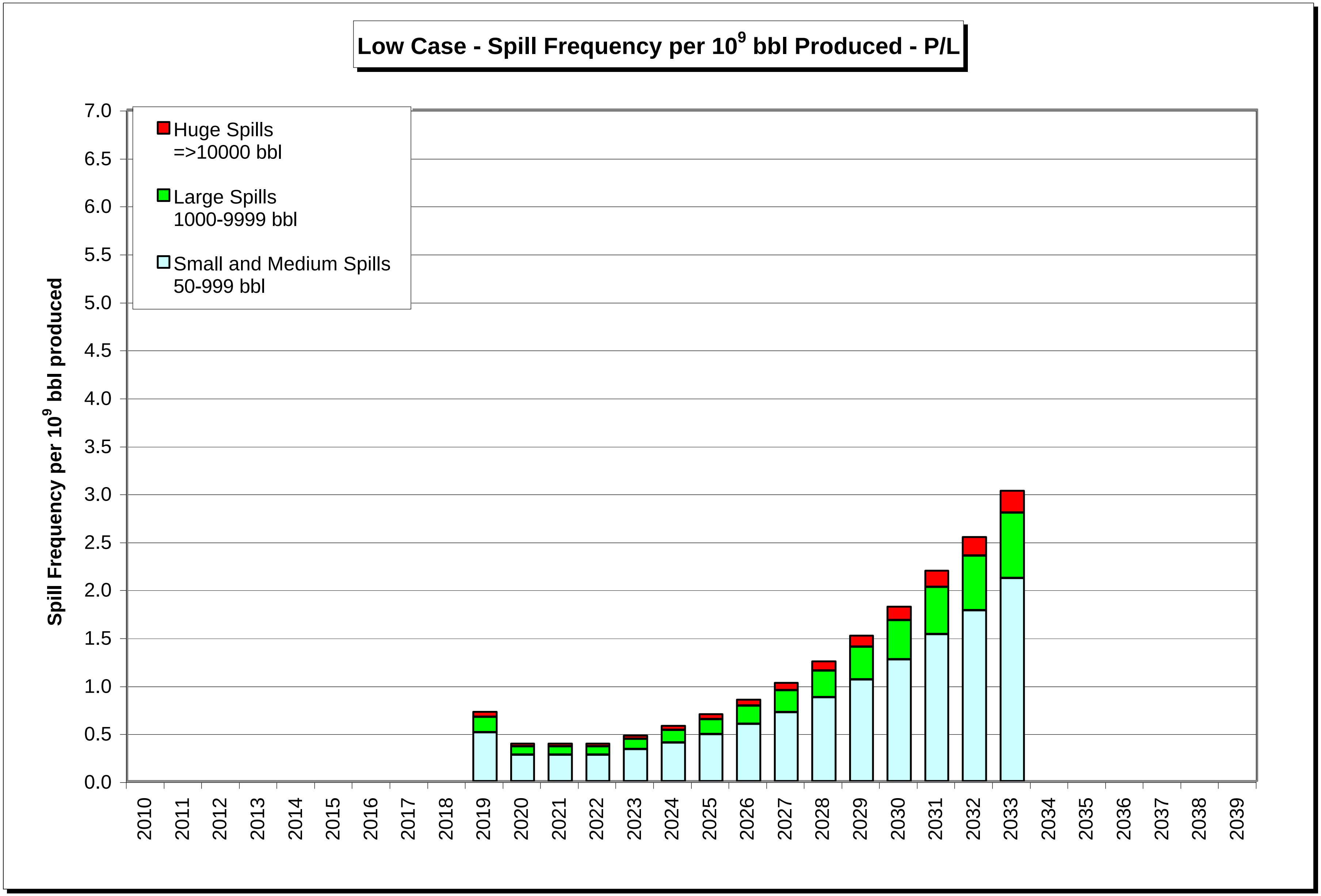

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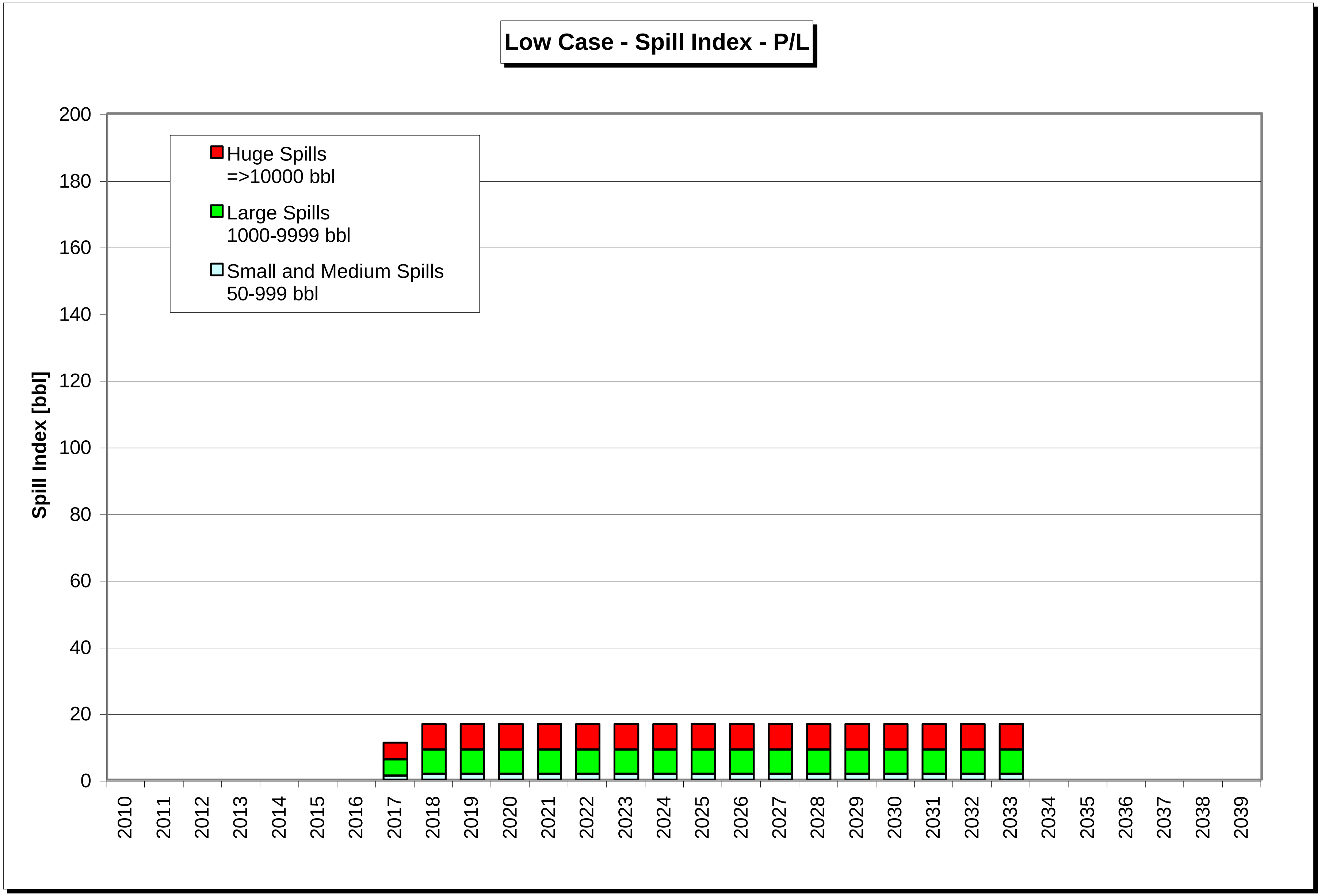

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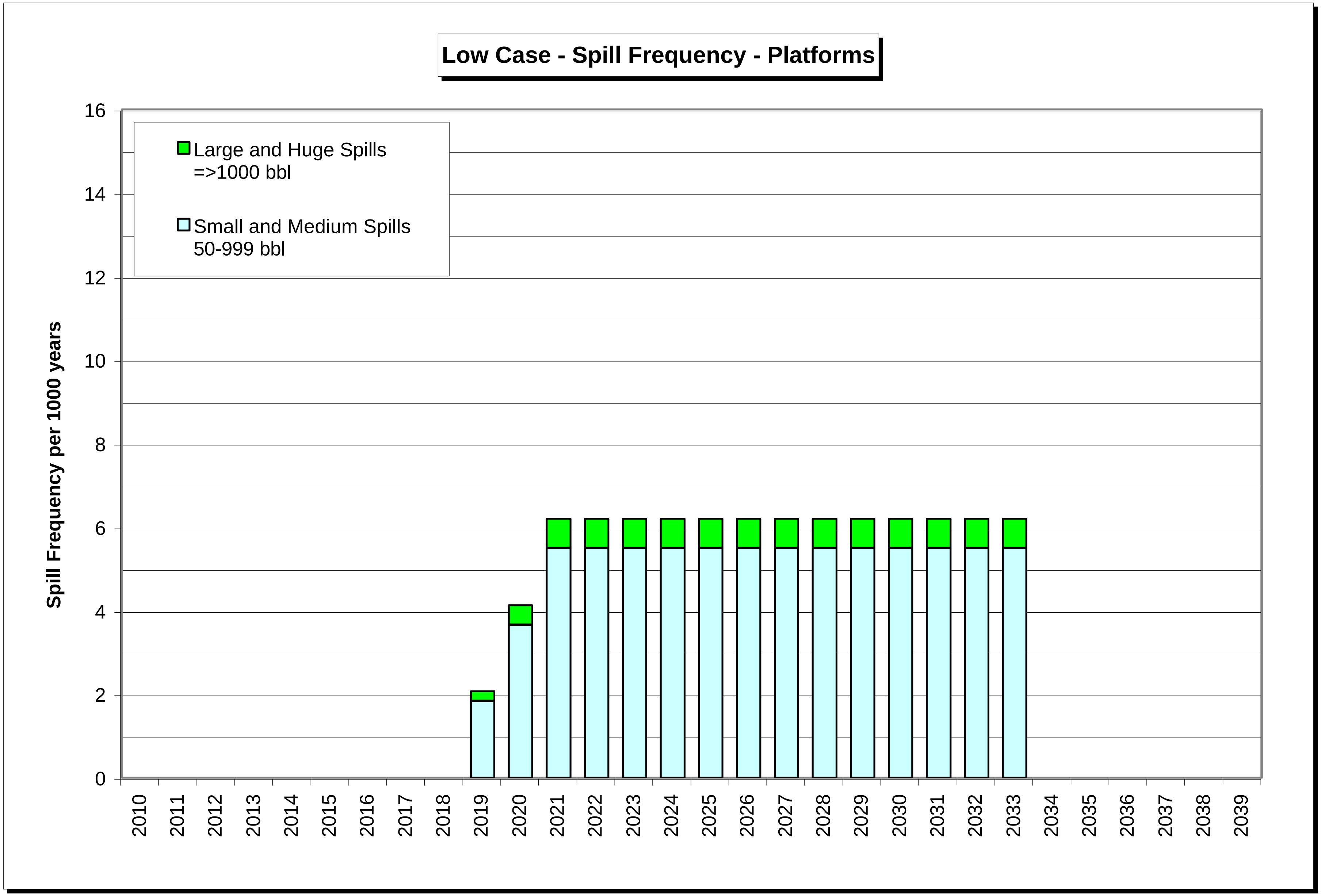

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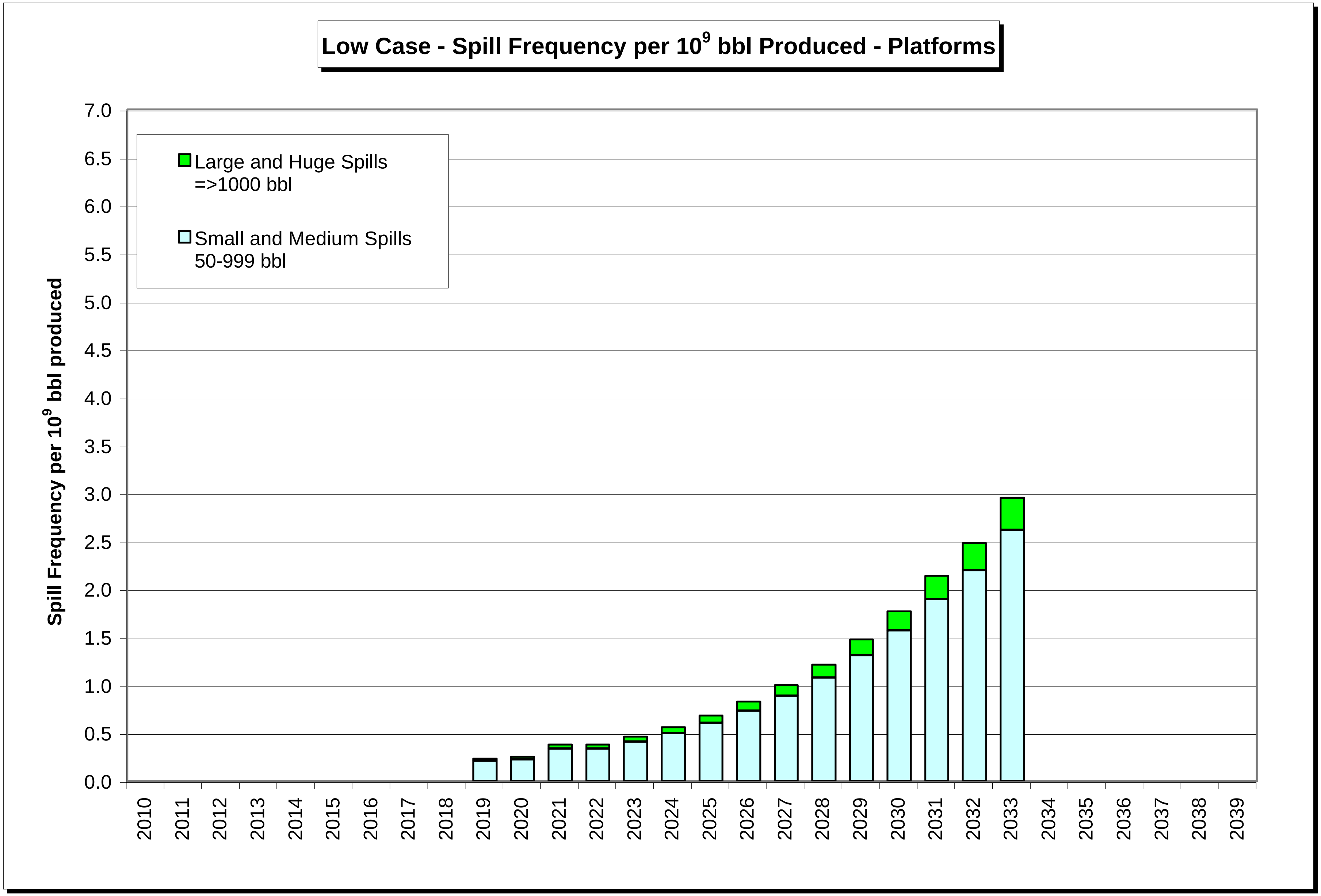

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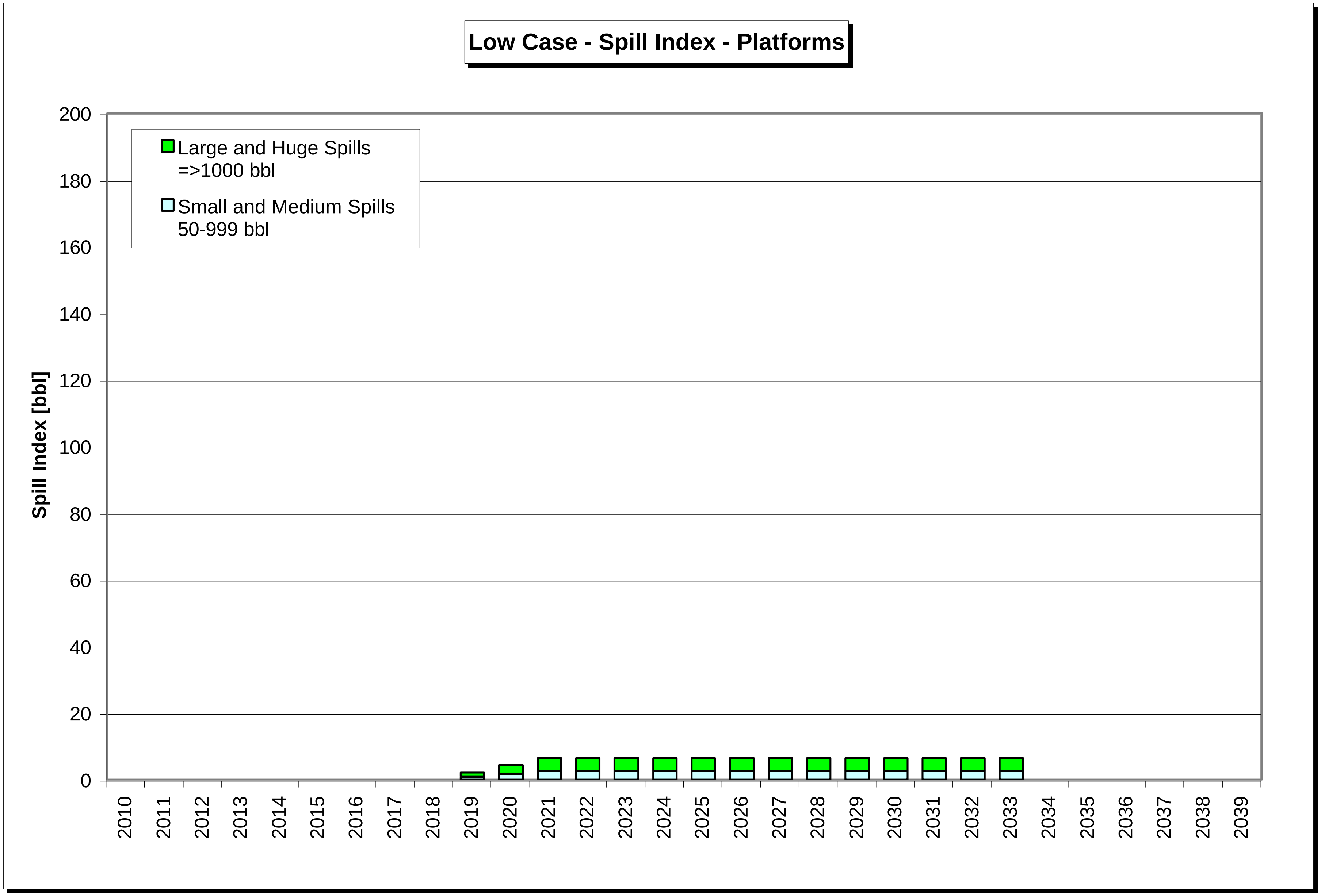

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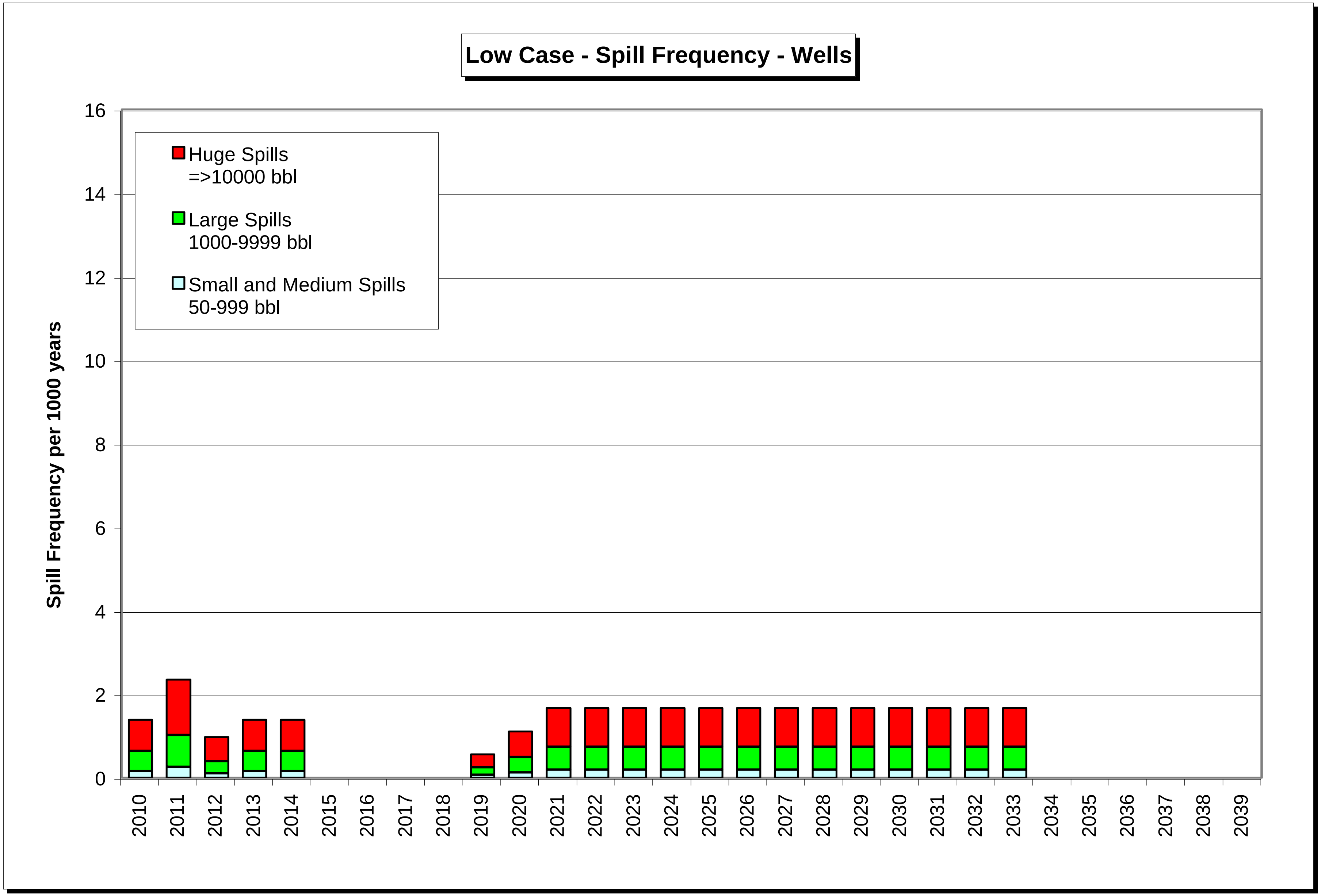

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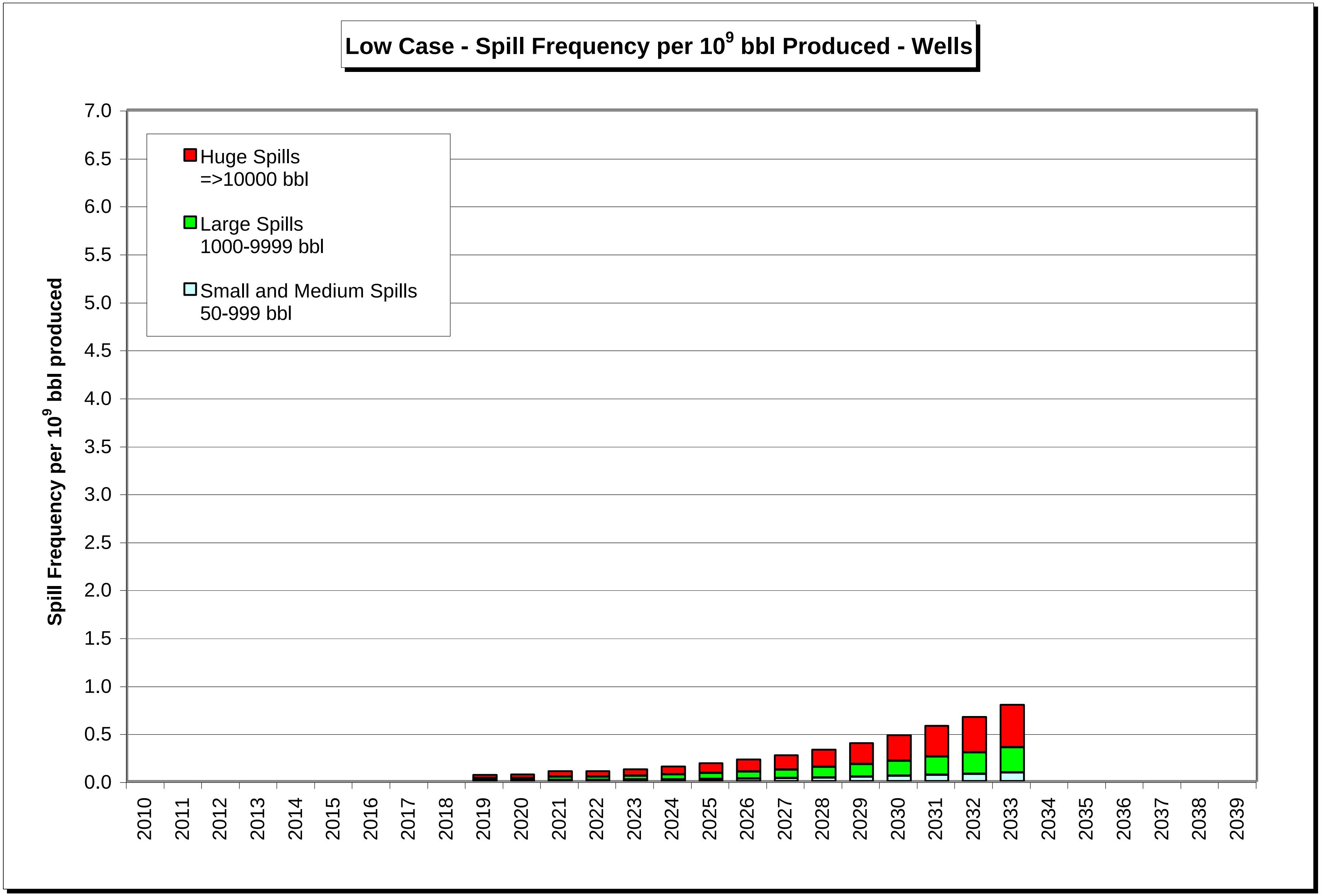

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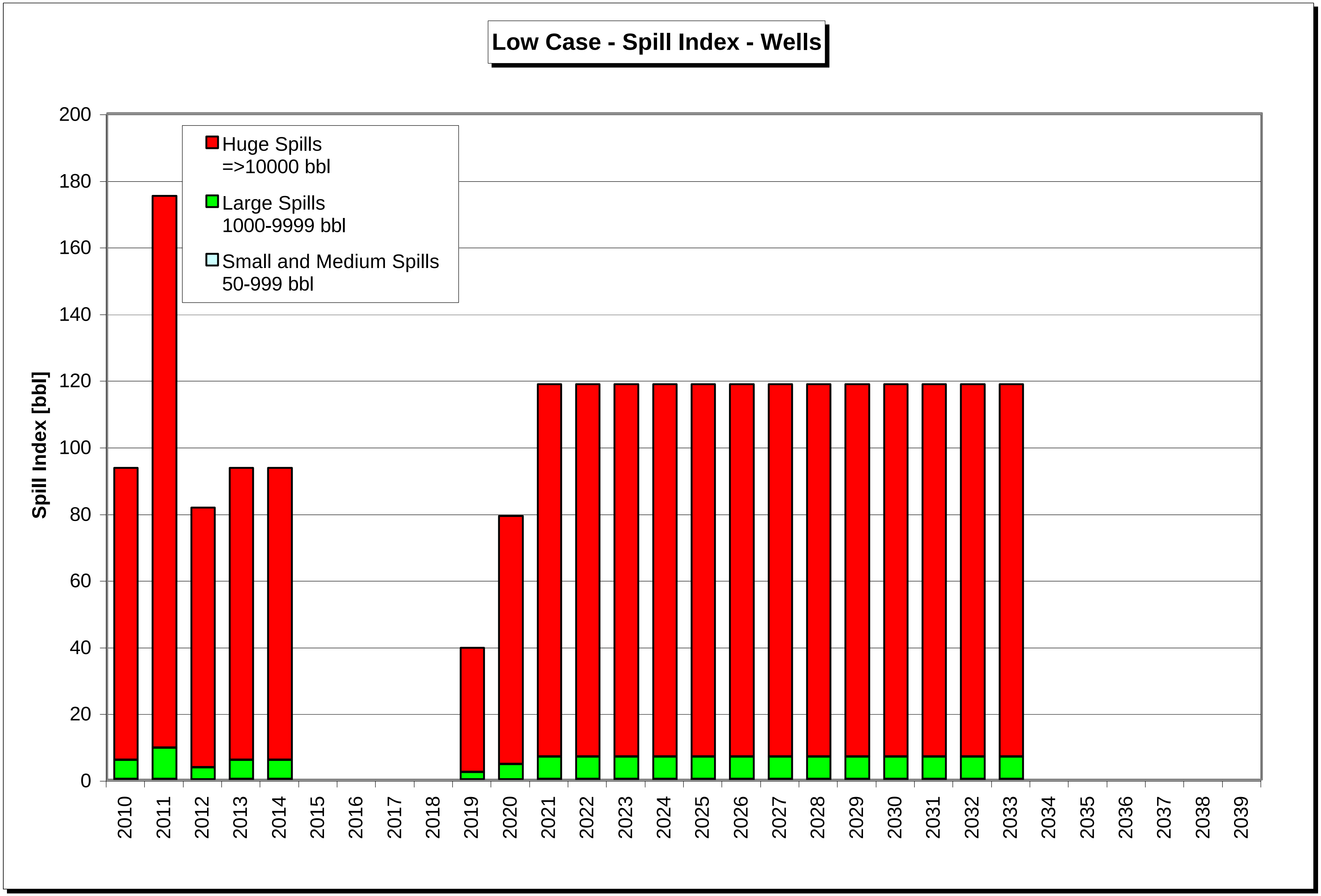

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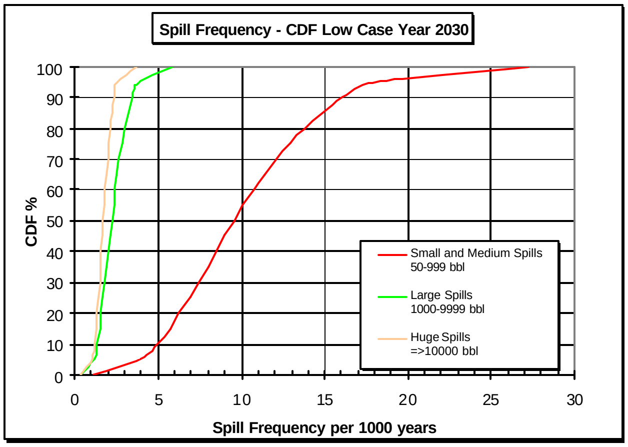
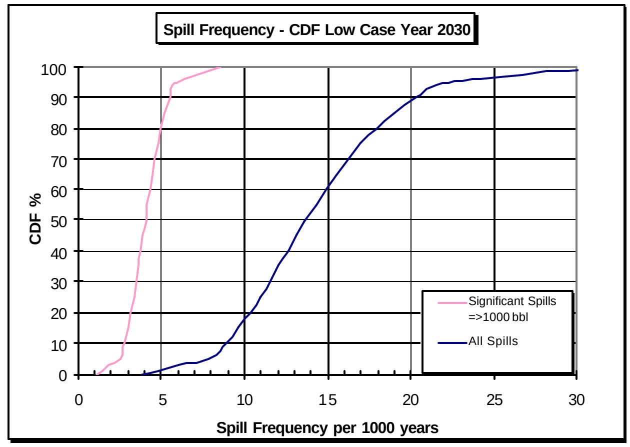
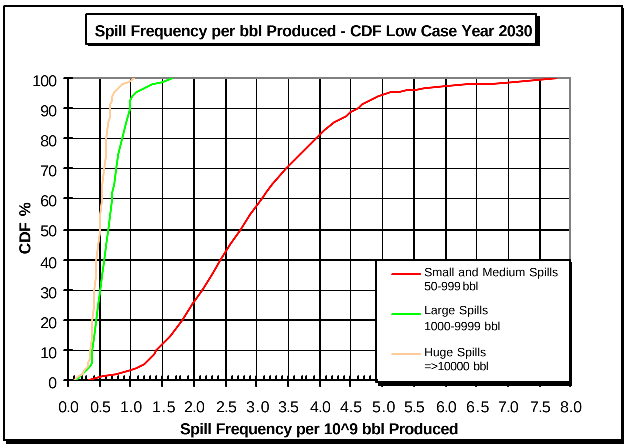
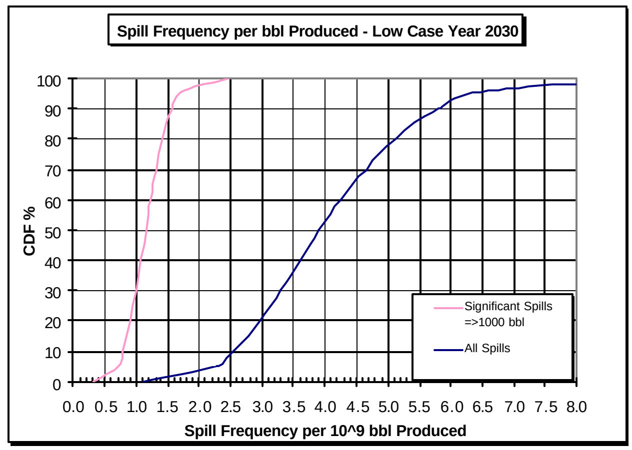
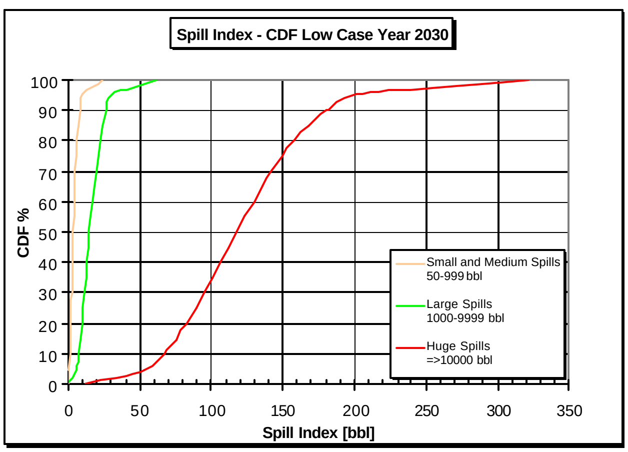
Figure 4.1.13 Spill Indicators – CDF – Year 2030











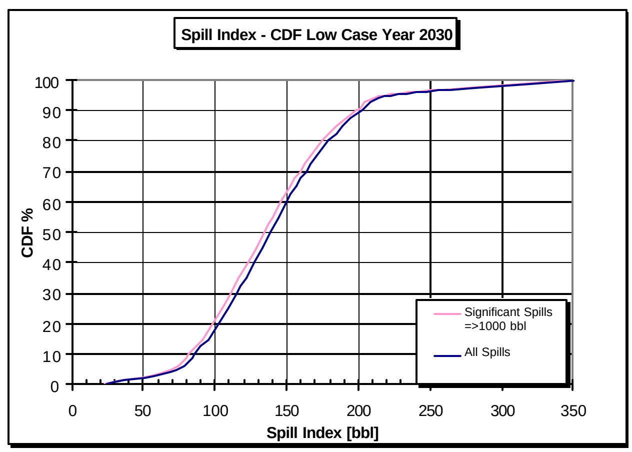


Figure 4.1.14 Spill Frequency – CDF – Low Case

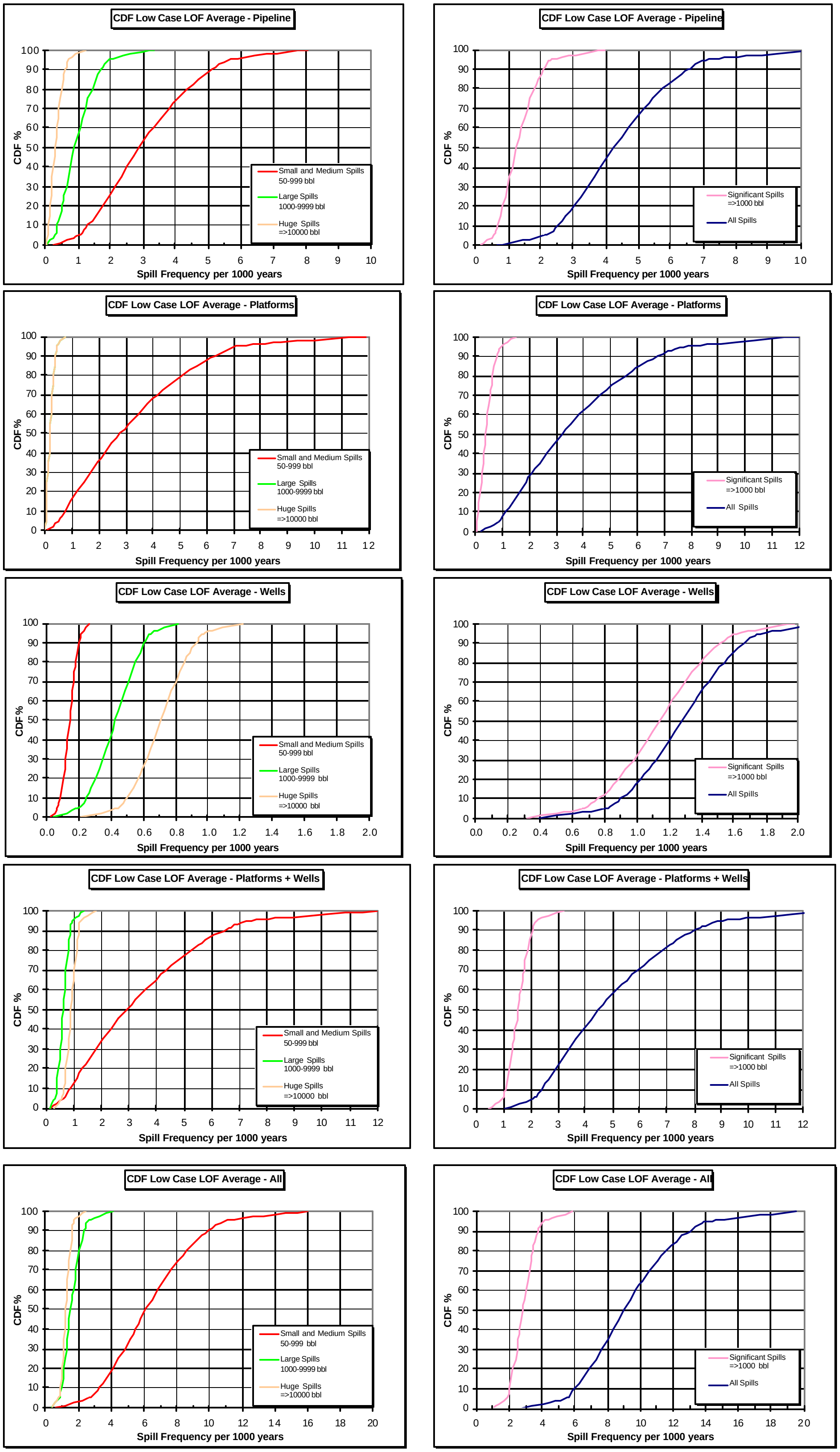


Figure 4.1.15 Spill Frequency per bbl produced– CDF – Low Case

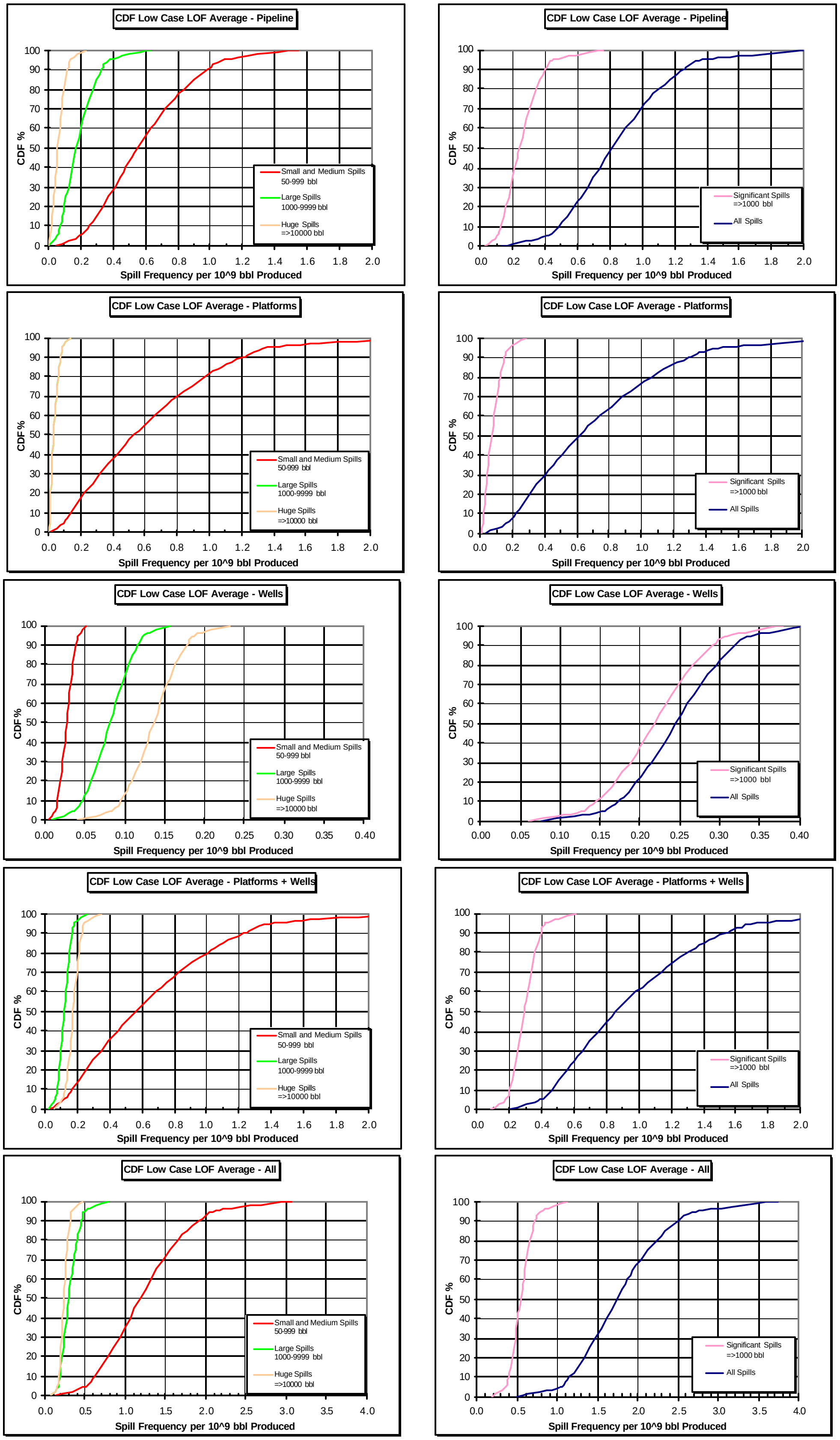
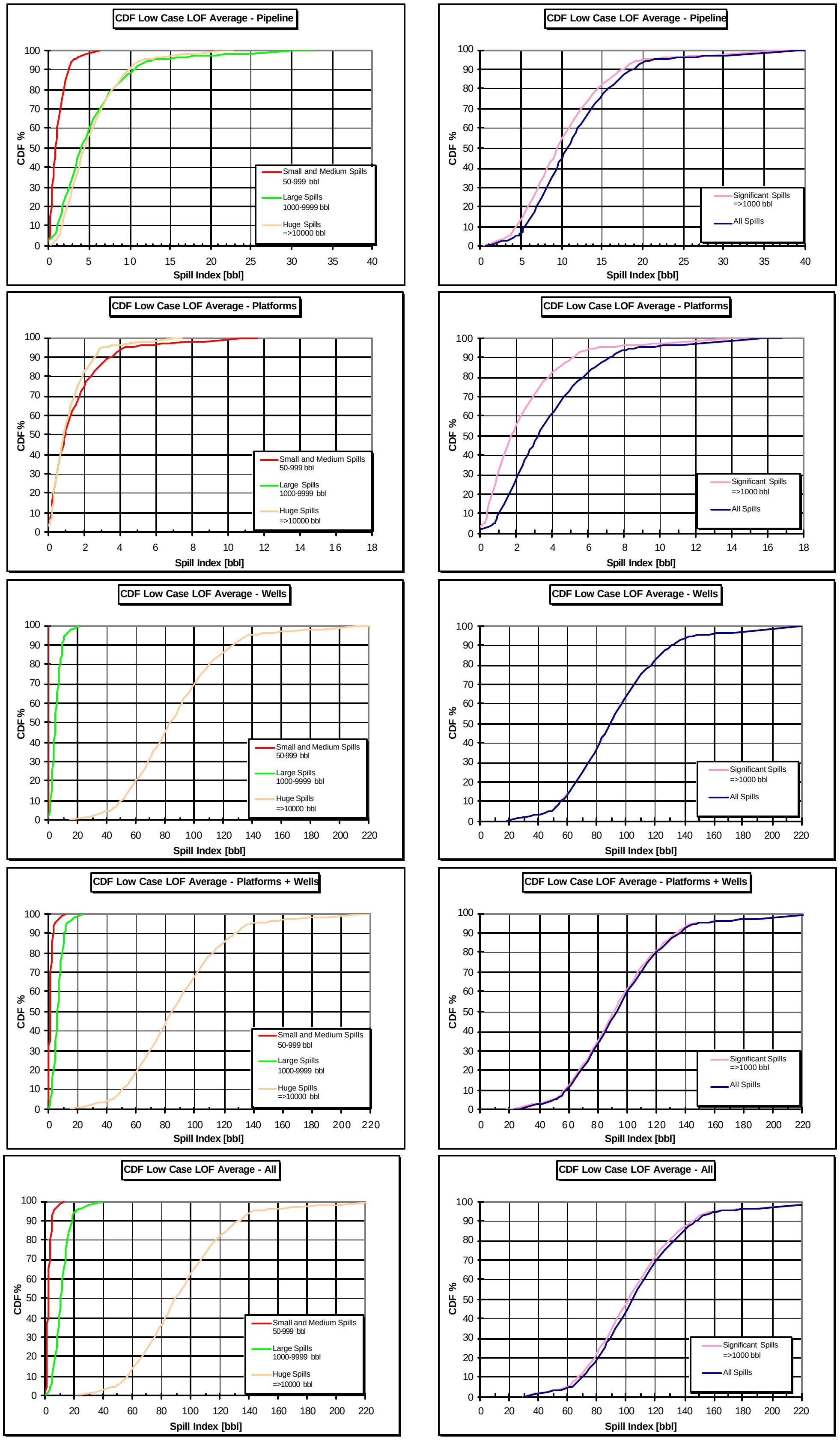


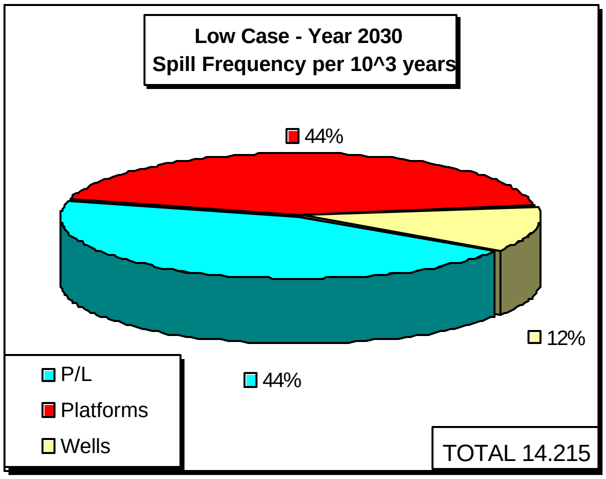
Figure 4.1.16 Spill Index [bbl] – CDF – Low Case

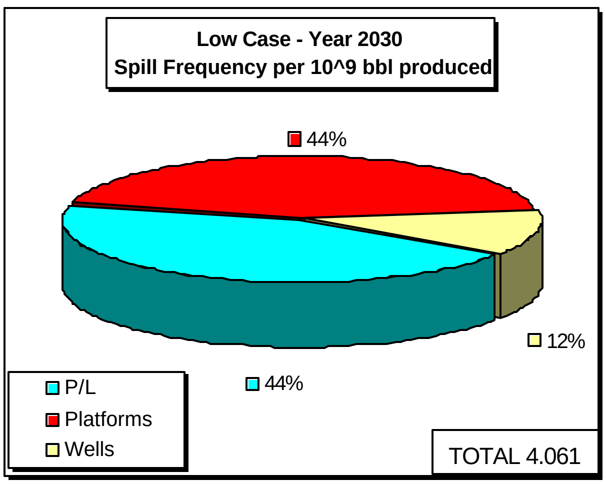


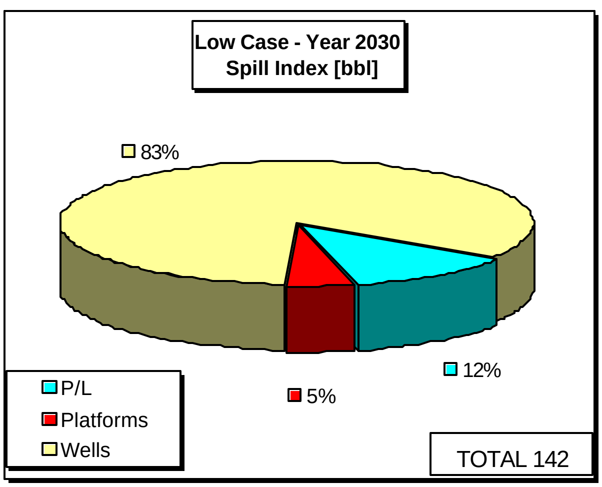
C4_1_LowCase_BS.xls F4116

Figure 4.1.17
Low Case - Year 2030 - Spill Indicators

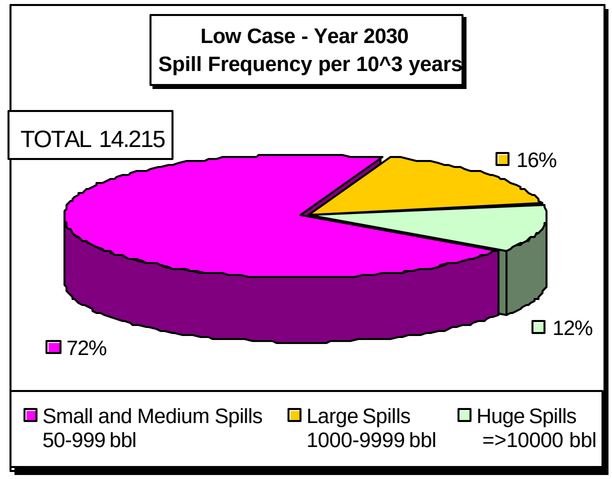
BY SPILL SOURCE

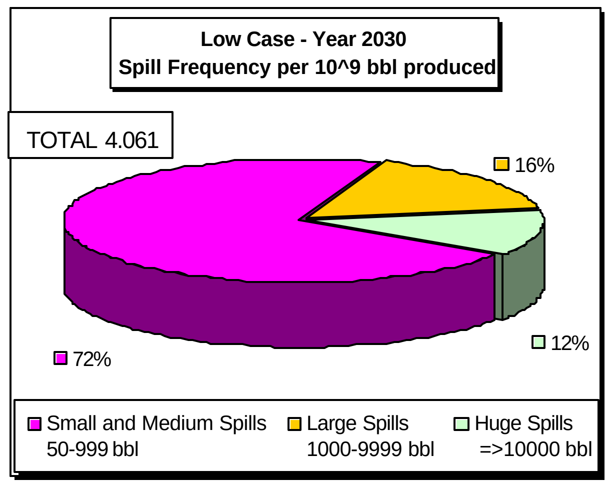






BY SPILL SIZE





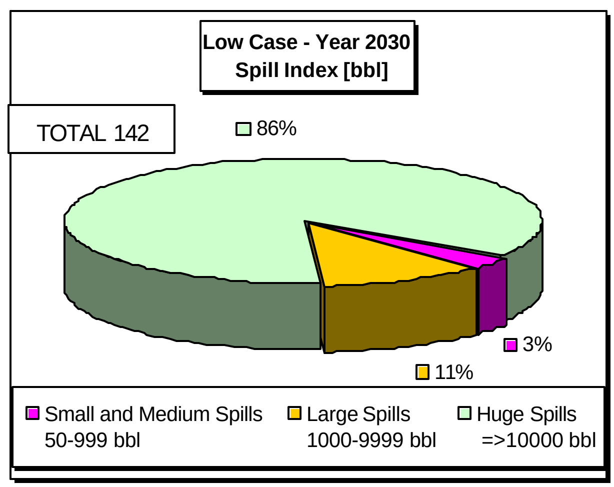
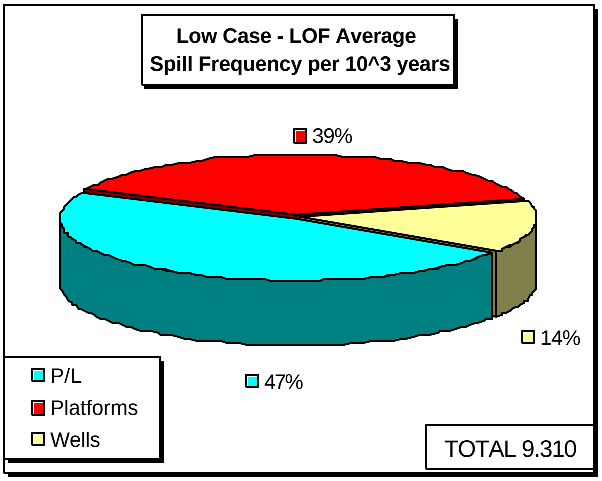
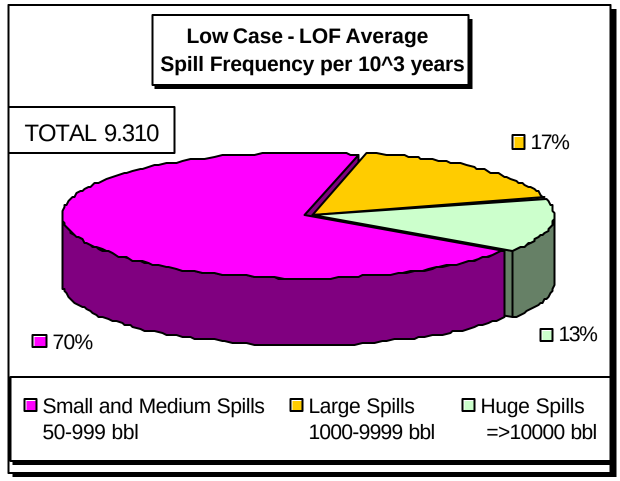


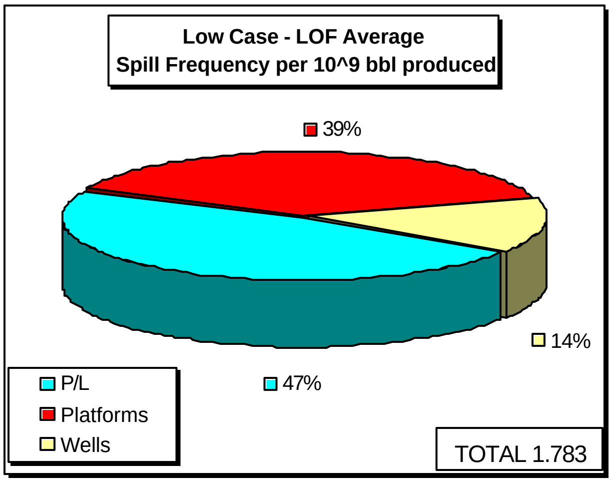
Figure 4.1.18
Low Case – LOF Average Spill Indicators

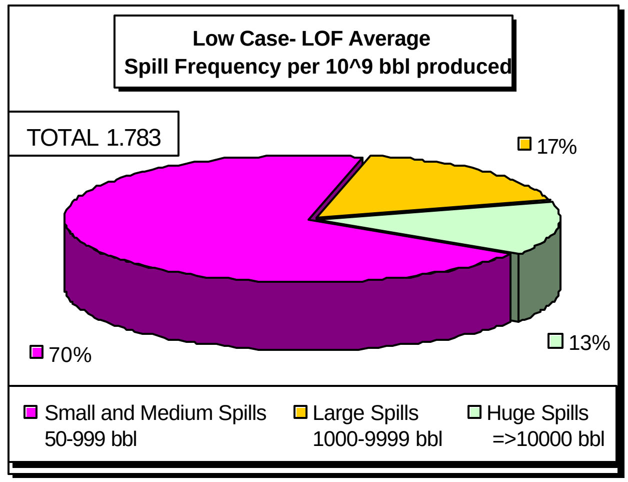
BY SPILL SOURCE

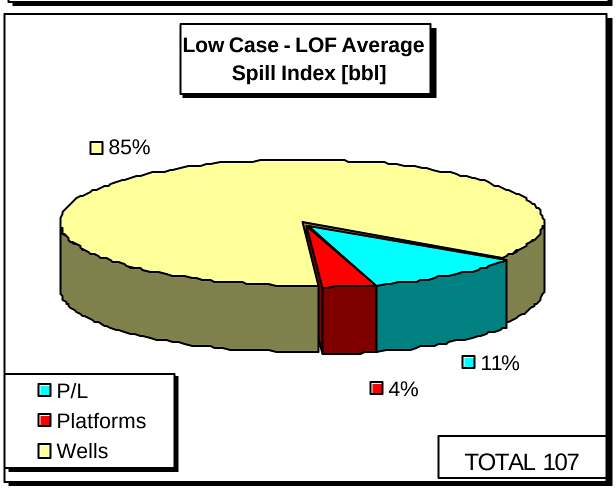
BY SPILL SIZE











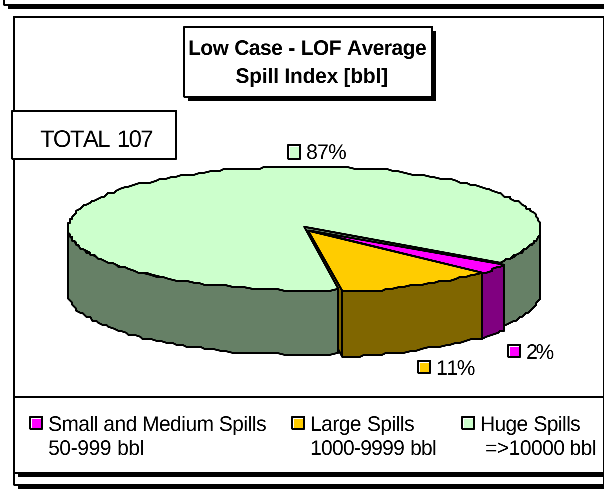


Table 4.2.1

Arctic Spill Occurrence Beaufort Sea High Case P/L Spills

P/L Dia <=10"

Year	Water Depth	P/L [miles]	Small Spills 50-99 bbl			Medium Spills 100-999 bbl			Large Spills 1000-9999 bbl			Huge Spills =>10000 bbl		
			Expected Spill [bbl] =		71	Expected Spill [bbl] =		485	Expected Spill [bbl] =		5279	Expected Spill [bbl] =		14880
		Cumm.	Frequency spills per 10^5km-year	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^5km-year	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^5km-year	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^5km-year	Frequency spills per 10^3years	Spill Index bbl
2010	Shallow		5.472			9.060			4.402			0.727		
	Medium		5.553			9.144			4.575			0.763		
	Deep		4.813			8.407			2.707			0.390		
	Total													
2011	Shallow		5.472			9.060			4.402			0.727		
	Medium		5.553			9.144			4.575			0.763		
	Deep		4.813			8.407			2.707			0.390		
	Total													
2012	Shallow		5.472			9.060			4.402			0.727		
	Medium		5.553			9.144			4.575			0.763		
	Deep		4.813			8.407			2.707			0.390		
	Total													
2013	Shallow		5.472			9.060			4.402			0.727		
	Medium		5.553			9.144			4.575			0.763		
	Deep		4.813			8.407			2.707			0.390		
	Total													
2014	Shallow		5.472			9.060			4.402			0.727		
	Medium		5.553			9.144			4.575			0.763		
	Deep		4.813			8.407			2.707			0.390		
	Total													
2015	Shallow		5.472			9.060			4.402			0.727		
	Medium		5.553			9.144			4.575			0.763		
	Deep		4.813			8.407			2.707			0.390		
	Total													
2016	Shallow		5.472			9.060			4.402			0.727		
	Medium		5.553			9.144			4.575			0.763		
	Deep		4.813			8.407			2.707			0.390		
	Total													
2017	Shallow		5.472			9.060			4.402			0.727		
	Medium		5.553			9.144			4.575			0.763		
	Deep		4.813			8.407			2.707			0.390		
	Total													
2018	Shallow		5.472			9.060			4.402			0.727		
	Medium		5.553			9.144			4.575			0.763		
	Deep		4.813			8.407			2.707			0.390		
	Total													
2019	Shallow		5.472			9.060			4.402			0.727		
	Medium		5.553			9.144			4.575			0.763		
	Deep		4.813			8.407			2.707			0.390		
	Total													
2020	Shallow		5.472			9.060			4.402			0.727		
	Medium		5.553			9.144			4.575			0.763		
	Deep		4.813			8.407			2.707			0.390		
	Total													
2021	Shallow		5.472			9.060			4.402			0.727		
	Medium		5.553			9.144			4.575			0.763		
	Deep		4.813			8.407			2.707			0.390		
	Total													
2022	Shallow		5.472			9.060			4.402			0.727		
	Medium		5.553			9.144			4.575			0.763		
	Deep		4.813			8.407			2.707			0.390		
	Total													
2023	Shallow		5.472			9.060			4.402			0.727		
	Medium		5.553			9.144			4.575			0.763		
	Deep	5	4.813	0.387	0.03	8.407	0.676	0.33	2.707	0.218	1.15	0.390	0.031	0.47
	Total	**5**		**0.387**	**0.03**		**0.676**	**0.33**		**0.218**	**1.15**		**0.031**	**0.47**
2024	Shallow		5.472			9.060			4.402			0.727		
	Medium		5.553			9.144			4.575			0.763		
	Deep	10	4.813	0.774	0.06	8.407	1.353	0.66	2.707	0.436	2.30	0.390	0.063	0.93
	Total	**10**		**0.774**	**0.06**		**1.353**	**0.66**		**0.436**	**2.30**		**0.063**	**0.93**
2025	Shallow		5.472			9.060			4.402			0.727		
	Medium		5.553			9.144			4.575			0.763		
	Deep	15	4.813	1.162	0.08	8.407	2.029	0.98	2.707	0.653	3.45	0.390	0.094	1.40
	Total	**15**		**1.162**	**0.08**		**2.029**	**0.98**		**0.653**	**3.45**		**0.094**	**1.40**
2026	Shallow		5.472			9.060			4.402			0.727		
	Medium		5.553			9.144			4.575			0.763		
	Deep	15	4.813	1.162	0.08	8.407	2.029	0.98	2.707	0.653	3.45	0.390	0.094	1.40
	Total	**15**		**1.162**	**0.08**		**2.029**	**0.98**		**0.653**	**3.45**		**0.094**	**1.40**
2027	Shallow		5.472			9.060			4.402			0.727		
	Medium		5.553			9.144			4.575			0.763		
	Deep	15	4.813	1.162	0.08	8.407	2.029	0.98	2.707	0.653	3.45	0.390	0.094	1.40
	Total	**15**		**1.162**	**0.08**		**2.029**	**0.98**		**0.653**	**3.45**		**0.094**	**1.40**
2028	Shallow		5.472			9.060			4.402			0.727		
	Medium		5.553			9.144			4.575			0.763		
	Deep	15	4.813	1.162	0.08	8.407	2.029	0.98	2.707	0.653	3.45	0.390	0.094	1.40
	Total	**15**		**1.162**	**0.08**		**2.029**	**0.98**		**0.653**	**3.45**		**0.094**	**1.40**
2029	Shallow		5.472			9.060			4.402			0.727		
	Medium		5.553			9.144			4.575			0.763		
	Deep	15	4.813	1.162	0.08	8.407	2.029	0.98	2.707	0.653	3.45	0.390	0.094	1.40

P/L Dia >10"

Year	Water Depth	P/L [miles]	Small Spills 50-99 bbl			Medium Spills 100-999 bbl			Large Spills 1000-9999 bbl			Huge Spills =>10000 bbl		
			Expected Spill [bbl] =		71	Expected Spill [bbl] =		516	Expected Spill [bbl] =		5176	Expected Spill [bbl] =		15552
		Cumm.	Frequency spills per 10^5km-year	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^5km-year	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^5km-year	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^5km-year	Frequency spills per 10^3years	Spill Index bbl
2010	Shallow		5.925			12.472			5.915			2.022		
	Medium		6.007			12.558			6.075			2.048		
	Deep		5.267			11.823			4.203			1.671		
	Total													
2011	Shallow		5.925			12.472			5.915			2.022		
	Medium		6.007			12.558			6.075			2.048		
	Deep		5.267			11.823			4.203			1.671		
	Total													
2012	Shallow		5.925			12.472			5.915			2.022		
	Medium		6.007			12.558			6.075			2.048		
	Deep		5.267			11.823			4.203			1.671		
	Total													
2013	Shallow		5.925			12.472			5.915			2.022		
	Medium		6.007			12.558			6.075			2.048		
	Deep		5.267			11.823			4.203			1.671		
	Total													
2014	Shallow		5.925			12.472			5.915			2.022		
	Medium		6.007			12.558			6.075			2.048		
	Deep		5.267			11.823			4.203			1.671		
	Total													
2015	Shallow		5.925			12.472			5.915			2.022		
	Medium		6.007			12.558			6.075			2.048		
	Deep		5.267			11.823			4.203			1.671		
	Total													
2016	Shallow		5.925			12.472			5.915			2.022		
	Medium		6.007			12.558			6.075			2.048		
	Deep		5.267			11.823			4.203			1.671		
	Total													
2017	Shallow	10	5.925	0.953	0.07	12.472	2.007	1.04	5.915	0.952	4.93	2.022	0.325	5.06
	Medium		6.007			12.558			6.075			2.048		
	Deep		5.267			11.823			4.203			1.671		
	Total	**10**		**0.953**	**0.07**		**2.007**	**1.04**		**0.952**	**4.93**		**0.325**	**5.06**
2018	Shallow	15	5.925	1.430	0.10	12.472	3.010	1.55	5.915	1.428	7.39	2.022	0.488	7.59
	Medium		6.007			12.558			6.075			2.048		
	Deep		5.267			11.823			4.203			1.671		
	Total	**15**		**1.430**	**0.10**		**3.010**	**1.55**		**1.428**	**7.39**		**0.488**	**7.59**
2019	Shallow	15	5.925	1.430	0.10	12.472	3.010	1.55	5.915	1.428	7.39	2.022	0.488	7.59
	Medium		6.007			12.558			6.075			2.048		
	Deep		5.267			11.823			4.203			1.671		
	Total	**15**		**1.430**	**0.10**		**3.010**	**1.55**		**1.428**	**7.39**		**0.488**	**7.59**
2020	Shallow	15	5.925	1.430	0.10	12.472	3.010	1.55	5.915	1.428	7.39	2.022	0.488	7.59
	Medium		6.007			12.558			6.075			2.048		
	Deep	10	5.267	0.847	0.06	11.823	1.902	0.98	4.203	0.676	3.50	1.671	0.269	4.18
	Total	**25**		**2.277**	**0.16**		**4.912**	**2.53**		**2.104**	**10.89**		**0.757**	**11.77**
2021	Shallow	15	5.925	1.430	0.10	12.472	3.010	1.55	5.915	1.428	7.39	2.022	0.488	7.59
	Medium		6.007			12.558			6.075			2.048		
	Deep	20	5.267	1.695	0.12	11.823	3.805	1.96	4.203	1.353	7.00	1.671	0.538	8.36
	Total	**35**		**3.125**	**0.22**		**6.815**	**3.52**		**2.780**	**14.39**		**1.026**	**15.95**
2022	Shallow	15	5.925	1.430	0.10	12.472	3.010	1.55	5.915	1.428	7.39	2.022	0.488	7.59
	Medium		6.007			12.558			6.075			2.048		
	Deep	35	5.267	2.966	0.21	11.823	6.658	3.44	4.203	2.367	12.25	1.671	0.941	14.63
	Total	**50**		**4.396**	**0.31**		**9.668**	**4.99**		**3.795**	**19.64**		**1.429**	**22.22**
2023	Shallow	15	5.925	1.430	0.10	12.472	3.010	1.55	5.915	1.428	7.39	2.022	0.488	7.59
	Medium		6.007			12.558			6.075			2.048		
	Deep	35	5.267	2.966	0.21	11.823	6.658	3.44	4.203	2.367	12.25	1.671	0.941	14.63
	Total	**50**		**4.396**	**0.31**		**9.668**	**4.99**		**3.795**	**19.64**		**1.429**	**22.22**
2024	Shallow	15	5.925	1.430	0.10	12.472	3.010	1.55	5.915	1.428	7.39	2.022	0.488	7.59
	Medium	10	6.007	0.966	0.07	12.558	2.021	1.04	6.075	0.978	5.06	2.048	0.329	5.12
	Deep	35	5.267	2.966	0.21	11.823	6.658	3.44	4.203	2.367	12.25	1.671	0.941	14.63
	Total	**60**		**5.362**	**0.38**		**11.689**	**6.03**		**4.772**	**24.70**		**1.758**	**27.35**
2025	Shallow	15	5.925	1.430	0.10	12.472	3.010	1.55	5.915	1.428	7.39	2.022	0.488	7.59
	Medium	25	6.007	2.416	0.17	12.558	5.052	2.61	6.075	2.444	12.65	2.048	0.824	12.81
	Deep	35	5.267	2.966	0.21	11.823	6.658	3.44	4.203	2.367	12.25	1.671	0.941	14.63
	Total	**75**		**6.812**	**0.48**		**14.720**	**7.59**		**6.238**	**32.29**		**2.253**	**35.03**
2026	Shallow	15	5.925	1.430	0.10	12.472	3.010	1.55	5.915	1.428	7.39	2.022	0.488	7.59
	Medium	25	6.007	2.416	0.17	12.558	5.052	2.61	6.075	2.444	12.65	2.048	0.824	12.81
	Deep	35	5.267	2.966	0.21	11.823	6.658	3.44	4.203	2.367	12.25	1.671	0.941	14.63
	Total	**75**		**6.812**	**0.48**		**14.720**	**7.59**		**6.238**	**32.29**		**2.253**	**35.03**
2027	Shallow	15	5.925	1.430	0.10	12.472	3.010	1.55	5.915	1.428	7.39	2.022	0.488	7.59
	Medium	25	6.007	2.416	0.17	12.558	5.052	2.61	6.075	2.444	12.65	2.048	0.824	12.81
	Deep	35	5.267	2.966	0.21	11.823	6.658	3.44	4.203	2.367	12.25	1.671	0.941	14.63
	Total	**75**		**6.812**	**0.48**		**14.720**	**7.59**		**6.238**	**32.29**		**2.253**	**35.03**
2028	Shallow	15	5.925	1.430	0.10	12.472	3.010	1.55	5.915	1.428	7.39	2.022	0.488	7.59
	Medium	25	6.007	2.416	0.17	12.558	5.052	2.61	6.075	2.444	12.65	2.048	0.824	12.81
	Deep	35	5.267	2.966	0.21	11.823	6.658	3.44	4.203	2.367	12.25	1.671	0.941	14.63
	Total	**75**		**6.812**	**0.48**		**14.720**	**7.59**		**6.238**	**32.29**		**2.253**	**35.03**
2029	Shallow	15	5.925	1.430	0.10	12.472	3.010	1.55	5.915	1.428	7.39	2.022	0.488	7.59
	Medium	25	6.007	2.416	0.17	12.558	5.052	2.61	6.075	2.444	12.65	2.048	0.824	12.81
	Deep	35	5.267	2.966	0.21	11.823	6.658	3.44	4.203	2.367	12.25	1.671	0.941	14.63

Table 4.2.1
Arctic Spill Occurrence Beaufort Sea High Case P/L Spills

Year	Water Depth	P/L Dia <=10"													P/L Dia >10"													
		P/L [miles]	Small Spills 50-99 bbl			Medium Spills 100-999 bbl			Large Spills 1000-9999 bbl			Huge Spills =>10000 bbl			P/L [miles]	Small Spills 50-99 bbl			Medium Spills 100-999 bbl			Large Spills 1000-9999 bbl			Huge Spills =>10000 bbl		
			Expected Spill [bbl] =		71	Expected Spill [bbl] =		485	Expected Spill [bbl] =		5279	Expected Spill [bbl] =		14880		Expected Spill [bbl] =		71	Expected Spill [bbl] =		516	Expected Spill [bbl] =		5176	Expected Spill [bbl] =		15552
		Cumm.	Frequency spills per 10^5km-year	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^5km-year	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^5km-year	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^5km-year	Frequency spills per 10^3years	Spill Index bbl	Cumm.	Frequency spills per 10^5km-year	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^5km-year	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^5km-year	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^5km-year	Frequency spills per 10^3years	Spill Index bbl
	Total	**15**		**1.162**	**0.08**		**2.029**	**0.98**		**0.653**	**3.45**		**0.094**	**1.40**	**75**		**6.812**	**0.48**		**14.720**	**7.59**		**6.238**	**32.29**		**2.253**	**35.03**
2030	Shallow		5.472			9.060			4.402			0.727			15	5.925	1.430	0.10	12.472	3.010	1.55	5.915	1.428	7.39	2.022	0.488	7.59
	Medium		5.553			9.144			4.575			0.763			25	6.007	2.416	0.17	12.558	5.052	2.61	6.075	2.444	12.65	2.048	0.824	12.81
	Deep	15	4.813	1.162	0.08	8.407	2.029	0.98	2.707	0.653	3.45	0.390	0.094	1.40	35	5.267	2.966	0.21	11.823	6.658	3.44	4.203	2.367	12.25	1.671	0.941	14.63
	Total	**15**		**1.162**	**0.08**		**2.029**	**0.98**		**0.653**	**3.45**		**0.094**	**1.40**	**75**		**6.812**	**0.48**		**14.720**	**7.59**		**6.238**	**32.29**		**2.253**	**35.03**
2031	Shallow		5.472			9.060			4.402			0.727			15	5.925	1.430	0.10	12.472	3.010	1.55	5.915	1.428	7.39	2.022	0.488	7.59
	Medium		5.553			9.144			4.575			0.763			25	6.007	2.416	0.17	12.558	5.052	2.61	6.075	2.444	12.65	2.048	0.824	12.81
	Deep	15	4.813	1.162	0.08	8.407	2.029	0.98	2.707	0.653	3.45	0.390	0.094	1.40	35	5.267	2.966	0.21	11.823	6.658	3.44	4.203	2.367	12.25	1.671	0.941	14.63
	Total	**15**		**1.162**	**0.08**		**2.029**	**0.98**		**0.653**	**3.45**		**0.094**	**1.40**	**75**		**6.812**	**0.48**		**14.720**	**7.59**		**6.238**	**32.29**		**2.253**	**35.03**
2032	Shallow		5.472			9.060			4.402			0.727			15	5.925	1.430	0.10	12.472	3.010	1.55	5.915	1.428	7.39	2.022	0.488	7.59
	Medium		5.553			9.144			4.575			0.763			25	6.007	2.416	0.17	12.558	5.052	2.61	6.075	2.444	12.65	2.048	0.824	12.81
	Deep	15	4.813	1.162	0.08	8.407	2.029	0.98	2.707	0.653	3.45	0.390	0.094	1.40	35	5.267	2.966	0.21	11.823	6.658	3.44	4.203	2.367	12.25	1.671	0.941	14.63
	Total	**15**		**1.162**	**0.08**		**2.029**	**0.98**		**0.653**	**3.45**		**0.094**	**1.40**	**75**		**6.812**	**0.48**		**14.720**	**7.59**		**6.238**	**32.29**		**2.253**	**35.03**
2033	Shallow		5.472			9.060			4.402			0.727			15	5.925	1.430	0.10	12.472	3.010	1.55	5.915	1.428	7.39	2.022	0.488	7.59
	Medium		5.553			9.144			4.575			0.763			25	6.007	2.416	0.17	12.558	5.052	2.61	6.075	2.444	12.65	2.048	0.824	12.81
	Deep	15	4.813	1.162	0.08	8.407	2.029	0.98	2.707	0.653	3.45	0.390	0.094	1.40	35	5.267	2.966	0.21	11.823	6.658	3.44	4.203	2.367	12.25	1.671	0.941	14.63
	Total	**15**		**1.162**	**0.08**		**2.029**	**0.98**		**0.653**	**3.45**		**0.094**	**1.40**	**75**		**6.812**	**0.48**		**14.720**	**7.59**		**6.238**	**32.29**		**2.253**	**35.03**
2034	Shallow		5.472			9.060			4.402			0.727				5.925			12.472			5.915			2.022		
	Medium		5.553			9.144			4.575			0.763			25	6.007	2.416	0.17	12.558	5.052	2.61	6.075	2.444	12.65	2.048	0.824	12.81
	Deep	15	4.813	1.162	0.08	8.407	2.029	0.98	2.707	0.653	3.45	0.390	0.094	1.40	35	5.267	2.966	0.21	11.823	6.658	3.44	4.203	2.367	12.25	1.671	0.941	14.63
	Total	**15**		**1.162**	**0.08**		**2.029**	**0.98**		**0.653**	**3.45**		**0.094**	**1.40**	**60**		**5.382**	**0.38**		**11.710**	**6.04**		**4.811**	**24.90**		**1.764**	**27.44**
2035	Shallow		5.472			9.060			4.402			0.727				5.925			12.472			5.915			2.022		
	Medium		5.553			9.144			4.575			0.763			25	6.007	2.416	0.17	12.558	5.052	2.61	6.075	2.444	12.65	2.048	0.824	12.81
	Deep	15	4.813	1.162	0.08	8.407	2.029	0.98	2.707	0.653	3.45	0.390	0.094	1.40	35	5.267	2.966	0.21	11.823	6.658	3.44	4.203	2.367	12.25	1.671	0.941	14.63
	Total	**15**		**1.162**	**0.08**		**2.029**	**0.98**		**0.653**	**3.45**		**0.094**	**1.40**	**60**		**5.382**	**0.38**		**11.710**	**6.04**		**4.811**	**24.90**		**1.764**	**27.44**
2036	Shallow		5.472			9.060			4.402			0.727				5.925			12.472			5.915			2.022		
	Medium		5.553			9.144			4.575			0.763			25	6.007	2.416	0.17	12.558	5.052	2.61	6.075	2.444	12.65	2.048	0.824	12.81
	Deep	15	4.813	1.162	0.08	8.407	2.029	0.98	2.707	0.653	3.45	0.390	0.094	1.40	35	5.267	2.966	0.21	11.823	6.658	3.44	4.203	2.367	12.25	1.671	0.941	14.63
	Total	**15**		**1.162**	**0.08**		**2.029**	**0.98**		**0.653**	**3.45**		**0.094**	**1.40**	**60**		**5.382**	**0.38**		**11.710**	**6.04**		**4.811**	**24.90**		**1.764**	**27.44**
2037	Shallow		5.472			9.060			4.402			0.727				5.925			12.472			5.915			2.022		
	Medium		5.553			9.144			4.575			0.763			25	6.007	2.416	0.17	12.558	5.052	2.61	6.075	2.444	12.65	2.048	0.824	12.81
	Deep	15	4.813	1.162	0.08	8.407	2.029	0.98	2.707	0.653	3.45	0.390	0.094	1.40	35	5.267	2.966	0.21	11.823	6.658	3.44	4.203	2.367	12.25	1.671	0.941	14.63
	Total	**15**		**1.162**	**0.08**		**2.029**	**0.98**		**0.653**	**3.45**		**0.094**	**1.40**	**60**		**5.382**	**0.38**		**11.710**	**6.04**		**4.811**	**24.90**		**1.764**	**27.44**
2038	Shallow		5.472			9.060			4.402			0.727				5.925			12.472			5.915			2.022		
	Medium		5.553			9.144			4.575			0.763			25	6.007	2.416	0.17	12.558	5.052	2.61	6.075	2.444	12.65	2.048	0.824	12.81
	Deep		4.813			8.407			2.707			0.390				5.267			11.823			4.203			1.671		
	Total														**25**		**2.416**	**0.17**		**5.052**	**2.61**		**2.444**	**12.65**		**0.824**	**12.81**
2039	Shallow		5.472			9.060			4.402			0.727				5.925			12.472			5.915			2.022		
	Medium		5.553			9.144			4.575			0.763				6.007			12.558			6.075			2.048		
	Deep		4.813			8.407			2.707			0.390				5.267			11.823			4.203			1.671		
	Total																										

Table 4.2.2
Arctic Spill Occurrence - High Case - P/L - Summary

Year	Production [MMbbl]	Small Spills 50-99 bbl			Medium Spills 100-999 bbl			Small and Medium Spills 50-999 bbl			Large Spills 1000-9999 bbl			Huge Spills =>10000 bbl			Significant Spills =>1000 bbl			All Spills		
		Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 103years	Frequency Spills per 109 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]
2010																						
2011																						
2012																						
2013																						
2014																						
2015																						
2016																						
2017		0.953		0.068	2.007		1.035	2.960		1.103	0.952		4.926	0.325		5.060	1.277		9.986	4.237		11.090
2018		1.430		0.102	3.010		1.553	4.440		1.655	1.428		7.389	0.488		7.591	1.916		14.980	6.356		16.634
2019	**8.8**	1.430	0.162	0.102	3.010	0.342	1.553	4.440	0.505	1.655	1.428	0.162	7.389	0.488	0.055	7.591	1.916	0.218	14.980	6.356	0.722	16.634
2020	**16.3**	2.277	0.140	0.162	4.912	0.301	2.535	7.190	0.441	2.697	2.104	0.129	10.889	0.757	0.046	11.771	2.861	0.176	22.660	10.051	0.617	25.357
2021	**16.3**	3.125	0.192	0.222	6.815	0.418	3.516	9.940	0.610	3.739	2.780	0.171	14.389	1.026	0.063	15.951	3.806	0.233	30.341	13.746	0.843	34.079
2022	**29.8**	4.396	0.148	0.313	9.668	0.324	4.988	14.064	0.472	5.301	3.795	0.127	19.640	1.429	0.048	22.222	5.223	0.175	41.861	19.288	0.647	47.163
2023	**30.3**	4.783	0.158	0.340	10.345	0.341	5.316	15.128	0.499	5.657	4.012	0.132	20.789	1.460	0.048	22.688	5.473	0.181	43.477	20.600	0.680	49.134
2024	**42.4**	6.137	0.145	0.437	13.042	0.308	6.687	19.179	0.452	7.124	5.208	0.123	26.998	1.821	0.043	28.278	7.029	0.166	55.277	26.207	0.618	62.400
2025	**55.4**	7.974	0.144	0.568	16.749	0.302	8.579	24.723	0.446	9.146	6.892	0.124	35.737	2.347	0.042	36.430	9.238	0.167	72.167	33.961	0.613	81.314
2026	**53.8**	7.974	0.148	0.568	16.749	0.311	8.579	24.723	0.460	9.146	6.892	0.128	35.737	2.347	0.044	36.430	9.238	0.172	72.167	33.961	0.631	81.314
2027	**52.5**	7.974	0.152	0.568	16.749	0.319	8.579	24.723	0.471	9.146	6.892	0.131	35.737	2.347	0.045	36.430	9.238	0.176	72.167	33.961	0.647	81.314
2028	**42.5**	7.974	0.188	0.568	16.749	0.394	8.579	24.723	0.582	9.146	6.892	0.162	35.737	2.347	0.055	36.430	9.238	0.217	72.167	33.961	0.799	81.314
2029	**34.5**	7.974	0.231	0.568	16.749	0.485	8.579	24.723	0.717	9.146	6.892	0.200	35.737	2.347	0.068	36.430	9.238	0.268	72.167	33.961	0.984	81.314
2030	**28.0**	7.974	0.285	0.568	16.749	0.598	8.579	24.723	0.883	9.146	6.892	0.246	35.737	2.347	0.084	36.430	9.238	0.330	72.167	33.961	1.213	81.314
2031	**22.7**	7.974	0.351	0.568	16.749	0.738	8.579	24.723	1.089	9.146	6.892	0.304	35.737	2.347	0.103	36.430	9.238	0.407	72.167	33.961	1.496	81.314
2032	**18.5**	7.974	0.431	0.568	16.749	0.905	8.579	24.723	1.336	9.146	6.892	0.373	35.737	2.347	0.127	36.430	9.238	0.499	72.167	33.961	1.836	81.314
2033	**15.1**	7.974	0.528	0.568	16.749	1.109	8.579	24.723	1.637	9.146	6.892	0.456	35.737	2.347	0.155	36.430	9.238	0.612	72.167	33.961	2.249	81.314
2034	**10.5**	6.544	0.623	0.466	13.739	1.308	7.026	20.283	1.932	7.491	5.464	0.520	28.348	1.858	0.177	28.840	7.323	0.697	57.188	27.605	2.629	64.679
2035	**8.5**	6.544	0.770	0.466	13.739	1.616	7.026	20.283	2.386	7.491	5.464	0.643	28.348	1.858	0.219	28.840	7.323	0.861	57.188	27.605	3.248	64.679
2036	**6.9**	6.544	0.948	0.466	13.739	1.991	7.026	20.283	2.940	7.491	5.464	0.792	28.348	1.858	0.269	28.840	7.323	1.061	57.188	27.605	4.001	64.679
2037	**5.6**	6.544	1.169	0.383	13.739	2.453	6.042	20.283	3.622	6.425	5.464	0.976	24.899	1.858	0.332	27.440	7.323	1.308	52.339	27.605	4.930	58.764
2038	**2.1**	2.416	1.151	0.172	5.052	2.406	2.606	7.468	3.556	2.778	2.444	1.164	12.649	0.824	0.392	12.809	3.267	1.556	25.458	10.735	5.112	28.236
2039																						
Total LOF	**500.5**	**124.886**		**9**	**263.559**		**134**	**388.445**		**143**	**108.031**		**557**	**37.171**		**576**	**145.202**		**1132**	**533.647**		**1275**
Average LOF		**4.306**	**0.250**	**0**	**9.088**	**0.527**	**5**	**13.395**	**0.776**	**5**	**3.725**	**0.216**	**19**	**1.282**	**0.074**	**20**	**5.007**	**0.290**	**39**	**18.402**	**1.066**	**44**

Table 4.2.3
Arctic Spill Occurrence - High Case - Platforms

Year	Water Depth	N Platforms	N P Wells	Small and Medium Spills 50-999 bbl			Large and Huge Spills =>1000 bbl		
				Expected Spill [bbl] =		452	Expected Spill [bbl] =		5631
		Cum.	Cum.	Frequency spills per 10^4well-year	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^4well-year	Frequency spills per 10^3years	Spill Index bbl
2010	Shallow			3.053			0.390		
	Medium			3.686			0.404		
	Deep			3.809			0.429		
	Total								
2011	Shallow			3.053			0.390		
	Medium			3.686			0.404		
	Deep			3.809			0.429		
	Total								
2012	Shallow			3.053			0.390		
	Medium			3.686			0.404		
	Deep			3.809			0.429		
	Total								
2013	Shallow			3.053			0.390		
	Medium			3.686			0.404		
	Deep			3.809			0.429		
	Total								
2014	Shallow			3.053			0.390		
	Medium			3.686			0.404		
	Deep			3.809			0.429		
	Total								
2015	Shallow			3.053			0.390		
	Medium			3.686			0.404		
	Deep			3.809			0.429		
	Total								
2016	Shallow			3.053			0.390		
	Medium			3.686			0.404		
	Deep			3.809			0.429		
	Total								
2017	Shallow			3.053			0.390		
	Medium			3.686			0.404		
	Deep			3.809			0.429		
	Total								
2018	Shallow			3.053			0.390		
	Medium			3.686			0.404		
	Deep			3.809			0.429		
	Total								
2019	Shallow	1	6	3.053	1.832	0.83	0.390	0.234	1.32
	Medium			3.686			0.404		
	Deep			3.809			0.429		
	Total	**1**	**6**		**1.832**	**0.83**		**0.234**	**1.32**
2020	Shallow	1	12	3.053	3.664	1.66	0.390	0.467	2.63
	Medium			3.686			0.404		
	Deep			3.809			0.429		
	Total	**1**	**12**		**3.664**	**1.66**		**0.467**	**2.63**
2021	Shallow	1	18	3.053	5.496	2.48	0.390	0.701	3.95
	Medium			3.686			0.404		
	Deep			3.809			0.429		
	Total	**1**	**18**		**5.496**	**2.48**		**0.701**	**3.95**
2022	Shallow	1	18	3.053	5.496	2.48	0.390	0.701	3.95
	Medium			3.686			0.404		
	Deep	1	6	3.809	2.285	1.03	0.429	0.257	1.45
	Total	**2**	**24**		**7.781**	**3.52**		**0.958**	**5.40**
2023	Shallow	1	18	3.053	5.496	2.48	0.390	0.701	3.95
	Medium			3.686			0.404		
	Deep	1	16	3.809	6.094	2.75	0.429	0.686	3.86
	Total	**2**	**34**		**11.590**	**5.24**		**1.387**	**7.81**
2024	Shallow	1	18	3.053	5.496	2.48	0.390	0.701	3.95
	Medium	1	6	3.686	2.211	1.00	0.404	0.242	1.36
	Deep	1	26	3.809	9.903	4.48	0.429	1.114	6.27
	Total	**3**	**50**		**17.611**	**7.96**		**2.058**	**11.59**
2025	Shallow	1	18	3.053	5.496	2.48	0.390	0.701	3.95
	Medium	1	12	3.686	4.423	2.00	0.404	0.484	2.73
	Deep	1	36	3.809	13.712	6.20	0.429	1.543	8.69
	Total	**3**	**66**		**23.631**	**10.68**		**2.728**	**15.36**
2026	Shallow	1	18	3.053	5.496	2.48	0.390	0.701	3.95
	Medium	1	18	3.686	6.634	3.00	0.404	0.726	4.09
	Deep	1	36	3.809	13.712	6.20	0.429	1.543	8.69

Table 4.2.3
Arctic Spill Occurrence - High Case - Platforms

Year	Water Depth	N Platforms	N P Wells	Small and Medium Spills 50-999 bbl			Large and Huge Spills =>1000 bbl		
				Expected Spill [bbl] =		452	Expected Spill [bbl] =		5631
		Cum.	Cum.	Frequency spills per 10^4well-year	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^4well-year	Frequency spills per 10^3years	Spill Index bbl
	Total	**3**	**72**		**25.842**	**11.68**		**2.970**	**16.73**
2027	Shallow	1	18	3.053	5.496	2.48	0.390	0.701	3.95
	Medium	1	18	3.686	6.634	3.00	0.404	0.726	4.09
	Deep	1	36	3.809	13.712	6.20	0.429	1.543	8.69
	Total	**3**	**72**		**25.842**	**11.68**		**2.970**	**16.73**
2028	Shallow	1	18	3.053	5.496	2.48	0.390	0.701	3.95
	Medium	1	18	3.686	6.634	3.00	0.404	0.726	4.09
	Deep	1	36	3.809	13.712	6.20	0.429	1.543	8.69
	Total	**3**	**72**		**25.842**	**11.68**		**2.970**	**16.73**
2029	Shallow	1	18	3.053	5.496	2.48	0.390	0.701	3.95
	Medium	1	18	3.686	6.634	3.00	0.404	0.726	4.09
	Deep	1	36	3.809	13.712	6.20	0.429	1.543	8.69
	Total	**3**	**72**		**25.842**	**11.68**		**2.970**	**16.73**
2030	Shallow	1	18	3.053	5.496	2.48	0.390	0.701	3.95
	Medium	1	18	3.686	6.634	3.00	0.404	0.726	4.09
	Deep	1	36	3.809	13.712	6.20	0.429	1.543	8.69
	Total	**3**	**72**		**25.842**	**11.68**		**2.970**	**16.73**
2031	Shallow	1	18	3.053	5.496	2.48	0.390	0.701	3.95
	Medium	1	18	3.686	6.634	3.00	0.404	0.726	4.09
	Deep	1	36	3.809	13.712	6.20	0.429	1.543	8.69
	Total	**3**	**72**		**25.842**	**11.68**		**2.970**	**16.73**
2032	Shallow	1	18	3.053	5.496	2.48	0.390	0.701	3.95
	Medium	1	18	3.686	6.634	3.00	0.404	0.726	4.09
	Deep	1	36	3.809	13.712	6.20	0.429	1.543	8.69
	Total	**3**	**72**		**25.842**	**11.68**		**2.970**	**16.73**
2033	Shallow	1	18	3.053	5.496	2.48	0.390	0.701	3.95
	Medium	1	18	3.686	6.634	3.00	0.404	0.726	4.09
	Deep	1	36	3.809	13.712	6.20	0.429	1.543	8.69
	Total	**3**	**72**		**25.842**	**11.68**		**2.970**	**16.73**
2034	Shallow			3.053			0.390		
	Medium	1	18	3.686	6.634	3.00	0.404	0.726	4.09
	Deep	1	36	3.809	13.712	6.20	0.429	1.543	8.69
	Total	**2**	**54**		**20.346**	**9.19**		**2.269**	**12.78**
2035	Shallow			3.053			0.390		
	Medium	1	18	3.686	6.634	3.00	0.404	0.726	4.09
	Deep	1	36	3.809	13.712	6.20	0.429	1.543	8.69
	Total	**2**	**54**		**20.346**	**9.19**		**2.269**	**12.78**
2036	Shallow			3.053			0.390		
	Medium	1	18	3.686	6.634	3.00	0.404	0.726	4.09
	Deep	1	36	3.809	13.712	6.20	0.429	1.543	8.69
	Total	**2**	**54**		**20.346**	**9.19**		**2.269**	**12.78**
2037	Shallow			3.053			0.390		
	Medium	1	18	3.686	6.634	3.00	0.404	0.726	4.09
	Deep	1	36	3.809	13.712	6.20	0.429	1.543	8.69
	Total	**2**	**54**		**20.346**	**9.19**		**2.269**	**12.78**
2038	Shallow			3.053			0.390		
	Medium	1	18	3.686	6.634	3.00	0.404	0.726	4.09
	Deep			3.809			0.429		
	Total	**1**	**18**		**6.634**	**3.00**		**0.726**	**4.09**
2039	Shallow			3.053			0.390		
	Medium			3.686			0.404		
	Deep			3.809			0.429		
	Total								

Table 4.2.4
Arctic Spill Occurrence - High Case - Platforms - Summary

Year	Production [MMbbl]	Small and Medium Spills 50-999 bbl			Large and Huge Spills =>1000 bbl			Significant Spills =>1000 bbl			All Spills		
		Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 103years	Frequency Spills per 109 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]
2010													
2011													
2012													
2013													
2014													
2015													
2016													
2017													
2018													
2019	**8.8**	1.832	0.208	0.828	0.234	0.027	1.316	0.234	0.027	1.316	2.066	0.235	2.144
2020	**16.3**	3.664	0.225	1.656	0.467	0.029	2.632	0.467	0.029	2.632	4.131	0.253	4.288
2021	**16.3**	5.496	0.337	2.484	0.701	0.043	3.949	0.701	0.043	3.949	6.197	0.380	6.432
2022	**29.8**	7.781	0.261	3.516	0.958	0.032	5.396	0.958	0.032	5.396	8.740	0.293	8.913
2023	**30.3**	11.590	0.383	5.238	1.387	0.046	7.809	1.387	0.046	7.809	12.977	0.428	13.047
2024	**42.4**	17.611	0.415	7.959	2.058	0.049	11.586	2.058	0.049	11.586	19.668	0.464	19.545
2025	**55.4**	23.631	0.427	10.679	2.728	0.049	15.363	2.728	0.049	15.363	26.359	0.476	26.042
2026	**53.8**	25.842	0.480	11.679	2.970	0.055	16.726	2.970	0.055	16.726	28.813	0.536	28.405
2027	**52.5**	25.842	0.492	11.679	2.970	0.057	16.726	2.970	0.057	16.726	28.813	0.549	28.405
2028	**42.5**	25.842	0.608	11.679	2.970	0.070	16.726	2.970	0.070	16.726	28.813	0.678	28.405
2029	**34.5**	25.842	0.749	11.679	2.970	0.086	16.726	2.970	0.086	16.726	28.813	0.835	28.405
2030	**28.0**	25.842	0.923	11.679	2.970	0.106	16.726	2.970	0.106	16.726	28.813	1.029	28.405
2031	**22.7**	25.842	1.138	11.679	2.970	0.131	16.726	2.970	0.131	16.726	28.813	1.269	28.405
2032	**18.5**	25.842	1.397	11.679	2.970	0.161	16.726	2.970	0.161	16.726	28.813	1.557	28.405
2033	**15.1**	25.842	1.711	11.679	2.970	0.197	16.726	2.970	0.197	16.726	28.813	1.908	28.405
2034	**10.5**	20.346	1.938	9.195	2.269	0.216	12.778	2.269	0.216	12.778	22.616	2.154	21.973
2035	**8.5**	20.346	2.394	9.195	2.269	0.267	12.778	2.269	0.267	12.778	22.616	2.661	21.973
2036	**6.9**	20.346	2.949	9.195	2.269	0.329	12.778	2.269	0.329	12.778	22.616	3.278	21.973
2037	**5.6**	20.346	3.633	9.195	2.269	0.405	12.778	2.269	0.405	12.778	22.616	4.039	21.973
2038	**2.1**	6.634	3.159	2.998	0.726	0.346	4.091	0.726	0.346	4.091	7.361	3.505	7.089
2039													
Total LOF	**500.5**	**366.363**		**166**	**42.100**		**237**	**42.100**		**237**	**408.464**		**403**
Average LOF		**12.633**	**0.732**	**6**	**1.452**	**0.084**	**8**	**1.452**	**0.084**	**8**	**14.085**	**0.816**	**14**

Table 4.2.5
Arctic Spill Occurrence - High Case - Production Wells

Year	Water Depth	Production Wells Blowout												
		N Wells	Small and Medium Spills 50-999 bbl			Large Spills 1000-9999 bbl			Spills 10000-149999 bbl			Spills =>150000 bbl		
			Expected Spill [bbl] =		519	Expected Spill [bbl] =		5292	Expected Spill [bbl] =		68349	Expected Spill [bbl] =		200000
		Cum.	Frequency spills per 10^4well-year	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^4well-year	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^4well-year	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^4well-year	Frequency spills per 10^3years	Spill Index bbl
2010	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep		0.103			0.718			0.308			0.205		
	Total													
2011	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep		0.103			0.718			0.308			0.205		
	Total													
2012	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep		0.103			0.718			0.308			0.205		
	Total													
2013	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep		0.103			0.718			0.308			0.205		
	Total													
2014	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep		0.103			0.718			0.308			0.205		
	Total													
2015	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep		0.103			0.718			0.308			0.205		
	Total													
2016	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep		0.103			0.718			0.308			0.205		
	Total													
2017	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep		0.103			0.718			0.308			0.205		
	Total													
2018	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep		0.103			0.718			0.308			0.205		
	Total													
2019	Shallow	6	0.103	0.062	0.03	0.718	0.431	2.28	0.308	0.185	12.62	0.205	0.123	24.63
	Medium		0.103			0.718			0.308			0.205		
	Deep		0.103			0.718			0.308			0.205		
	Total	**6**		0.062	**0.03**		0.431	**2.28**		0.185	**12.62**		0.123	**24.63**
2020	Shallow	12	0.103	0.123	0.06	0.718	0.862	4.56	0.308	0.369	25.25	0.205	0.246	49.25
	Medium		0.103			0.718			0.308			0.205		
	Deep		0.103			0.718			0.308			0.205		
	Total	**12**		0.123	**0.06**		0.862	**4.56**		0.369	**25.25**		0.246	**49.25**
2021	Shallow	18	0.103	0.185	0.10	0.718	1.293	6.84	0.308	0.554	37.87	0.205	0.369	73.88
	Medium		0.103			0.718			0.308			0.205		
	Deep		0.103			0.718			0.308			0.205		
	Total	**18**		0.185	**0.10**		1.293	**6.84**		0.554	**37.87**		0.369	**73.88**
2022	Shallow	18	0.103	0.185	0.10	0.718	1.293	6.84	0.308	0.554	37.87	0.205	0.369	73.88
	Medium		0.103			0.718			0.308			0.205		
	Deep	6	0.103	0.062	0.03	0.718	0.431	2.28	0.308	0.185	12.62	0.205	0.123	24.63
	Total	**24**		0.246	**0.13**		1.724	**9.12**		0.739	**50.50**		0.493	**98.51**
2023	Shallow	18	0.103	0.185	0.10	0.718	1.293	6.84	0.308	0.554	37.87	0.205	0.369	73.88
	Medium		0.103			0.718			0.308			0.205		
	Deep	16	0.103	0.164	0.09	0.718	1.149	6.08	0.308	0.493	33.66	0.205	0.328	65.67
	Total	**34**		0.349	**0.18**		2.442	**12.92**		1.047	**71.54**		0.698	**139.55**
2024	Shallow	18	0.103	0.185	0.10	0.718	1.293	6.84	0.308	0.554	37.87	0.205	0.369	73.88
	Medium	6	0.103	0.062	0.03	0.718	0.431	2.28	0.308	0.185	12.62	0.205	0.123	24.63
	Deep	26	0.103	0.267	0.14	0.718	1.868	9.88	0.308	0.800	54.71	0.205	0.534	106.72
	Total	**50**		0.513	**0.27**		3.591	**19.01**		1.539	**105.20**		1.026	**205.23**
2025	Shallow	18	0.103	0.185	0.10	0.718	1.293	6.84	0.308	0.554	37.87	0.205	0.369	73.88
	Medium	12	0.103	0.123	0.06	0.718	0.862	4.56	0.308	0.369	25.25	0.205	0.246	49.25
	Deep	36	0.103	0.369	0.19	0.718	2.586	13.68	0.308	1.108	75.75	0.205	0.739	147.76
	Total	**66**		0.677	**0.35**		4.741	**25.09**		2.032	**138.87**		1.354	**270.90**
2026	Shallow	18	0.103	0.185	0.10	0.718	1.293	6.84	0.308	0.554	37.87	0.205	0.369	73.88
	Medium	18	0.103	0.185	0.10	0.718	1.293	6.84	0.308	0.554	37.87	0.205	0.369	73.88
	Deep	36	0.103	0.369	0.19	0.718	2.586	13.68	0.308	1.108	75.75	0.205	0.739	147.76
	Total	**72**		0.739	**0.38**		5.172	**27.37**		2.216	**151.49**		1.478	**295.53**
2027	Shallow	18	0.103	0.185	0.10	0.718	1.293	6.84	0.308	0.554	37.87	0.205	0.369	73.88
	Medium	18	0.103	0.185	0.10	0.718	1.293	6.84	0.308	0.554	37.87	0.205	0.369	73.88
	Deep	36	0.103	0.369	0.19	0.718	2.586	13.68	0.308	1.108	75.75	0.205	0.739	147.76
	Total	**72**		0.739	**0.38**		5.172	**27.37**		2.216	**151.49**		1.478	**295.53**

Table 4.2.5
Arctic Spill Occurrence - High Case - Production Wells

Year	Water Depth	Production Wells Blowout												
		N Wells	Small and Medium Spills 50-999 bbl			Large Spills 1000-9999 bbl			Spills 10000-149999 bbl			Spills =>150000 bbl		
			Expected Spill [bbl] =		519	Expected Spill [bbl] =		5292	Expected Spill [bbl] =		68349	Expected Spill [bbl] =		200000
		Cum.	Frequency spills per 10^4well-year	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^4well-year	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^4well-year	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^4well-year	Frequency spills per 10^3years	Spill Index bbl
2028	Shallow	18	0.103	0.185	0.10	0.718	1.293	6.84	0.308	0.554	37.87	0.205	0.369	73.88
	Medium	18	0.103	0.185	0.10	0.718	1.293	6.84	0.308	0.554	37.87	0.205	0.369	73.88
	Deep	36	0.103	0.369	0.19	0.718	2.586	13.68	0.308	1.108	75.75	0.205	0.739	147.76
	Total	**72**		0.739	**0.38**		5.172	**27.37**		2.216	**151.49**		1.478	**295.53**
2029	Shallow	18	0.103	0.185	0.10	0.718	1.293	6.84	0.308	0.554	37.87	0.205	0.369	73.88
	Medium	18	0.103	0.185	0.10	0.718	1.293	6.84	0.308	0.554	37.87	0.205	0.369	73.88
	Deep	36	0.103	0.369	0.19	0.718	2.586	13.68	0.308	1.108	75.75	0.205	0.739	147.76
	Total	**72**		0.739	**0.38**		5.172	**27.37**		2.216	**151.49**		1.478	**295.53**
2030	Shallow	18	0.103	0.185	0.10	0.718	1.293	6.84	0.308	0.554	37.87	0.205	0.369	73.88
	Medium	18	0.103	0.185	0.10	0.718	1.293	6.84	0.308	0.554	37.87	0.205	0.369	73.88
	Deep	36	0.103	0.369	0.19	0.718	2.586	13.68	0.308	1.108	75.75	0.205	0.739	147.76
	Total	**72**		0.739	**0.38**		5.172	**27.37**		2.216	**151.49**		1.478	**295.53**
2031	Shallow	18	0.103	0.185	0.10	0.718	1.293	6.84	0.308	0.554	37.87	0.205	0.369	73.88
	Medium	18	0.103	0.185	0.10	0.718	1.293	6.84	0.308	0.554	37.87	0.205	0.369	73.88
	Deep	36	0.103	0.369	0.19	0.718	2.586	13.68	0.308	1.108	75.75	0.205	0.739	147.76
	Total	**72**		0.739	**0.38**		5.172	**27.37**		2.216	**151.49**		1.478	**295.53**
2032	Shallow	18	0.103	0.185	0.10	0.718	1.293	6.84	0.308	0.554	37.87	0.205	0.369	73.88
	Medium	18	0.103	0.185	0.10	0.718	1.293	6.84	0.308	0.554	37.87	0.205	0.369	73.88
	Deep	36	0.103	0.369	0.19	0.718	2.586	13.68	0.308	1.108	75.75	0.205	0.739	147.76
	Total	**72**		0.739	**0.38**		5.172	**27.37**		2.216	**151.49**		1.478	**295.53**
2033	Shallow	18	0.103	0.185	0.10	0.718	1.293	6.84	0.308	0.554	37.87	0.205	0.369	73.88
	Medium	18	0.103	0.185	0.10	0.718	1.293	6.84	0.308	0.554	37.87	0.205	0.369	73.88
	Deep	36	0.103	0.369	0.19	0.718	2.586	13.68	0.308	1.108	75.75	0.205	0.739	147.76
	Total	**72**		0.739	**0.38**		5.172	**27.37**		2.216	**151.49**		1.478	**295.53**
2034	Shallow		0.103			0.718			0.308			0.205		
	Medium	18	0.103	0.185	0.10	0.718	1.293	6.84	0.308	0.554	37.87	0.205	0.369	73.88
	Deep	36	0.103	0.369	0.19	0.718	2.586	13.68	0.308	1.108	75.75	0.205	0.739	147.76
	Total	**54**		0.554	**0.29**		3.879	**20.53**		1.662	**113.62**		1.108	**221.65**
2035	Shallow		0.103			0.718			0.308			0.205		
	Medium	18	0.103	0.185	0.10	0.718	1.293	6.84	0.308	0.554	37.87	0.205	0.369	73.88
	Deep	36	0.103	0.369	0.19	0.718	2.586	13.68	0.308	1.108	75.75	0.205	0.739	147.76
	Total	**54**		0.554	**0.29**		3.879	**20.53**		1.662	**113.62**		1.108	**221.65**
2036	Shallow		0.103			0.718			0.308			0.205		
	Medium	18	0.103	0.185	0.10	0.718	1.293	6.84	0.308	0.554	37.87	0.205	0.369	73.88
	Deep	36	0.103	0.369	0.19	0.718	2.586	13.68	0.308	1.108	75.75	0.205	0.739	147.76
	Total	**54**		0.554	**0.29**		3.879	**20.53**		1.662	**113.62**		1.108	**221.65**
2037	Shallow		0.103			0.718			0.308			0.205		
	Medium	18	0.103	0.185	0.10	0.718	1.293	6.84	0.308	0.554	37.87	0.205	0.369	73.88
	Deep	36	0.103	0.369	0.19	0.718	2.586	13.68	0.308	1.108	75.75	0.205	0.739	147.76
	Total	**54**		0.554	**0.29**		3.879	**20.53**		1.662	**113.62**		1.108	**221.65**
2038	Shallow		0.103			0.718			0.308			0.205		
	Medium	18	0.103	0.185	0.10	0.718	1.293	6.84	0.308	0.554	37.87	0.205	0.369	73.88
	Deep		0.103			0.718			0.308			0.205		
	Total	**18**		0.185	**0.10**		1.293	**6.84**		0.554	**37.87**		0.369	**73.88**
2039	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep		0.103			0.718			0.308			0.205		
	Total													

Table 4.2.6
Arctic Spill Occurrence - High Case - Production Wells - Summary

Year	Production [MMbbl]	Small and Medium Spills 50-99 bbl			Large Spills 1000-9999 bbl			Huge Spills =>10000 bbl			All Spills		
		Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]
2010													
2011													
2012													
2013													
2014													
2015													
2016													
2017													
2018													
2019	8.8	0.062	0.007	0.032	0.185	0.021	2.281	0.308	0.035	37.252	0.554	0.063	39.564
2020	16.3	0.123	0.008	0.064	0.369	0.023	4.562	0.616	0.038	74.503	1.108	0.068	79.129
2021	16.3	0.185	0.011	0.096	0.554	0.034	6.842	0.924	0.057	111.755	1.662	0.102	118.693
2022	29.8	0.246	0.008	0.128	0.739	0.025	9.123	1.231	0.041	149.006	2.216	0.074	158.257
2023	30.3	0.349	0.012	0.181	1.047	0.035	12.924	1.744	0.058	211.092	3.140	0.104	224.197
2024	42.4	0.513	0.012	0.266	1.539	0.036	19.006	2.565	0.061	310.429	4.618	0.109	329.702
2025	55.4	0.677	0.012	0.352	2.032	0.037	25.088	3.386	0.061	409.767	6.095	0.110	435.207
2026	53.8	0.739	0.014	0.384	2.216	0.041	27.369	3.694	0.069	447.018	6.649	0.124	474.771
2027	52.5	0.739	0.014	0.384	2.216	0.042	27.369	3.694	0.070	447.018	6.649	0.127	474.771
2028	42.5	0.739	0.017	0.384	2.216	0.052	27.369	3.694	0.087	447.018	6.649	0.156	474.771
2029	34.5	0.739	0.021	0.384	2.216	0.064	27.369	3.694	0.107	447.018	6.649	0.193	474.771
2030	28.0	0.739	0.026	0.384	2.216	0.079	27.369	3.694	0.132	447.018	6.649	0.237	474.771
2031	22.7	0.739	0.033	0.384	2.216	0.098	27.369	3.694	0.163	447.018	6.649	0.293	474.771
2032	18.5	0.739	0.040	0.384	2.216	0.120	27.369	3.694	0.200	447.018	6.649	0.359	474.771
2033	15.1	0.739	0.049	0.384	2.216	0.147	27.369	3.694	0.245	447.018	6.649	0.440	474.771
2034	10.5	0.554	0.053	0.288	1.662	0.158	20.527	2.771	0.264	335.264	4.987	0.475	356.078
2035	8.5	0.554	0.065	0.288	1.662	0.196	20.527	2.771	0.326	335.264	4.987	0.587	356.078
2036	6.9	0.554	0.080	0.288	1.662	0.241	20.527	2.771	0.402	335.264	4.987	0.723	356.078
2037	5.6	0.554	0.099	0.288	1.662	0.297	20.527	2.771	0.495	335.264	4.987	0.891	356.078
2038	2.1	0.185	0.088	0.096	0.554	0.264	6.842	0.924	0.440	111.755	1.662	0.792	118.693
2039													

Table 4.2.7
Occurrence Spill Risks - High Case - Exploration Wells

Year	Water Depth	Exploration Wells Blowout												
		N Wells	Small and Medium Spills 50-999 bbl			Large Spills 1000-9999 bbl			Spills 10000-149999 bbl			Spills =>150000 bbl		
			Expected Spill [bbl] =		519	Expected Spill [bbl] =		5292	Expected Spill [bbl] =		68349	Expected Spill [bbl] =		200000
		Cum.	Frequency spills per 10^4wells	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^4wells	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^4wells	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^4wells	Frequency spills per 10^3years	Spill Index bbl
2010	Shallow	1	1.583	0.158	0.08	11.077	1.108	5.86	4.759	0.476	32.53	2.755	0.276	55.11
	Medium		1.809			12.659			5.439			3.149		
	Deep		2.035			14.242			6.119			3.543		
	Total	**1**		0.158	**0.08**		1.108	**5.86**		0.476	**32.53**		0.276	**55.11**
2011	Shallow	1	1.583	0.158	0.08	11.077	1.108	5.86	4.759	0.476	32.53	2.755	0.276	55.11
	Medium		1.809			12.659			5.439			3.149		
	Deep		2.035			14.242			6.119			3.543		
	Total	**1**		0.158	**0.08**		1.108	**5.86**		0.476	**32.53**		0.276	**55.11**
2012	Shallow		1.583			11.077			4.759			2.755		
	Medium		1.809			12.659			5.439			3.149		
	Deep	1	2.035	0.204	0.11	14.242	1.424	7.54	6.119	0.612	41.82	3.543	0.354	70.85
	Total	**1**		0.204	**0.11**		1.424	**7.54**		0.612	**41.82**		0.354	**70.85**
2013	Shallow	1	1.583	0.158	0.08	11.077	1.108	5.86	4.759	0.476	32.53	2.755	0.276	55.11
	Medium		1.809			12.659			5.439			3.149		
	Deep	1	2.035	0.204	0.11	14.242	1.424	7.54	6.119	0.612	41.82	3.543	0.354	70.85
	Total	**2**		0.362	**0.19**		2.532	**13.40**		1.088	**74.35**		0.630	**125.96**
2014	Shallow	1	1.583	0.158	0.08	11.077	1.108	5.86	4.759	0.476	32.53	2.755	0.276	55.11
	Medium		1.809			12.659			5.439			3.149		
	Deep		2.035			14.242			6.119			3.543		
	Total	**1**		0.158	**0.08**		1.108	**5.86**		0.476	**32.53**		0.276	**55.11**
2015	Shallow		1.583			11.077			4.759			2.755		
	Medium	1	1.809	0.181	0.09	12.659	1.266	6.70	5.439	0.544	37.18	3.149	0.315	62.98
	Deep		2.035			14.242			6.119			3.543		
	Total	**1**		0.181	**0.09**		1.266	**6.70**		0.544	**37.18**		0.315	**62.98**
2016	Shallow		1.583			11.077			4.759			2.755		
	Medium	1	1.809	0.181	0.09	12.659	1.266	6.70	5.439	0.544	37.18	3.149	0.315	62.98
	Deep		2.035			14.242			6.119			3.543		
	Total	**1**		0.181	**0.09**		1.266	**6.70**		0.544	**37.18**		0.315	**62.98**
2017	Shallow		1.583			11.077			4.759			2.755		
	Medium	1	1.809	0.181	0.09	12.659	1.266	6.70	5.439	0.544	37.18	3.149	0.315	62.98
	Deep		2.035			14.242			6.119			3.543		
	Total	**1**		0.181	**0.09**		1.266	**6.70**		0.544	**37.18**		0.315	**62.98**
2018	Shallow		1.583			11.077			4.759			2.755		
	Medium		1.809			12.659			5.439			3.149		
	Deep		2.035			14.242			6.119			3.543		
	Total													
2019	Shallow		1.583			11.077			4.759			2.755		
	Medium		1.809			12.659			5.439			3.149		
	Deep		2.035			14.242			6.119			3.543		
	Total													
2020	Shallow		1.583			11.077			4.759			2.755		
	Medium		1.809			12.659			5.439			3.149		
	Deep		2.035			14.242			6.119			3.543		
	Total													
2021	Shallow		1.583			11.077			4.759			2.755		
	Medium		1.809			12.659			5.439			3.149		
	Deep		2.035			14.242			6.119			3.543		
	Total													
2022	Shallow		1.583			11.077			4.759			2.755		
	Medium		1.809			12.659			5.439			3.149		
	Deep		2.035			14.242			6.119			3.543		
	Total													
2023	Shallow		1.583			11.077			4.759			2.755		
	Medium		1.809			12.659			5.439			3.149		
	Deep		2.035			14.242			6.119			3.543		
	Total													
2024	Shallow		1.583			11.077			4.759			2.755		
	Medium		1.809			12.659			5.439			3.149		
	Deep		2.035			14.242			6.119			3.543		
	Total													
2025	Shallow		1.583			11.077			4.759			2.755		
	Medium		1.809			12.659			5.439			3.149		
	Deep		2.035			14.242			6.119			3.543		
	Total													
2026	Shallow		1.583			11.077			4.759			2.755		
	Medium		1.809			12.659			5.439			3.149		
	Deep		2.035			14.242			6.119			3.543		
	Total													
2027	Shallow		1.583			11.077			4.759			2.755		
	Medium		1.809			12.659			5.439			3.149		
	Deep		2.035			14.242			6.119			3.543		
	Total													
2028	Shallow		1.583			11.077			4.759			2.755		
	Medium		1.809			12.659			5.439			3.149		
	Deep		2.035			14.242			6.119			3.543		
	Total													
2029	Shallow		1.583			11.077			4.759			2.755		
	Medium		1.809			12.659			5.439			3.149		
	Deep		2.035			14.242			6.119			3.543		
	Total													
2030	Shallow		1.583			11.077			4.759			2.755		
	Medium		1.809			12.659			5.439			3.149		
	Deep		2.035			14.242			6.119			3.543		
	Total													
2031	Shallow		1.583			11.077			4.759			2.755		
	Medium		1.809			12.659			5.439			3.149		
	Deep		2.035			14.242			6.119			3.543		
	Total													
2032	Shallow		1.583			11.077			4.759			2.755		
	Medium		1.809			12.659			5.439			3.149		
	Deep		2.035			14.242			6.119			3.543		
	Total													
2033	Shallow		1.583			11.077			4.759			2.755		
	Medium		1.809			12.659			5.439			3.149		
	Deep		2.035			14.242			6.119			3.543		
	Total													
2034	Shallow		1.583			11.077			4.759			2.755		
	Medium		1.809			12.659			5.439			3.149		
	Deep		2.035			14.242			6.119			3.543		
	Total													
2035	Shallow		1.583			11.077			4.759			2.755		
	Medium		1.809			12.659			5.439			3.149		
	Deep		2.035			14.242			6.119			3.543		
	Total													

Table 4.2.7
Occurrence Spill Risks - High Case - Exploration Wells

Year	Water Depth	Exploration Wells Blowout												
		N Wells	Small and Medium Spills 50-999 bbl			Large Spills 1000-9999 bbl			Spills 10000-149999 bbl			Spills =>150000 bbl		
			Expected Spill [bbl] =		**519**	Expected Spill [bbl] =		**5292**	Expected Spill [bbl] =		**68349**	Expected Spill [bbl] =		**200000**
		Cum.	Frequency spills per 10^4wells	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^4wells	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^4wells	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^4wells	Frequency spills per 10^3years	Spill Index bbl
2036	Shallow		1.583			11.077			4.759			2.755		
	Medium		1.809			12.659			5.439			3.149		
	Deep		2.035			14.242			6.119			3.543		
	Total													
2037	Shallow		1.583			11.077			4.759			2.755		
	Medium		1.809			12.659			5.439			3.149		
	Deep		2.035			14.242			6.119			3.543		
	Total													
2038	Shallow		1.583			11.077			4.759			2.755		
	Medium		1.809			12.659			5.439			3.149		
	Deep		2.035			14.242			6.119			3.543		
	Total													
2039	Shallow		1.583			11.077			4.759			2.755		
	Medium		1.809			12.659			5.439			3.149		
	Deep		2.035			14.242			6.119			3.543		
	Total													

Table 4.2.8
Arctic Spill Occurrence - High Case - Exploration Wells - Summary

Year	Production [MMbbl]	Small and Medium Spills 50-99 bbl			Large Spills 1000-9999 bbl			Huge Spills =>10000 bbl			All Spills		
		Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]
2010		0.158		0.082	0.476		5.862	0.751		87.639	1.386		93.583
2011		0.158		0.082	0.476		5.862	0.751		87.639	1.386		93.583
2012		0.204		0.106	0.612		7.537	0.966		112.679	1.782		120.321
2013		0.362		0.188	1.088		13.399	1.718		200.318	3.167		213.905
2014		0.158		0.082	0.476		5.862	0.751		87.639	1.386		93.583
2015		0.181		0.094	0.544		6.699	0.859		100.159	1.584		106.952
2016		0.181		0.094	0.544		6.699	0.859		100.159	1.584		106.952
2017		0.181		0.094	0.544		6.699	0.859		100.159	1.584		106.952
2018													
2019	8.8												
2020	16.3												
2021	16.3												
2022	29.8												
2023	30.3												
2024	42.4												
2025	55.4												
2026	53.8												
2027	52.5												
2028	42.5												
2029	34.5												
2030	28.0												
2031	22.7												
2032	18.5												
2033	15.1												
2034	10.5												
2035	8.5												
2036	6.9												
2037	5.6												
2038	2.1												
2039													

Table 4.2.9
Arctic Spill Occurrence Beaufort Sea High Case
Development Wells

Year	Water Depth	Development Wells Blowout												
		N Wells	Small and Medium Spills 50-999 bbl			Large Spills 1000-9999 bbl			Spills 10000-149999 bbl			Spills =>150000 bbl		
			Expected Spill [bbl] =		519	Expected Spill [bbl] =		5292	Expected Spill [bbl] =		68349	Expected Spill [bbl] =		200000
		Cum.	Frequency spills per 10^4wells	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^4wells	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^4wells	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^4wells	Frequency spills per 10^3years	Spill Index bbl
2010	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total													
2011	Shallow	2	0.484	0.097	0.05	3.383	0.677	3.58	1.453	0.291	19.87	1.453	0.291	58.13
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total	**2**		0.097	**0.05**		0.677	**3.58**		0.291	**19.87**		0.291	**58.13**
2012	Shallow	2	0.484	0.097	0.05	3.383	0.677	3.58	1.453	0.291	19.87	1.453	0.291	58.13
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total	**2**		0.097	**0.05**		0.677	**3.58**		0.291	**19.87**		0.291	**58.13**
2013	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep	2	0.623	0.125	0.06	4.350	0.870	4.60	1.868	0.374	25.54	1.868	0.374	74.74
	Total	**2**		0.125	**0.06**		0.870	**4.60**		0.374	**25.54**		0.374	**74.74**
2014	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep	3	0.623	0.187	0.10	4.350	1.305	6.91	1.868	0.561	38.31	1.868	0.561	112.11
	Total	**3**		0.187	**0.10**		1.305	**6.91**		0.561	**38.31**		0.561	**112.11**
2015	Shallow		0.484			3.383			1.453			1.453		
	Medium	2	0.554	0.111	0.06	3.867	0.773	4.09	1.661	0.332	22.70	1.661	0.332	66.43
	Deep		0.623			4.350			1.868			1.868		
	Total	**2**		0.111	**0.06**		0.773	**4.09**		0.332	**22.70**		0.332	**66.43**
2016	Shallow		0.484			3.383			1.453			1.453		
	Medium	2	0.554	0.111	0.06	3.867	0.773	4.09	1.661	0.332	22.70	1.661	0.332	66.43
	Deep		0.623			4.350			1.868			1.868		
	Total	**2**		0.111	**0.06**		0.773	**4.09**		0.332	**22.70**		0.332	**66.43**
2017	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total													
2018	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total													
2019	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total													
2020	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total													
2021	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total													
2022	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total													
2023	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total													
2024	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total													
2025	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total													
2026	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total													
2027	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total													
2028	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total													
2029	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total													
2030	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total													
2031	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total													
2032	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total													
2033	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total													
2034	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total													
2035	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total													

Table 4.2.9
Arctic Spill Occurrence Beaufort Sea High Case
Development Wells

Year	Water Depth	N Wells	Development Wells Blowout											
			Small and Medium Spills 50-999 bbl			Large Spills 1000-9999 bbl			Spills 10000-149999 bbl			Spills =>150000 bbl		
			Expected Spill [bbl] =		519	Expected Spill [bbl] =		5292	Expected Spill [bbl] =		68349	Expected Spill [bbl] =		200000
		Cum.	Frequency spills per 10^4wells	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^4wells	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^4wells	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^4wells	Frequency spills per 10^3years	Spill Index bbl
2036	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total													
2037	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total													
2038	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total													
2039	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep		0.623			4.350			1.868			1.868		
	Total													

Table 4.2.10
Arctic Spill Occurrence - High Case - Development Wells - Summary

Year	Production [MMbbl]	Small and Medium Spills 50-99 bbl			Large Spills 1000-9999 bbl			Huge Spills =>10000 bbl			All Spills		
		Frequency Spills per 10^3 years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3 years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3 years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3 years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]
2010													
2011		0.097		0.050	0.291		3.581	0.581		77.994	0.969		81.626
2012		0.097		0.050	0.291		3.581	0.581		77.994	0.969		81.626
2013		0.125		0.065	0.374		4.604	0.747		100.278	1.246		104.947
2014		0.187		0.097	0.561		6.906	1.121		150.418	1.868		157.421
2015		0.111		0.058	0.332		4.093	0.664		89.136	1.107		93.287
2016		0.111		0.058	0.332		4.093	0.664		89.136	1.107		93.287
2017													
2018													
2019	8.8												
2020	16.3												
2021	16.3												
2022	29.8												
2023	30.3												
2024	42.4												
2025	55.4												
2026	53.8												
2027	52.5												
2028	42.5												
2029	34.5												
2030	28.0												
2031	22.7												
2032	18.5												
2033	15.1												
2034	10.5												
2035	8.5												
2036	6.9												
2037	5.6												
2038	2.1												
2039													

Table 4.2.11
Arctic Spill Occurrence - High Case - Wells - Summary

Year	Production [MMbbl]	Small and Medium Spills 50-999 bbl			Large Spills 1000-9999 bbl			Huge Spills =>10000 bbl			Significant Spills =>1000 bbl			All Spills		
		Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 103years	Frequency Spills per 109 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]
2010		0.158		0.082	0.476		5.862	0.751		87.639	1.227		93.501	1.386		93.583
2011		0.255		0.133	0.767		9.443	1.333		165.633	2.099		175.077	2.355		175.209
2012		0.300		0.156	0.903		11.118	1.547		190.673	2.450		201.791	2.750		201.947
2013		0.486		0.253	1.462		18.003	2.465		300.596	3.927		318.600	4.413		318.852
2014		0.345		0.179	1.036		12.768	1.873		238.057	2.909		250.825	3.254		251.004
2015		0.292		0.151	0.876		10.792	1.523		189.295	2.399		200.088	2.691		200.239
2016		0.292		0.151	0.876		10.792	1.523		189.295	2.399		200.088	2.691		200.239
2017		0.181		0.094	0.544		6.699	0.859		100.159	1.403		106.858	1.584		106.952
2018																
2019	**8.8**	0.062	0.007	0.032	0.185	0.021	2.281	0.308	0.035	37.252	0.493	0.056	39.532	0.554	0.063	39.564
2020	**16.3**	0.123	0.008	0.064	0.369	0.023	4.562	0.616	0.038	74.503	0.985	0.060	79.065	1.108	0.068	79.129
2021	**16.3**	0.185	0.011	0.096	0.554	0.034	6.842	0.924	0.057	111.755	1.478	0.091	118.597	1.662	0.102	118.693
2022	**29.8**	0.246	0.008	0.128	0.739	0.025	9.123	1.231	0.041	149.006	1.970	0.066	158.129	2.216	0.074	158.257
2023	**30.3**	0.349	0.012	0.181	1.047	0.035	12.924	1.744	0.058	211.092	2.791	0.092	224.016	3.140	0.104	224.197
2024	**42.4**	0.513	0.012	0.266	1.539	0.036	19.006	2.565	0.061	310.429	4.105	0.097	329.436	4.618	0.109	329.702
2025	**55.4**	0.677	0.012	0.352	2.032	0.037	25.088	3.386	0.061	409.767	5.418	0.098	434.855	6.095	0.110	435.207
2026	**53.8**	0.739	0.014	0.384	2.216	0.041	27.369	3.694	0.069	447.018	5.911	0.110	474.387	6.649	0.124	474.771
2027	**52.5**	0.739	0.014	0.384	2.216	0.042	27.369	3.694	0.070	447.018	5.911	0.113	474.387	6.649	0.127	474.771
2028	**42.5**	0.739	0.017	0.384	2.216	0.052	27.369	3.694	0.087	447.018	5.911	0.139	474.387	6.649	0.156	474.771
2029	**34.5**	0.739	0.021	0.384	2.216	0.064	27.369	3.694	0.107	447.018	5.911	0.171	474.387	6.649	0.193	474.771
2030	**28.0**	0.739	0.026	0.384	2.216	0.079	27.369	3.694	0.132	447.018	5.911	0.211	474.387	6.649	0.237	474.771
2031	**22.7**	0.739	0.033	0.384	2.216	0.098	27.369	3.694	0.163	447.018	5.911	0.260	474.387	6.649	0.293	474.771
2032	**18.5**	0.739	0.040	0.384	2.216	0.120	27.369	3.694	0.200	447.018	5.911	0.319	474.387	6.649	0.359	474.771
2033	**15.1**	0.739	0.049	0.384	2.216	0.147	27.369	3.694	0.245	447.018	5.911	0.391	474.387	6.649	0.440	474.771
2034	**10.5**	0.554	0.053	0.288	1.662	0.158	20.527	2.771	0.264	335.264	4.433	0.422	355.791	4.987	0.475	356.078
2035	**8.5**	0.554	0.065	0.288	1.662	0.196	20.527	2.771	0.326	335.264	4.433	0.522	355.791	4.987	0.587	356.078
2036	**6.9**	0.554	0.080	0.288	1.662	0.241	20.527	2.771	0.402	335.264	4.433	0.642	355.791	4.987	0.723	356.078
2037	**5.6**	0.554	0.099	0.288	1.662	0.297	20.527	2.771	0.495	335.264	4.433	0.792	355.791	4.987	0.891	356.078
2038	**2.1**	0.185	0.088	0.096	0.554	0.264	6.842	0.924	0.440	111.755	1.478	0.704	118.597	1.662	0.792	118.693
2039																
Total LOF	**500.5**	**12.776**		**7**	**38.339**		**473**	**64.207**		**7794**	**102.546**		**8267**	**115.323**		**8274**
Average LOF		**0.441**	**0.026**	**0**	**1.322**	**0.077**	**16**	**2.214**	**0.128**	**269**	**3.536**	**0.205**	**285**	**3.977**	**0.230**	**285**

Table 4.2.12
Arctic Spill Occurrence - High Case - Summary

Year	Facility	Production [MMbbl]	Small and Medium Spills 50-999 bbl			Large Spills 1000-9999 bbl			Huge Spills =>10000 bbl			All Spills		
			Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]
2010	Pipeline													
	Platforms													
	Production Wells													
	Exploration Wells		0.158		0.082	0.476		5.862	0.751		87.639	1.386		93.583
	Development Wells													
	Total		0.158		0.082	0.476		5.862	0.751		87.639	1.386		93.583
2011	Pipeline													
	Platforms													
	Production Wells													
	Exploration Wells		0.158		0.082	0.476		5.862	0.751		87.639	1.386		93.583
	Development Wells		0.097		0.050	0.291		3.581	0.581		77.994	0.969		81.626
	Total		0.255		0.133	0.767		9.443	1.333		165.633	2.355		175.209
2012	Pipeline													
	Platforms													
	Production Wells													
	Exploration Wells		0.204		0.106	0.612		7.537	0.966		112.679	1.782		120.321
	Development Wells		0.097		0.050	0.291		3.581	0.581		77.994	0.969		81.626
	Total		0.300		0.156	0.903		11.118	1.547		190.673	2.750		201.947
2013	Pipeline													
	Platforms													
	Production Wells													
	Exploration Wells		0.362		0.188	1.088		13.399	1.718		200.318	3.167		213.905
	Development Wells		0.125		0.065	0.374		4.604	0.747		100.278	1.246		104.947
	Total		0.486		0.253	1.462		18.003	2.465		300.596	4.413		318.852
2014	Pipeline													
	Platforms													
	Production Wells													
	Exploration Wells		0.158		0.082	0.476		5.862	0.751		87.639	1.386		93.583
	Development Wells		0.187		0.097	0.561		6.906	1.121		150.418	1.868		157.421
	Total		0.345		0.179	1.036		12.768	1.873		238.057	3.254		251.004
2015	Pipeline													
	Platforms													
	Production Wells													
	Exploration Wells		0.181		0.094	0.544		6.699	0.859		100.159	1.584		106.952
	Development Wells		0.111		0.058	0.332		4.093	0.664		89.136	1.107		93.287
	Total		0.292		0.151	0.876		10.792	1.523		189.295	2.691		200.239
2016	Pipeline													
	Platforms													
	Production Wells													
	Exploration Wells		0.181		0.094	0.544		6.699	0.859		100.159	1.584		106.952
	Development Wells		0.111		0.058	0.332		4.093	0.664		89.136	1.107		93.287
	Total		0.292		0.151	0.876		10.792	1.523		189.295	2.691		200.239
2017	Pipeline		2.960		1.103	0.952		4.926	0.325		5.060	4.237		11.090
	Platforms													
	Production Wells													
	Exploration Wells		0.181		0.094	0.544		6.699	0.859		100.159	1.584		106.952
	Development Wells													
	Total		3.141		1.197	1.496		11.625	1.184		105.219	5.821		118.042
2018	Pipeline		4.440		1.655	1.428		7.389	0.488		7.591	6.356		16.634
	Platforms													
	Production Wells													
	Exploration Wells													
	Development Wells													
	Total		4.440		1.655	1.428		7.389	0.488		7.591	6.356		16.634
2019	Pipeline	8.8	4.440	0.505	1.655	1.428	0.162	7.389	0.488	0.055	7.591	6.356	0.722	16.634
	Platforms		1.832	0.208	0.828	0.117	0.013	0.658	0.117	0.013	0.658	2.066	0.235	2.144
	Production Wells		0.062	0.007	0.032	0.185	0.021	2.281	0.308	0.035	37.252	0.554	0.063	39.564
	Exploration Wells													
	Development Wells													
	Total		6.334	0.720	2.515	1.729	0.196	10.328	0.913	0.104	45.500	8.976	1.020	58.343
2020	Pipeline	16.3	7.190	0.441	2.697	2.104	0.129	10.889	0.757	0.046	11.771	10.051	0.617	25.357
	Platforms		3.664	0.225	1.656	0.234	0.014	1.316	0.234	0.014	1.316	4.131	0.253	4.288
	Production Wells		0.123	0.008	0.064	0.369	0.023	4.562	0.616	0.038	74.503	1.108	0.068	79.129
	Exploration Wells													
	Development Wells													
	Total		10.977	0.673	4.416	2.707	0.166	16.767	1.606	0.099	87.590	15.290	0.938	108.774
2021	Pipeline	16.3	9.940	0.610	3.739	2.780	0.171	14.389	1.026	0.063	15.951	13.746	0.843	34.079
	Platforms		5.496	0.337	2.484	0.351	0.022	1.974	0.351	0.022	1.974	6.197	0.380	6.432
	Production Wells		0.185	0.011	0.096	0.554	0.034	6.842	0.924	0.057	111.755	1.662	0.102	118.693
	Exploration Wells													
	Development Wells													
	Total		15.620	0.958	6.318	3.685	0.226	23.206	2.300	0.141	129.680	21.605	1.325	159.204
2022	Pipeline	29.8	14.064	0.472	5.301	3.795	0.127	19.640	1.429	0.048	22.222	19.288	0.647	47.163
	Platforms		7.781	0.261	3.516	0.479	0.016	2.698	0.479	0.016	2.698	8.740	0.293	8.913
	Production Wells		0.246	0.008	0.128	0.739	0.025	9.123	1.231	0.041	149.006	2.216	0.074	158.257
	Exploration Wells													
	Development Wells													
	Total		22.092	0.741	8.946	5.013	0.168	31.461	3.139	0.105	173.926	30.244	1.015	214.333
2023	Pipeline	30.3	15.128	0.499	5.657	4.012	0.132	20.789	1.460	0.048	22.688	20.600	0.680	49.134
	Platforms		11.590	0.383	5.238	0.693	0.023	3.905	0.693	0.023	3.905	12.977	0.428	13.047
	Production Wells		0.349	0.012	0.181	1.047	0.035	12.924	1.744	0.058	211.092	3.140	0.104	224.197
	Exploration Wells													
	Development Wells													
	Total		27.067	0.893	11.076	5.752	0.190	37.618	3.898	0.129	237.685	36.717	1.212	286.379
2024	Pipeline	42.4	19.179	0.452	7.124	5.208	0.123	26.998	1.821	0.043	28.278	26.207	0.618	62.400
	Platforms		17.611	0.415	7.959	1.029	0.024	5.793	1.029	0.024	5.793	19.668	0.464	19.545
	Production Wells		0.513	0.012	0.266	1.539	0.036	19.006	2.565	0.061	310.429	4.618	0.109	329.702
	Exploration Wells													
	Development Wells													
	Total		37.302	0.880	15.349	7.776	0.183	51.798	5.415	0.128	344.501	50.493	1.191	411.647
2025	Pipeline	55.4	24.723	0.446	9.146	6.892	0.124	35.737	2.347	0.042	36.430	33.961	0.613	81.314
	Platforms		23.631	0.427	10.679	1.364	0.025	7.681	1.364	0.025	7.681	26.359	0.476	26.042
	Production Wells		0.677	0.012	0.352	2.032	0.037	25.088	3.386	0.061	409.767	6.095	0.110	435.207
	Exploration Wells													
	Development Wells													
	Total		49.031	0.885	20.177	10.288	0.186	68.507	7.097	0.128	453.878	66.416	1.199	542.563
2026	Pipeline	53.8	24.723	0.460	9.146	6.892	0.128	35.737	2.347	0.044	36.430	33.961	0.631	81.314
	Platforms		25.842	0.480	11.679	1.485	0.028	8.363	1.485	0.028	8.363	28.813	0.536	28.405
	Production Wells		0.739	0.014	0.384	2.216	0.041	27.369	3.694	0.069	447.018	6.649	0.124	474.771
	Exploration Wells													
	Development Wells													
	Total		51.304	0.954	21.209	10.593	0.197	71.469	7.526	0.140	491.812	69.423	1.290	584.490

Table 4.2.12
Arctic Spill Occurrence - High Case - Summary

Year	Facility	Production [MMbbl]	Small and Medium Spills 50-999 bbl			Large Spills 1000-9999 bbl			Huge Spills =>10000 bbl			All Spills		
			Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]
2027	Pipeline	52.5	24.723	0.471	9.146	6.892	0.131	35.737	2.347	0.045	36.430	33.961	0.647	81.314
	Platforms		25.842	0.492	11.679	1.485	0.028	8.363	1.485	0.028	8.363	28.813	0.549	28.405
	Production Wells		0.739	0.014	0.384	2.216	0.042	27.369	3.694	0.070	447.018	6.649	0.127	474.771
	Exploration Wells													
	Development Wells													
	Total		51.304	0.977	21.209	10.593	0.202	71.469	7.526	0.143	491.812	69.423	1.322	584.490
2028	Pipeline	42.5	24.723	0.582	9.146	6.892	0.162	35.737	2.347	0.055	36.430	33.961	0.799	81.314
	Platforms		25.842	0.608	11.679	1.485	0.035	8.363	1.485	0.035	8.363	28.813	0.678	28.405
	Production Wells		0.739	0.017	0.384	2.216	0.052	27.369	3.694	0.087	447.018	6.649	0.156	474.771
	Exploration Wells													
	Development Wells													
	Total		51.304	1.207	21.209	10.593	0.249	71.469	7.526	0.177	491.812	69.423	1.633	584.490
2029	Pipeline	34.5	24.723	0.717	9.146	6.892	0.200	35.737	2.347	0.068	36.430	33.961	0.984	81.314
	Platforms		25.842	0.749	11.679	1.485	0.043	8.363	1.485	0.043	8.363	28.813	0.835	28.405
	Production Wells		0.739	0.021	0.384	2.216	0.064	27.369	3.694	0.107	447.018	6.649	0.193	474.771
	Exploration Wells													
	Development Wells													
	Total		51.304	1.487	21.209	10.593	0.307	71.469	7.526	0.218	491.812	69.423	2.012	584.490
2030	Pipeline	28.0	24.723	0.883	9.146	6.892	0.246	35.737	2.347	0.084	36.430	33.961	1.213	81.314
	Platforms		25.842	0.923	11.679	1.485	0.053	8.363	1.485	0.053	8.363	28.813	1.029	28.405
	Production Wells		0.739	0.026	0.384	2.216	0.079	27.369	3.694	0.132	447.018	6.649	0.237	474.771
	Exploration Wells													
	Development Wells													
	Total		51.304	1.832	21.209	10.593	0.378	71.469	7.526	0.269	491.812	69.423	2.479	584.490
2031	Pipeline	22.7	24.723	1.089	9.146	6.892	0.304	35.737	2.347	0.103	36.430	33.961	1.496	81.314
	Platforms		25.842	1.138	11.679	1.485	0.065	8.363	1.485	0.065	8.363	28.813	1.269	28.405
	Production Wells		0.739	0.033	0.384	2.216	0.098	27.369	3.694	0.163	447.018	6.649	0.293	474.771
	Exploration Wells													
	Development Wells													
	Total		51.304	2.260	21.209	10.593	0.467	71.469	7.526	0.332	491.812	69.423	3.058	584.490
2032	Pipeline	18.5	24.723	1.336	9.146	6.892	0.373	35.737	2.347	0.127	36.430	33.961	1.836	81.314
	Platforms		25.842	1.397	11.679	1.485	0.080	8.363	1.485	0.080	8.363	28.813	1.557	28.405
	Production Wells		0.739	0.040	0.384	2.216	0.120	27.369	3.694	0.200	447.018	6.649	0.359	474.771
	Exploration Wells													
	Development Wells													
	Total		51.304	2.773	21.209	10.593	0.573	71.469	7.526	0.407	491.812	69.423	3.753	584.490
2033	Pipeline	15.1	24.723	1.637	9.146	6.892	0.456	35.737	2.347	0.155	36.430	33.961	2.249	81.314
	Platforms		25.842	1.711	11.679	1.485	0.098	8.363	1.485	0.098	8.363	28.813	1.908	28.405
	Production Wells		0.739	0.049	0.384	2.216	0.147	27.369	3.694	0.245	447.018	6.649	0.440	474.771
	Exploration Wells													
	Development Wells													
	Total		51.304	3.398	21.209	10.593	0.702	71.469	7.526	0.498	491.812	69.423	4.598	584.490
2034	Pipeline	10.5	20.283	1.932	7.491	5.464	0.520	28.348	1.858	0.177	28.840	27.605	2.629	64.679
	Platforms		20.346	1.938	9.195	1.135	0.108	6.389	1.135	0.108	6.389	22.616	2.154	21.973
	Production Wells		0.554	0.053	0.288	1.662	0.158	20.527	2.771	0.264	335.264	4.987	0.475	356.078
	Exploration Wells													
	Development Wells													
	Total		41.183	3.922	16.974	8.261	0.787	55.264	5.764	0.549	370.492	55.208	5.258	442.730
2035	Pipeline	8.5	20.283	2.386	7.491	5.464	0.643	28.348	1.858	0.219	28.840	27.605	3.248	64.679
	Platforms		20.346	2.394	9.195	1.135	0.133	6.389	1.135	0.133	6.389	22.616	2.661	21.973
	Production Wells		0.554	0.065	0.288	1.662	0.196	20.527	2.771	0.326	335.264	4.987	0.587	356.078
	Exploration Wells													
	Development Wells													
	Total		41.183	4.845	16.974	8.261	0.972	55.264	5.764	0.678	370.492	55.208	6.495	442.730
2036	Pipeline	6.9	20.283	2.940	7.491	5.464	0.792	28.348	1.858	0.269	28.840	27.605	4.001	64.679
	Platforms		20.346	2.949	9.195	1.135	0.164	6.389	1.135	0.164	6.389	22.616	3.278	21.973
	Production Wells		0.554	0.080	0.288	1.662	0.241	20.527	2.771	0.402	335.264	4.987	0.723	356.078
	Exploration Wells													
	Development Wells													
	Total		41.183	5.969	16.974	8.261	1.197	55.264	5.764	0.835	370.492	55.208	8.001	442.730
2037	Pipeline	5.6	20.283	3.622	6.425	5.464	0.976	24.899	1.858	0.332	27.440	27.605	4.930	58.764
	Platforms		20.346	3.633	9.195	1.135	0.203	6.389	1.135	0.203	6.389	22.616	4.039	21.973
	Production Wells		0.554	0.099	0.288	1.662	0.297	20.527	2.771	0.495	335.264	4.987	0.891	356.078
	Exploration Wells													
	Development Wells													
	Total		41.183	7.354	15.908	8.261	1.475	51.815	5.764	1.029	369.092	55.208	9.859	436.815
2038	Pipeline	2.1	7.468	3.556	2.778	2.444	1.164	12.649	0.824	0.392	12.809	10.735	5.112	28.236
	Platforms		6.634	3.159	2.998	0.363	0.173	2.045	0.363	0.173	2.045	7.361	3.505	7.089
	Production Wells		0.185	0.088	0.096	0.554	0.264	6.842	0.924	0.440	111.755	1.662	0.792	118.693
	Exploration Wells													
	Development Wells													
	Total		14.287	6.803	5.873	3.361	1.601	21.536	2.110	1.005	126.609	19.758	9.409	154.018
2039	Pipeline													
	Platforms													
	Production Wells													
	Exploration Wells													
	Development Wells													
	Total													

Table 4.2.13
Arctic Spill Occurrence - High Case - Annual Summary

Year	Production [MMbbl]	Small and Medium Spills 50-999 bbl			Large Spills 1000-9999 bbl			Huge Spills =>10000 bbl			Significant Spills =>1000 bbl			All Spills		
		Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 103years	Frequency Spills per 109 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]
2010		0.158		0.082	0.476		5.862	0.751		87.639	1.227		93.501	1.386		93.583
2011		0.255		0.133	0.767		9.443	1.333		165.633	2.099		175.077	2.355		175.209
2012		0.300		0.156	0.903		11.118	1.547		190.673	2.450		201.791	2.750		201.947
2013		0.486		0.253	1.462		18.003	2.465		300.596	3.927		318.600	4.413		318.852
2014		0.345		0.179	1.036		12.768	1.873		238.057	2.909		250.825	3.254		251.004
2015		0.292		0.151	0.876		10.792	1.523		189.295	2.399		200.088	2.691		200.239
2016		0.292		0.151	0.876		10.792	1.523		189.295	2.399		200.088	2.691		200.239
2017		3.141		1.197	1.496		11.625	1.184		105.219	2.680		116.845	5.821		118.042
2018		4.440		1.655	1.428		7.389	0.488		7.591	1.916		14.980	6.356		16.634
2019	**8.8**	6.334	0.720	2.515	1.729	0.196	10.328	0.913	0.104	45.500	2.642	0.300	55.828	8.976	1.020	58.343
2020	**16.3**	10.977	0.673	4.416	2.707	0.166	16.767	1.606	0.099	87.590	4.313	0.265	104.357	15.290	0.938	108.774
2021	**16.3**	15.620	0.958	6.318	3.685	0.226	23.206	2.300	0.141	129.680	5.985	0.367	152.886	21.605	1.325	159.204
2022	**29.8**	22.092	0.741	8.946	5.013	0.168	31.461	3.139	0.105	173.926	8.152	0.274	205.387	30.244	1.015	214.333
2023	**30.3**	27.067	0.893	11.076	5.752	0.190	37.618	3.898	0.129	237.685	9.651	0.318	275.303	36.717	1.212	286.379
2024	**42.4**	37.302	0.880	15.349	7.776	0.183	51.798	5.415	0.128	344.501	13.191	0.311	396.298	50.493	1.191	411.647
2025	**55.4**	49.031	0.885	20.177	10.288	0.186	68.507	7.097	0.128	453.878	17.385	0.314	522.385	66.416	1.199	542.563
2026	**53.8**	51.304	0.954	21.209	10.593	0.197	71.469	7.526	0.140	491.812	18.119	0.337	563.281	69.423	1.290	584.490
2027	**52.5**	51.304	0.977	21.209	10.593	0.202	71.469	7.526	0.143	491.812	18.119	0.345	563.281	69.423	1.322	584.490
2028	**42.5**	51.304	1.207	21.209	10.593	0.249	71.469	7.526	0.177	491.812	18.119	0.426	563.281	69.423	1.633	584.490
2029	**34.5**	51.304	1.487	21.209	10.593	0.307	71.469	7.526	0.218	491.812	18.119	0.525	563.281	69.423	2.012	584.490
2030	**28.0**	51.304	1.832	21.209	10.593	0.378	71.469	7.526	0.269	491.812	18.119	0.647	563.281	69.423	2.479	584.490
2031	**22.7**	51.304	2.260	21.209	10.593	0.467	71.469	7.526	0.332	491.812	18.119	0.798	563.281	69.423	3.058	584.490
2032	**18.5**	51.304	2.773	21.209	10.593	0.573	71.469	7.526	0.407	491.812	18.119	0.979	563.281	69.423	3.753	584.490
2033	**15.1**	51.304	3.398	21.209	10.593	0.702	71.469	7.526	0.498	491.812	18.119	1.200	563.281	69.423	4.598	584.490
2034	**10.5**	41.183	3.922	16.974	8.261	0.787	55.264	5.764	0.549	370.492	14.025	1.336	425.756	55.208	5.258	442.730
2035	**8.5**	41.183	4.845	16.974	8.261	0.972	55.264	5.764	0.678	370.492	14.025	1.650	425.756	55.208	6.495	442.730
2036	**6.9**	41.183	5.969	16.974	8.261	1.197	55.264	5.764	0.835	370.492	14.025	2.033	425.756	55.208	8.001	442.730
2037	**5.6**	41.183	7.354	15.908	8.261	1.475	51.815	5.764	1.029	369.092	14.025	2.504	420.908	55.208	9.859	436.815
2038	**2.1**	14.287	6.803	5.873	3.361	1.601	21.536	2.110	1.005	126.609	5.472	2.606	148.145	19.758	9.409	154.018
2039																
Total LOF	**500.5**	**767.585**		**315**	**167.420**		**1148**	**122.429**		**8488**	**289.849**		**9637**	**1057.433**		**9952**
Average LOF		**26.468**	**1.534**	**11**	**5.773**	**0.335**	**40**	**4.222**	**0.245**	**293**	**9.995**	**0.579**	**332**	**36.463**	**2.113**	**343**

Table 4.2.14
High Case - Year 2030 - Monte Carlo Results

High Case Year 2030	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills
	Frequency Spills per 10^3 years				
Mean =	51.28	10.60	7.52	18.13	69.41
Std Deviation =	19.44	3.74	1.97	4.58	19.96
Variance =	377.998	13.989	3.877	20.966	398.438
Skewness =	0.42	0.54	0.30	0.34	0.40
Kurtosis =	2.66	2.77	2.96	2.85	2.72
Mode =	71.07	6.97	5.34	16.17	46.94
Minimum =	8.187	2.032	1.482	4.991	22.983
5% Perc =	22.719	5.389	4.482	11.124	39.524
10% Perc =	27.384	6.180	5.078	12.493	44.751
15% Perc =	30.674	6.760	5.460	13.426	48.541
20% Perc =	33.600	7.250	5.818	14.162	51.569
25% Perc =	36.507	7.731	6.124	14.801	54.458
30% Perc =	39.133	8.203	6.410	15.451	56.917
35% Perc =	41.590	8.631	6.677	16.047	59.601
40% Perc =	44.149	9.086	6.916	16.611	62.153
45% Perc =	46.551	9.548	7.170	17.195	65.034
50% Perc =	49.191	10.034	7.417	17.804	67.702
55% Perc =	51.891	10.573	7.663	18.375	70.304
60% Perc =	54.883	11.136	7.911	18.944	73.117
65% Perc =	57.797	11.730	8.171	19.581	76.114
70% Perc =	61.119	12.383	8.482	20.325	79.330
75% Perc =	64.529	13.067	8.811	21.157	82.938
80% Perc =	68.465	13.822	9.176	22.033	86.727
85% Perc =	72.799	14.788	9.614	23.033	91.498
90% Perc =	78.323	16.002	10.166	24.402	96.995
95% Perc =	86.487	17.543	10.948	26.319	105.045
Maximum =	124.637	26.607	15.232	36.664	143.184

High Case Year 2030	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills
	Frequency Spills per 10^9 bbl Produced				
Mean =	1.83	0.38	0.27	0.65	2.48
Std Deviation =	0.69	0.13	0.07	0.16	0.71
Variance =	0.482	0.018	0.005	0.027	0.508
Skewness =	0.42	0.54	0.30	0.34	0.40
Kurtosis =	2.66	2.77	2.96	2.85	2.72
Mode =	1.54	0.48	0.19	0.58	1.68
Minimum =	0.292	0.073	0.053	0.178	0.821
5% Perc =	0.811	0.192	0.160	0.397	1.412
10% Perc =	0.978	0.221	0.181	0.446	1.598
15% Perc =	1.096	0.241	0.195	0.480	1.734
20% Perc =	1.200	0.259	0.208	0.506	1.842
25% Perc =	1.304	0.276	0.219	0.529	1.945
30% Perc =	1.398	0.293	0.229	0.552	2.033
35% Perc =	1.485	0.308	0.238	0.573	2.129
40% Perc =	1.577	0.325	0.247	0.593	2.220
45% Perc =	1.663	0.341	0.256	0.614	2.323
50% Perc =	1.757	0.358	0.265	0.636	2.418
55% Perc =	1.853	0.378	0.274	0.656	2.511
60% Perc =	1.960	0.398	0.283	0.677	2.611
65% Perc =	2.064	0.419	0.292	0.699	2.718
70% Perc =	2.183	0.442	0.303	0.726	2.833
75% Perc =	2.305	0.467	0.315	0.756	2.962
80% Perc =	2.445	0.494	0.328	0.787	3.097
85% Perc =	2.600	0.528	0.343	0.823	3.268
90% Perc =	2.797	0.572	0.363	0.871	3.464
95% Perc =	3.089	0.627	0.391	0.940	3.752
Maximum =	4.451	0.950	0.544	1.309	5.114

High Case Year 2030	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills
	Spill Index [bbl]				
Mean =	21.21	71.33	491.71	563.04	584.25
Std Deviation =	13.56	33.17	178.32	181.51	182.11
Variance =	183.771	1100.468	31797.980	32946.170	33164.640
Skewness =	1.30	0.92	0.45	0.42	0.42
Kurtosis =	5.14	4.13	3.09	3.08	3.08
Mode =	8.75	40.22	325.16	458.45	476.20
Minimum =	0.064	3.197	60.101	100.742	130.353
5% Perc =	5.312	26.808	222.457	286.804	307.398
10% Perc =	7.098	33.459	271.545	339.492	358.193
15% Perc =	8.632	38.793	308.502	376.638	396.569
20% Perc =	9.952	43.164	337.495	405.394	427.285
25% Perc =	11.144	47.115	363.157	433.984	454.829
30% Perc =	12.461	51.085	387.827	458.453	479.775
35% Perc =	13.758	54.667	410.997	482.887	504.145
40% Perc =	15.080	58.848	432.732	506.134	526.888
45% Perc =	16.489	62.366	454.688	526.781	547.199
50% Perc =	18.076	66.063	476.169	547.416	569.974
55% Perc =	19.621	69.916	500.021	570.307	592.075
60% Perc =	21.483	74.260	523.610	595.026	615.860
65% Perc =	23.400	79.144	548.968	621.246	641.803
70% Perc =	25.646	84.259	576.143	648.377	670.750
75% Perc =	28.080	90.096	605.128	677.459	700.516
80% Perc =	31.062	96.521	636.941	712.308	732.494
85% Perc =	34.475	104.665	677.985	753.098	776.324
90% Perc =	39.295	115.142	730.956	807.119	828.041
95% Perc =	48.128	134.545	810.522	884.107	904.597
Maximum =	97.373	249.105	1203.819	1297.845	1331.919

Table 4.2.15
High Case LOF Average - Pipeline - Monte Carlo Results

High Case Pipeline	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills
All years Average LOF	Frequency Spills per 10^3years				
Mean =	13.40	3.73	1.28	5.01	18.40
Std Deviation =	5.72	1.92	0.76	2.08	6.12
Variance =	32.773	3.684	0.572	4.309	37.460
Skewness =	0.46	0.68	0.69	0.61	0.41
Kurtosis =	2.59	2.83	2.83	2.92	2.67
Mode =	11.46	1.65	1.49	3.25	33.36
Minimum =	1.752	0.270	0.100	0.803	4.430
5% Perc =	5.241	1.229	0.309	2.128	9.459
10% Perc =	6.382	1.505	0.403	2.536	10.803
15% Perc =	7.317	1.714	0.486	2.858	11.893
20% Perc =	8.166	1.944	0.570	3.148	12.852
25% Perc =	8.872	2.166	0.657	3.417	13.739
30% Perc =	9.661	2.394	0.752	3.660	14.571
35% Perc =	10.407	2.621	0.844	3.904	15.408
40% Perc =	11.191	2.870	0.940	4.181	16.181
45% Perc =	11.930	3.131	1.044	4.453	16.984
50% Perc =	12.714	3.408	1.148	4.721	17.760
55% Perc =	13.513	3.672	1.261	5.000	18.639
60% Perc =	14.326	3.962	1.370	5.302	19.575
65% Perc =	15.272	4.287	1.494	5.632	20.479
70% Perc =	16.292	4.617	1.628	5.959	21.413
75% Perc =	17.380	4.983	1.776	6.337	22.513
80% Perc =	18.523	5.407	1.948	6.771	23.727
85% Perc =	19.836	5.919	2.147	7.265	25.265
90% Perc =	21.555	6.478	2.376	7.963	26.927
95% Perc =	23.800	7.380	2.715	8.870	29.344
Maximum =	33.775	11.054	4.430	13.267	41.171

High Case Pipeline	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills
All years Average LOF	Frequency Spills per 10^9 bbl Produced				
Mean =	0.78	0.22	0.07	0.29	1.07
Std Deviation =	0.33	0.11	0.04	0.12	0.35
Variance =	0.110	0.012	0.002	0.014	0.126
Skewness =	0.46	0.68	0.69	0.61	0.41
Kurtosis =	2.59	2.83	2.83	2.92	2.67
Mode =	0.84	0.10	0.03	0.19	0.89
Minimum =	0.102	0.016	0.006	0.047	0.257
5% Perc =	0.304	0.071	0.018	0.123	0.548
10% Perc =	0.370	0.087	0.023	0.147	0.626
15% Perc =	0.424	0.099	0.028	0.166	0.689
20% Perc =	0.473	0.113	0.033	0.182	0.745
25% Perc =	0.514	0.125	0.038	0.198	0.796
30% Perc =	0.560	0.139	0.044	0.212	0.844
35% Perc =	0.603	0.152	0.049	0.226	0.893
40% Perc =	0.648	0.166	0.054	0.242	0.938
45% Perc =	0.691	0.181	0.060	0.258	0.984
50% Perc =	0.737	0.197	0.067	0.274	1.029
55% Perc =	0.783	0.213	0.073	0.290	1.080
60% Perc =	0.830	0.230	0.079	0.307	1.134
65% Perc =	0.885	0.248	0.087	0.326	1.187
70% Perc =	0.944	0.267	0.094	0.345	1.241
75% Perc =	1.007	0.289	0.103	0.367	1.304
80% Perc =	1.073	0.313	0.113	0.392	1.375
85% Perc =	1.149	0.343	0.124	0.421	1.464
90% Perc =	1.249	0.375	0.138	0.461	1.560
95% Perc =	1.379	0.428	0.157	0.514	1.700
Maximum =	1.957	0.640	0.257	0.769	2.386

High Case Pipeline	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills
All years Average LOF	Spill Index [bbl]				
Mean =	4.91	19.17	19.89	39.06	43.97
Std Deviation =	3.74	14.61	12.66	19.40	19.78
Variance =	14.012	213.352	160.391	376.405	391.397
Skewness =	1.44	1.50	0.94	0.95	0.91
Kurtosis =	5.36	5.80	3.60	4.18	4.09
Mode =	2.33	20.98	27.30	34.53	50.28
Minimum =	-0.464	-3.156	1.336	2.543	5.133
5% Perc =	0.944	3.312	4.488	13.362	17.472
10% Perc =	1.283	4.921	5.857	17.009	21.329
15% Perc =	1.570	6.193	7.115	19.677	24.330
20% Perc =	1.837	7.435	8.469	22.225	26.930
25% Perc =	2.121	8.585	9.818	24.725	29.417
30% Perc =	2.410	9.774	11.106	26.884	31.645
35% Perc =	2.733	11.032	12.554	29.186	33.981
40% Perc =	3.088	12.352	14.007	31.546	36.370
45% Perc =	3.454	13.816	15.591	33.596	38.493
50% Perc =	3.862	15.240	17.214	35.862	40.767
55% Perc =	4.269	16.816	19.021	38.289	43.294
60% Perc =	4.785	18.667	20.774	40.825	45.969
65% Perc =	5.335	20.639	22.879	43.672	48.738
70% Perc =	5.994	22.913	25.081	46.666	51.997
75% Perc =	6.740	25.812	27.417	50.074	55.380
80% Perc =	7.554	29.102	30.188	54.134	59.240
85% Perc =	8.614	33.089	33.621	58.819	64.210
90% Perc =	10.125	39.031	38.037	64.684	70.364
95% Perc =	12.479	48.619	44.295	75.518	80.736
Maximum =	26.622	104.739	84.685	143.355	156.375

Table 4.2.16
High Case LOF Average - Platforms - Monte Carlo Results

High Case Platforms	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills
All years Average LOF	**Frequency Spills per 10^3 years**					**Frequency Spills per 10^9 bbl Produced**					**Spill Index [bbl]**				
Mean =	12.63	0.73	0.73	1.45	14.08	0.73	0.04	0.04	0.08	0.82	5.71	4.06	4.06	8.13	13.83
Std Deviation =	8.01	0.44	0.44	0.87	8.07	0.46	0.03	0.03	0.05	0.47	5.72	3.35	3.35	6.70	8.83
Variance =	64.206	0.190	0.190	0.761	65.159	0.216	0.001	0.001	0.003	0.219	32.676	11.213	11.213	44.851	77.978
Skewness =	0.58	0.61	0.61	0.61	0.57	0.58	0.61	0.61	0.61	0.57	1.69	1.34	1.34	1.34	1.09
Kurtosis =	2.45	2.56	2.56	2.56	2.46	2.45	2.56	2.56	2.56	2.46	6.15	4.97	4.97	4.97	4.32
Mode =	9.93	0.50	0.50	1.01	4.95	0.58	0.04	0.04	0.08	0.81	1.45	4.43	4.43	8.86	11.25
Minimum =	0.628	0.040	0.040	0.080	1.295	0.036	0.002	0.002	0.005	0.075	-1.586	-1.487	-1.487	-2.973	-2.731
5% Perc =	2.176	0.159	0.159	0.319	3.521	0.126	0.009	0.009	0.018	0.204	0.324	0.399	0.399	0.797	3.010
10% Perc =	3.100	0.212	0.212	0.424	4.537	0.180	0.012	0.012	0.025	0.263	0.617	0.719	0.719	1.437	4.244
15% Perc =	4.003	0.259	0.259	0.517	5.485	0.232	0.015	0.015	0.030	0.318	0.931	1.008	1.008	2.016	5.269
20% Perc =	4.896	0.309	0.309	0.618	6.386	0.284	0.018	0.018	0.036	0.370	1.243	1.270	1.270	2.541	6.237
25% Perc =	5.904	0.363	0.363	0.726	7.306	0.342	0.021	0.021	0.042	0.423	1.610	1.550	1.550	3.100	7.146
30% Perc =	6.860	0.417	0.417	0.833	8.317	0.397	0.024	0.024	0.048	0.482	1.981	1.841	1.841	3.682	8.110
35% Perc =	7.872	0.470	0.470	0.939	9.324	0.456	0.027	0.027	0.054	0.540	2.363	2.142	2.142	4.284	9.002
40% Perc =	8.986	0.529	0.529	1.059	10.405	0.521	0.031	0.031	0.061	0.603	2.793	2.454	2.454	4.908	9.970
45% Perc =	10.106	0.583	0.583	1.166	11.509	0.586	0.034	0.034	0.068	0.667	3.260	2.805	2.805	5.610	10.918
50% Perc =	11.228	0.648	0.648	1.296	12.770	0.651	0.038	0.038	0.075	0.740	3.786	3.178	3.178	6.356	11.946
55% Perc =	12.415	0.716	0.716	1.431	13.882	0.719	0.041	0.041	0.083	0.804	4.382	3.550	3.550	7.100	13.078
60% Perc =	13.771	0.783	0.783	1.567	15.259	0.798	0.045	0.045	0.091	0.884	5.044	4.000	4.000	8.000	14.246
65% Perc =	15.168	0.858	0.858	1.715	16.676	0.879	0.050	0.050	0.099	0.966	5.865	4.514	4.514	9.027	15.540
70% Perc =	16.654	0.939	0.939	1.879	18.217	0.965	0.054	0.054	0.109	1.056	6.794	5.070	5.070	10.140	17.127
75% Perc =	18.321	1.029	1.029	2.059	19.788	1.062	0.060	0.060	0.119	1.147	7.981	5.718	5.718	11.437	18.739
80% Perc =	20.065	1.124	1.124	2.247	21.554	1.163	0.065	0.065	0.130	1.249	9.373	6.453	6.453	12.906	20.574
85% Perc =	22.094	1.240	1.240	2.479	23.589	1.280	0.072	0.072	0.144	1.367	11.181	7.404	7.404	14.807	22.873
90% Perc =	24.460	1.367	1.367	2.734	26.040	1.417	0.079	0.079	0.158	1.509	13.664	8.703	8.703	17.406	26.171
95% Perc =	27.502	1.544	1.544	3.087	29.066	1.594	0.089	0.089	0.179	1.684	17.760	10.887	10.887	21.774	31.108
Maximum =	38.947	2.271	2.271	4.541	40.056	2.257	0.132	0.132	0.263	2.321	38.558	22.402	22.402	44.804	61.444

Table 4.2.17
High Case LOF Average - Wells - Monte Carlo Results

High Case Wells	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills
All years Average LOF	Frequency Spills per 10^3 years				
Mean =	0.44	1.32	2.21	3.54	3.98
Std Deviation =	0.15	0.45	0.54	0.95	0.96
Variance =	0.023	0.201	0.291	0.894	0.914
Skewness =	-0.01	-0.01	0.01	0.00	0.01
Kurtosis =	2.46	2.46	2.67	2.55	2.57
Mode =	0.40	1.09	1.85	4.29	3.43
Minimum =	0.037	0.156	0.477	0.688	0.962
5% Perc =	0.191	0.571	1.330	1.963	2.397
10% Perc =	0.240	0.722	1.510	2.281	2.711
15% Perc =	0.275	0.832	1.640	2.510	2.950
20% Perc =	0.306	0.923	1.744	2.699	3.140
25% Perc =	0.333	1.001	1.834	2.867	3.294
30% Perc =	0.358	1.071	1.921	3.018	3.441
35% Perc =	0.380	1.145	1.997	3.148	3.592
40% Perc =	0.401	1.206	2.067	3.281	3.717
45% Perc =	0.423	1.265	2.137	3.409	3.843
50% Perc =	0.441	1.324	2.213	3.537	3.970
55% Perc =	0.461	1.384	2.280	3.655	4.103
60% Perc =	0.480	1.443	2.351	3.783	4.223
65% Perc =	0.501	1.501	2.427	3.913	4.364
70% Perc =	0.523	1.568	2.509	4.064	4.504
75% Perc =	0.549	1.640	2.592	4.212	4.652
80% Perc =	0.574	1.725	2.688	4.383	4.827
85% Perc =	0.605	1.814	2.794	4.558	5.012
90% Perc =	0.641	1.919	2.919	4.793	5.249
95% Perc =	0.688	2.069	3.096	5.085	5.571
Maximum =	0.836	2.514	3.918	6.340	6.730

High Case Wells	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills
All years Average LOF	Frequency Spills per 10^9 bbl Produced				
Mean =	0.03	0.08	0.13	0.20	0.23
Std Deviation =	0.01	0.03	0.03	0.05	0.06
Variance =	0.000	0.001	0.001	0.003	0.003
Skewness =	-0.01	-0.01	0.01	0.00	0.01
Kurtosis =	2.46	2.46	2.67	2.55	2.57
Mode =	0.02	0.06	0.11	0.17	0.20
Minimum =	0.002	0.009	0.028	0.040	0.056
5% Perc =	0.011	0.033	0.077	0.114	0.139
10% Perc =	0.014	0.042	0.087	0.132	0.157
15% Perc =	0.016	0.048	0.095	0.145	0.171
20% Perc =	0.018	0.054	0.101	0.156	0.182
25% Perc =	0.019	0.058	0.106	0.166	0.191
30% Perc =	0.021	0.062	0.111	0.175	0.199
35% Perc =	0.022	0.066	0.116	0.182	0.208
40% Perc =	0.023	0.070	0.120	0.190	0.215
45% Perc =	0.024	0.073	0.124	0.198	0.223
50% Perc =	0.026	0.077	0.128	0.205	0.230
55% Perc =	0.027	0.080	0.132	0.212	0.238
60% Perc =	0.028	0.084	0.136	0.219	0.245
65% Perc =	0.029	0.087	0.141	0.227	0.253
70% Perc =	0.030	0.091	0.145	0.235	0.261
75% Perc =	0.032	0.095	0.150	0.244	0.270
80% Perc =	0.033	0.100	0.156	0.254	0.280
85% Perc =	0.035	0.105	0.162	0.264	0.290
90% Perc =	0.037	0.111	0.169	0.278	0.304
95% Perc =	0.040	0.120	0.179	0.295	0.323
Maximum =	0.048	0.146	0.227	0.367	0.390

High Case Wells	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills
All years Average LOF	Spill Index [bbl]				
Mean =	0.23	16.30	268.73	285.02	285.25
Std Deviation =	0.15	10.34	95.04	95.50	95.50
Variance =	0.023	106.884	9031.701	9120.809	9120.686
Skewness =	0.71	0.80	0.54	0.53	0.53
Kurtosis =	3.31	3.48	3.27	3.25	3.25
Mode =	0.20	9.62	177.84	237.80	133.57
Minimum =	-0.104	-4.298	27.867	33.048	33.106
5% Perc =	0.018	2.453	128.594	142.888	143.290
10% Perc =	0.048	4.330	154.683	169.973	170.104
15% Perc =	0.074	5.911	172.564	188.182	188.394
20% Perc =	0.095	7.230	186.322	202.997	203.131
25% Perc =	0.114	8.440	200.024	215.519	215.758
30% Perc =	0.133	9.618	212.887	228.232	228.483
35% Perc =	0.153	10.841	224.255	241.226	241.381
40% Perc =	0.171	12.047	236.396	252.900	253.310
45% Perc =	0.189	13.345	248.041	264.386	264.593
50% Perc =	0.207	14.734	259.094	275.395	275.680
55% Perc =	0.227	15.955	270.983	287.072	287.334
60% Perc =	0.249	17.344	283.417	300.379	300.561
65% Perc =	0.269	18.919	297.323	313.979	314.281
70% Perc =	0.292	20.545	311.297	328.061	328.364
75% Perc =	0.321	22.383	328.053	344.725	344.998
80% Perc =	0.353	24.749	346.210	361.284	361.514
85% Perc =	0.391	27.289	369.161	384.787	385.075
90% Perc =	0.443	30.878	397.384	413.988	414.442
95% Perc =	0.516	35.729	439.763	456.713	456.947
Maximum =	0.859	67.244	712.216	726.300	726.481

Table 4.2.18
High Case LOF Average Platforms + Wells - Monte Carlo Results

Frequency: Spills per 10^3 years

High Case Platforms + Wells — All years Average LOF	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills
Mean =	13.07	2.05	2.94	4.99	18.06
Std Deviation =	8.01	0.63	0.70	1.30	8.14
Variance =	64.190	0.399	0.490	1.687	66.204
Skewness =	0.58	0.20	0.14	0.18	0.55
Kurtosis =	2.45	2.74	2.77	2.75	2.47
Mode =	10.94	1.65	2.65	3.60	13.17
Minimum =	0.910	0.354	0.784	1.232	3.002
5% Perc =	2.607	1.047	1.810	2.916	7.270
10% Perc =	3.549	1.242	2.040	3.325	8.410
15% Perc =	4.454	1.387	2.201	3.618	9.405
20% Perc =	5.339	1.500	2.336	3.859	10.395
25% Perc =	6.346	1.604	2.448	4.073	11.346
30% Perc =	7.292	1.693	2.552	4.259	12.318
35% Perc =	8.331	1.778	2.649	4.434	13.322
40% Perc =	9.443	1.857	2.743	4.596	14.428
45% Perc =	10.575	1.933	2.832	4.772	15.495
50% Perc =	11.691	2.017	2.918	4.940	16.643
55% Perc =	12.876	2.101	3.006	5.102	17.870
60% Perc =	14.207	2.188	3.104	5.274	19.234
65% Perc =	15.619	2.269	3.198	5.452	20.720
70% Perc =	17.096	2.367	3.303	5.654	22.281
75% Perc =	18.752	2.478	3.410	5.865	23.821
80% Perc =	20.521	2.590	3.537	6.099	25.583
85% Perc =	22.542	2.724	3.684	6.393	27.662
90% Perc =	24.930	2.909	3.874	6.742	29.984
95% Perc =	27.909	3.134	4.125	7.204	33.045
Maximum =	39.657	4.348	5.628	9.830	44.943

Frequency: Spills per 10^9 bbl Produced

High Case Platforms + Wells — All years Average LOF	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills
Mean =	0.76	0.12	0.17	0.29	1.05
Std Deviation =	0.46	0.04	0.04	0.08	0.47
Variance =	0.216	0.001	0.002	0.006	0.222
Skewness =	0.58	0.20	0.14	0.18	0.55
Kurtosis =	2.45	2.74	2.77	2.75	2.47
Mode =	0.63	0.10	0.15	0.21	1.02
Minimum =	0.053	0.021	0.045	0.071	0.174
5% Perc =	0.151	0.061	0.105	0.169	0.421
10% Perc =	0.206	0.072	0.118	0.193	0.487
15% Perc =	0.258	0.080	0.128	0.210	0.545
20% Perc =	0.309	0.087	0.135	0.224	0.602
25% Perc =	0.368	0.093	0.142	0.236	0.657
30% Perc =	0.423	0.098	0.148	0.247	0.714
35% Perc =	0.483	0.103	0.153	0.257	0.772
40% Perc =	0.547	0.108	0.159	0.266	0.836
45% Perc =	0.613	0.112	0.164	0.277	0.898
50% Perc =	0.677	0.117	0.169	0.286	0.964
55% Perc =	0.746	0.122	0.174	0.296	1.035
60% Perc =	0.823	0.127	0.180	0.306	1.114
65% Perc =	0.905	0.131	0.185	0.316	1.201
70% Perc =	0.991	0.137	0.191	0.328	1.291
75% Perc =	1.087	0.144	0.198	0.340	1.380
80% Perc =	1.189	0.150	0.205	0.353	1.482
85% Perc =	1.306	0.158	0.213	0.370	1.603
90% Perc =	1.445	0.169	0.224	0.391	1.737
95% Perc =	1.617	0.182	0.239	0.417	1.915
Maximum =	2.298	0.252	0.326	0.570	2.604

Spill Index [bbl]

High Case Platforms + Wells — All years Average LOF	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills
Mean =	5.94	20.36	272.79	293.15	299.09
Std Deviation =	5.72	10.88	95.14	95.83	96.06
Variance =	32.699	118.323	9051.796	9183.875	9226.994
Skewness =	1.69	0.72	0.54	0.53	0.52
Kurtosis =	6.15	3.39	3.27	3.25	3.24
Mode =	1.38	17.48	264.58	234.97	128.31
Minimum =	-1.480	-4.118	36.960	51.234	51.056
5% Perc =	0.525	5.339	131.671	150.276	155.851
10% Perc =	0.843	7.514	158.520	176.704	182.940
15% Perc =	1.154	9.359	176.843	196.462	202.289
20% Perc =	1.475	10.808	190.276	210.297	216.437
25% Perc =	1.846	12.183	203.984	223.444	229.115
30% Perc =	2.217	13.615	217.153	237.056	242.658
35% Perc =	2.603	14.956	228.704	249.497	254.973
40% Perc =	3.024	16.236	240.346	261.396	266.853
45% Perc =	3.489	17.502	252.023	272.563	277.917
50% Perc =	4.012	18.813	263.000	283.754	289.550
55% Perc =	4.625	20.196	274.854	295.293	301.709
60% Perc =	5.286	21.622	287.255	308.770	314.901
65% Perc =	6.122	23.247	301.212	322.122	328.041
70% Perc =	7.038	24.913	315.285	336.242	342.346
75% Perc =	8.198	26.835	332.006	353.461	359.396
80% Perc =	9.600	29.219	350.132	370.190	376.959
85% Perc =	11.412	31.948	372.927	392.780	399.535
90% Perc =	13.933	35.413	401.541	422.444	428.391
95% Perc =	17.968	40.522	443.225	465.320	471.671
Maximum =	39.005	71.768	715.539	727.839	735.772

Table 4.2.19
High Case LOF Average - Monte Carlo Results

High Case	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills
All years Average LOF	Frequency Spills per 10^3 years					Frequency Spills per 10^9 bbl Produced					Spill Index [bbl]				
Mean =	26.47	5.77	4.22	10.00	36.47	1.53	0.33	0.24	0.58	2.11	10.85	39.53	292.68	332.21	343.06
Std Deviation =	9.90	2.02	1.02	2.44	10.22	0.57	0.12	0.06	0.14	0.59	6.88	18.05	95.90	97.81	98.15
Variance =	97.979	4.073	1.050	5.971	104.501	0.329	0.014	0.004	0.020	0.351	47.345	325.671	9195.993	9566.265	9634.276
Skewness =	0.41	0.58	0.31	0.39	0.36	0.41	0.58	0.31	0.39	0.36	1.26	0.91	0.53	0.51	0.50
Kurtosis =	2.70	2.84	2.92	2.97	2.71	2.70	2.84	2.92	2.97	2.71	4.88	4.17	3.26	3.23	3.23
Mode =	18.47	4.96	4.17	9.21	31.02	0.86	0.29	0.24	0.53	1.73	6.19	21.67	208.36	351.19	256.00
Minimum =	4.879	1.319	1.066	3.254	10.744	0.283	0.076	0.062	0.189	0.623	0.259	2.808	51.800	80.475	84.348
5% Perc =	11.702	2.994	2.634	6.289	21.161	0.678	0.173	0.153	0.364	1.226	2.820	15.322	151.646	187.317	197.641
10% Perc =	14.132	3.399	2.945	6.979	23.687	0.819	0.197	0.171	0.404	1.372	3.677	18.923	177.524	213.166	223.914
15% Perc =	15.876	3.677	3.159	7.441	25.602	0.920	0.213	0.183	0.431	1.483	4.428	21.670	196.067	232.959	243.386
20% Perc =	17.518	3.957	3.338	7.860	27.173	1.015	0.229	0.193	0.455	1.574	5.085	24.302	210.089	248.012	258.497
25% Perc =	18.943	4.207	3.490	8.221	28.707	1.098	0.244	0.202	0.476	1.663	5.716	26.466	223.373	262.439	273.181
30% Perc =	20.295	4.455	3.632	8.557	30.229	1.176	0.258	0.210	0.496	1.752	6.395	28.657	236.757	275.718	285.957
35% Perc =	21.604	4.707	3.760	8.881	31.615	1.252	0.273	0.218	0.515	1.832	7.095	30.536	248.243	287.438	297.775
40% Perc =	22.999	4.957	3.896	9.179	32.979	1.333	0.287	0.226	0.532	1.911	7.749	32.540	259.634	300.027	310.609
45% Perc =	24.317	5.222	4.021	9.503	34.345	1.409	0.303	0.233	0.551	1.990	8.465	34.657	271.407	311.652	322.512
50% Perc =	25.609	5.502	4.151	9.805	35.673	1.484	0.319	0.241	0.568	2.067	9.209	36.727	283.074	323.295	334.334
55% Perc =	26.959	5.768	4.283	10.135	37.079	1.562	0.334	0.248	0.587	2.148	10.025	38.931	295.227	334.966	345.622
60% Perc =	28.311	6.069	4.429	10.462	38.497	1.640	0.352	0.257	0.606	2.231	10.965	41.264	307.846	347.580	358.457
65% Perc =	29.786	6.378	4.579	10.806	39.992	1.726	0.370	0.265	0.626	2.317	11.940	43.827	321.833	361.169	372.755
70% Perc =	31.332	6.708	4.725	11.182	41.591	1.815	0.389	0.274	0.648	2.410	13.142	46.535	336.025	376.442	387.391
75% Perc =	33.136	7.107	4.893	11.588	43.350	1.920	0.412	0.284	0.671	2.512	14.348	49.756	351.724	392.451	403.778
80% Perc =	35.180	7.528	5.097	12.048	45.420	2.038	0.436	0.295	0.698	2.632	15.879	53.407	370.037	411.188	421.945
85% Perc =	37.391	7.996	5.309	12.589	47.623	2.166	0.463	0.308	0.729	2.759	17.866	57.618	394.037	434.172	445.477
90% Perc =	40.249	8.656	5.599	13.286	50.620	2.332	0.502	0.324	0.770	2.933	20.297	63.852	421.431	464.038	475.631
95% Perc =	44.025	9.516	6.010	14.332	54.443	2.551	0.551	0.348	0.830	3.155	24.287	73.335	464.276	509.617	520.215
Maximum =	62.017	13.227	8.740	21.878	74.039	3.593	0.766	0.506	1.268	4.290	47.632	144.890	728.989	760.450	775.476

Table 4.2.20
Composition of Spill Indicators - High Case - Year 2030

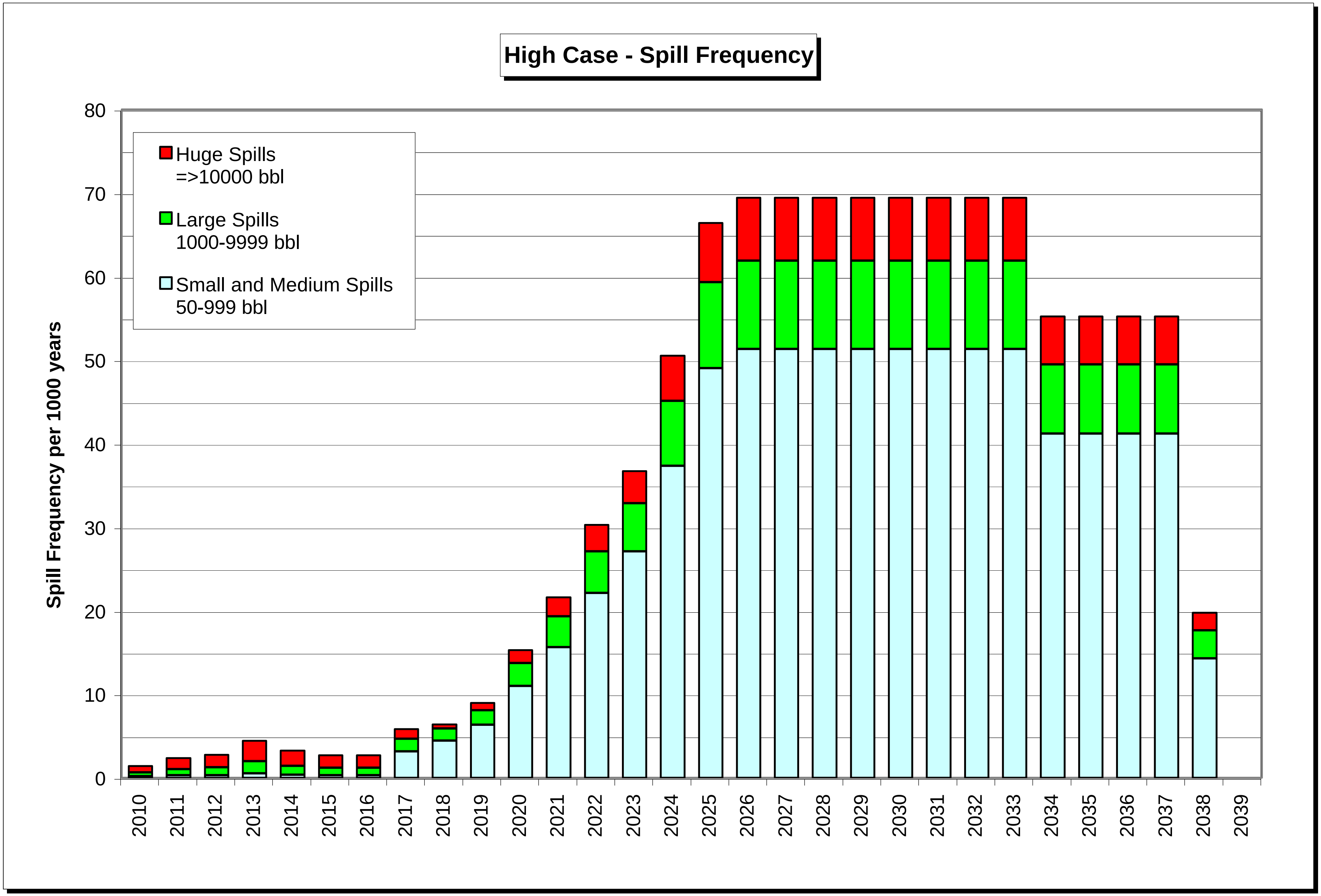
Spill Size	Spill Source									
	P/L		Platforms		Wells		Platforms and Wells		All	
	High Case - Year 2030 Spill Frequency per 10^3 years									
Small and Medium Spills 50-999 bbl	24.723	73%	25.842	90%	0.739	11%	26.581	75%	51.304	74%
Large Spills 1000-9999 bbl	6.892	20%	1.485	5%	2.216	33%	3.702	10%	10.593	15%
Huge Spills =>10000 bbl	2.347	7%	1.485	5%	3.694	56%	5.179	15%	7.526	11%
Significant Spills =>1000 bbl	9.238	27%	2.970	10%	5.911	89%	8.881	25%	18.119	26%
All Spills	**33.961**	**100%**	**28.813**	**100%**	**6.649**	**100%**	**35.462**	**100%**	**69.423**	**100%**
	High Case - Year 2030 Spill Frequency per 10^9 bbl produced									
Small and Medium Spills 50-999 bbl	0.883	73%	0.923	90%	0.026	11%	0.949	75%	1.832	74%
Large Spills 1000-9999 bbl	0.246	20%	0.053	5%	0.079	33%	0.132	10%	0.378	15%
Huge Spills =>10000 bbl	0.084	7%	0.053	5%	0.132	56%	0.185	15%	0.269	11%
Significant Spills =>1000 bbl	0.330	27%	0.106	10%	0.211	89%	0.317	25%	0.647	26%
All Spills	**1.213**	**100%**	**1.029**	**100%**	**0.237**	**100%**	**1.267**	**100%**	**2.479**	**100%**
	High Case - Year 2030 Spill Index [bbl]									
Small and Medium Spills 50-999 bbl	9	11%	12	41%	0	0%	12	2%	21	4%
Large Spills 1000-9999 bbl	36	44%	8	29%	27	6%	36	7%	71	12%
Huge Spills =>10000 bbl	36	45%	8	29%	447	94%	455	91%	492	84%
Significant Spills =>1000 bbl	72	89%	17	59%	474	100%	491	98%	563	96%
All Spills	**81**	**100%**	**28**	**100%**	**475**	**100%**	**503**	**100%**	**584**	**100%**

Spill Source	Spill Size									
	S+M 50-999 bbl		Large 1000-9999 bbl		Huge =>10000 bbl		Significant =>1000 bbl		All Spills	
	High Case - Year 2030 Spill Frequency per 10^3 years									
Pipelines	24.723	48%	6.892	65%	2.347	31%	9.238	51%	33.961	49%
Platforms	25.842	50%	1.485	14%	1.485	20%	2.970	16%	28.813	42%
Wells	0.739	1%	2.216	21%	3.694	49%	5.911	33%	6.649	10%
Platforms and Wells	26.581	52%	3.702	35%	5.179	69%	8.881	49%	35.462	51%
All	**51.304**	**100%**	**10.593**	**100%**	**7.526**	**100%**	**18.119**	**100%**	**69.423**	**100%**
	High Case - Year 2030 Spill Frequency per 10^9 bbl produced									
Pipelines	0.883	48%	0.246	65%	0.084	31%	0.330	51%	1.213	49%
Platforms	0.923	50%	0.053	14%	0.053	20%	0.106	16%	1.029	42%
Wells	0.026	1%	0.079	21%	0.132	49%	0.211	33%	0.237	10%
Platforms and Wells	0.949	52%	0.132	35%	0.185	69%	0.317	49%	1.267	51%
All	**1.832**	**100%**	**0.378**	**100%**	**0.269**	**100%**	**0.647**	**100%**	**2.479**	**100%**
	High Case - Year 2030 Spill Index [bbl]									
Pipelines	9	43%	36	50%	36	7%	72	13%	81	14%
Platforms	12	55%	8	12%	8	2%	17	3%	28	5%
Wells	0	2%	27	38%	447	91%	474	84%	475	81%
Platforms and Wells	12	57%	36	50%	455	93%	491	87%	503	86%
All	**21**	**100%**	**71**	**100%**	**492**	**100%**	**563**	**100%**	**584**	**100%**

Table 4.2.21
Composition of Spill Indicators - High Case - LOF Average

Spill Size	Spill Source									
	P/L		Platforms		Wells		Platforms and Wells		All	
	High Case - LOF Average Spill Frequency per 10^3 years									
Small and Medium Spills 50-999 bbl	13.395	73%	12.633	90%	0.441	11%	13.074	72%	26.468	73%
Large Spills 1000-9999 bbl	3.725	20%	0.726	5%	1.322	33%	2.048	11%	5.773	16%
Huge Spills =>10000 bbl	1.282	7%	0.726	5%	2.214	56%	2.940	16%	4.222	12%
Significant Spills =>1000 bbl	5.007	27%	1.452	10%	3.536	89%	4.988	28%	9.995	27%
All Spills	**18.402**	**100%**	**14.085**	**100%**	**3.977**	**100%**	**18.062**	**100%**	**36.463**	**100%**
	High Case - LOF Average Spill Frequency per 10^9 bbl produced									
Small and Medium Spills 50-999 bbl	0.776	73%	0.732	90%	0.026	11%	0.758	72%	1.534	73%
Large Spills 1000-9999 bbl	0.216	20%	0.042	5%	0.077	33%	0.119	11%	0.335	16%
Huge Spills =>10000 bbl	0.074	7%	0.042	5%	0.128	56%	0.170	16%	0.245	12%
Significant Spills =>1000 bbl	0.290	27%	0.084	10%	0.205	89%	0.289	28%	0.579	27%
All Spills	**1.066**	**100%**	**0.816**	**100%**	**0.230**	**100%**	**1.047**	**100%**	**2.113**	**100%**
	High Case - LOF Average Spill Index [bbl]									
Small and Medium Spills 50-999 bbl	5	11%	6	41%	0	0%	6	2%	11	3%
Large Spills 1000-9999 bbl	19	44%	4	29%	16	6%	20	7%	40	12%
Huge Spills =>10000 bbl	20	45%	4	29%	269	94%	273	91%	293	85%
Significant Spills =>1000 bbl	39	89%	8	59%	285	100%	293	98%	332	97%
All Spills	**44**	**100%**	**14**	**100%**	**285**	**100%**	**299**	**100%**	**343**	**100%**

Spill Source	Spill Size									
	S+M 50-999 bbl		Large 1000-9999 bbl		Huge =>10000 bbl		Significant =>1000 bbl		All Spills	
	High Case - LOF Average Spill Frequency per 10^3 years									
Pipelines	13.395	51%	3.725	65%	1.282	30%	5.007	50%	18.402	50%
Platforms	12.633	48%	0.726	13%	0.726	17%	1.452	15%	14.085	39%
Wells	0.441	2%	1.322	23%	2.214	52%	3.536	35%	3.977	11%
Platforms and Wells	13.074	49%	2.048	35%	2.940	70%	4.988	50%	18.062	50%
All	**26.468**	**100%**	**5.773**	**100%**	**4.222**	**100%**	**9.995**	**100%**	**36.463**	**100%**
	High Case- LOF Average Spill Frequency per 10^9 bbl produced									
Pipelines	0.776	51%	0.216	65%	0.074	30%	0.290	50%	1.066	50%
Platforms	0.732	48%	0.042	13%	0.042	17%	0.084	15%	0.816	39%
Wells	0.026	2%	0.077	23%	0.128	52%	0.205	35%	0.230	11%
Platforms and Wells	0.758	49%	0.119	35%	0.170	70%	0.289	50%	1.047	50%
All	**1.534**	**100%**	**0.335**	**100%**	**0.245**	**100%**	**0.579**	**100%**	**2.113**	**100%**
	High Case - LOF Average Spill Index [bbl]									
Pipelines	5	45%	19	48%	20	7%	39	12%	44	13%
Platforms	6	53%	4	10%	4	1%	8	2%	14	4%
Wells	0	2%	16	41%	269	92%	285	86%	285	83%
Platforms and Wells	6	55%	20	52%	273	93%	293	88%	299	87%
All	**11**	**100%**	**40**	**100%**	**293**	**100%**	**332**	**100%**	**343**	**100%**



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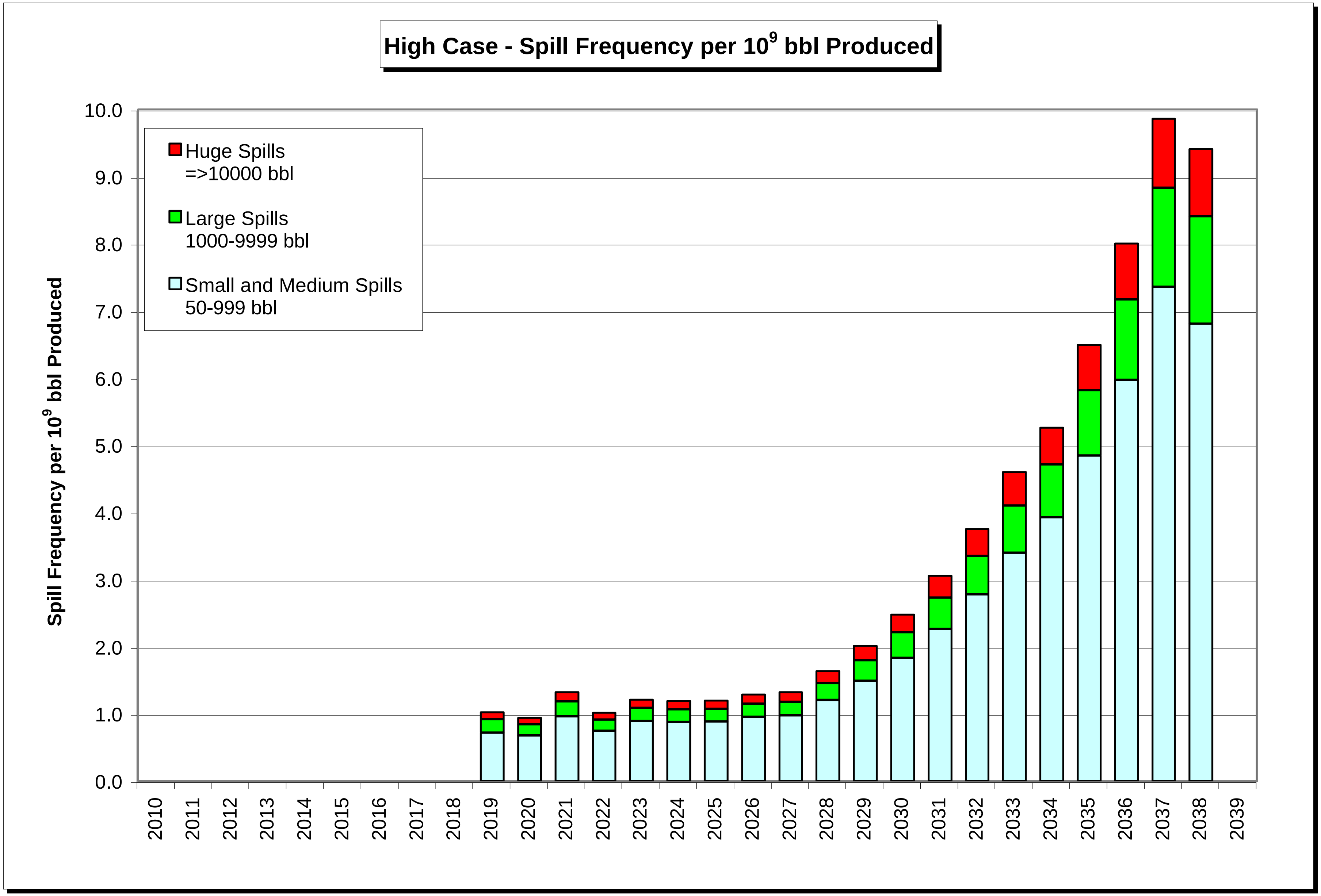

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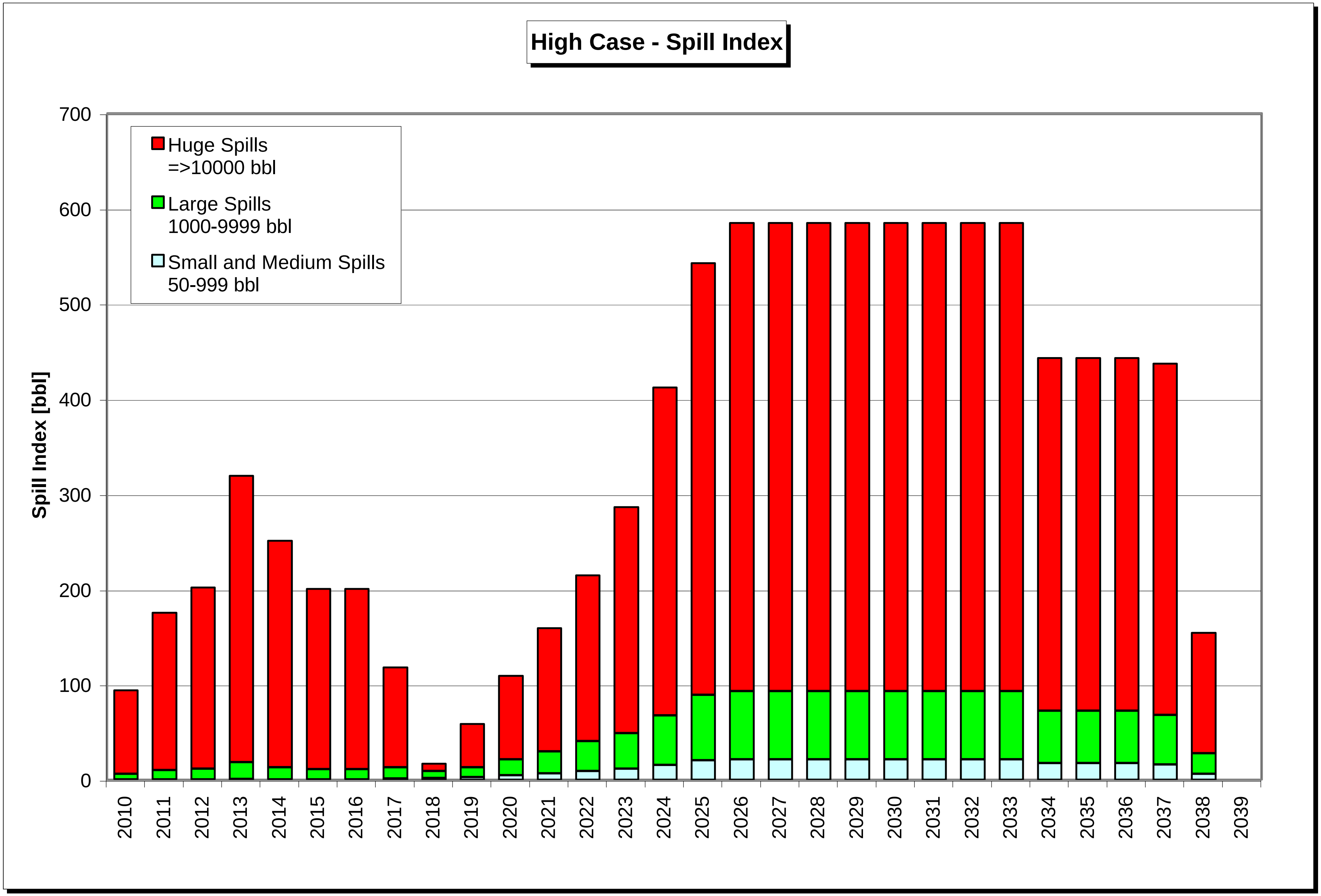

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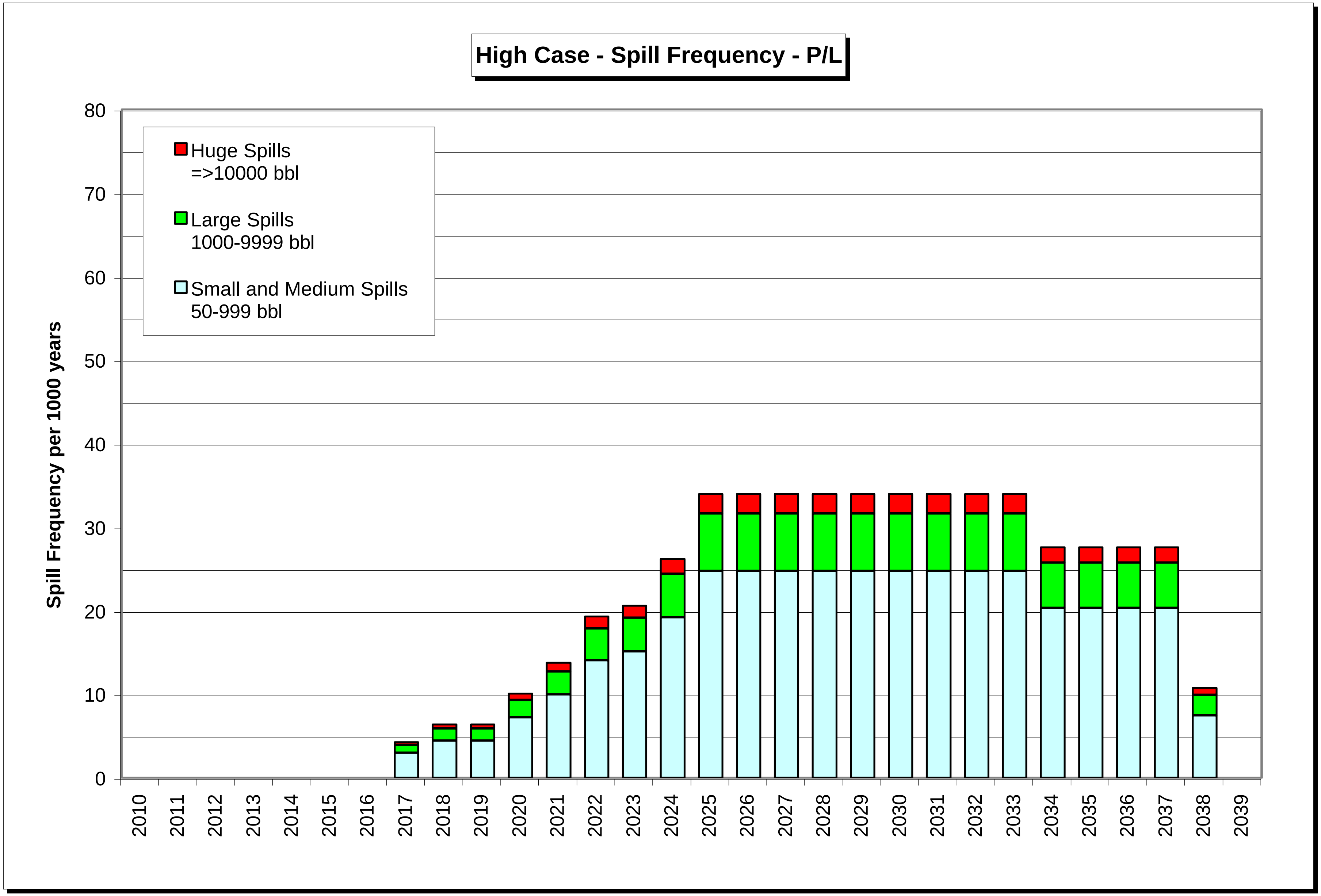

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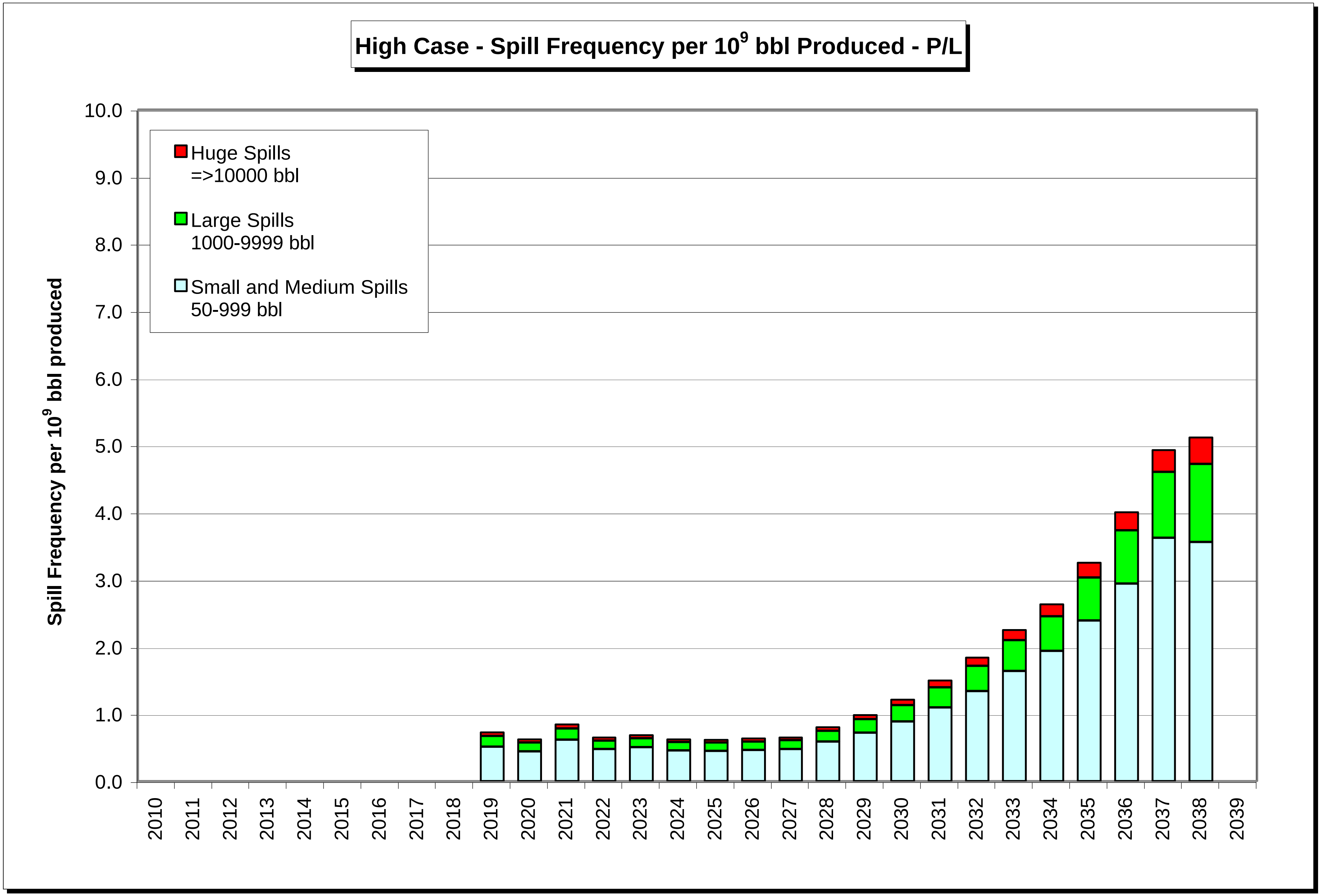

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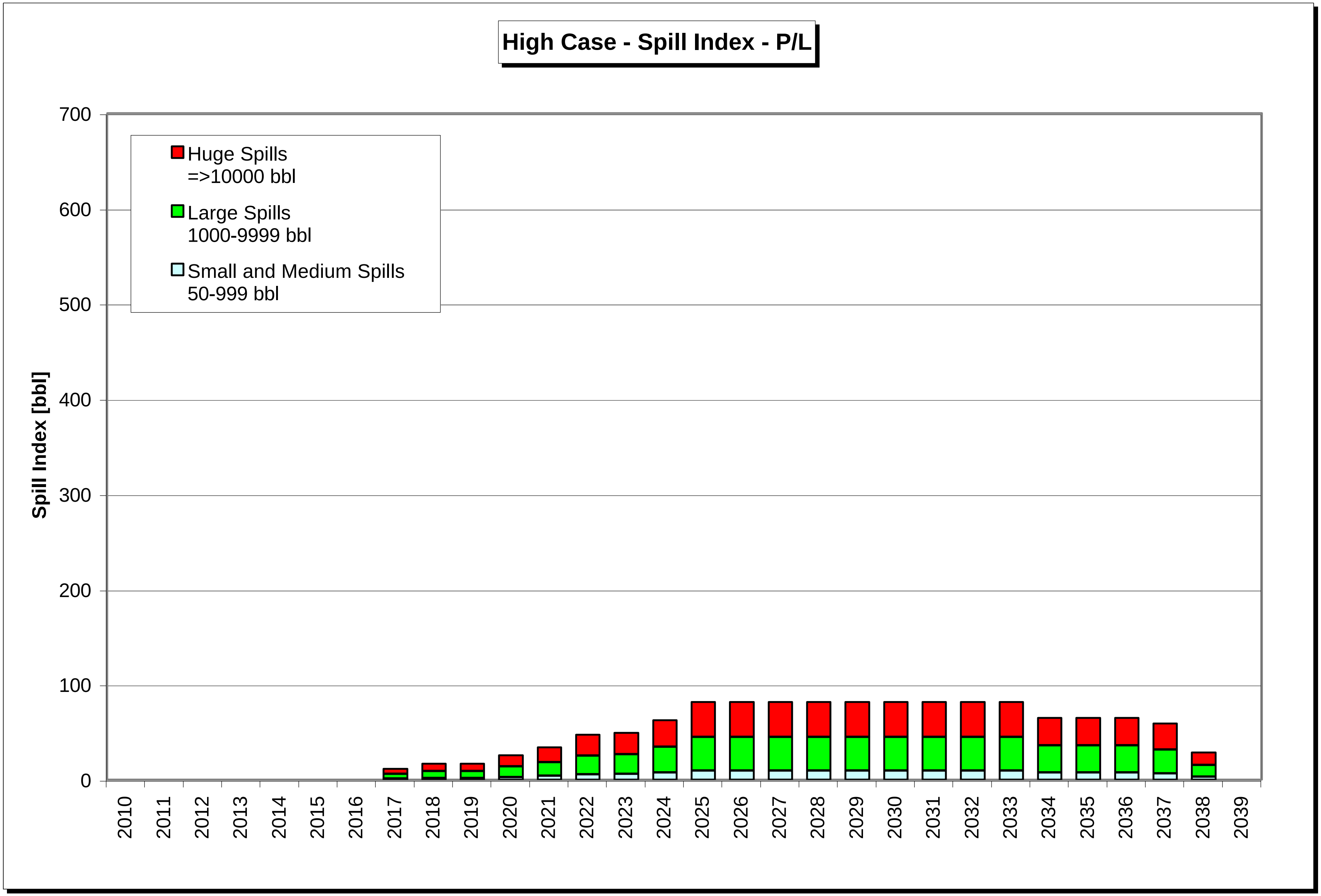

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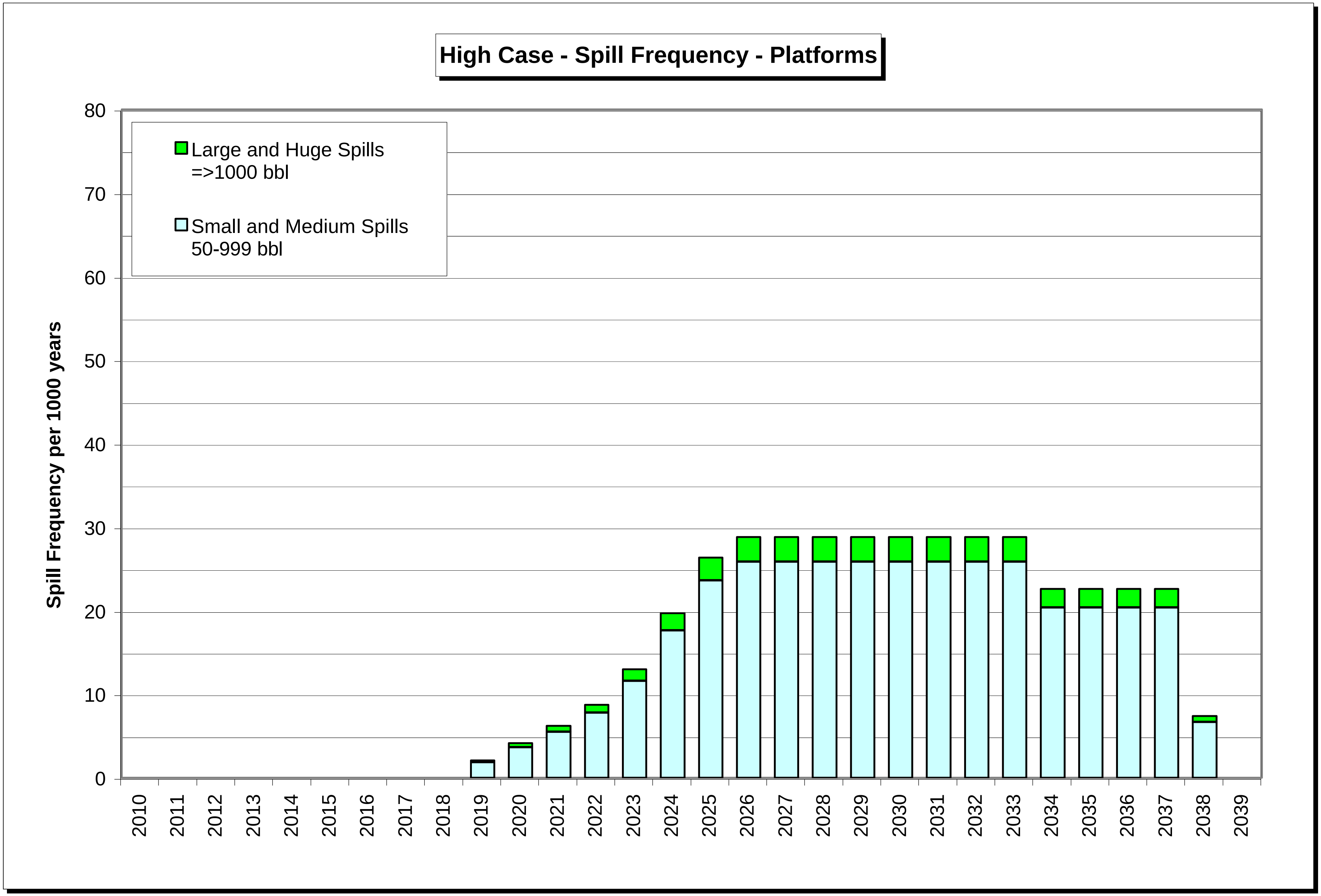

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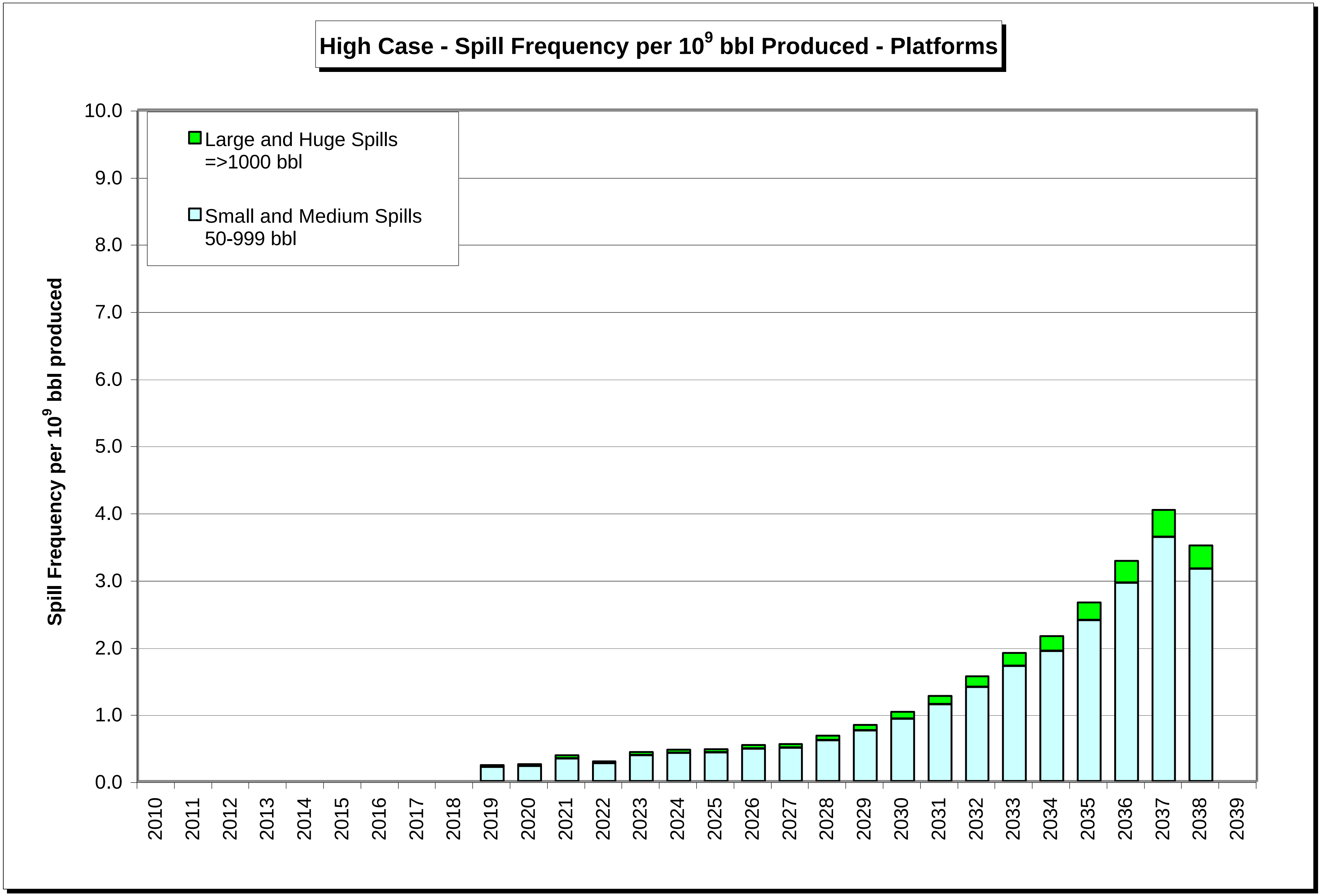

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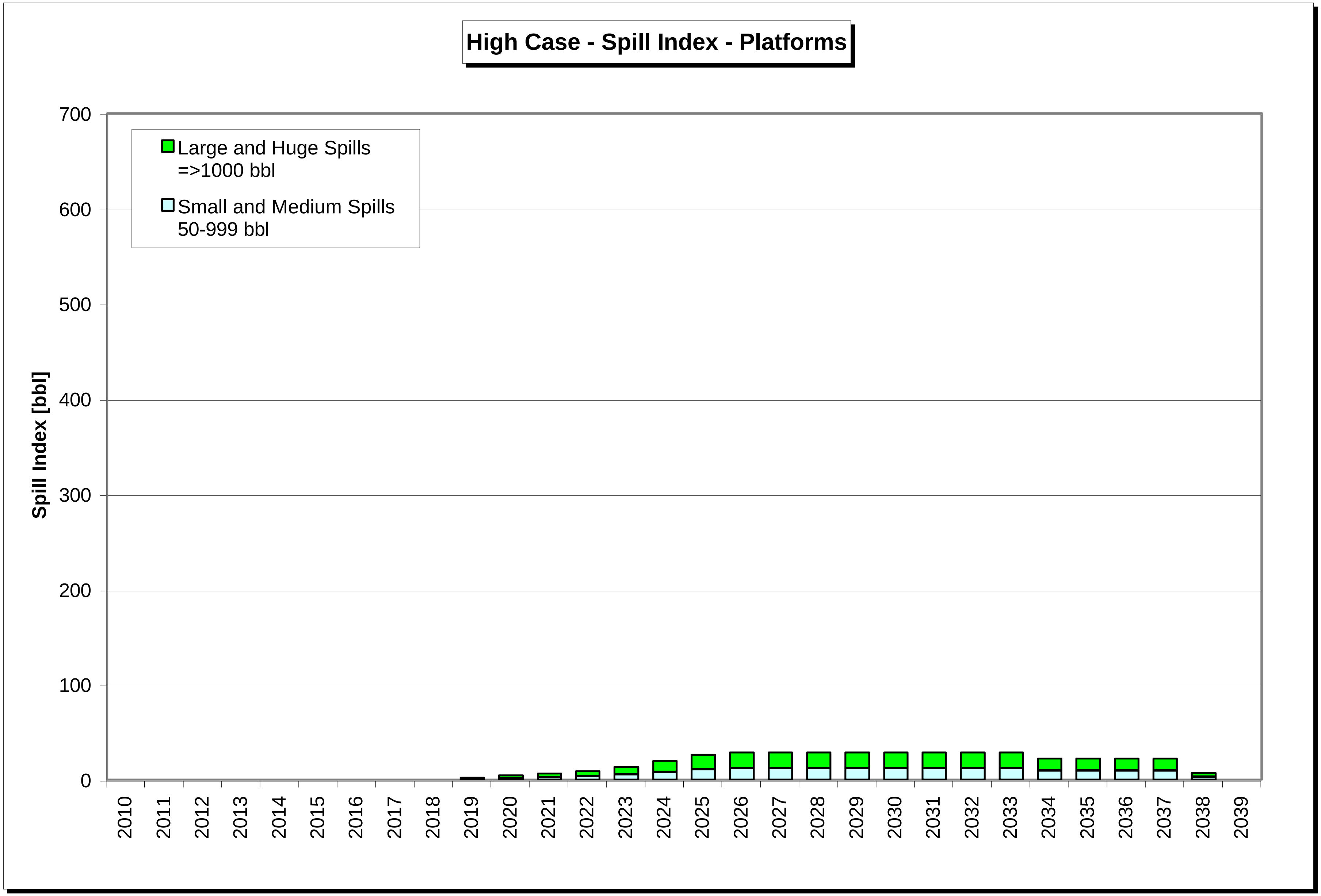

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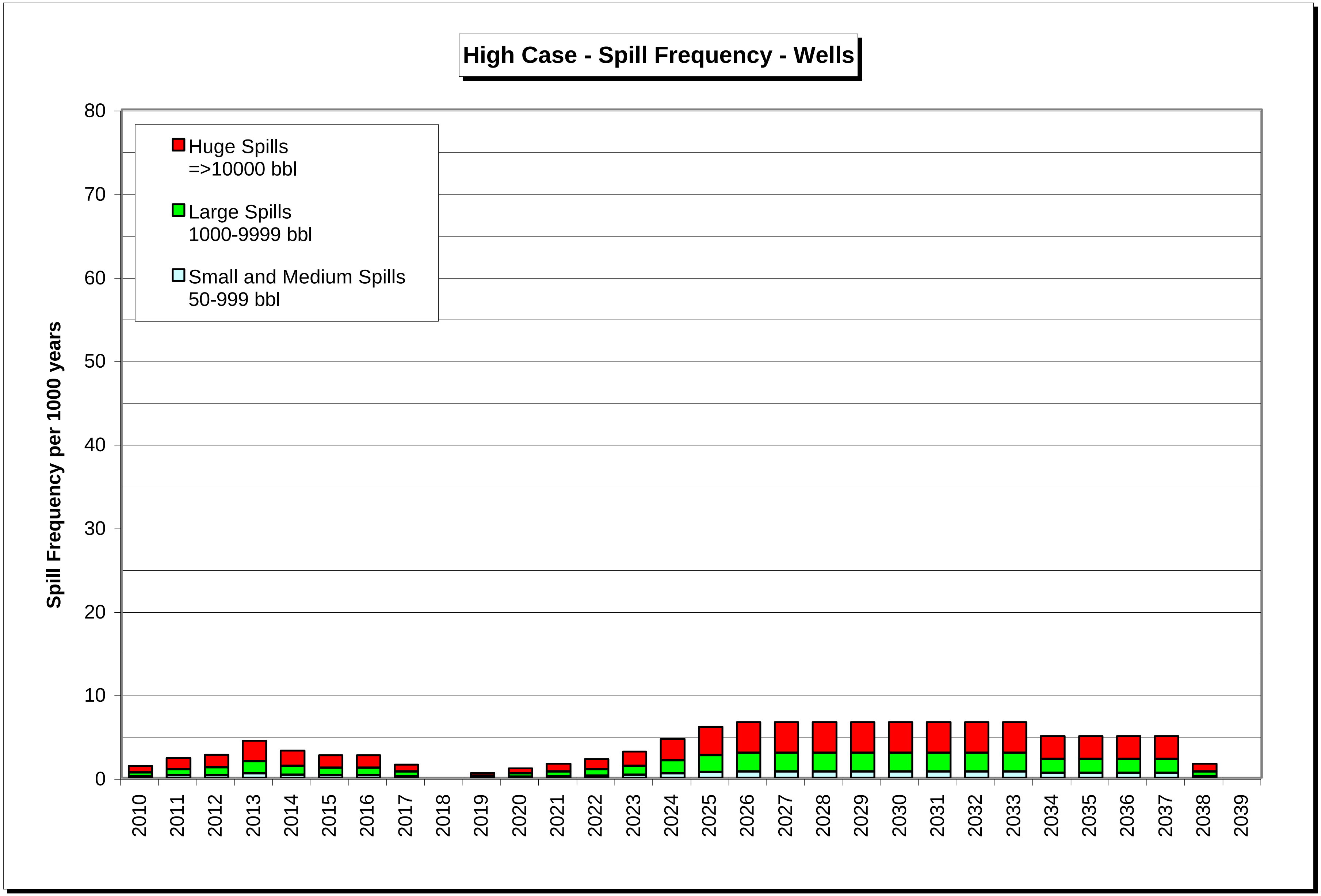

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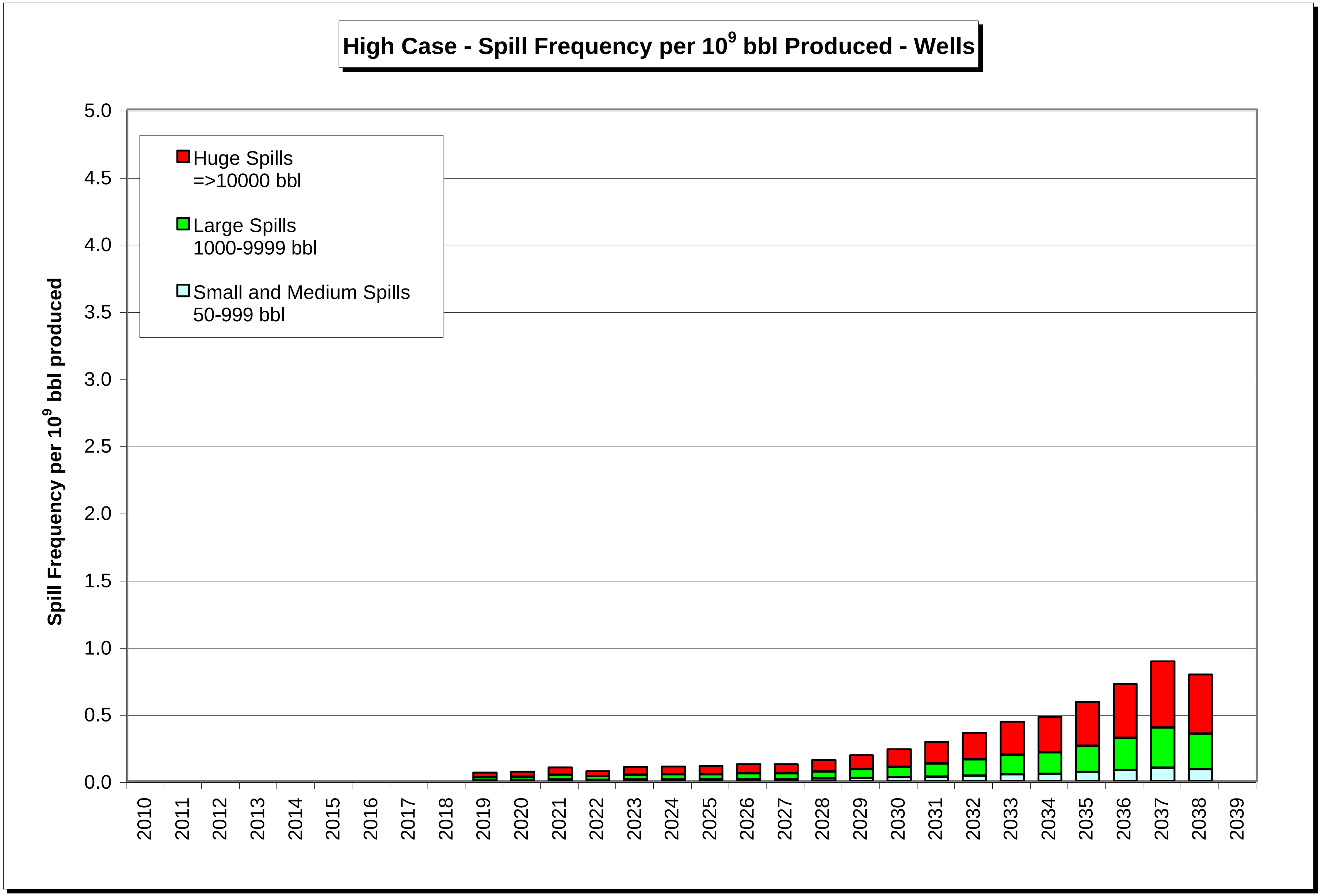

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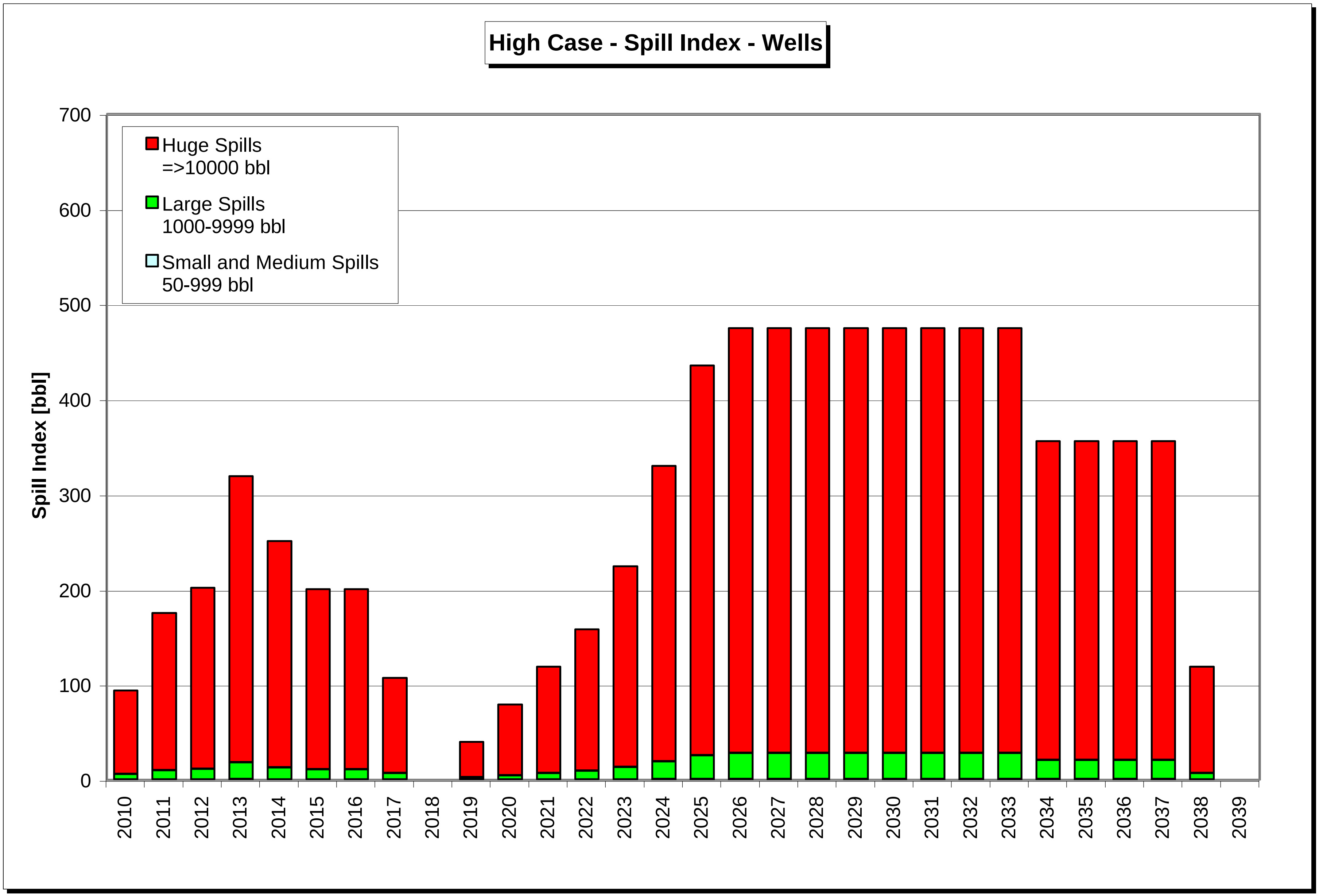

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Figure 4.2.13 Spill Indicators – CDF – Year 2030

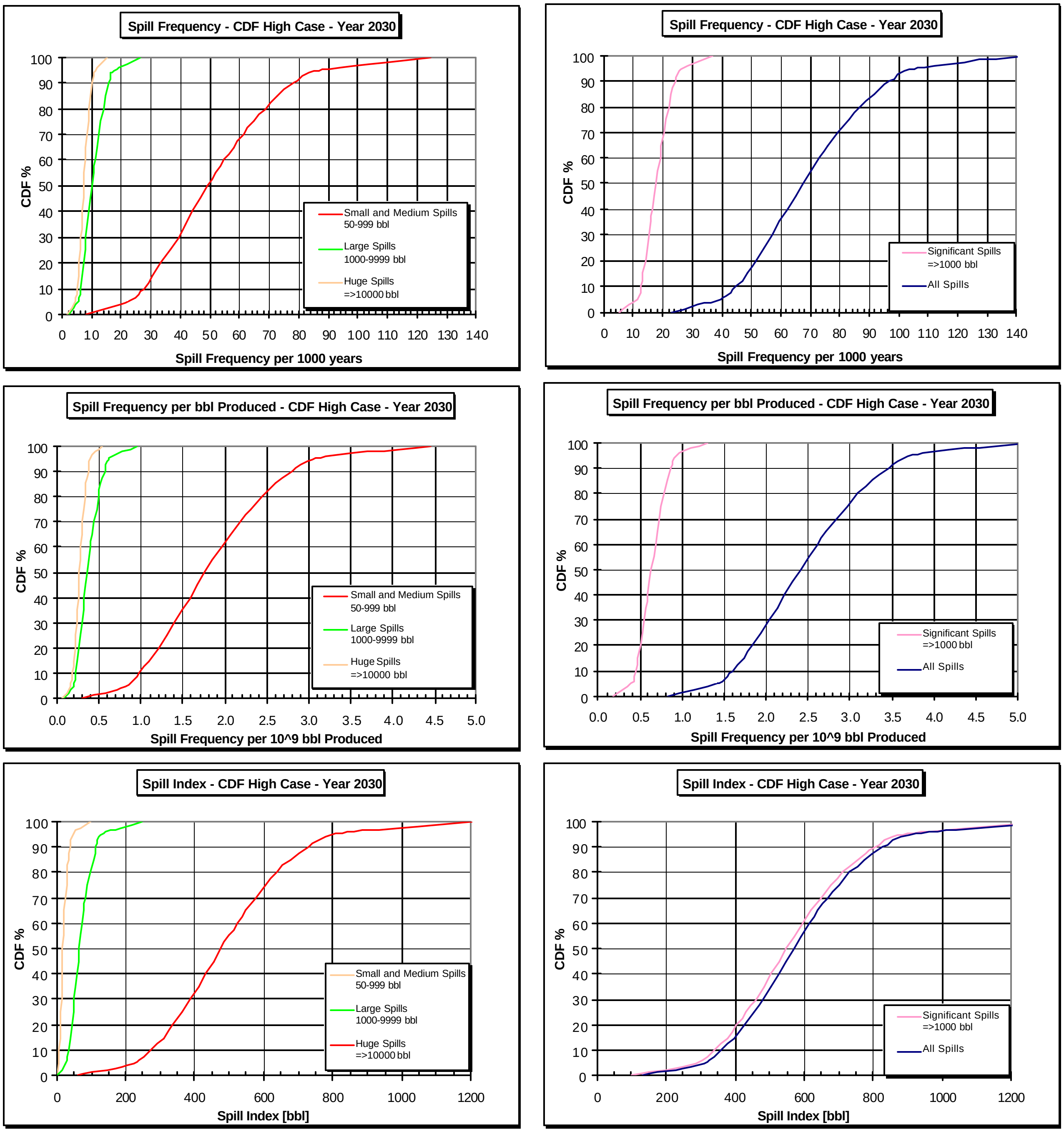


Figure 4.2.14 Spill Frequency – CDF – High Case

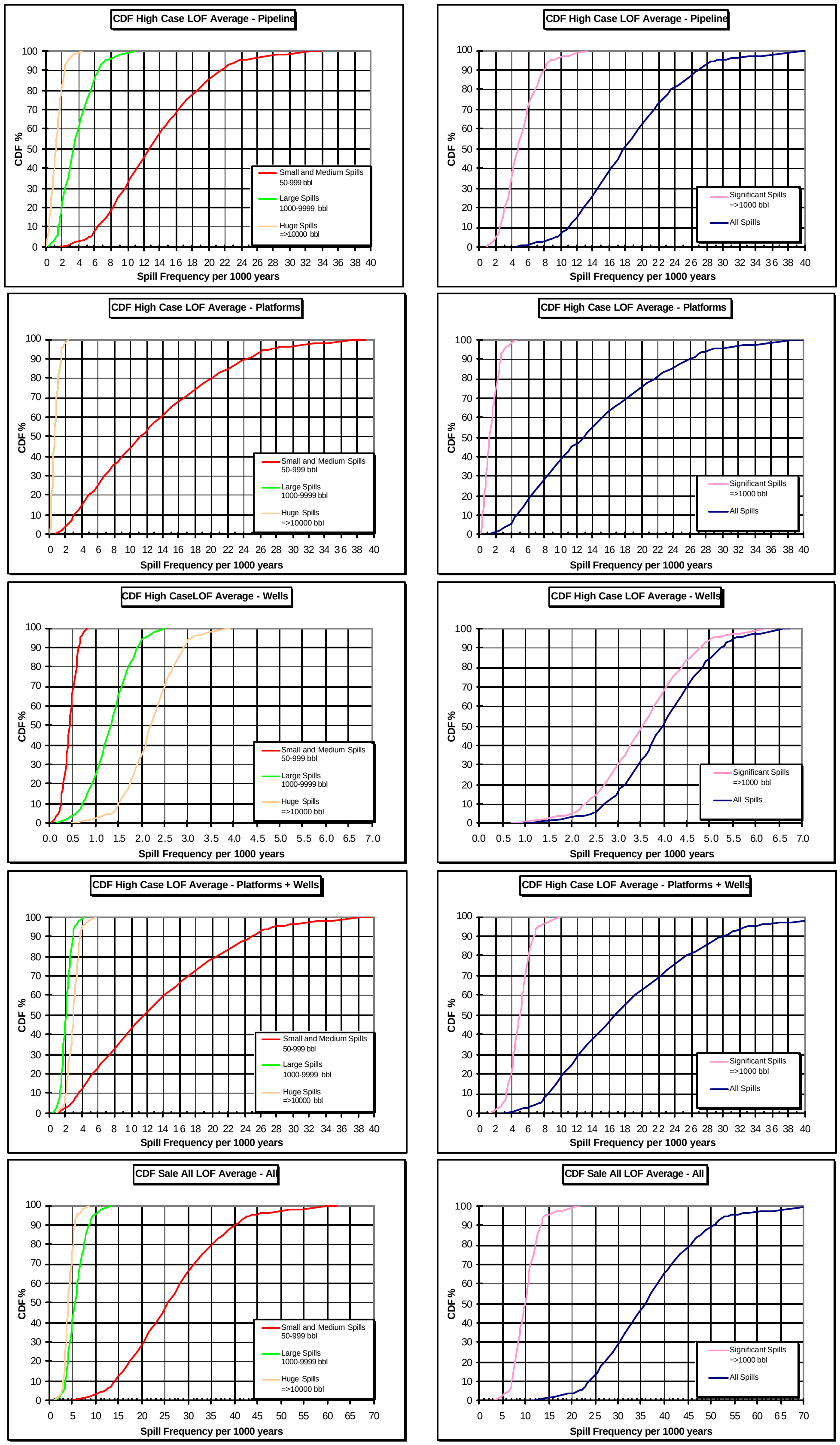


Figure 4.2.15 Spill Frequency per bbl produced – CDF – High Case

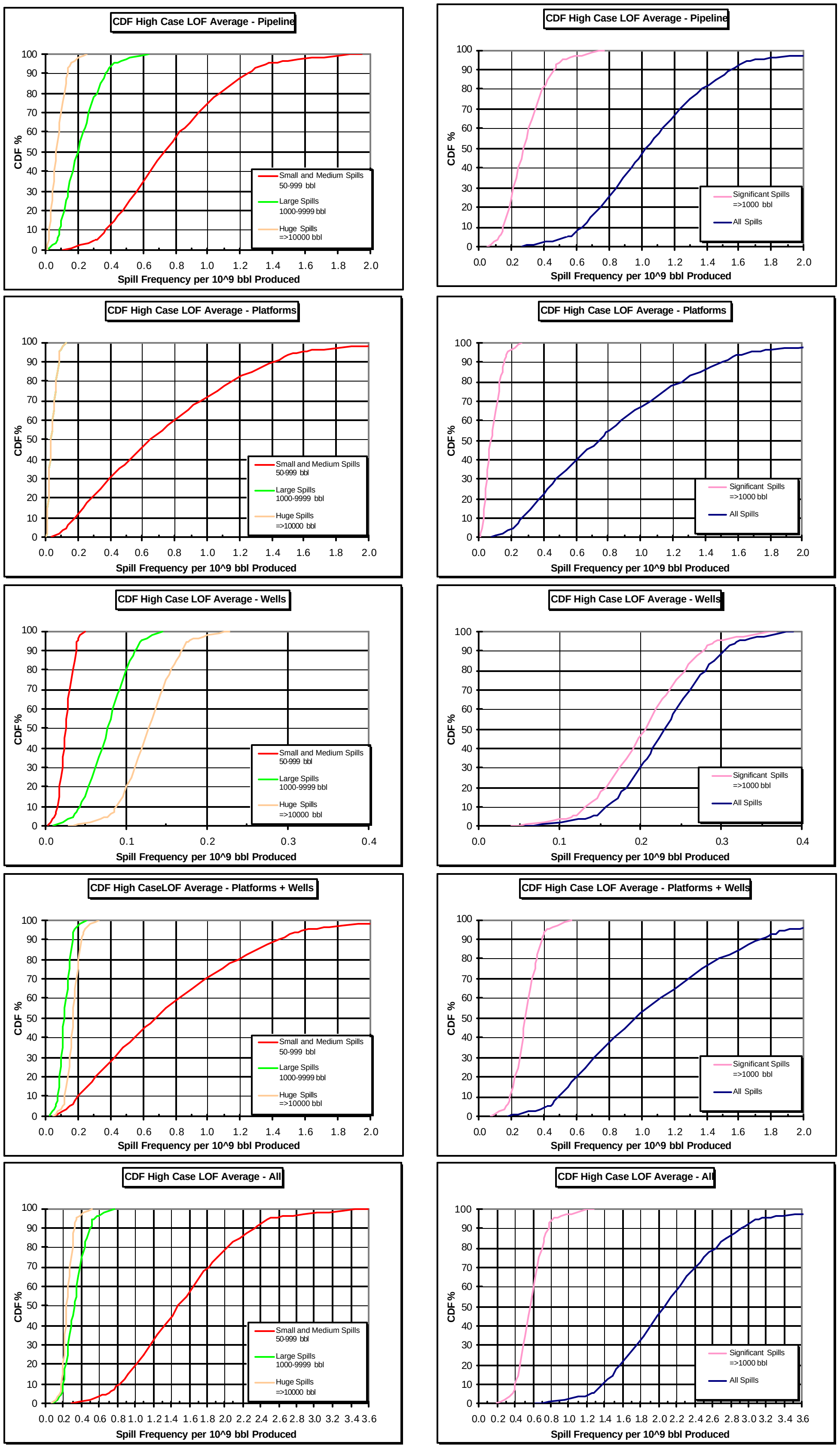


Figure 4.2.16 Spill Index [bbl] – CDF – High Case

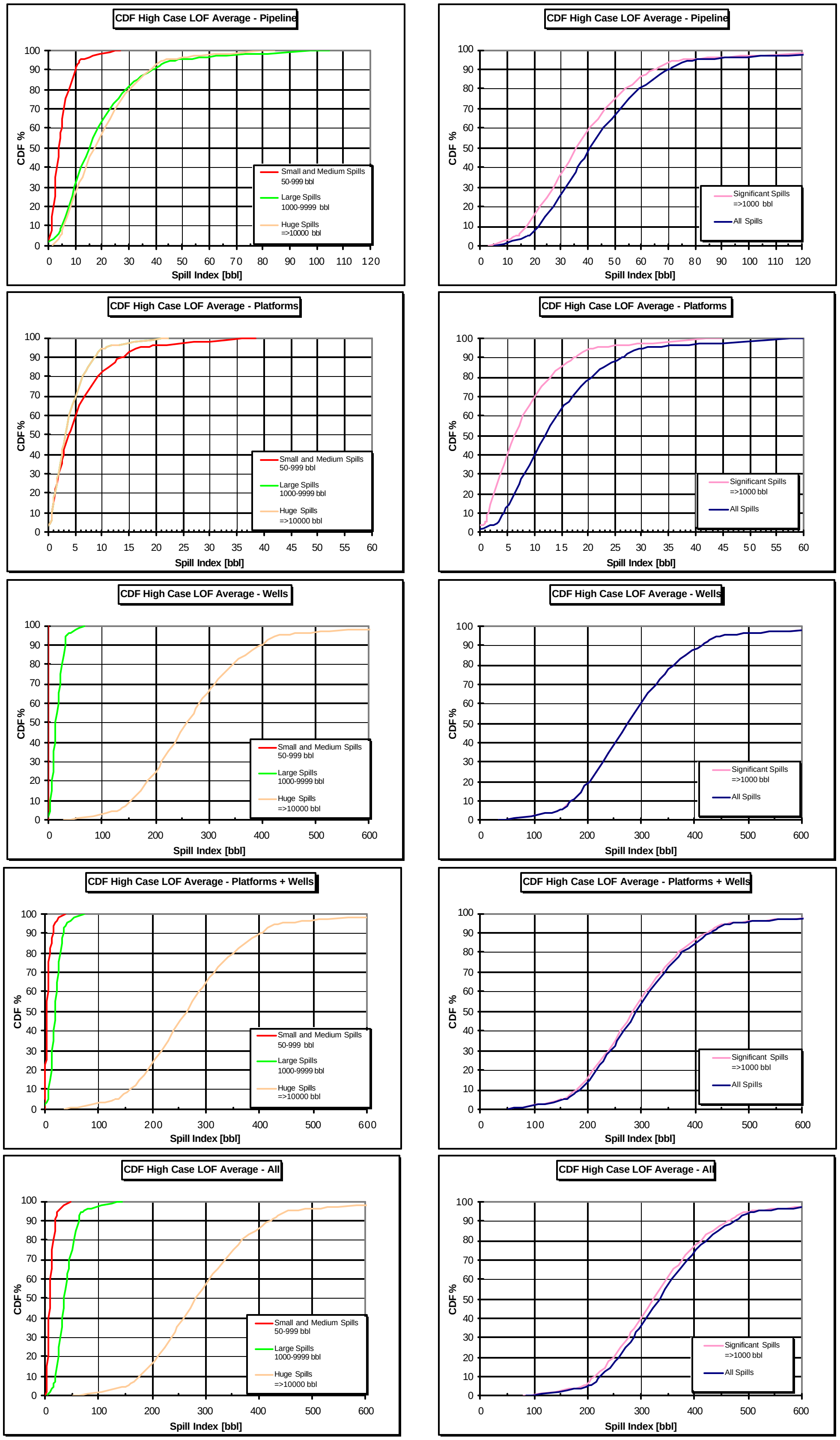
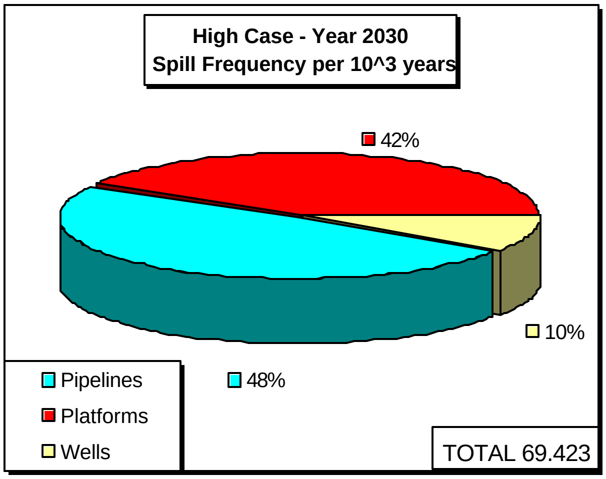
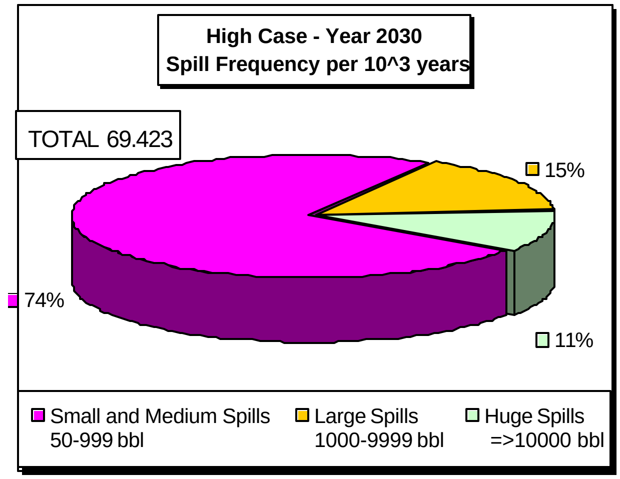


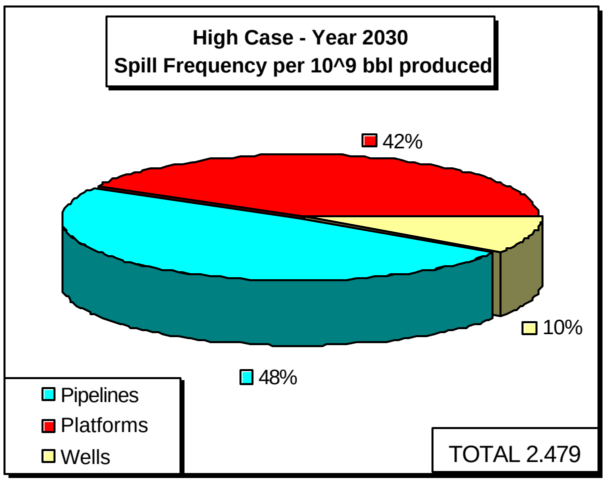
Figure 4.2.17
High Case - Year 2030 - Spill Indicators

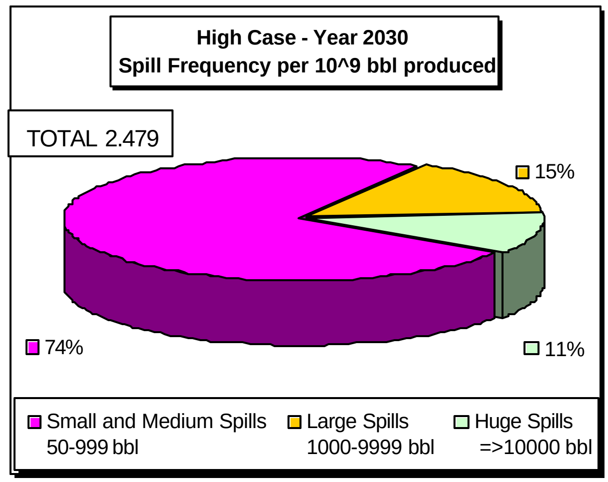
BY SPILL SOURCE

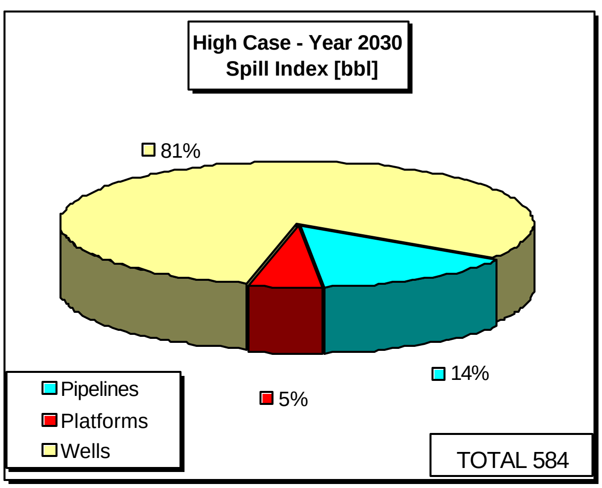
BY SPILL SIZE











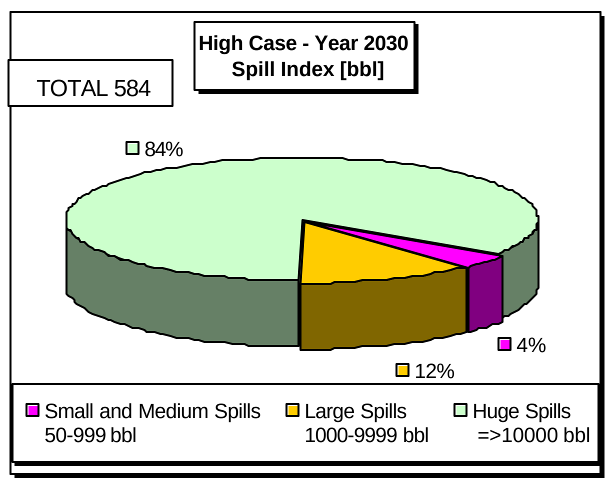


Figure 4.2.18
High Case – LOF Average Spill Indicators

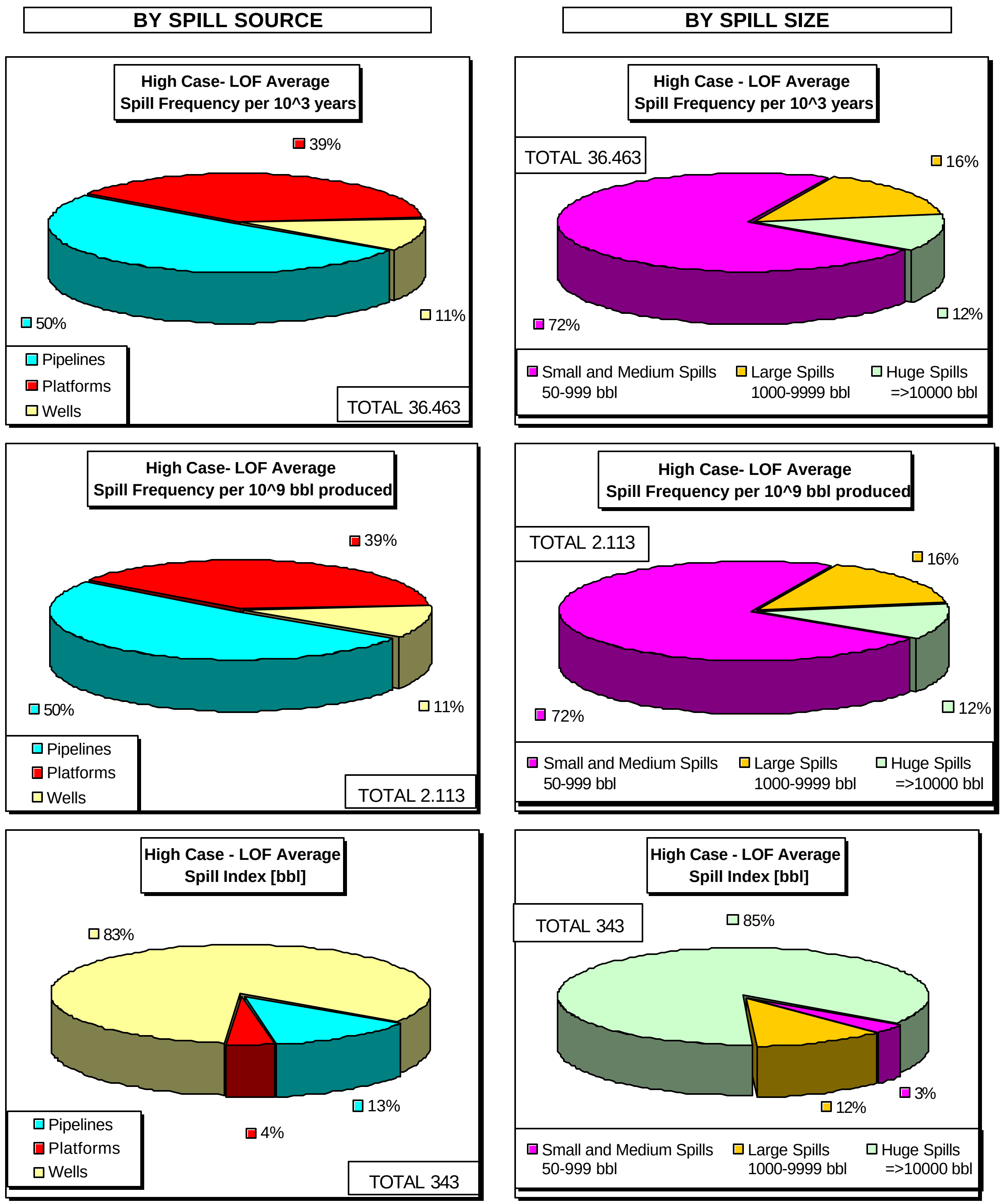


Table 4.3.1
Spill Occurrence Beaufort Sea High Case - non ArcticP/L Spills

P/L Dia <=10"

Year	Water Depth	P/L [miles]	Small Spills 50-99 bbl			Medium Spills 100-999 bbl			Large Spills 1000-9999 bbl			Huge Spills =>10000 bbl		
			Expected Spill [bbl] =		71	Expected Spill [bbl] =		485	Expected Spill [bbl] =		5279	Expected Spill [bbl] =		14880
		Cumm.	Frequency spills per 10^5km-year	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^5km-year	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^5km-year	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^5km-year	Frequency spills per 10^3years	Spill Index bbl
2010	Shallow		6.036			10.563			5.282			0.755		
	Medium		6.036			10.563			5.282			0.755		
	Deep		6.036			10.563			5.282			0.755		
	Total													
2011	Shallow		6.036			10.563			5.282			0.755		
	Medium		6.036			10.563			5.282			0.755		
	Deep		6.036			10.563			5.282			0.755		
	Total													
2012	Shallow		6.036			10.563			5.282			0.755		
	Medium		6.036			10.563			5.282			0.755		
	Deep		6.036			10.563			5.282			0.755		
	Total													
2013	Shallow		6.036			10.563			5.282			0.755		
	Medium		6.036			10.563			5.282			0.755		
	Deep		6.036			10.563			5.282			0.755		
	Total													
2014	Shallow		6.036			10.563			5.282			0.755		
	Medium		6.036			10.563			5.282			0.755		
	Deep		6.036			10.563			5.282			0.755		
	Total													
2015	Shallow		6.036			10.563			5.282			0.755		
	Medium		6.036			10.563			5.282			0.755		
	Deep		6.036			10.563			5.282			0.755		
	Total													
2016	Shallow		6.036			10.563			5.282			0.755		
	Medium		6.036			10.563			5.282			0.755		
	Deep		6.036			10.563			5.282			0.755		
	Total													
2017	Shallow		6.036			10.563			5.282			0.755		
	Medium		6.036			10.563			5.282			0.755		
	Deep		6.036			10.563			5.282			0.755		
	Total													
2018	Shallow		6.036			10.563			5.282			0.755		
	Medium		6.036			10.563			5.282			0.755		
	Deep		6.036			10.563			5.282			0.755		
	Total													
2019	Shallow		6.036			10.563			5.282			0.755		
	Medium		6.036			10.563			5.282			0.755		
	Deep		6.036			10.563			5.282			0.755		
	Total													
2020	Shallow		6.036			10.563			5.282			0.755		
	Medium		6.036			10.563			5.282			0.755		
	Deep		6.036			10.563			5.282			0.755		
	Total													
2021	Shallow		6.036			10.563			5.282			0.755		
	Medium		6.036			10.563			5.282			0.755		
	Deep		6.036			10.563			5.282			0.755		
	Total													
2022	Shallow		6.036			10.563			5.282			0.755		
	Medium		6.036			10.563			5.282			0.755		
	Deep		6.036			10.563			5.282			0.755		
	Total													
2023	Shallow		6.036			10.563			5.282			0.755		
	Medium		6.036			10.563			5.282			0.755		
	Deep	5	6.036	0.486	0.03	10.563	0.850	0.41	5.282	0.425	2.24	0.755	0.061	0.90
	Total	**5**		**0.486**	**0.03**		**0.850**	**0.41**		**0.425**	**2.24**		**0.061**	**0.90**
2024	Shallow		6.036			10.563			5.282			0.755		
	Medium		6.036			10.563			5.282			0.755		
	Deep	10	6.036	0.971	0.07	10.563	1.700	0.82	5.282	0.850	4.49	0.755	0.121	1.81
	Total	**10**		**0.971**	**0.07**		**1.700**	**0.82**		**0.850**	**4.49**		**0.121**	**1.81**
2025	Shallow		6.036			10.563			5.282			0.755		
	Medium		6.036			10.563			5.282			0.755		
	Deep	15	6.036	1.457	0.10	10.563	2.549	1.24	5.282	1.275	6.73	0.755	0.182	2.71
	Total	**15**		**1.457**	**0.10**		**2.549**	**1.24**		**1.275**	**6.73**		**0.182**	**2.71**
2026	Shallow		6.036			10.563			5.282			0.755		
	Medium		6.036			10.563			5.282			0.755		
	Deep	15	6.036	1.457	0.10	10.563	2.549	1.24	5.282	1.275	6.73	0.755	0.182	2.71
	Total	**15**		**1.457**	**0.10**		**2.549**	**1.24**		**1.275**	**6.73**		**0.182**	**2.71**
2027	Shallow		6.036			10.563			5.282			0.755		
	Medium		6.036			10.563			5.282			0.755		
	Deep	15	6.036	1.457	0.10	10.563	2.549	1.24	5.282	1.275	6.73	0.755	0.182	2.71
	Total	**15**		**1.457**	**0.10**		**2.549**	**1.24**		**1.275**	**6.73**		**0.182**	**2.71**
2028	Shallow		6.036			10.563			5.282			0.755		
	Medium		6.036			10.563			5.282			0.755		
	Deep	15	6.036	1.457	0.10	10.563	2.549	1.24	5.282	1.275	6.73	0.755	0.182	2.71
	Total	**15**		**1.457**	**0.10**		**2.549**	**1.24**		**1.275**	**6.73**		**0.182**	**2.71**
2029	Shallow		6.036			10.563			5.282			0.755		
	Medium		6.036			10.563			5.282			0.755		
	Deep	15	6.036	1.457	0.10	10.563	2.549	1.24	5.282	1.275	6.73	0.755	0.182	2.71

P/L Dia >10"

Year	Water Depth	P/L [miles]	Small Spills 50-99 bbl			Medium Spills 100-999 bbl			Large Spills 1000-9999 bbl			Huge Spills =>10000 bbl		
			Expected Spill [bbl] =		71	Expected Spill [bbl] =		516	Expected Spill [bbl] =		5176	Expected Spill [bbl] =		15552
		Cumm.	Frequency spills per 10^5km-year	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^5km-year	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^5km-year	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^5km-year	Frequency spills per 10^3years	Spill Index bbl
2010	Shallow		14.867			14.867			8.259			3.304		
	Medium		14.867			14.867			8.259			3.304		
	Deep		14.867			14.867			8.259			3.304		
	Total													
2011	Shallow		14.867			14.867			8.259			3.304		
	Medium		14.867			14.867			8.259			3.304		
	Deep		14.867			14.867			8.259			3.304		
	Total													
2012	Shallow		14.867			14.867			8.259			3.304		
	Medium		14.867			14.867			8.259			3.304		
	Deep		14.867			14.867			8.259			3.304		
	Total													
2013	Shallow		14.867			14.867			8.259			3.304		
	Medium		14.867			14.867			8.259			3.304		
	Deep		14.867			14.867			8.259			3.304		
	Total													
2014	Shallow		14.867			14.867			8.259			3.304		
	Medium		14.867			14.867			8.259			3.304		
	Deep		14.867			14.867			8.259			3.304		
	Total													
2015	Shallow		14.867			14.867			8.259			3.304		
	Medium		14.867			14.867			8.259			3.304		
	Deep		14.867			14.867			8.259			3.304		
	Total													
2016	Shallow		14.867			14.867			8.259			3.304		
	Medium		14.867			14.867			8.259			3.304		
	Deep		14.867			14.867			8.259			3.304		
	Total													
2017	Shallow	10	14.867	2.392	0.17	14.867	2.392	1.23	8.259	1.329	6.88	3.304	0.532	8.27
	Medium		14.867			14.867			8.259			3.304		
	Deep		14.867			14.867			8.259			3.304		
	Total	**10**		**2.392**	**0.17**		**2.392**	**1.23**		**1.329**	**6.88**		**0.532**	**8.27**
2018	Shallow	15	14.867	3.588	0.26	14.867	3.588	1.85	8.259	1.993	10.32	3.304	0.797	12.40
	Medium		14.867			14.867			8.259			3.304		
	Deep		14.867			14.867			8.259			3.304		
	Total	**15**		**3.588**	**0.26**		**3.588**	**1.85**		**1.993**	**10.32**		**0.797**	**12.40**
2019	Shallow	15	14.867	3.588	0.26	14.867	3.588	1.85	8.259	1.993	10.32	3.304	0.797	12.40
	Medium		14.867			14.867			8.259			3.304		
	Deep		14.867			14.867			8.259			3.304		
	Total	**15**		**3.588**	**0.26**		**3.588**	**1.85**		**1.993**	**10.32**		**0.797**	**12.40**
2020	Shallow	15	14.867	3.588	0.26	14.867	3.588	1.85	8.259	1.993	10.32	3.304	0.797	12.40
	Medium		14.867			14.867			8.259			3.304		
	Deep	10	14.867	2.392	0.17	14.867	2.392	1.23	8.259	1.329	6.88	3.304	0.532	8.27
	Total	**25**		**5.980**	**0.43**		**5.980**	**3.09**		**3.322**	**17.20**		**1.329**	**20.67**
2021	Shallow	15	14.867	3.588	0.26	14.867	3.588	1.85	8.259	1.993	10.32	3.304	0.797	12.40
	Medium		14.867			14.867			8.259			3.304		
	Deep	20	14.867	4.784	0.34	14.867	4.784	2.47	8.259	2.658	13.76	3.304	1.063	16.53
	Total	**35**		**8.372**	**0.60**		**8.372**	**4.32**		**4.651**	**24.07**		**1.861**	**28.93**
2022	Shallow	15	14.867	3.588	0.26	14.867	3.588	1.85	8.259	1.993	10.32	3.304	0.797	12.40
	Medium		14.867			14.867			8.259			3.304		
	Deep	35	14.867	8.372	0.60	14.867	8.372	4.32	8.259	4.651	24.07	3.304	1.861	28.93
	Total	**50**		**11.961**	**0.85**		**11.961**	**6.17**		**6.645**	**34.39**		**2.658**	**41.34**
2023	Shallow	15	14.867	3.588	0.26	14.867	3.588	1.85	8.259	1.993	10.32	3.304	0.797	12.40
	Medium		14.867			14.867			8.259			3.304		
	Deep	35	14.867	8.372	0.60	14.867	8.372	4.32	8.259	4.651	24.07	3.304	1.861	28.93
	Total	**50**		**11.961**	**0.85**		**11.961**	**6.17**		**6.645**	**34.39**		**2.658**	**41.34**
2024	Shallow	15	14.867	3.588	0.26	14.867	3.588	1.85	8.259	1.993	10.32	3.304	0.797	12.40
	Medium	10	14.867	2.392	0.17	14.867	2.392	1.23	8.259	1.329	6.88	3.304	0.532	8.27
	Deep	35	14.867	8.372	0.60	14.867	8.372	4.32	8.259	4.651	24.07	3.304	1.861	28.93
	Total	**60**		**14.353**	**1.02**		**14.353**	**7.41**		**7.974**	**41.27**		**3.189**	**49.60**
2025	Shallow	15	14.867	3.588	0.26	14.867	3.588	1.85	8.259	1.993	10.32	3.304	0.797	12.40
	Medium	25	14.867	5.980	0.43	14.867	5.980	3.09	8.259	3.322	17.20	3.304	1.329	20.67
	Deep	35	14.867	8.372	0.60	14.867	8.372	4.32	8.259	4.651	24.07	3.304	1.861	28.93
	Total	**75**		**17.941**	**1.28**		**17.941**	**9.26**		**9.967**	**51.59**		**3.987**	**62.00**
2026	Shallow	15	14.867	3.588	0.26	14.867	3.588	1.85	8.259	1.993	10.32	3.304	0.797	12.40
	Medium	25	14.867	5.980	0.43	14.867	5.980	3.09	8.259	3.322	17.20	3.304	1.329	20.67
	Deep	35	14.867	8.372	0.60	14.867	8.372	4.32	8.259	4.651	24.07	3.304	1.861	28.93
	Total	**75**		**17.941**	**1.28**		**17.941**	**9.26**		**9.967**	**51.59**		**3.987**	**62.00**
2027	Shallow	15	14.867	3.588	0.26	14.867	3.588	1.85	8.259	1.993	10.32	3.304	0.797	12.40
	Medium	25	14.867	5.980	0.43	14.867	5.980	3.09	8.259	3.322	17.20	3.304	1.329	20.67
	Deep	35	14.867	8.372	0.60	14.867	8.372	4.32	8.259	4.651	24.07	3.304	1.861	28.93
	Total	**75**		**17.941**	**1.28**		**17.941**	**9.26**		**9.967**	**51.59**		**3.987**	**62.00**
2028	Shallow	15	14.867	3.588	0.26	14.867	3.588	1.85	8.259	1.993	10.32	3.304	0.797	12.40
	Medium	25	14.867	5.980	0.43	14.867	5.980	3.09	8.259	3.322	17.20	3.304	1.329	20.67
	Deep	35	14.867	8.372	0.60	14.867	8.372	4.32	8.259	4.651	24.07	3.304	1.861	28.93
	Total	**75**		**17.941**	**1.28**		**17.941**	**9.26**		**9.967**	**51.59**		**3.987**	**62.00**
2029	Shallow	15	14.867	3.588	0.26	14.867	3.588	1.85	8.259	1.993	10.32	3.304	0.797	12.40
	Medium	25	14.867	5.980	0.43	14.867	5.980	3.09	8.259	3.322	17.20	3.304	1.329	20.67
	Deep	35	14.867	8.372	0.60	14.867	8.372	4.32	8.259	4.651	24.07	3.304	1.861	28.93

Table 4.3.1
Spill Occurrence Beaufort Sea High Case - non ArcticP/L Spills

Year	Water Depth	P/L Dia <=10"													P/L Dia >10"													
		P/L [miles]	Small Spills 50-99 bbl			Medium Spills 100-999 bbl			Large Spills 1000-9999 bbl			Huge Spills =>10000 bbl			P/L [miles]	Small Spills 50-99 bbl			Medium Spills 100-999 bbl			Large Spills 1000-9999 bbl			Huge Spills =>10000 bbl			
			Expected Spill [bbl] =		71	Expected Spill [bbl] =		485	Expected Spill [bbl] =		5279	Expected Spill [bbl] =		14880		Expected Spill [bbl] =		71	Expected Spill [bbl] =		516	Expected Spill [bbl] =		5176	Expected Spill [bbl] =		15552
		Cumm.	Frequency spills per 10^5km-year	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^5km-year	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^5km-year	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^5km-year	Frequency spills per 10^3years	Spill Index bbl	Cumm.	Frequency spills per 10^5km-year	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^5km-year	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^5km-year	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^5km-year	Frequency spills per 10^3years	Spill Index bbl
	Total	15		1.457	0.10		2.549	1.24		1.275	6.73		0.182	2.71	75		17.941	1.28		17.941	9.26		9.967	51.59		3.987	62.00
2030	Shallow		6.036			10.563			5.282			0.755			15	14.867	3.588	0.26	14.867	3.588	1.85	8.259	1.993	10.32	3.304	0.797	12.40
	Medium		6.036			10.563			5.282			0.755			25	14.867	5.980	0.43	14.867	5.980	3.09	8.259	3.322	17.20	3.304	1.329	20.67
	Deep	15	6.036	1.457	0.10	10.563	2.549	1.24	5.282	1.275	6.73	0.755	0.182	2.71	35	14.867	8.372	0.60	14.867	8.372	4.32	8.259	4.651	24.07	3.304	1.861	28.93
	Total	15		1.457	0.10		2.549	1.24		1.275	6.73		0.182	2.71	75		17.941	1.28		17.941	9.26		9.967	51.59		3.987	62.00
2031	Shallow		6.036			10.563			5.282			0.755			15	14.867	3.588	0.26	14.867	3.588	1.85	8.259	1.993	10.32	3.304	0.797	12.40
	Medium		6.036			10.563			5.282			0.755			25	14.867	5.980	0.43	14.867	5.980	3.09	8.259	3.322	17.20	3.304	1.329	20.67
	Deep	15	6.036	1.457	0.10	10.563	2.549	1.24	5.282	1.275	6.73	0.755	0.182	2.71	35	14.867	8.372	0.60	14.867	8.372	4.32	8.259	4.651	24.07	3.304	1.861	28.93
	Total	15		1.457	0.10		2.549	1.24		1.275	6.73		0.182	2.71	75		17.941	1.28		17.941	9.26		9.967	51.59		3.987	62.00
2032	Shallow		6.036			10.563			5.282			0.755			15	14.867	3.588	0.26	14.867	3.588	1.85	8.259	1.993	10.32	3.304	0.797	12.40
	Medium		6.036			10.563			5.282			0.755			25	14.867	5.980	0.43	14.867	5.980	3.09	8.259	3.322	17.20	3.304	1.329	20.67
	Deep	15	6.036	1.457	0.10	10.563	2.549	1.24	5.282	1.275	6.73	0.755	0.182	2.71	35	14.867	8.372	0.60	14.867	8.372	4.32	8.259	4.651	24.07	3.304	1.861	28.93
	Total	15		1.457	0.10		2.549	1.24		1.275	6.73		0.182	2.71	75		17.941	1.28		17.941	9.26		9.967	51.59		3.987	62.00
2033	Shallow		6.036			10.563			5.282			0.755			15	14.867	3.588	0.26	14.867	3.588	1.85	8.259	1.993	10.32	3.304	0.797	12.40
	Medium		6.036			10.563			5.282			0.755			25	14.867	5.980	0.43	14.867	5.980	3.09	8.259	3.322	17.20	3.304	1.329	20.67
	Deep	15	6.036	1.457	0.10	10.563	2.549	1.24	5.282	1.275	6.73	0.755	0.182	2.71	35	14.867	8.372	0.60	14.867	8.372	4.32	8.259	4.651	24.07	3.304	1.861	28.93
	Total	15		1.457	0.10		2.549	1.24		1.275	6.73		0.182	2.71	75		17.941	1.28		17.941	9.26		9.967	51.59		3.987	62.00
2034	Shallow		6.036			10.563			5.282			0.755				14.867			14.867			8.259			3.304		
	Medium		6.036			10.563			5.282			0.755			25	14.867	5.980	0.43	14.867	5.980	3.09	8.259	3.322	17.20	3.304	1.329	20.67
	Deep	15	6.036	1.457	0.10	10.563	2.549	1.24	5.282	1.275	6.73	0.755	0.182	2.71	35	14.867	8.372	0.60	14.867	8.372	4.32	8.259	4.651	24.07	3.304	1.861	28.93
	Total	15		1.457	0.10		2.549	1.24		1.275	6.73		0.182	2.71	60		14.353	1.02		14.353	7.41		7.974	41.27		3.189	49.60
2035	Shallow		6.036			10.563			5.282			0.755				14.867			14.867			8.259			3.304		
	Medium		6.036			10.563			5.282			0.755			25	14.867	5.980	0.43	14.867	5.980	3.09	8.259	3.322	17.20	3.304	1.329	20.67
	Deep	15	6.036	1.457	0.10	10.563	2.549	1.24	5.282	1.275	6.73	0.755	0.182	2.71	35	14.867	8.372	0.60	14.867	8.372	4.32	8.259	4.651	24.07	3.304	1.861	28.93
	Total	15		1.457	0.10		2.549	1.24		1.275	6.73		0.182	2.71	60		14.353	1.02		14.353	7.41		7.974	41.27		3.189	49.60
2036	Shallow		6.036			10.563			5.282			0.755				14.867			14.867			8.259			3.304		
	Medium		6.036			10.563			5.282			0.755			25	14.867	5.980	0.43	14.867	5.980	3.09	8.259	3.322	17.20	3.304	1.329	20.67
	Deep	15	6.036	1.457	0.10	10.563	2.549	1.24	5.282	1.275	6.73	0.755	0.182	2.71	35	14.867	8.372	0.60	14.867	8.372	4.32	8.259	4.651	24.07	3.304	1.861	28.93
	Total	15		1.457	0.10		2.549	1.24		1.275	6.73		0.182	2.71	60		14.353	1.02		14.353	7.41		7.974	41.27		3.189	49.60
2037	Shallow		6.036			10.563			5.282			0.755				14.867			14.867			8.259			3.304		
	Medium		6.036			10.563			5.282			0.755			25	14.867	5.980	0.43	14.867	5.980	3.09	8.259	3.322	17.20	3.304	1.329	20.67
	Deep	15	6.036	1.457	0.10	10.563	2.549	1.24	5.282	1.275	6.73	0.755	0.182	2.71	35	14.867	8.372	0.60	14.867	8.372	4.32	8.259	4.651	24.07	3.304	1.861	28.93
	Total	15		1.457	0.10		2.549	1.24		1.275	6.73		0.182	2.71	60		14.353	1.02		14.353	7.41		7.974	41.27		3.189	49.60
2038	Shallow		6.036			10.563			5.282			0.755				14.867			14.867			8.259			3.304		
	Medium		6.036			10.563			5.282			0.755			25	14.867	5.980	0.43	14.867	5.980	3.09	8.259	3.322	17.20	3.304	1.329	20.67
	Deep		6.036			10.563			5.282			0.755				14.867			14.867			8.259			3.304		
	Total														25		5.980	0.43		5.980	3.09		3.322	17.20		1.329	20.67
2039	Shallow		6.036			10.563			5.282			0.755				14.867			14.867			8.259			3.304		
	Medium		6.036			10.563			5.282			0.755				14.867			14.867			8.259			3.304		
	Deep		6.036			10.563			5.282			0.755				14.867			14.867			8.259			3.304		
	Total																										

Table 4.3.2
Spill Occurrence - High Case non Arctic- P/L - Summary

Year	Production [MMbbl]	Small Spills 50-99 bbl			Medium Spills 100-999 bbl			Small and Medium Spills 50-999 bbl			Large Spills 1000-9999 bbl			Huge Spills =>10000 bbl			Significant Spills =>1000 bbl			All Spills		
		Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 103years	Frequency Spills per 109 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]
2010																						
2011																						
2012																						
2013																						
2014																						
2015																						
2016																						
2017		2.392		0.170	2.392		1.234	4.784		1.404	1.329		6.878	0.532		8.267	1.861		15.145	6.645		16.550
2018		3.588		0.255	3.588		1.851	7.176		2.107	1.993		10.317	0.797		12.401	2.791		22.718	9.967		24.825
2019	**8.8**	3.588	0.408	0.255	3.588	0.408	1.851	7.176	0.815	2.107	1.993	0.227	10.317	0.797	0.091	12.401	2.791	0.317	22.718	9.967	1.133	24.825
2020	**16.3**	5.980	0.367	0.426	5.980	0.367	3.086	11.961	0.734	3.511	3.322	0.204	17.196	1.329	0.082	20.668	4.651	0.285	37.863	16.612	1.019	41.375
2021	**16.3**	8.372	0.514	0.596	8.372	0.514	4.320	16.745	1.027	4.916	4.651	0.285	24.074	1.861	0.114	28.935	6.512	0.399	53.009	23.257	1.427	57.924
2022	**29.8**	11.961	0.401	0.851	11.961	0.401	6.171	23.921	0.803	7.022	6.645	0.223	34.391	2.658	0.089	41.335	9.303	0.312	75.727	33.224	1.115	82.749
2023	**30.3**	12.446	0.411	0.886	12.810	0.423	6.583	25.256	0.834	7.469	7.070	0.233	36.634	2.719	0.090	42.238	9.788	0.323	78.873	35.045	1.157	86.342
2024	**42.4**	15.324	0.361	1.091	16.052	0.379	8.229	31.376	0.740	9.320	8.823	0.208	45.756	3.311	0.078	51.409	12.134	0.286	97.164	43.510	1.026	106.485
2025	**55.4**	19.398	0.350	1.381	20.490	0.370	10.493	39.888	0.720	11.873	11.242	0.203	58.316	4.169	0.075	64.713	15.411	0.278	123.029	55.299	0.998	134.902
2026	**53.8**	19.398	0.361	1.381	20.490	0.381	10.493	39.888	0.741	11.873	11.242	0.209	58.316	4.169	0.077	64.713	15.411	0.286	123.029	55.299	1.028	134.902
2027	**52.5**	19.398	0.369	1.381	20.490	0.390	10.493	39.888	0.760	11.873	11.242	0.214	58.316	4.169	0.079	64.713	15.411	0.294	123.029	55.299	1.053	134.902
2028	**42.5**	19.398	0.456	1.381	20.490	0.482	10.493	39.888	0.939	11.873	11.242	0.265	58.316	4.169	0.098	64.713	15.411	0.363	123.029	55.299	1.301	134.902
2029	**34.5**	19.398	0.562	1.381	20.490	0.594	10.493	39.888	1.156	11.873	11.242	0.326	58.316	4.169	0.121	64.713	15.411	0.447	123.029	55.299	1.603	134.902
2030	**28.0**	19.398	0.693	1.381	20.490	0.732	10.493	39.888	1.425	11.873	11.242	0.401	58.316	4.169	0.149	64.713	15.411	0.550	123.029	55.299	1.975	134.902
2031	**22.7**	19.398	0.855	1.381	20.490	0.903	10.493	39.888	1.757	11.873	11.242	0.495	58.316	4.169	0.184	64.713	15.411	0.679	123.029	55.299	2.436	134.902
2032	**18.5**	19.398	1.049	1.381	20.490	1.108	10.493	39.888	2.156	11.873	11.242	0.608	58.316	4.169	0.225	64.713	15.411	0.833	123.029	55.299	2.989	134.902
2033	**15.1**	19.398	1.285	1.381	20.490	1.357	10.493	39.888	2.642	11.873	11.242	0.744	58.316	4.169	0.276	64.713	15.411	1.021	123.029	55.299	3.662	134.902
2034	**10.5**	15.809	1.506	1.125	16.902	1.610	8.641	32.712	3.115	9.767	9.248	0.881	47.999	3.372	0.321	52.312	12.620	1.202	100.311	45.331	4.317	110.077
2035	**8.5**	15.809	1.860	1.125	16.902	1.988	8.641	32.712	3.848	9.767	9.248	1.088	47.999	3.372	0.397	52.312	12.620	1.485	100.311	45.331	5.333	110.077
2036	**6.9**	15.809	2.291	1.125	16.902	2.450	8.641	32.712	4.741	9.767	9.248	1.340	47.999	3.372	0.489	52.312	12.620	1.829	100.311	45.331	6.570	110.077
2037	**5.6**	15.809	2.823	1.022	16.902	3.018	7.405	32.712	5.841	8.427	9.248	1.651	41.270	3.372	0.602	49.602	12.620	2.254	90.872	45.331	8.095	99.299
2038	**2.1**	5.980	2.848	0.426	5.980	2.848	3.086	11.961	5.695	3.511	3.322	1.582	17.196	1.329	0.633	20.668	4.651	2.215	37.863	16.612	7.910	41.375
2039																						
Total LOF	**500.5**	**307.448**		**22**	**322.745**		**164**	**630.193**		**186**	**177.320**		**913**	**66.339**		**1027**	**243.659**		**1940**	**873.851**		**2126**
Average LOF		**10.980**	**0.614**	**1**	**11.527**	**0.645**	**6**	**22.507**	**1.259**	**7**	**6.333**	**0.354**	**33**	**2.369**	**0.133**	**37**	**8.702**	**0.487**	**69**	**31.209**	**1.746**	**76**

Table 4.3.3
Spill Occurrence - High Case non Arctic - Platforms

Year	Water Depth	N Platforms	N P Wells	Small and Medium Spills 50-999 bbl			Large and Huge Spills =>1000 bbl		
				Expected Spill [bbl] =		452	Expected Spill [bbl] =		5631
		Cum.	Cum.	Frequency spills per 10^4well-year	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^4well-year	Frequency spills per 10^3years	Spill Index bbl
2010	Shallow			4.601			0.481		
	Medium			4.601			0.481		
	Deep			4.601			0.481		
	Total								
2011	Shallow			4.601			0.481		
	Medium			4.601			0.481		
	Deep			4.601			0.481		
	Total								
2012	Shallow			4.601			0.481		
	Medium			4.601			0.481		
	Deep			4.601			0.481		
	Total								
2013	Shallow			4.601			0.481		
	Medium			4.601			0.481		
	Deep			4.601			0.481		
	Total								
2014	Shallow			4.601			0.481		
	Medium			4.601			0.481		
	Deep			4.601			0.481		
	Total								
2015	Shallow			4.601			0.481		
	Medium			4.601			0.481		
	Deep			4.601			0.481		
	Total								
2016	Shallow			4.601			0.481		
	Medium			4.601			0.481		
	Deep			4.601			0.481		
	Total								
2017	Shallow			4.601			0.481		
	Medium			4.601			0.481		
	Deep			4.601			0.481		
	Total								
2018	Shallow			4.601			0.481		
	Medium			4.601			0.481		
	Deep			4.601			0.481		
	Total								
2019	Shallow	1	6	4.601	2.761	1.25	0.481	0.288	1.62
	Medium			4.601			0.481		
	Deep			4.601			0.481		
	Total	**1**	**6**		**2.761**	**1.25**		**0.288**	**1.62**
2020	Shallow	1	12	4.601	5.521	2.50	0.481	0.577	3.25
	Medium			4.601			0.481		
	Deep			4.601			0.481		
	Total	**1**	**12**		**5.521**	**2.50**		**0.577**	**3.25**
2021	Shallow	1	18	4.601	8.282	3.74	0.481	0.865	4.87
	Medium			4.601			0.481		
	Deep			4.601			0.481		
	Total	**1**	**18**		**8.282**	**3.74**		**0.865**	**4.87**
2022	Shallow	1	18	4.601	8.282	3.74	0.481	0.865	4.87
	Medium			4.601			0.481		
	Deep	1	6	4.601	2.761	1.25	0.481	0.288	1.62
	Total	**2**	**24**		**11.042**	**4.99**		**1.154**	**6.50**
2023	Shallow	1	18	4.601	8.282	3.74	0.481	0.865	4.87
	Medium			4.601			0.481		
	Deep	1	16	4.601	7.361	3.33	0.481	0.769	4.33
	Total	**2**	**34**		**15.643**	**7.07**		**1.634**	**9.20**
2024	Shallow	1	18	4.601	8.282	3.74	0.481	0.865	4.87
	Medium	1	6	4.601	2.761	1.25	0.481	0.288	1.62
	Deep	1	26	4.601	11.962	5.41	0.481	1.250	7.04
	Total	**3**	**50**		**23.005**	**10.40**		**2.403**	**13.53**
2025	Shallow	1	18	4.601	8.282	3.74	0.481	0.865	4.87
	Medium	1	12	4.601	5.521	2.50	0.481	0.577	3.25
	Deep	1	36	4.601	16.563	7.49	0.481	1.730	9.74
	Total	**3**	**66**		**30.366**	**13.72**		**3.173**	**17.86**
2026	Shallow	1	18	4.601	8.282	3.74	0.481	0.865	4.87
	Medium	1	18	4.601	8.282	3.74	0.481	0.865	4.87
	Deep	1	36	4.601	16.563	7.49	0.481	1.730	9.74

Table 4.3.3
Spill Occurrence - High Case non Arctic - Platforms

Year	Water Depth	N Platforms Cum.	N P Wells Cum.	Small and Medium Spills 50-999 bbl, Expected Spill [bbl] = 452: Frequency spills per 10^4 well-year	Frequency spills per 10^3 years	Spill Index bbl	Large and Huge Spills =>1000 bbl, Expected Spill [bbl] = 5631: Frequency spills per 10^4 well-year	Frequency spills per 10^3 years	Spill Index bbl
	Total	**3**	**72**		**33.126**	**14.97**		**3.461**	**19.49**
2027	Shallow	1	18	4.601	8.282	3.74	0.481	0.865	4.87
	Medium	1	18	4.601	8.282	3.74	0.481	0.865	4.87
	Deep	1	36	4.601	16.563	7.49	0.481	1.730	9.74
	Total	**3**	**72**		**33.126**	**14.97**		**3.461**	**19.49**
2028	Shallow	1	18	4.601	8.282	3.74	0.481	0.865	4.87
	Medium	1	18	4.601	8.282	3.74	0.481	0.865	4.87
	Deep	1	36	4.601	16.563	7.49	0.481	1.730	9.74
	Total	**3**	**72**		**33.126**	**14.97**		**3.461**	**19.49**
2029	Shallow	1	18	4.601	8.282	3.74	0.481	0.865	4.87
	Medium	1	18	4.601	8.282	3.74	0.481	0.865	4.87
	Deep	1	36	4.601	16.563	7.49	0.481	1.730	9.74
	Total	**3**	**72**		**33.126**	**14.97**		**3.461**	**19.49**
2030	Shallow	1	18	4.601	8.282	3.74	0.481	0.865	4.87
	Medium	1	18	4.601	8.282	3.74	0.481	0.865	4.87
	Deep	1	36	4.601	16.563	7.49	0.481	1.730	9.74
	Total	**3**	**72**		**33.126**	**14.97**		**3.461**	**19.49**
2031	Shallow	1	18	4.601	8.282	3.74	0.481	0.865	4.87
	Medium	1	18	4.601	8.282	3.74	0.481	0.865	4.87
	Deep	1	36	4.601	16.563	7.49	0.481	1.730	9.74
	Total	**3**	**72**		**33.126**	**14.97**		**3.461**	**19.49**
2032	Shallow	1	18	4.601	8.282	3.74	0.481	0.865	4.87
	Medium	1	18	4.601	8.282	3.74	0.481	0.865	4.87
	Deep	1	36	4.601	16.563	7.49	0.481	1.730	9.74
	Total	**3**	**72**		**33.126**	**14.97**		**3.461**	**19.49**
2033	Shallow	1	18	4.601	8.282	3.74	0.481	0.865	4.87
	Medium	1	18	4.601	8.282	3.74	0.481	0.865	4.87
	Deep	1	36	4.601	16.563	7.49	0.481	1.730	9.74
	Total	**3**	**72**		**33.126**	**14.97**		**3.461**	**19.49**
2034	Shallow			4.601			0.481		
	Medium	1	18	4.601	8.282	3.74	0.481	0.865	4.87
	Deep	1	36	4.601	16.563	7.49	0.481	1.730	9.74
	Total	**2**	**54**		**24.845**	**11.23**		**2.596**	**14.62**
2035	Shallow			4.601			0.481		
	Medium	1	18	4.601	8.282	3.74	0.481	0.865	4.87
	Deep	1	36	4.601	16.563	7.49	0.481	1.730	9.74
	Total	**2**	**54**		**24.845**	**11.23**		**2.596**	**14.62**
2036	Shallow			4.601			0.481		
	Medium	1	18	4.601	8.282	3.74	0.481	0.865	4.87
	Deep	1	36	4.601	16.563	7.49	0.481	1.730	9.74
	Total	**2**	**54**		**24.845**	**11.23**		**2.596**	**14.62**
2037	Shallow			4.601			0.481		
	Medium	1	18	4.601	8.282	3.74	0.481	0.865	4.87
	Deep	1	36	4.601	16.563	7.49	0.481	1.730	9.74
	Total	**2**	**54**		**24.845**	**11.23**		**2.596**	**14.62**
2038	Shallow			4.601			0.481		
	Medium	1	18	4.601	8.282	3.74	0.481	0.865	4.87
	Deep			4.601			0.481		
	Total	**1**	**18**		**8.282**	**3.74**		**0.865**	**4.87**
2039	Shallow			4.601			0.481		
	Medium			4.601			0.481		
	Deep			4.601			0.481		
	Total								

Table 4.3.4
Spill Occurrence - High Case non Arctic - Platforms - Summary

Year	Production [MMbbl]	Small and Medium Spills 50-999 bbl			Large and Huge Spills =>1000 bbl			Significant Spills =>1000 bbl			All Spills		
		Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 103years	Frequency Spills per 109 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]
2010													
2011													
2012													
2013													
2014													
2015													
2016													
2017													
2018													
2019	**8.8**	2.761	0.314	1.248	0.288	0.033	1.624	0.288	0.033	1.624	3.049	0.346	2.872
2020	**16.3**	5.521	0.339	2.495	0.577	0.035	3.248	0.577	0.035	3.248	6.098	0.374	5.743
2021	**16.3**	8.282	0.508	3.743	0.865	0.053	4.872	0.865	0.053	4.872	9.147	0.561	8.615
2022	**29.8**	11.042	0.371	4.990	1.154	0.039	6.496	1.154	0.039	6.496	12.196	0.409	11.486
2023	**30.3**	15.643	0.516	7.069	1.634	0.054	9.203	1.634	0.054	9.203	17.277	0.570	16.272
2024	**42.4**	23.005	0.543	10.396	2.403	0.057	13.534	2.403	0.057	13.534	25.408	0.599	23.930
2025	**55.4**	30.366	0.548	13.723	3.173	0.057	17.865	3.173	0.057	17.865	33.539	0.605	31.588
2026	**53.8**	33.126	0.616	14.971	3.461	0.064	19.489	3.461	0.064	19.489	36.587	0.680	34.459
2027	**52.5**	33.126	0.631	14.971	3.461	0.066	19.489	3.461	0.066	19.489	36.587	0.697	34.459
2028	**42.5**	33.126	0.779	14.971	3.461	0.081	19.489	3.461	0.081	19.489	36.587	0.861	34.459
2029	**34.5**	33.126	0.960	14.971	3.461	0.100	19.489	3.461	0.100	19.489	36.587	1.061	34.459
2030	**28.0**	33.126	1.183	14.971	3.461	0.124	19.489	3.461	0.124	19.489	36.587	1.307	34.459
2031	**22.7**	33.126	1.459	14.971	3.461	0.152	19.489	3.461	0.152	19.489	36.587	1.612	34.459
2032	**18.5**	33.126	1.791	14.971	3.461	0.187	19.489	3.461	0.187	19.489	36.587	1.978	34.459
2033	**15.1**	33.126	2.194	14.971	3.461	0.229	19.489	3.461	0.229	19.489	36.587	2.423	34.459
2034	**10.5**	24.845	2.366	11.228	2.596	0.247	14.616	2.596	0.247	14.616	27.441	2.613	25.844
2035	**8.5**	24.845	2.923	11.228	2.596	0.305	14.616	2.596	0.305	14.616	27.441	3.228	25.844
2036	**6.9**	24.845	3.601	11.228	2.596	0.376	14.616	2.596	0.376	14.616	27.441	3.977	25.844
2037	**5.6**	24.845	4.437	11.228	2.596	0.464	14.616	2.596	0.464	14.616	27.441	4.900	25.844
2038	**2.1**	8.282	3.944	3.743	0.865	0.412	4.872	0.865	0.412	4.872	9.147	4.356	8.615
2039													
Total LOF	**500.5**	**469.292**		**212**	**49.030**		**276**	**49.030**		**276**	**518.322**		**488**
Average LOF		**16.182**	**0.938**	**7**	**1.691**	**0.098**	**10**	**1.691**	**0.098**	**10**	**17.873**	**1.036**	**17**

Table 4.3.5
Spill Occurrence - High Case non Arctic - Production Wells

Year	Water Depth	N Wells	Production Wells Blowout											
			Small and Medium Spills 50-999 bbl			Large Spills 1000-9999 bbl			Spills 10000-149999 bbl			Spills =>150000 bbl		
			Expected Spill [bbl] =		519	Expected Spill [bbl] =		5292	Expected Spill [bbl] =		68349	Expected Spill [bbl] =		200000
		Cum.	Frequency spills per 10^4well-year	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^4well-year	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^4well-year	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^4well-year	Frequency spills per 10^3years	Spill Index bbl
2010	Shallow		0.147			1.026			0.440			0.293		
	Medium		0.147			1.026			0.440			0.293		
	Deep		0.147			1.026			0.440			0.293		
	Total													
2011	Shallow		0.147			1.026			0.440			0.293		
	Medium		0.147			1.026			0.440			0.293		
	Deep		0.147			1.026			0.440			0.293		
	Total													
2012	Shallow		0.147			1.026			0.440			0.293		
	Medium		0.147			1.026			0.440			0.293		
	Deep		0.147			1.026			0.440			0.293		
	Total													
2013	Shallow		0.147			1.026			0.440			0.293		
	Medium		0.147			1.026			0.440			0.293		
	Deep		0.147			1.026			0.440			0.293		
	Total													
2014	Shallow		0.147			1.026			0.440			0.293		
	Medium		0.147			1.026			0.440			0.293		
	Deep		0.147			1.026			0.440			0.293		
	Total													
2015	Shallow		0.147			1.026			0.440			0.293		
	Medium		0.147			1.026			0.440			0.293		
	Deep		0.147			1.026			0.440			0.293		
	Total													
2016	Shallow		0.147			1.026			0.440			0.293		
	Medium		0.147			1.026			0.440			0.293		
	Deep		0.147			1.026			0.440			0.293		
	Total													
2017	Shallow		0.147			1.026			0.440			0.293		
	Medium		0.147			1.026			0.440			0.293		
	Deep		0.147			1.026			0.440			0.293		
	Total													
2018	Shallow		0.147			1.026			0.440			0.293		
	Medium		0.147			1.026			0.440			0.293		
	Deep		0.147			1.026			0.440			0.293		
	Total													
2019	Shallow	6	0.147	0.088	0.05	1.026	0.616	3.26	0.440	0.264	18.03	0.293	0.176	35.18
	Medium		0.147			1.026			0.440			0.293		
	Deep		0.147			1.026			0.440			0.293		
	Total	**6**		0.088	**0.05**		0.616	**3.26**		0.264	**18.03**		0.176	**35.18**
2020	Shallow	12	0.147	0.176	0.09	1.026	1.231	6.52	0.440	0.528	36.07	0.293	0.352	70.36
	Medium		0.147			1.026			0.440			0.293		
	Deep		0.147			1.026			0.440			0.293		
	Total	**12**		0.176	**0.09**		1.231	**6.52**		0.528	**36.07**		0.352	**70.36**
2021	Shallow	18	0.147	0.264	0.14	1.026	1.847	9.77	0.440	0.792	54.10	0.293	0.528	105.55
	Medium		0.147			1.026			0.440			0.293		
	Deep		0.147			1.026			0.440			0.293		
	Total	**18**		0.264	**0.14**		1.847	**9.77**		0.792	**54.10**		0.528	**105.55**
2022	Shallow	18	0.147	0.264	0.14	1.026	1.847	9.77	0.440	0.792	54.10	0.293	0.528	105.55
	Medium		0.147			1.026			0.440			0.293		
	Deep	6	0.147	0.088	0.05	1.026	0.616	3.26	0.440	0.264	18.03	0.293	0.176	35.18
	Total	**24**		0.352	**0.18**		2.463	**13.03**		1.055	**72.14**		0.704	**140.73**
2023	Shallow	18	0.147	0.264	0.14	1.026	1.847	9.77	0.440	0.792	54.10	0.293	0.528	105.55
	Medium		0.147			1.026			0.440			0.293		
	Deep	16	0.147	0.235	0.12	1.026	1.642	8.69	0.440	0.704	48.09	0.293	0.469	93.82
	Total	**34**		0.498	**0.26**		3.489	**18.46**		1.495	**102.20**		0.997	**199.36**
2024	Shallow	18	0.147	0.264	0.14	1.026	1.847	9.77	0.440	0.792	54.10	0.293	0.528	105.55
	Medium	6	0.147	0.088	0.05	1.026	0.616	3.26	0.440	0.264	18.03	0.293	0.176	35.18
	Deep	26	0.147	0.381	0.20	1.026	2.668	14.12	0.440	1.143	78.15	0.293	0.762	152.45
	Total	**50**		0.733	**0.38**		5.131	**27.15**		2.199	**150.29**		1.466	**293.18**
2025	Shallow	18	0.147	0.264	0.14	1.026	1.847	9.77	0.440	0.792	54.10	0.293	0.528	105.55
	Medium	12	0.147	0.176	0.09	1.026	1.231	6.52	0.440	0.528	36.07	0.293	0.352	70.36
	Deep	36	0.147	0.528	0.27	1.026	3.694	19.55	0.440	1.583	108.21	0.293	1.055	211.09
	Total	**66**		0.967	**0.50**		6.772	**35.84**		2.902	**198.38**		1.935	**387.00**
2026	Shallow	18	0.147	0.264	0.14	1.026	1.847	9.77	0.440	0.792	54.10	0.293	0.528	105.55
	Medium	18	0.147	0.264	0.14	1.026	1.847	9.77	0.440	0.792	54.10	0.293	0.528	105.55
	Deep	36	0.147	0.528	0.27	1.026	3.694	19.55	0.440	1.583	108.21	0.293	1.055	211.09
	Total	**72**		1.055	**0.55**		7.388	**39.10**		3.166	**216.42**		2.111	**422.18**
2027	Shallow	18	0.147	0.264	0.14	1.026	1.847	9.77	0.440	0.792	54.10	0.293	0.528	105.55
	Medium	18	0.147	0.264	0.14	1.026	1.847	9.77	0.440	0.792	54.10	0.293	0.528	105.55
	Deep	36	0.147	0.528	0.27	1.026	3.694	19.55	0.440	1.583	108.21	0.293	1.055	211.09
	Total	**72**		1.055	**0.55**		7.388	**39.10**		3.166	**216.42**		2.111	**422.18**

Table 4.3.5
Spill Occurrence - High Case non Arctic - Production Wells

Year	Water Depth	Production Wells Blowout												
		N Wells	Small and Medium Spills 50-999 bbl			Large Spills 1000-9999 bbl			Spills 10000-149999 bbl			Spills =>150000 bbl		
			Expected Spill [bbl] =		519	Expected Spill [bbl] =		5292	Expected Spill [bbl] =		68349	Expected Spill [bbl] =		200000
		Cum.	Frequency spills per 10^4 well-year	Frequency spills per 10^3 years	Spill Index bbl	Frequency spills per 10^4 well-year	Frequency spills per 10^3 years	Spill Index bbl	Frequency spills per 10^4 well-year	Frequency spills per 10^3 years	Spill Index bbl	Frequency spills per 10^4 well-year	Frequency spills per 10^3 years	Spill Index bbl
2028	Shallow	18	0.147	0.264	0.14	1.026	1.847	9.77	0.440	0.792	54.10	0.293	0.528	105.55
	Medium	18	0.147	0.264	0.14	1.026	1.847	9.77	0.440	0.792	54.10	0.293	0.528	105.55
	Deep	36	0.147	0.528	0.27	1.026	3.694	19.55	0.440	1.583	108.21	0.293	1.055	211.09
	Total	**72**		1.055	**0.55**		7.388	**39.10**		3.166	**216.42**		2.111	**422.18**
2029	Shallow	18	0.147	0.264	0.14	1.026	1.847	9.77	0.440	0.792	54.10	0.293	0.528	105.55
	Medium	18	0.147	0.264	0.14	1.026	1.847	9.77	0.440	0.792	54.10	0.293	0.528	105.55
	Deep	36	0.147	0.528	0.27	1.026	3.694	19.55	0.440	1.583	108.21	0.293	1.055	211.09
	Total	**72**		1.055	**0.55**		7.388	**39.10**		3.166	**216.42**		2.111	**422.18**
2030	Shallow	18	0.147	0.264	0.14	1.026	1.847	9.77	0.440	0.792	54.10	0.293	0.528	105.55
	Medium	18	0.147	0.264	0.14	1.026	1.847	9.77	0.440	0.792	54.10	0.293	0.528	105.55
	Deep	36	0.147	0.528	0.27	1.026	3.694	19.55	0.440	1.583	108.21	0.293	1.055	211.09
	Total	**72**		1.055	**0.55**		7.388	**39.10**		3.166	**216.42**		2.111	**422.18**
2031	Shallow	18	0.147	0.264	0.14	1.026	1.847	9.77	0.440	0.792	54.10	0.293	0.528	105.55
	Medium	18	0.147	0.264	0.14	1.026	1.847	9.77	0.440	0.792	54.10	0.293	0.528	105.55
	Deep	36	0.147	0.528	0.27	1.026	3.694	19.55	0.440	1.583	108.21	0.293	1.055	211.09
	Total	**72**		1.055	**0.55**		7.388	**39.10**		3.166	**216.42**		2.111	**422.18**
2032	Shallow	18	0.147	0.264	0.14	1.026	1.847	9.77	0.440	0.792	54.10	0.293	0.528	105.55
	Medium	18	0.147	0.264	0.14	1.026	1.847	9.77	0.440	0.792	54.10	0.293	0.528	105.55
	Deep	36	0.147	0.528	0.27	1.026	3.694	19.55	0.440	1.583	108.21	0.293	1.055	211.09
	Total	**72**		1.055	**0.55**		7.388	**39.10**		3.166	**216.42**		2.111	**422.18**
2033	Shallow	18	0.147	0.264	0.14	1.026	1.847	9.77	0.440	0.792	54.10	0.293	0.528	105.55
	Medium	18	0.147	0.264	0.14	1.026	1.847	9.77	0.440	0.792	54.10	0.293	0.528	105.55
	Deep	36	0.147	0.528	0.27	1.026	3.694	19.55	0.440	1.583	108.21	0.293	1.055	211.09
	Total	**72**		1.055	**0.55**		7.388	**39.10**		3.166	**216.42**		2.111	**422.18**
2034	Shallow		0.147			1.026			0.440			0.293		
	Medium	18	0.147	0.264	0.14	1.026	1.847	9.77	0.440	0.792	54.10	0.293	0.528	105.55
	Deep	36	0.147	0.528	0.27	1.026	3.694	19.55	0.440	1.583	108.21	0.293	1.055	211.09
	Total	**54**		0.792	**0.41**		5.541	**29.32**		2.375	**162.31**		1.583	**316.64**
2035	Shallow		0.147			1.026			0.440			0.293		
	Medium	18	0.147	0.264	0.14	1.026	1.847	9.77	0.440	0.792	54.10	0.293	0.528	105.55
	Deep	36	0.147	0.528	0.27	1.026	3.694	19.55	0.440	1.583	108.21	0.293	1.055	211.09
	Total	**54**		0.792	**0.41**		5.541	**29.32**		2.375	**162.31**		1.583	**316.64**
2036	Shallow		0.147			1.026			0.440			0.293		
	Medium	18	0.147	0.264	0.14	1.026	1.847	9.77	0.440	0.792	54.10	0.293	0.528	105.55
	Deep	36	0.147	0.528	0.27	1.026	3.694	19.55	0.440	1.583	108.21	0.293	1.055	211.09
	Total	**54**		0.792	**0.41**		5.541	**29.32**		2.375	**162.31**		1.583	**316.64**
2037	Shallow		0.147			1.026			0.440			0.293		
	Medium	18	0.147	0.264	0.14	1.026	1.847	9.77	0.440	0.792	54.10	0.293	0.528	105.55
	Deep	36	0.147	0.528	0.27	1.026	3.694	19.55	0.440	1.583	108.21	0.293	1.055	211.09
	Total	**54**		0.792	**0.41**		5.541	**29.32**		2.375	**162.31**		1.583	**316.64**
2038	Shallow		0.147			1.026			0.440			0.293		
	Medium	18	0.147	0.264	0.14	1.026	1.847	9.77	0.440	0.792	54.10	0.293	0.528	105.55
	Deep		0.147			1.026			0.440			0.293		
	Total	**18**		0.264	**0.14**		1.847	**9.77**		0.792	**54.10**		0.528	**105.55**
2039	Shallow		0.147			1.026			0.440			0.293		
	Medium		0.147			1.026			0.440			0.293		
	Deep		0.147			1.026			0.440			0.293		
	Total													

Table 4.3.6
Spill Occurrence - High Case non Arctic - Production Wells - Summary

Year	Production [MMbbl]	Small and Medium Spills 50-99 bbl			Large Spills 1000-9999 bbl			Huge Spills =>10000 bbl			All Spills		
		Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]
2010													
2011													
2012													
2013													
2014													
2015													
2016													
2017													
2018													
2019	**8.8**	0.088	0.010	0.046	0.264	0.030	3.258	0.440	0.050	53.216	0.792	0.090	56.520
2020	**16.3**	0.176	0.011	0.091	0.528	0.032	6.516	0.880	0.054	106.433	1.583	0.097	113.041
2021	**16.3**	0.264	0.016	0.137	0.792	0.049	9.775	1.319	0.081	159.649	2.375	0.146	169.561
2022	**29.8**	0.352	0.012	0.183	1.055	0.035	13.033	1.759	0.059	212.866	3.166	0.106	226.082
2023	**30.3**	0.498	0.016	0.259	1.495	0.049	18.463	2.492	0.082	301.560	4.486	0.148	320.282
2024	**42.4**	0.733	0.017	0.381	2.199	0.052	27.152	3.665	0.086	443.470	6.597	0.156	471.003
2025	**55.4**	0.967	0.017	0.503	2.902	0.052	35.841	4.837	0.087	585.381	8.707	0.157	621.724
2026	**53.8**	1.055	0.020	0.548	3.166	0.059	39.099	5.277	0.098	638.597	9.499	0.177	678.245
2027	**52.5**	1.055	0.020	0.548	3.166	0.060	39.099	5.277	0.101	638.597	9.499	0.181	678.245
2028	**42.5**	1.055	0.025	0.548	3.166	0.075	39.099	5.277	0.124	638.597	9.499	0.224	678.245
2029	**34.5**	1.055	0.031	0.548	3.166	0.092	39.099	5.277	0.153	638.597	9.499	0.275	678.245
2030	**28.0**	1.055	0.038	0.548	3.166	0.113	39.099	5.277	0.188	638.597	9.499	0.339	678.245
2031	**22.7**	1.055	0.046	0.548	3.166	0.139	39.099	5.277	0.232	638.597	9.499	0.418	678.245
2032	**18.5**	1.055	0.057	0.548	3.166	0.171	39.099	5.277	0.285	638.597	9.499	0.513	678.245
2033	**15.1**	1.055	0.070	0.548	3.166	0.210	39.099	5.277	0.349	638.597	9.499	0.629	678.245
2034	**10.5**	0.792	0.075	0.411	2.375	0.226	29.324	3.958	0.377	478.948	7.124	0.679	508.683
2035	**8.5**	0.792	0.093	0.411	2.375	0.279	29.324	3.958	0.466	478.948	7.124	0.838	508.683
2036	**6.9**	0.792	0.115	0.411	2.375	0.344	29.324	3.958	0.574	478.948	7.124	1.033	508.683
2037	**5.6**	0.792	0.141	0.411	2.375	0.424	29.324	3.958	0.707	478.948	7.124	1.272	508.683
2038	**2.1**	0.264	0.126	0.137	0.792	0.377	9.775	1.319	0.628	159.649	2.375	1.131	169.561
2039													

Table 4.3.7
Occurrence Spill Risks - High Case non Arctic - Exploration Wells

Year	Water Depth	N Wells	Exploration Wells Blowout											
			Small and Medium Spills 50-999 bbl			Large Spills 1000-9999 bbl			Spills 10000-149999 bbl			Spills =>150000 bbl		
			Expected Spill [bbl] =		519	Expected Spill [bbl] =		5292	Expected Spill [bbl] =		68349	Expected Spill [bbl] =		200000
		Cum.	Frequency spills per 10^4wells	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^4wells	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^4wells	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^4wells	Frequency spills per 10^3years	Spill Index bbl
2010	Shallow	1	2.262	0.226	0.12	15.824	1.582	8.37	6.799	0.680	46.47	3.936	0.394	78.73
	Medium		2.262			15.824			6.799			3.936		
	Deep		2.262			15.824			6.799			3.936		
	Total	**1**		0.226	**0.12**		1.582	**8.37**		0.680	**46.47**		0.394	**78.73**
2011	Shallow	1	2.262	0.226	0.12	15.824	1.582	8.37	6.799	0.680	46.47	3.936	0.394	78.73
	Medium		2.262			15.824			6.799			3.936		
	Deep		2.262			15.824			6.799			3.936		
	Total	**1**		0.226	**0.12**		1.582	**8.37**		0.680	**46.47**		0.394	**78.73**
2012	Shallow		2.262			15.824			6.799			3.936		
	Medium		2.262			15.824			6.799			3.936		
	Deep	1	2.262	0.226	0.12	15.824	1.582	8.37	6.799	0.680	46.47	3.936	0.394	78.73
	Total	**1**		0.226	**0.12**		1.582	**8.37**		0.680	**46.47**		0.394	**78.73**
2013	Shallow	1	2.262	0.226	0.12	15.824	1.582	8.37	6.799	0.680	46.47	3.936	0.394	78.73
	Medium		2.262			15.824			6.799			3.936		
	Deep	1	2.262	0.226	0.12	15.824	1.582	8.37	6.799	0.680	46.47	3.936	0.394	78.73
	Total	**2**		0.452	**0.23**		3.165	**16.75**		1.360	**92.94**		0.787	**157.45**
2014	Shallow	1	2.262	0.226	0.12	15.824	1.582	8.37	6.799	0.680	46.47	3.936	0.394	78.73
	Medium		2.262			15.824			6.799			3.936		
	Deep		2.262			15.824			6.799			3.936		
	Total	**1**		0.226	**0.12**		1.582	**8.37**		0.680	**46.47**		0.394	**78.73**
2015	Shallow		2.262			15.824			6.799			3.936		
	Medium	1	2.262	0.226	0.12	15.824	1.582	8.37	6.799	0.680	46.47	3.936	0.394	78.73
	Deep		2.262			15.824			6.799			3.936		
	Total	**1**		0.226	**0.12**		1.582	**8.37**		0.680	**46.47**		0.394	**78.73**
2016	Shallow		2.262			15.824			6.799			3.936		
	Medium	1	2.262	0.226	0.12	15.824	1.582	8.37	6.799	0.680	46.47	3.936	0.394	78.73
	Deep		2.262			15.824			6.799			3.936		
	Total	**1**		0.226	**0.12**		1.582	**8.37**		0.680	**46.47**		0.394	**78.73**
2017	Shallow		2.262			15.824			6.799			3.936		
	Medium	1	2.262	0.226	0.12	15.824	1.582	8.37	6.799	0.680	46.47	3.936	0.394	78.73
	Deep		2.262			15.824			6.799			3.936		
	Total	**1**		0.226	**0.12**		1.582	**8.37**		0.680	**46.47**		0.394	**78.73**
2018	Shallow		2.262			15.824			6.799			3.936		
	Medium		2.262			15.824			6.799			3.936		
	Deep		2.262			15.824			6.799			3.936		
	Total													
2019	Shallow		2.262			15.824			6.799			3.936		
	Medium		2.262			15.824			6.799			3.936		
	Deep		2.262			15.824			6.799			3.936		
	Total													
2020	Shallow		2.262			15.824			6.799			3.936		
	Medium		2.262			15.824			6.799			3.936		
	Deep		2.262			15.824			6.799			3.936		
	Total													
2021	Shallow		2.262			15.824			6.799			3.936		
	Medium		2.262			15.824			6.799			3.936		
	Deep		2.262			15.824			6.799			3.936		
	Total													
2022	Shallow		2.262			15.824			6.799			3.936		
	Medium		2.262			15.824			6.799			3.936		
	Deep		2.262			15.824			6.799			3.936		
	Total													
2023	Shallow		2.262			15.824			6.799			3.936		
	Medium		2.262			15.824			6.799			3.936		
	Deep		2.262			15.824			6.799			3.936		
	Total													
2024	Shallow		2.262			15.824			6.799			3.936		
	Medium		2.262			15.824			6.799			3.936		
	Deep		2.262			15.824			6.799			3.936		
	Total													
2025	Shallow		2.262			15.824			6.799			3.936		
	Medium		2.262			15.824			6.799			3.936		
	Deep		2.262			15.824			6.799			3.936		
	Total													
2026	Shallow		2.262			15.824			6.799			3.936		
	Medium		2.262			15.824			6.799			3.936		
	Deep		2.262			15.824			6.799			3.936		
	Total													
2027	Shallow		2.262			15.824			6.799			3.936		
	Medium		2.262			15.824			6.799			3.936		
	Deep		2.262			15.824			6.799			3.936		
	Total													
2028	Shallow		2.262			15.824			6.799			3.936		
	Medium		2.262			15.824			6.799			3.936		
	Deep		2.262			15.824			6.799			3.936		
	Total													
2029	Shallow		2.262			15.824			6.799			3.936		
	Medium		2.262			15.824			6.799			3.936		
	Deep		2.262			15.824			6.799			3.936		
	Total													
2030	Shallow		2.262			15.824			6.799			3.936		
	Medium		2.262			15.824			6.799			3.936		
	Deep		2.262			15.824			6.799			3.936		
	Total													
2031	Shallow		2.262			15.824			6.799			3.936		
	Medium		2.262			15.824			6.799			3.936		
	Deep		2.262			15.824			6.799			3.936		
	Total													
2032	Shallow		2.262			15.824			6.799			3.936		
	Medium		2.262			15.824			6.799			3.936		
	Deep		2.262			15.824			6.799			3.936		
	Total													
2033	Shallow		2.262			15.824			6.799			3.936		
	Medium		2.262			15.824			6.799			3.936		
	Deep		2.262			15.824			6.799			3.936		
	Total													
2034	Shallow		2.262			15.824			6.799			3.936		
	Medium		2.262			15.824			6.799			3.936		
	Deep		2.262			15.824			6.799			3.936		
	Total													
2035	Shallow		2.262			15.824			6.799			3.936		
	Medium		2.262			15.824			6.799			3.936		
	Deep		2.262			15.824			6.799			3.936		
	Total													

Table 4.3.7
Occurrence Spill Risks - High Case non Arctic - Exploration Wells

Year	Water Depth	N Wells	Exploration Wells Blowout											
			Small and Medium Spills 50-999 bbl			Large Spills 1000-9999 bbl			Spills 10000-149999 bbl			Spills =>150000 bbl		
			Expected Spill [bbl] =		**519**	Expected Spill [bbl] =		**5292**	Expected Spill [bbl] =		**68349**	Expected Spill [bbl] =		**200000**
		Cum.	Frequency spills per 10^4wells	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^4wells	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^4wells	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^4wells	Frequency spills per 10^3years	Spill Index bbl
2036	Shallow		2.262			15.824			6.799			3.936		
	Medium		2.262			15.824			6.799			3.936		
	Deep		2.262			15.824			6.799			3.936		
	Total													
2037	Shallow		2.262			15.824			6.799			3.936		
	Medium		2.262			15.824			6.799			3.936		
	Deep		2.262			15.824			6.799			3.936		
	Total													
2038	Shallow		2.262			15.824			6.799			3.936		
	Medium		2.262			15.824			6.799			3.936		
	Deep		2.262			15.824			6.799			3.936		
	Total													
2039	Shallow		2.262			15.824			6.799			3.936		
	Medium		2.262			15.824			6.799			3.936		
	Deep		2.262			15.824			6.799			3.936		
	Total													

Table 4.3.8
Spill Occurrence - High Case non Arctic - Exploration Wells - Summary

Year	Production [MMbbl]	Small and Medium Spills 50-99 bbl			Large Spills 1000-9999 bbl			Huge Spills =>10000 bbl			All Spills		
		Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]
2010		0.226		0.117	0.680		8.374	1.074		125.199	1.980		133.690
2011		0.226		0.117	0.680		8.374	1.074		125.199	1.980		133.690
2012		0.226		0.117	0.680		8.374	1.074		125.199	1.980		133.690
2013		0.452		0.235	1.360		16.749	2.147		250.397	3.959		267.381
2014		0.226		0.117	0.680		8.374	1.074		125.199	1.980		133.690
2015		0.226		0.117	0.680		8.374	1.074		125.199	1.980		133.690
2016		0.226		0.117	0.680		8.374	1.074		125.199	1.980		133.690
2017		0.226		0.117	0.680		8.374	1.074		125.199	1.980		133.690
2018													
2019	8.8												
2020	16.3												
2021	16.3												
2022	29.8												
2023	30.3												
2024	42.4												
2025	55.4												
2026	53.8												
2027	52.5												
2028	42.5												
2029	34.5												
2030	28.0												
2031	22.7												
2032	18.5												
2033	15.1												
2034	10.5												
2035	8.5												
2036	6.9												
2037	5.6												
2038	2.1												
2039													

Table 4.3.9
Spill Occurrence Beaufort Sea High Case non Arctic - Development Wells

Year	Water Depth	Development Wells Blowout												
		N Wells	Small and Medium Spills 50-999 bbl			Large Spills 1000-9999 bbl			Spills 10000-149999 bbl			Spills =>150000 bbl		
			Expected Spill [bbl] =		519	Expected Spill [bbl] =		5292	Expected Spill [bbl] =		68349	Expected Spill [bbl] =		200000
		Cum.	Frequency spills per 10^4wells	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^4wells	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^4wells	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^4wells	Frequency spills per 10^3years	Spill Index bbl
2010	Shallow		0.692			4.833			2.076			2.076		
	Medium		0.692			4.833			2.076			2.076		
	Deep		0.692			4.833			2.076			2.076		
	Total													
2011	Shallow	2	0.692	0.138	0.07	4.833	0.967	5.12	2.076	0.415	28.38	2.076	0.415	83.04
	Medium		0.692			4.833			2.076			2.076		
	Deep		0.692			4.833			2.076			2.076		
	Total	**2**		0.138	**0.07**		0.967	**5.12**		0.415	**28.38**		0.415	**83.04**
2012	Shallow	2	0.692	0.138	0.07	4.833	0.967	5.12	2.076	0.415	28.38	2.076	0.415	83.04
	Medium		0.692			4.833			2.076			2.076		
	Deep		0.692			4.833			2.076			2.076		
	Total	**2**		0.138	**0.07**		0.967	**5.12**		0.415	**28.38**		0.415	**83.04**
2013	Shallow		0.692			4.833			2.076			2.076		
	Medium		0.692			4.833			2.076			2.076		
	Deep	2	0.692	0.138	0.07	4.833	0.967	5.12	2.076	0.415	28.38	2.076	0.415	83.04
	Total	**2**		0.138	**0.07**		0.967	**5.12**		0.415	**28.38**		0.415	**83.04**
2014	Shallow		0.692			4.833			2.076			2.076		
	Medium		0.692			4.833			2.076			2.076		
	Deep	3	0.692	0.208	0.11	4.833	1.450	7.67	2.076	0.623	42.57	2.076	0.623	124.56
	Total	**3**		0.208	**0.11**		1.450	**7.67**		0.623	**42.57**		0.623	**124.56**
2015	Shallow		0.692			4.833			2.076			2.076		
	Medium	2	0.692	0.138	0.07	4.833	0.967	5.12	2.076	0.415	28.38	2.076	0.415	83.04
	Deep		0.692			4.833			2.076			2.076		
	Total	**2**		0.138	**0.07**		0.967	**5.12**		0.415	**28.38**		0.415	**83.04**
2016	Shallow		0.692			4.833			2.076			2.076		
	Medium	2	0.692	0.138	0.07	4.833	0.967	5.12	2.076	0.415	28.38	2.076	0.415	83.04
	Deep		0.692			4.833			2.076			2.076		
	Total	**2**		0.138	**0.07**		0.967	**5.12**		0.415	**28.38**		0.415	**83.04**
2017	Shallow		0.692			4.833			2.076			2.076		
	Medium		0.692			4.833			2.076			2.076		
	Deep		0.692			4.833			2.076			2.076		
	Total													
2018	Shallow		0.692			4.833			2.076			2.076		
	Medium		0.692			4.833			2.076			2.076		
	Deep		0.692			4.833			2.076			2.076		
	Total													
2019	Shallow		0.692			4.833			2.076			2.076		
	Medium		0.692			4.833			2.076			2.076		
	Deep		0.692			4.833			2.076			2.076		
	Total													
2020	Shallow		0.692			4.833			2.076			2.076		
	Medium		0.692			4.833			2.076			2.076		
	Deep		0.692			4.833			2.076			2.076		
	Total													
2021	Shallow		0.692			4.833			2.076			2.076		
	Medium		0.692			4.833			2.076			2.076		
	Deep		0.692			4.833			2.076			2.076		
	Total													
2022	Shallow		0.692			4.833			2.076			2.076		
	Medium		0.692			4.833			2.076			2.076		
	Deep		0.692			4.833			2.076			2.076		
	Total													
2023	Shallow		0.692			4.833			2.076			2.076		
	Medium		0.692			4.833			2.076			2.076		
	Deep		0.692			4.833			2.076			2.076		
	Total													
2024	Shallow		0.692			4.833			2.076			2.076		
	Medium		0.692			4.833			2.076			2.076		
	Deep		0.692			4.833			2.076			2.076		
	Total													
2025	Shallow		0.692			4.833			2.076			2.076		
	Medium		0.692			4.833			2.076			2.076		
	Deep		0.692			4.833			2.076			2.076		
	Total													
2026	Shallow		0.692			4.833			2.076			2.076		
	Medium		0.692			4.833			2.076			2.076		
	Deep		0.692			4.833			2.076			2.076		
	Total													
2027	Shallow		0.692			4.833			2.076			2.076		
	Medium		0.692			4.833			2.076			2.076		
	Deep		0.692			4.833			2.076			2.076		
	Total													
2028	Shallow		0.692			4.833			2.076			2.076		
	Medium		0.692			4.833			2.076			2.076		
	Deep		0.692			4.833			2.076			2.076		
	Total													
2029	Shallow		0.692			4.833			2.076			2.076		
	Medium		0.692			4.833			2.076			2.076		
	Deep		0.692			4.833			2.076			2.076		
	Total													
2030	Shallow		0.692			4.833			2.076			2.076		
	Medium		0.692			4.833			2.076			2.076		
	Deep		0.692			4.833			2.076			2.076		
	Total													
2031	Shallow		0.692			4.833			2.076			2.076		
	Medium		0.692			4.833			2.076			2.076		
	Deep		0.692			4.833			2.076			2.076		
	Total													
2032	Shallow		0.692			4.833			2.076			2.076		
	Medium		0.692			4.833			2.076			2.076		
	Deep		0.692			4.833			2.076			2.076		
	Total													
2033	Shallow		0.692			4.833			2.076			2.076		
	Medium		0.692			4.833			2.076			2.076		
	Deep		0.692			4.833			2.076			2.076		
	Total													
2034	Shallow		0.692			4.833			2.076			2.076		
	Medium		0.692			4.833			2.076			2.076		
	Deep		0.692			4.833			2.076			2.076		
	Total													
2035	Shallow		0.692			4.833			2.076			2.076		
	Medium		0.692			4.833			2.076			2.076		
	Deep		0.692			4.833			2.076			2.076		
	Total													

Table 4.3.9
Spill Occurrence Beaufort Sea High Case non Arctic - Development Wells

Year	Water Depth	N Wells	Development Wells Blowout										
			Small and Medium Spills 50-999 bbl			Large Spills 1000-9999 bbl			Spills 10000-149999 bbl			Spills =>150000 bbl		
			Expected Spill [bbl] =		**519**	Expected Spill [bbl] =		**5292**	Expected Spill [bbl] =		**68349**	Expected Spill [bbl] =		**200000**
		Cum.	Frequency spills per 10^4wells	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^4wells	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^4wells	Frequency spills per 10^3years	Spill Index bbl	Frequency spills per 10^4wells	Frequency spills per 10^3years	Spill Index bbl
2036	Shallow		0.692			4.833			2.076			2.076		
	Medium		0.692			4.833			2.076			2.076		
	Deep		0.692			4.833			2.076			2.076		
	Total													
2037	Shallow		0.692			4.833			2.076			2.076		
	Medium		0.692			4.833			2.076			2.076		
	Deep		0.692			4.833			2.076			2.076		
	Total													
2038	Shallow		0.692			4.833			2.076			2.076		
	Medium		0.692			4.833			2.076			2.076		
	Deep		0.692			4.833			2.076			2.076		
	Total													
2039	Shallow		0.692			4.833			2.076			2.076		
	Medium		0.692			4.833			2.076			2.076		
	Deep		0.692			4.833			2.076			2.076		
	Total													

Table 4.3.10
Spill Occurrence - High Case non Arctic - Development Wells - Summary

Year	Production [MMbbl]	Small and Medium Spills 50-99 bbl			Large Spills 1000-9999 bbl			Huge Spills =>10000 bbl			All Spills		
		Frequency Spills per 10^3 years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3 years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3 years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3 years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]
2010													
2011		0.138		0.072	0.415		5.116	0.830		111.421	1.384		116.608
2012		0.138		0.072	0.415		5.116	0.830		111.421	1.384		116.608
2013		0.138		0.072	0.415		5.116	0.830		111.421	1.384		116.608
2014		0.208		0.108	0.623		7.674	1.246		167.131	2.076		174.912
2015		0.138		0.072	0.415		5.116	0.830		111.421	1.384		116.608
2016		0.138		0.072	0.415		5.116	0.830		111.421	1.384		116.608
2017													
2018													
2019	**8.8**												
2020	**16.3**												
2021	**16.3**												
2022	**29.8**												
2023	**30.3**												
2024	**42.4**												
2025	**55.4**												
2026	**53.8**												
2027	**52.5**												
2028	**42.5**												
2029	**34.5**												
2030	**28.0**												
2031	**22.7**												
2032	**18.5**												
2033	**15.1**												
2034	**10.5**												
2035	**8.5**												
2036	**6.9**												
2037	**5.6**												
2038	**2.1**												
2039													

Table 4.3.11
Spill Occurrence - High Case non Arctic - Wells - Summary

Year	Production [MMbbl]	Small and Medium Spills 50-999 bbl			Large Spills 1000-9999 bbl			Huge Spills =>10000 bbl			Significant Spills =>1000 bbl			All Spills		
		Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 103years	Frequency Spills per 109 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]
2010		0.226		0.117	0.680		8.374	1.074		125.199	1.753		133.573	1.980		133.690
2011		0.365		0.189	1.095		13.490	1.904		236.619	2.999		250.109	3.364		250.299
2012		0.365		0.189	1.095		13.490	1.904		236.619	2.999		250.109	3.364		250.299
2013		0.591		0.307	1.775		21.864	2.978		361.818	4.753		383.682	5.343		383.989
2014		0.434		0.225	1.303		16.048	2.319		292.330	3.622		308.378	4.056		308.603
2015		0.365		0.189	1.095		13.490	1.904		236.619	2.999		250.109	3.364		250.299
2016		0.365		0.189	1.095		13.490	1.904		236.619	2.999		250.109	3.364		250.299
2017		0.226		0.117	0.680		8.374	1.074		125.199	1.753		133.573	1.980		133.690
2018																
2019	**8.8**	0.088	0.010	0.046	0.264	0.030	3.258	0.440	0.050	53.216	0.704	0.080	56.475	0.792	0.090	56.520
2020	**16.3**	0.176	0.011	0.091	0.528	0.032	6.516	0.880	0.054	106.433	1.407	0.086	112.949	1.583	0.097	113.041
2021	**16.3**	0.264	0.016	0.137	0.792	0.049	9.775	1.319	0.081	159.649	2.111	0.130	169.424	2.375	0.146	169.561
2022	**29.8**	0.352	0.012	0.183	1.055	0.035	13.033	1.759	0.059	212.866	2.815	0.094	225.899	3.166	0.106	226.082
2023	**30.3**	0.498	0.016	0.259	1.495	0.049	18.463	2.492	0.082	301.560	3.987	0.132	320.023	4.486	0.148	320.282
2024	**42.4**	0.733	0.017	0.381	2.199	0.052	27.152	3.665	0.086	443.470	5.864	0.138	470.622	6.597	0.156	471.003
2025	**55.4**	0.967	0.017	0.503	2.902	0.052	35.841	4.837	0.087	585.381	7.740	0.140	621.222	8.707	0.157	621.724
2026	**53.8**	1.055	0.020	0.548	3.166	0.059	39.099	5.277	0.098	638.597	8.444	0.157	677.696	9.499	0.177	678.245
2027	**52.5**	1.055	0.020	0.548	3.166	0.060	39.099	5.277	0.101	638.597	8.444	0.161	677.696	9.499	0.181	678.245
2028	**42.5**	1.055	0.025	0.548	3.166	0.075	39.099	5.277	0.124	638.597	8.444	0.199	677.696	9.499	0.224	678.245
2029	**34.5**	1.055	0.031	0.548	3.166	0.092	39.099	5.277	0.153	638.597	8.444	0.245	677.696	9.499	0.275	678.245
2030	**28.0**	1.055	0.038	0.548	3.166	0.113	39.099	5.277	0.188	638.597	8.444	0.302	677.696	9.499	0.339	678.245
2031	**22.7**	1.055	0.046	0.548	3.166	0.139	39.099	5.277	0.232	638.597	8.444	0.372	677.696	9.499	0.418	678.245
2032	**18.5**	1.055	0.057	0.548	3.166	0.171	39.099	5.277	0.285	638.597	8.444	0.456	677.696	9.499	0.513	678.245
2033	**15.1**	1.055	0.070	0.548	3.166	0.210	39.099	5.277	0.349	638.597	8.444	0.559	677.696	9.499	0.629	678.245
2034	**10.5**	0.792	0.075	0.411	2.375	0.226	29.324	3.958	0.377	478.948	6.333	0.603	508.272	7.124	0.679	508.683
2035	**8.5**	0.792	0.093	0.411	2.375	0.279	29.324	3.958	0.466	478.948	6.333	0.745	508.272	7.124	0.838	508.683
2036	**6.9**	0.792	0.115	0.411	2.375	0.344	29.324	3.958	0.574	478.948	6.333	0.918	508.272	7.124	1.033	508.683
2037	**5.6**	0.792	0.141	0.411	2.375	0.424	29.324	3.958	0.707	478.948	6.333	1.131	508.272	7.124	1.272	508.683
2038	**2.1**	0.264	0.126	0.137	0.792	0.377	9.775	1.319	0.628	159.649	2.111	1.005	169.424	2.375	1.131	169.561
2039																
Total LOF	**500.5**	**17.887**		**9**	**53.675**		**663**	**89.821**		**10898**	**143.496**		**11560**	**161.383**		**11570**
Average LOF		**0.617**	**0.036**	**0**	**1.851**	**0.107**	**23**	**3.097**	**0.179**	**376**	**4.948**	**0.287**	**399**	**5.565**	**0.322**	**399**

Table 4.3.12
Spill Occurrence - High Case non Arctic - Summary

Year	Facility	Production [MMbbl]	Small and Medium Spills 50-999 bbl			Large Spills 1000-9999 bbl			Huge Spills =>10000 bbl			All Spills		
			Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]
2010	Pipeline													
	Platforms													
	Production Wells													
	Exploration Wells		0.226		0.117	0.680		8.374	1.074		125.199	1.980		133.690
	Development Wells													
	Total		0.226		0.117	0.680		8.374	1.074		125.199	1.980		133.690
2011	Pipeline													
	Platforms													
	Production Wells													
	Exploration Wells		0.226		0.117	0.680		8.374	1.074		125.199	1.980		133.690
	Development Wells		0.138		0.072	0.415		5.116	0.830		111.421	1.384		116.608
	Total		0.365		0.189	1.095		13.490	1.904		236.619	3.364		250.299
2012	Pipeline													
	Platforms													
	Production Wells													
	Exploration Wells		0.226		0.117	0.680		8.374	1.074		125.199	1.980		133.690
	Development Wells		0.138		0.072	0.415		5.116	0.830		111.421	1.384		116.608
	Total		0.365		0.189	1.095		13.490	1.904		236.619	3.364		250.299
2013	Pipeline													
	Platforms													
	Production Wells													
	Exploration Wells		0.452		0.235	1.360		16.749	2.147		250.397	3.959		267.381
	Development Wells		0.138		0.072	0.415		5.116	0.830		111.421	1.384		116.608
	Total		0.591		0.307	1.775		21.864	2.978		361.818	5.343		383.989
2014	Pipeline													
	Platforms													
	Production Wells													
	Exploration Wells		0.226		0.117	0.680		8.374	1.074		125.199	1.980		133.690
	Development Wells		0.208		0.108	0.623		7.674	1.246		167.131	2.076		174.912
	Total		0.434		0.225	1.303		16.048	2.319		292.330	4.056		308.603
2015	Pipeline													
	Platforms													
	Production Wells													
	Exploration Wells		0.226		0.117	0.680		8.374	1.074		125.199	1.980		133.690
	Development Wells		0.138		0.072	0.415		5.116	0.830		111.421	1.384		116.608
	Total		0.365		0.189	1.095		13.490	1.904		236.619	3.364		250.299
2016	Pipeline													
	Platforms													
	Production Wells													
	Exploration Wells		0.226		0.117	0.680		8.374	1.074		125.199	1.980		133.690
	Development Wells		0.138		0.072	0.415		5.116	0.830		111.421	1.384		116.608
	Total		0.365		0.189	1.095		13.490	1.904		236.619	3.364		250.299
2017	Pipeline		4.784		1.404	1.329		6.878	0.532		8.267	6.645		16.550
	Platforms													
	Production Wells													
	Exploration Wells		0.226		0.117	0.680		8.374	1.074		125.199	1.980		133.690
	Development Wells													
	Total		5.010		1.522	2.009		15.253	1.605		133.466	8.624		150.240
2018	Pipeline		7.176		2.107	1.993		10.317	0.797		12.401	9.967		24.825
	Platforms													
	Production Wells													
	Exploration Wells													
	Development Wells													
	Total		7.176		2.107	1.993		10.317	0.797		12.401	9.967		24.825
2019	Pipeline	8.8	7.176	0.815	2.107	1.993	0.227	10.317	0.797	0.091	12.401	9.967	1.133	24.825
	Platforms		2.761	0.314	1.248	0.144	0.016	0.812	0.144	0.016	0.812	3.049	0.346	2.872
	Production Wells		0.088	0.010	0.046	0.264	0.030	3.258	0.440	0.050	53.216	0.792	0.090	56.520
	Exploration Wells													
	Development Wells													
	Total		10.025	1.139	3.400	2.401	0.273	14.388	1.381	0.157	66.429	13.808	1.569	84.217
2020	Pipeline	16.3	11.961	0.734	3.511	3.322	0.204	17.196	1.329	0.082	20.668	16.612	1.019	41.375
	Platforms		5.521	0.339	2.495	0.288	0.018	1.624	0.288	0.018	1.624	6.098	0.374	5.743
	Production Wells		0.176	0.011	0.091	0.528	0.032	6.516	0.880	0.054	106.433	1.583	0.097	113.041
	Exploration Wells													
	Development Wells													
	Total		17.658	1.083	6.098	4.139	0.254	25.336	2.497	0.153	128.725	24.293	1.490	160.158
2021	Pipeline	16.3	16.745	1.027	4.916	4.651	0.285	24.074	1.861	0.114	28.935	23.257	1.427	57.924
	Platforms		8.282	0.508	3.743	0.433	0.027	2.436	0.433	0.027	2.436	9.147	0.561	8.615
	Production Wells		0.264	0.016	0.137	0.792	0.049	9.775	1.319	0.081	159.649	2.375	0.146	169.561
	Exploration Wells													
	Development Wells													
	Total		25.290	1.552	8.795	5.876	0.360	36.285	3.612	0.222	191.020	34.778	2.134	236.100
2022	Pipeline	29.8	23.921	0.803	7.022	6.645	0.223	34.391	2.658	0.089	41.335	33.224	1.115	82.749
	Platforms		11.042	0.371	4.990	0.577	0.019	3.248	0.577	0.019	3.248	12.196	0.409	11.486
	Production Wells		0.352	0.012	0.183	1.055	0.035	13.033	1.759	0.059	212.866	3.166	0.106	226.082
	Exploration Wells													
	Development Wells													
	Total		35.315	1.185	12.195	8.277	0.278	50.672	4.994	0.168	257.449	48.586	1.630	320.317
2023	Pipeline	30.3	25.256	0.834	7.469	7.070	0.233	36.634	2.719	0.090	42.238	35.045	1.157	86.342
	Platforms		15.643	0.516	7.069	0.817	0.027	4.601	0.817	0.027	4.601	17.277	0.570	16.272
	Production Wells		0.498	0.016	0.259	1.495	0.049	18.463	2.492	0.082	301.560	4.486	0.148	320.282
	Exploration Wells													
	Development Wells													
	Total		41.398	1.366	14.797	9.382	0.310	59.699	6.028	0.199	348.400	56.808	1.875	422.896
2024	Pipeline	42.4	31.376	0.740	9.320	8.823	0.208	45.756	3.311	0.078	51.409	43.510	1.026	106.485
	Platforms		23.005	0.543	10.396	1.202	0.028	6.767	1.202	0.028	6.767	25.408	0.599	23.930
	Production Wells		0.733	0.017	0.381	2.199	0.052	27.152	3.665	0.086	443.470	6.597	0.156	471.003
	Exploration Wells													
	Development Wells													
	Total		55.114	1.300	20.097	12.224	0.288	79.675	8.177	0.193	501.646	75.515	1.781	601.418
2025	Pipeline	55.4	39.888	0.720	11.873	11.242	0.203	58.316	4.169	0.075	64.713	55.299	0.998	134.902
	Platforms		30.366	0.548	13.723	1.586	0.029	8.932	1.586	0.029	8.932	33.539	0.605	31.588
	Production Wells		0.967	0.017	0.503	2.902	0.052	35.841	4.837	0.087	585.381	8.707	0.157	621.724
	Exploration Wells													
	Development Wells													
	Total		71.221	1.286	26.099	15.731	0.284	103.089	10.593	0.191	659.026	97.545	1.761	788.214
2026	Pipeline	53.8	39.888	0.741	11.873	11.242	0.209	58.316	4.169	0.077	64.713	55.299	1.028	134.902
	Platforms		33.126	0.616	14.971	1.730	0.032	9.744	1.730	0.032	9.744	36.587	0.680	34.459
	Production Wells		1.055	0.020	0.548	3.166	0.059	39.099	5.277	0.098	638.597	9.499	0.177	678.245
	Exploration Wells													
	Development Wells													
	Total		74.070	1.377	27.392	16.139	0.300	107.159	11.177	0.208	713.054	101.385	1.884	847.606

Table 4.3.12
Spill Occurrence - High Case non Arctic - Summary

Year	Facility	Production [MMbbl]	Small and Medium Spills 50-999 bbl			Large Spills 1000-9999 bbl			Huge Spills =>10000 bbl			All Spills		
			Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]
2027	Pipeline	52.5	39.888	0.760	11.873	11.242	0.214	58.316	4.169	0.079	64.713	55.299	1.053	134.902
	Platforms		33.126	0.631	14.971	1.730	0.033	9.744	1.730	0.033	9.744	36.587	0.697	34.459
	Production Wells		1.055	0.020	0.548	3.166	0.060	39.099	5.277	0.101	638.597	9.499	0.181	678.245
	Exploration Wells													
	Development Wells													
	Total		74.070	1.411	27.392	16.139	0.307	107.159	11.177	0.213	713.054	101.385	1.931	847.606
2028	Pipeline	42.5	39.888	0.939	11.873	11.242	0.265	58.316	4.169	0.098	64.713	55.299	1.301	134.902
	Platforms		33.126	0.779	14.971	1.730	0.041	9.744	1.730	0.041	9.744	36.587	0.861	34.459
	Production Wells		1.055	0.025	0.548	3.166	0.075	39.099	5.277	0.124	638.597	9.499	0.224	678.245
	Exploration Wells													
	Development Wells													
	Total		74.070	1.743	27.392	16.139	0.380	107.159	11.177	0.263	713.054	101.385	2.386	847.606
2029	Pipeline	34.5	39.888	1.156	11.873	11.242	0.326	58.316	4.169	0.121	64.713	55.299	1.603	134.902
	Platforms		33.126	0.960	14.971	1.730	0.050	9.744	1.730	0.050	9.744	36.587	1.061	34.459
	Production Wells		1.055	0.031	0.548	3.166	0.092	39.099	5.277	0.153	638.597	9.499	0.275	678.245
	Exploration Wells													
	Development Wells													
	Total		74.070	2.147	27.392	16.139	0.468	107.159	11.177	0.324	713.054	101.385	2.939	847.606
2030	Pipeline	28.0	39.888	1.425	11.873	11.242	0.401	58.316	4.169	0.149	64.713	55.299	1.975	134.902
	Platforms		33.126	1.183	14.971	1.730	0.062	9.744	1.730	0.062	9.744	36.587	1.307	34.459
	Production Wells		1.055	0.038	0.548	3.166	0.113	39.099	5.277	0.188	638.597	9.499	0.339	678.245
	Exploration Wells													
	Development Wells													
	Total		74.070	2.645	27.392	16.139	0.576	107.159	11.177	0.399	713.054	101.385	3.621	847.606
2031	Pipeline	22.7	39.888	1.757	11.873	11.242	0.495	58.316	4.169	0.184	64.713	55.299	2.436	134.902
	Platforms		33.126	1.459	14.971	1.730	0.076	9.744	1.730	0.076	9.744	36.587	1.612	34.459
	Production Wells		1.055	0.046	0.548	3.166	0.139	39.099	5.277	0.232	638.597	9.499	0.418	678.245
	Exploration Wells													
	Development Wells													
	Total		74.070	3.263	27.392	16.139	0.711	107.159	11.177	0.492	713.054	101.385	4.466	847.606
2032	Pipeline	18.5	39.888	2.156	11.873	11.242	0.608	58.316	4.169	0.225	64.713	55.299	2.989	134.902
	Platforms		33.126	1.791	14.971	1.730	0.094	9.744	1.730	0.094	9.744	36.587	1.978	34.459
	Production Wells		1.055	0.057	0.548	3.166	0.171	39.099	5.277	0.285	638.597	9.499	0.513	678.245
	Exploration Wells													
	Development Wells													
	Total		74.070	4.004	27.392	16.139	0.872	107.159	11.177	0.604	713.054	101.385	5.480	847.606
2033	Pipeline	15.1	39.888	2.642	11.873	11.242	0.744	58.316	4.169	0.276	64.713	55.299	3.662	134.902
	Platforms		33.126	2.194	14.971	1.730	0.115	9.744	1.730	0.115	9.744	36.587	2.423	34.459
	Production Wells		1.055	0.070	0.548	3.166	0.210	39.099	5.277	0.349	638.597	9.499	0.629	678.245
	Exploration Wells													
	Development Wells													
	Total		74.070	4.905	27.392	16.139	1.069	107.159	11.177	0.740	713.054	101.385	6.714	847.606
2034	Pipeline	10.5	32.712	3.115	9.767	9.248	0.881	47.999	3.372	0.321	52.312	45.331	4.317	110.077
	Platforms		24.845	2.366	11.228	1.298	0.124	7.308	1.298	0.124	7.308	27.441	2.613	25.844
	Production Wells		0.792	0.075	0.411	2.375	0.226	29.324	3.958	0.377	478.948	7.124	0.679	508.683
	Exploration Wells													
	Development Wells													
	Total		58.348	5.557	21.406	12.921	1.231	84.631	8.627	0.822	538.568	79.896	7.609	644.605
2035	Pipeline	8.5	32.712	3.848	9.767	9.248	1.088	47.999	3.372	0.397	52.312	45.331	5.333	110.077
	Platforms		24.845	2.923	11.228	1.298	0.153	7.308	1.298	0.153	7.308	27.441	3.228	25.844
	Production Wells		0.792	0.093	0.411	2.375	0.279	29.324	3.958	0.466	478.948	7.124	0.838	508.683
	Exploration Wells													
	Development Wells													
	Total		58.348	6.864	21.406	12.921	1.520	84.631	8.627	1.015	538.568	79.896	9.400	644.605
2036	Pipeline	6.9	32.712	4.741	9.767	9.248	1.340	47.999	3.372	0.489	52.312	45.331	6.570	110.077
	Platforms		24.845	3.601	11.228	1.298	0.188	7.308	1.298	0.188	7.308	27.441	3.977	25.844
	Production Wells		0.792	0.115	0.411	2.375	0.344	29.324	3.958	0.574	478.948	7.124	1.033	508.683
	Exploration Wells													
	Development Wells													
	Total		58.348	8.456	21.406	12.921	1.873	84.631	8.627	1.250	538.568	79.896	11.579	644.605
2037	Pipeline	5.6	32.712	5.841	8.427	9.248	1.651	41.270	3.372	0.602	49.602	45.331	8.095	99.299
	Platforms		24.845	4.437	11.228	1.298	0.232	7.308	1.298	0.232	7.308	27.441	4.900	25.844
	Production Wells		0.792	0.141	0.411	2.375	0.424	29.324	3.958	0.707	478.948	7.124	1.272	508.683
	Exploration Wells													
	Development Wells													
	Total		58.348	10.419	20.066	12.921	2.307	77.902	8.627	1.541	535.859	79.896	14.267	633.827
2038	Pipeline	2.1	11.961	5.695	3.511	3.322	1.582	17.196	1.329	0.633	20.668	16.612	7.910	41.375
	Platforms		8.282	3.944	3.743	0.433	0.206	2.436	0.433	0.206	2.436	9.147	4.356	8.615
	Production Wells		0.264	0.126	0.137	0.792	0.377	9.775	1.319	0.628	159.649	2.375	1.131	169.561
	Exploration Wells													
	Development Wells													
	Total		20.506	9.765	7.391	4.547	2.165	29.406	3.081	1.467	182.753	28.133	13.397	219.550
2039	Pipeline													
	Platforms													
	Production Wells													
	Exploration Wells													
	Development Wells													
	Total													

Table 4.3.13
Spill Occurrence - High Case non Arctic - Annual Summary

Year	Production [MMbbl]	Small and Medium Spills 50-999 bbl			Large Spills 1000-9999 bbl			Huge Spills =>10000 bbl			Significant Spills =>1000 bbl			All Spills		
		Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]	Frequency Spills per 103years	Frequency Spills per 109 bbl Produced	Spill Index [bbl]	Frequency Spills per 10^3years	Frequency Spills per 10^9 bbl Produced	Spill Index [bbl]
2010		0.226		0.117	0.680		8.374	1.074		125.199	1.753		133.573	1.980		133.690
2011		0.365		0.189	1.095		13.490	1.904		236.619	2.999		250.109	3.364		250.299
2012		0.365		0.189	1.095		13.490	1.904		236.619	2.999		250.109	3.364		250.299
2013		0.591		0.307	1.775		21.864	2.978		361.818	4.753		383.682	5.343		383.989
2014		0.434		0.225	1.303		16.048	2.319		292.330	3.622		308.378	4.056		308.603
2015		0.365		0.189	1.095		13.490	1.904		236.619	2.999		250.109	3.364		250.299
2016		0.365		0.189	1.095		13.490	1.904		236.619	2.999		250.109	3.364		250.299
2017		5.010		1.522	2.009		15.253	1.605		133.466	3.614		148.718	8.624		150.240
2018		7.176		2.107	1.993		10.317	0.797		12.401	2.791		22.718	9.967		24.825
2019	**8.8**	10.025	1.139	3.400	2.401	0.273	14.388	1.381	0.157	66.429	3.783	0.430	80.817	13.808	1.569	84.217
2020	**16.3**	17.658	1.083	6.098	4.139	0.254	25.336	2.497	0.153	128.725	6.635	0.407	154.061	24.293	1.490	160.158
2021	**16.3**	25.290	1.552	8.795	5.876	0.360	36.285	3.612	0.222	191.020	9.488	0.582	227.305	34.778	2.134	236.100
2022	**29.8**	35.315	1.185	12.195	8.277	0.278	50.672	4.994	0.168	257.449	13.271	0.445	308.122	48.586	1.630	320.317
2023	**30.3**	41.398	1.366	14.797	9.382	0.310	59.699	6.028	0.199	348.400	15.410	0.509	408.099	56.808	1.875	422.896
2024	**42.4**	55.114	1.300	20.097	12.224	0.288	79.675	8.177	0.193	501.646	20.401	0.481	581.321	75.515	1.781	601.418
2025	**55.4**	71.221	1.286	26.099	15.731	0.284	103.089	10.593	0.191	659.026	26.323	0.475	762.115	97.545	1.761	788.214
2026	**53.8**	74.070	1.377	27.392	16.139	0.300	107.159	11.177	0.208	713.054	27.315	0.508	820.214	101.385	1.884	847.606
2027	**52.5**	74.070	1.411	27.392	16.139	0.307	107.159	11.177	0.213	713.054	27.315	0.520	820.214	101.385	1.931	847.606
2028	**42.5**	74.070	1.743	27.392	16.139	0.380	107.159	11.177	0.263	713.054	27.315	0.643	820.214	101.385	2.386	847.606
2029	**34.5**	74.070	2.147	27.392	16.139	0.468	107.159	11.177	0.324	713.054	27.315	0.792	820.214	101.385	2.939	847.606
2030	**28.0**	74.070	2.645	27.392	16.139	0.576	107.159	11.177	0.399	713.054	27.315	0.976	820.214	101.385	3.621	847.606
2031	**22.7**	74.070	3.263	27.392	16.139	0.711	107.159	11.177	0.492	713.054	27.315	1.203	820.214	101.385	4.466	847.606
2032	**18.5**	74.070	4.004	27.392	16.139	0.872	107.159	11.177	0.604	713.054	27.315	1.477	820.214	101.385	5.480	847.606
2033	**15.1**	74.070	4.905	27.392	16.139	1.069	107.159	11.177	0.740	713.054	27.315	1.809	820.214	101.385	6.714	847.606
2034	**10.5**	58.348	5.557	21.406	12.921	1.231	84.631	8.627	0.822	538.568	21.548	2.052	623.199	79.896	7.609	644.605
2035	**8.5**	58.348	6.864	21.406	12.921	1.520	84.631	8.627	1.015	538.568	21.548	2.535	623.199	79.896	9.400	644.605
2036	**6.9**	58.348	8.456	21.406	12.921	1.873	84.631	8.627	1.250	538.568	21.548	3.123	623.199	79.896	11.579	644.605
2037	**5.6**	58.348	10.419	20.066	12.921	2.307	77.902	8.627	1.541	535.859	21.548	3.848	613.761	79.896	14.267	633.827
2038	**2.1**	20.506	9.765	7.391	4.547	2.165	29.406	3.081	1.467	182.753	7.627	3.632	212.160	28.133	13.397	219.550
2039																
Total LOF	**500.5**	**1117.372**		**407**	**255.510**		**1713**	**180.675**		**12063**	**436.185**		**13777**	**1553.557**		**14184**
Average LOF		**38.530**	**2.233**	**14**	**8.811**	**0.511**	**59**	**6.230**	**0.361**	**416**	**15.041**	**0.871**	**475**	**53.571**	**3.104**	**489**

Table 4.3.14
High Case non Arctic - Year 2030 - Monte Carlo Results

Frequency — Spills per 10^3 years

High Case non Arctic Year 2030	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills
Mean =	74.07	16.14	11.18	27.32	101.39
Std Deviation =	33.31	6.83	3.29	7.96	34.24
Variance =	1109.271	46.680	10.814	63.285	1172.705
Skewness =	0.39	0.51	0.30	0.35	0.37
Kurtosis =	2.68	2.50	2.64	2.71	2.73
Mode =	67.79	19.56	10.09	15.99	71.61
Minimum =	6.414	1.810	2.537	6.885	19.295
5% Perc =	24.089	6.797	6.200	15.374	49.827
10% Perc =	31.601	8.015	7.032	17.444	57.785
15% Perc =	37.698	8.931	7.693	18.915	64.288
20% Perc =	43.400	9.801	8.264	20.236	70.229
25% Perc =	48.488	10.628	8.737	21.406	75.357
30% Perc =	53.475	11.487	9.188	22.514	80.435
35% Perc =	58.468	12.347	9.627	23.535	85.117
40% Perc =	62.866	13.173	10.054	24.609	89.928
45% Perc =	67.035	14.135	10.468	25.630	94.534
50% Perc =	71.685	15.127	10.921	26.677	99.326
55% Perc =	76.296	16.074	11.360	27.742	103.802
60% Perc =	80.957	17.217	11.841	28.878	108.567
65% Perc =	85.713	18.362	12.362	30.078	113.407
70% Perc =	90.626	19.615	12.900	31.331	118.648
75% Perc =	96.604	20.930	13.442	32.621	124.183
80% Perc =	103.045	22.334	14.074	34.220	130.897
85% Perc =	110.198	24.046	14.844	35.937	138.370
90% Perc =	119.277	26.132	15.653	38.246	147.830
95% Perc =	132.826	28.759	16.954	41.421	161.690
Maximum =	196.684	37.151	22.343	55.891	235.798

Frequency — Spills per 10^9 bbl Produced

High Case non Arctic Year 2030	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills
Mean =	2.65	0.58	0.40	0.98	3.62
Std Deviation =	1.19	0.24	0.12	0.28	1.22
Variance =	1.415	0.060	0.014	0.081	1.496
Skewness =	0.39	0.51	0.30	0.35	0.37
Kurtosis =	2.68	2.50	2.64	2.71	2.73
Mode =	1.89	0.70	0.26	0.57	2.56
Minimum =	0.229	0.065	0.091	0.246	0.689
5% Perc =	0.860	0.243	0.221	0.549	1.780
10% Perc =	1.129	0.286	0.251	0.623	2.064
15% Perc =	1.346	0.319	0.275	0.676	2.296
20% Perc =	1.550	0.350	0.295	0.723	2.508
25% Perc =	1.732	0.380	0.312	0.765	2.691
30% Perc =	1.910	0.410	0.328	0.804	2.873
35% Perc =	2.088	0.441	0.344	0.841	3.040
40% Perc =	2.245	0.470	0.359	0.879	3.212
45% Perc =	2.394	0.505	0.374	0.915	3.376
50% Perc =	2.560	0.540	0.390	0.953	3.547
55% Perc =	2.725	0.574	0.406	0.991	3.707
60% Perc =	2.891	0.615	0.423	1.031	3.877
65% Perc =	3.061	0.656	0.441	1.074	4.050
70% Perc =	3.237	0.701	0.461	1.119	4.237
75% Perc =	3.450	0.747	0.480	1.165	4.435
80% Perc =	3.680	0.798	0.503	1.222	4.675
85% Perc =	3.936	0.859	0.530	1.283	4.942
90% Perc =	4.260	0.933	0.559	1.366	5.280
95% Perc =	4.744	1.027	0.605	1.479	5.775
Maximum =	7.024	1.327	0.798	1.996	8.421

Spill Index [bbl]

High Case non Arctic Year 2030	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills
Mean =	27.38	107.28	712.54	819.81	847.20
Std Deviation =	18.31	55.79	256.01	262.27	262.97
Variance =	335.142	3112.486	65542.060	68783.550	69151.930
Skewness =	1.29	1.05	0.45	0.43	0.43
Kurtosis =	5.02	4.34	3.14	3.15	3.15
Mode =	18.72	83.42	222.53	523.77	583.56
Minimum =	-0.275	-1.018	46.297	124.036	142.599
5% Perc =	5.984	36.264	327.067	425.345	450.286
10% Perc =	8.414	46.058	394.726	496.107	522.760
15% Perc =	10.249	53.322	446.329	546.576	572.262
20% Perc =	11.999	60.037	491.598	590.966	618.033
25% Perc =	13.710	66.447	526.515	632.180	660.938
30% Perc =	15.442	71.844	562.860	671.890	699.005
35% Perc =	17.318	78.076	596.445	703.735	732.173
40% Perc =	19.177	83.987	628.714	736.220	764.552
45% Perc =	21.061	90.166	661.083	769.831	796.057
50% Perc =	23.049	96.917	693.844	801.327	828.055
55% Perc =	25.415	103.484	726.888	833.316	860.232
60% Perc =	27.743	111.311	761.494	868.370	894.679
65% Perc =	30.305	119.336	795.061	902.147	931.509
70% Perc =	33.215	127.296	833.115	943.040	970.709
75% Perc =	36.630	136.685	874.314	984.443	1012.572
80% Perc =	40.460	148.681	920.381	1033.769	1062.273
85% Perc =	45.394	163.680	975.527	1088.711	1117.281
90% Perc =	52.271	184.067	1051.321	1166.277	1195.865
95% Perc =	63.471	215.548	1163.734	1283.600	1313.915
Maximum =	142.091	436.283	1796.243	1874.544	1902.851

Table 4.3.15
High Case non Arctic LOF Average - Pipeline - Monte Carlo Results

High Case non Arctic Pipeline	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills
All years Average LOF	Frequency Spills per 10^3years				
Mean =	22.51	6.33	2.37	8.70	31.21
Std Deviation =	13.56	3.78	1.51	4.08	14.17
Variance =	183.909	14.300	2.269	16.662	200.893
Skewness =	0.55	0.55	0.56	0.47	0.50
Kurtosis =	2.40	2.41	2.40	2.55	2.50
Mode =	11.28	8.91	4.67	6.07	17.48
Minimum =	1.030	0.192	0.031	0.468	4.002
5% Perc =	4.745	1.332	0.404	2.917	11.544
10% Perc =	6.305	1.841	0.569	3.677	14.120
15% Perc =	7.817	2.265	0.736	4.324	16.167
20% Perc =	9.466	2.698	0.918	4.911	18.131
25% Perc =	11.155	3.154	1.096	5.500	19.997
30% Perc =	12.750	3.640	1.291	6.056	21.598
35% Perc =	14.549	4.124	1.485	6.555	23.413
40% Perc =	16.391	4.631	1.681	7.098	25.129
45% Perc =	18.231	5.159	1.888	7.629	27.142
50% Perc =	20.251	5.731	2.114	8.174	29.204
55% Perc =	22.346	6.268	2.353	8.785	31.273
60% Perc =	24.493	6.870	2.585	9.381	33.479
65% Perc =	26.920	7.534	2.850	10.035	35.823
70% Perc =	29.305	8.260	3.135	10.727	38.298
75% Perc =	32.141	8.984	3.434	11.486	40.986
80% Perc =	35.088	9.858	3.767	12.328	44.163
85% Perc =	38.494	10.842	4.162	13.365	47.718
90% Perc =	42.725	11.931	4.611	14.529	51.626
95% Perc =	47.920	13.427	5.183	16.178	57.336
Maximum =	60.437	17.466	6.605	21.564	75.669

High Case non Arctic Pipeline	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills
All years Average LOF	Frequency Spills per 10^9 bbl Produced				
Mean =	1.26	0.35	0.13	0.49	1.75
Std Deviation =	0.76	0.21	0.08	0.23	0.79
Variance =	0.576	0.045	0.007	0.052	0.629
Skewness =	0.55	0.55	0.56	0.47	0.50
Kurtosis =	2.40	2.41	2.40	2.55	2.50
Mode =	1.06	0.39	0.26	0.34	0.98
Minimum =	0.058	0.011	0.002	0.026	0.224
5% Perc =	0.265	0.075	0.023	0.163	0.646
10% Perc =	0.353	0.103	0.032	0.206	0.790
15% Perc =	0.437	0.127	0.041	0.242	0.904
20% Perc =	0.530	0.151	0.051	0.275	1.014
25% Perc =	0.624	0.176	0.061	0.308	1.119
30% Perc =	0.714	0.204	0.072	0.339	1.208
35% Perc =	0.814	0.231	0.083	0.367	1.310
40% Perc =	0.917	0.259	0.094	0.397	1.406
45% Perc =	1.020	0.289	0.106	0.427	1.518
50% Perc =	1.133	0.321	0.118	0.457	1.634
55% Perc =	1.250	0.351	0.132	0.491	1.750
60% Perc =	1.371	0.384	0.145	0.525	1.873
65% Perc =	1.506	0.421	0.159	0.561	2.004
70% Perc =	1.640	0.462	0.175	0.600	2.143
75% Perc =	1.798	0.503	0.192	0.643	2.293
80% Perc =	1.963	0.552	0.211	0.690	2.471
85% Perc =	2.153	0.607	0.233	0.748	2.670
90% Perc =	2.390	0.667	0.258	0.813	2.888
95% Perc =	2.681	0.751	0.290	0.905	3.208
Maximum =	3.381	0.977	0.369	1.206	4.233

High Case non Arctic Pipeline	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills
All years Average LOF	Spill Index [bbl]				
Mean =	6.63	32.61	36.70	69.30	75.94
Std Deviation =	5.17	27.01	24.87	36.87	37.21
Variance =	26.774	729.431	618.530	1359.263	1384.751
Skewness =	1.33	1.44	0.78	0.83	0.80
Kurtosis =	4.83	5.26	2.97	3.67	3.65
Mode =	2.01	52.85	15.88	45.48	54.72
Minimum =	-0.020	-6.852	0.407	3.044	5.068
5% Perc =	1.019	4.229	5.994	19.727	25.487
10% Perc =	1.473	6.450	8.339	26.237	32.412
15% Perc =	1.872	8.400	10.929	31.478	37.757
20% Perc =	2.279	10.416	13.594	36.672	42.762
25% Perc =	2.701	12.461	16.283	41.515	47.821
30% Perc =	3.126	14.550	19.034	46.060	52.383
35% Perc =	3.585	16.828	21.922	50.288	57.167
40% Perc =	4.071	19.106	25.012	54.769	61.578
45% Perc =	4.594	21.680	28.315	58.940	65.895
50% Perc =	5.168	24.847	31.612	63.602	70.321
55% Perc =	5.796	28.086	35.209	68.524	75.333
60% Perc =	6.559	31.531	39.219	73.598	80.665
65% Perc =	7.302	35.451	43.109	78.984	85.897
70% Perc =	8.247	40.070	47.551	84.818	91.670
75% Perc =	9.233	45.263	52.757	90.942	98.008
80% Perc =	10.421	51.664	58.517	98.471	105.390
85% Perc =	11.892	59.675	64.785	107.381	114.614
90% Perc =	13.951	70.605	72.923	119.870	126.505
95% Perc =	17.109	87.665	85.117	138.249	144.650
Maximum =	32.844	174.252	129.849	245.649	257.436

Table 4.3.16
High Case non Arctic LOF Average - Platforms - Monte Carlo Results

High Case non Arctic Platforms	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills
All years Average LOF	**Frequency Spills per 10^3years**					**Frequency Spills per 10^9 bbl Produced**					**Spill Index [bbl]**				
Mean =	16.18	0.85	0.85	1.69	17.87	0.94	0.05	0.05	0.10	1.04	7.29	4.77	4.77	9.53	16.82
Std Deviation =	11.44	0.60	0.60	1.20	11.53	0.66	0.03	0.03	0.07	0.67	7.80	4.37	4.37	8.75	11.92
Variance =	130.936	0.357	0.357	1.429	132.892	0.440	0.001	0.001	0.005	0.446	60.821	19.140	19.140	76.561	142.004
Skewness =	0.57	0.57	0.57	0.57	0.56	0.57	0.57	0.57	0.57	0.56	1.74	1.29	1.29	1.29	1.13
Kurtosis =	2.40	2.40	2.40	2.40	2.43	2.40	2.40	2.40	2.40	2.43	6.33	4.57	4.57	4.57	4.47
Mode =	0.12	0.03	0.03	0.06	9.13	0.01	0.00	0.00	0.00	0.70	2.46	0.22	0.22	0.44	35.16
Minimum =	0.001	0.000	0.000	0.000	0.083	0.000	0.000	0.000	0.000	0.005	-2.407	-1.811	-1.811	-3.623	-3.391
5% Perc =	1.227	0.064	0.064	0.128	2.764	0.071	0.004	0.004	0.007	0.160	0.171	0.148	0.148	0.295	2.359
10% Perc =	2.489	0.130	0.130	0.260	4.202	0.144	0.008	0.008	0.015	0.244	0.469	0.401	0.401	0.801	3.835
15% Perc =	3.788	0.198	0.198	0.396	5.477	0.219	0.011	0.011	0.023	0.317	0.810	0.700	0.700	1.399	5.191
20% Perc =	5.125	0.268	0.268	0.535	6.867	0.297	0.016	0.016	0.031	0.398	1.185	1.014	1.014	2.027	6.606
25% Perc =	6.503	0.340	0.340	0.679	8.137	0.377	0.020	0.020	0.039	0.471	1.624	1.352	1.352	2.704	7.779
30% Perc =	7.929	0.414	0.414	0.828	9.591	0.459	0.024	0.024	0.048	0.556	2.151	1.712	1.712	3.425	8.990
35% Perc =	9.406	0.491	0.491	0.983	11.034	0.545	0.028	0.028	0.057	0.639	2.703	2.112	2.112	4.224	10.290
40% Perc =	10.940	0.572	0.572	1.143	12.628	0.634	0.033	0.033	0.066	0.732	3.260	2.551	2.551	5.101	11.585
45% Perc =	12.541	0.655	0.655	1.310	14.244	0.727	0.038	0.038	0.076	0.825	3.942	2.982	2.982	5.964	12.959
50% Perc =	14.219	0.743	0.743	1.486	15.939	0.824	0.043	0.043	0.086	0.924	4.648	3.533	3.533	7.067	14.323
55% Perc =	15.978	0.835	0.835	1.669	17.719	0.926	0.048	0.048	0.097	1.027	5.477	4.097	4.097	8.195	15.753
60% Perc =	17.840	0.932	0.932	1.864	19.609	1.034	0.054	0.054	0.108	1.136	6.320	4.714	4.714	9.428	17.339
65% Perc =	19.826	1.036	1.036	2.071	21.481	1.149	0.060	0.060	0.120	1.245	7.405	5.372	5.372	10.744	19.071
70% Perc =	21.954	1.147	1.147	2.294	23.579	1.272	0.066	0.066	0.133	1.367	8.646	6.113	6.113	12.226	20.960
75% Perc =	24.273	1.268	1.268	2.536	26.002	1.406	0.073	0.073	0.147	1.507	10.165	6.952	6.952	13.904	23.401
80% Perc =	26.833	1.402	1.402	2.804	28.494	1.555	0.081	0.081	0.162	1.651	12.276	8.103	8.103	16.206	25.916
85% Perc =	29.741	1.554	1.554	3.108	31.505	1.723	0.090	0.090	0.180	1.825	14.798	9.357	9.357	18.713	29.076
90% Perc =	33.195	1.734	1.734	3.468	34.992	1.923	0.100	0.100	0.201	2.028	18.253	10.966	10.966	21.933	33.426
95% Perc =	37.681	1.969	1.969	3.937	39.477	2.183	0.114	0.114	0.228	2.287	23.681	13.610	13.610	27.219	39.775
Maximum =	48.237	2.517	2.517	5.034	51.865	2.795	0.146	0.146	0.292	3.005	52.539	26.254	26.254	52.508	87.377

Table 4.3.17
High Case non Arctic LOF Average - Wells - Monte Carlo Results

High Case non Arctic Wells	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills
All years Average LOF	Frequency Spills per 10^3years					Frequency Spills per 10^9 bbl Produced					Spill Index [bbl]				
Mean =	0.62	1.85	3.10	4.95	5.56	0.04	0.11	0.18	0.29	0.32	0.32	22.86	376.03	398.89	399.21
Std Deviation =	0.21	0.64	0.77	1.35	1.36	0.01	0.04	0.04	0.08	0.08	0.22	14.63	134.83	135.77	135.77
Variance =	0.046	0.409	0.590	1.817	1.861	0.000	0.001	0.002	0.006	0.006	0.047	214.137	18179.100	18433.710	18433.670
Skewness =	-0.01	-0.01	0.00	-0.01	-0.01	-0.01	-0.01	0.00	-0.01	-0.01	0.73	0.81	0.49	0.49	0.49
Kurtosis =	2.45	2.43	2.67	2.52	2.55	2.45	2.43	2.67	2.52	2.55	3.42	3.46	3.18	3.18	3.18
Mode =	0.43	1.21	2.19	4.76	2.47	0.02	0.09	0.13	0.26	0.14	0.19	7.25	273.41	346.92	309.66
Minimum =	0.061	0.187	0.724	1.082	1.666	0.004	0.011	0.042	0.063	0.097	-0.150	-5.629	61.156	72.473	72.464
5% Perc =	0.261	0.782	1.836	2.712	3.303	0.015	0.045	0.106	0.157	0.191	0.027	3.379	176.177	195.592	196.139
10% Perc =	0.328	0.982	2.095	3.125	3.741	0.019	0.057	0.121	0.181	0.217	0.066	5.976	211.475	234.267	234.420
15% Perc =	0.381	1.150	2.267	3.464	4.084	0.022	0.067	0.131	0.201	0.237	0.100	8.084	238.014	260.035	260.493
20% Perc =	0.426	1.278	2.412	3.743	4.356	0.025	0.074	0.140	0.217	0.252	0.130	9.977	259.362	281.533	281.876
25% Perc =	0.464	1.392	2.552	3.984	4.593	0.027	0.081	0.148	0.231	0.266	0.158	11.790	278.414	299.787	300.129
30% Perc =	0.498	1.494	2.676	4.207	4.814	0.029	0.087	0.155	0.244	0.279	0.184	13.488	296.366	318.394	318.669
35% Perc =	0.532	1.594	2.793	4.409	5.022	0.031	0.092	0.162	0.255	0.291	0.211	15.166	313.659	335.862	336.149
40% Perc =	0.562	1.686	2.907	4.593	5.204	0.033	0.098	0.168	0.266	0.302	0.237	16.892	329.544	352.199	352.642
45% Perc =	0.591	1.767	3.004	4.791	5.397	0.034	0.102	0.174	0.278	0.313	0.264	18.659	346.026	368.995	369.256
50% Perc =	0.619	1.854	3.102	4.974	5.566	0.036	0.107	0.180	0.288	0.323	0.292	20.479	363.812	387.153	387.553
55% Perc =	0.644	1.933	3.203	5.134	5.754	0.037	0.112	0.186	0.297	0.333	0.320	22.457	381.864	404.960	405.305
60% Perc =	0.674	2.024	3.304	5.311	5.929	0.039	0.117	0.191	0.308	0.344	0.348	24.527	399.996	423.539	423.964
65% Perc =	0.703	2.112	3.406	5.492	6.126	0.041	0.122	0.197	0.318	0.355	0.380	26.490	419.556	441.827	442.145
70% Perc =	0.737	2.212	3.519	5.689	6.314	0.043	0.128	0.204	0.330	0.366	0.415	28.733	439.419	463.355	463.788
75% Perc =	0.770	2.311	3.631	5.905	6.545	0.045	0.134	0.210	0.342	0.379	0.452	31.310	461.387	484.109	484.478
80% Perc =	0.808	2.425	3.761	6.141	6.770	0.047	0.140	0.218	0.356	0.392	0.495	34.597	485.768	509.715	510.126
85% Perc =	0.851	2.560	3.919	6.406	7.029	0.049	0.148	0.227	0.371	0.407	0.548	38.211	516.073	541.265	541.642
90% Perc =	0.901	2.711	4.095	6.721	7.366	0.052	0.157	0.237	0.389	0.427	0.616	43.107	557.282	580.060	580.315
95% Perc =	0.973	2.919	4.359	7.192	7.826	0.056	0.169	0.253	0.417	0.453	0.727	50.923	615.175	640.975	641.216
Maximum =	1.192	3.568	5.691	9.070	9.669	0.069	0.207	0.330	0.526	0.560	1.280	87.303	987.676	1017.765	1018.076

Table 4.3.18
High Case non Arctic LOF Average Platforms + Wells - Monte Carlo Results

High Case non Arctic Platforms + Wells	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills
All years Average LOF	Frequency Spills per 10^3 years				
Mean =	16.80	2.70	3.94	6.64	23.44
Std Deviation =	11.45	0.88	0.97	1.80	11.62
Variance =	131.010	0.769	0.949	3.256	134.921
Skewness =	0.57	0.16	0.12	0.15	0.55
Kurtosis =	2.40	2.68	2.75	2.70	2.44
Mode =	17.69	2.15	3.05	4.18	14.20
Minimum =	0.252	0.393	0.857	1.332	3.249
5% Perc =	1.835	1.283	2.369	3.714	8.029
10% Perc =	3.140	1.571	2.695	4.334	9.686
15% Perc =	4.426	1.777	2.900	4.724	11.101
20% Perc =	5.770	1.934	3.085	5.061	12.425
25% Perc =	7.118	2.065	3.251	5.336	13.801
30% Perc =	8.542	2.189	3.398	5.613	15.127
35% Perc =	10.008	2.318	3.546	5.871	16.672
40% Perc =	11.549	2.435	3.671	6.119	18.212
45% Perc =	13.123	2.558	3.796	6.360	19.854
50% Perc =	14.851	2.677	3.928	6.605	21.512
55% Perc =	16.602	2.786	4.043	6.828	23.314
60% Perc =	18.533	2.900	4.183	7.069	25.170
65% Perc =	20.423	3.024	4.314	7.310	27.096
70% Perc =	22.559	3.155	4.450	7.582	29.317
75% Perc =	24.887	3.295	4.602	7.873	31.664
80% Perc =	27.464	3.442	4.778	8.193	34.136
85% Perc =	30.342	3.640	4.978	8.554	37.083
90% Perc =	33.836	3.861	5.221	9.025	40.615
95% Perc =	38.307	4.200	5.590	9.716	45.201
Maximum =	48.954	5.452	7.442	12.462	58.776

High Case non Arctic Platforms + Wells	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills
All years Average LOF	Frequency Spills per 10^9 bbl Produced				
Mean =	0.97	0.16	0.23	0.38	1.36
Std Deviation =	0.66	0.05	0.06	0.10	0.67
Variance =	0.440	0.003	0.003	0.011	0.453
Skewness =	0.57	0.16	0.12	0.15	0.55
Kurtosis =	2.40	2.68	2.75	2.70	2.44
Mode =	0.06	0.12	0.15	0.30	0.82
Minimum =	0.015	0.023	0.050	0.077	0.188
5% Perc =	0.106	0.074	0.137	0.215	0.465
10% Perc =	0.182	0.091	0.156	0.251	0.561
15% Perc =	0.256	0.103	0.168	0.274	0.643
20% Perc =	0.334	0.112	0.179	0.293	0.720
25% Perc =	0.412	0.120	0.188	0.309	0.800
30% Perc =	0.495	0.127	0.197	0.325	0.876
35% Perc =	0.580	0.134	0.205	0.340	0.966
40% Perc =	0.669	0.141	0.213	0.355	1.055
45% Perc =	0.760	0.148	0.220	0.369	1.150
50% Perc =	0.860	0.155	0.228	0.383	1.246
55% Perc =	0.962	0.161	0.234	0.396	1.351
60% Perc =	1.073	0.168	0.242	0.410	1.458
65% Perc =	1.183	0.175	0.250	0.424	1.570
70% Perc =	1.307	0.183	0.258	0.439	1.699
75% Perc =	1.442	0.191	0.267	0.456	1.835
80% Perc =	1.591	0.199	0.277	0.475	1.978
85% Perc =	1.758	0.211	0.288	0.496	2.149
90% Perc =	1.961	0.224	0.303	0.523	2.353
95% Perc =	2.220	0.243	0.324	0.563	2.619
Maximum =	2.836	0.316	0.431	0.722	3.406

High Case non Arctic Platforms + Wells	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills
All years Average LOF	Spill Index [bbl]				
Mean =	7.61	27.63	380.79	408.42	416.03
Std Deviation =	7.80	15.28	134.90	136.06	136.31
Variance =	60.858	233.408	18198.520	18511.080	18579.380
Skewness =	1.74	0.74	0.49	0.48	0.48
Kurtosis =	6.33	3.41	3.18	3.17	3.17
Mode =	10.22	17.24	386.31	304.75	343.65
Minimum =	-2.248	-4.728	65.136	72.466	78.039
5% Perc =	0.474	6.573	181.005	206.150	213.025
10% Perc =	0.813	9.705	216.065	242.245	248.544
15% Perc =	1.131	12.205	242.574	269.088	276.412
20% Perc =	1.520	14.209	263.418	290.472	298.319
25% Perc =	1.961	16.305	282.284	309.316	317.258
30% Perc =	2.469	18.183	300.868	328.846	336.217
35% Perc =	3.008	19.930	317.852	345.523	353.047
40% Perc =	3.573	21.687	334.651	361.820	369.575
45% Perc =	4.238	23.495	351.226	378.423	386.260
50% Perc =	4.983	25.415	369.625	396.923	403.908
55% Perc =	5.809	27.354	386.308	414.526	421.605
60% Perc =	6.694	29.421	404.887	433.697	441.195
65% Perc =	7.743	31.620	424.240	451.455	459.194
70% Perc =	9.014	33.982	444.399	472.946	480.687
75% Perc =	10.483	36.637	465.945	493.751	500.788
80% Perc =	12.556	39.689	490.631	520.247	527.421
85% Perc =	15.177	43.553	521.315	550.710	558.094
90% Perc =	18.610	48.998	561.649	590.601	598.320
95% Perc =	24.051	56.579	620.603	649.550	657.705
Maximum =	53.163	93.819	999.796	1030.774	1033.642

Table 4.3.19
High Case non Arctic LOF Average - Monte Carlo Results

High Case non Arctic	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Huge Spills =>10000 bbl	Significant Spills =>1000 bbl	All Spills
All years Average LOF	Frequency Spills per 10^3 years					Frequency Spills per 10^9 bbl Produced					Spill Index [bbl]				
Mean =	39.31	9.03	6.31	15.34	54.65	2.23	0.51	0.36	0.87	3.10	14.24	60.24	417.49	477.72	491.96
Std Deviation =	17.91	3.88	1.79	4.46	18.46	1.02	0.22	0.10	0.25	1.05	9.37	30.98	137.08	141.28	141.63
Variance =	320.619	15.084	3.221	19.895	340.792	1.034	0.047	0.010	0.063	1.098	87.714	960.044	18792.090	19960.500	20058.310
Skewness =	0.43	0.52	0.34	0.39	0.40	0.42	0.52	0.33	0.39	0.40	1.22	1.01	0.46	0.45	0.45
Kurtosis =	2.70	2.47	2.69	2.69	2.74	2.70	2.48	2.70	2.70	2.74	4.69	4.22	3.12	3.14	3.14
Mode =	33.32	10.85	4.24	14.13	42.99	0.77	0.26	0.31	0.80	2.43	11.48	40.92	463.68	351.34	408.44
Minimum =	2.839	1.403	1.528	4.112	13.157	0.161	0.080	0.088	0.236	0.746	-0.519	-1.272	91.000	125.080	135.523
5% Perc =	12.817	3.764	3.641	8.753	27.116	0.726	0.215	0.209	0.500	1.542	3.121	19.734	213.214	265.072	278.318
10% Perc =	16.597	4.434	4.078	9.844	31.514	0.943	0.253	0.235	0.562	1.789	4.392	26.033	246.343	304.666	317.670
15% Perc =	20.008	4.936	4.412	10.646	34.974	1.137	0.281	0.253	0.607	1.988	5.411	30.370	276.402	332.015	345.696
20% Perc =	22.939	5.397	4.719	11.367	37.767	1.302	0.307	0.271	0.648	2.147	6.312	33.956	298.559	355.655	369.502
25% Perc =	25.474	5.875	4.983	12.024	40.618	1.446	0.334	0.286	0.686	2.308	7.267	37.675	318.106	376.474	390.953
30% Perc =	28.001	6.325	5.216	12.586	43.216	1.591	0.360	0.299	0.718	2.455	8.212	40.788	337.054	395.222	408.838
35% Perc =	30.540	6.817	5.447	13.200	45.695	1.736	0.387	0.313	0.751	2.597	9.160	44.292	354.621	412.243	426.621
40% Perc =	33.018	7.339	5.697	13.755	48.350	1.874	0.416	0.327	0.783	2.747	10.101	47.595	370.718	430.742	445.171
45% Perc =	35.460	7.863	5.927	14.300	50.920	2.012	0.445	0.340	0.814	2.893	11.033	51.072	388.512	449.436	462.499
50% Perc =	37.858	8.396	6.173	14.903	53.264	2.149	0.475	0.353	0.847	3.026	12.049	54.534	405.744	467.545	481.342
55% Perc =	40.317	9.022	6.400	15.504	55.724	2.292	0.510	0.366	0.880	3.164	13.114	58.378	423.654	486.450	499.821
60% Perc =	42.805	9.623	6.651	16.148	58.243	2.435	0.544	0.380	0.917	3.310	14.330	62.212	442.795	503.682	517.844
65% Perc =	45.427	10.300	6.915	16.768	60.844	2.583	0.581	0.395	0.952	3.452	15.762	66.785	462.067	523.117	537.905
70% Perc =	48.184	10.974	7.201	17.478	63.763	2.739	0.619	0.411	0.993	3.619	17.275	71.422	482.833	543.621	558.126
75% Perc =	51.135	11.771	7.508	18.348	66.960	2.906	0.664	0.429	1.041	3.804	19.130	76.856	503.787	567.656	582.093
80% Perc =	54.436	12.574	7.869	19.266	70.562	3.092	0.709	0.449	1.092	4.008	21.147	83.643	529.903	593.921	607.809
85% Perc =	58.883	13.538	8.305	20.342	74.664	3.338	0.762	0.473	1.152	4.240	23.712	91.834	561.669	624.596	637.922
90% Perc =	64.249	14.694	8.796	21.519	79.862	3.646	0.828	0.501	1.219	4.536	26.981	102.382	601.000	666.016	681.740
95% Perc =	71.083	16.256	9.517	23.367	87.520	4.041	0.916	0.542	1.322	4.972	32.724	120.063	659.779	729.838	745.204
Maximum =	101.742	21.643	12.647	31.780	121.068	5.782	1.220	0.721	1.801	6.883	61.361	233.662	1011.569	1099.364	1123.227

Table 4.3.20
Composition of Spill Indicators - High Case non Arctic - Year 2030

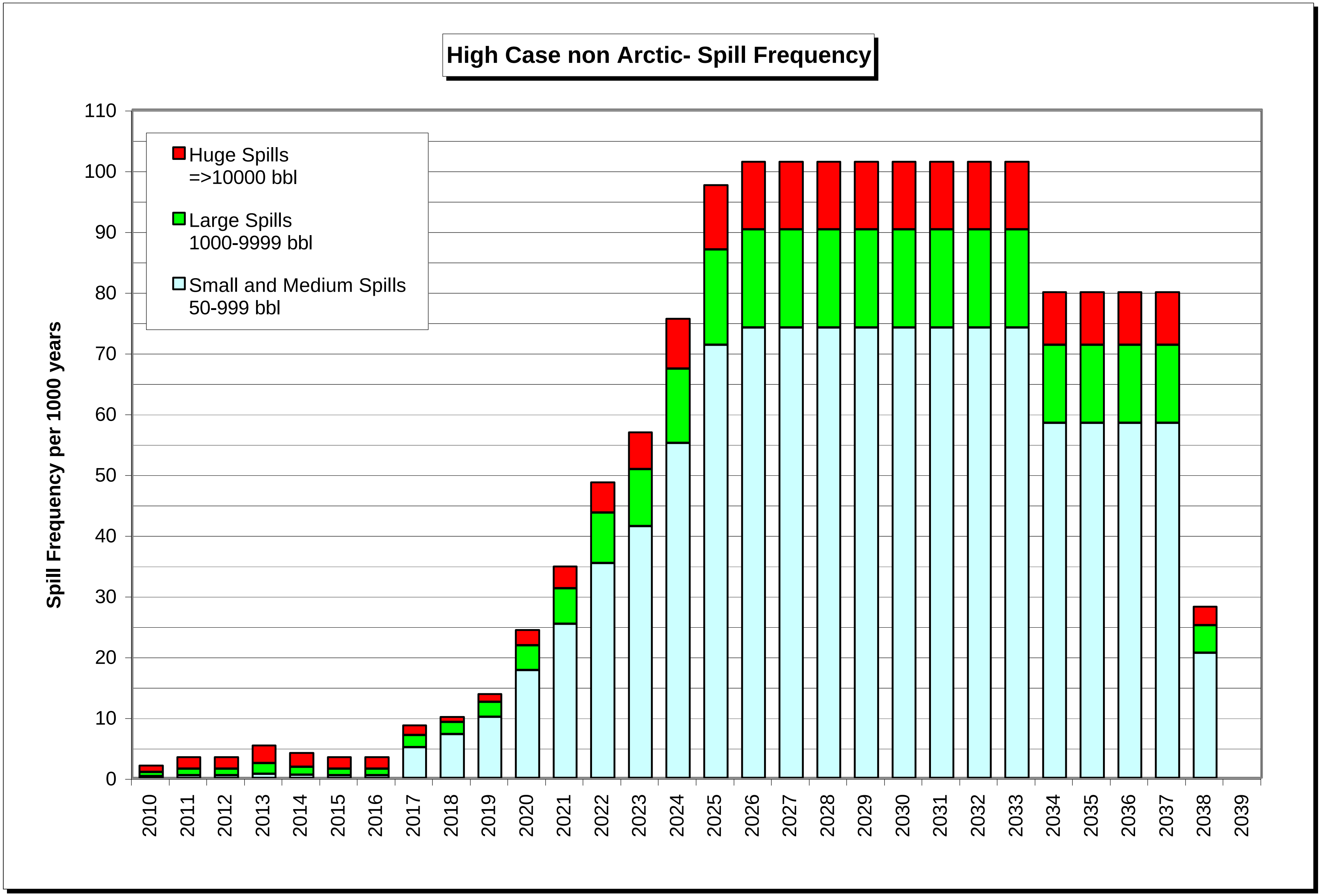
Spill Size	Spill Source: P/L		Platforms		Wells		Platforms and Wells		All	
	High Case non Arctic - Year 2030 Spill Frequency per 10^3 years									
Small and Medium Spills 50-999 bbl	39.888	72%	33.126	91%	1.055	11%	34.182	74%	74.070	73%
Large Spills 1000-9999 bbl	11.242	20%	1.730	5%	3.166	33%	4.897	11%	16.139	16%
Huge Spills =>10000 bbl	4.169	8%	1.730	5%	5.277	56%	7.008	15%	11.177	11%
Significant Spills =>1000 bbl	15.411	28%	3.461	9%	8.444	89%	11.905	26%	27.315	27%
All Spills	**55.299**	**100%**	**36.587**	**100%**	**9.499**	**100%**	**46.087**	**100%**	**101.385**	**100%**
	High Case non Arctic - Year 2030 Spill Frequency per 10^9 bbl produced									
Small and Medium Spills 50-999 bbl	1.425	72%	1.183	91%	0.038	11%	1.221	74%	2.645	73%
Large Spills 1000-9999 bbl	0.401	20%	0.062	5%	0.113	33%	0.175	11%	0.576	16%
Huge Spills =>10000 bbl	0.149	8%	0.062	5%	0.188	56%	0.250	15%	0.399	11%
Significant Spills =>1000 bbl	0.550	28%	0.124	9%	0.302	89%	0.425	26%	0.976	27%
All Spills	**1.975**	**100%**	**1.307**	**100%**	**0.339**	**100%**	**1.646**	**100%**	**3.621**	**100%**
	High Case non Arctic - Year 2030 Spill Index [bbl]									
Small and Medium Spills 50-999 bbl	12	9%	15	43%	1	0%	16	2%	27	3%
Large Spills 1000-9999 bbl	58	43%	10	28%	39	6%	49	7%	107	13%
Huge Spills =>10000 bbl	65	48%	10	28%	639	94%	648	91%	713	84%
Significant Spills =>1000 bbl	123	91%	19	57%	678	100%	697	98%	820	97%
All Spills	**135**	**100%**	**34**	**100%**	**678**	**100%**	**713**	**100%**	**848**	**100%**

Spill Source	Spill Size: S+M 50-999 bbl		Large 1000-9999 bbl		Huge =>10000 bbl		Significant =>1000 bbl		All Spills	
	High Case non Arctic - Year 2030 Spill Frequency per 10^3 years									
P/L	39.888	54%	11.242	70%	4.169	37%	15.411	56%	55.299	55%
Platforms	33.126	45%	1.730	11%	1.730	15%	3.461	13%	36.587	36%
Wells	1.055	1%	3.166	20%	5.277	47%	8.444	31%	9.499	9%
Platforms and Wells	34.182	46%	4.897	30%	7.008	63%	11.905	44%	46.087	45%
All	**74.070**	**100%**	**16.139**	**100%**	**11.177**	**100%**	**27.315**	**100%**	**101.385**	**100%**
	High Case non Arctic - Year 2030 Spill Frequency per 10^9 bbl produced									
P/L	1.425	54%	0.401	70%	0.149	37%	0.550	56%	1.975	55%
Platforms	1.183	45%	0.062	11%	0.062	15%	0.124	13%	1.307	36%
Wells	0.038	1%	0.113	20%	0.188	47%	0.302	31%	0.339	9%
Platforms and Wells	1.221	46%	0.175	30%	0.250	63%	0.425	44%	1.646	45%
All	**2.645**	**100%**	**0.576**	**100%**	**0.399**	**100%**	**0.976**	**100%**	**3.621**	**100%**
	High Case non Arctic - Year 2030 Spill Index [bbl]									
P/L	12	43%	58	54%	65	9%	123	15%	135	16%
Platforms	15	55%	10	9%	10	1%	19	2%	34	4%
Wells	1	2%	39	36%	639	90%	678	83%	678	80%
Platforms and Wells	16	57%	49	46%	648	91%	697	85%	713	84%
All	**27**	**100%**	**107**	**100%**	**713**	**100%**	**820**	**100%**	**848**	**100%**

Table 4.3.21
Composition of Spill Indicators - High Case non Arctic - LOF Average

Spill Size	Spill Source: P/L		Platforms		Wells		Platforms and Wells		All	
	High Case non Arctic - LOF Average Spill Frequency per 10^3 years									
Small and Medium Spills 50-999 bbl	22.507	72%	16.182	91%	0.617	11%	16.799	72%	39.306	72%
Large Spills 1000-9999 bbl	6.333	20%	0.845	5%	1.851	33%	2.696	12%	9.029	17%
Huge Spills =>10000 bbl	2.369	8%	0.845	5%	3.097	56%	3.943	17%	6.312	12%
Significant Spills =>1000 bbl	8.702	28%	1.691	9%	4.948	89%	6.639	28%	15.341	28%
All Spills	**31.209**	**100%**	**17.873**	**100%**	**5.565**	**100%**	**23.438**	**100%**	**54.647**	**100%**
	High Case non Arctic - LOF Average Spill Frequency per 10^9 bbl produced									
Small and Medium Spills 50-999 bbl	1.259	72%	0.938	91%	0.036	11%	0.973	72%	2.233	72%
Large Spills 1000-9999 bbl	0.354	20%	0.049	5%	0.107	33%	0.156	12%	0.511	16%
Huge Spills =>10000 bbl	0.133	8%	0.049	5%	0.179	56%	0.228	17%	0.361	12%
Significant Spills =>1000 bbl	0.487	28%	0.098	9%	0.287	89%	0.385	28%	0.871	28%
All Spills	**1.746**	**100%**	**1.036**	**100%**	**0.322**	**100%**	**1.358**	**100%**	**3.104**	**100%**
	High Case non Arctic - LOF Average Spill Index [bbl]									
Small and Medium Spills 50-999 bbl	7	9%	7	43%	0	0%	8	2%	14	3%
Large Spills 1000-9999 bbl	33	43%	5	28%	23	6%	28	7%	60	12%
Huge Spills =>10000 bbl	37	48%	5	28%	376	94%	381	92%	417	85%
Significant Spills =>1000 bbl	69	91%	10	57%	399	100%	408	98%	477	97%
All Spills	**76**	**100%**	**17**	**100%**	**399**	**100%**	**416**	**100%**	**492**	**100%**

Spill Source	Spill Size: S+M 50-999 bbl		Large 1000-9999 bbl		Huge =>10000 bbl		Significant =>1000 bbl		All Spills	
	High Case non Arctic - LOF Average Spill Frequency per 10^3 years									
P/L	22.507	57%	6.333	70%	2.369	38%	8.702	57%	31.209	57%
Platforms	16.182	41%	0.845	9%	0.845	13%	1.691	11%	17.873	33%
Wells	0.617	2%	1.851	20%	3.097	49%	4.948	32%	5.565	10%
Platforms and Wells	16.799	43%	2.696	30%	3.943	62%	6.639	43%	23.438	43%
All	**39.306**	**100%**	**9.029**	**100%**	**6.312**	**100%**	**15.341**	**100%**	**54.647**	**100%**
	High Case non Arctic - LOF Average Spill Frequency per 10^9 bbl produced									
P/L	1.259	56%	0.354	69%	0.133	37%	0.487	56%	1.746	56%
Platforms	0.938	42%	0.049	10%	0.049	14%	0.098	11%	1.036	33%
Wells	0.036	2%	0.107	21%	0.179	50%	0.287	33%	0.322	10%
Platforms and Wells	0.973	44%	0.156	31%	0.228	63%	0.385	44%	1.358	44%
All	**2.233**	**100%**	**0.511**	**100%**	**0.361**	**100%**	**0.871**	**100%**	**3.104**	**100%**
	High Case non Arctic - LOF Average Spill Index [bbl]									
P/L	7	47%	33	54%	37	9%	69	15%	76	15%
Platforms	7	51%	5	8%	5	1%	10	2%	17	3%
Wells	0	2%	23	38%	376	90%	399	83%	399	81%
Platforms and Wells	8	53%	28	46%	381	91%	408	85%	416	85%
All	**14**	**100%**	**60**	**100%**	**417**	**100%**	**477**	**100%**	**492**	**100%**



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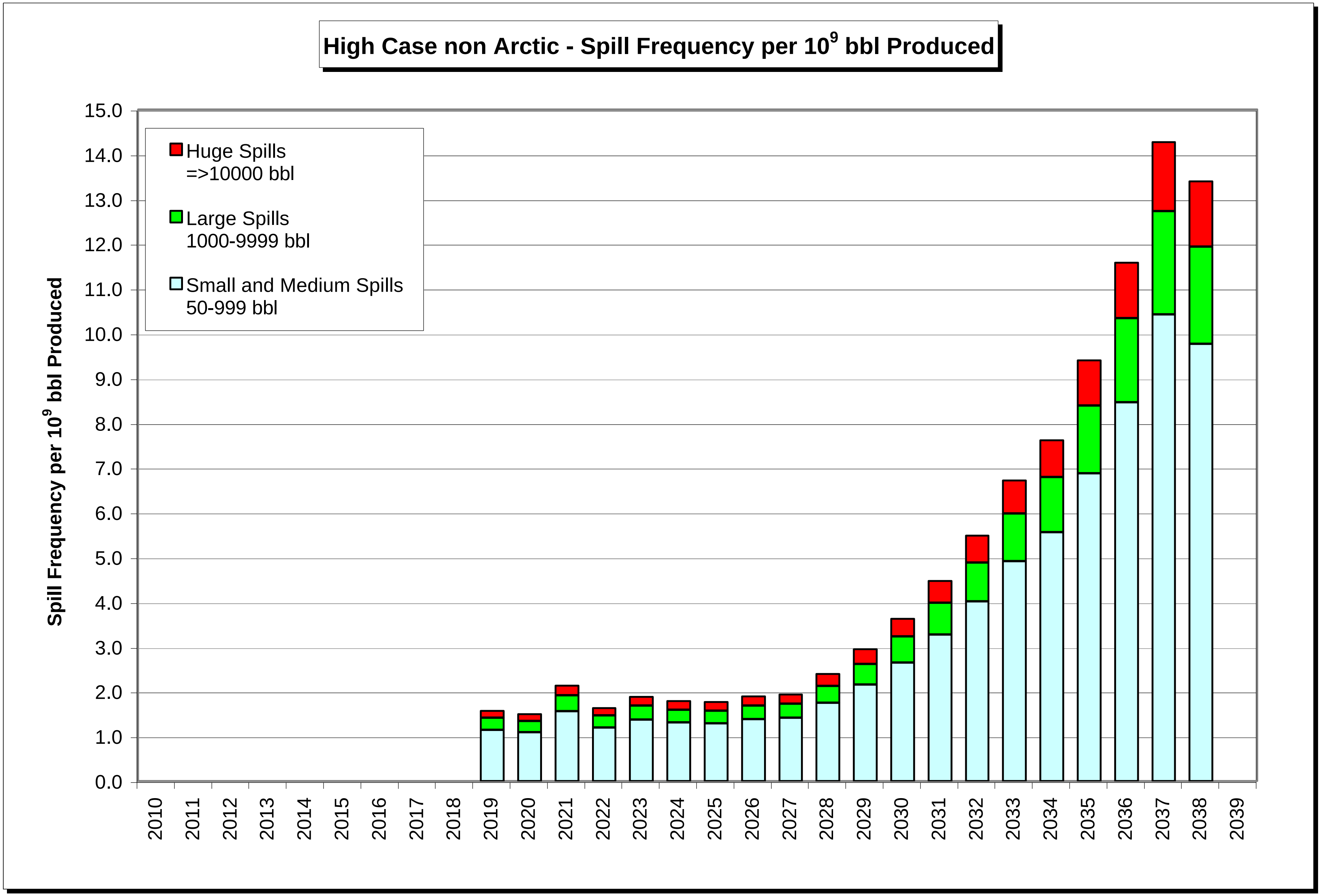

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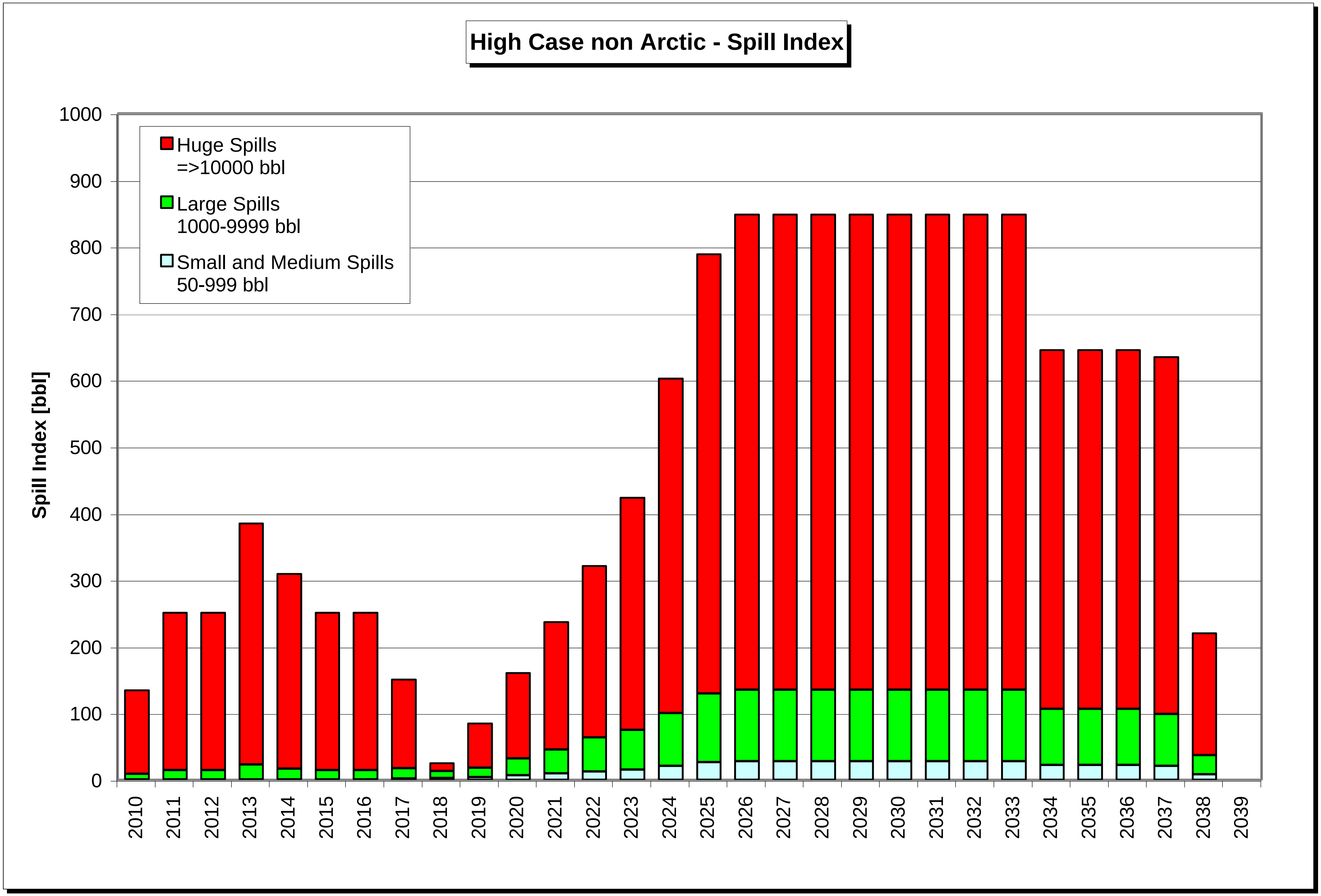

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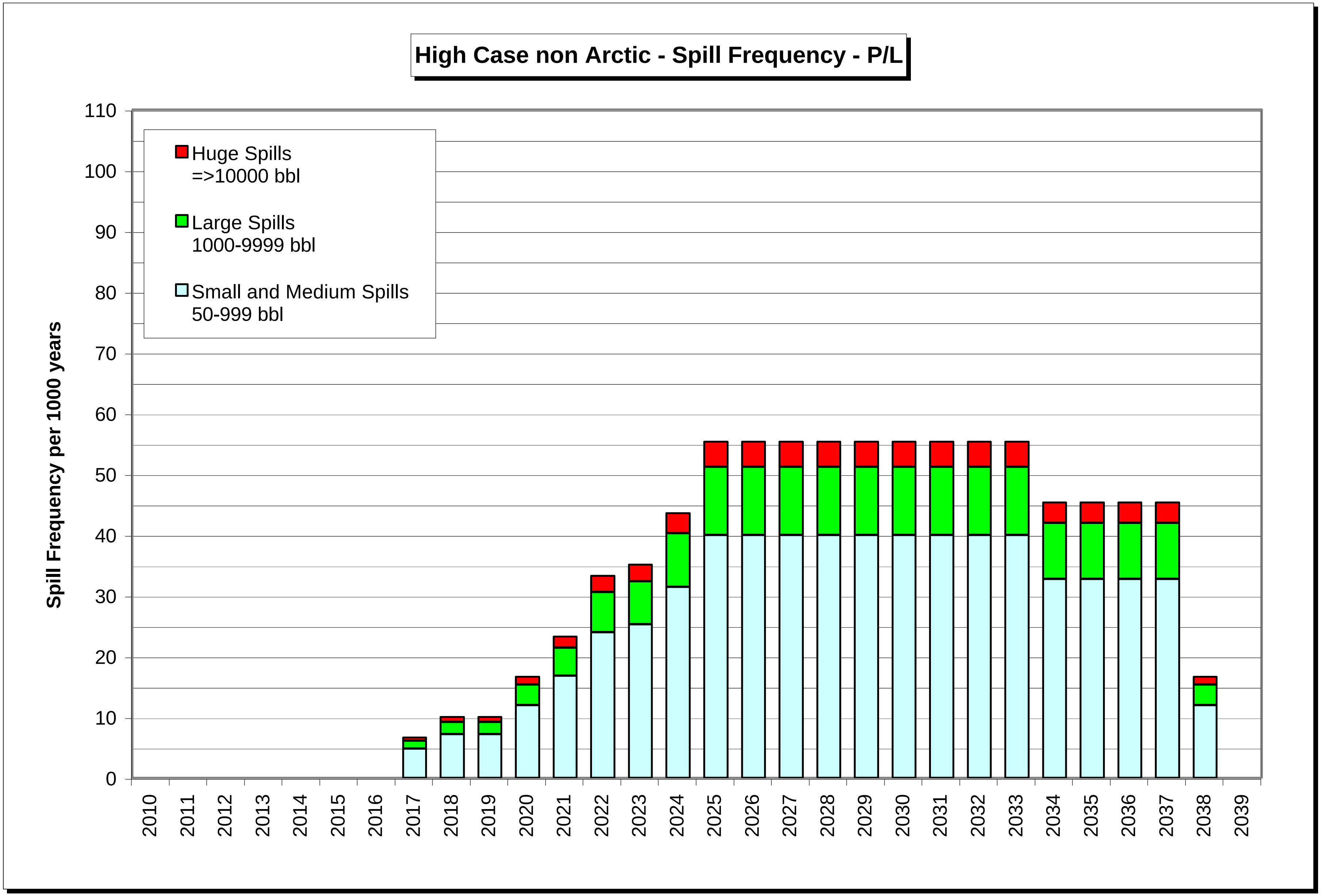

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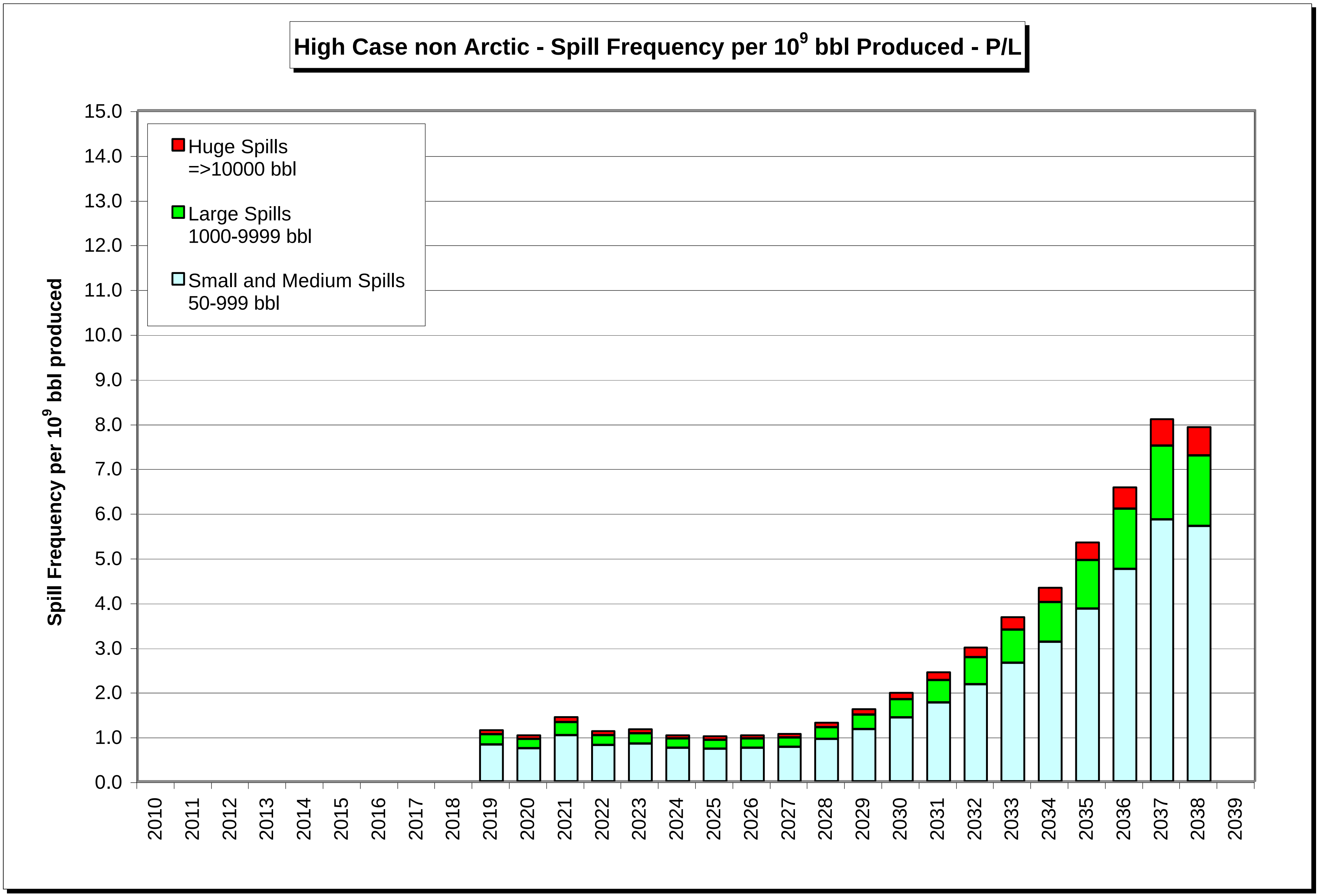

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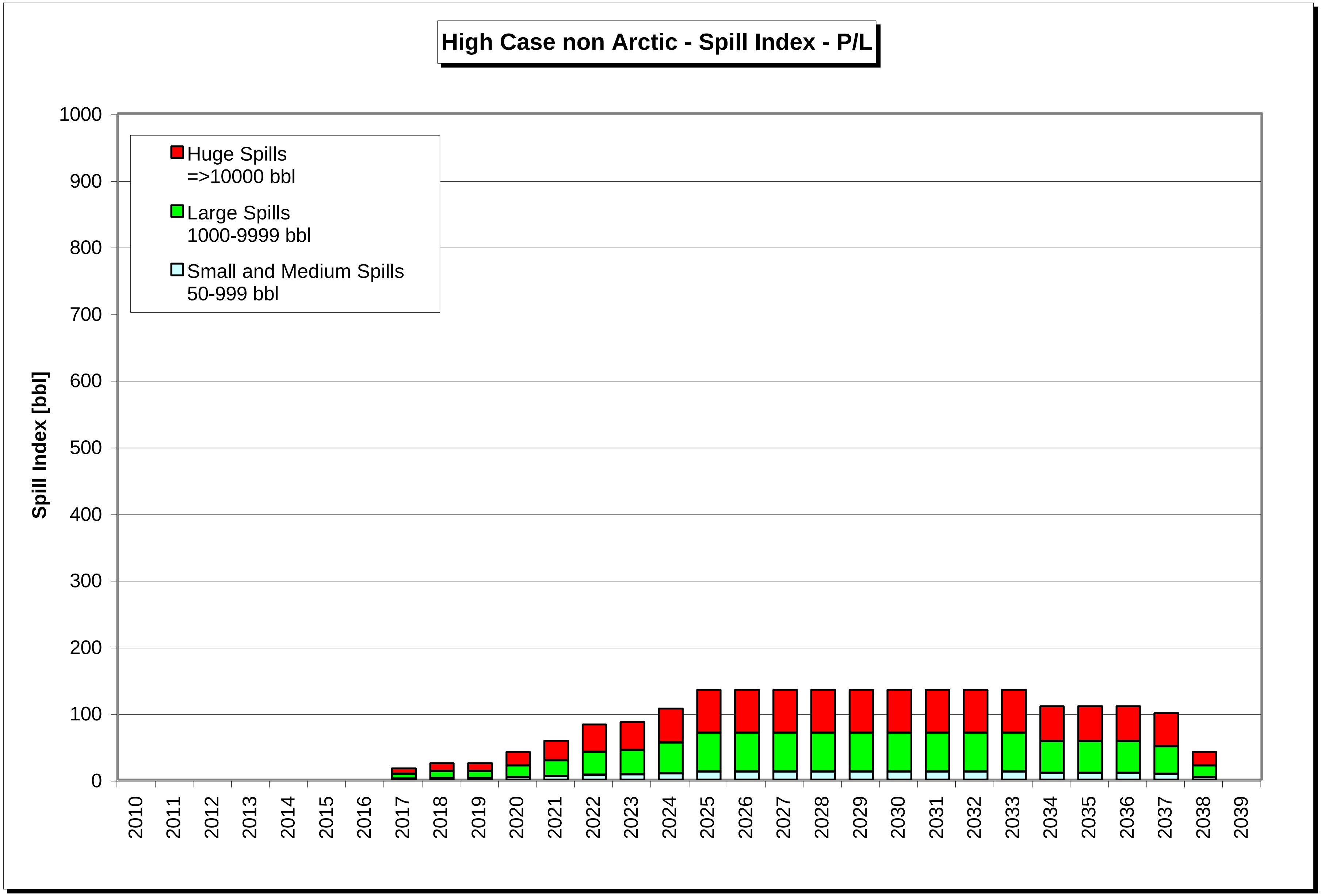

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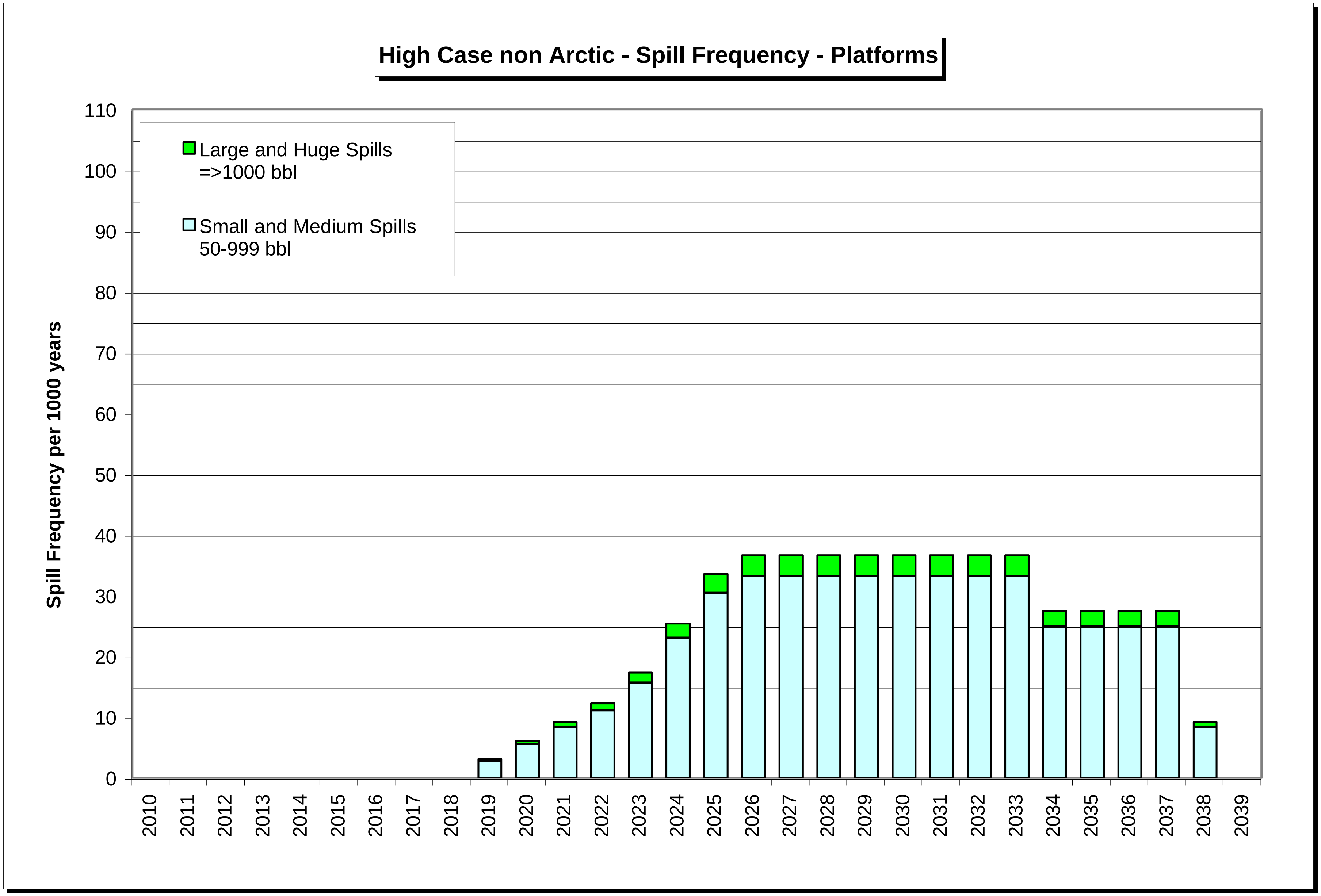

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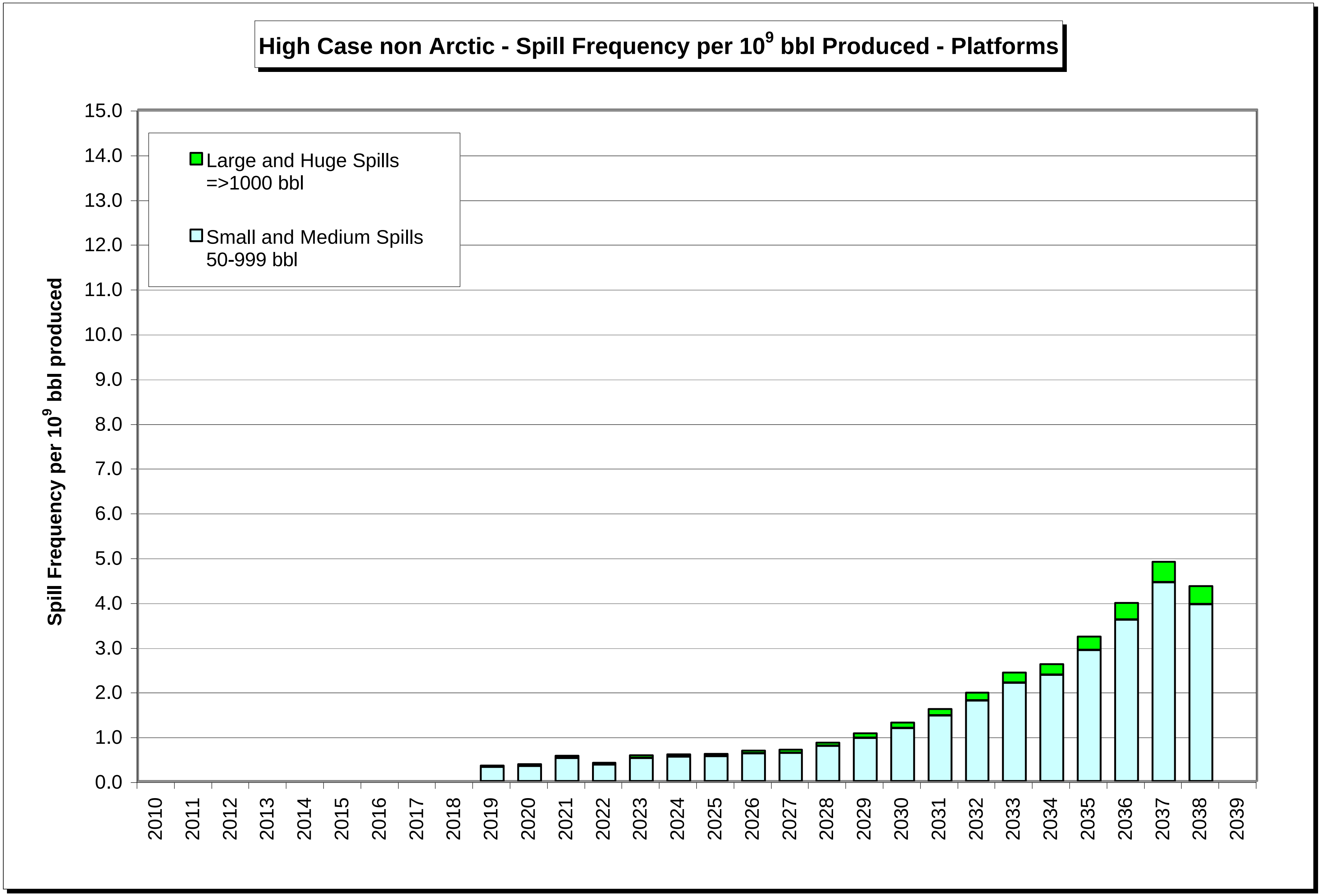

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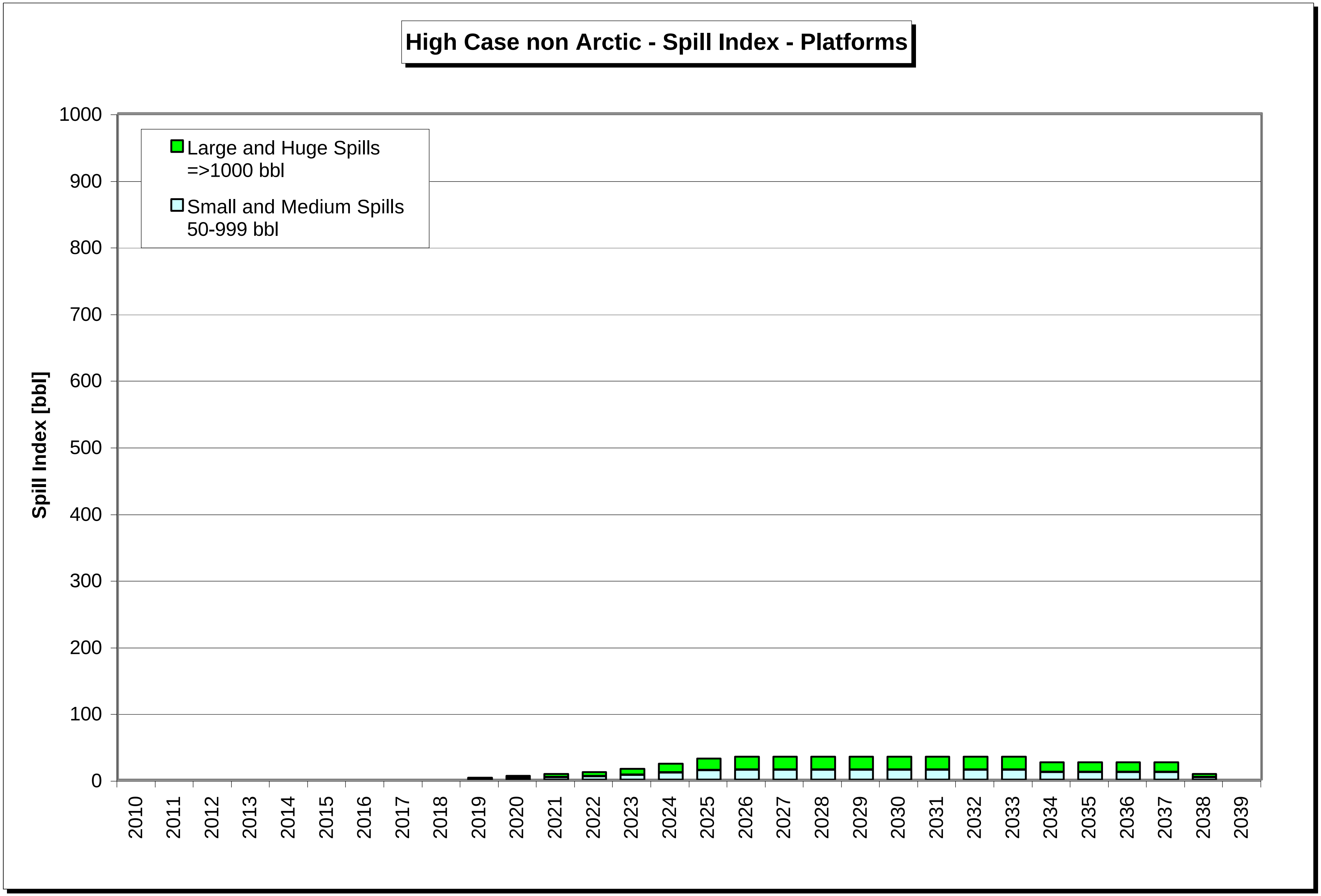

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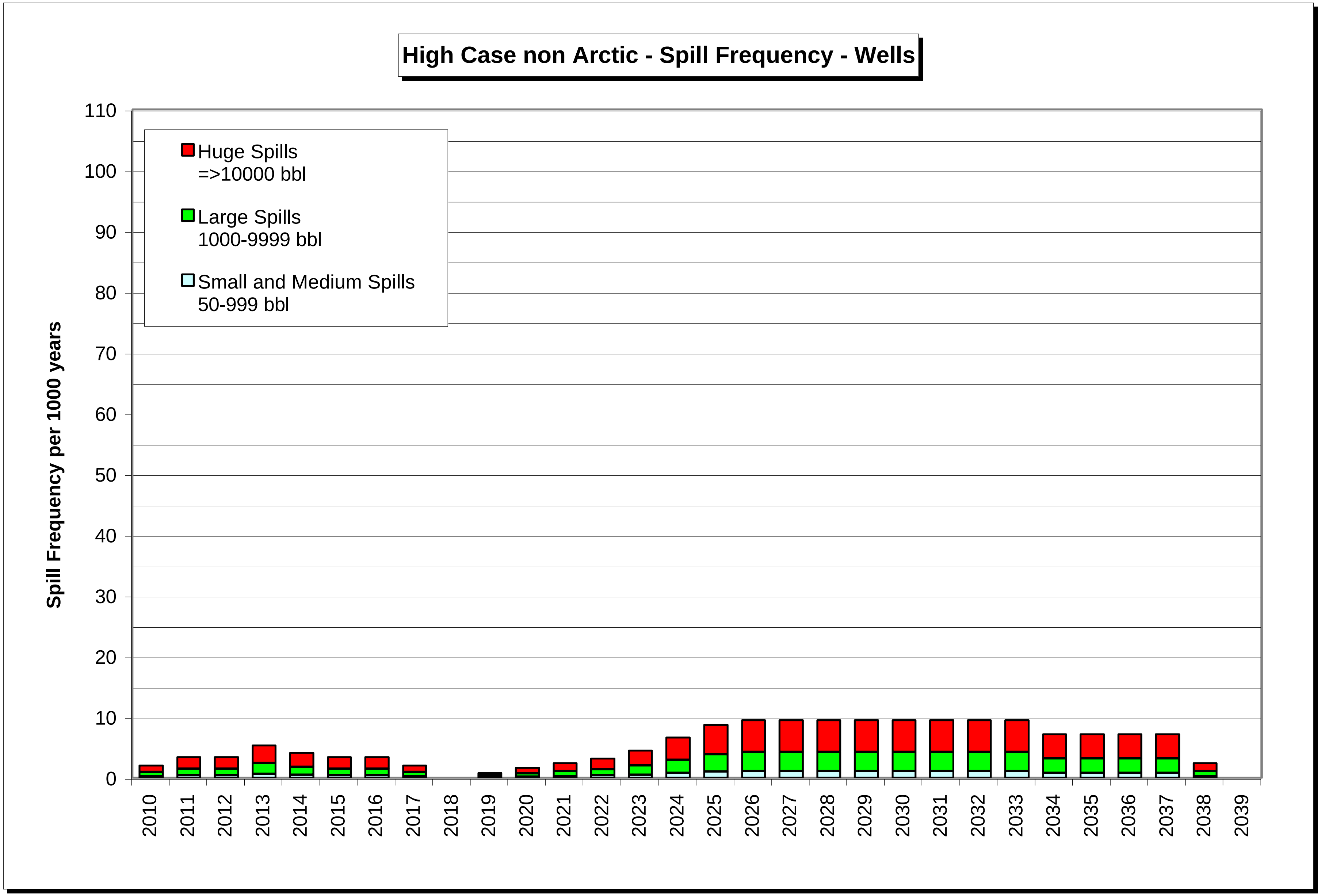

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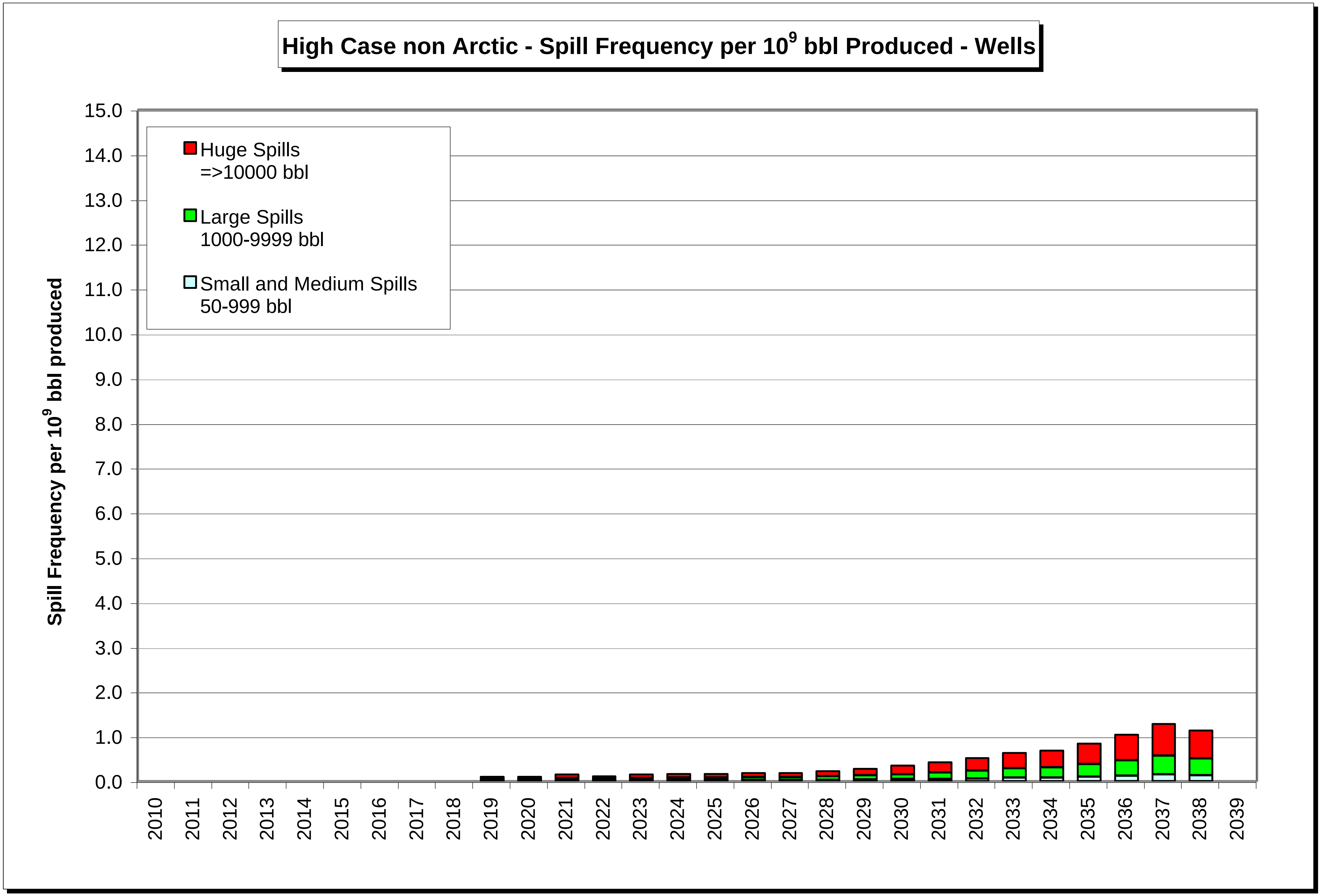

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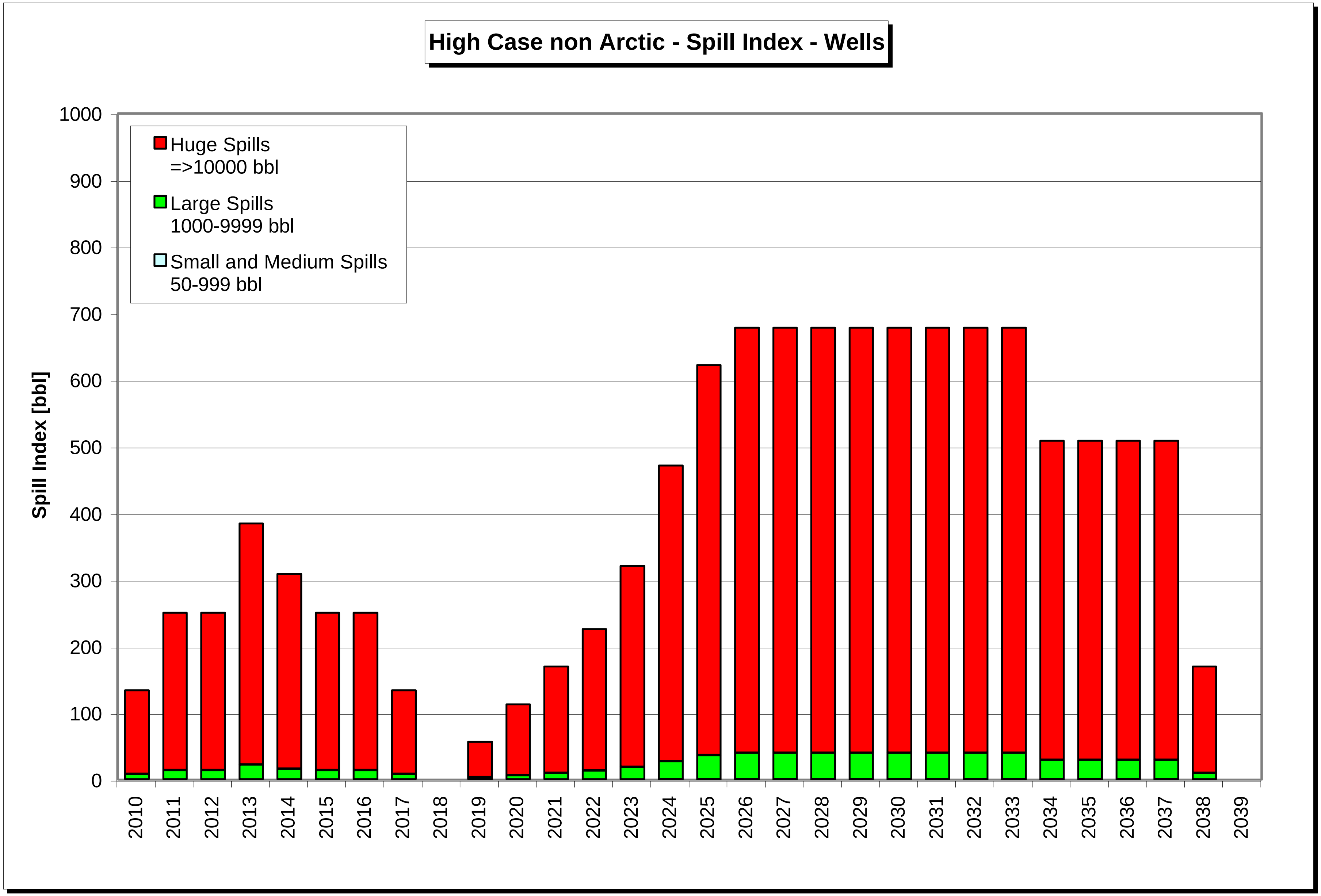

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Figure 4.3.13 Spill Indicators – CDF – High Case non Arctic – Year 2030

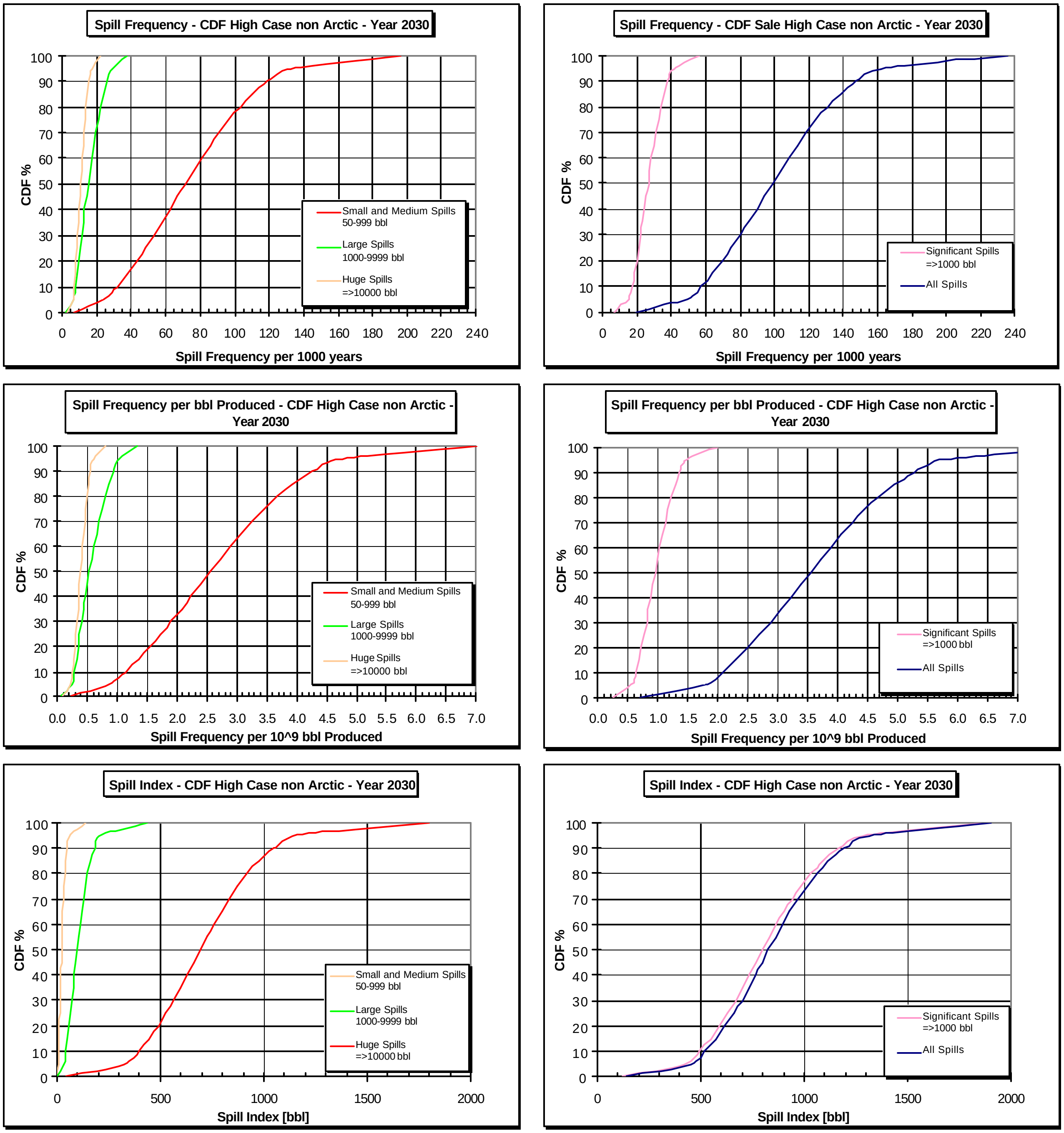


Figure 4.3.14 Spill Frequency – CDF – High Case non Arctic

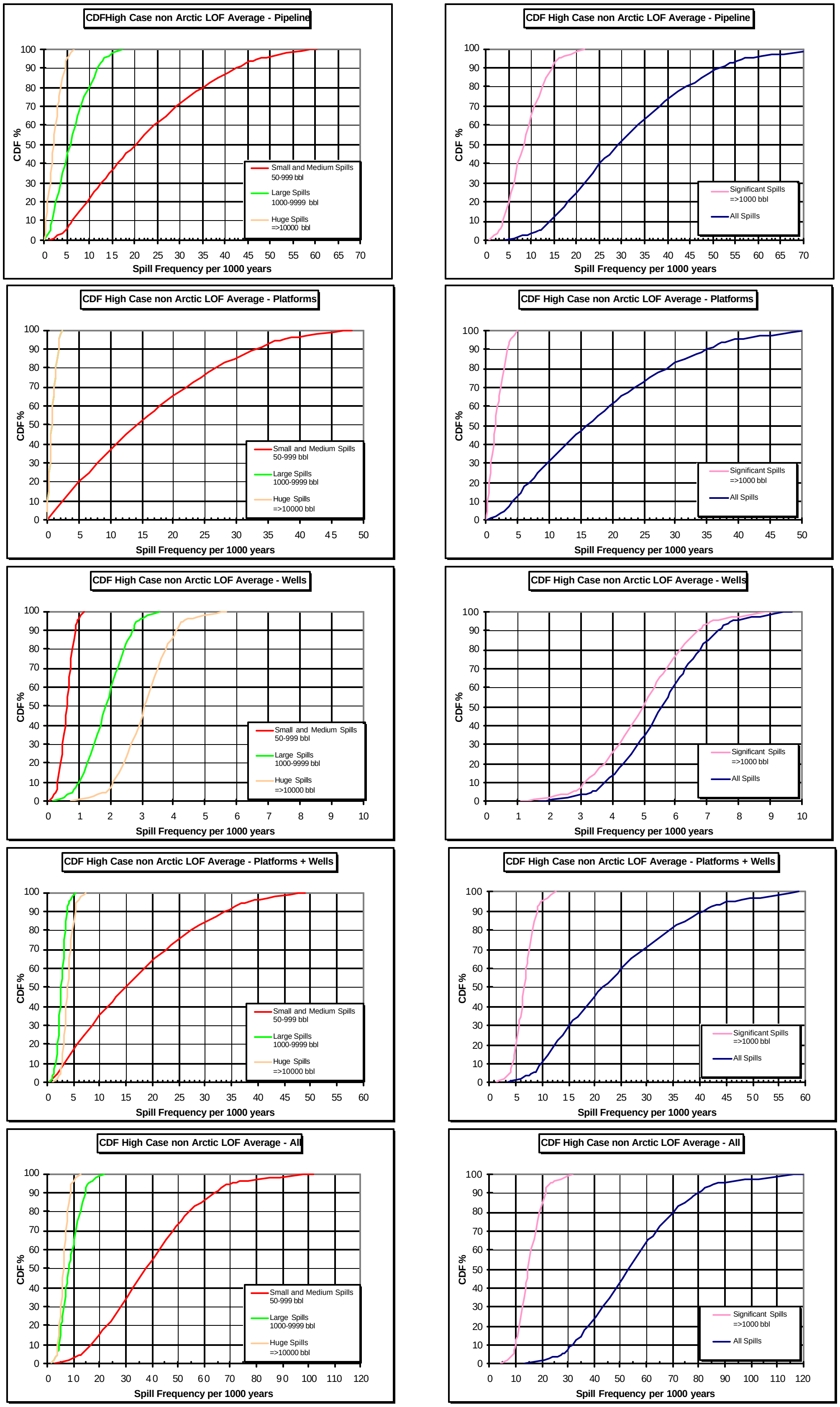


Figure 4.3.15 Spill Frequency per bbl produced– CDF – High Case non Arctic

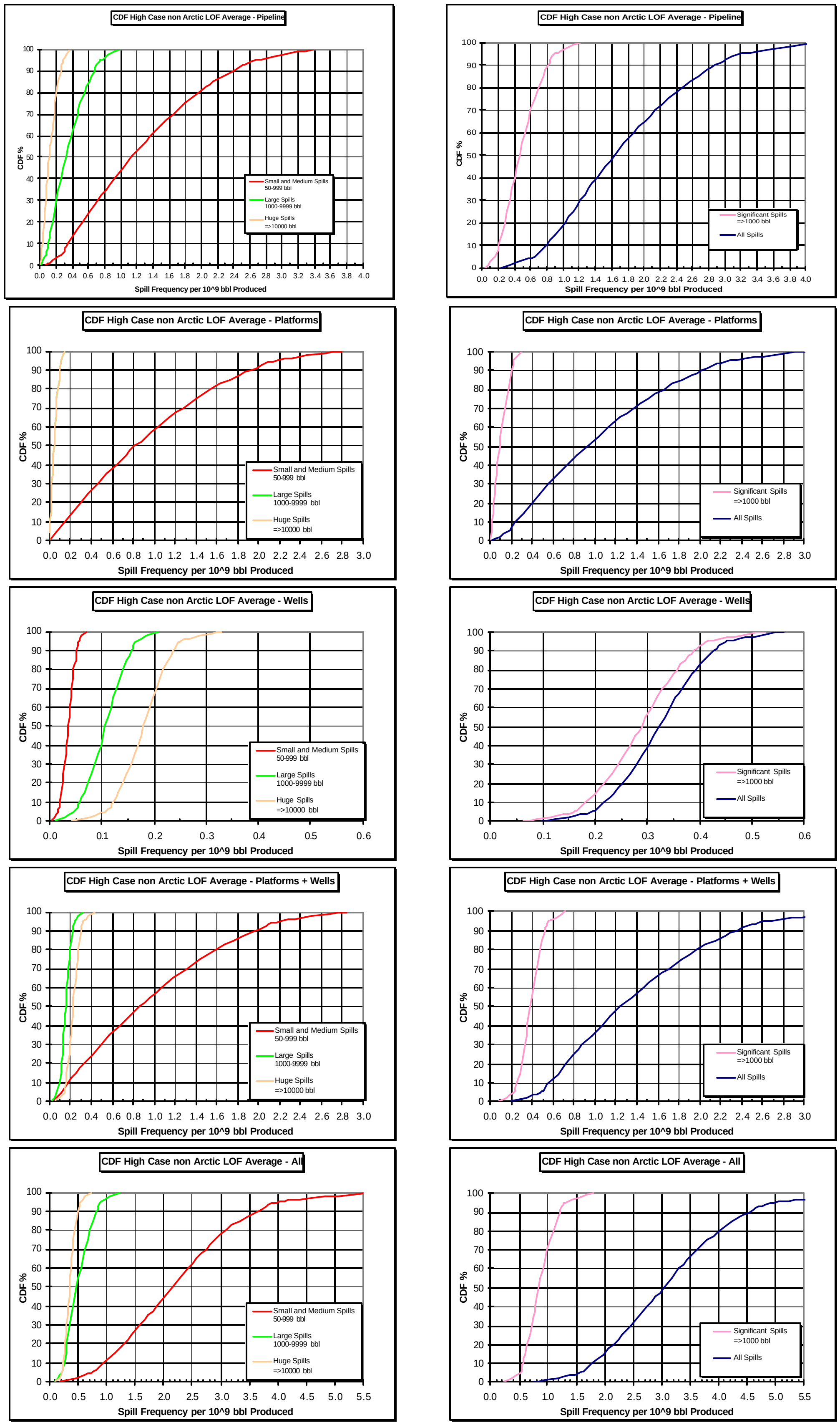
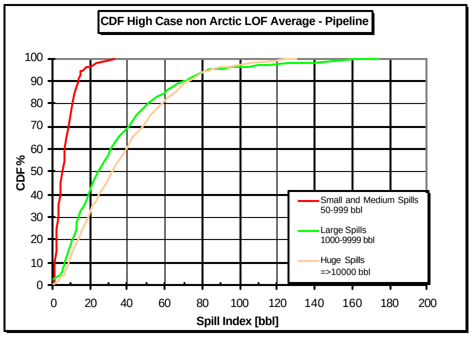
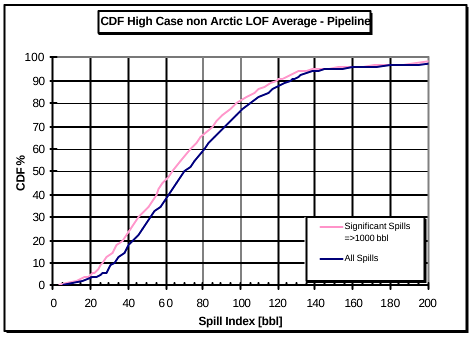
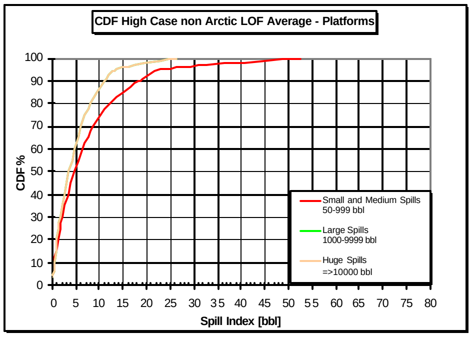
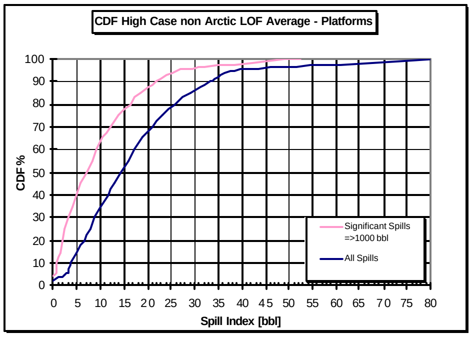


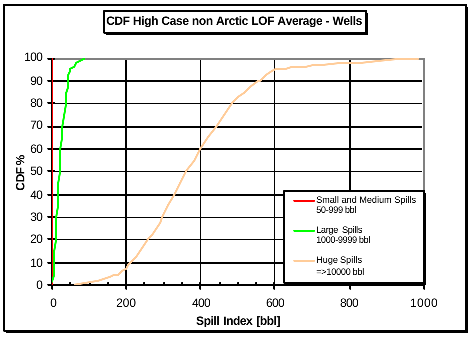
Figure 4.3.16 Spill Index [bbl] – CDF – High Case non Arctic

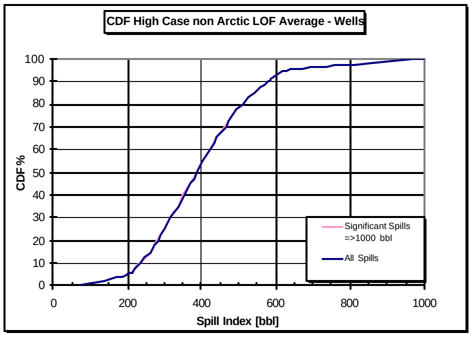


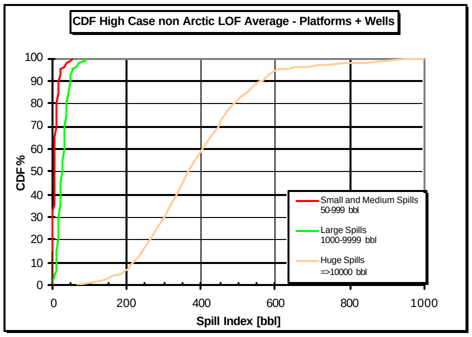


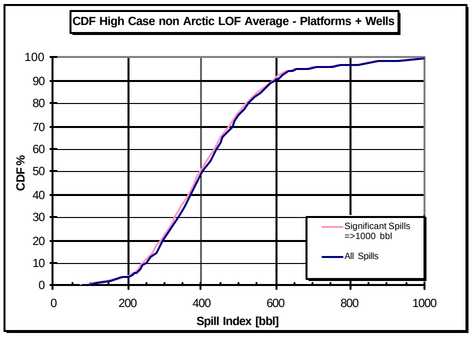


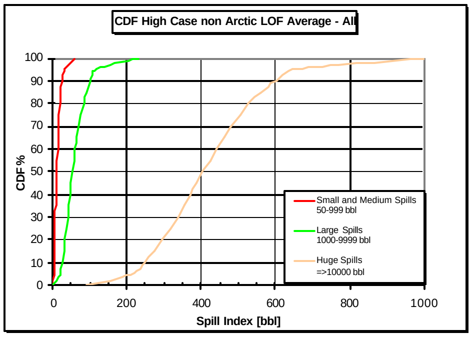












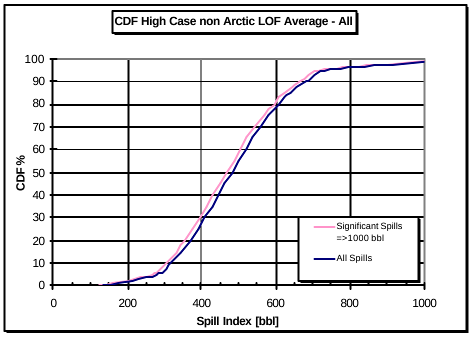
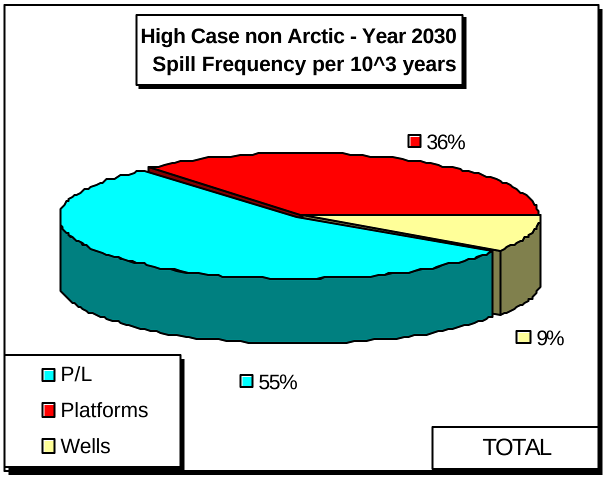
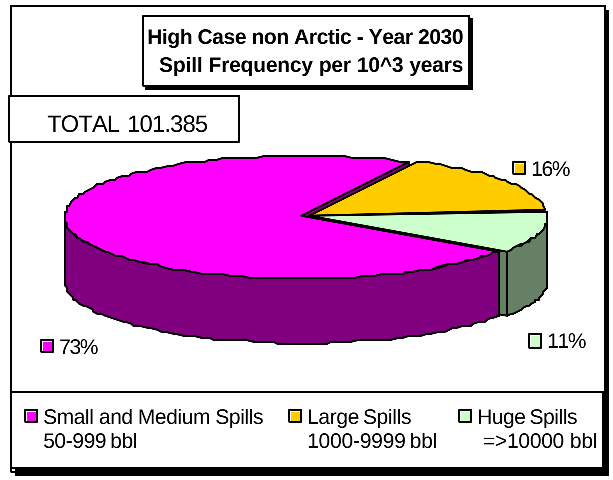
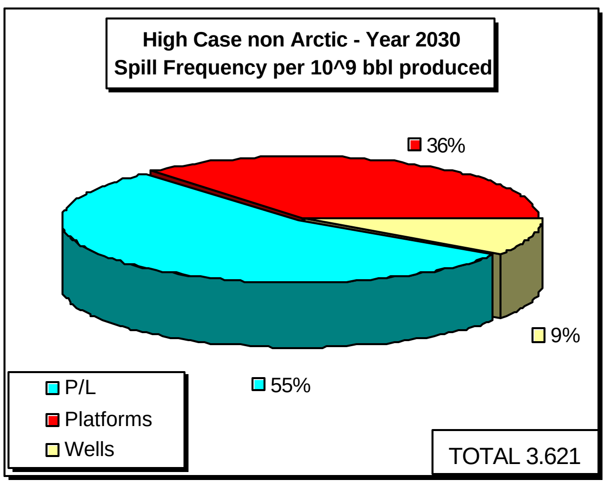


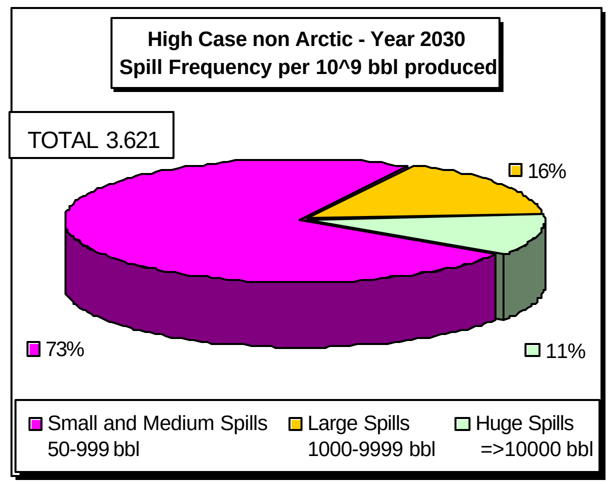
Figure 4.3.17
High Case non Arctic - Year 2030 - Spill Indicators

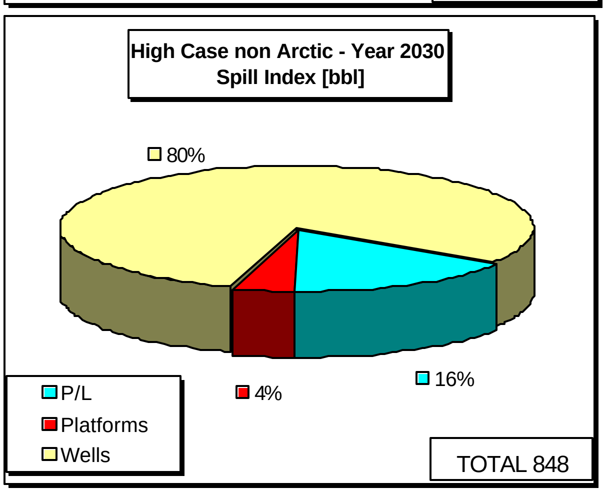
BY SPILL SOURCE	BY SPILL SIZE











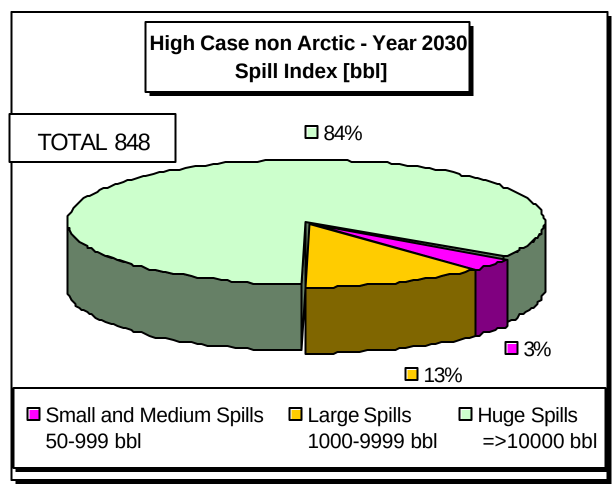
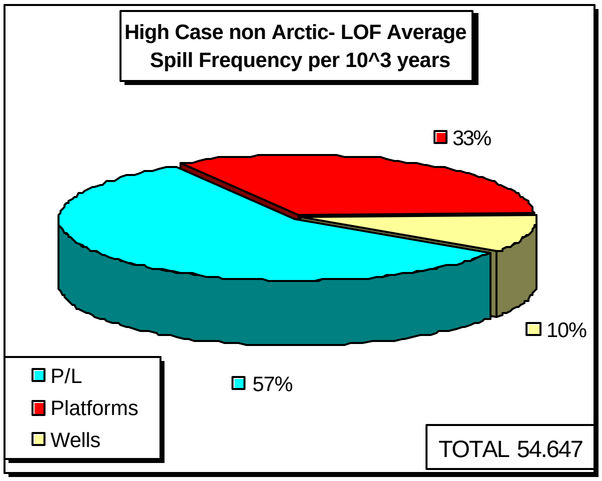
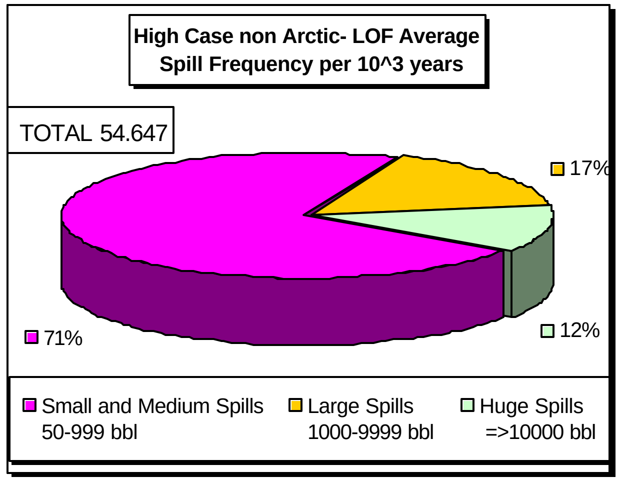
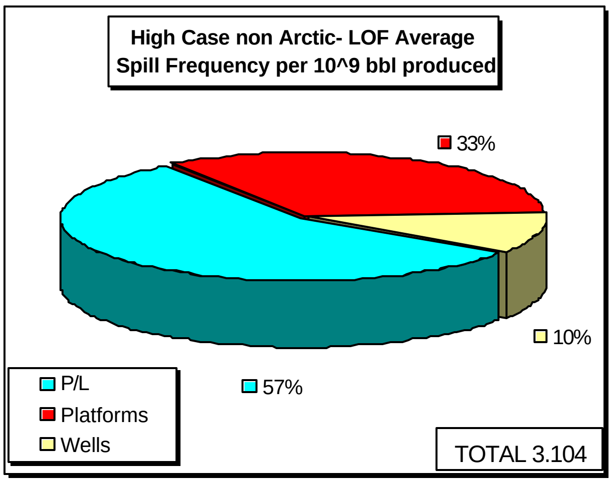


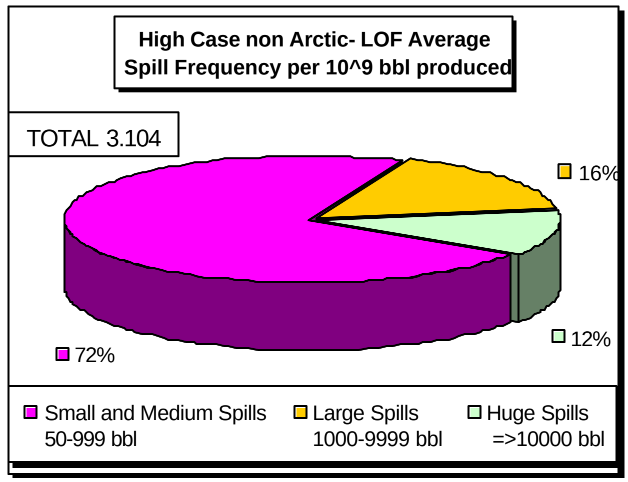
Figure 4.3.18
High Case non Arctic – LOF Average Spill Indicators

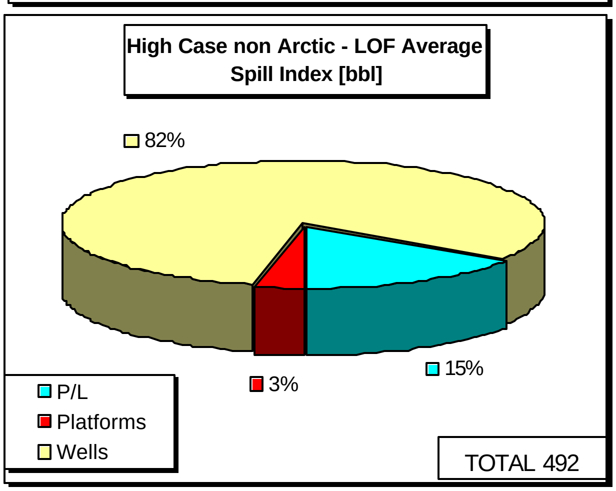
BY SPILL SOURCE	BY SPILL SIZE











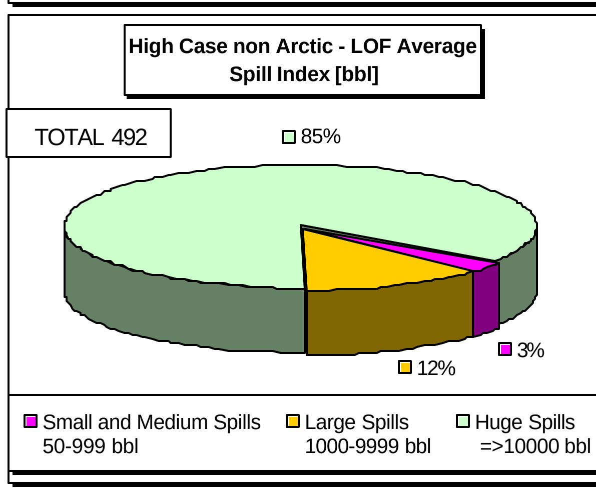
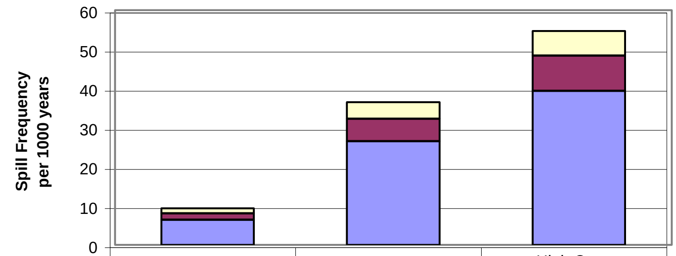


Table 5.1
Summary of Spill Indicators for All Scenarios

Spill Indicators LOF Average	Low Case			High Case			High Case non Arctic		
	Spill Frequency per 10^3 years	Spill Frequency per 10^9 bbl produced	Spill Index [bbl]	Spill Frequency per 10^3 years	Spill Frequency per 10^9 bbl produced	Spill Index [bbl]	Spill Frequency per 10^3 years	Spill Frequency per 10^9 bbl produced	Spill Index [bbl]
Small and Medium Spills 50-999 bbl	6.431	1.232	3	26.468	1.534	11	39.306	2.233	14
	69%	**69%**	**2%**	**73%**	**73%**	**3%**	**72%**	**72%**	**3%**
Large Spills 1000-9999 bbl	1.623	0.311	12	5.773	0.335	40	9.029	0.511	60
	17%	**17%**	**11%**	**16%**	**16%**	**12%**	**17%**	**16%**	**12%**
Huge Spills =>10000 bbl	1.256	0.241	93	4.222	0.245	293	6.312	0.361	417
	13%	**13%**	**87%**	**12%**	**12%**	**85%**	**12%**	**12%**	**85%**
Significant Spills =>1000 bbl	2.879	0.551	104	9.995	0.579	332	15.341	0.871	477
	31%	**31%**	**98%**	**27%**	**27%**	**97%**	**28%**	**28%**	**97%**
All Spills	9.310	1.783	107	36.463	2.113	343	54.647	3.104	492
	100%	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
Pipeline Spills	4.414	0.845	12	18.402	1.066	44	31.209	1.746	76
	47%	**47%**	**11%**	**50%**	**50%**	**13%**	**57%**	**56%**	**15%**
Platform Spills	3.615	0.692	4	14.085	0.816	14	17.873	1.036	17
	39%	**39%**	**4%**	**39%**	**39%**	**4%**	**33%**	**33%**	**3%**
Well Spills	1.281	0.245	92	3.977	0.230	285	5.565	0.322	399
	14%	**14%**	**86%**	**11%**	**11%**	**83%**	**10%**	**10%**	**81%**
Platform and Well Spills	4.896	0.938	95	18.062	1.047	299	23.438	1.358	416
	53%	**53%**	**89%**	**50%**	**50%**	**87%**	**43%**	**44%**	**85%**
All Spills	9.310	1.783	107	36.463	2.113	343	54.647	3.104	492
	100%	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

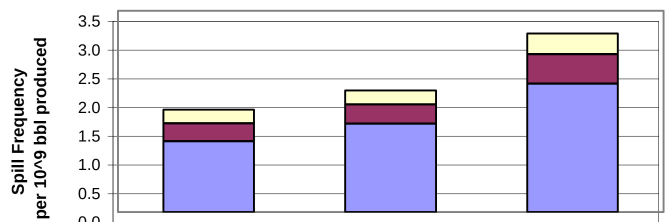
Figure 5.1 LOF Spill Indicators - By Size

Life of Field Average



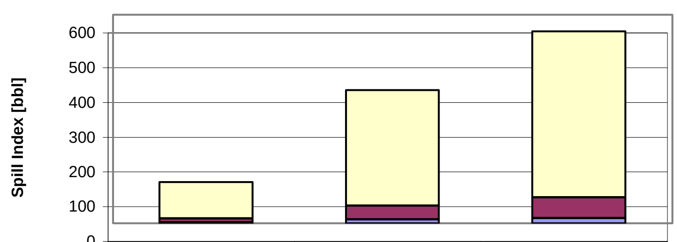
	Low Case	High Case	High Case non Arctic
Huge Spills =>10000 bbl	1.256	4.222	6.312
Large Spills 1000-9999 bbl	1.623	5.773	9.029
Small and Medium Spills 50-999 bbl	6.431	26.468	39.306

Life of Field Average



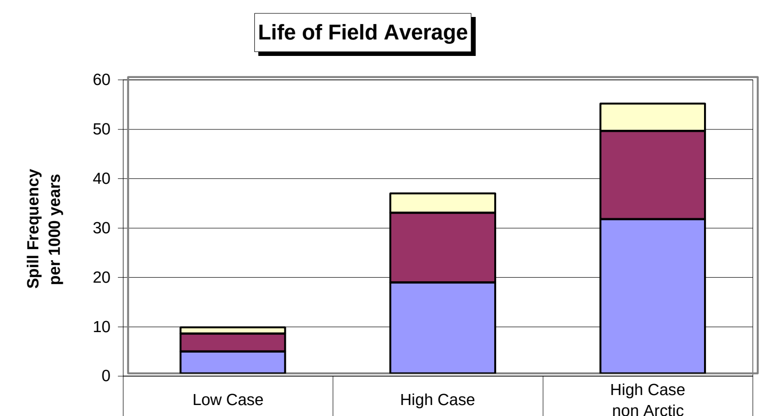
	Low Case	High Case	High Case non Arctic
Huge Spills =>10000 bbl	0.241	0.245	0.361
Large Spills 1000-9999 bbl	0.311	0.335	0.511
Small and Medium Spills 50-999 bbl	1.232	1.534	2.233

Life of Field Average

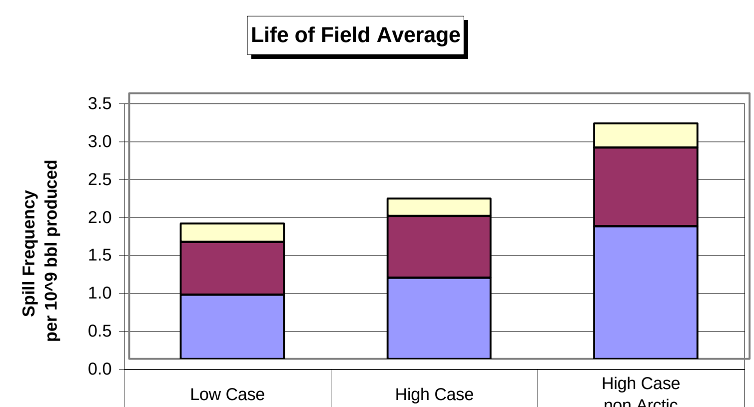


	Low Case	High Case	High Case non Arctic
Huge Spills =>10000 bbl	104	332	477
Large Spills 1000-9999 bbl	12	40	60
Small and Medium Spills 50-999 bbl	3	11	14

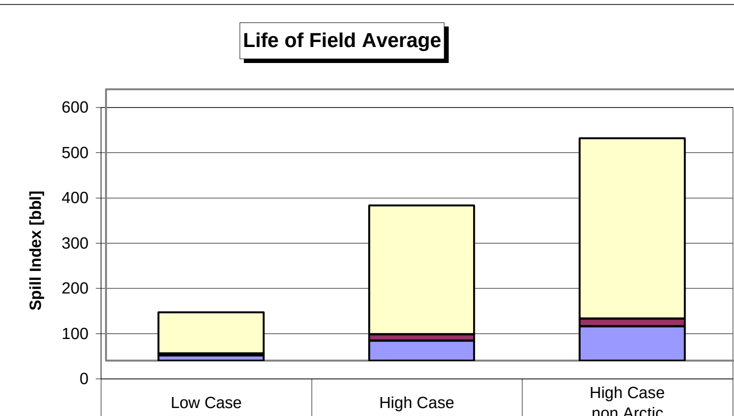
Figure 5.2 LOF Spill Indicators - By Source



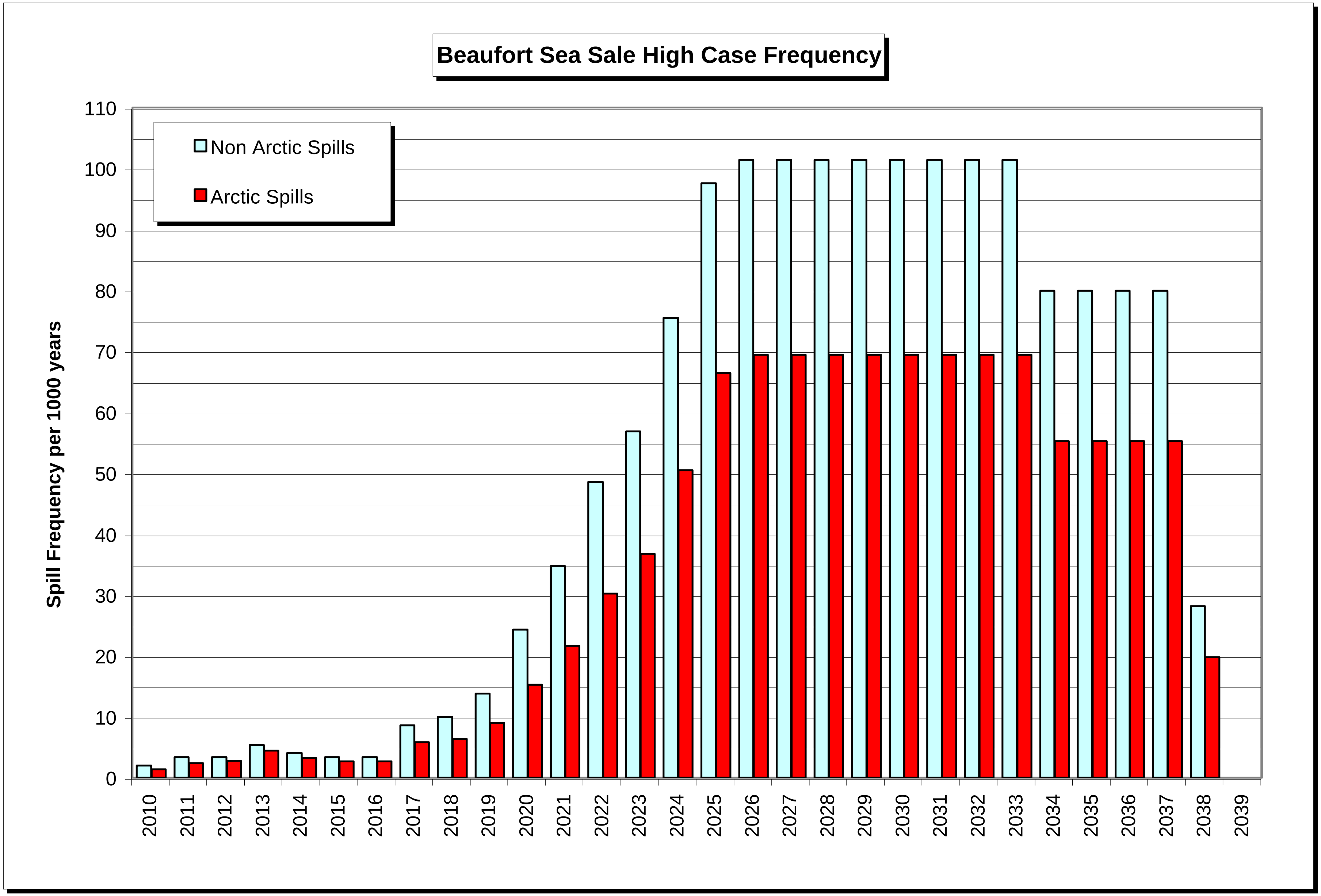
	Low Case	High Case	High Case non Arctic
Well Spills	1.281	3.977	5.565
Platform Spills	3.615	14.085	17.873
Pipeline Spills	4.414	18.402	31.209



	Low Case	High Case	High Case non Arctic
Well Spills	0.245	0.230	0.322
Platform Spills	0.692	0.816	1.036
Pipeline Spills	0.845	1.066	1.746



	Low Case	High Case	High Case non Arctic
Well Spills	92	285	399
Platform Spills	4	14	17
Pipeline Spills	12	44	76



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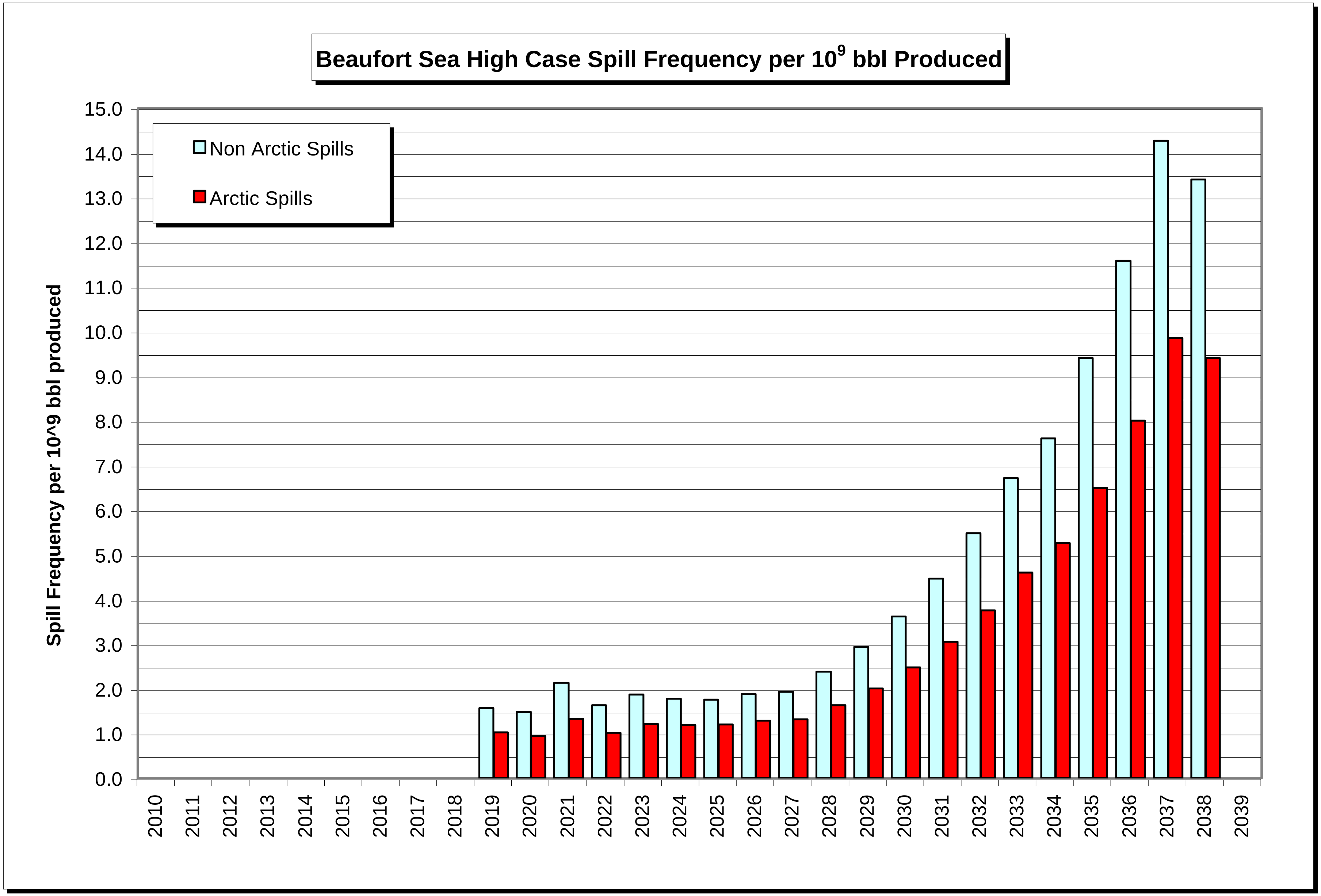

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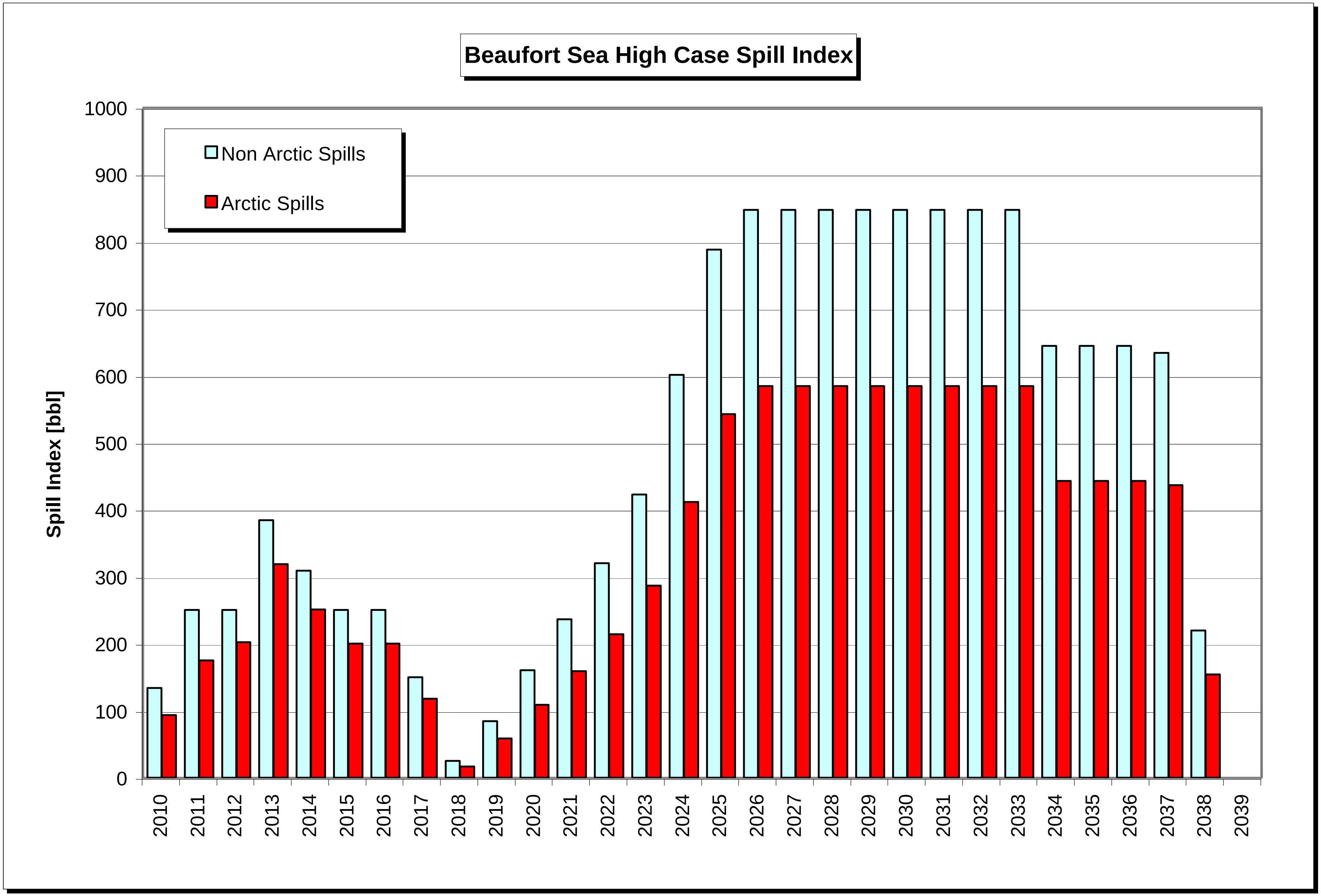

C5 Conclusions_BS.xlsF505

The Department of the Interior Mission

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

The Minerals Management Service Mission

As a bureau of the Department of the Interior, the Minerals Management Service's (MMS) primary responsibilities are to manage the mineral resources located on the Nation's Outer Continental Shelf (OCS), collect revenue from the Federal OCS and onshore Federal and Indian lands, and distribute those revenues.

Moreover, in working to meet its responsibilities, the **Offshore Minerals Management Program** administers the OCS competitive leasing program and oversees the safe and environmentally sound exploration and production of our Nation's offshore natural gas, oil and other mineral resources. The MMS **Royalty Management Program** meets its responsibilities by ensuring the efficient, timely and accurate collection and disbursement of revenue from mineral leasing and production due to Indian tribes and allottees, States and the U.S. Treasury.

The MMS strives to fulfill its responsibilities through the general guiding principles of: (1) being responsive to the public's concerns and interests by maintaining a dialogue with all potentially affected parties and (2) carrying out its programs with an emphasis on working to enhance the quality of life for all Americans by lending MMS assistance and expertise to economic development and environmental protection.