OCS Study MMS 2008-036

FINAL TASK 4A.2 REPORT

VOLUME I

Alternative Oil Spill Occurrence Estimators and their Variability for the Chukchi 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 2008-036

FINAL TASK 4A.2 REPORT

VOLUME I

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

March 2008

Principal Investigator: Dr. Frank G. Bercha, P.Eng.

Bercha International Inc.
2926 Parkdale Boulevard N.W.
Calgary, Alberta, T2N 3S9, Canada
Email: berchaf@berchagroup.com

This study was funded by the U.S. Department of the Interior, Minerals Management Service (MMS), Alaska Outer Continental Shelf Region, Anchorage, under Contract No. 1435-01-05-CT-39348, as part of the MMS Alaska Environmental Studies Program.

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 Chukchi 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 Chukchi Sea development scenario, with a range of development parameters, in duration up to 28 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.

ACKNOWLEDGEMENTS

Grateful acknowledgement for funding and direction is made to MMS Alaska OCS Region. In particular, the following MMS personnel are acknowledged together with their roles:

- Dr. Dick Prentki, Contracting Officer's Representative
- Dr. James Craig, Resource Evaluation Section
- 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 Chukchi 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 Chukchi 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
- 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

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 Chukchi Sea exploration and development scenarios, extending up to 30 years from 2011 to 2040. 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 deep water offshore development scenarios in the Chukchi 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 and Source

How do spill indicators for the Chukchi scenario and for its non-Arctic counterpart vary by spill size and location? Table 1 and Figure 1 and 2 summarize the Life of Field average spill indicator values by spill size and source. The following can be observed from Table 1.

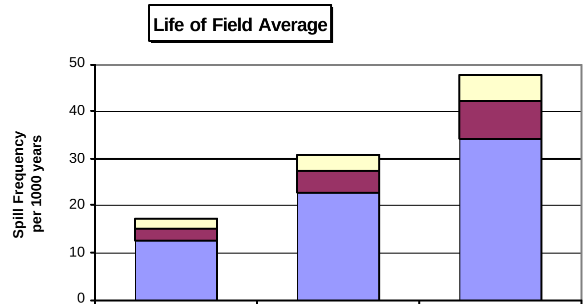
- Spill frequency per year and per barrel-year decreases significantly with increasing spill size for all scenarios.
- The spill index increases significantly with spill size for all scenarios.
- All non-Arctic scenario spill indicators are greater than their Arctic counterparts. High Case non-Arctic spill indicators are approximately 35% greater than Arctic High Case counterparts.

How do the spill indicators vary by facility type for representative scenarios? The contributions of spill indicators by facility have been summarized by representative scenario years, again, 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 Table 1:

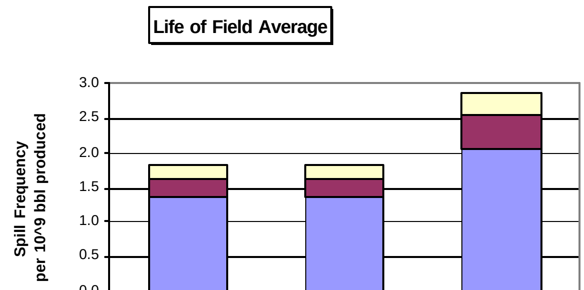
- Pipelines contribute the most (57%) to the two Arctic spill frequency indicators.
- Platforms are next in relative contribution to spill frequencies (33%) and least in contribution to spill index (4%).
- Wells are by far (at 80%) the highest contributors to spill index, while platforms and wells together are responsible for an 84% contribution to the spill index.

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

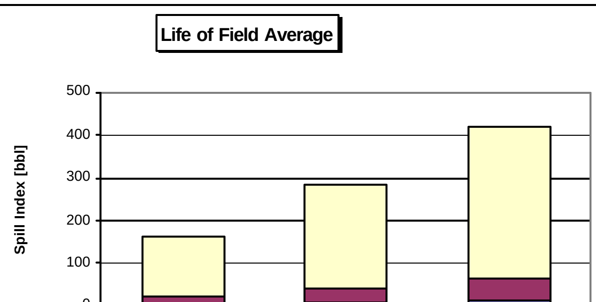
Spill Indicators LOF Average	Low Case			High Case			High Case Non-Arctic		
	Spill Frequency per 10^3 years	Spill Frequency per 10^9 bbl produced	Spill Index [bbl]	Spill Frequency per 10^3 years	Spill Frequency per 10^9 bbl produced	Spill Index [bbl]	Spill Frequency per 10^3 years	Spill Frequency per 10^9 bbl produced	Spill Index [bbl]
Small and Medium Spills 50-999 bbl	12.499	1.350	5	22.491	1.349	9	34.237	2.054	12
	73%	**73%**	**4%**	**74%**	**74%**	**4%**	**72%**	**72%**	**3%**
Large Spills 1000-9999 bbl	2.631	0.284	18	4.715	0.283	31	8.155	0.489	52
	15%	**15%**	**12%**	**15%**	**15%**	**12%**	**17%**	**17%**	**14%**
Huge Spills =>10000 bbl	1.899	0.205	121	3.385	0.203	213	5.239	0.314	302
	11%	**11%**	**84%**	**11%**	**11%**	**84%**	**11%**	**11%**	**83%**
Significant Spills =>1000 bbl	4.529	0.489	138	8.100	0.486	245	13.394	0.804	353
	27%	**27%**	**96%**	**26%**	**26%**	**96%**	**28%**	**28%**	**97%**
All Spills	17.028	1.839	143	30.592	1.835	254	47.631	2.858	365
	100%	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
Pipeline Spills	9.725	1.050	23	17.506	1.050	42	31.452	1.887	78
	57%	**57%**	**16%**	**57%**	**57%**	**16%**	**66%**	**66%**	**21%**
Platform Spills	5.702	0.616	6	10.263	0.616	10	12.331	0.740	12
	33%	**33%**	**4%**	**34%**	**34%**	**4%**	**26%**	**26%**	**3%**
Well Spills	1.601	0.173	114	2.823	0.169	202	3.848	0.231	275
	9%	**9%**	**80%**	**9%**	**9%**	**80%**	**8%**	**8%**	**75%**
Platform and Well Spills	7.303	0.789	120	13.086	0.785	212	16.179	0.971	287
	43%	**43%**	**84%**	**43%**	**43%**	**84%**	**34%**	**34%**	**79%**
All Spills	17.028	1.839	143	30.592	1.835	254	47.631	2.858	365
	100%	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**



	Low Case	High Case	High Case non Arctic
Huge Spills =>10000 bbl	1.899	3.385	5.239
Large Spills 1000-9999 bbl	2.631	4.715	8.155
Small and Medium Spills 50-999 bbl	12.499	22.491	34.237

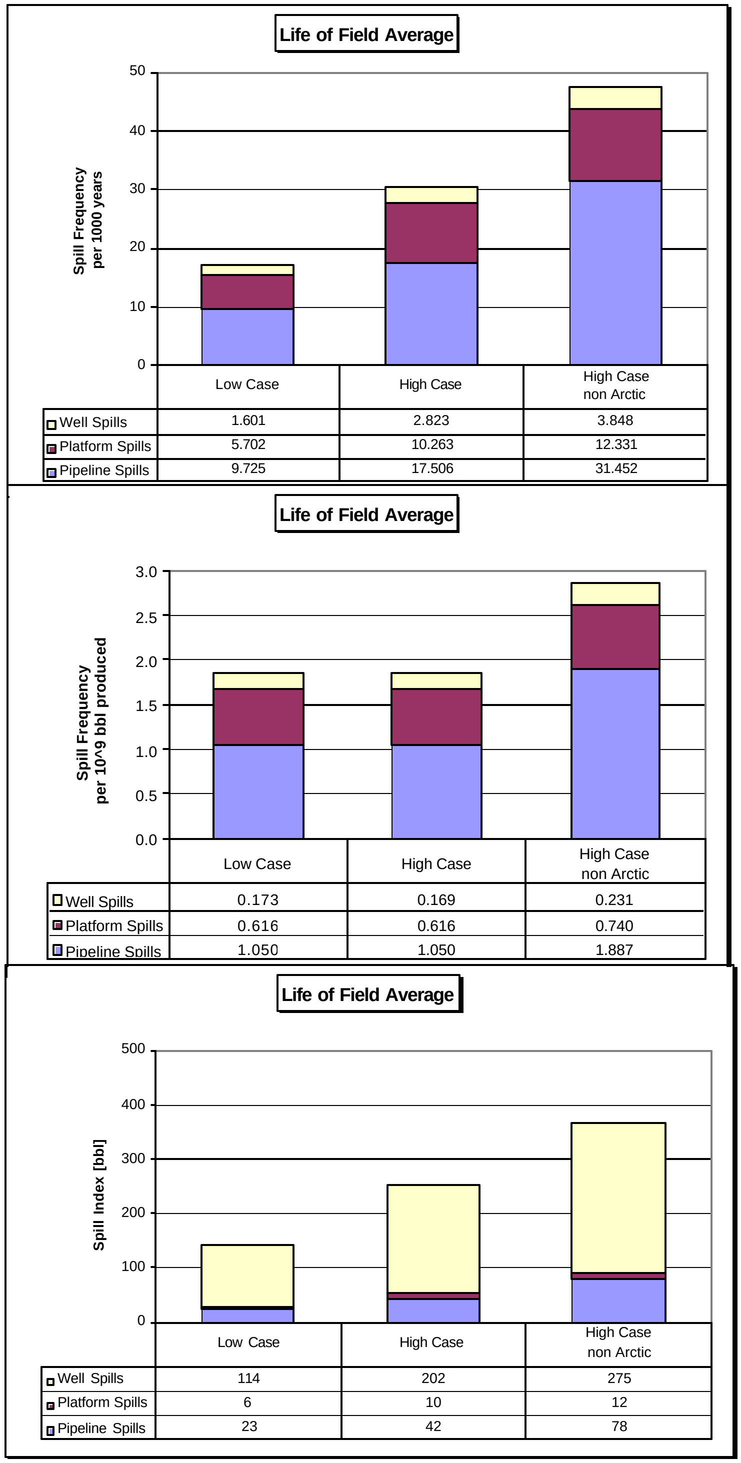


	Low Case	High Case	High Case non Arctic
Huge Spills =>10000 bbl	0.205	0.203	0.314
Large Spills 1000-9999 bbl	0.284	0.283	0.489
Small and Medium Spills 50-999 bbl	1.350	1.349	2.054



	Low Case	High Case	High Case non Arctic
Huge Spills =>10000 bbl	138	245	353
Large Spills 1000-9999 bbl	18	31	52
Small and Medium Spills 50-999 bbl	5	9	12

Figure 1
Chukchi Sea Life of Field Spill Indicators – By Spill Size
(Appendix Figure 5.1)



	Low Case	High Case	High Case non Arctic
Well Spills	1.601	2.823	3.848
Platform Spills	5.702	10.263	12.331
Pipeline Spills	9.725	17.506	31.452

	Low Case	High Case	High Case non Arctic
Well Spills	0.173	0.169	0.231
Platform Spills	0.616	0.616	0.740
Pipeline Spills	1.050	1.050	1.887

	Low Case	High Case	High Case non Arctic
Well Spills	114	202	275
Platform Spills	6	10	12
Pipeline Spills	23	42	78

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

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. Platforms will be in between, with more spills than wells.

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.

B.3 The Variance of Oil Spill Occurrence Indicators

Figures 5, 6, and 7 show the Cumulative Distribution Functions (CDF) for each of the three Chukchi Sea High Case Life of Field average spill indicators. The variability of these indicators is fairly representative of the trends in variability for spill indicators for all sales and locations studied. 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. For example, in the top right-hand graph of Figure 5, the significant spills plot has a much steeper (and hence less variable) slope than that of all spills. Similarly, in the top left-hand graph, small and medium spills illustrate the largest variability; huge spills show the least variability for these facilities.
- The opposite occurs for wells, where large spills show greater variance than small ones.
- The variability of the spill index (Figure 7) shows variance trends opposite to those of the frequency spill indicators.

The Cumulative Distribution Functions contain extensive information on the statistical properties of the spill indicators. For example, from Figure 5, it can be seen, for all significant spills, that the Life of Field average mean (50%) value of 8 (spills per 1,000 years) ranges between about 15 and 3 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 6. The spill index variability shown in Figure 7 is proportionally higher. For example, in Figure 7, the mean value of the significant spills index of 240 per billion barrels produced ranges from 150 to 400.

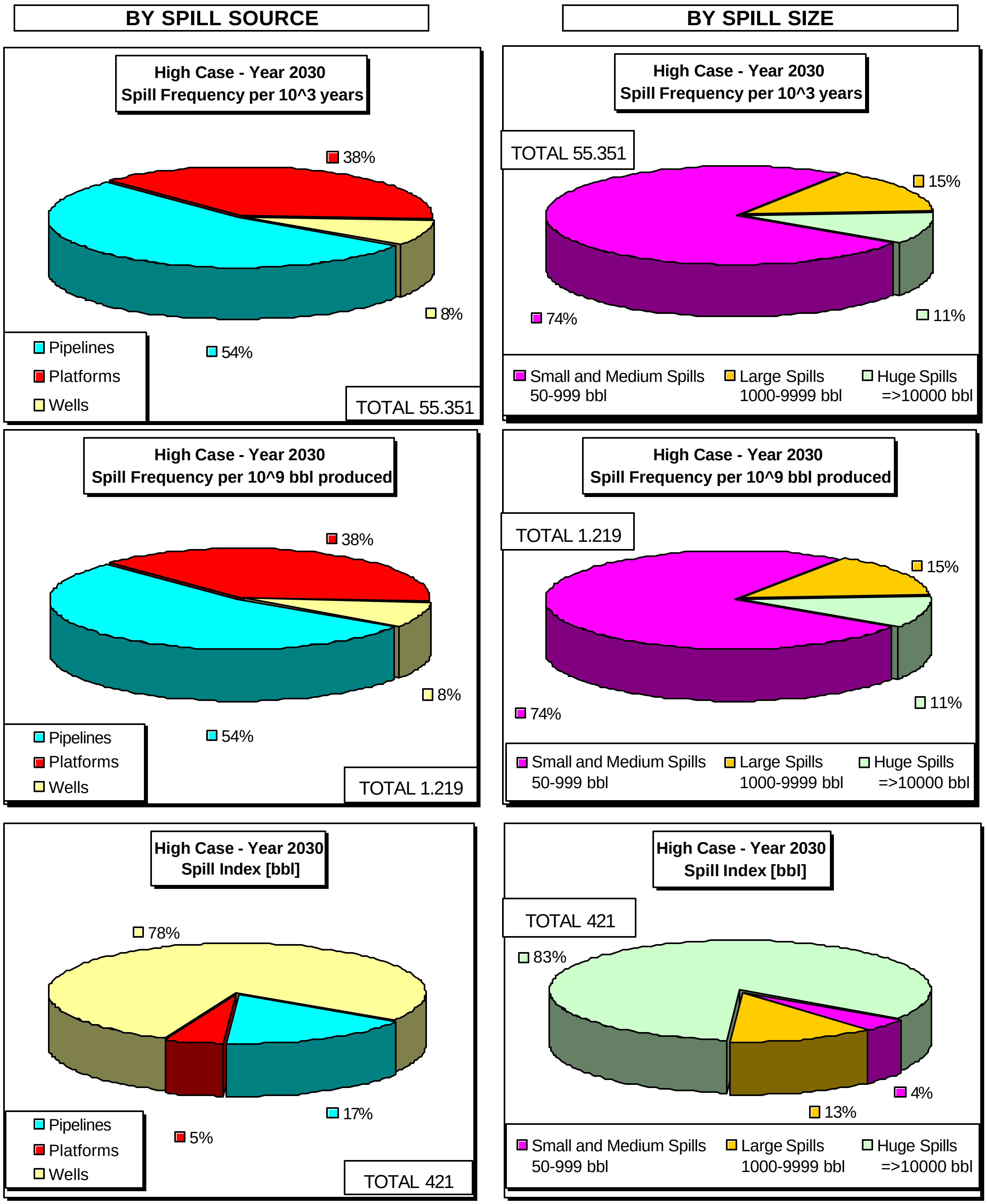


Figure 3
Chukchi Sea High Case – Year 2030 –
Spill Indicator Composition by Source and Spill Size
(Appendix Figure 4.2.17)

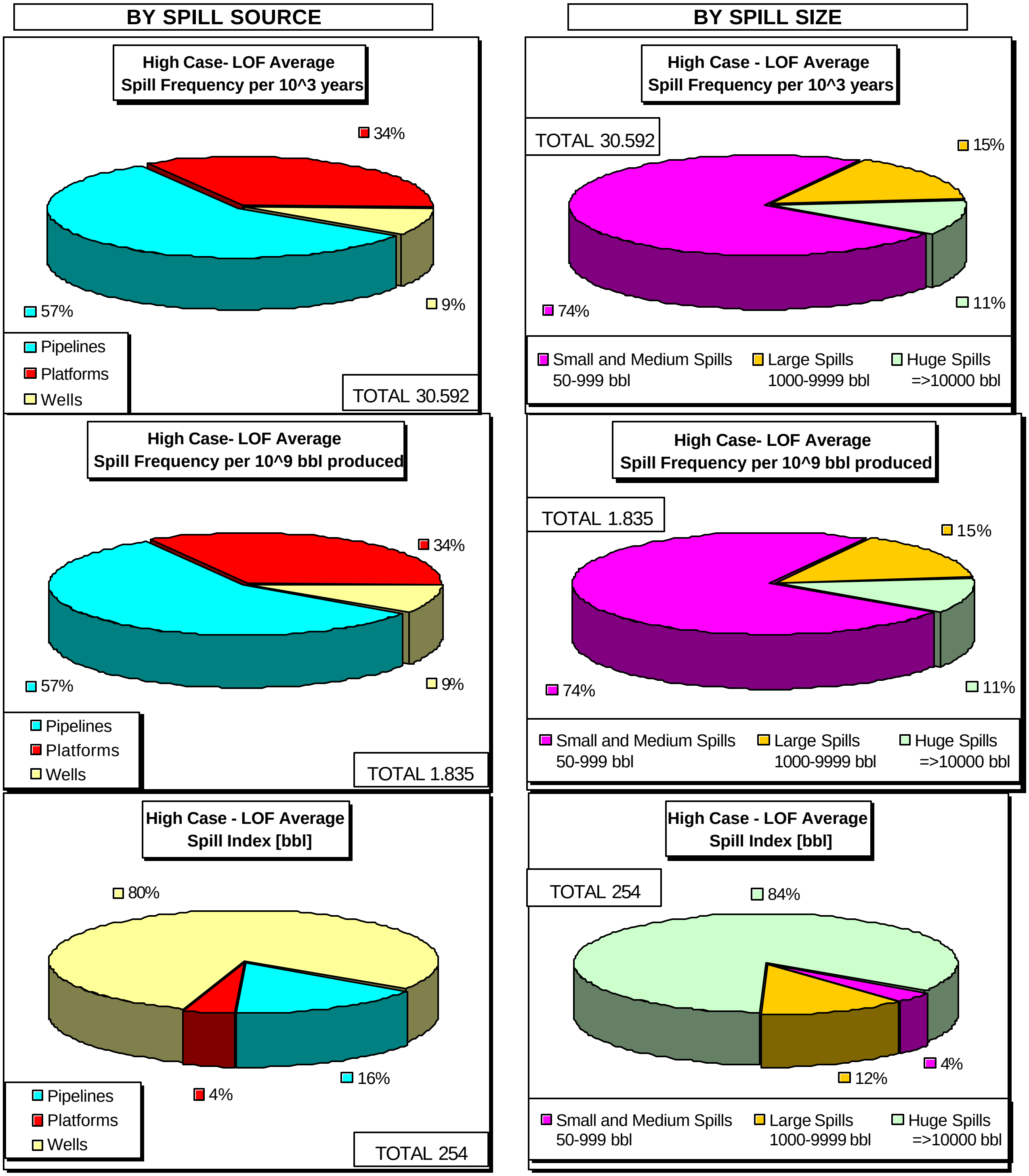


Figure 4
Chukchi Sea High Case – Life of Field Average Spill Indicator
Composition by Source and Spill Size
(Appendix Figure 4.2.18)

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

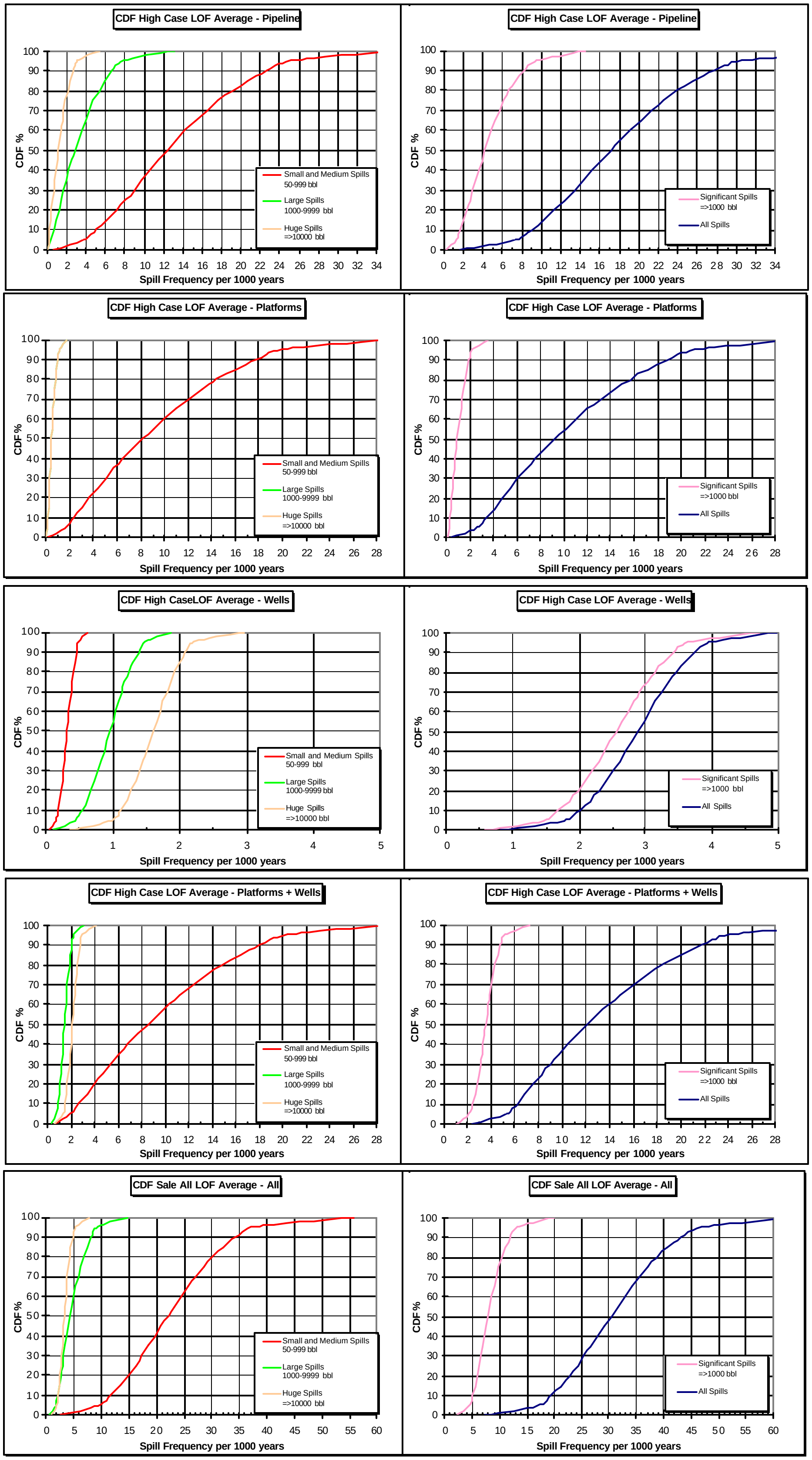
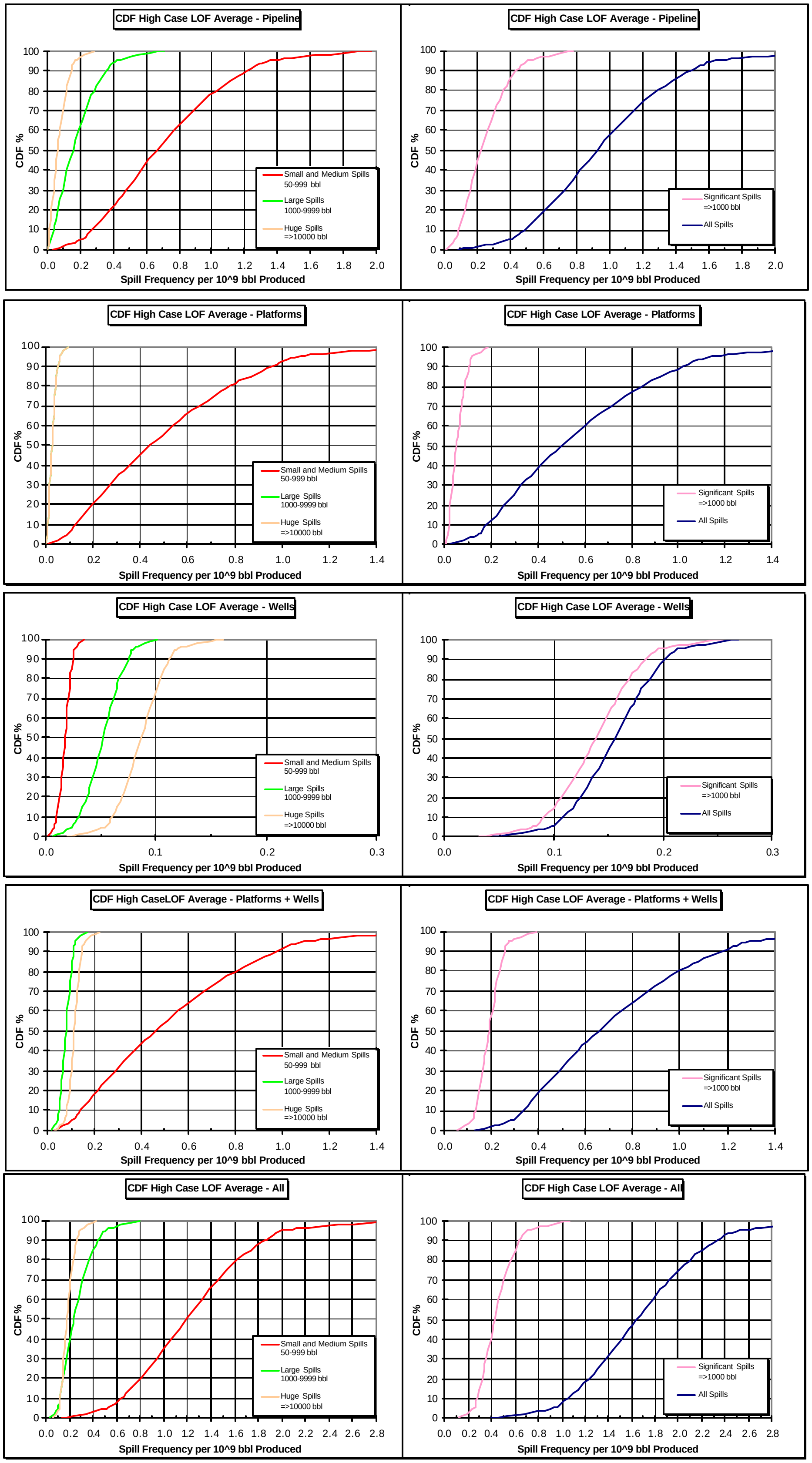


Figure 6
Chukchi Sea
High Case
Life of Field
Average Spills
per Barrel Produced
(Appendix
Figure 4.2.15)



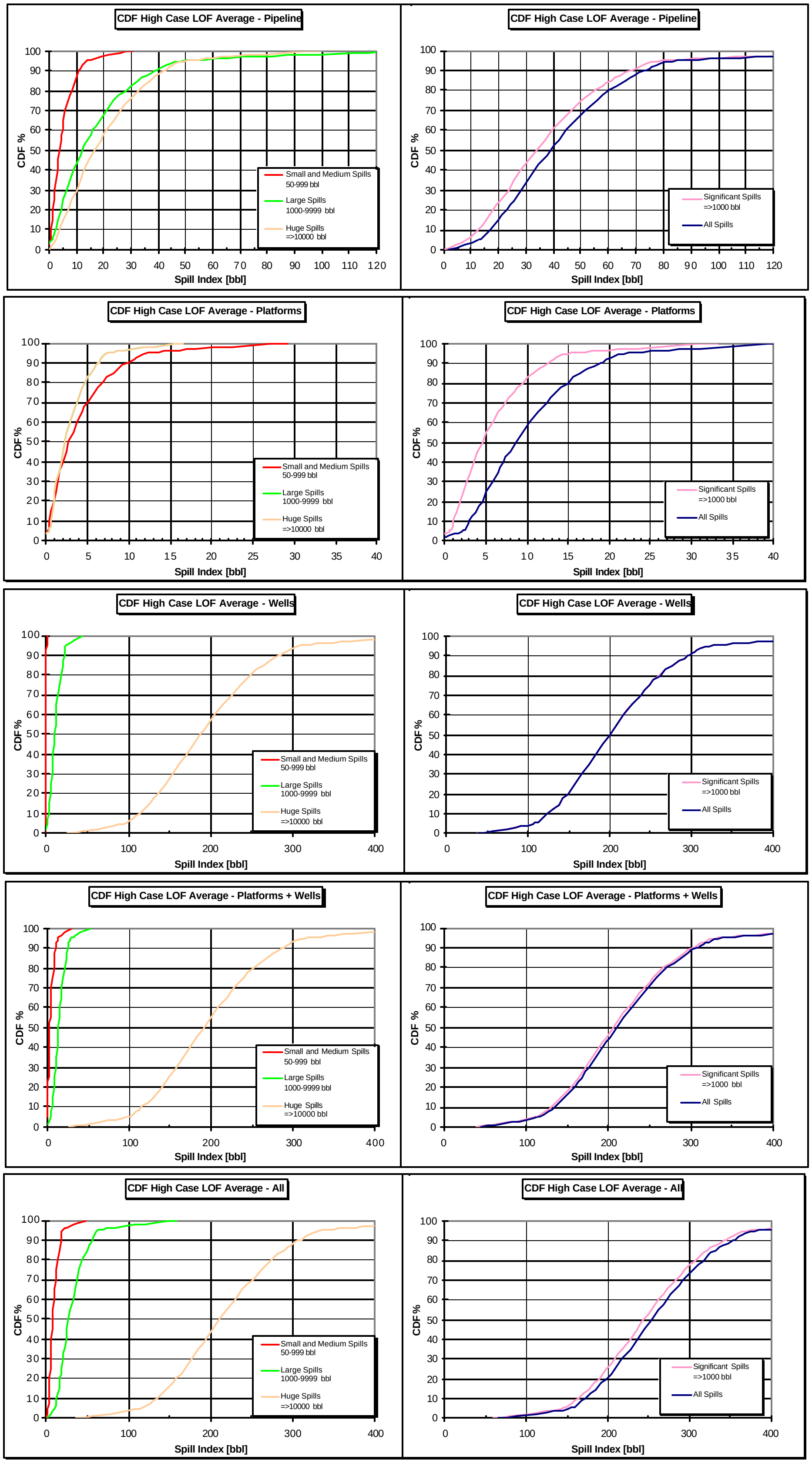


Figure 7
Chukchi Sea High Case Life of Field Average Spill Index (bbl) – CDF
(Appendix Figure 4.2.16)

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 Chukchi 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 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 relative cursory way restricted to engineering judgment.

- Upheaval buckling effect assessments were included on the basis of an educated guess used in previous studies; no engineering analysis was carried out for the assessment of frequencies to be expected for these effects.

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 the 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.

TABLE OF CONTENTS

VOLUME I

CHAPTER **PAGE**

LIST OF APPENDICES

(VOLUME II – APPENDICES)

APPENDIX

LIST OF TABLES

TABLE **PAGE**

LIST OF FIGURES

FIGURE **PAGE**

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 deeper waters in the Chukchi and Beaufort Seas.

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], 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 and Chukchi Seas 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. In the present study, as well as in the preceding Chukchi Sea study [13],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:

- 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 Chukchi Sea sales.

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

- Develop the fault tree method for estimating oil spill occurrences from Chukchi 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. Chukchi 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 Year 2011 to 2040. Within the Chukchi study area, the present development is located in deep water; earlier studies [14] dealt with medium and shallow developments. It is assumed that the development in this study is limited to the deep water location while connecting to land through previously studied developments [13].

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 [12], 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

Task 1: *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 Technoloty (SINTEF), United Kingdom Health & Safety Executive (HSE), and others.

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

d) Chukchi Sea scenario development from MMS information.

Task 2: *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.

Task 3: *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.

Task 4: *Generation of Oil Spill Occurrence Estimator Probability Distributions*

a) Variability in future development scenario parameters.

b) Model runs for variable Chukchi Sea High and Low scenarios.

c) Model runs for comparative non-Arctic scenario.

Task 5: *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.

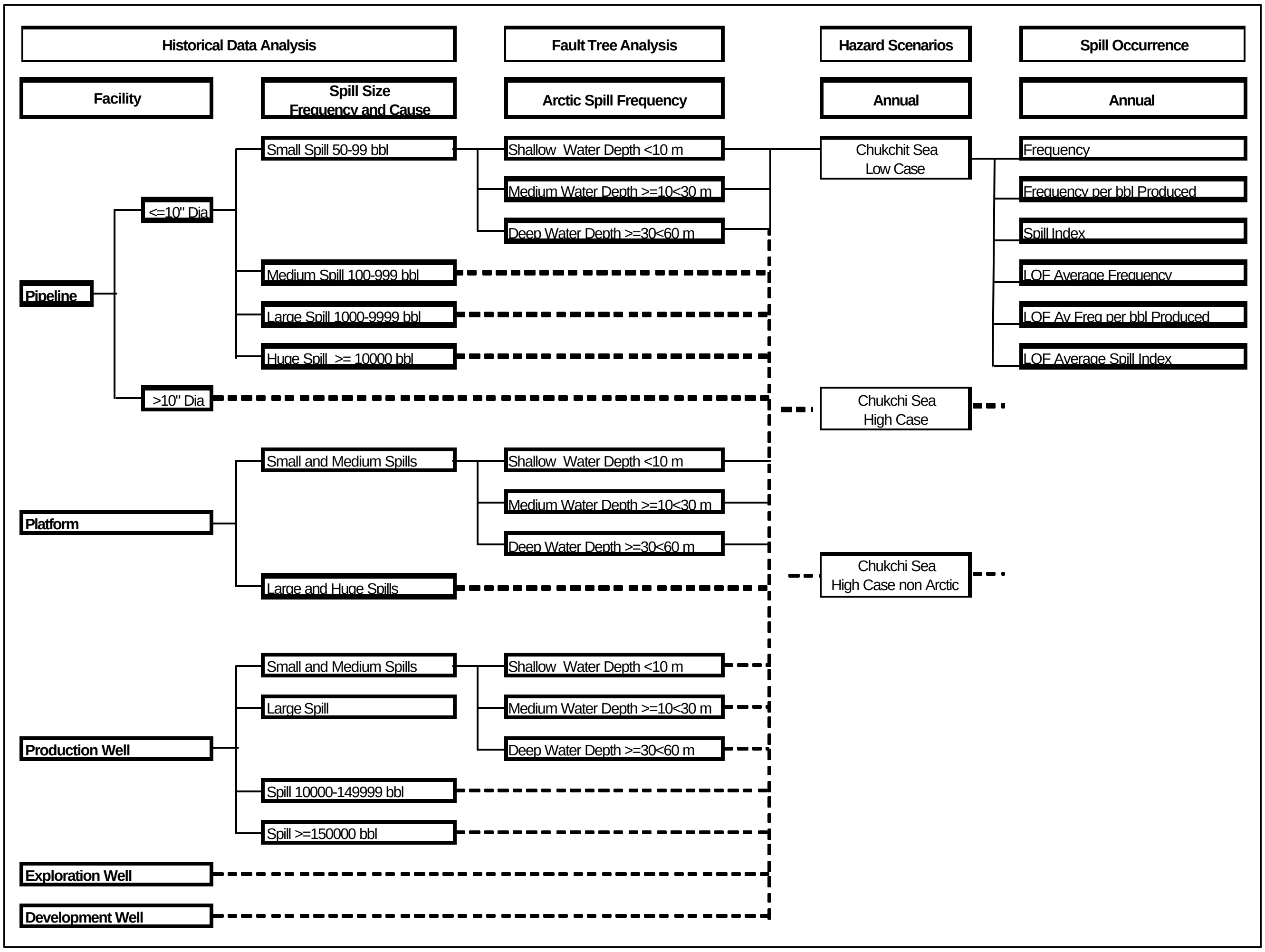


Figure 1.2
Calculation Flow Chart

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 Chukchi Sea extended beyond the 60-meter isobath.

Two principal future development scenarios were defined for the Chukchi Sea, as well as a compatible non-Arctic (hypothetical) scenario. The two Arctic scenarios represent a High and Low production volume case. Each scenario was described for each year in its development history, from the year 2011 to the year 2040. 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:

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

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.

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.

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

2.5.2 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:

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

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 present deep water location in the Chukchi, ice gouging does not occur.

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 – so that for the present study, they do not apply.

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 quantified in previous work [12, 13]. Assuming that a upheaval buckling occurs 20% as often as strudel scour [13], 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. Other Arctic effects have been incorporated on the basis of values used in preceding studies [12, 13].

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. As there are no permafrost strata in the Chukchi study area, no thaw settlement is expected.

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.

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

CAUSE CLASSIFICATION	Spill Size	Deep – Frequency Increment per 10^5 km-year		
		Min	Mode	Max
Upheaval Buckling	S	0.00221	0.00469	0.02761
	M	0.00221	0.00469	0.02761
	L	0.00552	0.01174	0.06904
	H	0.00110	0.00235	0.01381
Other Arctic	S	0.00033	0.00070	0.00414
	M	0.00033	0.00070	0.00414
	L	0.00083	0.00176	0.01036
	H	0.00017	0.00035	0.00207

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

CAUSE	SPILL SIZE	Water Depth – Deep – Frequency Increment per 10^4 well-year – Expected / *Mode*	REASON
Ice Force	SM	0.3256	Assumed 10,000 year return period ice force causes spill 4% of occurrences (96% reliability). 85% of the spills are SM.
		0.0765	
	LH	0.0575	
		0.0135	
Facility Low Temperature	SM	0.0986	Assumed fraction of Historical Equipment Failure release frequency with 6% for SM and 1% for LH spill sizes.
		0.0986	
	LH	0.0164	
		0.0164	
Other Arctic	SM	0.0212	5% of sum of above.
		0.0088	
	LH	0.0037	
		0.0015	

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 [14].

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

The subject development is assumed to be entirely in deep water; pipelines connecting the current estimated location to shore were considered in previous studies [13]. For the purposes of the fault tree analysis utilized in this study, future Chukchi 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 (deep water only)
- 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. As indicated above, the subject development is located entirely in deep water.

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 is the Chukchi Sea lease deep water location.

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 Chukchi Sea Development Scenarios

As a basis for the current analysis, the geographic 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. Table 3.2 summarizes the key quantity parameters of a possible High and Low production Chukchi scenario. The facility quantities are hypothetical, and not based on any operator's plan. No facilities are assumed in the very deep region; all are in the deep region. Onshore facilities are mentioned in Table 3.2 for completeness, but excluded in the analysis.

Table 3.3 summarizes the High Case development scenario including its temporal development from 2011 to Year 2040, after which time it is forecast to cease production. 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 Table 3.3:

- Exploration wells drilled – annual
- Delineation wells drilled – annual
- Production platforms – annual and cumulative
- 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.

Table 3.4 summarizes the Low Case Chukchi development scenario.

The high and low values given in Tables 3.3 and 3.4, respectively, were used in the balance of the calculations.

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

Scenario Element	Range		Comments
	High	Low	
Maximum oil production (Bbbl / year)	54	30	-
Natural gas production	0	0	Delayed for North Slope gas line; reinjected
Exploration wells	7	4	-
Delineation wells	8	4	Confirm and define the commercial discovery
Production platforms	2	1	Central platform with processing facility; supports 20-100 wells.
Production wells	50	25	On platform
Service wells	-	-	All service wells are on platform
In-field flowlines (mi)	0	0	None
Offshore pipeline (mi)	80	40	Additional pipelines to shore were included in the previous study [13]
Onshore sales pipeline (mi)	300	300	Connecting to existing/future North Slope pipelines (n/a)
Years of activity	30	28	Period from lease sale to end of oil production

Table 3.3
Chukchi Sea High Case Development Data (2011-2040)
(App. Table 3.3)

Year	Water Depth	Exploration Wells	Delineation Wells	Expl./Del. Rigs	Production Platforms							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.	
2011	Shallow																	
	Medium																	
	Deep	1		1														
	Total	**1**		**1**														
2012	Shallow																	
	Medium																	
	Deep	1	1	1														
	Total	**1**	**1**	**1**														
2013	Shallow																	
	Medium																	
	Deep		2	1														
	Total		**2**	**1**														
2014	Shallow																	
	Medium																	
	Deep	1	1	1														
	Total	**1**	**1**	**1**														
2015	Shallow																	
	Medium																	
	Deep	2	1	2														
	Total	**2**	**1**	**2**														
2016	Shallow																	
	Medium																	
	Deep	1	2	2														
	Total	**1**	**2**	**2**														
2017	Shallow																	
	Medium																	
	Deep	1	1	1														
	Total	**1**	**1**	**1**														
2018	Shallow																	
	Medium																	
	Deep																	
	Total																	
2019	Shallow																	
	Medium																	
	Deep													10	10	10	10	
	Total													**10**	**10**	10	10	
2020	Shallow																	
	Medium																	
	Deep													10	20	10	20	
	Total													**10**	**20**	10	20	

Table 3.3 ~ *Continued* ~

Year	Water Depth	Exploration Wells	Delineation Wells	Expl./Del. Rigs	Production Platforms							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.	
2021	Shallow																	
	Medium																	
	Deep													20	40	20	40	
	Total													**20**	**40**	20	40	
2022	Shallow																	
	Medium																	
	Deep				1	1	6	6			1			10	50	10	50	13.5
	Total				**1**	**1**	**6**	**6**			**1**			**10**	**50**	10	50	**13.5**
2023	Shallow																	
	Medium																	
	Deep					1	7	13			1			10	60	10	60	16.9
	Total					**1**	**7**	**13**			**1**			**10**	**60**	10	60	**16.9**
2024	Shallow																	
	Medium																	
	Deep					1	7	20			1			20	80	20	80	22.5
	Total					**1**	**7**	**20**			**1**			**20**	**80**	20	80	**22.5**
2025	Shallow																	
	Medium																	
	Deep				1	2	11	31			2				80		80	43.5
	Total				**1**	**2**	**11**	**31**			**2**				**80**		80	**43.5**
2026	Shallow																	
	Medium																	
	Deep					2	7	38			1				80		80	46.9
	Total					**2**	**7**	**38**			**1**				**80**		80	**46.9**
2027	Shallow																	
	Medium																	
	Deep					2	7	45			1				80		80	52.5
	Total					**2**	**7**	**45**			**1**				**80**		80	**52.5**
2028	Shallow																	
	Medium																	
	Deep					2	5	50			1				80		80	54.0
	Total					**2**	**5**	**50**			**1**				**80**		80	**54.0**
2029	Shallow																	
	Medium																	
	Deep					2		50							80		80	49.2
	Total					**2**		**50**							**80**		80	**49.2**
2030	Shallow																	
	Medium																	
	Deep					2		50							80		80	45.4
	Total					**2**		**50**							**80**		80	**45.4**

Table 3.3 ~ *Continued ~*

Year	Water Depth	Exploration Wells	Delineation Wells	Expl./Del. Rigs	Production Platforms							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																	
	Medium																	
	Deep					2		50							80		80	36.3
	Total					**2**		**50**							**80**		80	**36.3**
2032	Shallow																	
	Medium																	
	Deep					2		50							80		80	29.0
	Total					**2**		**50**							**80**		80	**29.0**
2033	Shallow																	
	Medium																	
	Deep					2		50							80		80	23.3
	Total					**2**		**50**							**80**		80	**23.3**
2034	Shallow																	
	Medium																	
	Deep					2		50							80		80	18.6
	Total					**2**		**50**							**80**		80	**18.6**
2035	Shallow																	
	Medium																	
	Deep					2		50							80		80	14.8
	Total					**2**		**50**							**80**		80	**14.8**
2036	Shallow																	
	Medium																	
	Deep					2		50							80		80	11.9
	Total					**2**		**50**							**80**		80	**11.9**
2037	Shallow																	
	Medium																	
	Deep					2		50							80		80	9.5
	Total					**2**		**50**							**80**		80	**9.5**
2038	Shallow																	
	Medium																	
	Deep				-1	1	-25	25						-40	40	-40	40	5.0
	Total				**-1**	**1**	**-25**	**25**						**-40**	**40**	-40	40	**5.0**
2039	Shallow																	
	Medium																	
	Deep					1		25							40		40	4.0
	Total					**1**		**25**							**40**		40	**4.0**
2040	Shallow																	
	Medium																	
	Deep					1		25							40		40	3.2
	Total					**1**		**25**							**40**		40	**3.2**

Table 3.4
Chukchi Sea Low Case Development Data (2011-2038)

Year	Water Depth	Exploration Wells	Delineation Wells	Expl./Del. Rigs	Production Platforms							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.	
2011	Shallow																	
	Medium																	
	Deep	1		1														
	Total	**1**		**1**														
2012	Shallow																	
	Medium																	
	Deep	1	1	1														
	Total	**1**	**1**	**1**														
2013	Shallow																	
	Medium																	
	Deep		2	1														
	Total		**2**	**1**														
2014	Shallow																	
	Medium																	
	Deep	1	1	1														
	Total	**1**	**1**	**1**														
2015	Shallow																	
	Medium																	
	Deep	1		1														
	Total	**1**		**1**														
2016	Shallow																	
	Medium																	
	Deep																	
	Total																	
2017	Shallow																	
	Medium																	
	Deep																	
	Total																	
2018	Shallow																	
	Medium																	
	Deep																	
	Total																	
2019	Shallow																	
	Medium																	
	Deep													10	10	10	10	
	Total													**10**	**10**	10	10	
2020	Shallow																	
	Medium																	
	Deep													10	20	10	20	
	Total													**10**	**20**	10	20	

Table 3.4 ~ *Continued* ~

Year	Water Depth	Exploration Wells	Delineation Wells	Expl./Del. Rigs	Production Platforms							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.	
2021	Shallow																	
	Medium																	
	Deep													20	40	20	40	
	Total													**20**	**40**	20	40	
2022	Shallow																	
	Medium																	
	Deep				1	1	6	6			1				40		40	13.5
	Total				**1**	**1**	**6**	**6**			**1**				**40**		40	**13.5**
2023	Shallow																	
	Medium																	
	Deep					1	7	13			1				40		40	16.9
	Total					**1**	**7**	**13**			**1**				**40**		40	**16.9**
2024	Shallow																	
	Medium																	
	Deep					1	7	20			1				40		40	22.5
	Total					**1**	**7**	**20**			**1**				**40**		40	**22.5**
2025	Shallow																	
	Medium																	
	Deep					1	5	25			1				40		40	30.0
	Total					**1**	**5**	**25**			**1**				**40**		40	**30.0**
2026	Shallow																	
	Medium																	
	Deep					1		25							40		40	30.0
	Total					**1**		**25**							**40**		40	**30.0**
2027	Shallow																	
	Medium																	
	Deep					1		25							40		40	30.0
	Total					**1**		**25**							**40**		40	**30.0**
2028	Shallow																	
	Medium																	
	Deep					1		25							40		40	24.0
	Total					**1**		**25**							**40**		40	**24.0**
2029	Shallow																	
	Medium																	
	Deep					1		25							40		40	19.2
	Total					**1**		**25**							**40**		40	**19.2**
2030	Shallow																	
	Medium																	
	Deep					1		25							40		40	15.4
	Total					**1**		**25**							**40**		40	**15.4**

Table 3.4 ~ *Continued ~*

Year	Water Depth	Exploration Wells	Delineation Wells	Expl./Del. Rigs	Production Platforms							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																	
	Medium																	
	Deep					1		25							40		40	12.3
	Total					**1**		**25**							**40**		40	**12.3**
2032	Shallow																	
	Medium																	
	Deep					1		25							40		40	9.8
	Total					**1**		**25**							**40**		40	**9.8**
2033	Shallow																	
	Medium																	
	Deep					1		25							40		40	7.9
	Total					**1**		**25**							**40**		40	**7.9**
2034	Shallow																	
	Medium																	
	Deep					1		25							40		40	6.3
	Total					**1**		**25**							**40**		40	**6.3**
2035	Shallow																	
	Medium																	
	Deep					1		25							40		40	5.0
	Total					**1**		**25**							**40**		40	**5.0**
2036	Shallow																	
	Medium																	
	Deep					1		25							40		40	4.0
	Total					**1**		**25**							**40**		40	**4.0**
2037	Shallow																	
	Medium																	
	Deep					1		25							40		40	3.2
	Total					**1**		**25**							**40**		40	**3.2**
2038	Shallow																	
	Medium																	
	Deep				-1		-25							-40		-40		
	Total				**-1**		**-25**							**-40**		-40		

CHAPTER 4

FAULT TREE ANALYSIS FOR ARCTIC OIL SPILL FREQUENCIES

4.1 General Description of Fault Tree Analysis

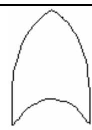
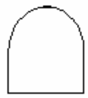
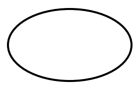
Fault trees are a method for modeling the occurrence of failures. They are used when an adequate history to provide failure statistics is not available. Developed initially by Rasmussen for the US Nuclear Regulatory Commission in the early 1970s [65, 51], fault trees have become a popular risk analytic 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

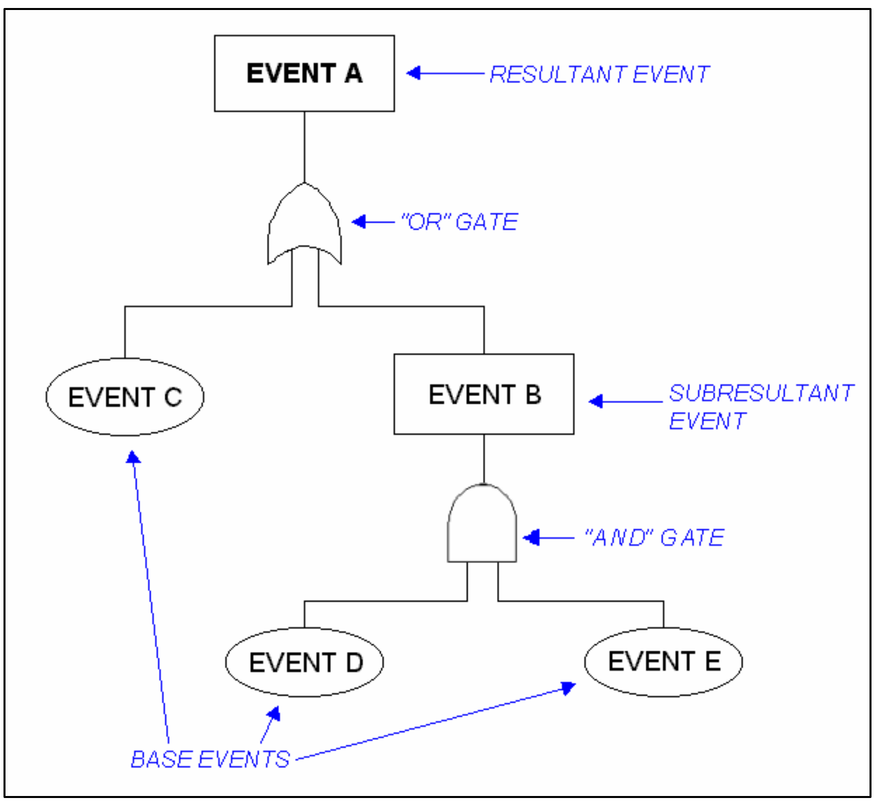
4.2.1 Fault Tree Analysis Basics

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, 14, 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, …

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

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

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.

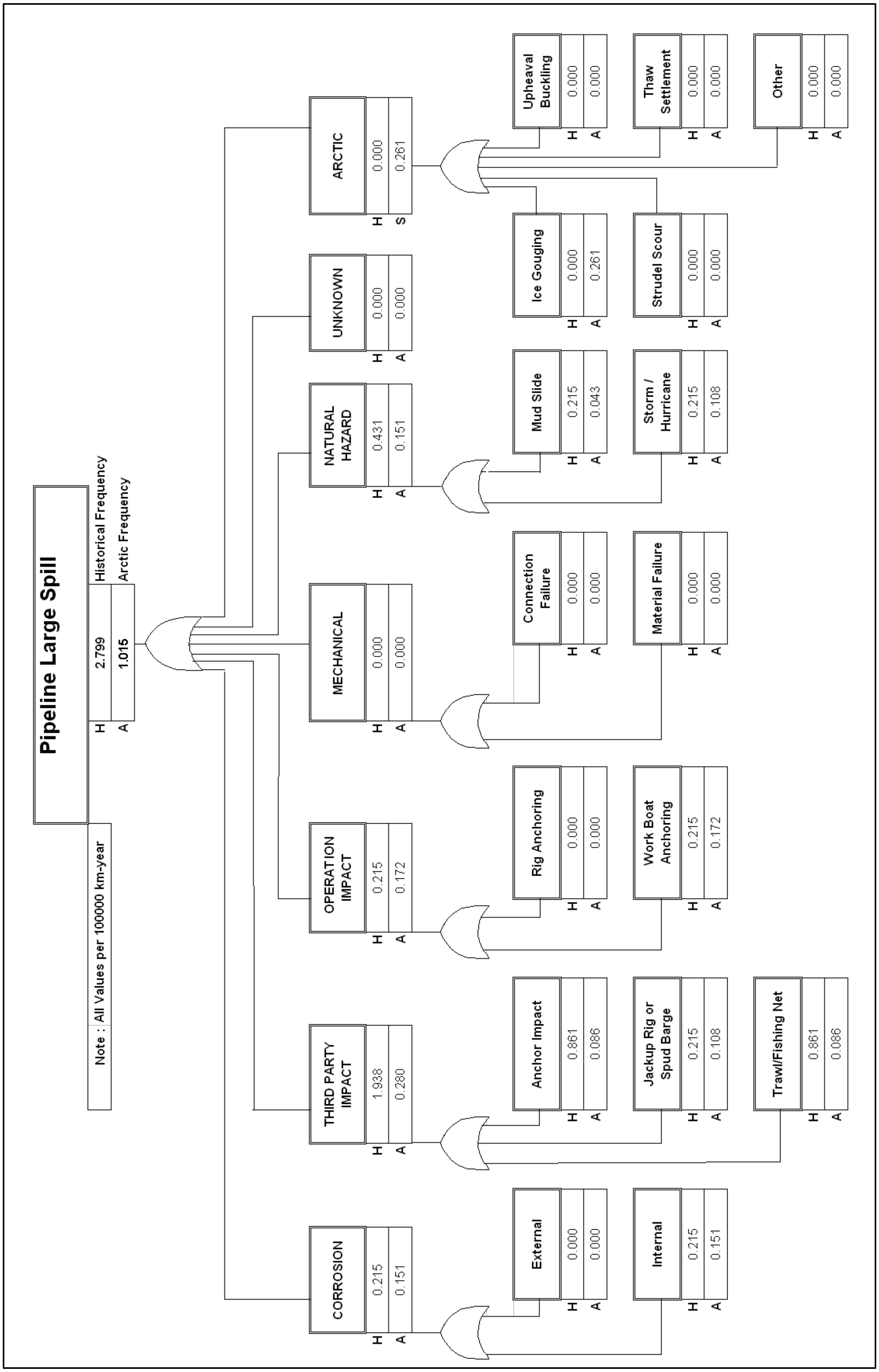


Figure 4.2
Example of Fault Tree to Transform Historical (GOM) to Arctic Spill Frequencies[1]

[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:

$$X = X_1 + X_2 \quad \textbf{(4.3)}$$

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.

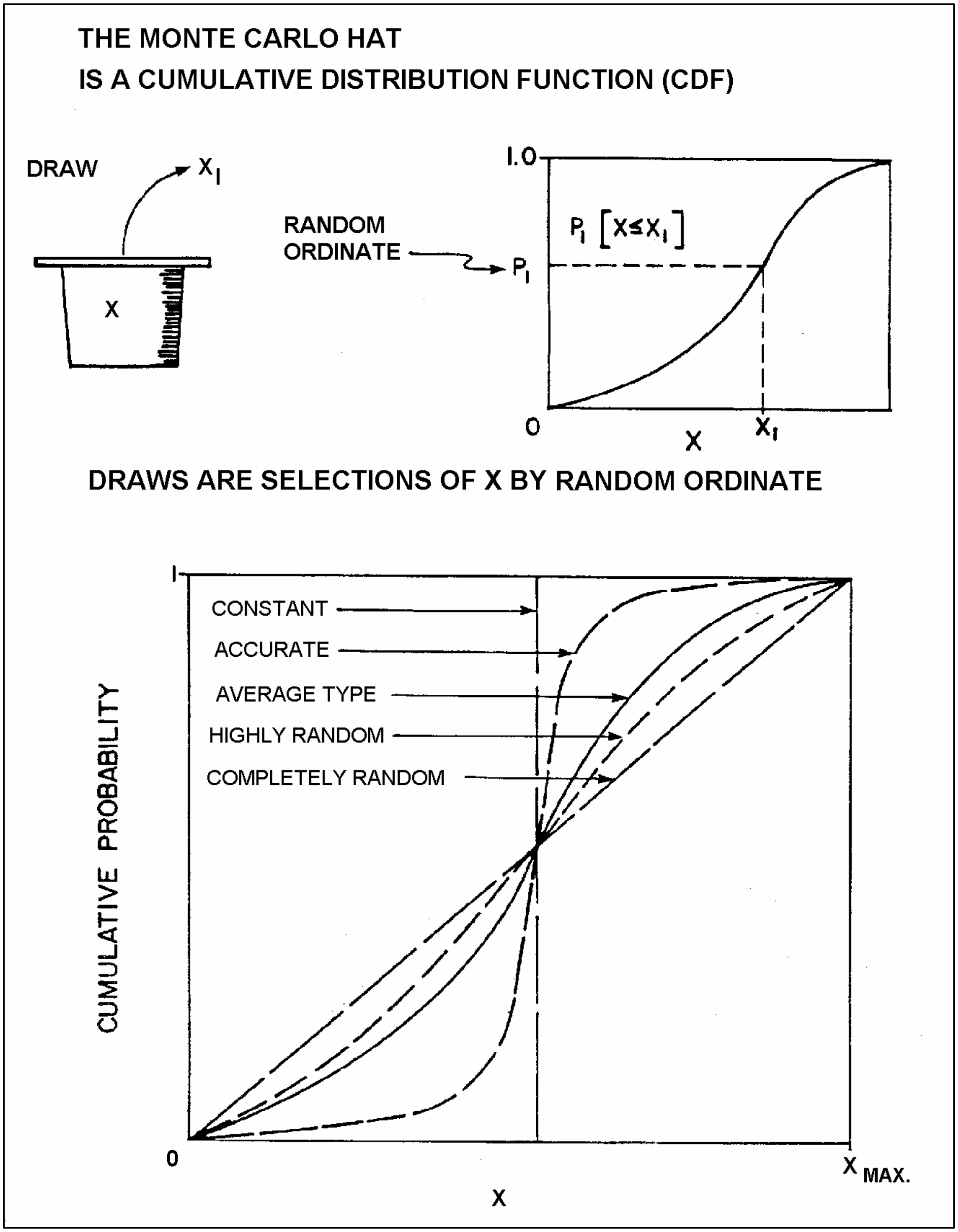


Figure 4.3
Monte Carlo Technique Schematic

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 study [12], a Triangular Distribution was selected.

According to [13], 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:

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

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	Deep Historical Expected Frequency Change %	Reason
CORROSION			
External	All	(30)	Low temperature and bio effects. Extra smart pigging.
Internal	All	(30)	Extra smart pigging.
THIRD PARTY IMPACT			
Anchor Impact	All	(50)	Low traffic.
Jackup Rig or Spud Barge	All	(50)	Low facility density.
Trawl/Fishing Net	All	(50)	Low fishing activity. Less bottom fishing in deeper water.
OPERATION IMPACT			
Rig Anchoring	All	(20)	Low marine traffic during ice season (8 months).
Work Boat Anchoring	All	(20)	Low work boat traffic during ice season (8 months).
MECHANICAL			
Connection Failure	All		
Material Failure	All		
NATURAL HAZARD			
Mud Slide	All	(80)	Gradient low. Mud slide potential (gradient) increases with water depth.
Storm/ Hurricane	All	(60)	Fewer severe storms.
		Freq. Increment per 10^5 km-year **Expected** **Mode**	
ARCTIC			
Upheaval Buckling	S	0.0129 0.0047	The failure frequency is 20% of that of Strudel Scour [13].
	M	0.0129 0.0047	
	L	0.0323 0.0117	
	H	0.0065 0.0023	
Other Arctic	S	0.0019 0.0007	Assessed as 10% of all Arctic effects [13].
	M	0.0019 0.0007	
	L	0.0048 0.0018	
	H	0.0010 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 $^1/_{10}$ of the modal value.

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

CAUSE CLASSIFICATION	Spill Size	Deep		
		Frequency Change %		
		Min	Mode	Max
CORROSION				
External	**All**	(90)	(30)	(10)
Internal	**All**	(90)	(30)	(10)
THIRD PARTY IMPACT				
Anchor Impact	**All**	(90)	(50)	(10)
Jackup Rig or Spud Barge	**All**	(90)	(50)	(10)
Trawl/Fishing Net	**All**	(90)	(50)	(10)
OPERATION IMPACT				
Rig Anchoring	**All**	(50)	(20)	(10)
Work Boat Anchoring	**All**	(50)	(20)	(10)
MECHANICAL				
Connection Failure	**All**			
Material Failure	**All**			
NATURAL HAZARD				
Mud Slide	**All**	(90)	(80)	(10)
Storm/ Hurricane	**All**	(90)	(60)	(10)
		Frequency Increment per 10^5 km-year		
ARCTIC UNIQUE				
Upheaval Buckling	**S**	0.00221	0.00469	0.02761
	M	0.00221	0.00469	0.02761
	L	0.00552	0.01174	0.06904
	H	0.00110	0.00235	0.01381
Other Arctic	**S**	0.00033	0.00070	0.00414
	M	0.00033	0.00070	0.00414
	L	0.00083	0.00176	0.01036
	H	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. Although only deep water is applicable for this development, frequencies derived for shallow and medium depth categories are shown, but not used later. 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 2.750 for deep water. A similar reduction of failure frequencies 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.

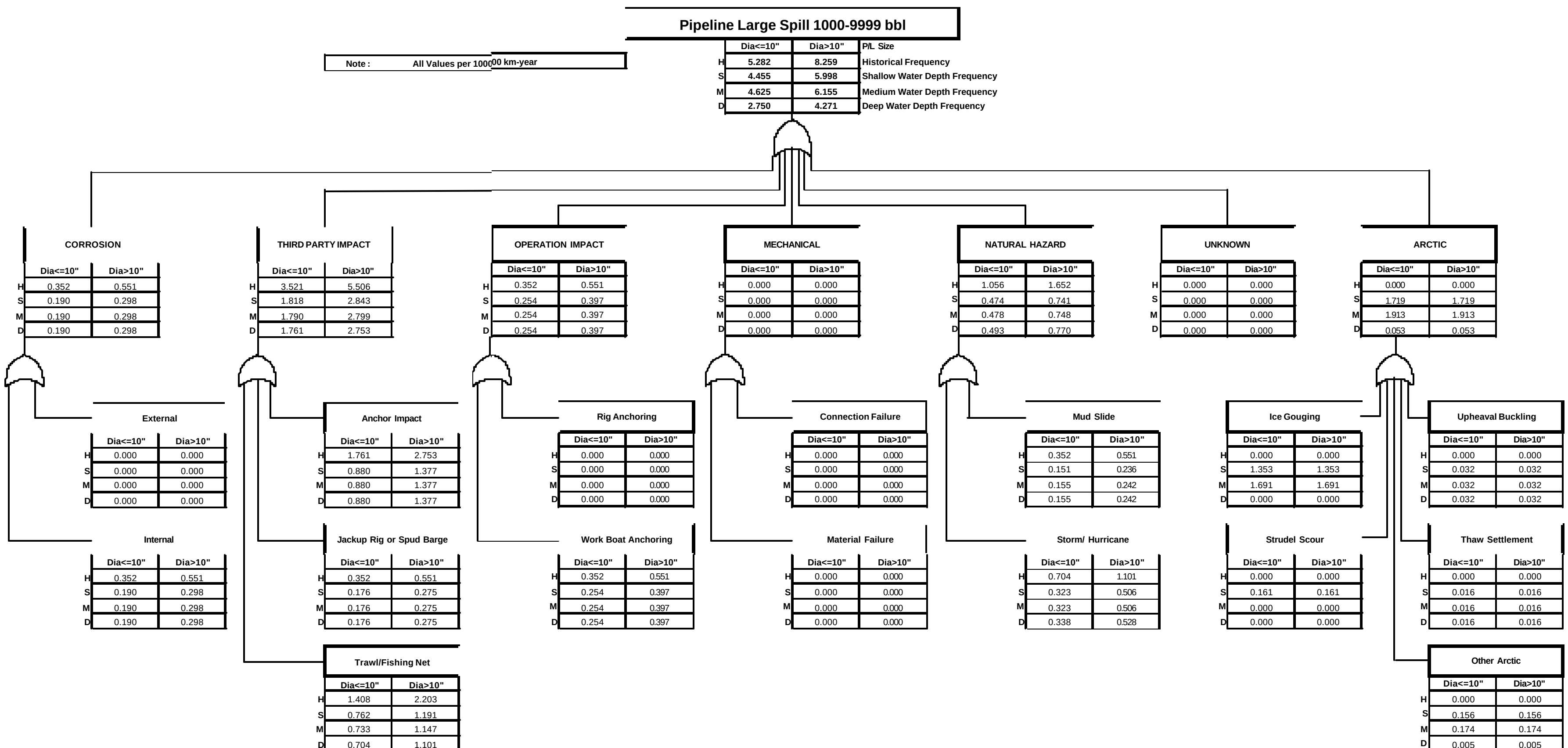


Figure 4.4
Large Spill Frequencies for Pipeline
(Appendix Figure 2.3)

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

CAUSE CLASSIFICATION	HISTORICAL DISTRIBUTION %	SMALL SPILLS 50-99 bbl							
		Pipeline Diameter <=10"				Pipeline Diameter >10"			
			Deep				Deep		
		FREQUENCY spills per 10^5km-year	Frequency Change	New Frequency	New Distribution %	FREQUENCY spills per 10^5km-year	Frequency Change	New Frequency	New Distribution %
CORROSION	**8.57**	**0.517**	**(0.238)**	**0.280**	**5.84**	**0.566**	**(0.260)**	**0.306**	**5.84**
External	2.86	0.172	(0.079)	0.093	1.95	0.189	(0.087)	0.102	1.95
Internal	5.71	0.345	(0.158)	0.187	3.89	0.378	(0.173)	0.204	3.89
THIRD PARTY IMPACT	**22.86**	**1.380**	**(0.690)**	**0.690**	**14.39**	**1.510**	**(0.755)**	**0.755**	**14.40**
Anchor Impact	20.00	1.207	(0.604)	0.604	12.60	1.322	(0.661)	0.661	12.60
Jackup Rig or Spud Barge									
Trawl/Fishing Net	2.86	0.172	(0.086)	0.086	1.80	0.189	(0.094)	0.094	1.80
OPERATION IMPACT	**8.57**	**0.517**	**(0.145)**	**0.373**	**7.78**	**0.566**	**(0.158)**	**0.408**	**7.78**
Rig Anchoring	2.86	0.172	(0.048)	0.124	2.59	0.189	(0.053)	0.136	2.59
Work Boat Anchoring	5.71	0.345	(0.096)	0.249	5.19	0.378	(0.106)	0.272	5.19
MECHANICAL	**5.71**	**0.345**		**0.345**	**7.20**	**0.378**		**0.378**	**7.20**
Connection Failure	2.86	0.172		0.172	3.60	0.189		0.189	3.60
Material Failure	2.86	0.172		0.172	3.60	0.189		0.189	3.60
NATURAL HAZARD	**48.57**	**2.932**	**(0.193)**	**2.739**	**57.15**	**3.209**	**(0.211)**	**2.998**	**57.17**
Mud Slide	5.71	0.345	(0.193)	0.152	3.17	0.378	(0.211)	0.166	3.17
Storm/ Hurricane	42.86	2.587		2.587	53.98	2.832		2.832	54.00
ARCTIC			**0.021**	**0.021**	**0.44**		**0.021**	**0.021**	**0.41**
Ice Gouging									
Strudel Scour									
Upheaval Buckling			0.0129	0.0129	0.27		0.0129	0.0129	0.25
Thaw Settlement			0.0065	0.0065	0.13		0.0065	0.0065	0.12
Other Arctic			0.0019	0.0019	0.04		0.0019	0.0019	0.04
UNKNOWN	**5.71**	**0.345**		**0.345**	**7.20**	**0.378**		**0.378**	**7.20**
TOTALS	**100.00**	**6.036**	**(1.244)**	**4.792**	**100.00**	**6.608**	**(1.363)**	**5.244**	**100.00**

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

CAUSE CLASSIFICATION	HISTORICAL DISTRIBUTION %	MEDIUM SPILLS 100-999 bbl							
		Pipeline Diameter <=10"				Pipeline Diameter >10"			
		FREQUENCY spills per 10^5km-year	Deep			FREQUENCY spills per 10^5km-year	Deep		
			Frequency Change	New Frequency	New Distribution %		Frequency Change	New Frequency	New Distribution %
CORROSION	**8.57**	**0.905**	**(0.416)**	**0.490**	**5.85**	**1.274**	**(0.585)**	**0.689**	**5.86**
External	2.86	0.302	(0.139)	0.163	1.95	0.425	(0.195)	0.230	1.95
Internal	5.71	0.604	(0.277)	0.327	3.90	0.850	(0.390)	0.460	3.90
THIRD PARTY IMPACT	**22.86**	**2.414**	**(1.207)**	**1.207**	**14.42**	**3.398**	**(1.699)**	**1.699**	**14.43**
Anchor Impact	20.00	2.113	(1.056)	1.056	12.62	2.973	(1.487)	1.487	12.63
Jackup Rig or Spud Barge									
Trawl/Fishing Net	2.86	0.302	(0.151)	0.151	1.80	0.425	(0.212)	0.212	1.80
OPERATION IMPACT	**8.57**	**0.905**	**(0.253)**	**0.652**	**7.79**	**1.274**	**(0.356)**	**0.918**	**7.80**
Rig Anchoring	2.86	0.302	(0.084)	0.217	2.60	0.425	(0.119)	0.306	2.60
Work Boat Anchoring	5.71	0.604	(0.169)	0.435	5.20	0.850	(0.237)	0.612	5.20
MECHANICAL	**5.71**	**0.604**		**0.604**	**7.21**	**0.850**		**0.850**	**7.22**
Connection Failure	2.86	0.302		0.302	3.61	0.425		0.425	3.61
Material Failure	2.86	0.302		0.302	3.61	0.425		0.425	3.61
NATURAL HAZARD	**48.57**	**5.131**	**(0.338)**	**4.793**	**57.26**	**7.221**	**(0.475)**	**6.746**	**57.30**
Mud Slide	5.71	0.604	(0.338)	0.266	3.18	0.850	(0.475)	0.374	3.18
Storm/ Hurricane	42.86	4.527		4.527	54.08	6.372		6.372	54.12
ARCTIC			**0.021**	**0.021**	**0.25**		**0.021**	**0.021**	**0.18**
Ice Gouging									
Strudel Scour									
Upheaval Buckling			0.0129	0.0129	0.15		0.0129	0.0129	0.11
Thaw Settlement			0.0065	0.0065	0.08		0.0065	0.0065	0.05
Other Arctic			0.0019	0.0019	0.02		0.0019	0.0019	0.02
UNKNOWN	**5.71**	**0.604**		**0.604**	**7.21**	**0.850**		**0.850**	**7.22**
TOTALS	**100.00**	**10.563**	**(2.192)**	**8.371**	**100.00**	**14.867**	**(3.094)**	**11.773**	**100.00**

Table 4.8
Arctic Pipeline Large Spill (1,000-9,999 bbl) Frequencies
(App. Table 2.5)

CAUSE CLASSIFICATION	HISTORICAL DISTRIBUTION %	LARGE SPILLS 1000-9999 bbl							
		Pipeline Diameter <=10"				Pipeline Diameter >10"			
			Deep				Deep		
		FREQUENCY spills per 10^5km-year	Frequency Change	New Frequency	New Distribution %	FREQUENCY spills per 10^5km-year	Frequency Change	New Frequency	New Distribution %
CORROSION	**6.67**	**0.352**	**(0.162)**	**0.190**	**6.92**	**0.551**	**(0.253)**	**0.298**	**6.97**
External									
Internal	6.67	0.352	(0.162)	0.190	6.92	0.551	(0.253)	0.298	6.97
THIRD PARTY IMPACT	**66.67**	**3.521**	**(1.761)**	**1.761**	**64.01**	**5.506**	**(2.753)**	**2.753**	**64.46**
Anchor Impact	33.33	1.761	(0.880)	0.880	32.00	2.753	(1.377)	1.377	32.23
Jackup Rig or Spud Barge	6.67	0.352	(0.176)	0.176	6.40	0.551	(0.275)	0.275	6.45
Trawl/Fishing Net	26.67	1.408	(0.704)	0.704	25.60	2.203	(1.101)	1.101	25.78
OPERATION IMPACT	**6.67**	**0.352**	**(0.098)**	**0.254**	**9.22**	**0.551**	**(0.154)**	**0.397**	**9.29**
Rig Anchoring									
Work Boat Anchoring	6.67	0.352	(0.098)	0.254	9.22	0.551	(0.154)	0.397	9.29
MECHANICAL									
Connection Failure									
Material Failure									
NATURAL HAZARD	**20.00**	**1.056**	**(0.564)**	**0.493**	**17.91**	**1.652**	**(0.882)**	**0.770**	**18.03**
Mud Slide	6.67	0.352	(0.197)	0.155	5.64	0.551	(0.308)	0.242	5.68
Storm/ Hurricane	13.33	0.704	(0.367)	0.338	12.27	1.101	(0.573)	0.528	12.36
ARCTIC			**0.053**	**0.053**	**1.93**		**0.053**	**0.053**	**1.25**
Ice Gouging									
Strudel Scour									
Upheaval Buckling			0.0323	0.0323	1.17		0.0323	0.0323	0.76
Thaw Settlement			0.0161	0.0161	0.59		0.0161	0.0161	0.38
Other Arctic			0.0048	0.0048	0.18		0.0048	0.0048	0.11
UNKNOWN									
TOTALS	**100.00**	**5.282**	**(2.531)**	**2.750**	**100.00**	**8.259**	**(3.988)**	**4.271**	**100.00**

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

CAUSE CLASSIFICATION	HISTORICAL DISTRIBUTION %	HUGE SPILLS =>10000 bbl							
		Pipeline Diameter <=10"				Pipeline Diameter >10"			
			Deep				Deep		
		FREQUENCY spills per 10^5km-year	Frequency Change	New Frequency	New Distribution %	FREQUENCY spills per 10^5km-year	Frequency Change	New Frequency	New Distribution %
CORROSION	**6.67**	**0.050**	**(0.023)**	**0.027**	**6.87**	**0.220**	**(0.101)**	**0.119**	**7.02**
External									
Internal	6.67	0.050	(0.023)	0.027	6.87	0.220	(0.101)	0.119	7.02
THIRD PARTY IMPACT	**66.67**	**0.503**	**(0.252)**	**0.252**	**63.52**	**2.203**	**(1.101)**	**1.101**	**64.86**
Anchor Impact	33.33	0.252	(0.126)	0.126	31.76	1.101	(0.551)	0.551	32.43
Jackup Rig or Spud Barge	6.67	0.050	(0.025)	0.025	6.35	0.220	(0.110)	0.110	6.49
Trawl/Fishing Net	26.67	0.201	(0.101)	0.101	25.41	0.881	(0.441)	0.441	25.95
OPERATION IMPACT	**6.67**	**0.050**	**(0.014)**	**0.036**	**9.15**	**0.220**	**(0.062)**	**0.159**	**9.35**
Rig Anchoring									
Work Boat Anchoring	6.67	0.050	(0.014)	0.036	9.15	0.220	(0.062)	0.159	9.35
MECHANICAL									
Connection Failure									
Material Failure									
NATURAL HAZARD	**20.00**	**0.151**	**(0.081)**	**0.070**	**17.77**	**0.661**	**(0.353)**	**0.308**	**18.15**
Mud Slide	6.67	0.050	(0.028)	0.022	5.59	0.220	(0.123)	0.097	5.71
Storm/ Hurricane	13.33	0.101	(0.052)	0.048	12.18	0.441	(0.229)	0.211	12.43
ARCTIC			**0.011**	**0.011**	**2.69**		**0.011**	**0.011**	**0.63**
Ice Gouging									
Strudel Scour									
Upheaval Buckling			0.0065	0.0065	1.63		0.0065	0.0065	0.38
Thaw Settlement			0.0032	0.0032	0.81		0.0032	0.0032	0.19
Other Arctic			0.0010	0.0010	0.24		0.0010	0.0010	0.06
UNKNOWN									
TOTALS	**100.00**	**0.755**	**(0.359)**	**0.396**	**100.00**	**3.304**	**(1.606)**	**1.698**	**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 Deep	Historical Frequency spills per 10^5km-year	Arctic Frequency Deep
SMALL SPILLS 50-99 bbl	**6.036**	4.792	**6.608**	5.244
MEDIUM SPILLS 100-999 bbl	**10.563**	8.371	**14.867**	11.773
LARGE SPILLS 1000-9999 bbl	**5.282**	2.750	**8.259**	4.271
HUGE SPILLS =>10000 bbl	**0.755**	0.396	**3.304**	1.698

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, the process facility release, storage tank release, and structural 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. As before, storms tend to be less severe in the Arctic, and certainly during the ice season would have limited impact on the facility. Due to the extremely low traffic density, as for the case of pipelines, the ship collision cause has been reduced by 50%.

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 % Deep	Reason
EQUIPMENT FAILURE	**All**		
Process Equipment	**All**	(30)	State of the art now, High QC, High Inspection and Maintenance Requirements
Transfer Hose	**All**	(30)	State of the art now, High QC, High Inspection and Maintenance Requirements
Incorrect Operation	**All**	(30)	State of the art now, High QC, High Inspection and Maintenance Requirements
HUMAN ERROR	**All**	(20)	More qualified personnel - training, education, but colder
TANK FAILURE	**All**	(30)	State of the art now, High QC, High Inspection and Maintenance Requirements
SHIP COLLISION	**All**	(40)	Very low traffic density.
WEATHER	**All**	20	Cold Temperatures, cycling
HURRICANE	**All**	(60)	Less severe storms. More intensity in deep water.
OTHER	**All**		
		Freq. Increment per 10^4 well-year	
		Expected	
		Mode	
ARCTIC UNIQUE			
Ice Force	**SM**	0.3256	Assumed 10,000 year return period ice force causes spill 4% of occurrences (96% reliability). 85% of the spills are SM.
		0.0765	
	LH	0.0575	
		0.0135	
Facility Low Temperature	**SM**	0.0986	Assumed fraction of Historical Equipment Failure release frequency with 6% for SM and 1% for LH spill sizes.
		0.0986	
	LH	0.0164	
		0.0164	
Other Arctic	**SM**	0.0212	5% of sum of above.
		0.0088	
	LH	0.0037	
		0.0015	

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

CAUSE CLASSIFICATION	Spill Size	Deep		
		Frequency Change %		
		Min	Mode	Max
EQUIPMENT FAILURE	**All**			
Process Equipment	**All**	(60)	(30)	(10)
Transfer Hose	**All**	(60)	(30)	(10)
Incorrect Operation	**All**	(60)	(30)	(10)
HUMAN ERROR	**All**	(60)	(20)	(10)
TANK FAILURE	**All**	(60)	(30)	(10)
SHIP COLLISION	**All**	(60)	(40)	(10)
WEATHER	**All**	10	20	30
HURRICANE	**All**	(90)	(60)	(10)
OTHER	**All**			
		Frequency Increment per 10^4 well-year		
ARCTIC UNIQUE				
Ice Force	**SM**	0.008	0.077	0.765
	LH	0.001	0.014	0.135
Facility Low Temperature	**SM**	0.049	0.099	0.148
	LH	0.008	0.016	0.025
Other Arctic	**SM**	0.0028	0.0088	0.0456
	LH	0.0005	0.0015	0.0080

Note: All Values per 10000 well-years

Platform Spill

	SM 50-999 bbl	LH =>1000 bbl	Spill Size
H	4.601	0.481	Historical Frequency
S	3.052	0.393	Shallow Water Depth Frequency
M	3.681	0.406	Medium Water Depth Frequency
D	3.799	0.430	Deep Water Depth Frequency

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	0.220	0.044
M	0.220	0.044
D	0.220	0.044

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	0.095	0.095
M	0.095	0.095
D	0.099	0.099

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	0.255	0.044
M	0.331	0.057
D	0.445	0.078

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	0.012	0.002
M	0.016	0.003
D	0.021	0.004

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	HISTORICAL DISTRIBUTION %	SMALL AND MEDIUM SPILLS 50-999 bbl			
		FREQUENCY spills per 10^4 well-year	Deep		
			Frequency Change	New Frequency	New Distribution %
EQUIPMENT FAILURE	**52.24**	**2.403**	**(0.816)**	**1.587**	**41.78**
Process Equipment	**20.90**	**0.961**	**(0.327)**	**0.635**	**16.71**
Transfer Hose	**17.91**	**0.824**	**(0.280)**	**0.544**	**14.32**
Incorrect Operation	**13.43**	**0.618**	**(0.210)**	**0.408**	**10.74**
HUMAN ERROR	**17.91**	**0.824**	**(0.263)**	**0.561**	**14.76**
TANK FAILURE	**2.99**	**0.137**	**(0.047)**	**0.091**	**2.39**
SHIP COLLISION	**7.46**	**0.343**	**(0.124)**	**0.220**	**5.78**
WEATHER	**11.94**	**0.549**	**0.110**	**0.659**	**17.35**
HURRICANE	**4.48**	**0.206**	**(0.107)**	**0.099**	**2.60**
OTHER	**2.99**	**0.137**		**0.137**	**3.62**
ARCTIC			**0.445**	**0.445**	**11.72**
Ice Force			0.326	0.326	8.57
Facility Low Temperature			0.099	0.099	2.60
Other Arctic			0.021	0.021	0.56
TOTALS	**100.00**	**4.601**	**(0.802)**	**3.799**	**100.00**

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

CAUSE CLASSIFICATION	HISTORICAL DISTRIBUTION %	LARGE AND HUGE SPILLS =>1000 bbl			
		FREQUENCY spills per 10^4 well-year	Deep		
			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**	**10.54**
SHIP COLLISION	**14.29**	**0.069**	**(0.025)**	**0.044**	**10.21**
WEATHER	**28.57**	**0.137**	**0.027**	**0.165**	**38.29**
HURRICANE	**42.86**	**0.206**	**(0.107)**	**0.099**	**22.94**
OTHER					
ARCTIC			**0.078**	**0.078**	**18.02**
Ice Force			0.057	0.057	13.35
Facility Low Temperature			0.016	0.016	3.82
Other Arctic			0.004	0.004	0.86
TOTALS	**100.00**	**0.481**	**(0.050)**	**0.430**	**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 km-year	Arctic Frequency
		Deep
SMALL AND MEDIUM SPILLS 50-999 bbl	**4.601**	3.799
LARGE AND HUGE SPILLS =>1000 bbl	**0.481**	0.430

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)

EVENT	FREQUENCY UNIT	Historical Expected Frequency Change % Deep	Reason
		Small and Medium Spills: 50-999 bbl	
PRODUCTION WELL	spill per 10^4 well-year	(30)	State of the art now, High QC, High Inspection and Maintenance Requirements
EXPLORATION WELL DRILLING	spill per 10^4 wells	(10)	Highly qualified drilling contractor. Better logistics support in shallow water.
DEVELOPMENT WELL DRILLING	spill per 10^4 wells	(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)	State of the art now, High QC, High Inspection and Maintenance Requirements
EXPLORATION WELL DRILLING	spill per 10^4 wells	(10)	Highly qualified drilling contractor. Better logistics support in shallow water.
DEVELOPMENT WELL DRILLING	spill per 10^4 wells	(10)	Highly qualified drilling contractor. Better logistics support in shallow water.
		Spill: 10000-149999 bbl	
PRODUCTION WELL	spill per 10^4 well-year	(30)	State of the art now, High QC, High Inspection and Maintenance Requirements
EXPLORATION WELL DRILLING	spill per 10^4 wells	(10)	Highly qualified drilling contractor. Better logistics support in shallow water.
DEVELOPMENT WELL DRILLING	spill per 10^4 wells	(10)	Highly qualified drilling contractor. Better logistics support in shallow water.
		Spill: >=150000 bbl	
PRODUCTION WELL	spill per 10^4 well-year	(30)	State of the art now, High QC, High Inspection and Maintenance Requirements
EXPLORATION WELL DRILLING	spill per 10^4 wells	(10)	Highly qualified drilling contractor. Better logistics support in shallow water.
DEVELOPMENT WELL DRILLING	spill per 10^4 wells	(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	Deep: Frequency Change	Deep: New Frequency
Small and Medium Spills 50-999 bbl				
PRODUCTION WELL	spill per 10^4 well-year	0.147	-0.044	0.103
EXPLORATION WELL DRILLING	spill per 10^4 wells	2.262	-0.226	2.035
DEVELOPMENT WELL DRILLING	spill per 10^4 wells	0.692	-0.069	0.623
Large Spills 1000-9999 bbl				
PRODUCTION WELL	spill per 10^4 well-year	1.026	-0.308	0.718
EXPLORATION WELL DRILLING	spill per 10^4 wells	15.824	-1.582	14.242
DEVELOPMENT WELL DRILLING	spill per 10^4 wells	4.833	-0.483	4.350
Spills 10000-149999 bbl				
PRODUCTION WELL	spill per 10^4 well-year	0.440	-0.132	0.308
EXPLORATION WELL DRILLING	spill per 10^4 wells	6.799	-0.680	6.119
DEVELOPMENT WELL DRILLING	spill per 10^4 wells	2.076	-0.208	1.868
Spills >=150000 bbl				
PRODUCTION WELL	spill per 10^4 well-year	0.293	-0.088	0.205
EXPLORATION WELL DRILLING	spill per 10^4 wells	3.936	-0.394	3.543
DEVELOPMENT WELL DRILLING	spill per 10^4 wells	2.076	-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).
  - High Case
  - Low Case
  - High Case Non-Arctic
- By water depth (deep only).
- By facility type (six types).
- By spill size (four sizes).
- By year (2011 to 2040 which is 30 years inclusive).

The above combinations translate into 72 sets of spill indicators per year. Given that these are calculated for each year, with the scenario lasting for 30 years, gives 2,160 sets of indicators. In this chapter, we will try to summarize only the salient results of the indicators; the Appendix 4 gives the full calculation printouts for the Monte Carlo results used in the body of this report.

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 2,200), 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 2,200 combinations needs to be sampled, in this case a sampling of 2,200 iterations was carried out for each combination studied. This translates into roughly 10 million arithmetic operations to generate the Monte Carlo results.

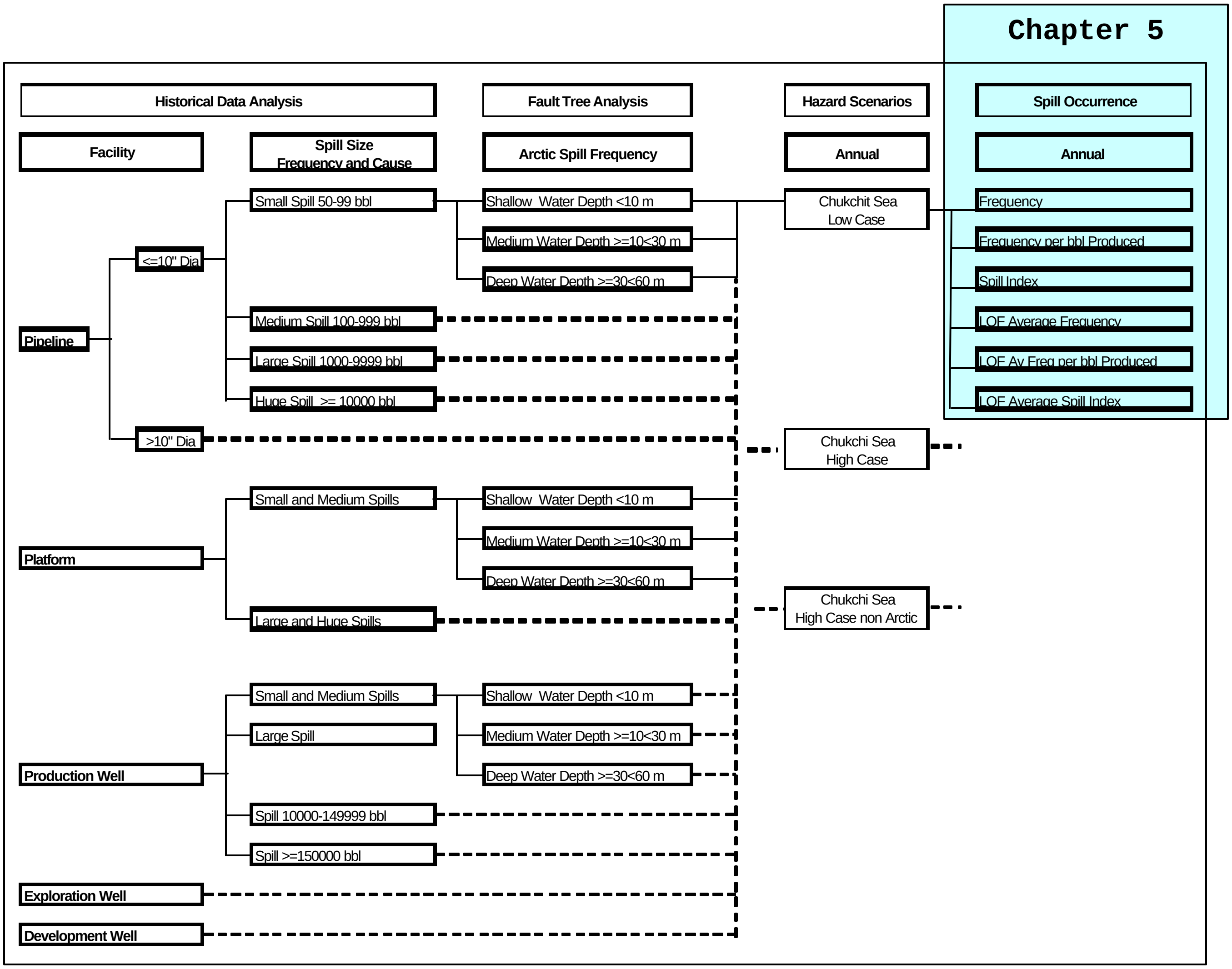


Figure 5.1
Calculation Flow Chart

5.3 Summary of Chukchi Sea Oil Spill Occurrence Indicators

5.3.1 Chukchi Sea High Case Oil Spill Occurrence Indicators

Each of the principal oil spill occurrence indicators calculated for the pipelines, platforms, and wells under 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 2040 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 41.0 per thousand years. Next, in that year, large spills are approximately 8.0 per thousand years, as shown in the second bar increment (i.e., 49.0 – 41.0 = 8.0). Finally, the top increment corresponds to huge spills, and is approximately 6.0 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. The spills per barrel produced continue to rise to the final production year (2043), because the facility quantities (and hence spill rate) remain relatively high, while production volumes decrease significantly each year. Clearly, the spill index (Figure 5.4) is dominated by the huge spills. 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 pipelines (Figure 5.6). In earlier studies [12], platforms caused the most spills. The largest of the facility spill expectations, as represented by spill index, are the wells (Figure 5.7), simply because they have the potential to release the largest amounts of oil in blowouts.

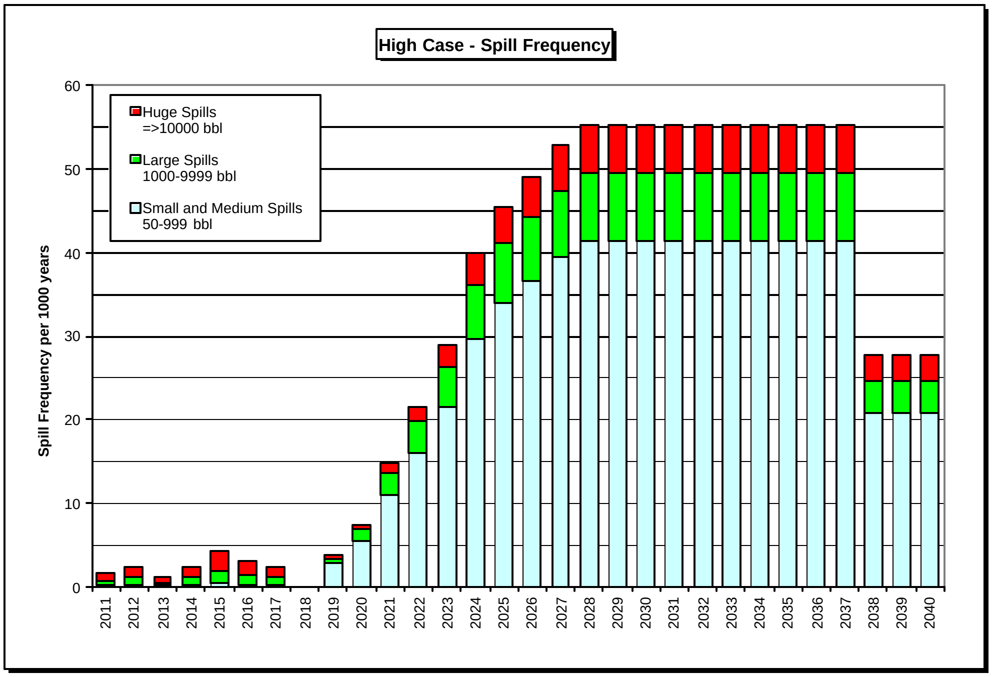


Figure 5.2
Chukchi Sea High Case Spill Frequency per 1,000 Years
(Appendix Figure 4.2.01)

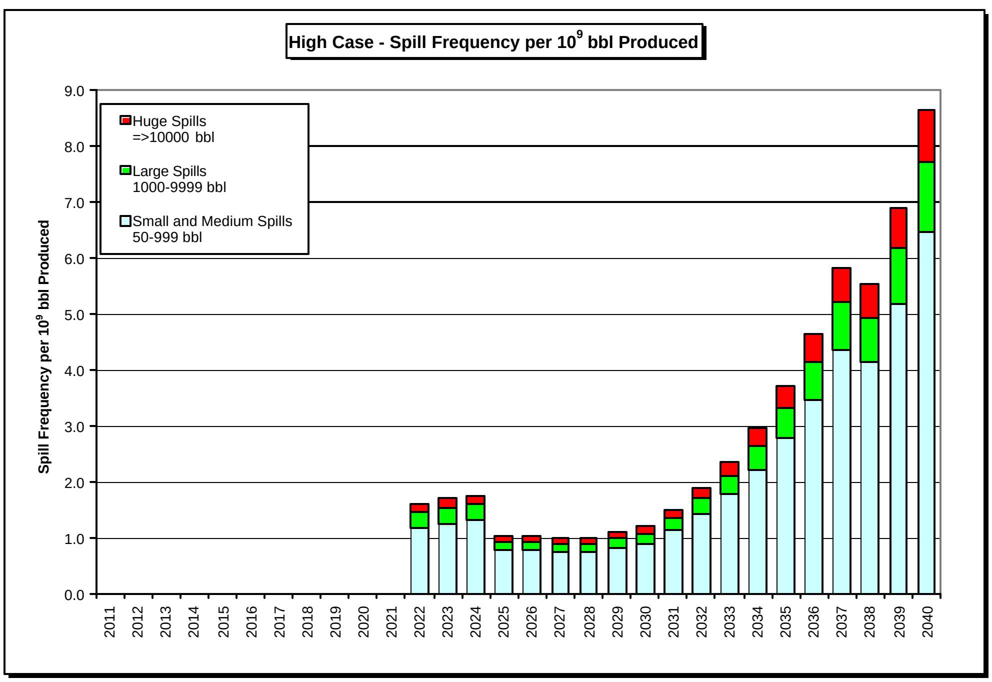


Figure 5.3
Chukchi Sea High Case Spill Frequency per 10^9 Barrels Produced
(Appendix Figure 4.2.02)

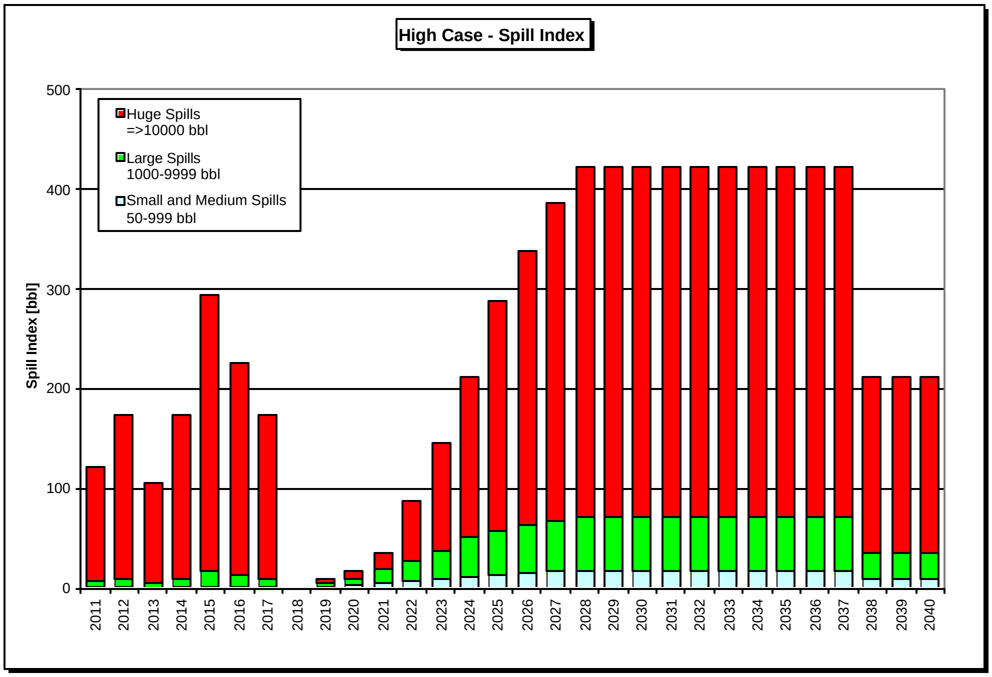


Figure 5.4
Chukchi Sea High Case Spill Index
(Appendix Figure 4.2.03)

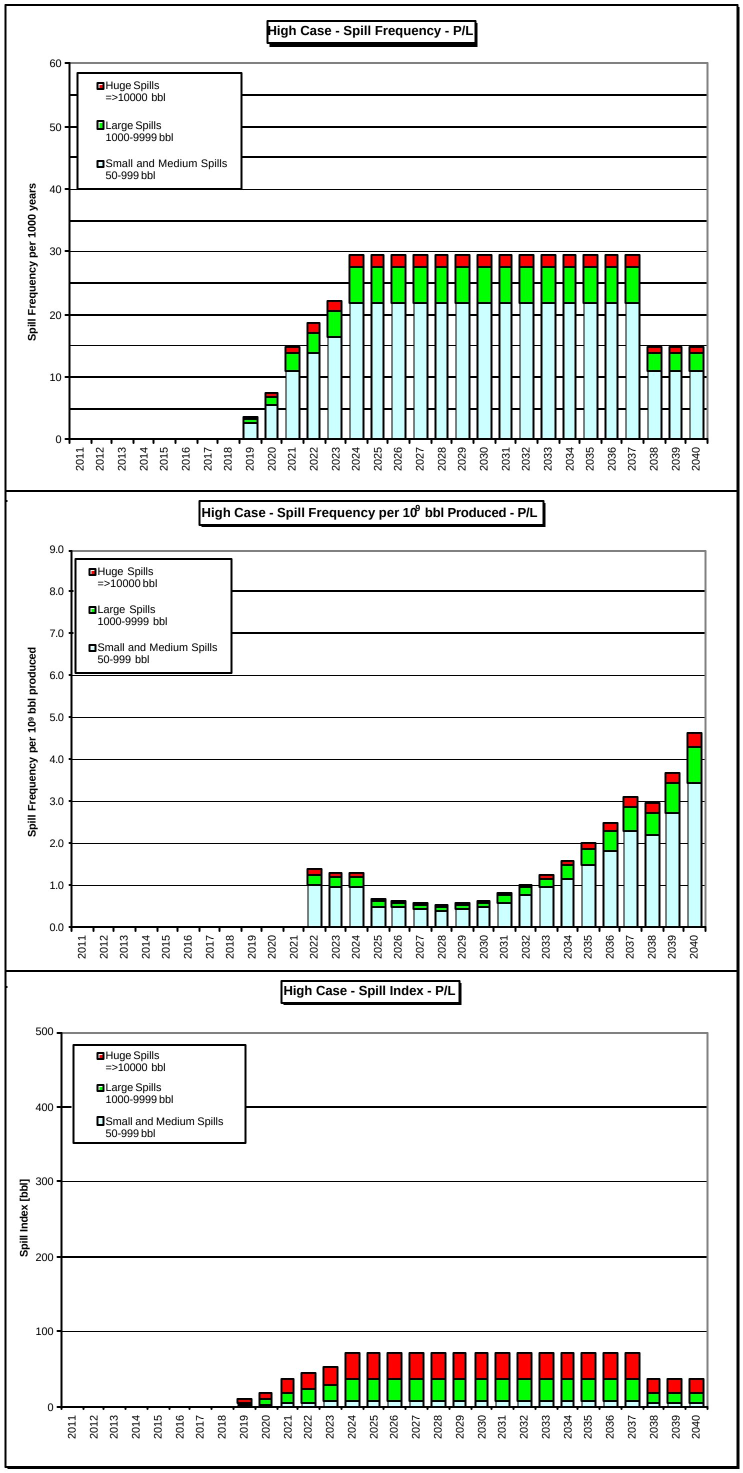


Figure 5.5
Chukchi Sea High Case Spill Indicators – Pipeline
(Appendix Figures 4.2.04, 4.2.05, 4.2.06)

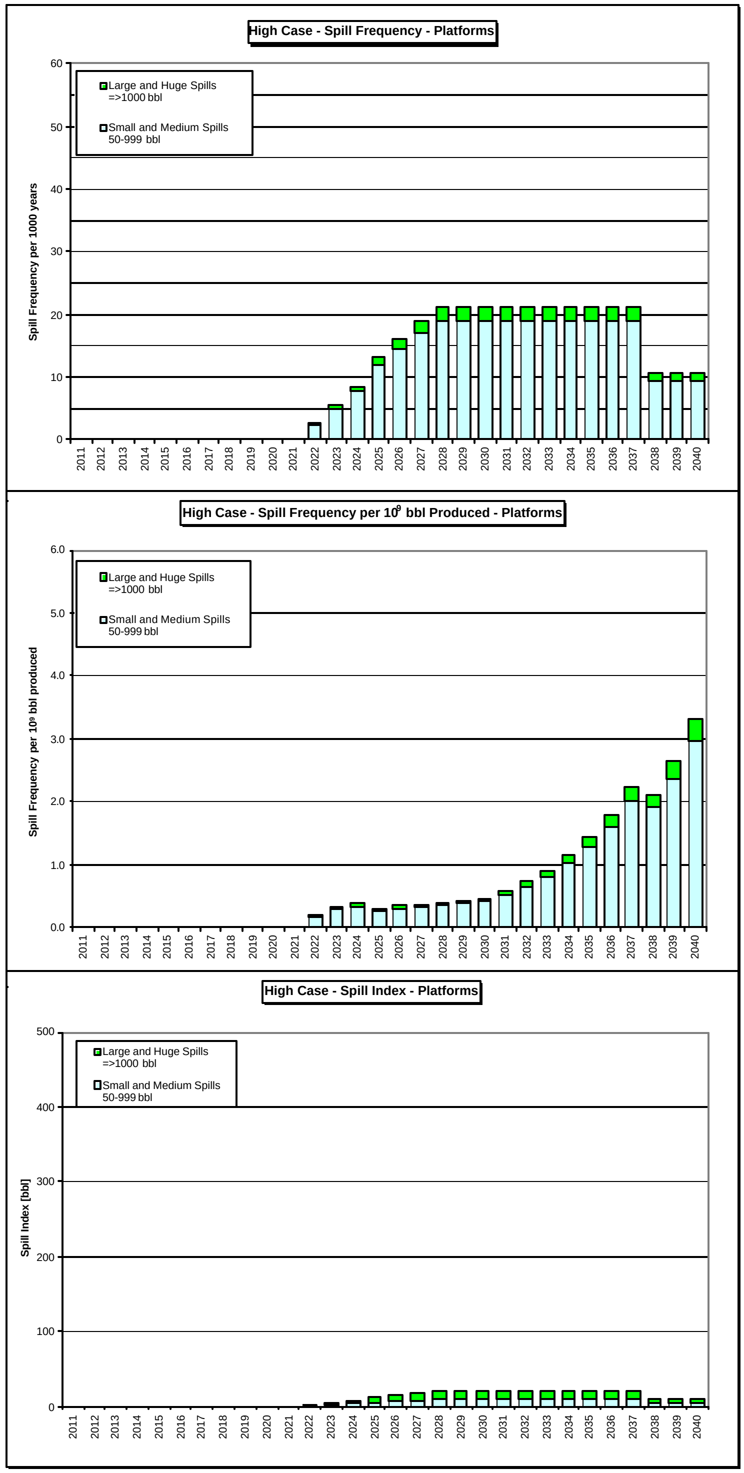


Figure 5.6
Chukchi Sea High Case Spill Indicators – Platforms
(Appendix Figures 4.2.07, 4.2.08, 4.2.09)

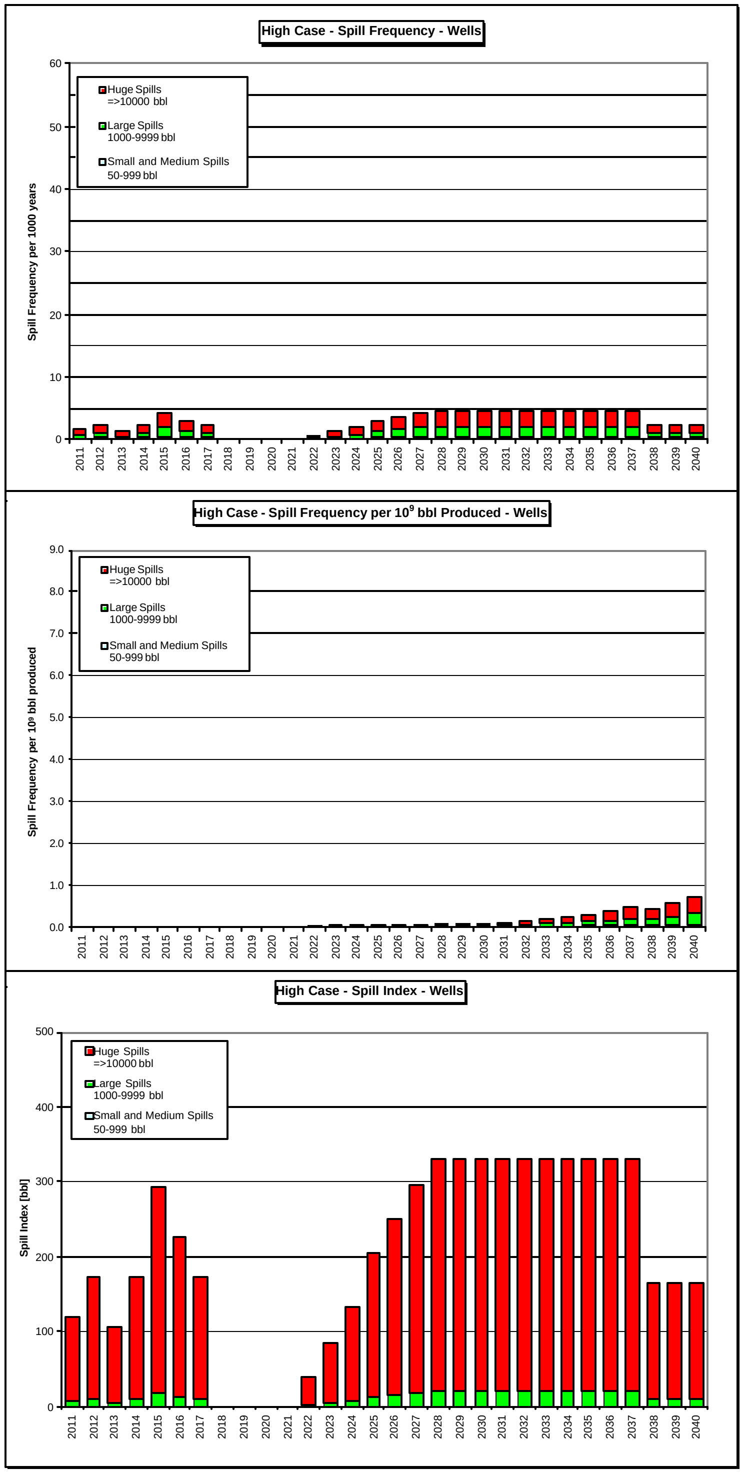


Figure 5.7
Chukchi Sea High Case Spill Indicators – Wells
(Appendix Figures 4.2.10, 4.2.11, 4.2.12)

Finally, as part of the assessment of the Chukchi 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-hand 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 0.25 per billion barrels produced in year 2030. In other words, there is a 50% chance that large and huge spills will occur at a rate of 0.25 per billion bbl or less.

The frequency spill indicator variability can be estimated from the upper (95%) and lower (5%) bound values. For example, for large spill frequency (from Table 5.1), the lower bound (3.040) is 41% of the mean (7.363); the upper bound (15.75), 213% of the mean. 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 Sale 1 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 Chukchi 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 36%. The spills per barrel produced are also significantly reduced, as can be seen in Figures 5.14 and 5.15. The spill index (Figure 5.13), because of the disproportionate effect of large spills, shows a reduction of approximately 34%. 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 5.1
Chukchi Sea High Case Year 2030 – Monte Carlo Results
(App. Table 4.2.14)

Frequency – Spills per 10^3 years

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
Mean =	41.42	8.12	5.82	13.94	55.36
Std Deviation =	16.25	3.97	1.84	4.55	16.88
Variance =	263.985	15.778	3.377	20.739	284.882
Skewness =	0.39	0.81	0.53	0.58	0.34
Kurtosis =	2.76	3.28	3.04	3.18	2.77
Mode =	36.28	4.27	4.07	8.34	50.08
Minimum =	3.871	0.885	1.303	2.996	14.957
5% Perc =	17.034	3.040	3.176	7.436	29.511
10% Perc =	21.054	3.645	3.612	8.444	34.279
15% Perc =	24.068	4.115	3.947	9.286	37.378
20% Perc =	26.904	4.575	4.223	9.964	40.346
25% Perc =	29.216	5.008	4.477	10.588	42.868
30% Perc =	31.429	5.417	4.721	11.167	45.296
35% Perc =	33.596	5.867	4.952	11.726	47.465
40% Perc =	35.695	6.353	5.175	12.255	49.766
45% Perc =	37.950	6.837	5.393	12.813	51.987
50% Perc =	40.180	7.363	5.613	13.408	54.255
55% Perc =	42.498	7.941	5.839	13.978	56.461
60% Perc =	44.645	8.494	6.091	14.632	58.829
65% Perc =	46.986	9.157	6.374	15.321	61.082
70% Perc =	49.541	9.795	6.658	16.012	63.987
75% Perc =	52.349	10.609	6.975	16.800	66.969
80% Perc =	55.702	11.429	7.348	17.690	69.996
85% Perc =	59.070	12.412	7.784	18.796	73.424
90% Perc =	63.486	13.724	8.388	20.245	78.263
95% Perc =	69.929	15.750	9.181	22.229	84.766
Maximum =	103.278	26.645	13.348	34.536	123.456

Frequency – Spills per 10^9 bbl Produced

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
Mean =	0.91	0.18	0.13	0.31	1.22
Std Deviation =	0.36	0.09	0.04	0.10	0.37
Variance =	0.128	0.008	0.002	0.010	0.138
Skewness =	0.39	0.81	0.53	0.58	0.34
Kurtosis =	2.76	3.28	3.04	3.18	2.77
Mode =	0.80	0.09	0.11	0.23	1.09
Minimum =	0.085	0.019	0.029	0.066	0.329
5% Perc =	0.375	0.067	0.070	0.164	0.650
10% Perc =	0.464	0.080	0.080	0.186	0.755
15% Perc =	0.530	0.091	0.087	0.205	0.823
20% Perc =	0.593	0.101	0.093	0.219	0.889
25% Perc =	0.644	0.110	0.099	0.233	0.944
30% Perc =	0.692	0.119	0.104	0.246	0.998
35% Perc =	0.740	0.129	0.109	0.258	1.045
40% Perc =	0.786	0.140	0.114	0.270	1.096
45% Perc =	0.836	0.151	0.119	0.282	1.145
50% Perc =	0.885	0.162	0.124	0.295	1.195
55% Perc =	0.936	0.175	0.129	0.308	1.244
60% Perc =	0.983	0.187	0.134	0.322	1.296
65% Perc =	1.035	0.202	0.140	0.337	1.345
70% Perc =	1.091	0.216	0.147	0.353	1.409
75% Perc =	1.153	0.234	0.154	0.370	1.475
80% Perc =	1.227	0.252	0.162	0.390	1.542
85% Perc =	1.301	0.273	0.171	0.414	1.617
90% Perc =	1.398	0.302	0.185	0.446	1.724
95% Perc =	1.540	0.347	0.202	0.490	1.867
Maximum =	2.275	0.587	0.294	0.761	2.719

Spill Index [bbl]

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
Mean =	17.18	53.65	350.17	403.81	420.99
Std Deviation =	11.24	30.54	126.17	130.07	130.55
Variance =	126.420	932.414	15919.700	16919.380	17044.490
Skewness =	1.19	1.30	0.48	0.44	0.43
Kurtosis =	4.72	5.49	3.23	3.19	3.19
Mode =	2.95	44.19	230.87	282.47	272.68
Minimum =	-1.173	0.253	43.711	79.588	93.237
5% Perc =	3.679	16.317	159.178	205.605	221.727
10% Perc =	5.191	21.417	194.466	243.633	260.638
15% Perc =	6.355	25.454	219.726	268.809	285.557
20% Perc =	7.585	28.830	239.049	291.201	306.962
25% Perc =	8.732	31.836	259.937	309.981	327.689
30% Perc =	9.872	34.897	277.879	329.193	346.124
35% Perc =	10.996	37.873	294.988	346.155	362.699
40% Perc =	12.223	40.687	310.034	362.745	379.059
45% Perc =	13.438	43.947	325.413	378.929	396.493
50% Perc =	14.731	47.283	339.752	394.991	411.829
55% Perc =	16.111	50.527	355.949	410.934	428.056
60% Perc =	17.586	54.382	372.612	428.474	445.263
65% Perc =	19.165	58.910	389.375	446.661	463.237
70% Perc =	20.976	63.721	408.942	466.399	484.155
75% Perc =	23.159	68.874	428.273	487.342	504.280
80% Perc =	25.567	74.766	452.753	509.295	528.176
85% Perc =	28.416	82.896	480.314	536.438	554.049
90% Perc =	32.541	94.300	516.986	574.305	593.308
95% Perc =	38.906	112.703	576.375	635.191	653.137
Maximum =	81.979	249.893	945.258	983.543	1003.756

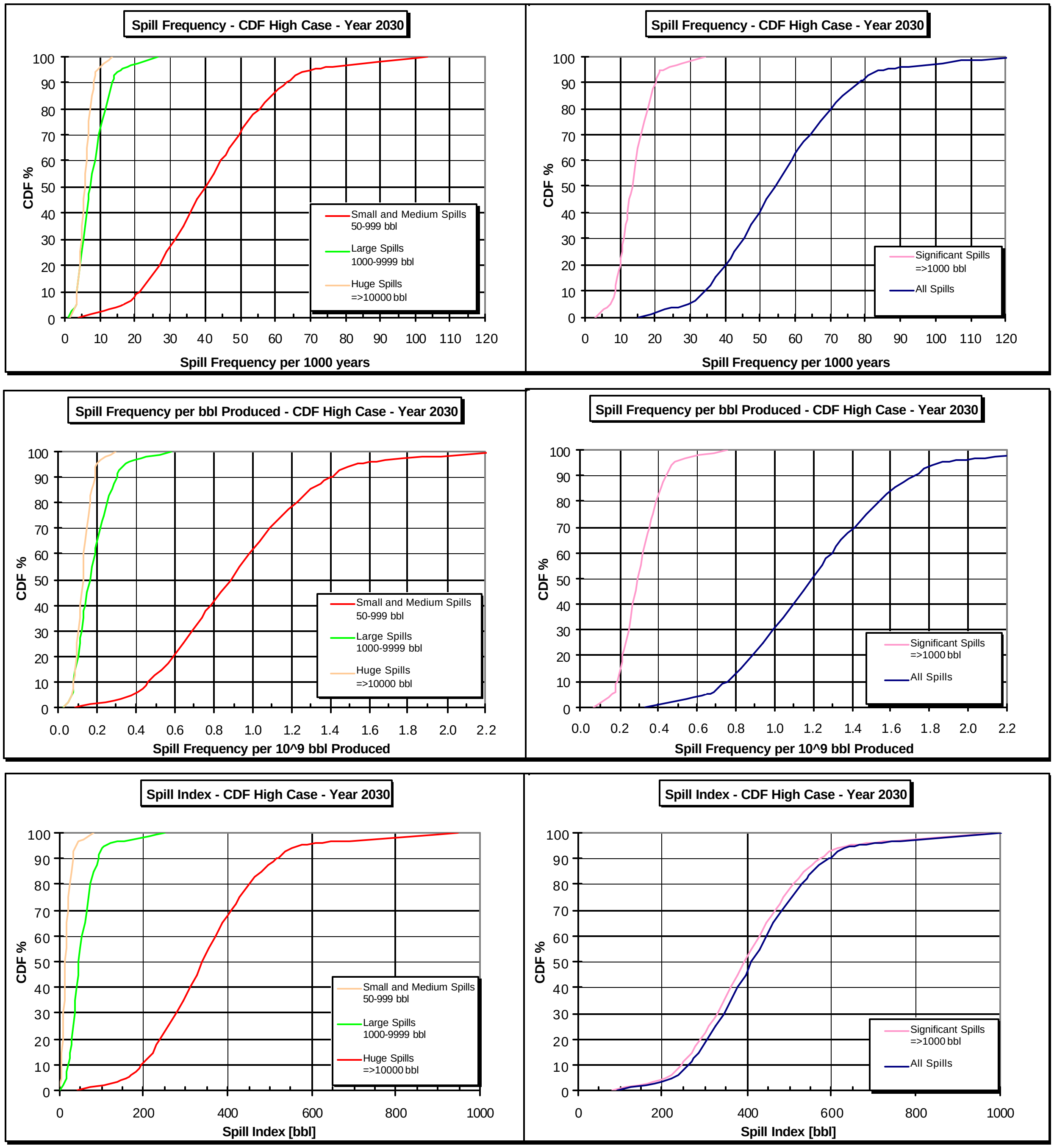


Figure 5.8
Chuckchi Sea High Case Spill Indicator Distributions – Year 2030
(Appendix Figure 4.2.13)

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

Spill Size	Spill Source									
	Pipelines		Platforms		Wells		Platforms and Wells		All	
	LOF Average - Spill Frequency per 10^3 years									
Small and Medium Spills 50-999 bbl	12.960	74%	9.219	90%	0.313	11%	9.532	73%	22.491	74%
Large Spills 1000-9999 bbl	3.253	19%	0.522	5%	0.940	33%	1.462	11%	4.715	15%
Huge Spills =>10000 bbl	1.293	7%	0.522	5%	1.570	56%	2.092	16%	3.385	11%
Significant Spills =>1000 bbl	4.546	26%	1.044	10%	2.510	89%	3.554	27%	8.100	26%
All Spills	**17.506**	**100%**	**10.263**	**100%**	**2.823**	**100%**	**13.086**	**100%**	**30.592**	**100%**
	LOF Average - Spill Frequency per 10^9 bbl produced									
Small and Medium Spills 50-999 bbl	0.778	74%	0.553	90%	0.019	11%	0.572	73%	1.349	74%
Large Spills 1000-9999 bbl	0.195	19%	0.031	5%	0.056	33%	0.088	11%	0.283	15%
Huge Spills =>10000 bbl	0.078	7%	0.031	5%	0.094	56%	0.126	16%	0.203	11%
Significant Spills =>1000 bbl	0.273	26%	0.063	10%	0.151	89%	0.213	27%	0.486	26%
All Spills	**1.050**	**100%**	**0.616**	**100%**	**0.169**	**100%**	**0.785**	**100%**	**1.835**	**100%**
	LOF Average - Spill Index [bbl]									
Small and Medium Spills 50-999 bbl	5	12%	4	41%	0	0%	4	2%	9	4%
Large Spills 1000-9999 bbl	17	40%	3	29%	12	6%	15	7%	31	12%
Huge Spills =>10000 bbl	20	48%	3	29%	190	94%	193	91%	213	84%
Significant Spills =>1000 bbl	37	88%	6	59%	202	100%	208	98%	245	96%
All Spills	**42**	**100%**	**10**	**100%**	**202**	**100%**	**212**	**100%**	**254**	**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	12.960	58%	3.253	69%	1.293	38%	4.546	56%	17.506	57%
Platforms	9.219	41%	0.522	11%	0.522	15%	1.044	13%	10.263	34%
Wells	0.313	1%	0.940	20%	1.570	46%	2.510	31%	2.823	9%
Platforms and Wells	9.532	42%	1.462	31%	2.092	62%	3.554	44%	13.086	43%
All	**22.491**	**100%**	**4.715**	**100%**	**3.385**	**100%**	**8.100**	**100%**	**30.592**	**100%**
	LOF Average - Spill Frequency per 10^9 bbl produced									
Pipelines	0.778	58%	0.195	69%	0.078	38%	0.273	56%	1.050	57%
Platforms	0.553	41%	0.031	11%	0.031	15%	0.063	13%	0.616	34%
Wells	0.019	1%	0.056	20%	0.094	46%	0.151	31%	0.169	9%
Platforms and Wells	0.572	42%	0.088	31%	0.126	62%	0.213	44%	0.785	43%
All	**1.349**	**100%**	**0.283**	**100%**	**0.203**	**100%**	**0.486**	**100%**	**1.835**	**100%**
	LOF Average - Spill Index [bbl]									
Pipelines	5	53%	17	54%	20	9%	37	15%	42	16%
Platforms	4	45%	3	9%	3	1%	6	2%	10	4%
Wells	0	2%	12	37%	190	89%	202	83%	202	80%
Platforms and Wells	4	47%	15	46%	193	91%	208	85%	212	84%
All	**9**	**100%**	**31**	**100%**	**213**	**100%**	**245**	**100%**	**254**	**100%**

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

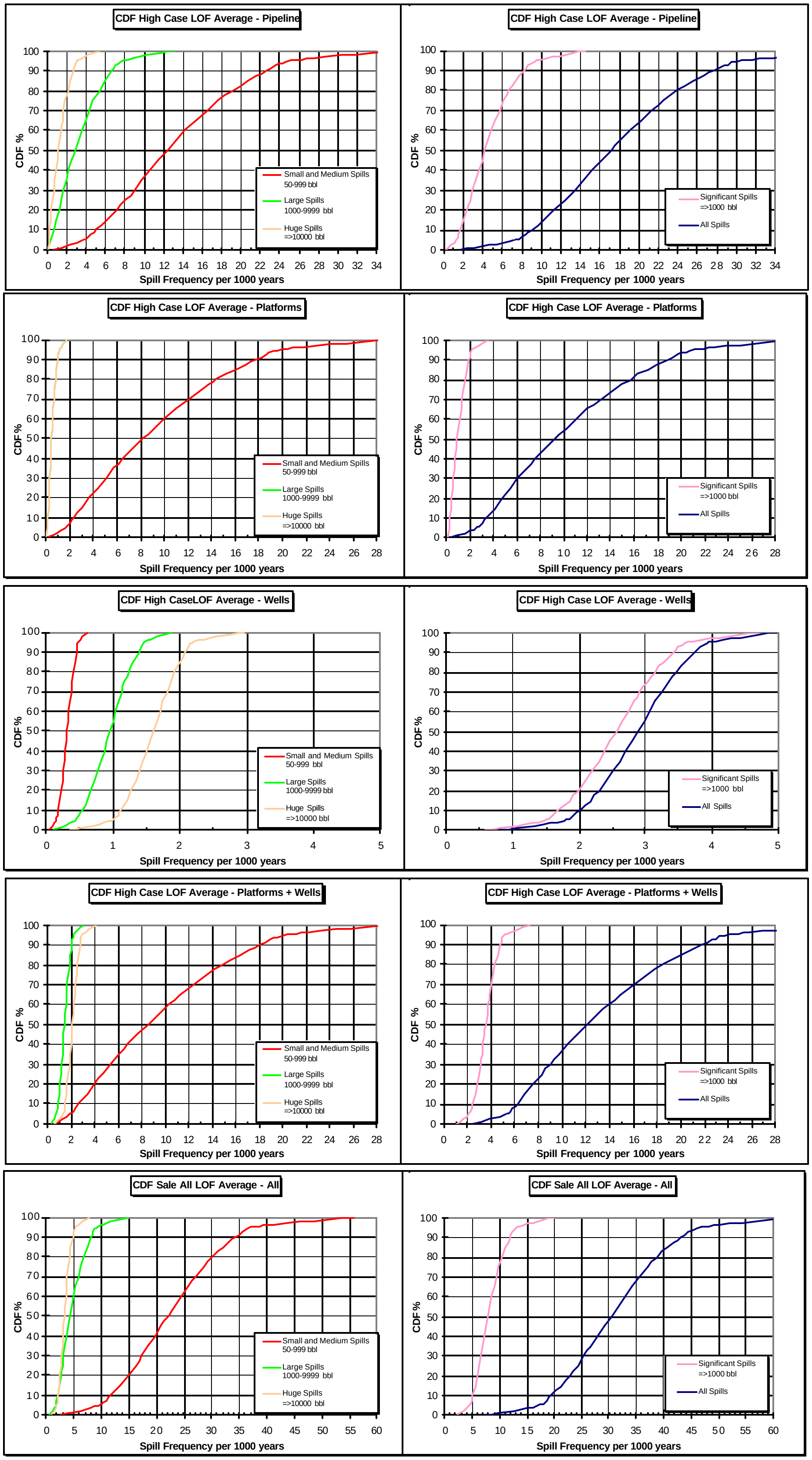
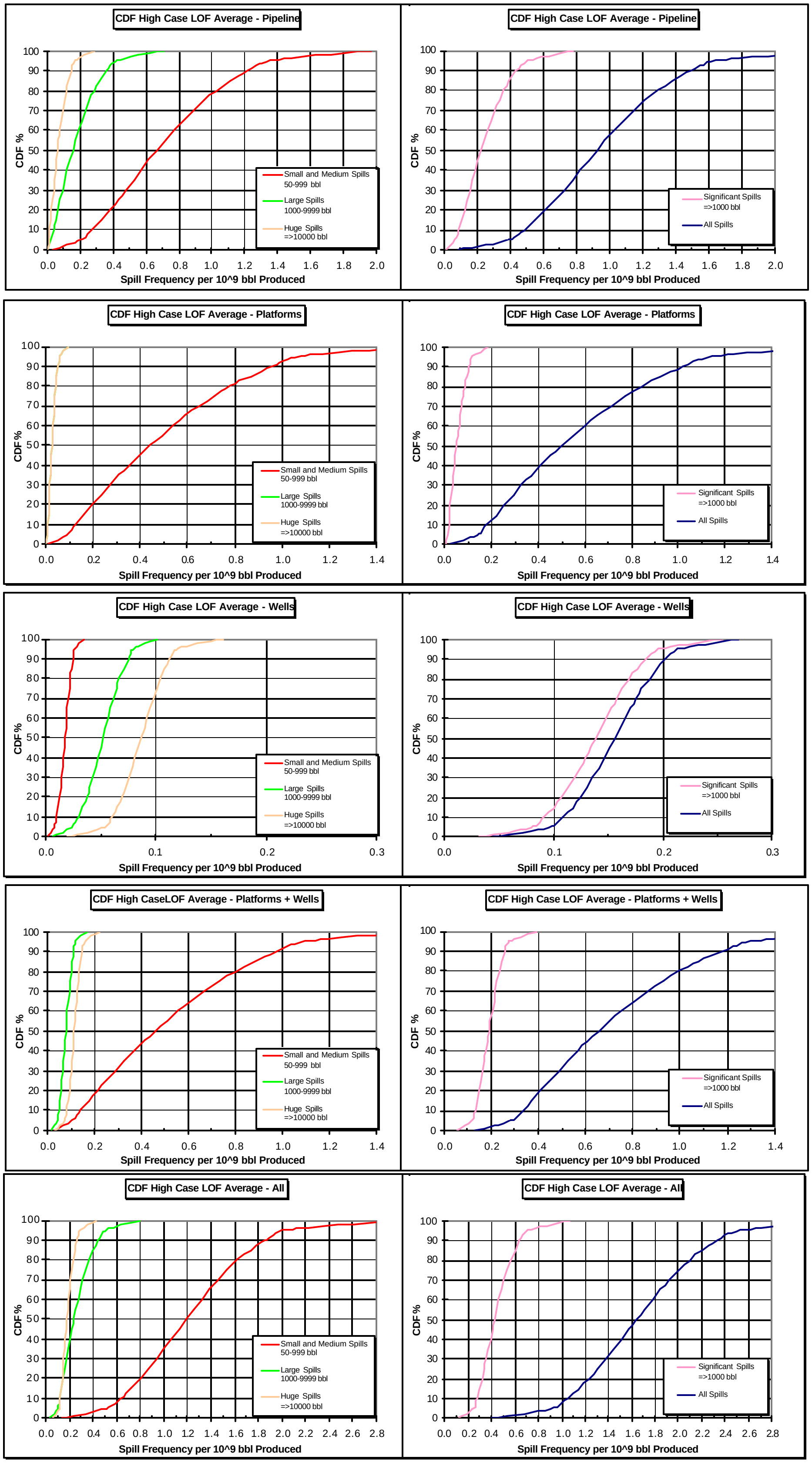


Figure 5.10
Chukchi Sea
High Case
Life of Field
Average Spills
per Barrel Produced
(Appendix
Figure 4.2.15)



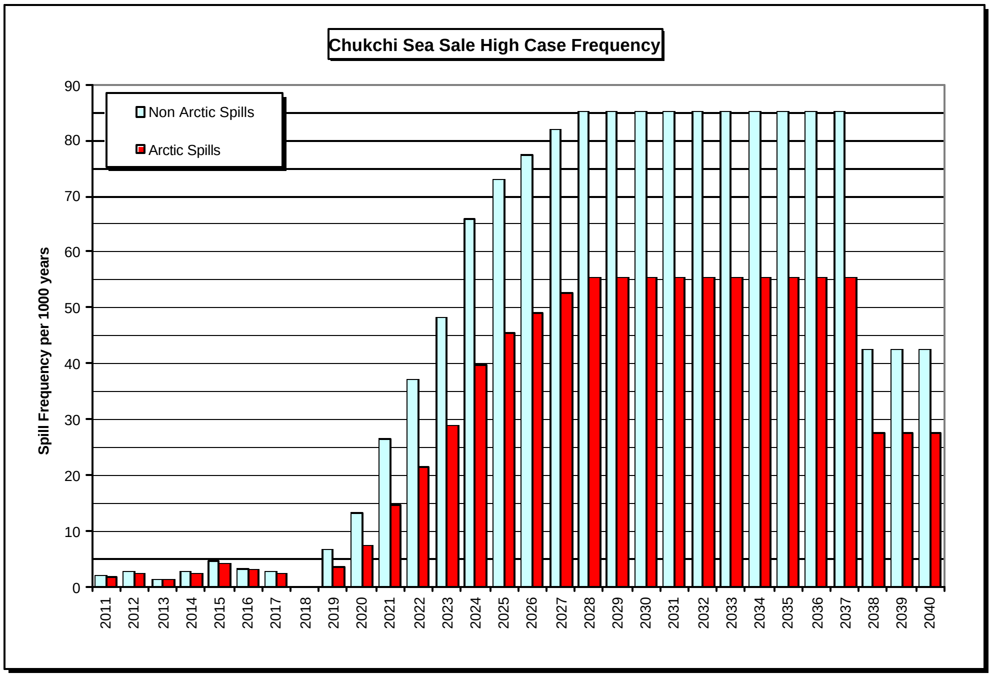


Figure 5.11
Chukchi Sea High Case Spill Frequency – Arctic and Non-Arctic
(Appendix Figure 5.3)

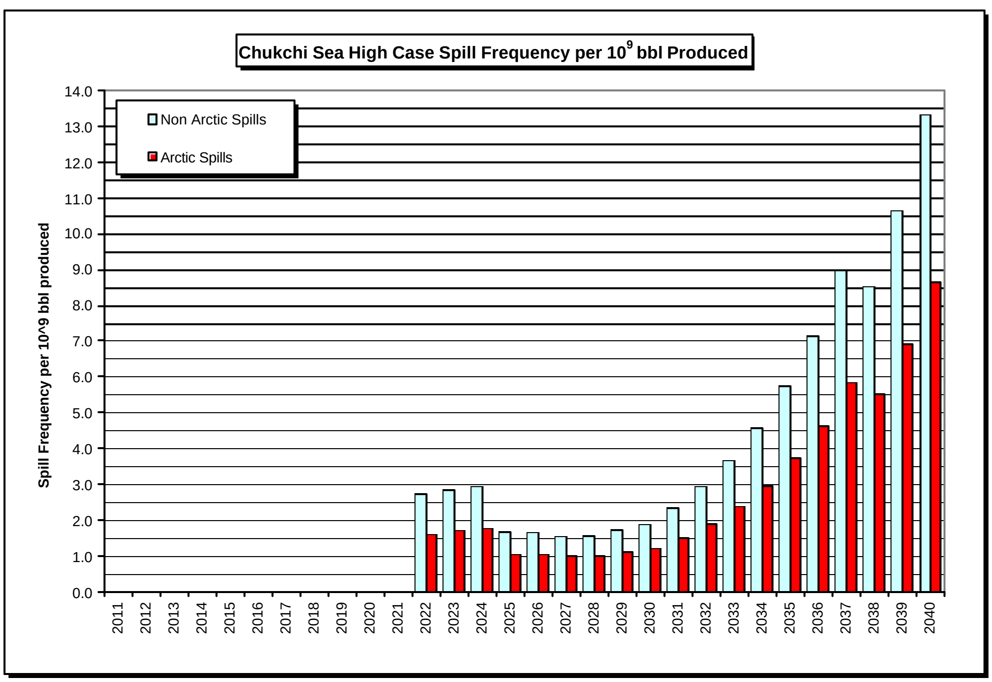


Figure 5.12
Chukchi Sea High Case Spill Frequency per 10^9 Barrels Produced – Arctic and Non-Arctic
(Appendix Figure 5.4)

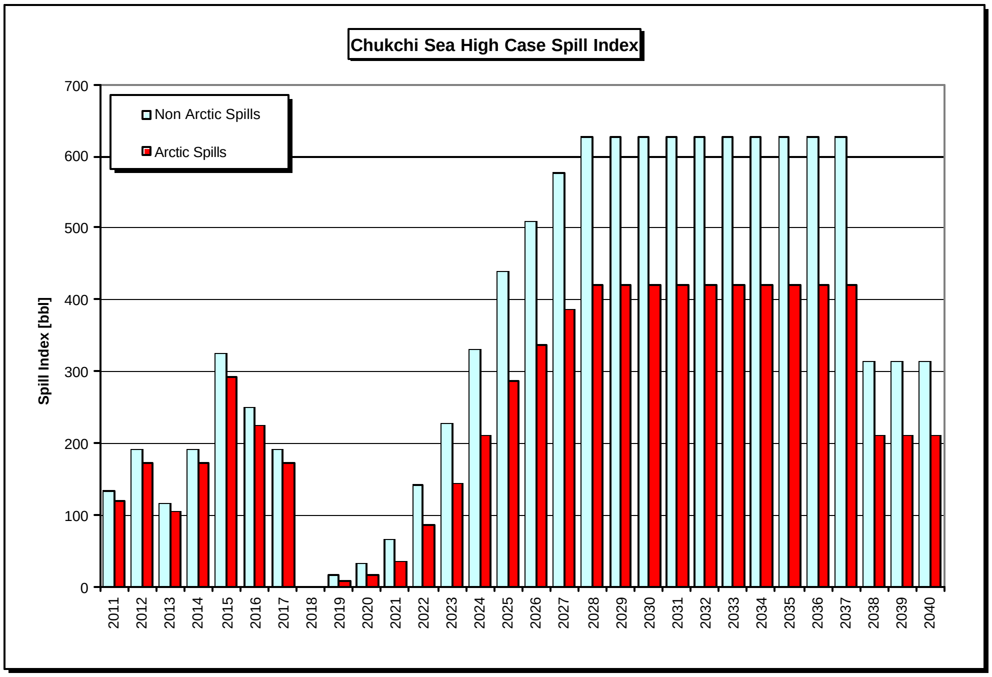
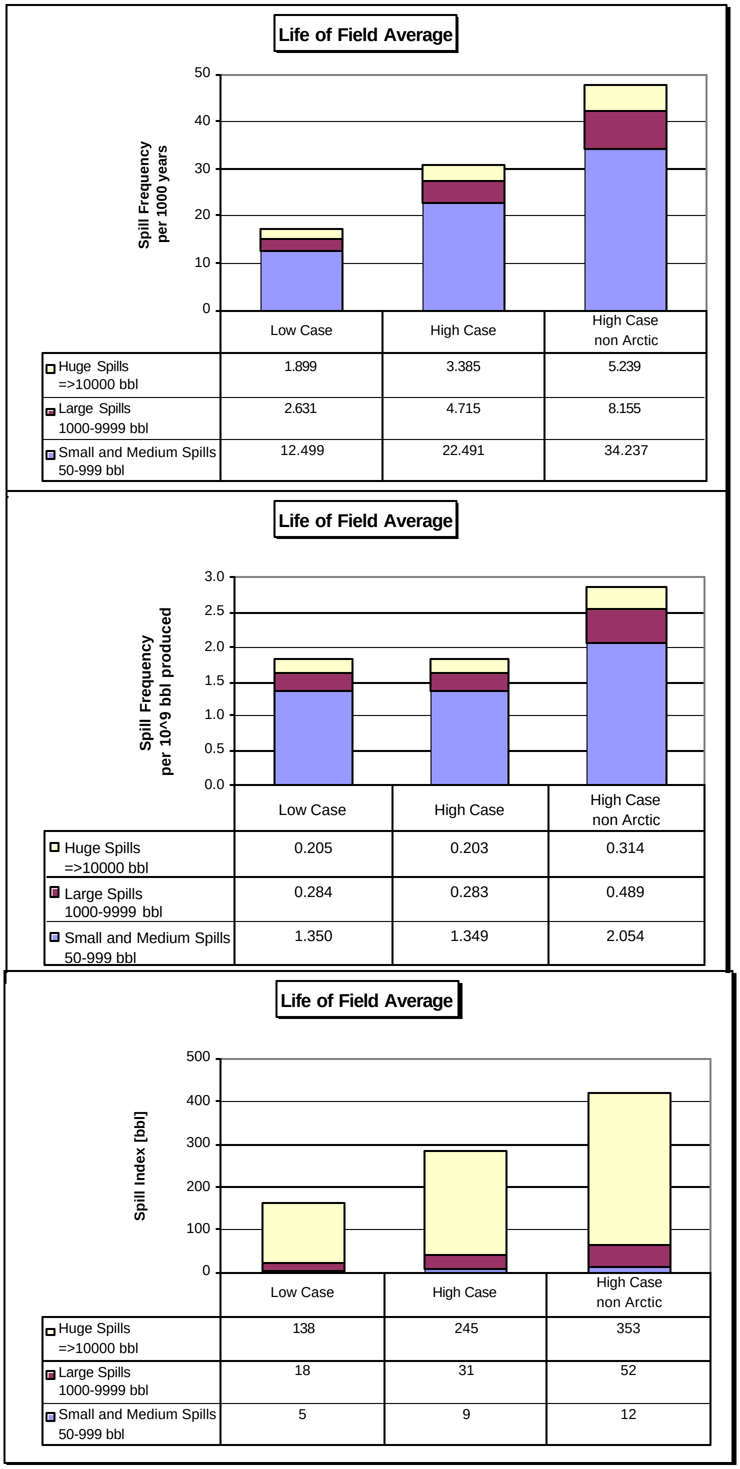


Figure 5.13
Chukchi Sea High Case Spill Index – Arctic and Non-Arctic
(Appendix Figure 5.5)

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	12.499	1.350	5	22.491	1.349	9	34.237	2.054	12
	73%	**73%**	**4%**	**74%**	**74%**	**4%**	**72%**	**72%**	**3%**
Large Spills 1000-9999 bbl	2.631	0.284	18	4.715	0.283	31	8.155	0.489	52
	15%	**15%**	**12%**	**15%**	**15%**	**12%**	**17%**	**17%**	**14%**
Huge Spills =>10000 bbl	1.899	0.205	121	3.385	0.203	213	5.239	0.314	302
	11%	**11%**	**84%**	**11%**	**11%**	**84%**	**11%**	**11%**	**83%**
Significant Spills =>1000 bbl	4.529	0.489	138	8.100	0.486	245	13.394	0.804	353
	27%	**27%**	**96%**	**26%**	**26%**	**96%**	**28%**	**28%**	**97%**
All Spills	17.028	1.839	143	30.592	1.835	254	47.631	2.858	365
	100%	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
Pipeline Spills	9.725	1.050	23	17.506	1.050	42	31.452	1.887	78
	57%	**57%**	**16%**	**57%**	**57%**	**16%**	**66%**	**66%**	**21%**
Platform Spills	5.702	0.616	6	10.263	0.616	10	12.331	0.740	12
	33%	**33%**	**4%**	**34%**	**34%**	**4%**	**26%**	**26%**	**3%**
Well Spills	1.601	0.173	114	2.823	0.169	202	3.848	0.231	275
	9%	**9%**	**80%**	**9%**	**9%**	**80%**	**8%**	**8%**	**75%**
Platform and Well Spills	7.303	0.789	120	13.086	0.785	212	16.179	0.971	287
	43%	**43%**	**84%**	**43%**	**43%**	**84%**	**34%**	**34%**	**79%**
All Spills	17.028	1.839	143	30.592	1.835	254	47.631	2.858	365
	100%	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

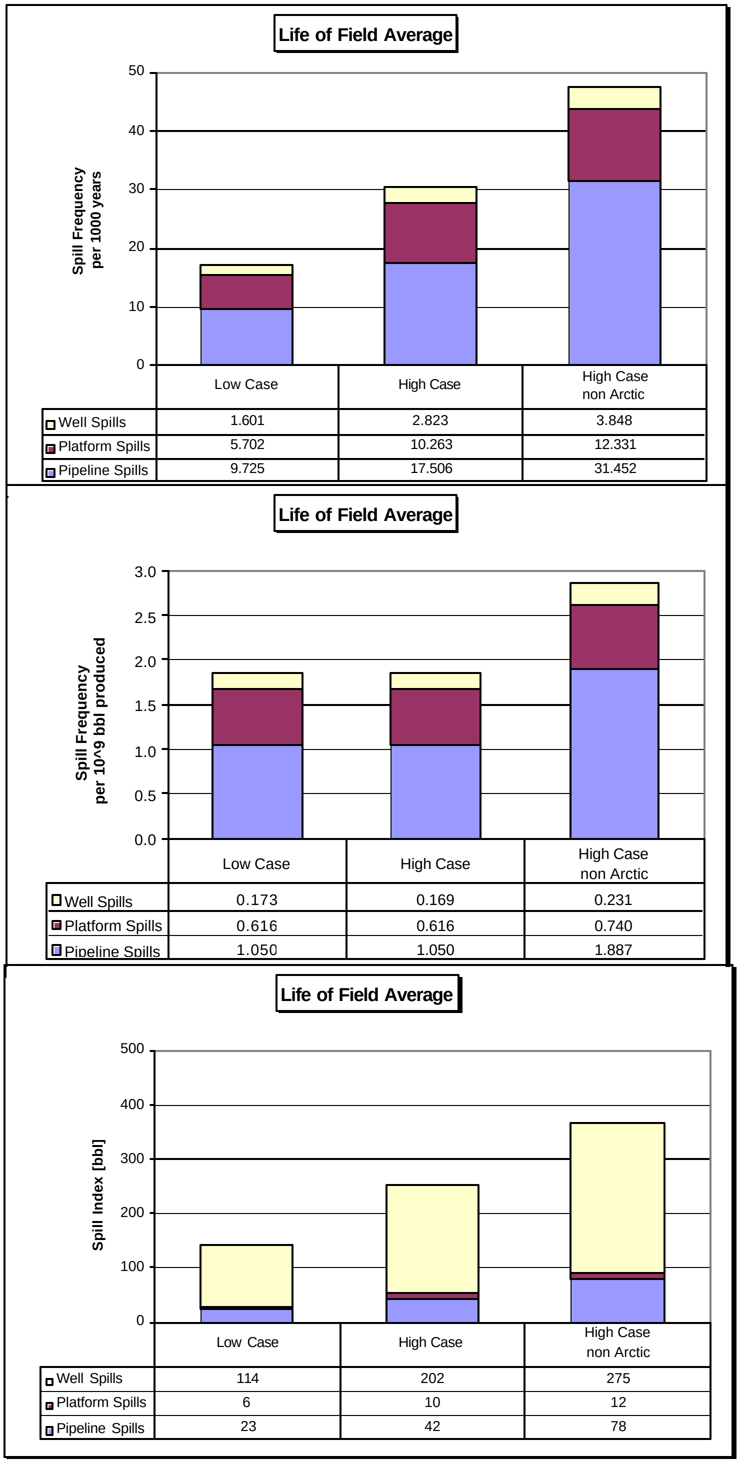


	Low Case	High Case	High Case non Arctic
Huge Spills =>10000 bbl	1.899	3.385	5.239
Large Spills 1000-9999 bbl	2.631	4.715	8.155
Small and Medium Spills 50-999 bbl	12.499	22.491	34.237

	Low Case	High Case	High Case non Arctic
Huge Spills =>10000 bbl	0.205	0.203	0.314
Large Spills 1000-9999 bbl	0.284	0.283	0.489
Small and Medium Spills 50-999 bbl	1.350	1.349	2.054

	Low Case	High Case	High Case non Arctic
Huge Spills =>10000 bbl	138	245	353
Large Spills 1000-9999 bbl	18	31	52
Small and Medium Spills 50-999 bbl	5	9	12

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



	Low Case	High Case	High Case non Arctic
Well Spills	1.601	2.823	3.848
Platform Spills	5.702	10.263	12.331
Pipeline Spills	9.725	17.506	31.452

	Low Case	High Case	High Case non Arctic
Well Spills	0.173	0.169	0.231
Platform Spills	0.616	0.616	0.740
Pipeline Spills	1.050	1.050	1.887

	Low Case	High Case	High Case non Arctic
Well Spills	114	202	275
Platform Spills	6	10	12
Pipeline Spills	23	42	78

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

5.4 Summary of Representative Oil Spill Occurrence Indicator Results

How do spill indicators for the Chukchi scenario and for its non-Arctic counterpart vary by spill size and location? Table 5.3 and Figure 5.14 and 5.15 summarize the Life of Field average spill indicator values by spill size and source. 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 scenarios.
- The spill index increases significantly with spill size for all scenarios.
- All non-Arctic scenario spill indicators are greater than their Arctic counterparts. High Case non-Arctic spill indicators are approximately 35% greater than Arctic High Case counterparts.

How do the spill indicators vary by facility type for representative scenarios? The contributions of spill indicators by facility have been summarized by representative scenario years, again, 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 Table 5.3:

- Pipelines contribute the most (57%) to the two spill frequency indicators.
- Platforms are next in relative contribution to spill frequencies (33%) and least in contribution to spill index (4%).
- Wells are by far (at 80%) the highest contributors to spill index, while platforms and wells together are responsible for a 84% contribution to the 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. Platforms will be in between, with more spills than wells.

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.

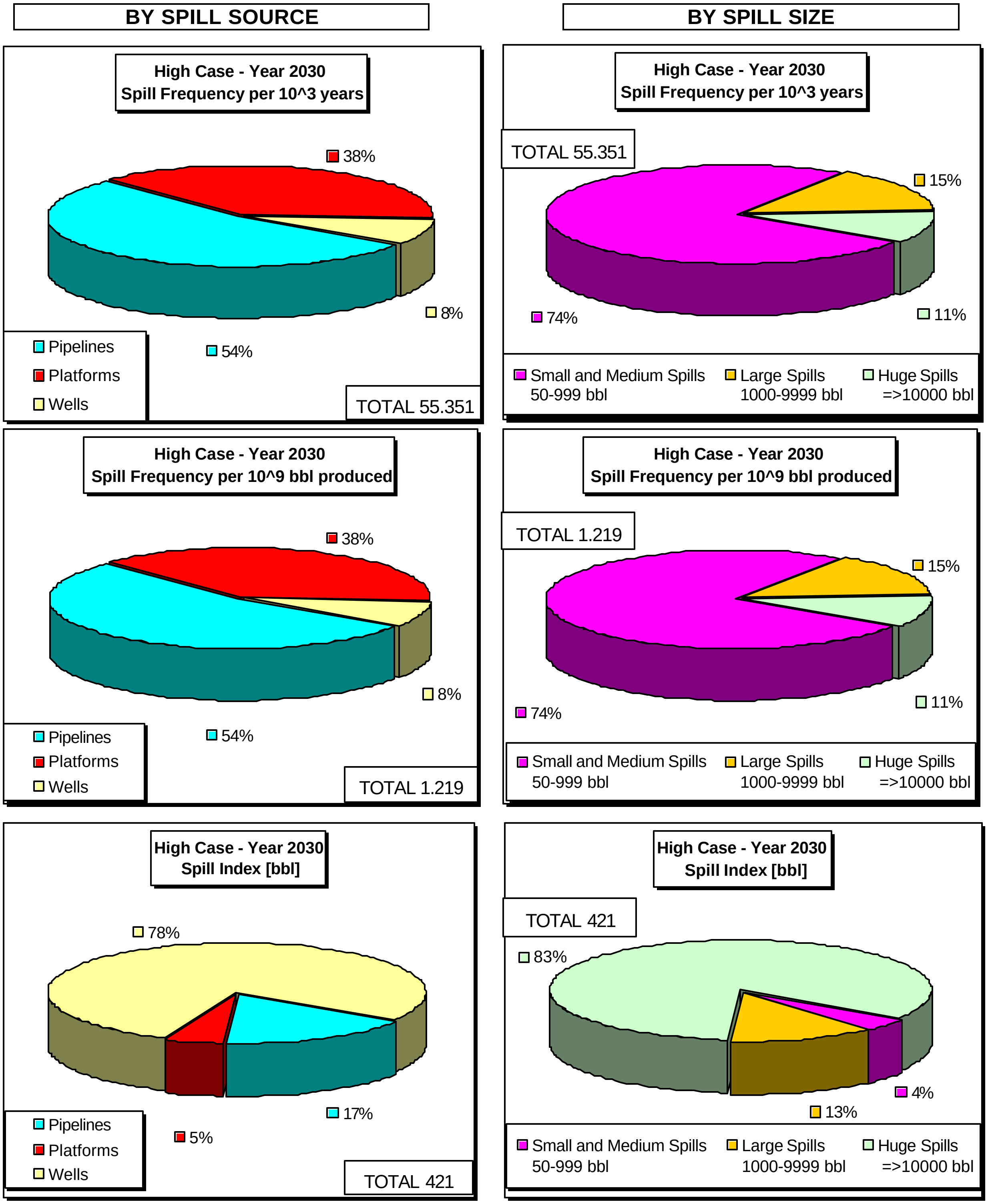


Figure 5.16
Chukchi Sea High Case – Year 2030 –
Spill Indicator Composition by Source and Spill Size
(Appendix Figure 4.2.17)

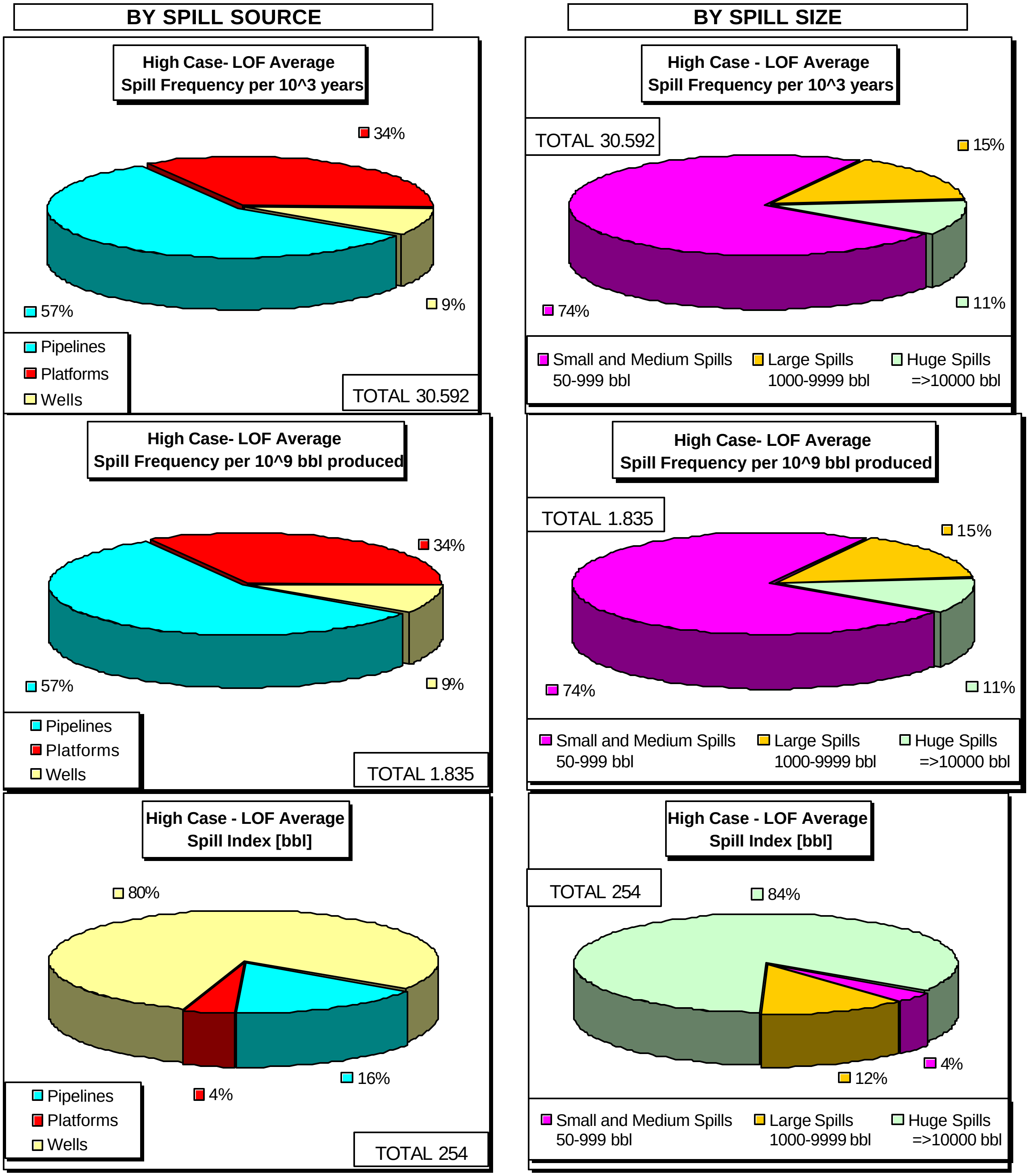


Figure 5.17
Chukchi Sea High Case – Life of Field Average Spill Indicator
Composition by Source and Spill Size
(Appendix Figure 4.2.18)

Figures[1] 5.18, 5.19, and 5.20 show the Cumulative Distribution Functions (CDF) for each of the three Chukchi Sea High Case Life of Field average spill indicators. The variability of these indicators is fairly representative of the trends in variability for spill indicators for all sales and locations studied. 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. For example, in the top right-hand graph of Figure 5.18, the significant spills plot has a much steeper (and hence less variable) slope than that of all spills. Similarly, in the top left-hand graph, small and medium spills illustrate the largest variability; huge spills show the least variability for these facilities.

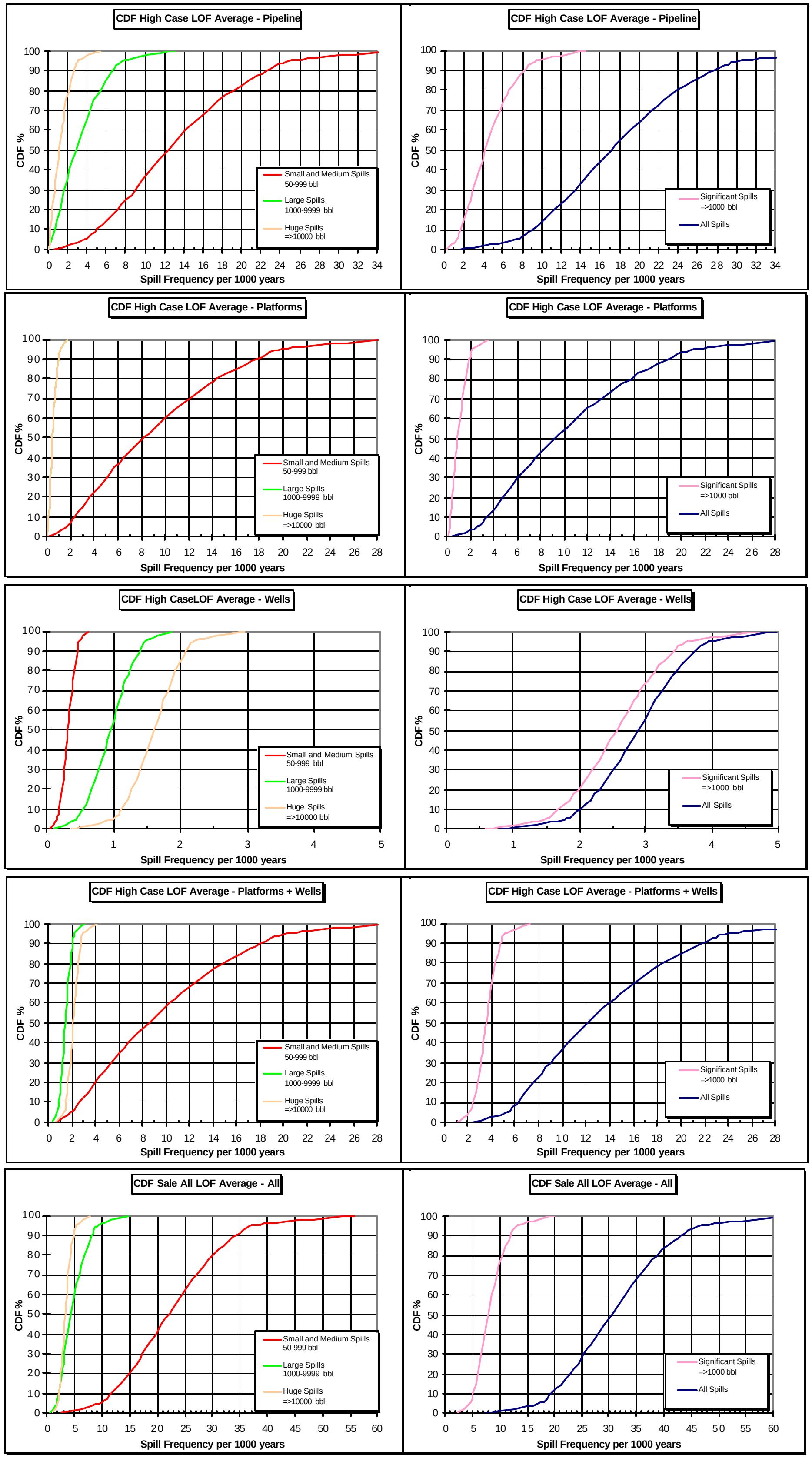
- The opposite occurs for wells, where large spills show greater variance than small ones.

- The variability of the spill index (Figure 5.20) shows variance trends opposite to those of the frequency spill indicators.

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 8 (spills per 1,000 years) ranges between about 15 and 3 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 240 per billion barrels produced ranges from 150 to 400.

[1] Note: Figures 5.18 and 5.19 are duplicated here, from Figures 5.9 and 5.10, for convenience.

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



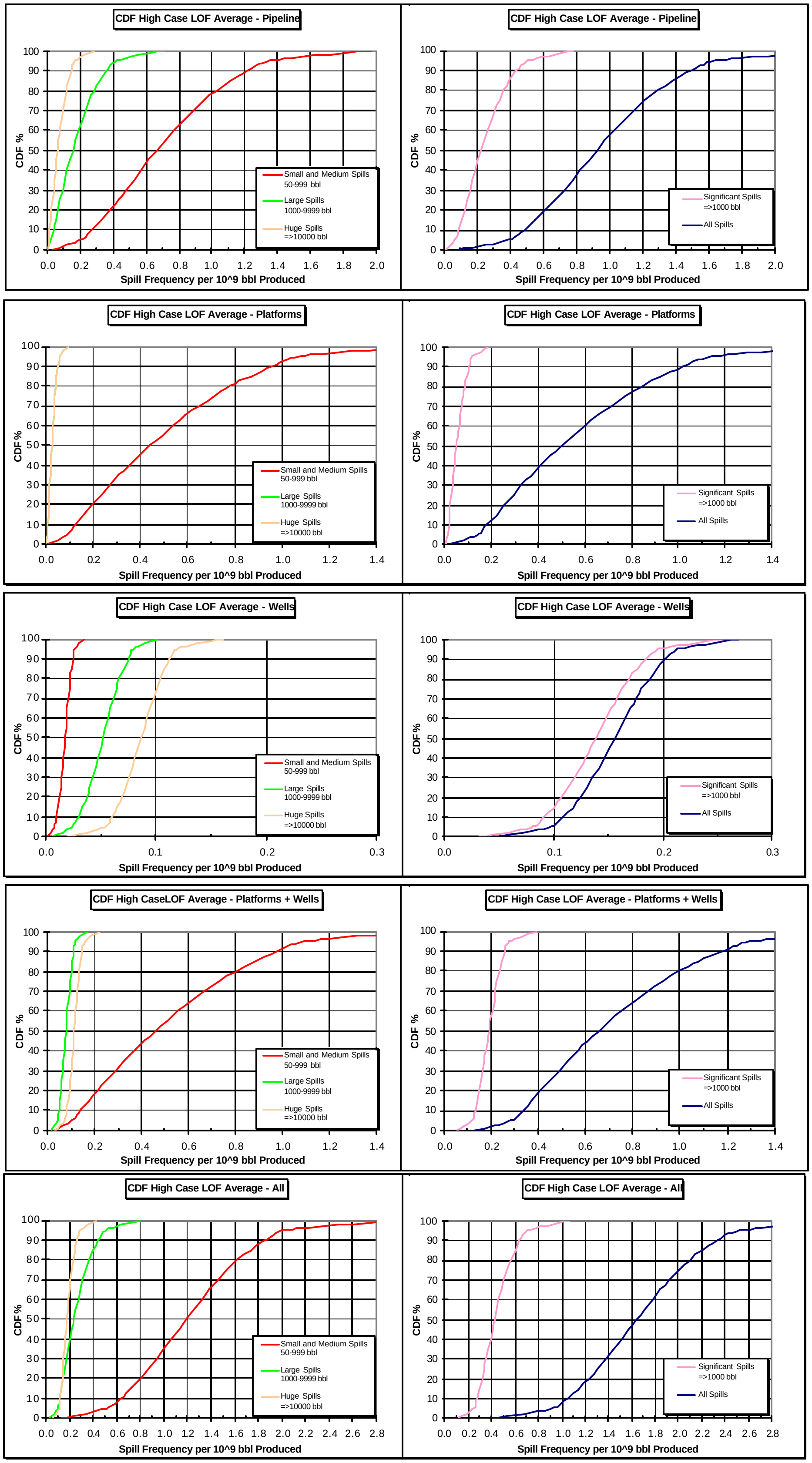


Figure 5.19
Chukchi Sea
High Case
Life of Field
Average Spills
per Barrel Produced
(Appendix
Figure 4.2.15)

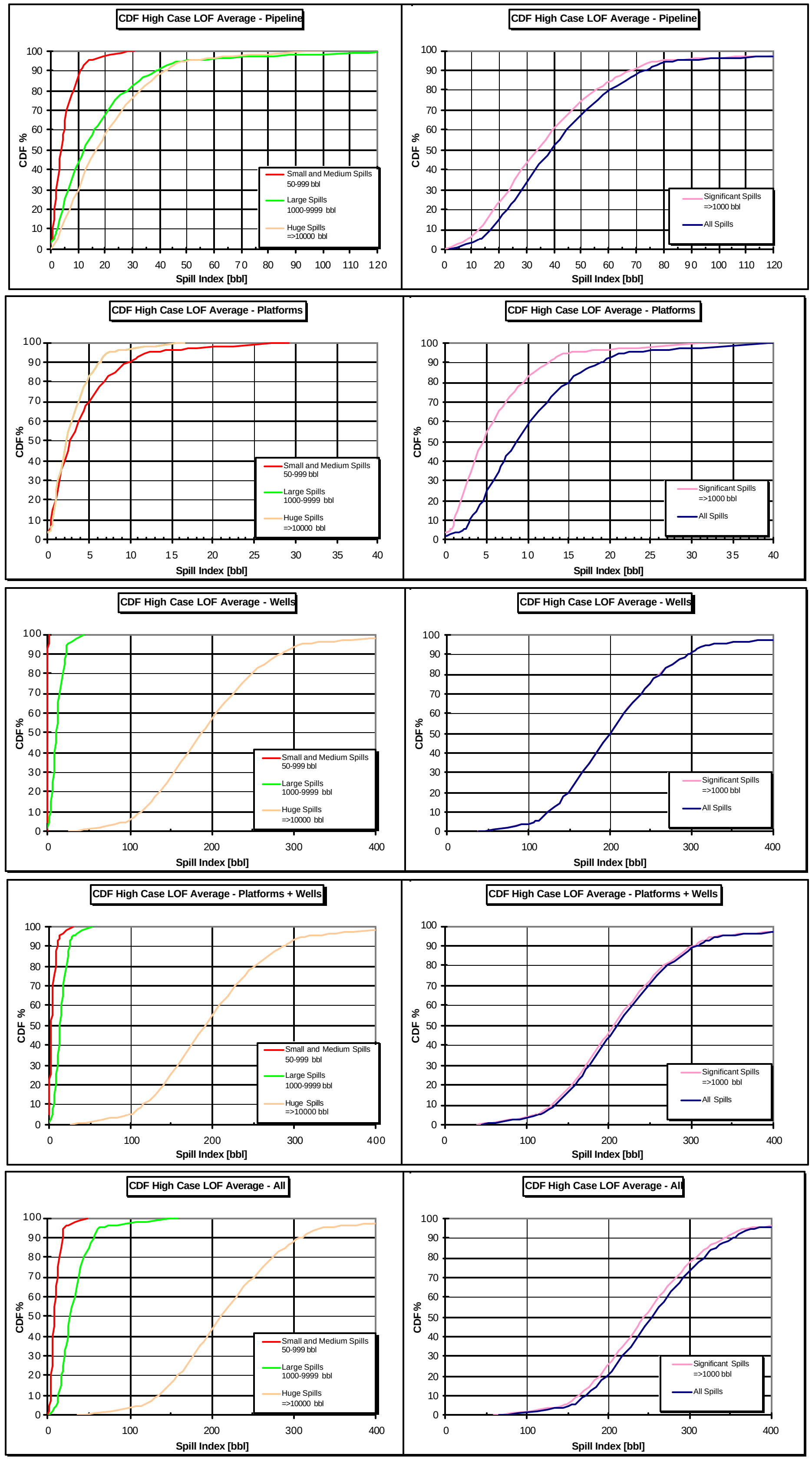


Figure 5.20
Chukchi Sea High Case Life of Field Average Spill Index (bbl) – CDF
(Appendix Figure 4.2.16)

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

6.1.1 General Conclusions

Oil spill occurrence indicators were quantified for future deep water offshore development scenarios in the Chukchi 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 and Source

How do spill indicators for the Chukchi scenario and for its non-Arctic counterpart vary by spill size and location? Table 6.1 and Figure 6.1 and 6.2 summarize the Life of Field average spill indicator values by spill size and source. 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. High Case non-Arctic spill indicators are approximately 35% greater than Arctic High Case counterparts.

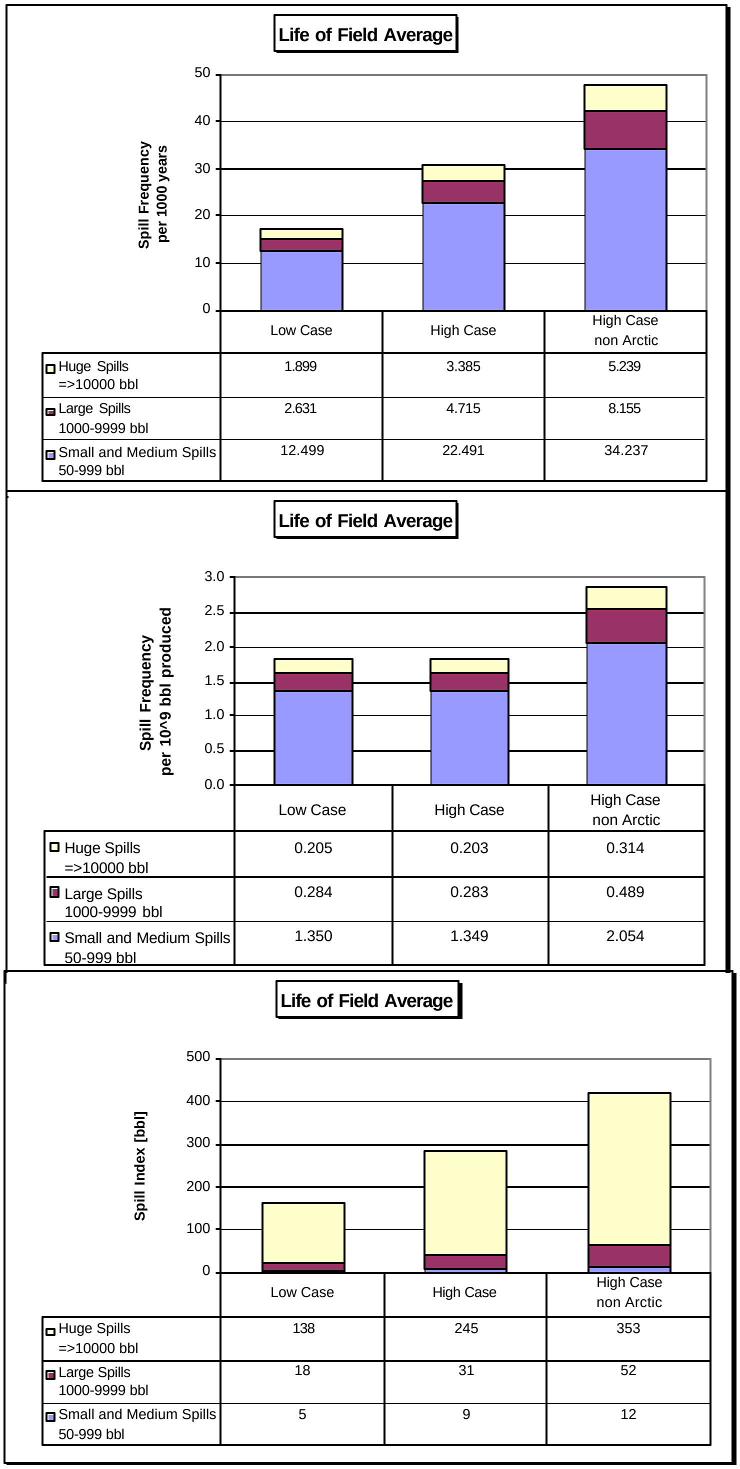
How do the spill indicators vary by facility type for representative scenarios? The contributions of spill indicators by facility have been summarized by representative scenario years, again, in Table 6.1 and also in Figure 6.2. Table 6.1 and Figure 6.2 give the component contributions, in absolute value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

- Pipelines contribute the most (57%) to the two Arctic spill frequency indicators.
- Platforms are next in relative contribution to spill frequencies (33%) and least in contribution to spill index (4%).
- Wells are by far (at 80%) the highest contributors to spill index, while platforms and wells together are responsible for an 84% contribution to the 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. Platforms will be in between, with more spills than wells.

Table 6.1
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	12.499	1.350	5	22.491	1.349	9	34.237	2.054	12
	73%	**73%**	**4%**	**74%**	**74%**	**4%**	**72%**	**72%**	**3%**
Large Spills 1000-9999 bbl	2.631	0.284	18	4.715	0.283	31	8.155	0.489	52
	15%	**15%**	**12%**	**15%**	**15%**	**12%**	**17%**	**17%**	**14%**
Huge Spills =>10000 bbl	1.899	0.205	121	3.385	0.203	213	5.239	0.314	302
	11%	**11%**	**84%**	**11%**	**11%**	**84%**	**11%**	**11%**	**83%**
Significant Spills =>1000 bbl	4.529	0.489	138	8.100	0.486	245	13.394	0.804	353
	27%	**27%**	**96%**	**26%**	**26%**	**96%**	**28%**	**28%**	**97%**
All Spills	17.028	1.839	143	30.592	1.835	254	47.631	2.858	365
	100%	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
Pipeline Spills	9.725	1.050	23	17.506	1.050	42	31.452	1.887	78
	57%	**57%**	**16%**	**57%**	**57%**	**16%**	**66%**	**66%**	**21%**
Platform Spills	5.702	0.616	6	10.263	0.616	10	12.331	0.740	12
	33%	**33%**	**4%**	**34%**	**34%**	**4%**	**26%**	**26%**	**3%**
Well Spills	1.601	0.173	114	2.823	0.169	202	3.848	0.231	275
	9%	**9%**	**80%**	**9%**	**9%**	**80%**	**8%**	**8%**	**75%**
Platform and Well Spills	7.303	0.789	120	13.086	0.785	212	16.179	0.971	287
	43%	**43%**	**84%**	**43%**	**43%**	**84%**	**34%**	**34%**	**79%**
All Spills	17.028	1.839	143	30.592	1.835	254	47.631	2.858	365
	100%	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**



Life of Field Average – Spill Frequency per 1000 years

	Low Case	High Case	High Case non Arctic
Huge Spills =>10000 bbl	1.899	3.385	5.239
Large Spills 1000-9999 bbl	2.631	4.715	8.155
Small and Medium Spills 50-999 bbl	12.499	22.491	34.237

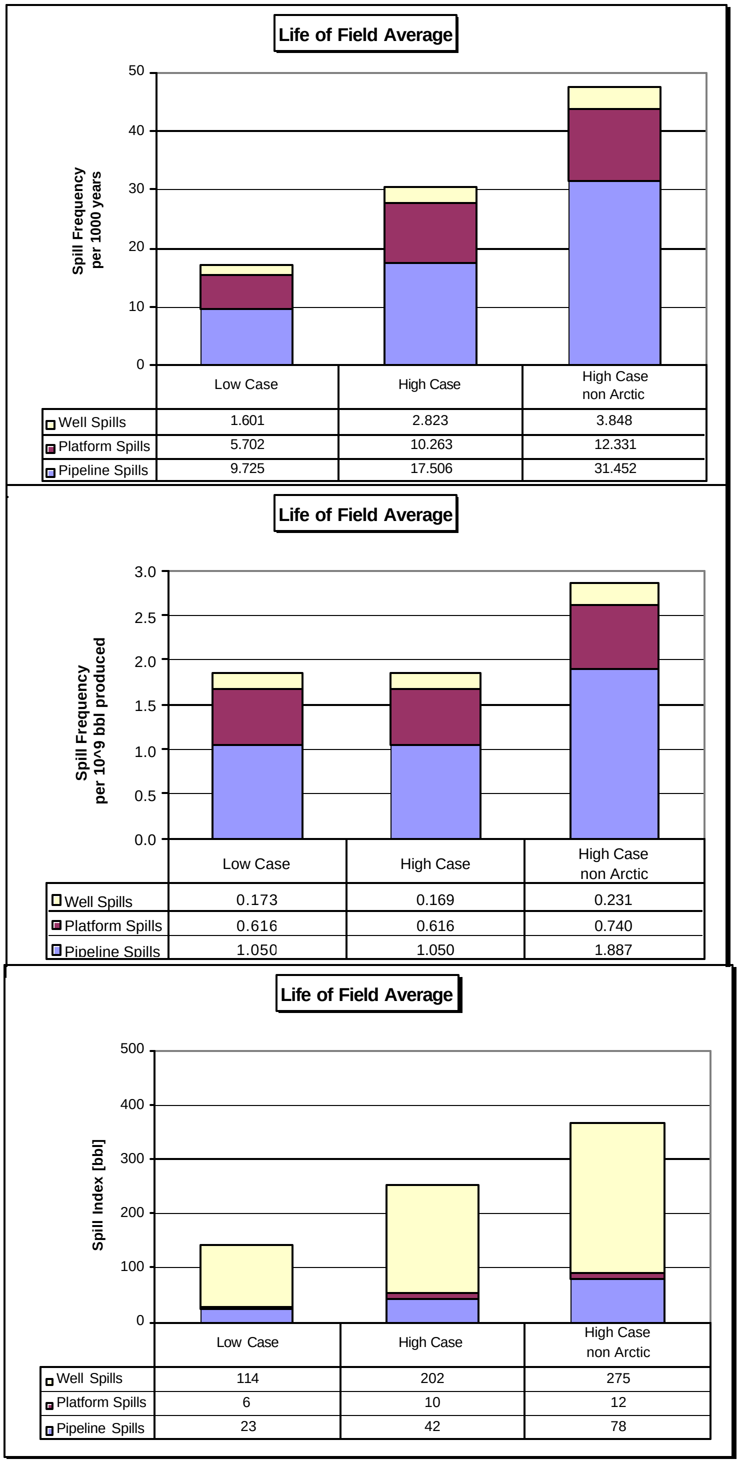
Life of Field Average – Spill Frequency per 10^9 bbl produced

	Low Case	High Case	High Case non Arctic
Huge Spills =>10000 bbl	0.205	0.203	0.314
Large Spills 1000-9999 bbl	0.284	0.283	0.489
Small and Medium Spills 50-999 bbl	1.350	1.349	2.054

Life of Field Average – Spill Index [bbl]

	Low Case	High Case	High Case non Arctic
Huge Spills =>10000 bbl	138	245	353
Large Spills 1000-9999 bbl	18	31	52
Small and Medium Spills 50-999 bbl	5	9	12

Figure 6.1
Chukchi Sea Life of Field Spill Indicators – By Spill Size
(Appendix Figure 5.1)



	Low Case	High Case	High Case non Arctic
Well Spills	1.601	2.823	3.848
Platform Spills	5.702	10.263	12.331
Pipeline Spills	9.725	17.506	31.452

	Low Case	High Case	High Case non Arctic
Well Spills	0.173	0.169	0.231
Platform Spills	0.616	0.616	0.740
Pipeline Spills	1.050	1.050	1.887

	Low Case	High Case	High Case non Arctic
Well Spills	114	202	275
Platform Spills	6	10	12
Pipeline Spills	23	42	78

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

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.

6.1.3 The Variance of Oil Spill Occurrence Indicators

Figures 6.5, 6.6, and 6.7 show the Cumulative Distribution Functions (CDF) for each of the three Chukchi Sea High Case Life of Field average spill indicators. The variability of these indicators is fairly representative of the trends in variability for spill indicators for all sales and locations studied. 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. For example, in the top right-hand graph of Figure 6.5, the significant spills plot has a much steeper (and hence less variable) slope than that of all spills. Similarly, in the top left-hand graph, small and medium spills illustrate the largest variability; huge spills show the least variability for these facilities.
- The opposite occurs for wells, where large spills show greater variance than small ones.
- The variability of the spill index (Figure 6.7) shows variance trends opposite to those of the frequency spill indicators.

The Cumulative Distribution Functions contain extensive information on the statistical properties of the spill indicators. For example, from Figure 6.5, it can be seen, for all significant spills, that the Life of Field average mean (50%) value of 8 (spills per 1,000 years) ranges between about 15 and 3 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 6.6. The spill index variability shown in Figure 6.7 is proportionally higher. For example, in Figure 6.7, the mean value of the significant spills index of 240 per billion barrels produced ranges from 150 to 400.

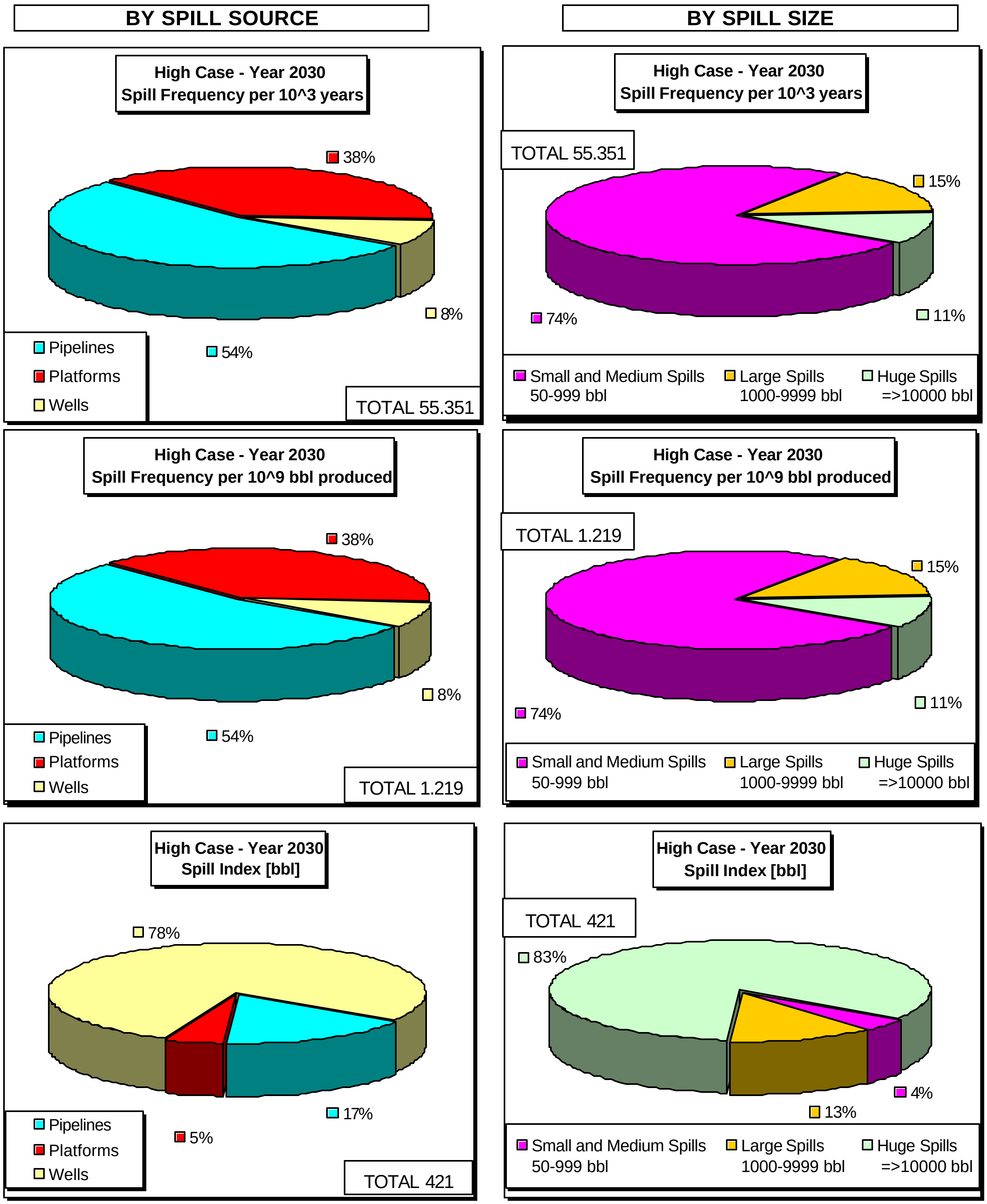


Figure 6.3
Chukchi Sea High Case – Year 2030 –
Spill Indicator Composition by Source and Spill Size
(Appendix Figure 4.2.17)

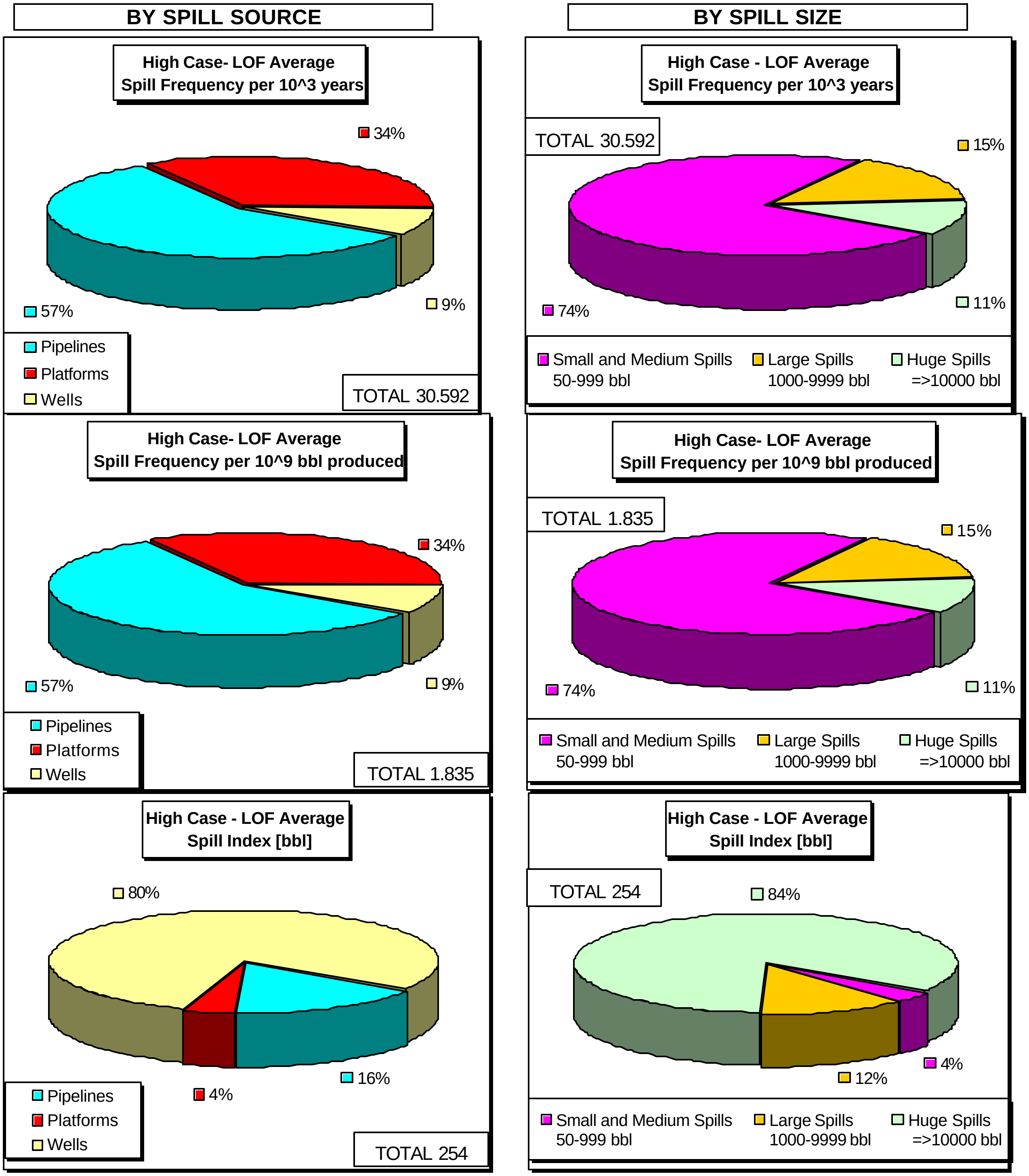


Figure 6.4
Chukchi Sea High Case – Life of Field Average Spill Indicator
Composition by Source and Spill Size
(Appendix Figure 4.2.18)

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

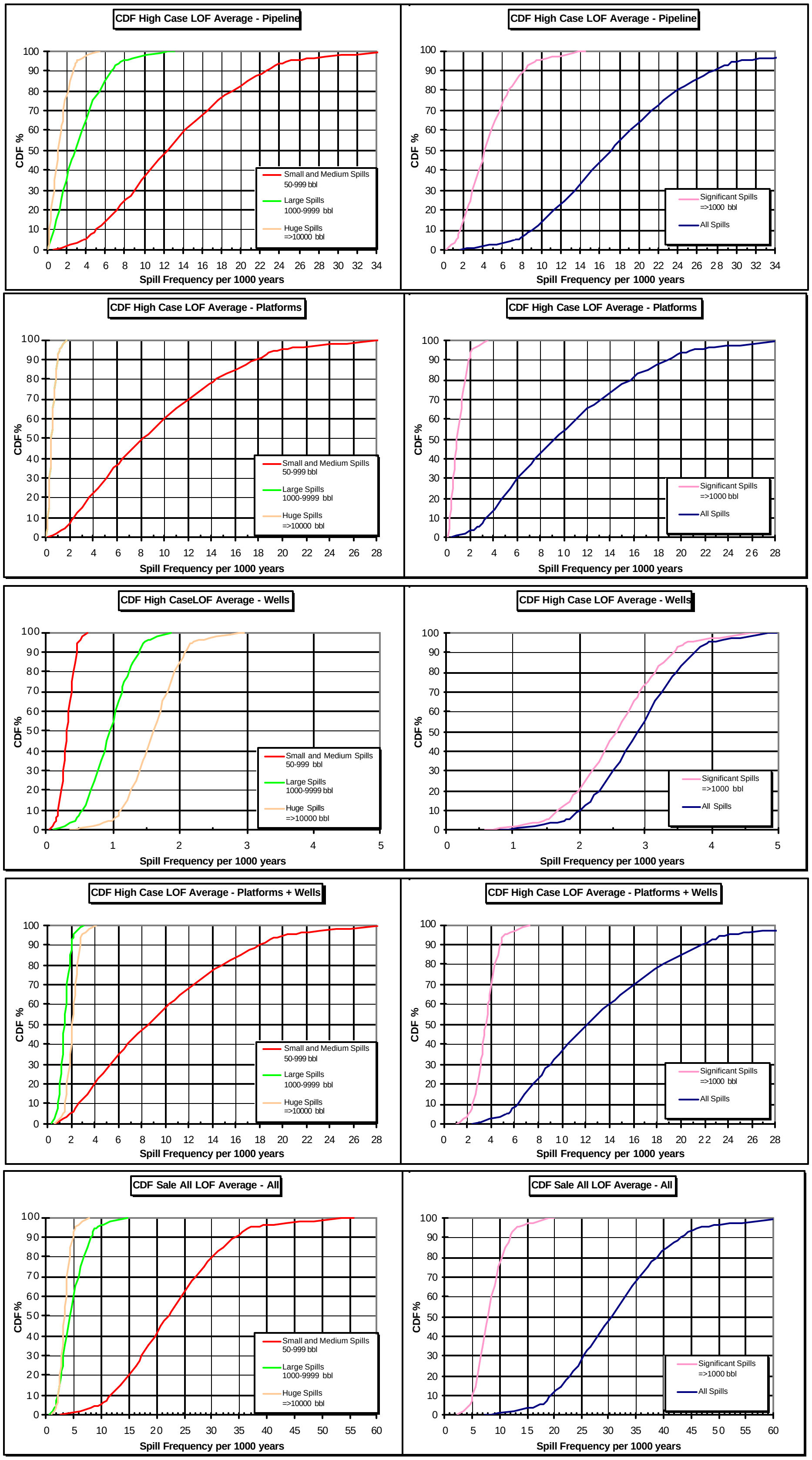
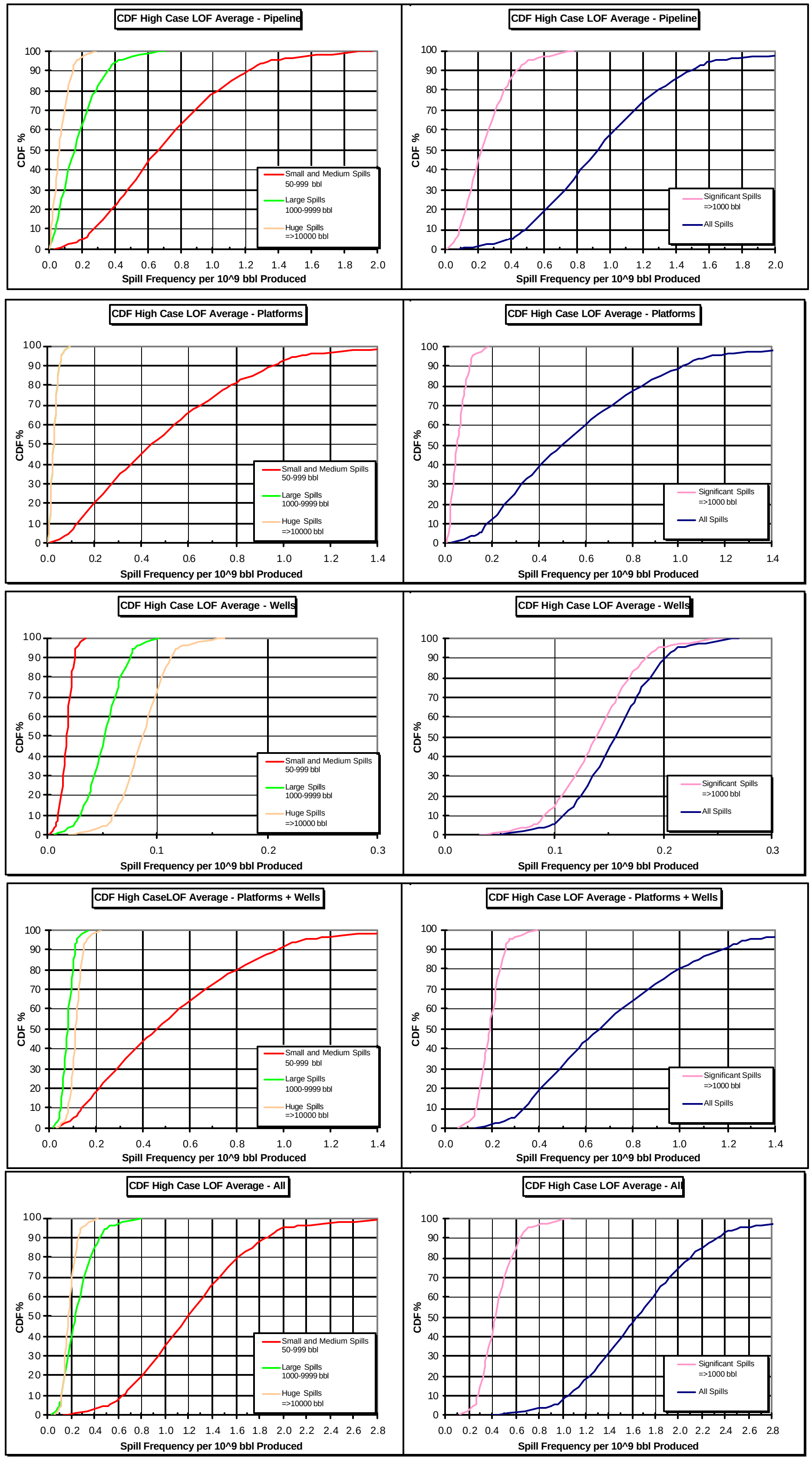


Figure 6.6
Chukchi Sea
High Case
Life of Field
Average Spills
per Barrel Produced
(Appendix
Figure 4.2.15)



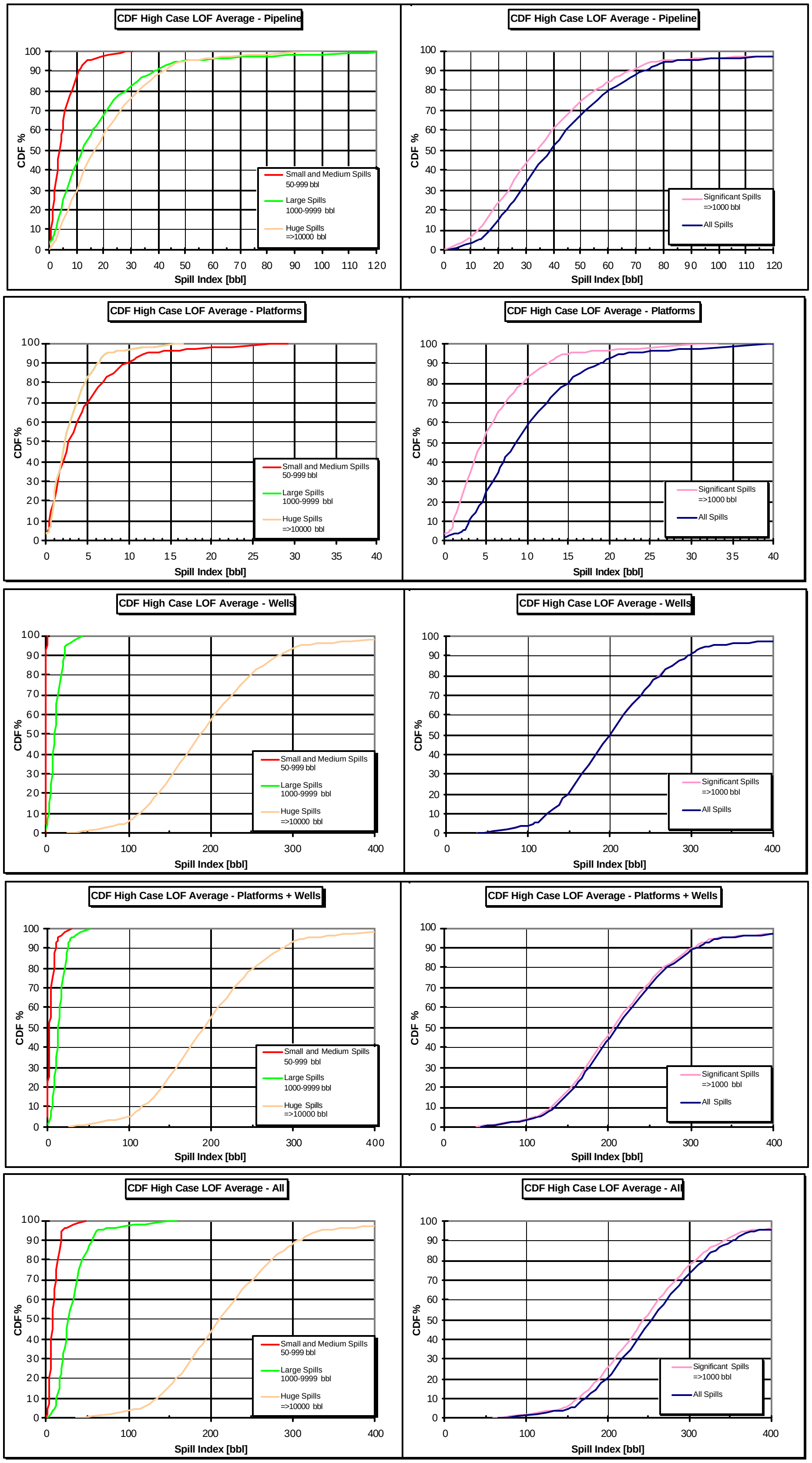


Figure 6.7
Chukchi Sea
High Case
Life of Field
Average
Spill Index (bbl)
– CDF
(Appendix
Figure 4.2.16)

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 Chukchi 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 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 relative cursory way restricted to engineering judgment.

- Upheaval buckling effect assessments were included on the basis of an educated guess used in previous studies; no engineering analysis was carried out for the assessment of frequencies to be expected for these effects.

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 the 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.

REFERENCES

1. AIChE, "Guidelines for Chemical Process Quantitative Risk Analysis", 2nd Edition, Center for Chemical Process Safety, NY, 2000.
2. Anderson, Cheryl McMahon, and Robert P. LaBelle, "Update of Comparative Occurrence Rates for Offshore Oil Spills", Spill Science & Technology Bulletin, Vol. 6., No. 5/6, pp. 303-321, 2000.
3. Beaumont, S., “Refinery Construction in Arctic Weather Conditions – Some Construction, Inspection, and Corrosion Concerns”, in Material Performance, Vol. 26:8, pp 53-56, 01 August 1987.
4. Bercha F.G., "Special Problems in Pipeline Risk Assessment", Proceedings of IPC 2000, International Pipeline Conference, Calgary, AB, October 1-5, 2000.
5. Bercha, F.G., A.C. Churcher, and M. Cerovšek, “Escape, Evacuation, and Rescue Modeling for Frontier Offshore Installations”, Offshore Technology Conference, Houston, Texas, USA, 2000.
6. Bercha, F.G., and M. Cerovšek, Large Arctic Offshore Project Risk Analysis” Proceeding of Russian Arctic Offshore Conference, St. Petersburg, Russia, 1997.
7. Bercha, F.G., "Fault Trees for Everyday Risk Analysis", Proceedings of Canadian Society for Chemical Engineering, Risk Analysis Seminar, Edmonton, 1990.
8. Bercha, F.G., and Associates (Alberta) Limited, "Ice Scour Methodology Study", Final Report to Gulf Canada Resources, Calgary, AB, March 1986.
9. Bercha, F.G., “Application of Risk Analysis to Offshore Drilling and Risk Mitigation,” Proceedings, Risk Analysis Seminar, Royal Commission of the Ocean Ranger Marine Disaster, Toronto, 1984.
10. Bercha, F.G., "Probabilities of Blowouts in the Canadian Arctic", North Sea Offshore Conference, Stavanger, Norway, 1978.
11. Bercha International Inc., “Alternative Oil Spill Occurrence Estimators for the Beaufort and Chukchi Seas – Fault Tree Method”, Volumes I and II, OCS Study MMS 2002-047, Final Report to US Department of the Interior, Minerals Management Service, Alaska Outer Continental Shelf Region, August 2002.
12. Bercha International Inc., “Alternative Oil Spill Occurrence Estimators and their Variability for the Beaufort Sea – Fault Tree Method”, Volumes I and II, OCS Study MMS 2005-061, Final Report to US Department of the Interior, Minerals Management Service, Alaska Outer Continental Shelf Region, January 2006.
13. Bercha International Inc., “Alternative Oil Spill Occurrence Estimators and their Variability for the Chukchi Sea – Fault Tree Method”, Volumes I and II, OCS Study MMS 2006-033, Final Task 1 Report to US Department of the Interior, Minerals Management Service, Alaska Outer Continental Shelf Region, October 2006.

14. Bercha International Inc., “Alternative Oil Spill Occurrence Estimators and their Variability for the Beaufort Sea – Fault Tree Method ~ Update of GOM OCS Statistics to 2006”, OCS Study MMS 2008-025, Final Task 3.1 Report to US Department of the Interior, Minerals Management Service, Alaska Outer Continental Shelf Region, March 3, 2008.
15. Doelp, L.C., G.K. Lee, R.E Linney, and R.W. Ormsby, “Quantitative Fault Tree Analysis: Gate-by-Gate Method”, in Plant/Operations Progress, 4(3) 227-238, 1984.
16. E&P Forum, Quantitative Risk Assessment (QRA) Data Sheet Directory, The Oil Industry International Exploration and Production Forum, 25-28 Old Burlington Street, London, 1996.
17. Fairweather E&P Services, Inc., "Historical Blowout Study, North Slope, Alaska", Study for BP-Amoco Exploration (Alaska), Anchorage, AK, June 2000.
18. Fussell, J.B., “How to Hand Calculate System Reliability and Safety Characteristics”, in IEEE Transactions on Reliability, R-24(3), 169-174, 1975.
19. Gadd, P.E., G. Hearon, C.B. Leidersdorf, W.G. McDougal, J. Ellsworth, and D. Thomas, "Slope Armor Design and Construction Northstar Production Island", in Proceedings, Volume 1, 16th International Conference on Port and Ocean Engineering under Arctic Conditions (POAC), Ottawa, ON, August 12-17, 2001.
20. Goff, R., J. Hammond, and A.C. Nogueira, "Northstar Sub Sea Pipeline Design of Metallurgy, Weldability, and Supporting Full Scale Bending Tests", in Proceedings, Volume 1, 16th International Conference on Port and Ocean Engineering under Arctic Conditions (POAC), Ottawa, ON, August 12-17, 2001.
21. Gulf Canada, "Analysis of Accidents in Offshore Operations Where Hydrocarbons Were Lost", Report by the Houston Technical Services Center of Gulf Research and Development Company for Gulf Canada Resources, Inc., Calgary, AB, 1981.
22. Hart Crowser Inc., "Estimation of Oil Spill Risk From Alaska North Slope, Trans-Alaskan Pipeline, and Arctic Canada Oil Spill Data Sets", OCS Study MMS 2000-007, Study for US Department of the Interior, Minerals Management Service, Alaska Outer Continental Shelf Region, Anchorage, AK, April 2000.
23. Henley, E.J., and H. Kumamoto, “Reliability Engineering and Risk Assessment”, Printice-Hall, Englewood Cliffs, NJ, (ISBN 0-13-772251-6), 1981.
24. Hnatiuk, J., and K.D. Brown, "Sea Bottom Scouring in the Canadian Beaufort Sea", 9th Annual OTC, Houston, TX, May 2-5, 1983.
25. Holand, Per, Offshore Blowouts, Causes and Control, Gulf Publishing, Houston, Texas, USA, 1997.
26. Hoyland, A., and M. Rausand, “System Reliability Theory: Models and Statistical Methods”, John Wiley and Sons, New York, NY, 1994.
27. Hunt, D.M., K.R. McClusky, R. Shirley, and R. Spitzenberger, "Facility Engineering for Arctic Conditions", in Proceedings, Volume 1, 16th International Conference on Port and Ocean Engineering under Arctic Conditions (POAC), Ottawa, ON, August 12-17, 2001.

28. ISO WG8, Arctic Structures, Reliability, Chapter 7, Section 7.2.2.3, October 30, 2006..

29. Lanan, G.A., and J.O. Ennis, "Northstar Offshore Arctic Pipeline Project", in Proceedings, Volume 1, 16th International Conference on Port and Ocean Engineering under Arctic Conditions (POAC), Ottawa, ON, August 12-17, 2001.

30. Leidersdorf, C.B., G.E. Hearon, R.C. Hollar, P.E. Gadd, and T.C. Sullivan, "Ice Gouge and Strudel Scour Data for the Northstar Pipelines", in Proceedings, Volume 1, 16th International Conference on Port and Ocean Engineering under Arctic Conditions (POAC), Ottawa, ON, August 12-17, 2001.

31. Lowrance, W.W., "Of Acceptable Risk", Kaufmann Inc., 1976.

32. Masterson, D.M., A.B. Christopherson, and J.W. Pickering, "Sheet Pile Design for Offshore Gravel Islands", in Proceedings, Volume 1, 16th International Conference on Port and Ocean Engineering under Arctic Conditions (POAC), Ottawa, ON, August 12-17, 2001.

33. Miller, D.L., "Hypersaline Permafrost under a Lagoon of the Arctic Ocean", in Proceedings, Volume 1, 16th International Conference on Port and Ocean Engineering under Arctic Conditions (POAC), Ottawa, ON, August 12-17, 2001.

34. MMS (Minerals Management Service), "Accidents Associated with Oil and Gas Operations: Outer Continental Shelf 1956-1990", OCS Report MMS 92-0058, 1992.

35. MMS (Minerals Management Service), "Federal Offshore Statistics: 1995. Leasing, exploration, production and revenues to December 31, 1995", US Department of the Interior, Mineral Management Service, Operations and Safety Management, OCS Report MMS 97-0007, 1997.

36. MMS (US Department of the Interior, Minerals Management Service, Alaska OCS Region), "Alaska Outer Continental Shelf - Beaufort Sea Planning Area Oil and Gas Lease Sale 144 - Final Environmental Impact Statement", Vol. II, OCS EIS/EA MMS 96-0012, May 1996.

37. MMS (US Department of the Interior, Minerals Management Service, Alaska OCS Region), "Alaska Outer Continental Shelf - Beaufort Sea Planning Area Oil and Gas Lease Sale 170 - Final Environmental Impact Statement", OCS EIS/EA MMS 98-0007, February 1998.

38. MMS (US Department of the Interior, Minerals Management Service, Alaska OCS Region), "Alaska Outer Continental Shelf - Chukchi Sea Oil & Gas Lease Sale 126 - Final Environmental Impact Statement", Vol. II, OCS EIS/EA MMS 90-0095, Anchorage, AK, January 1991.

39. MMS (US Department of the Interior, Minerals Management Service, Alaska OCS Region), "Undiscovered Oil and Gas Resources, Alaska Federal Offshore", OCS Monograph MMS 98-0054, Anchorage, AK, 1998.

40. MMS (US Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region), "Investigation of Shell Offshore Inc., Hobbit Pipeline Leak Ship Shoal Block 281, January 24, 1990, Gulf of Mexico, Offshore Louisiana", OCS Report MMS 91-0025, New Orleans, March 1991.

41. MMS (US Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region), "Investigation of the Exxon Company USA Pipeline Leak /Eugene Island Block 314, May 6, 1990, Gulf of Mexico, Offshore Louisiana", OCS Report MMS 91-0066, New Orleans, November 1991.

42. MMS (US Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Regional Office), "Investigation of Chevron Pipe Line Company Pipeline Leak, South Pass Block 38, September 29, 1998, Gulf of Mexico Off the Louisiana Coast", OCS Report MMS 99-0053, New Orleans, September 1999.

43. MMS (US Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Regional Office), "Investigation of Shell Offshore Inc., Hobbit Pipeline Leak, Ship Shoal Block 281, November 16, 1994, Gulf of Mexico, Off the Louisiana Coast", OCS Report MMS 97-0031, New Orleans, August 1997.

44. MMS (US Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Regional Office), "Investigation of Shell Pipe Line Corporation Pipeline Leak South Pass Block 65 December 30, 1986, Gulf of Mexico off the Louisiana Coast", OCS Report MMS 87-0114, December 1987.

45. Modarres, M., M. Kaminsky, and V. Krisvtsov, "Reliability Engineering and Risk Analysis", Marcel Deker Inc., 1999.

46. O'Connor, M.J, and Associates Ltd., Preliminary Ice Keel/Seabed Interaction Study", Final Report to GCRI, March 1984.

47. Offshore Technology Research Center, "Comparative Risk Analysis for Deepwater Production Systems", Final Project Report for Minerals Management Service, January 2001.

48. OPL, "Field Development Concepts of the World", 1990.

49. Owen, L., D. Blanchet, and P. Flones, "The Northstar Project - Year-Round Production in the Alaskan Beaufort Sea", in Proceedings, Volume 1, 16th International Conference on Port and Ocean Engineering under Arctic Conditions (POAC), Ottawa, ON, August 12-17, 2001.

50. Paulin, M.J., D. Nixon, G.A. Lanan, and B. McShane, "Environmental Loadings & Geotechnical Considerations for the Northstar Offshore Pipelines", in Proceedings, Volume 1, 16th International Conference on Port and Ocean Engineering under Arctic Conditions (POAC), Ottawa, ON, August 12-17, 2001.

51. Roberts, N.H., W.E. Veseley, D.F. Haasl, and F.F. Goldberg, "Fault Tree Handbook", NUREG-0492, US Nuclear Regulatory Commission, Washington, DC, 1985.

52. S.L. Ross Environmental Research Ltd., "Blowout and Spill Probability Assessment for the Northstar and Liberty Oil Development Projects in the Alaska North Slope", Report to BP Exploration (Alaska), Inc., November 1998.

53. Ross, S.L., c.W. Ross, F. Lepine, and K.E. Langtry, "*Ixtoc I* Oil Blowout", Environment Canada E.P.S. Spill Technology Newsletter, pp. 245-256, July-August 1979.

54. S.L. Ross Environmental Research Ltd., "Blowout and Spill Probability Assessment for the Sable Offshore Energy Project", Report to Mobil Oil Canada Properties, November 1995.
55. S.L. Ross Environmental Research Ltd., "Contingency Plans to Monitor and Clean Up Large Spills from SOEP Offshore Facilities", Prepared for Sable Offshore Energy Project, Halifax, NS, March 31, 1998.
56. S.L. Ross Environmental Research Ltd., "Large Oil Spills and Blowouts from Exploration Drilling on Georges Bank: An Analysis of their Probability, Behaviour, Control and Environmental Effects", Chevron Canada Resources and Texaco Canada Petroleum Inc., submitted to the Georges Bank Review Panel, January 1999.
57. S.L. Ross Environmental Research Ltd., "Oil Spills Associated with the Terra Nova Development Project off Newfoundland: Risk Assessment; Spill Fate, Behaviour and Impact; Countermeasures; and Contingency Planning", Report to Petro-Canada Inc., December 1996.
58. S.L. Ross Environmental Research Ltd., "Panuke/Cohasset Field Development Project: Risk, Behaviour and Effects of Oil Spills", Report to IONA Resources Ltd. and Nova Scotia Resources Ltd., July 1989.
59. ScanPower A.S., "Blowout Frequency Assessment of Northstar", Report to BP Exploration (Alaska), Report No. 27.83.01/R1, Kjeller, Norway, July 2, 2001.
60. Sefton, A.D., "The Development of the U.K. Safety Case Regime: A Shift in Responsibility from Government to Industry", Offshore Technology Conference, Houston, USA, 1994.
61. Shared Services Drilling, "A Review of Alaska North Slope Blowouts, 1974-1997", June 30, 1998.
62. Sharples, B.P.M., J.J. Stiff, D.W. Kalinowski and W.G. Tidmarsh, "Statistical Risk Methodology: Application for Pollution Risks from Canadian Georges Bank Drilling Program", 21st Annual Offshore Technology Conference, Houston, TX, May 1-4, 1989.
63. Southwest Research Institute, "New Methods for Rapid Leak Detection in Offshore Pipelines", Final Report to Minerals management Service, US Department of the Interior, SwRI Project No. 04-4558, April 1992.
64. System Safety and Reliability Committee, Santa Barbara County, Energy Division, "Risk Matrix Guidelines", 1998.
65. U.S. Nuclear Regulatory Commission, "Reactor Safety Study", WASH-1400, NUREG-75/014, Appendix I – IV, October 1975.
66. Upstream Technology Group, "Analysis of Strudel Scours and Ice Gouges for the Liberty Development Pipeline", Final Draft, *no date.*
67. Weeks, W.F., P.W. Barnes, D.M. Rearic, and E. Reimnitz, "Some Probabilistic Aspects of Ice Gouging on the Alaskan Shelf of the Beaufort Sea", US Army Cold Regions Research and Engineering Laboratory, June 7, 1983.
68. Weeks, W.F., P.W. Barnes, D.M. Rearic, and E. Reimnitz, "Statistical Aspects of Ice Gouging on the Alaskan Shelf of the Beaufort Sea", US Army Cold Regions Research and Engineering Laboratory, 1982.
69. Wylie, W.W., and A.B. Visram, "Drilling Kick Statistics", Proceedings, IADC/SPE Drilling Conference, Houston, TX, February 27-March 2, 1980.

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 2008-036

FINAL TASK 4A.2 REPORT

VOLUME II – APPENDICES

Alternative Oil Spill Occurrence Estimators and their Variability for the Chukchi 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 2008-036

FINAL TASK 4A.2 REPORT

VOLUME II – APPENDICES

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

March 2008

Principal Investigator: Dr. Frank G. Bercha, P.Eng.

Bercha International Inc.
2926 Parkdale Boulevard N.W.
Calgary, Alberta, T2N 3S9, Canada
Email: berchaf@berchagroup.com

This study was funded by the U.S. Department of the Interior, Minerals Management Service (MMS), Alaska Outer Continental Shelf Region, Anchorage, under Contract No. 1435-01-05-CT-39348, as part of the MMS Alaska Environmental Studies Program.

LIST OF APPENDICES

(VOLUME II – APPENDICES)

APPENDIX

T.0 Table of Contents

T.0 Table of Contents

T.0 Table of Contents

T.0 Table of Contents

Figure 0 Flow Chart

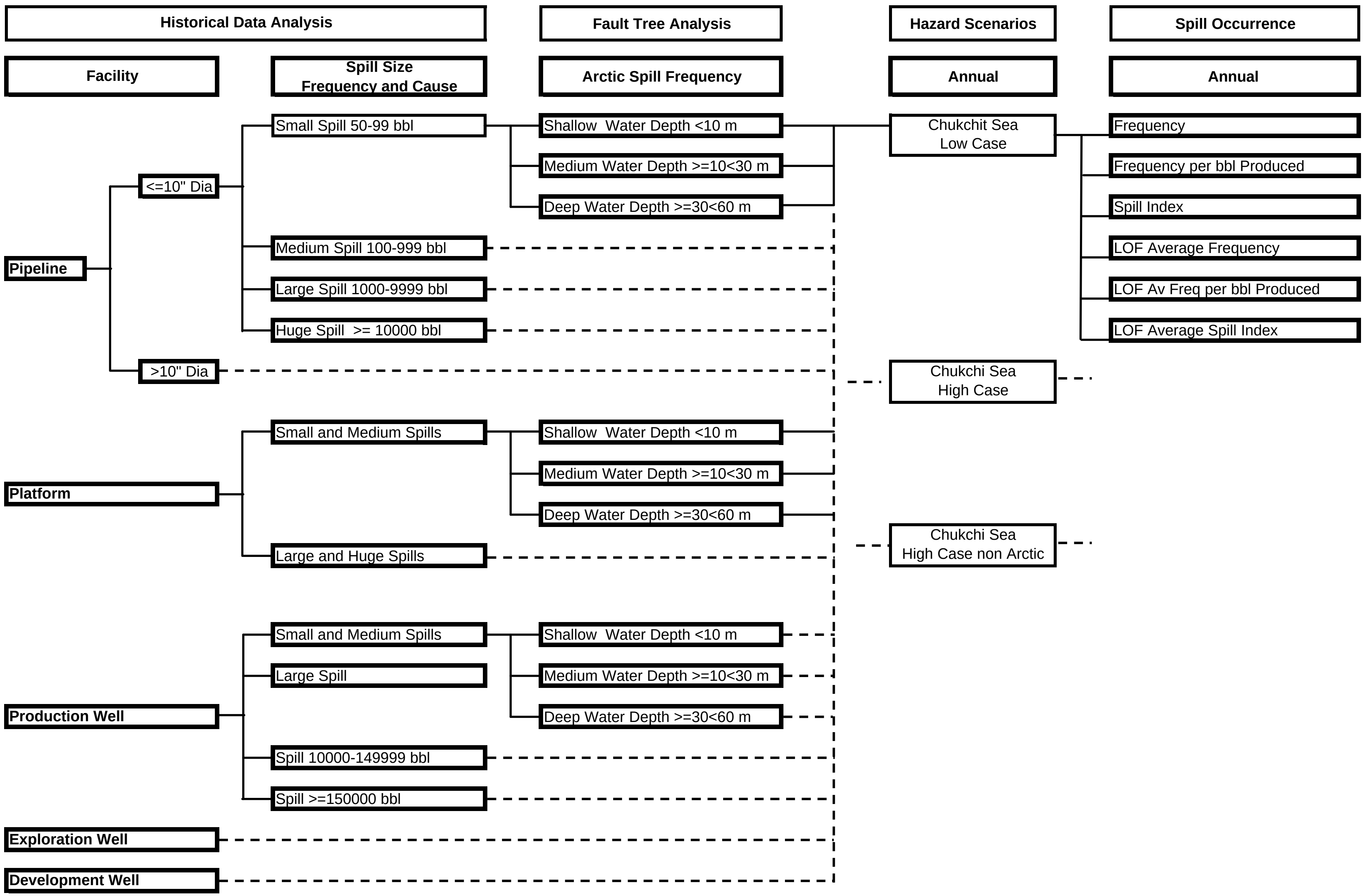


Table 1.1
Analysis of Historical Spills - Pipeline

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**		**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 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	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 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	(30)	(40)	(50)	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	(90)	(80)	(80)	Gradient low. Mud slide potential (gradient) increases with water depth.
Storm/ Hurricane	All	(70)	(70)	(60)	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)	(30)	(10)	(90)	(40)	(10)	(90)	(50)	(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)	(90)	(10)	(90)	(80)	(10)	(90)	(80)	(10)
Storm/ Hurricane	**All**	(90)	(70)	(10)	(90)	(70)	(10)	(90)	(60)	(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**	5.461	5.540	4.792	**6.608**	5.913	5.992	5.244
MEDIUM SPILLS 100-999 bbl	**10.563**	9.042	9.121	8.371	**14.867**	12.445	12.525	11.773
LARGE SPILLS 1000-9999 bbl	**5.282**	4.455	4.625	2.750	**8.259**	5.998	6.155	4.271
HUGE SPILLS =>10000 bbl	**0.755**	0.735	0.770	0.396	**3.304**	2.055	2.079	1.698

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
Strdel 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**	**5.12**	**(0.238)**	**0.280**	**5.05**	**(0.238)**	**0.280**	**5.84**	**0.566**	**(0.260)**	**0.306**	**5.18**	**(0.260)**	**0.306**	**5.11**	**(0.260)**	**0.306**	**5.84**
External	2.86	0.172	(0.079)	0.093	1.71	(0.079)	0.093	1.68	(0.079)	0.093	1.95	0.189	(0.087)	0.102	1.73	(0.087)	0.102	1.70	(0.087)	0.102	1.95
Internal	5.71	0.345	(0.158)	0.187	3.42	(0.158)	0.187	3.37	(0.158)	0.187	3.89	0.378	(0.173)	0.204	3.45	(0.173)	0.204	3.41	(0.173)	0.204	3.89
THIRD PARTY IMPACT	**22.86**	**1.380**	**(0.683)**	**0.697**	**12.76**	**(0.686)**	**0.693**	**12.52**	**(0.690)**	**0.690**	**14.39**	**1.510**	**(0.747)**	**0.763**	**12.90**	**(0.751)**	**0.759**	**12.67**	**(0.755)**	**0.755**	**14.40**
Anchor Impact	20.00	1.207	(0.604)	0.604	11.05	(0.604)	0.604	10.90	(0.604)	0.604	12.60	1.322	(0.661)	0.661	11.17	(0.661)	0.661	11.03	(0.661)	0.661	12.60
Jackup Rig or Spud Barge																					
Trawl/Fishing Net	2.86	0.172	(0.079)	0.093	1.71	(0.083)	0.090	1.62	(0.086)	0.086	1.80	0.189	(0.087)	0.102	1.73	(0.090)	0.098	1.64	(0.094)	0.094	1.80
OPERATION IMPACT	**8.57**	**0.517**	**(0.145)**	**0.373**	**6.83**	**(0.145)**	**0.373**	**6.73**	**(0.145)**	**0.373**	**7.78**	**0.566**	**(0.158)**	**0.408**	**6.90**	**(0.158)**	**0.408**	**6.81**	**(0.158)**	**0.408**	**7.78**
Rig Anchoring	2.86	0.172	(0.048)	0.124	2.28	(0.048)	0.124	2.24	(0.048)	0.124	2.59	0.189	(0.053)	0.136	2.30	(0.053)	0.136	2.27	(0.053)	0.136	2.59
Work Boat Anchoring	5.71	0.345	(0.096)	0.249	4.55	(0.096)	0.249	4.49	(0.096)	0.249	5.19	0.378	(0.106)	0.272	4.60	(0.106)	0.272	4.54	(0.106)	0.272	5.19
MECHANICAL	**5.71**	**0.345**		**0.345**	**6.32**		**0.345**	**6.23**		**0.345**	**7.20**	**0.378**		**0.378**	**6.39**		**0.378**	**6.30**		**0.378**	**7.20**
Connection Failure	2.86	0.172		0.172	3.16		0.172	3.11		0.172	3.60	0.189		0.189	3.19		0.189	3.15		0.189	3.60
Material Failure	2.86	0.172		0.172	3.16		0.172	3.11		0.172	3.60	0.189		0.189	3.19		0.189	3.15		0.189	3.60
NATURAL HAZARD	**48.57**	**2.932**	**(0.197)**	**2.734**	**50.07**	**(0.193)**	**2.739**	**49.44**	**(0.193)**	**2.739**	**57.15**	**3.209**	**(0.216)**	**2.993**	**50.62**	**(0.211)**	**2.998**	**50.03**	**(0.211)**	**2.998**	**57.17**
Mud Slide	5.71	0.345	(0.197)	0.148	2.70	(0.193)	0.152	2.74	(0.193)	0.152	3.17	0.378	(0.216)	0.162	2.73	(0.211)	0.166	2.77	(0.211)	0.166	3.17
Storm/ Hurricane	42.86	2.587		2.587	47.37		2.587	46.70		2.587	53.98	2.832		2.832	47.89		2.832	47.26		2.832	54.00
ARCTIC			**0.687**	**0.687**	**12.59**	**0.765**	**0.765**	**13.81**	**0.021**	**0.021**	**0.44**		**0.687**	**0.687**	**11.63**	**0.765**	**0.765**	**12.77**	**0.021**	**0.021**	**0.41**
Ice Gouging			0.5411	0.5411	9.91	0.6763	0.6763	12.21					0.5411	0.5411	9.15	0.6763	0.6763	11.29			
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	0.22	0.0129	0.0129	0.25
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	1.26	0.0019	0.0019	0.04		0.0625	0.0625	1.06	0.0696	0.0696	1.16	0.0019	0.0019	0.04
UNKNOWN	**5.71**	**0.345**		**0.345**	**6.32**		**0.345**	**6.23**		**0.345**	**7.20**	**0.378**		**0.378**	**6.39**		**0.378**	**6.30**		**0.378**	**7.20**
TOTALS	**100.00**	**6.036**	**(0.575)**	**5.461**	**100.00**	**(0.496)**	**5.540**	**100.00**	**(1.244)**	**4.792**	**100.00**	**6.608**	**(0.694)**	**5.913**	**100.00**	**(0.616)**	**5.992**	**100.00**	**(1.363)**	**5.244**	**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**	**5.42**	**(0.416)**	**0.490**	**5.37**	**(0.416)**	**0.490**	**5.85**	**1.274**	**(0.585)**	**0.689**	**5.54**	**(0.585)**	**0.689**	**5.50**	**(0.585)**	**0.689**	**5.86**
External	2.86	0.302	(0.139)	0.163	1.81	(0.139)	0.163	1.79	(0.139)	0.163	1.95	0.425	(0.195)	0.230	1.85	(0.195)	0.230	1.83	(0.195)	0.230	1.95
Internal	5.71	0.604	(0.277)	0.327	3.61	(0.277)	0.327	3.58	(0.277)	0.327	3.90	0.850	(0.390)	0.460	3.69	(0.390)	0.460	3.67	(0.390)	0.460	3.90
THIRD PARTY IMPACT	**22.86**	**2.414**	**(1.195)**	**1.220**	**13.49**	**(1.201)**	**1.213**	**13.30**	**(1.207)**	**1.207**	**14.42**	**3.398**	**(1.682)**	**1.716**	**13.79**	**(1.690)**	**1.708**	**13.64**	**(1.699)**	**1.699**	**14.43**
Anchor Impact	20.00	2.113	(1.056)	1.056	11.68	(1.056)	1.056	11.58	(1.056)	1.056	12.62	2.973	(1.487)	1.487	11.95	(1.487)	1.487	11.87	(1.487)	1.487	12.63
Jackup Rig or Spud Barge																					
Trawl/Fishing Net	2.86	0.302	(0.139)	0.163	1.81	(0.145)	0.157	1.72	(0.151)	0.151	1.80	0.425	(0.195)	0.230	1.85	(0.204)	0.221	1.77	(0.212)	0.212	1.80
OPERATION IMPACT	**8.57**	**0.905**	**(0.253)**	**0.652**	**7.21**	**(0.253)**	**0.652**	**7.15**	**(0.253)**	**0.652**	**7.79**	**1.274**	**(0.356)**	**0.918**	**7.38**	**(0.356)**	**0.918**	**7.33**	**(0.356)**	**0.918**	**7.80**
Rig Anchoring	2.86	0.302	(0.084)	0.217	2.40	(0.084)	0.217	2.38	(0.084)	0.217	2.60	0.425	(0.119)	0.306	2.46	(0.119)	0.306	2.44	(0.119)	0.306	2.60
Work Boat Anchoring	5.71	0.604	(0.169)	0.435	4.81	(0.169)	0.435	4.77	(0.169)	0.435	5.20	0.850	(0.237)	0.612	4.92	(0.237)	0.612	4.89	(0.237)	0.612	5.20
MECHANICAL	**5.71**	**0.604**		**0.604**	**6.68**		**0.604**	**6.62**		**0.604**	**7.21**	**0.850**		**0.850**	**6.83**		**0.850**	**6.78**		**0.850**	**7.22**
Connection Failure	2.86	0.302		0.302	3.34		0.302	3.31		0.302	3.61	0.425		0.425	3.41		0.425	3.39		0.425	3.61
Material Failure	2.86	0.302		0.302	3.34		0.302	3.31		0.302	3.61	0.425		0.425	3.41		0.425	3.39		0.425	3.61
NATURAL HAZARD	**48.57**	**5.131**	**(0.345)**	**4.785**	**52.93**	**(0.338)**	**4.793**	**52.55**	**(0.338)**	**4.793**	**57.26**	**7.221**	**(0.486)**	**6.735**	**54.12**	**(0.475)**	**6.746**	**53.86**	**(0.475)**	**6.746**	**57.30**
Mud Slide	5.71	0.604	(0.345)	0.258	2.86	(0.338)	0.266	2.91	(0.338)	0.266	3.18	0.850	(0.486)	0.363	2.92	(0.475)	0.374	2.99	(0.475)	0.374	3.18
Storm/ Hurricane	42.86	4.527		4.527	50.07		4.527	49.63		4.527	54.08	6.372		6.372	51.20		6.372	50.87		6.372	54.12
ARCTIC			**0.687**	**0.687**	**7.60**	**0.765**	**0.765**	**8.39**	**0.021**	**0.021**	**0.25**		**0.687**	**0.687**	**5.52**	**0.765**	**0.765**	**6.11**	**0.021**	**0.021**	**0.18**
Ice Gouging			0.5411	0.5411	5.98	0.6763	0.6763	7.42					0.5411	0.5411	4.35	0.6763	0.6763	5.40			
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	0.56	0.0019	0.0019	0.02
UNKNOWN	**5.71**	**0.604**		**0.604**	**6.68**		**0.604**	**6.62**		**0.604**	**7.21**	**0.850**		**0.850**	**6.83**		**0.850**	**6.78**		**0.850**	**7.22**
TOTALS	**100.00**	**10.563**	**(1.522)**	**9.042**	**100.00**	**(1.442)**	**9.121**	**100.00**	**(2.192)**	**8.371**	**100.00**	**14.867**	**(2.422)**	**12.445**	**100.00**	**(2.342)**	**12.525**	**100.00**	**(3.094)**	**11.773**	**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**	**4.28**	**(0.162)**	**0.190**	**4.12**	**(0.162)**	**0.190**	**6.92**	**0.551**	**(0.253)**	**0.298**	**4.97**	**(0.253)**	**0.298**	**4.84**	**(0.253)**	**0.298**	**6.97**
External																					
Internal	6.67	0.352	(0.162)	0.190	4.28	(0.162)	0.190	4.12	(0.162)	0.190	6.92	0.551	(0.253)	0.298	4.97	(0.253)	0.298	4.84	(0.253)	0.298	6.97
THIRD PARTY IMPACT	**66.67**	**3.521**	**(1.703)**	**1.818**	**40.81**	**(1.731)**	**1.790**	**38.69**	**(1.761)**	**1.761**	**64.01**	**5.506**	**(2.663)**	**2.843**	**47.41**	**(2.707)**	**2.799**	**45.48**	**(2.753)**	**2.753**	**64.46**
Anchor Impact	33.33	1.761	(0.880)	0.880	19.76	(0.880)	0.880	19.03	(0.880)	0.880	32.00	2.753	(1.377)	1.377	22.95	(1.377)	1.377	22.37	(1.377)	1.377	32.23
Jackup Rig or Spud Barge	6.67	0.352	(0.176)	0.176	3.95	(0.176)	0.176	3.81	(0.176)	0.176	6.40	0.551	(0.275)	0.275	4.59	(0.275)	0.275	4.47	(0.275)	0.275	6.45
Trawl/Fishing Net	26.67	1.408	(0.647)	0.762	17.10	(0.675)	0.733	15.86	(0.704)	0.704	25.60	2.203	(1.011)	1.191	19.87	(1.056)	1.147	18.64	(1.101)	1.101	25.78
OPERATION IMPACT	**6.67**	**0.352**	**(0.098)**	**0.254**	**5.69**	**(0.098)**	**0.254**	**5.48**	**(0.098)**	**0.254**	**9.22**	**0.551**	**(0.154)**	**0.397**	**6.61**	**(0.154)**	**0.397**	**6.45**	**(0.154)**	**0.397**	**9.29**
Rig Anchoring																					
Work Boat Anchoring	6.67	0.352	(0.098)	0.254	5.69	(0.098)	0.254	5.48	(0.098)	0.254	9.22	0.551	(0.154)	0.397	6.61	(0.154)	0.397	6.45	(0.154)	0.397	9.29
MECHANICAL																					
Connection Failure																					
Material Failure																					
NATURAL HAZARD	**20.00**	**1.056**	**(0.582)**	**0.474**	**10.64**	**(0.578)**	**0.478**	**10.34**	**(0.564)**	**0.493**	**17.91**	**1.652**	**(0.911)**	**0.741**	**12.36**	**(0.904)**	**0.748**	**12.15**	**(0.882)**	**0.770**	**18.03**
Mud Slide	6.67	0.352	(0.201)	0.151	3.38	(0.197)	0.155	3.35	(0.197)	0.155	5.64	0.551	(0.315)	0.236	3.93	(0.308)	0.242	3.94	(0.308)	0.242	5.68
Storm/ Hurricane	13.33	0.704	(0.381)	0.323	7.26	(0.381)	0.323	6.99	(0.367)	0.338	12.27	1.101	(0.596)	0.506	8.43	(0.596)	0.506	8.21	(0.573)	0.528	12.36
ARCTIC			**1.719**	**1.719**	**38.58**	**1.913**	**1.913**	**41.36**	**0.053**	**0.053**	**1.93**		**1.719**	**1.719**	**28.65**	**1.913**	**1.913**	**31.09**	**0.053**	**0.053**	**1.25**
Ice Gouging			1.3527	1.3527	30.36	1.6908	1.6908	36.56					1.3527	1.3527	22.55	1.6908	1.6908	27.47			
Strudel Scour			0.1613	0.1613	3.62								0.1613	0.1613	2.69						
Upheaval Buckling			0.0323	0.0323	0.72	0.0323	0.0323	0.70	0.0323	0.0323	1.17		0.0323	0.0323	0.54	0.0323	0.0323	0.52	0.0323	0.0323	0.76
Thaw Settlement			0.0161	0.0161	0.36	0.0161	0.0161	0.35	0.0161	0.0161	0.59		0.0161	0.0161	0.27	0.0161	0.0161	0.26	0.0161	0.0161	0.38
Other Arctic			0.1562	0.1562	3.51	0.1739	0.1739	3.76	0.0048	0.0048	0.18		0.1562	0.1562	2.60	0.1739	0.1739	2.83	0.0048	0.0048	0.11
UNKNOWN																					
TOTALS	**100.00**	**5.282**	**(0.827)**	**4.455**	**100.00**	**(0.656)**	**4.625**	**100.00**	**(2.531)**	**2.750**	**100.00**	**8.259**	**(2.262)**	**5.998**	**100.00**	**(2.105)**	**6.155**	**100.00**	**(3.988)**	**4.271**	**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**	**3.70**	**(0.023)**	**0.027**	**3.53**	**(0.023)**	**0.027**	**6.87**	**0.220**	**(0.101)**	**0.119**	**5.80**	**(0.101)**	**0.119**	**5.73**	**(0.101)**	**0.119**	**7.02**
External																					
Internal	6.67	0.050	(0.023)	0.027	3.70	(0.023)	0.027	3.53	(0.023)	0.027	6.87	0.220	(0.101)	0.119	5.80	(0.101)	0.119	5.73	(0.101)	0.119	7.02
THIRD PARTY IMPACT	**66.67**	**0.503**	**(0.243)**	**0.260**	**35.36**	**(0.247)**	**0.256**	**33.20**	**(0.252)**	**0.252**	**63.52**	**2.203**	**(1.065)**	**1.137**	**55.34**	**(1.083)**	**1.120**	**53.84**	**(1.101)**	**1.101**	**64.86**
Anchor Impact	33.33	0.252	(0.126)	0.126	17.12	(0.126)	0.126	16.33	(0.126)	0.126	31.76	1.101	(0.551)	0.551	26.79	(0.551)	0.551	26.48	(0.551)	0.551	32.43
Jackup Rig or Spud Barge	6.67	0.050	(0.025)	0.025	3.42	(0.025)	0.025	3.27	(0.025)	0.025	6.35	0.220	(0.110)	0.110	5.36	(0.110)	0.110	5.30	(0.110)	0.110	6.49
Trawl/Fishing Net	26.67	0.201	(0.092)	0.109	14.82	(0.096)	0.105	13.61	(0.101)	0.101	25.41	0.881	(0.404)	0.477	23.19	(0.422)	0.459	22.06	(0.441)	0.441	25.95
OPERATION IMPACT	**6.67**	**0.050**	**(0.014)**	**0.036**	**4.93**	**(0.014)**	**0.036**	**4.71**	**(0.014)**	**0.036**	**9.15**	**0.220**	**(0.062)**	**0.159**	**7.72**	**(0.062)**	**0.159**	**7.63**	**(0.062)**	**0.159**	**9.35**
Rig Anchoring																					
Work Boat Anchoring	6.67	0.050	(0.014)	0.036	4.93	(0.014)	0.036	4.71	(0.014)	0.036	9.15	0.220	(0.062)	0.159	7.72	(0.062)	0.159	7.63	(0.062)	0.159	9.35
MECHANICAL																					
Connection Failure																					
Material Failure																					
NATURAL HAZARD	**20.00**	**0.151**	**(0.083)**	**0.068**	**9.22**	**(0.083)**	**0.068**	**8.87**	**(0.081)**	**0.070**	**17.77**	**0.661**	**(0.364)**	**0.296**	**14.42**	**(0.362)**	**0.299**	**14.39**	**(0.353)**	**0.308**	**18.15**
Mud Slide	6.67	0.050	(0.029)	0.022	2.93	(0.028)	0.022	2.88	(0.028)	0.022	5.59	0.220	(0.126)	0.094	4.58	(0.123)	0.097	4.66	(0.123)	0.097	5.71
Storm/ Hurricane	13.33	0.101	(0.054)	0.046	6.29	(0.054)	0.046	6.00	(0.052)	0.048	12.18	0.441	(0.238)	0.202	9.84	(0.238)	0.202	9.73	(0.229)	0.211	12.43
ARCTIC			**0.344**	**0.344**	**46.79**	**0.383**	**0.383**	**49.69**	**0.011**	**0.011**	**2.69**		**0.344**	**0.344**	**16.72**	**0.383**	**0.383**	**18.40**	**0.011**	**0.011**	**0.63**
Ice Gouging			0.2705	0.2705	36.83	0.3382	0.3382	43.91					0.2705	0.2705	13.16	0.3382	0.3382	16.26			
Strudel Scour			0.0323	0.0323	4.39								0.0323	0.0323	1.57						
Upheaval Buckling			0.0065	0.0065	0.88	0.0065	0.0065	0.84	0.0065	0.0065	1.63		0.0065	0.0065	0.31	0.0065	0.0065	0.31	0.0065	0.0065	0.38
Thaw Settlement			0.0032	0.0032	0.44	0.0032	0.0032	0.42	0.0032	0.0032	0.81		0.0032	0.0032	0.16	0.0032	0.0032	0.16	0.0032	0.0032	0.19
Other Arctic			0.0312	0.0312	4.25	0.0348	0.0348	4.52	0.0010	0.0010	0.24		0.0312	0.0312	1.52	0.0348	0.0348	1.67	0.0010	0.0010	0.06
UNKNOWN																					
TOTALS	**100.00**	**0.755**	**(0.020)**	**0.735**	**100.00**	**0.016**	**0.770**	**100.00**	**(0.359)**	**0.396**	**100.00**	**3.304**	**(1.248)**	**2.055**	**100.00**	**(1.225)**	**2.079**	**100.00**	**(1.606)**	**1.698**	**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**	(40)	(40)	(40)	Very low traffic density.
WEATHER	**All**	20	20	20	Cold Teperatures, cycling
HURRICANE	**All**	(70)	(70)	(60)	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**	0.0121	0.0157	0.0212	5% of sum of above.
		0.0066	0.0075	0.0088	
	LH	0.0021	0.0027	0.0037	
		0.0011	0.0013	0.0015	

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)	(40)	(10)	(60)	(40)	(10)	(60)	(40)	(10)
WEATHER	**All**	10	20	30	10	20	30	10	20	30
HURRICANE	**All**	(90)	(70)	(10)	(90)	(70)	(10)	(90)	(60)	(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**	0.0026	0.0066	0.0244	0.0027	0.0075	0.0329	0.0028	0.0088	0.0456
	LH	0.0004	0.0011	0.0042	0.0005	0.0013	0.0057	0.0005	0.0015	0.0080

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**	3.052	3.681	3.799
LARGE AND HUGE SPILLS =>1000 bbl	**0.481**	0.393	0.406	0.430

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	52.01	(0.816)	1.587	43.12	(0.816)	1.587	41.78
Process Equipment	20.90	0.961	(0.327)	0.635	20.80	(0.327)	0.635	17.25	(0.327)	0.635	16.71
Transfer Hose	17.91	0.824	(0.280)	0.544	17.83	(0.280)	0.544	14.78	(0.280)	0.544	14.32
Incorrect Operation	13.43	0.618	(0.210)	0.408	13.37	(0.210)	0.408	11.09	(0.210)	0.408	10.74
HUMAN ERROR	17.91	0.824	(0.816)	0.008	0.26	(0.263)	0.561	15.23	(0.263)	0.561	14.76
TANK FAILURE	2.99	0.137	(0.047)	0.091	2.97	(0.047)	0.091	2.46	(0.047)	0.091	2.39
SHIP COLLISION	7.46	0.343	(0.124)	0.220	7.20	(0.124)	0.220	5.97	(0.124)	0.220	5.78
WEATHER	11.94	0.549	0.110	0.659	21.60	0.110	0.659	17.91	0.110	0.659	17.35
HURRICANE	4.48	0.206	(0.111)	0.095	3.10	(0.111)	0.095	2.57	(0.107)	0.099	2.60
OTHER	2.99	0.137		0.137	4.50		0.137	3.73		0.137	3.62
ARCTIC			0.255	0.255	8.37	0.331	0.331	9.00	0.445	0.445	11.72
Ice Force			0.145	0.145	4.74	0.217	0.217	5.90	0.326	0.326	8.57
Facility Low Temperature			0.099	0.099	3.23	0.099	0.099	2.68	0.099	0.099	2.60
Other Arctic			0.012	0.012	0.40	0.016	0.016	0.43	0.021	0.021	0.56
TOTALS	100.00	4.601	(1.549)	3.052	100.00	(0.920)	3.681	100.00	(0.802)	3.799	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**	**11.55**	**(0.023)**	**0.045**	**11.17**	**(0.023)**	**0.045**	**10.54**
SHIP COLLISION	**14.29**	**0.069**	**(0.025)**	**0.044**	**11.18**	**(0.025)**	**0.044**	**10.82**	**(0.025)**	**0.044**	**10.21**
WEATHER	**28.57**	**0.137**	**0.027**	**0.165**	**41.97**	**0.027**	**0.165**	**40.58**	**0.027**	**0.165**	**38.29**
HURRICANE	**42.86**	**0.206**	**(0.111)**	**0.095**	**24.08**	**(0.111)**	**0.095**	**23.29**	**(0.107)**	**0.099**	**22.94**
OTHER											
ARCTIC			**0.044**	**0.044**	**11.22**	**0.057**	**0.057**	**14.15**	**0.078**	**0.078**	**18.02**
Ice Force			0.026	0.026	6.50	0.038	0.038	9.43	0.057	0.057	13.35
Facility Low Temperature			0.016	0.016	4.18	0.016	0.016	4.05	0.016	0.016	3.82
Other Arctic			0.002	0.002	0.53	0.003	0.003	0.67	0.004	0.004	0.86
TOTALS	**100.00**	**0.481**	**(0.088)**	**0.393**	**100.00**	**(0.075)**	**0.406**	**100.00**	**(0.050)**	**0.430**	**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 Frequency Change	Shallow New Frequency	Medium Frequency Change	Medium New Frequency	Deep Frequency Change	Deep 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

Note : All Values per 100000 km-year

Pipeline Small Spill 50-99 bbl

	Dia<=10"	Dia>10"	P/L Size
H	6.036	6.608	Historical Frequency
S	5.461	5.913	Shallow Water Depth Frequency
M	5.540	5.992	Medium Water Depth Frequency
D	4.792	5.244	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	0.697	0.763
M	0.693	0.759
D	0.690	0.755

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	0.093	0.102
M	0.090	0.098
D	0.086	0.094

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	2.734	2.993
M	2.739	2.998
D	2.739	2.998

Mud Slide

	Dia<=10"	Dia>10"
H	0.345	0.378
S	0.148	0.162
M	0.152	0.166
D	0.152	0.166

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

Pipeline Medium Spill 100 - 999 bbl

Note : All Values per 100000 km-year

	Dia<=10"	Dia>10"	P/L Size
H	10.563	14.867	Historical Frequency
S	9.042	12.445	Shallow Water Depth Frequency
M	9.121	12.525	Medium Water Depth Frequency
D	8.371	11.773	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	1.220	1.716
M	1.213	1.708
D	1.207	1.699

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	0.163	0.230
M	0.157	0.221
D	0.151	0.212

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	4.785	6.735
M	4.793	6.746
D	4.793	6.746

Mud Slide

	Dia<=10"	Dia>10"
H	0.604	0.850
S	0.258	0.363
M	0.266	0.374
D	0.266	0.374

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	4.455	5.998	Shallow Water Depth Frequency
M	4.625	6.155	Medium Water Depth Frequency
D	2.750	4.271	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	1.818	2.843
M	1.790	2.799
D	1.761	2.753

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	0.762	1.191
M	0.733	1.147
D	0.704	1.101

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	0.474	0.741
M	0.478	0.748
D	0.493	0.770

Mud Slide

	Dia<=10"	Dia>10"
H	0.352	0.551
S	0.151	0.236
M	0.155	0.242
D	0.155	0.242

Storm/ Hurricane

	Dia<=10"	Dia>10"
H	0.704	1.101
S	0.323	0.506
M	0.323	0.506
D	0.338	0.528

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	0.735	2.055	Shallow Water Depth Frequency
M	0.770	2.079	Medium Water Depth Frequency
D	0.396	1.698	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	0.260	1.137
M	0.256	1.120
D	0.252	1.101

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	0.109	0.477
M	0.105	0.459
D	0.101	0.441

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	0.296
M	0.068	0.299
D	0.070	0.308

Mud Slide

	Dia<=10"	Dia>10"
H	0.050	0.220
S	0.022	0.094
M	0.022	0.097
D	0.022	0.097

Storm/ Hurricane

	Dia<=10"	Dia>10"
H	0.101	0.441
S	0.046	0.202
M	0.046	0.202
D	0.048	0.211

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

Note : All Values per 10000 well-years

	SM 50-999 bbl	LH =>1000 bbl	Spill Size
H	4.601	0.481	Historical Frequency
S	3.052	0.393	Shallow Water Depth Frequency
M	3.681	0.406	Medium Water Depth Frequency
D	3.799	0.430	Deep Water Depth Frequency

EQUIPMENT FAILURE

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

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

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	0.220	0.044
M	0.220	0.044
D	0.220	0.044

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	0.095	0.095
M	0.095	0.095
D	0.099	0.099

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	0.255	0.044
M	0.331	0.057
D	0.445	0.078

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	0.012	0.002
M	0.016	0.003
D	0.021	0.004

Figure 2.5 Fault Tree - Platform Spills

Table 3.1
Chukchi Sea Low Case 2011 - 2040

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.	
2011	Shallow																	
	Medium																	
	Deep	1		1														
	Total	**1**		**1**														
2012	Shallow																	
	Medium																	
	Deep	1	1	1														
	Total	**1**	**1**	**1**														
2013	Shallow																	
	Medium																	
	Deep		2	1														
	Total		**2**	**1**														
2014	Shallow																	
	Medium																	
	Deep	1	1	1														
	Total	**1**	**1**	**1**														
2015	Shallow																	
	Medium																	
	Deep	1		1														
	Total	**1**		**1**														
2016	Shallow																	
	Medium																	
	Deep																	
	Total																	
2017	Shallow																	
	Medium																	
	Deep																	
	Total																	
2018	Shallow																	
	Medium																	
	Deep																	
	Total																	
2019	Shallow																	
	Medium																	
	Deep													10	10	10	10	
	Total													**10**	**10**	10	10	
2020	Shallow																	
	Medium																	
	Deep													10	20	10	20	
	Total													**10**	**20**	10	20	
2021	Shallow																	
	Medium																	
	Deep													20	40	20	40	
	Total													**20**	**40**	20	40	
2022	Shallow																	
	Medium																	
	Deep				1	1	6	6			1				40		40	13.5
	Total				**1**	**1**	**6**	**6**			**1**				**40**		40	**13.5**
2023	Shallow																	
	Medium																	
	Deep					1	7	13			1				40		40	16.9
	Total					**1**	**7**	**13**			**1**				**40**		40	**16.9**
2024	Shallow																	
	Medium																	
	Deep					1	7	20			1				40		40	22.5
	Total					**1**	**7**	**20**			**1**				**40**		40	**22.5**
2025	Shallow																	
	Medium																	
	Deep					1	5	25			1				40		40	30.0
	Total					**1**	**5**	**25**			**1**				**40**		40	**30.0**
2026	Shallow																	
	Medium																	
	Deep					1		25							40		40	30.0
	Total					**1**		**25**							**40**		40	**30.0**
2027	Shallow																	
	Medium																	
	Deep					1		25							40		40	30.0
	Total					**1**		**25**							**40**		40	**30.0**
2028	Shallow																	
	Medium																	
	Deep					1		25							40		40	24.0
	Total					**1**		**25**							**40**		40	**24.0**
2029	Shallow																	
	Medium																	
	Deep					1		25							40		40	19.2
	Total					**1**		**25**							**40**		40	**19.2**
2030	Shallow																	
	Medium																	
	Deep					1		25							40		40	15.4
	Total					**1**		**25**							**40**		40	**15.4**
2031	Shallow																	
	Medium																	
	Deep					1		25							40		40	12.3
	Total					**1**		**25**							**40**		40	**12.3**

Table 3.1
Chukchi Sea Low Case 2011 - 2040

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.	
2032	Shallow																	
	Medium																	
	Deep					1		25							40		40	9.8
	Total					**1**		**25**							**40**		40	**9.8**
2033	Shallow																	
	Medium																	
	Deep					1		25							40		40	7.9
	Total					**1**		**25**							**40**		40	**7.9**
2034	Shallow																	
	Medium																	
	Deep					1		25							40		40	6.3
	Total					**1**		**25**							**40**		40	**6.3**
2035	Shallow																	
	Medium																	
	Deep					1		25							40		40	5.0
	Total					**1**		**25**							**40**		40	**5.0**
2036	Shallow																	
	Medium																	
	Deep					1		25							40		40	4.0
	Total					**1**		**25**							**40**		40	**4.0**
2037	Shallow																	
	Medium																	
	Deep					1		25							40		40	3.2
	Total					**1**		**25**							**40**		40	**3.2**
2038	Shallow																	
	Medium																	
	Deep				-1		-25							-40		-40		
	Total				**-1**		**-25**							**-40**		-40		
2039	Shallow																	
	Medium																	
	Deep																	
	Total																	
2040	Shallow																	
	Medium																	
	Deep																	
	Total																	

Table 3.3
Chukchi Sea High Case 2011 - 2040

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.	
2011	Shallow																	
	Medium																	
	Deep	1		1														
	Total	**1**		**1**														
2012	Shallow																	
	Medium																	
	Deep	1	1	1														
	Total	**1**	**1**	**1**														
2013	Shallow																	
	Medium																	
	Deep		2	1														
	Total		**2**	**1**														
2014	Shallow																	
	Medium																	
	Deep	1	1	1														
	Total	**1**	**1**	**1**														
2015	Shallow																	
	Medium																	
	Deep	2	1	2														
	Total	**2**	**1**	**2**														
2016	Shallow																	
	Medium																	
	Deep	1	2	2														
	Total	**1**	**2**	**2**														
2017	Shallow																	
	Medium																	
	Deep	1	1	1														
	Total	**1**	**1**	**1**														
2018	Shallow																	
	Medium																	
	Deep																	
	Total																	
2019	Shallow																	
	Medium																	
	Deep													10	10	10	10	
	Total													**10**	**10**	10	10	
2020	Shallow																	
	Medium																	
	Deep													10	20	10	20	
	Total													**10**	**20**	10	20	
2021	Shallow																	
	Medium																	
	Deep													20	40	20	40	
	Total													**20**	**40**	20	40	
2022	Shallow																	
	Medium																	
	Deep				1	1	6	6			1			10	50	10	50	13.5
	Total				**1**	**1**	**6**	**6**			**1**			**10**	**50**	10	50	**13.5**
2023	Shallow																	
	Medium																	
	Deep					1	7	13			1			10	60	10	60	16.9
	Total					**1**	**7**	**13**			**1**			**10**	**60**	10	60	**16.9**
2024	Shallow																	
	Medium																	
	Deep					1	7	20			1			20	80	20	80	22.5
	Total					**1**	**7**	**20**			**1**			**20**	**80**	20	80	**22.5**
2025	Shallow																	
	Medium																	
	Deep				1	2	11	31			2				80		80	43.5
	Total				**1**	**2**	**11**	**31**			**2**				**80**		80	**43.5**
2026	Shallow																	
	Medium																	
	Deep					2	7	38			1				80		80	46.9
	Total					**2**	**7**	**38**			**1**				**80**		80	**46.9**
2027	Shallow																	
	Medium																	
	Deep					2	7	45			1				80		80	52.5
	Total					**2**	**7**	**45**			**1**				**80**		80	**52.5**
2028	Shallow																	
	Medium																	
	Deep					2	5	50			1				80		80	54.0
	Total					**2**	**5**	**50**			**1**				**80**		80	**54.0**
2029	Shallow																	
	Medium																	
	Deep					2		50							80		80	49.2
	Total					**2**		**50**							**80**		80	**49.2**
2030	Shallow																	
	Medium																	
	Deep					2		50							80		80	45.4
	Total					**2**		**50**							**80**		80	**45.4**

Table 3.3
Chukchi Sea High Case 2011 - 2040

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.	
2031	Shallow																	
	Medium																	
	Deep					2		50							80		80	36.3
	Total					**2**		**50**							**80**		80	**36.3**
2032	Shallow																	
	Medium																	
	Deep					2		50							80		80	29.0
	Total					**2**		**50**							**80**		80	**29.0**
2033	Shallow																	
	Medium																	
	Deep					2		50							80		80	23.3
	Total					**2**		**50**							**80**		80	**23.3**
2034	Shallow																	
	Medium																	
	Deep					2		50							80		80	18.6
	Total					**2**		**50**							**80**		80	**18.6**
2035	Shallow																	
	Medium																	
	Deep					2		50							80		80	14.8
	Total					**2**		**50**							**80**		80	**14.8**
2036	Shallow																	
	Medium																	
	Deep					2		50							80		80	11.9
	Total					**2**		**50**							**80**		80	**11.9**
2037	Shallow																	
	Medium																	
	Deep					2		50							80		80	9.5
	Total					**2**		**50**							**80**		80	**9.5**
2038	Shallow																	
	Medium																	
	Deep				-1	1	-25	25						-40	40	-40	40	5.0
	Total				**-1**	**1**	**-25**	**25**						**-40**	**40**	-40	40	**5.0**
2039	Shallow																	
	Medium																	
	Deep					1		25							40		40	4.0
	Total					**1**		**25**							**40**		40	**4.0**
2040	Shallow																	
	Medium																	
	Deep					1		25							40		40	3.2
	Total					**1**		**25**							**40**		40	**3.2**
2041	Shallow																	
	Medium																	
	Deep				-1		-25							-40		-40		
	Total				**-1**		**-25**							**-40**		-40		

Table 4.1.1
Arctic Spill Occurrence Chukchi 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
2011	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396				5.244			11.773			4.271			1.698		
	Total																										
2012	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396				5.244			11.773			4.271			1.698		
	Total																										
2013	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396				5.244			11.773			4.271			1.698		
	Total																										
2014	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396				5.244			11.773			4.271			1.698		
	Total																										
2015	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396				5.244			11.773			4.271			1.698		
	Total																										
2016	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396				5.244			11.773			4.271			1.698		
	Total																										
2017	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396				5.244			11.773			4.271			1.698		
	Total																										
2018	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396				5.244			11.773			4.271			1.698		
	Total																										
2019	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396			10	5.244	0.844	0.06	11.773	1.894	0.98	4.271	0.687	3.56	1.698	0.273	4.25
	Total														**10**		**0.844**	**0.06**		**1.894**	**0.98**		**0.687**	**3.56**		**0.273**	**4.25**
2020	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396			20	5.244	1.688	0.12	11.773	3.788	1.95	4.271	1.374	7.11	1.698	0.546	8.50
	Total														**20**		**1.688**	**0.12**		**3.788**	**1.95**		**1.374**	**7.11**		**0.546**	**8.50**
2021	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396			40	5.244	3.375	0.24	11.773	7.577	3.91	4.271	2.749	14.23	1.698	1.093	16.99
	Total														**40**		**3.375**	**0.24**		**7.577**	**3.91**		**2.749**	**14.23**		**1.093**	**16.99**
2022	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396			40	5.244	3.375	0.24	11.773	7.577	3.91	4.271	2.749	14.23	1.698	1.093	16.99
	Total														**40**		**3.375**	**0.24**		**7.577**	**3.91**		**2.749**	**14.23**		**1.093**	**16.99**
2023	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396			40	5.244	3.375	0.24	11.773	7.577	3.91	4.271	2.749	14.23	1.698	1.093	16.99
	Total														**40**		**3.375**	**0.24**		**7.577**	**3.91**		**2.749**	**14.23**		**1.093**	**16.99**
2024	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396			40	5.244	3.375	0.24	11.773	7.577	3.91	4.271	2.749	14.23	1.698	1.093	16.99
	Total														**40**		**3.375**	**0.24**		**7.577**	**3.91**		**2.749**	**14.23**		**1.093**	**16.99**
2025	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396			40	5.244	3.375	0.24	11.773	7.577	3.91	4.271	2.749	14.23	1.698	1.093	16.99
	Total														**40**		**3.375**	**0.24**		**7.577**	**3.91**		**2.749**	**14.23**		**1.093**	**16.99**
2026	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396			40	5.244	3.375	0.24	11.773	7.577	3.91	4.271	2.749	14.23	1.698	1.093	16.99
	Total														**40**		**3.375**	**0.24**		**7.577**	**3.91**		**2.749**	**14.23**		**1.093**	**16.99**
2027	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396			40	5.244	3.375	0.24	11.773	7.577	3.91	4.271	2.749	14.23	1.698	1.093	16.99
	Total														**40**		**3.375**	**0.24**		**7.577**	**3.91**		**2.749**	**14.23**		**1.093**	**16.99**
2028	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396			40	5.244	3.375	0.24	11.773	7.577	3.91	4.271	2.749	14.23	1.698	1.093	16.99
	Total														**40**		**3.375**	**0.24**		**7.577**	**3.91**		**2.749**	**14.23**		**1.093**	**16.99**
2029	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396			40	5.244	3.375	0.24	11.773	7.577	3.91	4.271	2.749	14.23	1.698	1.093	16.99
	Total														**40**		**3.375**	**0.24**		**7.577**	**3.91**		**2.749**	**14.23**		**1.093**	**16.99**
2030	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396			40	5.244	3.375	0.24	11.773	7.577	3.91	4.271	2.749	14.23	1.698	1.093	16.99

Table 4.1.1
Arctic Spill Occurrence Chukchi 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														**40**		**3.375**	**0.24**		**7.577**	**3.91**		**2.749**	**14.23**		**1.093**	**16.99**
2031	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396			40	5.244	3.375	0.24	11.773	7.577	3.91	4.271	2.749	14.23	1.698	1.093	16.99
	Total														**40**		**3.375**	**0.24**		**7.577**	**3.91**		**2.749**	**14.23**		**1.093**	**16.99**
2032	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396			40	5.244	3.375	0.24	11.773	7.577	3.91	4.271	2.749	14.23	1.698	1.093	16.99
	Total														**40**		**3.375**	**0.24**		**7.577**	**3.91**		**2.749**	**14.23**		**1.093**	**16.99**
2033	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396			40	5.244	3.375	0.24	11.773	7.577	3.91	4.271	2.749	14.23	1.698	1.093	16.99
	Total														**40**		**3.375**	**0.24**		**7.577**	**3.91**		**2.749**	**14.23**		**1.093**	**16.99**
2034	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396			40	5.244	3.375	0.24	11.773	7.577	3.91	4.271	2.749	14.23	1.698	1.093	16.99
	Total														**40**		**3.375**	**0.24**		**7.577**	**3.91**		**2.749**	**14.23**		**1.093**	**16.99**
2035	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396			40	5.244	3.375	0.24	11.773	7.577	3.91	4.271	2.749	14.23	1.698	1.093	16.99
	Total														**40**		**3.375**	**0.24**		**7.577**	**3.91**		**2.749**	**14.23**		**1.093**	**16.99**
2036	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396			40	5.244	3.375	0.24	11.773	7.577	3.91	4.271	2.749	14.23	1.698	1.093	16.99
	Total														**40**		**3.375**	**0.24**		**7.577**	**3.91**		**2.749**	**14.23**		**1.093**	**16.99**
2037	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396			40	5.244	3.375	0.24	11.773	7.577	3.91	4.271	2.749	14.23	1.698	1.093	16.99
	Total														**40**		**3.375**	**0.24**		**7.577**	**3.91**		**2.749**	**14.23**		**1.093**	**16.99**
2038	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396				5.244			11.773			4.271			1.698		
	Total																										
2039	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396				5.244			11.773			4.271			1.698		
	Total																										
2040	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396				5.244			11.773			4.271			1.698		
	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]
2011																						
2012																						
2013																						
2014																						
2015																						
2016																						
2017																						
2018																						
2019		0.844		0.060	1.894		0.977	2.738		1.037	0.687		3.557	0.273		4.249	0.960		7.805	3.698		8.843
2020		1.688		0.120	3.788		1.955	5.476		2.075	1.374		7.114	0.546		8.497	1.921		15.611	7.397		17.686
2021		3.375		0.240	7.577		3.909	10.952		4.150	2.749		14.228	1.093		16.994	3.842		31.222	14.794		35.371
2022	**13.5**	3.375	0.250	0.240	7.577	0.561	3.909	10.952	0.811	4.150	2.749	0.204	14.228	1.093	0.081	16.994	3.842	0.285	31.222	14.794	1.096	35.371
2023	**16.9**	3.375	0.200	0.240	7.577	0.448	3.909	10.952	0.648	4.150	2.749	0.163	14.228	1.093	0.065	16.994	3.842	0.227	31.222	14.794	0.875	35.371
2024	**22.5**	3.375	0.150	0.240	7.577	0.337	3.909	10.952	0.487	4.150	2.749	0.122	14.228	1.093	0.049	16.994	3.842	0.171	31.222	14.794	0.657	35.371
2025	**30.0**	3.375	0.113	0.240	7.577	0.253	3.909	10.952	0.365	4.150	2.749	0.092	14.228	1.093	0.036	16.994	3.842	0.128	31.222	14.794	0.493	35.371
2026	**30.0**	3.375	0.113	0.240	7.577	0.253	3.909	10.952	0.365	4.150	2.749	0.092	14.228	1.093	0.036	16.994	3.842	0.128	31.222	14.794	0.493	35.371
2027	**30.0**	3.375	0.113	0.240	7.577	0.253	3.909	10.952	0.365	4.150	2.749	0.092	14.228	1.093	0.036	16.994	3.842	0.128	31.222	14.794	0.493	35.371
2028	**24.0**	3.375	0.141	0.240	7.577	0.316	3.909	10.952	0.456	4.150	2.749	0.115	14.228	1.093	0.046	16.994	3.842	0.160	31.222	14.794	0.616	35.371
2029	**19.2**	3.375	0.176	0.240	7.577	0.395	3.909	10.952	0.570	4.150	2.749	0.143	14.228	1.093	0.057	16.994	3.842	0.200	31.222	14.794	0.771	35.371
2030	**15.4**	3.375	0.219	0.240	7.577	0.492	3.909	10.952	0.711	4.150	2.749	0.179	14.228	1.093	0.071	16.994	3.842	0.249	31.222	14.794	0.961	35.371
2031	**12.3**	3.375	0.274	0.240	7.577	0.616	3.909	10.952	0.890	4.150	2.749	0.223	14.228	1.093	0.089	16.994	3.842	0.312	31.222	14.794	1.203	35.371
2032	**9.8**	3.375	0.344	0.240	7.577	0.773	3.909	10.952	1.118	4.150	2.749	0.281	14.228	1.093	0.112	16.994	3.842	0.392	31.222	14.794	1.510	35.371
2033	**7.9**	3.375	0.427	0.240	7.577	0.959	3.909	10.952	1.386	4.150	2.749	0.348	14.228	1.093	0.138	16.994	3.842	0.486	31.222	14.794	1.873	35.371
2034	**6.3**	3.375	0.536	0.240	7.577	1.203	3.909	10.952	1.738	4.150	2.749	0.436	14.228	1.093	0.173	16.994	3.842	0.610	31.222	14.794	2.348	35.371
2035	**5.0**	3.375	0.675	0.240	7.577	1.515	3.909	10.952	2.190	4.150	2.749	0.550	14.228	1.093	0.219	16.994	3.842	0.768	31.222	14.794	2.959	35.371
2036	**4.0**	3.375	0.844	0.240	7.577	1.894	3.909	10.952	2.738	4.150	2.749	0.687	14.228	1.093	0.273	16.994	3.842	0.960	31.222	14.794	3.698	35.371
2037	**3.2**	3.375	1.055	0.240	7.577	2.368	3.909	10.952	3.422	4.150	2.749	0.859	14.228	1.093	0.341	16.994	3.842	1.201	31.222	14.794	4.623	35.371
2038																						
2039																						
2040																						
Total LOF	**250.0**	**59.908**		**4**	**134.489**		**69**	**194.397**		**74**	**48.794**		**253**	**19.396**		**302**	**68.190**		**554**	**262.587**		**628**
Average LOF		**2.219**	**0.240**	**0**	**4.981**	**0.538**	**3**	**7.200**	**0.778**	**3**	**1.807**	**0.195**	**9**	**0.718**	**0.078**	**11**	**2.526**	**0.273**	**21**	**9.725**	**1.050**	**23**

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 10^4 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
2011	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep			3.799			0.430		
	Total								
2012	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep			3.799			0.430		
	Total								
2013	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep			3.799			0.430		
	Total								
2014	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep			3.799			0.430		
	Total								
2015	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep			3.799			0.430		
	Total								
2016	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep			3.799			0.430		
	Total								
2017	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep			3.799			0.430		
	Total								
2018	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep			3.799			0.430		
	Total								
2019	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep			3.799			0.430		
	Total								
2020	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep			3.799			0.430		
	Total								
2021	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep			3.799			0.430		
	Total								
2022	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep	1	6	3.799	2.279	1.03	0.430	0.258	1.45
	Total	**1**	**6**		**2.279**	**1.03**		**0.258**	**1.45**
2023	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep	1	13	3.799	4.938	2.23	0.430	0.559	3.15
	Total	**1**	**13**		**4.938**	**2.23**		**0.559**	**3.15**
2024	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep	1	20	3.799	7.598	3.43	0.430	0.861	4.85
	Total	**1**	**20**		**7.598**	**3.43**		**0.861**	**4.85**
2025	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep	1	25	3.799	9.497	4.29	0.430	1.076	6.06
	Total	**1**	**25**		**9.497**	**4.29**		**1.076**	**6.06**
2026	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep	1	25	3.799	9.497	4.29	0.430	1.076	6.06
	Total	**1**	**25**		**9.497**	**4.29**		**1.076**	**6.06**
2027	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep	1	25	3.799	9.497	4.29	0.430	1.076	6.06
	Total	**1**	**25**		**9.497**	**4.29**		**1.076**	**6.06**
2028	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep	1	25	3.799	9.497	4.29	0.430	1.076	6.06
	Total	**1**	**25**		**9.497**	**4.29**		**1.076**	**6.06**
2029	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep	1	25	3.799	9.497	4.29	0.430	1.076	6.06
	Total	**1**	**25**		**9.497**	**4.29**		**1.076**	**6.06**
2030	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep	1	25	3.799	9.497	4.29	0.430	1.076	6.06
	Total	**1**	**25**		**9.497**	**4.29**		**1.076**	**6.06**
2031	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep	1	25	3.799	9.497	4.29	0.430	1.076	6.06
	Total	**1**	**25**		**9.497**	**4.29**		**1.076**	**6.06**
	Shallow			3.052			0.393		

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
2032	Medium			3.681			0.406		
	Deep	1	25	3.799	9.497	4.29	0.430	1.076	6.06
	Total	**1**	**25**		**9.497**	**4.29**		**1.076**	**6.06**
2033	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep	1	25	3.799	9.497	4.29	0.430	1.076	6.06
	Total	**1**	**25**		**9.497**	**4.29**		**1.076**	**6.06**
2034	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep	1	25	3.799	9.497	4.29	0.430	1.076	6.06
	Total	**1**	**25**		**9.497**	**4.29**		**1.076**	**6.06**
2035	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep	1	25	3.799	9.497	4.29	0.430	1.076	6.06
	Total	**1**	**25**		**9.497**	**4.29**		**1.076**	**6.06**
2036	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep	1	25	3.799	9.497	4.29	0.430	1.076	6.06
	Total	**1**	**25**		**9.497**	**4.29**		**1.076**	**6.06**
2037	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep	1	25	3.799	9.497	4.29	0.430	1.076	6.06
	Total	**1**	**25**		**9.497**	**4.29**		**1.076**	**6.06**
2038	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep			3.799			0.430		
	Total								
2039	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep			3.799			0.430		
	Total								
2040	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep			3.799			0.430		
	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]
2011													
2012													
2013													
2014													
2015													
2016													
2017													
2018													
2019													
2020													
2021													
2022	**13.5**	2.279	0.169	1.030	0.258	0.019	1.454	0.258	0.019	1.454	2.538	0.188	2.484
2023	**16.9**	4.938	0.292	2.232	0.559	0.033	3.151	0.559	0.033	3.151	5.498	0.325	5.382
2024	**22.5**	7.598	0.338	3.434	0.861	0.038	4.847	0.861	0.038	4.847	8.458	0.376	8.280
2025	**30.0**	9.497	0.317	4.292	1.076	0.036	6.059	1.076	0.036	6.059	10.573	0.352	10.351
2026	**30.0**	9.497	0.317	4.292	1.076	0.036	6.059	1.076	0.036	6.059	10.573	0.352	10.351
2027	**30.0**	9.497	0.317	4.292	1.076	0.036	6.059	1.076	0.036	6.059	10.573	0.352	10.351
2028	**24.0**	9.497	0.396	4.292	1.076	0.045	6.059	1.076	0.045	6.059	10.573	0.441	10.351
2029	**19.2**	9.497	0.495	4.292	1.076	0.056	6.059	1.076	0.056	6.059	10.573	0.551	10.351
2030	**15.4**	9.497	0.617	4.292	1.076	0.070	6.059	1.076	0.070	6.059	10.573	0.687	10.351
2031	**12.3**	9.497	0.772	4.292	1.076	0.087	6.059	1.076	0.087	6.059	10.573	0.860	10.351
2032	**9.8**	9.497	0.969	4.292	1.076	0.110	6.059	1.076	0.110	6.059	10.573	1.079	10.351
2033	**7.9**	9.497	1.202	4.292	1.076	0.136	6.059	1.076	0.136	6.059	10.573	1.338	10.351
2034	**6.3**	9.497	1.507	4.292	1.076	0.171	6.059	1.076	0.171	6.059	10.573	1.678	10.351
2035	**5.0**	9.497	1.899	4.292	1.076	0.215	6.059	1.076	0.215	6.059	10.573	2.115	10.351
2036	**4.0**	9.497	2.374	4.292	1.076	0.269	6.059	1.076	0.269	6.059	10.573	2.643	10.351
2037	**3.2**	9.497	2.968	4.292	1.076	0.336	6.059	1.076	0.336	6.059	10.573	3.304	10.351
2038													
2039													
2040													
Total LOF	**250.0**	**138.278**		**62**	**15.666**		**88**	**15.666**		**88**	**153.944**		**151**
Average LOF		**5.121**	**0.553**	**2**	**0.580**	**0.063**	**3**	**0.580**	**0.063**	**3**	**5.702**	**0.616**	**6**

Table 4.1.5
Arctic Spill Occurrence - Low 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
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		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													
2020	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													
2021	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													
2022	Shallow		0.103			0.718			0.308			0.205		
	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	**6**		0.062	**0.03**		0.431	**2.28**		0.185	**12.62**		0.123	**24.63**
2023	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep	13	0.103	0.133	0.07	0.718	0.934	4.94	0.308	0.400	27.35	0.205	0.267	53.36
	Total	**13**		0.133	**0.07**		0.934	**4.94**		0.400	**27.35**		0.267	**53.36**
2024	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep	20	0.103	0.205	0.11	0.718	1.437	7.60	0.308	0.616	42.08	0.205	0.410	82.09
	Total	**20**		0.205	**0.11**		1.437	**7.60**		0.616	**42.08**		0.410	**82.09**
2025	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep	25	0.103	0.257	0.13	0.718	1.796	9.50	0.308	0.770	52.60	0.205	0.513	102.61
	Total	**25**		0.257	**0.13**		1.796	**9.50**		0.770	**52.60**		0.513	**102.61**
2026	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep	25	0.103	0.257	0.13	0.718	1.796	9.50	0.308	0.770	52.60	0.205	0.513	102.61
	Total	**25**		0.257	**0.13**		1.796	**9.50**		0.770	**52.60**		0.513	**102.61**
2027	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep	25	0.103	0.257	0.13	0.718	1.796	9.50	0.308	0.770	52.60	0.205	0.513	102.61
	Total	**25**		0.257	**0.13**		1.796	**9.50**		0.770	**52.60**		0.513	**102.61**
2028	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep	25	0.103	0.257	0.13	0.718	1.796	9.50	0.308	0.770	52.60	0.205	0.513	102.61
	Total	**25**		0.257	**0.13**		1.796	**9.50**		0.770	**52.60**		0.513	**102.61**
2029	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep	25	0.103	0.257	0.13	0.718	1.796	9.50	0.308	0.770	52.60	0.205	0.513	102.61
	Total	**25**		0.257	**0.13**		1.796	**9.50**		0.770	**52.60**		0.513	**102.61**

Table 4.1.5
Arctic Spill Occurrence - Low 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
2030	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep	25	0.103	0.257	0.13	0.718	1.796	9.50	0.308	0.770	52.60	0.205	0.513	102.61
	Total	**25**		0.257	**0.13**		1.796	**9.50**		0.770	**52.60**		0.513	**102.61**
2031	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep	25	0.103	0.257	0.13	0.718	1.796	9.50	0.308	0.770	52.60	0.205	0.513	102.61
	Total	**25**		0.257	**0.13**		1.796	**9.50**		0.770	**52.60**		0.513	**102.61**
2032	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep	25	0.103	0.257	0.13	0.718	1.796	9.50	0.308	0.770	52.60	0.205	0.513	102.61
	Total	**25**		0.257	**0.13**		1.796	**9.50**		0.770	**52.60**		0.513	**102.61**
2033	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep	25	0.103	0.257	0.13	0.718	1.796	9.50	0.308	0.770	52.60	0.205	0.513	102.61
	Total	**25**		0.257	**0.13**		1.796	**9.50**		0.770	**52.60**		0.513	**102.61**
2034	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep	25	0.103	0.257	0.13	0.718	1.796	9.50	0.308	0.770	52.60	0.205	0.513	102.61
	Total	**25**		0.257	**0.13**		1.796	**9.50**		0.770	**52.60**		0.513	**102.61**
2035	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep	25	0.103	0.257	0.13	0.718	1.796	9.50	0.308	0.770	52.60	0.205	0.513	102.61
	Total	**25**		0.257	**0.13**		1.796	**9.50**		0.770	**52.60**		0.513	**102.61**
2036	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep	25	0.103	0.257	0.13	0.718	1.796	9.50	0.308	0.770	52.60	0.205	0.513	102.61
	Total	**25**		0.257	**0.13**		1.796	**9.50**		0.770	**52.60**		0.513	**102.61**
2037	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep	25	0.103	0.257	0.13	0.718	1.796	9.50	0.308	0.770	52.60	0.205	0.513	102.61
	Total	**25**		0.257	**0.13**		1.796	**9.50**		0.770	**52.60**		0.513	**102.61**
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													
2040	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 10^3years	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]
2011													
2012													
2013													
2014													
2015													
2016													
2017													
2018													
2019													
2020													
2021													
2022	**13.5**	0.062	0.005	0.032	0.185	0.014	2.281	0.308	0.023	37.252	0.554	0.041	39.564
2023	**16.9**	0.133	0.008	0.069	0.400	0.024	4.942	0.667	0.039	80.712	1.201	0.071	85.723
2024	**22.5**	0.205	0.009	0.107	0.616	0.027	7.603	1.026	0.046	124.172	1.847	0.082	131.881
2025	**30.0**	0.257	0.009	0.133	0.770	0.026	9.503	1.283	0.043	155.215	2.309	0.077	164.851
2026	**30.0**	0.257	0.009	0.133	0.770	0.026	9.503	1.283	0.043	155.215	2.309	0.077	164.851
2027	**30.0**	0.257	0.009	0.133	0.770	0.026	9.503	1.283	0.043	155.215	2.309	0.077	164.851
2028	**24.0**	0.257	0.011	0.133	0.770	0.032	9.503	1.283	0.053	155.215	2.309	0.096	164.851
2029	**19.2**	0.257	0.013	0.133	0.770	0.040	9.503	1.283	0.067	155.215	2.309	0.120	164.851
2030	**15.4**	0.257	0.017	0.133	0.770	0.050	9.503	1.283	0.083	155.215	2.309	0.150	164.851
2031	**12.3**	0.257	0.021	0.133	0.770	0.063	9.503	1.283	0.104	155.215	2.309	0.188	164.851
2032	**9.8**	0.257	0.026	0.133	0.770	0.079	9.503	1.283	0.131	155.215	2.309	0.236	164.851
2033	**7.9**	0.257	0.032	0.133	0.770	0.097	9.503	1.283	0.162	155.215	2.309	0.292	164.851
2034	**6.3**	0.257	0.041	0.133	0.770	0.122	9.503	1.283	0.204	155.215	2.309	0.366	164.851
2035	**5.0**	0.257	0.051	0.133	0.770	0.154	9.503	1.283	0.257	155.215	2.309	0.462	164.851
2036	**4.0**	0.257	0.064	0.133	0.770	0.192	9.503	1.283	0.321	155.215	2.309	0.577	164.851
2037	**3.2**	0.257	0.080	0.133	0.770	0.241	9.503	1.283	0.401	155.215	2.309	0.722	164.851
2038													
2039													
2040													

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
2011	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**
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		1.583			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													
2014	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**
2015	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**
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													
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													

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
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													
2040	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]
2011		0.204		0.106	0.612		7.537	0.966		112.679	1.782		120.321
2012		0.204		0.106	0.612		7.537	0.966		112.679	1.782		120.321
2013													
2014		0.204		0.106	0.612		7.537	0.966		112.679	1.782		120.321
2015		0.204		0.106	0.612		7.537	0.966		112.679	1.782		120.321
2016													
2017													
2018													
2019													
2020													
2021													
2022	**13.5**												
2023	**16.9**												
2024	**22.5**												
2025	**30.0**												
2026	**30.0**												
2027	**30.0**												
2028	**24.0**												
2029	**19.2**												
2030	**15.4**												
2031	**12.3**												
2032	**9.8**												
2033	**7.9**												
2034	**6.3**												
2035	**5.0**												
2036	**4.0**												
2037	**3.2**												
2038													
2039													
2040													

Table 4.1.9
Arctic Spill Occurrence Chukchi Sea Low 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
2011	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													
2012	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep	1	0.623	0.062	0.03	4.350	0.435	2.30	1.868	0.187	12.77	1.868	0.187	37.37
	Total	**1**		0.062	**0.03**		0.435	**2.30**		0.187	**12.77**		0.187	**37.37**
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	1	0.623	0.062	0.03	4.350	0.435	2.30	1.868	0.187	12.77	1.868	0.187	37.37
	Total	**1**		0.062	**0.03**		0.435	**2.30**		0.187	**12.77**		0.187	**37.37**
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													
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													

Table 4.1.9
Arctic Spill Occurrence Chukchi Sea Low 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
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													
2040	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 10^3 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]
2011													
2012		0.062		0.032	0.187		2.302	0.374		50.139	0.623		52.474
2013		0.125		0.065	0.374		4.604	0.747		100.278	1.246		104.947
2014		0.062		0.032	0.187		2.302	0.374		50.139	0.623		52.474
2015													
2016													
2017													
2018													
2019													
2020													
2021													
2022	13.5												
2023	16.9												
2024	22.5												
2025	30.0												
2026	30.0												
2027	30.0												
2028	24.0												
2029	19.2												
2030	15.4												
2031	12.3												
2032	9.8												
2033	7.9												
2034	6.3												
2035	5.0												
2036	4.0												
2037	3.2												
2038													
2039													
2040													

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]
2011		0.204		0.106	0.612		7.537	0.966		112.679	1.578		120.216	1.782		120.321
2012		0.266		0.138	0.799		9.839	1.340		162.818	2.139		172.657	2.404		172.795
2013		0.125		0.065	0.374		4.604	0.747		100.278	1.121		104.883	1.246		104.947
2014		0.266		0.138	0.799		9.839	1.340		162.818	2.139		172.657	2.404		172.795
2015		0.204		0.106	0.612		7.537	0.966		112.679	1.578		120.216	1.782		120.321
2016																
2017																
2018																
2019																
2020																
2021																
2022	**13.5**	0.062	0.005	0.032	0.185	0.014	2.281	0.308	0.023	37.252	0.493	0.036	39.532	0.554	0.041	39.564
2023	**16.9**	0.133	0.008	0.069	0.400	0.024	4.942	0.667	0.039	80.712	1.067	0.063	85.653	1.201	0.071	85.723
2024	**22.5**	0.205	0.009	0.107	0.616	0.027	7.603	1.026	0.046	124.172	1.642	0.073	131.774	1.847	0.082	131.881
2025	**30.0**	0.257	0.009	0.133	0.770	0.026	9.503	1.283	0.043	155.215	2.052	0.068	164.718	2.309	0.077	164.851
2026	**30.0**	0.257	0.009	0.133	0.770	0.026	9.503	1.283	0.043	155.215	2.052	0.068	164.718	2.309	0.077	164.851
2027	**30.0**	0.257	0.009	0.133	0.770	0.026	9.503	1.283	0.043	155.215	2.052	0.068	164.718	2.309	0.077	164.851
2028	**24.0**	0.257	0.011	0.133	0.770	0.032	9.503	1.283	0.053	155.215	2.052	0.086	164.718	2.309	0.096	164.851
2029	**19.2**	0.257	0.013	0.133	0.770	0.040	9.503	1.283	0.067	155.215	2.052	0.107	164.718	2.309	0.120	164.851
2030	**15.4**	0.257	0.017	0.133	0.770	0.050	9.503	1.283	0.083	155.215	2.052	0.133	164.718	2.309	0.150	164.851
2031	**12.3**	0.257	0.021	0.133	0.770	0.063	9.503	1.283	0.104	155.215	2.052	0.167	164.718	2.309	0.188	164.851
2032	**9.8**	0.257	0.026	0.133	0.770	0.079	9.503	1.283	0.131	155.215	2.052	0.209	164.718	2.309	0.236	164.851
2033	**7.9**	0.257	0.032	0.133	0.770	0.097	9.503	1.283	0.162	155.215	2.052	0.260	164.718	2.309	0.292	164.851
2034	**6.3**	0.257	0.041	0.133	0.770	0.122	9.503	1.283	0.204	155.215	2.052	0.326	164.718	2.309	0.366	164.851
2035	**5.0**	0.257	0.051	0.133	0.770	0.154	9.503	1.283	0.257	155.215	2.052	0.410	164.718	2.309	0.462	164.851
2036	**4.0**	0.257	0.064	0.133	0.770	0.192	9.503	1.283	0.321	155.215	2.052	0.513	164.718	2.309	0.577	164.851
2037	**3.2**	0.257	0.080	0.133	0.770	0.241	9.503	1.283	0.401	155.215	2.052	0.641	164.718	2.309	0.722	164.851
2038																
2039																
2040																
Total LOF	**250.0**	**4.798**		**2**	**14.400**		**178**	**24.035**		**2911**	**38.436**		**3089**	**43.234**		**3091**
Average LOF		**0.178**	**0.019**	**0**	**0.533**	**0.058**	**7**	**0.890**	**0.096**	**108**	**1.424**	**0.154**	**114**	**1.601**	**0.173**	**114**

Table 4.1.12
Arctic Spill Occurrence - Low Case - Summary

Year	Facility	Production [MMbbl]	Small and Medium Spills 50-999 bbl: Frequency Spills per 10^3years	Small and Medium Spills 50-999 bbl: Frequency Spills per 10^9 bbl Produced	Small and Medium Spills 50-999 bbl: Spill Index [bbl]	Large Spills 1000-9999 bbl: Frequency Spills per 10^3years	Large Spills 1000-9999 bbl: Frequency Spills per 10^9 bbl Produced	Large Spills 1000-9999 bbl: Spill Index [bbl]	Huge Spills =>10000 bbl: Frequency Spills per 10^3years	Huge Spills =>10000 bbl: Frequency Spills per 10^9 bbl Produced	Huge Spills =>10000 bbl: Spill Index [bbl]	All Spills: Frequency Spills per 10^3years	All Spills: Frequency Spills per 10^9 bbl Produced	All Spills: Spill Index [bbl]
2011	Pipeline													
	Platforms													
	Production Wells													
	Exploration Wells		0.204		0.106	0.612		7.537	0.966		112.679	1.782		120.321
	Development Wells													
	Total		0.204		0.106	0.612		7.537	0.966		112.679	1.782		120.321
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		0.062		0.032	0.187		2.302	0.374		50.139	0.623		52.474
	Total		0.266		0.138	0.799		9.839	1.340		162.818	2.404		172.795
2013	Pipeline													
	Platforms													
	Production Wells													
	Exploration Wells													
	Development Wells		0.125		0.065	0.374		4.604	0.747		100.278	1.246		104.947
	Total		0.125		0.065	0.374		4.604	0.747		100.278	1.246		104.947
2014	Pipeline													
	Platforms													
	Production Wells													
	Exploration Wells		0.204		0.106	0.612		7.537	0.966		112.679	1.782		120.321
	Development Wells		0.062		0.032	0.187		2.302	0.374		50.139	0.623		52.474
	Total		0.266		0.138	0.799		9.839	1.340		162.818	2.404		172.795
2015	Pipeline													
	Platforms													
	Production Wells													
	Exploration Wells		0.204		0.106	0.612		7.537	0.966		112.679	1.782		120.321
	Development Wells													
	Total		0.204		0.106	0.612		7.537	0.966		112.679	1.782		120.321
2016	Pipeline													
	Platforms													
	Production Wells													
	Exploration Wells													
	Development Wells													
	Total													
2017	Pipeline													
	Platforms													
	Production Wells													
	Exploration Wells													
	Development Wells													
	Total													
2018	Pipeline													
	Platforms													
	Production Wells													
	Exploration Wells													
	Development Wells													
	Total													
2019	Pipeline		2.738		1.037	0.687		3.557	0.273		4.249	3.698		8.843
	Platforms													
	Production Wells													
	Exploration Wells													
	Development Wells													
	Total		2.738		1.037	0.687		3.557	0.273		4.249	3.698		8.843
2020	Pipeline		5.476		2.075	1.374		7.114	0.546		8.497	7.397		17.686
	Platforms													
	Production Wells													
	Exploration Wells													
	Development Wells													
	Total		5.476		2.075	1.374		7.114	0.546		8.497	7.397		17.686
2021	Pipeline		10.952		4.150	2.749		14.228	1.093		16.994	14.794		35.371
	Platforms													
	Production Wells													
	Exploration Wells													
	Development Wells													
	Total		10.952		4.150	2.749		14.228	1.093		16.994	14.794		35.371
2022	Pipeline	13.5	10.952	0.811	4.150	2.749	0.204	14.228	1.093	0.081	16.994	14.794	1.096	35.371
	Platforms		2.279	0.169	1.030	0.129	0.010	0.727	0.129	0.010	0.727	2.538	0.188	2.484
	Production Wells		0.062	0.005	0.032	0.185	0.014	2.281	0.308	0.023	37.252	0.554	0.041	39.564
	Exploration Wells													
	Development Wells													
	Total		13.293	0.985	5.212	3.063	0.227	17.236	1.530	0.113	54.973	17.885	1.325	77.420
2023	Pipeline	16.9	10.952	0.648	4.150	2.749	0.163	14.228	1.093	0.065	16.994	14.794	0.875	35.371
	Platforms		4.938	0.292	2.232	0.280	0.017	1.575	0.280	0.017	1.575	5.498	0.325	5.382
	Production Wells		0.133	0.008	0.069	0.400	0.024	4.942	0.667	0.039	80.712	1.201	0.071	85.723
	Exploration Wells													
	Development Wells													
	Total		16.024	0.948	6.451	3.429	0.203	20.745	2.039	0.121	99.281	21.492	1.272	126.476
2024	Pipeline	22.5	10.952	0.487	4.150	2.749	0.122	14.228	1.093	0.049	16.994	14.794	0.657	35.371
	Platforms		7.598	0.338	3.434	0.430	0.019	2.423	0.430	0.019	2.423	8.458	0.376	8.280
	Production Wells		0.205	0.009	0.107	0.616	0.027	7.603	1.026	0.046	124.172	1.847	0.082	131.881
	Exploration Wells													
	Development Wells													
	Total		18.755	0.834	7.690	3.795	0.169	24.254	2.549	0.113	143.589	25.099	1.116	175.533
2025	Pipeline	30.0	10.952	0.365	4.150	2.749	0.092	14.228	1.093	0.036	16.994	14.794	0.493	35.371
	Platforms		9.497	0.317	4.292	0.538	0.018	3.029	0.538	0.018	3.029	10.573	0.352	10.351
	Production Wells		0.257	0.009	0.133	0.770	0.026	9.503	1.283	0.043	155.215	2.309	0.077	164.851
	Exploration Wells													
	Development Wells													
	Total		20.706	0.690	8.575	4.057	0.135	26.760	2.913	0.097	175.238	27.675	0.923	210.573
2026	Pipeline	30.0	10.952	0.365	4.150	2.749	0.092	14.228	1.093	0.036	16.994	14.794	0.493	35.371
	Platforms		9.497	0.317	4.292	0.538	0.018	3.029	0.538	0.018	3.029	10.573	0.352	10.351
	Production Wells		0.257	0.009	0.133	0.770	0.026	9.503	1.283	0.043	155.215	2.309	0.077	164.851
	Exploration Wells													
	Development Wells													
	Total		20.706	0.690	8.575	4.057	0.135	26.760	2.913	0.097	175.238	27.675	0.923	210.573
2027	Pipeline	30.0	10.952	0.365	4.150	2.749	0.092	14.228	1.093	0.036	16.994	14.794	0.493	35.371
	Platforms		9.497	0.317	4.292	0.538	0.018	3.029	0.538	0.018	3.029	10.573	0.352	10.351
	Production Wells		0.257	0.009	0.133	0.770	0.026	9.503	1.283	0.043	155.215	2.309	0.077	164.851
	Exploration Wells													
	Development Wells													
	Total		20.706	0.690	8.575	4.057	0.135	26.760	2.913	0.097	175.238	27.675	0.923	210.573

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]
2028	Pipeline	24.0	10.952	0.456	4.150	2.749	0.115	14.228	1.093	0.046	16.994	14.794	0.616	35.371
	Platforms		9.497	0.396	4.292	0.538	0.022	3.029	0.538	0.022	3.029	10.573	0.441	10.351
	Production Wells		0.257	0.011	0.133	0.770	0.032	9.503	1.283	0.053	155.215	2.309	0.096	164.851
	Exploration Wells													
	Development Wells													
	Total		20.706	0.863	8.575	4.057	0.169	26.760	2.913	0.121	175.238	27.675	1.153	210.573
2029	Pipeline	19.2	10.952	0.570	4.150	2.749	0.143	14.228	1.093	0.057	16.994	14.794	0.771	35.371
	Platforms		9.497	0.495	4.292	0.538	0.028	3.029	0.538	0.028	3.029	10.573	0.551	10.351
	Production Wells		0.257	0.013	0.133	0.770	0.040	9.503	1.283	0.067	155.215	2.309	0.120	164.851
	Exploration Wells													
	Development Wells													
	Total		20.706	1.078	8.575	4.057	0.211	26.760	2.913	0.152	175.238	27.675	1.441	210.573
2030	Pipeline	15.4	10.952	0.711	4.150	2.749	0.179	14.228	1.093	0.071	16.994	14.794	0.961	35.371
	Platforms		9.497	0.617	4.292	0.538	0.035	3.029	0.538	0.035	3.029	10.573	0.687	10.351
	Production Wells		0.257	0.017	0.133	0.770	0.050	9.503	1.283	0.083	155.215	2.309	0.150	164.851
	Exploration Wells													
	Development Wells													
	Total		20.706	1.345	8.575	4.057	0.263	26.760	2.913	0.189	175.238	27.675	1.797	210.573
2031	Pipeline	12.3	10.952	0.890	4.150	2.749	0.223	14.228	1.093	0.089	16.994	14.794	1.203	35.371
	Platforms		9.497	0.772	4.292	0.538	0.044	3.029	0.538	0.044	3.029	10.573	0.860	10.351
	Production Wells		0.257	0.021	0.133	0.770	0.063	9.503	1.283	0.104	155.215	2.309	0.188	164.851
	Exploration Wells													
	Development Wells													
	Total		20.706	1.683	8.575	4.057	0.330	26.760	2.913	0.237	175.238	27.675	2.250	210.573
2032	Pipeline	9.8	10.952	1.118	4.150	2.749	0.281	14.228	1.093	0.112	16.994	14.794	1.510	35.371
	Platforms		9.497	0.969	4.292	0.538	0.055	3.029	0.538	0.055	3.029	10.573	1.079	10.351
	Production Wells		0.257	0.026	0.133	0.770	0.079	9.503	1.283	0.131	155.215	2.309	0.236	164.851
	Exploration Wells													
	Development Wells													
	Total		20.706	2.113	8.575	4.057	0.414	26.760	2.913	0.297	175.238	27.675	2.824	210.573
2033	Pipeline	7.9	10.952	1.386	4.150	2.749	0.348	14.228	1.093	0.138	16.994	14.794	1.873	35.371
	Platforms		9.497	1.202	4.292	0.538	0.068	3.029	0.538	0.068	3.029	10.573	1.338	10.351
	Production Wells		0.257	0.032	0.133	0.770	0.097	9.503	1.283	0.162	155.215	2.309	0.292	164.851
	Exploration Wells													
	Development Wells													
	Total		20.706	2.621	8.575	4.057	0.513	26.760	2.913	0.369	175.238	27.675	3.503	210.573
2034	Pipeline	6.3	10.952	1.738	4.150	2.749	0.436	14.228	1.093	0.173	16.994	14.794	2.348	35.371
	Platforms		9.497	1.507	4.292	0.538	0.085	3.029	0.538	0.085	3.029	10.573	1.678	10.351
	Production Wells		0.257	0.041	0.133	0.770	0.122	9.503	1.283	0.204	155.215	2.309	0.366	164.851
	Exploration Wells													
	Development Wells													
	Total		20.706	3.287	8.575	4.057	0.644	26.760	2.913	0.462	175.238	27.675	4.393	210.573
2035	Pipeline	5.0	10.952	2.190	4.150	2.749	0.550	14.228	1.093	0.219	16.994	14.794	2.959	35.371
	Platforms		9.497	1.899	4.292	0.538	0.108	3.029	0.538	0.108	3.029	10.573	2.115	10.351
	Production Wells		0.257	0.051	0.133	0.770	0.154	9.503	1.283	0.257	155.215	2.309	0.462	164.851
	Exploration Wells													
	Development Wells													
	Total		20.706	4.141	8.575	4.057	0.811	26.760	2.913	0.583	175.238	27.675	5.535	210.573
2036	Pipeline	4.0	10.952	2.738	4.150	2.749	0.687	14.228	1.093	0.273	16.994	14.794	3.698	35.371
	Platforms		9.497	2.374	4.292	0.538	0.134	3.029	0.538	0.134	3.029	10.573	2.643	10.351
	Production Wells		0.257	0.064	0.133	0.770	0.192	9.503	1.283	0.321	155.215	2.309	0.577	164.851
	Exploration Wells													
	Development Wells													
	Total		20.706	5.176	8.575	4.057	1.014	26.760	2.913	0.728	175.238	27.675	6.919	210.573
2037	Pipeline	3.2	10.952	3.422	4.150	2.749	0.859	14.228	1.093	0.341	16.994	14.794	4.623	35.371
	Platforms		9.497	2.968	4.292	0.538	0.168	3.029	0.538	0.168	3.029	10.573	3.304	10.351
	Production Wells		0.257	0.080	0.133	0.770	0.241	9.503	1.283	0.401	155.215	2.309	0.722	164.851
	Exploration Wells													
	Development Wells													
	Total		20.706	6.470	8.575	4.057	1.268	26.760	2.913	0.910	175.238	27.675	8.649	210.573
2038	Pipeline													
	Platforms													
	Production Wells													
	Exploration Wells													
	Development Wells													
	Total													
2039	Pipeline													
	Platforms													
	Production Wells													
	Exploration Wells													
	Development Wells													
	Total													
2040	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]
2011		0.204		0.106	0.612		7.537	0.966		112.679	1.578		120.216	1.782		120.321
2012		0.266		0.138	0.799		9.839	1.340		162.818	2.139		172.657	2.404		172.795
2013		0.125		0.065	0.374		4.604	0.747		100.278	1.121		104.883	1.246		104.947
2014		0.266		0.138	0.799		9.839	1.340		162.818	2.139		172.657	2.404		172.795
2015		0.204		0.106	0.612		7.537	0.966		112.679	1.578		120.216	1.782		120.321
2016																
2017																
2018																
2019		2.738		1.037	0.687		3.557	0.273		4.249	0.960		7.805	3.698		8.843
2020		5.476		2.075	1.374		7.114	0.546		8.497	1.921		15.611	7.397		17.686
2021		10.952		4.150	2.749		14.228	1.093		16.994	3.842		31.222	14.794		35.371
2022	**13.5**	13.293	0.985	5.212	3.063	0.227	17.236	1.530	0.113	54.973	4.592	0.340	72.208	17.885	1.325	77.420
2023	**16.9**	16.024	0.948	6.451	3.429	0.203	20.745	2.039	0.121	99.281	5.468	0.324	120.026	21.492	1.272	126.476
2024	**22.5**	18.755	0.834	7.690	3.795	0.169	24.254	2.549	0.113	143.589	6.344	0.282	167.843	25.099	1.116	175.533
2025	**30.0**	20.706	0.690	8.575	4.057	0.135	26.760	2.913	0.097	175.238	6.970	0.232	201.998	27.675	0.923	210.573
2026	**30.0**	20.706	0.690	8.575	4.057	0.135	26.760	2.913	0.097	175.238	6.970	0.232	201.998	27.675	0.923	210.573
2027	**30.0**	20.706	0.690	8.575	4.057	0.135	26.760	2.913	0.097	175.238	6.970	0.232	201.998	27.675	0.923	210.573
2028	**24.0**	20.706	0.863	8.575	4.057	0.169	26.760	2.913	0.121	175.238	6.970	0.290	201.998	27.675	1.153	210.573
2029	**19.2**	20.706	1.078	8.575	4.057	0.211	26.760	2.913	0.152	175.238	6.970	0.363	201.998	27.675	1.441	210.573
2030	**15.4**	20.706	1.345	8.575	4.057	0.263	26.760	2.913	0.189	175.238	6.970	0.453	201.998	27.675	1.797	210.573
2031	**12.3**	20.706	1.683	8.575	4.057	0.330	26.760	2.913	0.237	175.238	6.970	0.567	201.998	27.675	2.250	210.573
2032	**9.8**	20.706	2.113	8.575	4.057	0.414	26.760	2.913	0.297	175.238	6.970	0.711	201.998	27.675	2.824	210.573
2033	**7.9**	20.706	2.621	8.575	4.057	0.513	26.760	2.913	0.369	175.238	6.970	0.882	201.998	27.675	3.503	210.573
2034	**6.3**	20.706	3.287	8.575	4.057	0.644	26.760	2.913	0.462	175.238	6.970	1.106	201.998	27.675	4.393	210.573
2035	**5.0**	20.706	4.141	8.575	4.057	0.811	26.760	2.913	0.583	175.238	6.970	1.394	201.998	27.675	5.535	210.573
2036	**4.0**	20.706	5.176	8.575	4.057	1.014	26.760	2.913	0.728	175.238	6.970	1.742	201.998	27.675	6.919	210.573
2037	**3.2**	20.706	6.470	8.575	4.057	1.268	26.760	2.913	0.910	175.238	6.970	2.178	201.998	27.675	8.649	210.573
2038																
2039																
2040																
Total LOF	**250.0**	**337.473**		**139**	**71.027**		**474**	**51.264**		**3257**	**122.291**		**3731**	**459.764**		**3870**
Average LOF		**12.499**	**1.350**	**5**	**2.631**	**0.284**	**18**	**1.899**	**0.205**	**121**	**4.529**	**0.489**	**138**	**17.028**	**1.839**	**143**

Table 4.1.14
Low Case - Year 2030 - Monte Carlo Results

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	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 10^3years					Frequency Spills per 10^9 bbl Produced					Spill Index [bbl]				
Mean =	20.71	4.06	2.92	6.98	27.68	1.34	0.26	0.19	0.45	1.80	8.58	26.68	175.48	202.16	210.74
Std Deviation =	8.13	1.97	0.93	2.27	8.42	0.53	0.13	0.06	0.15	0.55	5.59	14.84	62.50	64.36	64.52
Variance =	66.108	3.889	0.860	5.138	70.928	0.279	0.016	0.004	0.022	0.299	31.263	220.212	3905.954	4142.394	4162.506
Skewness =	0.38	0.81	0.59	0.62	0.35	0.38	0.81	0.59	0.62	0.35	1.11	1.23	0.45	0.43	0.42
Kurtosis =	2.79	3.29	3.17	3.28	2.80	2.79	3.29	3.17	3.28	2.80	4.24	5.19	3.14	3.15	3.15
Mode =	18.24	3.18	3.33	4.85	32.41	1.28	0.21	0.18	0.32	1.49	4.98	8.44	132.16	163.99	137.65
Minimum =	2.465	0.463	0.583	1.442	7.376	0.160	0.030	0.038	0.094	0.479	-0.602	0.498	18.872	30.947	31.818
5% Perc =	8.318	1.531	1.591	3.751	14.950	0.540	0.099	0.103	0.244	0.971	1.920	8.250	80.687	104.118	112.717
10% Perc =	10.477	1.824	1.819	4.276	17.088	0.680	0.118	0.118	0.278	1.110	2.638	10.643	97.796	121.843	130.982
15% Perc =	12.097	2.077	1.972	4.684	18.755	0.786	0.135	0.128	0.304	1.218	3.202	12.547	110.568	135.971	144.248
20% Perc =	13.389	2.291	2.111	5.005	20.166	0.869	0.149	0.137	0.325	1.309	3.782	14.345	121.134	146.739	155.256
25% Perc =	14.620	2.510	2.231	5.307	21.470	0.949	0.163	0.145	0.345	1.394	4.305	15.892	130.865	156.358	165.055
30% Perc =	15.828	2.736	2.345	5.569	22.694	1.028	0.178	0.152	0.362	1.474	4.872	17.426	139.625	165.289	173.744
35% Perc =	16.937	2.956	2.465	5.865	23.812	1.100	0.192	0.160	0.381	1.546	5.448	19.010	147.641	173.286	181.518
40% Perc =	17.970	3.192	2.577	6.145	24.878	1.167	0.207	0.167	0.399	1.615	6.038	20.550	155.306	181.445	189.776
45% Perc =	19.044	3.437	2.687	6.409	25.945	1.237	0.223	0.175	0.416	1.685	6.636	22.181	162.985	189.414	197.928
50% Perc =	20.104	3.683	2.802	6.711	27.083	1.305	0.239	0.182	0.436	1.759	7.265	23.678	170.696	196.988	205.807
55% Perc =	21.214	3.960	2.928	6.999	28.199	1.378	0.257	0.190	0.454	1.831	8.030	25.465	178.346	205.156	214.217
60% Perc =	22.357	4.257	3.051	7.306	29.403	1.452	0.276	0.198	0.474	1.909	8.772	27.310	186.797	213.774	222.502
65% Perc =	23.446	4.558	3.180	7.614	30.681	1.522	0.296	0.207	0.494	1.992	9.659	29.411	194.850	222.958	231.764
70% Perc =	24.620	4.897	3.318	7.999	31.954	1.599	0.318	0.215	0.519	2.075	10.595	31.676	204.759	233.031	241.490
75% Perc =	26.029	5.288	3.484	8.387	33.289	1.690	0.343	0.226	0.545	2.162	11.664	34.313	215.087	243.325	251.876
80% Perc =	27.719	5.700	3.681	8.821	34.845	1.800	0.370	0.239	0.573	2.263	12.840	37.302	227.391	255.168	263.666
85% Perc =	29.498	6.210	3.913	9.361	36.665	1.915	0.403	0.254	0.608	2.381	14.313	41.202	241.095	269.102	277.739
90% Perc =	31.743	6.863	4.196	10.049	39.086	2.061	0.446	0.272	0.653	2.538	16.361	46.214	259.121	287.413	296.313
95% Perc =	35.055	7.815	4.626	11.131	42.506	2.276	0.507	0.300	0.723	2.760	19.645	55.256	285.373	315.026	323.145
Maximum =	49.920	12.452	6.956	17.753	59.182	3.242	0.809	0.452	1.153	3.843	37.964	119.232	442.486	476.880	482.247

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 10^3 years				
Mean =	7.20	1.81	0.72	2.53	9.72
Std Deviation =	3.61	1.27	0.51	1.37	3.87
Variance =	13.015	1.606	0.257	1.883	14.946
Skewness =	0.48	0.86	0.85	0.72	0.43
Kurtosis =	2.60	3.24	3.24	3.14	2.75
Mode =	8.99	0.91	0.66	3.57	7.74
Minimum =	0.253	0.032	0.008	0.152	1.217
5% Perc =	2.065	0.249	0.095	0.687	4.020
10% Perc =	2.780	0.381	0.146	0.921	4.907
15% Perc =	3.359	0.509	0.201	1.109	5.668
20% Perc =	3.878	0.648	0.250	1.292	6.273
25% Perc =	4.369	0.782	0.308	1.465	6.782
30% Perc =	4.852	0.918	0.364	1.631	7.277
35% Perc =	5.317	1.057	0.422	1.799	7.785
40% Perc =	5.773	1.213	0.482	1.965	8.292
45% Perc =	6.236	1.366	0.547	2.131	8.803
50% Perc =	6.732	1.549	0.613	2.302	9.352
55% Perc =	7.230	1.717	0.688	2.480	9.889
60% Perc =	7.798	1.913	0.770	2.674	10.455
65% Perc =	8.343	2.123	0.846	2.896	11.031
70% Perc =	9.002	2.367	0.938	3.139	11.681
75% Perc =	9.715	2.599	1.040	3.388	12.364
80% Perc =	10.473	2.892	1.152	3.684	13.107
85% Perc =	11.279	3.208	1.280	4.024	13.982
90% Perc =	12.298	3.628	1.442	4.464	15.085
95% Perc =	13.727	4.243	1.687	5.106	16.596
Maximum =	19.233	7.488	2.739	8.305	26.082

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 =	0.78	0.20	0.08	0.27	1.05
Std Deviation =	0.39	0.14	0.05	0.15	0.42
Variance =	0.152	0.019	0.003	0.022	0.174
Skewness =	0.48	0.86	0.85	0.72	0.43
Kurtosis =	2.60	3.24	3.24	3.14	2.75
Mode =	0.97	0.10	0.07	0.16	1.16
Minimum =	0.027	0.004	0.001	0.016	0.131
5% Perc =	0.223	0.027	0.010	0.074	0.434
10% Perc =	0.300	0.041	0.016	0.099	0.530
15% Perc =	0.363	0.055	0.022	0.120	0.612
20% Perc =	0.419	0.070	0.027	0.140	0.678
25% Perc =	0.472	0.084	0.033	0.158	0.732
30% Perc =	0.524	0.099	0.039	0.176	0.786
35% Perc =	0.574	0.114	0.046	0.194	0.841
40% Perc =	0.623	0.131	0.052	0.212	0.896
45% Perc =	0.673	0.148	0.059	0.230	0.951
50% Perc =	0.727	0.167	0.066	0.249	1.010
55% Perc =	0.781	0.185	0.074	0.268	1.068
60% Perc =	0.842	0.207	0.083	0.289	1.129
65% Perc =	0.901	0.229	0.091	0.313	1.191
70% Perc =	0.972	0.256	0.101	0.339	1.262
75% Perc =	1.049	0.281	0.112	0.366	1.335
80% Perc =	1.131	0.312	0.124	0.398	1.416
85% Perc =	1.218	0.347	0.138	0.435	1.510
90% Perc =	1.328	0.392	0.156	0.482	1.629
95% Perc =	1.482	0.458	0.182	0.551	1.792
Maximum =	2.077	0.809	0.296	0.897	2.817

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 =	2.72	9.42	11.17	20.58	23.31
Std Deviation =	2.35	9.06	8.30	12.39	12.62
Variance =	5.518	82.106	68.809	153.594	159.359
Skewness =	1.52	1.84	1.06	1.07	1.01
Kurtosis =	5.63	7.64	3.96	4.54	4.36
Mode =	1.20	1.46	8.56	17.30	26.30
Minimum =	-0.758	-1.927	0.111	-0.165	1.173
5% Perc =	0.321	0.627	1.410	4.800	6.964
10% Perc =	0.489	1.167	2.153	6.701	9.182
15% Perc =	0.643	1.705	2.983	8.349	10.866
20% Perc =	0.798	2.274	3.767	9.867	12.506
25% Perc =	0.969	2.883	4.609	11.321	14.014
30% Perc =	1.143	3.539	5.479	12.716	15.355
35% Perc =	1.325	4.238	6.353	14.046	16.672
40% Perc =	1.547	5.006	7.265	15.428	18.004
45% Perc =	1.788	5.820	8.266	16.856	19.419
50% Perc =	2.044	6.640	9.281	18.340	21.150
55% Perc =	2.303	7.610	10.323	19.969	22.824
60% Perc =	2.610	8.699	11.518	21.593	24.471
65% Perc =	2.942	9.958	12.901	23.231	26.163
70% Perc =	3.338	11.384	14.265	25.063	27.971
75% Perc =	3.798	13.217	15.927	27.221	30.196
80% Perc =	4.335	15.133	17.778	30.006	33.020
85% Perc =	5.006	17.817	19.874	33.401	36.208
90% Perc =	5.961	21.331	22.790	37.364	40.362
95% Perc =	7.579	27.422	27.420	43.928	47.008
Maximum =	16.956	73.697	51.854	90.962	94.679

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
All years Average LOF	**Frequency Spills per 10^3 years**				
Mean =	5.12	0.29	0.29	0.58	5.70
Std Deviation =	3.23	0.18	0.18	0.35	3.25
Variance =	10.456	0.031	0.031	0.123	10.557
Skewness =	0.60	0.69	0.69	0.69	0.59
Kurtosis =	2.53	2.86	2.86	2.86	2.54
Mode =	1.27	0.30	0.30	0.61	3.55
Minimum =	0.116	0.006	0.006	0.013	0.375
5% Perc =	0.909	0.062	0.062	0.125	1.421
10% Perc =	1.299	0.086	0.086	0.172	1.864
15% Perc =	1.652	0.108	0.108	0.215	2.220
20% Perc =	2.018	0.127	0.127	0.254	2.599
25% Perc =	2.409	0.147	0.147	0.293	3.003
30% Perc =	2.803	0.167	0.167	0.334	3.409
35% Perc =	3.229	0.188	0.188	0.377	3.811
40% Perc =	3.664	0.211	0.211	0.422	4.262
45% Perc =	4.093	0.233	0.233	0.466	4.696
50% Perc =	4.553	0.257	0.257	0.515	5.184
55% Perc =	5.038	0.286	0.286	0.571	5.650
60% Perc =	5.563	0.313	0.313	0.627	6.133
65% Perc =	6.119	0.342	0.342	0.684	6.697
70% Perc =	6.734	0.373	0.373	0.746	7.320
75% Perc =	7.366	0.406	0.406	0.812	7.971
80% Perc =	8.094	0.444	0.444	0.889	8.655
85% Perc =	8.892	0.487	0.487	0.975	9.499
90% Perc =	9.832	0.542	0.542	1.084	10.420
95% Perc =	11.194	0.621	0.621	1.241	11.814
Maximum =	16.159	0.959	0.959	1.917	16.735

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
All years Average LOF	**Frequency Spills per 10^9 bbl Produced**				
Mean =	0.55	0.03	0.03	0.06	0.62
Std Deviation =	0.35	0.02	0.02	0.04	0.35
Variance =	0.122	0.000	0.000	0.001	0.123
Skewness =	0.60	0.69	0.69	0.69	0.59
Kurtosis =	2.53	2.86	2.86	2.86	2.54
Mode =	0.14	0.03	0.03	0.07	0.38
Minimum =	0.012	0.001	0.001	0.001	0.040
5% Perc =	0.098	0.007	0.007	0.013	0.154
10% Perc =	0.140	0.009	0.009	0.019	0.201
15% Perc =	0.178	0.012	0.012	0.023	0.240
20% Perc =	0.218	0.014	0.014	0.027	0.281
25% Perc =	0.260	0.016	0.016	0.032	0.324
30% Perc =	0.303	0.018	0.018	0.036	0.368
35% Perc =	0.349	0.020	0.020	0.041	0.412
40% Perc =	0.396	0.023	0.023	0.046	0.460
45% Perc =	0.442	0.025	0.025	0.050	0.507
50% Perc =	0.492	0.028	0.028	0.056	0.560
55% Perc =	0.544	0.031	0.031	0.062	0.610
60% Perc =	0.601	0.034	0.034	0.068	0.662
65% Perc =	0.661	0.037	0.037	0.074	0.723
70% Perc =	0.727	0.040	0.040	0.081	0.791
75% Perc =	0.796	0.044	0.044	0.088	0.861
80% Perc =	0.874	0.048	0.048	0.096	0.935
85% Perc =	0.960	0.053	0.053	0.105	1.026
90% Perc =	1.062	0.059	0.059	0.117	1.125
95% Perc =	1.209	0.067	0.067	0.134	1.276
Maximum =	1.745	0.104	0.104	0.207	1.807

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
All years Average LOF	**Spill Index [bbl]**				
Mean =	2.32	1.64	1.64	3.27	5.60
Std Deviation =	2.32	1.35	1.35	2.71	3.52
Variance =	5.363	1.832	1.832	7.327	12.412
Skewness =	1.67	1.33	1.33	1.33	1.01
Kurtosis =	6.19	5.02	5.02	5.02	4.12
Mode =	1.02	2.69	2.69	5.38	6.09
Minimum =	-0.738	-0.539	-0.539	-1.078	-0.618
5% Perc =	0.124	0.147	0.147	0.294	1.186
10% Perc =	0.252	0.271	0.271	0.543	1.668
15% Perc =	0.379	0.396	0.396	0.792	2.103
20% Perc =	0.502	0.501	0.501	1.002	2.517
25% Perc =	0.645	0.617	0.617	1.234	2.900
30% Perc =	0.789	0.738	0.738	1.476	3.309
35% Perc =	0.948	0.853	0.853	1.706	3.696
40% Perc =	1.136	0.981	0.981	1.963	4.086
45% Perc =	1.337	1.126	1.126	2.252	4.507
50% Perc =	1.550	1.274	1.274	2.548	4.941
55% Perc =	1.811	1.437	1.437	2.873	5.388
60% Perc =	2.094	1.627	1.627	3.255	5.892
65% Perc =	2.431	1.818	1.818	3.636	6.350
70% Perc =	2.811	2.049	2.049	4.099	6.941
75% Perc =	3.279	2.306	2.306	4.611	7.575
80% Perc =	3.828	2.627	2.627	5.254	8.283
85% Perc =	4.593	3.020	3.020	6.041	9.216
90% Perc =	5.596	3.540	3.540	7.080	10.454
95% Perc =	7.174	4.347	4.347	8.695	12.426
Maximum =	17.053	9.345	9.345	18.691	26.747

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 10^3 years					Frequency Spills per 10^9 bbl Produced					Spill Index [bbl]				
Mean =	0.18	0.53	0.89	1.42	1.60	0.02	0.06	0.10	0.15	0.17	0.09	6.59	107.80	114.39	114.48
Std Deviation =	0.06	0.18	0.21	0.37	0.38	0.01	0.02	0.02	0.04	0.04	0.06	4.15	37.40	37.62	37.63
Variance =	0.003	0.031	0.044	0.137	0.141	0.000	0.000	0.001	0.002	0.002	0.004	17.251	1398.565	1415.640	1415.684
Skewness =	0.00	-0.01	-0.03	-0.03	-0.03	0.00	-0.01	-0.03	-0.03	-0.03	0.69	0.79	0.52	0.51	0.51
Kurtosis =	2.50	2.51	2.66	2.56	2.58	2.50	2.51	2.66	2.56	2.58	3.29	3.48	3.20	3.20	3.20
Mode =	0.19	0.62	0.88	1.09	1.32	0.02	0.07	0.08	0.12	0.14	0.12	5.25	58.32	109.36	141.36
Minimum =	0.021	0.047	0.229	0.333	0.433	0.002	0.005	0.025	0.036	0.047	-0.040	-1.349	18.928	19.118	19.199
5% Perc =	0.080	0.240	0.542	0.808	0.975	0.009	0.026	0.059	0.087	0.105	0.007	0.971	52.783	58.783	58.853
10% Perc =	0.098	0.297	0.611	0.927	1.104	0.011	0.032	0.066	0.100	0.119	0.020	1.764	62.217	68.495	68.580
15% Perc =	0.114	0.340	0.666	1.019	1.195	0.012	0.037	0.072	0.110	0.129	0.030	2.367	69.340	75.510	75.585
20% Perc =	0.126	0.378	0.707	1.096	1.268	0.014	0.041	0.076	0.118	0.137	0.039	2.926	75.524	81.947	82.052
25% Perc =	0.137	0.408	0.742	1.166	1.339	0.015	0.044	0.080	0.126	0.145	0.046	3.436	80.965	87.316	87.386
30% Perc =	0.146	0.439	0.775	1.224	1.398	0.016	0.047	0.084	0.132	0.151	0.054	3.975	85.855	92.271	92.380
35% Perc =	0.154	0.464	0.805	1.278	1.454	0.017	0.050	0.087	0.138	0.157	0.062	4.469	90.578	97.070	97.147
40% Perc =	0.162	0.488	0.835	1.327	1.503	0.018	0.053	0.090	0.143	0.162	0.069	4.924	94.750	101.286	101.391
45% Perc =	0.170	0.512	0.864	1.376	1.553	0.018	0.055	0.093	0.149	0.168	0.076	5.412	99.390	105.947	106.023
50% Perc =	0.177	0.534	0.892	1.424	1.602	0.019	0.058	0.096	0.154	0.173	0.084	5.955	103.647	110.367	110.480
55% Perc =	0.185	0.556	0.919	1.472	1.652	0.020	0.060	0.099	0.159	0.178	0.092	6.482	108.523	115.142	115.275
60% Perc =	0.193	0.580	0.947	1.522	1.703	0.021	0.063	0.102	0.164	0.184	0.100	7.056	113.978	120.604	120.693
65% Perc =	0.201	0.605	0.977	1.576	1.758	0.022	0.065	0.105	0.170	0.190	0.109	7.633	119.330	126.149	126.304
70% Perc =	0.210	0.632	1.006	1.630	1.811	0.023	0.068	0.109	0.176	0.196	0.119	8.303	125.200	131.920	132.008
75% Perc =	0.219	0.659	1.040	1.690	1.871	0.024	0.071	0.112	0.183	0.202	0.131	9.052	131.316	138.058	138.126
80% Perc =	0.229	0.687	1.074	1.754	1.934	0.025	0.074	0.116	0.189	0.209	0.142	9.896	138.388	145.009	145.100
85% Perc =	0.242	0.724	1.115	1.822	2.005	0.026	0.078	0.120	0.197	0.217	0.157	10.919	147.055	153.594	153.683
90% Perc =	0.257	0.766	1.166	1.912	2.093	0.028	0.083	0.126	0.207	0.226	0.177	12.275	158.433	165.675	165.767
95% Perc =	0.276	0.825	1.233	2.026	2.216	0.030	0.089	0.133	0.219	0.239	0.208	14.534	175.273	182.176	182.235
Maximum =	0.353	1.035	1.543	2.536	2.702	0.038	0.112	0.167	0.274	0.292	0.371	25.004	302.477	310.913	310.972

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

Frequency: Spills per 10^3 years

Low 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 =	5.29	0.82	1.18	2.00	7.30
Std Deviation =	3.23	0.25	0.27	0.51	3.28
Variance =	10.457	0.062	0.075	0.260	10.730
Skewness =	0.60	0.24	0.18	0.22	0.57
Kurtosis =	2.53	2.86	2.88	2.87	2.55
Mode =	7.44	0.71	1.11	1.12	7.69
Minimum =	0.300	0.119	0.351	0.596	1.417
5% Perc =	1.097	0.430	0.739	1.189	2.953
10% Perc =	1.472	0.508	0.828	1.352	3.437
15% Perc =	1.828	0.561	0.890	1.465	3.823
20% Perc =	2.196	0.609	0.943	1.564	4.218
25% Perc =	2.575	0.652	0.988	1.647	4.600
30% Perc =	2.980	0.684	1.027	1.719	4.995
35% Perc =	3.404	0.716	1.065	1.784	5.426
40% Perc =	3.841	0.749	1.100	1.852	5.832
45% Perc =	4.268	0.779	1.137	1.919	6.291
50% Perc =	4.747	0.813	1.170	1.983	6.771
55% Perc =	5.219	0.844	1.206	2.050	7.250
60% Perc =	5.748	0.878	1.244	2.119	7.748
65% Perc =	6.297	0.913	1.282	2.187	8.288
70% Perc =	6.916	0.949	1.320	2.258	8.926
75% Perc =	7.536	0.988	1.361	2.345	9.586
80% Perc =	8.276	1.031	1.410	2.436	10.257
85% Perc =	9.055	1.084	1.470	2.543	11.096
90% Perc =	10.009	1.149	1.542	2.674	12.073
95% Perc =	11.357	1.252	1.645	2.880	13.424
Maximum =	16.275	1.826	2.248	4.074	17.820

Frequency: Spills per 10^9 bbl Produced

Low 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 =	0.57	0.09	0.13	0.22	0.79
Std Deviation =	0.35	0.03	0.03	0.06	0.35
Variance =	0.122	0.001	0.001	0.003	0.125
Skewness =	0.60	0.24	0.18	0.22	0.57
Kurtosis =	2.53	2.86	2.88	2.87	2.55
Mode =	0.43	0.08	0.11	0.15	0.89
Minimum =	0.032	0.013	0.038	0.064	0.153
5% Perc =	0.118	0.046	0.080	0.128	0.319
10% Perc =	0.159	0.055	0.089	0.146	0.371
15% Perc =	0.197	0.061	0.096	0.158	0.413
20% Perc =	0.237	0.066	0.102	0.169	0.456
25% Perc =	0.278	0.070	0.107	0.178	0.497
30% Perc =	0.322	0.074	0.111	0.186	0.540
35% Perc =	0.368	0.077	0.115	0.193	0.586
40% Perc =	0.415	0.081	0.119	0.200	0.630
45% Perc =	0.461	0.084	0.123	0.207	0.679
50% Perc =	0.513	0.088	0.126	0.214	0.731
55% Perc =	0.564	0.091	0.130	0.221	0.783
60% Perc =	0.621	0.095	0.134	0.229	0.837
65% Perc =	0.680	0.099	0.138	0.236	0.895
70% Perc =	0.747	0.103	0.143	0.244	0.964
75% Perc =	0.814	0.107	0.147	0.253	1.035
80% Perc =	0.894	0.111	0.152	0.263	1.108
85% Perc =	0.978	0.117	0.159	0.275	1.198
90% Perc =	1.081	0.124	0.167	0.289	1.304
95% Perc =	1.227	0.135	0.178	0.311	1.450
Maximum =	1.758	0.197	0.243	0.440	1.925

Spill Index [bbl]

Low 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 =	2.42	8.22	109.44	117.66	120.08
Std Deviation =	2.32	4.38	37.44	37.75	37.82
Variance =	5.363	19.166	1401.493	1425.324	1430.561
Skewness =	1.67	0.72	0.52	0.51	0.51
Kurtosis =	6.18	3.38	3.20	3.21	3.20
Mode =	1.02	6.18	99.78	122.79	99.79
Minimum =	-0.681	-1.121	19.198	22.090	24.901
5% Perc =	0.211	2.166	54.287	61.695	64.057
10% Perc =	0.341	3.075	63.767	71.472	73.618
15% Perc =	0.467	3.788	70.768	78.885	81.176
20% Perc =	0.600	4.402	77.083	85.004	87.255
25% Perc =	0.734	4.950	82.640	90.488	93.046
30% Perc =	0.885	5.509	87.465	95.484	97.875
35% Perc =	1.045	6.075	92.051	100.023	102.461
40% Perc =	1.228	6.549	96.356	104.751	107.076
45% Perc =	1.420	7.067	100.852	109.176	111.674
50% Perc =	1.645	7.622	105.391	113.728	116.251
55% Perc =	1.899	8.177	110.255	118.593	121.186
60% Perc =	2.188	8.731	115.619	123.898	126.325
65% Perc =	2.532	9.402	120.943	129.425	131.930
70% Perc =	2.917	10.052	126.919	135.373	137.479
75% Perc =	3.374	10.854	133.064	141.642	143.931
80% Perc =	3.910	11.707	139.966	148.462	151.184
85% Perc =	4.677	12.755	148.693	157.040	159.703
90% Perc =	5.670	14.248	160.053	169.040	171.570
95% Perc =	7.275	16.501	176.825	185.652	188.220
Maximum =	17.104	27.206	303.218	312.394	312.740

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 10^3years**					**Frequency Spills per 10^9 bbl Produced**					**Spill Index [bbl]**				
Mean =	12.49	2.63	1.90	4.53	17.02	1.35	0.28	0.21	0.49	1.84	5.14	17.64	120.61	138.25	143.39
Std Deviation =	4.80	1.30	0.58	1.47	5.03	0.52	0.14	0.06	0.16	0.54	3.32	10.05	38.29	39.80	39.96
Variance =	23.024	1.677	0.331	2.158	25.329	0.269	0.020	0.004	0.025	0.295	10.991	100.907	1466.364	1584.249	1597.057
Skewness =	0.36	0.79	0.59	0.57	0.33	0.36	0.79	0.59	0.57	0.33	1.15	1.39	0.50	0.48	0.47
Kurtosis =	2.77	3.16	3.14	3.03	2.78	2.77	3.16	3.14	3.03	2.78	4.52	5.98	3.20	3.20	3.19
Mode =	12.64	1.18	1.66	2.35	16.65	1.79	0.13	0.16	0.44	1.52	1.79	10.86	170.38	83.58	98.70
Minimum =	1.637	0.388	0.543	1.049	4.021	0.177	0.042	0.059	0.113	0.434	-0.138	0.376	28.662	32.796	37.654
5% Perc =	5.168	0.981	1.091	2.440	9.259	0.558	0.106	0.118	0.263	1.000	1.162	5.542	63.590	78.498	83.472
10% Perc =	6.420	1.165	1.220	2.768	10.607	0.693	0.126	0.132	0.299	1.146	1.598	7.214	73.617	89.539	94.374
15% Perc =	7.420	1.320	1.315	3.010	11.740	0.801	0.143	0.142	0.325	1.268	1.963	8.376	81.334	97.585	102.772
20% Perc =	8.225	1.463	1.395	3.226	12.552	0.888	0.158	0.151	0.348	1.356	2.295	9.462	87.818	104.158	109.135
25% Perc =	8.959	1.605	1.468	3.442	13.349	0.968	0.173	0.159	0.372	1.442	2.638	10.488	93.239	109.822	114.627
30% Perc =	9.621	1.749	1.537	3.616	14.055	1.039	0.189	0.166	0.391	1.518	2.980	11.525	98.292	114.879	120.191
35% Perc =	10.241	1.896	1.610	3.799	14.716	1.106	0.205	0.174	0.410	1.589	3.334	12.475	102.976	119.979	125.165
40% Perc =	10.861	2.047	1.679	3.978	15.399	1.173	0.221	0.181	0.430	1.663	3.661	13.490	107.371	124.793	129.834
45% Perc =	11.472	2.202	1.750	4.164	16.070	1.239	0.238	0.189	0.450	1.736	4.024	14.556	112.085	129.618	134.601
50% Perc =	12.172	2.374	1.828	4.352	16.708	1.315	0.256	0.197	0.470	1.804	4.391	15.575	116.846	134.573	139.681
55% Perc =	12.862	2.552	1.907	4.528	17.368	1.389	0.276	0.206	0.489	1.876	4.793	16.670	122.105	139.637	144.808
60% Perc =	13.467	2.747	1.990	4.747	18.063	1.454	0.297	0.215	0.513	1.951	5.231	17.885	127.147	145.122	150.607
65% Perc =	14.145	2.954	2.074	4.972	18.788	1.528	0.319	0.224	0.537	2.029	5.715	19.205	132.587	150.647	156.387
70% Perc =	14.883	3.204	2.161	5.209	19.546	1.607	0.346	0.233	0.563	2.111	6.336	20.714	138.144	156.925	162.271
75% Perc =	15.690	3.462	2.266	5.452	20.353	1.695	0.374	0.245	0.589	2.198	6.932	22.505	144.415	163.340	168.534
80% Perc =	16.600	3.746	2.377	5.767	21.315	1.793	0.405	0.257	0.623	2.302	7.664	24.518	152.335	170.500	175.801
85% Perc =	17.708	4.059	2.513	6.128	22.390	1.912	0.438	0.271	0.662	2.418	8.611	26.950	160.594	180.100	185.290
90% Perc =	18.935	4.478	2.687	6.599	23.759	2.045	0.484	0.290	0.713	2.566	9.755	30.649	172.610	192.368	197.407
95% Perc =	20.901	5.108	2.959	7.216	25.869	2.257	0.552	0.320	0.779	2.794	11.564	37.049	189.455	209.555	215.003
Maximum =	30.128	8.300	4.340	10.513	36.312	3.254	0.896	0.469	1.135	3.922	24.478	80.731	306.293	329.409	332.688

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

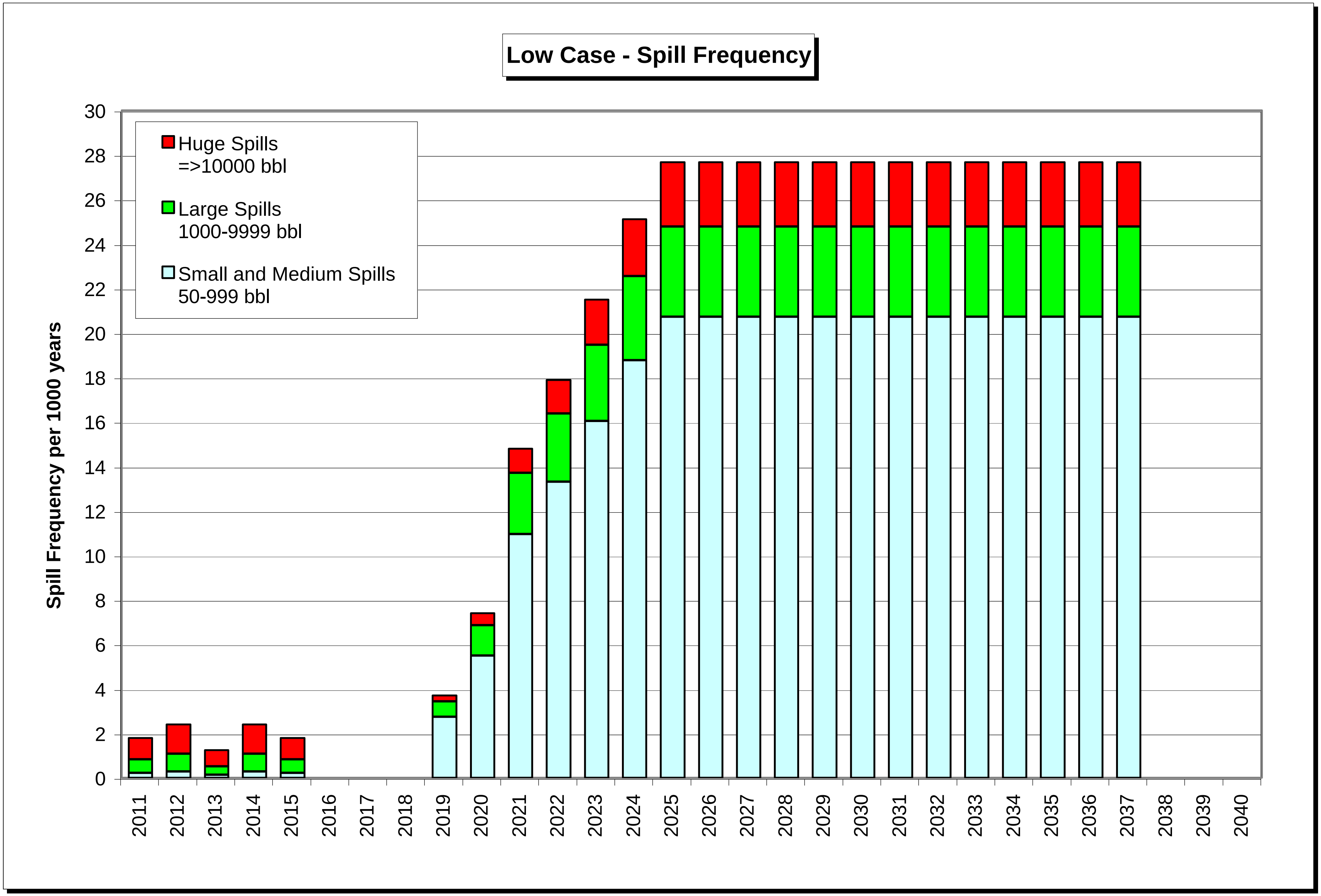
Spill Size	Spill Source: P/L		Platforms		Wells		Platforms and Wells		All	
Low Case - Year 2030 Spill Frequency per 10^3 years										
Small and Medium Spills 50-999 bbl	10.952	74%	9.497	90%	0.257	11%	9.754	76%	20.706	75%
Large Spills 1000-9999 bbl	2.749	19%	0.538	5%	0.770	33%	1.308	10%	4.057	15%
Huge Spills =>10000 bbl	1.093	7%	0.538	5%	1.283	56%	1.821	14%	2.913	11%
Significant Spills =>1000 bbl	3.842	26%	1.076	10%	2.052	89%	3.128	24%	6.970	25%
All Spills	**14.794**	**100%**	**10.573**	**100%**	**2.309**	**100%**	**12.882**	**100%**	**27.675**	**100%**
Low Case - Year 2030 Spill Frequency per 10^9 bbl produced										
Small and Medium Spills 50-999 bbl	0.711	74%	0.617	90%	0.017	11%	0.633	76%	1.345	75%
Large Spills 1000-9999 bbl	0.179	19%	0.035	5%	0.050	33%	0.085	10%	0.263	15%
Huge Spills =>10000 bbl	0.071	7%	0.035	5%	0.083	56%	0.118	14%	0.189	11%
Significant Spills =>1000 bbl	0.249	26%	0.070	10%	0.133	89%	0.203	24%	0.453	25%
All Spills	**0.961**	**100%**	**0.687**	**100%**	**0.150**	**100%**	**0.836**	**100%**	**1.797**	**100%**
Low Case - Year 2030 Spill Index [bbl]										
Small and Medium Spills 50-999 bbl	4	12%	4	41%	0	0%	4	3%	9	4%
Large Spills 1000-9999 bbl	14	40%	3	29%	10	6%	13	7%	27	13%
Huge Spills =>10000 bbl	17	48%	3	29%	155	94%	158	90%	175	83%
Significant Spills =>1000 bbl	31	88%	6	59%	165	100%	171	97%	202	96%
All Spills	**35**	**100%**	**10**	**100%**	**165**	**100%**	**175**	**100%**	**211**	**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	10.952	53%	2.749	68%	1.093	38%	3.842	55%	14.794	53%
Platforms	9.497	46%	0.538	13%	0.538	18%	1.076	15%	10.573	38%
Wells	0.257	1%	0.770	19%	1.283	44%	2.052	29%	2.309	8%
Platforms and Wells	9.754	47%	1.308	32%	1.821	62%	3.128	45%	12.882	47%
All	**20.706**	**100%**	**4.057**	**100%**	**2.913**	**100%**	**6.970**	**100%**	**27.675**	**100%**
Low Case - Year 2030 Spill Frequency per 10^9 bbl produced										
P/L	0.711	53%	0.179	68%	0.071	38%	0.249	55%	0.961	53%
Platforms	0.617	46%	0.035	13%	0.035	18%	0.070	15%	0.687	38%
Wells	0.017	1%	0.050	19%	0.083	44%	0.133	29%	0.150	8%
Platforms and Wells	0.633	47%	0.085	32%	0.118	62%	0.203	45%	0.836	47%
All	**1.345**	**100%**	**0.263**	**100%**	**0.189**	**100%**	**0.453**	**100%**	**1.797**	**100%**
Low Case - Year 2030 Spill Index [bbl]										
P/L	4	48%	14	53%	17	10%	31	15%	35	17%
Platforms	4	50%	3	11%	3	2%	6	3%	10	5%
Wells	0	2%	10	36%	155	89%	165	82%	165	78%
Platforms and Wells	4	52%	13	47%	158	90%	171	85%	175	83%
All	**9**	**100%**	**27**	**100%**	**175**	**100%**	**202**	**100%**	**211**	**100%**

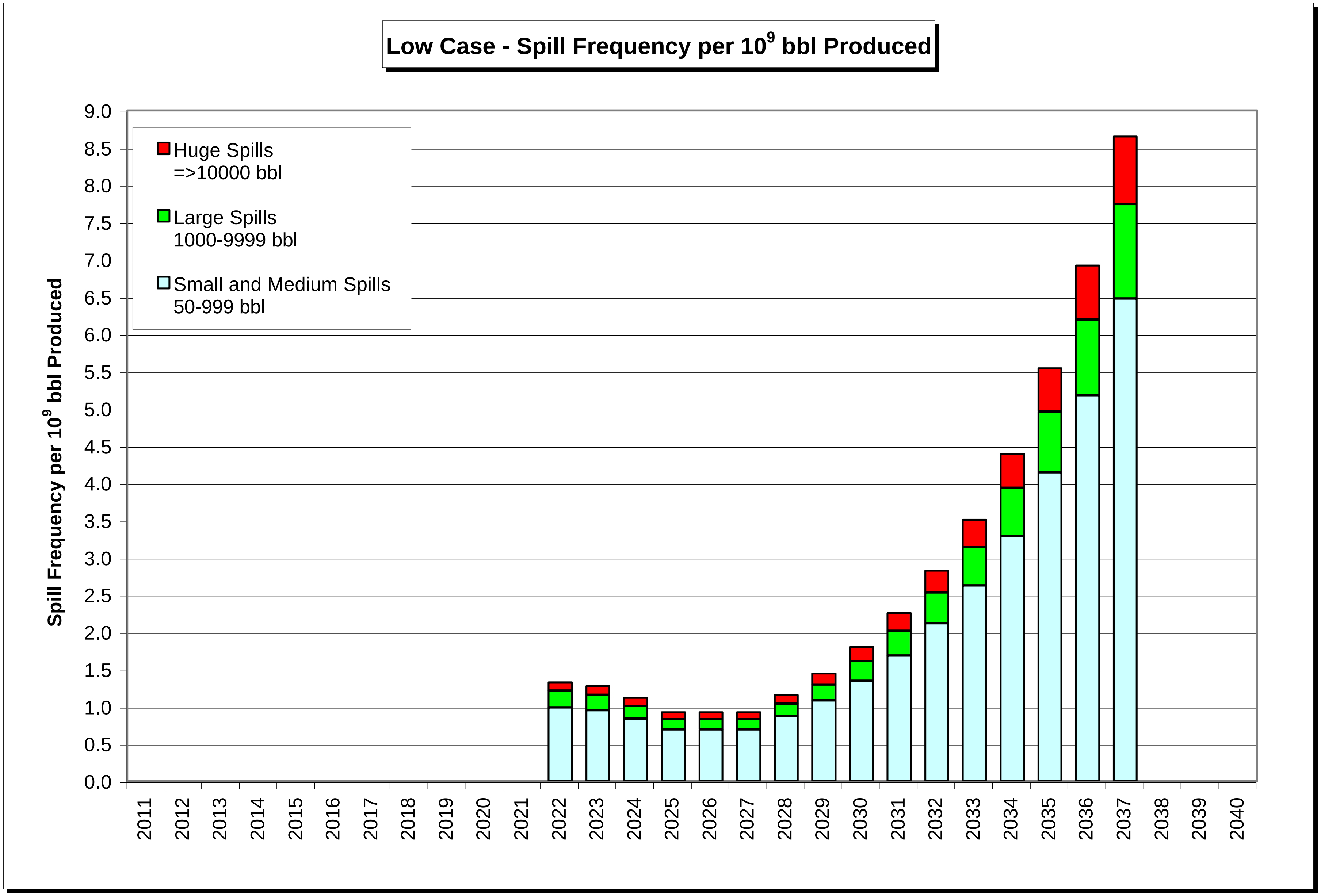
Table 4.1.21
Composition of Spill Indicators - Low Case - LOF Average

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	7.200	74%	5.121	90%	0.178	11%	5.299	73%	12.499	73%
Large Spills 1000-9999 bbl	1.807	19%	0.290	5%	0.533	33%	0.823	11%	2.631	15%
Huge Spills =>10000 bbl	0.718	7%	0.290	5%	0.890	56%	1.180	16%	1.899	11%
Significant Spills =>1000 bbl	2.526	26%	0.580	10%	1.424	89%	2.004	27%	4.529	27%
All Spills	**9.725**	**100%**	**5.702**	**100%**	**1.601**	**100%**	**7.303**	**100%**	**17.028**	**100%**
	Low Case - LOF Average Spill Frequency per 10^9 bbl produced									
Small and Medium Spills 50-999 bbl	0.778	74%	0.553	90%	0.019	11%	0.572	73%	1.350	73%
Large Spills 1000-9999 bbl	0.195	19%	0.031	5%	0.058	33%	0.089	11%	0.284	15%
Huge Spills =>10000 bbl	0.078	7%	0.031	5%	0.096	56%	0.127	16%	0.205	11%
Significant Spills =>1000 bbl	0.273	26%	0.063	10%	0.154	89%	0.216	27%	0.489	27%
All Spills	**1.050**	**100%**	**0.616**	**100%**	**0.173**	**100%**	**0.789**	**100%**	**1.839**	**100%**
	Low Case - LOF Average Spill Index [bbl]									
Small and Medium Spills 50-999 bbl	3	12%	2	41%	0	0%	2	2%	5	4%
Large Spills 1000-9999 bbl	9	40%	2	29%	7	6%	8	7%	18	12%
Huge Spills =>10000 bbl	11	48%	2	29%	108	94%	109	91%	121	84%
Significant Spills =>1000 bbl	21	88%	3	59%	114	100%	118	98%	138	96%
All Spills	**23**	**100%**	**6**	**100%**	**114**	**100%**	**120**	**100%**	**143**	**100%**

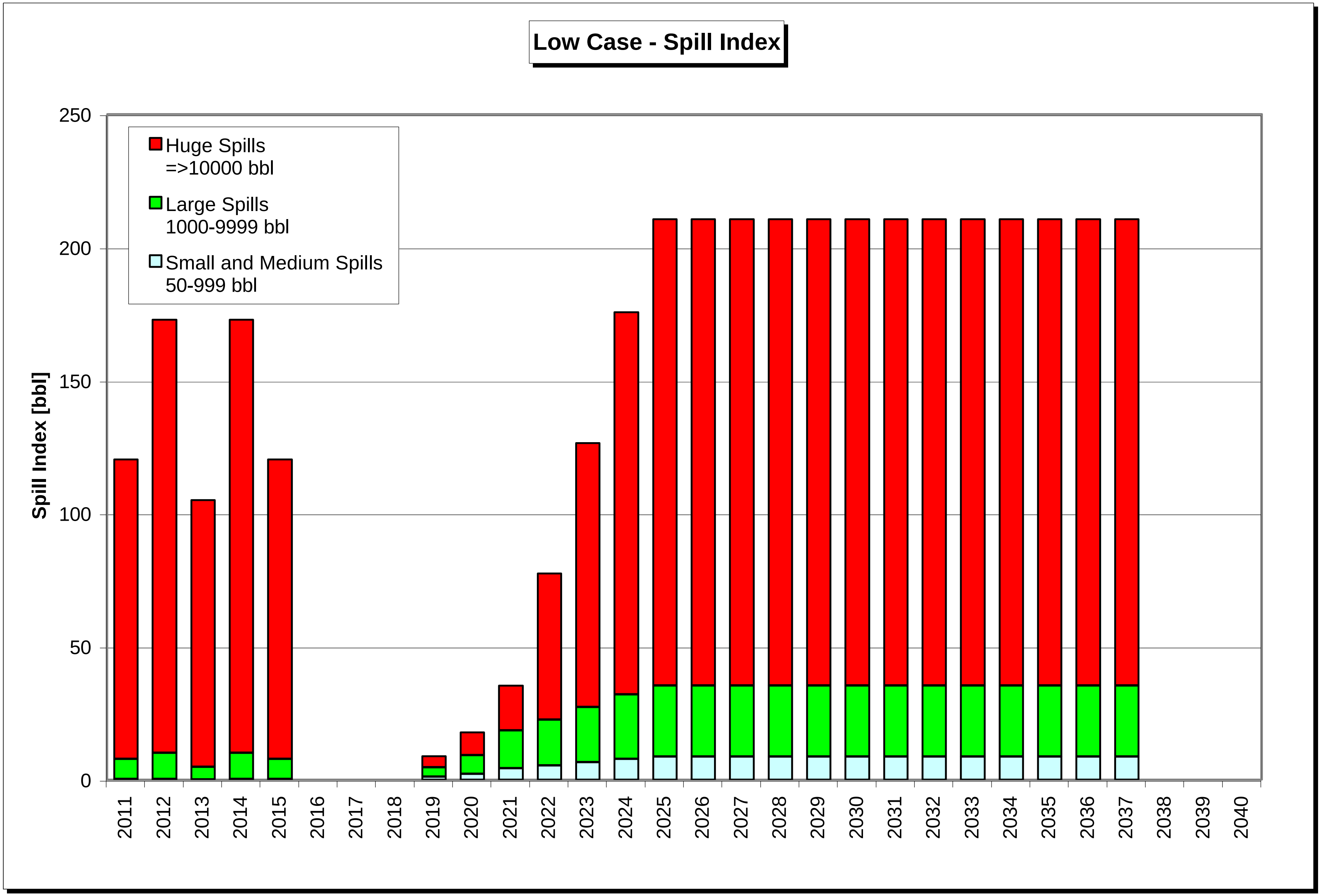
Spill Source	Spill Size									
	S+M 50-999 bbl		Large 1000-9999 bbl		Huge =>10000 bbl		Significant =>1000 bbl		All Spills	
	Low Case - LOF Average Spill Frequency per 10^3 years									
P/L	7.200	58%	1.807	69%	0.718	38%	2.526	56%	9.725	57%
Platforms	5.121	41%	0.290	11%	0.290	15%	0.580	13%	5.702	33%
Wells	0.178	1%	0.533	20%	0.890	47%	1.424	31%	1.601	9%
Platforms and Wells	5.299	42%	0.823	31%	1.180	62%	2.004	44%	7.303	43%
All	**12.499**	**100%**	**2.631**	**100%**	**1.899**	**100%**	**4.529**	**100%**	**17.028**	**100%**
	Low Case - LOF Average Spill Frequency per 10^9 bbl produced									
P/L	0.778	58%	0.195	69%	0.078	38%	0.273	56%	1.050	57%
Platforms	0.553	41%	0.031	11%	0.031	15%	0.063	13%	0.616	33%
Wells	0.019	1%	0.058	20%	0.096	47%	0.154	31%	0.173	9%
Platforms and Wells	0.572	42%	0.089	31%	0.127	62%	0.216	44%	0.789	43%
All	**1.350**	**100%**	**0.284**	**100%**	**0.205**	**100%**	**0.489**	**100%**	**1.839**	**100%**
	Low Case - LOF Average Spill Index [bbl]									
P/L	3	53%	9	53%	11	9%	21	15%	23	16%
Platforms	2	45%	2	9%	2	1%	3	2%	6	4%
Wells	0	2%	7	37%	108	89%	114	83%	114	80%
Platforms and Wells	2	47%	8	47%	109	91%	118	85%	120	84%
All	**5**	**100%**	**18**	**100%**	**121**	**100%**	**138**	**100%**	**143**	**100%**



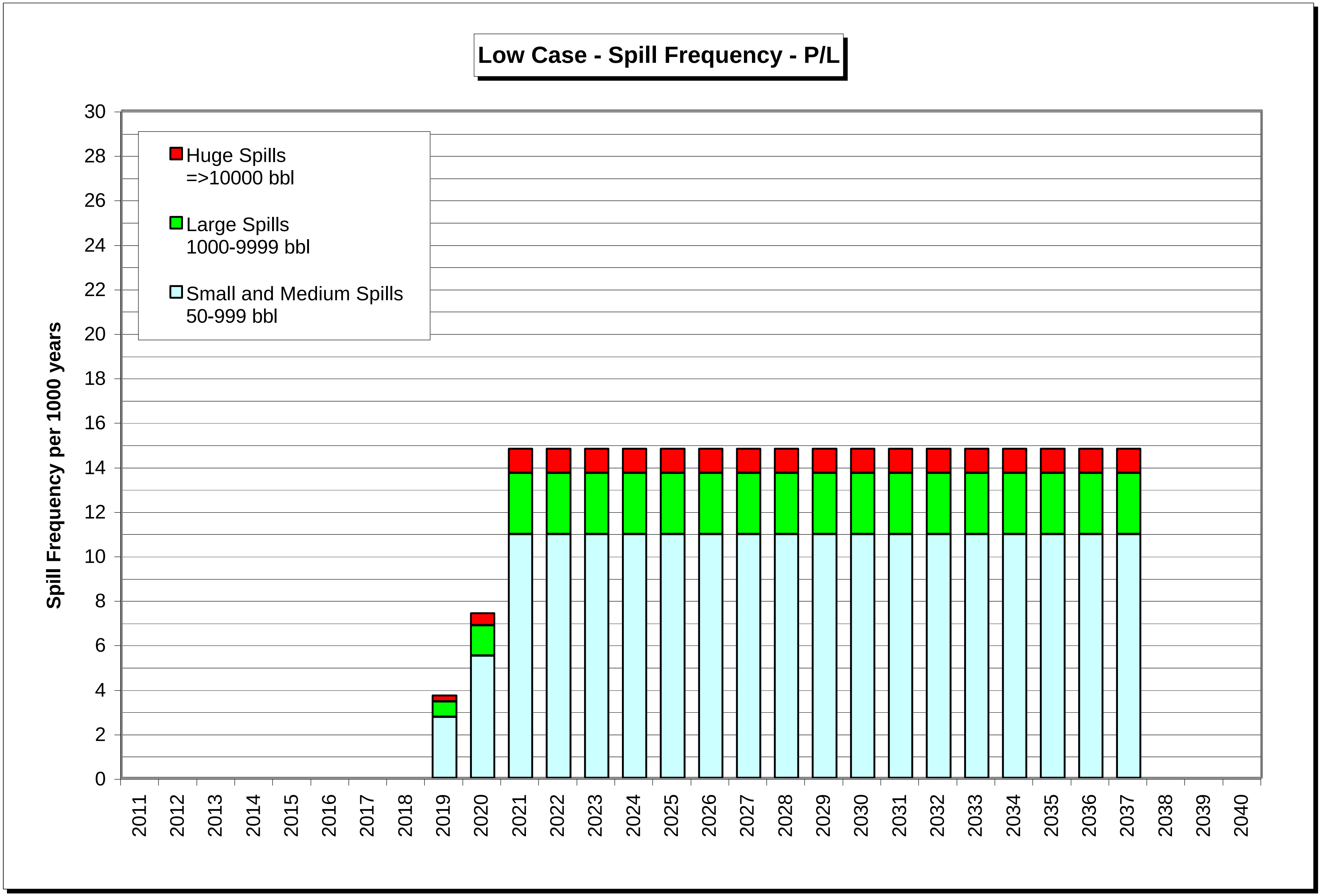
C4_1_LowCase_CS.xlsF4101



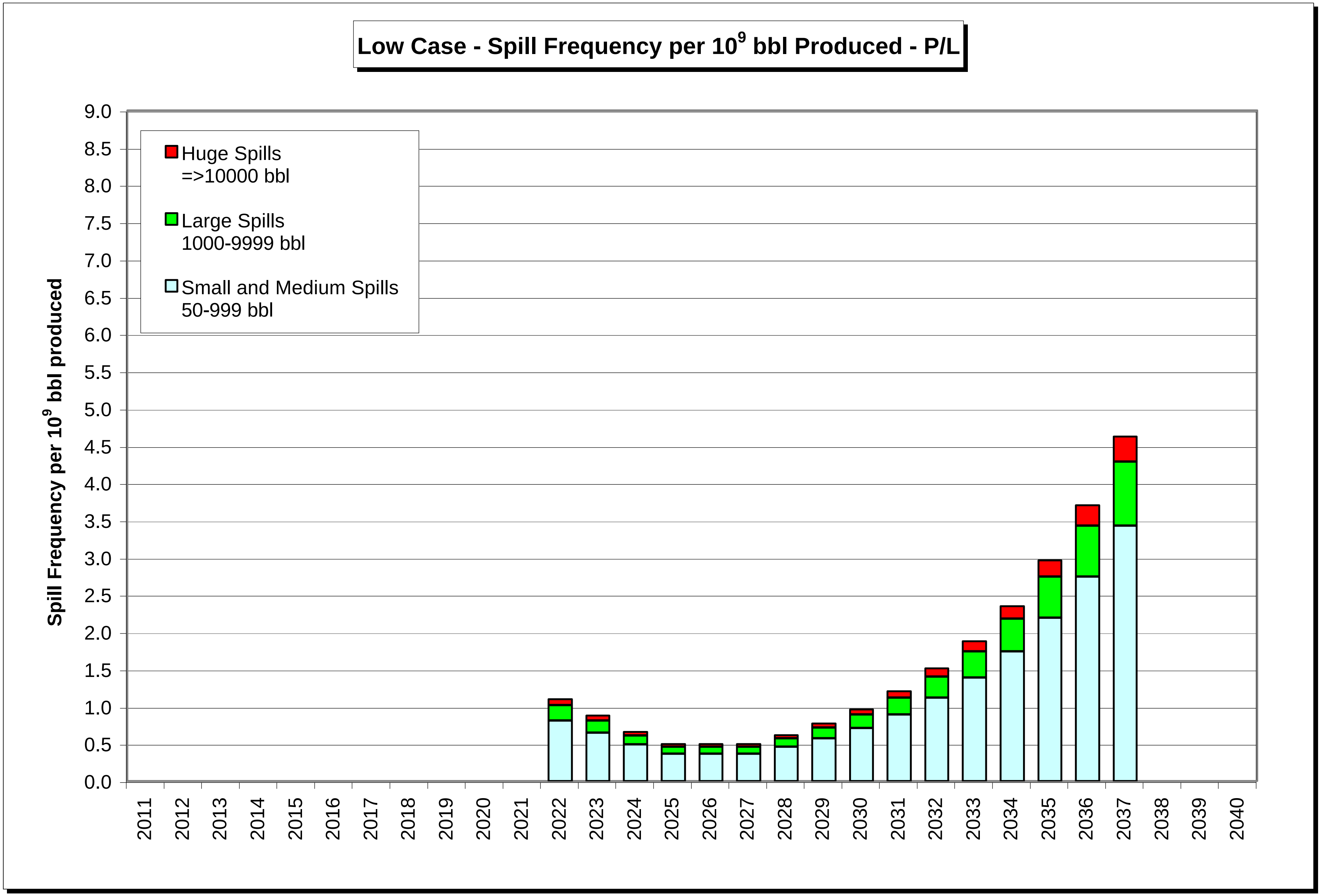
C4_1_LowCase_CS.xlsF4102



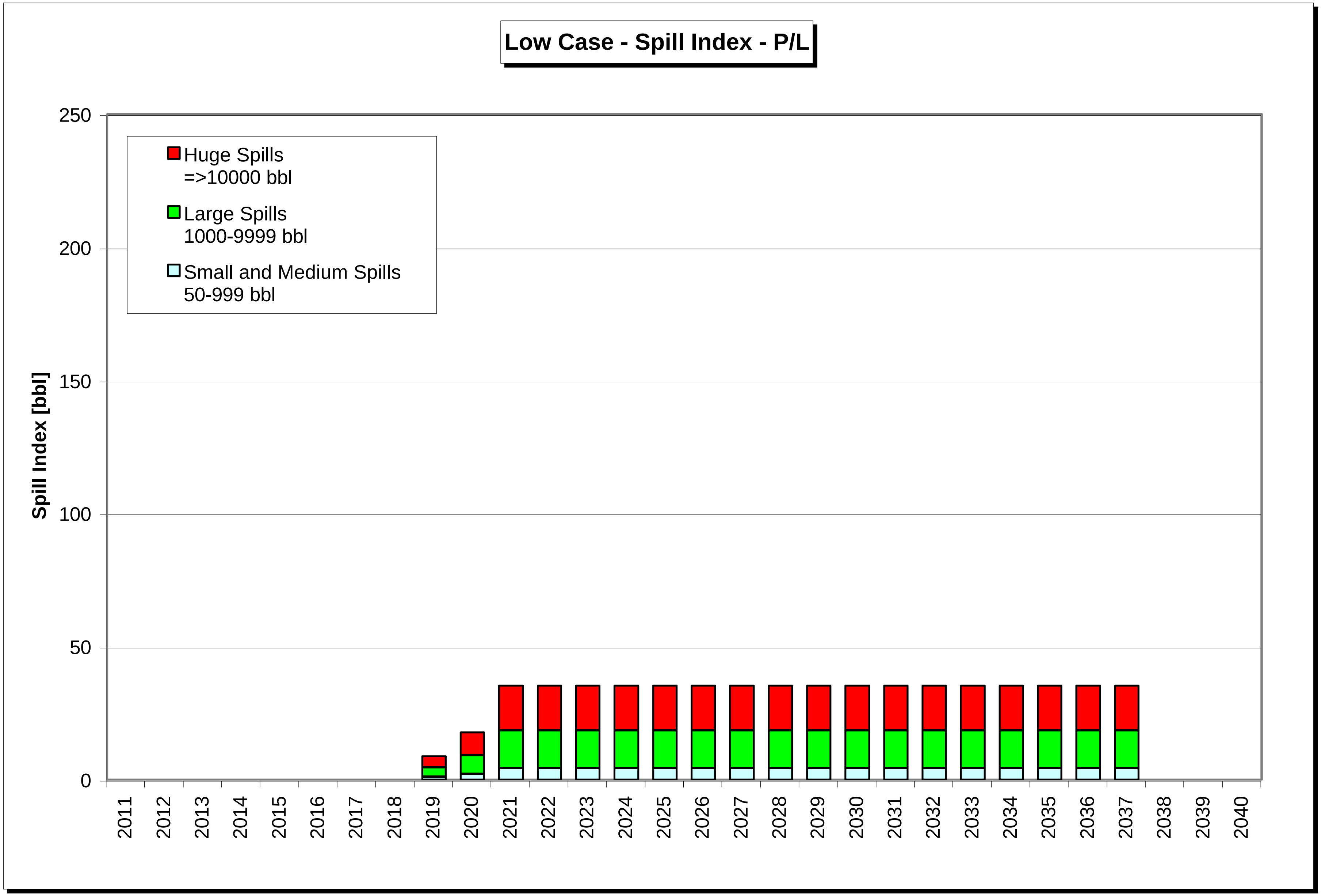
C4_1_LowCase_CS.xlsF4103



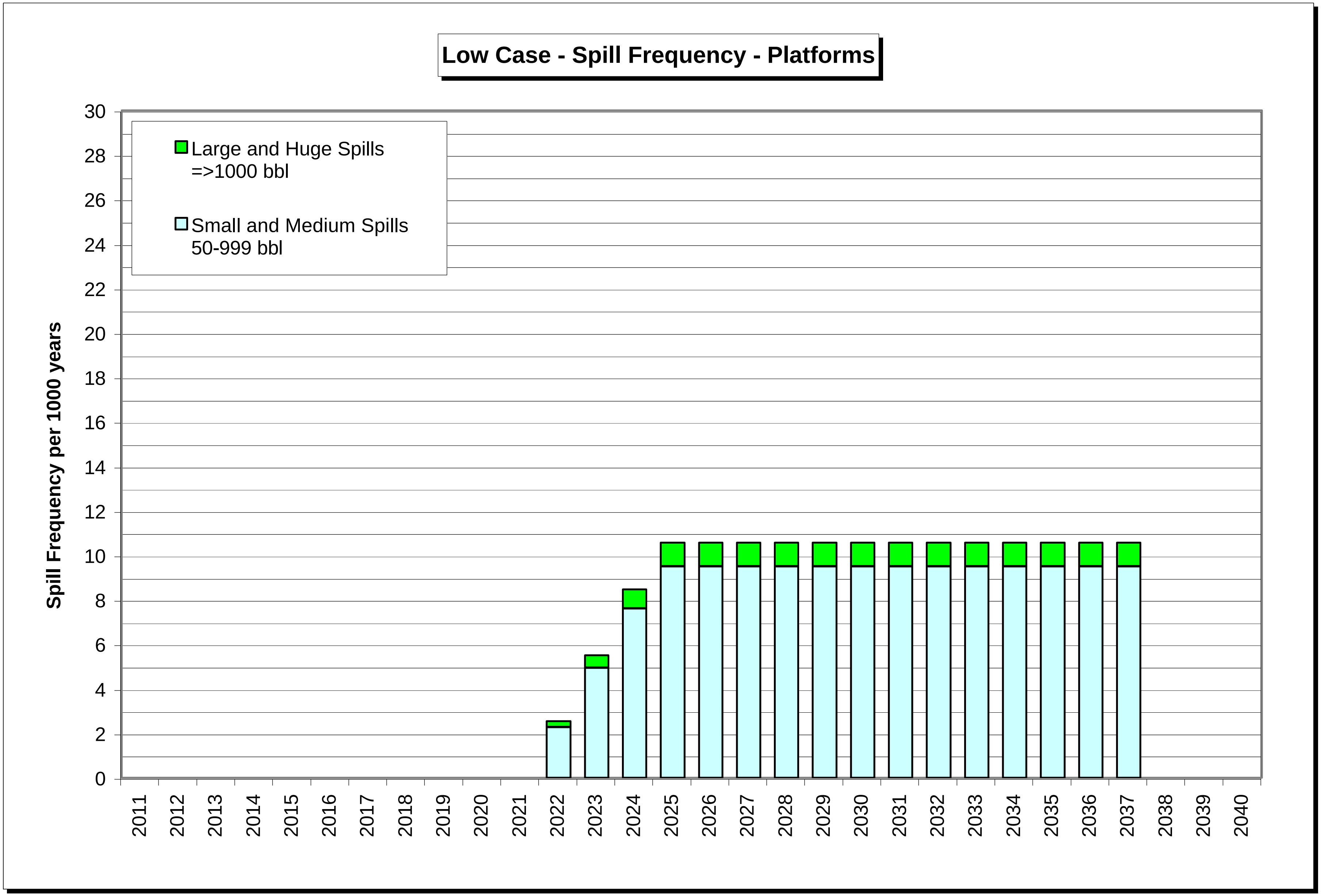
C4_1_LowCase_CS.xlsF4104



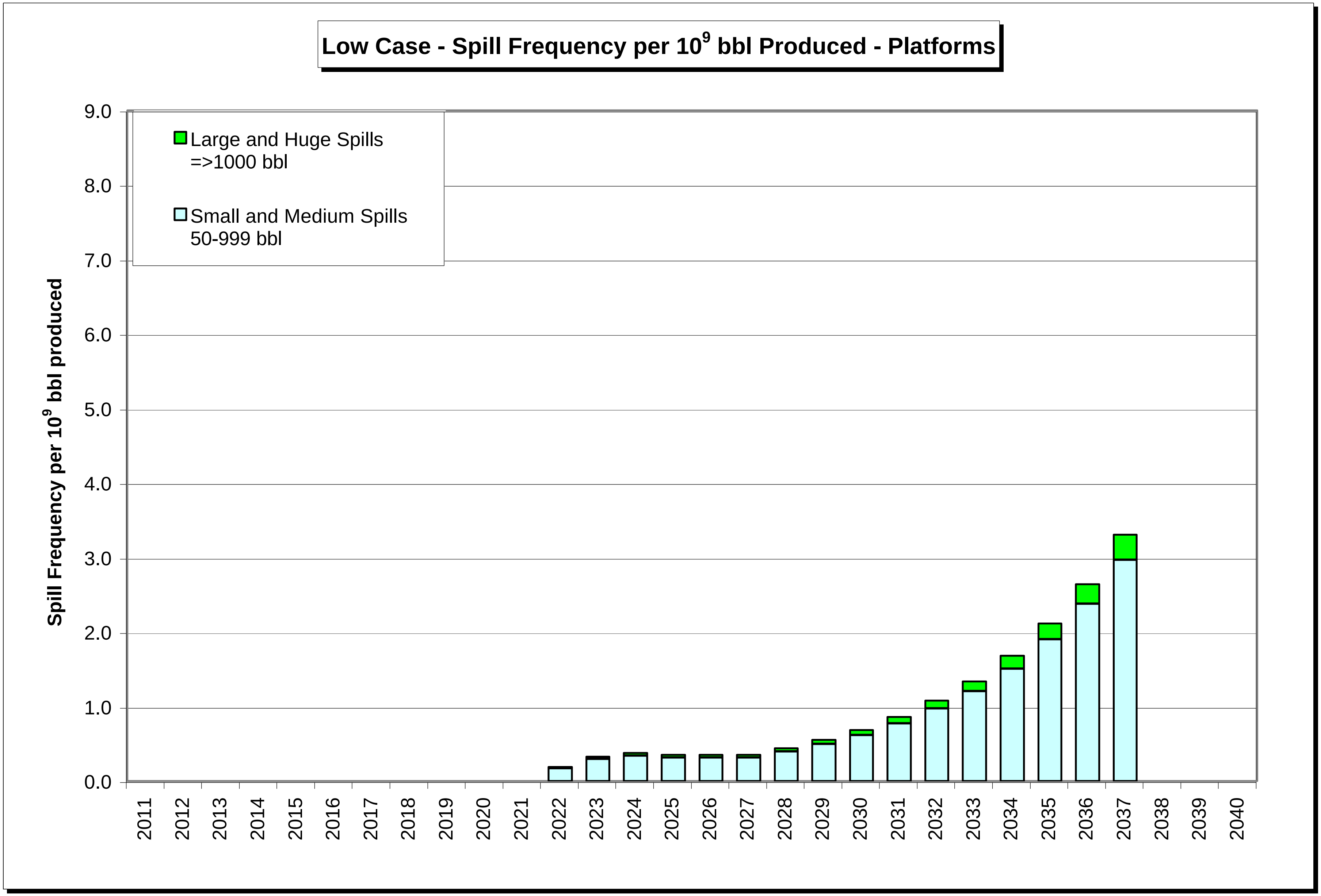
C4_1_LowCase_CS.xlsF4105



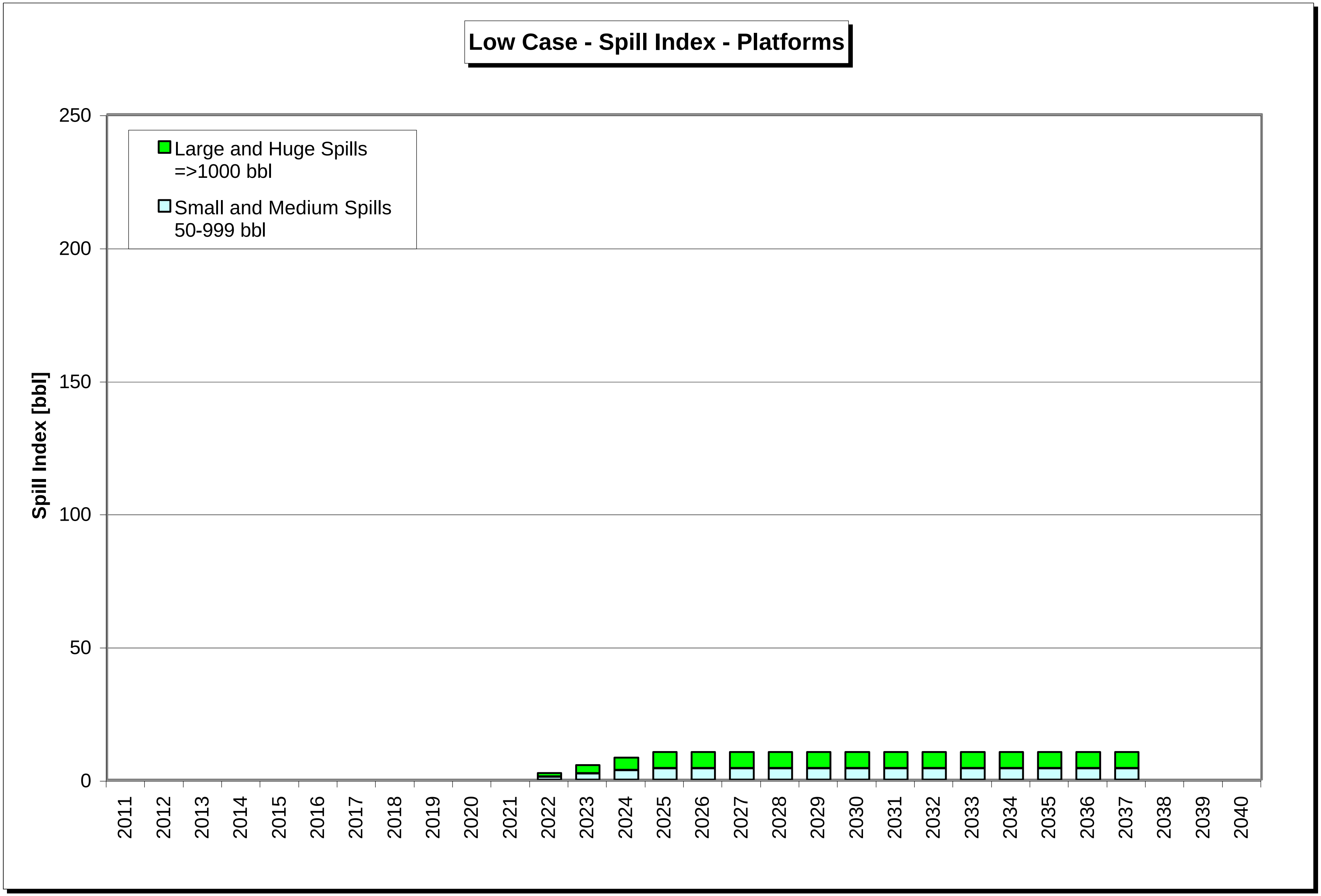
C4_1_LowCase_CS.xlsF4106



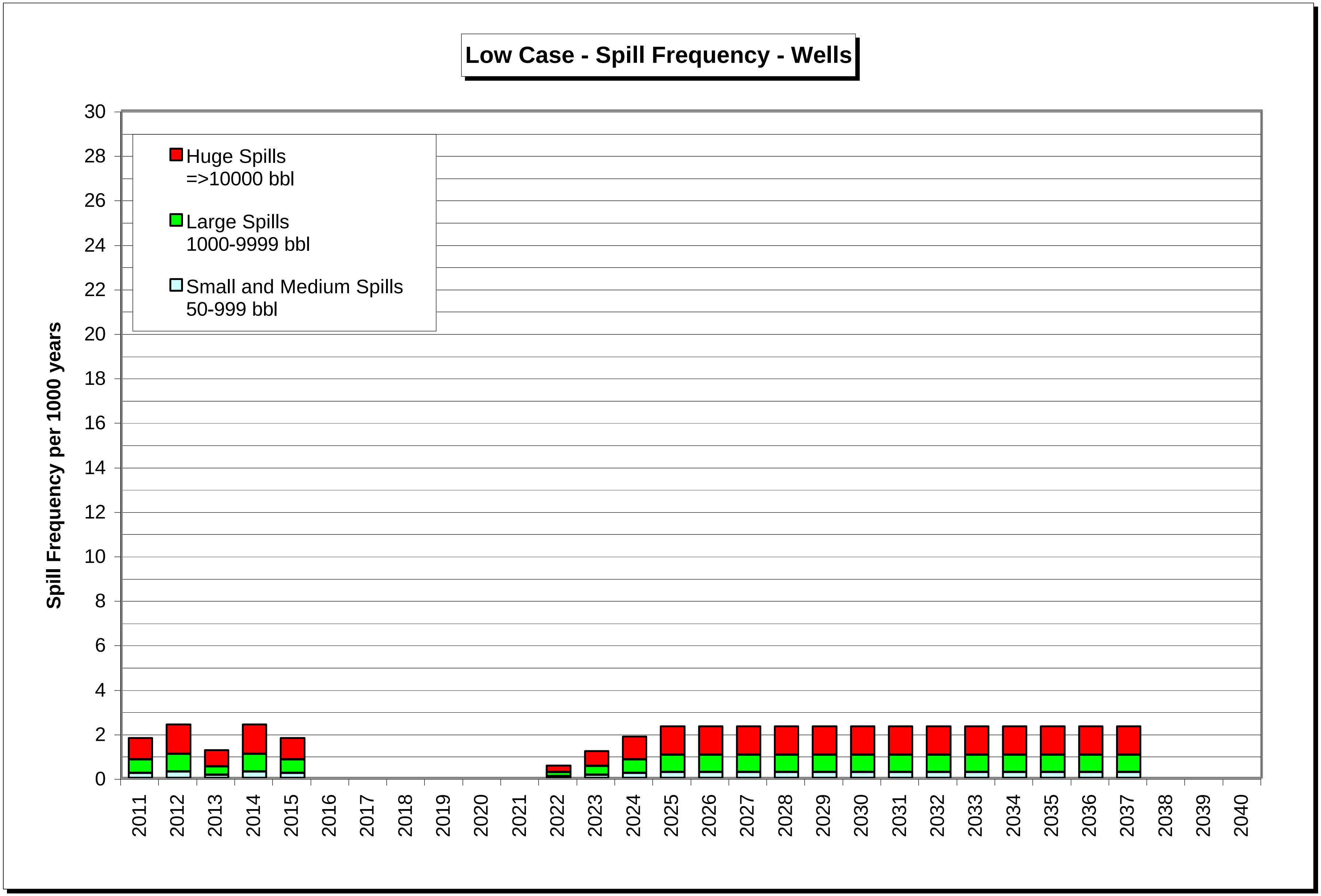
C4_1_LowCase_CS.xlsF4107



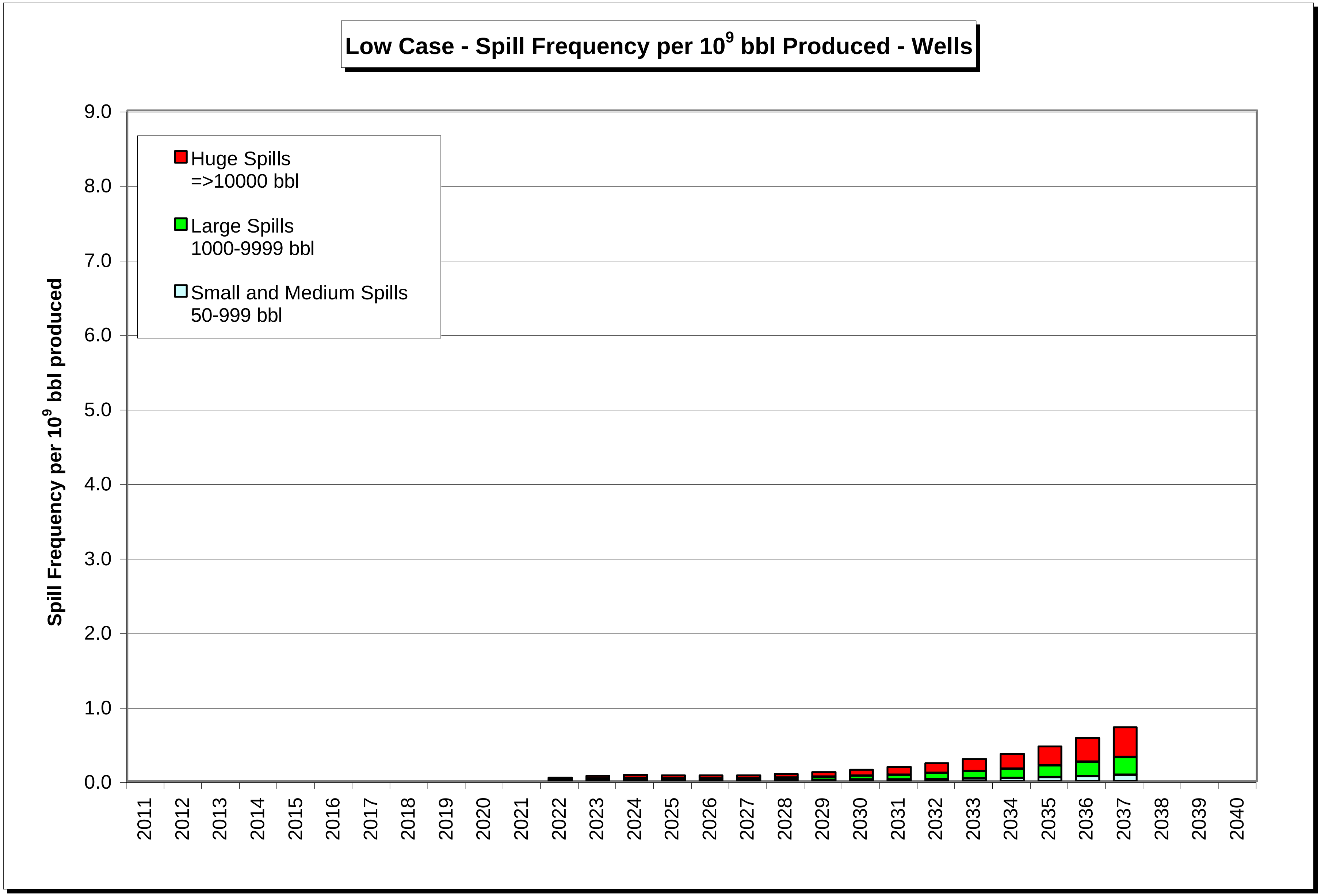
C4_1_LowCase_CS.xlsF4108



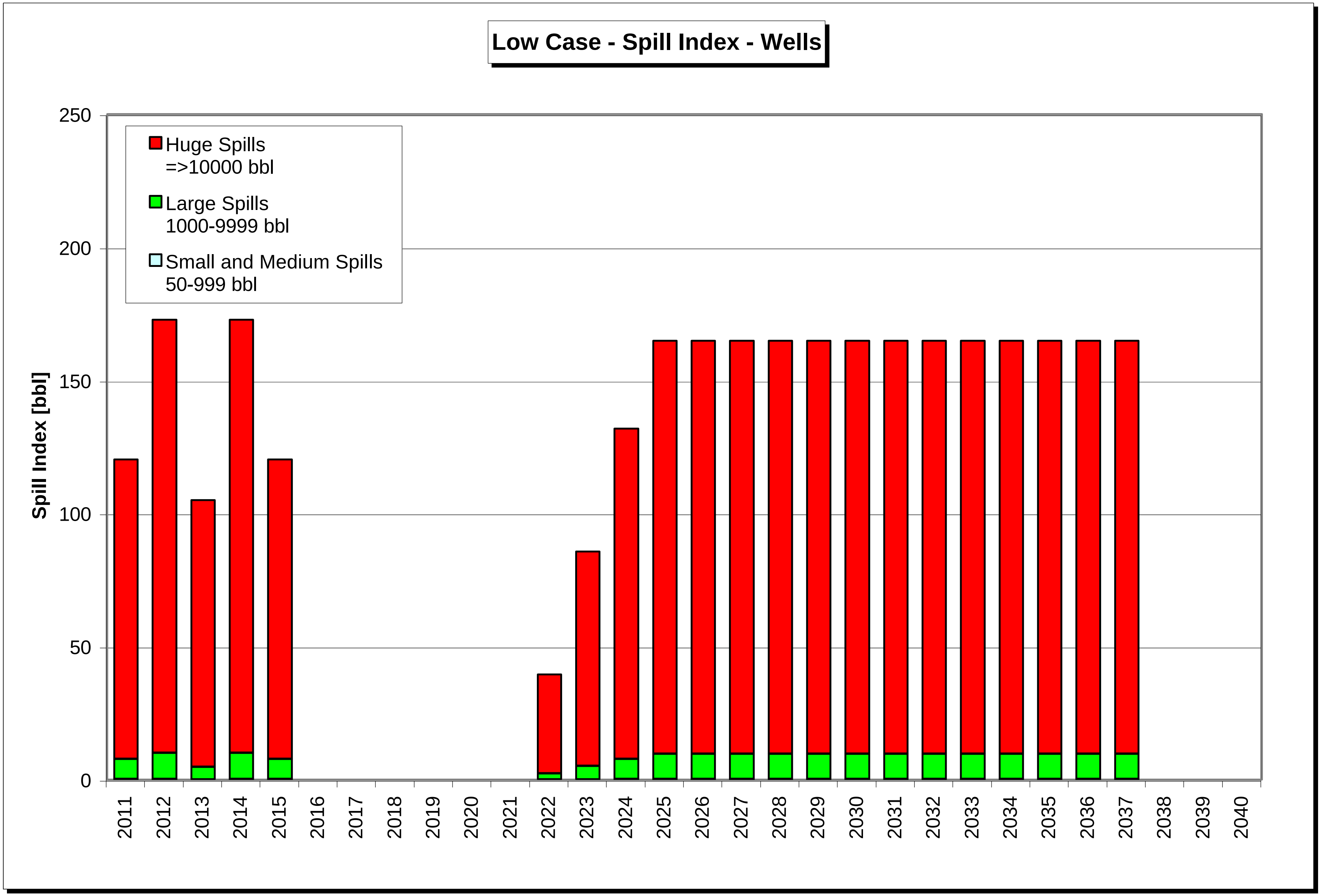
C4_1_LowCase_CS.xlsF4109



C4_1_LowCase_CS.xlsF4110

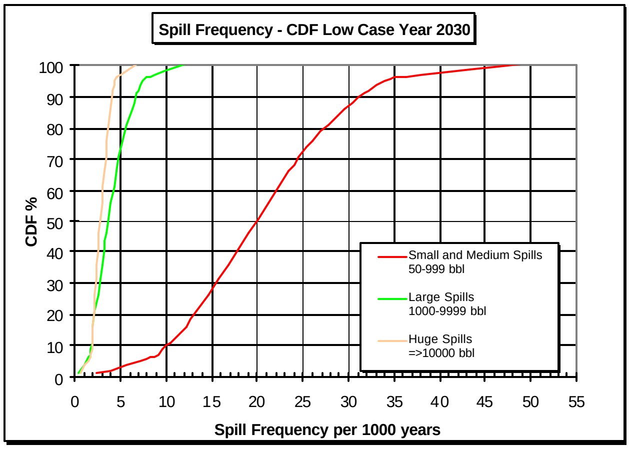


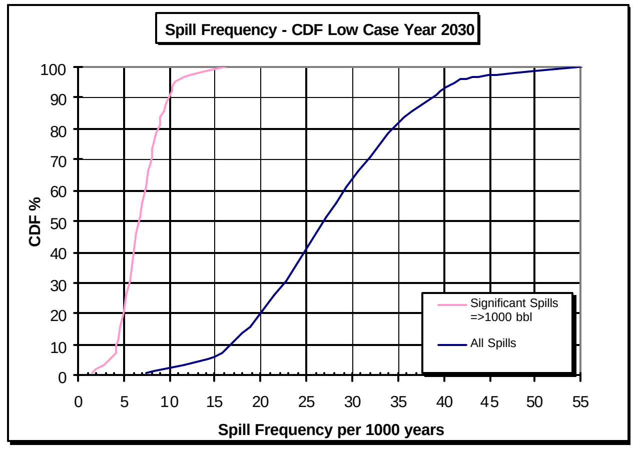
C4_1_LowCase_CS.xlsF4111

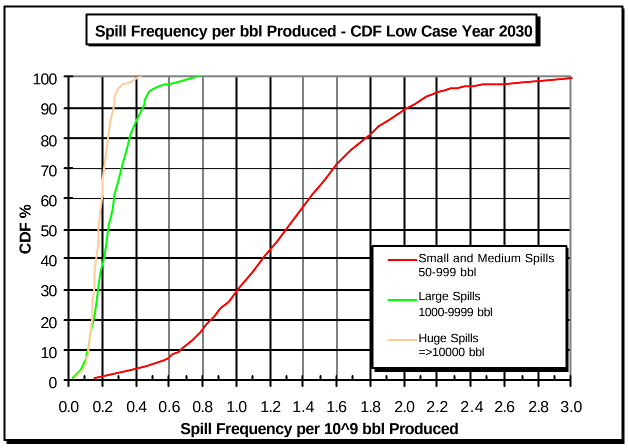


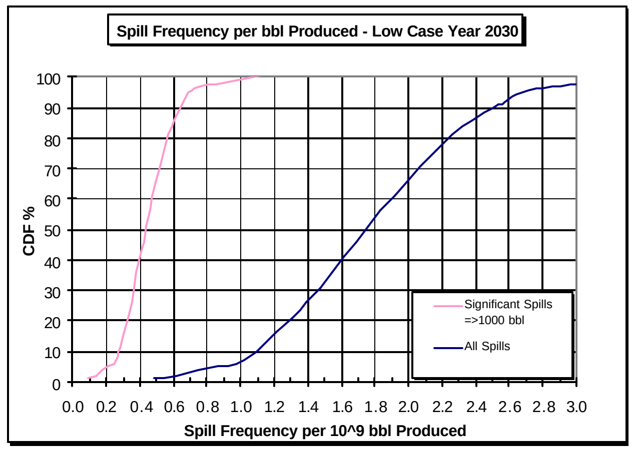
C4_1_LowCase_CS.xlsF4112

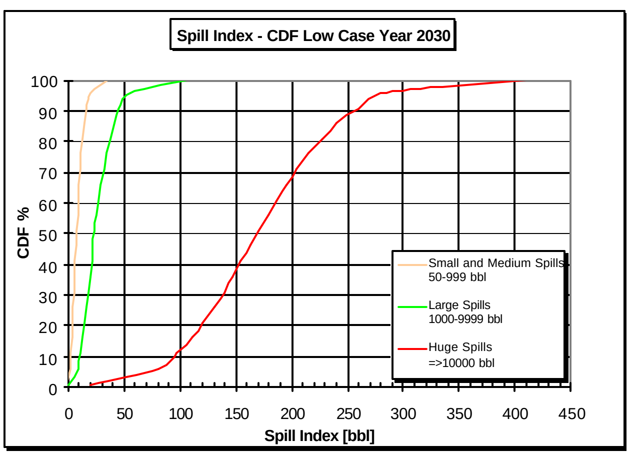
Figure 4.1.13 Spill Indicators – CDF – Year 2030











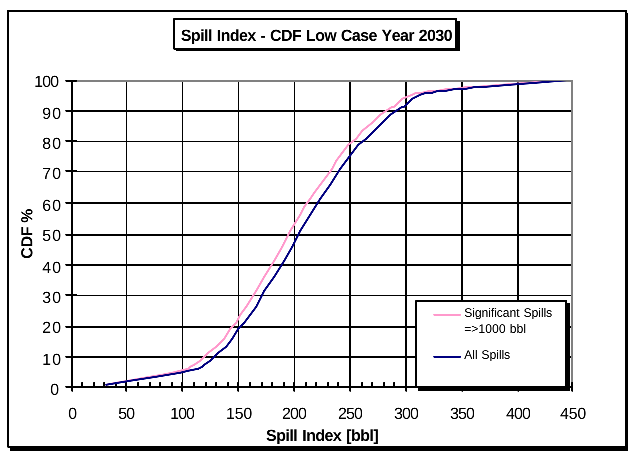


Figure 4.1.14 Spill Frequency – CDF – Low Case

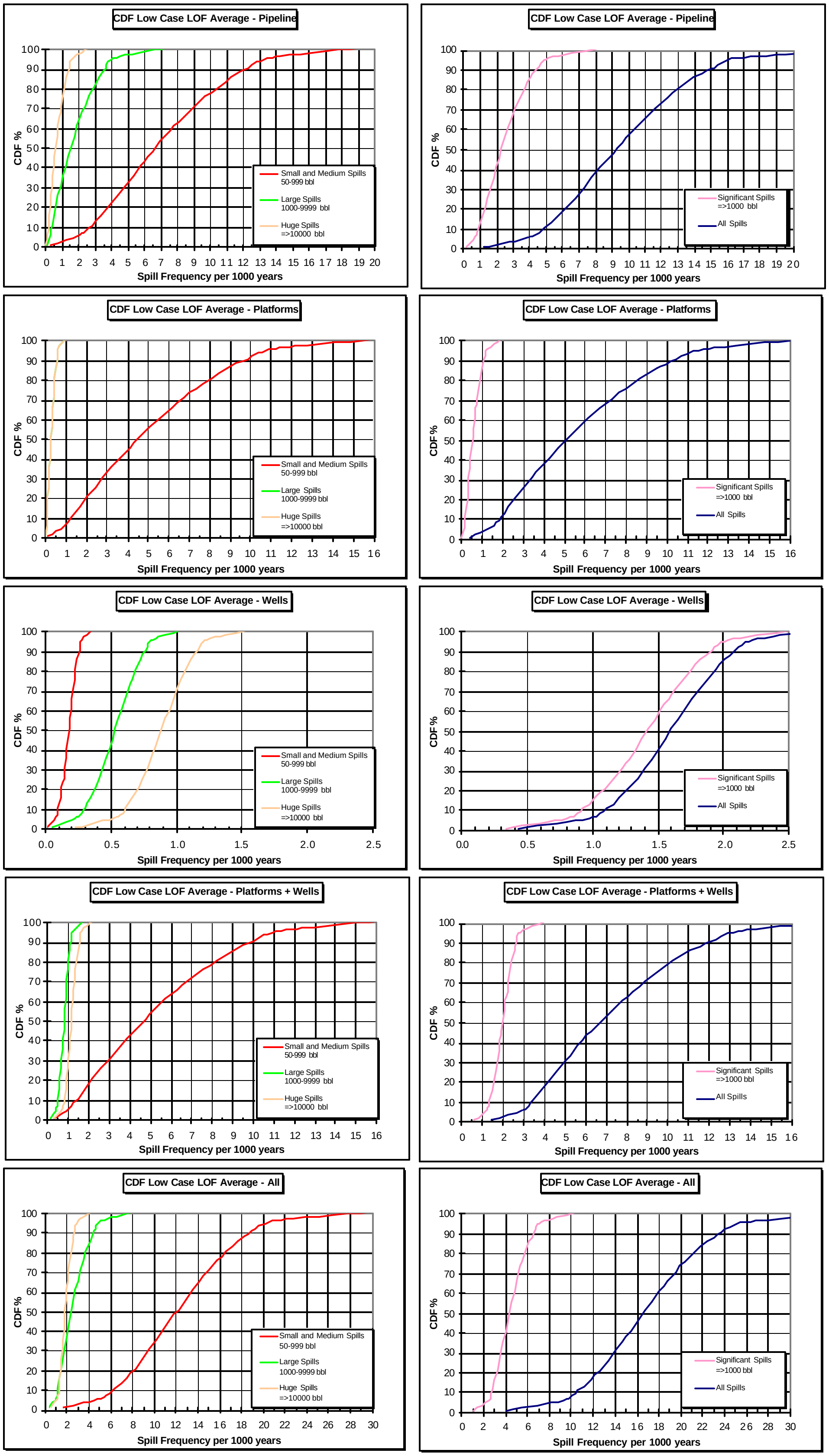


Figure 4.1.15 Spill Frequency per bbl produced– CDF – Low Case

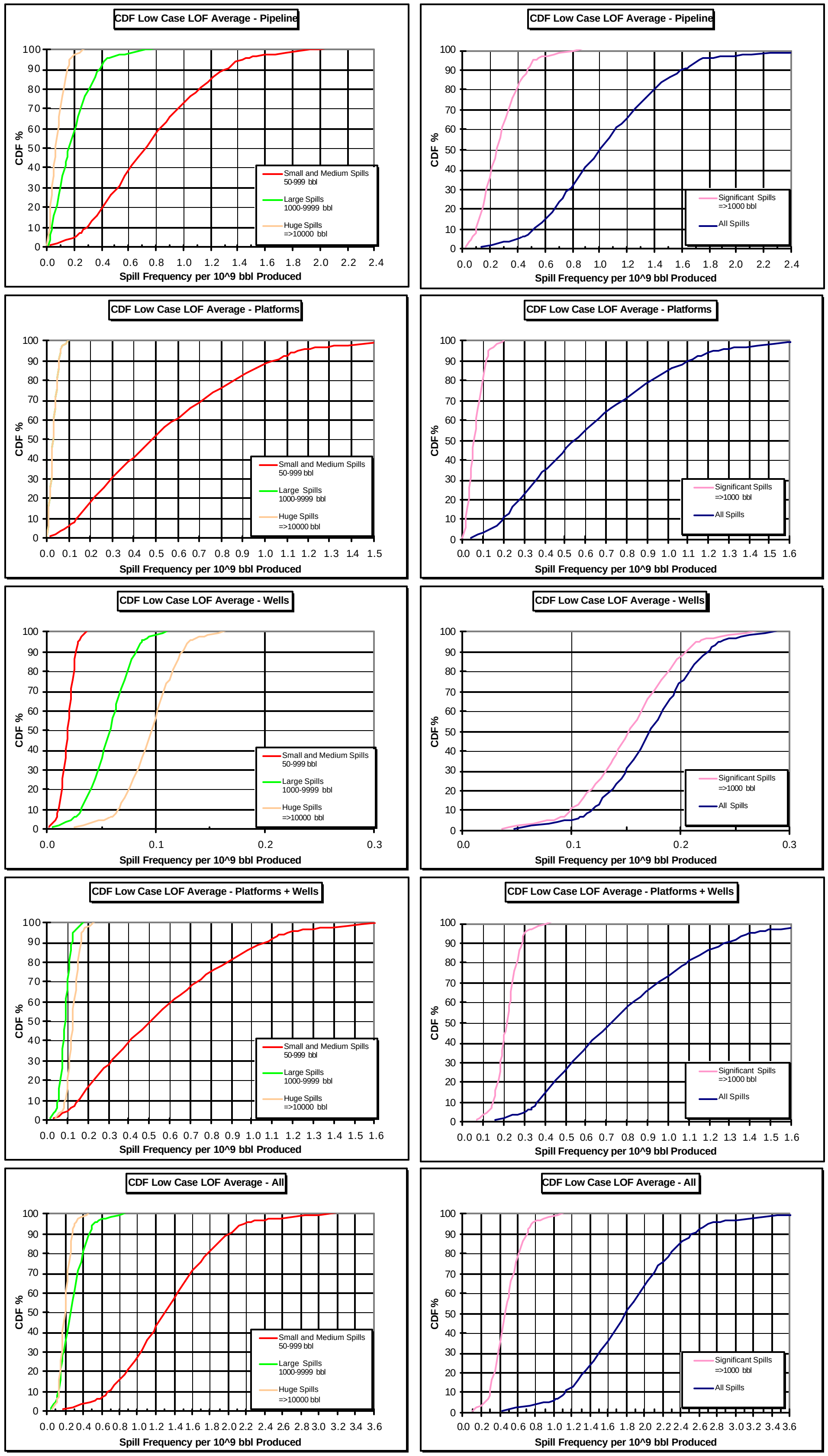


Figure 4.1.16 Spill Index [bbl] – CDF – Low Case

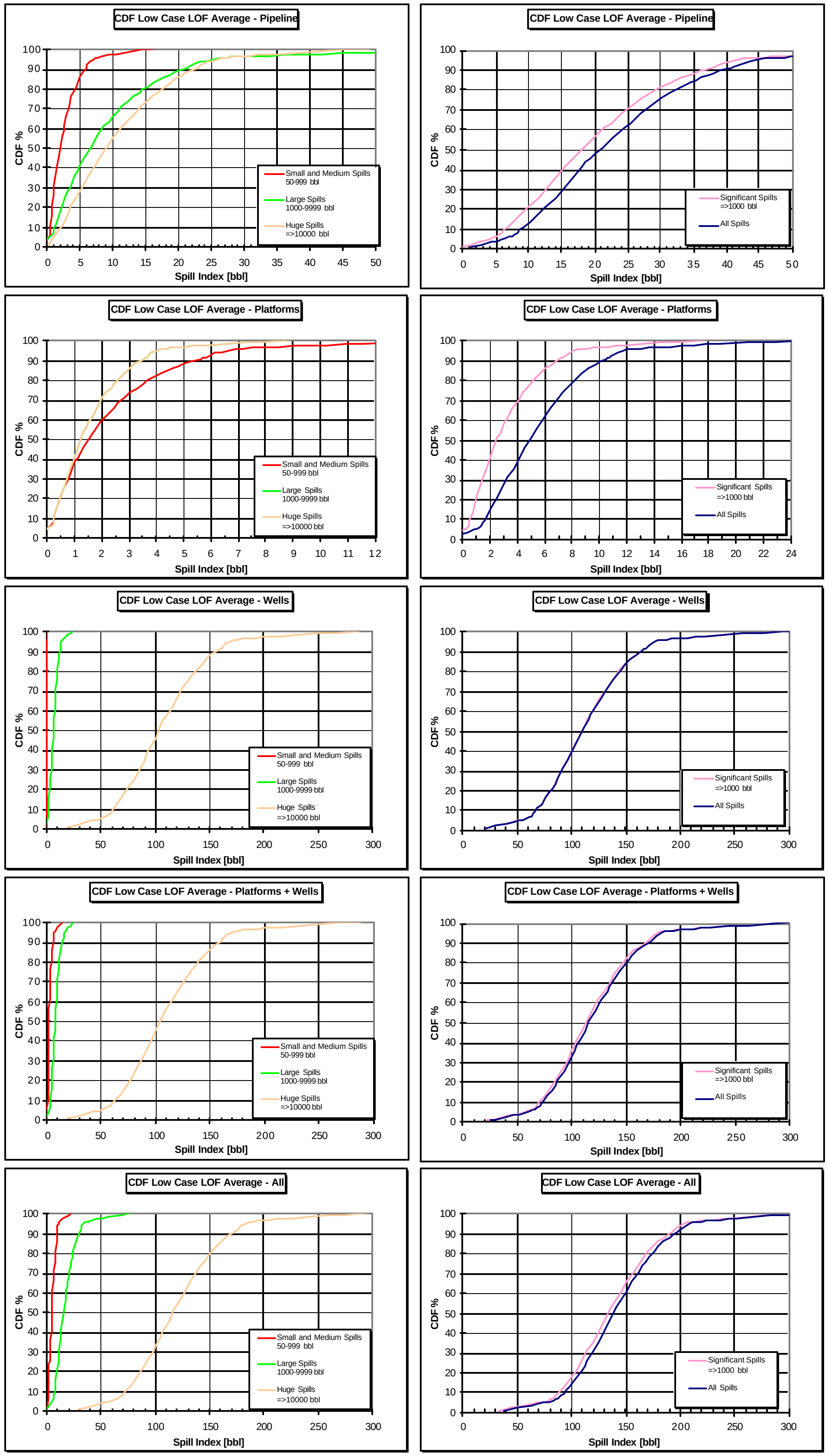


Figure 4.1.17
Low Case - Year 2030 - Spill Indicators

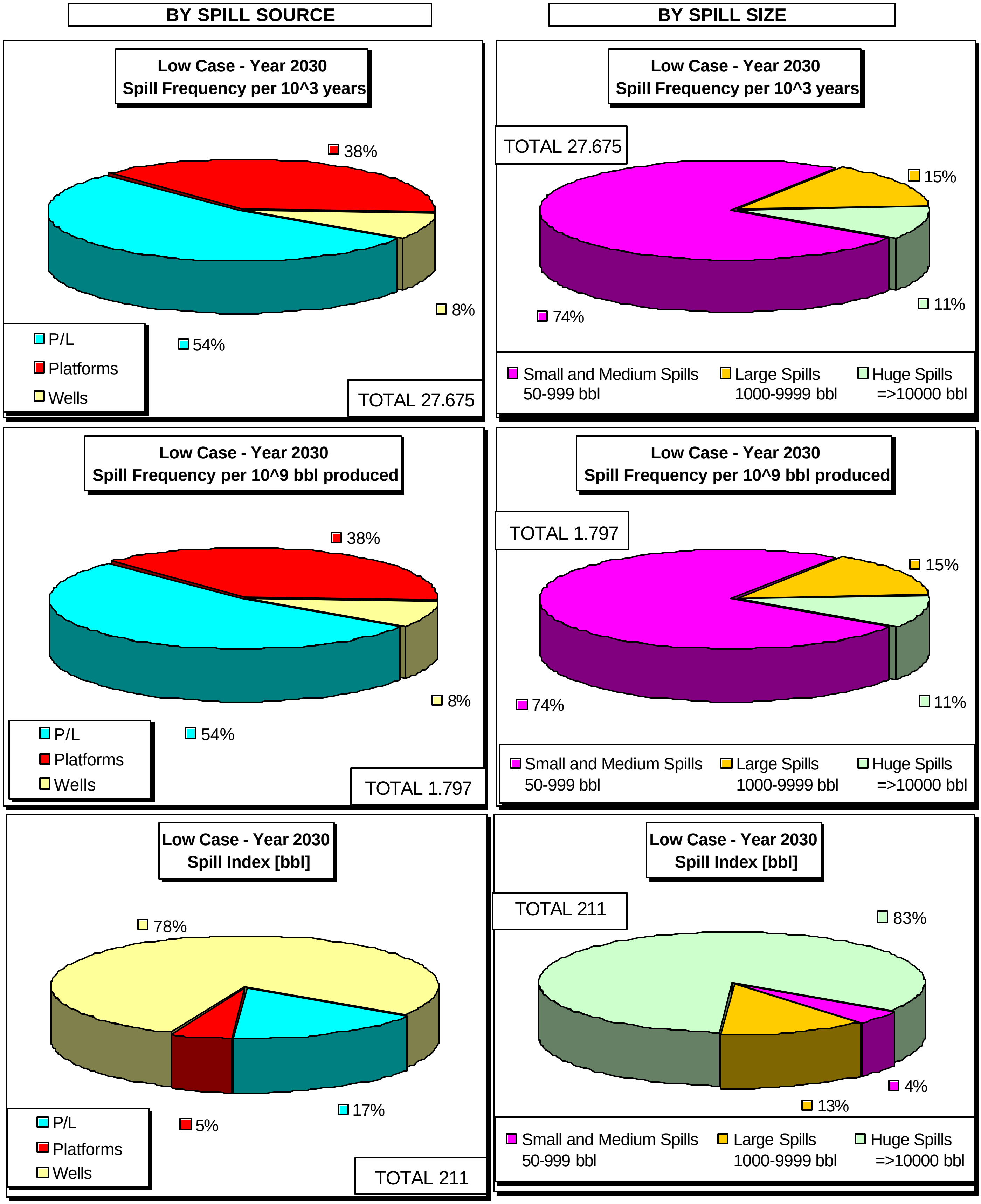
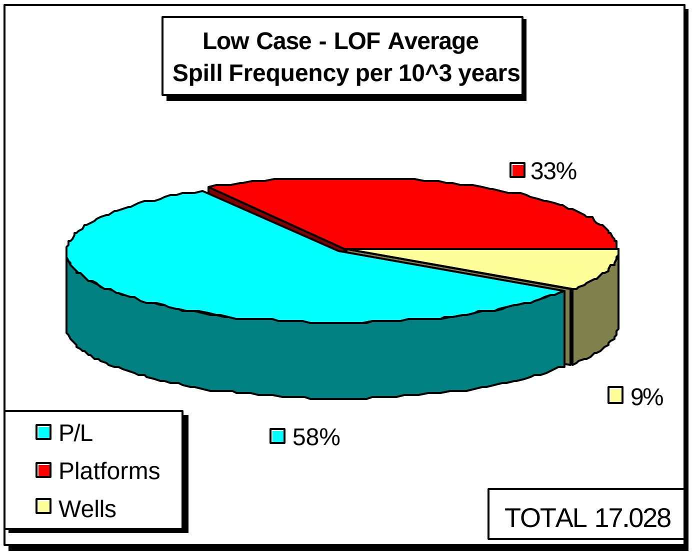
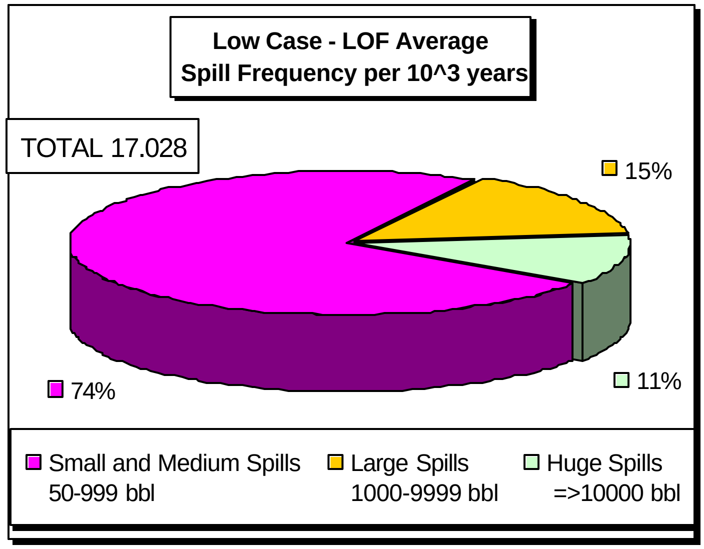
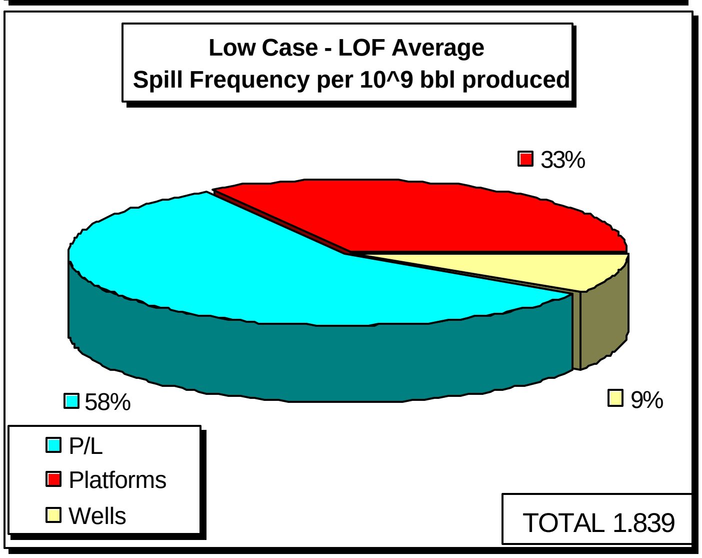


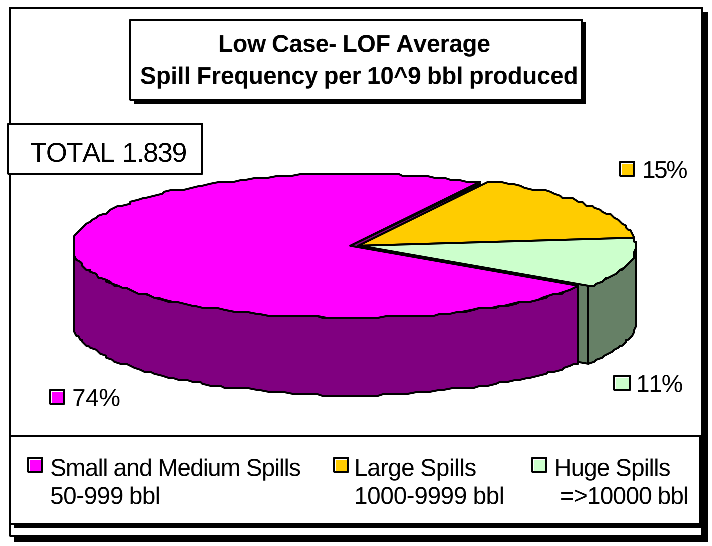
Figure 4.1.18
Low Case – LOF Average Spill Indicators

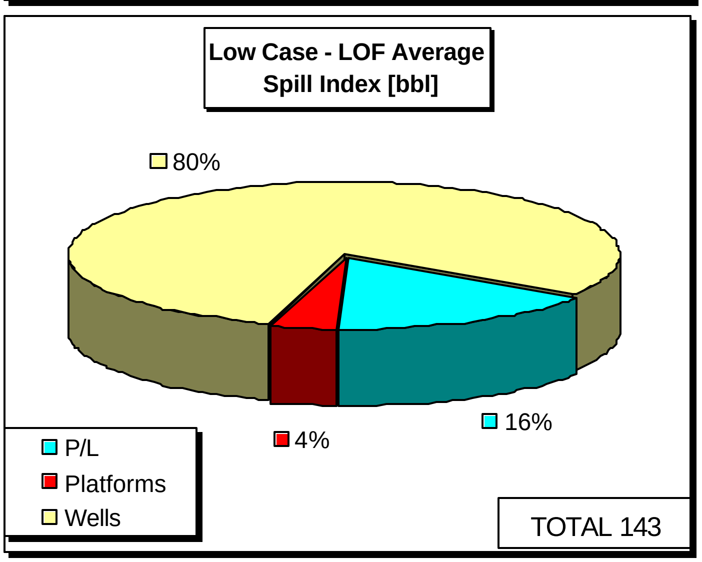
BY SPILL SOURCE	BY SPILL SIZE











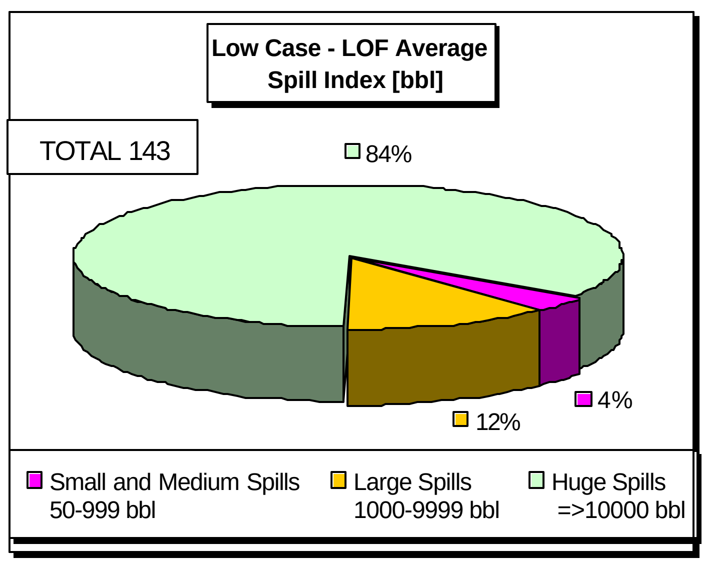


Table 4.2.1
Arctic Spill Occurrence Chikchi Sea High Case P/L Spills

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
2011	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396				5.244			11.773			4.271			1.698		
	Total																										
2012	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396				5.244			11.773			4.271			1.698		
	Total																										
2013	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396				5.244			11.773			4.271			1.698		
	Total																										
2014	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396				5.244			11.773			4.271			1.698		
	Total																										
2015	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396				5.244			11.773			4.271			1.698		
	Total																										
2016	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396				5.244			11.773			4.271			1.698		
	Total																										
2017	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396				5.244			11.773			4.271			1.698		
	Total																										
2018	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396				5.244			11.773			4.271			1.698		
	Total																										
2019	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396			10	5.244	0.844	0.06	11.773	1.894	0.98	4.271	0.687	3.56	1.698	0.273	4.25
	Total														**10**		**0.844**	**0.06**		**1.894**	**0.98**		**0.687**	**3.56**		**0.273**	**4.25**
2020	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396			20	5.244	1.688	0.12	11.773	3.788	1.95	4.271	1.374	7.11	1.698	0.546	8.50
	Total														**20**		**1.688**	**0.12**		**3.788**	**1.95**		**1.374**	**7.11**		**0.546**	**8.50**
2021	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396			40	5.244	3.375	0.24	11.773	7.577	3.91	4.271	2.749	14.23	1.698	1.093	16.99
	Total														**40**		**3.375**	**0.24**		**7.577**	**3.91**		**2.749**	**14.23**		**1.093**	**16.99**
2022	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396			50	5.244	4.219	0.30	11.773	9.471	4.89	4.271	3.436	17.78	1.698	1.366	21.24
	Total														**50**		**4.219**	**0.30**		**9.471**	**4.89**		**3.436**	**17.78**		**1.366**	**21.24**
2023	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396			60	5.244	5.063	0.36	11.773	11.365	5.86	4.271	4.123	21.34	1.698	1.639	25.49
	Total														**60**		**5.063**	**0.36**		**11.365**	**5.86**		**4.123**	**21.34**		**1.639**	**25.49**
2024	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396			80	5.244	6.750	0.48	11.773	15.154	7.82	4.271	5.498	28.46	1.698	2.185	33.99
	Total														**80**		**6.750**	**0.48**		**15.154**	**7.82**		**5.498**	**28.46**		**2.185**	**33.99**
2025	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396			80	5.244	6.750	0.48	11.773	15.154	7.82	4.271	5.498	28.46	1.698	2.185	33.99
	Total														**80**		**6.750**	**0.48**		**15.154**	**7.82**		**5.498**	**28.46**		**2.185**	**33.99**
2026	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396			80	5.244	6.750	0.48	11.773	15.154	7.82	4.271	5.498	28.46	1.698	2.185	33.99
	Total														**80**		**6.750**	**0.48**		**15.154**	**7.82**		**5.498**	**28.46**		**2.185**	**33.99**
2027	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396			80	5.244	6.750	0.48	11.773	15.154	7.82	4.271	5.498	28.46	1.698	2.185	33.99
	Total														**80**		**6.750**	**0.48**		**15.154**	**7.82**		**5.498**	**28.46**		**2.185**	**33.99**
2028	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396			80	5.244	6.750	0.48	11.773	15.154	7.82	4.271	5.498	28.46	1.698	2.185	33.99
	Total														**80**		**6.750**	**0.48**		**15.154**	**7.82**		**5.498**	**28.46**		**2.185**	**33.99**
2029	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396			80	5.244	6.750	0.48	11.773	15.154	7.82	4.271	5.498	28.46	1.698	2.185	33.99
	Total														**80**		**6.750**	**0.48**		**15.154**	**7.82**		**5.498**	**28.46**		**2.185**	**33.99**
2030	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396			80	5.244	6.750	0.48	11.773	15.154	7.82	4.271	5.498	28.46	1.698	2.185	33.99

Table 4.2.1
Arctic Spill Occurrence Chikchi 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														**80**		**6.750**	**0.48**		**15.154**	**7.82**		**5.498**	**28.46**		**2.185**	**33.99**
	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
2031	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396			80	5.244	6.750	0.48	11.773	15.154	7.82	4.271	5.498	28.46	1.698	2.185	33.99
	Total														**80**		**6.750**	**0.48**		**15.154**	**7.82**		**5.498**	**28.46**		**2.185**	**33.99**
	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
2032	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396			80	5.244	6.750	0.48	11.773	15.154	7.82	4.271	5.498	28.46	1.698	2.185	33.99
	Total														**80**		**6.750**	**0.48**		**15.154**	**7.82**		**5.498**	**28.46**		**2.185**	**33.99**
	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
2033	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396			80	5.244	6.750	0.48	11.773	15.154	7.82	4.271	5.498	28.46	1.698	2.185	33.99
	Total														**80**		**6.750**	**0.48**		**15.154**	**7.82**		**5.498**	**28.46**		**2.185**	**33.99**
	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
2034	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396			80	5.244	6.750	0.48	11.773	15.154	7.82	4.271	5.498	28.46	1.698	2.185	33.99
	Total														**80**		**6.750**	**0.48**		**15.154**	**7.82**		**5.498**	**28.46**		**2.185**	**33.99**
	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
2035	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396			80	5.244	6.750	0.48	11.773	15.154	7.82	4.271	5.498	28.46	1.698	2.185	33.99
	Total														**80**		**6.750**	**0.48**		**15.154**	**7.82**		**5.498**	**28.46**		**2.185**	**33.99**
	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
2036	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396			80	5.244	6.750	0.48	11.773	15.154	7.82	4.271	5.498	28.46	1.698	2.185	33.99
	Total														**80**		**6.750**	**0.48**		**15.154**	**7.82**		**5.498**	**28.46**		**2.185**	**33.99**
	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
2037	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396			80	5.244	6.750	0.48	11.773	15.154	7.82	4.271	5.498	28.46	1.698	2.185	33.99
	Total														**80**		**6.750**	**0.48**		**15.154**	**7.82**		**5.498**	**28.46**		**2.185**	**33.99**
	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
2038	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396			40	5.244	3.375	0.24	11.773	7.577	3.91	4.271	2.749	14.23	1.698	1.093	16.99
	Total														**40**		**3.375**	**0.24**		**7.577**	**3.91**		**2.749**	**14.23**		**1.093**	**16.99**
	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
2039	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396			40	5.244	3.375	0.24	11.773	7.577	3.91	4.271	2.749	14.23	1.698	1.093	16.99
	Total														**40**		**3.375**	**0.24**		**7.577**	**3.91**		**2.749**	**14.23**		**1.093**	**16.99**
	Shallow		5.461			9.042			4.455			0.735				5.913			12.445			5.998			2.055		
2040	Medium		5.540			9.121			4.625			0.770				5.992			12.525			6.155			2.079		
	Deep		4.792			8.371			2.750			0.396			40	5.244	3.375	0.24	11.773	7.577	3.91	4.271	2.749	14.23	1.698	1.093	16.99
	Total														**40**		**3.375**	**0.24**		**7.577**	**3.91**		**2.749**	**14.23**		**1.093**	**16.99**

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]
2011																						
2012																						
2013																						
2014																						
2015																						
2016																						
2017																						
2018																						
2019		0.844		0.060	1.894		0.977	2.738		1.037	0.687		3.557	0.273		4.249	0.960		7.805	3.698		8.843
2020		1.688		0.120	3.788		1.955	5.476		2.075	1.374		7.114	0.546		8.497	1.921		15.611	7.397		17.686
2021		3.375		0.240	7.577		3.909	10.952		4.150	2.749		14.228	1.093		16.994	3.842		31.222	14.794		35.371
2022	**13.5**	4.219	0.313	0.300	9.471	0.702	4.887	13.690	1.014	5.187	3.436	0.255	17.785	1.366	0.101	21.243	4.802	0.356	39.027	18.492	1.370	44.214
2023	**16.9**	5.063	0.300	0.360	11.365	0.673	5.864	16.428	0.972	6.224	4.123	0.244	21.342	1.639	0.097	25.491	5.763	0.341	46.833	22.190	1.313	53.057
2024	**22.5**	6.750	0.300	0.480	15.154	0.673	7.819	21.904	0.974	8.299	5.498	0.244	28.456	2.185	0.097	33.988	7.683	0.341	62.444	29.587	1.315	70.743
2025	**43.5**	6.750	0.155	0.480	15.154	0.348	7.819	21.904	0.504	8.299	5.498	0.126	28.456	2.185	0.050	33.988	7.683	0.177	62.444	29.587	0.680	70.743
2026	**46.9**	6.750	0.144	0.480	15.154	0.323	7.819	21.904	0.467	8.299	5.498	0.117	28.456	2.185	0.047	33.988	7.683	0.164	62.444	29.587	0.631	70.743
2027	**52.5**	6.750	0.129	0.480	15.154	0.289	7.819	21.904	0.417	8.299	5.498	0.105	28.456	2.185	0.042	33.988	7.683	0.146	62.444	29.587	0.564	70.743
2028	**54.0**	6.750	0.125	0.480	15.154	0.281	7.819	21.904	0.406	8.299	5.498	0.102	28.456	2.185	0.040	33.988	7.683	0.142	62.444	29.587	0.548	70.743
2029	**49.2**	6.750	0.137	0.480	15.154	0.308	7.819	21.904	0.445	8.299	5.498	0.112	28.456	2.185	0.044	33.988	7.683	0.156	62.444	29.587	0.601	70.743
2030	**45.4**	6.750	0.149	0.480	15.154	0.334	7.819	21.904	0.482	8.299	5.498	0.121	28.456	2.185	0.048	33.988	7.683	0.169	62.444	29.587	0.652	70.743
2031	**36.3**	6.750	0.186	0.480	15.154	0.417	7.819	21.904	0.603	8.299	5.498	0.151	28.456	2.185	0.060	33.988	7.683	0.212	62.444	29.587	0.815	70.743
2032	**29.0**	6.750	0.233	0.480	15.154	0.523	7.819	21.904	0.755	8.299	5.498	0.190	28.456	2.185	0.075	33.988	7.683	0.265	62.444	29.587	1.020	70.743
2033	**23.3**	6.750	0.290	0.480	15.154	0.650	7.819	21.904	0.940	8.299	5.498	0.236	28.456	2.185	0.094	33.988	7.683	0.330	62.444	29.587	1.270	70.743
2034	**18.6**	6.750	0.363	0.480	15.154	0.815	7.819	21.904	1.178	8.299	5.498	0.296	28.456	2.185	0.117	33.988	7.683	0.413	62.444	29.587	1.591	70.743
2035	**14.8**	6.750	0.456	0.480	15.154	1.024	7.819	21.904	1.480	8.299	5.498	0.371	28.456	2.185	0.148	33.988	7.683	0.519	62.444	29.587	1.999	70.743
2036	**11.9**	6.750	0.567	0.480	15.154	1.273	7.819	21.904	1.841	8.299	5.498	0.462	28.456	2.185	0.184	33.988	7.683	0.646	62.444	29.587	2.486	70.743
2037	**9.5**	6.750	0.711	0.480	15.154	1.595	7.819	21.904	2.306	8.299	5.498	0.579	28.456	2.185	0.230	33.988	7.683	0.809	62.444	29.587	3.114	70.743
2038	**5.0**	3.375	0.675	0.240	7.577	1.515	3.909	10.952	2.190	4.150	2.749	0.550	14.228	1.093	0.219	16.994	3.842	0.768	31.222	14.794	2.959	35.371
2039	**4.0**	3.375	0.844	0.240	7.577	1.894	3.909	10.952	2.738	4.150	2.749	0.687	14.228	1.093	0.273	16.994	3.842	0.960	31.222	14.794	3.698	35.371
2040	**3.2**	3.375	1.055	0.240	7.577	2.368	3.909	10.952	3.422	4.150	2.749	0.859	14.228	1.093	0.341	16.994	3.842	1.201	31.222	14.794	4.623	35.371
Total LOF	**500.0**	**119.816**		**9**	**268.978**		**139**	**388.793**		**147**	**97.588**		**505**	**38.792**		**603**	**136.380**		**1108**	**525.173**		**1256**
Average LOF		**3.994**	**0.240**	**0**	**8.966**	**0.538**	**5**	**12.960**	**0.778**	**5**	**3.253**	**0.195**	**17**	**1.293**	**0.078**	**20**	**4.546**	**0.273**	**37**	**17.506**	**1.050**	**42**

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
2011	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep			3.799			0.430		
	Total								
2012	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep			3.799			0.430		
	Total								
2013	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep			3.799			0.430		
	Total								
2014	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep			3.799			0.430		
	Total								
2015	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep			3.799			0.430		
	Total								
2016	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep			3.799			0.430		
	Total								
2017	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep			3.799			0.430		
	Total								
2018	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep			3.799			0.430		
	Total								
2019	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep			3.799			0.430		
	Total								
2020	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep			3.799			0.430		
	Total								
2021	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep			3.799			0.430		
	Total								
2022	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep	1	6	3.799	2.279	1.03	0.430	0.258	1.45
	Total	**1**	**6**		**2.279**	**1.03**		**0.258**	**1.45**
2023	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep	1	13	3.799	4.938	2.23	0.430	0.559	3.15
	Total	**1**	**13**		**4.938**	**2.23**		**0.559**	**3.15**
2024	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep	1	20	3.799	7.598	3.43	0.430	0.861	4.85
	Total	**1**	**20**		**7.598**	**3.43**		**0.861**	**4.85**
2025	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep	2	31	3.799	11.776	5.32	0.430	1.334	7.51
	Total	**2**	**31**		**11.776**	**5.32**		**1.334**	**7.51**
2026	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep	2	38	3.799	14.436	6.52	0.430	1.635	9.21
	Total	**2**	**38**		**14.436**	**6.52**		**1.635**	**9.21**
2027	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep	2	45	3.799	17.095	7.73	0.430	1.937	10.91

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	**2**	**45**		**17.095**	**7.73**		**1.937**	**10.91**
2028	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep	2	50	3.799	18.994	8.58	0.430	2.152	12.12
	Total	**2**	**50**		**18.994**	**8.58**		**2.152**	**12.12**
2029	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep	2	50	3.799	18.994	8.58	0.430	2.152	12.12
	Total	**2**	**50**		**18.994**	**8.58**		**2.152**	**12.12**
2030	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep	2	50	3.799	18.994	8.58	0.430	2.152	12.12
	Total	**2**	**50**		**18.994**	**8.58**		**2.152**	**12.12**
2031	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep	2	50	3.799	18.994	8.58	0.430	2.152	12.12
	Total	**2**	**50**		**18.994**	**8.58**		**2.152**	**12.12**
2032	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep	2	50	3.799	18.994	8.58	0.430	2.152	12.12
	Total	**2**	**50**		**18.994**	**8.58**		**2.152**	**12.12**
2033	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep	2	50	3.799	18.994	8.58	0.430	2.152	12.12
	Total	**2**	**50**		**18.994**	**8.58**		**2.152**	**12.12**
2034	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep	2	50	3.799	18.994	8.58	0.430	2.152	12.12
	Total	**2**	**50**		**18.994**	**8.58**		**2.152**	**12.12**
2035	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep	2	50	3.799	18.994	8.58	0.430	2.152	12.12
	Total	**2**	**50**		**18.994**	**8.58**		**2.152**	**12.12**
2036	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep	2	50	3.799	18.994	8.58	0.430	2.152	12.12
	Total	**2**	**50**		**18.994**	**8.58**		**2.152**	**12.12**
2037	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep	2	50	3.799	18.994	8.58	0.430	2.152	12.12
	Total	**2**	**50**		**18.994**	**8.58**		**2.152**	**12.12**
2038	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep	1	25	3.799	9.497	4.29	0.430	1.076	6.06
	Total	**1**	**25**		**9.497**	**4.29**		**1.076**	**6.06**
2039	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep	1	25	3.799	9.497	4.29	0.430	1.076	6.06
	Total	**1**	**25**		**9.497**	**4.29**		**1.076**	**6.06**
2040	Shallow			3.052			0.393		
	Medium			3.681			0.406		
	Deep	1	25	3.799	9.497	4.29	0.430	1.076	6.06
	Total	**1**	**25**		**9.497**	**4.29**		**1.076**	**6.06**

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]
2011													
2012													
2013													
2014													
2015													
2016													
2017													
2018													
2019													
2020													
2021													
2022	**13.5**	2.279	0.169	1.030	0.258	0.019	1.454	0.258	0.019	1.454	2.538	0.188	2.484
2023	**16.9**	4.938	0.292	2.232	0.559	0.033	3.151	0.559	0.033	3.151	5.498	0.325	5.382
2024	**22.5**	7.598	0.338	3.434	0.861	0.038	4.847	0.861	0.038	4.847	8.458	0.376	8.280
2025	**43.5**	11.776	0.271	5.322	1.334	0.031	7.513	1.334	0.031	7.513	13.111	0.301	12.835
2026	**46.9**	14.436	0.308	6.524	1.635	0.035	9.209	1.635	0.035	9.209	16.071	0.343	15.733
2027	**52.5**	17.095	0.326	7.725	1.937	0.037	10.906	1.937	0.037	10.906	19.031	0.363	18.631
2028	**54.0**	18.994	0.352	8.584	2.152	0.040	12.117	2.152	0.040	12.117	21.146	0.392	20.701
2029	**49.2**	18.994	0.386	8.584	2.152	0.044	12.117	2.152	0.044	12.117	21.146	0.430	20.701
2030	**45.4**	18.994	0.418	8.584	2.152	0.047	12.117	2.152	0.047	12.117	21.146	0.466	20.701
2031	**36.3**	18.994	0.523	8.584	2.152	0.059	12.117	2.152	0.059	12.117	21.146	0.583	20.701
2032	**29.0**	18.994	0.655	8.584	2.152	0.074	12.117	2.152	0.074	12.117	21.146	0.729	20.701
2033	**23.3**	18.994	0.815	8.584	2.152	0.092	12.117	2.152	0.092	12.117	21.146	0.908	20.701
2034	**18.6**	18.994	1.021	8.584	2.152	0.116	12.117	2.152	0.116	12.117	21.146	1.137	20.701
2035	**14.8**	18.994	1.283	8.584	2.152	0.145	12.117	2.152	0.145	12.117	21.146	1.429	20.701
2036	**11.9**	18.994	1.596	8.584	2.152	0.181	12.117	2.152	0.181	12.117	21.146	1.777	20.701
2037	**9.5**	18.994	1.999	8.584	2.152	0.227	12.117	2.152	0.227	12.117	21.146	2.226	20.701
2038	**5.0**	9.497	1.899	4.292	1.076	0.215	6.059	1.076	0.215	6.059	10.573	2.115	10.351
2039	**4.0**	9.497	2.374	4.292	1.076	0.269	6.059	1.076	0.269	6.059	10.573	2.643	10.351
2040	**3.2**	9.497	2.968	4.292	1.076	0.336	6.059	1.076	0.336	6.059	10.573	3.304	10.351
Total LOF	**500.0**	**276.555**		**125**	**31.332**		**176**	**31.332**		**176**	**307.887**		**301**
Average LOF		**9.219**	**0.553**	**4**	**1.044**	**0.063**	**6**	**1.044**	**0.063**	**6**	**10.263**	**0.616**	**10**

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 10^4 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
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		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													
2020	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													
2021	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													
2022	Shallow		0.103			0.718			0.308			0.205		
	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	**6**		0.062	**0.03**		0.431	**2.28**		0.185	**12.62**		0.123	**24.63**
2023	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep	13	0.103	0.133	0.07	0.718	0.934	4.94	0.308	0.400	27.35	0.205	0.267	53.36
	Total	**13**		0.133	**0.07**		0.934	**4.94**		0.400	**27.35**		0.267	**53.36**
2024	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep	20	0.103	0.205	0.11	0.718	1.437	7.60	0.308	0.616	42.08	0.205	0.410	82.09
	Total	**20**		0.205	**0.11**		1.437	**7.60**		0.616	**42.08**		0.410	**82.09**
2025	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep	31	0.103	0.318	0.17	0.718	2.227	11.78	0.308	0.954	65.23	0.205	0.636	127.24
	Total	**31**		0.318	**0.17**		2.227	**11.78**		0.954	**65.23**		0.636	**127.24**
2026	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep	38	0.103	0.390	0.20	0.718	2.730	14.44	0.308	1.170	79.95	0.205	0.780	155.97
	Total	**38**		0.390	**0.20**		2.730	**14.44**		1.170	**79.95**		0.780	**155.97**
2027	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep	45	0.103	0.462	0.24	0.718	3.232	17.11	0.308	1.385	94.68	0.205	0.924	184.70
	Total	**45**		0.462	**0.24**		3.232	**17.11**		1.385	**94.68**		0.924	**184.70**
2028	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep	50	0.103	0.513	0.27	0.718	3.591	19.01	0.308	1.539	105.20	0.205	1.026	205.23
	Total	**50**		0.513	**0.27**		3.591	**19.01**		1.539	**105.20**		1.026	**205.23**

Table 4.2.5
Arctic Spill Occurrence - High 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
2029	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep	50	0.103	0.513	0.27	0.718	3.591	19.01	0.308	1.539	105.20	0.205	1.026	205.23
	Total	**50**		0.513	**0.27**		3.591	**19.01**		1.539	**105.20**		1.026	**205.23**
2030	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep	50	0.103	0.513	0.27	0.718	3.591	19.01	0.308	1.539	105.20	0.205	1.026	205.23
	Total	**50**		0.513	**0.27**		3.591	**19.01**		1.539	**105.20**		1.026	**205.23**
2031	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep	50	0.103	0.513	0.27	0.718	3.591	19.01	0.308	1.539	105.20	0.205	1.026	205.23
	Total	**50**		0.513	**0.27**		3.591	**19.01**		1.539	**105.20**		1.026	**205.23**
2032	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep	50	0.103	0.513	0.27	0.718	3.591	19.01	0.308	1.539	105.20	0.205	1.026	205.23
	Total	**50**		0.513	**0.27**		3.591	**19.01**		1.539	**105.20**		1.026	**205.23**
2033	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep	50	0.103	0.513	0.27	0.718	3.591	19.01	0.308	1.539	105.20	0.205	1.026	205.23
	Total	**50**		0.513	**0.27**		3.591	**19.01**		1.539	**105.20**		1.026	**205.23**
2034	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep	50	0.103	0.513	0.27	0.718	3.591	19.01	0.308	1.539	105.20	0.205	1.026	205.23
	Total	**50**		0.513	**0.27**		3.591	**19.01**		1.539	**105.20**		1.026	**205.23**
2035	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep	50	0.103	0.513	0.27	0.718	3.591	19.01	0.308	1.539	105.20	0.205	1.026	205.23
	Total	**50**		0.513	**0.27**		3.591	**19.01**		1.539	**105.20**		1.026	**205.23**
2036	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep	50	0.103	0.513	0.27	0.718	3.591	19.01	0.308	1.539	105.20	0.205	1.026	205.23
	Total	**50**		0.513	**0.27**		3.591	**19.01**		1.539	**105.20**		1.026	**205.23**
2037	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep	50	0.103	0.513	0.27	0.718	3.591	19.01	0.308	1.539	105.20	0.205	1.026	205.23
	Total	**50**		0.513	**0.27**		3.591	**19.01**		1.539	**105.20**		1.026	**205.23**
2038	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep	25	0.103	0.257	0.13	0.718	1.796	9.50	0.308	0.770	52.60	0.205	0.513	102.61
	Total	**25**		0.257	**0.13**		1.796	**9.50**		0.770	**52.60**		0.513	**102.61**
2039	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep	25	0.103	0.257	0.13	0.718	1.796	9.50	0.308	0.770	52.60	0.205	0.513	102.61
	Total	**25**		0.257	**0.13**		1.796	**9.50**		0.770	**52.60**		0.513	**102.61**
2040	Shallow		0.103			0.718			0.308			0.205		
	Medium		0.103			0.718			0.308			0.205		
	Deep	25	0.103	0.257	0.13	0.718	1.796	9.50	0.308	0.770	52.60	0.205	0.513	102.61
	Total	**25**		0.257	**0.13**		1.796	**9.50**		0.770	**52.60**		0.513	**102.61**

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]
2011													
2012													
2013													
2014													
2015													
2016													
2017													
2018													
2019													
2020													
2021													
2022	**13.5**	0.062	0.005	0.032	0.185	0.014	2.281	0.308	0.023	37.252	0.554	0.041	39.564
2023	**16.9**	0.133	0.008	0.069	0.400	0.024	4.942	0.667	0.039	80.712	1.201	0.071	85.723
2024	**22.5**	0.205	0.009	0.107	0.616	0.027	7.603	1.026	0.046	124.172	1.847	0.082	131.881
2025	**43.5**	0.318	0.007	0.165	0.954	0.022	11.784	1.591	0.037	192.466	2.863	0.066	204.415
2026	**46.9**	0.390	0.008	0.203	1.170	0.025	14.445	1.950	0.042	235.926	3.509	0.075	250.574
2027	**52.5**	0.462	0.009	0.240	1.385	0.026	17.106	2.309	0.044	279.386	4.156	0.079	296.732
2028	**54.0**	0.513	0.010	0.266	1.539	0.029	19.006	2.565	0.048	310.429	4.618	0.086	329.702
2029	**49.2**	0.513	0.010	0.266	1.539	0.031	19.006	2.565	0.052	310.429	4.618	0.094	329.702
2030	**45.4**	0.513	0.011	0.266	1.539	0.034	19.006	2.565	0.057	310.429	4.618	0.102	329.702
2031	**36.3**	0.513	0.014	0.266	1.539	0.042	19.006	2.565	0.071	310.429	4.618	0.127	329.702
2032	**29.0**	0.513	0.018	0.266	1.539	0.053	19.006	2.565	0.088	310.429	4.618	0.159	329.702
2033	**23.3**	0.513	0.022	0.266	1.539	0.066	19.006	2.565	0.110	310.429	4.618	0.198	329.702
2034	**18.6**	0.513	0.028	0.266	1.539	0.083	19.006	2.565	0.138	310.429	4.618	0.248	329.702
2035	**14.8**	0.513	0.035	0.266	1.539	0.104	19.006	2.565	0.173	310.429	4.618	0.312	329.702
2036	**11.9**	0.513	0.043	0.266	1.539	0.129	19.006	2.565	0.216	310.429	4.618	0.388	329.702
2037	**9.5**	0.513	0.054	0.266	1.539	0.162	19.006	2.565	0.270	310.429	4.618	0.486	329.702
2038	**5.0**	0.257	0.051	0.133	0.770	0.154	9.503	1.283	0.257	155.215	2.309	0.462	164.851
2039	**4.0**	0.257	0.064	0.133	0.770	0.192	9.503	1.283	0.321	155.215	2.309	0.577	164.851
2040	**3.2**	0.257	0.080	0.133	0.770	0.241	9.503	1.283	0.401	155.215	2.309	0.722	164.851

Table 4.2.7
Occurrence Spill Risks - High 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
2011	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**
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		1.583			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													
2014	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**
2015	Shallow		1.583			11.077			4.759			2.755		
	Medium		1.809			12.659			5.439			3.149		
	Deep	2	2.035	0.407	0.21	14.242	2.848	15.07	6.119	1.224	83.65	3.543	0.709	141.71
	Total	**2**		0.407	**0.21**		2.848	**15.07**		1.224	**83.65**		0.709	**141.71**
2016	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**
2017	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**
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													
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													

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
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													
2040	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 10^3 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]
2011		0.204		0.106	0.612		7.537	0.966		112.679	1.782		120.321
2012		0.204		0.106	0.612		7.537	0.966		112.679	1.782		120.321
2013													
2014		0.204		0.106	0.612		7.537	0.966		112.679	1.782		120.321
2015		0.407		0.211	1.224		15.074	1.932		225.358	3.563		240.643
2016		0.204		0.106	0.612		7.537	0.966		112.679	1.782		120.321
2017		0.204		0.106	0.612		7.537	0.966		112.679	1.782		120.321
2018													
2019													
2020													
2021													
2022	13.5												
2023	16.9												
2024	22.5												
2025	43.5												
2026	46.9												
2027	52.5												
2028	54.0												
2029	49.2												
2030	45.4												
2031	36.3												
2032	29.0												
2033	23.3												
2034	18.6												
2035	14.8												
2036	11.9												
2037	9.5												
2038	5.0												
2039	4.0												
2040	3.2												

Table 4.2.9
Arctic Spill Occurrence Chikchi 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
2011	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													
2012	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep	1	0.623	0.062	0.03	4.350	0.435	2.30	1.868	0.187	12.77	1.868	0.187	37.37
	Total	**1**		0.062	**0.03**		0.435	**2.30**		0.187	**12.77**		0.187	**37.37**
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	1	0.623	0.062	0.03	4.350	0.435	2.30	1.868	0.187	12.77	1.868	0.187	37.37
	Total	**1**		0.062	**0.03**		0.435	**2.30**		0.187	**12.77**		0.187	**37.37**
2015	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep	1	0.623	0.062	0.03	4.350	0.435	2.30	1.868	0.187	12.77	1.868	0.187	37.37
	Total	**1**		0.062	**0.03**		0.435	**2.30**		0.187	**12.77**		0.187	**37.37**
2016	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**
2017	Shallow		0.484			3.383			1.453			1.453		
	Medium		0.554			3.867			1.661			1.661		
	Deep	1	0.623	0.062	0.03	4.350	0.435	2.30	1.868	0.187	12.77	1.868	0.187	37.37
	Total	**1**		0.062	**0.03**		0.435	**2.30**		0.187	**12.77**		0.187	**37.37**
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													
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													

Table 4.2.9
Arctic Spill Occurrence Chikchi 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
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													
2040	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]
2011													
2012		0.062		0.032	0.187		2.302	0.374		50.139	0.623		52.474
2013		0.125		0.065	0.374		4.604	0.747		100.278	1.246		104.947
2014		0.062		0.032	0.187		2.302	0.374		50.139	0.623		52.474
2015		0.062		0.032	0.187		2.302	0.374		50.139	0.623		52.474
2016		0.125		0.065	0.374		4.604	0.747		100.278	1.246		104.947
2017		0.062		0.032	0.187		2.302	0.374		50.139	0.623		52.474
2018													
2019													
2020													
2021													
2022	13.5												
2023	16.9												
2024	22.5												
2025	43.5												
2026	46.9												
2027	52.5												
2028	54.0												
2029	49.2												
2030	45.4												
2031	36.3												
2032	29.0												
2033	23.3												
2034	18.6												
2035	14.8												
2036	11.9												
2037	9.5												
2038	5.0												
2039	4.0												
2040	3.2												

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]
2011		0.204		0.106	0.612		7.537	0.966		112.679	1.578		120.216	1.782		120.321
2012		0.266		0.138	0.799		9.839	1.340		162.818	2.139		172.657	2.404		172.795
2013		0.125		0.065	0.374		4.604	0.747		100.278	1.121		104.883	1.246		104.947
2014		0.266		0.138	0.799		9.839	1.340		162.818	2.139		172.657	2.404		172.795
2015		0.469		0.244	1.411		17.376	2.306		275.497	3.717		292.873	4.186		293.117
2016		0.328		0.170	0.986		12.141	1.714		212.957	2.699		225.098	3.027		225.269
2017		0.266		0.138	0.799		9.839	1.340		162.818	2.139		172.657	2.404		172.795
2018																
2019																
2020																
2021																
2022	**13.5**	0.062	0.005	0.032	0.185	0.014	2.281	0.308	0.023	37.252	0.493	0.036	39.532	0.554	0.041	39.564
2023	**16.9**	0.133	0.008	0.069	0.400	0.024	4.942	0.667	0.039	80.712	1.067	0.063	85.653	1.201	0.071	85.723
2024	**22.5**	0.205	0.009	0.107	0.616	0.027	7.603	1.026	0.046	124.172	1.642	0.073	131.774	1.847	0.082	131.881
2025	**43.5**	0.318	0.007	0.165	0.954	0.022	11.784	1.591	0.037	192.466	2.545	0.059	204.250	2.863	0.066	204.415
2026	**46.9**	0.390	0.008	0.203	1.170	0.025	14.445	1.950	0.042	235.926	3.119	0.067	250.371	3.509	0.075	250.574
2027	**52.5**	0.462	0.009	0.240	1.385	0.026	17.106	2.309	0.044	279.386	3.694	0.070	296.492	4.156	0.079	296.732
2028	**54.0**	0.513	0.010	0.266	1.539	0.029	19.006	2.565	0.048	310.429	4.105	0.076	329.436	4.618	0.086	329.702
2029	**49.2**	0.513	0.010	0.266	1.539	0.031	19.006	2.565	0.052	310.429	4.105	0.083	329.436	4.618	0.094	329.702
2030	**45.4**	0.513	0.011	0.266	1.539	0.034	19.006	2.565	0.057	310.429	4.105	0.090	329.436	4.618	0.102	329.702
2031	**36.3**	0.513	0.014	0.266	1.539	0.042	19.006	2.565	0.071	310.429	4.105	0.113	329.436	4.618	0.127	329.702
2032	**29.0**	0.513	0.018	0.266	1.539	0.053	19.006	2.565	0.088	310.429	4.105	0.142	329.436	4.618	0.159	329.702
2033	**23.3**	0.513	0.022	0.266	1.539	0.066	19.006	2.565	0.110	310.429	4.105	0.176	329.436	4.618	0.198	329.702
2034	**18.6**	0.513	0.028	0.266	1.539	0.083	19.006	2.565	0.138	310.429	4.105	0.221	329.436	4.618	0.248	329.702
2035	**14.8**	0.513	0.035	0.266	1.539	0.104	19.006	2.565	0.173	310.429	4.105	0.277	329.436	4.618	0.312	329.702
2036	**11.9**	0.513	0.043	0.266	1.539	0.129	19.006	2.565	0.216	310.429	4.105	0.345	329.436	4.618	0.388	329.702
2037	**9.5**	0.513	0.054	0.266	1.539	0.162	19.006	2.565	0.270	310.429	4.105	0.432	329.436	4.618	0.486	329.702
2038	**5.0**	0.257	0.051	0.133	0.770	0.154	9.503	1.283	0.257	155.215	2.052	0.410	164.718	2.309	0.462	164.851
2039	**4.0**	0.257	0.064	0.133	0.770	0.192	9.503	1.283	0.321	155.215	2.052	0.513	164.718	2.309	0.577	164.851
2040	**3.2**	0.257	0.080	0.133	0.770	0.241	9.503	1.283	0.401	155.215	2.052	0.641	164.718	2.309	0.722	164.851
Total LOF	**500.0**	**9.393**		**5**	**28.189**		**348**	**47.104**		**5710**	**75.293**		**6058**	**84.687**		**6063**
Average LOF		**0.313**	**0.019**	**0**	**0.940**	**0.056**	**12**	**1.570**	**0.094**	**190**	**2.510**	**0.151**	**202**	**2.823**	**0.169**	**202**

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]
2011	Pipeline													
	Platforms													
	Production Wells													
	Exploration Wells		0.204		0.106	0.612		7.537	0.966		112.679	1.782		120.321
	Development Wells													
	Total		0.204		0.106	0.612		7.537	0.966		112.679	1.782		120.321
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		0.062		0.032	0.187		2.302	0.374		50.139	0.623		52.474
	Total		0.266		0.138	0.799		9.839	1.340		162.818	2.404		172.795
2013	Pipeline													
	Platforms													
	Production Wells													
	Exploration Wells													
	Development Wells		0.125		0.065	0.374		4.604	0.747		100.278	1.246		104.947
	Total		0.125		0.065	0.374		4.604	0.747		100.278	1.246		104.947
2014	Pipeline													
	Platforms													
	Production Wells													
	Exploration Wells		0.204		0.106	0.612		7.537	0.966		112.679	1.782		120.321
	Development Wells		0.062		0.032	0.187		2.302	0.374		50.139	0.623		52.474
	Total		0.266		0.138	0.799		9.839	1.340		162.818	2.404		172.795
2015	Pipeline													
	Platforms													
	Production Wells													
	Exploration Wells		0.407		0.211	1.224		15.074	1.932		225.358	3.563		240.643
	Development Wells		0.062		0.032	0.187		2.302	0.374		50.139	0.623		52.474
	Total		0.469		0.244	1.411		17.376	2.306		275.497	4.186		293.117
2016	Pipeline													
	Platforms													
	Production Wells													
	Exploration Wells		0.204		0.106	0.612		7.537	0.966		112.679	1.782		120.321
	Development Wells		0.125		0.065	0.374		4.604	0.747		100.278	1.246		104.947
	Total		0.328		0.170	0.986		12.141	1.714		212.957	3.027		225.269
2017	Pipeline													
	Platforms													
	Production Wells													
	Exploration Wells		0.204		0.106	0.612		7.537	0.966		112.679	1.782		120.321
	Development Wells		0.062		0.032	0.187		2.302	0.374		50.139	0.623		52.474
	Total		0.266		0.138	0.799		9.839	1.340		162.818	2.404		172.795
2018	Pipeline													
	Platforms													
	Production Wells													
	Exploration Wells													
	Development Wells													
	Total													
2019	Pipeline		2.738		1.037	0.687		3.557	0.273		4.249	3.698		8.843
	Platforms													
	Production Wells													
	Exploration Wells													
	Development Wells													
	Total		2.738		1.037	0.687		3.557	0.273		4.249	3.698		8.843
2020	Pipeline		5.476		2.075	1.374		7.114	0.546		8.497	7.397		17.686
	Platforms													
	Production Wells													
	Exploration Wells													
	Development Wells													
	Total		5.476		2.075	1.374		7.114	0.546		8.497	7.397		17.686
2021	Pipeline		10.952		4.150	2.749		14.228	1.093		16.994	14.794		35.371
	Platforms													
	Production Wells													
	Exploration Wells													
	Development Wells													
	Total		10.952		4.150	2.749		14.228	1.093		16.994	14.794		35.371
2022	Pipeline	13.5	13.690	1.014	5.187	3.436	0.255	17.785	1.366	0.101	21.243	18.492	1.370	44.214
	Platforms		2.279	0.169	1.030	0.129	0.010	0.727	0.129	0.010	0.727	2.538	0.188	2.484
	Production Wells		0.062	0.005	0.032	0.185	0.014	2.281	0.308	0.023	37.252	0.554	0.041	39.564
	Exploration Wells													
	Development Wells													
	Total		16.031	1.187	6.249	3.750	0.278	20.793	1.803	0.134	59.221	21.584	1.599	86.263
2023	Pipeline	16.9	16.428	0.972	6.224	4.123	0.244	21.342	1.639	0.097	25.491	22.190	1.313	53.057
	Platforms		4.938	0.292	2.232	0.280	0.017	1.575	0.280	0.017	1.575	5.498	0.325	5.382
	Production Wells		0.133	0.008	0.069	0.400	0.024	4.942	0.667	0.039	80.712	1.201	0.071	85.723
	Exploration Wells													
	Development Wells													
	Total		21.500	1.272	8.525	4.803	0.284	27.859	2.586	0.153	107.778	28.889	1.709	144.162
2024	Pipeline	22.5	21.904	0.974	8.299	5.498	0.244	28.456	2.185	0.097	33.988	29.587	1.315	70.743
	Platforms		7.598	0.338	3.434	0.430	0.019	2.423	0.430	0.019	2.423	8.458	0.376	8.280
	Production Wells		0.205	0.009	0.107	0.616	0.027	7.603	1.026	0.046	124.172	1.847	0.082	131.881
	Exploration Wells													
	Development Wells													
	Total		29.707	1.320	11.839	6.544	0.291	38.482	3.642	0.162	160.583	39.893	1.773	210.904
2025	Pipeline	43.5	21.904	0.504	8.299	5.498	0.126	28.456	2.185	0.050	33.988	29.587	0.680	70.743
	Platforms		11.776	0.271	5.322	0.667	0.015	3.756	0.667	0.015	3.756	13.111	0.301	12.835
	Production Wells		0.318	0.007	0.165	0.954	0.022	11.784	1.591	0.037	192.466	2.863	0.066	204.415
	Exploration Wells													
	Development Wells													
	Total		33.998	0.782	13.786	7.119	0.164	43.996	4.443	0.102	230.211	45.561	1.047	287.993
2026	Pipeline	46.9	21.904	0.467	8.299	5.498	0.117	28.456	2.185	0.047	33.988	29.587	0.631	70.743
	Platforms		14.436	0.308	6.524	0.818	0.017	4.605	0.818	0.017	4.605	16.071	0.343	15.733
	Production Wells		0.390	0.008	0.203	1.170	0.025	14.445	1.950	0.042	235.926	3.509	0.075	250.574
	Exploration Wells													
	Development Wells													
	Total		36.729	0.783	15.025	7.485	0.160	47.505	4.953	0.106	274.519	49.168	1.048	337.049
2027	Pipeline	52.5	21.904	0.417	8.299	5.498	0.105	28.456	2.185	0.042	33.988	29.587	0.564	70.743
	Platforms		17.095	0.326	7.725	0.968	0.018	5.453	0.968	0.018	5.453	19.031	0.363	18.631
	Production Wells		0.462	0.009	0.240	1.385	0.026	17.106	2.309	0.044	279.386	4.156	0.079	296.732
	Exploration Wells													
	Development Wells													
	Total		39.460	0.752	16.264	7.852	0.150	51.014	5.463	0.104	318.827	52.775	1.005	386.106

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 10^3 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]
2028	Pipeline	54.0	21.904	0.406	8.299	5.498	0.102	28.456	2.185	0.040	33.988	29.587	0.548	70.743
	Platforms		18.994	0.352	8.584	1.076	0.020	6.059	1.076	0.020	6.059	21.146	0.392	20.701
	Production Wells		0.513	0.010	0.266	1.539	0.029	19.006	2.565	0.048	310.429	4.618	0.086	329.702
	Exploration Wells													
	Development Wells													
	Total		41.411	0.767	17.149	8.113	0.150	53.521	5.827	0.108	350.476	55.351	1.025	421.146
2029	Pipeline	49.2	21.904	0.445	8.299	5.498	0.112	28.456	2.185	0.044	33.988	29.587	0.601	70.743
	Platforms		18.994	0.386	8.584	1.076	0.022	6.059	1.076	0.022	6.059	21.146	0.430	20.701
	Production Wells		0.513	0.010	0.266	1.539	0.031	19.006	2.565	0.052	310.429	4.618	0.094	329.702
	Exploration Wells													
	Development Wells													
	Total		41.411	0.842	17.149	8.113	0.165	53.521	5.827	0.118	350.476	55.351	1.125	421.146
2030	Pipeline	45.4	21.904	0.482	8.299	5.498	0.121	28.456	2.185	0.048	33.988	29.587	0.652	70.743
	Platforms		18.994	0.418	8.584	1.076	0.024	6.059	1.076	0.024	6.059	21.146	0.466	20.701
	Production Wells		0.513	0.011	0.266	1.539	0.034	19.006	2.565	0.057	310.429	4.618	0.102	329.702
	Exploration Wells													
	Development Wells													
	Total		41.411	0.912	17.149	8.113	0.179	53.521	5.827	0.128	350.476	55.351	1.219	421.146
2031	Pipeline	36.3	21.904	0.603	8.299	5.498	0.151	28.456	2.185	0.060	33.988	29.587	0.815	70.743
	Platforms		18.994	0.523	8.584	1.076	0.030	6.059	1.076	0.030	6.059	21.146	0.583	20.701
	Production Wells		0.513	0.014	0.266	1.539	0.042	19.006	2.565	0.071	310.429	4.618	0.127	329.702
	Exploration Wells													
	Development Wells													
	Total		41.411	1.141	17.149	8.113	0.224	53.521	5.827	0.161	350.476	55.351	1.525	421.146
2032	Pipeline	29.0	21.904	0.755	8.299	5.498	0.190	28.456	2.185	0.075	33.988	29.587	1.020	70.743
	Platforms		18.994	0.655	8.584	1.076	0.037	6.059	1.076	0.037	6.059	21.146	0.729	20.701
	Production Wells		0.513	0.018	0.266	1.539	0.053	19.006	2.565	0.088	310.429	4.618	0.159	329.702
	Exploration Wells													
	Development Wells													
	Total		41.411	1.428	17.149	8.113	0.280	53.521	5.827	0.201	350.476	55.351	1.909	421.146
2033	Pipeline	23.3	21.904	0.940	8.299	5.498	0.236	28.456	2.185	0.094	33.988	29.587	1.270	70.743
	Platforms		18.994	0.815	8.584	1.076	0.046	6.059	1.076	0.046	6.059	21.146	0.908	20.701
	Production Wells		0.513	0.022	0.266	1.539	0.066	19.006	2.565	0.110	310.429	4.618	0.198	329.702
	Exploration Wells													
	Development Wells													
	Total		41.411	1.777	17.149	8.113	0.348	53.521	5.827	0.250	350.476	55.351	2.376	421.146
2034	Pipeline	18.6	21.904	1.178	8.299	5.498	0.296	28.456	2.185	0.117	33.988	29.587	1.591	70.743
	Platforms		18.994	1.021	8.584	1.076	0.058	6.059	1.076	0.058	6.059	21.146	1.137	20.701
	Production Wells		0.513	0.028	0.266	1.539	0.083	19.006	2.565	0.138	310.429	4.618	0.248	329.702
	Exploration Wells													
	Development Wells													
	Total		41.411	2.226	17.149	8.113	0.436	53.521	5.827	0.313	350.476	55.351	2.976	421.146
2035	Pipeline	14.8	21.904	1.480	8.299	5.498	0.371	28.456	2.185	0.148	33.988	29.587	1.999	70.743
	Platforms		18.994	1.283	8.584	1.076	0.073	6.059	1.076	0.073	6.059	21.146	1.429	20.701
	Production Wells		0.513	0.035	0.266	1.539	0.104	19.006	2.565	0.173	310.429	4.618	0.312	329.702
	Exploration Wells													
	Development Wells													
	Total		41.411	2.798	17.149	8.113	0.548	53.521	5.827	0.394	350.476	55.351	3.740	421.146
2036	Pipeline	11.9	21.904	1.841	8.299	5.498	0.462	28.456	2.185	0.184	33.988	29.587	2.486	70.743
	Platforms		18.994	1.596	8.584	1.076	0.090	6.059	1.076	0.090	6.059	21.146	1.777	20.701
	Production Wells		0.513	0.043	0.266	1.539	0.129	19.006	2.565	0.216	310.429	4.618	0.388	329.702
	Exploration Wells													
	Development Wells													
	Total		41.411	3.480	17.149	8.113	0.682	53.521	5.827	0.490	350.476	55.351	4.651	421.146
2037	Pipeline	9.5	21.904	2.306	8.299	5.498	0.579	28.456	2.185	0.230	33.988	29.587	3.114	70.743
	Platforms		18.994	1.999	8.584	1.076	0.113	6.059	1.076	0.113	6.059	21.146	2.226	20.701
	Production Wells		0.513	0.054	0.266	1.539	0.162	19.006	2.565	0.270	310.429	4.618	0.486	329.702
	Exploration Wells													
	Development Wells													
	Total		41.411	4.359	17.149	8.113	0.854	53.521	5.827	0.613	350.476	55.351	5.826	421.146
2038	Pipeline	5.0	10.952	2.190	4.150	2.749	0.550	14.228	1.093	0.219	16.994	14.794	2.959	35.371
	Platforms		9.497	1.899	4.292	0.538	0.108	3.029	0.538	0.108	3.029	10.573	2.115	10.351
	Production Wells		0.257	0.051	0.133	0.770	0.154	9.503	1.283	0.257	155.215	2.309	0.462	164.851
	Exploration Wells													
	Development Wells													
	Total		20.706	4.141	8.575	4.057	0.811	26.760	2.913	0.583	175.238	27.675	5.535	210.573
2039	Pipeline	4.0	10.952	2.738	4.150	2.749	0.687	14.228	1.093	0.273	16.994	14.794	3.698	35.371
	Platforms		9.497	2.374	4.292	0.538	0.134	3.029	0.538	0.134	3.029	10.573	2.643	10.351
	Production Wells		0.257	0.064	0.133	0.770	0.192	9.503	1.283	0.321	155.215	2.309	0.577	164.851
	Exploration Wells													
	Development Wells													
	Total		20.706	5.176	8.575	4.057	1.014	26.760	2.913	0.728	175.238	27.675	6.919	210.573
2040	Pipeline	3.2	10.952	3.422	4.150	2.749	0.859	14.228	1.093	0.341	16.994	14.794	4.623	35.371
	Platforms		9.497	2.968	4.292	0.538	0.168	3.029	0.538	0.168	3.029	10.573	3.304	10.351
	Production Wells		0.257	0.080	0.133	0.770	0.241	9.503	1.283	0.401	155.215	2.309	0.722	164.851
	Exploration Wells													
	Development Wells													
	Total		20.706	6.470	8.575	4.057	1.268	26.760	2.913	0.910	175.238	27.675	8.649	210.573

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]
2011		0.204		0.106	0.612		7.537	0.966		112.679	1.578		120.216	1.782		120.321
2012		0.266		0.138	0.799		9.839	1.340		162.818	2.139		172.657	2.404		172.795
2013		0.125		0.065	0.374		4.604	0.747		100.278	1.121		104.883	1.246		104.947
2014		0.266		0.138	0.799		9.839	1.340		162.818	2.139		172.657	2.404		172.795
2015		0.469		0.244	1.411		17.376	2.306		275.497	3.717		292.873	4.186		293.117
2016		0.328		0.170	0.986		12.141	1.714		212.957	2.699		225.098	3.027		225.269
2017		0.266		0.138	0.799		9.839	1.340		162.818	2.139		172.657	2.404		172.795
2018																
2019		2.738		1.037	0.687		3.557	0.273		4.249	0.960		7.805	3.698		8.843
2020		5.476		2.075	1.374		7.114	0.546		8.497	1.921		15.611	7.397		17.686
2021		10.952		4.150	2.749		14.228	1.093		16.994	3.842		31.222	14.794		35.371
2022	**13.5**	16.031	1.187	6.249	3.750	0.278	20.793	1.803	0.134	59.221	5.553	0.411	80.014	21.584	1.599	86.263
2023	**16.9**	21.500	1.272	8.525	4.803	0.284	27.859	2.586	0.153	107.778	7.389	0.437	135.636	28.889	1.709	144.162
2024	**22.5**	29.707	1.320	11.839	6.544	0.291	38.482	3.642	0.162	160.583	10.186	0.453	199.065	39.893	1.773	210.904
2025	**43.5**	33.998	0.782	13.786	7.119	0.164	43.996	4.443	0.102	230.211	11.562	0.266	274.207	45.561	1.047	287.993
2026	**46.9**	36.729	0.783	15.025	7.485	0.160	47.505	4.953	0.106	274.519	12.438	0.265	322.024	49.168	1.048	337.049
2027	**52.5**	39.460	0.752	16.264	7.852	0.150	51.014	5.463	0.104	318.827	13.314	0.254	369.841	52.775	1.005	386.106
2028	**54.0**	41.411	0.767	17.149	8.113	0.150	53.521	5.827	0.108	350.476	13.940	0.258	403.997	55.351	1.025	421.146
2029	**49.2**	41.411	0.842	17.149	8.113	0.165	53.521	5.827	0.118	350.476	13.940	0.283	403.997	55.351	1.125	421.146
2030	**45.4**	41.411	0.912	17.149	8.113	0.179	53.521	5.827	0.128	350.476	13.940	0.307	403.997	55.351	1.219	421.146
2031	**36.3**	41.411	1.141	17.149	8.113	0.224	53.521	5.827	0.161	350.476	13.940	0.384	403.997	55.351	1.525	421.146
2032	**29.0**	41.411	1.428	17.149	8.113	0.280	53.521	5.827	0.201	350.476	13.940	0.481	403.997	55.351	1.909	421.146
2033	**23.3**	41.411	1.777	17.149	8.113	0.348	53.521	5.827	0.250	350.476	13.940	0.598	403.997	55.351	2.376	421.146
2034	**18.6**	41.411	2.226	17.149	8.113	0.436	53.521	5.827	0.313	350.476	13.940	0.749	403.997	55.351	2.976	421.146
2035	**14.8**	41.411	2.798	17.149	8.113	0.548	53.521	5.827	0.394	350.476	13.940	0.942	403.997	55.351	3.740	421.146
2036	**11.9**	41.411	3.480	17.149	8.113	0.682	53.521	5.827	0.490	350.476	13.940	1.171	403.997	55.351	4.651	421.146
2037	**9.5**	41.411	4.359	17.149	8.113	0.854	53.521	5.827	0.613	350.476	13.940	1.467	403.997	55.351	5.826	421.146
2038	**5.0**	20.706	4.141	8.575	4.057	0.811	26.760	2.913	0.583	175.238	6.970	1.394	201.998	27.675	5.535	210.573
2039	**4.0**	20.706	5.176	8.575	4.057	1.014	26.760	2.913	0.728	175.238	6.970	1.742	201.998	27.675	6.919	210.573
2040	**3.2**	20.706	6.470	8.575	4.057	1.268	26.760	2.913	0.910	175.238	6.970	2.178	201.998	27.675	8.649	210.573
Total LOF	**500.0**	**674.742**		**277**	**141.443**		**941**	**101.562**		**6401**	**243.005**		**7342**	**917.747**		**7620**
Average LOF		**22.491**	**1.349**	**9**	**4.715**	**0.283**	**31**	**3.385**	**0.203**	**213**	**8.100**	**0.486**	**245**	**30.592**	**1.835**	**254**

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 =	41.42	8.12	5.82	13.94	55.36
Std Deviation =	16.25	3.97	1.84	4.55	16.88
Variance =	263.985	15.778	3.377	20.739	284.882
Skewness =	0.39	0.81	0.53	0.58	0.34
Kurtosis =	2.76	3.28	3.04	3.18	2.77
Mode =	36.28	4.27	4.07	8.34	50.08
Minimum =	3.871	0.885	1.303	2.996	14.957
5% Perc =	17.034	3.040	3.176	7.436	29.511
10% Perc =	21.054	3.645	3.612	8.444	34.279
15% Perc =	24.068	4.115	3.947	9.286	37.378
20% Perc =	26.904	4.575	4.223	9.964	40.346
25% Perc =	29.216	5.008	4.477	10.588	42.868
30% Perc =	31.429	5.417	4.721	11.167	45.296
35% Perc =	33.596	5.867	4.952	11.726	47.465
40% Perc =	35.695	6.353	5.175	12.255	49.766
45% Perc =	37.950	6.837	5.393	12.813	51.987
50% Perc =	40.180	7.363	5.613	13.408	54.255
55% Perc =	42.498	7.941	5.839	13.978	56.461
60% Perc =	44.645	8.494	6.091	14.632	58.829
65% Perc =	46.986	9.157	6.374	15.321	61.082
70% Perc =	49.541	9.795	6.658	16.012	63.987
75% Perc =	52.349	10.609	6.975	16.800	66.969
80% Perc =	55.702	11.429	7.348	17.690	69.996
85% Perc =	59.070	12.412	7.784	18.796	73.424
90% Perc =	63.486	13.724	8.388	20.245	78.263
95% Perc =	69.929	15.750	9.181	22.229	84.766
Maximum =	103.278	26.645	13.348	34.536	123.456

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 =	0.91	0.18	0.13	0.31	1.22
Std Deviation =	0.36	0.09	0.04	0.10	0.37
Variance =	0.128	0.008	0.002	0.010	0.138
Skewness =	0.39	0.81	0.53	0.58	0.34
Kurtosis =	2.76	3.28	3.04	3.18	2.77
Mode =	0.80	0.09	0.11	0.23	1.09
Minimum =	0.085	0.019	0.029	0.066	0.329
5% Perc =	0.375	0.067	0.070	0.164	0.650
10% Perc =	0.464	0.080	0.080	0.186	0.755
15% Perc =	0.530	0.091	0.087	0.205	0.823
20% Perc =	0.593	0.101	0.093	0.219	0.889
25% Perc =	0.644	0.110	0.099	0.233	0.944
30% Perc =	0.692	0.119	0.104	0.246	0.998
35% Perc =	0.740	0.129	0.109	0.258	1.045
40% Perc =	0.786	0.140	0.114	0.270	1.096
45% Perc =	0.836	0.151	0.119	0.282	1.145
50% Perc =	0.885	0.162	0.124	0.295	1.195
55% Perc =	0.936	0.175	0.129	0.308	1.244
60% Perc =	0.983	0.187	0.134	0.322	1.296
65% Perc =	1.035	0.202	0.140	0.337	1.345
70% Perc =	1.091	0.216	0.147	0.353	1.409
75% Perc =	1.153	0.234	0.154	0.370	1.475
80% Perc =	1.227	0.252	0.162	0.390	1.542
85% Perc =	1.301	0.273	0.171	0.414	1.617
90% Perc =	1.398	0.302	0.185	0.446	1.724
95% Perc =	1.540	0.347	0.202	0.490	1.867
Maximum =	2.275	0.587	0.294	0.761	2.719

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 =	17.18	53.65	350.17	403.81	420.99
Std Deviation =	11.24	30.54	126.17	130.07	130.55
Variance =	126.420	932.414	15919.700	16919.380	17044.490
Skewness =	1.19	1.30	0.48	0.44	0.43
Kurtosis =	4.72	5.49	3.23	3.19	3.19
Mode =	2.95	44.19	230.87	282.47	272.68
Minimum =	-1.173	0.253	43.711	79.588	93.237
5% Perc =	3.679	16.317	159.178	205.605	221.727
10% Perc =	5.191	21.417	194.466	243.633	260.638
15% Perc =	6.355	25.454	219.726	268.809	285.557
20% Perc =	7.585	28.830	239.049	291.201	306.962
25% Perc =	8.732	31.836	259.937	309.981	327.689
30% Perc =	9.872	34.897	277.879	329.193	346.124
35% Perc =	10.996	37.873	294.988	346.155	362.699
40% Perc =	12.223	40.687	310.034	362.745	379.059
45% Perc =	13.438	43.947	325.413	378.929	396.493
50% Perc =	14.731	47.283	339.752	394.991	411.829
55% Perc =	16.111	50.527	355.949	410.934	428.056
60% Perc =	17.586	54.382	372.612	428.474	445.263
65% Perc =	19.165	58.910	389.375	446.661	463.237
70% Perc =	20.976	63.721	408.942	466.399	484.155
75% Perc =	23.159	68.874	428.273	487.342	504.280
80% Perc =	25.567	74.766	452.753	509.295	528.176
85% Perc =	28.416	82.896	480.314	536.438	554.049
90% Perc =	32.541	94.300	516.986	574.305	593.308
95% Perc =	38.906	112.703	576.375	635.191	653.137
Maximum =	81.979	249.893	945.258	983.543	1003.756

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	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 =	12.96	3.25	1.29	4.54	17.50	0.78	0.19	0.08	0.27	1.05	4.93	16.78	20.10	36.88	41.82
Std Deviation =	6.53	2.27	0.91	2.46	6.98	0.39	0.14	0.05	0.15	0.42	4.28	15.88	14.97	22.02	22.48
Variance =	42.593	5.144	0.826	6.040	48.771	0.153	0.019	0.003	0.022	0.176	18.313	252.308	223.986	485.020	505.279
Skewness =	0.50	0.86	0.84	0.73	0.43	0.50	0.86	0.84	0.73	0.43	1.52	1.68	1.06	0.98	0.95
Kurtosis =	2.64	3.31	3.21	3.20	2.67	2.64	3.31	3.21	3.20	2.67	5.58	6.53	3.96	4.14	4.08
Mode =	10.12	0.85	2.44	3.58	6.07	0.61	0.05	0.15	0.18	1.10	3.11	7.70	17.92	76.75	36.53
Minimum =	0.676	0.034	0.012	0.265	2.534	0.041	0.002	0.001	0.016	0.152	-0.919	-4.600	0.182	0.591	2.187
5% Perc =	3.605	0.470	0.173	1.229	7.259	0.216	0.028	0.010	0.074	0.436	0.569	1.149	2.633	8.541	12.507
10% Perc =	4.981	0.686	0.266	1.685	8.841	0.299	0.041	0.016	0.101	0.530	0.852	2.174	4.000	12.109	16.226
15% Perc =	6.027	0.913	0.354	2.027	10.106	0.362	0.055	0.021	0.122	0.606	1.126	3.086	5.321	14.909	19.617
20% Perc =	7.071	1.147	0.452	2.339	11.250	0.424	0.069	0.027	0.140	0.675	1.442	4.059	6.719	17.773	22.517
25% Perc =	7.933	1.388	0.552	2.637	12.242	0.476	0.083	0.033	0.158	0.735	1.731	5.201	8.258	20.200	25.061
30% Perc =	8.740	1.637	0.652	2.916	13.121	0.524	0.098	0.039	0.175	0.787	2.060	6.301	9.711	22.750	27.465
35% Perc =	9.571	1.911	0.755	3.200	13.954	0.574	0.115	0.045	0.192	0.837	2.428	7.479	11.254	25.262	30.068
40% Perc =	10.326	2.212	0.873	3.490	14.885	0.620	0.133	0.052	0.209	0.893	2.804	8.818	12.996	27.816	32.645
45% Perc =	11.146	2.485	0.987	3.817	15.816	0.669	0.149	0.059	0.229	0.949	3.225	10.408	14.717	30.182	35.267
50% Perc =	12.050	2.775	1.105	4.139	16.786	0.723	0.166	0.066	0.248	1.007	3.692	11.997	16.633	32.905	37.764
55% Perc =	13.013	3.112	1.226	4.444	17.722	0.781	0.187	0.074	0.267	1.063	4.191	13.772	18.672	35.666	40.603
60% Perc =	13.983	3.466	1.368	4.831	18.699	0.839	0.208	0.082	0.290	1.122	4.722	15.600	20.711	38.629	43.682
65% Perc =	15.049	3.829	1.520	5.191	19.838	0.903	0.230	0.091	0.311	1.190	5.354	17.865	23.124	41.963	46.977
70% Perc =	16.214	4.206	1.692	5.630	20.973	0.973	0.252	0.102	0.338	1.258	6.027	20.344	25.774	45.425	50.528
75% Perc =	17.404	4.640	1.863	6.104	22.143	1.044	0.278	0.112	0.366	1.329	6.860	23.554	28.594	49.366	54.792
80% Perc =	18.683	5.163	2.069	6.635	23.555	1.121	0.310	0.124	0.398	1.413	7.820	27.237	32.154	54.192	59.447
85% Perc =	20.313	5.762	2.309	7.265	25.261	1.219	0.346	0.139	0.436	1.516	9.079	31.844	36.201	59.868	65.093
90% Perc =	22.272	6.509	2.599	8.050	27.249	1.336	0.391	0.156	0.483	1.635	10.786	38.239	41.357	67.210	72.611
95% Perc =	24.915	7.608	3.032	9.059	30.163	1.495	0.457	0.182	0.544	1.810	13.866	49.490	49.243	78.415	84.009
Maximum =	35.321	14.390	5.063	16.928	42.830	2.119	0.863	0.304	1.016	2.570	29.619	138.980	96.411	165.293	178.175

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 =	9.22	0.52	0.52	1.04	10.26	0.55	0.03	0.03	0.06	0.62	4.17	2.94	2.94	5.87	10.04
Std Deviation =	5.84	0.32	0.32	0.63	5.88	0.35	0.02	0.02	0.04	0.35	4.21	2.40	2.40	4.81	6.34
Variance =	34.115	0.100	0.100	0.399	34.568	0.123	0.000	0.000	0.001	0.124	17.708	5.783	5.783	23.132	40.197
Skewness =	0.60	0.68	0.68	0.68	0.59	0.60	0.68	0.68	0.68	0.59	1.77	1.29	1.29	1.29	1.01
Kurtosis =	2.53	2.79	2.79	2.79	2.54	2.53	2.79	2.79	2.79	2.54	6.70	4.80	4.80	4.80	4.07
Mode =	11.96	1.13	1.13	2.26	2.12	0.72	0.07	0.07	0.14	0.13	2.23	0.77	0.77	1.54	9.73
Minimum =	0.271	0.017	0.017	0.034	0.663	0.016	0.001	0.001	0.002	0.040	-1.524	-1.101	-1.101	-2.201	-0.976
5% Perc =	1.596	0.113	0.113	0.226	2.544	0.096	0.007	0.007	0.014	0.153	0.215	0.265	0.265	0.530	2.127
10% Perc =	2.328	0.156	0.156	0.312	3.347	0.140	0.009	0.009	0.019	0.201	0.465	0.502	0.502	1.004	3.061
15% Perc =	3.007	0.193	0.193	0.386	4.046	0.180	0.012	0.012	0.023	0.243	0.684	0.714	0.714	1.427	3.811
20% Perc =	3.676	0.228	0.228	0.456	4.737	0.221	0.014	0.014	0.027	0.284	0.920	0.911	0.911	1.821	4.490
25% Perc =	4.340	0.264	0.264	0.528	5.414	0.260	0.016	0.016	0.032	0.325	1.167	1.119	1.119	2.237	5.216
30% Perc =	5.069	0.300	0.300	0.601	6.099	0.304	0.018	0.018	0.036	0.366	1.431	1.344	1.344	2.687	5.894
35% Perc =	5.789	0.340	0.340	0.680	6.844	0.347	0.020	0.020	0.041	0.411	1.738	1.574	1.574	3.148	6.588
40% Perc =	6.524	0.378	0.378	0.756	7.571	0.391	0.023	0.023	0.045	0.454	2.064	1.795	1.795	3.590	7.281
45% Perc =	7.340	0.419	0.419	0.837	8.354	0.440	0.025	0.025	0.050	0.501	2.403	2.015	2.015	4.030	8.023
50% Perc =	8.185	0.464	0.464	0.927	9.226	0.491	0.028	0.028	0.056	0.554	2.794	2.289	2.289	4.577	8.801
55% Perc =	9.042	0.513	0.513	1.026	10.158	0.543	0.031	0.031	0.062	0.610	3.203	2.576	2.576	5.153	9.591
60% Perc =	10.014	0.560	0.560	1.120	11.054	0.601	0.034	0.034	0.067	0.663	3.697	2.890	2.890	5.780	10.490
65% Perc =	10.990	0.611	0.611	1.223	12.030	0.659	0.037	0.037	0.073	0.722	4.238	3.296	3.296	6.592	11.358
70% Perc =	12.132	0.670	0.670	1.341	13.220	0.728	0.040	0.040	0.080	0.793	4.917	3.706	3.706	7.413	12.402
75% Perc =	13.285	0.733	0.733	1.465	14.383	0.797	0.044	0.044	0.088	0.863	5.817	4.199	4.199	8.398	13.619
80% Perc =	14.568	0.802	0.802	1.604	15.650	0.874	0.048	0.048	0.096	0.939	6.821	4.715	4.715	9.430	14.947
85% Perc =	16.149	0.880	0.880	1.760	17.189	0.969	0.053	0.053	0.106	1.031	8.132	5.417	5.417	10.834	16.659
90% Perc =	17.814	0.981	0.981	1.961	18.865	1.069	0.059	0.059	0.118	1.132	9.930	6.309	6.309	12.618	18.851
95% Perc =	20.182	1.116	1.116	2.233	21.261	1.211	0.067	0.067	0.134	1.276	12.962	7.722	7.722	15.444	22.266
Maximum =	27.998	1.675	1.675	3.349	29.532	1.680	0.100	0.100	0.201	1.772	30.532	16.380	16.380	32.759	45.225

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	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 =	0.31	0.94	1.57	2.51	2.82	0.02	0.06	0.09	0.15	0.17	0.16	11.60	190.25	201.85	202.01
Std Deviation =	0.10	0.31	0.38	0.66	0.67	0.01	0.02	0.02	0.04	0.04	0.11	7.32	66.77	67.03	67.03
Variance =	0.011	0.098	0.142	0.437	0.449	0.000	0.000	0.001	0.002	0.002	0.012	53.512	4458.521	4492.840	4492.879
Skewness =	-0.01	0.00	0.02	0.02	0.01	-0.01	0.00	0.02	0.02	0.01	0.71	0.78	0.55	0.53	0.53
Kurtosis =	2.47	2.49	2.73	2.60	2.64	2.47	2.49	2.73	2.60	2.64	3.34	3.41	3.30	3.28	3.28
Mode =	0.14	0.92	1.29	2.59	2.47	0.02	0.06	0.10	0.16	0.15	0.20	6.33	175.87	151.55	220.61
Minimum =	0.041	0.101	0.344	0.541	0.838	0.002	0.006	0.021	0.032	0.050	-0.075	-2.340	27.478	44.091	44.259
5% Perc =	0.139	0.412	0.952	1.423	1.709	0.008	0.025	0.057	0.085	0.103	0.014	1.702	92.661	102.934	103.028
10% Perc =	0.172	0.517	1.080	1.636	1.949	0.010	0.031	0.065	0.098	0.117	0.036	3.097	109.067	120.393	120.593
15% Perc =	0.198	0.600	1.167	1.793	2.096	0.012	0.036	0.070	0.108	0.126	0.053	4.165	121.350	133.034	133.181
20% Perc =	0.221	0.659	1.242	1.927	2.234	0.013	0.040	0.075	0.116	0.134	0.067	5.163	132.697	143.752	143.895
25% Perc =	0.239	0.717	1.303	2.047	2.354	0.014	0.043	0.078	0.123	0.141	0.081	6.100	142.337	153.760	153.843
30% Perc =	0.256	0.768	1.367	2.147	2.459	0.015	0.046	0.082	0.129	0.148	0.095	6.952	150.780	162.304	162.429
35% Perc =	0.272	0.815	1.425	2.240	2.552	0.016	0.049	0.085	0.134	0.153	0.108	7.873	158.802	170.643	170.828
40% Perc =	0.285	0.856	1.474	2.333	2.644	0.017	0.051	0.088	0.140	0.159	0.121	8.671	167.317	179.126	179.332
45% Perc =	0.300	0.900	1.520	2.422	2.735	0.018	0.054	0.091	0.145	0.164	0.134	9.563	175.821	187.085	187.267
50% Perc =	0.313	0.942	1.570	2.509	2.825	0.019	0.057	0.094	0.151	0.170	0.147	10.492	184.282	195.565	195.689
55% Perc =	0.327	0.981	1.620	2.595	2.916	0.020	0.059	0.097	0.156	0.175	0.161	11.388	192.203	203.950	204.132
60% Perc =	0.340	1.020	1.668	2.684	3.001	0.020	0.061	0.100	0.161	0.180	0.175	12.342	200.903	213.338	213.513
65% Perc =	0.357	1.065	1.720	2.775	3.094	0.021	0.064	0.103	0.167	0.186	0.191	13.463	210.645	222.952	223.117
70% Perc =	0.372	1.113	1.773	2.873	3.180	0.022	0.067	0.106	0.172	0.191	0.209	14.562	220.526	232.209	232.382
75% Perc =	0.389	1.162	1.830	2.964	3.290	0.023	0.070	0.110	0.178	0.197	0.229	15.897	231.438	243.299	243.433
80% Perc =	0.406	1.218	1.894	3.084	3.410	0.024	0.073	0.114	0.185	0.205	0.250	17.459	244.179	256.498	256.670
85% Perc =	0.426	1.284	1.965	3.225	3.538	0.026	0.077	0.118	0.194	0.212	0.277	19.358	259.422	271.766	271.893
90% Perc =	0.451	1.355	2.062	3.381	3.701	0.027	0.081	0.124	0.203	0.222	0.313	21.769	279.319	291.167	291.408
95% Perc =	0.485	1.465	2.194	3.614	3.937	0.029	0.088	0.132	0.217	0.236	0.368	25.624	310.924	323.568	323.825
Maximum =	0.593	1.824	2.881	4.676	4.886	0.036	0.109	0.173	0.281	0.293	0.681	41.575	505.511	513.877	514.072

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

High 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	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 =	9.53	1.46	2.09	3.55	13.09	0.57	0.09	0.13	0.21	0.79	4.33	14.54	193.18	207.72	212.05
Std Deviation =	5.84	0.44	0.49	0.91	5.92	0.35	0.03	0.03	0.05	0.36	4.21	7.72	66.79	67.16	67.25
Variance =	34.137	0.196	0.237	0.821	35.095	0.123	0.001	0.001	0.003	0.126	17.719	59.673	4461.480	4511.082	4522.332
Skewness =	0.60	0.24	0.18	0.22	0.58	0.60	0.24	0.18	0.22	0.58	1.78	0.72	0.55	0.53	0.53
Kurtosis =	2.53	2.83	2.86	2.84	2.55	2.53	2.83	2.86	2.84	2.55	6.72	3.34	3.31	3.29	3.29
Mode =	6.03	0.93	1.81	3.24	10.92	0.39	0.06	0.11	0.18	0.43	0.70	19.17	129.92	131.97	137.94
Minimum =	0.464	0.279	0.654	0.980	2.407	0.028	0.017	0.039	0.059	0.144	-1.491	-1.203	28.617	49.254	51.625
5% Perc =	1.902	0.760	1.315	2.115	5.249	0.114	0.046	0.079	0.127	0.315	0.378	3.808	95.438	108.653	112.907
10% Perc =	2.624	0.903	1.467	2.403	6.137	0.157	0.054	0.088	0.144	0.368	0.630	5.573	111.906	126.273	130.361
15% Perc =	3.305	0.998	1.583	2.601	6.861	0.198	0.060	0.095	0.156	0.412	0.846	6.798	124.495	138.839	142.867
20% Perc =	3.985	1.075	1.674	2.766	7.534	0.239	0.064	0.100	0.166	0.452	1.073	7.765	135.554	149.766	153.763
25% Perc =	4.631	1.148	1.756	2.917	8.237	0.278	0.069	0.105	0.175	0.494	1.331	8.834	145.024	159.533	163.864
30% Perc =	5.389	1.212	1.823	3.046	8.925	0.323	0.073	0.109	0.183	0.536	1.604	9.759	153.734	167.934	172.267
35% Perc =	6.094	1.274	1.888	3.163	9.648	0.366	0.076	0.113	0.190	0.579	1.911	10.656	161.948	176.760	180.724
40% Perc =	6.829	1.329	1.952	3.287	10.402	0.410	0.080	0.117	0.197	0.624	2.228	11.589	170.339	184.886	189.151
45% Perc =	7.672	1.387	2.015	3.400	11.231	0.460	0.083	0.121	0.204	0.674	2.568	12.464	178.622	192.929	197.449
50% Perc =	8.515	1.440	2.075	3.513	12.054	0.511	0.086	0.125	0.211	0.723	2.955	13.388	187.077	201.367	205.890
55% Perc =	9.367	1.494	2.137	3.636	12.945	0.562	0.090	0.128	0.218	0.777	3.372	14.400	195.344	209.427	214.169
60% Perc =	10.314	1.559	2.201	3.752	13.898	0.619	0.094	0.132	0.225	0.834	3.858	15.460	203.686	219.046	223.479
65% Perc =	11.316	1.623	2.267	3.878	14.938	0.679	0.097	0.136	0.233	0.896	4.411	16.572	213.982	228.974	233.288
70% Perc =	12.459	1.687	2.338	4.014	16.016	0.747	0.101	0.140	0.241	0.961	5.094	17.797	223.648	238.812	242.638
75% Perc =	13.595	1.754	2.418	4.154	17.189	0.816	0.105	0.145	0.249	1.031	5.958	19.155	234.711	249.237	253.679
80% Perc =	14.874	1.837	2.507	4.326	18.476	0.892	0.110	0.150	0.260	1.109	6.975	20.770	247.318	262.419	266.833
85% Perc =	16.411	1.930	2.607	4.510	20.021	0.985	0.116	0.156	0.271	1.201	8.284	22.685	262.686	277.686	281.820
90% Perc =	18.148	2.043	2.730	4.750	21.729	1.089	0.123	0.164	0.285	1.304	10.114	25.222	282.290	297.396	301.309
95% Perc =	20.500	2.222	2.923	5.107	24.184	1.230	0.133	0.175	0.306	1.451	13.078	29.022	314.207	328.154	332.465
Maximum =	28.441	3.075	3.990	7.065	33.641	1.706	0.185	0.239	0.424	2.018	30.697	47.387	510.280	523.414	531.636

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 =	22.49	4.71	3.38	8.09	30.58	1.35	0.28	0.20	0.49	1.83	9.26	31.32	213.29	244.61	253.87
Std Deviation =	8.76	2.31	1.03	2.62	9.17	0.53	0.14	0.06	0.16	0.55	6.01	17.71	68.31	70.55	70.76
Variance =	76.652	5.334	1.070	6.862	84.164	0.276	0.019	0.004	0.025	0.303	36.130	313.509	4666.300	4976.985	5006.932
Skewness =	0.39	0.82	0.60	0.62	0.34	0.39	0.82	0.60	0.62	0.34	1.18	1.28	0.54	0.51	0.50
Kurtosis =	2.86	3.28	3.12	3.13	2.86	2.86	3.28	3.12	3.13	2.86	4.63	5.22	3.33	3.29	3.27
Mode =	19.93	2.69	2.27	8.75	43.04	1.20	0.32	0.14	0.38	1.54	11.37	22.11	205.53	238.02	157.21
Minimum =	2.153	0.639	0.942	2.294	7.599	0.129	0.038	0.057	0.138	0.456	-1.030	0.152	36.702	69.674	73.722
5% Perc =	9.256	1.805	1.928	4.427	16.545	0.555	0.108	0.116	0.266	0.993	2.049	10.098	112.924	139.848	148.213
10% Perc =	11.463	2.112	2.156	4.958	18.930	0.688	0.127	0.129	0.298	1.136	2.854	12.836	130.293	159.021	167.412
15% Perc =	13.132	2.365	2.332	5.419	20.835	0.788	0.142	0.140	0.325	1.250	3.540	14.881	143.967	172.204	182.082
20% Perc =	14.599	2.604	2.489	5.791	22.397	0.876	0.156	0.149	0.347	1.344	4.147	16.833	154.649	183.819	192.929
25% Perc =	16.033	2.870	2.628	6.140	23.875	0.962	0.172	0.158	0.368	1.433	4.722	18.668	164.494	193.899	203.085
30% Perc =	17.245	3.123	2.744	6.465	25.249	1.035	0.187	0.165	0.388	1.515	5.345	20.447	172.977	203.263	211.896
35% Perc =	18.439	3.394	2.863	6.791	26.476	1.106	0.204	0.172	0.407	1.589	5.968	22.125	181.369	212.395	221.680
40% Perc =	19.603	3.660	2.984	7.093	27.630	1.176	0.220	0.179	0.426	1.658	6.610	23.866	190.227	221.100	230.442
45% Perc =	20.746	3.960	3.114	7.415	28.808	1.245	0.238	0.187	0.445	1.728	7.250	25.592	198.373	229.654	239.481
50% Perc =	21.933	4.257	3.250	7.738	30.049	1.316	0.255	0.195	0.464	1.803	8.024	27.588	206.767	238.407	248.108
55% Perc =	23.027	4.596	3.382	8.074	31.249	1.382	0.276	0.203	0.484	1.875	8.716	29.397	215.424	247.291	256.551
60% Perc =	24.196	4.936	3.530	8.436	32.496	1.452	0.296	0.212	0.506	1.950	9.469	31.704	224.618	255.882	265.879
65% Perc =	25.465	5.305	3.678	8.808	33.678	1.528	0.318	0.221	0.528	2.021	10.298	33.946	233.538	266.097	275.198
70% Perc =	26.823	5.692	3.836	9.249	35.218	1.609	0.341	0.230	0.555	2.113	11.298	36.770	243.940	276.624	285.961
75% Perc =	28.237	6.120	4.027	9.721	36.719	1.694	0.367	0.242	0.583	2.203	12.382	39.797	255.674	288.756	297.927
80% Perc =	29.904	6.636	4.237	10.302	38.422	1.794	0.398	0.254	0.618	2.305	13.700	43.612	268.676	301.884	311.558
85% Perc =	31.948	7.248	4.502	10.985	40.308	1.917	0.435	0.270	0.659	2.419	15.360	48.589	284.719	317.570	327.459
90% Perc =	34.241	8.026	4.839	11.771	42.897	2.054	0.482	0.290	0.706	2.574	17.560	55.374	303.924	338.023	348.058
95% Perc =	37.845	9.122	5.321	12.914	46.516	2.271	0.547	0.319	0.775	2.791	21.092	66.230	335.711	371.295	380.302
Maximum =	57.603	15.286	7.480	19.567	68.684	3.456	0.917	0.449	1.174	4.121	43.553	147.663	553.162	569.935	579.884

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

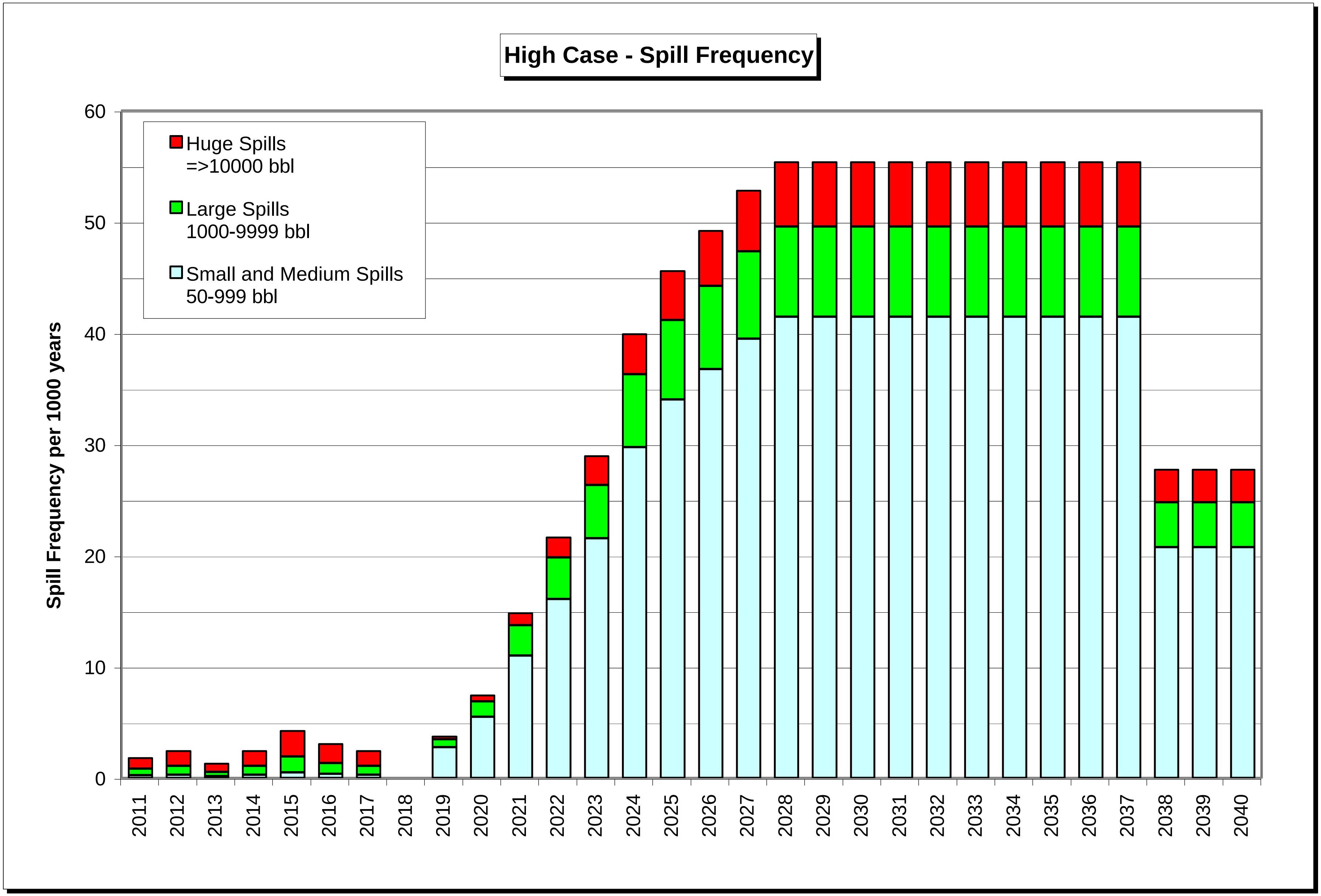
Spill Size	Spill Source									
	P/L		Platforms		Wells		Platforms and Wells		All	
	High Case - Year 2030 Spill Frequency per 10^3 years									
Small and Medium Spills 50-999 bbl	21.904	74%	18.994	90%	0.513	11%	19.507	76%	41.411	75%
Large Spills 1000-9999 bbl	5.498	19%	1.076	5%	1.539	33%	2.615	10%	8.113	15%
Huge Spills =>10000 bbl	2.185	7%	1.076	5%	2.565	56%	3.641	14%	5.827	11%
Significant Spills =>1000 bbl	7.683	26%	2.152	10%	4.105	89%	6.256	24%	13.940	25%
All Spills	**29.587**	**100%**	**21.146**	**100%**	**4.618**	**100%**	**25.764**	**100%**	**55.351**	**100%**
	High Case - Year 2030 Spill Frequency per 10^9 bbl produced									
Small and Medium Spills 50-999 bbl	0.482	74%	0.418	90%	0.011	11%	0.430	76%	0.912	75%
Large Spills 1000-9999 bbl	0.121	19%	0.024	5%	0.034	33%	0.058	10%	0.179	15%
Huge Spills =>10000 bbl	0.048	7%	0.024	5%	0.057	56%	0.080	14%	0.128	11%
Significant Spills =>1000 bbl	0.169	26%	0.047	10%	0.090	89%	0.138	24%	0.307	25%
All Spills	**0.652**	**100%**	**0.466**	**100%**	**0.102**	**100%**	**0.567**	**100%**	**1.219**	**100%**
	High Case - Year 2030 Spill Index [bbl]									
Small and Medium Spills 50-999 bbl	8	12%	9	41%	0	0%	9	3%	17	4%
Large Spills 1000-9999 bbl	28	40%	6	29%	19	6%	25	7%	54	13%
Huge Spills =>10000 bbl	34	48%	6	29%	310	94%	316	90%	350	83%
Significant Spills =>1000 bbl	62	88%	12	59%	329	100%	342	97%	404	96%
All Spills	**71**	**100%**	**21**	**100%**	**330**	**100%**	**350**	**100%**	**421**	**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	21.904	53%	5.498	68%	2.185	38%	7.683	55%	29.587	53%
Platforms	18.994	46%	1.076	13%	1.076	18%	2.152	15%	21.146	38%
Wells	0.513	1%	1.539	19%	2.565	44%	4.105	29%	4.618	8%
Platforms and Wells	19.507	47%	2.615	32%	3.641	62%	6.256	45%	25.764	47%
All	**41.411**	**100%**	**8.113**	**100%**	**5.827**	**100%**	**13.940**	**100%**	**55.351**	**100%**
	High Case - Year 2030 Spill Frequency per 10^9 bbl produced									
Pipelines	0.482	53%	0.121	68%	0.048	38%	0.169	55%	0.652	53%
Platforms	0.418	46%	0.024	13%	0.024	18%	0.047	15%	0.466	38%
Wells	0.011	1%	0.034	19%	0.057	44%	0.090	29%	0.102	8%
Platforms and Wells	0.430	47%	0.058	32%	0.080	62%	0.138	45%	0.567	47%
All	**0.912**	**100%**	**0.179**	**100%**	**0.128**	**100%**	**0.307**	**100%**	**1.219**	**100%**
	High Case - Year 2030 Spill Index [bbl]									
Pipelines	8	48%	28	53%	34	10%	62	15%	71	17%
Platforms	9	50%	6	11%	6	2%	12	3%	21	5%
Wells	0	2%	19	36%	310	89%	329	82%	330	78%
Platforms and Wells	9	52%	25	47%	316	90%	342	85%	350	83%
All	**17**	**100%**	**54**	**100%**	**350**	**100%**	**404**	**100%**	**421**	**100%**

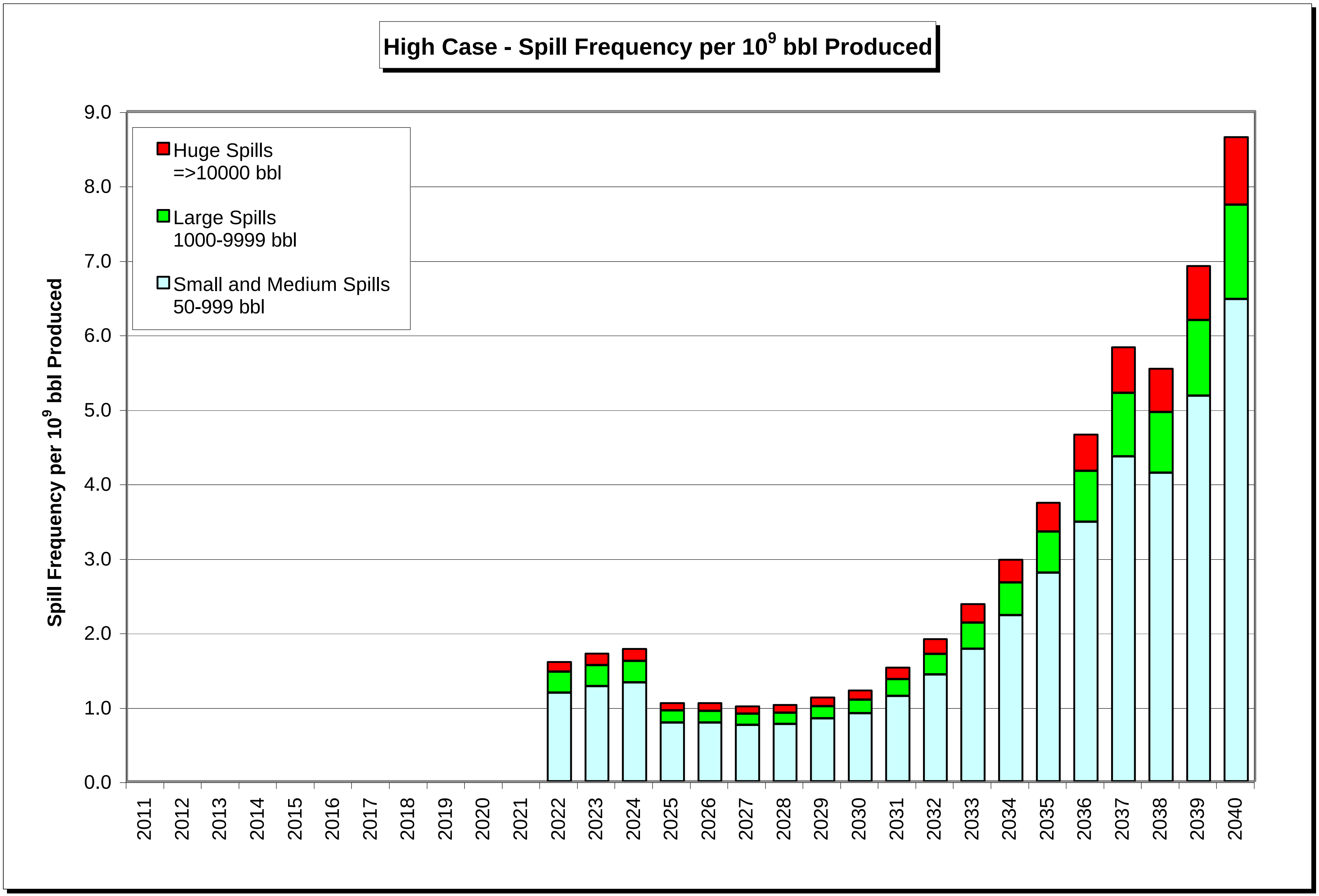
Table 4.2.21
Composition of Spill Indicators - High Case - LOF Average

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	12.960	74%	9.219	90%	0.313	11%	9.532	73%	22.491	74%
Large Spills 1000-9999 bbl	3.253	19%	0.522	5%	0.940	33%	1.462	11%	4.715	15%
Huge Spills =>10000 bbl	1.293	7%	0.522	5%	1.570	56%	2.092	16%	3.385	11%
Significant Spills =>1000 bbl	4.546	26%	1.044	10%	2.510	89%	3.554	27%	8.100	26%
All Spills	**17.506**	**100%**	**10.263**	**100%**	**2.823**	**100%**	**13.086**	**100%**	**30.592**	**100%**
High Case - LOF Average Spill Frequency per 10^9 bbl produced										
Small and Medium Spills 50-999 bbl	0.778	74%	0.553	90%	0.019	11%	0.572	73%	1.349	74%
Large Spills 1000-9999 bbl	0.195	19%	0.031	5%	0.056	33%	0.088	11%	0.283	15%
Huge Spills =>10000 bbl	0.078	7%	0.031	5%	0.094	56%	0.126	16%	0.203	11%
Significant Spills =>1000 bbl	0.273	26%	0.063	10%	0.151	89%	0.213	27%	0.486	26%
All Spills	**1.050**	**100%**	**0.616**	**100%**	**0.169**	**100%**	**0.785**	**100%**	**1.835**	**100%**
High Case - LOF Average Spill Index [bbl]										
Small and Medium Spills 50-999 bbl	5	12%	4	41%	0	0%	4	2%	9	4%
Large Spills 1000-9999 bbl	17	40%	3	29%	12	6%	15	7%	31	12%
Huge Spills =>10000 bbl	20	48%	3	29%	190	94%	193	91%	213	84%
Significant Spills =>1000 bbl	37	88%	6	59%	202	100%	208	98%	245	96%
All Spills	**42**	**100%**	**10**	**100%**	**202**	**100%**	**212**	**100%**	**254**	**100%**

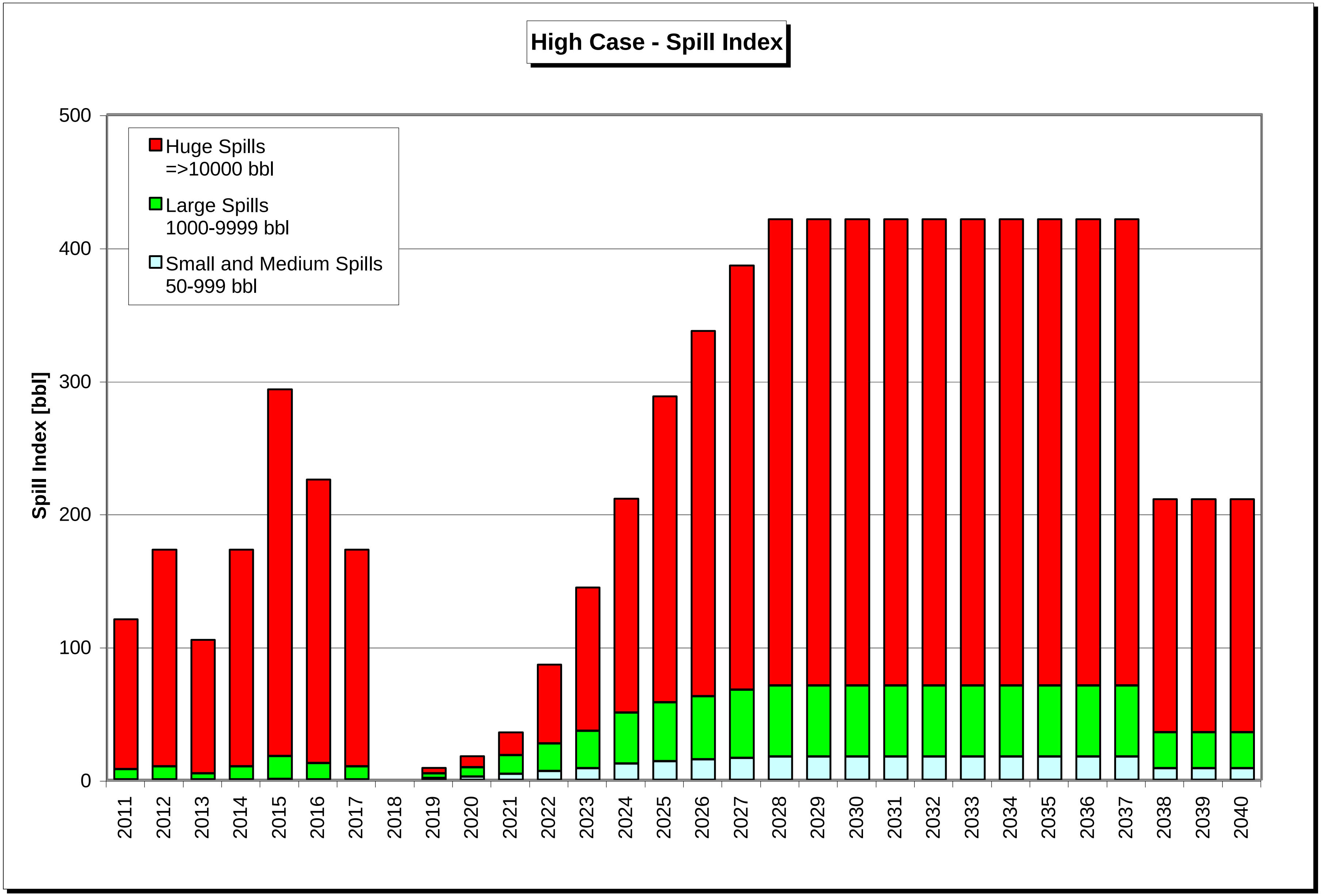
Spill Source	Spill Size: S+M 50-999 bbl		Large 1000-9999 bbl		Huge =>10000 bbl		Significant =>1000 bbl		All Spills	
High Case - LOF Average Spill Frequency per 10^3 years										
Pipelines	12.960	58%	3.253	69%	1.293	38%	4.546	56%	17.506	57%
Platforms	9.219	41%	0.522	11%	0.522	15%	1.044	13%	10.263	34%
Wells	0.313	1%	0.940	20%	1.570	46%	2.510	31%	2.823	9%
Platforms and Wells	9.532	42%	1.462	31%	2.092	62%	3.554	44%	13.086	43%
All	**22.491**	**100%**	**4.715**	**100%**	**3.385**	**100%**	**8.100**	**100%**	**30.592**	**100%**
High Case- LOF Average Spill Frequency per 10^9 bbl produced										
Pipelines	0.778	58%	0.195	69%	0.078	38%	0.273	56%	1.050	57%
Platforms	0.553	41%	0.031	11%	0.031	15%	0.063	13%	0.616	34%
Wells	0.019	1%	0.056	20%	0.094	46%	0.151	31%	0.169	9%
Platforms and Wells	0.572	42%	0.088	31%	0.126	62%	0.213	44%	0.785	43%
All	**1.349**	**100%**	**0.283**	**100%**	**0.203**	**100%**	**0.486**	**100%**	**1.835**	**100%**
High Case - LOF Average Spill Index [bbl]										
Pipelines	5	53%	17	54%	20	9%	37	15%	42	16%
Platforms	4	45%	3	9%	3	1%	6	2%	10	4%
Wells	0	2%	12	37%	190	89%	202	83%	202	80%
Platforms and Wells	4	47%	15	46%	193	91%	208	85%	212	84%
All	**9**	**100%**	**31**	**100%**	**213**	**100%**	**245**	**100%**	**254**	**100%**



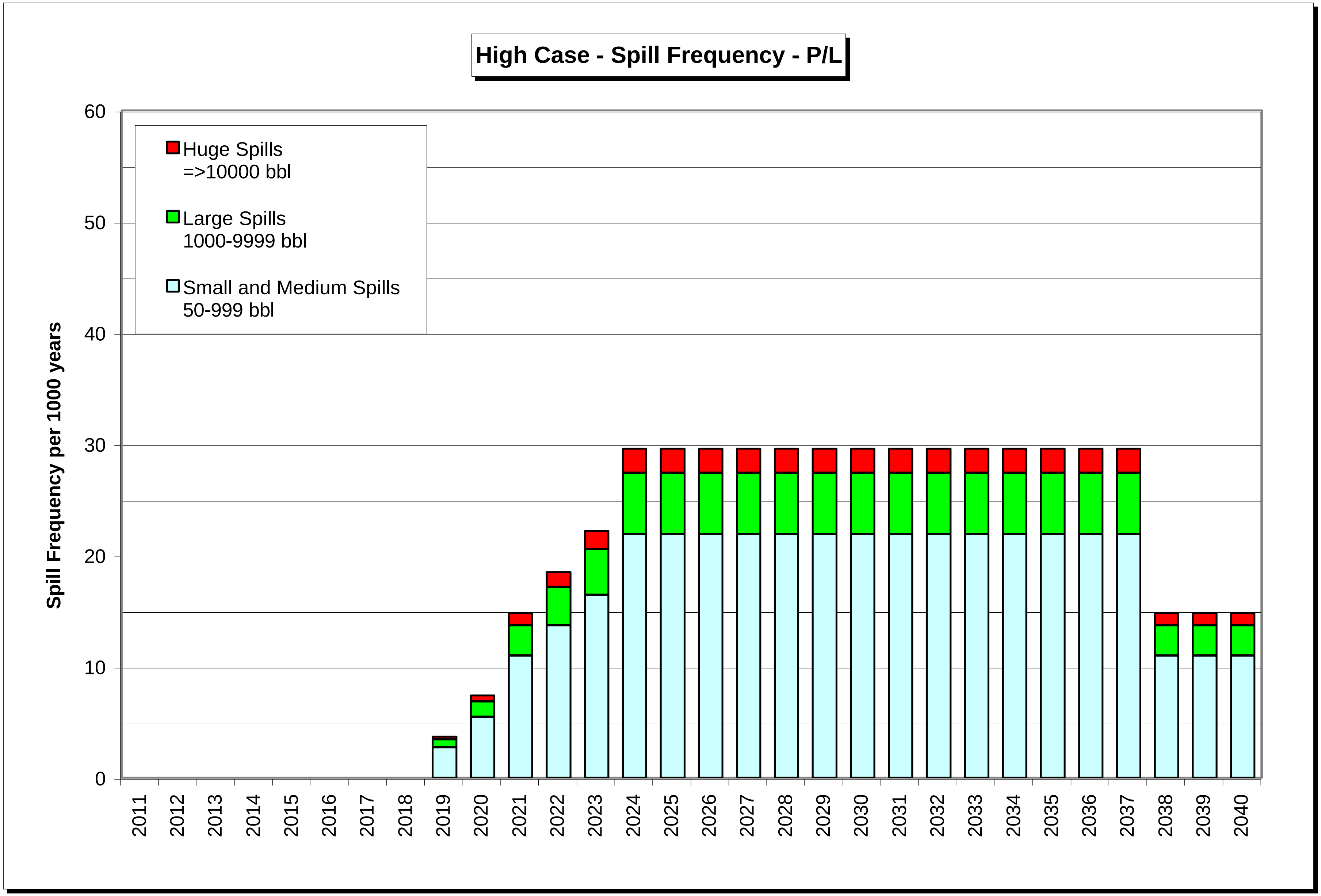
C4_2_HighCase_CS.xlsF4201



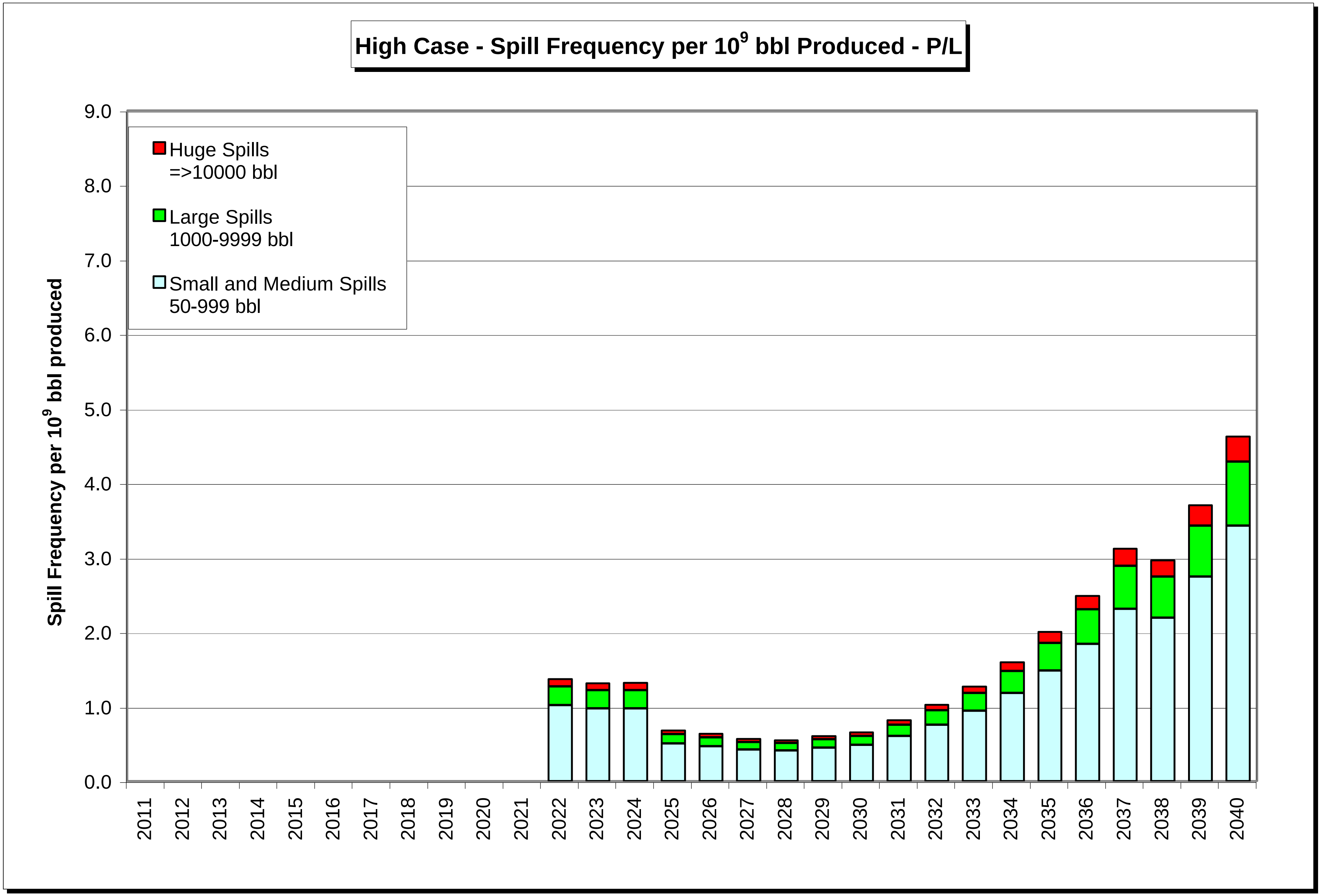
C4_2_HighCase_CS.xlsF4202



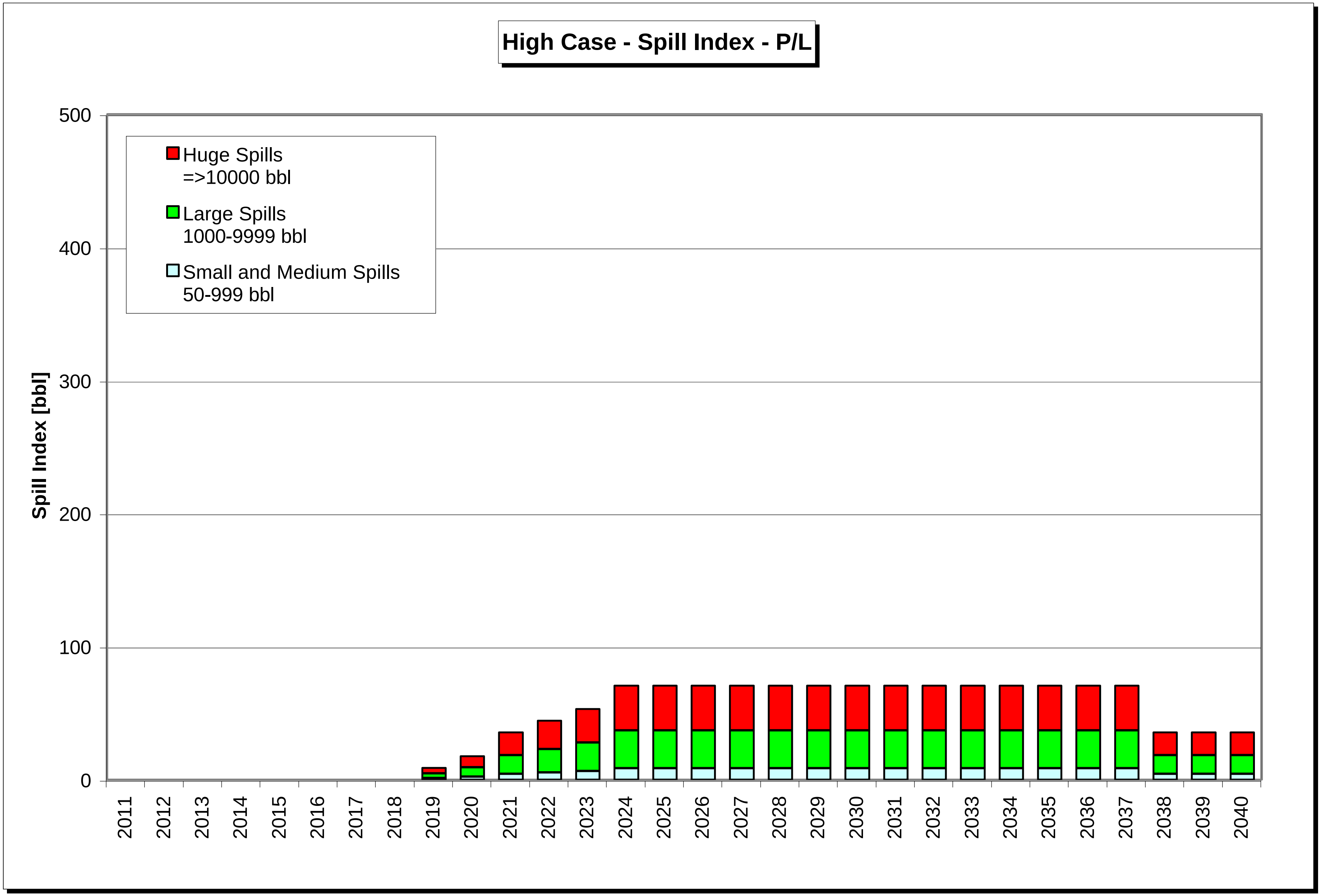
C4_2_HighCase_CS.xlsF4203



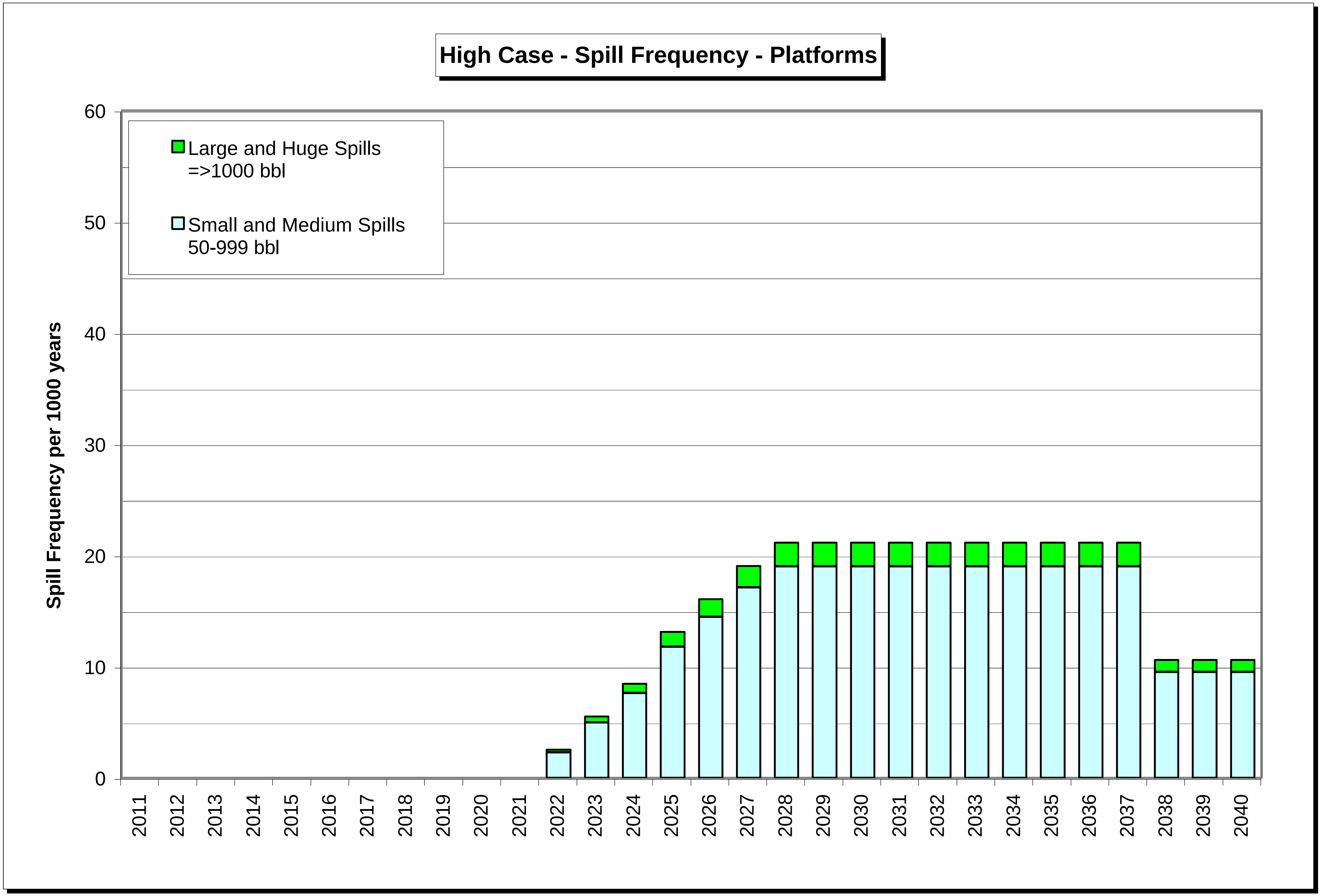
C4_2_HighCase_CS.xlsF4204



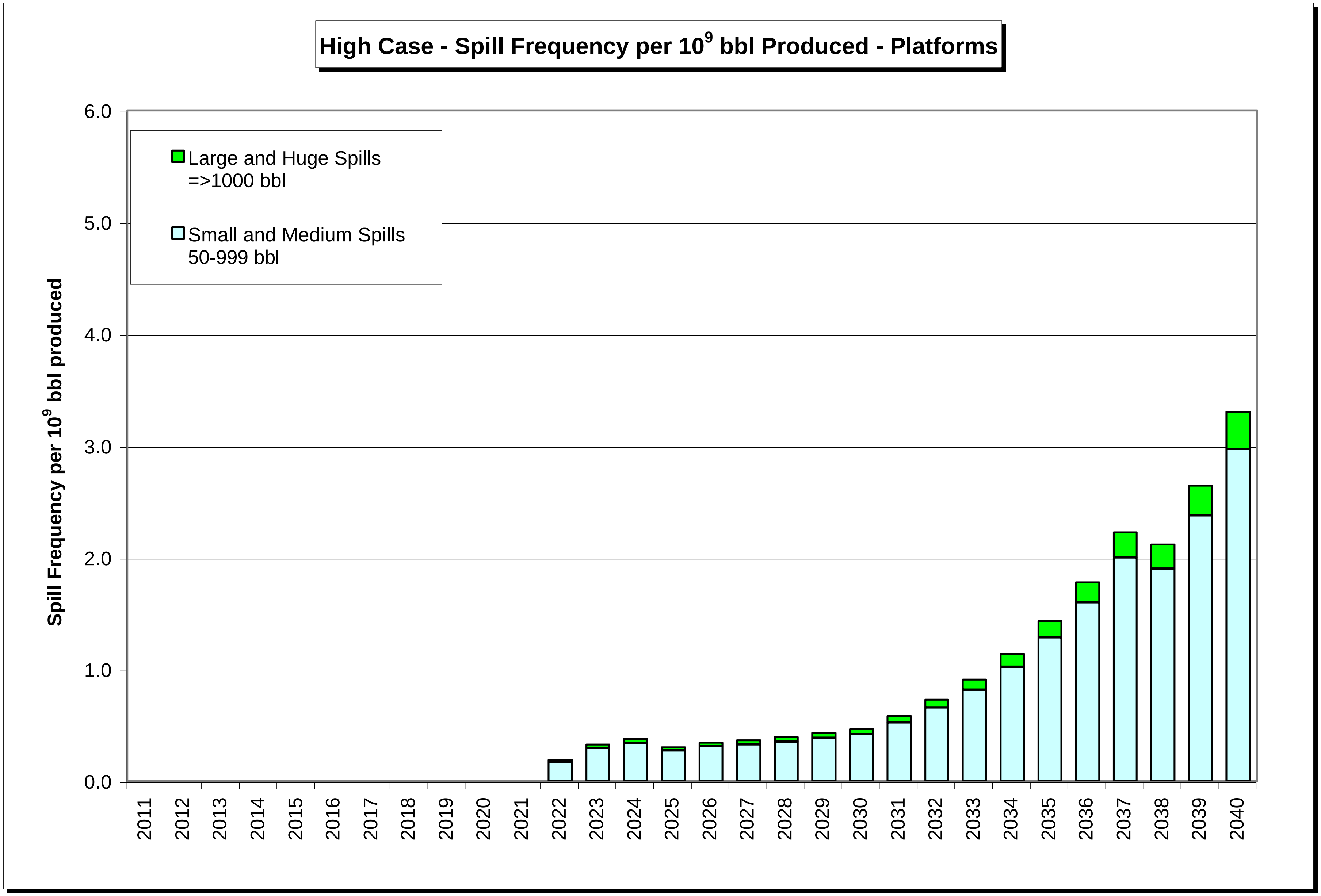
C4_2_HighCase_CS.xlsF4205



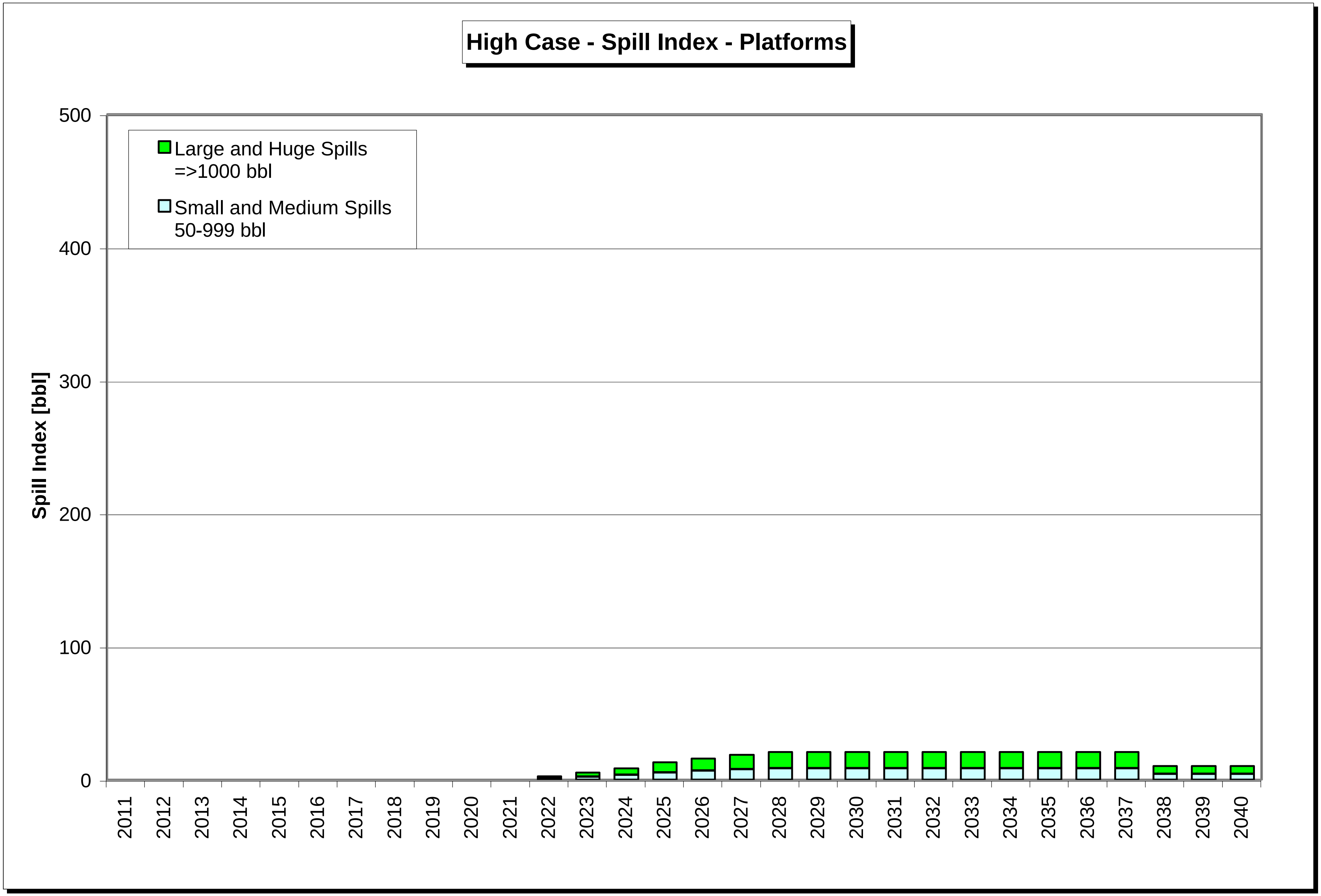
C4_2_HighCase_CS.xlsF4206



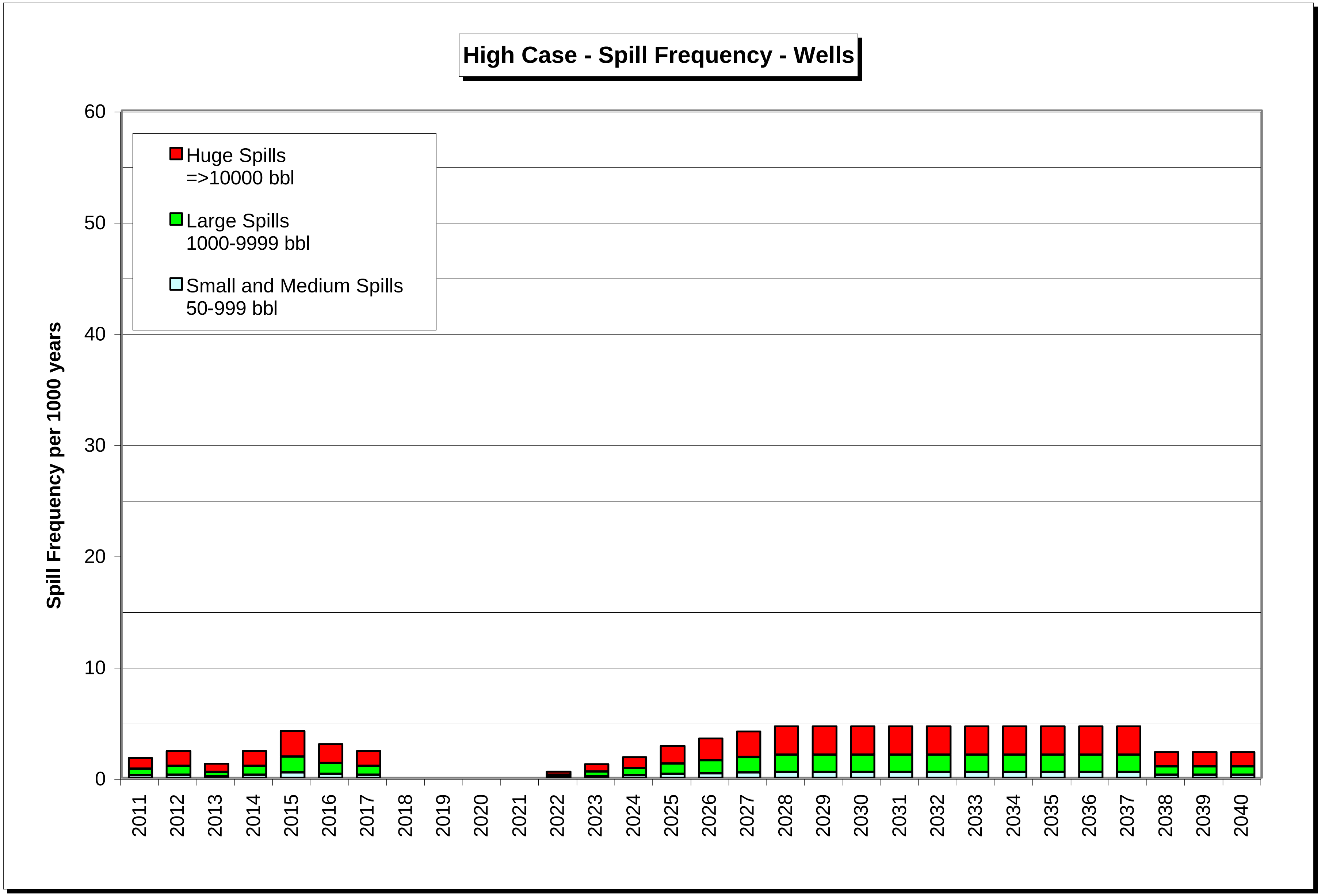
C4_2_HighCase_CS.xlsF4207



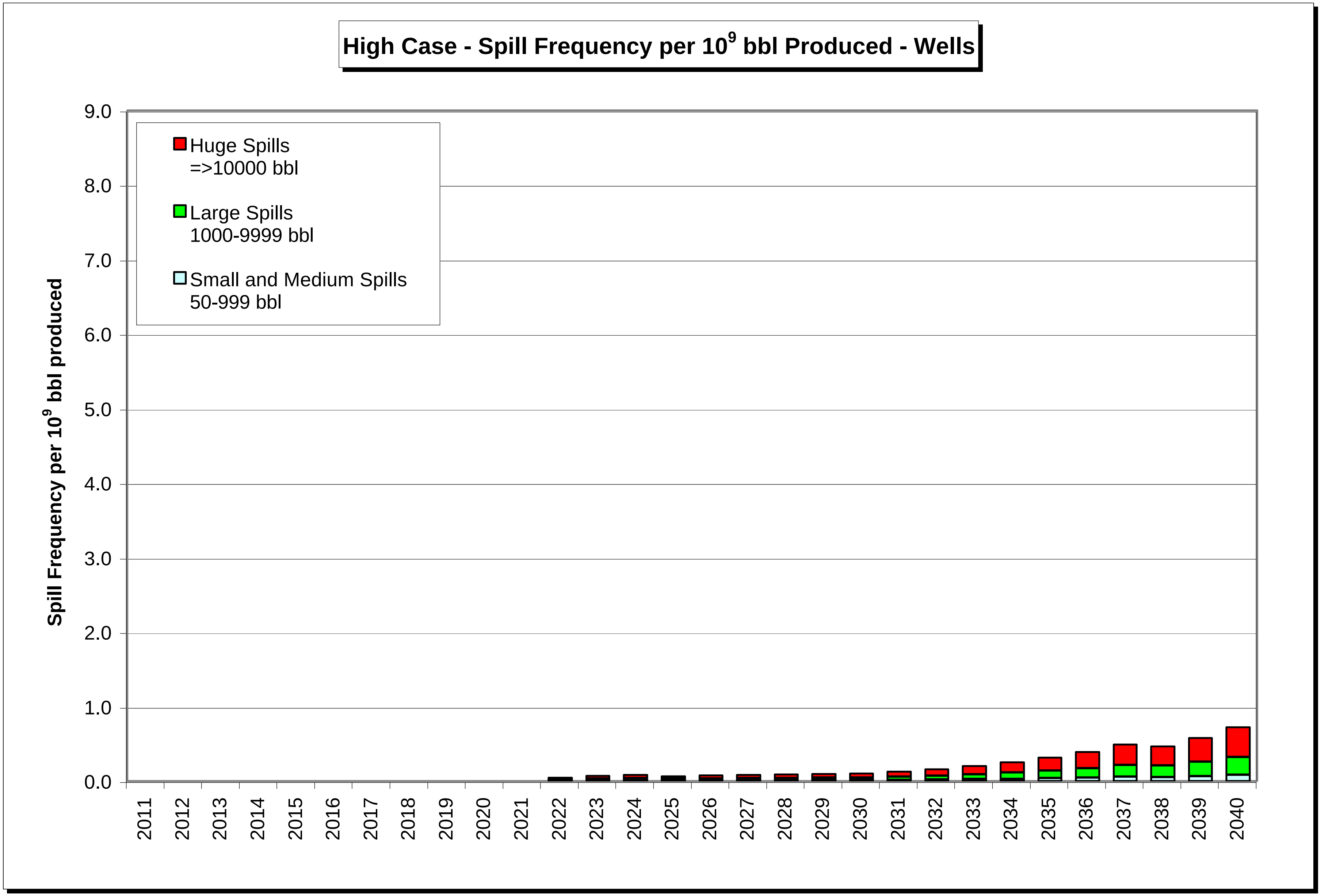
C4_2_HighCase_CS.xlsF4208



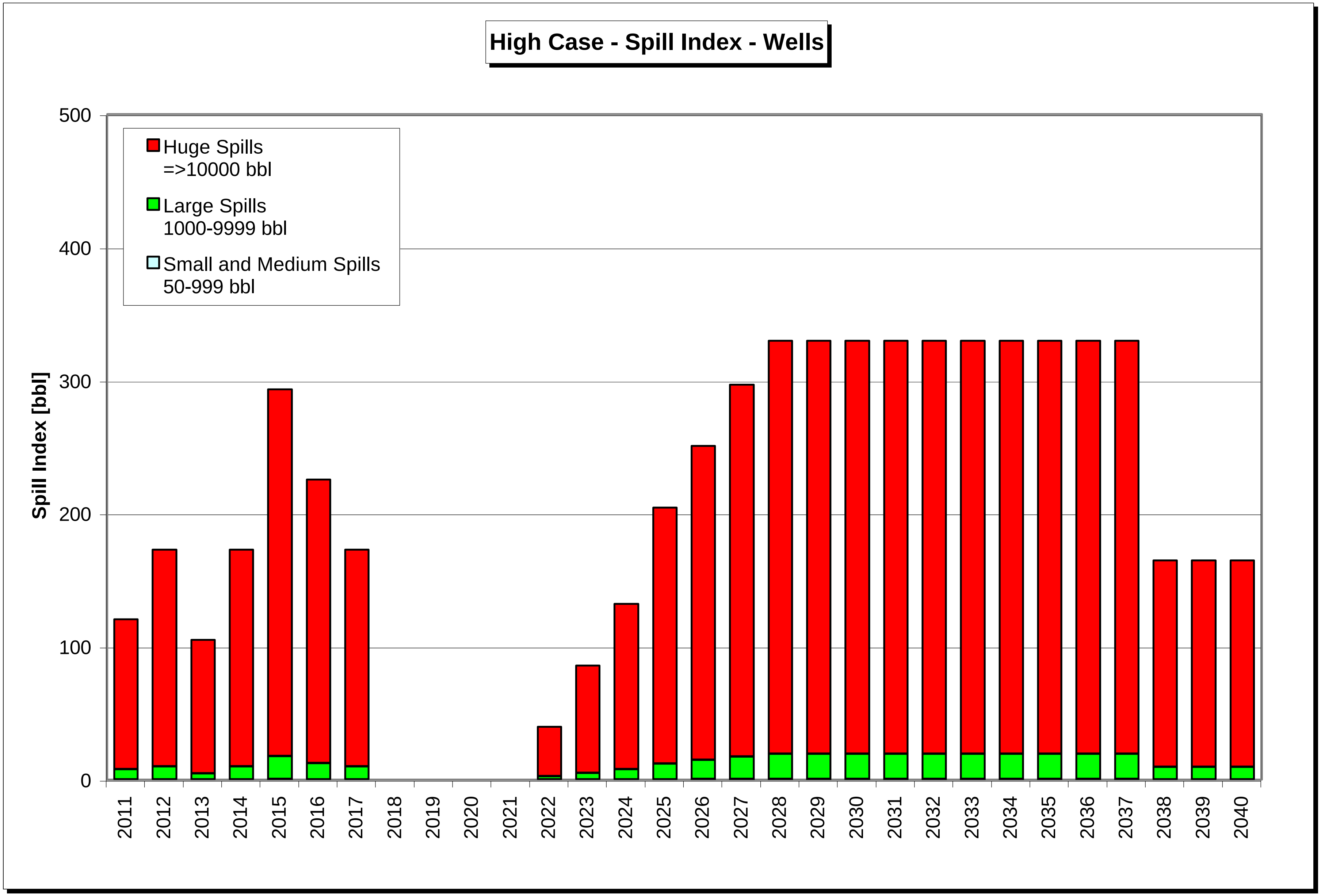
C4_2_HighCase_CS.xlsF4209



C4_2_HighCase_CS.xlsF4210



C4_2_HighCase_CS.xlsF4211



C4_2_HighCase_CS.xlsF4212

Figure 4.2.13 Spill Indicators – CDF – Year 2030

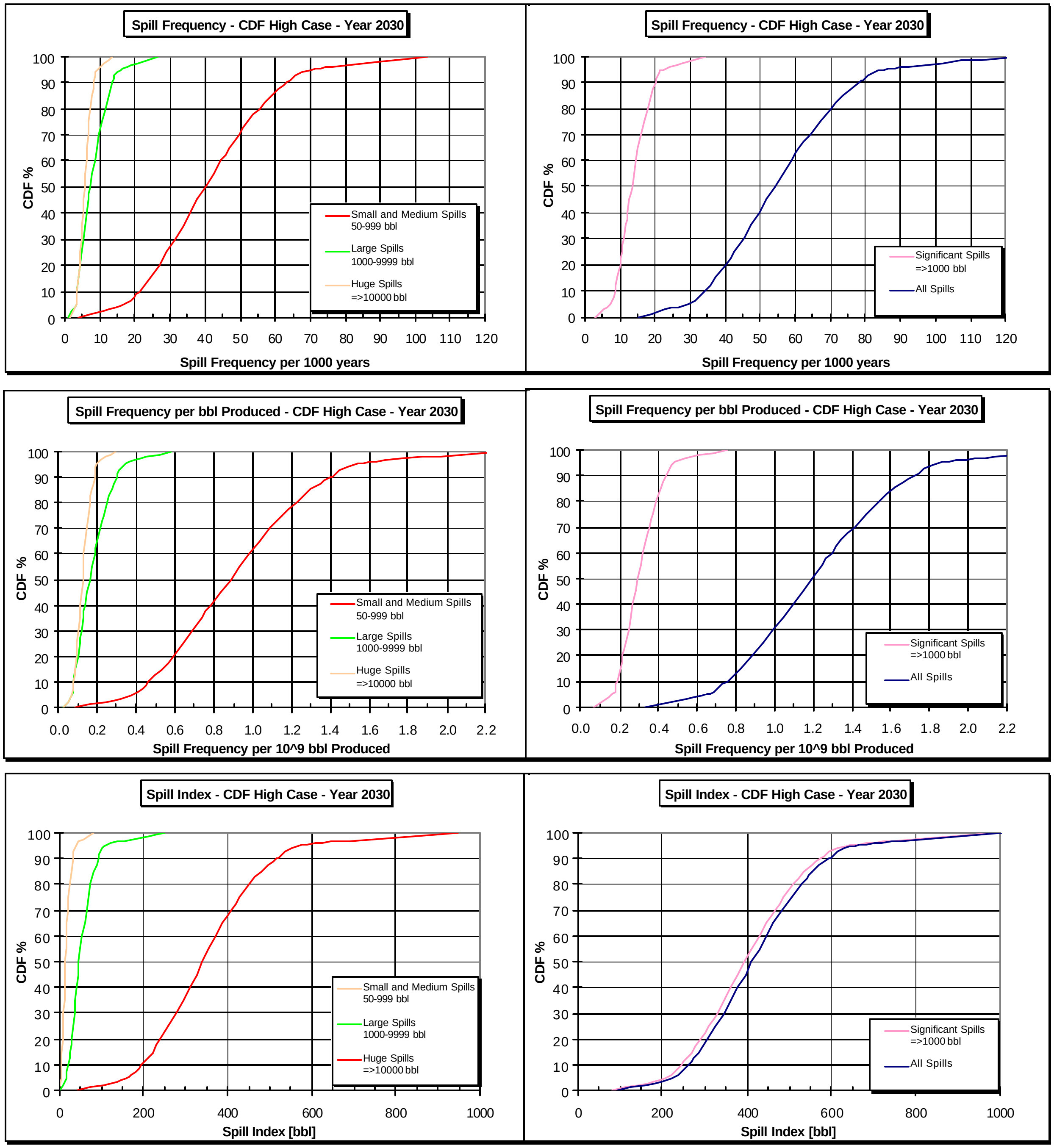


Figure 4.2.14 Spill Frequency – CDF – High Case

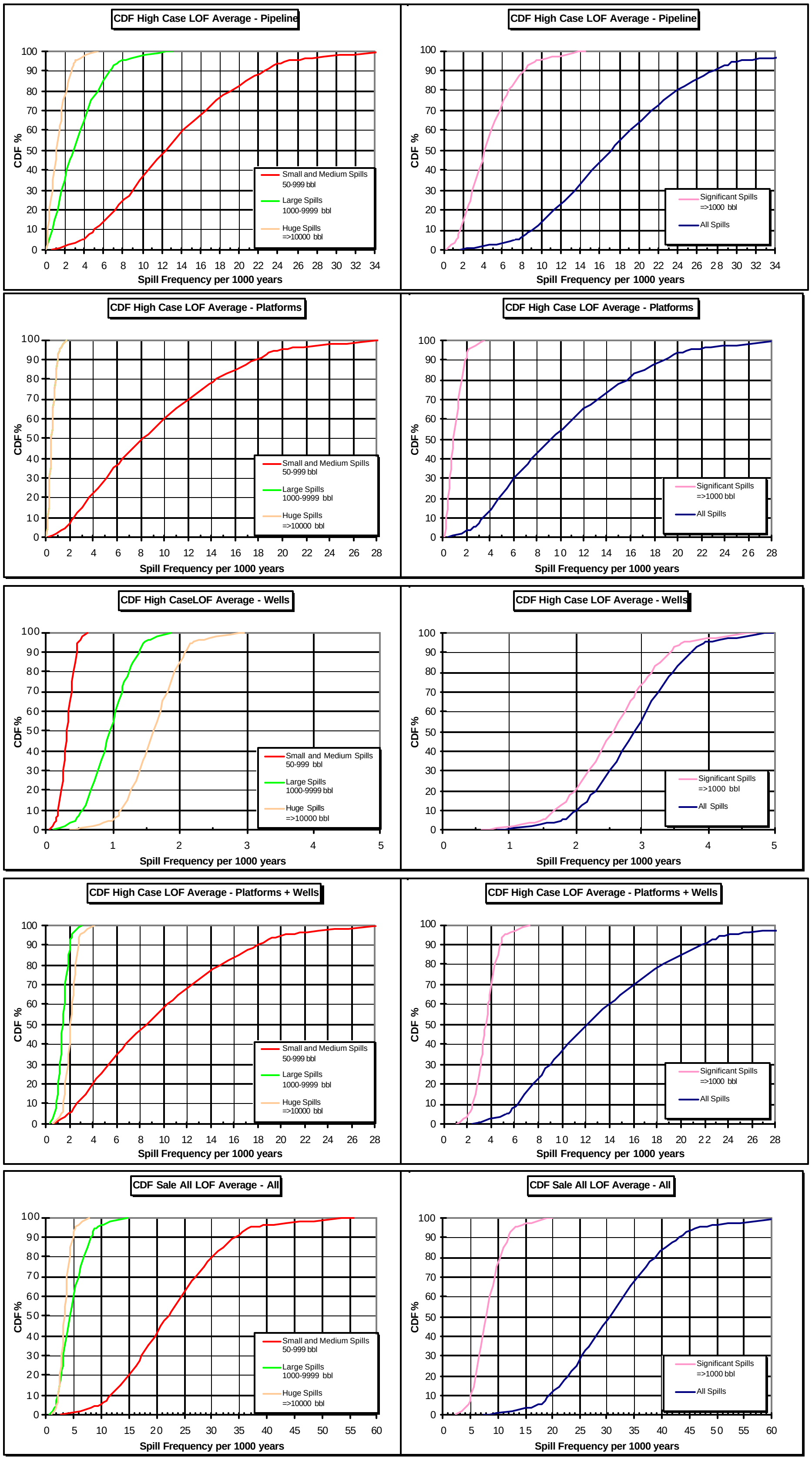
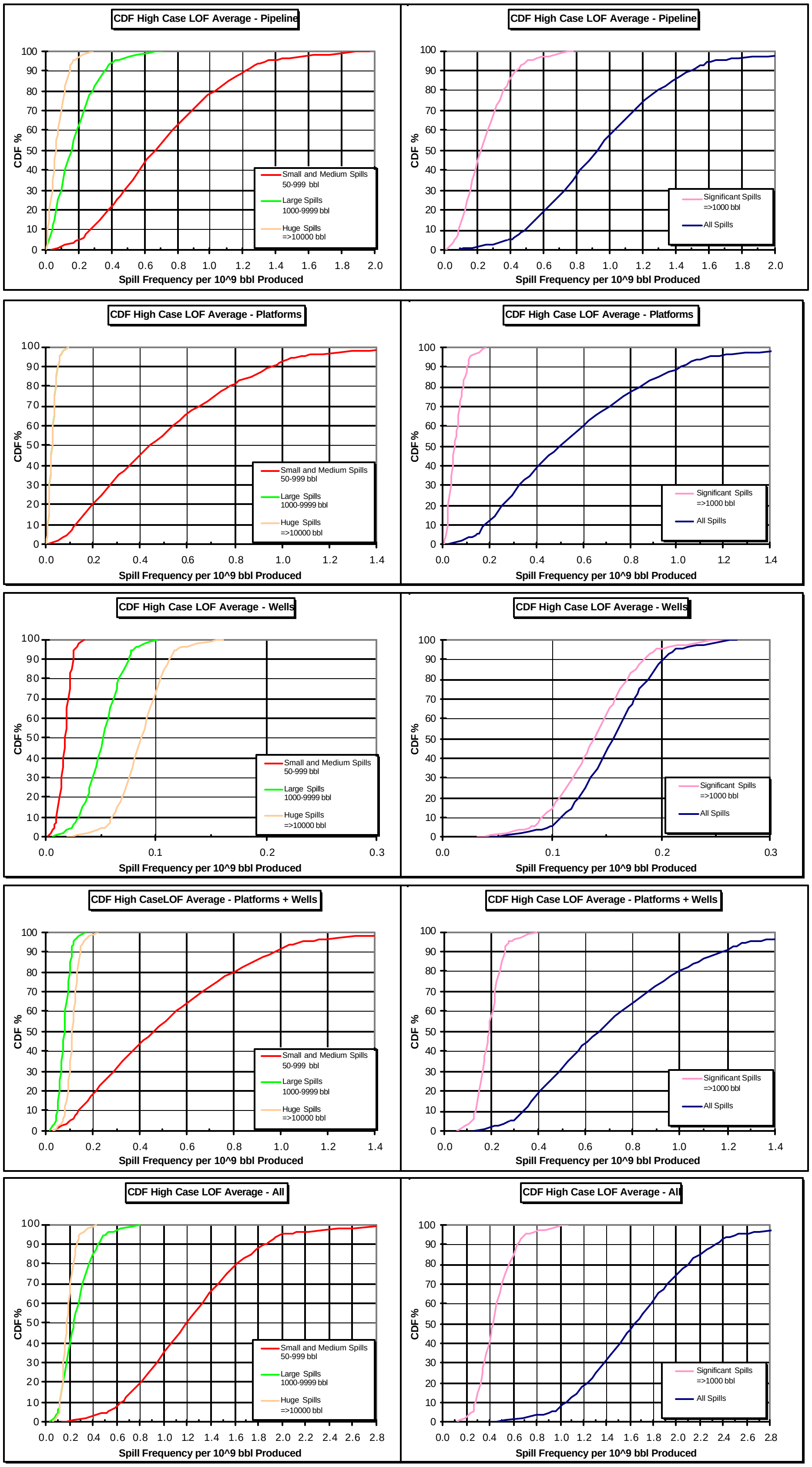


Figure 4.2.15 Spill Frequency per bbl produced – CDF – High Case



C4_2_HighCase_CS.xls F4215

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

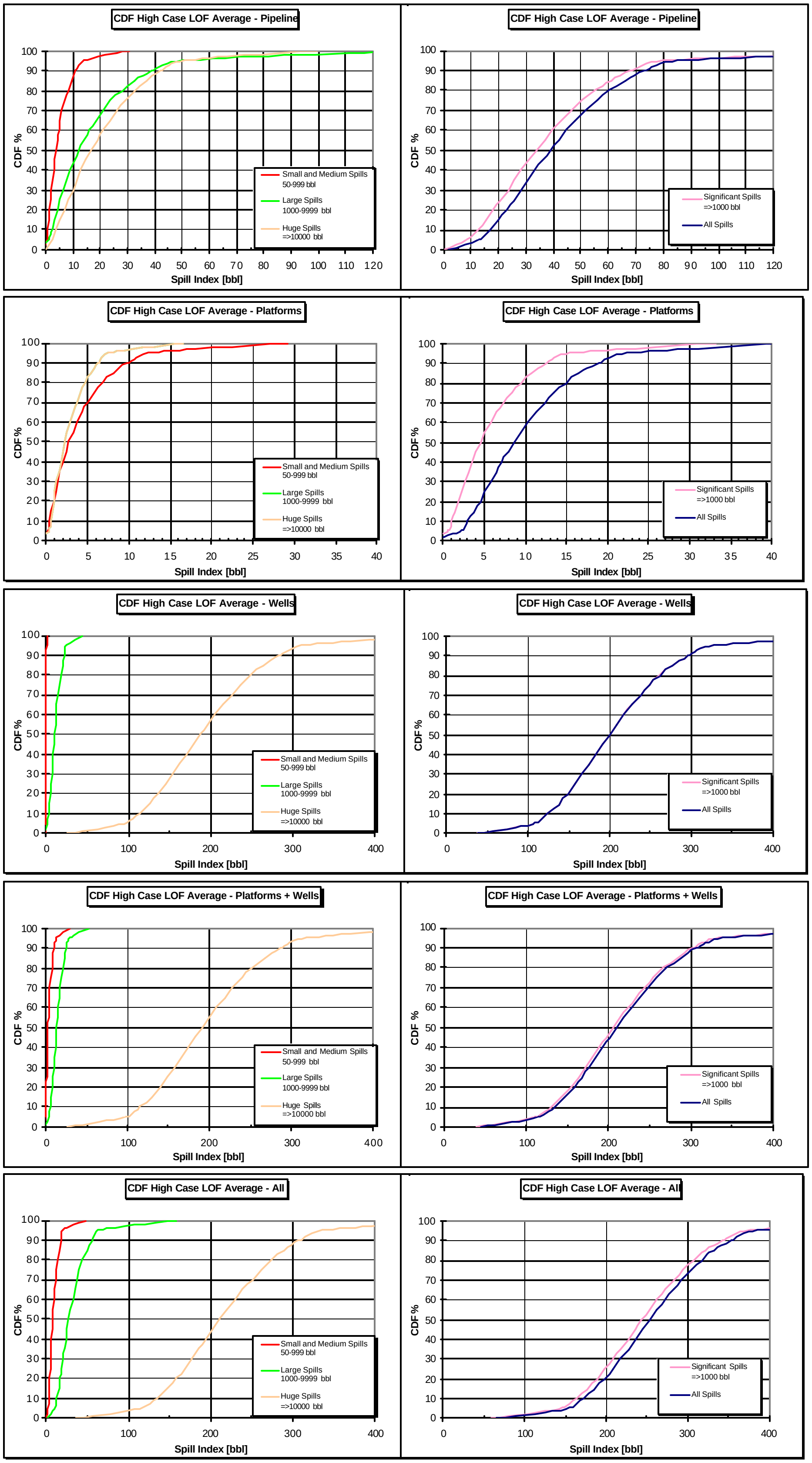


Figure 4.2.17
High Case - Year 2030 - Spill Indicators

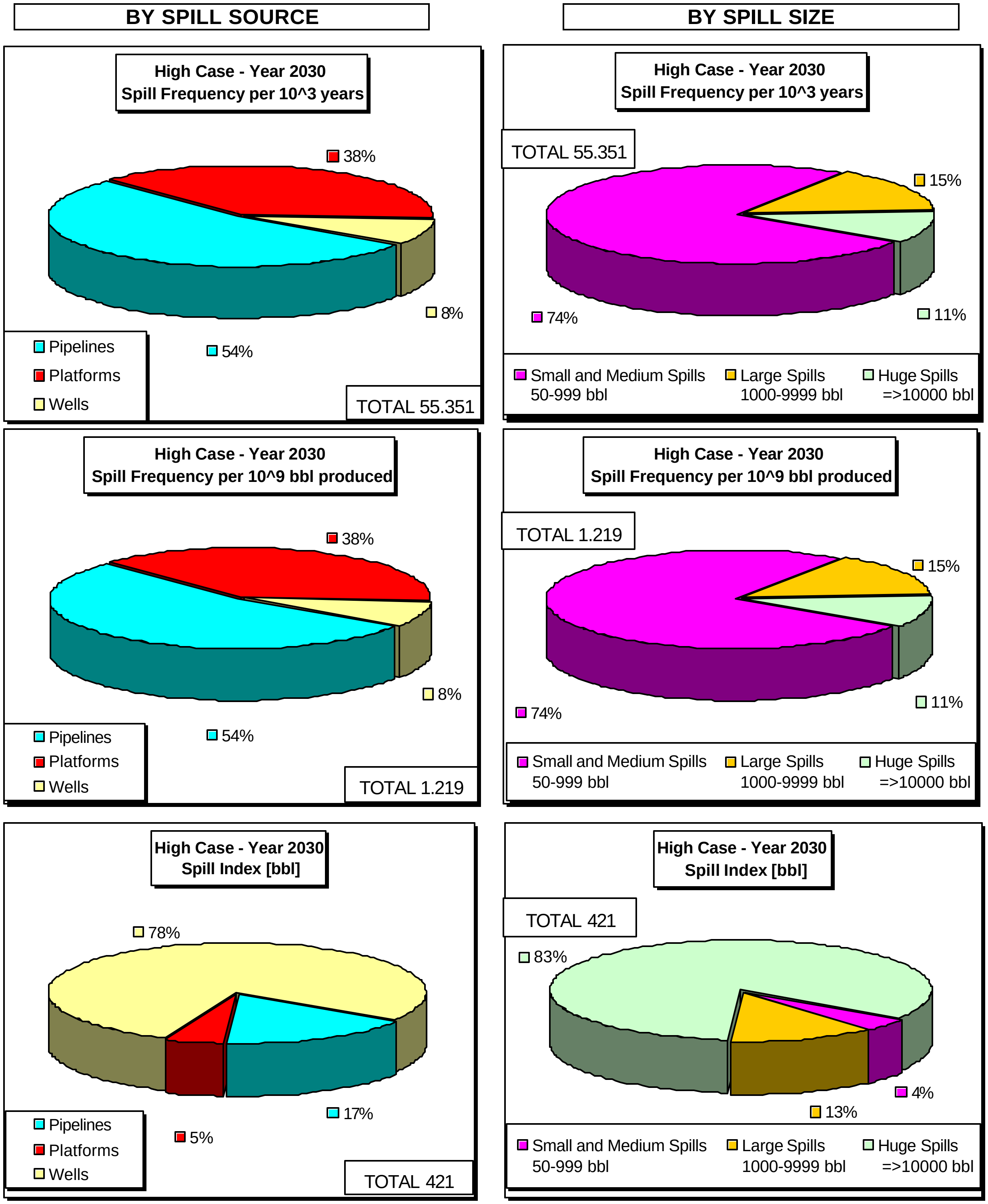


Figure 4.2.18
High Case – LOF Average Spill Indicators

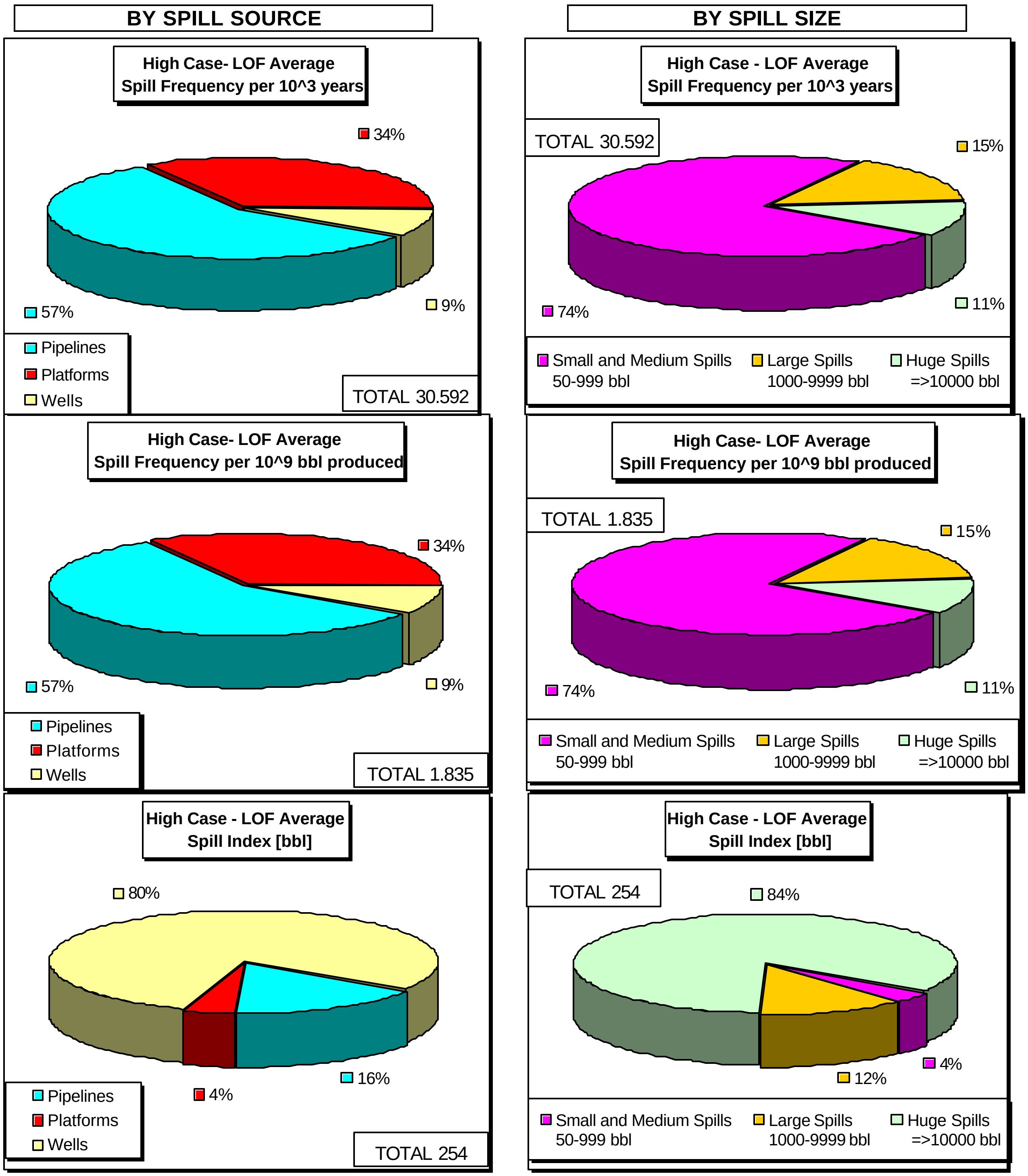


Table 4.3.1
Spill Occurrence Chukchi Sea High Case - non ArcticP/L Spills

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
2011	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																										
2012	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																										
2013	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																										
2014	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																										
2015	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																										
2016	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																										
2017	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																										
2018	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																										
2019	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			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														**10**		**2.392**	**0.17**		**2.392**	**1.23**		**1.329**	**6.88**		**0.532**	**8.27**
2020	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			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														**20**		**4.784**	**0.34**		**4.784**	**2.47**		**2.658**	**13.76**		**1.063**	**16.53**
2021	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			40	14.867	9.568	0.68	14.867	9.568	4.94	8.259	5.316	27.51	3.304	2.126	33.07
	Total														**40**		**9.568**	**0.68**		**9.568**	**4.94**		**5.316**	**27.51**		**2.126**	**33.07**
2022	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			50	14.867	11.961	0.85	14.867	11.961	6.17	8.259	6.645	34.39	3.304	2.658	41.34
	Total														**50**		**11.961**	**0.85**		**11.961**	**6.17**		**6.645**	**34.39**		**2.658**	**41.34**
2023	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			60	14.867	14.353	1.02	14.867	14.353	7.41	8.259	7.974	41.27	3.304	3.189	49.60
	Total														**60**		**14.353**	**1.02**		**14.353**	**7.41**		**7.974**	**41.27**		**3.189**	**49.60**
2024	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			80	14.867	19.137	1.36	14.867	19.137	9.87	8.259	10.632	55.03	3.304	4.253	66.14
	Total														**80**		**19.137**	**1.36**		**19.137**	**9.87**		**10.632**	**55.03**		**4.253**	**66.14**
2025	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			80	14.867	19.137	1.36	14.867	19.137	9.87	8.259	10.632	55.03	3.304	4.253	66.14
	Total														**80**		**19.137**	**1.36**		**19.137**	**9.87**		**10.632**	**55.03**		**4.253**	**66.14**
2026	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			80	14.867	19.137	1.36	14.867	19.137	9.87	8.259	10.632	55.03	3.304	4.253	66.14
	Total														**80**		**19.137**	**1.36**		**19.137**	**9.87**		**10.632**	**55.03**		**4.253**	**66.14**
2027	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			80	14.867	19.137	1.36	14.867	19.137	9.87	8.259	10.632	55.03	3.304	4.253	66.14
	Total														**80**		**19.137**	**1.36**		**19.137**	**9.87**		**10.632**	**55.03**		**4.253**	**66.14**
2028	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			80	14.867	19.137	1.36	14.867	19.137	9.87	8.259	10.632	55.03	3.304	4.253	66.14
	Total														**80**		**19.137**	**1.36**		**19.137**	**9.87**		**10.632**	**55.03**		**4.253**	**66.14**
2029	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			80	14.867	19.137	1.36	14.867	19.137	9.87	8.259	10.632	55.03	3.304	4.253	66.14
	Total														**80**		**19.137**	**1.36**		**19.137**	**9.87**		**10.632**	**55.03**		**4.253**	**66.14**
2030	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			80	14.867	19.137	1.36	14.867	19.137	9.87	8.259	10.632	55.03	3.304	4.253	66.14

Table 4.3.1
Spill Occurrence Chukchi 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														**80**		**19.137**	**1.36**		**19.137**	**9.87**		**10.632**	**55.03**		**4.253**	**66.14**
2031	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			80	14.867	19.137	1.36	14.867	19.137	9.87	8.259	10.632	55.03	3.304	4.253	66.14
	Total														**80**		**19.137**	**1.36**		**19.137**	**9.87**		**10.632**	**55.03**		**4.253**	**66.14**
2032	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			80	14.867	19.137	1.36	14.867	19.137	9.87	8.259	10.632	55.03	3.304	4.253	66.14
	Total														**80**		**19.137**	**1.36**		**19.137**	**9.87**		**10.632**	**55.03**		**4.253**	**66.14**
2033	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			80	14.867	19.137	1.36	14.867	19.137	9.87	8.259	10.632	55.03	3.304	4.253	66.14
	Total														**80**		**19.137**	**1.36**		**19.137**	**9.87**		**10.632**	**55.03**		**4.253**	**66.14**
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				14.867			14.867			8.259			3.304		
	Deep		6.036			10.563			5.282			0.755			80	14.867	19.137	1.36	14.867	19.137	9.87	8.259	10.632	55.03	3.304	4.253	66.14
	Total														**80**		**19.137**	**1.36**		**19.137**	**9.87**		**10.632**	**55.03**		**4.253**	**66.14**
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				14.867			14.867			8.259			3.304		
	Deep		6.036			10.563			5.282			0.755			80	14.867	19.137	1.36	14.867	19.137	9.87	8.259	10.632	55.03	3.304	4.253	66.14
	Total														**80**		**19.137**	**1.36**		**19.137**	**9.87**		**10.632**	**55.03**		**4.253**	**66.14**
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				14.867			14.867			8.259			3.304		
	Deep		6.036			10.563			5.282			0.755			80	14.867	19.137	1.36	14.867	19.137	9.87	8.259	10.632	55.03	3.304	4.253	66.14
	Total														**80**		**19.137**	**1.36**		**19.137**	**9.87**		**10.632**	**55.03**		**4.253**	**66.14**
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				14.867			14.867			8.259			3.304		
	Deep		6.036			10.563			5.282			0.755			80	14.867	19.137	1.36	14.867	19.137	9.87	8.259	10.632	55.03	3.304	4.253	66.14
	Total														**80**		**19.137**	**1.36**		**19.137**	**9.87**		**10.632**	**55.03**		**4.253**	**66.14**
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				14.867			14.867			8.259			3.304		
	Deep		6.036			10.563			5.282			0.755			40	14.867	9.568	0.68	14.867	9.568	4.94	8.259	5.316	27.51	3.304	2.126	33.07
	Total														**40**		**9.568**	**0.68**		**9.568**	**4.94**		**5.316**	**27.51**		**2.126**	**33.07**
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			40	14.867	9.568	0.68	14.867	9.568	4.94	8.259	5.316	27.51	3.304	2.126	33.07
	Total														**40**		**9.568**	**0.68**		**9.568**	**4.94**		**5.316**	**27.51**		**2.126**	**33.07**
2040	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			40	14.867	9.568	0.68	14.867	9.568	4.94	8.259	5.316	27.51	3.304	2.126	33.07
	Total														**40**		**9.568**	**0.68**		**9.568**	**4.94**		**5.316**	**27.51**		**2.126**	**33.07**

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]
2011																						
2012																						
2013																						
2014																						
2015																						
2016																						
2017																						
2018																						
2019		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
2020		4.784		0.341	4.784		2.468	9.568		2.809	2.658		13.757	1.063		16.534	3.721		30.291	13.289		33.100
2021		9.568		0.681	9.568		4.937	19.137		5.618	5.316		27.513	2.126		33.068	7.442		60.581	26.579		66.199
2022	**13.5**	11.961	0.886	0.851	11.961	0.886	6.171	23.921	1.772	7.022	6.645	0.492	34.391	2.658	0.197	41.335	9.303	0.689	75.727	33.224	2.461	82.749
2023	**16.9**	14.353	0.849	1.022	14.353	0.849	7.405	28.705	1.699	8.427	7.974	0.472	41.270	3.189	0.189	49.602	11.163	0.661	90.872	39.868	2.359	99.299
2024	**22.5**	19.137	0.851	1.362	19.137	0.851	9.874	38.274	1.701	11.236	10.632	0.473	55.026	4.253	0.189	66.136	14.884	0.662	121.162	53.158	2.363	132.398
2025	**43.5**	19.137	0.440	1.362	19.137	0.440	9.874	38.274	0.880	11.236	10.632	0.244	55.026	4.253	0.098	66.136	14.884	0.342	121.162	53.158	1.222	132.398
2026	**46.9**	19.137	0.408	1.362	19.137	0.408	9.874	38.274	0.816	11.236	10.632	0.227	55.026	4.253	0.091	66.136	14.884	0.317	121.162	53.158	1.133	132.398
2027	**52.5**	19.137	0.365	1.362	19.137	0.365	9.874	38.274	0.729	11.236	10.632	0.203	55.026	4.253	0.081	66.136	14.884	0.284	121.162	53.158	1.013	132.398
2028	**54.0**	19.137	0.354	1.362	19.137	0.354	9.874	38.274	0.709	11.236	10.632	0.197	55.026	4.253	0.079	66.136	14.884	0.276	121.162	53.158	0.984	132.398
2029	**49.2**	19.137	0.389	1.362	19.137	0.389	9.874	38.274	0.778	11.236	10.632	0.216	55.026	4.253	0.086	66.136	14.884	0.303	121.162	53.158	1.080	132.398
2030	**45.4**	19.137	0.422	1.362	19.137	0.422	9.874	38.274	0.843	11.236	10.632	0.234	55.026	4.253	0.094	66.136	14.884	0.328	121.162	53.158	1.171	132.398
2031	**36.3**	19.137	0.527	1.362	19.137	0.527	9.874	38.274	1.054	11.236	10.632	0.293	55.026	4.253	0.117	66.136	14.884	0.410	121.162	53.158	1.464	132.398
2032	**29.0**	19.137	0.660	1.362	19.137	0.660	9.874	38.274	1.320	11.236	10.632	0.367	55.026	4.253	0.147	66.136	14.884	0.513	121.162	53.158	1.833	132.398
2033	**23.3**	19.137	0.821	1.362	19.137	0.821	9.874	38.274	1.643	11.236	10.632	0.456	55.026	4.253	0.183	66.136	14.884	0.639	121.162	53.158	2.281	132.398
2034	**18.6**	19.137	1.029	1.362	19.137	1.029	9.874	38.274	2.058	11.236	10.632	0.572	55.026	4.253	0.229	66.136	14.884	0.800	121.162	53.158	2.858	132.398
2035	**14.8**	19.137	1.293	1.362	19.137	1.293	9.874	38.274	2.586	11.236	10.632	0.718	55.026	4.253	0.287	66.136	14.884	1.006	121.162	53.158	3.592	132.398
2036	**11.9**	19.137	1.608	1.362	19.137	1.608	9.874	38.274	3.216	11.236	10.632	0.893	55.026	4.253	0.357	66.136	14.884	1.251	121.162	53.158	4.467	132.398
2037	**9.5**	19.137	2.014	1.362	19.137	2.014	9.874	38.274	4.029	11.236	10.632	1.119	55.026	4.253	0.448	66.136	14.884	1.567	121.162	53.158	5.596	132.398
2038	**5.0**	9.568	1.914	0.681	9.568	1.914	4.937	19.137	3.827	5.618	5.316	1.063	27.513	2.126	0.425	33.068	7.442	1.488	60.581	26.579	5.316	66.199
2039	**4.0**	9.568	2.392	0.681	9.568	2.392	4.937	19.137	4.784	5.618	5.316	1.329	27.513	2.126	0.532	33.068	7.442	1.861	60.581	26.579	6.645	66.199
2040	**3.2**	9.568	2.990	0.681	9.568	2.990	4.937	19.137	5.980	5.618	5.316	1.661	27.513	2.126	0.664	33.068	7.442	2.326	60.581	26.579	8.306	66.199
Total LOF	**500.0**	**339.679**		**24**	**339.679**		**175**	**679.358**		**199**	**188.711**		**977**	**75.484**		**1174**	**264.195**		**2151**	**943.553**		**2350**
Average LOF		**11.323**	**0.679**	**1**	**11.323**	**0.679**	**6**	**22.645**	**1.359**	**7**	**6.290**	**0.377**	**33**	**2.516**	**0.151**	**39**	**8.806**	**0.528**	**72**	**31.452**	**1.887**	**78**

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: Frequency spills per 10^4 well-year	Frequency spills per 10^3 years	Spill Index bbl	Large and Huge Spills =>1000 bbl: Frequency spills per 10^4 well-year	Frequency spills per 10^3 years	Spill Index bbl
				Expected Spill [bbl] =		452	Expected Spill [bbl] =		5631
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			4.601			0.481		
	Medium			4.601			0.481		
	Deep			4.601			0.481		
	Total								
2020	Shallow			4.601			0.481		
	Medium			4.601			0.481		
	Deep			4.601			0.481		
	Total								
2021	Shallow			4.601			0.481		
	Medium			4.601			0.481		
	Deep			4.601			0.481		
	Total								
2022	Shallow			4.601			0.481		
	Medium			4.601			0.481		
	Deep	1	6	4.601	2.761	1.25	0.481	0.288	1.62
	Total	**1**	**6**		**2.761**	**1.25**		**0.288**	**1.62**
2023	Shallow			4.601			0.481		
	Medium			4.601			0.481		
	Deep	1	13	4.601	5.981	2.70	0.481	0.625	3.52
	Total	**1**	**13**		**5.981**	**2.70**		**0.625**	**3.52**
2024	Shallow			4.601			0.481		
	Medium			4.601			0.481		
	Deep	1	20	4.601	9.202	4.16	0.481	0.961	5.41
	Total	**1**	**20**		**9.202**	**4.16**		**0.961**	**5.41**
2025	Shallow			4.601			0.481		
	Medium			4.601			0.481		
	Deep	2	31	4.601	14.263	6.45	0.481	1.490	8.39
	Total	**2**	**31**		**14.263**	**6.45**		**1.490**	**8.39**
2026	Shallow			4.601			0.481		
	Medium			4.601			0.481		
	Deep	2	38	4.601	17.483	7.90	0.481	1.827	10.29
	Total	**2**	**38**		**17.483**	**7.90**		**1.827**	**10.29**
2027	Shallow			4.601			0.481		
	Medium			4.601			0.481		
	Deep	2	45	4.601	20.704	9.36	0.481	2.163	12.18

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
	Total	**2**	**45**		**20.704**	**9.36**		**2.163**	**12.18**
2028	Shallow			4.601			0.481		
	Medium			4.601			0.481		
	Deep	2	50	4.601	23.005	10.40	0.481	2.403	13.53
	Total	**2**	**50**		**23.005**	**10.40**		**2.403**	**13.53**
2029	Shallow			4.601			0.481		
	Medium			4.601			0.481		
	Deep	2	50	4.601	23.005	10.40	0.481	2.403	13.53
	Total	**2**	**50**		**23.005**	**10.40**		**2.403**	**13.53**
2030	Shallow			4.601			0.481		
	Medium			4.601			0.481		
	Deep	2	50	4.601	23.005	10.40	0.481	2.403	13.53
	Total	**2**	**50**		**23.005**	**10.40**		**2.403**	**13.53**
2031	Shallow			4.601			0.481		
	Medium			4.601			0.481		
	Deep	2	50	4.601	23.005	10.40	0.481	2.403	13.53
	Total	**2**	**50**		**23.005**	**10.40**		**2.403**	**13.53**
2032	Shallow			4.601			0.481		
	Medium			4.601			0.481		
	Deep	2	50	4.601	23.005	10.40	0.481	2.403	13.53
	Total	**2**	**50**		**23.005**	**10.40**		**2.403**	**13.53**
2033	Shallow			4.601			0.481		
	Medium			4.601			0.481		
	Deep	2	50	4.601	23.005	10.40	0.481	2.403	13.53
	Total	**2**	**50**		**23.005**	**10.40**		**2.403**	**13.53**
2034	Shallow			4.601			0.481		
	Medium			4.601			0.481		
	Deep	2	50	4.601	23.005	10.40	0.481	2.403	13.53
	Total	**2**	**50**		**23.005**	**10.40**		**2.403**	**13.53**
2035	Shallow			4.601			0.481		
	Medium			4.601			0.481		
	Deep	2	50	4.601	23.005	10.40	0.481	2.403	13.53
	Total	**2**	**50**		**23.005**	**10.40**		**2.403**	**13.53**
2036	Shallow			4.601			0.481		
	Medium			4.601			0.481		
	Deep	2	50	4.601	23.005	10.40	0.481	2.403	13.53
	Total	**2**	**50**		**23.005**	**10.40**		**2.403**	**13.53**
2037	Shallow			4.601			0.481		
	Medium			4.601			0.481		
	Deep	2	50	4.601	23.005	10.40	0.481	2.403	13.53
	Total	**2**	**50**		**23.005**	**10.40**		**2.403**	**13.53**
2038	Shallow			4.601			0.481		
	Medium			4.601			0.481		
	Deep	1	25	4.601	11.502	5.20	0.481	1.202	6.77
	Total	**1**	**25**		**11.502**	**5.20**		**1.202**	**6.77**
2039	Shallow			4.601			0.481		
	Medium			4.601			0.481		
	Deep	1	25	4.601	11.502	5.20	0.481	1.202	6.77
	Total	**1**	**25**		**11.502**	**5.20**		**1.202**	**6.77**
2040	Shallow			4.601			0.481		
	Medium			4.601			0.481		
	Deep	1	25	4.601	11.502	5.20	0.481	1.202	6.77
	Total	**1**	**25**		**11.502**	**5.20**		**1.202**	**6.77**

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]
2011													
2012													
2013													
2014													
2015													
2016													
2017													
2018													
2019													
2020													
2021													
2022	**13.5**	2.761	0.204	1.248	0.288	0.021	1.624	0.288	0.021	1.624	3.049	0.226	2.872
2023	**16.9**	5.981	0.354	2.703	0.625	0.037	3.519	0.625	0.037	3.519	6.606	0.391	6.222
2024	**22.5**	9.202	0.409	4.158	0.961	0.043	5.414	0.961	0.043	5.414	10.163	0.452	9.572
2025	**43.5**	14.263	0.328	6.446	1.490	0.034	8.391	1.490	0.034	8.391	15.753	0.362	14.837
2026	**46.9**	17.483	0.373	7.901	1.827	0.039	10.286	1.827	0.039	10.286	19.310	0.412	18.187
2027	**52.5**	20.704	0.394	9.357	2.163	0.041	12.180	2.163	0.041	12.180	22.867	0.436	21.537
2028	**54.0**	23.005	0.426	10.396	2.403	0.045	13.534	2.403	0.045	13.534	25.408	0.471	23.930
2029	**49.2**	23.005	0.468	10.396	2.403	0.049	13.534	2.403	0.049	13.534	25.408	0.516	23.930
2030	**45.4**	23.005	0.507	10.396	2.403	0.053	13.534	2.403	0.053	13.534	25.408	0.560	23.930
2031	**36.3**	23.005	0.634	10.396	2.403	0.066	13.534	2.403	0.066	13.534	25.408	0.700	23.930
2032	**29.0**	23.005	0.793	10.396	2.403	0.083	13.534	2.403	0.083	13.534	25.408	0.876	23.930
2033	**23.3**	23.005	0.987	10.396	2.403	0.103	13.534	2.403	0.103	13.534	25.408	1.090	23.930
2034	**18.6**	23.005	1.237	10.396	2.403	0.129	13.534	2.403	0.129	13.534	25.408	1.366	23.930
2035	**14.8**	23.005	1.554	10.396	2.403	0.162	13.534	2.403	0.162	13.534	25.408	1.717	23.930
2036	**11.9**	23.005	1.933	10.396	2.403	0.202	13.534	2.403	0.202	13.534	25.408	2.135	23.930
2037	**9.5**	23.005	2.422	10.396	2.403	0.253	13.534	2.403	0.253	13.534	25.408	2.675	23.930
2038	**5.0**	11.502	2.300	5.198	1.202	0.240	6.767	1.202	0.240	6.767	12.704	2.541	11.965
2039	**4.0**	11.502	2.876	5.198	1.202	0.300	6.767	1.202	0.300	6.767	12.704	3.176	11.965
2040	**3.2**	11.502	3.594	5.198	1.202	0.376	6.767	1.202	0.376	6.767	12.704	3.970	11.965
Total LOF	**500.0**	**334.946**		**151**	**34.994**		**197**	**34.994**		**197**	**369.940**		**348**
Average LOF		**11.165**	**0.670**	**5**	**1.166**	**0.070**	**7**	**1.166**	**0.070**	**7**	**12.331**	**0.740**	**12**

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 10^4well-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
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		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													
2020	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													
2021	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													
2022	Shallow		0.147			1.026			0.440			0.293		
	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	**6**		0.088	**0.05**		0.616	**3.26**		0.264	**18.03**		0.176	**35.18**
2023	Shallow		0.147			1.026			0.440			0.293		
	Medium		0.147			1.026			0.440			0.293		
	Deep	13	0.147	0.191	0.10	1.026	1.334	7.06	0.440	0.572	39.08	0.293	0.381	76.23
	Total	**13**		0.191	**0.10**		1.334	**7.06**		0.572	**39.08**		0.381	**76.23**
2024	Shallow		0.147			1.026			0.440			0.293		
	Medium		0.147			1.026			0.440			0.293		
	Deep	20	0.147	0.293	0.15	1.026	2.052	10.86	0.440	0.880	60.12	0.293	0.586	117.27
	Total	**20**		0.293	**0.15**		2.052	**10.86**		0.880	**60.12**		0.586	**117.27**
2025	Shallow		0.147			1.026			0.440			0.293		
	Medium		0.147			1.026			0.440			0.293		
	Deep	31	0.147	0.454	0.24	1.026	3.181	16.83	0.440	1.363	93.18	0.293	0.909	181.77
	Total	**31**		0.454	**0.24**		3.181	**16.83**		1.363	**93.18**		0.909	**181.77**
2026	Shallow		0.147			1.026			0.440			0.293		
	Medium		0.147			1.026			0.440			0.293		
	Deep	38	0.147	0.557	0.29	1.026	3.899	20.64	0.440	1.671	114.22	0.293	1.114	222.82
	Total	**38**		0.557	**0.29**		3.899	**20.64**		1.671	**114.22**		1.114	**222.82**
2027	Shallow		0.147			1.026			0.440			0.293		
	Medium		0.147			1.026			0.440			0.293		
	Deep	45	0.147	0.660	0.34	1.026	4.618	24.44	0.440	1.979	135.26	0.293	1.319	263.86
	Total	**45**		0.660	**0.34**		4.618	**24.44**		1.979	**135.26**		1.319	**263.86**
2028	Shallow		0.147			1.026			0.440			0.293		
	Medium		0.147			1.026			0.440			0.293		
	Deep	50	0.147	0.733	0.38	1.026	5.131	27.15	0.440	2.199	150.29	0.293	1.466	293.18
	Total	**50**		0.733	**0.38**		5.131	**27.15**		2.199	**150.29**		1.466	**293.18**

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 10^4 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		0.147			1.026			0.440			0.293		
	Medium		0.147			1.026			0.440			0.293		
	Deep	50	0.147	0.733	0.38	1.026	5.131	27.15	0.440	2.199	150.29	0.293	1.466	293.18
	Total	**50**		0.733	**0.38**		5.131	**27.15**		2.199	**150.29**		1.466	**293.18**
2030	Shallow		0.147			1.026			0.440			0.293		
	Medium		0.147			1.026			0.440			0.293		
	Deep	50	0.147	0.733	0.38	1.026	5.131	27.15	0.440	2.199	150.29	0.293	1.466	293.18
	Total	**50**		0.733	**0.38**		5.131	**27.15**		2.199	**150.29**		1.466	**293.18**
2031	Shallow		0.147			1.026			0.440			0.293		
	Medium		0.147			1.026			0.440			0.293		
	Deep	50	0.147	0.733	0.38	1.026	5.131	27.15	0.440	2.199	150.29	0.293	1.466	293.18
	Total	**50**		0.733	**0.38**		5.131	**27.15**		2.199	**150.29**		1.466	**293.18**
2032	Shallow		0.147			1.026			0.440			0.293		
	Medium		0.147			1.026			0.440			0.293		
	Deep	50	0.147	0.733	0.38	1.026	5.131	27.15	0.440	2.199	150.29	0.293	1.466	293.18
	Total	**50**		0.733	**0.38**		5.131	**27.15**		2.199	**150.29**		1.466	**293.18**
2033	Shallow		0.147			1.026			0.440			0.293		
	Medium		0.147			1.026			0.440			0.293		
	Deep	50	0.147	0.733	0.38	1.026	5.131	27.15	0.440	2.199	150.29	0.293	1.466	293.18
	Total	**50**		0.733	**0.38**		5.131	**27.15**		2.199	**150.29**		1.466	**293.18**
2034	Shallow		0.147			1.026			0.440			0.293		
	Medium		0.147			1.026			0.440			0.293		
	Deep	50	0.147	0.733	0.38	1.026	5.131	27.15	0.440	2.199	150.29	0.293	1.466	293.18
	Total	**50**		0.733	**0.38**		5.131	**27.15**		2.199	**150.29**		1.466	**293.18**
2035	Shallow		0.147			1.026			0.440			0.293		
	Medium		0.147			1.026			0.440			0.293		
	Deep	50	0.147	0.733	0.38	1.026	5.131	27.15	0.440	2.199	150.29	0.293	1.466	293.18
	Total	**50**		0.733	**0.38**		5.131	**27.15**		2.199	**150.29**		1.466	**293.18**
2036	Shallow		0.147			1.026			0.440			0.293		
	Medium		0.147			1.026			0.440			0.293		
	Deep	50	0.147	0.733	0.38	1.026	5.131	27.15	0.440	2.199	150.29	0.293	1.466	293.18
	Total	**50**		0.733	**0.38**		5.131	**27.15**		2.199	**150.29**		1.466	**293.18**
2037	Shallow		0.147			1.026			0.440			0.293		
	Medium		0.147			1.026			0.440			0.293		
	Deep	50	0.147	0.733	0.38	1.026	5.131	27.15	0.440	2.199	150.29	0.293	1.466	293.18
	Total	**50**		0.733	**0.38**		5.131	**27.15**		2.199	**150.29**		1.466	**293.18**
2038	Shallow		0.147			1.026			0.440			0.293		
	Medium		0.147			1.026			0.440			0.293		
	Deep	25	0.147	0.366	0.19	1.026	2.565	13.58	0.440	1.099	75.14	0.293	0.733	146.59
	Total	**25**		0.366	**0.19**		2.565	**13.58**		1.099	**75.14**		0.733	**146.59**
2039	Shallow		0.147			1.026			0.440			0.293		
	Medium		0.147			1.026			0.440			0.293		
	Deep	25	0.147	0.366	0.19	1.026	2.565	13.58	0.440	1.099	75.14	0.293	0.733	146.59
	Total	**25**		0.366	**0.19**		2.565	**13.58**		1.099	**75.14**		0.733	**146.59**
2040	Shallow		0.147			1.026			0.440			0.293		
	Medium		0.147			1.026			0.440			0.293		
	Deep	25	0.147	0.366	0.19	1.026	2.565	13.58	0.440	1.099	75.14	0.293	0.733	146.59
	Total	**25**		0.366	**0.19**		2.565	**13.58**		1.099	**75.14**		0.733	**146.59**

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 10^3 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]
2011													
2012													
2013													
2014													
2015													
2016													
2017													
2018													
2019													
2020													
2021													
2022	**13.5**	0.088	0.007	0.046	0.264	0.020	3.258	0.440	0.033	53.216	0.792	0.059	56.520
2023	**16.9**	0.191	0.011	0.099	0.572	0.034	7.060	0.953	0.056	115.302	1.715	0.101	122.461
2024	**22.5**	0.293	0.013	0.152	0.880	0.039	10.861	1.466	0.065	177.388	2.639	0.117	188.401
2025	**43.5**	0.454	0.010	0.236	1.363	0.031	16.834	2.272	0.052	274.952	4.090	0.094	292.022
2026	**46.9**	0.557	0.012	0.289	1.671	0.036	20.636	2.785	0.059	337.038	5.013	0.107	357.962
2027	**52.5**	0.660	0.013	0.343	1.979	0.038	24.437	3.298	0.063	399.123	5.937	0.113	423.903
2028	**54.0**	0.733	0.014	0.381	2.199	0.041	27.152	3.665	0.068	443.470	6.597	0.122	471.003
2029	**49.2**	0.733	0.015	0.381	2.199	0.045	27.152	3.665	0.074	443.470	6.597	0.134	471.003
2030	**45.4**	0.733	0.016	0.381	2.199	0.048	27.152	3.665	0.081	443.470	6.597	0.145	471.003
2031	**36.3**	0.733	0.020	0.381	2.199	0.061	27.152	3.665	0.101	443.470	6.597	0.182	471.003
2032	**29.0**	0.733	0.025	0.381	2.199	0.076	27.152	3.665	0.126	443.470	6.597	0.227	471.003
2033	**23.3**	0.733	0.031	0.381	2.199	0.094	27.152	3.665	0.157	443.470	6.597	0.283	471.003
2034	**18.6**	0.733	0.039	0.381	2.199	0.118	27.152	3.665	0.197	443.470	6.597	0.355	471.003
2035	**14.8**	0.733	0.050	0.381	2.199	0.149	27.152	3.665	0.248	443.470	6.597	0.446	471.003
2036	**11.9**	0.733	0.062	0.381	2.199	0.185	27.152	3.665	0.308	443.470	6.597	0.554	471.003
2037	**9.5**	0.733	0.077	0.381	2.199	0.231	27.152	3.665	0.386	443.470	6.597	0.694	471.003
2038	**5.0**	0.366	0.073	0.190	1.099	0.220	13.576	1.832	0.366	221.735	3.298	0.660	235.502
2039	**4.0**	0.366	0.092	0.190	1.099	0.275	13.576	1.832	0.458	221.735	3.298	0.825	235.502
2040	**3.2**	0.366	0.115	0.190	1.099	0.344	13.576	1.832	0.573	221.735	3.298	1.031	235.502

Table 4.3.7
Occurrence Spill Risks - High Case non Arctic - 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
2011	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**
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		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													
2014	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**
2015	Shallow		2.262			15.824			6.799			3.936		
	Medium		2.262			15.824			6.799			3.936		
	Deep	2	2.262	0.452	0.23	15.824	3.165	16.75	6.799	1.360	92.94	3.936	0.787	157.45
	Total	**2**		0.452	**0.23**		3.165	**16.75**		1.360	**92.94**		0.787	**157.45**
2016	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**
2017	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**
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													
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													

Table 4.3.7
Occurrence Spill Risks - High Case non Arctic - 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
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													
2040	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]
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													
2014		0.226		0.117	0.680		8.374	1.074		125.199	1.980		133.690
2015		0.452		0.235	1.360		16.749	2.147		250.397	3.959		267.381
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													
2020													
2021													
2022	13.5												
2023	16.9												
2024	22.5												
2025	43.5												
2026	46.9												
2027	52.5												
2028	54.0												
2029	49.2												
2030	45.4												
2031	36.3												
2032	29.0												
2033	23.3												
2034	18.6												
2035	14.8												
2036	11.9												
2037	9.5												
2038	5.0												
2039	4.0												
2040	3.2												

Table 4.3.9
Spill Occurrence Chukchi 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
2011	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													
2012	Shallow		0.692			4.833			2.076			2.076		
	Medium		0.692			4.833			2.076			2.076		
	Deep	1	0.692	0.069	0.04	4.833	0.483	2.56	2.076	0.208	14.19	2.076	0.208	41.52
	Total	**1**		0.069	**0.04**		0.483	**2.56**		0.208	**14.19**		0.208	**41.52**
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	1	0.692	0.069	0.04	4.833	0.483	2.56	2.076	0.208	14.19	2.076	0.208	41.52
	Total	**1**		0.069	**0.04**		0.483	**2.56**		0.208	**14.19**		0.208	**41.52**
2015	Shallow		0.692			4.833			2.076			2.076		
	Medium		0.692			4.833			2.076			2.076		
	Deep	1	0.692	0.069	0.04	4.833	0.483	2.56	2.076	0.208	14.19	2.076	0.208	41.52
	Total	**1**		0.069	**0.04**		0.483	**2.56**		0.208	**14.19**		0.208	**41.52**
2016	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**
2017	Shallow		0.692			4.833			2.076			2.076		
	Medium		0.692			4.833			2.076			2.076		
	Deep	1	0.692	0.069	0.04	4.833	0.483	2.56	2.076	0.208	14.19	2.076	0.208	41.52
	Total	**1**		0.069	**0.04**		0.483	**2.56**		0.208	**14.19**		0.208	**41.52**
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													
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													

Table 4.3.9
Spill Occurrence Chukchi 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
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													
2040	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]
2011													
2012		0.069		0.036	0.208		2.558	0.415		55.710	0.692		58.304
2013		0.138		0.072	0.415		5.116	0.830		111.421	1.384		116.608
2014		0.069		0.036	0.208		2.558	0.415		55.710	0.692		58.304
2015		0.069		0.036	0.208		2.558	0.415		55.710	0.692		58.304
2016		0.138		0.072	0.415		5.116	0.830		111.421	1.384		116.608
2017		0.069		0.036	0.208		2.558	0.415		55.710	0.692		58.304
2018													
2019													
2020													
2021													
2022	13.5												
2023	16.9												
2024	22.5												
2025	43.5												
2026	46.9												
2027	52.5												
2028	54.0												
2029	49.2												
2030	45.4												
2031	36.3												
2032	29.0												
2033	23.3												
2034	18.6												
2035	14.8												
2036	11.9												
2037	9.5												
2038	5.0												
2039	4.0												
2040	3.2												

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]
2011		0.226		0.117	0.680		8.374	1.074		125.199	1.753		133.573	1.980		133.690
2012		0.295		0.153	0.888		10.932	1.489		180.909	2.376		191.841	2.672		191.995
2013		0.138		0.072	0.415		5.116	0.830		111.421	1.246		116.536	1.384		116.608
2014		0.295		0.153	0.888		10.932	1.489		180.909	2.376		191.841	2.672		191.995
2015		0.522		0.271	1.567		19.307	2.562		306.108	4.130		325.414	4.651		325.685
2016		0.365		0.189	1.095		13.490	1.904		236.619	2.999		250.109	3.364		250.299
2017		0.295		0.153	0.888		10.932	1.489		180.909	2.376		191.841	2.672		191.995
2018																
2019																
2020																
2021																
2022	**13.5**	0.088	0.007	0.046	0.264	0.020	3.258	0.440	0.033	53.216	0.704	0.052	56.475	0.792	0.059	56.520
2023	**16.9**	0.191	0.011	0.099	0.572	0.034	7.060	0.953	0.056	115.302	1.525	0.090	122.362	1.715	0.101	122.461
2024	**22.5**	0.293	0.013	0.152	0.880	0.039	10.861	1.466	0.065	177.388	2.345	0.104	188.249	2.639	0.117	188.401
2025	**43.5**	0.454	0.010	0.236	1.363	0.031	16.834	2.272	0.052	274.952	3.635	0.084	291.786	4.090	0.094	292.022
2026	**46.9**	0.557	0.012	0.289	1.671	0.036	20.636	2.785	0.059	337.038	4.456	0.095	357.673	5.013	0.107	357.962
2027	**52.5**	0.660	0.013	0.343	1.979	0.038	24.437	3.298	0.063	399.123	5.277	0.101	423.560	5.937	0.113	423.903
2028	**54.0**	0.733	0.014	0.381	2.199	0.041	27.152	3.665	0.068	443.470	5.864	0.109	470.622	6.597	0.122	471.003
2029	**49.2**	0.733	0.015	0.381	2.199	0.045	27.152	3.665	0.074	443.470	5.864	0.119	470.622	6.597	0.134	471.003
2030	**45.4**	0.733	0.016	0.381	2.199	0.048	27.152	3.665	0.081	443.470	5.864	0.129	470.622	6.597	0.145	471.003
2031	**36.3**	0.733	0.020	0.381	2.199	0.061	27.152	3.665	0.101	443.470	5.864	0.162	470.622	6.597	0.182	471.003
2032	**29.0**	0.733	0.025	0.381	2.199	0.076	27.152	3.665	0.126	443.470	5.864	0.202	470.622	6.597	0.227	471.003
2033	**23.3**	0.733	0.031	0.381	2.199	0.094	27.152	3.665	0.157	443.470	5.864	0.252	470.622	6.597	0.283	471.003
2034	**18.6**	0.733	0.039	0.381	2.199	0.118	27.152	3.665	0.197	443.470	5.864	0.315	470.622	6.597	0.355	471.003
2035	**14.8**	0.733	0.050	0.381	2.199	0.149	27.152	3.665	0.248	443.470	5.864	0.396	470.622	6.597	0.446	471.003
2036	**11.9**	0.733	0.062	0.381	2.199	0.185	27.152	3.665	0.308	443.470	5.864	0.493	470.622	6.597	0.554	471.003
2037	**9.5**	0.733	0.077	0.381	2.199	0.231	27.152	3.665	0.386	443.470	5.864	0.617	470.622	6.597	0.694	471.003
2038	**5.0**	0.366	0.073	0.190	1.099	0.220	13.576	1.832	0.366	221.735	2.932	0.586	235.311	3.298	0.660	235.502
2039	**4.0**	0.366	0.092	0.190	1.099	0.275	13.576	1.832	0.458	221.735	2.932	0.733	235.311	3.298	0.825	235.502
2040	**3.2**	0.366	0.115	0.190	1.099	0.344	13.576	1.832	0.573	221.735	2.932	0.916	235.311	3.298	1.031	235.502
Total LOF	**500.0**	**12.809**		**7**	**38.436**		**474**	**64.196**		**7779**	**102.631**		**8253**	**115.440**		**8260**
Average LOF		**0.427**	**0.026**	**0**	**1.281**	**0.077**	**16**	**2.140**	**0.128**	**259**	**3.421**	**0.205**	**275**	**3.848**	**0.231**	**275**

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]
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													
	Total		0.226		0.117	0.680		8.374	1.074		125.199	1.980		133.690
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		0.069		0.036	0.208		2.558	0.415		55.710	0.692		58.304
	Total		0.295		0.153	0.888		10.932	1.489		180.909	2.672		191.995
2013	Pipeline													
	Platforms													
	Production Wells													
	Exploration Wells													
	Development Wells		0.138		0.072	0.415		5.116	0.830		111.421	1.384		116.608
	Total		0.138		0.072	0.415		5.116	0.830		111.421	1.384		116.608
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		0.069		0.036	0.208		2.558	0.415		55.710	0.692		58.304
	Total		0.295		0.153	0.888		10.932	1.489		180.909	2.672		191.995
2015	Pipeline													
	Platforms													
	Production Wells													
	Exploration Wells		0.452		0.235	1.360		16.749	2.147		250.397	3.959		267.381
	Development Wells		0.069		0.036	0.208		2.558	0.415		55.710	0.692		58.304
	Total		0.522		0.271	1.567		19.307	2.562		306.108	4.651		325.685
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													
	Platforms													
	Production Wells													
	Exploration Wells		0.226		0.117	0.680		8.374	1.074		125.199	1.980		133.690
	Development Wells		0.069		0.036	0.208		2.558	0.415		55.710	0.692		58.304
	Total		0.295		0.153	0.888		10.932	1.489		180.909	2.672		191.995
2018	Pipeline													
	Platforms													
	Production Wells													
	Exploration Wells													
	Development Wells													
	Total													
2019	Pipeline		4.784		1.404	1.329		6.878	0.532		8.267	6.645		16.550
	Platforms													
	Production Wells													
	Exploration Wells													
	Development Wells													
	Total		4.784		1.404	1.329		6.878	0.532		8.267	6.645		16.550
2020	Pipeline		9.568		2.809	2.658		13.757	1.063		16.534	13.289		33.100
	Platforms													
	Production Wells													
	Exploration Wells													
	Development Wells													
	Total		9.568		2.809	2.658		13.757	1.063		16.534	13.289		33.100
2021	Pipeline		19.137		5.618	5.316		27.513	2.126		33.068	26.579		66.199
	Platforms													
	Production Wells													
	Exploration Wells													
	Development Wells													
	Total		19.137		5.618	5.316		27.513	2.126		33.068	26.579		66.199
2022	Pipeline	13.5	23.921	1.772	7.022	6.645	0.492	34.391	2.658	0.197	41.335	33.224	2.461	82.749
	Platforms		2.761	0.204	1.248	0.144	0.011	0.812	0.144	0.011	0.812	3.049	0.226	2.872
	Production Wells		0.088	0.007	0.046	0.264	0.020	3.258	0.440	0.033	53.216	0.792	0.059	56.520
	Exploration Wells													
	Development Wells													
	Total		26.770	1.983	8.316	7.053	0.522	38.462	3.242	0.240	95.364	37.064	2.745	142.141
2023	Pipeline	16.9	28.705	1.699	8.427	7.974	0.472	41.270	3.189	0.189	49.602	39.868	2.359	99.299
	Platforms		5.981	0.354	2.703	0.312	0.018	1.759	0.312	0.018	1.759	6.606	0.391	6.222
	Production Wells		0.191	0.011	0.099	0.572	0.034	7.060	0.953	0.056	115.302	1.715	0.101	122.461
	Exploration Wells													
	Development Wells													
	Total		34.877	2.064	11.229	8.858	0.524	50.088	4.455	0.264	166.664	48.190	2.851	227.981
2024	Pipeline	22.5	38.274	1.701	11.236	10.632	0.473	55.026	4.253	0.189	66.136	53.158	2.363	132.398
	Platforms		9.202	0.409	4.158	0.481	0.021	2.707	0.481	0.021	2.707	10.163	0.452	9.572
	Production Wells		0.293	0.013	0.152	0.880	0.039	10.861	1.466	0.065	177.388	2.639	0.117	188.401
	Exploration Wells													
	Development Wells													
	Total		47.769	2.123	15.547	11.992	0.533	68.594	6.199	0.276	246.231	65.960	2.932	330.372
2025	Pipeline	43.5	38.274	0.880	11.236	10.632	0.244	55.026	4.253	0.098	66.136	53.158	1.222	132.398
	Platforms		14.263	0.328	6.446	0.745	0.017	4.195	0.745	0.017	4.195	15.753	0.362	14.837
	Production Wells		0.454	0.010	0.236	1.363	0.031	16.834	2.272	0.052	274.952	4.090	0.094	292.022
	Exploration Wells													
	Development Wells													
	Total		52.991	1.218	17.918	12.740	0.293	76.056	7.270	0.167	345.284	73.001	1.678	439.257
2026	Pipeline	46.9	38.274	0.816	11.236	10.632	0.227	55.026	4.253	0.091	66.136	53.158	1.133	132.398
	Platforms		17.483	0.373	7.901	0.913	0.019	5.143	0.913	0.019	5.143	19.310	0.412	18.187
	Production Wells		0.557	0.012	0.289	1.671	0.036	20.636	2.785	0.059	337.038	5.013	0.107	357.962
	Exploration Wells													
	Development Wells													
	Total		56.314	1.201	19.426	13.216	0.282	80.804	7.951	0.170	408.317	77.481	1.652	508.548
2027	Pipeline	52.5	38.274	0.729	11.236	10.632	0.203	55.026	4.253	0.081	66.136	53.158	1.013	132.398
	Platforms		20.704	0.394	9.357	1.082	0.021	6.090	1.082	0.021	6.090	22.867	0.436	21.537
	Production Wells		0.660	0.013	0.343	1.979	0.038	24.437	3.298	0.063	399.123	5.937	0.113	423.903
	Exploration Wells													
	Development Wells													
	Total		59.637	1.136	20.935	13.692	0.261	85.553	8.632	0.164	471.350	81.962	1.561	577.838

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]
2028	Pipeline	54.0	38.274	0.709	11.236	10.632	0.197	55.026	4.253	0.079	66.136	53.158	0.984	132.398
	Platforms		23.005	0.426	10.396	1.202	0.022	6.767	1.202	0.022	6.767	25.408	0.471	23.930
	Production Wells		0.733	0.014	0.381	2.199	0.041	27.152	3.665	0.068	443.470	6.597	0.122	471.003
	Exploration Wells													
	Development Wells													
	Total		62.011	1.148	22.013	14.032	0.260	88.945	9.119	0.169	516.374	85.162	1.577	627.332
2029	Pipeline	49.2	38.274	0.778	11.236	10.632	0.216	55.026	4.253	0.086	66.136	53.158	1.080	132.398
	Platforms		23.005	0.468	10.396	1.202	0.024	6.767	1.202	0.024	6.767	25.408	0.516	23.930
	Production Wells		0.733	0.015	0.381	2.199	0.045	27.152	3.665	0.074	443.470	6.597	0.134	471.003
	Exploration Wells													
	Development Wells													
	Total		62.011	1.260	22.013	14.032	0.285	88.945	9.119	0.185	516.374	85.162	1.731	627.332
2030	Pipeline	45.4	38.274	0.843	11.236	10.632	0.234	55.026	4.253	0.094	66.136	53.158	1.171	132.398
	Platforms		23.005	0.507	10.396	1.202	0.026	6.767	1.202	0.026	6.767	25.408	0.560	23.930
	Production Wells		0.733	0.016	0.381	2.199	0.048	27.152	3.665	0.081	443.470	6.597	0.145	471.003
	Exploration Wells													
	Development Wells													
	Total		62.011	1.366	22.013	14.032	0.309	88.945	9.119	0.201	516.374	85.162	1.876	627.332
2031	Pipeline	36.3	38.274	1.054	11.236	10.632	0.293	55.026	4.253	0.117	66.136	53.158	1.464	132.398
	Platforms		23.005	0.634	10.396	1.202	0.033	6.767	1.202	0.033	6.767	25.408	0.700	23.930
	Production Wells		0.733	0.020	0.381	2.199	0.061	27.152	3.665	0.101	443.470	6.597	0.182	471.003
	Exploration Wells													
	Development Wells													
	Total		62.011	1.708	22.013	14.032	0.387	88.945	9.119	0.251	516.374	85.162	2.346	627.332
2032	Pipeline	29.0	38.274	1.320	11.236	10.632	0.367	55.026	4.253	0.147	66.136	53.158	1.833	132.398
	Platforms		23.005	0.793	10.396	1.202	0.041	6.767	1.202	0.041	6.767	25.408	0.876	23.930
	Production Wells		0.733	0.025	0.381	2.199	0.076	27.152	3.665	0.126	443.470	6.597	0.227	471.003
	Exploration Wells													
	Development Wells													
	Total		62.011	2.138	22.013	14.032	0.484	88.945	9.119	0.314	516.374	85.162	2.937	627.332
2033	Pipeline	23.3	38.274	1.643	11.236	10.632	0.456	55.026	4.253	0.183	66.136	53.158	2.281	132.398
	Platforms		23.005	0.987	10.396	1.202	0.052	6.767	1.202	0.052	6.767	25.408	1.090	23.930
	Production Wells		0.733	0.031	0.381	2.199	0.094	27.152	3.665	0.157	443.470	6.597	0.283	471.003
	Exploration Wells													
	Development Wells													
	Total		62.011	2.661	22.013	14.032	0.602	88.945	9.119	0.391	516.374	85.162	3.655	627.332
2034	Pipeline	18.6	38.274	2.058	11.236	10.632	0.572	55.026	4.253	0.229	66.136	53.158	2.858	132.398
	Platforms		23.005	1.237	10.396	1.202	0.065	6.767	1.202	0.065	6.767	25.408	1.366	23.930
	Production Wells		0.733	0.039	0.381	2.199	0.118	27.152	3.665	0.197	443.470	6.597	0.355	471.003
	Exploration Wells													
	Development Wells													
	Total		62.011	3.334	22.013	14.032	0.754	88.945	9.119	0.490	516.374	85.162	4.579	627.332
2035	Pipeline	14.8	38.274	2.586	11.236	10.632	0.718	55.026	4.253	0.287	66.136	53.158	3.592	132.398
	Platforms		23.005	1.554	10.396	1.202	0.081	6.767	1.202	0.081	6.767	25.408	1.717	23.930
	Production Wells		0.733	0.050	0.381	2.199	0.149	27.152	3.665	0.248	443.470	6.597	0.446	471.003
	Exploration Wells													
	Development Wells													
	Total		62.011	4.190	22.013	14.032	0.948	88.945	9.119	0.616	516.374	85.162	5.754	627.332
2036	Pipeline	11.9	38.274	3.216	11.236	10.632	0.893	55.026	4.253	0.357	66.136	53.158	4.467	132.398
	Platforms		23.005	1.933	10.396	1.202	0.101	6.767	1.202	0.101	6.767	25.408	2.135	23.930
	Production Wells		0.733	0.062	0.381	2.199	0.185	27.152	3.665	0.308	443.470	6.597	0.554	471.003
	Exploration Wells													
	Development Wells													
	Total		62.011	5.211	22.013	14.032	1.179	88.945	9.119	0.766	516.374	85.162	7.157	627.332
2037	Pipeline	9.5	38.274	4.029	11.236	10.632	1.119	55.026	4.253	0.448	66.136	53.158	5.596	132.398
	Platforms		23.005	2.422	10.396	1.202	0.126	6.767	1.202	0.126	6.767	25.408	2.675	23.930
	Production Wells		0.733	0.077	0.381	2.199	0.231	27.152	3.665	0.386	443.470	6.597	0.694	471.003
	Exploration Wells													
	Development Wells													
	Total		62.011	6.527	22.013	14.032	1.477	88.945	9.119	0.960	516.374	85.162	8.964	627.332
2038	Pipeline	5.0	19.137	3.827	5.618	5.316	1.063	27.513	2.126	0.425	33.068	26.579	5.316	66.199
	Platforms		11.502	2.300	5.198	0.601	0.120	3.383	0.601	0.120	3.383	12.704	2.541	11.965
	Production Wells		0.366	0.073	0.190	1.099	0.220	13.576	1.832	0.366	221.735	3.298	0.660	235.502
	Exploration Wells													
	Development Wells													
	Total		31.006	6.201	11.006	7.016	1.403	44.472	4.560	0.912	258.187	42.581	8.516	313.666
2039	Pipeline	4.0	19.137	4.784	5.618	5.316	1.329	27.513	2.126	0.532	33.068	26.579	6.645	66.199
	Platforms		11.502	2.876	5.198	0.601	0.150	3.383	0.601	0.150	3.383	12.704	3.176	11.965
	Production Wells		0.366	0.092	0.190	1.099	0.275	13.576	1.832	0.458	221.735	3.298	0.825	235.502
	Exploration Wells													
	Development Wells													
	Total		31.006	7.751	11.006	7.016	1.754	44.472	4.560	1.140	258.187	42.581	10.645	313.666
2040	Pipeline	3.2	19.137	5.980	5.618	5.316	1.661	27.513	2.126	0.664	33.068	26.579	8.306	66.199
	Platforms		11.502	3.594	5.198	0.601	0.188	3.383	0.601	0.188	3.383	12.704	3.970	11.965
	Production Wells		0.366	0.115	0.190	1.099	0.344	13.576	1.832	0.573	221.735	3.298	1.031	235.502
	Exploration Wells													
	Development Wells													
	Total		31.006	9.689	11.006	7.016	2.193	44.472	4.560	1.425	258.187	42.581	13.307	313.666

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]
2011		0.226		0.117	0.680		8.374	1.074		125.199	1.753		133.573	1.980		133.690
2012		0.295		0.153	0.888		10.932	1.489		180.909	2.376		191.841	2.672		191.995
2013		0.138		0.072	0.415		5.116	0.830		111.421	1.246		116.536	1.384		116.608
2014		0.295		0.153	0.888		10.932	1.489		180.909	2.376		191.841	2.672		191.995
2015		0.522		0.271	1.567		19.307	2.562		306.108	4.130		325.414	4.651		325.685
2016		0.365		0.189	1.095		13.490	1.904		236.619	2.999		250.109	3.364		250.299
2017		0.295		0.153	0.888		10.932	1.489		180.909	2.376		191.841	2.672		191.995
2018																
2019		4.784		1.404	1.329		6.878	0.532		8.267	1.861		15.145	6.645		16.550
2020		9.568		2.809	2.658		13.757	1.063		16.534	3.721		30.291	13.289		33.100
2021		19.137		5.618	5.316		27.513	2.126		33.068	7.442		60.581	26.579		66.199
2022	**13.5**	26.770	1.983	8.316	7.053	0.522	38.462	3.242	0.240	95.364	10.295	0.763	133.825	37.064	2.745	142.141
2023	**16.9**	34.877	2.064	11.229	8.858	0.524	50.088	4.455	0.264	166.664	13.313	0.788	216.752	48.190	2.851	227.981
2024	**22.5**	47.769	2.123	15.547	11.992	0.533	68.594	6.199	0.276	246.231	18.191	0.808	314.825	65.960	2.932	330.372
2025	**43.5**	52.991	1.218	17.918	12.740	0.293	76.056	7.270	0.167	345.284	20.010	0.460	421.339	73.001	1.678	439.257
2026	**46.9**	56.314	1.201	19.426	13.216	0.282	80.804	7.951	0.170	408.317	21.167	0.451	489.121	77.481	1.652	508.548
2027	**52.5**	59.637	1.136	20.935	13.692	0.261	85.553	8.632	0.164	471.350	22.325	0.425	556.903	81.962	1.561	577.838
2028	**54.0**	62.011	1.148	22.013	14.032	0.260	88.945	9.119	0.169	516.374	23.151	0.429	605.319	85.162	1.577	627.332
2029	**49.2**	62.011	1.260	22.013	14.032	0.285	88.945	9.119	0.185	516.374	23.151	0.471	605.319	85.162	1.731	627.332
2030	**45.4**	62.011	1.366	22.013	14.032	0.309	88.945	9.119	0.201	516.374	23.151	0.510	605.319	85.162	1.876	627.332
2031	**36.3**	62.011	1.708	22.013	14.032	0.387	88.945	9.119	0.251	516.374	23.151	0.638	605.319	85.162	2.346	627.332
2032	**29.0**	62.011	2.138	22.013	14.032	0.484	88.945	9.119	0.314	516.374	23.151	0.798	605.319	85.162	2.937	627.332
2033	**23.3**	62.011	2.661	22.013	14.032	0.602	88.945	9.119	0.391	516.374	23.151	0.994	605.319	85.162	3.655	627.332
2034	**18.6**	62.011	3.334	22.013	14.032	0.754	88.945	9.119	0.490	516.374	23.151	1.245	605.319	85.162	4.579	627.332
2035	**14.8**	62.011	4.190	22.013	14.032	0.948	88.945	9.119	0.616	516.374	23.151	1.564	605.319	85.162	5.754	627.332
2036	**11.9**	62.011	5.211	22.013	14.032	1.179	88.945	9.119	0.766	516.374	23.151	1.945	605.319	85.162	7.157	627.332
2037	**9.5**	62.011	6.527	22.013	14.032	1.477	88.945	9.119	0.960	516.374	23.151	2.437	605.319	85.162	8.964	627.332
2038	**5.0**	31.006	6.201	11.006	7.016	1.403	44.472	4.560	0.912	258.187	11.576	2.315	302.659	42.581	8.516	313.666
2039	**4.0**	31.006	7.751	11.006	7.016	1.754	44.472	4.560	1.140	258.187	11.576	2.894	302.659	42.581	10.645	313.666
2040	**3.2**	31.006	9.689	11.006	7.016	2.193	44.472	4.560	1.425	258.187	11.576	3.617	302.659	42.581	13.307	313.666
Total LOF	**500.0**	**1027.112**		**357**	**244.643**		**1550**	**157.177**		**9051**	**401.820**		**10601**	**1428.933**		**10959**
Average LOF		**34.237**	**2.054**	**12**	**8.155**	**0.489**	**52**	**5.239**	**0.314**	**302**	**13.394**	**0.804**	**353**	**47.631**	**2.858**	**365**

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

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
	Frequency Spills per 10^3years				
Mean =	62.01	14.03	9.12	23.15	85.16
Std Deviation =	30.13	7.14	3.13	8.00	31.12
Variance =	908.072	50.931	9.770	63.945	968.192
Skewness =	0.41	0.53	0.44	0.43	0.37
Kurtosis =	2.63	2.43	2.64	2.63	2.66
Mode =	88.41	9.26	7.11	19.46	85.51
Minimum =	2.733	0.958	1.553	2.758	13.921
5% Perc =	17.689	4.518	4.594	11.495	38.415
10% Perc =	23.626	5.563	5.325	13.412	45.484
15% Perc =	29.257	6.447	5.873	14.819	51.605
20% Perc =	34.148	7.260	6.315	15.945	56.778
25% Perc =	38.897	8.129	6.693	17.026	61.583
30% Perc =	43.145	8.997	7.083	18.131	65.981
35% Perc =	47.276	9.939	7.520	19.102	70.027
40% Perc =	51.286	10.868	7.930	20.037	74.341
45% Perc =	55.248	11.830	8.353	21.038	78.761
50% Perc =	59.127	12.906	8.764	22.182	82.928
55% Perc =	63.621	13.989	9.202	23.287	87.106
60% Perc =	67.960	15.026	9.692	24.555	91.450
65% Perc =	72.568	16.286	10.143	25.799	95.974
70% Perc =	77.320	17.682	10.658	27.282	100.852
75% Perc =	82.353	19.059	11.240	28.759	106.191
80% Perc =	88.132	20.609	11.882	30.277	111.916
85% Perc =	95.051	22.465	12.624	32.091	119.041
90% Perc =	103.376	24.560	13.512	34.409	127.722
95% Perc =	116.464	27.371	14.778	37.534	141.236
Maximum =	169.423	36.234	19.955	50.788	198.978

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
	Frequency Spills per 10^9 bbl Produced				
Mean =	1.37	0.31	0.20	0.51	1.88
Std Deviation =	0.66	0.16	0.07	0.18	0.69
Variance =	0.441	0.025	0.005	0.031	0.470
Skewness =	0.41	0.53	0.44	0.43	0.37
Kurtosis =	2.63	2.43	2.64	2.63	2.66
Mode =	1.62	0.20	0.16	0.43	1.88
Minimum =	0.060	0.021	0.034	0.061	0.307
5% Perc =	0.390	0.100	0.101	0.253	0.846
10% Perc =	0.520	0.123	0.117	0.295	1.002
15% Perc =	0.644	0.142	0.129	0.326	1.137
20% Perc =	0.752	0.160	0.139	0.351	1.251
25% Perc =	0.857	0.179	0.147	0.375	1.356
30% Perc =	0.950	0.198	0.156	0.399	1.453
35% Perc =	1.041	0.219	0.166	0.421	1.542
40% Perc =	1.130	0.239	0.175	0.441	1.637
45% Perc =	1.217	0.261	0.184	0.463	1.735
50% Perc =	1.302	0.284	0.193	0.489	1.827
55% Perc =	1.401	0.308	0.203	0.513	1.919
60% Perc =	1.497	0.331	0.213	0.541	2.014
65% Perc =	1.598	0.359	0.223	0.568	2.114
70% Perc =	1.703	0.389	0.235	0.601	2.221
75% Perc =	1.814	0.420	0.248	0.633	2.339
80% Perc =	1.941	0.454	0.262	0.667	2.465
85% Perc =	2.094	0.495	0.278	0.707	2.622
90% Perc =	2.277	0.541	0.298	0.758	2.813
95% Perc =	2.565	0.603	0.325	0.827	3.111
Maximum =	3.732	0.798	0.440	1.119	4.383

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
	Spill Index [bbl]				
Mean =	21.99	89.05	516.14	605.19	627.18
Std Deviation =	14.75	53.63	182.07	190.32	190.70
Variance =	217.594	2876.581	33148.890	36223.280	36365.840
Skewness =	1.13	1.19	0.46	0.43	0.42
Kurtosis =	4.38	4.51	3.20	3.16	3.14
Mode =	8.49	50.76	395.09	426.53	426.69
Minimum =	-1.244	1.302	61.920	109.849	116.626
5% Perc =	4.218	24.342	241.617	314.345	335.355
10% Perc =	6.129	32.369	289.472	367.171	388.891
15% Perc =	7.756	39.119	326.872	408.487	431.399
20% Perc =	9.167	44.770	359.791	440.212	462.789
25% Perc =	10.722	50.280	385.635	469.684	490.870
30% Perc =	12.197	55.447	410.936	496.624	517.297
35% Perc =	13.810	60.587	434.400	522.493	543.444
40% Perc =	15.465	65.281	459.294	546.803	567.440
45% Perc =	17.129	70.427	480.923	570.332	591.474
50% Perc =	18.898	76.435	504.329	591.209	613.783
55% Perc =	20.789	82.977	526.832	615.304	637.580
60% Perc =	22.625	89.898	549.379	639.478	663.127
65% Perc =	24.682	96.981	574.239	667.078	689.529
70% Perc =	27.046	105.616	600.231	692.704	715.000
75% Perc =	29.662	115.878	629.473	723.229	745.686
80% Perc =	33.190	128.391	663.589	760.432	783.226
85% Perc =	37.271	143.501	703.470	802.095	824.393
90% Perc =	42.658	163.353	757.351	858.054	879.504
95% Perc =	51.123	196.464	837.399	941.836	964.026
Maximum =	106.209	350.350	1264.173	1382.051	1392.749

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

High Case non Arctic Pipeline 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
	Frequency Spills per 10^3 years				
Mean =	22.65	6.29	2.52	8.81	31.45
Std Deviation =	14.95	4.15	1.66	4.48	15.66
Variance =	223.590	17.252	2.760	20.030	245.187
Skewness =	0.56	0.56	0.56	0.48	0.51
Kurtosis =	2.40	2.40	2.40	2.57	2.53
Mode =	3.30	0.92	0.37	7.39	33.01
Minimum =	0.049	0.037	0.013	0.311	1.889
5% Perc =	3.136	0.872	0.349	2.436	9.874
10% Perc =	4.786	1.330	0.532	3.326	12.587
15% Perc =	6.479	1.800	0.720	4.070	14.891
20% Perc =	8.224	2.284	0.914	4.682	16.869
25% Perc =	10.021	2.784	1.114	5.271	18.934
30% Perc =	11.885	3.301	1.320	5.823	20.986
35% Perc =	13.811	3.837	1.535	6.474	22.816
40% Perc =	15.816	4.393	1.757	7.037	24.826
45% Perc =	17.905	4.974	1.990	7.615	26.834
50% Perc =	20.093	5.581	2.233	8.206	29.133
55% Perc =	22.392	6.220	2.488	8.885	31.440
60% Perc =	24.823	6.896	2.758	9.539	33.776
65% Perc =	27.412	7.614	3.046	10.277	36.442
70% Perc =	30.193	8.386	3.355	11.043	39.367
75% Perc =	33.213	9.226	3.691	11.839	42.352
80% Perc =	36.558	10.156	4.062	12.791	45.427
85% Perc =	40.356	11.210	4.484	13.903	49.411
90% Perc =	44.860	12.460	4.984	15.286	54.390
95% Perc =	50.727	14.089	5.635	16.969	60.424
Maximum =	64.526	17.951	7.157	23.613	83.557

High Case non Arctic Pipeline 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
	Frequency Spills per 10^9 bbl Produced				
Mean =	1.36	0.38	0.15	0.53	1.89
Std Deviation =	0.90	0.25	0.10	0.27	0.94
Variance =	0.805	0.062	0.010	0.072	0.883
Skewness =	0.56	0.56	0.56	0.48	0.51
Kurtosis =	2.40	2.40	2.40	2.57	2.53
Mode =	0.20	0.06	0.02	0.41	4.18
Minimum =	0.003	0.002	0.001	0.019	0.113
5% Perc =	0.188	0.052	0.021	0.146	0.592
10% Perc =	0.287	0.080	0.032	0.200	0.755
15% Perc =	0.389	0.108	0.043	0.244	0.893
20% Perc =	0.493	0.137	0.055	0.281	1.012
25% Perc =	0.601	0.167	0.067	0.316	1.136
30% Perc =	0.713	0.198	0.079	0.349	1.259
35% Perc =	0.829	0.230	0.092	0.388	1.369
40% Perc =	0.949	0.264	0.105	0.422	1.490
45% Perc =	1.074	0.298	0.119	0.457	1.610
50% Perc =	1.206	0.335	0.134	0.492	1.748
55% Perc =	1.344	0.373	0.149	0.533	1.886
60% Perc =	1.489	0.414	0.165	0.572	2.027
65% Perc =	1.645	0.457	0.183	0.617	2.186
70% Perc =	1.812	0.503	0.201	0.662	2.362
75% Perc =	1.993	0.554	0.221	0.710	2.541
80% Perc =	2.193	0.609	0.244	0.767	2.726
85% Perc =	2.421	0.673	0.269	0.834	2.965
90% Perc =	2.692	0.748	0.299	0.917	3.263
95% Perc =	3.044	0.845	0.338	1.018	3.625
Maximum =	3.872	1.077	0.429	1.417	5.013

High Case non Arctic Pipeline 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
	Spill Index [bbl]				
Mean =	6.65	32.59	39.14	71.73	78.38
Std Deviation =	5.71	29.58	27.47	40.42	40.90
Variance =	32.640	874.895	754.664	1633.754	1672.530
Skewness =	1.38	1.46	0.80	0.83	0.81
Kurtosis =	5.01	5.25	3.01	3.67	3.61
Mode =	2.69	4.94	7.65	140.22	89.07
Minimum =	-0.004	-6.339	0.227	-0.418	4.744
5% Perc =	0.624	2.102	5.232	17.438	23.058
10% Perc =	1.004	4.050	7.887	24.723	30.521
15% Perc =	1.400	5.978	10.657	30.428	36.922
20% Perc =	1.842	8.130	13.451	35.984	42.638
25% Perc =	2.298	10.380	16.696	41.038	47.462
30% Perc =	2.759	12.655	19.846	46.033	52.173
35% Perc =	3.241	15.121	23.031	50.795	57.375
40% Perc =	3.786	18.010	26.522	55.552	62.332
45% Perc =	4.338	20.739	29.946	60.576	67.261
50% Perc =	5.014	23.894	33.650	65.960	72.301
55% Perc =	5.709	27.450	37.656	71.030	77.588
60% Perc =	6.506	31.491	41.470	76.273	83.272
65% Perc =	7.403	35.455	45.861	82.042	88.970
70% Perc =	8.362	40.084	51.059	88.401	95.609
75% Perc =	9.407	46.095	56.489	95.738	102.764
80% Perc =	10.774	53.461	62.674	103.974	110.883
85% Perc =	12.466	61.973	70.103	113.581	120.628
90% Perc =	14.634	74.068	79.518	126.916	133.968
95% Perc =	18.161	93.012	92.454	147.648	154.489
Maximum =	37.712	185.590	142.052	265.966	273.311

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
All years Average LOF	Frequency Spills per 10^3 years				
Mean =	11.16	0.58	0.58	1.17	12.33
Std Deviation =	7.89	0.41	0.41	0.82	7.94
Variance =	62.327	0.170	0.170	0.680	62.969
Skewness =	0.57	0.57	0.57	0.57	0.56
Kurtosis =	2.40	2.40	2.40	2.40	2.41
Mode =	0.08	0.01	0.01	0.03	20.77
Minimum =	0.001	0.000	0.000	0.000	0.118
5% Perc =	0.848	0.044	0.044	0.089	1.957
10% Perc =	1.717	0.090	0.090	0.179	2.900
15% Perc =	2.614	0.136	0.136	0.273	3.801
20% Perc =	3.535	0.185	0.185	0.369	4.710
25% Perc =	4.487	0.234	0.234	0.469	5.655
30% Perc =	5.469	0.286	0.286	0.571	6.663
35% Perc =	6.490	0.339	0.339	0.678	7.612
40% Perc =	7.548	0.394	0.394	0.789	8.748
45% Perc =	8.654	0.452	0.452	0.904	9.862
50% Perc =	9.809	0.512	0.512	1.025	11.019
55% Perc =	11.024	0.576	0.576	1.152	12.228
60% Perc =	12.308	0.643	0.643	1.286	13.535
65% Perc =	13.679	0.715	0.715	1.429	14.846
70% Perc =	15.148	0.791	0.791	1.582	16.379
75% Perc =	16.746	0.875	0.875	1.750	17.932
80% Perc =	18.514	0.967	0.967	1.934	19.708
85% Perc =	20.518	1.072	1.072	2.144	21.633
90% Perc =	22.901	1.196	1.196	2.393	24.133
95% Perc =	26.002	1.358	1.358	2.716	27.239
Maximum =	33.418	1.748	1.748	3.496	35.931

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
All years Average LOF	Frequency Spills per 10^9 bbl Produced				
Mean =	0.67	0.03	0.03	0.07	0.74
Std Deviation =	0.47	0.02	0.02	0.05	0.48
Variance =	0.224	0.001	0.001	0.002	0.227
Skewness =	0.57	0.57	0.57	0.57	0.56
Kurtosis =	2.40	2.40	2.40	2.40	2.41
Mode =	0.01	0.00	0.00	0.00	1.25
Minimum =	0.000	0.000	0.000	0.000	0.007
5% Perc =	0.051	0.003	0.003	0.005	0.117
10% Perc =	0.103	0.005	0.005	0.011	0.174
15% Perc =	0.157	0.008	0.008	0.016	0.228
20% Perc =	0.212	0.011	0.011	0.022	0.283
25% Perc =	0.269	0.014	0.014	0.028	0.339
30% Perc =	0.328	0.017	0.017	0.034	0.400
35% Perc =	0.389	0.020	0.020	0.041	0.457
40% Perc =	0.453	0.024	0.024	0.047	0.525
45% Perc =	0.519	0.027	0.027	0.054	0.592
50% Perc =	0.589	0.031	0.031	0.061	0.661
55% Perc =	0.661	0.035	0.035	0.069	0.734
60% Perc =	0.738	0.039	0.039	0.077	0.812
65% Perc =	0.821	0.043	0.043	0.086	0.891
70% Perc =	0.909	0.047	0.047	0.095	0.983
75% Perc =	1.005	0.052	0.052	0.105	1.076
80% Perc =	1.111	0.058	0.058	0.116	1.182
85% Perc =	1.231	0.064	0.064	0.129	1.298
90% Perc =	1.374	0.072	0.072	0.144	1.448
95% Perc =	1.560	0.081	0.081	0.163	1.634
Maximum =	2.005	0.105	0.105	0.210	2.156

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
All years Average LOF	Spill Index [bbl]				
Mean =	5.04	3.26	3.26	6.52	11.56
Std Deviation =	5.38	2.98	2.98	5.96	8.00
Variance =	28.991	8.871	8.871	35.483	64.012
Skewness =	1.78	1.28	1.28	1.28	1.03
Kurtosis =	6.65	4.53	4.53	4.53	4.19
Mode =	0.02	2.44	2.44	4.88	3.67
Minimum =	-1.586	-1.134	-1.134	-2.267	-1.938
5% Perc =	0.112	0.105	0.105	0.210	1.671
10% Perc =	0.322	0.274	0.274	0.548	2.780
15% Perc =	0.564	0.481	0.481	0.961	3.679
20% Perc =	0.840	0.691	0.691	1.381	4.506
25% Perc =	1.160	0.940	0.940	1.879	5.362
30% Perc =	1.504	1.199	1.199	2.398	6.306
35% Perc =	1.875	1.484	1.484	2.967	7.145
40% Perc =	2.283	1.774	1.774	3.548	7.959
45% Perc =	2.731	2.092	2.092	4.185	8.860
50% Perc =	3.214	2.435	2.435	4.870	9.803
55% Perc =	3.758	2.809	2.809	5.617	10.906
60% Perc =	4.402	3.165	3.165	6.330	12.095
65% Perc =	5.188	3.639	3.639	7.278	13.336
70% Perc =	6.090	4.150	4.150	8.301	14.650
75% Perc =	7.094	4.765	4.765	9.531	16.058
80% Perc =	8.386	5.545	5.545	11.090	17.938
85% Perc =	10.070	6.404	6.404	12.808	19.961
90% Perc =	12.349	7.571	7.571	15.142	22.956
95% Perc =	16.203	9.281	9.281	18.563	27.058
Maximum =	35.835	17.816	17.816	35.633	62.997

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 10^3 years					Frequency Spills per 10^9 bbl Produced					Spill Index [bbl]				
Mean =	0.43	1.28	2.14	3.42	3.85	0.03	0.08	0.13	0.21	0.23	0.22	15.83	259.11	274.94	275.17
Std Deviation =	0.15	0.44	0.53	0.93	0.94	0.01	0.03	0.03	0.06	0.06	0.15	10.17	92.78	93.49	93.49
Variance =	0.022	0.195	0.284	0.873	0.893	0.000	0.001	0.001	0.003	0.003	0.022	103.397	8608.767	8740.230	8740.036
Skewness =	-0.01	-0.01	0.03	0.01	0.01	-0.01	-0.01	0.03	0.01	0.01	0.73	0.83	0.49	0.48	0.49
Kurtosis =	2.43	2.46	2.69	2.57	2.60	2.43	2.46	2.69	2.57	2.60	3.34	3.55	3.22	3.22	3.23
Mode =	0.40	1.61	2.26	2.53	2.47	0.02	0.10	0.11	0.15	0.15	0.06	4.72	172.89	226.25	196.98
Minimum =	0.046	0.154	0.544	0.805	1.083	0.003	0.009	0.033	0.048	0.065	-0.110	-3.494	31.075	46.452	46.626
5% Perc =	0.179	0.541	1.269	1.885	2.288	0.011	0.032	0.076	0.113	0.137	0.019	2.427	121.235	135.957	136.245
10% Perc =	0.229	0.688	1.451	2.185	2.598	0.014	0.041	0.087	0.131	0.156	0.047	4.143	144.827	159.996	160.194
15% Perc =	0.266	0.794	1.576	2.410	2.825	0.016	0.048	0.095	0.145	0.169	0.069	5.622	163.859	178.947	179.235
20% Perc =	0.294	0.887	1.675	2.598	3.015	0.018	0.053	0.100	0.156	0.181	0.090	6.850	179.153	195.249	195.422
25% Perc =	0.321	0.970	1.762	2.757	3.179	0.019	0.058	0.106	0.165	0.191	0.110	8.186	192.075	208.007	208.193
30% Perc =	0.344	1.040	1.842	2.904	3.338	0.021	0.062	0.111	0.174	0.200	0.128	9.365	205.012	220.236	220.373
35% Perc =	0.368	1.103	1.922	3.047	3.480	0.022	0.066	0.115	0.183	0.209	0.146	10.531	217.049	232.725	232.890
40% Perc =	0.389	1.165	1.997	3.173	3.605	0.023	0.070	0.120	0.190	0.216	0.163	11.588	228.283	243.623	243.814
45% Perc =	0.409	1.224	2.069	3.292	3.712	0.025	0.073	0.124	0.197	0.223	0.182	12.776	239.938	254.686	254.975
50% Perc =	0.428	1.285	2.139	3.422	3.836	0.026	0.077	0.128	0.205	0.230	0.200	14.059	251.048	267.129	267.302
55% Perc =	0.446	1.341	2.206	3.542	3.967	0.027	0.080	0.132	0.213	0.238	0.220	15.451	262.800	279.009	279.327
60% Perc =	0.466	1.398	2.281	3.664	4.102	0.028	0.084	0.137	0.220	0.246	0.239	16.895	275.309	290.993	291.197
65% Perc =	0.487	1.460	2.353	3.786	4.226	0.029	0.088	0.141	0.227	0.254	0.262	18.354	288.598	303.872	304.158
70% Perc =	0.509	1.526	2.429	3.935	4.366	0.031	0.092	0.146	0.236	0.262	0.286	20.016	302.214	318.725	318.895
75% Perc =	0.532	1.596	2.508	4.084	4.518	0.032	0.096	0.150	0.245	0.271	0.312	21.984	317.317	333.302	333.570
80% Perc =	0.558	1.672	2.601	4.253	4.684	0.033	0.100	0.156	0.255	0.281	0.342	23.995	334.148	350.947	351.230
85% Perc =	0.589	1.768	2.706	4.438	4.866	0.035	0.106	0.162	0.266	0.292	0.380	26.521	355.744	371.922	372.049
90% Perc =	0.624	1.869	2.841	4.655	5.092	0.037	0.112	0.170	0.279	0.306	0.431	29.776	383.462	399.352	399.656
95% Perc =	0.671	2.018	3.030	4.956	5.412	0.040	0.121	0.182	0.297	0.325	0.506	35.387	424.062	442.470	442.583
Maximum =	0.812	2.457	3.831	6.068	6.783	0.049	0.147	0.230	0.364	0.407	0.886	59.773	719.258	769.898	770.007

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

Frequency – Spills per 10^3 years

High Case non Arctic 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 =	11.59	1.86	2.72	4.59	16.18
Std Deviation =	7.89	0.61	0.67	1.25	7.98
Variance =	62.313	0.366	0.454	1.555	63.750
Skewness =	0.57	0.21	0.16	0.20	0.54
Kurtosis =	2.40	2.75	2.86	2.80	2.42
Mode =	6.98	1.13	2.56	4.03	18.33
Minimum =	0.176	0.218	0.617	0.883	2.412
5% Perc =	1.252	0.902	1.662	2.617	5.571
10% Perc =	2.169	1.099	1.875	3.014	6.717
15% Perc =	3.045	1.229	2.016	3.286	7.680
20% Perc =	3.953	1.337	2.146	3.515	8.583
25% Perc =	4.910	1.432	2.254	3.715	9.509
30% Perc =	5.910	1.519	2.350	3.876	10.487
35% Perc =	6.923	1.597	2.443	4.045	11.502
40% Perc =	7.986	1.679	2.525	4.209	12.571
45% Perc =	9.086	1.760	2.614	4.368	13.712
50% Perc =	10.227	1.839	2.700	4.542	14.840
55% Perc =	11.426	1.913	2.786	4.701	16.127
60% Perc =	12.746	1.995	2.868	4.868	17.437
65% Perc =	14.124	2.090	2.964	5.034	18.750
70% Perc =	15.547	2.184	3.067	5.208	20.231
75% Perc =	17.156	2.272	3.172	5.421	21.783
80% Perc =	18.949	2.384	3.296	5.646	23.558
85% Perc =	20.969	2.506	3.440	5.928	25.544
90% Perc =	23.303	2.670	3.612	6.261	28.046
95% Perc =	26.402	2.922	3.880	6.748	31.061
Maximum =	33.668	3.941	5.155	8.875	39.579

Frequency – Spills per 10^9 bbl Produced

High Case non Arctic 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 =	0.70	0.11	0.16	0.28	0.97
Std Deviation =	0.47	0.04	0.04	0.07	0.48
Variance =	0.224	0.001	0.002	0.006	0.230
Skewness =	0.57	0.21	0.16	0.20	0.54
Kurtosis =	2.40	2.75	2.86	2.80	2.42
Mode =	0.40	0.07	0.15	0.24	1.07
Minimum =	0.011	0.013	0.037	0.053	0.145
5% Perc =	0.075	0.054	0.100	0.157	0.334
10% Perc =	0.130	0.066	0.112	0.181	0.403
15% Perc =	0.183	0.074	0.121	0.197	0.461
20% Perc =	0.237	0.080	0.129	0.211	0.515
25% Perc =	0.295	0.086	0.135	0.223	0.571
30% Perc =	0.355	0.091	0.141	0.233	0.629
35% Perc =	0.415	0.096	0.147	0.243	0.690
40% Perc =	0.479	0.101	0.152	0.253	0.754
45% Perc =	0.545	0.106	0.157	0.262	0.823
50% Perc =	0.614	0.110	0.162	0.273	0.890
55% Perc =	0.686	0.115	0.167	0.282	0.968
60% Perc =	0.765	0.120	0.172	0.292	1.046
65% Perc =	0.847	0.125	0.178	0.302	1.125
70% Perc =	0.933	0.131	0.184	0.313	1.214
75% Perc =	1.029	0.136	0.190	0.325	1.307
80% Perc =	1.137	0.143	0.198	0.339	1.413
85% Perc =	1.258	0.150	0.206	0.356	1.533
90% Perc =	1.398	0.160	0.217	0.376	1.683
95% Perc =	1.584	0.175	0.233	0.405	1.864
Maximum =	2.020	0.236	0.309	0.532	2.375

Spill Index [bbl]

High Case non Arctic 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 =	5.26	19.09	262.37	281.47	286.72
Std Deviation =	5.38	10.60	92.83	93.67	93.87
Variance =	28.985	112.465	8616.576	8773.986	8811.831
Skewness =	1.78	0.77	0.49	0.48	0.48
Kurtosis =	6.63	3.53	3.22	3.23	3.23
Mode =	2.99	15.52	328.43	176.71	250.13
Minimum =	-1.366	-3.350	35.536	50.524	53.626
5% Perc =	0.322	4.470	124.780	142.112	147.089
10% Perc =	0.552	6.745	148.253	166.527	171.397
15% Perc =	0.785	8.430	166.892	185.233	190.371
20% Perc =	1.081	9.914	182.468	200.931	205.455
25% Perc =	1.383	11.224	195.403	214.098	219.927
30% Perc =	1.732	12.449	208.123	226.682	230.969
35% Perc =	2.103	13.730	220.178	238.563	243.783
40% Perc =	2.522	14.909	231.628	250.557	255.875
45% Perc =	2.964	16.163	242.863	261.635	267.275
50% Perc =	3.429	17.508	254.204	273.155	278.534
55% Perc =	3.962	18.870	266.179	285.652	291.100
60% Perc =	4.628	20.355	278.875	297.436	303.050
65% Perc =	5.412	21.942	291.617	310.579	315.656
70% Perc =	6.311	23.574	305.459	324.379	330.024
75% Perc =	7.285	25.455	320.297	340.280	345.823
80% Perc =	8.620	27.625	337.667	357.224	361.777
85% Perc =	10.280	30.170	359.368	379.702	385.180
90% Perc =	12.581	33.473	386.447	406.183	411.937
95% Perc =	16.421	38.993	427.545	450.277	456.186
Maximum =	35.774	68.549	727.666	786.713	796.384

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
All years Average LOF	Frequency Spills per 10^3 years				
Mean =	34.24	8.15	5.24	13.39	47.63
Std Deviation =	16.87	4.20	1.80	4.66	17.57
Variance =	284.706	17.649	3.225	21.670	308.611
Skewness =	0.41	0.54	0.48	0.44	0.38
Kurtosis =	2.57	2.44	2.58	2.62	2.65
Mode =	19.14	4.22	3.47	17.96	43.45
Minimum =	0.743	0.816	1.267	2.540	8.157
5% Perc =	9.442	2.579	2.717	6.708	21.355
10% Perc =	13.056	3.159	3.086	7.666	25.678
15% Perc =	15.928	3.674	3.364	8.477	28.809
20% Perc =	18.438	4.174	3.627	9.174	31.619
25% Perc =	21.043	4.652	3.845	9.790	34.318
30% Perc =	23.630	5.177	4.059	10.412	36.711
35% Perc =	25.908	5.724	4.267	11.005	38.994
40% Perc =	28.019	6.269	4.481	11.633	41.299
45% Perc =	30.338	6.881	4.710	12.249	43.526
50% Perc =	32.573	7.473	4.989	12.873	46.118
55% Perc =	34.885	8.081	5.257	13.517	48.666
60% Perc =	37.350	8.772	5.538	14.205	51.263
65% Perc =	39.954	9.503	5.832	14.899	53.747
70% Perc =	42.744	10.289	6.143	15.682	56.591
75% Perc =	45.853	11.085	6.482	16.553	59.670
80% Perc =	49.237	12.054	6.865	17.513	62.810
85% Perc =	53.111	13.100	7.295	18.609	66.863
90% Perc =	57.915	14.348	7.805	19.971	72.033
95% Perc =	64.354	15.982	8.515	21.898	78.741
Maximum =	93.227	20.942	11.331	30.402	109.529

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
All years Average LOF	Frequency Spills per 10^9 bbl Produced				
Mean =	2.05	0.49	0.31	0.80	2.86
Std Deviation =	1.01	0.25	0.11	0.28	1.05
Variance =	1.025	0.064	0.012	0.078	1.111
Skewness =	0.41	0.54	0.48	0.44	0.38
Kurtosis =	2.57	2.44	2.58	2.62	2.65
Mode =	1.15	0.21	0.20	0.68	2.61
Minimum =	0.045	0.049	0.076	0.152	0.489
5% Perc =	0.567	0.155	0.163	0.402	1.281
10% Perc =	0.783	0.190	0.185	0.460	1.541
15% Perc =	0.956	0.221	0.202	0.509	1.729
20% Perc =	1.106	0.250	0.218	0.550	1.897
25% Perc =	1.263	0.279	0.231	0.587	2.059
30% Perc =	1.418	0.311	0.244	0.625	2.203
35% Perc =	1.554	0.343	0.256	0.660	2.340
40% Perc =	1.681	0.376	0.269	0.698	2.478
45% Perc =	1.820	0.413	0.283	0.735	2.612
50% Perc =	1.954	0.448	0.299	0.772	2.767
55% Perc =	2.093	0.485	0.315	0.811	2.920
60% Perc =	2.241	0.526	0.332	0.852	3.076
65% Perc =	2.397	0.570	0.350	0.894	3.225
70% Perc =	2.565	0.617	0.369	0.941	3.395
75% Perc =	2.751	0.665	0.389	0.993	3.580
80% Perc =	2.954	0.723	0.412	1.051	3.769
85% Perc =	3.187	0.786	0.438	1.117	4.012
90% Perc =	3.475	0.861	0.468	1.198	4.322
95% Perc =	3.861	0.959	0.511	1.314	4.724
Maximum =	5.594	1.257	0.680	1.824	6.572

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
All years Average LOF	Spill Index [bbl]				
Mean =	11.91	51.68	301.52	353.20	365.10
Std Deviation =	7.84	31.36	97.00	102.21	102.50
Variance =	61.511	983.506	9408.547	10446.500	10505.340
Skewness =	1.13	1.23	0.46	0.44	0.44
Kurtosis =	4.49	4.71	3.20	3.20	3.20
Mode =	6.67	21.58	246.01	225.55	275.16
Minimum =	-0.468	1.056	48.901	73.614	87.596
5% Perc =	2.348	14.393	156.078	197.936	209.569
10% Perc =	3.397	18.540	183.324	228.389	240.451
15% Perc =	4.261	22.315	203.479	248.685	260.091
20% Perc =	5.095	25.688	218.142	266.049	277.256
25% Perc =	5.948	28.953	231.798	280.439	292.449
30% Perc =	6.837	31.877	245.246	293.523	305.718
35% Perc =	7.639	34.869	257.665	306.897	319.341
40% Perc =	8.487	37.981	269.188	319.398	331.320
45% Perc =	9.368	41.146	281.003	332.948	345.055
50% Perc =	10.261	44.419	293.703	345.582	357.364
55% Perc =	11.242	48.316	305.940	358.088	370.714
60% Perc =	12.324	51.870	317.912	371.245	383.755
65% Perc =	13.360	56.735	331.738	385.025	396.673
70% Perc =	14.671	61.586	346.214	400.449	412.159
75% Perc =	16.040	67.379	362.751	417.847	429.344
80% Perc =	17.824	73.764	380.691	436.335	448.068
85% Perc =	19.999	82.829	402.956	460.099	473.267
90% Perc =	22.725	94.066	430.383	489.159	501.952
95% Perc =	27.100	115.173	475.142	534.783	545.492
Maximum =	53.741	207.583	773.208	859.933	870.999

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

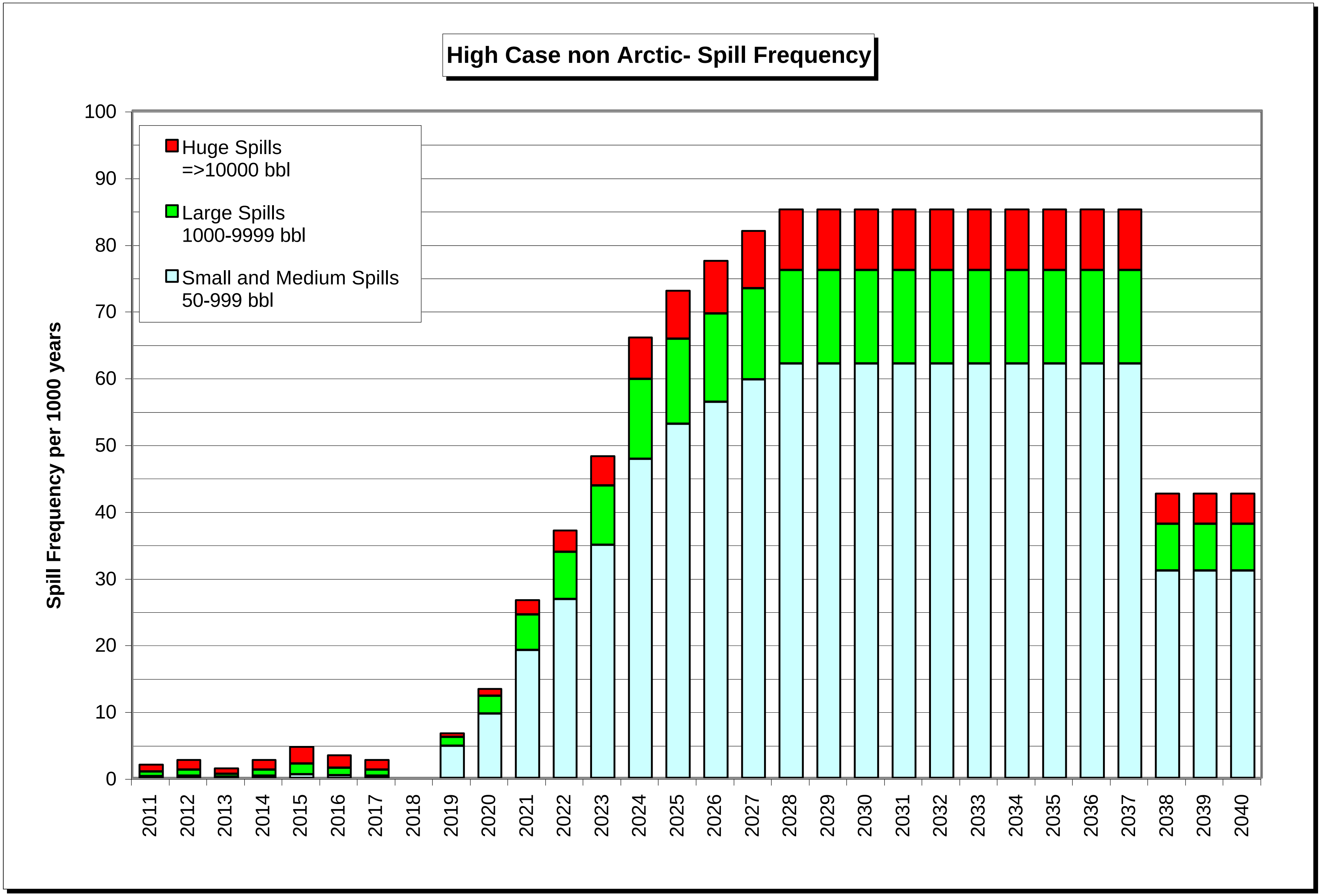
Spill Size	Spill Source: P/L		Platforms		Wells		Platforms and Wells		All	
	High Case non Arctic - Year 2030 Spill Frequency per 10^3 years									
Small and Medium Spills 50-999 bbl	38.274	72%	23.005	91%	0.733	11%	23.737	74%	62.011	73%
Large Spills 1000-9999 bbl	10.632	20%	1.202	5%	2.199	33%	3.401	11%	14.032	16%
Huge Spills =>10000 bbl	4.253	8%	1.202	5%	3.665	56%	4.866	15%	9.119	11%
Significant Spills =>1000 bbl	14.884	28%	2.403	9%	5.864	89%	8.267	26%	23.151	27%
All Spills	**53.158**	**100%**	**25.408**	**100%**	**6.597**	**100%**	**32.005**	**100%**	**85.162**	**100%**
	High Case non Arctic - Year 2030 Spill Frequency per 10^9 bbl produced									
Small and Medium Spills 50-999 bbl	0.843	72%	0.507	91%	0.016	11%	0.523	74%	1.366	73%
Large Spills 1000-9999 bbl	0.234	20%	0.026	5%	0.048	33%	0.075	11%	0.309	16%
Huge Spills =>10000 bbl	0.094	8%	0.026	5%	0.081	56%	0.107	15%	0.201	11%
Significant Spills =>1000 bbl	0.328	28%	0.053	9%	0.129	89%	0.182	26%	0.510	27%
All Spills	**1.171**	**100%**	**0.560**	**100%**	**0.145**	**100%**	**0.705**	**100%**	**1.876**	**100%**
	High Case non Arctic - Year 2030 Spill Index [bbl]									
Small and Medium Spills 50-999 bbl	11	8%	10	43%	0	0%	11	2%	22	4%
Large Spills 1000-9999 bbl	55	42%	7	28%	27	6%	34	7%	89	14%
Huge Spills =>10000 bbl	66	50%	7	28%	443	94%	450	91%	516	82%
Significant Spills =>1000 bbl	121	92%	14	57%	471	100%	484	98%	605	96%
All Spills	**132**	**100%**	**24**	**100%**	**471**	**100%**	**495**	**100%**	**627**	**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	38.274	62%	10.632	76%	4.253	47%	14.884	64%	53.158	62%
Platforms	23.005	37%	1.202	9%	1.202	13%	2.403	10%	25.408	30%
Wells	0.733	1%	2.199	16%	3.665	40%	5.864	25%	6.597	8%
Platforms and Wells	23.737	38%	3.401	24%	4.866	53%	8.267	36%	32.005	38%
All	**62.011**	**100%**	**14.032**	**100%**	**9.119**	**100%**	**23.151**	**100%**	**85.162**	**100%**
	High Case non Arctic - Year 2030 Spill Frequency per 10^9 bbl produced									
P/L	0.843	62%	0.234	76%	0.094	47%	0.328	64%	1.171	62%
Platforms	0.507	37%	0.026	9%	0.026	13%	0.053	10%	0.560	30%
Wells	0.016	1%	0.048	16%	0.081	40%	0.129	25%	0.145	8%
Platforms and Wells	0.523	38%	0.075	24%	0.107	53%	0.182	36%	0.705	38%
All	**1.366**	**100%**	**0.309**	**100%**	**0.201**	**100%**	**0.510**	**100%**	**1.876**	**100%**
	High Case non Arctic - Year 2030 Spill Index [bbl]									
P/L	11	51%	55	62%	66	13%	121	20%	132	21%
Platforms	10	47%	7	8%	7	1%	14	2%	24	4%
Wells	0	2%	27	31%	443	86%	471	78%	471	75%
Platforms and Wells	11	49%	34	38%	450	87%	484	80%	495	79%
All	**22**	**100%**	**89**	**100%**	**516**	**100%**	**605**	**100%**	**627**	**100%**

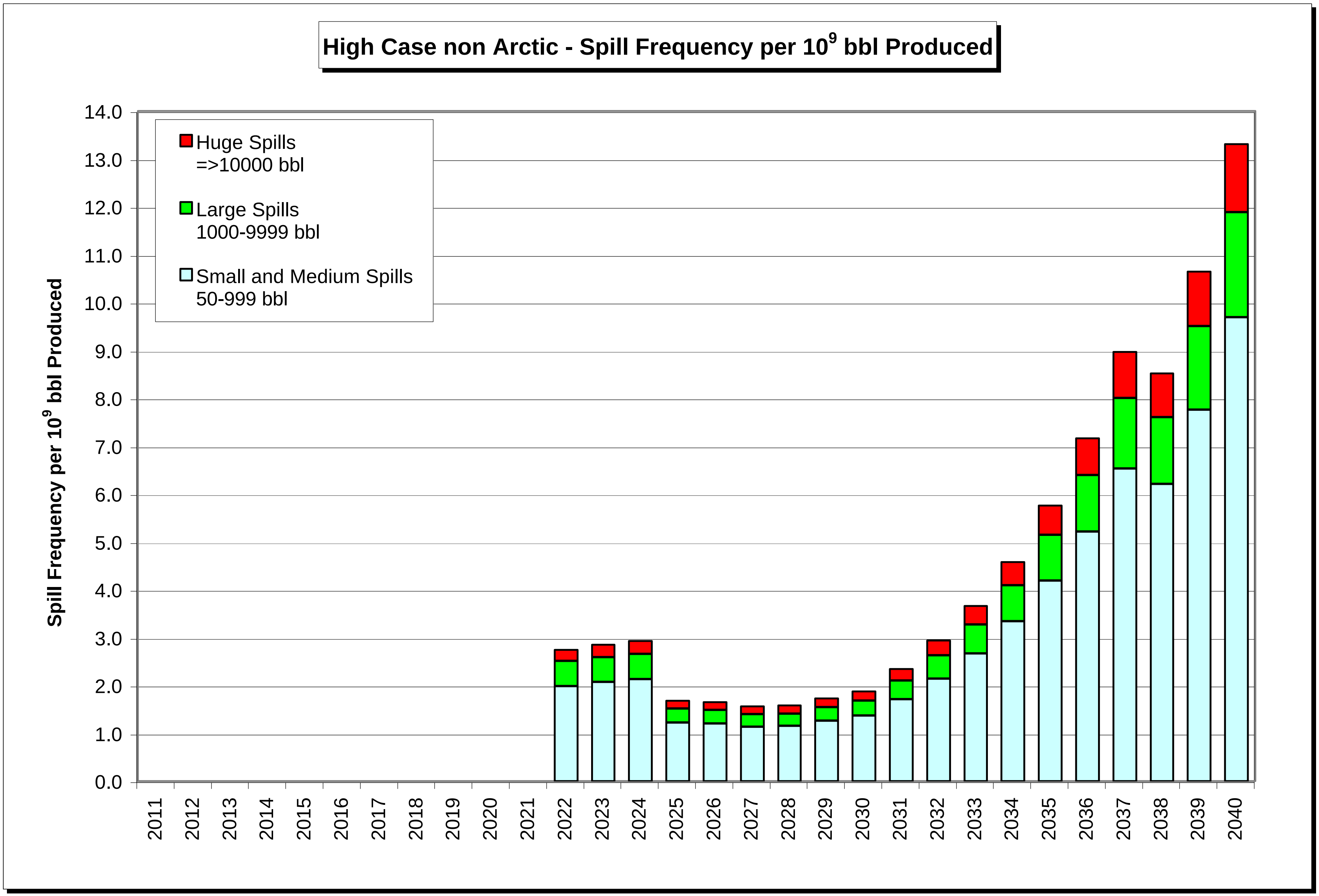
Table 4.3.21
Composition of Spill Indicators - High Case non Arctic - LOF Average

Spill Size	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	22.645	72%	11.165	91%	0.427	11%	11.592	72%	34.237	72%
Large Spills 1000-9999 bbl	6.290	20%	0.583	5%	1.281	33%	1.864	12%	8.155	17%
Huge Spills =>10000 bbl	2.516	8%	0.583	5%	2.140	56%	2.723	17%	5.239	11%
Significant Spills =>1000 bbl	8.806	28%	1.166	9%	3.421	89%	4.588	28%	13.394	28%
All Spills	**31.452**	**100%**	**12.331**	**100%**	**3.848**	**100%**	**16.179**	**100%**	**47.631**	**100%**
	High Case non Arctic - LOF Average Spill Frequency per 10^9 bbl produced									
Small and Medium Spills 50-999 bbl	1.359	72%	0.670	91%	0.026	11%	0.696	72%	2.054	72%
Large Spills 1000-9999 bbl	0.377	20%	0.035	5%	0.077	33%	0.112	12%	0.489	17%
Huge Spills =>10000 bbl	0.151	8%	0.035	5%	0.128	56%	0.163	17%	0.314	11%
Significant Spills =>1000 bbl	0.528	28%	0.070	9%	0.205	89%	0.275	28%	0.804	28%
All Spills	**1.887**	**100%**	**0.740**	**100%**	**0.231**	**100%**	**0.971**	**100%**	**2.858**	**100%**
	High Case non Arctic - LOF Average Spill Index [bbl]									
Small and Medium Spills 50-999 bbl	7	8%	5	43%	0	0%	5	2%	12	3%
Large Spills 1000-9999 bbl	33	42%	3	28%	16	6%	19	7%	52	14%
Huge Spills =>10000 bbl	39	50%	3	28%	259	94%	263	92%	302	83%
Significant Spills =>1000 bbl	72	92%	7	57%	275	100%	282	98%	353	97%
All Spills	**78**	**100%**	**12**	**100%**	**275**	**100%**	**287**	**100%**	**365**	**100%**

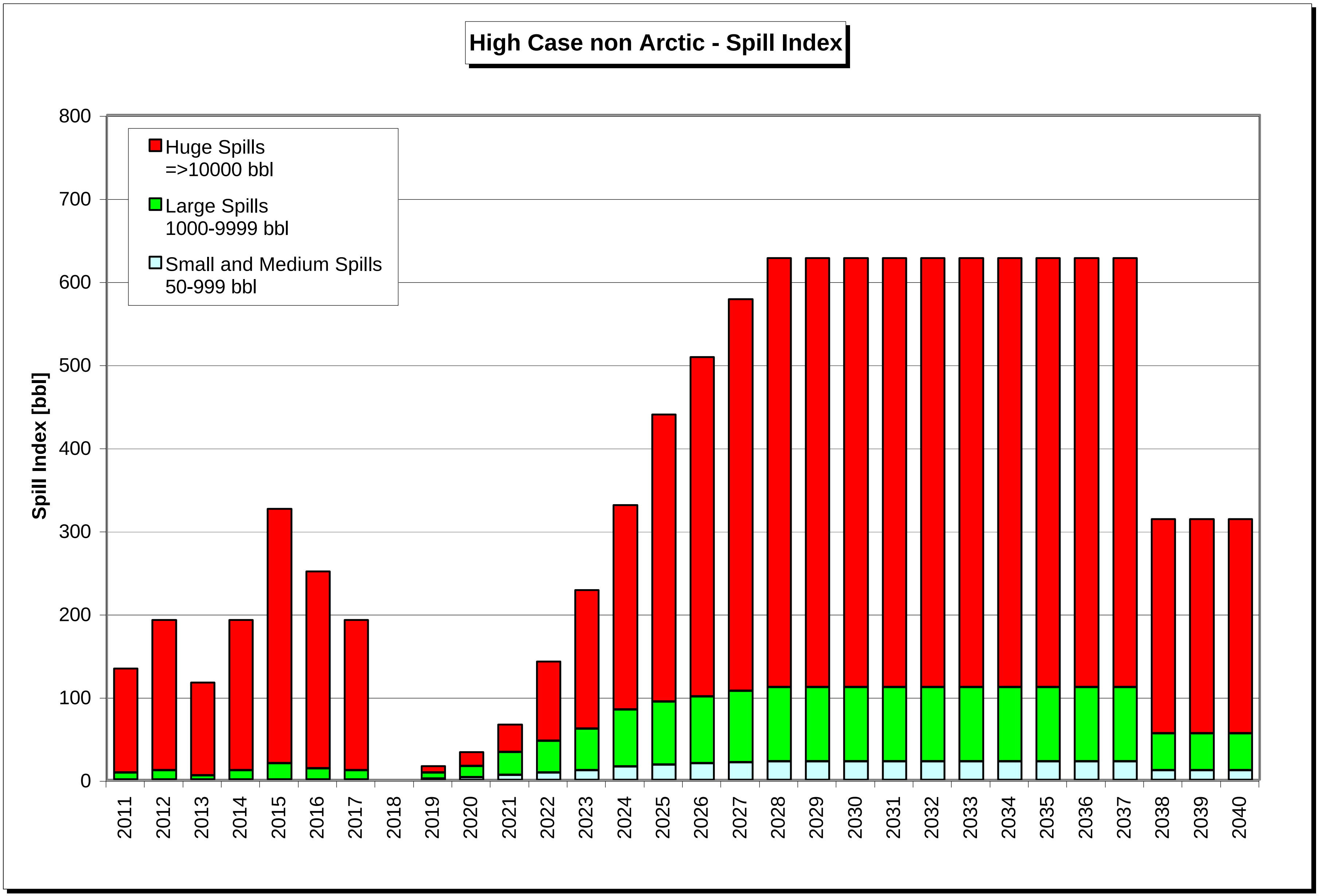
Spill Source	S+M 50-999 bbl		Large 1000-9999 bbl		Huge =>10000 bbl		Significant =>1000 bbl		All Spills	
	High Case non Arctic - LOF Average Spill Frequency per 10^3 years									
P/L	22.645	66%	6.290	77%	2.516	48%	8.806	66%	31.452	66%
Platforms	11.165	33%	0.583	7%	0.583	11%	1.166	9%	12.331	26%
Wells	0.427	1%	1.281	16%	2.140	41%	3.421	26%	3.848	8%
Platforms and Wells	11.592	34%	1.864	23%	2.723	52%	4.588	34%	16.179	34%
All	**34.237**	**100%**	**8.155**	**100%**	**5.239**	**100%**	**13.394**	**100%**	**47.631**	**100%**
	High Case non Arctic - LOF Average Spill Frequency per 10^9 bbl produced									
P/L	1.359	66%	0.377	77%	0.151	48%	0.528	66%	1.887	66%
Platforms	0.670	33%	0.035	7%	0.035	11%	0.070	9%	0.740	26%
Wells	0.026	1%	0.077	16%	0.128	41%	0.205	26%	0.231	8%
Platforms and Wells	0.696	34%	0.112	23%	0.163	52%	0.275	34%	0.971	34%
All	**2.054**	**100%**	**0.489**	**100%**	**0.314**	**100%**	**0.804**	**100%**	**2.858**	**100%**
	High Case non Arctic - LOF Average Spill Index [bbl]									
P/L	7	56%	33	63%	39	13%	72	20%	78	21%
Platforms	5	42%	3	6%	3	1%	7	2%	12	3%
Wells	0	2%	16	31%	259	86%	275	78%	275	75%
Platforms and Wells	5	44%	19	37%	263	87%	282	80%	287	79%
All	**12**	**100%**	**52**	**100%**	**302**	**100%**	**353**	**100%**	**365**	**100%**



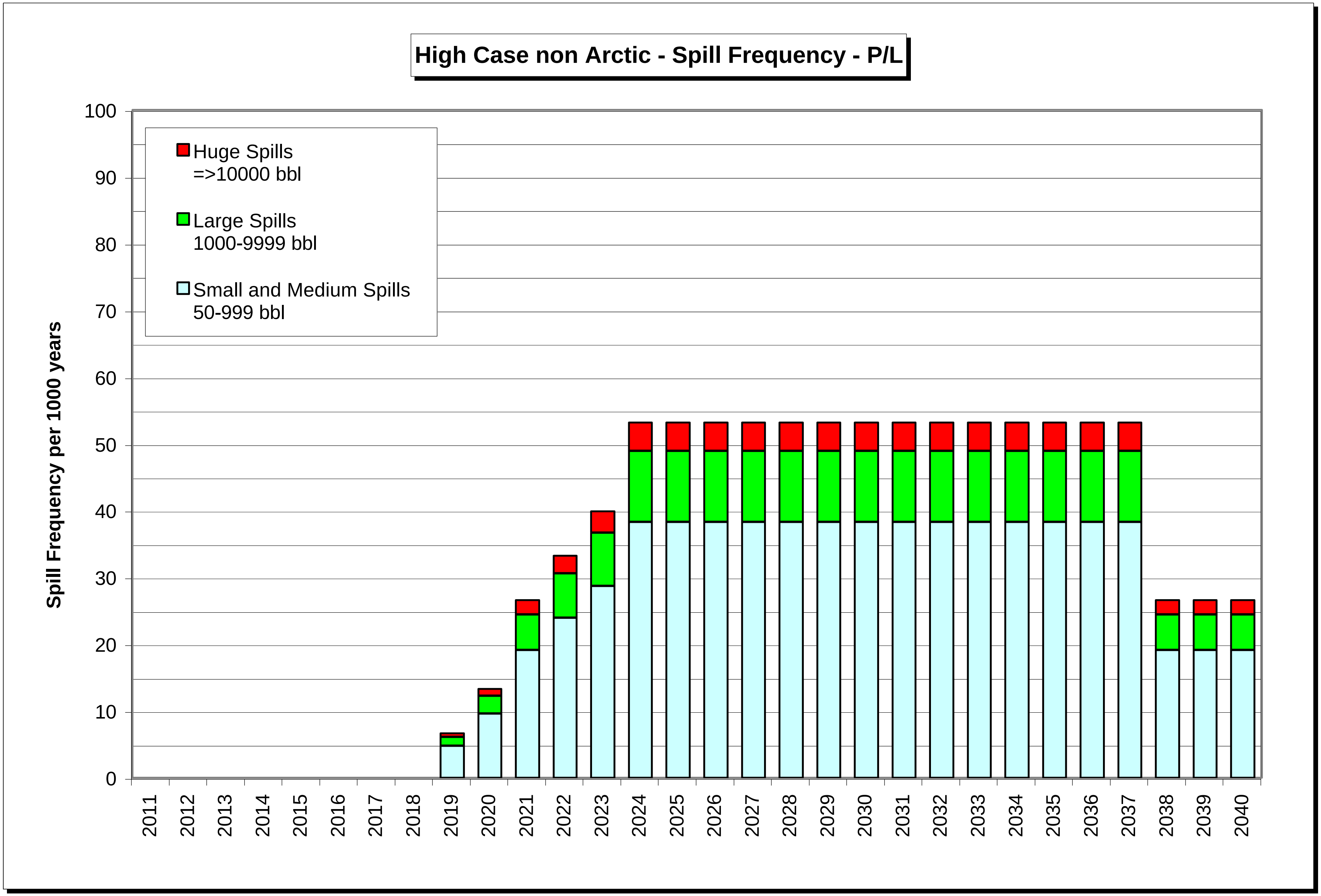
C4_3HighcaseNonArtic_CS.xlsF4301



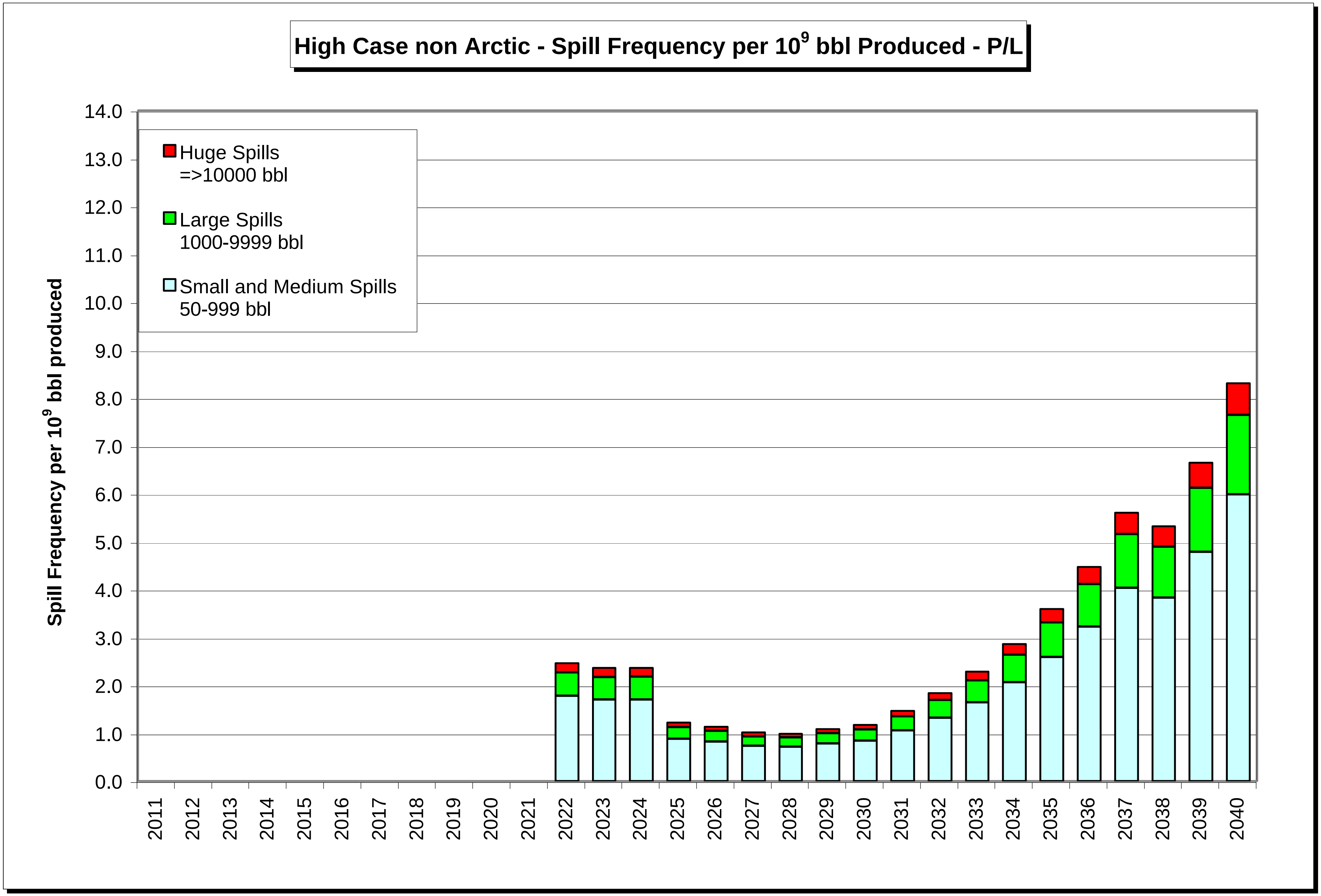
C4_3HighcaseNonArtic_CS.xlsF4302



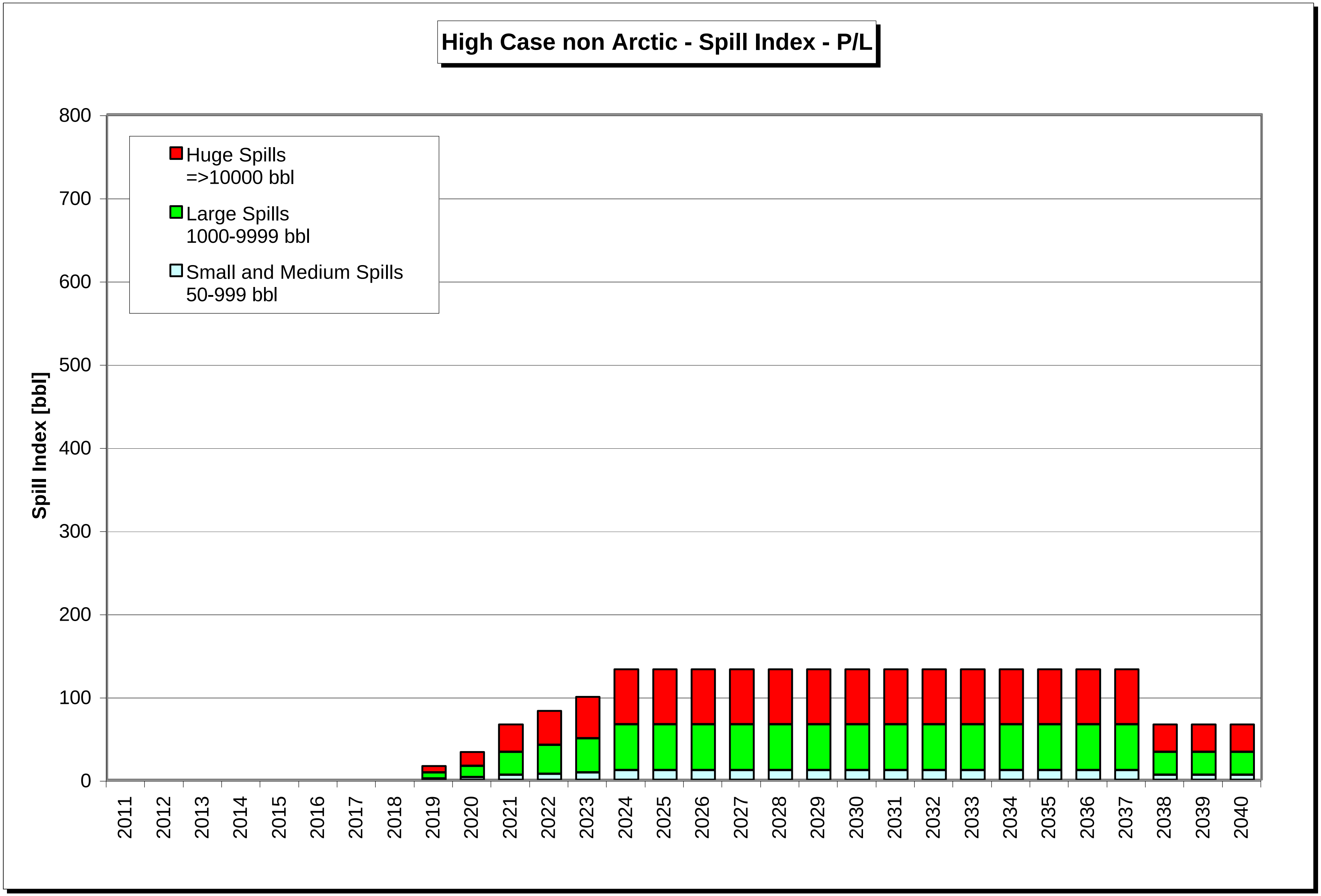
C4_3HighcaseNonArtic_CS.xlsF4303



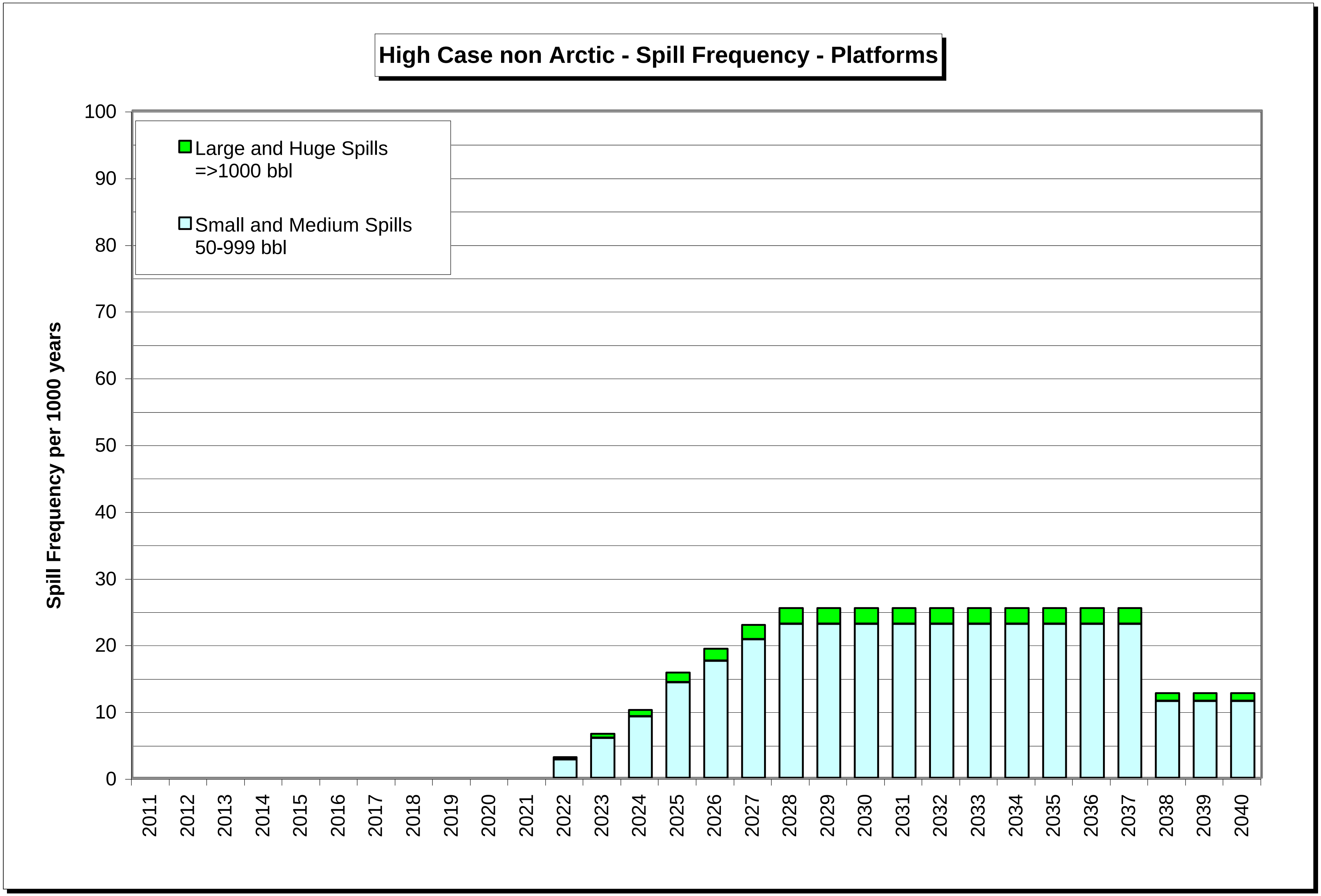
C4_3HighcaseNonArtic_CS.xlsF4304



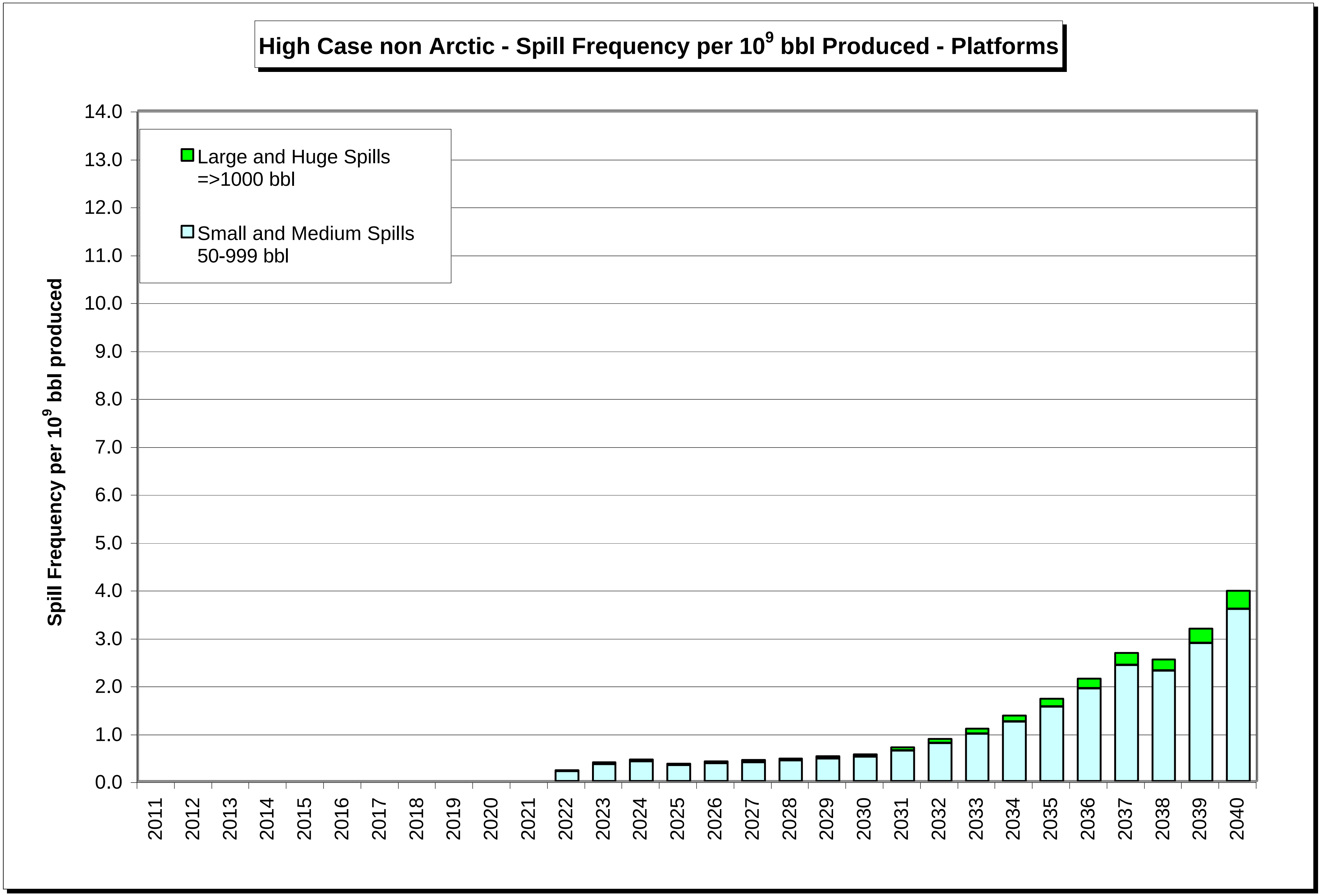
C4_3HighcaseNonArtic_CS.xlsF4305



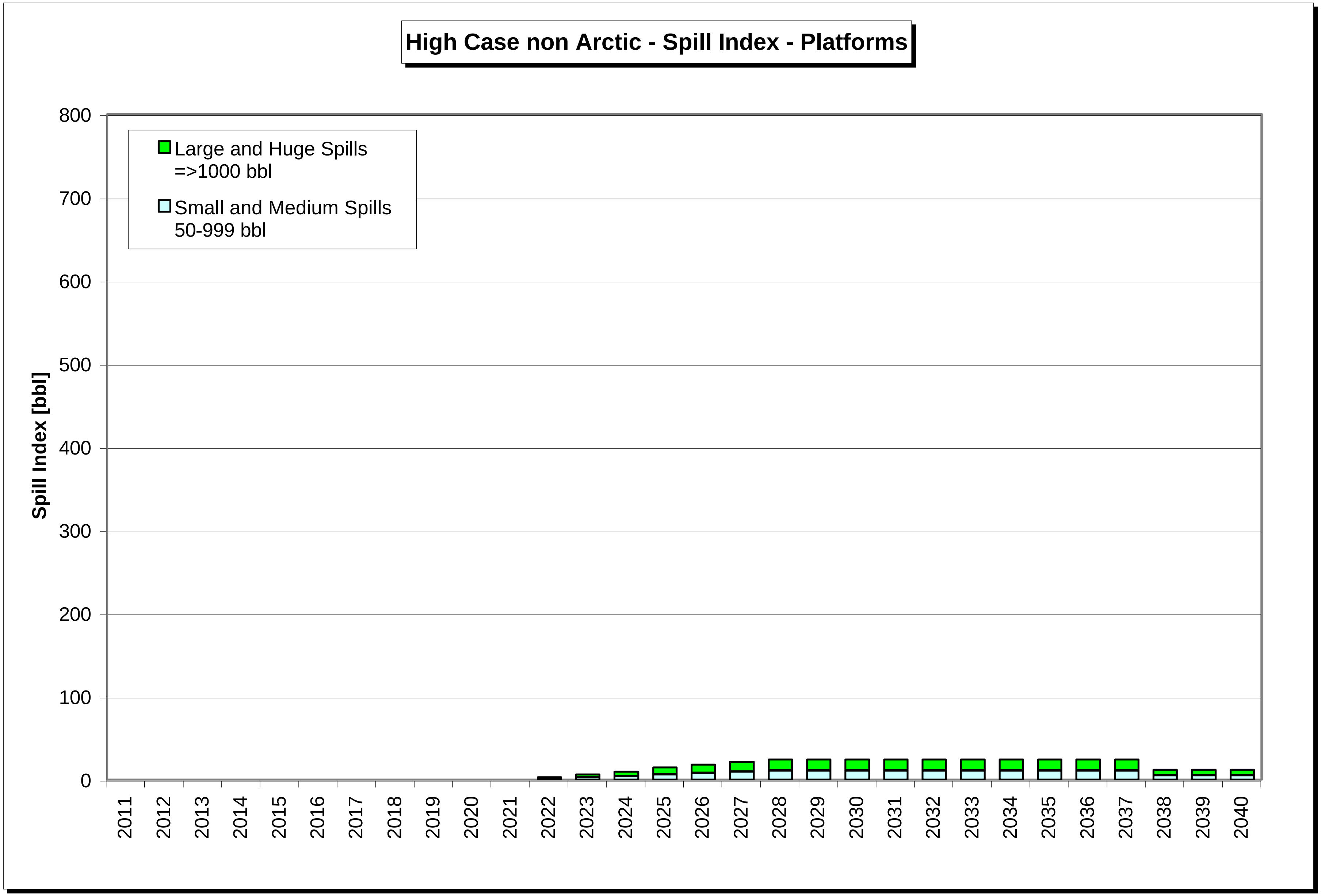
C4_3HighcaseNonArtic_CS.xlsF4306



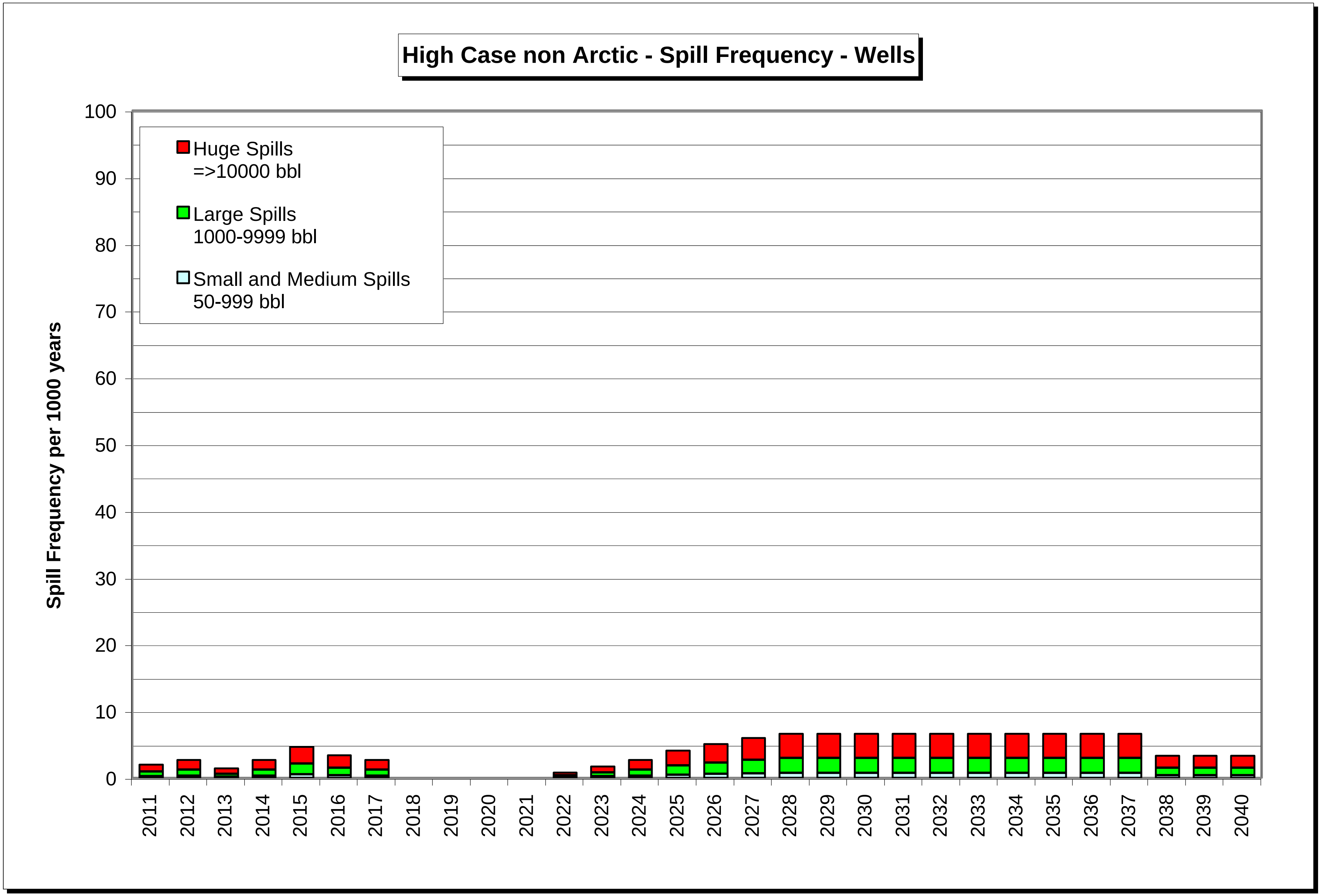
C4_3HighcaseNonArtic_CS.xlsF4307



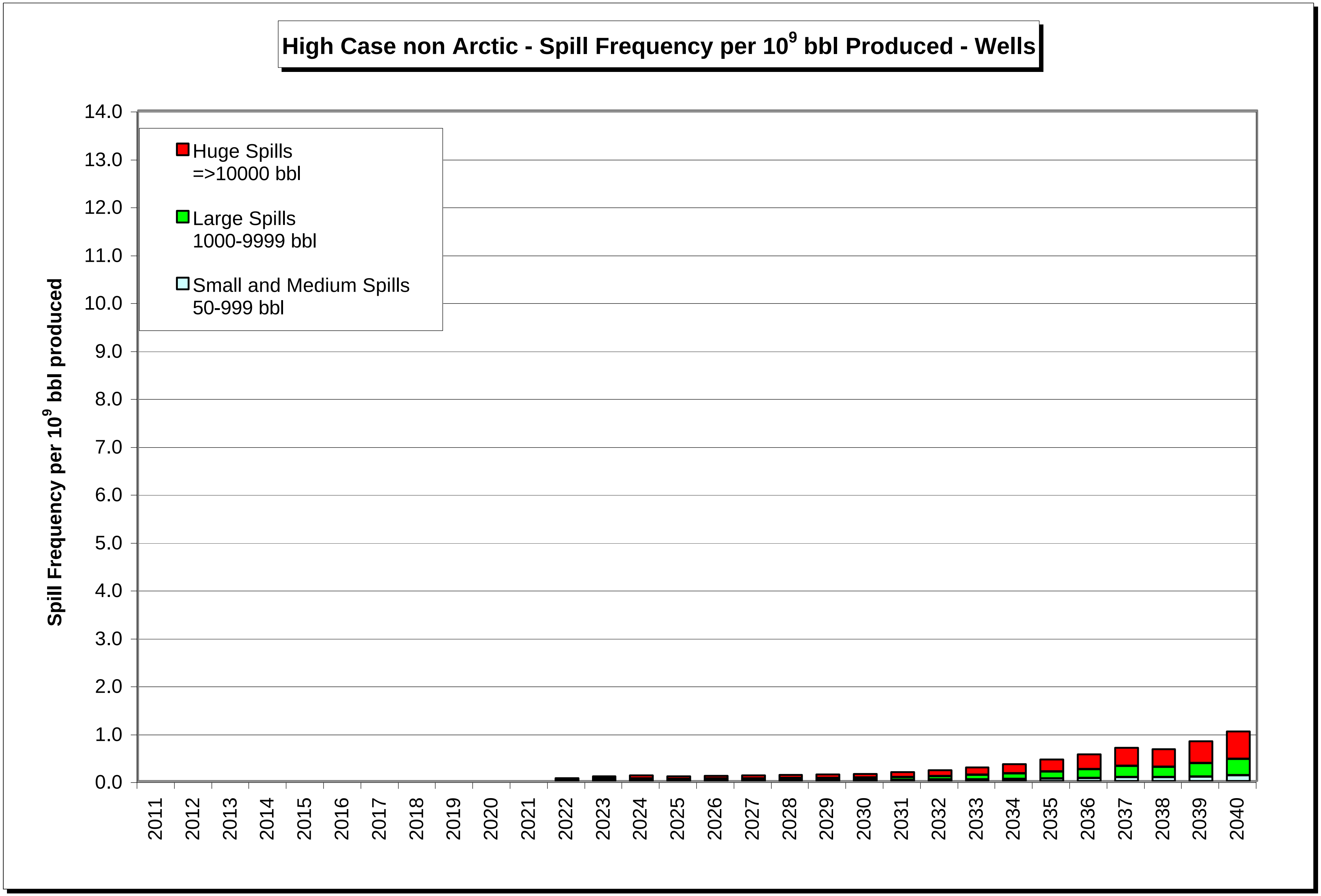
C4_3HighcaseNonArtic_CS.xlsF4308



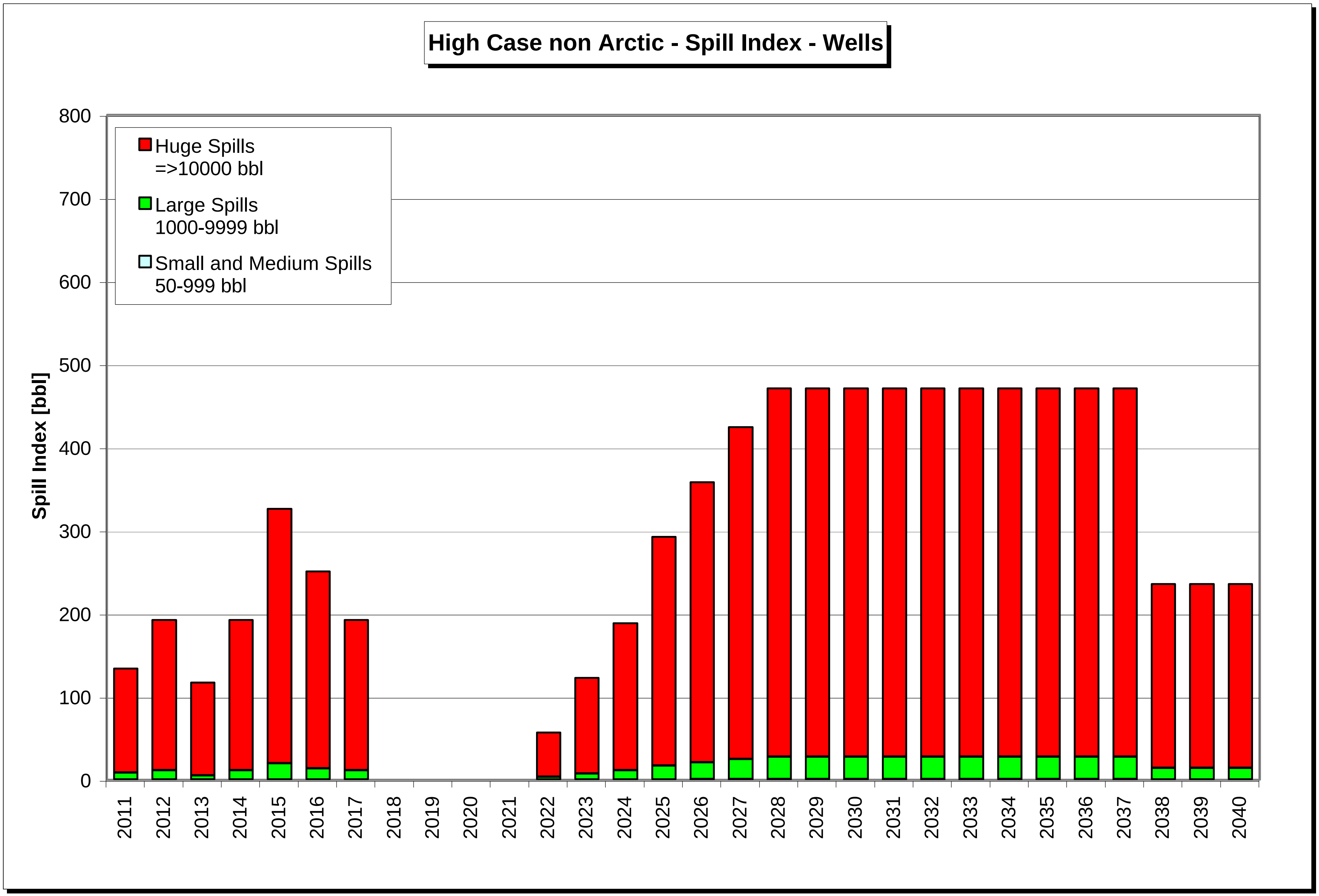
C4_3HighcaseNonArtic_CS.xlsF4309



C4_3HighcaseNonArtic_CS.xlsF4310

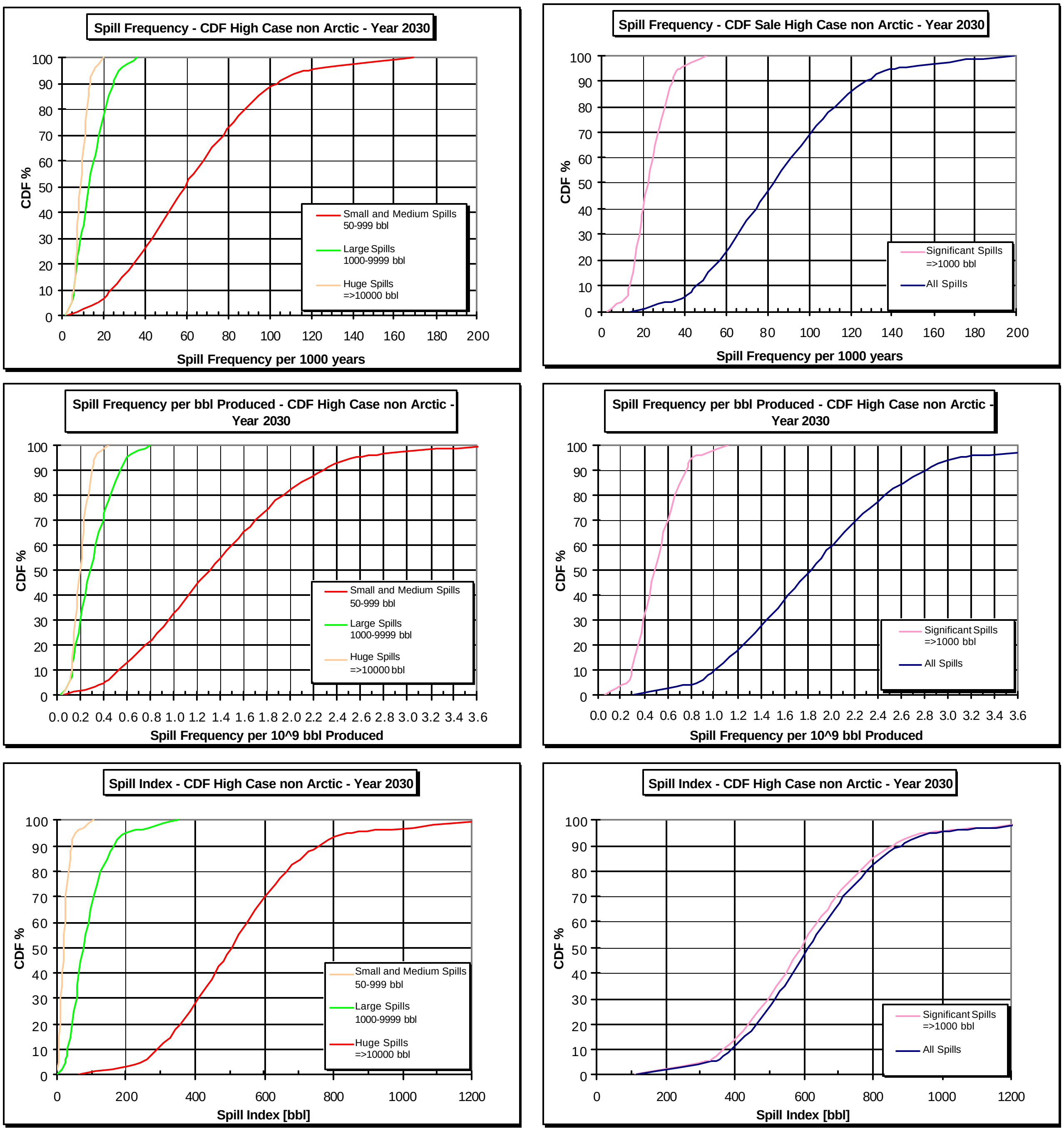


C4_3HighcaseNonArtic_CS.xlsF4311



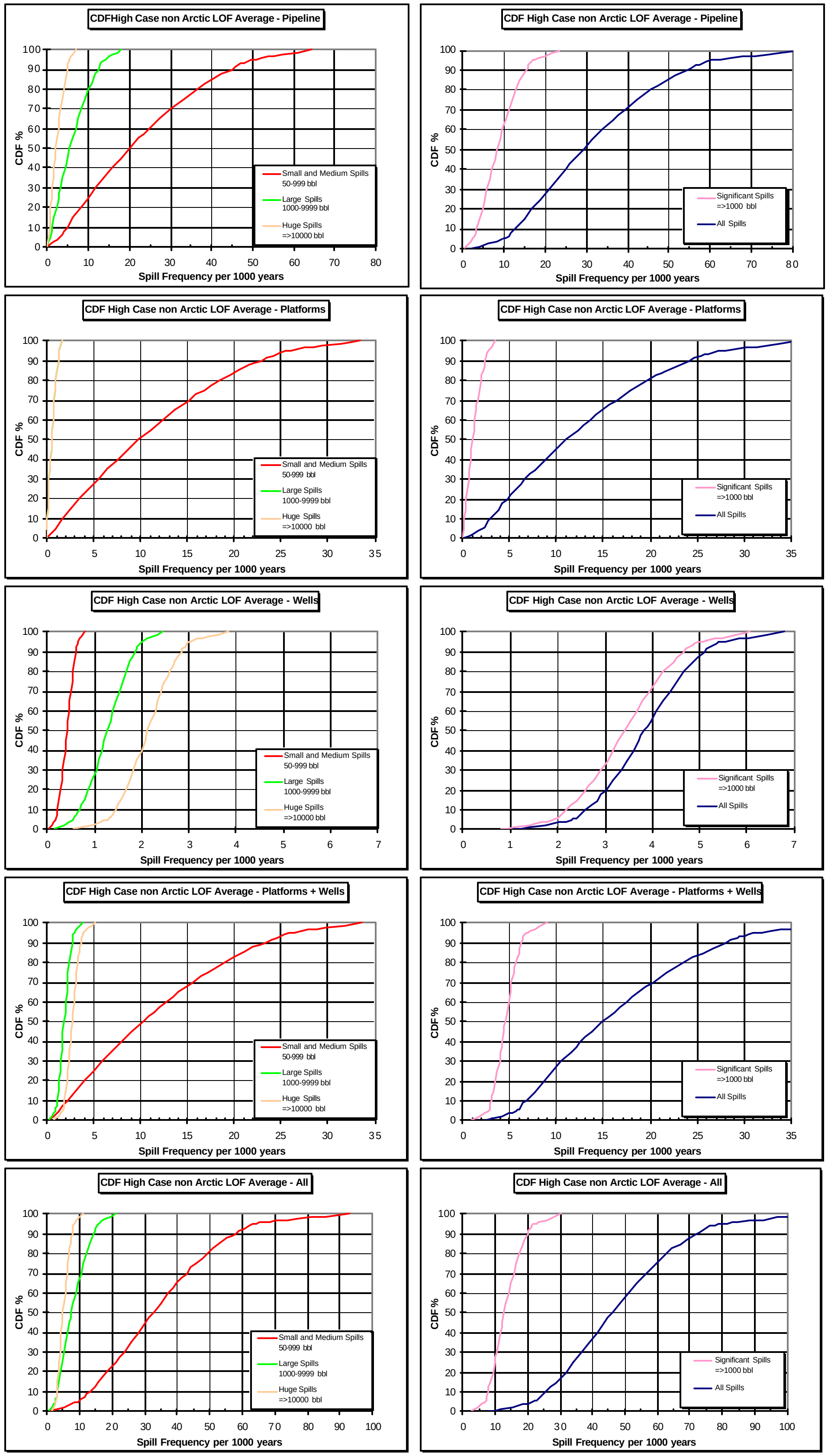
C4_3HighcaseNonArtic_CS.xlsF4312

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



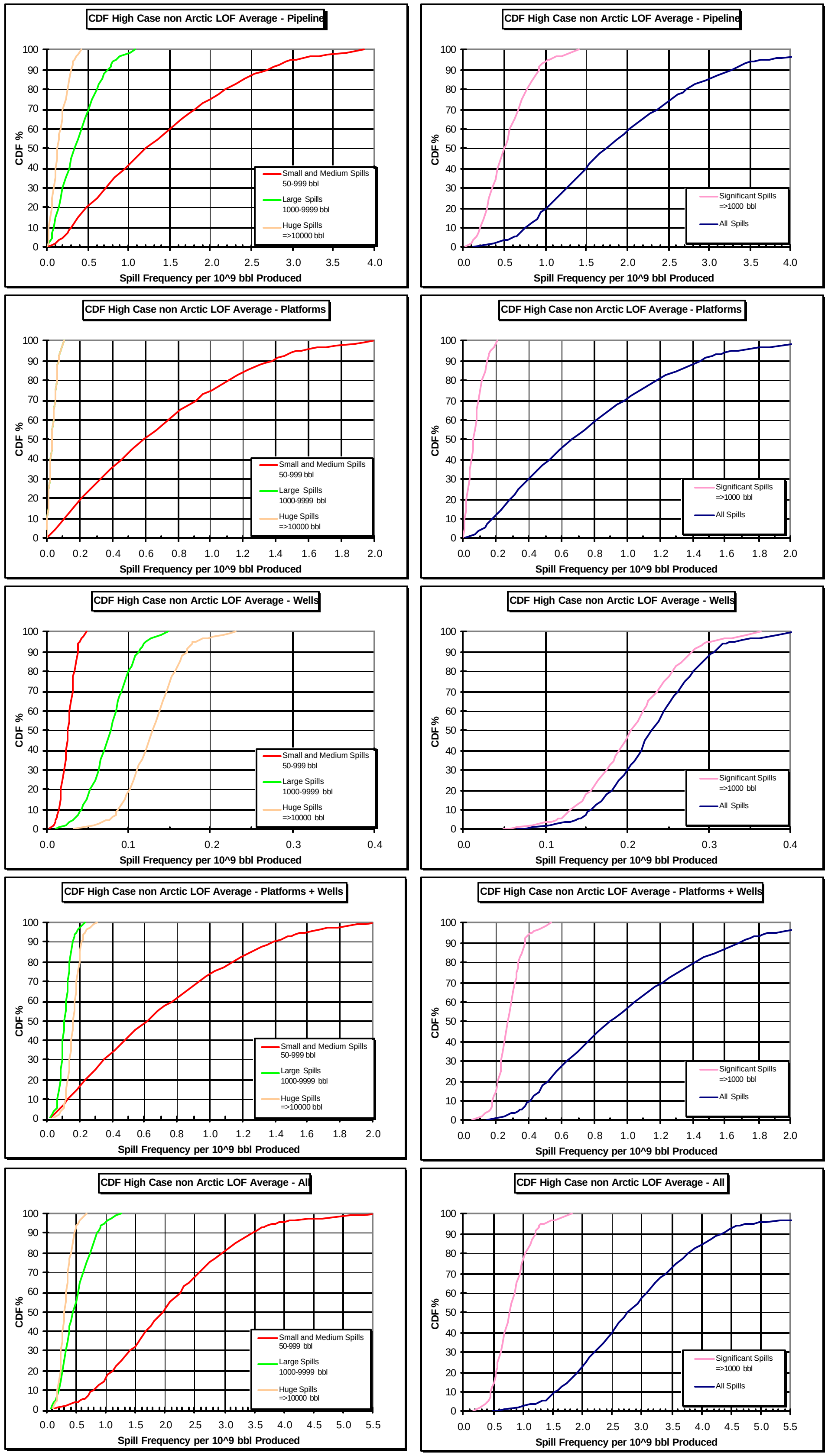
C4_3HighcaseNonArtic_CS.xls F4313

Figure 4.3.14 Spill Frequency – CDF – High Case non Arctic



C4_3HighcaseNonArtic_CS.xls F4314

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



C4_3HighcaseNonArtic_CS.xls F4315

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

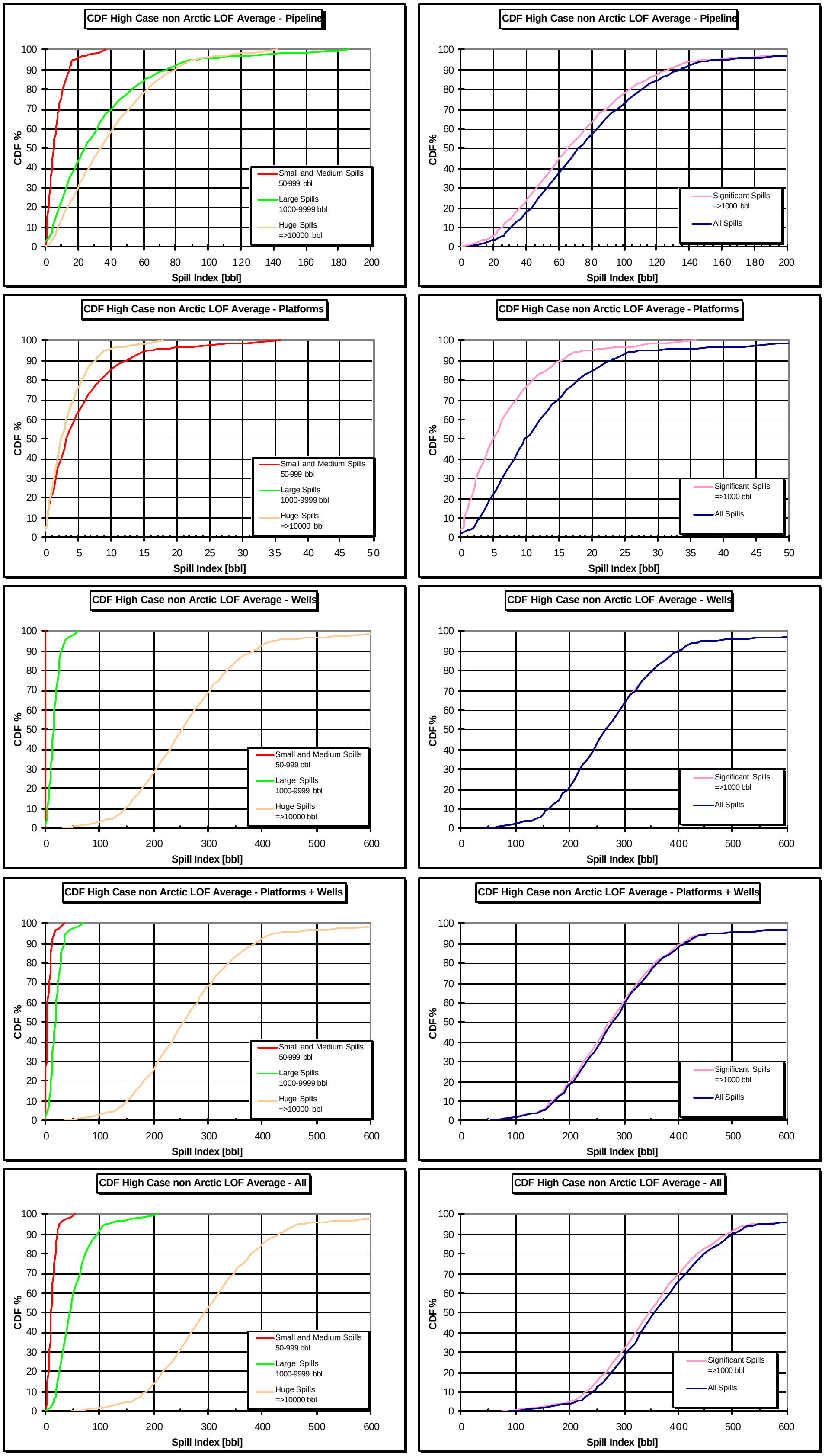
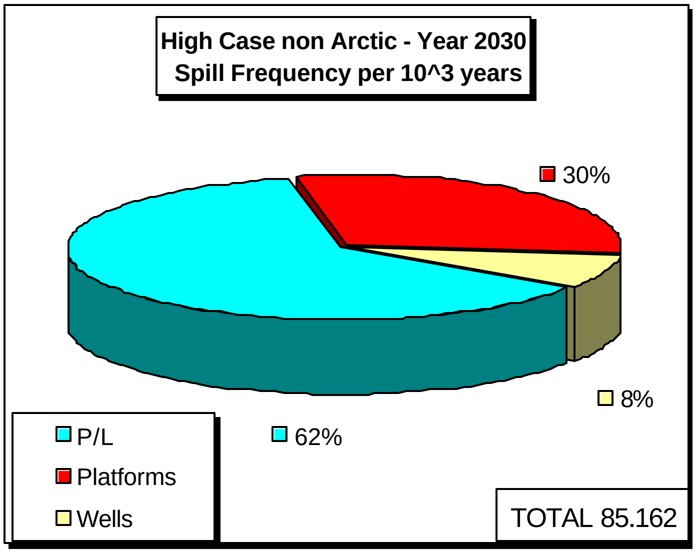
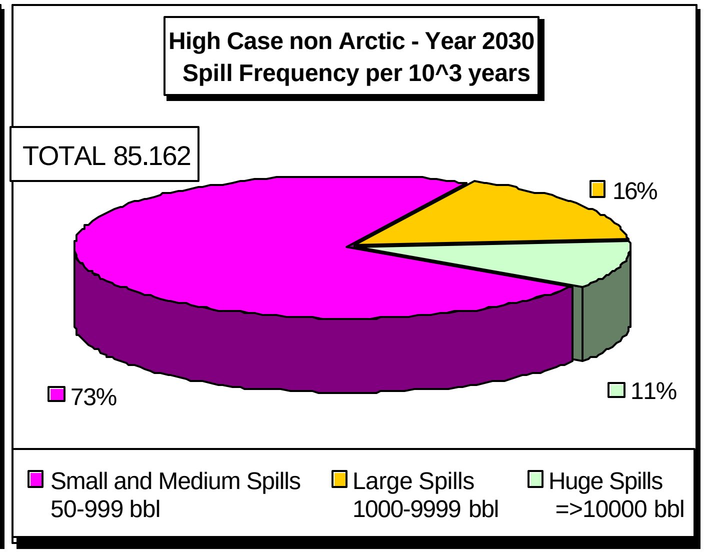
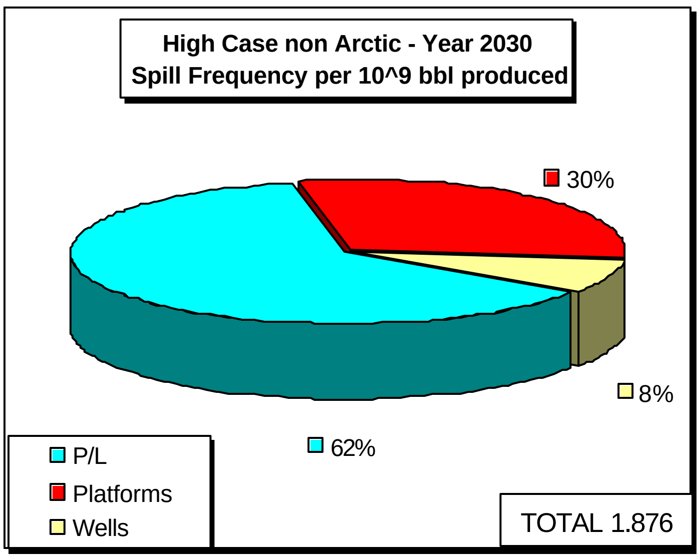


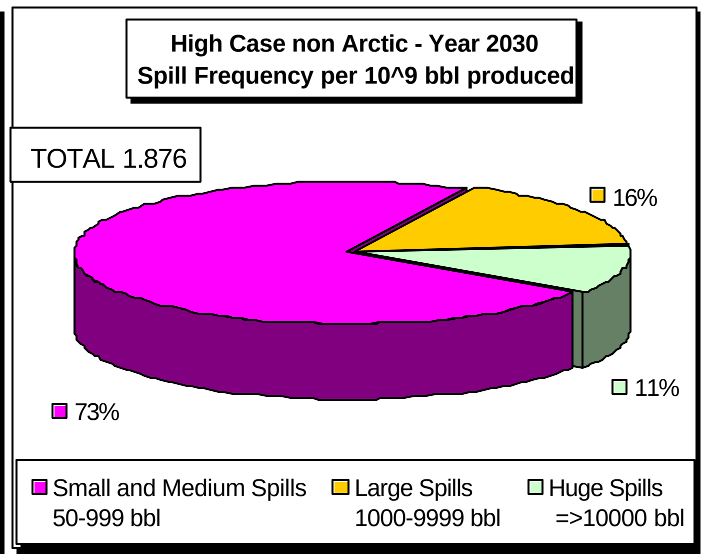
Figure 4.3.17
High Case non Arctic - Year 2030 - Spill Indicators

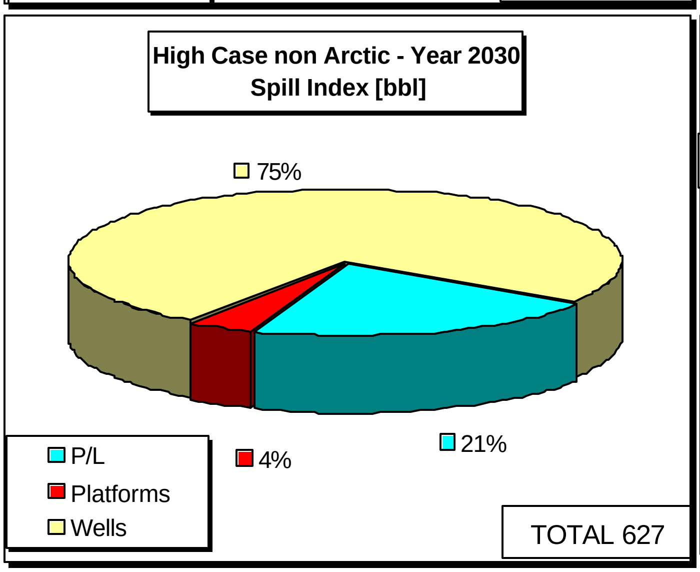
BY SPILL SOURCE	BY SPILL SIZE











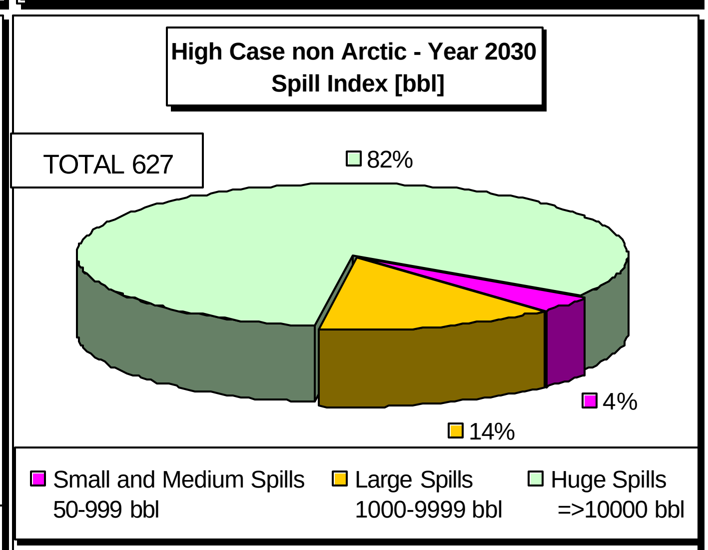
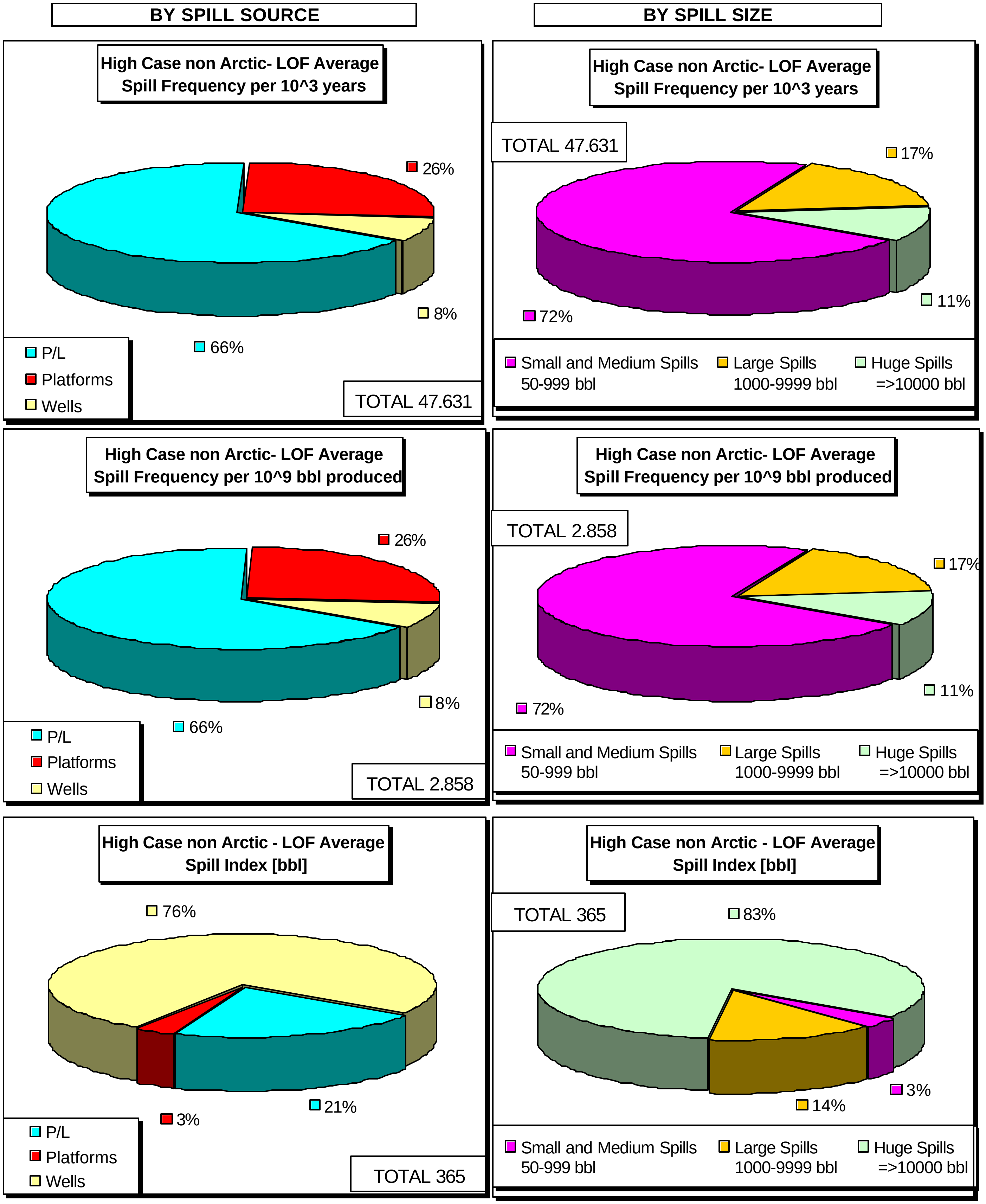


Figure 4.3.18
High Case non Arctic – LOF Average Spill Indicators

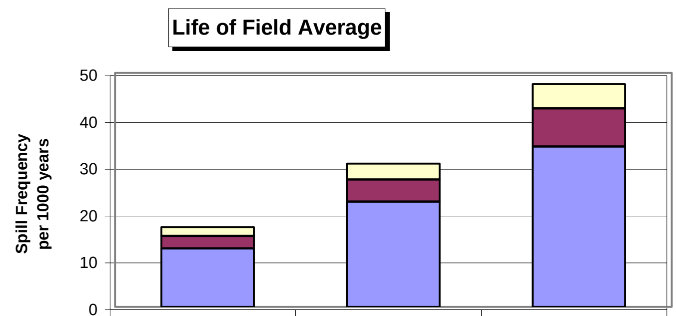


C4_3HighcaseNonArtic_CS.xls F4318

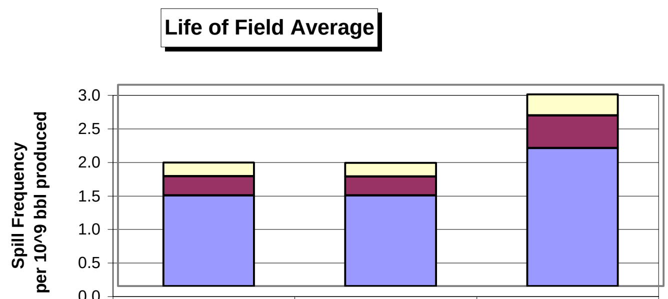
Table 5.1
Summary of Spill Indicators for All Scenarios

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	12.499	1.350	5	22.491	1.349	9	34.237	2.054	12
	73%	**73%**	**4%**	**74%**	**74%**	**4%**	**72%**	**72%**	**3%**
Large Spills 1000-9999 bbl	2.631	0.284	18	4.715	0.283	31	8.155	0.489	52
	15%	**15%**	**12%**	**15%**	**15%**	**12%**	**17%**	**17%**	**14%**
Huge Spills =>10000 bbl	1.899	0.205	121	3.385	0.203	213	5.239	0.314	302
	11%	**11%**	**84%**	**11%**	**11%**	**84%**	**11%**	**11%**	**83%**
Significant Spills =>1000 bbl	4.529	0.489	138	8.100	0.486	245	13.394	0.804	353
	27%	**27%**	**96%**	**26%**	**26%**	**96%**	**28%**	**28%**	**97%**
All Spills	17.028	1.839	143	30.592	1.835	254	47.631	2.858	365
	100%	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
Pipeline Spills	9.725	1.050	23	17.506	1.050	42	31.452	1.887	78
	57%	**57%**	**16%**	**57%**	**57%**	**16%**	**66%**	**66%**	**21%**
Platform Spills	5.702	0.616	6	10.263	0.616	10	12.331	0.740	12
	33%	**33%**	**4%**	**34%**	**34%**	**4%**	**26%**	**26%**	**3%**
Well Spills	1.601	0.173	114	2.823	0.169	202	3.848	0.231	275
	9%	**9%**	**80%**	**9%**	**9%**	**80%**	**8%**	**8%**	**75%**
Platform and Well Spills	7.303	0.789	120	13.086	0.785	212	16.179	0.971	287
	43%	**43%**	**84%**	**43%**	**43%**	**84%**	**34%**	**34%**	**79%**
All Spills	17.028	1.839	143	30.592	1.835	254	47.631	2.858	365
	100%	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

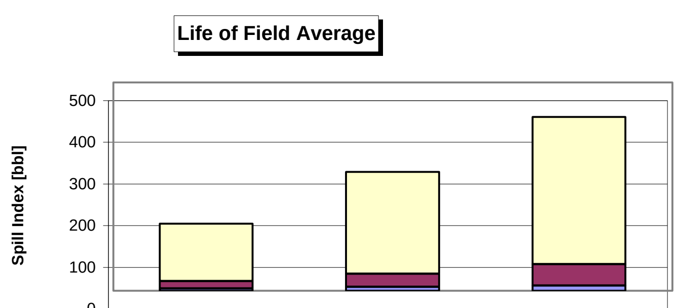
Figure 5.1 LOF Spill Indicators - By Size



	Low Case	High Case	High Case non Arctic
Huge Spills =>10000 bbl	1.899	3.385	5.239
Large Spills 1000-9999 bbl	2.631	4.715	8.155
Small and Medium Spills 50-999 bbl	12.499	22.491	34.237

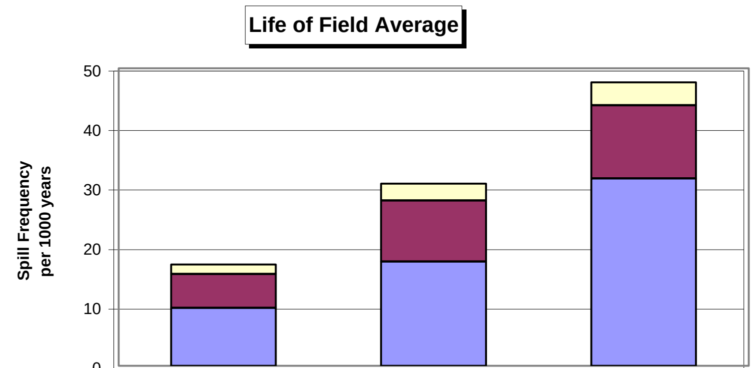


	Low Case	High Case	High Case non Arctic
Huge Spills =>10000 bbl	0.205	0.203	0.314
Large Spills 1000-9999 bbl	0.284	0.283	0.489
Small and Medium Spills 50-999 bbl	1.350	1.349	2.054

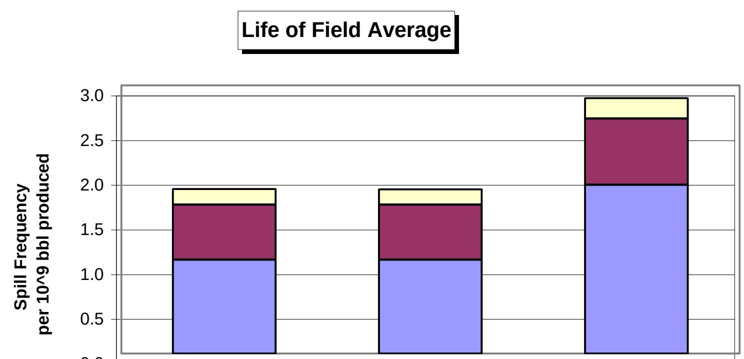


	Low Case	High Case	High Case non Arctic
Huge Spills =>10000 bbl	138	245	353
Large Spills 1000-9999 bbl	18	31	52
Small and Medium Spills 50-999 bbl	5	9	12

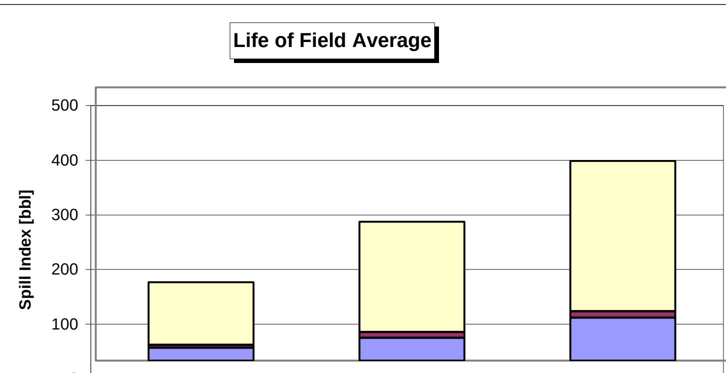
Figure 5.2 LOF Spill Indicators - By Source



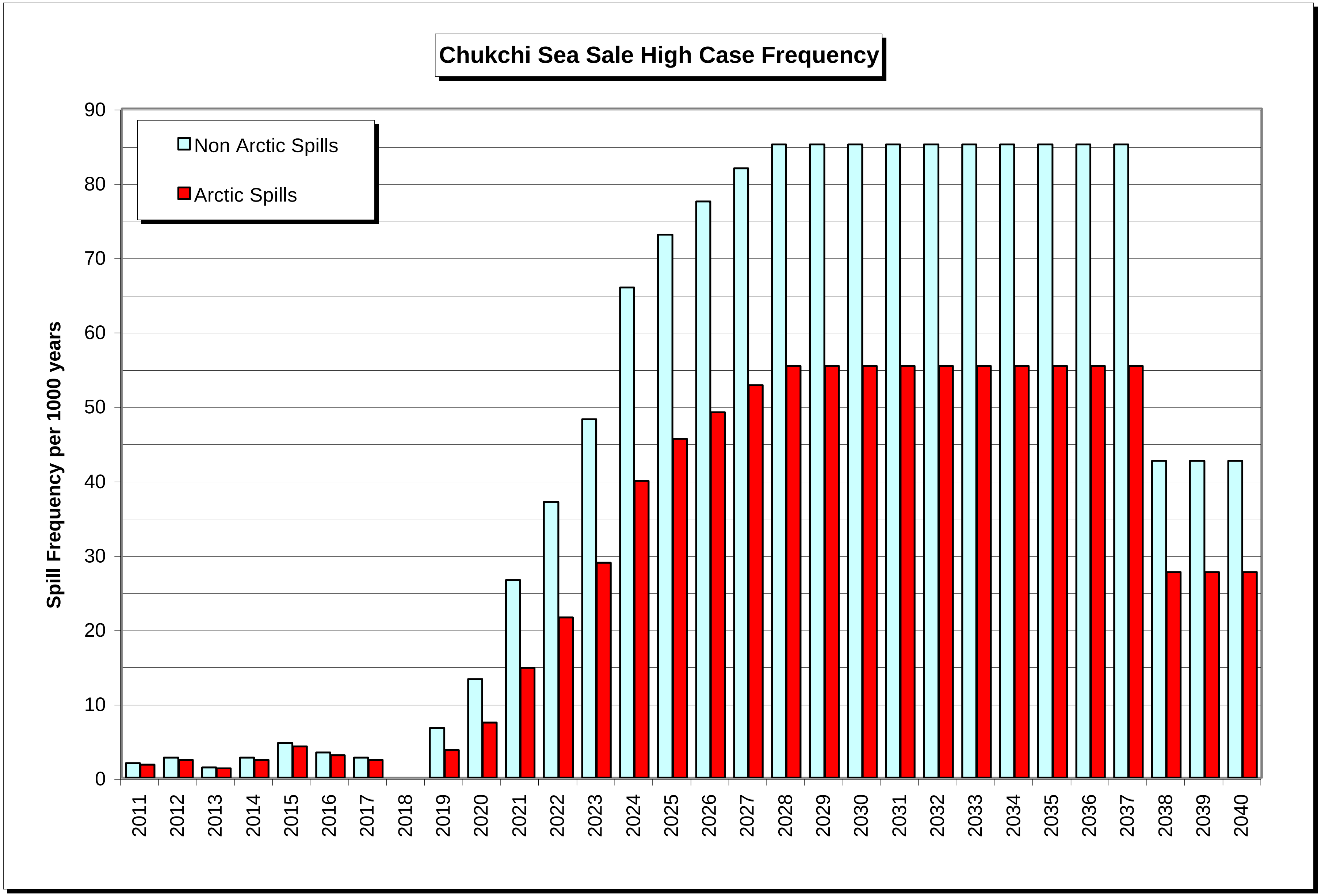
	Low Case	High Case	High Case non Arctic
Well Spills	1.601	2.823	3.848
Platform Spills	5.702	10.263	12.331
Pipeline Spills	9.725	17.506	31.452



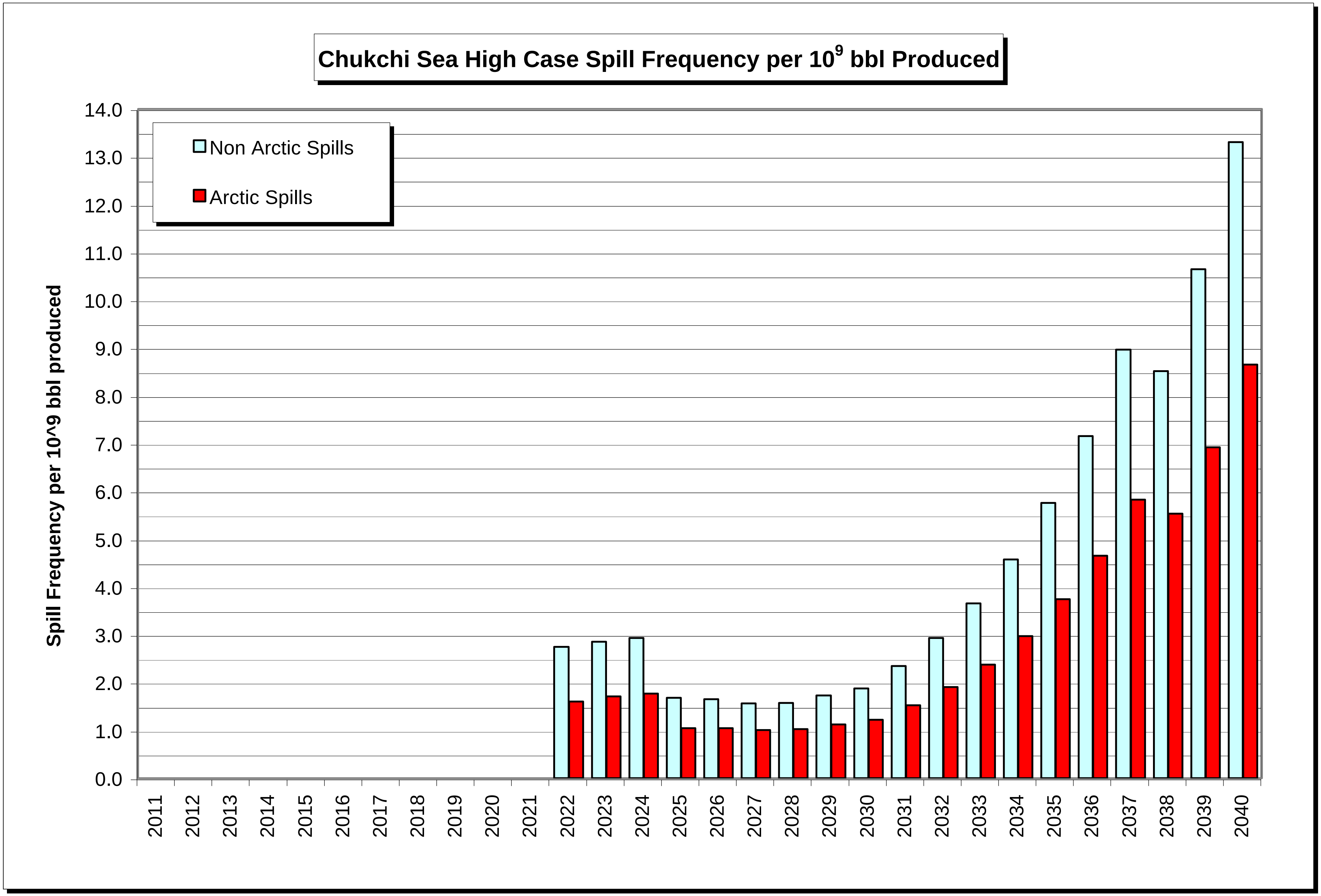
	Low Case	High Case	High Case non Arctic
Well Spills	0.173	0.169	0.231
Platform Spills	0.616	0.616	0.740
Pipeline Spills	1.050	1.050	1.887

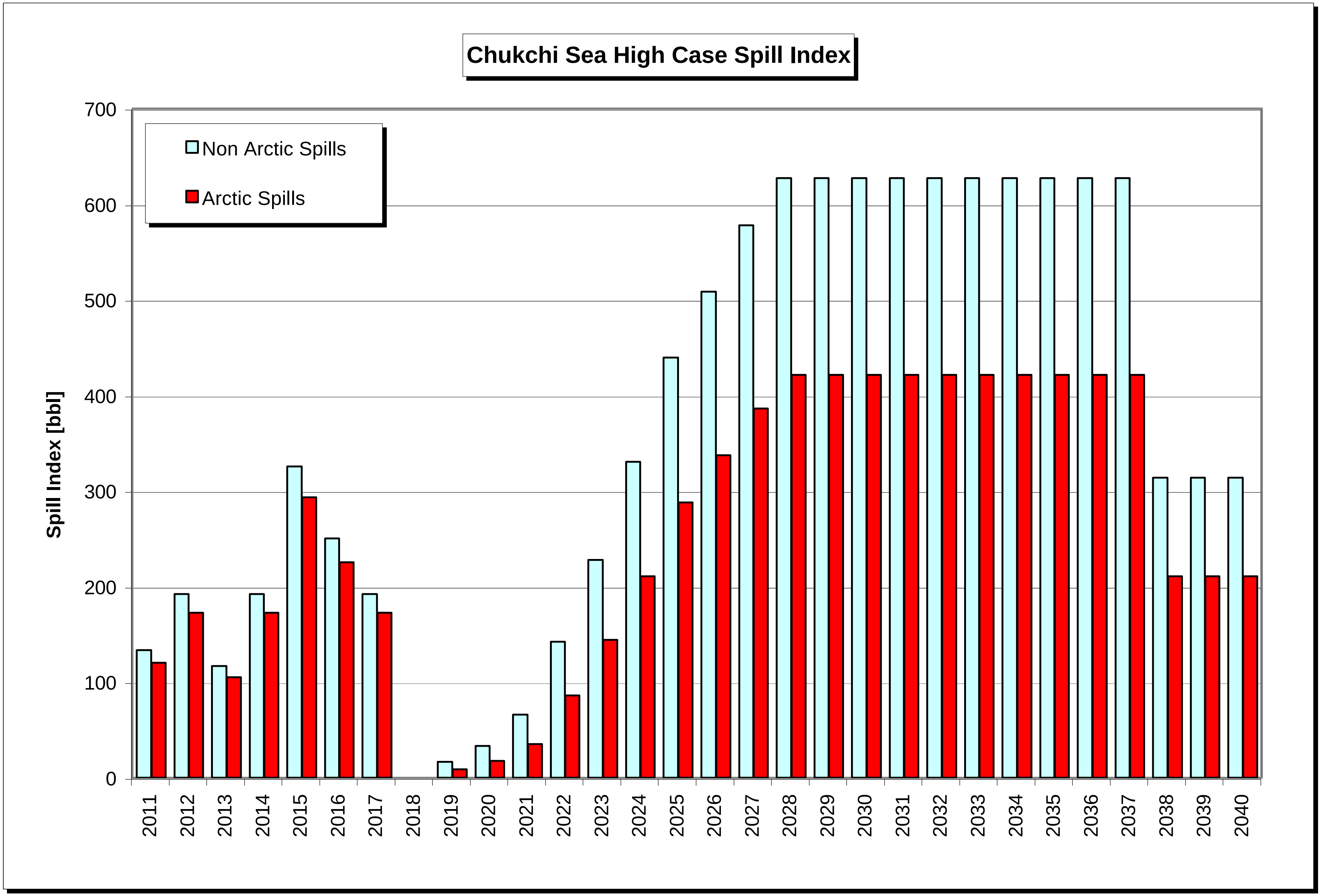


	Low Case	High Case	High Case non Arctic
Well Spills	114	202	275
Platform Spills	6	10	12
Pipeline Spills	23	42	78



C5 Conclusions_CS.xlsF503


Chukchi Sea High Case Spill Frequency per 10^9 bbl Produced
Non Arctic Spills
Arctic Spills
Spill Frequency per 10^9 bbl produced
14.0
13.0
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
2039
2040



C5 Conclusions_CS.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.