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Appendix A

Frequency – Volume Study of Keystone Pipeline

DNV CONSULTING

Frequency-Volume Study of Keystone Pipeline:

Report for TransCanada PipeLines Limited
Report no.: 70015849-2
Rev 1, 01 May 2006

MANAGING RISK DNV

Frequency-Volume Study of Keystone Pipeline

for

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Summary: DNV Consulting is assisting TransCanada with risk management and regulatory compliance for the Keystone Pipeline, specifically, assessing the U.S. portion of the Keystone Pipeline to quantify oil spill risk in terms of frequency and volume.

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Executive summary:

TransCanada Pipelines Limited is proposing the Keystone Pipeline Project to transport a nominal 435,000 bpd (591,000 bpd maximum) of crude oil from facilities near Hardisty, Alberta, to the vicinity of Patoka, Illinois, and to Cushing, Oklahoma.

DNV Consulting is assisting TransCanada with risk management and regulatory compliance for the Keystone Pipeline, specifically, assessing the U.S. portion of the Keystone Pipeline to quantify oil spill risk. The outputs will enable refinement of the ecological assessment being conducted for compliance with the National Environmental Policy Act. This report documents the frequency of potential spilled volumes from the Keystone Pipeline. The current design of Keystone was reviewed and the latest techniques in quantitative risk analysis were used to quantify the likelihood of realistic maximum spill volumes.

The pipeline spill frequency was estimated by adjusting historical pipeline failure frequencies using Keystone-specific modification factors. This study segmented the pipeline into lengths that each pose virtually constant spill frequency based on causes of failure. The relevant failure mechanisms specific to Keystone that could impact the frequency of leaks were identified.

The frequency of failure was estimated for three hole sizes for each cause of failure, for each segment. Overall, the likelihood of a leak greater than 50 barrels anywhere along the pipeline is estimated to be about 0.14 per year, or once every 7 years. The leak volume per mile for Keystone is approximately 0.37 bbl per mile per year. For purposes of comparison, pipelines in the U.S. had a leak frequency of 0.49 bbl per pipeline mile per year during the period 1992 to 2003 (OPS, 2006).

Approximately 53.5% of the spills would be from small holes (pinholes), 32.5% would be from medium sized holes (1 in), and 14% would be from large holes (10 in or greater). The most likely cause of a leak is estimated to be corrosion.

Realistic maximum spill volumes were calculated based on estimated leakrates for each segment and each hole size. Draindown procedures and line depressurization were not accounted for in the spill volume estimates, resulting in conservative estimations of potential maximum spill volumes.

Two throughput scenarios were evaluated, a 435,000 bpd throughput scenario (nominal case) and a 657,000 bpd throughput scenario (best available data to represent the 591,000 bpd case). Cumulative frequency-volume curves were developed, describing the likelihood of a spill of a given volume occurring from the Keystone Pipeline in its current design phase. These curves provide a visual illustration of the risk profile of Keystone.

These two scenarios bound this study of Keystone Pipeline. However, alone they do not provide an accurate picture of potential spills from Keystone. Evaluation of risk requires assessing frequency and consequence together rather than separately, because the worst risk scenario is often not the greatest volume release, because a large volume release often is associated with the smallest frequencies.

To identify the worst-case pairing on frequency and volume, the frequency and volume were multiplied and summed per segment, providing a "risk" number with which to compare the segments of Keystone. The segment with the largest frequency-volume pairing was at milepost 208, with an estimated volume of 3.6 bbl/yr.

At the appropriate design phase, a consequence study should estimate the severity of potential spills from Keystone (paired with their respective frequencies) and identify those segments posing the greatest risk to the environment. Potential preventive measures could then be evaluated on a cost-benefit basis to determine which are the most effective in reducing environmental risk.

Contents:

1.0 Introduction

TransCanada is proposing the Keystone Pipeline Project, which would transport a nominal 435,000 bpd (591,000 bpd maximum) of crude oil from facilities near Hardisty, Alberta, to the vicinity of Patoka, Illinois and Cushing, Oklahoma. The pipeline would interconnect with other existing crude oil pipelines that supply refinery markets in the U.S.

In the United States, the Keystone Pipeline Project will require federal approvals from agencies such as the U.S. Department of State and the U.S. Army Corps of Engineers. In Canada, approvals from the National Energy Board (NEB) will be required. The project may also require additional local, state, and regional approvals.

DNV Consulting is assisting TransCanada with risk management and regulatory compliance for the Keystone Pipeline, specifically, assessing the U.S. portion of the Keystone Pipeline to quantify oil spill risk in terms of frequency and volume of potential spills. The outputs will enable refinement of the ecological assessment being conducted for compliance with the National Environmental Policy Act.

This two-phase study focuses on quantifying the risk of a spill of crude oil, in terms of the frequency related to a given volume of oil that may potentially be spilled to the environment. This report encompasses both phases: Phase I the frequency study; and Phase II the volume study. The study estimated the frequency and volume of releases for each segment for three postulated hole sizes, and developed a frequency-volume curve for the pipeline as a whole.

Two throughput scenarios were evaluated, a 435,000 bpd throughput scenario (nominal case) and a 657,000 bpd throughput scenario (best available data to represent the 591,000 bpd case). A detailed hydraulic profile is not yet available for the nominal and maximum throughput cases, but will be developed when there is additional certainty regarding the locations of pump stations and other design details.

The project background is described briefly in Section 2.0. A methodology overview is presented in Section 3.0.

Section 4.0 describes the base leak frequencies and modification factors relevant for Keystone.

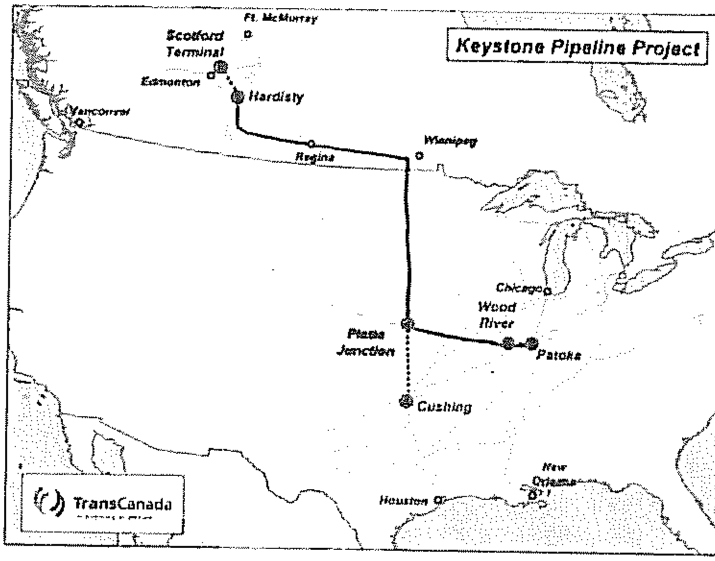
Section 5.0 describes the methodology used to calculate realistic maximum spill volumes

The final summary and conclusions are provided in Section 6.0.

This study is a quantitative assessment of risks for the pipeline as a whole, and of individual segments of the pipeline. Each segment was defined so that it would comprise a virtually consistent risk profile, using the best available quantification techniques to represent the risk profile of the pipeline.

2.0 Background

The total length of the proposed Keystone Pipeline is 1830 mi, comprising about 760 mi in Canada and 1073 mi in the U.S. The U.S. portion consists of newly-constructed pipeline and 24 new pump stations..



The timeline for the project includes submission of major regulatory applications in the U.S. and Canada in Spring 2006, with completion of associated field studies and environmental assessments throughout 2006. Route refinement may continue as commercial requirements and input from agencies, stakeholders, and design teams are gathered.

In 2007, the engineering design is expected to be complete, with the necessary approvals and licenses. The construction and conversion of facilities and startup are anticipated in 2008 and 2009.

The pipeline is expected to be designed and operated within the following key parameters (Table 2-1) relevant to spill risk, which were provided by TransCanada:

Table 2-1 Key Study Input Parameters

Parameter	Value
Diameter	30 in; 24 in
Above vs. below ground	Belowground mainline; aboveground within pump station battery limits
Pipe wall thickness	0.375 in; 0.343 in
Remote gate valves	58 (including 30 at Pump Stations)
Check valves	45 (each with two flanges), each associated with a (powered) manual gate valve
Mainline location	In GIS
Pump station locations	In GIS; not aligned with current hydraulic profile
Pump station equipment	3 pumps per station; additional piping
Leak detection	Capable of detecting 1.5% leak in 138 mi and a 15% leak in 18 min

Parameter	Value
Surveillance	Within U.S. DOT requirements
Hydraulic profile	Base case 435,000 bpd; high throughput case 657,000 bpd. This study is being conducted prior to the detailed hydraulic analysis.

3.0 Methodology

All spills begin with an initiator, or cause, of an initial loss of crude oil from the pipeline. Once the leak starts, the scenario unfolds in four phases: leak detection, mainline shutdown, leak isolation, and stoppage of flow from the pipe (if possible). The duration of each phase ultimately determines the quantity of crude spilled.

This study segmented the pipeline to allow estimation of leak frequency and realistic maximum leak volume for portions of the pipeline over which the frequency and volume were virtually constant. The frequency of failure for three hole sizes (small, medium, and large) was estimated for each segment by identifying the relevant failure mechanisms specific to Keystone that could impact the frequency (or volume) of leaks. Historical base frequencies were adjusted using Keystone-specific modification factors for each cause of failure.

Each segment was analyzed to estimate the maximum realistic volume of a leak for each hole size from each failure cause. For small and medium hole leaks, it was assumed that a trained response crew would be able to plug or block the hole and stop the leak within a certain timeframe.

The remainder of this section discusses the potential causes of spills, describe the methodology used for the segmentation process, and presents relevant baseline frequencies and Keystone modification factors.

3.1 Causes of Spills

More than 17 factors (not necessarily independent) could influence pipeline spill initiation (Table 3-1). These factors were identified via literature review and DNV experience in assessing this type of pipeline risk. It should be noted that the factors are similar but not identical to the U.S. Department of Transportation Office of Pipeline Safety (OPS) categories of failure (e.g., third party harm).

Table 3-1 Factors Influencing Pipeline Spill Initiation

Factor	Description
Flange, seal, and fitting leak	A leak from a flange, seal, or fitting.
Mechanical defect	Failures due to flaws within the material structure of the pipe, caused by material or manufacturing defects, improper welding, or installation errors.
Corrosion (external or internal)	Failures due to general and pitting type corrosion caused by fluids inside the pipeline or corrosive soils or conditions outside of the pipe.
Corrosion assisted initiators	These are several rather than one, and include operational transients, error in pressure setpoint control, material property deviations, etc.
Hydraulic (pressure surge) event	Overpressure caused by human or mechanical error, combined with overpressure protection failure.
Excavation damage	Excavation equipment damages underground piping; by Keystone maintenance personnel or by third parties
Maintenance damage	A leak caused by crews conducting maintenance work on the pipeline.
Third party harm	Accidental acts by a third party (such as a hunting accident) that cause a leak (vehicle, train, and aircraft operation were evaluated separately) This study scope excludes strategic, intentional acts.
Human/operator error	Improper performance of maintenance or operating procedures leading to a line failure.
Seismic event	Earthquake or other vigorous displacement of the pipeline due to seismic activity or ground movement.
Settlement	Thaw settlement or frost jacking causes line to buckle.
Slope instability	Avalanche damages piping or instability lead to loss of piping support.
Washout/bridge failure	River bottom pipe exposed by heavy runoff, line may float and buckle. Bridge supports may corrode and cause line failure (no bridge crossings are planned for Keystone).
Vehicle impact	Line failure due to large vehicles, typically transport trucks, leaving the roadway and impacting the line.
Aircraft impact	Impact fractures underground piping
Train derailment	Impact fractures underground piping
External fire or explosion	Fire impinging on the pipe, or an explosion resulting in a leak.

From the above 17 factors that could influence pipeline spills, six distinct and practically independent causes (from a frequency estimation point of view) were identified as applicable to Keystone and evaluated in detail in this study (see Section 4.0).

1. Corrosion (external or internal)
2. Excavation damage
3. Mechanical defect
4. Hydraulic (pressure surge) event
5. Flange, seal, and fitting leak
6. Washout

Table 3-2 lists the eight factors that were not quantified as separate causes in this study, with explanation.

Table 3-2 Factors not Individually Quantified in this Study

Factor	Reason
Corrosion assisted initiators	This failure frequency is incorporated into other historical causal frequencies (such as hydraulic event and corrosion).
Maintenance damage	This is included in the excavation cause for belowground pipeline
Third party harm	Accidental harm to the pipeline was considered only credible for above ground pipe. For Keystone, the only above ground pipe is within Pump Stations, which are secured. As a result, this cause was deemed not relevant
Human/operator error	After detailed design and operating procedures are drafted, this cause can be evaluated in detail.
Seismic Event	DNV was unable to quantify this very low level of risk in the timeframe required with the conceptual level of design currently available for the pipeline. It is unlikely that this risk factor would contribute significantly to the pipeline risk picture.
Settlement	Major settlement is often associated with thaw which causes a deformation of the pipe and subsequent pipe failure. DNV was unable to quantify this very low level of risk in the timeframe required with the conceptual level of design currently available for the pipeline. It is unlikely that this risk factor would contribute significantly to the pipeline risk picture, as less than 1% of 1986-2001 recorded incidents were attributable to the OPS category "subsidence".
Slope instability	Substantial slope instability risk is not anticipated in the areas near the proposed Keystone Pipeline based on a preliminary review of terrain near the pipeline.
Vehicle impact	A truck-pipe collision with sufficient momentum to break the pipe. The probability of a belowground portion of pipe being affected by a vehicle impact results in a frequency less than 1×10^{-7}, which is not a credible scenario.
Train derailment	DNV was unable to quantify this very low level of risk in the timeframe required with the conceptual level of design currently available for the pipeline. It is unlikely that this risk factor would contribute significantly to the pipeline risk picture.
Aircraft impact	Since the Keystone mainline is belowground, aircraft impact risk is estimated at less than 1×10^{-6}. This could be quantified based on sizes of aircraft and activity levels, if desired; however, it is unlikely to contribute to the pipeline risk picture.
Fire or explosion	Since the majority of the pipeline is belowground, this is a credible scenario only at the pump stations. The primary sources of ignition might be station equipment fire, agricultural burns, and wildfires. These can be evaluated in detail when exact pump station locations have been determined and detailed equipment descriptions are available, but are expected not to affect the frequency or volume study outputs for the pump station segments.

Distribution of Hole Sizes for Each Cause

A specific distribution of small, medium and large sized holes was developed and applied for each spill cause (described further in Section 4.0). Note that hole size is not the same as spill volume. Some leaks from small holes could occur for a long period of time and result in a large spill volume because they would not be detected as quickly as some leaks from larger holes.

The estimation of frequency for a given spill volume is linked to hole size, because for any failure cause, one hole size is more or less likely than another. In assessing the distribution of hole sizes for each cause, the failure mechanism and pipe material properties were considered. The size of the hole is a function of many factors including stress levels and material properties such as ductility. For instance, corrosion is characterized by a failure mechanism of slow removal of metal, and therefore is generally prone to result in pinhole-type leaks rather than full bore failures. In contrast, outside forces such as vehicle impact on aboveground pipeline are more likely to cause larger holes.

Three sizes of leak were assessed for each cause:

- Small, equivalent to 0.1 inch diameter hole
- Medium, equivalent to 1 inch diameter hole
- Large, equivalent to 10 inch diameter hole and larger

The representative hole sizes were chosen to allow use of the best statistically significant set of data for pipelines. Further detail regarding the generic data sets used in this analysis is provided in Appendix I..

3.2 Segmentation

The pipeline was segmented for this assessment based on an offset of factors, all related to the physical and environmental characteristics that would create unique failure mechanisms for various lengths of pipe. These segments were used as the basis for calculating frequency of spill volumes. DNV defined each segment as the length of pipe over which none of the risk characterization parameters changes significantly.

An alternative approach would have been to define each segment by a static geographic distance; however, the current approach was deemed more suitable for any future spill risk studies incorporating consequence of a spill.

Table 3-3 lists the characterization parameters used as inputs to segmentation.

Table 3-3 Segmentation Parameters

Parameter	**Related cause**	**Discussion**
Above versus below ground location of pipeline	Excavation damage Corrosion (external or internal)	The majority of Keystone Pipeline is below ground, with transitions to above ground only within secure areas at pump stations.
Pipe wall thickness	Excavation damage Corrosion (external or internal)	Wall thickness is a risk factor for both excavation (mechanical) damage and corrosion caused leaks.
Excavation activity level	Excavation damage	This input factor characterizes segments by the potential for excavation activity. *Road crossings per mile* was the best available data for estimation of excavation activity (because of the potential for impact to the pipe from activities related to roadside drainage ditches and culverts). In the future, additional data may come available concerning utility crossings and crossings with other pipelines. The additional data should be incorporated into the frequency study when it becomes available.
Hydraulic event susceptibility	Hydraulic (pressure surge) event	The sections of Keystone operating closer to MAOP are assigned greater susceptibility to hydraulic damage in the event of human or mechanical error.
Washout event susceptibility	Washout	The washout event susceptibility is used to identify segments that cross rivers with a potential to remove sediments surrounding the pipe.
Pipeline patrol frequency	NA (related to leak detection time)	The patrol frequency contributes to both the likelihood of finding unauthorized excavation and the timeliness of detection for small hole leaks.

A new segment was created at each point where a change in any of the risk characterization parameters occurred. This approach minimized the number of segments necessary to analyze the entire pipeline at the full resolution of the input data. Figure 3-1 provides a visual representation of the segmentation process.

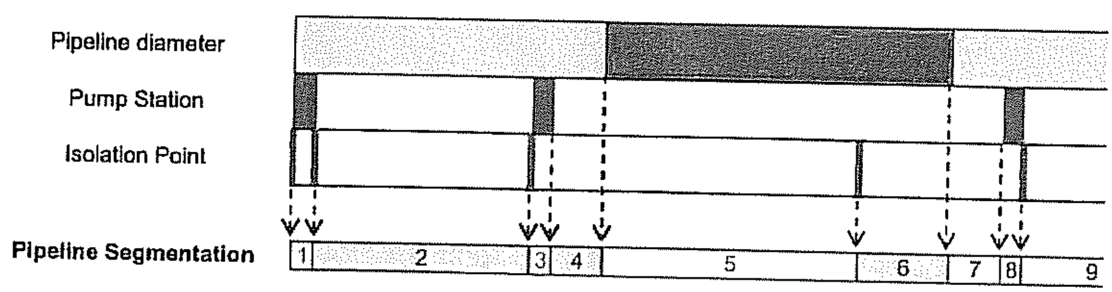


Figure 3-1 Segmentation Process Diagram

Non-discrete (or nearly continuous) risk characterization parameters are not suitable inputs to a segmentation process. These parameters have either a continuously varying value or a large number of values along the length of the pipeline, and would result in a very large number of segments. Instead of using these as inputs to the process, a single value for each parameter was established for each segment after segmentation is complete. The segment value was assigned by analyzing the range of values for a given parameter within a given segment, and assigning either the maximum, minimum, count, or average to the entire segment. This resulted in a representative but conservative value being applied to each segment.

The values for such non-segmentation parameters were assigned as follows (Table 3-4):

Table 3-4 Non-Segmentation Parameter Values

Parameter	Related cause	Discussion
Depth of cover	Excavation damage Washout Vehicle impact Aircraft impact Train derailment	Depth of cover is currently assigned a constant value of 4 ft for the entire pipeline. When additional detailed data are available, the *minimum* depth of cover between the start and end mileposts of each segment will be applied to the entire segment, since this will provide the best reasonable conservative estimate as an input to excavation leak frequency.
Pipeline internal pressure	NA (volume related)	The *maximum* pipeline internal pressure between the start and end mileposts of each segment will be applied to the entire segment, since this will give the most conservative estimate of before isolation release rate.
Pipeline elevation	NA (volume related)	The *minimum* pipeline elevation between the start and end mileposts of each segment will be applied to the entire segment, since this will give the most conservative estimates of before isolation and after isolation release rates.
Fittings count	Flange, seal, and fitting leak	The number of fittings between the start and end mileposts of each segment will be *counted* and applied to the segment.

4.0 Base Frequencies and Modification Factors

The frequency of an event is the expected number of times per length of pipe that an event will occur in a year. As an illustration, the excavation damage frequency for a given segment might be 1.4×10^{-6}. That frequency represents the number of times that a vehicle is expected to impact that segment of the pipe in a year.

For each segment of the pipeline, the frequency of events (and thus possible leaks) was determined by first assessing the frequency of each spill cause individually, distributed among the three hole sizes. These were summed to give the total leak frequency.

$$f = f_{co} + f_{ex} + f_{md} + f_{hy} + f_{fl} + f_{wo} \quad (4.2) \quad (4.1)$$

Where:

f = the total leak frequency for a section

f_{co} = leak frequency from corrosion

f_{ex} = leak frequency from excavation

f_{md} = leak frequency from mechanical defect

f_{hy} = leak frequency from hydraulic event

f_{fl} = leak frequency from flange(s)

f_{wo} = leak frequency from washout event

The individual frequencies were determined by applying modification factors to a base leak frequency for each spill cause. The specific modification factors and hole size distributions are discussed for each of the relevant causes in the following subsections.

4.1 1 Corrosion

This event is defined as the failure of mainline pipe to withstand internal pressure due to a transient, at a location of external or internal corrosion-degraded (thinned) pipe. The reliability of the pressure relief system is directly accounted for in the analysis.

Analysis by Taylor (1995) suggests a base frequency for corrosion leaks of 6.0×10^{-5} per mile of pipeline per year. DNV considers that because of the expected frequency of intelligent pigging (every three years) in the Keystone system, and the comprehensive use of active cathodic protection along the pipeline, a reduction is warranted in the base frequency (also see generic analyses in Appendix I). A 50% reduction was applied, resulting in a base frequency for corrosion leaks of 3.0×10^{-5} per mile of pipeline per year.

Modification factors were applied to the base frequency to represent the following issues:

- Whether the segment was above or below ground
- Initial wall thickness of the segment

f_{co}, the leak frequency from corrosion, was therefore calculated as follows:

$$f_{co} = f'_{co}(M_{Location} M_{Thickness}) \quad (4.3)$$

Where:

f'_{co} = the base frequency of corrosion resulting in a leak (3×10^{-5} per mile year)

$M_{Location}$ = modification factor whether the segment was above or below ground

$M_{Thickness}$ = modification factor for initial wall thickness (set to 1 for Keystone)

Above or Below Ground Location

The Keystone Pipeline is being designed to consist entirely of below ground pipe except within Pump Station fence lines. Segments of the pipeline below ground were considered to be more likely to incur corrosion than above ground sections.

Based on proprietary analysis of CSFM (1993), CONCAWE (1998), and EGIG (1993) data for external corrosion, DNV developed modification factors for below ground versus above ground piping. The modifying factors shown in Table 4-1 were used to account for the effect of the location of the pipeline on corrosion leak frequencies.

Table 4-1 Corrosion Location Modifying Factor

Location	Factor
Above Ground	0.2
Below Ground	1

Engineering judgment was used to develop the hole size distribution shown in Table 4-2, which were applied to leaks resulting from corrosion.

Table 4-2 Hole Size Distribution for Corrosion Leaks

Hole Size	Distribution
Small	87%
Medium	10%
Large	3%

4.1.2 Excavation Damage

This event is defined as a leak resulting from digging equipment striking the pipeline. The base frequency of excavation resulting in a leak is 8.4×10^{-5} per mile of pipeline per year. This value was based on DOT data for "external force" type incidents for natural gas transmission lines. Natural gas pipeline data is appropriate for excavation damage because the product being carried in the pipe has almost no effect on whether excavation damage will occur, or how severe it will be. The frequency is essentially the same for gas and for oil pipelines.

Leaks caused by excavation damage are considered only for below ground sections of the pipeline. Modification factors were applied to the base frequency to represent the following features:

- Depth of cover – assigned as a nominal 4 ft.
- Wall thickness of the pipeline – assumed to be 0.375 in for the 30-in sections and 0.343 in for the 24-in sections of pipe.
- Patrol frequency for the pipeline – assumed to be every two weeks.
- Level of excavation activity – estimated based on the number of road crossings in a given segment, with the numbers of crossings summed for each mile. The values were then compared to the criteria in Table 4-4 to assign an excavation activity level for the segment. A new segment was created at each milepost where the excavation activity level changed, resulting in a constant activity level for each segment.

f_{ex}, the leak frequency from excavation activity, was therefore calculated as follows:

$$f_{ex} = f'_{ex}(M_{Activity} M_{Depth} M_{Thickness} M_{Patrol}) \tag{4.4}$$

Where:

f'_{ex} = the base frequency of excavation resulting in a leak (8.4×10^{-5} / mile year)

$M_{Activity}$ = modification factor for activity level

M_{Depth} = modification factor for depth of cover

$M_{Thickness}$ = modification factor for wall thickness

M_{Patrol} = modification factor for patrol frequency

The hole size distribution shown in Table 4-3 was applied for excavation damage leaks. The distribution was based on EGIG (1993) data, details of which can be found in Appendix I.

Table 4-3 Hole Size Distribution for Excavation Damage Leaks

Hole Size	Distribution
Small	25%
Medium	55%
Large	20%

Activity Level

Data for the activity levels along the pipeline were assessed using a system suggested by Muhlbauer (1992). This presented three levels of activity: high, medium and low. DNV also identified areas of no expected activity (none).

Table 4-4 Excavation Activity Categorization

Level	One or more of the following
High	Frequent construction activities High volume of on-call or reconnaissance reports (> 2 / week) Significant roadway culvert risk – summed road crossing value greater than 30 per mile Many other buried utilities nearby
Medium	No routine construction activities that could pose a threat Moderate roadway culvert risk – summed road crossing value greater than 10 to 30 per mile Few on-call or reconnaissance reports (> 2 / week) Few other buried utilities nearby
Low	Virtually no activity reports (< 10 / year) No routine harmless activities in area. Agricultural activities that cannot penetrate to within 1 ft of the pipeline depth may be considered harmless. Very low roadway culvert risk – summed road crossing value greater than 0 to 10 per mile
Very Low	No expected excavation activity, except from maintenance activities Trivial roadway culvert risk – summed road crossing value of 0

When available, utility line crossings can be identified along the Keystone route. The utility crossing areas will be designated as medium activity, with the remainder of the pipeline assigned a lower activity level.

The modifying factors shown in Table 4-5 were used for excavation activity level.

Table 4-5 Excavation Activity Level Modifying Factor

Level of Activity	Factor
High	1.5
Medium	1
Low	0.5
None	0.01

Depth of Cover

Detailed data for the depth of cover of below ground sections of the pipeline is currently not available for Keystone. The modifying factors shown in Table 4-6 were used for depth of cover, and can be applied in a comprehensive manner when detailed data is available. The modifying factors in the table were based on detailed analysis of the UK Health & Safety Executive (HSE) data (ADL, 1999) and DNV engineering judgment for interpolation. They are discussed further in Appendix I.

Table 4-6 Depth of Cover Modifying Factor

Depth of Cover	Factor
0-3 ft	1
3-6 ft	0.7
6-9 ft	0.5
> 9 ft	0.01

4.1.3 Mechanical Defect

This event was defined as a break in the mainline pipe caused by material or manufacturing defects, improper welding, or installation errors. Empirical data was used to quantify this value.

For the period 1988-2000, DOT data shows the base frequency of mechanical or material defects causing leak as 3.81×10^{-5} leaks per mile of pipeline per year (DOT, 2001). This is based upon 34 reported leaks for 893,061 miles of pipeline, utilizing a population of pipelines constructed over a wide range of years. Pipelines built more recently will have been designed and built using more modern codes and standards, and inspected using more advanced techniques. These pipelines, such as Keystone, are less likely to suffer leaks as a result of mechanical or material defects in the pipeline.

Data provided by Kiefner and Trench (2001) supports the conclusion that pipelines constructed after 1970 have a reduced likelihood of construction related defects than those built prior to 1970. This decrease is most significant for longitudinal welds, which are typically performed during manufacturing. A lesser decrease is seen for girth welds, which are typically performed during installation. The following are key inputs to the assessment of mechanical defects:

A 50% reduction in the DOT leak frequency was applied to the entire pipeline because the U.S. portion of Keystone will consist of entirely new materials and be constructed to meet current standards and requirements.

Mechanical defects were considered equally likely to occur anywhere along the pipeline, and no modification factors were applied based on location.

The hole size distribution is based on European Gas Pipeline Incident Data Group (EGIG) (1993) data, details of which can be found in Appendix I. DNV's analysis of the data resulted in the a hole size distribution (Table 4-7) applicable to leaks caused by mechanical defects.

Table 4-7 Hole Size Distribution for Mechanical Defect Leaks

Hole Size	Distribution
Small	65%
Medium	25%
Large	10%

Wall Thickness

Additional wall thickness beyond that required for the pipeline operating pressure could protect the pipe from external damage. Data concerning the minimum wall thickness was provided to DNV by TransCanada.

The modifying factors shown in Table 4-8 are used for wall thickness. These factors are based on a baseline wall thickness of approximately 0.3 in, and the calculation of the modifying factor for thickness relative to the baseline value from EGIG (1993) data, as detailed in Appendix I.

Table 4-8 Wall Thickness Modifying Factor

Keystone Pipeline Diameter	Minimum Wall Thickness	Factor
30 in	0.375 in	0.5
24 in	0.343 in	1

Patrol Frequency

Regular patrols of the pipeline result in earlier identification of excavation activities and improved advance management of such activities. Patrols reduce the likelihood of excavation damage to the pipeline. Patrol frequency is expected to be every two weeks for Keystone, with a resultant modifying factor of 1.3.

Patrol frequency is required by pipeline safety regulations as at least 26 times a year (averaging at two week intervals), but not exceeding intervals of three weeks (49 CFR 195.412). The modifying factors shown in Table 4-9 were used for patrol frequency. The more frequent the patrols, the more likely the patrol is to observe excavation and assure it is being conducted in a appropriate manner, and the greater benefit the patrolling has in reducing spill risk from excavation.

Table 4-9 Patrol Frequency Modifying Factor

Frequency	Factor
Monthly – Weekly	1.3
Weekly	1
2 times per week	0.8
4 times per week	0.65
Daily	0.5

4.1.4 Hydraulic Event

This event is defined as an overpressure of the pipeline severe enough to cause a leak or rupture of the line. This scenario involves a series of concurrent hardware or human errors and can occur at a limited number of locations.

Overpressure pipe failures can occur through two distinctly different means. Pipe can fail due to overpressurization if the internal pressure surpasses the designed bursting strength of the pipeline; however, corroded or fatigued pipe will have a reduced bursting strength and may fail at lower pressures. The following scenarios could result in overpressurization:

- Failure of pressure relief system
- Uncommanded closure of battery limit or gate valves
- Failure of RGVs downstream of high elevation areas to fully close during line shutdown. Hydraulic head will create a high pressure at first sealed valve
- Weakening of pipeline at point where slack and tight line meet, due to the impact of pigs, will reduce bursting strength
- Corrosion damage may reduce the bursting strength of the pipeline

The base frequency for hydraulic event leaks is 9.3×10^{-5} per mile of pipeline per year, based on analysis by Taylor (1995). A modification factor was applied to the base frequency to represent susceptibility to hydraulic events. f_{hy}, the leak frequency from hydraulic events, was therefore calculated as follows:

$$f_{hy} = f'_{co} M_{Hyd} \tag{4.5}$$

Where:

f'_{hy} = the base frequency of hydraulic events resulting in a leak (9.3×10^{-5} per mile year)

M_{Hyd} = modification factor for susceptibility to hydraulic events

The hole size distribution shown in Table 4-10 was applied for hydraulic event leaks. This is based on engineering judgment concerning the types of leaks represented.

Table 4-10 Hole Size Distribution for Hydraulic Event Leaks

Hole Size	Distribution
Small	20%
Medium	50%
Large	30%

Hydraulic Event Susceptibility

The modifying factors shown in Table 4-11 were used for Hydraulic Event Susceptibility. Given the current design phase of the pipeline and the design criteria, it appears that the pipeline warrants a hydraulic susceptibility level of "low", resulting in a modifying factor of 1. Should additional detailed information be developed, the hydraulic event susceptibility should be re-assessed.

Table 4-11 Hydraulic Event Susceptibility Modifying Factor

Susceptibility		Factor
High	Expected operating pressure >1390 psi	3
Medium	Expected operating pressure between 1000 psi and 1390 psi	1
Low	Expected operating pressure between 500 psi and 1000 psi	0.1
None	Expected operating pressure <500 psi	0

4.1.5 Flange or Seal Leak

A flange is a rim at the end of a section of pipe. For Keystone, bolted flange connections will be installed at checkvalve connections along the pipeline. A section of pipe ending in a flange will be bolted to a checkvalve with a flange. They will compress a gasket at a specified load and form a seal.

The base frequency for flange and seal leaks is 1.0×10^{-4} per fitting per year and is taken from Taylor (1995). This value is in line with other flange leak data such as that discussed in Lees (1996). No modification factors were applied to this base frequency. It was assumed that each checkvalve has two flanges. A segment break was introduced at each check valve, resulting in one flange being counted in each of the adjacent segments.

The hole size distribution shown in Table 4-12 was applied for flange leaks. This is based on engineering judgment concerning the types of leaks represented.

Table 4-12 Hole Size Distribution for Flange Leaks

Hole Size	Distribution
Small	100%
Medium	0%
Large	0%

4.1.6 Washout

This event is defined as failure of the mainline pipe below a river bottom due to severe water erosion. Under severe runoff conditions, pipelines have been known to leak due to the forces applied during pipe displacement. The base frequency of failure (Table 4-13) was estimated using proprietary pipeline washout data and engineering judgment.

Table 4-13 Frequency Estimate for Washout Failures

Basis	Source
0.1 pipe exposures / yr assuming 1000 river crossings	proprietary data
0.1 failure probability on exposure	engineering judgment
= 1×10^{-5} failures / per crossing	

The total pipeline frequency was applied to a stream crossing segment by ratioing the number of stream crossings for the segment to the number for the entire system (806). Each mile of pipeline was assigned a river crossing "value" based on the river type (Table 4-14). This was used to segment the pipeline where the density of river crossing varied. Each segment's frequency was then calculated by applying two modification factors to the base frequency:

- River type - National Hydrological Dataset (2006) (F Code) in Table 4-14.
- Depth of cover in Table 4-15

Table 4-14 River Crossing Modification Factors

River Type	Modification Factor
River	1
Intermittent/ephemeral stream	0.5
Canal/ditch	0.2
Artificial path or none	0

Table 4-15 Depth of Cover Modifying Factor for Washout Leaks

Depth	Factor
0-10 ft	1
>10 ft	0.5

Engineering judgment was used to develop the hole size distribution shown in Table 4-16, which were applied to leaks resulting from washout.

Table 4-16 Hole Size Distribution for Washout Leaks

Hole Size	Distribution
Small	90%
Medium	9.9%
Large	0.1%

5.0 Realistic Maximum Spill Volume

The second phase of this assessment calculated the quantity of crude oil that could be lost from each segment of the pipeline. The quantity of material released during a spill is dependent upon the following parameters:

1. Time until leak is detected, verified and pipeline isolated
2. Initial leak rate, under pipeline pressure
3. Quantity of material in isolated section of pipeline
4. Leak rate after isolation, driven by hydrostatic head in the pipeline

And, depending on whether containment of the leak source is being considered:

5. Time to effectively contain the leak source (via clamping or some other method)

Detection time is the time required for a potential leak to be identified as such. Verification time is the time required for an operator to confirm that a leak is occurring and decide to take action. Isolation time is the time required from completed leak verification to closure of the remote gate valve(s) (RGV)and a relevant downstream check valve, if applicable. Effective valve closure limits the spill volume to the amount trapped between the valves.

A remote gate valve is a block valve that stops oil flow in both directions when given a command from a remote location, such as an operations center (or locally if such an option is provided in the design). RGV are located at every pump station and at every major river crossing.

A check valve allows one-way flow only and prevents the reverse flow of oil. Check valves are designed to be held open by flowing oil and to drop closed automatically and nearly effective immediately when oil flow stops or is reversed. Check valves are located on the downstream side of major river crossing along the pipeline. Co-located with each check valve, there is also a manual valve.

Prior to valve closure, the leak rate from the pipe ("initial leak rate") is estimated to be the rate that oil would flow out of the hole size being evaluated assuming that the mainline pumps continue to operate. After valve closure, the volume trapped between the upstream RGV and the downstream checkvalve ("isolated section volume") is the maximum that could practically be released. For every potential leak location, the relevant RGV are identified and valve closure times applied based on the values in the tables presented in following subsections.

Actual spill volumes are expected to be significantly less than the potential drain down volume. Accounting for procedures to reduce spill volume, such as depressurization and drain down, may significantly reduce the predicted spill volumes estimated for the Keystone Pipeline.

5.1 Detection, Verification, and Isolation

The time required to detect and verify a spill is dependent on the leak detection mechanism that would alert an operator, related to leak rate. The type of cause affects the estimate of times to detect and verify. If the spill cause is such that an individual would be expected to be present and report the leak immediately, the detection/verification times would be different than if the leak detection system was the only means of identifying a spill.

For the purpose of discussion, a cause is called, "reported" if a person is expected to be present at the scene, and very likely to observe the leak and called it in within a short timeframe (regardless of whether the leak is detectable by the leak detection system). An example is excavation damage. Such an event would likely be observed at the time of the incident, and a phone call would be placed to report that a pipeline had been hit during excavation activities. The two reported causes are:

- Excavation damage
- Hydraulic (pressure surge) event

For reported causes, it is assumed that the leak is observed, reported, verified, and valves instructed to close in the times indicated in Table 5-1.

Table 5-1 Time from Leak Start to Closure of RGVs for Reported Causes

Hole size	Detection	Valve closure
Small	30 min	2.5 min
Medium	15 min	2.5 min
Large	9 min	2.5 min

Non-reported causes are expected to occur without any person present to witness and report the event; thus, the leak detection system and surveillance is assumed to be the only means of leak detection for these causes. For example, a corrosion leak is not normally related to the presence of people who might observe it, and would have to be detected via the Keystone systems designed for that purpose. The non-reported causes are:

- Mechanical defect
- Corrosion (external or internal)
- Flange, seal, and fitting leak
- Washout

The estimated times to detect, verify, initiate valve closure, and complete valve closure (isolation) for non-reported causes are provided in Table 5-2. For large leaks, the time for detection system response is independent of whether the leak is above or below ground. Small leaks below ground (necessarily detected by surveillance) may take significantly longer to detect than small leaks above ground.

Table 5-2 Time from Leak Start to Closure of RGVs for Non-Reported Causes

Leak Rate	Detection and Verification		Isolation
	Below Ground Pipe	Above Ground Pipe	Time for RGV to Close
Less than 1.5%	90 days	14 days	2.5 min
1.5%	138 min	138 min	2.5 min
15%	18 min	18 min	2.5 min
50%	9 min	9 min	2.5 min

For leak rates between those presented in the above tables, times were interpolated using a logarithmic straight line fit. This gave the profile in Figure 5-1 for detection time versus leak rate.

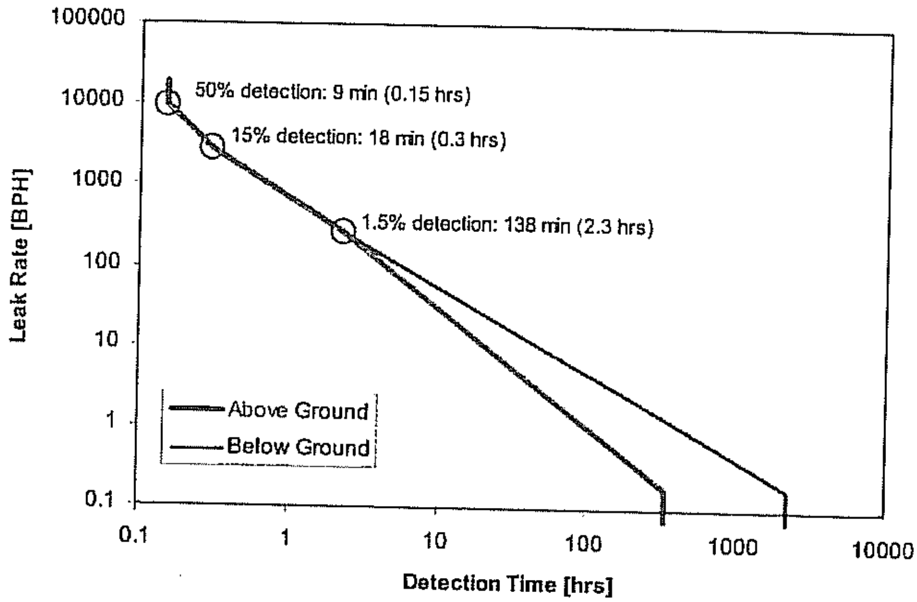


Figure 5-1 Leak Detection & Verification Times

This study assumes that all valves close on demand (0% failure rate). Valve failure concurrent with a leak could result in spill volumes greater than estimated in this study; any failure resulting in a delay in leak isolation would increase the spill volume. Such possible complications in leak isolation are:

- RGV fails to close on command
- Checkvalve fails to drop on loss of flow
- Controller for pump station isolation valves is damaged

5.2 Initial Leak Rate

Standard orifice discharge rates were used based on the representative hole size and the operating pressure of the given segment of the pipeline. This formula is given by:

$$Q_D = C_d A \sqrt{\frac{2\Delta P}{\rho}}$$

where:

Q_D	=	liquid discharge rate (m^3/s)
C_d	=	discharge coefficient, set to 0.61
A	=	hole cross-sectional area (m^2)
ΔP	=	driving pressure for the leak (Pa)
ρ	=	density (kg/m^3), 938 kg/m^3 for Keystone

During the initial phase of the leak before the valves close, the driving pressure is based on line pressure at the point of the leak.

5.3 Isolated Section Volumes

Once flow through the pipeline is stopped by shut down of pump stations and closure of RGV, material can still leak from the pipeline via gravitational effects. RGV will stop material flowing in from sections upstream and downstream of the isolation valves, and check valves will stop material flowing back from sections downstream. However, material upstream will be able to flow through check valves, since this is the normal direction of flow.

It was assumed that gravitational effects were the sole mechanism for release after isolation. Siphoning effects, draindown procedures, and line depressurization were neglected. Therefore, the sections of the pipeline that were able to contribute to the spill quantity were those satisfying the following criteria (Figure 5-2):

1. Located between the same two remote gate valves as the leak point
2. No further downstream of the leak point than the first downstream check valve
3. At a higher elevation than the leak point
4. At a higher elevation than any other point located on the same side of the leak, and closer the leak point

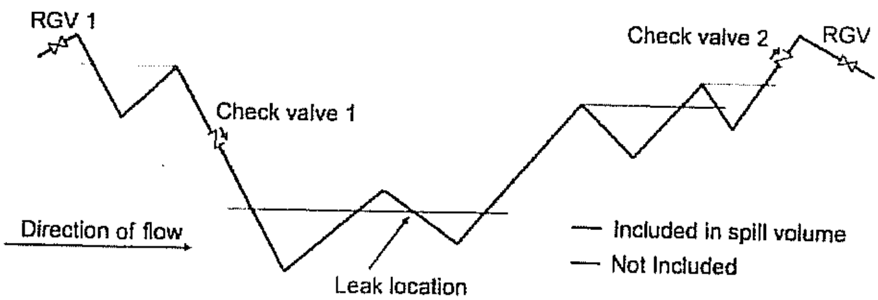


Figure 5-2 **Isolated Section Volumes**

5.4 Leak Rate After Isolation

In the static phase of the leak, the driving pressure is based on the highest point above the leak, as in isolated volumes, accounting for a closed valve or a peak in the line. For the static phase, the height differential was used to calculate the discharge rate. This formula is given by:

$$Q_S = C_d A \sqrt{2g\Delta h}$$

where:

C_d = discharge coefficient, set to 0.61

A = hole cross-sectional area (m2)

g = gravitational constant 9.81 (m/s2)

Δh = differential height of crude in line (m)

5.5 Source Control Time

It is assumed that following leak detection, the pipeline will be shut down by means of stopping the pumps and closing the RGV. For small leaks it is also possible to limit the draininage by various source control measures (clamping, gel block). These means have been assumed to be in place within four hours throughout the pipeline. Therefore the maximum gravity assisted leak is limited to fours hours for medium and small hole sizes.

5.6 Calculation of Spill Volumes

Spill volumes were calculated based on the leak rate and time to isolate. It is important to note that this assessment adopts a conservative approach to estimating spill volumes. The method does not take credit for any reduction in spill volume due to additional actions to control the source aside from shutdown, RGV closure, and plugging. Thus, procedures to reduce spill volume involving depressurization and draindown are not estimated or included. Such procedures would likely be effective for only small and perhaps medium holes. This level of detail could be incorporated into a future study.

6.0 Summary and Conclusions

6.1 Calculated Likelihood of Leaks

The risk analysis of Keystone focused on the likelihood of leaks over the entire pipeline, caused by a variety of factors. Overall, the likelihood of a leak greater than 50 barrels anywhere along the pipeline is estimated to be about 0.14 per year, or once every 7 years.

The calculated likelihood of spills less than 50 bbl is considerably less than practical experience would dictate. This is primarily the result of historical reporting requirements, as 50 bbl spills were not required to be reported to the DOT within the historical data set.

The overall contribution of various causes to leaks along the pipeline is shown in Table 6-1 and Figure 6-1. For each cause, the percent contribution is the total frequency for that cause divided by the total leak frequency for all causes.

Table 6-1 Predicted Pipeline Leak Frequency by Cause

Cause	435K bpd Case		657K bpd Case	
	Percent Contribution	Frequency (per year)	Percent Contribution	Frequency (per year)
Corrosion	28.6%	0.041	22.0%	0.041
Excavation	27.3%	0.039	21.1%	0.039
Hydraulic Event	19.6%	0.028	38.0%	0.071
Mechanical Defect	18.1%	0.026	14.0%	0.026
Flanges	3.3%	0.005	2.6%	0.005
Washout	3.0%	0.004	2.3%	0.004
Total	**100.0%**	**0.143**	**100.0%**	**0.186**

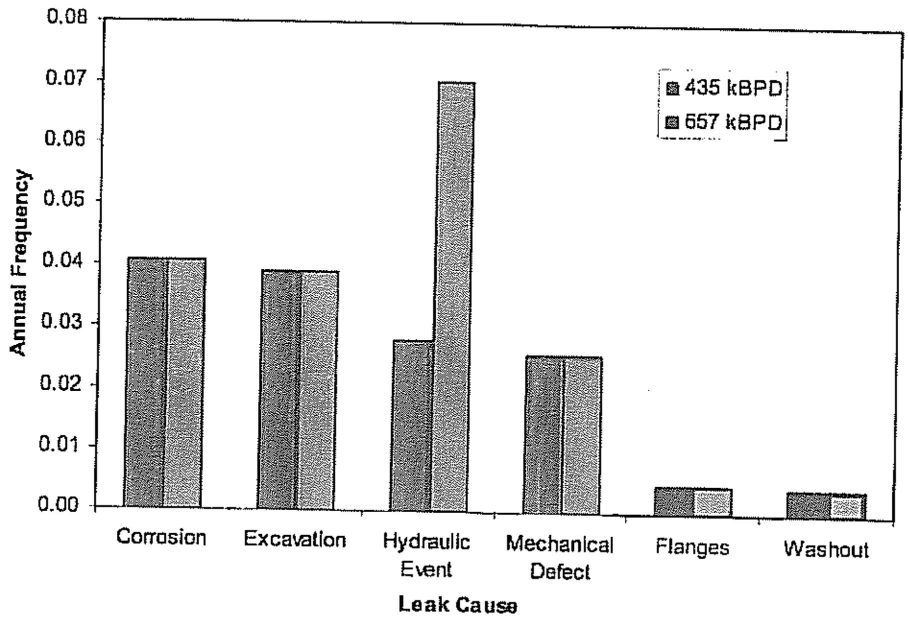


Figure 6-1 Distribution of Pipeline Leak Causes

For the 435,000 bpd case, the greatest contributing cause is corrosion, followed by excavation and hydraulic events. For the 657,000 bpd case, the greatest contributing cause is hydraulic event, followed by corrosion and excavation. However, this is more an artifact of the available hydraulic profile and the method used to differentiate higher risk segments regarding hydraulic risk.

Approximately 53.5% of the spills would be from small holes (pinholes), 32.5% would be from medium sized holes (1 in), and 14% would be from large holes (10 in or greater).

6.2 Summary of Frequency-Volume Results

In general, reported incidents over decades provide a good basis for estimating spill volumes and frequencies for new pipelines. However, there are some key weaknesses in this use of such data:

1. Small volume spills are significantly underreported, particularly those less than the reportable quantity (50 bbl).
2. Extremely infrequent events may not have occurred during the period of data collection of incidents.

Figure 6-2 and Figure 6-3 provide a view of the total frequency of spill volumes.

The necessary assumptions and the current design phase of the pipeline required conservative assumptions to be applied, with the result no identified spill volumes between 50 bbl and 200 bbl. The spill volume risk analysis shows the highest frequency for the 200 to 1000 bbl category of spill volumes. Spill volumes in this category are driven by small leaks that take a long time to detect, as well as medium leaks. Spill volumes between 1000 and 10,000 bbl consist entirely of medium hole leaks, and spills greater than 10,000 bbl consist of large hole size leaks.

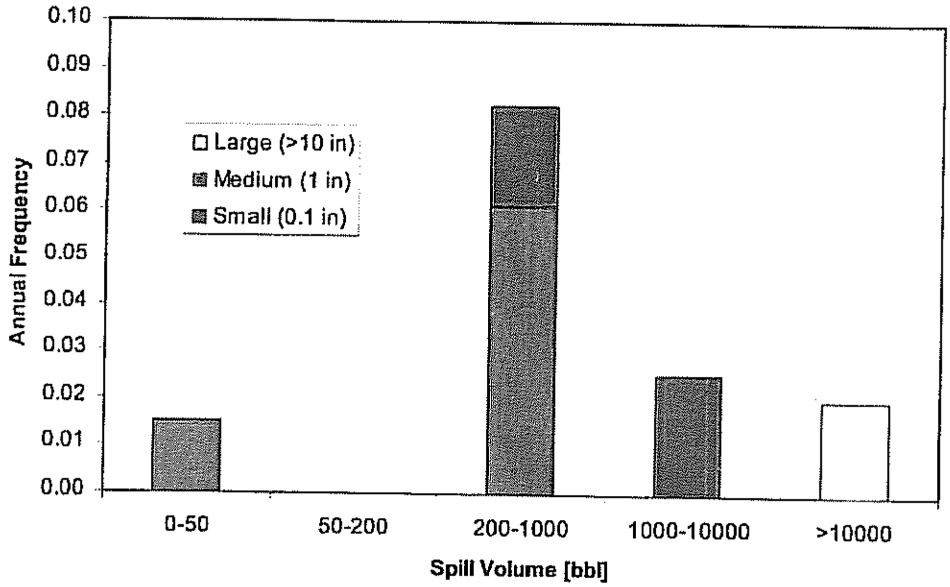


Figure 6-2 Frequency of Spill Volumes by Category (435,000 bpd)

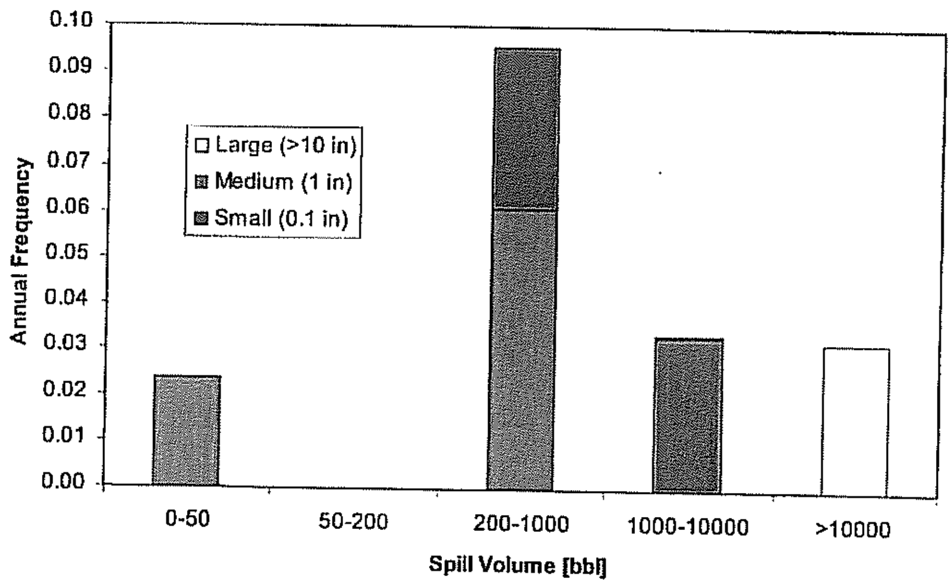


Figure 6-3 Frequency of Spill Volumes by Category (637,000 bpd)

Figure 6-4 provides a view of the spill size distribution. It can be seen that 10% of leaks result in spills greater than 20,000 barrels and only 5% of the leaks evaluated in this study result in spills greater than 30,000 barrels. Note that less than 2 percent of historical hazardous liquid spills released more than 5,000 barrels of product to the environment. Figure 6-4 could be modified to include this estimate; however, the portion of interest (larger spills) would be minimal in perspective.

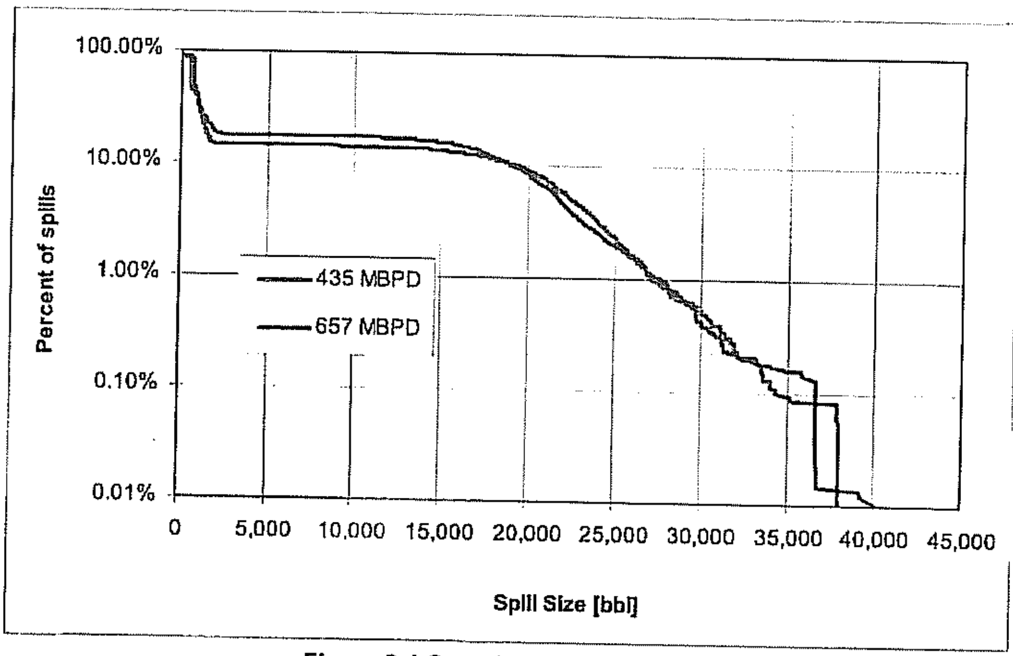


Figure 6-4 Cumulative Spill Volume

These two scenarios bound this study of Keystone Pipeline. However, alone they do not provide an accurate picture of potential spills from Keystone. Evaluation of risk requires assessing frequency and consequence together rather than separately, because the worst risk scenario is often not the greatest volume release, because a large volume release often is associated with the smallest frequencies.

To identify the worst-case pairing on frequency and volume, the frequency and volume were multiplied and summed per segment, providing a "risk" number with which to compare the segments of Keystone. The segment with the largest frequency-volume pairing was at milepost 208, with an estimated volume of 3.6 bbl/yr.

Table 6-2 The Largest Spill Volume Segments

Section of Pipeline	Milepost Begin	Segment Length [mi]	Annual Volume [bbl]	% of Total Length	% of Total Annual Volume
Main line	208.0	6.0	3.6	0.4%	0.7%
Main line	20.0	3.0	3.4	0.2%	0.7%
Main line	732.0	2.0	2.8	0.1%	0.6%
Main line	786.1	3.0	2.7	0.2%	0.5%
Cushing	186.0	4.0	2.6	0.3%	0.5%
Main line	904.0	3.0	2.5	0.2%	0.5%
Main line	158.0	2.9	2.5	0.2%	0.5%
Main line	204.0	2.0	2.3	0.1%	0.4%
Main line	871.0	3.0	2.1	0.2%	0.4%
Main line	200.0	6.0	2.1	0.4%	0.4%

At the appropriate design phase, a consequence study should estimate the severity of potential spills from Keystone (paired with their respective frequencies) and identify those segments posing the greatest risk to the environment. Potential preventive measures could then be evaluated on a cost-benefit basis to determine which are the most effective in reducing environmental risk.

This frequency-volume study provides TransCanada with a detailed database of failure causes, corresponding likelihood, and consequence (in terms of volume released) for the Keystone Pipeline, divided into the smallest relevant subdivisions. The associated database can be used to identify pipeline segments posing the greatest risk (in terms of frequency and volume). This information, taken with fate and transport modeling, can be used to determine where and which additional mitigation measures are appropriate.

6.3 Comparison with Generic Pipeline Leak Frequency

The leak volume per mile for Keystone is approximately 0.37 bbl per mile per year. For purposes of comparison, pipelines in the U.S. had a leak frequency of 0.49 bbl per pipeline mile per year during the period 1992 to 2003 (OPS, 2006).

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Pipeline Risk Assessment and Environmental Consequence Analysis

ENSR Corporation
June 2006
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Prepared for: Keystone Pipeline Project
TransCanada Keystone Pipeline, LP

Pipeline Risk Assessment and Environmental Consequence Analysis

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June 2006
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1.0 Project Overview

TransCanada Keystone Pipeline, LP (Keystone) proposes to construct and operate a crude oil pipeline and related facilities from Hardisty, Alberta, Canada, to Patoka, Illinois, in the United States (U.S.). The project, known as the Keystone Pipeline Project or Keystone, initially will have the capacity to deliver 435,000 barrels per day (bpd) of crude oil from an oil supply hub near Hardisty to existing terminals in Salisbury, Missouri, and Wood River and Patoka, Illinois. If market conditions warrant expansion in the future, additional pumping capacity could be added to increase the average throughput to 591,000 bpd. Based on shipper interest, Keystone also is considering the construction of two pipeline extensions to take crude oil from terminals in Fort Saskatchewan, Alberta, and deliver to Cushing, Oklahoma.

In total, the Keystone Pipeline Project will consist of approximately 1,833 miles of pipeline, including about 760 miles in Canada and 1,073 miles within the U.S. (**Figure 1-1**). These distances will increase if either or both of two potential pipeline extensions to Fort Saskatchewan, Alberta, or Cushing, Oklahoma, are constructed as discussed below.

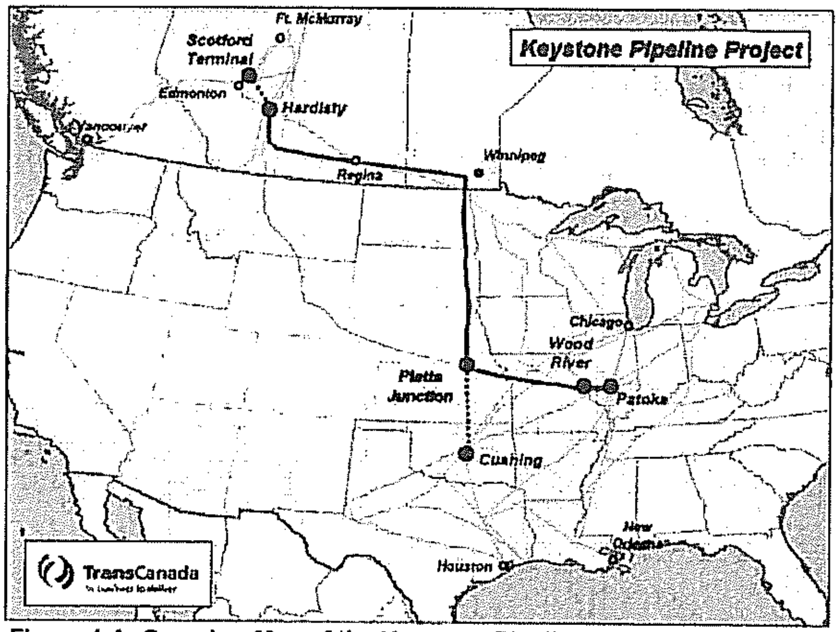

Figure 1-1 Overview Map of the Keystone Pipeline Project (Potential expansions represented by the dotted line)

In the U.S., Keystone will construct and operate a new 1,073-mile pipeline (Keystone Mainline) that will transport crude oil from the Canadian border to existing terminals in the Midwest. The proposed pipeline will consist of 1,018 miles of 30-inch pipe between the Canadian border and Wood River, Illinois and a 55-mile segment of 24-inch pipeline between Wood River and Patoka, Illinois. Depending on the results of an additional binding Open Season to be held later in 2006, Keystone also may construct a 291-mile 30-inch pipeline extension to Cushing, Oklahoma (Cushing Extension). Thus, there will be 1,365 total miles of new pipeline in the U.S. if the Cushing Extension is constructed. Unless specified, the remainder of this Supplemental Filing describes and evaluates the U.S. portion of the Keystone Pipeline Project, including both the Keystone Mainline and Cushing Extension, and the additional facilities required to increase capacity to 591,000 bpd.

The Keystone Pipeline Project will require the issuance of a Presidential Permit by the U.S. Department of State to cross the U.S./Canadian border. Issuance of the Presidential Permit is considered a federal action and is subject to environmental review pursuant to the National Environmental Policy Act (NEPA) (42 United States Code § 4321 et seq.). Keystone filed a Presidential Permit Application and Environmental Report (ER) on April 19, 2006. The ER was intended to provide the Department of State and other involved agencies with adequate information to commence review of the Keystone Pipeline Project under NEPA. The ER includes an objective disclosure of beneficial and adverse environmental impacts resulting from the Keystone Pipeline Project, as well as a set of reasonable alternatives. Keystone has stated that it will supplement the environmental information provided in the ER with the results of its field studies and pipeline risk assessment as they are completed.

2.0 Introduction

This portion of the supplemental filing represents Keystone's initial evaluation of the risk of a pipeline disruption and its potential environmental consequences. This section focuses on the potential for spills during operations and the subsequent potential effects on sensitive resources and humans associated with major spills. Additional effects on public health and safety that could occur during project construction are discussed under other resource sections (e.g., air quality, water resources, transportation, land use, and aesthetics) within the Keystone Pipeline Project's ER, which was submitted to the Department of State on April 19, 2006.

General information on pipeline safety and historical spills as documented in the U.S. Department of Transportation (USDOT) incident database were previously presented in Section 3.12 of the ER. Section 3.12 of the ER also summarized the location and extent of natural hazards and sensitive natural and human resources near the Keystone Pipeline Project.

This report builds upon the baseline information presented in the ER. The report presents the results of a pipeline oil spill frequency and spill analysis based on Keystone's current project-specific design and operations criteria and applies the resulting risk probabilities to an environmental consequence analysis that incorporates project-specific environmental data. Specifically, this report evaluates the risk of crude oil spills during pipeline operations, including contribution of natural hazards to spill risk, and the subsequent potential effects on humans and other sensitive resources, called high consequence areas (HCAs), that include populated areas, drinking water areas, and/or ecologically sensitive areas.

As Keystone collects additional information to support the risk assessment through ongoing design work and environmental field surveys, this risk assessment and its supporting reference documents will continue to evolve. The risk assessment process is an iterative procedure in which information is continually updated and refined in an effort to improve the specificity of the assessment. Keystone anticipates submitting an updated consequence analysis in November 2006 that incorporates the additional design and environmental data into the assessment.

3.0 Spill Frequency-Volume Study

A project-specific oil spill frequency and volume study for the Keystone Pipeline Project was conducted by DNV Consulting and is provided in **Appendix A.** DNV Consulting assessed the U.S. portion of the Keystone Pipeline in terms of frequency and volume of potential spills to quantify the likelihood of realistic maximum spill volumes. The study estimated the frequency and volume of releases for each defined pipeline segment for three postulated hole sizes and six distinct and independent failure causes, and developed a frequency-volume curve for the pipeline as a whole.

The study is a quantitative assessment of spill potential for the entire pipeline system and of individual segments of the pipeline. The Keystone Pipeline system was partitioned into 1,317 segments based on similar design, operational, terrain, and other potential risk parameters, each with a virtually consistent risk profile. Spill frequency was estimated for each segment along with potential spill volumes, based on small holes (<0.1-inch diameter), medium holes (1-inch diameter), and large holes (>10-inch diameter).

Two throughput scenarios were evaluated, a 435,000 bpd and a 591,000 bpd throughput case (nominal and maximum throughput). For the assessment, a leak detection capability of 1.5 percent in 138 minutes and a 15 percent leak detected within 18 minutes was assumed. Because Keystone is currently engineering the pipeline system, a detailed hydraulic profile and leak detection systems are not currently available. As the engineering and design progresses, the information will be integrated into the study and revised spill frequency and spill volumes will be estimated.

3.1 Spill Frequency

Spill frequencies were estimated from historical data and modified by project-specific factors to estimate spill frequencies for the Keystone Pipeline system. Based on the available information, the study produced an overall frequency for spills or leaks greater than 50 barrels of 0.14 spills per year for a throughput of 435,000 bpd over the entire pipeline system, equivalent to one spill every 7 years. **Table 3-1** shows the number of spills that might occur along the Keystone Pipeline system during the next 10 years.

Table 3-1 Spill Occurrence Interval Associated with the Proposed Keystone Project over 10 Years

	Spills[1]
Keystone Mainline (1,073 miles)	1.1
Cushing Extension (291 miles)	0.3
Total Keystone Project (1,365 miles)	1.4

[1]Calculated based on project-specific analysis of spill probabilities for 435,000 bpd (**Appendix A**).

While future events cannot be known with absolute certainty, spill frequencies can be used to estimate the number of events that might occur. Actual frequency may differ from the predicted values of this analysis. Notably, with the implementation of USDOT's Integrity Management Rule, the number of spills is expected to decline from historical levels observed on other pipelines. Incident frequencies have been steadily decreasing and are five times lower in recent years compared with thirty years ago (EGIG 2005).

3.2 Spill Volume

Estimated spill volumes were based on leak rate and time to isolate for throughputs of 435,000 and 591,000 bpd along the Keystone Pipeline system. The study currently assumes complete drain down within the affected segment, recognizing that actual spill volumes are expected to be significantly less. Actual incident data from the *Hazardous Liquid Pipeline Risk Assessment* (California State Fire Marshal 1993) indicate that spill volumes are significantly less than the potential drain down volume. For example, in 50 percent of the cases, the actual spill volume represented less than 0.75 percent of the maximum potential drain down volume. In 75 percent of the cases, the actual spill volume represented less than 4.6 percent of the maximum drain down volume. Procedures to reduce spill volume, such as depressurization and drain down, may significantly reduce the predicted spill volumes estimated for the Keystone Pipeline, bringing the spill volume distribution more in line with USDOT historical data. Spill volume estimates, revised to account for drain down and depressurization, will be included in Keystone's November 2006 Supplemental filing.

Of the postulated 1.4 spills along the Keystone Pipeline system during a 10-year period, the study's findings suggest that approximately 0.2 would be 50 barrels or less; 0.8 would consist of between 50 and 1,000 barrels; 0.3 would consist of between 1,000 and 10,000 barrels; and 0.2 would contain more than 10,000 barrels[1] (**Appendix A**). The spill volume frequency distribution likely underestimates the proportion of spill volumes under 50 barrels due to reliance upon the greater than 50 barrel reporting criteria within the USDOT incident database. The current analysis tends to overemphasize larger spills and underreport the small spills, making the assessment conservative.

Based on probabilities generated from the study, the estimated occurrence intervals for a spill of 50 barrels or less occurring anywhere along the entire pipeline system is once every 65 years, a spill between 50 and 1,000 barrels might occur once in 12 years; a spill of 1,000 and 10,000 barrels might occur once in 39 years; and a spill containing more than 10,000 barrels might occur once in 50 years. Applying these statistics to a 1-mile section, the chances of a large spill (greater than 10,000 barrels) would be less than once every 67,000 years. The results of the study are incorporated into the environmental consequence analysis presented in Section 4.0 below.

3.3 Contribution of Natural Hazards to Spill Potential

As part of its National Pipeline Mapping System (NPMS) program, the USDOT has compiled data from a variety of sources to identify areas of high geologic hazard potential for pipelines (USDOT-NPMS 2005). The Integrity Management Rule (2002) states that segments of pipeline with a high geologic risk and the potential to impact HCAs must implement protective measures. HCAs are specific locales and areas where a release could have the most significant adverse consequences. Examples of protective measures may include: enhanced damage prevention programs, reduced inspection intervals, corrosion control program improvements, leak detection system enhancements, installation of Emergency Flow Restricting Devices (EFRDs), and emergency preparedness improvements. **Table 3-2** provides a summary of the geologic hazards and pipeline miles identified with HCAs.

[1] Total does not sum to 1.4 spills due to rounding.

Table 3-2 **Summary of Geological Hazard HCAs Identified Along the Keystone Pipeline Project**

	Potential Geological Hazards (miles of pipeline)		
	Earthquake	Flood	Landslide
Keystone Mainline			
North Dakota	0.0	3.0	0.0
South Dakota	0.0	21.9	7.7
Nebraska	0.0	21.9	13.1
Kansas	0.0	10.9	0.0
Missouri	0.0	99.5	30.1
Illinois	0.0	12.8	6.9
Keystone Mainline subtotal	*0.0*	*170.1*	*57.8*
Cushing Extension			
Nebraska	0.0	2.5	2.5
Kansas	0.0	107.2	7.0
Oklahoma	0.0	27.8	0.0
Cushing Extension Subtotal	*0.0*	*137.4*	*9.5*
Project Total	**0.0**	**307.5**	**67.3**

Seismicity and Faults. Seismic damage to buried pipelines is due to the combination of seismic wave propagation and permanent ground displacement. Strong ground shaking also can cause water-saturated soils to become liquified (liquifaction). Earthquakes tend to cause more damage to segmented pipelines than to continuous pipelines that have joints consisting of full penetration welded steel. The Keystone Pipeline will be a continuous pipeline. Buckling and pinhole leaks (typically at previously weakened areas of corrosion) are the most common types of pipeline damage caused by seismic events.

Nationwide, earthquakes (and other natural hazards) are responsible for less than 3 percent of all pipeline incidents each year. Moreover, O'Rourke and Palmer (1996) studied earthquake performance data for steel transmission and distribution pipelines over a 61-year period. Their review of the data found that post-1945 electric arc-welded transmission pipelines in good repair have performed very well in earthquakes.

Keystone will construct all new facilities to current Uniform Building Code standards. Additional engineering measures to account for seismic activity are not expected to be required due to relatively low seismic activity in the region crossed by the Keystone Pipeline Project.

Federal regulations (49 CFR 195) require Keystone to conduct an internal inspection if an earthquake, landslide, or soil liquefaction is suspected of having caused abnormal movement of the pipeline. Consequently, damage to the pipeline would be detected quickly and spills would be averted or minimized. The likelihood of earthquake damage to the Keystone Pipeline is low, as the entire Keystone Pipeline Project falls outside of the USDOT-defined high earthquake hazard areas.

Landslides. Three segments of the Keystone Pipeline Project cross areas identified by the NPMS as having high landslide potential (**Table 3-2**). These areas are located at 1) the Missouri River crossing near Yankton, South Dakota; 2) the Nebraska-Kansas border at Silver Hills; and 3) the Missouri and Mississippi River crossings. These areas will be field verified and evaluated for recent landslide activity and determination of whether HCAs could be impacted. Overall, landslides are considered a low hazard to the Keystone Pipeline system.

Subsidence. Subsidence of the ground surface can result in damage due to loss of support and the transfer of stresses in the ground to structures and facilities. Subsidence can be caused by several factors, but the cause of subsidence considered here is the dissolution of subsurface strata. Limestone, dolomite, gypsum or other susceptible rock is susceptible to water solution. The dissolution may cause surface effects such as sinkholes or depressions of the ground surface, caves, sinking streams, springs and seeps, and valleys with closed drainage (Kastning and Kastning 1999). The surface effects of dissolution are referred to as karst terrain.

Several areas of potential karst hazards were identified along the proposed route based on the map produced by Davies et al. (1984). In South Dakota and Nebraska, Upper Cretaceous Niobrara Formation and equivalents are identified as strata that could be involved in the formation of karst. Areas in northeast Kansas and Missouri are underlain by limestones in Pennsylvanian and Permian-age strata. The solution features are characterized as irregularly spaced (1,000 feet or more) small fissures (less than 1,000 feet long and 50 feet deep) with 50 feet or more overburden. Overall, subsidence is a low hazard to the Keystone Pipeline System.

Flooding. Scattered portions of the Keystone Pipeline Project cross areas that are ranked as high flood hazard areas by the NPMS (**Table 3-2**). These areas are more prevalent along the southern portion of the route and are generally collocated with major river systems, such as the Missouri, Platte, Kansas, Arkansas, and Mississippi Rivers. These areas will be field verified and cross-checked with Federal Emergency Management Agency flood maps. If the area is highly susceptible to flooding, then the portion of pipeline within the affected area will be cross-referenced for presence of HCAs and, if present, protective measures will be taken, as per 49 CFR Part 195. Additionally, if aboveground facilities are located within potential floodplains, Keystone will evaluate the potential for relocating these facilities and/or measures to reduce damage to aboveground facilities should flooding occur.

4.0 Consequences of a Spill

4.1 Human Consequences

The risk associated with the Keystone Pipeline system can be compared with the general risk to the population encountered in everyday life. Proposed actions that result in negligible additional risk are generally acceptable. The National Center for Health Statistics (CDC 2003) age-adjusted average annual death rate in the U.S. is approximately 830 per 100,000. The USDOT reports the historical average risk to the general population per year associated with hazardous liquids transmission pipelines, such as Keystone, is 1 in 27,708,096 (USDOT 2002). Therefore, the predicted risk of fatality to the public from incidents associated with the Keystone Pipeline over and above the normal U.S. death rate is negligible (<1 percent).

4.2 Environmental Consequences

The environmental risk posed by a crude oil pipeline is a function of 1) the probability of an accidental release, 2) the probability of a release reaching an environmental receptor (e.g., waterbody, fish), 3) the concentration of the contamination once it reaches the receptor, and 4) the hazard posed by that concentration of crude oil to the receptor. Based on spill probabilities and estimated spill volumes, this environmental assessment determines the probability of exposure to environmental receptors and the probable impacts based on a range of potential concentrations.

4.2.1 Environmental Fate of Crude Oil Spills

4.2.1.1 Crude Oil Composition

The composition of crude oil varies widely, depending on the source and processing. Crude oils are complex mixtures of hundreds of organic (and a few inorganic) compounds. These compounds differ in their solubility, toxicity, persistence, and other properties that profoundly affect their impact on the environment. The effects of a specific crude oil cannot be thoroughly understood without taking its composition into account.

Crude oil transported by the Keystone Pipeline Project is derived from the Alberta oil sands region. The oil extracted from the sands is called bitumen, a black and thick oil. In order for the bitumen to be transported by pipeline, an upgrading technology is applied to convert the bitumen to synthetic crude oil. The precise composition of synthetic crude will vary by shipper and is considered proprietary information.

The primary classes of compounds found in crude oil are alkanes (hydrocarbon chains), cycloalkanes (hydrocarbons containing saturated carbon rings), and aromatics (hydrocarbons with unsaturated carbon rings). Most crude oils are more than 95 percent carbon and hydrogen, with small amounts of sulfur, nitrogen, oxygen, and traces of other elements. Crude oils contain lightweight straight-chained alkanes (e.g., hexane, heptane), cycloalkanes (e.g., cyclyohexane), aromatics (e.g., benzene, toluene), cycloalkanes, and heavy aromatic hydrocarbons (e.g., polycyclic aromatic hydrocarbons [PAHs], asphaltines). Straight-chained alkanes are more easily degraded in the environment than branched alkanes. Cycloalkanes are extremely resistant to biodegradation. Aromatics (i.e., benzene, toluene, ethylbenzene, xylenes [BTEX compounds]) pose the most potential for environmental concern. Because of their lower molecular weight they are more soluble in water than alkanes and cycloalkanes.

4.2.1.2 Environmental Fate and Transport

Accidental releases of crude oil can occur during transport by pipeline. Once released into the environment, the crude oil will pool in low-lying areas. Some lighter volatile constituents of the crude oil will evaporate into air, while other constituents will bind or leach into soils, or dissolve into water. Hydrocarbons that volatilize into the atmosphere are broken down by sunlight into smaller compounds. This process, referred to as photodegradation, occurs rapidly in air and the rate of photodegradation increases as molecular weight increases. If released onto soil, a portion of the crude oil will penetrate the soil as a result of the effects of gravity and capillary action. The rate of penetration will depend on the nature of the soil. Since crude oil is more viscous than water, crude oils penetrate soils less quickly. When released into water, a portion of the crude oil will tend to float to the surface where it can evaporate, other fractions will dissolve, and some material may descend to the bottom as sedimentation.

Spreading of crude oil increases with wind and current speed and increasing temperature. Most crude oils spread across surface waters at a rate of 100 to 300 meters per hour. Surface ice will greatly reduce the spreading rate of oil across a waterbody. Spreading reduces the bulk quantity of crude oil present in the vicinity of the spill but increases the spatial area within which adverse effects may occur. Thus crude oil in flowing, as opposed to contained, waterbodies will be less concentrated in any given location, but may cause impacts, albeit reduced in intensity, over a much larger area. Spreading and thinning of spilled crude oil also increases the surface area of the slick, thus enhancing surface dependent fate processes such as evaporation, degradation, and dissolution.

Dispersion of crude oil increases with increasing surface turbulence. The dispersion of crude oil into water may serve to increase the surface area of crude oil susceptible to dissolution and degradation processes and thereby limit the potential for physical impacts.

Evaporation will be the primary mechanism of loss for low molecular weight constituents and light oil products. As lighter components evaporate, remaining crude oil becomes denser and more viscous. Evaporation thus tends to reduce crude oil toxicity but enhances crude oil persistence. Bulk evaporation of Alberta crude oil accounted for an almost 50 percent reduction in volume over a 12-day period (Shiu et al. 1988). Evaporation increases with increased spreading of a slick, increased temperature, and increased wind and wave action.

Dissolution of crude oil in water is not a significant process controlling the crude oil's fate in the environment, since most components of oils are relatively insoluble (Neff and Anderson 1981). Moreover, overall solubility of crude oils tend to be less than their constituents since solubility is limited to the partitioning between oil and water interface and individual compounds are often more soluble in oil than in water, thus they tend to remain in the oil. Nevertheless, dissolution is one of the primary processes affecting the toxic effects of a spill, especially in confined waterbodies. Dissolution increases with decreasing molecular weight, increasing temperature, decreasing salinity, and increasing concentrations of dissolved organic matter. Greater photodegradation also tends to enhance the solubility of crude oil in water.

Heavy molecular weight hydrocarbons will bind to suspended particulates, and this process can be significant in highly turbid or eutrophic waters. Organic particles (e.g., biogenic material) tend to be more effective at sorbing oils than inorganic particles (e.g., clays). Sorption processes and sedimentation reduce the quantity of heavy hydrocarbons present in the water column and available to aquatic organisms. However, these processes also render hydrocarbons less susceptible to degradation. Sedimented oil tends to be highly persistent and can cause shoreline impacts.

Photodegradation of crude oil increases with greater solar intensity. It can be a significant factor controlling the disappearance of a slick, especially of lighter oil constituents; but it will be less important during cloudy days and winter months. Photodegraded crude oil constituents tend to be more soluble and more toxic than parent compounds. Extensive photodegradation, like dissolution, may thus increase the biological impacts of a spill event.

In the immediate aftermath of a crude oil spill, natural biodegradation of crude oil will not tend to be a significant process controlling the fate of spilled crude oil in waterbodies previously unexposed to oil. Microbial populations must become established before biodegradation can proceed at any appreciable rate. Also, prior to weathering (i.e., evaporation and dissolution of light-end constituents), oils may be toxic to the very organisms responsible for biodegradation and high molecular weight constituents tend to be resistant to biodegradation. Biodegradation is nutrient and oxygen demanding and may be precluded in nutrient-poor aquatic systems. It also may deplete oxygen reserves in closed waterbodies, causing adverse secondary effects to aquatic organisms.

With time, however, microorganisms capable of consuming crude oil generally increase in number and the biodegradation process naturally remediates the previously contaminated soil. The biodegradation process is enhanced as the surface area of spilled oil increases (e.g., by dispersion or spreading). Biodegradation has been shown to be an effective method of remediating soils and sediments contaminated by crude oil.

Overall, the environmental fate of released crude oil is controlled by many confounding factors and persistence is difficult to predict with great accuracy. Major factors affecting the environmental fate include spill volume, type of crude oil, dispersal rate of the crude oil, terrain, receiving media, and weather. Once released, the physical environment largely dictates the environmental persistence of the spilled material. Along the Keystone Pipeline route, the primary habitats of concern include low gradient streams, rivers, and small intermittent ponds. Wetlands also are frequently located along the proposed pipeline route. Estimates of the length of time materials could persist at potentially acute concentrations vary depending on the size of spill and environmental conditions. In warm summer months, the acutely toxic volatile component of crude oil will evaporate quickly, and a relatively small release into a high gradient stream would be expected to rapidly dissipate. In contrast, crude oil released into a small stream in winter could become trapped under pockets of ice and, thus persist longer.

4.2.2 Environmental Impacts

An evaluation of the potential impacts resulting from the accidental release of crude oil into the environment is discussed by environmental resource below.

4.2.2.1 Soils

Soils could be impacted because pipelines are buried and soil absorption of spilled crude oil would occur. In contrast with crude oil releases to surface waters where the oil would disperse downstream, subsurface releases to soil tend to disperse more slowly and are generally located within a contiguous and discrete area. Effects to soils can be quite slow to develop, allowing time for emergency response and cleanup actions to mitigate effects to potential receptors.

Depending on a number of factors (including size and rate of release, topography of the release site, vegetative cover, soil moisture, bulk density and soil porosity), a portion of the released materials would enter the surrounding soil and disperse both vertically and horizontally in the soil. High rates of release from the buried pipeline would result in a greater likelihood that released materials would reach the ground surface, while low rates of release would be more likely to primarily remain within the less compacted pipe trench backfill with a smaller portion dispersing within surrounding, consolidated subsurface materials. The sandy soils found throughout most of the pipeline route would likely facilitate horizontal and vertical dispersion. If present, soil moisture and moisture from precipitation would increase the dispersion and migration of crude oil.

Crude oil released to the soil's surface could potentially produce localized effects on plant populations (see Vegetation, Section 3.2.3 below). Within areas of active agriculture, the release of crude oil could result in the contamination of soils. Keystone would be responsible for cleanup of contaminated soils. Once remedial cleanup levels were achieved in the soils, no adverse or long-term impacts to agricultural lands would be expected.

Both on the surface and in the subsurface, rapid attenuation of light, volatile constituents (due to volatilization) would quickly reduce the total volume of product, while heavier constituents would be more persistent. Except in cases of high rate and high total volume releases, and environmental settings characterized by steep topography or karst terrain, soil impacts would be confined to a relatively small, contiguous, and easily defined area. This would facilitate cleanup and remediation. Within a relatively short time, lateral migration would generally stabilize and downward vertical migration could begin to occur.

If a spill were to occur, the majority of the crude oil would likely reside in the less consolidated soil (lower soil bulk density) within the pipeline trench. The vast majority of the pipeline is located in relatively flat terrain. In these flat locations, the oil would disperse horizontally within the pipeline trench with a smaller portion of the spilled oil moving into the surrounding, more consolidated soil. If the spill were to occur on a steep slope, crude oil would likely pool primarily within the trench behind the trench breakers. If sufficient volume existed, the crude oil would breach the soil's surface as it extended over the top of the trench breaker. Once on the soil's surface, the release would be more apparent to leak surveillance patrols. Soil types and the presence of clay lenses, layers of bedrock, or karst terrain would significantly influence the dispersal pattern of spilled materials.

Crude oil released to the environment would tend to have greater dispersion in sandy and badland soils than in more consolidated soils. If a release were to occur in sandy soils or badland areas, it is likely that the spatial extent of the contamination would be greater than in areas containing more organic soils. Consequently, the amount of soil that would need to be cleaned up would be less than or equal to the maximum amount. Crude oil released into sandy or badland soils would likely become visible to aerial surveillance due to product on the soils surface or discoloration of vegetation.

The removal and disposal of contaminated soil likely represents the remedial action that would cause the greatest amount of surface disturbance. Based on a spill volume of 2,000 barrels (over 80 percent of spills are smaller than this volume), the maximum amount of soil that would need to be removed was calculated. Soil cleanup levels for benzene in soil from petroleum releases vary by state (Nebraska: 3.63 parts per million [ppm]; Illinois: 1.6 ppm; South Dakota: 17 ppm; Kansas 9.8 ppm). The volume of soil remediation is based upon two different calculations to aid in identifying worst-case (2,001,277 cubic yards) and best-case (2,059 cubic yards) volume estimates. The worst-case estimate assumes a 2,000-barrel release, an estimated concentration of benzene in the oil, and a uniform distribution of oil to achieve the most stringent state recommended soil cleanup level (RCL) for benzene (1.6 ppm). The approach assumes that all the oil is evenly spread to a mass of oil such that the resulting oil benzene concentration is 1.6 milligrams per kilograms. Because the RCL is used as a target, the resulting volume of soil is actually the volume of soil at which no removal action would be needed. The best case estimate assumes the same 2000 barrel release but calculates the volume of soil that could fill with the volume of the release based on an estimated 30 percent soil porosity and a 10 percent soil moisture content and would likely be the minimum volume of soil to be removed. The actual remediation soil volume would likely be closer to the best-case estimate although higher than this estimate.

These estimates are gross estimations. Release dynamics such as leak rate, leak duration, and effects of isolation controls would result in different surface spreading and infiltration rates, which in turn, affect the final volume of affected soil to be remediated.

4.2.2.2 Water Resources

While normal operations would not adversely affect water resources, abnormal operations could result in released crude oil entering water resources. As part of project planning and in recognition of the environmental sensitivity of waterbodies, the Keystone Pipeline routing process attempted to minimize the waterbodies crossed. Furthermore, valves have been strategically located along the Keystone Pipeline to help reduce the amount of crude oil that could potentially spill into waterbodies, if such an event were to occur. The location of valves, spill containment measures, and the Keystone Emergency Response Plan would mitigate adverse effects to both surface and groundwater.

Flowing Surface Waters

To evaluate the likelihood of adverse effects to surface water resources, measurement endpoints were developed to correspond with the most sensitive resource potentially affected (surface water that provides drinking water and supports aquatic life) and to address the primary regulatory thresholds that trigger emergency response and remediation. These measurement endpoints (toxicity thresholds and drinking water standards) were compared to the maximum possible concentration of benzene. Benzene values were selected for comparison because they were the most likely to show adverse impacts to aquatic biota and drinking water.

These measurement endpoints were compared to estimated concentrations of crude oil in the surface water. Rather than evaluate the risk to each waterbody crossed by the Keystone Pipeline, this risk assessment evaluated streams categories, broadly classified by magnitude of streamflow and stream width. **Table 4-1** summarizes the stream categories used for the assessment and identifies several representative streams within these categories.

Table 4-1 Stream Categories

	Streamflow (cubic feet per second; cfs)	Stream Width (feet)	Representative Streams
Low Flow Stream	10 – 100	<50	Shell Creek, Mill Creek
Lower Moderate Flow Stream	100 – 1,000	50 – 500	Pembina Creek, James River, Sheyenne River, Cuivre River
Upper Moderate Flow Stream	1,000 – 10,000	500 – 1,000	Platte River, Chariton River, Missouri River
High Flow Stream	>10,000	1,000 – 2,500	Mississippi River

Although the concentration of crude oil constituents in an actual spill would vary both temporally and spatially and localized toxicity could occur from virtually any size of crude oil spill, for this analysis it was conservatively assumed that the entire volume of the spill was released directly into a waterbody and that complete, instantaneous mixing occurred. These assumptions are highly conservative and, thus, overestimate potential toxic effects. These estimated benzene concentrations within the surface waterbodies were then compared with acute and chronic toxicity thresholds for human health drinking water thresholds and for aquatic biota.

The promulgated drinking water standards for humans vary by several orders of magnitude for crude oil constituents. For human health protection, the national Maximum Contaminant Level (MCL) is an enforceable standard established by the U.S. Environmental Protection Agency (USEPA) and is designed to protect long-term human health. Of the various crude oil constituents, benzene has the lowest national MCL at 0.005 ppm[2] and, therefore, it was used to evaluate impacts on drinking water supplies, whether from surface or groundwaters.

An evaluation of water quality was conducted to assess potential risk to drinking water supplies. The estimated concentrations of benzene within representative streamflows are summarized in **Tables 4-2** and **4-3**. A 1-hour release period for the entire spill volume was assumed in order to maximize the product concentration in water. Results suggest that most spills that enter a waterbody could result in exceedence of the national MCL for benzene. These findings indicate that rapid notification of managers of municipal water intakes downstream

[2] All affected states along the Keystone Pipeline route use the national MCL value of 0.005 ppm.

of a spill would be essential so that any drinking water intakes could be closed to bypass river water containing crude oil.

To evaluate the potential for drinking water impacts to occur in any specific waterbody, the occurrence interval for a spill at the river crossing was calculated based on probabilities generated from the USDOT database. To be conservative, a 500-foot buffer on either side of the river was added to the crossing widths identified in **Table 4-1**.

Results indicate that the chance of a spill occurring at any specific waterbody is very low. Depending on throughput, occurrence intervals ranged from about 16,000 years for a large waterbody to over 450,000 years for a small waterbody. If any release did occur, it is likely that the total release volume of a spill likely would be 50 barrels or less based on historical spill volumes, or less than 1,000 barrels based on the spill volume study **(Appendix A)**.

In summary, while a release of crude oil into any given waterbody would likely cause an exceedance of drinking water standards, the frequency of such an event would be low. Nevertheless, streams and rivers with downstream drinking water intakes represent the sensitive environmental resources and could be temporarily impacted by a crude oil release.

Wetlands/Prairie Potholes/Playa Lakes

Although planning and routing efforts attempted to reduce the overall number of wetlands (including prairie potholes and playa lake environments) and static waterbodies environment crossed by the Keystone Pipeline, wetlands and waterbodies with persistently saturated soils commonly occur along and adjacent to the Keystone Pipeline route. The effects of crude oil released into a wetland environment will depend not only upon the quantity of oil released, but also on the physical conditions of the wetland at the time of the release. Wetlands include a wide range of environmental conditions. Wetlands can consist of many acres of standing water dissected with ponds and channels, or they may simply be areas of saturated soil with no open water. A single wetland can even vary between these two extremes as seasonal precipitation varies. Wetland surfaces are generally low gradient with very slow unidirectional flow or no discernable flow. The presence of vegetation or narrow spits of dry land protruding into wetlands also may isolate parts of the wetland. Given these conditions, spilled materials may remain in restricted areas for longer periods than in river environments.

Crude oil released from a subsurface pipe within a wetland could reach the soil surface. If the water table reaches the surface, the release would manifest as floating crude oil. The general lack of surface flow within a wetland would restrict crude oil movement. Where surface water is present within a wetland, the spill would spread laterally across the water's surface and be readily visible during routine right-of-way (ROW) surveillance. The depth of soil impacts likely would be minimal, due to shallow (or emergent) groundwater conditions. Conversely, groundwater impacts within the wetland are likely to be confined to the near-surface, enhancing the potential for biodegradation. If humans or other important resource exposures were to occur in proximity to the wetland, then regulatory drivers would mandate the scope of remedial actions, timeframe for remediation activities, and cleanup levels. However, response and remediation efforts in a wetland have the potential for appreciable adverse effects from construction/cleanup equipment. If no active remediation activities were undertaken, natural biodegradation and attenuation would ultimately allow a return to baseline conditions in both soil and groundwater. This would likely require a timeframe on the order of tens of years.

The evaluation of spill effects on fish and aquatic invertebrates also is applicable to wetland environments and plants. Based on a review of toxicity literature for wetland plant groups (i.e., algae, annual macrophytes, and perennial macrophytes), crude oil is toxic to aquatic plants but at higher concentrations than observed for fish and invertebrates. Therefore, assumptions and calculations based on aquatic life standards are conservative (i.e., more likely to show an adverse effect than if the limited amount of wetland toxicity data were used). Therefore, spill concentrations that are less than toxic effect levels for fish and invertebrates also would be protective for wetland plant species.

Table 4-2 Estimated Benzene Concentrations from Crude Oil Release Compared with Human Drinking Water for Streams Crossed by the Proposed Action

Throughput – 435,000 bpd	Benzene MCL (ppm)	Stream Flow Rate (cfs)	Product Released					
			Small spill: 50 barrels		Moderate spill: 1,000 barrels		Large spill: 10,000 barrels	
			Concentration (ppm)	Occurrence Interval (years)	Concentration (ppm)	Occurrence Interval (years)	Concentration (ppm)	Occurrence Interval (years)
Low Flow Stream	0.005	10	11	457,042	220	63,562	2,201	342,782
Lower Moderate Flow Stream	0.005	100	1.1	319,930	22	44,494	220	239,947
Upper Moderate Flow Stream	0.005	1,000	0.11	239,947	2.2	33,370	22	179,690
High Flow Stream	0.005	10,000	0.01	137,113	0.2	19,069	2.2	102,835

Notes:

-Predicted rates apply for each stream crossing.

-Estimated concentration is based on release of benzene into water over a 24-hour period with uniform mixing conditions.

-Concentrations are based on a 0.15 percent by weight benzene content of the crude oil.

-Benzene concentrations compared to benzene's MCL of 0.005 ppm.

-Shading indicates concentrations that could exceed the MCL.

-Occurrence intervals are based on a predicted incident frequency of 0.14 spills/year for 435,000 bpd along the entire Keystone Pipeline (**Appendix A**) and estimated stream widths. Widths of higher flow streams are greater than widths of lower flow streams, with more distance where an incident might occur. This results in a greater predicted frequency for high flow streams and a corresponding lower occurrence interval.

Table 4-3 Estimated Benzene Concentrations from Crude Oil Release Compared with Human Drinking Water Standard for Streams Crossed by the Proposed Action

Throughput – 591,000 bpd	Benzene MCL (ppm)	Stream Flow Rate (cfs)	Product Released					
			Small spill: 50 barrels		Moderate spill: 1,000 barrels		Large spill: 10,000 barrels	
			Concentration (ppm)	Occurrence Interval (years)	Concentration (ppm)	Occurrence Interval (years)	Concentration (ppm)	Occurrence Interval (years)
Low Flow Stream	0.005	10	11	281,692	220	52,783	2,201	217,030
Lower Moderate Flow Stream	0.005	100	1.1	197,149	22	36,948	220	151,921
Upper Moderate Flow Stream	0.005	1,000	0.11	147,862	2.2	27,711	22	113,941
High Flow Stream	0.005	10,000	0.01	84,493	0.2	15,835	2.2	65,109

Notes:

-Predicted rates apply for each stream crossing.

-Estimated concentration is based on release of benzene into water over a 24-hour period with uniform mixing conditions.

-Concentrations are based on a 0.15 percent by weight benzene content of the crude oil.

-Benzene concentrations compared to benzene's MCL of 0.005 ppm.

-Shading indicates concentrations that could exceed the MCL.

-Occurrence intervals are based on a predicted incident frequency of 0.19 spills/year for 591,000 bpd along the entire Keystone Pipeline (**Appendix A**) and estimated stream widths. Widths of higher flow streams are greater than widths of lower flow streams, with more distance where an incident might occur. This results in a greater predicted frequency for high flow streams and a corresponding lower occurrence interval.

Results indicate that the chance of a spill occurring at any specific wetland is very low. Based on National Wetlands Inventory mapping, wetlands comprise 46.4 miles of the entire Keystone Pipeline system (Table 3.5-8 of the Keystone Environmental Report). Of the estimated 1.4 spills postulated to occur during a 10-year period within the entire pipeline system, about 0.05 spills would be expected to occur within wetland areas (equivalent to one spill every 200 years). If any release did occur, it is likely that the total release volume of a spill likely would be 50 barrels or less based on historical spill volumes, or less than 1,000 barrels based on the spill volume study (**Appendix A**).

The predicted effects of a spill reaching standing water (e.g., reservoirs, prairie potholes) would depend largely upon the volume of crude oil entering the waterbody and the volume of water within the waterbody. **Table 4-4** summarizes the amount of water necessary to dilute spill volumes below aquatic toxicity and drinking water thresholds. While this preliminary approach does not account for fate and transport mechanisms, mixing zones, environmental factors, and emergency response capabilities, it does provide an initial benchmark for identifying areas of potential concern. An evaluation of standing water resources that could be impacted by a crude oil spill will be evaluated more completely in Keystone's November 2006 supplemental filing.

Table 4-4 Amount of Water Required to Dilute Crude Oil Spills Below Threshold Values

Barrels of Crude Oil	Volume of Water Required to Dilute Crude Oil Below Threshold (acre-feet)[1]		
	Acute Toxicity Threshold (7.4 milligrams per liter [mg/L])	Chronic Toxicity Threshold (1.4 mg/L)	Drinking Water MCL (0.005 mg/L)
50	4.6	25	6,890
150	14	74	20,669
1,000	93	492	137,790
10,000	931	4,921	1,377,904

[1]Thresholds based on aquatic toxicity and drinking water thresholds established for benzene. For the Keystone crude oil, the benzene content is estimated to be 0.15 percent by weight.

In summary, while a release of crude oil into wetland and static waterbodies has the potential to cause temporary environmental impacts, the frequency of such an event would be low. Nevertheless, wetlands and static waterbodies represent the sensitive environmental resources and further evaluation of potential impacts is warranted.

Groundwater

Multiple groundwater aquifers underlie the proposed Keystone Pipeline system. Vulnerability of these aquifers is a function of the depth to groundwater and the permeability of the overlying soils. While routine operation of the Keystone Pipeline would not affect groundwater, there is the possibility that a release could migrate through the overlying surface materials and enter a groundwater system.

In general, the potential for groundwater contamination following a spill would be more probable in locations where a release into or on the surface of soils has occurred:

- Where a relatively shallow water table is present (as opposed to locations where a deeper, confined aquifer system is present); and
- Where relatively porous soil conditions are present throughout the unsaturated zone.

Depending on soil properties, the depth to groundwater, and the amount of crude oil in the unsaturated zone, groundwater contamination can result from the migration of dissolved constituents and free crude oil. Movement in the dissolved phase typically extends for greater distances than movement of pure crude oil in the subsurface. Crude oil is less dense than water and initially would tend to form a floating pool after reaching the groundwater surface. This pool would tend to migrate laterally in the direction of groundwater flow, and the oil flow velocity would be a function of the soil properties and groundwater flow rate. Those compounds in the crude oil that are soluble in water will form a larger, dissolved "plume." This plume also would tend to migrate laterally in the direction of groundwater flow. The flow velocity of dissolved constituents also would be a function of the groundwater flow rate and would tend to migrate at a faster rate than free crude oil itself.

The extent to which potential groundwater receptors may be contaminated by a release of crude oil depends upon the rate of contaminant transport in the subsurface. The rate of contaminant movement depends, in turn, on the rate of groundwater movement and the attenuation mechanisms that act to retard contaminant movement relative to groundwater movement. In shallow aquifer systems where impacts from released crude oil are most likely, the rate of groundwater movement depends upon the hydraulic gradient, aquifer permeability and porosity, and the geometry of the aquifer system. Groundwater flow rates typically move less than 1 foot per year, though there can be much more rapid movement in individual locations (Wilson 1986). Individual constituents tend to move faster than the groundwater itself; however, contamination often takes years to disperse one mile from the point of origin (Wilson 1986).

If exposure to humans or other important resources would be possible from a release into groundwater, then regulatory drivers would mandate the scope of remedial actions, timeframe for remediation activities, and cleanup levels. However, response and remediation efforts have the potential for appreciable adverse effects from construction/cleanup equipment. If no active remediation activities were undertaken, natural biodegradation and attenuation would ultimately allow a return to baseline conditions in both soil and groundwater. Depending on the amount of crude oil reaching the groundwater and natural attenuation rates, this would likely require a timeframe up to the range of tens of years.

Attenuation mechanisms that retard the movement of contaminants include dispersion, sorption, volatilization, abiotic chemical degradation, and biological degradation. The extent to which any of these mechanisms would retard contaminant movement at a given location depends upon site-specific conditions. In general, crude oil in groundwater tends to biodegrade as described for soil releases. Even in the case of large released volumes and floating free crude oil, dispersive forces become balanced with biodegradation and attenuation mechanisms, establishing degradation equilibrium. The typical result is a relatively limited zone of impact, typically 200 meters or less downgradient (USGS 1998). Over time, these natural degradation mechanisms, along with other natural attenuation mechanisms, including dispersion, result in the removal and/or destruction of crude oil materials; both in groundwater, and in overlying impacted soils. Observed degradation rates indicate this process would typically occur in timeframes measured in tens of years, depending on the concentration of crude oil in the groundwater.

4.2.2.3 Vegetation

Terrestrial plants are much less sensitive to crude oil than aquatic species. The lowest toxicity threshold for terrestrial plants found in the USEPA ECOTOX database (USEPA 2001) was 18.2 ppm for benzene, higher than the 7.4 ppm threshold for aquatic species and the 0.005 ppm threshold for human drinking water. Similarly, available data from the USEPA database indicate that earthworms also are less sensitive than aquatic species (toxicity threshold was greater than 1,000 ppm). If concentrations were sufficiently high, crude oil in the root zone could harm individual plants and organisms.

Release of crude oil could result in the contamination of soils (see Soils, Section 3.2.1 above). Keystone would be responsible for cleanup of contaminated soils. Once remedial cleanup levels were achieved in the soils, no adverse or long-term impacts to vegetation would be expected.

4.2.2.4 Wildlife and Aquatic Resources

Spilled crude oil can affect organisms directly and indirectly. Direct effects include physical processes, such as oiling of feathers and fur, and toxicological effects, which can cause sickness or death. Indirect effects are less conspicuous and include habitat impacts, nutrient cycling disruptions, and alterations in ecosystem relationships. The magnitude of effects varies with multiple factors, the most significant of which include the amount of material released, the size of the spill dispersal area, the type of crude oil spilled, the species assemblage present, climate, and the spill response tactics employed.

The toxicity of crude oil is dependent upon its composition and that of its water-soluble fraction (WSF), especially of its aromatic content. The WSF of crude oil is dominated by one- and two-ringed aromatics (e.g., benzene and naphthalene) along with some short-chained alkanes. Long-chained alkanes (e.g., decane) and aromatic compounds with many rings (e.g., PAHs) tend to be less soluble in water. As an example, **Table 4-5** summarizes the toxicity of various crude oil hydrocarbons to the zooplankton, *Daphnia magna*. The relative toxicity of decane is much lower than for benzene or ethylbenzene because of the comparatively low solubility of decane. Most investigators have concluded that the acute toxicity of crude oil is related to the concentrations of relatively lightweight aromatic constituents (BETX and naphthalenes), particularly benzene.

Because of competing effects of solubility and toxicity, the higher the concentration of these aromatics in a particular crude oil, the more toxic it will be. Studies have shown that lighter, more volatile compounds (e.g., benzene) are more acutely toxic than heavier, more viscous compounds. While lightweight aromatics tend to be water soluble and relatively toxic, they also are highly volatile. Thus, most or all of the lightweight hydrocarbons accidentally released into the environment evaporate, and the environmental persistence of crude oil tends to be low.

High molecular weight aromatic compounds, including PAHs, are not very water-soluble and have a high affinity for organic material. Consequently, these compounds, if present, have limited bioavailability, which render them substantially less toxic than more water-soluble compounds (Neff 1979). Additionally, these compounds generally do not accumulate to any great extent because these compounds are rapidly metabolized (Lawrence and Weber 1984; West et al.1984). There are some indications, however, that prolonged exposure to elevated concentrations of these compounds may result in a higher incidence of growth abnormalities and hyperplastic diseases (Couch and Harshbarger 1985).

The sensitivity of organisms to crude oil is extremely varied. **Table 4-6** summarizes acute toxicity data for a broad range of species based on USEPA's AQUIRE database (USEPA 2000). Acute toxicity refers to the death or complete immobility of an organism within a short period of exposure. The LC_{50} is the concentration of a compound necessary to cause 50 percent mortality in laboratory test organisms. For aquatic biota, most acute LC_{50}s for monoaromatics range between 10 and 100 ppm. LC_{50}s for the polyaromatic naphthalene were generally between 1 and 10 ppm, while LC_{50} values for anthracene were generally less than 1 ppm. Fish are among the most sensitive aquatic biota, while aquatic invertebrates generally have intermediate sensitivities, and algae and bacteria tend to be the least sensitive. Nevertheless, even when major fish kills have occurred as a result of oil spills, population recovery has been observed, and long-term changes in fish abundance have not been reported. Benthic (bottom-dwelling) aquatic invertebrates tend to be more sensitive than algae, but are equally or less sensitive than fish. Planktonic (floating) species tend to be more sensitive than most benthic insects, crustaceans, and molluscs.

Fewer data are available to evaluate the toxicity of crude oil hydrocarbons on terrestrial organisms. **Table 4-7** summarizes toxicity data from the EPA's ECOTOX database (2001) for earthworms and terrestrial plants. Comparison of LC_{50} values for benzene suggests that aquatic species are more sensitive to crude oil than terrestrial organisms. Insufficient information was available to evaluate other constituents of concern.

Significantly, some constituents in crude oil may have greater environmental persistence than lightweight compounds (e.g., benzene), but their limited bioavailability renders them substantially less toxic than other more soluble compounds. For example, aromatics with four or more rings are not acutely toxic at their limits of solubility (Muller 1987).

Table 4-5 Acute Toxicity of Crude Oil Hydrocarbons to *Daphnia magna*

Compound	48-hr LC_{50} (ppm)	Optimum Solubility (ppm)	Relative Toxicity
Hexane	3.9	9.5	2.4
Octane	0.37	0.66	1.8
Decane	0.028	0.052	1.9
Cyclohexane	3.8	55	14.5
methyl cyclohexane	1.5	14	9.3
Benzene	9.2	1,800	195.6
Toluene	11.5	515	44.8
Ethylbenzene	2.1	152	72.4
p-xylene	8.5	185	21.8
m-xylene	9.6	162	16.9
o-xylene	3.2	175	54.7
1,2,4-trimethylbenzene	3.6	57	15.8
1,3,5-trimethylbenzene	6	97	16.2
Cumene	0.6	50	83.3
1,2,4,5-tetramethylbenzene	0.47	3.5	7.4
1-methylnaphthalene	1.4	28	20.0
2-methylnaphthalene	1.8	32	17.8
Biphenyl	3.1	21	6.8
Phenanthrene	1.2	6.6	5.5
Anthracene	3	5.9	2.0
9-methylanthracene	0.44	0.88	2.0
Pyrene	1.8	2.8	1.6

Note: The LC_{50} is the concentration of a compound necessary to cause 50 percent mortality in laboratory test organisms within a predetermined time period (e.g., 48 hours) (USEPA 2000).

Relative toxicity = optimum solubility/LC_{50}.

Table 4-6 Acute Toxicity of Aromatic Hydrocarbons to Freshwater Organisms

Species	Toxicity Values (ppm)				
	Benzene	Toluene	Xylene	Naphthalene	Anthracene
Carp (*Cyprinus carpio*)	40.4	—	780	—	—
Channel catfish (*Kctalurus*)	—[1]	240	—	—	—
Clarias catfish (*Clarias* sp.)	425	26	—	—	—
Coho salmon (*Oncorhyncus kisutch*)	100	—	—	2.6	—
Fathead minnow (*Pimephales*)	—	36	25	4.9	25
Goldfish (*Carasslus auratus*)	34.4	23	24	—	—
Guppy (*Poecilia reticulate*)	56.8	41	—	—	—
Largemouth bass (*Micropterus*)	—	—	—	0.59	—
Medaka (*Oryzias* sp.)	82.3	54	—	—	—
Mosquitofish (*Gambusia affinis*)	—	1,200	—	150	—
Rainbow trout (*Oncorhyncus mykis*)	7.4	8.9	8.2	3.4	—
Zebrafish (*Therapon iarbua*)	—	25	20	—	—
Rotifer (*Brachionus calyciflorus*)	>1,000	110	250	—	—
Midge (*Chironomus attenuatus*)	—	—	—	15	—
Midge (*Chironomus tentans*)	—	—	—	2.8	—
Zooplankton (*Daphnia magna*)	30	41	—	6.3	0.43
Zooplankton (*Daphnia pulex*)	111	—	—	9.2	—
Zooplanton (*Diaptomus forbesi*)	—	450	100	68	—
Amphipod (*Gammarus lacustris*)	—	—	0.35	—	—
Amphipod (*Gammarus minus*)	—	—	—	3.9	—
Snail (*Physa gyrina*)	—	—	—	5.0	—
Insect (*Somatochloa cingulata*)	—	—	—	1.0	—
Chlorella vulgaris	—	230	—	25	—
Microcystis aeruginosa	—	—	—	0.85	—
Nitzschia palea	—	—	—	2.8	—
Scenedesmus subspicatus	—	130	—	—	—
Selenastrum capricornutum	70	25	72	7.5	—

[1] — indicates no value was available in the database.

Note: Data summarize conventional acute toxicity endpoints from USEPA's ECOTOX database. When several results were available for a given species, the geometric mean of the reported LC_{50} values was calculated.

Table 4-7 Comparison of Benzene Toxicity Concentrations for Various Organisms

	Benzene
Aquatic species	7.4 ppm
Terrestrial plant	18.2 ppm
Earthworm	>1,000 ppm

Table 4-8 summarizes chronic toxicity (most frequently measured as reduced reproduction, growth, or weight) of benzene to freshwater biota. Benzene was selected as the most conservative measure of chronic toxicity due to its combined water solubility and chronic toxicity value. Chronic toxicity from other oil constituents may occur, however, if sufficient quantities of crude oil are continually released into the water to maintain elevated concentrations.

Table 4-8 Chronic Toxicity of Benzene to Freshwater Biota

Taxa	Test species	Chronic Value (ppm)
Fish	Fathead minnow (*Pimephales promelas*)	17.2 *
	Guppy (*Poecilia reticulata*)	63
	Coho salmon (*Oncorhynchus kitsutch*)	1.4
Amphibian	Leopard frog (*Rana pipens*)	3.7
Invertebrate	Zooplankton (*Daphnia* spp.)	>98
Algae	Green algae (*Selenastrum capricornutum*)	41 4.8 *

Note:Test endpoint was mortality unless denoted with an asterisk (*). The test endpoint for these studies was growth.

Wildlife Impacts

Wildlife, especially birds and shoreline mammals, are typically among the most visibly affected organisms in any crude oil spill. Effects of crude oil can be differentiated into physical (mechanical) and toxicological (chemical) effects. Physical effects result from the actual coating of animals with crude oil, causing reductions in thermal insulative capacity and buoyancy of plumage (feathers) and pelage (fur).

Crude oil released to the environment may cause adverse biological effects on birds and mammals via inhalation or ingestion exposure. Ingestion of crude oil may occur when animals consume oil-contaminated food, drink oil-contaminated water, or orally consume crude oil during preening and grooming behaviors.

Potential adverse effects could result from direct acute exposure. Acute toxic effects include drying of the skin, irritation of mucous membranes, diarrhea, narcotic effects, and possible death. While releases of crude oil may have an immediate and direct effect on wildlife populations, the potential for physical and toxicological effects attenuates with time as the volume of material diminishes, leaving behind more persistent, less volatile, and less water-soluble compounds. Although many of these remaining compounds are toxic and potentially carcinogenic, they do not readily disperse in the environment and their bioavailability is low, and therefore, the potential for impacts is low.

Unlike aquatic organisms that frequently cannot avoid spills in their habitats, the behavioral responses of terrestrial wildlife may help reduce potential adverse effects. Many birds and mammals are mobile and generally will avoid oil-impacted areas and contaminated food (Sharp 1990; Stubblefield et al. 1995). In a few cases, such as cave-dwelling species, organisms that are obligate users of contaminated habitat may be exposed. However, most terrestrial species have alternative, unimpacted habitat available, as will often be the case with localized spills (in contrast to large-scale oil spills in marine systems), therefore, mortality of these species would be limited (Stubblefield et al. 1995).

Indirect environmental effects of spills can include reduction of suitable habitat or food supply. Primary producers (e.g., algae and plants) may experience an initial decrease in primary productivity due to physical effects and acute toxicity of the spill. However, these effects tend to be short-lived and a decreased food supply is not considered to be a major chronic stressor to herbivorous organisms after a spill. If mortality occurs to local invertebrate and wildlife populations, the ability of the population to recover will depend upon the size of the impact area and the ability of surrounding populations to repopulate the area.

Aquatic Toxicity

In aquatic environments, toxicity is a function of the concentration of a compound necessary to cause toxic effects combined with the compound's water solubility. For example, a compound may be highly toxic, but if it were not very soluble in water then its toxicity to aquatic biota would be relatively low. The toxicity of crude oil is dependent of the toxicity of its constituents. Among these, benzene is generally considered the most toxic constituent due to the low concentrations at which toxic effects are observed and its high water solubility. Other compounds in crude oil are considered much less toxic. For this assessment, the benzene content within the crude oil hypothetically entering the waterbody was assumed to be completely dissolved in the water. This assumption overestimates the actual amount of benzene that likely would become solubilized in the water. Concentrations of benzene were compared to benzene toxicity thresholds to assess whether toxic effects might be anticipated.

For aquatic biota, the acute and chronic toxicity thresholds for benzene are 7.4 ppm and 1.4 ppm, respectively, based on standardized trout toxicity tests (USEPA 2000). These toxicity threshold values are considered protective of acute and chronic effects to other aquatic biota, since other major constituents of crude oil are less toxic. Although trout are not found in many of the habitats crossed by the project, trout studies were selected because trout are among the most sensitive aquatic species and reliable acute and chronic trout toxicity data are available.

Tables 4-9 to **4-12** summarize the predicted acute and chronic toxicity to aquatic resources, based on the amount of crude oil released and the streamflow. Broadly, acute toxicity could potentially occur if substantial amounts of crude oil were to enter most rivers and streams, as demonstrated by the Moderate and Large Spill Scenarios. If such an event were to occur within a small stream, toxicity could potentially kill or injure aquatic species in the immediate vicinity and downstream of the rupture. Under these two scenarios, chronic toxicity also could potentially occur in small and moderate sized streams and rivers. However, emergency response, containment, and cleanup efforts would help reduce the concentrations and minimize the potential for chronic toxicity. In comparison, relatively small spills (less than 50 barrels) into moderate and large rivers would not pose a major toxicological threat. In small to moderate sized streams and rivers, some toxicity might occur in localized areas, such as backwaters where concentrations would likely be higher than in the mainstream of the river.

The likelihood of a release into any particular waterbody is low, with an occurrence interval of once every 16,000 to 500,000 years. If any release did occur, it is likely that the total release volume of a spill likely would be 50 barrels or less based on historical spill volumes, or less than 1,000 barrels based on the spill volume study (**Appendix A**).

In summary, while a release of crude oil into any given waterbody might cause immediate localized toxicity to aquatic biota, particularly in smaller streams and rivers, the frequency of such an event would be low. Nevertheless, streams and rivers with aquatic biota represent the sensitive environmental resources that could be temporarily impacted by a crude oil release.

4.3 Risk to Populated and High Consequence Areas (HCAs)

Consequences of inadvertent releases from pipelines can vary greatly, depending on where the release occurs. Pipeline safety regulations use the concept of HCAs to identify specific locales and areas where a release could have the most significant adverse consequences. HCAs include populated areas, drinking water, and unusually sensitive ecologically resource areas (USAs) that could be environmentally damaged from a hazardous liquid pipeline release (**Table 4-13**). HCAs are subject to higher levels of inspection, per 49 CFR Part 195. These data are compiled from a variety of data sources, including federal and state agencies (e.g., state drinking water agencies and the Environmental Protection Agency). These USDOT-designated HCAs are continually refined and updated. The USDOT acknowledges that spills within a sensitive area might not actually impact the sensitive resource and encourages operators to conduct detailed analysis, as needed. TransCanada will conduct a thorough analysis of potential impacts to HCAs as part of its compliance with federal regulations.

Assuming that 1.4 spills occurred along the Keystone Pipeline system in a 10-year period, it is estimated that approximately 0.18 of these spills would occur in HCAs (**Table 4-13**). Although the number of predicted spills in HCAs is relatively small, the potential impacts of these individual spills are expected to be greater than in other areas due to the environmental sensitivity within these areas. **Table 4-14** also shows the number of spills and their predicted sizes.

4.3.1 Populated Areas

Highly populated HCAs occur along 4.0 miles of the Keystone Pipeline system. These highly populated areas have been identified as HCAs by the USDOT based on U.S. Census data (**Table 4-14**). More than 99 percent of these miles are near St. Louis, Illinois. Because of the recent population growth in some areas, Keystone also will review other populated areas, including those around Troy (Missouri), Edwardsville (Missouri) and the St. Louis area (Missouri and Illinois), to determine if these areas qualify as HCAs.

Table 4-9 Comparison of Estimated Crude Oil Concentrations Following a Spill to the Acute Toxicity Thresholds for Aquatic Life (7.4 ppm) for Streams Crossed by the Proposed Action

Throughput – 435,000 bpd	Stream Flow Rate (cfs)	Acute Toxicity Threshold (ppm)	Product Released					
			Small spill: 50 barrels		Moderate spill: 1,000 barrels		Large spill: 10,000 barrels	
			Concentration (ppm)	Occurrence Interval (years)	Concentration (ppm)	Occurrence Interval (years)	Concentration (ppm)	Occurrence Interval (years)
Low Flow Stream	10	7.4	**11**	**457,042**	**220**	**63,562**	**2,201**	**342,782**
Lower Moderate Flow Stream	100	7.4	1.1	319,930	**22**	**44,494**	**220**	**239,947**
Upper Moderate Flow Stream	1,000	7.4	0.11	239,947	2.2	33,370	**22**	**179,690**
High Flow Stream	10,000	7.4	2.2	102,835	0.2	19,069	0.01	137,113

Notes:

-Predicted rates apply for each stream crossing.

-Estimated proportion of benzene in the crude oil is 0.15 percent, and is assumed to be entirely water solubilized in the event of a spill. The resulting concentration was calculated by multiplying 0.15 percent of the total amount of crude oil released divided by 96 hours of stream flow volume. The model assumes uniform mixing conditions.

-Benzene concentrations are compared against the acute toxicity threshold for benzene.

-Shading indicates concentrations that could potentially cause acute toxicity to aquatic species. The darkest shading represents high probability of acute toxicity (>10 times the toxicity threshold); lighter shading represents moderate probability of acute toxicity (1 to 10 times the toxicity threshold); and unshaded areas represent low probability of acute toxicity (<toxicity threshold).

-Occurrence intervals are based on a predicted incident frequency of 0.14 spills/year along the entire Keystone Pipeline (**Appendix A**) and estimated stream widths. Widths of higher flow streams are greater than widths of lower flow streams, with more distance where an incident might occur. This results in a greater predicted frequency for high flow streams and a corresponding lower occurrence interval.

Table 4-10 Comparison of Estimated Crude Oil Concentrations Following a Spill to the Acute Toxicity Thresholds for Aquatic Life for Streams Crossed by the Proposed Action

Throughput – 591,000 bpd	Stream Flow Rate (cfs)	Acute Toxicity Threshold (ppm)	Product Released					
			Small spill: 50 barrels		Moderate spill: 1,000 barrels		Large spill: 10,000 barrels	
			Concentration (ppm)	Occurrence Interval (years)	Concentration (ppm)	Occurrence Interval (years)	Concentration (ppm)	Occurrence Interval (years)
Low Flow Stream	10	7.4	**11**	**281,692**	220	52,783	2,201	217,030
Lower Moderate Flow Stream	100	7.4	1.1	197,149	**22**	**36,948**	220	151,921
Upper Moderate Flow Stream	1,000	7.4	0.11	147,862	2.2	27,711	**22**	**113,941**
High Flow Stream	10,000	7.4	0.01	84,493	0.2	15,835	2.2	65,109

Notes:

-Predicted rates apply for each stream crossing.

-Estimated proportion of benzene in the crude oil is 0.15 percent, and is assumed to be entirely water solubilized in the event of a spill. The resulting concentration was calculated by multiplying 0.15 percent of the total amount of crude oil released divided by 96 hours of stream flow volume. The model assumes uniform mixing conditions.

-Shading indicates concentrations that could potentially cause acute toxicity to aquatic species. The darkest shading represents high probability of acute toxicity (>10 times the toxicity threshold); lighter shading represents moderate probability of acute toxicity (1 to 10 times the toxicity threshold); and unshaded areas represent low probability of acute toxicity (<toxicity threshold).

-Occurrence intervals are based on a predicted incident frequency of 0.19 spills/year along the entire Keystone Pipeline (**Appendix A**) and estimated stream widths. Widths of higher flow streams are greater than widths of lower flow streams, with more distance where an incident might occur. This results in a greater predicted frequency for high flow streams and a corresponding lower occurrence interval.

Table 4-11 Estimated Crude Oil Concentrations Compared to the Chronic Toxicity Threshold for Aquatic Life for Streams Crossed by the Proposed Action

Throughput – 435,000 bpd	Stream Flow Rate (cfs)	Chronic Toxicity Threshold (ppm)	Product Released					
			Small spill: 50 barrels		Moderate spill: 1,000 barrels		Large spill: 10,000 barrels	
			Concentration (ppm)	Occurrence Interval (years)	Concentration (ppm)	Occurrence Interval (years)	Concentration (ppm)	Occurrence Interval (years)
Low Flow Stream	10	1.4	0.07	457,042	1.3	63,562	13	342,782
Lower Moderate Flow Stream	100	1.4	0.007	319,930	0.1	44,494	1.3	239,947
Upper Moderate Flow Stream	1,000	1.4	0.001	239,947	0.01	33,370	0.1	179,690
High Flow Stream	10,000	1.4	0.0001	137,113	0.001	19,069	0.01	102,835

-Predicted rates apply for each stream crossing.

-Estimated proportion of benzene in the crude oil is 0.15 percent, and is assumed to be entirely water solubilized in the event of a spill. The resulting concentration was calculated by multiplying 0.15 percent of the total amount of crude oil released divided by 7 days of stream flow volume. The model assumes uniform mixing conditions.

-The chronic toxicity value for benzene is based on a 7-day toxicity value of 1.4 ppm for trout.

-Exposure concentrations were estimated over a 7-day period since the chronic toxicity value was based on a 7-day exposure.

-Shading indicates concentrations that could potentially cause chronic toxicity to aquatic species. The darkest shading represents high probability of chronic toxicity (>10 times the toxicity threshold); lighter shading represents moderate probability of chronic toxicity (1 to 10 times the toxicity threshold); and unshaded areas represent low probability of chronic toxicity (<toxicity threshold).

-Occurrence intervals are based on a predicted incident frequency of 0.14 spills/year along the entire Keystone Pipeline (Appendix A) and estimated stream widths. Widths of higher flow streams are greater than widths of lower flow streams, with more distance where an incident might occur This results in a greater predicted frequency for high flow streams and a corresponding lower occurrence interval.

Table 4-12 Estimated Crude Oil Concentrations Compared to the Chronic Toxicity Threshold for Aquatic Life for Streams Crossed by the Proposed Action

Throughput – 591,000 bpd	Stream Flow Rate (cfs)	Chronic Toxicity Threshold (ppm)	Product Released					
			Small spill: 50 barrels		Moderate spill: 1,000 barrels		Large spill: 10,000 barrels	
			Concentration (ppm)	Occurrence Interval (years)	Concentration (ppm)	Occurrence Interval (years)	Concentration (ppm)	Occurrence Interval (years)
Low Flow Stream	10	1.4	0.07	281,692	1.3	52,783	13	217,030
Lower Moderate Flow Stream	100	1.4	0.007	197,149	0.1	36,948	1.3	151,921
Upper Moderate Flow Stream	1,000	1.4	0.001	147,862	0.01	27,711	0.1	113,941
High Flow Stream	10,000	1.4	0.0001	84,493	0.001	15,835	0.01	65,109

-Predicted rates apply for each stream crossing.

-Estimated proportion of benzene in the crude oil is 0.15 percent, and is assumed to be entirely water solubilized in the event of a spill. The resulting concentration was calculated by multiplying 0.15 percent of the total amount of crude oil released divided by 7 days of stream flow volume. The model assumes uniform mixing conditions.

-The chronic toxicity value for benzene is based on a 7-day toxicity value of 1.4 ppm for trout.

-Exposure concentrations were estimated over a 7-day period since the chronic toxicity value was based on a 7-day exposure.

-Shading indicates concentrations that could potentially cause chronic toxicity to aquatic species. The darkest shading represents high probability of chronic toxicity (>10 times the toxicity threshold); lighter shading represents moderate probability of chronic toxicity (1 to 10 times the toxicity threshold); and unshaded areas represent low probability of chronic toxicity (<toxicity threshold).

-Occurrence intervals are based on a predicted incident frequency of 0.19 spills/year along the entire Keystone Pipeline (**Appendix A**) and estimated stream widths. Widths of higher flow streams are greater than widths of lower flow streams, with more distance where an incident might occur. This results in a greater predicted frequency for high flow streams and a corresponding lower occurrence interval.

Table 4-13 Mileage Summary of USDOT-Defined HCAs Identified Along the Keystone Pipeline Project

	Miles of Pipeline				Number of Spills in 10 years *(occurrence interval)*			
	Highly Populated Areas	Drinking Water	Ecologically Sensitive Area	Total in HCAs[1]	Highly Populated Areas	Drinking Water	Ecologically Sensitive Area	Total HCAs
North Dakota	0.0	7.0	2.0	9.0	NA	0.007 (1,300 yrs)	0.002 (4,700 yrs)	0.01
South Dakota	0.0	7.8	22.5	26.9	NA	0.008 (1,200 yrs)	0.024 (420 yrs)	0.03
Nebraska	0.0	7.9	9.3	12.6	NA	0.008 (1,200 yrs)	0.009 (1,000 yrs)	0.01
Kansas	0.0	8.4	18.3	26. 7	NA	0.008 (1,100 yrs)	0.019 (510 yrs)	0.03
Missouri	0.1	16.7	59.0	69.6	NA	0.018 (560 yrs)	0.063 (160 yrs)	0.07
Illinois	3.9	16.8	7.3	25.2	0.004 (2,500 yrs)	0.018 (560 yrs)	0.007 (1,300 yrs)	0.03
Keystone Mainline subtotal	*4.0*	*64.6*	*118.4*	*169.9*	*0.004 (2,500 yrs)*	*0.069 (145 yrs)*	*0.13 (79 yrs)*	*0.18*
Nebraska	0.0	0.0	0.0	0.0	NA	0.0	0.0	0.00
Kansas	0.0	45.3	47.7	59.7	NA	0.048 (210 yrs)	0.051 (200 yrs)	0.06
Oklahoma	0.0	18.3	7.7	11.4	NA	0.019 (510 yrs)	0.008 (1,200 yrs)	0.01
Cushing Extension Subtotal	*0.0*	*63.6*	*55.4*	*71.1*	*NA*	*0.068 (150 yrs)*	*0.060 (170 yrs)*	*0.07*
Project Total	**4.0**	**128.2**	**173.8**	**0.0**	**0.004 (2,500 yrs)**	**0.14 (73 yrs)**	**0.19 (54 yrs)**	**0.00**

[1] Numbers do not add up because some miles overlap in the different types of HCAs.

Note: NA indicates no highly populated area within the segment.

Table 4-14 Release and Spill Volume Occurrence Interval Associated with the Keystone Pipeline Project

	Miles of Pipe[1]	Number of Spills in 10 years (occurrence interval)				
		Total Number	<50 barrels (bbls)	50 to 1,000 bbls	1,000 to >10,000 bbls	>10,000 bbls
KEYSTONE MAINLINE						
Populated Areas	3.9	0.004 (2,500 years)	0.0004 (23,000 years)	0.002 (4,000 years)	0.0007 (14,000 years)	0.0006 (18,000 years)
Drinking Water Areas	64.6	0.069 (140 years)	0.007 (1,300 years)	0.04 (250 years)	0.01 (820 years)	0.01 (1,000 years)
Ecologically Sensitive Areas	118.4	0.13 (77 years)	0.014 (710 years)	0.075 (130 years)	0.023 (430 years)	0.018 (560 years)
CUSHING EXTENSION						
Populated Areas[2]	0.0	0.0	0.0	0.0	0.0	0.0
Drinking Water Areas	63.6	0.068 (150 years)	0.007 (1,400 years)	0.039 (260 years)	0.012 (830 years)	0.010 (1,000 years)
Ecologically Sensitive Areas	55.4	0.060 (170 years)	0.006 (1,700 years)	0.035 (290 years)	0.011 (910 years)	0.008 (1,250 years)

[1]The amount of pipe located within HCAs was quantified by geographical information system (GIS) and was based on the intersection of a 1,000-foot-wide corridor (centered on the pipeline route) and USDOT-defined HCAs.

4.3.2 Drinking Water

Surface water USAs identified for their potential as a drinking water resource have a 5-mile buffer placed around their intake location. The groundwater USAs have buffers that vary in size. These buffers are designated by the state's source water protection program or their wellhead protection program and the buffer sizes vary from state to state.

Isolated segments of the Keystone Pipeline Project cross areas that are considered HCAs by the USDOT due to potential risks to sensitive drinking water resources (**Table 4-13**). These areas are scattered throughout both the Keystone Mainline and Cushing Extension Pipeline routes. Keystone will conduct a more thorough evaluation to identify HCAs associated with sensitive drinking water resources. HCA will be subject to higher levels of inspection, as per 49 CFR Part 195. Keystone will evaluate the location of valves as a measure to reduce potential risk to highly sensitive drinking water resources.

4.3.3 Ecologically Sensitive Areas

Portions of the Keystone Pipeline Project cross areas that are considered HCAs by the USDOT due to potential risks to ecologically sensitive resources (**Table 4-13**). These areas are generally associated with major river systems (e.g., Missouri, Platte, and Mississippi Rivers) and the Flint Hills in central Kansas. As with other HCAs, these locations will be subject to higher levels of inspection, as per 49 CFR Part 195, in order to reduce the probability of pipeline incident.

4.3.4 Distribution of Risk Among HCAs

In this initial assessment, it has been presumed that risk is distributed evenly across the pipeline route. However, risk of a spill tends to concentrate in some areas more than others due to differences in hydraulic gradients, numbers of roads, and other factors (**Appendix A**). Spill frequency and volume was calculated for 1,314 individual segments and two throughput cases.

When the throughput is 435,000 bpd, 25 percent of the overall spill risk predicted for the pipeline is contained within 82 segments (representing 13 percent of the pipeline system length). Within these 82 segments, there are 0.1 mile located within highly populated areas, 0.0 mile within ecologically sensitive areas, and 11.6 miles located within drinking water HCAs.

Similarly, the top 59 segments (representing 9 percent of the pipeline system length) account for 25 percent of the overall spill risk predicted for the pipeline when the throughput is 591,000 bpd. Within these 59 segments, there are 0.0 miles located within highly populated areas, 0.0 mile within ecologically sensitive areas, and 4.3 miles located within drinking water HCAs.

To protect these sensitive resources, HCAs would be subject to a higher level of inspection per USDOT regulations. Federal regulations require periodic assessment of the pipe condition and correction of identified anomalies within HCAs. In compliance with federal regulations, Keystone will develop management and analysis processes that integrate available integrity-related data and information and assess the risks associated with segments that can affect HCAs. Furthermore, Keystone will implement additional risk control measures if needed to protect HCAs. Examples of these additional measures may include: enhanced damage prevention programs, reduced inspection intervals, corrosion control program improvements, leak detection system enhancements, installation of EFRDs, and emergency preparedness improvements.

5.0 Keystone's Pipeline Safety Program

Pipelines are one of the safest forms of crude oil transportation. The Keystone Pipeline system will be designed, constructed and maintained in a manner that meets or exceeds industry standards. All pipelines will be built within an approved ROW and highly visible signs will be installed at all road, railway, and water crossings indicating that a pipeline is located in the area to prevent damage or impact to the pipeline. Keystone will manage a crossing and encroachment approval system for all other operators. Keystone will ensure safety near its facilities through a combination of programs encompassing engineering design, construction, and operations; public awareness and incident prevention programs; and emergency response programs.

Historically, the most significant risk associated with operating a crude oil pipeline is the potential for third-party excavation damage. Keystone will mitigate this risk by implementing a comprehensive Integrated Public Awareness program focused on education and awareness. The cornerstone of the program encourages use of the state One-Call system before people begin excavating. Keystone's operating staff also will complete regular visual inspections of the ROW and monitor activity in the area.

Keystone will have a preventative maintenance, inspection and repair program that ensures the integrity of all its pipeline. Keystone's annual Pipeline Maintenance Program will be designed to maintain the safe operation of the pipeline system. The system will include routine visual inspections of the ROW, regular inline inspections, and collection of predictive data, underpinned by a company wide goal to ensure facilities are reliable and in service. Data collected in each year of the program will fed back into the decision making process for the development of the following year's program, which aids in facilitating a safe pipeline system. The pipeline system will be monitored 24 hours a day, 365 days a year.

In compliance with applicable regulations governing the operation of pipelines, periodic in-line inspections will be conducted to collect information on the status of pipe for the entire length of the system. In-line inspection represents the state-of-the-art methodology to detect internal and external corrosion, a major cause of pipeline spills. From this type of inspection, suspected areas of corrosion or other types of damage (e.g., scratch in the pipe from third-party excavation damage) can be identified and proactively repaired. Additional types of information collected along the pipeline will include cathodic protection readings, geotechnical investigations, aerial patrol reports and routine investigative digs. In addition, line patrol, leak detection systems, supervisory control and data acquisition (SCADA), fusion bond epoxy coating and construction techniques with associated quality control will be implemented.

Keystone will carry out routine visual inspections and other operating activities with an awareness of pipeline and facility safety, and the prevention of unauthorized trespass or access.

Keystone will have an Emergency Response Program in place to manage a variety of events. Human health and the environment are of the utmost importance to the Keystone in these types of situations. Risk assessment is an iterative process. As additional engineering and design information and refinements become available, Keystone will update its risk assessment and submit the updated assessment in an expected November 2006 filling with the Department of State.

In summary, the analysis shows that the frequency of incidents is low and the environmental consequences would likely be nominal. In addition, compliance with regulations, use of state-of-the-art inspection methodology and adherence to safety procedures will help to ensure environmentally sound and safe operation of the pipeline.

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7.0 Glossary

Accidental Release

An accidental release is an unplanned occurrence that results in a release of oil or natural gas from the pipeline.

Acute exposure

Exposure to a chemical or situation for a short period of time.

Acute toxicity

The ability of a substance to cause severe biological harm or death soon after a single exposure or dose.

Adverse effect

Any effect that causes harm to the normal functioning of plants or animals due to exposure to a substance (i.e., a chemical contaminant).

Algae

Chiefly aquatic, eucaryotic one-celled or multicellular plants without true stems, roots and leaves that are typically autotrophic, photosynthetic, and contain chlorophyll. They are food for fish and small aquatic animals.

Aquifer

An underground layer of water-bearing permeable rock, or unconsolidated materials (gravel, sand, silt or clay) from which groundwater can be usefully extracted using a water well.

Barrel

A barrel is a standard measure of a volume of oil and is equal to 42 gallons.

Benthic Invertebrates

Those animals without backbones that live on or in the sediments of a lake, pond, river, etc.

Bioavailability

How easily a plant or animal can take up a particular contaminant from the environment.

Biodegradation

Biodegradation is the breakdown of organic contaminants by microbial organisms into smaller compounds. The microbial organisms transform the contaminants through metabolic or enzymatic processes. Biodegradation processes vary greatly, but frequently the final product of the degradation is carbon dioxide or methane.

Blue Barrel (bbl)

In the late 1800's Standard Oil began manufacturing 42 gallon barrels painted blue for the express purpose of transporting petroleum. This blue barrel became the standard in industry. Hence, the abbreviation bbl for 1 barrel of oil.

BPD

Abbreviation for barrels per day

Cathodic Protection System

A technique to provide corrosion protection to a metal surface by making the surface of the metal object the cathode of an electrochemical cell. In the pipeline industry that is done using impressed current. Impressed current Cathodic Protection (ICCP) systems use an anode connected to a DC power source (a cathodic protection rectifier).

Chronic toxicity

The capacity of a substance to cause long-term poisonous health effects in humans, animals, fish, and other organisms. Biological tests that use sublethal effects such as abnormal development, growth, and reproduction, rather than solely lethality, as endpoints.

Contaminant

Any physical, chemical, biological, or radiological substance found in air, water, soil or biological matter that has a harmful effect on plants or animals; harmful or hazardous matter introduced into the environment.

Ecosystem

The sum of all the living plants and animals, their interactions, and the physical components in a particular area.

Emergency Flow Restricting Device (EFRD)

An emergency flow-restricting device is a device used to restrict or limit the amount of oil or gas that can release out of a leak or break in a pipeline. Check valves and remote control valves are types of EFRDs.

Exposure

How a biological system (i.e., ecosystem), plant, or animal comes in contact with a chemical.

Event

An event is a significant occurrence or happening. As applicable to pipeline safety, an event could be an accident, abnormal condition, incident, equipment failure, human failure, or release.

Facility

Any structure, underground or above used to transmit a product.

Failure Frequency

Failure frequency is the rate at which failures are observed or are predicted to occur, expressed as events per given timeframe.

Failure Probability

Failure probability is the probability that a structure, device, equipment, system, etc. will fail on demand or will fail in a given time interval, expressed as a value from 0 to 1.

Failure Rate

Failure rate is the rate at which failures occur. It is the number of failure events that occur divided by the total elapsed operating time during which those events occur or by the total number of demands, as applicable.

Geographical Information System (GIS)

A computer data system for creating and managing spatial data and associated attributes.

Habitat

The place where a population of plants or animals and its surroundings are located, including both living and non-living components.

High Consequence Area (HCA)

A high consequence area is a location that is specially defined in pipeline safety regulations as an area where pipeline releases could have greater consequences to health and safety or the environment. For oil pipelines, HCAs include high population areas, other population areas, commercially navigable waterways and areas unusually sensitive to environmental damage. Regulations require a pipeline operator to take specific steps to ensure the integrity of a pipeline for which a release could affect an HCA and, thereby, the protection of the HCA.

High Population Area (HPA)

A high population area is an urbanized area, as defined and delineated by the U.S. Census Bureau, which contains 50,000 or more people and has a population density of at least 1,000 people per square mile. High population areas are considered HCAs.

Incident

As used in pipeline safety regulations, an incident is an event occurring on a pipeline for which the operator must make a report to the Office of Pipeline Safety. There are specific reporting criteria that define an incident that include the volume of the material released, monetary property damage, injuries, and fatalities (Reference 49 CFR 191.3, 49CFR 195.50).

Integrity Management Program

An integrity management program is a documented set of policies, processes, and procedures that are implemented to ensure the integrity of a pipeline. An oil pipeline operator's Integrity Management Program must comply with the federal regulations (i.e., the Integrity Management Rule, 49 CFR 195).

Integrity Management Rule

The Integrity Management Rule specifies regulations to assess, evaluate, repair, and validate the integrity of gas transmission lines that, in the event of a leak or failure, could affect HCAs.

Invertebrates

Animals without backbones: e.g., insects, spiders, crayfish, worms, snails, mussels, clams, etc.

LC_{50}

A concentration expected to be lethal to 50 percent of a group of test organisms.

Leak

A leak is a small opening, crack, or hole in a pipeline allowing a release of oil or gas.

Likelihood

Likelihood refers to the probability that something possible may occur. The likelihood may be expressed as a frequency (e.g., events per year), a probability of occurrence during a time interval (e.g., annual probability), or a conditional probability (e.g., probability of occurrence, given that a precursor event has occurred).

Maximum Contaminant Level (MCL)

The maximum level of a contaminant allowed in drinking water by federal or state law. Based on health effects and currently available treatment methods.

National Pipeline Mapping System (NPMS)

The National Pipeline Mapping System is a GIS database that contains the locations and selected attributes of natural gas transmission lines, hazardous liquid trunklines, and liquefied natural gas (LNG) facilities operating in onshore and offshore territories of the United States.

One-Call System

A one-call system is a system that allows excavators (individuals, professional contractors, and governmental organizations) to make one telephone call to underground facility operators to provide notification of their intent to dig. The facility operators or, in some cases, the one-call center can then locate the facilities before the excavation begins so that extra care can be taken to avoid damaging the facilities. All 50 states within the U.S. are covered by one-call systems. Most states have laws requiring the use of the one-call system at least 48 hours before beginning an excavation.

Operator

An operator is a person who engages in the transportation of gas (Reference 49 CFR 192.3) or a person who owns or operates pipeline facilities (Reference 49 CFR 195.2).

Polycyclic Aromatic Hydrocarbons (PAHs)

Group of organic chemicals.

Pipeline

Used broadly, pipeline includes all parts of those physical facilities through which gas, hazardous liquid, or carbon dioxide moves in transportation. Pipeline includes but is not limited to: line pipe, valves and other appurtenances attached to the pipe, pumping/compressor units and associated fabricated units, metering, regulating, and delivery stations, and holders and fabricated assemblies located therein, and breakout tanks.

Playa Lake

A rain-filled small, round depression in the surface of the ground.

Prairie Pothole

Water-holding depressions of glacial origin in the prairies of northern United States and southern Canada. Water is supplied by rainfall, basin runoff and seepage inflow of groundwater.

Receptor

The species, population, community, habitat, etc. that may be exposed to contaminants.

Risk

Risk is a measure of both the likelihood that an adverse event could occur and the magnitude of the expected consequences should it occur.

Sediment

The material of the bottom of a body of water (i.e., pond, river, stream, etc.).

Stressor

Any factor that may harm plants or animals; includes chemical (e.g. metals or organic compounds), physical (e.g. extreme temperatures, fire, storms, flooding, and construction/development) and biological (e.g. disease, parasites, depredation, and competition).

Supervisory Control and Data Acquisition System (SCADA)

A SCADA is a pipeline control system designed to gather information such as pipeline pressures and flow rates from remote locations and regularly transmit this information to a central control facility where the data can be monitored and analyzed.

Throughput

Amount of oil through a pipeline during a specified time.

Toxicity Testing

A type of test that studies the harmful effects of chemicals on particular plants or animals.

Toxicity Threshold

Numerical values that represent concentrations of contaminants in abiotic media (sediments, water, soil) or tissues of plants and animals above which those contaminants are expected to cause harm.

Unusually Sensitive Areas (USAs)

A USA is a drinking water or ecological resource area that is unusually sensitive to environmental damage from a hazardous liquid pipeline release, as defined in 49CFR 195.6.

Zooplankton

Small, usually microscopic animals (such as protozoans) found in lakes and reservoirs.

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TransCanada
In business to deliver

TransCanada Keystone, LP

Keystone Pipeline

Emergency Response Plan

(Oil Spill Response Plan)

24 Hour Emergency No.
1(XXX) XXX-XXXX

Manual No: ____________

Assigned to: ____________

OIL SPILL RESPONSE PLAN DESCRIPTION

The Oil Spill Response Plan as prescribed under 49CFR§194 is divided into the following two parts, which function as an integrated document:

Core Plan (Sections 1 through 8)

The Core Plan (Sections 1 through 8) contains general information outlining Company oil spill response procedures.

Response Zone Appendices (Sections 9 through 11)

The response zone appendices contain the individual Oil Spill Response Plans for each zone which are to be followed in the event of an oil spill.

Prior to completing the Response Zone Appendices, Keystone will also review the National Contingency Plan (NCP) and each applicable Regional Integrated Contingency Plan (RICP), to ensure the Keystone Oil Spill Response Plan is consistent with the applicable Environmental Protection Agency RICP and the NCP.

OIL SPILL RESPONSE PLAN

Revision Record

The purpose of this Revision Record is to document receipt and insertion of all revisions to the Oil Spill Response Plan, as well as to provide a record that the manual contains the most current information.

After you receive each revision and have updated your manual, please date and sign in the space provided, corresponding to the appropriate revision number.

Section	Revision Number/Effective Date	Date Inserted	Signature

LIST OF ACRONYMS

API	American Petroleum Institute
CE	Cushing Extension
EOC	Emergency Operations Center
EMS	Emergency Management System
EPA	Environmental Protection Agency
ESM	Emergency Site Manager
FOSC	Federal On Scene Coordinator
GPS	Global Positioning System
HAZWOPER	Hazardous Waste Operations and Emergency Response Standard
ICS	Incident Command System
MP	Mile Post
NCP	National Contingency Plan
NFPA	National Fire Protection Association
OCC	Operations Control Center
OSRO	Oil Spill Response Organization
PHMSA	Pipeline and Hazardous Material Safety Administration
PREP	National Preparedness for Response Exercise Program
QI	Qualified Individual
RICP	Regional Integrated Contingency Plan
SCADA	Supervisory Control and Data Acquisition

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1.0 CORE PLAN INFORMATION SUMMARY

The TransCanada Keystone, LP (hereafter referred to as Keystone) Core Plan (Sections 1 through 8) provides the base information utilized to develop the specific Oil Spill Response Plans. These Oil Spill Response Plans are to be followed in the event of a spill and are found in each Response Zone Appendix.

1.1 Operator Information

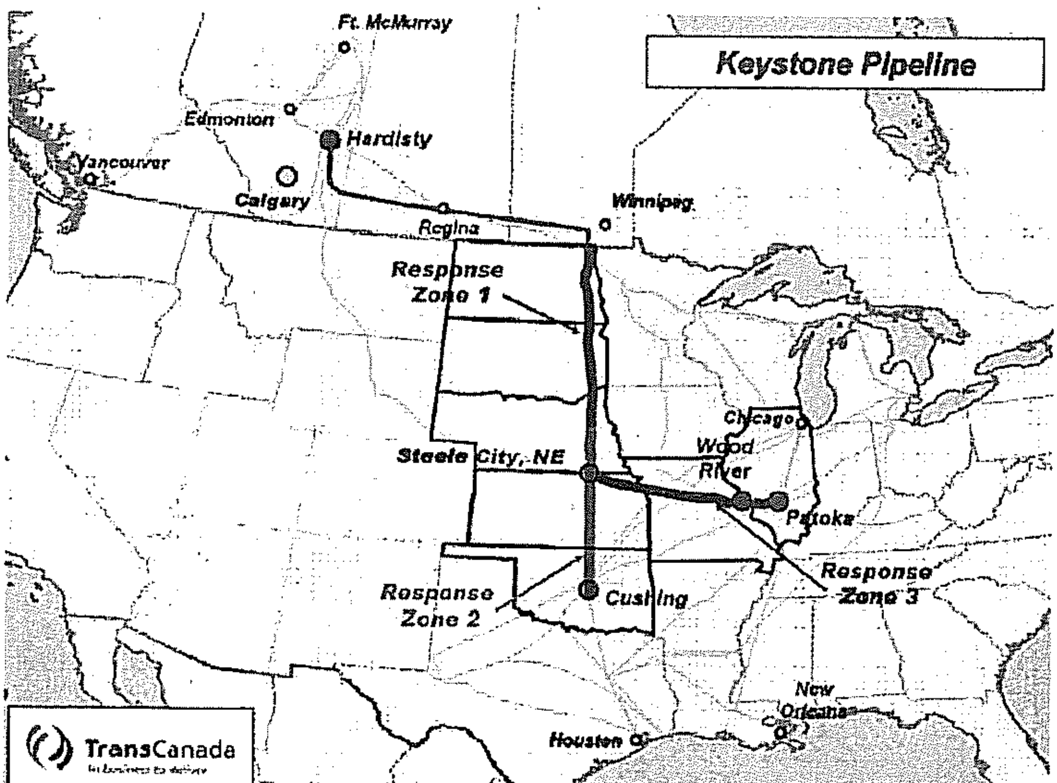
TransCanada Keystone, LP
450 – 1st Street S.W.
Calgary, Alberta, Canada T2P 5H1

1.1.1 Pipeline System Description

This document provides a preliminary Oil Spill Response Plan and outlines Keystone's processes and procedures established to comply with 49CFR§194. This plan will be updated upon completion of the detailed design of this project.

This Oil Spill Response Plan is intended to cover the U.S. segment of the pipeline system operated by Keystone. Three preliminary Response Zones have been established considering mileage and distribution of high consequence areas. Figure 1 provides a pipeline system map and illustrates the specific Response Zones.

Figure 1: Keystone Pipeline System and Oil Spill Response Zones.



The U.S. portion of the Keystone Pipeline consists of approximately 1,309 miles of 30-inch-diameter pipeline and 55 miles of 24-inch-diameter pipeline (located from Wood River to Patoka, Illinois). Crude oil receipts will initiate from an oil supply hub near Hardisty, Alberta, Canada for movement to delivery sites in Cushing, Oklahoma, as well as Wood River and Patoka, Illinois. For the purposes of developing this Oil Spill Response Plan and associated worst case discharge calculations, the maximum design capacity of 657,000 bpd will be utilized.

Primarily, crude oil transported by Keystone Pipeline will be derived from the Alberta oil sands region. The oil extracted from the sands is called bitumen. The bitumen is upgraded either through additional processing or by combining the bitumen with diluents. The upgraded product is then classified as synthetic crude oil. While the precise composition of synthetic crude will vary by shipper, and is considered proprietary information, Keystone expects to transport crude oils in the range of 12 to 45° API (American Petroleum Institute).

The Keystone Pipeline is controlled from the Operations Control Center (OCC), located in Calgary, Alberta, Canada. The OCC is staffed 24 hours per day 7 days a week, and utilizes a computer based Supervisory Control and Data Acquisition (SCADA) System to continuously monitor and control pipeline operations.

Keystone's 24 hour emergency contact phone number is 1 (XXX) XXX-XXXX and is posted on all pipeline marker posts and facility signs.

1.2 MSDS Information

This section will provide MSDS information on the slate of crude oils transported by Keystone.

1.3 Response Zone Summaries

For this preliminary Oil Spill Response Plan, the pipeline system has been segmented into 3 Response Zones. The specific Oil Spill Response Plans and information for each Response Zone is provided in the Appendices.

Changes to both the number and location of Response Zones are anticipated as the design is further developed and refined. For the purposes of this document Response Zones are defined as follows:

1.3.1 Response Zone One – North Dakota, South Dakota, Nebraska (part)

Milepost (MP) = 0 at U.S./Canadian Border to MP = 535

North Dakota (MP 0 to ≈ MP 215)

Counties:

Pembina, Cavalier, Walsh, Nelson, Steele, Barnes, Ransom, and Sargent

South Dakota (MP 215 to ≈ MP 431)

Counties:

Marshall, Day, Clark, Beadle, Kingsbury, Miner, Hanson, McCook, Hutchinson, and Yankton

Nebraska (MP 431 to ≈ MP 535)

Counties:

Cedar, Wayne, Stanton, Platte, Colfax

Table 1: Preliminary High Consequence Areas – Zone One

Each entry in the table below represents a unique location.

	Miles (Approximate)		
State	**Population**	**Drinking Water**	**Sensitive Areas**
North Dakota	0	6.96	2.03
South Dakota	0	1.96 5.87	9.36 5.95 7.15
Nebraska	0	5.38	6.19 0.99
TOTAL	**0**	**20.17**	**31.67**

1.3.2 Response Zone Two – Nebraska (part), Kansas, Oklahoma

Milepost (MP) = MP 535 to MP 634 and Cushing Extension (CE), CE MP 0 to CE MP 291

Nebraska (MP 535 to ≈ MP 634, CE MP 0 to ≈ CE MP 4)
Counties:
Butler, Seward, Saline and Jefferson

Kansas (CE MP 4 to ≈ CE MP 212)

Counties:

Washington, Clay, Dickinson, Marion, Butler, and Cowley

Oklahoma (CE MP 212 to ≈ CE MP 291)

Counties:

Kay, Noble, and Payne

Table 2: Preliminary High Consequence Areas – Zone Two

Each entry in the table below represents a unique location.

	Miles (Approximate)		
State	**Population**	**Drinking Water**	**Sensitive Areas**
Nebraska	0	0.70	2.13
Kansas	0	4.14 7.89 9.73 15.52 8.06	23.16 9.12 15.41
Oklahoma	0	9.11 9.17	7.71
TOTAL	**0**	**64.32**	**57.53**

1.3.3 Response Zone Three – Nebraska (part), Kansas, Missouri, Illinois

Milepost (MP) = MP 634 to MP 1073

Nebraska (MP 634 to ≈ MP 649)
Counties:
Jefferson, Gage

Kansas (MP 649 to ≈ MP 743)
Counties:

Marshall, Nemaha, Brown, and Doniphan

Missouri (MP 743 to ≈ MP 1016)

Counties:

Buchanan, Clinton, Caldwell, Carroll, Chariton, Randolph, Audrain, Montgomery, Lincoln, and St. Charles

Illinois (MP 1016 to ≈ MP 1073)

Counties:

Madison, Bond, Fayette, and Marion

Table 3: Preliminary High Consequence Areas – Zone Three

Each entry in the table below represents a unique location.

	Miles (Approximate)		
State	**Population**	**Drinking Water**	**Sensitive Areas**
Nebraska	0	1.86	0
Kansas	0	3.49	12.59
		4.91	5.68
Missouri	0	4.82 12.01	5.76 12.08 9.31 7.38 24.48
Illinois	0.64 3.24	1.08 6.79 3.10 5.67	5.22 2.09
TOTAL	**3.88**	**43.73**	**84.59**

1.4 Certification

Pending completion of the final engineering design, Keystone will certify that it has obtained, through contract or other means, the necessary personnel and equipment to respond to the maximum extent practical, to the worst case discharge, or to the substantial threat of such a discharge.

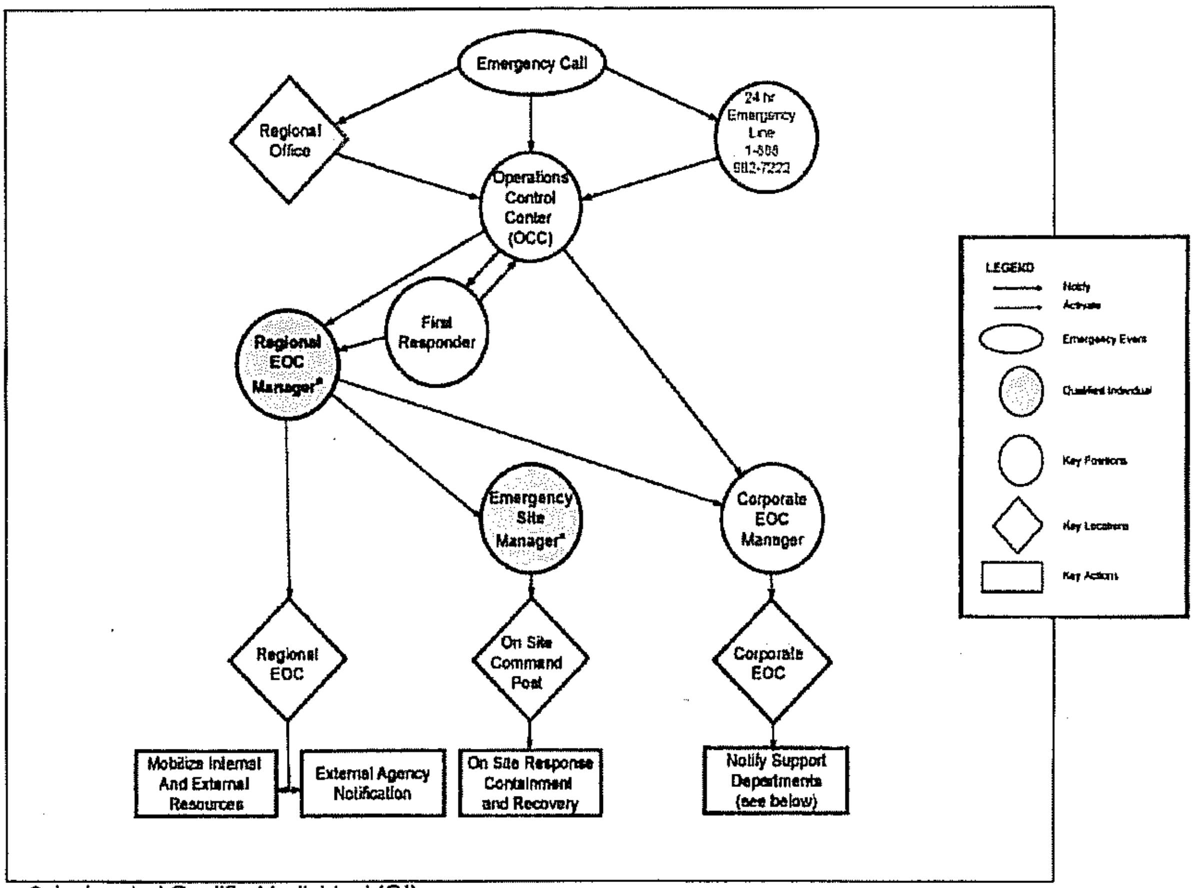
2.0 NOTIFICATION PROCEDURES

2.1 Notification Requirements

Figure 2 outlines the notification process for reporting and evaluating a potential oil spill, as well as activation of the Oil Spill Response Plan.

The Regional EOC Manager (Qualified Individual) is the key individual responsible for evaluating and activating the Oil Spill Response Plan.

Figure 2: Basic Oil Spill Response Initial Notification Process



* designated Qualified Individual (QI)
EOC = Emergency Operation Center
Corporate EOC Support Departments (from above) include but are not limited to:

- Asset Protection
- Communications
- Land, Community and Aboriginal Relations
- Health Safety and Environment
- Legal
- Regulatory Compliance
- Corporate Security
- Customer Services
- Operations Control Center
- Asset Reliability
- Insurance and Risk Management
- Facility Services and Real Estate
- Information Systems
- Human Resources
- Administration Support

2.2 Prioritized Notification Checklist for Key Individuals

2.2.1 First Responder

- ☐ Notification of potential spill and dispatch received from OCC
- ☐ SPILL VERIFIED
- ☐ Notification of Emergency Services, if required

  Verify with OCC:
  - ☐ Pipeline shutdown and status
  - ☐ Pipeline segment isolation
- ☐ Regional EOC Manager (QI) notified

2.2.2 Regional EOC Manager (QI)

- ☐ Notification received from OCC
- ☐ Notification of spill details received from First Responder
- ☐ OIL SPILL RESPONSE PLAN ACTIVATED
- ☐ Emergency Site Manager (QI) notified
- ☐ Regional EOC activated
- ☐ Mobilize response resources requested by Emergency Site Manager (QI)
- ☐ Corporate EOC Manager contacted
- ☐ Agency contacts initiated as per Section 2.3

2.2.3 Emergency Site Manager (QI)

- ☐ Notification received from Regional EOC Manager (QI)
- ☐ On site First Responder contacted to obtain briefing on spill
- ☐ On Site Command Post activated
- ☐ Regional EOC advised of resource requirements
- ☐ First Responder relieved

2.3 Notification Contacts

The contact list is currently incomplete but identifies the key contact positions required for activation of the Oil Spill Response Plan. Specific data fields will be completed when Keystone's personnel organization structure is finalized and State and Local requirements and contacts have been determined.

2.3.1 Keystone

Table 4: Keystone Notification

Position Making Call	Keystone Contacts	Primary Telephone No.	Secondary Telephone No.
OCC	**First Responder**		
	Regional EOC Manager (QI)		
	- Primary		
	- Alternate		
	Corporate EOC		
Regional EOC Manager (QI)	**Emergency Site Manager (QI)**		
	- Primary		
	- Alternate		
	Corporate EOC Manager		

2.3.2 Agency

Table 5: Agency Notification

Position Making Call	Agency Contact List	Telephone	Other Telephone/Fax
Regional EOC Manager (QI)	**Federal**		
	National Response Center	1-800-424-8802	
	State		
	Local		

2.3.3 Emergency Services

Table 6: Emergency Services Notification

Position Making Call	Emergency Contact List	Telephone	Other Telephone/Fax
Emergency Site Manager (QI)	Emergency Services		
	Fire/Ambulance		
	Police/Sheriff		
	Hospital		

2.4 Procedures for Notifying Qualified Individuals

In the event of a suspected leak, the OCC activates the communications process and contacts the Regional EOC Manager (QI), as illustrated in Figure 2: Basic Oil Spill Response Initial Notification Process, Page 6. Qualified Individuals are available on call 24/7 and on call list are maintained by the OCC. The Regional EOC Manager (QI) is responsible for activating the Oil Spill Response Plan and contacting the Emergency Site Manager (QI).

The Regional EOC Manager (QI) will be contacted primarily on a land line phone (home or office) or by cellular telephone backup. In the event that land and cellular communication are not functional, satellite phones are available. All on call Regional EOC Managers and Emergency Site Managers are equipped with cellular telephones.

2.5 Information Reported to Agencies

Communication Report (Call) Record

Regional EOC Manager (QI)

The following agency mandatory information, ***as identified in bold italic***, will be provided initially with subsequent notifications to complete the required mandatory criteria or advise of any changes.

Name of Pipeline:____

Time of Discharge:____

Location of Discharge (MP):____________________________________

(GPS):____________________________________

Type of Oil:____

Reason of Discharge:____________________________________

Estimated Volume of Oil Spill:__________________________________

Weather Condition on Scene: ________________________________

Action taken/ Planned by Person on Scene: __________________________

Injuries: ____

Extent of Injuries: ____________________________________

Evacuation: ____

Public Consequence: ____________________________________

3.0 SPILL DETECTION AND ON-SCENE SPILL MITIGATION PROCEDURES

3.1 Methods of Initial Discharge Detection

The following outlines the concepts and philosophies currently under consideration at this preliminary stage in the design of the Keystone Pipeline. Upon completion of the required design details, this section of the document will be revised and updated accordingly.

Keystone will utilize a comprehensive SCADA system to monitor and control the pipeline. Data provided by the SCADA system may alert the OCC operator to an abnormal operating condition which may signify a possible spill or leak. A back-up communication system will also be available should SCADA communications fail between field locations and the OCC.

In addition, Keystone will utilize a dedicated Leak Detection System to alert the OCC operator of a potential leak or spill.

The SCADA system will continuously monitor pipeline conditions and update information provided to the OCC operator. Data received via the SCADA system will also be directed to the dedicated Leak Detection System, capable of independently alarming to the OCC operator.

Standard operating and response procedures will be utilized by OCC operator in responding to abnormal pipeline conditions including leak alarms. The OCC operator will have the full and complete authority to execute a pipeline shutdown.

Notification of a possible initial pipeline release may be received by the OCC operator as follows:

1. Employee reported
2. Abnormal pipeline condition observed by OCC operator
3. Leak Detection System alarm
4. Third party reported

Upon receipt of notification as outlined above, the OCC operator will execute the following procedures:

1. Follow prescribed OCC operating and response procedures for specific directions on abnormal pipeline condition or alarm response
2. Dispatch First Responder
3. Shutdown pipeline within a predetermined time threshold if abnormal conditions or leak alarm can not be positively ruled out as a leak
4. Complete internal notifications as outlined in Figure 2: Basic Oil Spill Response Initial Notification Process, page 6.

3.2 On Scene Spill Mitigation and Recovery Procedures

This section of the document provides a listing of response strategies and techniques currently contemplated for use on the Keystone pipeline system. Those selected will be fully developed within the final Oil Spill Response Plan.

Keystone recognizes that certain River crossings along the pipeline route are considered high volume areas and will ensure the final Oil Spill Plan delivers the resources to respond to a potential release, in a more rapid fashion as required.

3.2.1 Spills on Water

- Small Creeks, Ponds and Bogs
- Large Rivers and Floodplains
- Large Lakes
- Beach Berming
- Beach Sumps
- Boom Techniques
- Calm Water Containment Booms
- Flowing Water Containment Booms
- Open Water Containment Booms
- Marine Diversion Booming
- Exclusion Booms
- Cascading Booms Calm
- Skimmers
- Rotating Discs
- Weir Devices
- Dam Techniques
- Blocking Dams
- Flowing Water Dams
- Sorbent Booms and Barriers
- Spills on Ice
- Spills under Ice

- Spill during Freeze-up or Break-up

3.2.2 Spills on Land

- Open Land and Forests
- Streets and Highways
- Earth Containment Berms
- Street Containment
- Culvert Blocking
- Storm Drain Blocking
- Interception Barriers
- Heavy Equipment
- Suction Devices
- Rotating Discs
- Spills on Sensitive Areas

3.2.3 Spills in Sensitive Areas

- Historical or Archaeological Sites
- Natural Areas
- National, State and Local Parks
- Protected Waterways
- Recreational Sites
- Water Supply Intakes
- Wetlands
- Wildlife Refuges

3.3 Equipment for Response Activities

See Section 5.4 for a listing of equipment for response activities.

3.4 Personnel for Response Activities

See Section 5.4 for a listing of personnel for response activities

3.5 Oil Transportation and Reclamation Facilities and Services

See Section 5.4 for a listing of oil transportation and reclamation facilities and services.

4.0 RESPONSE ACTIVITIES

4.1 Oil Spill Initial Response

All Keystone employees are authorized to communicate directly with the OCC should they observe conditions that may signify a possible spill (see Figure 2: Basic Oil Spill Response Initial Notification Process, page 6).

OCC operators have the full and complete authority to shutdown the pipeline and proceed with pipeline segment isolation in the area of the leak. The OCC can designate any qualified Keystone field employee as a First Responder in order to mitigate the early impacts of the spill. The First Responder is required to immediately respond and investigate the suspected location.

The First Responder serves as the Emergency Site Manager until relieved of this task by the assigned Emergency Site Manager (QI).

4.2 Oil Spill Response Organization, Responsibilities, Roles and Authority

The Organizational Chart for the Keystone Oil Spill Response Team is presented in Figure 3: Keystone Oil Spill Response Team Organization Chart, Page 15. The Emergency Site Manager (QI) in conjunction with the Regional EOC Manager (QI) is responsible for creating an oil spill response organization to effectively manage the incident. Role assignments for the Regional EOC and the Command Post represent the specific functional areas that the Emergency Site Manager (QI) and Regional EOC Manager (QI) determine are necessary to address a specific spill.

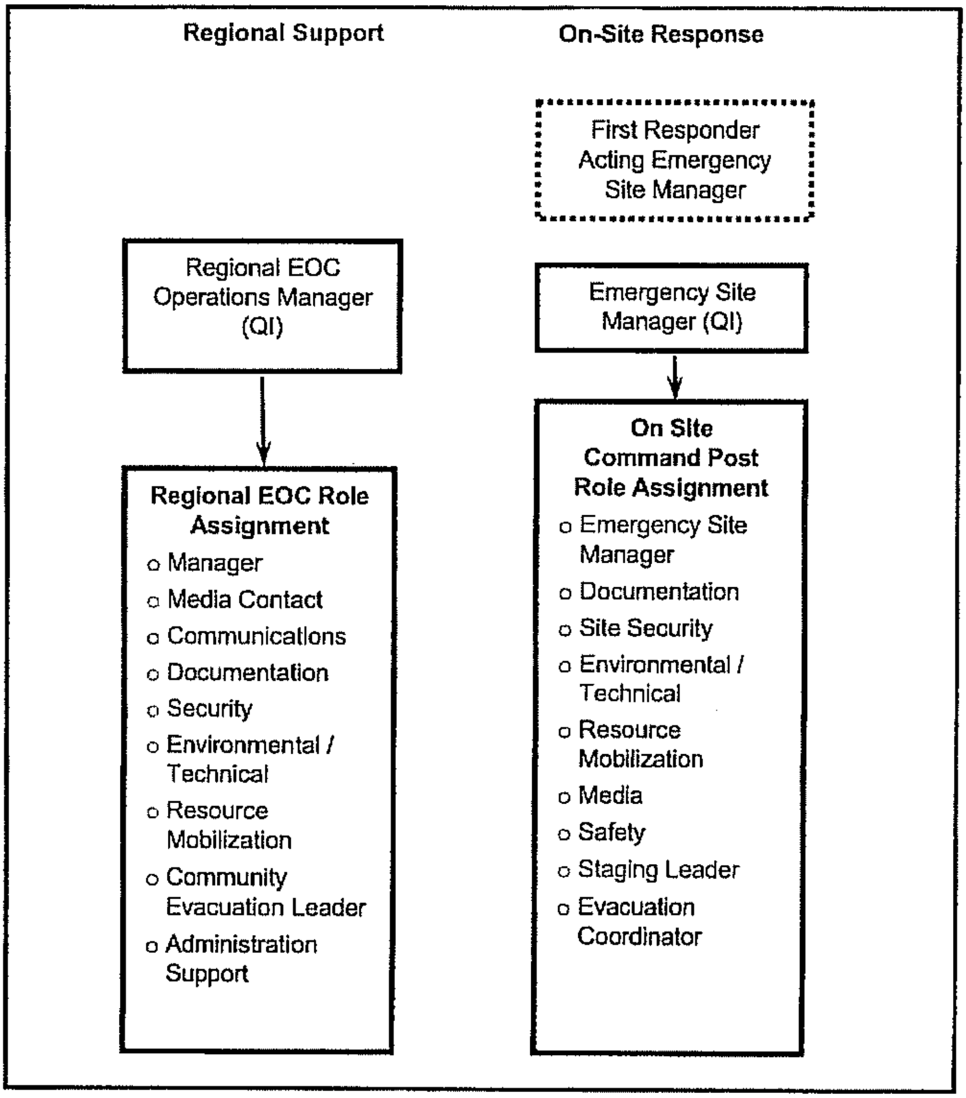
Procedures are established within Keystone outlining regular signing and financial authority limits. It is recognized that these standard authorities may not apply in an emergency due to the requirement to immediately contain and control the emergency situation.

Keystone has established the following policy related to Financial Authority in an emergency:

The Emergency Site Manager (QI) or Region EOC Manager (QI) has financial authority to obtain any and all resources necessary to contain and control the emergency situation.

Receipts, bills and invoices must be obtained for all supplies, services, equipment and contractors engaged as a result of the emergency, and submitted to the Emergency Site Manager (QI) or designated individual for cost management.

Figure 3: Keystone Oil Spill Response Team Organization Chart



4.2.1 First Responder

Responsibilities of the First Responder in priority include:

- Not putting yourself at risk
- Provide confirmation of emergency event and ensure pipeline isolation with the OCC
- Request emergency response personnel at the scene and advise the local authorities of a possible need for evacuation, as required
- Rescue if safe to do so
- Evacuate immediate area if necessary to preserve life and health
- Attempt to notify people at risk without entering the hazard area
- Secure the area and establish a perimeter at a safe distance

- Act as the Emergency Site Manager until relieved by the assigned Emergency Site Manager (QI)
- Work cooperatively with emergency response personnel and municipal authorities at the scene
- Instruct people not to touch or move anything
- Do Not disturb the scene except to preserve life or prevent injury

4.2.2 Regional EOC Manager (QI)

Following notification from the Operations Control Center of a possible oil spill, the Regional EOC Manager (QI) gathers information to assess the incident and is responsible for activation of the Oil Spill Response Plan.

The Regional EOC Manager (QI) determines the amount of resources required to address the emergency within the Regional EOC. Not all roles will be activated, or others may be added, in any given spill event. Furthermore, one person may take on several roles, and conversely one role may take several people.

The Regional EOC Manager (QI) contacts the Operations Control Center (OCC) to ensure that the Corporate EOC has been established. Specific responsibilities of the Regional EOC Manager (QI) in priority include, but are not limited to:

- Activate the Oil Spill Response Plan
- Establish and maintain contact with the Emergency Site Manager (ESM)
- Ensure all Regulatory notifications have been made
- Provide support as requested to the Command Post
- Document all actions using the Emergency Incident Log
- Establish contact with the Corporate EOC and communicate updates
- Remain advised of repair and restoration, accident and incident investigations, and other activities on site
- Assume financial authority to contain and control the emergency
- Ensure work order and other processes are established to track financial commitments

4.2.3 Regional EOC Roles

Regional EOC Communications

The Regional EOC Communications Role may make regulatory notifications if requested by the Regional EOC Manager (QI) and responds to requests for information. Notifications must be assigned a high priority. Specific responsibilities include but are not limited to:

- Document all actions using the Emergency Incident Log
- Have available all required contact lists for the specific incident in progress
- Assemble confirmed facts about the incident although it may not be possible to answer all the following questions:
  - Name of Pipeline:
  - Time of Discharge:
  - Location of Discharge:
  - Type of Oil:
  - Reason of Discharge:
  - Estimated Volume of Oil Spill:
  - Weather Condition on Scene:
  - Action taken/ Planned by Person On Scene:

- Injuries:
- Extent of Injuries:
- Evacuation:
- Public Consequences:

- Assemble Information on relevant products
- Local municipal authorities must be advised immediately of any Keystone emergency in their area if:

  - A landowner or community is being evacuated (notifications must also be made to the evacuating community and receiving community)
  - Local services such as power, water or gas supply is disrupted as a result of the emergency
  - Media attention is occurring or likely to occur
  - When there is a 3rd party injury or death
  - Members of the community called to report incident or incident is visible to the community

- Log any requests for information and follow-up

Regional EOC Security

The Regional EOC Security priorities at the EOC are to prevent unauthorized entry into the center, to facilitate any requests from the Command Post including requests to obtain contract security forces in a timely manner and to liaison with law enforcement agencies. Specific responsibilities include but are not limited to:

- Document all actions taken using the Emergency Incident Log
- Prevent unauthorized entry
- Ensure you identify yourself as Keystone's EOC Security to any Emergency Services or municipal emergency personnel attending the EOC
- Staff the entrance door to the EOC at all times
- Provide those working in the EOC with Identification cards (e.g., clipped to their shirts / chains around neck) to identify them as being a part of the Regional EOC response
- Refer all media inquiries to Media Relations
- Verify the identity of everyone entering the EOC and record those persons on the Visitor Log
- Maintain a list of authorized personnel attending the emergency site
- Notify the Security person at the Emergency Site of all persons authorized to attend the site

Regional EOC Resource Mobilization

The Regional Mobilization Role coordinates the movement to the site of equipment and materials, assembles and activates the relevant Mutual Aid agreements. Specific responsibilities include but are not limited to:

- Document all actions using the Emergency Incident Log
- Assemble and activate any relevant Mutual Aid agreements
- Coordinate the movement of personnel, material and equipment to site with the Resources contact at site
- Advise the Resources contact at site of any changes in resource availability or scheduled arrival
- Advise suppliers of any changes in the requirement for particular resources, or changes to the schedule of arrival at site

- Track hours worked by personnel at the EOC and at the site
- Advise the Regional EOC Manager (QI) of anticipated needs for relief personnel, etc.
- Setup work order structure to collect costs and prepare reports

Regional EOC Environmental / Technical

The Regional EOC Environmental / Technical role is to provide support and technical expertise to personnel at site. Specific responsibilities include but are not limited to:

- Document all actions using the Emergency Incident Log
- Provide specific technical expertise such as environmental, water management etc., depending on the nature of the emergency, to contain and control hazards
- Provide support to Environmental / Technical personnel at site
- Coordinate with Resources personnel in the EOC, identifying and mobilizing environmental resources to the site and other technical support as required
- Coordinate work with the Operations Control Center

Regional EOC Media Contact

The Regional EOC Media Contact responds to any media located at EOC and provides support to Media Contact working at the Command Post. Corporate Media Training is required for this position. Specific responsibilities include but are not limited to:

- Document all actions using the Media Contact Log and forward completed logs to documentation personnel in the EOC
- Document all requests for additional information on the Media Contact Log and forward to Corporate Communications
- Advise the media that Communications will respond as soon as possible to their inquiries
- Log all phone and personal contacts with media using Media Contact Log and provide to Corporate Communications
- Serve as media contact until advised of a Corporate Communications or Community Representative name and contact number off-site to which all media inquiries can be directed
- Ensure all telephone media inquiries go to Corporate Communications
- Maintain contact with Command Post Media Contact for regular factual updates, if no corporate media relations representative is in place
- Ensure Media representatives are not allowed into the EOC
- Provide factual updates to Media representatives, only when a corporate media relations representative is not in place

Regional EOC Documentation

The Regional EOC Documentation role consolidates information for electronic distribution, gathers and files all paper documentation. Specific responsibilities include but are not limited to:

- Prepare status reports for distribution on an electronic medium using information provided from EOC personnel logs
- Edit and consolidate the log information using the following general guidelines:
    - Major events and responses
    - Summary of actions taken by personnel
    - What is happening?
    - Who is involved?
    - Are there injuries?

- ➢ Is the public at risk?
- ➢ Where is the emergency?
- ➢ What is the magnitude of the situation?
- ➢ What has been done, so far?
- ➢ Obtain approval for status report from the Regional EOC Manager (QI) before sending

- o Ensure all written instructions, logs, reports, telephone logs and related documentation are recorded and filed

Regional EOC Community Evacuation Leader

The Regional EOC Community Evacuation Leader coordinates and implements any resident notifications for evacuations. Specific responsibilities include but are not limited to:

- o Document all conversations and activities using the Emergency Incident Log
- o Determine whether residents should be initially alerted or evacuated (in consultation with the Regional EOC Manager (QI) and local Emergency Services
- o Have available information on municipal evacuation centers and evacuee care should evacuation seem likely
- o For evacuations:
  - ➢ Determine the priority for contacting the public taking into account the incident, the potential for the situation to deteriorate, weather conditions and potential sensitivities of neighbors
  - ➢ Determine best method of contacting the public (phone, personal visits or through municipal authority)
  - ➢ After contacting the public, initiate and coordinate the ongoing communications with neighbors and the public outside of the emergency awareness zone who may have been impacted by the incident

Regional EOC Administrative Support

The Regional EOC Administrative Support person provides general support to all Regional EOC personnel. Specific responsibilities include but are not limited to:

- o Document all actions using the Emergency Incident Log
- o Support all EOC personnel as required
- o Record time, date and name of each person notified on the Emergency Incident Log
- o Word-processing
- o Telephones, faxing, etc
- o Assist with gathering and distributing information

4.2.4 Emergency Site Manager (QI)

The Emergency Site Manager (QI) coordinates and manages all aspects of emergency operations including site security, site access, containment, control point selection, recovery and clean-up operations.

The Emergency Site Manager (QI) in conjunction with the Regional EOC Manager (QI) determines the amount of resources within the Command Post. Not all roles will be activated, or others may be added, in any given spill. Furthermore, one person may take on several roles, and conversely one role may take several people.

Specific responsibilities in priority include but are not limited to:

- Establish emergency organization (command post), assign and brief personnel on key tasks
- Ensure that all parties can clearly identify the Keystone Emergency Site Manager (QI)
- Assign the Documentation Role and determine what other roles are required
- Maintain primary contact with the Federal On Scene Coordinator (FOSC)
- Conduct an Emergency Incident Assessment, based on the information available about the incident, and identify priority issues and objectives
- Determine manpower and equipment resources required, based on the nature of the spill
- Notify and maintain contact with local emergency response agencies (e.g., police, fire, ambulance, government, etc.) and citizens or landowners immediately affected by incident
- Notify Regional EOC Manager (QI) regarding incident status and maintain contact, as required, throughout incident
- Assume duties and responsibilities related to the incident which have not been assigned to other emergency personnel
- Ensure documentation is kept related to incident costs, product recovery and a log of incident activities
- Anticipate potential changes to the incident, and identify any additional resources required (e.g., additional equipment or supplies, relief or back-up personnel, lighting for night operations, etc.)
- Work in conjunction with emergency response personnel and municipal authorities at the scene
- Determine when the emergency is over in consultation with the Corporate EOC Manager and the Regional EOC Manager (QI)

4.2.5 Command Post

Site Security

Security is responsible to secure the scene, preserve evidence, and prevent theft.

Site security should be established and routes into the site should be sealed to prevent unauthorized access, and protect the safety of the public. Site security personnel may be Company personnel, hired contractors or local police authorities who assist in the incident. Specific responsibilities include but are not limited to:

- Document all actions using the Emergency Incident Log
- Maintain and monitor a security perimeter established around the site
- Ensure the protection of equipment or supplies stored at the site
- Preserve and protect evidence related to the incident for investigation and follow-up
- Check-in of authorized personnel coming into the site
- Convey necessary information to authorized personnel entering the site
- Post signs, warnings or barricades on-site
- Supervise the contract security personnel
- Identify yourself as Keystone's Site Security to any Fire, Police, or Ambulance personnel at the scene
- Refer all media inquiries to the Media Contact person
- Staff the entry point at all times with a minimum of two people
- Record all personnel entering the emergency site using Visitor Log
- Restrict entry to the site to authorized persons only

- Once the perimeter is secure preserve any items (evidence) which you feel may be used in investigations of the emergency
- Photograph the area where any items are located prior to moving if area must be disturbed
- Prevent unauthorized persons from examining or photographing evidence items
- Cover the evidence items with plastic, tarps, cardboard, plywood, etc. to prevent damage if weather is inclement

Resource Mobilization

The Resource Mobilization person determines requirements for personnel, equipment and materials. This position also records hours worked by personnel on site and provides this information to the Regional EOC Resources contact as well as the Emergency Site Manager (QI). Specific responsibilities include but are not limited to:

- Document all actions using the Emergency Incident Log
- Serve as the "single window" contact at the site for all personnel requiring resources (e.g., safety equipment, technical supplies)
- Advise the Emergency Site Manager (QI) immediately of any cancellations or schedule changes
- Advise the Resources contact in the Regional EOC of any changes in the need for resources, or in the mobilization schedule

Staging Leader

The Staging Leader locates a suitable staging area, upwind from the emergency site and ensures the orderly deployment of equipment to the site. Specific responsibilities include but are not limited to:

- Document all actions using the Emergency Incident Log
- Document all resources entering or leaving staging area using the Emergency Incident Log
- Direct resources to proper locations
- Work closely with the Regional EOC Resources contact to ensure accurate information about the type, quantity, and arrival times of resources to the staging area
- Communicate to the Regional EOC Resources contact any difficulties, delays, etc. in supplying resources to the scene from the Staging Area

Environmental / Technical

The Environmental / Technical Roles work with the Regional EOC Environmental / Technical persons and provide technical expertise needed to contain and control hazards. This will require various areas of expertise depending on the type of emergency event being managed. Specific responsibilities include but are not limited to:

- Document all actions using the Emergency Incident Log
- Provide specific technical expertise such as environmental, water management etc., depending on the nature of the emergency, to contain and control hazards
- Conduct an environmental assessment to identify potential environmental issues or concerns, through review of environmental sensitivity information, site reconnaissance, and liaison with government officials
- Identify short term and long term environmental issues and recommend appropriate environmental procedures to the Emergency Site Manager (QI) for minimizing or mitigating environmental impacts at the site
- Coordinate environmental sampling, protection and clean-up efforts

- Advise Keystone personnel and contractors on environmental concerns or constraints related to site activities
- Coordinate post emergency site assessment and development of a site specific remediation plan
- Evaluate technical resources requirements and advise Resource Role of requirements

Safety

The Safety Role ensures safety of personnel, and use of safe practices on site. Specific responsibilities include but are not limited to:

- Document all actions using the Emergency Incident Log
- Ensure the site is initially inspected and monitored to ensure it is safe for workers, based on the product hazards involved and site conditions
- Monitor the safety of personnel at the emergency site by ensuring safe work practices are being followed and safety precautions are being taken
- Prepare and implement the site safety/evacuation plan for the site
- Identify the nearest medical facilities and transport method
- Ensure all personnel receive a site safety orientation identifying hazards and control measures including a product hazard briefing, prior to undertaking any emergency response activity
- Ensure all new contractors (i.e., contractors who have not worked for the company before, and are unfamiliar with company safety procedures), have completed the Contractor Safety Orientation and have a valid confirmation card
- Ensure proper safety equipment is available for workers and is used in a proper manner
- Ensure site monitoring is continued on a regular basis
- Ensure safety precautions are in place to protect the public
- Evaluate site safety operations on a continuous basis, and report concerns or recommendations to the Emergency Site Manager (QI)

Media Contact

The Media Contact responds to various media questions and ensures the safety of all media personnel. Completion of Media training is a requirement of this position. Specific responsibilities include but are not limited to:

- Document all actions using the Emergency Incident Log
- Gather media personnel in a single location at a safe, reasonable distance from the emergency site
- Work with the media until Keystone's media specialist arrives
- Maintain contact with Communications in the Corporate EOC to determine what is to be released to media
- Maintain a list of all media personnel on site using Media Contact Log
- Log all questions and requests for information from media using the Media Contact Log
- Maintain contact with Media Contact in the Regional Emergency Operations Center and provide regular factual updates
- Clear all requests for photo opportunities through the Emergency Site Manager (QI)

Documentation

The Documentation person works directly with the Emergency Site Manager (QI) and documents all activities on site. Specific responsibilities include but are not limited to:

- Document all actions of the Emergency Site Manager (QI), using the Emergency Incident Log
- Provide direct support to the Emergency Site Manager (QI)
- Log and handle all communications for the Emergency Site Manager (QI), as requested

Community Evacuation Coordinator

The Community Evacuation Coordinator works with the Regional EOC Community Evacuation Leader and the local authorities with evacuation at or near the emergency site. Specific responsibilities include but are not limited to:

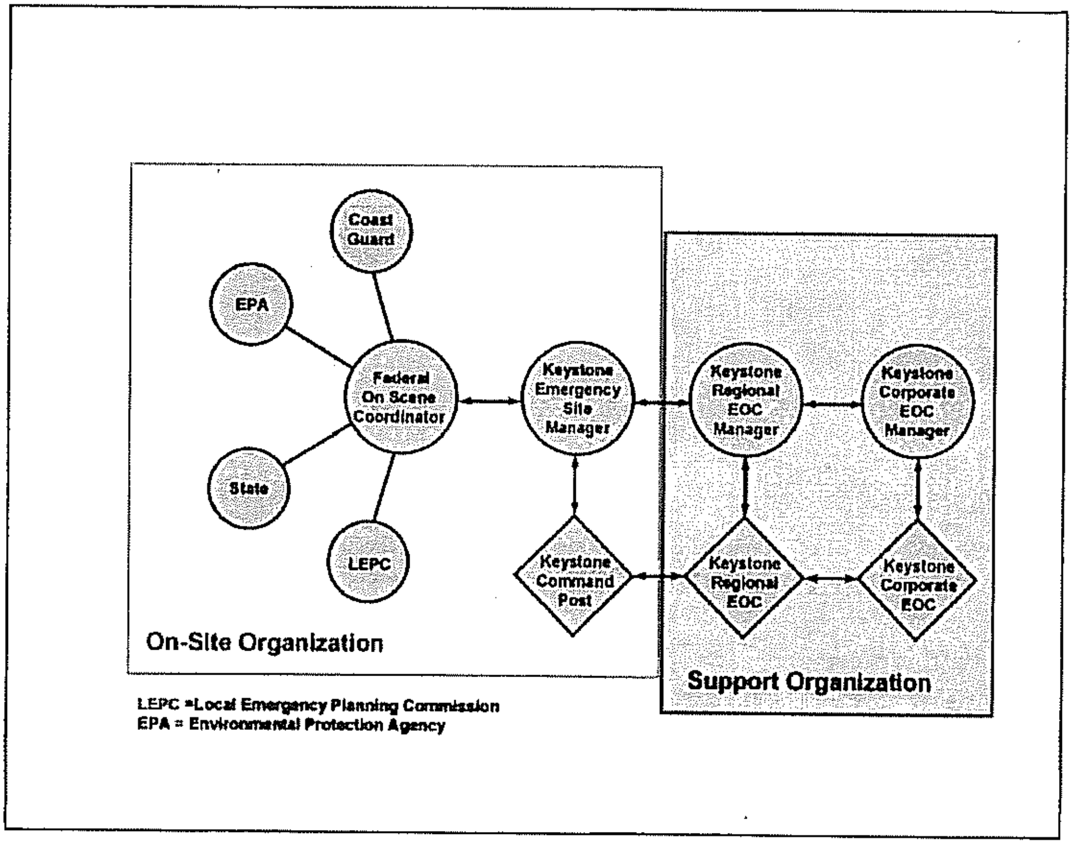
- Document all actions using the Emergency Incident Log
- Keep the Evacuation Leader at the Regional EOC informed of the evacuation center status and issues
- Work with local authorities who are managing the evacuation and evacuation center(s)
- Obtain a record of the evacuees' arrival at the designated evacuation center
- Keep the Regional EOC Evacuation Leader briefed on the status of the arrival of evacuees at the center
- In conjunction with Community Relations, provide information to the evacuees on the status of the incident
- Ensure there is a record kept of temporary destinations when evacuees leave the center
- Do not put yourself at risk

4.3 Federal On-Scene Coordinator Coordination Process

The Emergency Site Manager (QI) is the primary contact for the Federal On Scene Coordinator (FOSC). The FOSC is the lead agency and is responsible for monitoring and directing activities related to the spill.

A flow diagram outlining the action and communication paths under a Unified Command structure to be utilized in oil spill response is shown in Figure 4.

Figure 4: Basic Unified Command Structure



5.0 LIST OF CONTACTS

The contact list is currently incomplete but identifies the key contact positions required for activation of the Oil Spill Response Plan. Specific data fields will be completed when Keystone's personnel organization structure is finalized, State and Local requirements and contacts along with contract resources and contacts have been determined.

5.1 Qualified Individuals for Each Response Zone

Table 7: Contact Information for Qualified Individuals

Position	**Regional EOC Manager (QI)**
Name	
Address	
Telephone	Secondary Telephone
Position	**Alternate Regional EOC Manager**
Name	
Address	
Telephone	Secondary Telephone
Position	**Emergency Site Manager (QI)**
Name	
Address	
Telephone	Secondary Telephone
Position	**Alternate Emergency Site Manager**
Name	
Address	
Telephone	Secondary Telephone

5.2 Agency Contacts

Table 8: Agency Contacts

Agency/Company	**Contact**	**Telephone Numbers**
Federal		
National Response Center		800-424-8802
State		
Local		

5.3 Corporate Financial Contact for each Response Zone

Table 9: Corporate Financial (Insurance)

Name	Company	Telephone Numbers

5.4 Oil Spill Response Organizations and Contractors, Services and Resources

Table 10: OSRO Contacts

OSRO/Contractor	Contractor Responsibility	Resource Capability for First 7 Days	Quantity of Equipment or Service Available
Name:			
24 Hour Contact No.:			
Address:			
Response Time:			

5.5 Oil Transportation and Reclamation Facilities and Services

Table 11: Oil Transportation and Reclamation Facilities

Contractor	Service Provided	Capacity	Availability
Name:			
24 Hour Contact No.:			
Address:			

6.0 TRAINING PROCEDURES

The requirements listed identify specialized training for individuals prior to taking on responsibilities under the Oil Spill Response Plan.

6.1 On Site Personnel

Table 12: Training Requirements – On Site Personnel

Position	Specialized Training to Meet Oil Spill Response Duties
First Responders	o HAZWOPER Training to Hazmat Technician Level 3 with annual refresher as required o Keystone Emergency Management System (EMS) training o National Fire Protection Association (NFPA) training
Emergency Site Manager – Qualified Individual	o HAZWOPER Training to Hazmat Level 4 Specialist with annual refresher as required o Incident Command System (ICS) Communication training o Keystone Emergency Management System (EMS) training o National Fire Protection Association (NFPA) training
Command Post Media	o Keystone Emergency Management System (EMS) training o Keystone Media Relations training
Command Post Safety	o Keystone Emergency Management System (EMS) training o Advanced safety related training
Command Post Documentation	o Keystone Emergency Management System (EMS) training
Command Post Site Security	
Command Post Resource Mobilization	
Command Post Technical	
Command Post Staging Leader	
Command Post Evacuation Coordinator	

6.2 Regional EOC

Table 13: Training Requirements - Regional EOC

Position	Specialized Training to Meet Oil Spill Response Duties
Regional EOC Manager – Qualified Individual	o HAZWOPER Training to the Level of Hazardous Materials Specialist with annual refresher as required o Incident Command System (ICS) training o Keystone Emergency Management System (EMS) training
Regional EOC Media Contact	o Keystone Emergency Management System (EMS) training o Keystone Media Relations training
Regional EOC Communications	o Keystone Emergency Management System (EMS) training
Regional EOC Documentation	
Regional EOC Security	
Regional EOC Technical	
Regional EOC Resource Mobilization	
Regional EOC Community Evacuation Leader	
Regional EOC Administration Support	

6.3 Training Records

Keystone will utilize an electronic system to track and maintain records of training, including refresher training, for all employees. The system will be located at Keystone's head office.

Contractors are responsible for maintaining all training records for their employees. Periodic audits will be conducted by Keystone, to ensure contractors training records comply with emergency training requirements. Audit documentation will be retained in Keystone's files.

7.0 EXERCISE PROCEDURES

Keystone's exercise program is designed to meet the exercise requirements as outlined in the National Preparedness for Response Exercise Program (PREP) Guidelines developed by the U.S. Coast Guard and adopted by the Pipeline and Hazardous Materials Safety Administration (PHMSA), the Minerals Management Service (MMS), and the U.S. Environmental Protection Agency (EPA). Participation in this program ensures that the Company meets all federal exercise requirements mandated by OPA '90.

The primary elements of the exercise program are notification exercises, table top exercises, Company owned equipment deployment exercises, contractor exercises, unannounced exercises by government agencies and area-wide exercises up to and including actual field drills conducted by industry and the government agencies.

Keystone will ensure that operating personnel participate in exercises or responses on an annual basis in order to ensure they remain trained and qualified to operate the equipment in the operating environment and to ensure the Oil Spill Response Plans are effective, if ever needed. However, personnel and equipment that are assigned to multiple Response Zones will participate in only one deployment exercise per year.

The exercise year for all Company facilities will be from January 1 to December 31.

In addition to the exercise program as outlined in Table 14, Keystone will also participate in both unannounced Federal Agency led exercises and Area exercises when requested.

Table 14: Exercise Program Type and Frequency

Exercise Type (for each Response Zone)	Exercises Conducted in Triennial Cycle
Qualified Individual Notification Exercises (one per year to be conducted during non-business hours)	12
Spill Management Team Tabletop Exercises (one must involve a worst case discharge scenario)	3
Equipment Deployment Exercises (using either internal and/or external)	3
Unannounced Exercise (any of the above Exercises, with the exception to the Qualified Individual Notification Exercise, if conducted unannounced, satisfy this requirement)	3

The terms referenced in the above Table are defined as follows:

- Tabletop exercise is an exercise of the response plan and the spill management team's response efforts without the actual deployment of equipment.
- Spill management team is the group of personnel identified to staff the appropriate organizational structure to manage spill response implementation in accordance with the response plan.

- Internal exercises are those that are conducted wholly within the plan holder's organization. Internal exercises include personnel such as the qualified individual and those affiliated with the plan holder's spill management team, including OSRO's. The internal exercises do not involve other members of the response community.

- External exercises are those that extended beyond the internal focus of the plan holder's organization, and involve other members of the response community. The external exercises are designed to examine the response plan and the plan holder's ability to coordinate with the response community to conduct an effective response to an incident.

7.1 Debriefing and Documentation

At the conclusion of an actual spill event or a field exercise, a debriefing will be conducted to evaluate the response, local procedures and the overall Emergency Management System (EMS). All company personnel involved in responding, managing, or performing a support function during an actual spill event or exercise will participate in their respective debriefing. This debriefing should take place the same day or as soon as practical thereafter. At the discretion of the Regional EOC Manager (QI), and when appropriate, debriefing sessions will be organized as follows:

- Internal Debriefings are to discuss all aspects of Keystone's emergency preparedness and response.
- External debriefings are designed to discuss only those aspects related to Keystone and agency interaction with respect to communications.
- Media debriefings will be held separately from all other debriefings. Media debriefings will focus on Keystone's interaction with the media.

Representatives from each of the debriefing sessions will then meet to discuss the results of their session and combine information, presenting a complete review of the event. When appropriate, the information derived from these debriefing sessions will be incorporated into the Oil Spill Response Plan.

Lists of exercises conducted, the objectives met, and the results of the debriefing sessions identified above will be documented. This documentation will be in writing and signed by the individual having responsibility for the facility conducting the exercise. All spill response exercise documentation records will be maintained on file at the facility for a minimum of five years.

8.0 RESPONSE PLAN REVIEW AND UPDATE PROCEDURES

All sections of the Oil Spill Response Plan will be reviewed at least annually and revised as required by the Keystone Emergency Management Specialist, or as required, based on new data, additions and modifications to the pipeline system or new government regulatory requirements.

Revisions will incorporate recommendations from training drills or actual spills, industry research into spill countermeasures, new equipment information and updated emergency contact information.

In the event of a worst case discharge, the response will be reviewed and assessed against the Oil Spill Response Plan to evaluate and record the Plan's effectiveness.

The Oil Spill Response Plan will be resubmitted every 5 years from the date of last submission in accordance with 49CFR§194.121, for the areas of the pipeline that have been designated as potentially causing significant and substantial harm.

If a new or different operating condition or information would substantially affect the implementation of the Response Plan, Keystone will immediately modify its Response Plan to address such a change and resubmit to the Pipeline and Hazardous Material Safety Administration (PHMSA) within 30 days of making the change.

9.0 RESPONSE ZONE ONE APPENDIX

9.1 Information Summary

Response Area Location	Milepost (MP) = 0 at Canadian Border to MP = 535 in mid-Nebraska, south end of Colfax County
State	**North Dakota** (MP 0 to ≈ MP 215)
Counties	Pembina, Cavalier, Walsh, Nelson, Steele, Barnes, Ransom, and Sargent
State	**South Dakota** (MP 215 to ≈ MP 431)
Counties	Marshall, Day, Clark, Beadle, Kingsbury, Miner, Hanson, McCook, Hutchinson, and Yankton
State	**Nebraska** (MP 431 to ≈ MP 535)
Counties	Cedar, Wayne, Stanton, Platte, Colfax
Owner	Keystone
Emergency Telephone	1 (XXX) XXX-XXXX
Owner Location (Street)	450 - 1st Street SW
City: Calgary	Province: Alberta Postal Code: T2P 5H1

9.2 Qualified Individuals

The contact list is currently incomplete but identifies the key contact positions required for activation of the Oil Spill Response Plan. Specific data fields will be completed when Keystone's personnel organization structure is finalized.

Position	**Regional EOC Manager (QI)**
Name	
Address	
Emergency Telephone	Secondary Telephone
Position	**Alternate Regional EOC Manager**
Name	
Address	
Emergency Telephone	Secondary Telephone
Position	**Emergency Site Manager (QI)**
Name	
Address	
Emergency Telephone	Secondary Telephone
Position	**Alternate Emergency Site Manager**
Name	
Address	
Emergency Telephone	Secondary Telephone

9.3 Determination of Harm

The operator expects that Response Zone One will meet the "significant and substantial" harm criteria due to the proximity of high consequence areas. However, a final determination is reserved pending completion of the design details required to perform the analysis. For the purposes of this preliminary document, Keystone has assumed the aforementioned criteria will be met.

9.4 Notification Procedures

The Regional EOC Manager (QI) is the key individual responsible for evaluating and activating the Oil Spill Response.

9.4.1 Prioritized Notification Checklist for Key Individuals

First Responder

- ☐ Notification of potential spill and dispatch received from OCC
- ☐ SPILL VERIFIED
- ☐ Notification of Emergency Services, if required

  Verify with OCC:
  - ☐ Pipeline shutdown and status
  - ☐ Pipeline segment isolation
- ☐ Regional EOC Manager (QI) notified

Regional EOC Manager (QI)

- ☐ Notification received from OCC
- ☐ Notification of spill details received from First Responder
- ☐ OIL SPILL RESPONSE PLAN ACTIVATED
- ☐ Emergency Site Manager (QI) notified
- ☐ Regional EOC activated
- ☐ Mobilize response resources requested by Emergency Site Manager (QI)
- ☐ Corporate EOC Manager contacted
- ☐ Agency contacts initiated as per Section 2.3

Emergency Site Manager (QI)

- ☐ Notification received from Regional EOC Manager (QI)
- ☐ On site First Responder contacted to obtain briefing on spill
- ☐ On Site Command Post activated
- ☐ Regional EOC advised of resource requirements
- ☐ First Responder relieved

9.4.2 Notification Contacts

The contact list is currently incomplete but identifies the key contact positions required for activation of the Oil Spill Response Plan. Specific data fields will be completed when Keystone's personnel organization structure is finalized and State and Local requirements and contacts have been determined.

Keystone

Table 15: Response Zone One Keystone Notification

Position Making Call	Keystone Contacts	Primary Telephone No.	Secondary Telephone No.
OCC	**First Responder**		
	Regional EOC Manager (QI)		
	- Primary		
	- Alternate		
	Corporate EOC		
Regional EOC Manager (QI)	**Emergency Site Manager (QI)**		
	- Primary		
	- Alternate		
	Corporate EOC Manager		

Agency

Table 16: Response Zone One Agency Notification

Position Making Call	Agency Contact List	Telephone	Other Telephone/Fax
Regional EOC Manager (QI)	**Federal**		
	National Response Center	1-800-424-8802	
	State		
	Local		

Emergency Services

Table 17: Response Zone One Emergency Services Notification

Position Making Call	Emergency Contact List	Telephone	Other Telephone/Fax
Emergency Site Manager (QI)	Emergency Services		
	Fire/Ambulance		
	Police/Sheriff		
	Hospital		

9.4.3 Information Reported to Agencies

Communication Report (Call) Record

Regional EOC Manager (QI)

The following agency mandatory information, ***as identified in bold italic***, will be provided initially with subsequent notifications to complete the required mandatory criteria or advise of any changes.

Name of Pipeline:____

Time of Discharge:____

Location of Discharge (MP):______________________________________

(GPS):______________________________________

Type of Oil:____

Reason of Discharge:____

Estimated Volume of Oil Spill:____________________________________

Weather Condition on Scene: ____________________________________

Action taken/ Planned by Person on Scene: ____________________________

Injuries: ____

Extent of Injuries: ____

Evacuation: ____

Public Consequence: ______________________________________

9.5 Spill Detection and Mitigation Procedures

Response Zone specific procedures will be identified and described following completion of the necessary design details.

9.6 Oil Spill Response Organizations and Contractors, Services and Resources

The contact lists below are currently incomplete and will be updated as Keystone identifies contract resources and contact information.

Table 18: Response Zone One OSRO Contacts

OSRO/Contractor	Contractor Responsibility	Resource Capability for First 7 Days	Quantity of Equipment or Service Available
Name:			
24 Hour Contact No.:			
Address:			
Response Time:			

9.7 Oil Transportation and Reclamation Facilities and Services

The contact lists below are currently incomplete and will be updated as Keystone identifies contract resources and contact information.

Table 19: Response Zone One Oil Transportation and Reclamation Facilities

Contractor	Service Provided	Capacity	Availability
Name:			
24 Hour Contact No.:			
Address:			

9.8 Type of Oil, Volume and Calculation Method for Worst Case Discharge Volume

Pending completion of the necessary engineering design details a worst case discharge calculation will be undertaken.

Keystone expects to transport crude oils in the range of 12 to 45° API.

9.9 Maps and Drawings

9.9.1 Location of Worst Case Discharge

Pending completion of engineering design details this information will be provided.

9.9.2 Location of Potentially affected Public Drinking Water Intakes

Pending completion of engineering design details this information will be provided.

9.9.3 Potentially affected environmentally sensitive areas

Pending completion of engineering design details this information will be provided.

9.9.4 Control Points and access descriptions

Pending completion of engineering design details this information will be provided.

9.10 Piping Diagram and Plan Profile

Pending completion of engineering design details this information will be provided.

10.0 RESPONSE ZONE TWO APPENDIX

10.1 Information Summary

Response Area Location	(MP) = MP 535 to MP 634 and Cushing Extension (CE), CE MP 0 to CE MP 291
State	**Nebraska** (MP 535 to ≈ MP 634) and Cushing Extension (CE) MP 0 to ≈ MP 4
Counties	Butler, Seward, Saline and Jefferson
State	**Kansas** (CE MP 4 to ≈ CE MP 212)
Counties	Washington, Clay, Dickinson, Marion, Butler, and Cowley
State	**Oklahoma** (CE MP 212 to ≈ CE MP 291)
Counties	Kay, Noble, and Payne
Owner	Keystone
Emergency Telephone	1 (XXX) XXX-XXXX
Owner Location (Street)	450 - 1st Street SW
City: Calgary	Province: Alberta Postal Code: T2P 5H1

10.2 Qualified Individuals

The contact list is currently incomplete but identifies the key contact positions required for activation of the Oil Spill Response Plan. Specific data fields will be completed when Keystone's personnel organization structure is finalized.

Position	**Regional EOC Manager (QI)**	
Name		
Address		
Emergency Telephone		Secondary Telephone
Position	**Alternate Regional EOC Manager**	
Name		
Address		
Emergency Telephone		Secondary Telephone
Position	**Emergency Site Manager (QI)**	
Name		
Address		
Emergency Telephone		Secondary Telephone
Position	**Alternate Emergency Site Manager**	
Name		
Address		
Emergency Telephone		Secondary Telephone

10.3 Determination of Harm

The operator expects that Response Zone Two will meet the "significant and substantial" harm criteria due to the proximity of high consequence areas. However, a final determination is reserved pending completion of the design details required to perform the analysis. For the purposes of this preliminary document, Keystone has assumed the aforementioned criteria will be met.

10.4 Notification Procedures

The Regional EOC Manager (QI) is the key individual responsible for evaluating and activating the Oil Spill Response.

10.4.1 Prioritized Notification Checklist for Key Individuals

First Responder

- ☐ Notification of potential spill and dispatch received from OCC
- ☐ SPILL VERIFIED
- ☐ Notification of Emergency Services, if required

  Verify with OCC:
  - ☐ Pipeline shutdown and status
  - ☐ Pipeline segment isolation
- ☐ Regional EOC Manager (QI) notified

Regional EOC Manager (QI)

- ☐ Notification received from OCC
- ☐ Notification of spill details received from First Responder
- ☐ OIL SPILL RESPONSE PLAN ACTIVATED
- ☐ Emergency Site Manager (QI) notified
- ☐ Regional EOC activated
- ☐ Mobilize response resources requested by Emergency Site Manager (QI)
- ☐ Corporate EOC Manager contacted
- ☐ Agency contacts initiated as per Section 2.3

Emergency Site Manager (QI)

- ☐ Notification received from Regional EOC Manager (QI)
- ☐ On site First Responder contacted to obtain briefing on spill
- ☐ On Site Command Post activated
- ☐ Regional EOC advised of resource requirements
- ☐ First Responder relieved

10.4.2 Notification Contacts

The contact list is currently incomplete but identifies the key contact positions required for activation of the Oil Spill Response Plan. Specific data fields will be completed when Keystone's personnel organization structure is finalized and State and Local requirements and contacts have been determined.

Keystone

Table 20: Response Zone Two Keystone Notification

Position Making Call	Keystone Contacts	Primary Telephone No.	Secondary Telephone No.
OCC	**First Responder**		
	Regional EOC Manager (QI)		
	- Primary		
	- Alternate		
	Corporate EOC		
Regional EOC Manager (QI)	**Emergency Site Manager (QI)**		
	- Primary		
	- Alternate		
	Corporate EOC Manager		

Agency

Table 21: Response Zone Two Agency Notification

Position Making Call	Agency Contact List	Telephone	Other Telephone/Fax
Regional EOC Manager (QI)	**Federal**		
	National Response Center	1-800-424-8802	
	State		
	Local		

Emergency Services

Table 22: Response Zone Two Emergency Services Notification

Position Making Call	Emergency Contact List	Telephone	Other Telephone/Fax
Emergency Site Manager (QI)	Emergency Services		
	Fire/Ambulance		
	Police/Sheriff		
	Hospital		

10.4.3 Information Reported to Agencies

Communication Report (Call) Record

Regional EOC Manager (QI)

The following agency mandatory information, ***as identified in bold italic***, will be provided initially with subsequent notifications to complete the required mandatory criteria or advise of any changes.

Name of Pipeline:______________________________________

Time of Discharge:______________________________________

Location of Discharge (MP):________________________________

(GPS):__________________________________

Type of Oil:____

Reason of Discharge:____________________________________

Estimated Volume of Oil Spill:________________________________

Weather Condition on Scene: ________________________________

Action taken/ Planned by Person on Scene: __________________________

Injuries: ____

Extent of Injuries: _______________________________________

Evacuation: ____

Public Consequence: ______________________________________

10.5 Spill Detection and Mitigation Procedures

Response Zone specific procedures will be identified and described following completion of the necessary design details.

10.6 Oil Spill Response Organizations and Contractors, Services and Resources

The contact lists below are currently incomplete and will be updated as Keystone identifies contract resources and contact information.

Table 23: Response Zone Two OSRO Contacts

OSRO/Contractor	Contractor Responsibility	Resource Capability for First 7 Days	Quantity of Equipment or Service Available
Name:			
24 Hour Contact No.:			
Address:			
Response Time:			

10.7 Oil Transportation and Reclamation Facilities and Services

The contact lists below are currently incomplete and will be updated as Keystone identifies contract resources and contact information.

Table 24: Response Zone Two Oil Transportation and Reclamation Facilities

Contractor	Service Provided	Capacity	Availability
Name:			
24 Hour Contact No.:			
Address:			

10.8 Type of Oil, Volume and Calculation Method for Worst Case Discharge Volume

Pending completion of the necessary engineering design details a worst case discharge calculation will be undertaken.

Keystone expects to transport crude oils in the range of 12 to 45° API.

10.9 Maps and Drawings

10.9.1 Location of Worst Case Discharge

Pending completion of engineering design details this information will be provided.

10.9.2 Location of Potentially affected Public Drinking Water Intakes

Pending completion of engineering design details this information will be provided.

10.9.3 Potentially affected environmentally sensitive areas

Pending completion of engineering design details this information will be provided.

10.9.4 Control Points and access descriptions

Pending completion of engineering design details this information will be provided.

10.10 Piping Diagram and Plan Profile

Pending completion of engineering design details this information will be provided.

11.0 RESPONSE ZONE THREE APPENDIX

11.1 Information Summary

Response Area Location	Milepost (MP) = MP 634 to MP 1073
State	**Nebraska** (MP 634 to ≈ MP 649)
Counties	Jefferson, Gage
State	**Kansas** (MP 649 to ≈ MP 743)
Counties	Marshall, Nemaha, Brown, and Doniphan
State	**Missouri** (MP 743 to ≈ MP 1016)
Counties	Buchanan, Clinton, Caldwell, Carroll, Chariton, Randolph, Audrain, Montgomery, Lincoln, and St. Charles
State	**Illinois** (MP 1016 to ≈ MP 1073
Counties	Madison, Bond, Fayette, and Marion
Owner	Keystone
Emergency Telephone	1 (XXX) XXX-XXXX
Owner Location (Street)	450 - 1st Street SW
City: Calgary	Province: Alberta Postal Code: T2P 5H1

11.2 Qualified Individuals

The contact list is currently incomplete but identifies the key contact positions required for activation of the Oil Spill Response Plan. Specific data fields will be completed when Keystone's personnel organization structure is finalized.

Position	**Regional EOC Manager (QI)**
Name	
Address	
Emergency Telephone	Secondary Telephone
Position	**Alternate Regional EOC Manager (QI)**
Name	
Address	
Emergency Telephone	Secondary Telephone
Position	**Emergency Site Manager (QI)**
Name	
Address	
Emergency Telephone	Secondary Telephone
Position	**Alternate Emergency Site Manager**
Name	
Address	
Emergency Telephone	Secondary Telephone

11.3 Determination of Harm

The operator expects that Response Zone Three will meet the "significant and substantial" harm criteria due to the proximity of high consequence areas. However, a final determination is reserved pending completion of the design details required to perform the analysis. For the purposes of this preliminary document, Keystone has assumed the aforementioned criteria will be met.

11.4 Notification Procedures

The Regional EOC Manager (QI) is the key individual responsible for evaluating and activating the Oil Spill Response.

11.4.1 Prioritized Notification Checklist for Key Individuals

First Responder

- ☐ Notification of potential spill and dispatch received from OCC
- ☐ SPILL VERIFIED
- ☐ Notification of Emergency Services, if required

  Verify with OCC:
  - ☐ Pipeline shutdown and status
  - ☐ Pipeline segment isolation
- ☐ Regional EOC Manager (QI) notified

Regional EOC Manager (QI)

- ☐ Notification received from OCC
- ☐ Notification of spill details received from First Responder
- ☐ OIL SPILL RESPONSE PLAN ACTIVATED
- ☐ Emergency Site Manager (QI) notified
- ☐ Regional EOC activated
- ☐ Mobilize response resources requested by Emergency Site Manager (QI)
- ☐ Corporate EOC Manager contacted
- ☐ Agency contacts initiated as per Section 2.3

Emergency Site Manager (QI)

- ☐ Notification received from Regional EOC Manager (QI)
- ☐ On site First Responder contacted to obtain briefing on spill
- ☐ On Site Command Post activated
- ☐ Regional EOC advised of resource requirements
- ☐ First Responder relieved

11.4.2 Notification Contacts

The contact list is currently incomplete but identifies the key contact positions required for activation of the Oil Spill Response Plan. Specific data fields will be completed when Keystone's personnel organization structure is finalized and State and Local requirements and contacts have been determined.

Keystone

Table 25: Response Zone Three Keystone Notification

Position Making Call	Keystone Contacts	Primary Telephone No.	Secondary Telephone No.
OCC	**First Responder**		
	Regional EOC Manager (QI)		
	- Primary		
	- Alternate		
	Corporate EOC		
Regional EOC Manager (QI)	**Emergency Site Manager (QI)**		
	- Primary		
	- Alternate		
	Corporate EOC Manager		

Agency

Table 26: Response Zone Three Agency Notification

Position Making Call	Agency Contact List	Telephone	Other Telephone/Fax
Regional EOC Manager (QI)	**Federal**		
	National Response Center	1-800-424-8802	
	State		
	Local		

Emergency Services

Table 27: Response Zone Three Emergency Services Notification

Position Making Call	Emergency Contact List	Telephone	Other Telephone/Fax
Emergency Site Manager (QI)	Emergency Services		
	Fire/Ambulance		
	Police/Sheriff		
	Hospital		

Information Reported to Agencies

Communication Report (Call) Record

Regional EOC Manager (QI)

The following agency mandatory information, ***as identified in bold italic***, will be provided initially with subsequent notifications to complete the required mandatory criteria or advise of any changes.

Name of Pipeline:______________________________

Time of Discharge:______________________________

Location of Discharge (MP):______________________________

(GPS):______________________________

Type of Oil:______________________________

Reason of Discharge:______________________________

Estimated Volume of Oil Spill:______________________________

Weather Condition on Scene: ______________________________

Action taken/ Planned by Person on Scene: ______________________________

Injuries: ______________________________

Extent of Injuries: ______________________________

Evacuation: ______________________________

Public Consequence: ______________________________

11.5 Spill Detection and Mitigation Procedures

Response Zone specific procedures will be identified and described following completion of the necessary design details.

11.6 Oil Spill Response Organizations and Contractors, Services and Resources

The contact lists below are currently incomplete and will be updated as Keystone identifies contract resources and contact information.

Table 28: Response Zone Three OSRO Contacts

OSRO/Contractor	Contractor Responsibility	Resource Capability for First 7 Days	Quantity of Equipment or Service Available
Name:			
24 Hour Contact No.:			
Address:			
Response Time:			

11.7 Oil Transportation and Reclamation Facilities and Services

The contact lists below are currently incomplete and will be updated as Keystone identifies contract resources and contact information.

Table 29: Response Zone Three Oil Transportation and Reclamation Facilities

Contractor	Service Provided	Capacity	Availability
Name:			
24 Hour Contact No.:			
Address:			

11.8 Type of Oil, Volume and Calculation Method for Worst Case Discharge Volume

Pending completion of the necessary engineering design details a worst case discharge calculation will be undertaken.

Keystone expects to transport crude oils in the range of 12 to 45° API.

11.9 Maps and Drawings

11.9.1 Location of Worst Case Discharge

Pending completion of engineering design details this information will be provided.

11.9.2 Location of Potentially affected Public Drinking Water Intakes

Pending completion of engineering design details this information will be provided.

11.9.3 Potentially affected environmentally sensitive areas

Pending completion of engineering design details this information will be provided.

11.9.4 Control Points and access descriptions

Pending completion of engineering design details this information will be provided.

11.10 Piping Diagram and Plan Profile

Pending completion of engineering design details this information will be provided.