Note to file.

The details contained in the Appendices to this report were not placed in the public docket for this accident.

Olympic Pipe Line Company

16" - Ferndale to Allen

Block Valve & Check Valve Effectiveness Evaluation

November 17, 1999
Revised November 7, 2000

MARMAC Project #2829

OLYMPIC PIPE LINE COMPANY

16" – Ferndale to Allen Block Valve and Check Valve Effectiveness Evaluation

Prepared By

MARMAC Engineering

November 17, 1999
Revised November 7, 2000

Olympic Pipe Line Company
Block Valve and Check Valve Effectiveness Evaluation
16" - Ferndale to Allen

PREFACE

This document supersedes and replaces the *16" Ferndale to Allen Block Valve and Check Valve Effectiveness Evaluation* dated November 17, 1999, which was previously issued to the DOT/OPS. The revision date of this document reflects the latest date that is applicable to work performed in the selection of new valve placements and existing valve modifications. Other revisions to the text may have been made at a more recent date.

This Evaluation has been expanded to include enhancements, clarifications and additional information as outlined below:

- Transient-release volume estimations have been deleted from the discussion in order to eliminate potential confusion. These volumes are released prior to full closure of the block valves. Valve placements have a greater influence on the static-release volumes, which are the volumes released after full closure of the valves. These are the volumes contained between two adjacent closed valves. Since the purpose of this evaluation is to determine valve location effectiveness, static release volumes are used exclusively.
- Check valves were added at mileposts 16.76 and 25.28 for additional protection. This results in twelve "line sections" vs. ten in the November 17, 1999 Evaluation.
- Graphs of the elevation profile and potential static release-volume profiles for this section of pipeline have been combined into a single document for easier comparison. Release-volume profiles include three cases: 1) "No valves", a hypothetical case; 2) "Existing valves", the valves present at the time of the 1999 Bellingham incident; and 3) "Existing plus converted & new valves", which includes the "existing" valves plus the new valves installed or scheduled to be installed or converted (modified) as a result of this Evaluation.
- Potential static-release volumes have been tabulated for "existing valves" and "existing plus converted & new valves" for easier comparison of the benefits attained.
- A drainage analysis has been performed, tabulating bodies of water that could be impacted by a potential release of sufficient volume. Drainage patterns have also been added to the maps to illustrate the sensitive resources that could ultimately be within the drainage paths.

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The Ferndale-to-Allen section of pipeline covered by this Evaluation includes the Bellingham area, for which a separate Evaluation has been performed. These Evaluations are consistent with one another as relates to valve implementation and calculated potential static-release volumes.

MARMAC Engineering

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1.0 INTRODUCTION

This evaluation is a review of the Olympic Pipe Line Company (OPL) 16” refined products pipeline from Ferndale Station to Allen Station, a distance of 42 miles, in the State of Washington. This section of pipeline has been evaluated with regard to the effectiveness of the existing block valves and check valves in the protection of sensitive areas that may be impacted by a pipeline release. Title 49, Code of Federal Regulations, Part 195, Section 195.260 (c) of the Federal Pipeline Safety Standards for Hazardous Liquid pipelines requires that a valve be installed on each mainline at locations that "will minimize damage or pollution from accidental hazardous liquid discharge, as appropriate for the terrain in open country, for offshore areas, or populated areas”. All block valves considered for addition to the pipeline are remotely controlled valves (RCV). Consideration is also given to the installation of new check valves (CV), and to the addition of remotely controlled actuators to any existing hand-operated block valves (HOV) to satisfy these guidelines.

Evaluating the spacing and effectiveness of the existing valve sites on this section of pipeline entailed the following steps:

- Evaluation of drainage paths and destinations on topographical maps, resulting in predicted drainage footprints, for a pipeline release of sufficient volume if it were to occur at any point along this pipeline section.
- Identification of Sensitive Resources, where a greater level of loss-control may be warranted.
- Development of a pipeline elevation vs. milepost (MP) profile (graph) for the OPL Ferndale-to-Allen pipeline section.
- Determination of potential static liquid release volumes (valves closed) for a major pipeline failure at any point along this pipeline section, if it were to occur.

- Consideration of the addition of new valves and the modification of existing valves in order to effect a greater level of loss control where warranted, and calculation of the revised release volumes with inclusion of these valves.

Results of this evaluation are shown in Appendices A, B & C, and Tables 1 through 5. The maps in Appendix-C are organized by milepost number. Identified on each map are the following:

- Pipeline alignment,
- Location and type of valves,
- OPL Mileposts,
- Sensitive resources, including but not limited to environmentally sensitive features, population and business centers, schools and hospitals within a one (1)-mile corridor of the pipeline, and
- Drainage footprints, showing the predicted path to be followed by a release of sufficient volume.

The Department of Transportation's Research and Special Programs Administration (RSPA) issued an amendment to 49 CFR Part 195 that takes effect on March 31, 2001. It requires hazardous liquid pipeline operators with more than 500 miles of pipeline to assess and validate the integrity of their pipeline segments that could affect "high consequence areas" (HCA). The new amendment also defines the criteria to be used for identifying HCA's. The work to prepare this Valve Effectiveness Evaluation was initiated and substantially completed before these new Pipeline Safety regulations were finalized. Although all sections of the pipeline were evaluated, it should be noted that only specific sensitive resources were examined in this evaluation, rather than all the components discussed in the final rule defining HCA's.

2.0 METHODOLOGY

The analysis is divided into the following tasks, summarized below.

Drainage Analysis – The drainage analysis described in Section 5.0 is conducted by drawing the pipeline route on United States Geological Survey (USGS) quadrangle maps. Then the maps are used to predict the flow path of product if it were to be released anywhere along the pipeline route. Results of the analysis are then drawn on the same maps.

Identification of Sensitive Resources – Some of the sensitive resources within a 1-mile corridor along each pipeline right-of-way (ROW) are plotted on the maps showing the pipeline routes, in Appendix-C.

Elevation Profile – The elevation profile for the pipeline is graphically depicted using data points obtained from OPL pipeline alignment sheets. Although the data points attempt to recreate the basic profile of the pipeline, the profile does not account for all minor curvatures in the terrain. Locations and types of "existing" valves are indicated on the profile. "Existing" valves were present at the time of the 1999 Bellingham release incident. The profile is then utilized to establish an Excel spreadsheet for the calculation of potential static-release volume at each data point. Review of the elevation profile also assists in the selection of sites for new or modified valves after the release analysis has been performed for the "existing" valves. The selected new or newly modified valves are then added to the profile. The elevation profile is graphically displayed in Appendix-B.

Release Analysis and Valve Selection – The potential static-release volumes for each data point are calculated for the existing valves and results are tabulated. A static-release volume profile, showing locations of existing valves, is used to assist in the evaluation. Sensitive resources identified on the maps are then compared with the tabulated and profiled release data. Locations requiring additional protection are identified, new and/or newly modified valve locations are selected, and calculations are then performed to include the existing and the proposed new and/or newly modified valves. These results are then compared to those for only the existing valves in order to determine the level of improvement obtained. The selected new and/or newly modified valves are then displayed on the elevation profile. Release volume profiles are graphically displayed in Appendix-B.

3.0 PIPELINE RELEASE VOLUMES

This evaluation follows the precepts of a report titled "Hazardous Liquid Pipeline Risk Assessment" by California State Fire Marshall dated March 1993, regarding the effectiveness of block valves on release volumes from liquid pipelines. It states that a block valve's effectiveness is related to the physical proximity of the release point to the valve, the pipeline elevation profile, and the time required to close the valve once a pipeline release has been identified. A block valve would be effective in minimizing the static drain-down portion of a release caused by a leak located immediately down-slope from it, assuming it is readily closed. On the other hand, in many cases it would have no effect on the drain-down portion of a release immediately up-slope from it, even if it could be immediately closed. It can also be concluded from the report that: block valves downstream of a leak do not reduce pipeline release volumes caused by continued pumping; downstream block valves are effective only in reducing the drain-down component of a pipeline release; and block valves are not effective in significantly reducing the total pipeline release volume unless the release can be quickly identified for pipeline shut down and block valve closures.

The total volume released by a pipeline failure includes two components:

1) Transient volume - the liquid released prior to full closure of the valves, and
2) Static volume - the liquid that drains from the pipeline after the valves are fully closed.

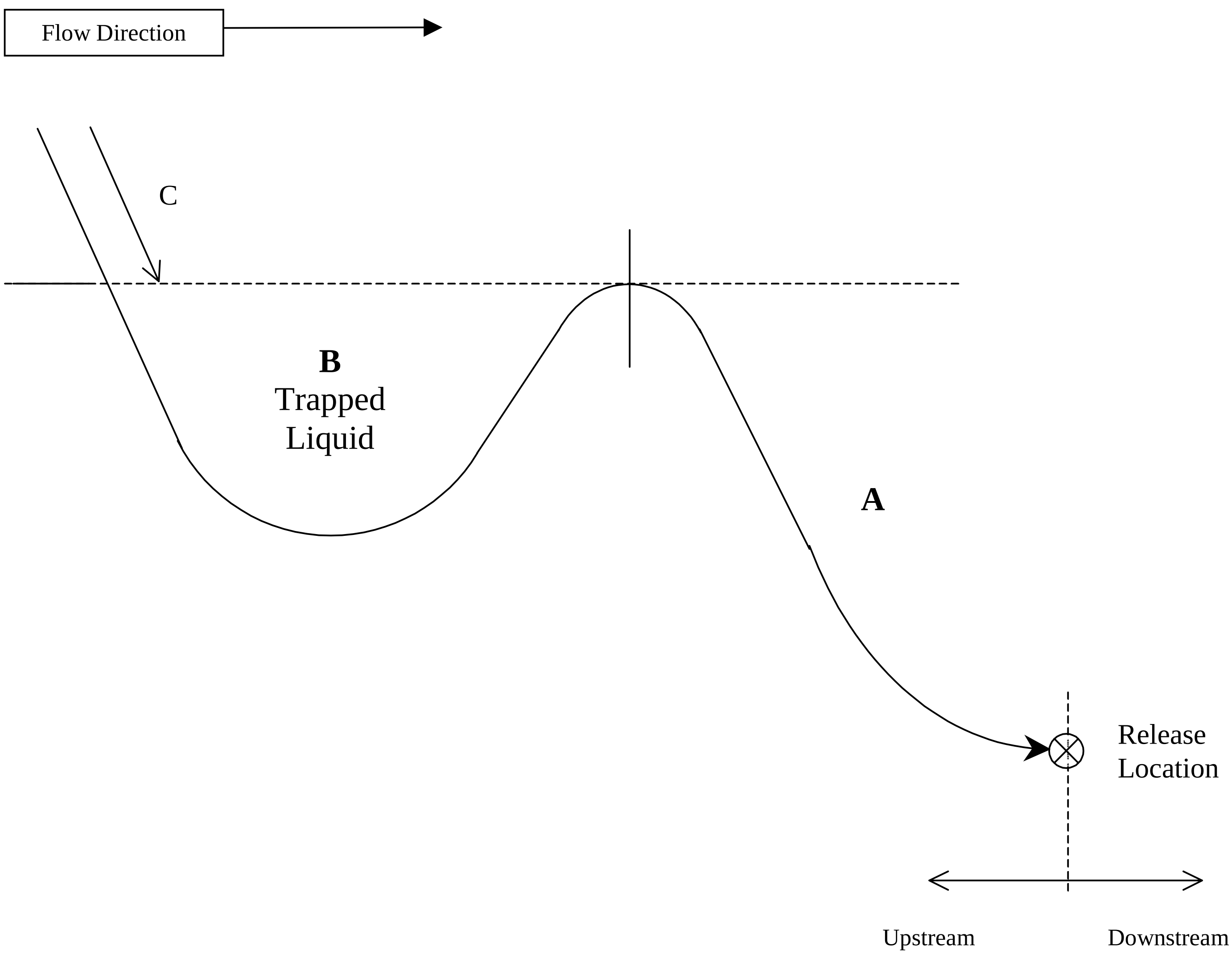
Valve placements have a direct influence on the static-release volumes, which are the volumes released after full closure of the valves. These are also the volumes contained between two adjacent closed valves. Since the purpose of this evaluation is to determine valve location effectiveness, static release volumes are used exclusively.

The static release volume, or drain-down volume, at any given point includes only the liquid in the upstream and downstream segments of pipe that is available to be released at that point by gravity-flow only, were a leak to occur. These volumes are initially located at elevations higher than or equal to the release point elevation and are, by definition, always isolated between two fully closed valves. These valves are 1) the nearest RCV valve upstream of the release point, and, 2) the nearest RCV or check valve downstream of the release point. The static volume component is independent of the pumping rate and does not include the volume of liquid in depressed areas of the pipeline that trap the liquid. In Figure 3-1, the upstream static component includes the volume of liquid in Sections-A and -C of the pipe. The upstream static component does not include the volume of liquid trapped in Section-B of the pipe. The static release volume at any given release point is affected by the locations of the block valves and check valves, and by the topographical features between those valves. Although Figure 3-1 shows only the segment of pipeline upstream of a potential release site, the downstream static component is determined by the same method as the upstream static component.

The elevation profile of the pipeline is plotted using OPL pipeline alignment sheets. This profile is used to set up the static-release volume spreadsheet with the mileposts, associated elevations, high and low points, pipe lengths, valve locations, and sensitive resources descriptions.

Valve selections and locations are based upon the static release volumes only. Transient release volumes are much less affected by valve placements and are not used herein to determine valve effectiveness. As a comparison for the effectiveness of the existing and new valves, static release volumes for the "existing" and the "existing plus converted & new" valve cases are graphically displayed in Appendix-B. These graphs plot the potential static-release volume at each milepost location based upon complete loss of liquid from the pipeline. In the majority of cases, the flow of product from most pipeline leaks will not be from a complete line-separation failure or "guillotine release," but from a smaller opening in the pipeline system. In this case, static drain-down would be at a lower rate than that observed in a guillotine failure. A lower static-release rate may facilitate plugging of the pipeline at the leak point by OPL response crews during pipeline drain-down, prior to complete loss of product from the isolated line segment. This may result in lower static and total release volumes.

FIGURE 3-1, STATIC RELEASE COMPONENTS



The Appendix-A spreadsheets tabulate the calculated static release volumes for three static release conditions. The first condition, "No Valves," shows the calculated release volumes at identified points on the pipeline assuming there are no valves to isolate a leaking segment. The second condition, "Existing RCV's and Check Valves," shows the calculated release volumes at identified points on the pipeline assuming closure of only the "existing" RCV block valves and check valves. The third condition, "Existing + Converted & New RCV's and Check Valves," shows the calculated release volumes at identified points on the pipeline assuming closure of all RCV block valves and check valves, both "existing" and "new". For all release volume calculations, all HOV block valves are assumed to remain in the "open" position. Results of the Appendix-A spreadsheets are graphically displayed in Appendix-B.

The largest calculated potential static-release volume with the existing valve configuration, or "peak" static release, is approximately 7,733 barrels (bbl), occurring at milepost MP-35.32 and located 2½-miles downstream of the Samish River crossing. The release at this milepost is reduced to 2,461 bbl with operation of the new RCV at MP-33.66, a 68% reduction. With operation of the existing, converted and new valves, the peak potential static-release from Ferndale to Allen would decrease from 7,733 bbl to 3,963 bbl and would now occur at MP-32.74, the location of the Samish River crossing. This represents a 49% reduction in the peak static-release volume for the Ferndale-Allen section of pipeline.

The "average" and "peak" release volumes in Table 1A are calculated for each line section[1]. Analysis of the calculated "average" and "peak" release volumes in Table 1A shows, in Table 1B, the effectiveness, or benefits of the additional new valves and valve conversions. The new valves and conversions are shown to decrease both the "average" release volumes and "peak" release volumes for the "Existing + Converted & New Valves" vs. "Existing Valves Only". "Average reduction", as used in Table 1B, is defined as the average of all the single-point reductions within any given line section. "Peak reduction" is defined as the greatest single-point reduction observed among all points within any given line section. Any reduction in observed static release volume within a given line section can be fully attributed to one or both of the valves at the ends of that section. Tabulation of potential release-volume reductions for line sections allows the evaluator to show the combined effectiveness of any two adjacent valves on a given section.

The most significant reductions are shown in Sections 2, 5, 10 and 11. A new check valve was installed on an up-sloping section at milepost 16.18, line section 5, adjacent to an existing RCV and in the area of the prior Bellingham spill. The benefits of this valve do not appear in the static-release volume calculations because it is in the same location as the RCV. Because of its quick closure upon flow reversal, the check valve will more rapidly isolate the pipeline than the RCV alone, in case of a sufficient upstream release or pipeline shutdown. It will serve to reduce the liquid volume back flowing from the downstream (up-slope) portion of the pipeline, past the RCV, while the leak is being detected and the RCV is being closed. If the upstream leak is not of a sufficient release rate, the liquid may not back flow and the check valve may not close before the RCV has closed.

[1] A "line section" is defined as a continuous run of pipe that is contained between adjacent pressure pump stations, between a pressure pump station and a terminal or breakout tank, between a pressure pump station and a block valve, or between adjacent block valves.

TABLE 1A - STATIC RELEASE VOLUMES AT LINE SECTIONS

(Valve-to-Valve)

Location		***Static Release Volume [bbl]*** ***Existing Valves (E), and Existing + New Valves (E+N)*** *Releases are evaluated with HOV's in the "open" position*			
Line Section Number	***Actual Mileposts***	***Average[2]***		***Peak[3]***	
		(E)	***(E+N)***	***(E)***	***(E+N)***
1	(E) RCV @ 0.00–to-(E) RCV @ 6.79	2,159	2,159	3,691 @ MP-5.59	3,691 @ MP-5.59
2	(E) RCV @ 6.79-to-(N) CV @ 8.10	3,282	334	3,689 @ MP-7.64	613 @ MP-6.82
3	(N) CV @ 8.10-to-(N) RCV @ 11.93	2,127	1,434	3,315 @ MP-9.04	2,642 @ MP-9.04
4	(N) RCV @ 11.93-to-(E) RCV & (N) CV @ 16.18	1,514	1,048	2,954 @ MP-12.34	1,846 @ MP-12.34
5	(E) RCV & (N) CV @ 16.18-to-(N) CV @ 16.76	2,570	385	2,864 @ MP-16.20	679 @ MP-16.20
6	(N) CV @ 16.76-to-(N) CV @ 20.60	1,180	1,031	2,185 @ MP-16.76	2,185 @ MP-16.76
7	(N) CV @ 20.60-to-(N) CV @ 22.02	999	642	1,731 @ MP-21.86	873 @ MP-20.74
8	(N) CV @ 22.02-to-(N) CV @ 25.28	2,039	1,558	3,543 @ MP- 25.28	2,565 @ MP-24.69
9	(N) CV @ 25.28-to-Conv. RCV @ 27.80	1,813	1,813	3,340 @ MP-25.43	3,340 @ MP-25.43
10	Conv. RCV @ 27.80-to-Conv. RCV @ 33.66	4,962	2,055	7,479 @ MP-32.74	3,963 @ MP-32.74
11	Conv. RCV @ 33.66-to-(E) RCV @ 39.39	6,309	1,515	7,733 @ MP-35.32	2,461 @ MP-35.32
12	(E) RCV @ 39.39-to-(E) RCV @ 41.42	784	784	1,420 @ MP-40.58	1,420 @ MP-40.58

[2] "Average" is the mathematical average of all the milepost release volumes evaluated within a given section.
[3] "Peak" is the single point of greatest value of all the milepost release volumes evaluated within a given section.

TABLE 1B - EFFECTIVENESS OF NEW VALVES ON LINE SECTION SPILL REDUCTIONS

(Valve-to-Valve)

***Line* Section**	***Actual Mileposts***	***Average Reduction [bbl]***	***Peak Reduction [bbl]***
1	0.00 - 6.79	0	0
2	6.79 – 8.10	2,948	3,096
3	8.10 – 11.93	693	839
4	11.93 – 16.18	466	1,108
5	16.18 – 16.76	2,185	2,185
6	16.76 – 20.60	149	319
7	20.60 – 22.02	357	866
8	22.02 – 25.28	482	1,036
9	25.28 – 27.80	0	0
10	27.80 – 33.66	2,907	3,516
11	33.66 – 39.39	4,794	5,272
12	39.39 – 41.42	0	0

Potential Release Volume Calculation

The following is a typical procedure of the release volume calculation:

Point-to-point volume = (Length of pipe) x (Inside section area of pipe)

Where,

Length of pipe $= [(\Delta \text{ Elevation})^2 + (\Delta \text{ Distance})^2]^{1/2}$, and

Inside section area of pipe $= \pi$ (Inside radius of pipe, ft.)^2

$= \pi$ [(Outside diameter of pipe)/2-(Pipe wall thickness)]^2

After this "point-to-point" volume has been calculated for all points, the static-release volume at each point is calculated as follows:

Static release = [volume upstream of location] + [volume downstream of location] – [trapped volume upstream of location] – [trapped volume downstream of location]

Only volumes which could gravity flow to a given leakage location and contribute to a spill are used in this calculation. Trapped volumes, volumes contained in sections that are topographically isolated from the leak point and volumes that are isolated by valves from the leak point are not included.

Transient-release volumes are released prior to full closure of the RCV's and are not relevant to the scope of this evaluation.

Total release volume is calculated as follows:

Total release volume = (static release) + (transient release)

This same procedure applies to the calculations for the "no valves," the "existing valves," and the "existing plus new valves" conditions. The static release volume at each point can be found in Appendix-A. Evaluation of total release volumes is not relevant to the scope of this evaluation.

4.0 VALVE LOCATIONS

Review of block valve and check valve effectiveness utilizes the valves listed in Table 2. "Existing" valves were present at the time of the 1999 Bellingham area pipeline failure on the Ferndale to Allen section, and "New" valves are those installed or modified as a result of this study, completed since the pipeline failure.

TABLE 2 - VALVE LOCATIONS

Actual Milepost	*Valve Type*	*Operation*	*Valve Status*
0.00	Block Valve	Remote Controlled	Existing
6.79	Block Valve	Remote Controlled	Existing
8.10	Check Valve	Automatic	New
11.93	Block Valve	Remote Controlled	New
16.18	Check Valve	Automatic	New
16.18	Block Valve	Remote Controlled	Existing
16.76	Check Valve	Automatic	New
20.60	Check Valve	Automatic	New
22.02	Check Valve	Automatic	New
25.28	Check Valve	Automatic	New
27.80	Block Valve	Remote Controlled	Converted[4]
33.66	Block Valve	Remote Controlled	Converted [4]
39.39	Block Valve	Remote Controlled	Existing
41.42[5]	Block Valve	Remote Controlled	Existing

[4] This is an existing hand operated valve that has been converted to a remote controlled valve.

[5] Note that the longer Allen-to-Bayview-to-Allen segment of this pipeline was installed after the original pipeline from Ferndale to Portland. This segment of pipeline bypasses Allen Station at approximately MP-37.35 and returns at MP-41.42. Subsequent downstream references to Allen Station identify it as its original MP-37.35 location.

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There are two valves located at MP-16.18. The new check valve is located upstream of the existing RCV block valve, located on an up-sloping grade. This check valve, the check valve at MP-8.10 and the RCV at MP-11.93 were installed in accordance with the “Pipeline Safety Immediate Action Plan”. The check valve at MP-16.18 will provide a more rapid response than the existing RCV in case of an upstream major release.

The new valve sites and converted valve sites were selected considering the abundance of sensitive resources within a 1-mile perimeter of the pipeline ROW, with emphasis on the abundance within the predicted drainage paths. Areas of abundant sensitive resources are compared with the static-release volume profile. New valves are added or existing HOV’s are converted in sensitive areas where volumes are comparatively high and significant improvements can be obtained.

5.0 DRAINAGE AND VALVE LOCATION ANALYSIS

Drainage Analysis

A spill of sufficient volume has the potential to find its way to a stream or river, and thence to a lake or bay. In order to determine the possible drainage paths and destinations of product released along the pipeline, from Ferndale to Allen, a drainage analysis was prepared. To conduct the analysis, USGS topographical maps of 1:24,000 scale (7.5-minute meridians) were obtained to cover the pipeline section from Ferndale Station to Allen Station. The resulting drainage "footprints" are shown in Appendix-C. Shaded areas adjacent to the pipeline indicate land areas that could potentially be impacted by an up-gradient spill. Flow lines within these areas indicate the likely drainage paths that would be followed by the liquid. Each shaded area converges to a stream path, directly impacts a water body, or encounters a barrier or depression. Table 3 indicates the destination and drainage path of potential spills at given milepost locations.

The drainage path analysis does not consider valve locations, valve effectiveness, or potential spill volumes. It simply models a possible surface flow-path for any liquid of sufficient volume originating along the pipeline route. The actual fate of a given spill would depend upon the total volume and rate of release, the location, soil permeability and porosity along the drainage path, slope of the path, and other factors. A small "leak" may impact only the area local to the spill, whereas a "guillotine failure" near a river, stream, creek, or slough could impact a greater area. Specific considerations for each portion of this pipeline section are pointed out in the "Valve Location Analysis" discussion.

The analysis is interpretive in that it relies on the elevation contours on the USGS maps. The pipeline route was drawn on the maps with OPL milepost markers indicated. Then the topography, as well as the presence of streams, rivers, sloughs, etc., was examined to predict the probable drainage footprints for a liquid released anywhere along the pipeline route. The topographic elevation contour interval on the maps is 20 feet, although the 10 feet above sea level contour is included in some areas. The liquid is assumed to follow the gravitational path of least resistance (the steepest slopes) until a natural stream, a water body, physical barrier, or depression within a one-mile distance is encountered. When a stream is encountered, it is followed to its ultimate destination. Any features that are not apparent on the 7.5-minute maps are not considered in the analysis. However, the predicted drainage footprints and paths are believed to be reasonably representative of actual drainage conditions. In some sections, the path may not lead to a water body.

Releases that occur near developed areas have the potential to enter storm drains through openings along roadways. Developed areas are shown on the maps; however, actual locations of storm drains and storm drain openings have not been identified.

The "average" and "peak" release volumes in Table 4 are calculated for each drainage section[6]. Analysis of the calculated "average" and "peak" release volumes in Table 4 shows, in Table 5, the effectiveness, or benefits of the additional new valves and valve conversions to the environmental areas. The new valves and conversions are shown to decrease both the "average" release volumes and "peak" release volumes. The most significant reductions are shown in Sections 28 to 32.

Some Drainage Sections have two spill-drainage possibilities. "Option 1" represents drainage to a water body and "option 2" represents pooling in a depression. These two options appear in Tables 3, 4 and 5 and apply to Drainage Sections 22 - 23, and Sections 28 - 29.

[6] A "drainage section" is defined as a section of pipeline where any liquid originating from a release within that section would follow the same drainage path.

Valve Location Analysis

Pipeline sections are discussed herein with respect to static release volumes. When evaluated for potential spill reductions, the static volume is the component primarily affected by valve location. In selecting possible valve locations, consideration is given not only to the size of potential static-release volumes, but also to the impact on sensitive resources.

A remote controlled block valve (RCV) is capable of stopping flow when a leak is located on either its upstream or downstream side. A check valve allows flow in only one direction and so is capable of stopping flow only when the leak is located on its upstream side. The valve type selected for protecting a given location is based on the pipeline elevation profile, the slope direction of the pipeline at that point, and on the area to be protected. The upstream side of a valve is the side that the fluid enters when the pumps are operating, and the downstream side is that which the fluid exits from when the pumps are operating. Check valves are typically located where the fluid is being pumped uphill during normal pipeline operation. Block valves can be beneficially located on up-slopes or down-slopes.

In the text, spreadsheets and charts of this study, "actual pipe length mileposts," are calculated to two decimal places, and used for pipeline volume calculations. Other milepost designations are from OPL's field numbering system. These two types of mileposts may differ slightly at any given location. Both types have been identified on the spreadsheets. OPL milepost designations are the only ones that appear on the maps.

In performing the valve location analysis, the Ferndale-Allen pipeline section is broken down into smaller segments. Each segment is essentially self-contained in that a failure within any given segment will result in containment of the static liquid volume within that segment, after closure of existing RCV's and CV's. In some cases, there may be a minor exchange of liquid volumes between neighboring segments. An attempt was made to maximize the length of each segment by utilizing the natural topographical high points, as well as the existing valves, for isolation. All liquid volumes in the following discussions are calculated from potential static (drain-down) releases with the RCV's and CV's closed. The data, profiles and maps located in the Appendices were used to develop this analysis.

Milepost-0.00 to MP-14.63

Location Review with Previously-Existing Valves

This segment of the pipeline is between MP-0.00, Ferndale Station on the north end at 180-ft. elevation and MP-14.63 at 350-ft. elevation. MP-14.63 is on the north edge of the City of Bellingham. The pipeline passes through the City of Ferndale between OPL mileposts 3 and 5. At OPL milepost 8, the pipeline crosses Silver Creek at a point where it flows northward. Squalicum Creek is crossed at OPL milepost 13, where, about ¾ mile downstream of the crossing, a school and child day care center (CDC) are adjacent to the creek. Existing valves in this pipeline segment were RCV's located at Ferndale Station and at MP-6.79 (OPL MP-7). A potential existed for a static release of 3,578 barrels at MP-7.75, Silver Creek crossing, which could flow in the creek towards sensitive resources in Ferndale. At MP-12.96, Squalicum Creek, the potential static-release volume was 2,908 barrels, and it could enter the City of Bellingham via the creek.

Improvements Made

Two new valves have been installed as follows: a new check valve at MP-8.10 (OPL 8) and a new RCV at MP-11.93 (OPL 12). The check valve reduces potential static drain-down at the adjacent Silver Creek crossings from 3,600-3,700 bbl to 500-600-bbl, a 3,100-bbl (85%) reduction. At MP-12.96, Squalicum Creek crossing, the new RCV decreases potential static drain-down from 2,908 bbl to 1,800 bbl, a 1,108-bbl (62%) reduction. This RCV location also protects the unnamed stream crossing at MP-12.34 and the Hannegan Rd. crossing at MP-12.37.

Milepost 14.63 to MP-18.56

Location Review with Previously-Existing Valves

This segment extends southward, from MP-14.63 at an elevation of 350-ft., to MP-18.56 at an elevation of 870-ft. at the Ferndale-Allen pipeline section high-point. The City of Bellingham is located between OPL mileposts 14 and 17, and has the greatest abundance of sensitive resources. Whatcom Creek, the location of the 1999 spill, is located at OPL milepost 16. An existing RCV was located at MP-16.18 (OPL 16). Potential static release within the City of Bellingham was 0–1,072 bbl upstream (north) of the RCV and 1,898-2,864 bbl downstream of the RCV.

Improvements Made

Two new valves have been installed as follows: a new check valve at MP-16.18 and a new check valve at MP-16.76 (OPL 17).

- The check valve at MP-16.18, in accordance with the "Pipeline Safety Immediate Action Plan," backs up the existing RCV at the same milepost. It's purpose is to reduce the response time required to isolate this segment, as well as to serve as a backup in case the RCV fails to close. There is no calculated reduction in potential static drain-down for this valve. However, this valve will reduce the transient release volume resulting from a major upstream leak because it will close automatically upon flow reversal rather than waiting for operator intervention after leak detection.

- The addition of a new check valve at MP-16.76 reduces potential static drain-down by 2,185 bbl at all points between this CV and the valves at MP-16.18. The peak potential static-release, which occurs at MP-16.20, is reduced from 2,864 bbl to 679 bbl (76% reduction). At the upstream end of this CV, there is a reduction from 2,185 bbl to zero barrels (100% reduction). This CV reduces the potential volume that could enter Whatcom Creek via the stream path adjacent and parallel to the pipeline in this segment. It also protects the area near the middle school located up-slope from the valves at MP-16.18. In the densely populated area within the Bellingham City limits, between MP-13.80 and MP-17.00, the average potential static drain-down volume is reduced from 1,150 bbl to 801 bbl, a 349-bbl (30%) reduction.

Milepost 18.56 to MP-21.45

Location Review with Previously-Existing Valves

This segment extends southward, from MP-18.56 at the pipeline section high-point of 870-ft. elevation, to an elevation of 825-ft. at MP-21.45. In this segment, the pipeline dips to a low elevation of 350-ft. at MP-20.36, the Chuckanut Creek crossing. The pipeline crosses Interstate Highway I-5 at MP-20.22 and Chuckanut Creek at MP-20.52. The peak potential static-release in this segment was 1,950 bbl at MP-20.36. This segment is lightly populated adjacent to the pipeline ROW. There were no existing valves in this segment.

Improvements Made

A new CV has been installed at MP-20.60. It reduces potential static release at the I-5 crossing from 1,950 barrels to 1,632 barrels, a 319-bbl (16%) reduction. At MP-20.52, Chuckanut Creek, the reduction is from 1,578 bbl to 1,259 bbl, a 319-bbl (20%) reduction. The peak potential static-release occurring at MP-20.36 is reduced from 1,950 bbl to 1,632 bbl, a 319-bbl (16%) reduction.

Milepost 21.45 to MP-22.73

Location Review with Previously-Existing Valves

This segment extends southward from MP-21.45 at an elevation of 825 ft. to MP-22.73 at an elevation of 720 ft. The pipeline in this segment dips to a low elevation of 250 ft. at the Lake Samish crossing, MP-21.86. The peak potential static-release in this segment was 1,731 bbl at Lake Samish. This segment is lightly populated adjacent to the pipeline ROW. There were no existing valves in this segment.

Improvements Made

A new check valve has been installed at MP-22.02. It reduces the potential static release at Lake Samish MP-21.86 from 1,731 barrels to 865 barrels, an 866-bbl (50%) reduction. The potential release at Roy Rd. (MP-21.93) is reduced from 1,525 barrels to 658 barrels, an 866-bbl (57%) reduction. The peak potential static-release of 1,082-bbl would now occur at MP-22.25, reduced from 1,731 barrels at MP-21.86, a 649-bbl (37%) reduction.

Milepost 22.73 to MP-26.14
Location Review with Previously-Existing Valves

This segment extends southward from MP-22.73 at an elevation of 720-ft. to MP-26.14 at an elevation of 685-ft. The pipeline in this segment dips to a low elevation of 425 ft. at the Bear Creek crossing, MP-24.69. Bear Creek drains to nearby Lake Samish. The peak potential static-release of 3,543 bbl in this segment would have occurred at MP-25.28. This segment is lightly populated adjacent to the pipeline ROW. There were no existing valves in this segment.

Improvements Made

A new check valve has been installed at MP-25.28. It reduces potential static release at Bear Creek from 3,339 bbl to 2,565 bbl, a 773-bbl (23%) reduction. The peak potential static-release is not affected.

Milepost 26.14 to MP-41.42
Location Review with Previously-Existing Valves

This segment extends southward from MP-26.14 at an elevation of 685-ft. elevation to MP-41.42, Allen Station at an elevation of 15-ft. The general drainage direction of this segment is from north to south, towards Allen Station. The pipeline crosses Colony Creek at MP-28.36 and MP-28.93; Edison Slough at MP-31.74; Hwy 1 at MP-32.39; the Samish River at MP-32.74; and Leary Slough at MP-34.71. The Upland Bird State Wildlife Refuge is located just south of OPL MP-34. Olympia Marsh covers the general area between OPL mileposts 34 and 37. The peak potential static-release with the existing valve configuration was 7,733 bbl at MP-35.32. Existing valves were RCV's at MP-39.39 and Allen Station. This segment is lightly populated adjacent to the pipeline ROW.

Improvements Made

Conversions of existing HOV's to RCV's were made at MP-27.80 and MP-33.66.

- The RCV at MP-27.80 (OPL 28) protects the area between the two new valves (OPL 28 to 34). Reductions in potential static releases effected by this valve are; Colony Creek, from 3,975 barrels to 1,338 barrels, a 2,637-bbl (66%) reduction; Edison Slough, from 5,438 barrels to 2,543 barrels, a 2,895-bbl (53%) reduction; Highway 1, from 5,529 barrels to 2,414 barrels, a 3,115-bbl (56%) reduction; Samish River, from 7,479 barrels to 3,963 barrels, a 3,516-bbl (47%) reduction; and Leary Slough, from 7,337 barrels to 2,065 barrels, a 5,272-bbl (72%) reduction.

- The RCV at MP-33.66 (OPL 34) primarily protects the wildlife refuge and Olympia Marsh. The average potential static release in this area is reduced from 6,615 barrels to 1,531 barrels, a 5,084-bbl (77%) reduction.

The peak potential static-release for this Ferndale to Allen segment is reduced from 7,733 barrels at MP-35.32 to 3,963 barrels at MP-32.74, a 3,773-bbl (49%) reduction.

TABLE 3 - SPILL DESTINATIONS AND PATHS FOR DRAINAGE SECTIONS

Drainage Section	*OPL Mileposts*	*Water Body Destination*	*Destination Location*	*Via Path*
1	0.0 - 0.7	Strait of Georgia	Neptune Beach	
2	0.7 - 1.3	Lummi Bay	N. of Sandy Point Shores	unnamed stream
3	1.3 - 3.0	Lummi Bay	N end of seawall at golf course	unnamed creeks/culverts
4	3.0 - 4.0	Lummi Bay	Lummi River outlet, S end of seawall	Lummi River, via unnamed stream
5	4.0 - 4.6	Lummi Bay	Lummi River outlet, S end of seawall	Lummi River
6	4.6 - 5.4	Bellingham Bay	Fish Point	Slater Slough, via unnamed streams/culverts
7	5.4 - 5.7	Bellingham Bay	Fish Point	Nooksack River
8	5.7 - 6.4	Bellingham Bay	1 mile SW of Marietta	Silver Creek, via unnamed stream
9	6.4 - 10.7	Bellingham Bay	1 mile SW of Marietta	Silver Creek
10	10.7 - 11.5	Bellingham Bay	Squalicum Creek, outlet to bay	Squalicum Creek, via unnamed streams
11	11.5 - 12.2	Possible pooling	Depression SW of pipeline	Note: Overflow would run to Bellingham Bay as indicated in previous entry
12	12.2 - 12.8	Bellingham Bay	Squalicum Creek, outlet to bay	Squalicum Creek, via unnamed streams
13	12.8 - 14.3	Bellingham Bay	Squalicum Creek outlet to bay	Squalicum Creek
14	14.3 - 15.8	Bellingham Bay	Bellingham	Whatcom Creek, via unnamed stream
15	15.8 - 16.7	Bellingham Bay	Bellingham	Whatcom Creek
16	16.7 - 18.7	Bellingham Bay	Bellingham	Whatcom Creek, via unnamed stream
17	18.7 - 19.2	Bellingham Bay	South Bellingham	Padden Creek, via Lake Padden, via unnamed stream
18	19.2 - 20.2	Bellingham Bay	South Bellingham	Padden Creek, via Lake Padden, via unnamed stream
19	20.2 - 21.5	Chuckanut Bay	Chuckanut Village	Chuckanut Creek
20	21.5 – 23.5	Samish Bay	Inlet SW of Edison	Samish River, via Friday Creek, via Samish Lake
21	23.5 – 25.4	Samish Bay	Inlet SW of Edison	Samish River, via Friday Creek, via Bear Creek, via Samish Lake
22	25.4 – 26.2 (option 1)	Samish Bay	Inlet SW of Edison	Samish River, via Friday Creek, via Bear Creek, via Samish Lake
23	25.4 – 26.2 (option 2)	Possible pooling	Depression East and West of pipeline	Note: Overflow would run to Samish Bay as indicated in previous entry
24	26.2 – 28.5	Samish Bay	SE of Windy Point	Colony Creek
25	28.5 - 29.4	Samish Bay	SE of Windy Point	Colony Creek

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TABLE 3 - SPILL DESTINATIONS AND PATHS FOR DRAINAGE SECTIONS

Drainage Section	*OPL Mileposts*	*Water Body Destination*	*Destination Location*	*Via Path*
26	29.4 - 31.9	Samish Bay	W of Edison	Edison Slough
27	31.9 - 33.6	Samish Bay	Inlet SW of Edison	Samish River
28	33.6 - 33.9 (option 1)	Padilla Bay	W of View Edison Dr. at D'Arcy Rd.	Joe Leary Slough
29	33.6 - 33.9 (option 2)	Possible pooling	Depression West of pipeline	Note: Overflow would run to Padilla Bay as indicated in previous entry
30	33.9 - 35.0	Padilla Bay	W of View Edison Dr. at D'Arcy Rd.	Joe Leary Slough, via unnamed streams
31	35.0 - 36.0	Padilla Bay	W of View Edison Dr. at D'Arcy Rd.	Joe Leary Slough, via unnamed streams
32	36.0 - 37.0	Padilla Bay	S end of bay	Indian Slough, via unnamed stream
33	37.0 – 41.4	Padila Bay	S end of bay	Indian Slough, via unnamed stream

TABLE 4 - STATIC RELEASE VOLUMES AT DRAINAGE SECTIONS

Location		*Average Release Volume [bbl]*			*Peak Release Volume [bbl]*		
Drainage Section	*OPL Mileposts*	*No Block Valves*	*Existing Valves*	*Exist. And New Valves*	*No Block Valves*	*Existing Valves*	*Exist. And New Valves*
1	0.0 - 0.7	4,598	395	395	4,771	574	574
2	0.7 - 1.3	4,966	447	447	5,498	861	861
3	1.3 - 3.0	7,222	1,536	1,536	9,802	3,662	3,662
4	3.0 - 4.0	9,418	3,277	3,277	9,774	3,633	3,633
5	4.0 - 4.6	8,857	2,716	2,716	9,142	3,001	3,001
6	4.6 - 5.4	9,389	3,248	3,248	9,812	3,671	3,671
7	5.4 - 5.7	9,355	3,305	3,305	9,831	3,691	3,691
8	5.7 - 6.4	8,651	2,510	2,510	9,265	3,124	3,124
9	6.4 – 10.7	7,110	2,888	1,150	8,595	3,689	2,642
10	10.7 – 11.5	4,081	1,305	632	4,311	1,535	862
11	11.5 – 12.2	4,712	1,935	1,135	5,052	2,275	1,436
12	12.2 – 12.8	5,415	2,639	1,531	5,730	2,954	1,846
13	12.8 – 14.3	4,769	1,993	1,172	5,685	2,908	1,800
14	14.3 – 15.8	3,565	699	699	4,012	1,149	1,149
15	15.8 – 16.7	3,563	1,467	812	4,024	2,864	1,137
16	16.7 – 18.7	1,203	1,203	984	2,185	2,185	2,185
17	18.7 – 19.2	540	540	431	707	707	575
18	19.2 – 20.2	1,199	1,199	947	1,497	1,497	1,258
19	20.2 – 21.5	950	950	839	1,950	1,950	1,632
20	21.5 – 23.5	1,209	1,209	757	1,806	1,806	1,395
21	23.5 – 25.4	2,787	2,787	2,124	3,543	3,543	3,340
22	25.4 – 26.2 (option 1)	1,418	1,418	1,418	2,233	2,233	2,233
23	25.4 – 26.2 (option 2)	1,418	1,418	1,418	2,233	2,233	2,233
24	26.2 – 28.5	2,365	2,365	1,406	3,975	3,975	2,637
25	28.5 – 29.4	3,613	3,613	977	4,069	4,069	1,432
26	29.4 – 31.9	5,024	5,024	2,237	6,538	6,538	3,643
27	31.9 – 33.6	6,484	6,484	3,096	7,479	7,479	3,963
28	33.6 – 33.9 (option 1)	6,544	6,544	1,272	6,702	6,702	1,430
29	33.6 – 33.9 (option 2)	6,544	6,544	1,272	6,702	6,702	1,430
30	33.9 – 35.0	7,030	7,030	1,759	7,337	7,337	2,065
31	35.0 - 36.0	6,632	6,632	1,413	7,733	7,733	2,461

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Location		*Average Release Volume [bbl]*			*Peak Release Volume [bbl]*		
Drainage Section	***OPL Mileposts***	***No Block Valves***	***Existing Valves***	***Exist. And New Valves***	***No Block Valves***	***Existing Valves***	***Exist. And New Valves***
32	36.0 - 37.0	5,090	5,090	359	5,286	5,286	574
33	37.0 – 41.4	6,230	3,907	1,216	6,953	6,953	2,242

TABLE 5 - EFFECTIVENESS OF NEW VALVES ON DRAINAGE SECTION SPILL REDUCTIONS

***Drainage* Section**	***OPL Mileposts***	***Average Reduction [bbl]***	***Peak Reduction [bbl]***
1	0.0 - 0.7	0	0
2	0.7 - 1.3	0	0
3	1.3 - 3.0	0	0
4	3.0 - 4.0	0	0
5	4.0 - 4.6	0	0
6	4.6 - 5.4	0	0
7	5.4 - 5.7	0	0
8	5.7 - 6.4	0	0
9	6.4 - 10.7	1,738	3,096
10	10.7 - 11.5	673	673
11	11.5 - 12.2	800	839
12	12.2 - 12.8	1,108	1,108
13	12.8 - 14.3	820	1,108
14	14.3 - 15.8	0	0
15	15.8 - 16.7	655	2,185
16	16.7 - 18.7	218	2,185
17	18.7 - 19.2	109	132
18	19.2 - 20.2	252	283
19	20.2 - 21.5	111	319
20	21.5 - 23.5	452	866
21	23.5 - 25.4	663	1,036
22 (option 1)	25.4 - 26.2	0	0
23 (option 2)	25.4 - 26.2	0	0
24	26.2 - 28.5	959	2,637
25	28.5 - 29.4	2,637	2,637
26	29.4 - 31.9	2,788	2,895
27	31.9 - 33.6	3,389	3,516
28	33.6 - 33.9	5,272	5,272
29	33.6 - 33.9	5,272	5,272
30	33.9 - 35.0	5,272	5,272
31	35.0 - 36.0	5,220	5,272
32	36.0 - 37.0	4,731	4,790
33	37.0 – 41.4	2,691	4,741

6.0 SENSITIVE RESOURCES

For the purpose of this evaluation, Sensitive Resources were identified using input from the following sources:

- Yahoo! Internet Yellow Pages, dated Oct. 5, 1999;
- Washington Education Directory, Office of State Superintendent of Public Instruction, Copyright 1999-2000;
- Major buildings and landmarks from the Olympic Pipe Line Company Geographic Response Plan (GRP), dated Jan. 1996;
- U S WEST Dex, White & Yellow Pages, Bellingham and Whatcom County, Wash., 1999 – Jan. 2000;
- GTE White and Yellow Pages, Skagit County, Wash., Nov. 1999 – Winter 2000;
- Totem Atlas of Island, Skagit, Whatcom, and San Juan Counties, Copyright 1999;
- Thomas Guide, Pacific Northwest, Copyright 1998;
- USGS Topographic Quadrangle Maps, 1:24,000 Scale

The resulting data, which was obtained from these sources, may be found on the topographical maps in Appendix-C, under the heading "Pipeline Alignment and Predicted Drainage Paths". The sensitive resources include residential areas, population and business centers, schools, hospitals, rivers, creeks, streams, lakes, parks and wildlife preserves. All sensitive resources may not have been identified, necessarily, but an attempt was made to obtain a sufficient sampling to show points of concentration. Since most residential areas have grown since the USGS topographical maps were originally prepared, current Thomas maps were used to determine these areas.

Evaluation of all potential spill impacts has been made by comparing the release volume profiles in Appendix-B with the drainage maps in Appendix-C. Areas of relatively high release volumes were identified and then compared with the abundance or concentration of sensitive resources identified on the maps in the same locations, particularly those within the potential drainage paths. Valve recommendations were then made where significant spill volume reductions could be obtained.

7.0 SUMMARY

With milepost and elevation information from the pipeline alignment sheets, a pipeline elevation profile has been developed and point-to-point pipeline-volume spreadsheets have been prepared for the 16" Ferndale to Allen pipeline. Review of the elevation profile assisted in the development of spreadsheet formulas for potential pipeline release volumes. Applicable volumes that could gravity-drain from a leak at each milepost, after the pipeline valves have been closed, were then calculated. These are called "potential static-release volumes". These volumes were initially calculated for the "No Valves" case. Then, volumes were calculated for closure of the existing remote control valves (RCV) and check valves (CV). Review of the release volume profile for closure of existing valves enables the evaluator to determine areas with relatively high potential releases. "Existing" valves are those that were present at the time of the 1999 Bellingham area pipeline failure. Static release volumes are used to evaluate valve effectiveness because valve locations primarily affect these volumes, which release after the valves have fully closed.

United States Geological Survey topographical maps were prepared with spill drainage footprints for use in determining potentially affected areas. Sensitive resources were identified on these maps along the pipeline right-of-way. These were compared with potential spill-drainage paths to determine which sensitive resources may be directly affected by a pipeline release. The drain-down volume released within a line section, after closure of the existing RCV's and CV's, was then compared with the locations and abundance of sensitive resources within that same section. This comparison was performed for each section. New valves and conversions (modification) of existing hand-operated valves (HOV) to RCV's were then proposed where significant improvements could be obtained, and release volumes were re-calculated to determine the level of improvement with the new and converted valves. Remote control conversion of HOV's significantly reduces the response time required to close them.

As the distance between a potential leak site and a valve increases, the potential static volume that may be released also increases. Therefore, the further a valve is from a leak, the less effective the valve is in reducing the size of the release. In general, check valves are located at or prior to upward sloping areas and block valves are located at or following downward sloping areas to reduce product release to the "valley" areas. The deeper valley areas have the potential for the greatest release volumes. However, placing a valve closer to the bottom of one of these valleys reduces the length of pipeline that is protected. Hence, the selected valve location may be a balance between spill reduction size and size of the area protected.

There are nine (9) new or modified valve milepost (MP) locations. These locations are MP-8.10, MP-11.93, MP-16.18, MP-16.76, MP-20.60, MP-22.02, MP-25.28, MP-27.80 and MP-33.66. None of these locations uses hand-operated valves for calculation of potential static-release volumes. The eight (8) existing, new and modified RCV's located at MP-0.00, MP-6.79, MP-11.93, MP-16.18, MP-27.80, MP-33.66, MP-39.33 and MP-41.42 are operated through the supervisory control and data acquisition (SCADA) system at the Olympic Pipe Line Company Renton control center. In case of a pipeline release, the pumps will be shut down and these valves will be remotely actuated to close. The check valves will close automatically upon a sufficient upstream release or upon pipeline shutdown.

In accordance with the "Pipeline Safety Immediate Action Plan," a check valve was installed with the existing RCV at MP-16.18. A check valve will more rapidly isolate the pipeline segment than the RCV alone because of its quick automatic closure upon flow reversal. It will serve to reduce the potential liquid release that could back-flow from the downstream (up-slope) portion of the pipeline, past the RCV, while the leak is being detected and the RCV is being closed.

The valve locations at MP-8.10, MP-16.76, MP-20.60, MP-22.02 and MP-25.28 have check valves only.

In the densely populated area within the Bellingham City limits, between mileposts 13.80 and 17.00, an average reduction in potential static-release volume of approximately 30% has been achieved. Between MP-5.59 and MP-8.10, which includes schools, Silver Creek and a State Wildlife Area, the average reduction is approximately 52%. For the Olympia Marsh / State Wildlife Refuge Area between MP-33.66 and MP-36.27, an average reduction of approximately 77 % has been achieved.

At MP-35.32, the site of the largest calculated potential static-release volume with existing valves, the volume is reduced from 7,733 barrels (bbl) to 2,461 bbl, via operation of the new RCV at MP-33.66. This represents a 68% reduction for this location. With operation of the existing and new valves, the largest calculated static-release would be reduced from 7,733 bbl to 3,963 bbl and it would now potentially occur at MP-32.74. This represents a 49% reduction in the largest calculated static-release volume for any point between Ferndale and Allen.

Significant reductions in potential static-release volumes have been achieved via implementation of the new and modified valves, compared to volumes associated with existing valves only. These drainage volumes and reductions are summarized in Tables 1A, 1B, 4 and 5, and graphically displayed in Appendix-B.

APPENDIX A

System and Static Release Data

APPENDIX B

Elevation and Release Volume Profiles

- Elevation Profile
- Release Volume Profiles
  - No Valves
  - “Existing” RCV’s and Check Valves
  - “Existing” Plus New & Converted RCV’s and Check Valves

APPENDIX C

Pipeline Alignment and Predicted Drainage Paths

16” Ferndale-to-Allen Pipeline, 10-pp.