Appendix 9A

Post-Mitigation Relative Probability-of-Failure Scores

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Longhorn Pipeline post-mitigation conditions and activities were re-assessed at several stages of the Environmental Assessment (EA) process using the EA relative risk model. The intent of the assessments was to capture the latest mitigation commitments and ensure that an appropriate level of mitigation is applied to all areas along the pipeline.

Since the risk picture is constantly changing, assessments provide a snapshot at one point in time. Assessments were conducted several times since the publication of the draft EA in October 1999. The pre-mitigation assessment is described in the draft EA and reflects conditions and activities as of the summer of 1999. This report references an assessment conducted in March of 2000, which is referred to as the "3-00 assessment." The final assessment, conducted in September 2000, is described in this report and reflects the point in time where the first in-line inspection (ILI) and follow-up is complete, all other mitigation measures are complete and/or continuing as described in the Longhorn Mitigation Plan (LMP), and the intended MOP is available to Longhorn (the interim MOP is to be used until after the first ILI, so this is not a factor in this risk assessment).

The post-mitigation assessment was performed on the System after it was sectioned as summarized in the following table:

Tier	1	2	3	Total
Length, ft	3,066,137	480,479	116,055	3,662,671
Count of sections	4,687	1,056	372	6,115
Length, miles	580.7	91.0	22.0	693.7

The section count changed from the pre-mitigation assessment of ~8000 segments to ~6100 segments. Note (from EA Chapter 6) that section breaks are inserted whenever a risk factor changes. The reduction in number of sections is due to the replacement of several data sets and to mitigation measures that reduced the risk variability along the line. Examples include the use of results from the specific earth movement studies which replaced the more general USGS data for landslides, seismic, and scour potential that was used in the pre-mitigation assessment.

Discussion of Results

1. For the 3-00 assessment, eight (out of 63) algorithms were modified from the original (summer 1999) pre-mitigation assessment to accommodate new information. Additional modifications were made in this final assessment to accommodate new information and correct minor errors in previous assessments. Modifications are explained in this document and all equations used to produce final scores are shown Attachments A and B of this appendix.

2. A histogram of the index sums was prepared. It shows a generally symmetrical distribution about the average, although a disproportionate number of sections are scoring in a rather narrow range. Investigation of these sections shows that they have very consistent Corrosion Index Scores, higher than the overall average because of better scores given to the variables of buried_coating and buried_environment. These variables in turn are a function of several sub-variables such as coating age, soil corrosivity, and the results of previous visual inspections. It is not clear whether this pipeline has an imbalance of sections with these common characteristics or whether the model is preferentially producing scores in this range. It does not appear to be related to the section lengths, since an examination of the length-adjusted Corrosion Index scores produces similar results. Since this pattern does not appear to be correlated with tier sensitivities and since the suspect scores are indicating above-average conditions, any possible model bias toward these scores is not thought to impact the EA.

3. Quality assurance and quality control checks were performed by charting data and performing various correlations between variables.

4. Final scores are very close to previous 3-00 assessment scores.

5. All sections are in compliance with tier level targets.

6. No apparent deficiencies are noted within each index.

The results of the final assessment are shown in the following tables:

	Index Sum*	**Third-Party Damage**	**Corrosion**	**Design**	**Incorrect Operations**
Pre-mitigation Scores: Averages	195.3	52.0	37.2	39.8	66.3
Post-mitigation Scores: Overall Averages	289.4	71.9	77.4	67.3	79.1
Post-mitigation Scores: Tier 1 Averages	287.1	71.5	79.5	64.3	79.0
Post-mitigation Scores: Tier 2 Averages	298.2	72.6	68.2	76.4	79.3
Post-mitigation Scores: Tier 3 Averages	313.0	75.1	77.2	79.5	80.7

*length-adjusted

Post-mitigation Assessment			
	Target Levels	**Average Index Sum**	**Min Index Sum**
Tier 1	200	287.1	237.7
Tier 2	240	298.2	260.3
Tier 3	280	313.0	280.2
Overall	NA	289.4	237.7

As is detailed in the following paragraphs, judgements were made as to an appropriate level of assumptions to employ, in assigning scores to the changing situation. In general, clearly defined mitigation measures that are readily verified during subsequent audits are credited in this assessment. In contrast, information and data changes based on informal reports, are sometimes not credited. Consequently, any Longhorn self-assessments might differ from this assessment.

Process Steps Used to Complete Final Assessment:

1. Began with 8-16-99 file showing original input data and scores for pre-mitigation state as well as results of 3-00 assessment. The 8-16-99 file is the assessment that was used as a starting point in the EA process to identify deficiencies and recommend mitigations (the first scoring efforts were completed around October 1999).

2. Added/replaced information in the previous assessments with information received from WES reflecting 7-1-00 conditions. Several updates were received from WES through July and August 2000. Created new events table. New events include results of pipe replacements, recoats, re-burials, surge pressure profile, etc.

3. Added new codes for some new information such as '60' reported for re-burials, concrete caps, 'new' for pipe replacement and coating replacement.

4. Re-sectioned based on new events table. New section count is ~6100. Fewer sections since much risk variation has been removed by the LMP. (Some difficulties with re-sectioning since previous re-scoring had modified existing sections rather than creating new events. Data clean up required.)

5. Review point-assignment SQL from 3-00 assessment to verify previous LMP interpretations and see if any assignments need to be changed due to LMP changes since the last assessment.

6. Create a new point-assignment SQL to apply to the new sections. Use new SQL to modify data in new sections to reflect a post-mitigation state. Issues and assumptions are similar to those of 3-00 scoring exercise.

7. Review scoring algorithms from 3-00 assessment. Determined final algorithms needed to assess post-mitigation state. Use modified scoring algorithms to create new scores for new sections.

8. Calculate statistics and length-weighted statistics on the new scores to check for tier compliance and appropriate scores for individual indexes.

Algorithm Modifications Required

Changes to algorithms were minimized but some were necessary due to new information available for this assessment that was not originally available, and due to logic complications after mitigations are assumed. Some of these changes were made for the 3-00 assessment and others are made for this assessment. All are described below and detailed in Attachments A and B of this appendix.

1. Create option for ‘entire segment is above-ground’. For overhead crossings, this removes penalties for potential buried metal corrosion. Original model did not allow for a segment unburied for its entire length. Six segments are effected by this change (3-00 change).

2. Change to pre-set internal corrosion score of 17 out of 20 points. This is based on LPP commitments to do internal monitoring, inhibitor injection, pigging, and visual inspections. Previous assessment algorithm is correctly superceded in light of this new information which better portrays the future situation (3-00 change).

3. Changed coating assessment algorithm. Previously it made use of pipe-to-soil potentials as indications that coating might be deteriorating. Since, in the post-mitigation state, no ‘poor’ pipe-to-soil readings are allowed, these readings no longer provide as much information by which to assess coating. Algorithm is changed to emphasize coating age, past visual inspections, past corrosion flaws, and to a lessor degree, previous CP readings (3-00 change).

4. Mechanical corrosion was based on soil corrosivity and stress levels. This is being superceded by the completed study and assessment of pertinent variables (SCC study). Mechanical corrosion is now scored as 5 out of 5 points since virtually no threat is present (3-00 change).

5. More weighting is given to CIS over test lead readings due to the considerably higher amount of information obtained from CIS compared to test lead readings. This was apparently an error in the original algorithm. The change tends to penalize pipe segments that had previously been credited with adequate CP based on test leads rather than CIS (3-00 change).

6. Changed from hydrostatic test pressures to test ratios, in some cases, since new hydrostatic tests are underway. Assumed LMP test pressures for Tier 2 and Tier 3; used 1995 test pressures otherwise. Ignored proof test (1.1 MOP hydrotest). See further discussion below (3-00 change).

7. Changed several earth movement potential variables to reflect the latest studies. The model no longer uses USGS PGA values for seismic; USGS landslide potential scores

for landslide assessment. These values and the resulting implications to the pipeline are considered in the more definitive assessment done in the earth movement studies. Current scoring is: seismic = 6 points, landslide potential = 6 points, scour potential = 6 points, each out of possible 6 points, indicating no risk from these issues. This anticipates successful incorporation of all recommendations from the studies (3-00 and 7-00 changes).

8. All previous leaks and repairs removed from scoring consideration since root cause analysis addresses these (3-00 change).

9. Calculate pipe_Barlow in the SQL instead of in a separate spreadsheet as had been done previously. This is for convenience and has no assessment implications.

10. Found and corrected an error in 3-00 scoring. Intended penalty to corrosion index score for older than 1994 pipe was not calculating correctly ([yr]<94 when [yr] is in 4 digits, not two). This means that 3-00 corrosion index scores were overstated.

11. Added consideration of coating age. This shows improvements in corrosion prevention where coating replacements occur. Not given in 3-00 assessment.

12. Since fatigue monitoring and ORA-driven fatigue mitigation is a commitment, the assessment should reflect fatigue potential and the new mitigation efforts. The scoring scheme is 7 pts for older pipe (in light of low frequency ERW concerns and pre-existing cracks), 15 points for newer pipe. But Tier 2 and 3 areas receiving the 1.25 hydrotest recover 4 pts despite their age. Therefore, worst case is untested, low freq ERW (7 pts); then partially tested (1.1 hydro) (8 pts); >1970 pipe, partially tested (11 pts); then >1970 pipe, tested (14 pts); and finally new pipe, tested, never in operation (15 pts).

13. Found error in activity level calcs—one-call scale was reversed, so 3-00 results for activity level were in error. New algorithm put in place so that the three scored elements of activity level are assessed as follows: utilities is 0-5.5 pts, pop is 1 to 10 pts; and one-calls is 0-4.5 pts; to total 1-20 pts for the activity score. Eliminated use of WPC_activity since WES (WPC) reports that this variable was assessed with exactly the same data and would therefore be redundant and less accurate since it was an average assessment over a long distance.

14. Change "overpressure potential" score (Incorrect Operations Index) to rely only on “surge potential” since other stress considerations previously considered were redundant to this. Ideally, this variable would include a full analysis of scenarios that can cause overpressure due to human error.

15. Surge profile from WES is now being used. Surge potential of 0.8 x MOP or less warrants full 15 points. Then ratioed to MOP level at which point 0 pts are awarded. Surge_scores are unmitigated surge potentials unless surge is calculated to exceed MOP in Tier 2 or Tier 3 areas. In those cases, the use of 4 relief systems to be

installed is included. These should limit the surges to no greater than MOP in those areas. The surge profile provided by WES show no surges greater than 1 x MOP in Tiers 2 and 3.

16. Changed scale of interference scoring for better sensitivity to actual count of casings and utilities, rather than only two categories.

17. Exposed facilities are now accurately noted in the database so the previously used WPC_abv_grnd variable is no longer needed. This same change also appears in the atm_facilities variable for the same reason. Otherwise, the atmospheric corrosion assessment is the same as before: it penalizes for above ground components or casings, assumes excellent coating conditions (per LMP) for aboveground components, and uses the atmospheric types as used in the original assessment. A segment with no atmospheric exposures gets 10 points; if there is a casing or other exposure, points are a function of coating condition and atmospheric type.

Issues

This latest risk assessment effort captures most, but not all current information. A few updates will be required as described below. Longhorn's own assessments have included some of these already, but this effort has not, mostly because of lack of documentation and occasionally for reasons of modeling convenience. In all cases, the model results currently overestimate risk, pending the updates.

1. For the Valve J1 to Crane line, hydrotest pressure ratio's are used instead of actual test pressures, pending completion of testing when actual test data is unavailable. Actual test pressures should be higher than ratio's, indicating reduced risk. A test date of 2-1-00 is used. For GATX to J1 and Crane to El Paso, actual test pressures and dates are used.

2. New info received and used in this assessment includes pipe grade, wall, seam; valve locations, surge as fraction of MOP, coating type, casings, overhead crossings, exposed facility locations, modified CIS readings (all "bad" removed).

3. No credit is currently given to segments that will benefit from nearby tier requirements. For example, more frequent patrol requirements in Tier 2 and 3 will also include bounded and nearby Tier 1 areas.

4. No credit is given for protective barriers around aboveground valves, remote locations, or for valve vaults or other low-impact potential configurations. Therefore, all aboveground valves are presently considered at relatively high risk from outside forces, even though this is clearly not the case.

5. ILI_crack is replaced by ILI (any type tool) in the integrity variable. Since there is a pre70 ERW pipe penalty in other parts of the model and since it is not conclusive that the ILI_crack tool is necessary for integrity verification, the integrity assessment can award full credit for either the hydrostatic test or the ILI. Under the new scoring

regime, full credit for the integrity variable when there is a recent hydrostatic test and MFL or crack tool type ILI.

6. ILI_95 is a data set of anomalies reported in the 1995 ILI. This data set remains in the current assessment even though this data will be replaced by the new ILI. Rationale is that the previous anomalies may or may not have been repaired. If so, they should have been in the repair_ind dataset which was updated for this assessment (root cause analyses removed these penalties). The indicators conservatively remain since they might indicate the start of a problem even if repairs are not needed.

Assumptions

In order to capture the effects of proposed mitigation measures, including SIP activities, some inferences are needed. These are taken directly from LMP (version 21) stipulations.

Examples of LMP inferences used in assigning scores include:

1. No test lead readings below -0.850 MV (or other criteria); all readings are IR compensated; and checked twice per year and prior to start up.

2. Test leads read twice during start up year in Tier 2 and Tier 3.

3. No CIS readings below -0.850 MV (or other criteria); readings are all IR compensated.

4. No “unknown” CIS or test lead readings except short stretches for roads, paving, etc.

5. CIS is performed in T3 in start up year with no low readings, IR compensation, and no gaps in survey.

6. ILI technique is state-of-art with robust follow-up protocols, for all pipe older than 1998.

7. Successful root cause analyses on all historical leaks and repairs.

8. Studies and implementation of all recommendations removes all reasonable risk from scour, seismic, landslide, stress corrosion cracking.

9. Mitigation #25 (public education) assumption is that everything shown gets done in Tier 2 and Tier 3.

10. Pipe replacements and reburials are all 5-ft cover or equivalent.

11. Safety systems to have redundancy, no single point of failure, on site, remote control parameters consistent with a score of 9 points, to be detailed in the system integrity plan.

12. All atmospheric exposures (except casings) are remediated and maintained to an "excellent" condition (new paint).

13. No casing shorts or suspected shorts remaining.

The risk assessment is dependent upon these assumptions. These are by no means trivial. Some will in fact be challenging to achieve and maintain. The scoring protocols are detailed in Attachments A and B of this appendix.

Limitations of Analyses

As is implied above, judgements were made as to an appropriate level of assumptions to include in the scoring. Assumptions will of course limit the analysis to some extent. In general limitations to this latest analysis are:

1. No field verification of proposed changes. Many points are awarded based on commitments to do future actions and should be verified as they are accomplished. Points are also awarded based on information received directly from Longhorn or their operator, WES, with only limited confirmations. Examples include pipe SMYS, valve locations, pipe replace or recoat locations, etc.

2. The full score-review process that was done as part of the original assessment, was not repeated for new scores. However, given the close tracking with the original set of scores and some level of checking on this set, significant deficiencies are not likely.

3. Crane-to-Odessa Lateral was not re-assessed since the original assessment showed this section of newly constructed pipe to already exceed target levels.

4. This assessment reflects a point in time, as described in the introduction. Risk can change over time and as conditions and/or activities change. Longhorn has committed to regularly perform risk assessments and act on the results (see LMP).

Attachment A. Adjustments to Raw Data to Reflect Post-Mitigation Conditions

Data	Adjustment for Final Assessment*	Notes
secno		
begstation		
endstation		
mile	[begstation]/5280	
area		
89coat_inspect		
90coat_inspect		
91coat_inspect		
92coat_inspect		
93coat_inspect		
94coat_inspect		
95coat_inspect		
96coat_inspect		
97coat_inspect	0.5	
98coat_inspect		
air_patrl_freq		
atm_coating	5	
atm_type		
casing_clear		
casing_unchecked		
CIS_98	IIf([area]=3,20,[sectioned1_pts].[CIS_98]*2)	
CIS_date	IIf([area]=3,2000,1998)	
coat_type		
communications_score		
construction_design_score	9	
cover	iif([post mit points]![cover] = 60,18, [post mit points]![cover])	18 for 5' cover; could be higher since conc cap used in many instances
crack_ILI_date		
crack_ILI_type	15	
cult_field		
exp_fac		
hydro_date		
hydro_press		
ILI_95	iif([yr]=2000,10,[sectioned1_pts].[ILI_95])	
ILI_date	2000	
ILI_tech	10	
internal_corr	17	

Data	Adjustment for Final Assessment*	Notes
landslide_potential	6	
leak	0	
leaks_unknown	0	
maint_score		
maps_records_score		
mech_corr	5	
mech_err_prev_score		
MOP		
MOP%_gas_72		
one_call_score		
one_calls		
other_maxpress	IIf(IsNull([sectioned1_pts].[other_maxpress]),10000,[sectioned1_pts].[other_maxpress])	for non-pipe components
over_head		
overpress_pot_score		
pipe_grade	IIf([sectioned1_pts].[pipe_grade]=10,56000,[sectioned1_pts].[pipe_grade])	for new pipe specs, representative specs chosen
pipe_od		
pipe_seam		
pipe_wall	IIf(IsNull([sectioned1_pts].[pipe_wall]),0.375,[sectioned1_pts].[pipe_wall])	for new pipe specs, representative specs chosen
pop		
procedures_score		
prod_corr		
public_ed	IIf([area]=2 Or [area]=3,14,[sectioned1_pts].[public_ed])	every two year door-to-door in t2 and t3; plus excavator education program
repair_ind	0	
risk_ass_score		
ROW	5	
safety_sys_score	9	
scour	6	
seismic	6	
soil_corr		
surge_score		
test_lead	IIf([area]=2 Or [area]=3,9,6)	twice a yr in t2 & t3
training_score		
utilities		
yr		

*SQL (Structured Query Language) for Microsoft Access Software

Attachment B. Final Scoring Algorithms to Show Post-Mitigation Scores

Max Pts	Risk Variable	Algorithm*
20	depth_cover,	[cover]
20	activity,	iif([utilities]=0,5.5,(1/[utilities])*4)+((1/[pop])*5)+[one_calls]
10	exposed_facilities,	(iif([exp_fac] = 1, 0, 5)+IIf([cover]=0,0,5))
15	one_call,	([one_call_score])
15	public_edn,	([public_ed])
5	ROW_cond,	([ROW])
15	patrol,	iif(isnull([air_patrl_freq]),iif([area] = 2 OR [area] = 3,9,6),[air_patrl_freq])
10	atmos_corr,	(IIf([atm_facilities]>0,([atm_corr]+[atm_coating]),10))
10	buried_environ,	IIf([overhead]=1,10,IIf([casings]>0,0,[soil_corr]))
20	internal_corr,	17
15	cath_prot,	IIf([overhead]=1,15,([CIS]+[test_lead])/2*[ILI_corr_flaw])
15	coating_buried,	IIf([over_head]=1OR [coat_type] = 50,15,((([CIS]+[test_lead])/6+[coat_type]*[coat_age]*2)*(IIf([coat_insp]>0,IIf([coat_insp]>5,1,0.8),0.2))*([ILI_corr_flaw]))
15	interference,	(IIf([yr]>=1998,5,0)+ (10-(IIf(([utilities]+[casings])>10,10,([utilities]+[casings]))))
5	mech_corr,	5
10	ILI,	[ILI_age]*[ILI_tech]
20	CIS,	([CIS_reading]*IIf([yr]>=1998,1,[CIS_age]))
5	atm_corr,	(IIf([casings]>0,0,[atm_type]))
20	coat_insp,	
count	casings,	([casing_shorted]+[casing_unchecked]+[casing_clear])
	atm_facilities,	(IIf([casings]>0,1,0)+[shallow_cover]+IIf([exp_fac]=1,1,0) + iif([overhead]=1,1,0)+IIf([coat_type]=1,1,0))
20	pipe_fctr,	(IIf([pipe_maxpress]/[MOP]<1,0,IIf(([pipe_maxpress]/[MOP])>2,20,([pipe_maxpress]/[MOP]-1)*20))*[ILI_design_flaw])
10	sys_fctr,	
15	fatigue,	iif([yr]>1998,15, iif([yr]<1970,7,10)+iif([area]=2 OR [area]=3,4,1)
15	surge,	(IIf(([surge_score])<0.8,15, iif([surge_score]>1,0,(1-[surge_score])*75)))
20	integrity_test,	(IIf([hydro_test]+[ILI]>20,20,[hydro_test]+[ILI]))
20	earth_mvmnts,	([scour]+[seismic]+[landslide_potential])
20	hydro_test,	(IIf([hydro_ratio]*[hydro_age]<0,0,([hydro_ratio]*[hydro_age])))
20	crack_ILI,	([crack_ILI_age]*[crack_ILI_type])
	max_press,	
10	construction_design,	([construction_design_score])
20	training,	([training_score])
15	procedures,	([procedures_score])

Max Pts	Risk Variable	Algorithm*
5	maps_records,	([maps_records_score])
10	overpress_pot,	(2/3)*[surge]
10	safety_sys,	([safety_sys_score])
10	maint,	([maint_score])
10	communications,	([communications_score])
5	mech_err_prev,	([mech_err_prev_score])
5	risk_ass,	([risk_ass_score])
	CIS_age,	(IIf(Year(Now())-([CIS_date])>5,0,(1-(Year(Now())-([CIS_date]))/5)))
	CIS_reading,	(IIf([yr]>=1998,20,[CIS_98]*2))
	coat_age,	(IIf(2000-[yr]<5,1,IIf(2000-[yr]<10,0.8,IIf(2000-[yr]<20,0.6,IIf(2000-[yr]<50,0.4,0.2)))))
	crack_ILI_age,	
	hydro_age,	(IIf(Year(Now())-Year(([hydro_date]))>5,0,(1-(Year(Now())-Year(([hydro_date])))/5)))
	hydro_ratio,	IIf([hydro_press]=0,IIf([area]=2 Or [area]=3,10,4),(IIf([hydro_press]/[MOP]>1.5,0.5,([hydro_press] /[MOP]-1))*40))
	ILI_age,	(IIf(Year(Now())-[ILI_date]>5,0,(1-(Year(Now())-[ILI_date])/5)))
	ILI_corr_flaw,	(IIf([ILI_flaw]=7,0.9,IIf([ILI_flaw]=0,IIf([yr]>=98,1,0.9),1)))
	ILI_design_flaw,	(IIf([ILI_flaw]=8,0.9,IIf([ILI_flaw]=9,0.9,IIf([ILI_flaw]=0,0.9,1))))
	ILI_flaw,	(IIf([ILI_95]=10,IIf([yr]>=1998,10,(1-([ILI_age])/10)),[ILI_95]))
	pipe_Barlow,	iif(pipe_grade=1, other_maxpress, (2*[pipe_grade]*[pipe_wall]/[pipe_od]))
	pipe_maxpress,	(IIf(IsNull([pipe_barlow]),1480,iif([pipe_barlow]<1,1000,[pipe_barlow]))*(IIf([yr]<72,(IIf([pipe_seam]=1,(IIf([integrity_test]<5,0.8,0.95)),0.95)),0.95)))
	pipe_stress_fatigue,	NA
	pipe_stress_surge,	NA
	repair_corr,	NA
	repair_design,	NA
	repair_thd_pty,	NA
	seismic,	NA
	shallow_cover,	(IIf([cover]=0,1,0))
400	IndexSum,	((ThdPtySum+DesignSum+CorrSum+IncOpsSum)
100	ThdPtySum,	([depth_cover]+[activity]+[exposed_facilities]+[one_call]+[patrol]+[public_edn]+[ROW_cond])

Max Pts	Risk Variable	Algorithm*
100	CorrSum,	([atmos_corr]+[buried_environ]+[internal_corr]+[cath_prot]+[coating_buried]+[interference]+[mech_corr]+[ILI])*[ILI_corr_flaw])
100	DesignSum,	(IIf(IsNull([pipe_fctr]),10,[pipe_fctr])+[sys_fctr]+[fatigue]+[surge]+[integrity_test]+[earth_mvmnts])
100	IncOpsSum	([construction_design]+[training]+[procedures]+[maps_records]+[overpress_pot]+[safety_sys]+[maint]+[communications]+[mech_err_prev]+[risk_ass])

*SQL (Structured Query Language) for Microsoft Access software