A Technical Review of the Pembina Report
"A *Peak* Into the Future"

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Energy, Mines and Resources

Pembina Institute Report "A *Peak* into the Future"

Technical Discussion of Pembina Report Assumptions as they apply to the Peel Plateau and Yukon Government Responses

I. Executive Summary

The Pembina Institute has published a report entitled "*A Peak into the Future*." The report was funded by the Canadian Parks and Wilderness Society and Canadian Arctic Resources Committee[1] and states that it "illustrates the potential physical footprint of gas development within northern Canada's sedimentary basins: The Mackenzie Delta, Colville Hills and Peel Plateau."[2] In this study a cumulative effects model known as ALCES was used to model natural gas exploration and development scenarios in these areas and estimate the effects of development on the landscapes.

The portion of the report dealing with the Peel Plateau makes a number of erroneous assumptions that are used as input to the ALCES model. Among these are:

a) unlimited pipeline transmission capacity via the Mackenzie Valley pipeline, hence, no external limit to development and production rates in each field;

b) 17 kilometres of seismic line per well, uniformly five meters wide;

c) single well pads only, with no directional wells or multi-well pads;

d) zero overlap of seismic lines, trails, roads, flowlines and pipelines;

e) consistent 30 metre wide roads, with no apparent distinction between all-weather roads and winter ice roads used for exploration;

f) consistent 30 metre wide pipeline rights-of-way;

g) no distinction between intra-field flowlines and inter-field pipelines; and

h) 30 year lifespan of all infrastructure.

By consistently assuming unrealistic or unrepresentative inputs to the ALCES model, the Pembina study yields results that are misleading. Future exploration and development in the Peel Plateau is open to speculation and subject to many unknowns; what is certain, however, is that it will not resemble the scenario presented by the Pembina Institute report.

II. Discussion

The Pembina report models the exploration and development of the Peel Plateau using assumptions and analogies from other more mature petroleum basins. There are a number of assumptions in the model that do not accurately reflect current industry practices or those of the foreseeable future. From the initial exploration phase to final abandonment, these are:

A. Exploration

1. Amount of seismic over time

The modellers have assumed a British Columbia average of 17 kilometres of seismic per well drilled[3]; this is a very simplistic linear relationship, considering that the activities of seismic and drilling occur over different time frames and at different paces. This independence is apparently not reflected in the model. In general:

a) Seismic precedes drilling, normally by a number of years. Older seismic is commonly re-processed repeatedly and re-interpreted as play and prospect knowledge advances. It should be expected that existing seismic data will be re-processed in future exploration of the region and used in conjunction with data yet to be acquired.

b) Seismic is used to investigate the structure and stratigraphy of the subsurface. As such, a seismic program can generate any number of plays and potential drillable prospects, depending on the complexity of the geology. The geology of the region will determine what relationship exists between the amount of seismic acquired and the number of wells drilled.

It is clear that the assumption of 17 kilometre of seismic per well is a simplistic relationship to begin with; it does not realistically model the different rates of seismic and drilling and will yield an inflated effects.

2. Seismic Line Width

a) The Pembina report assumes a consistent five metre line width[4] and states,

> "*Given that a five metre-width is considered low impact for seismic lines, this study conservatively assumes the use of this width in future development,…*"

While a five metre line may well be considered to be low-impact in other areas, it is wider than anything done in the Yukon in the last thirty years. All seismic in the Yukon since devolution in 1998, and in fact since the last programs in the 1980s, has been heliportable, i.e. less than 1.5 meters wide. The Devon 2D program in Eagle Plains proposed two metre wide source lines using low-impact tracked vehicles. Snow conditions forced a switch to more expensive but lower impact heliportable seismic. The most recent proposed 3D seismic program in Yukon specifies four metre line widths for the vibroseis source lines and a maximum of 1.5 meters for the receiver lines.

b) Source lines may be as much as four or five meters wide for vibroseis equipment, two meters wide for low-impact tracked equipment or effectively zero for heliportable seismic - shothole drilling equipment is carried to each location by helicopter. Where separate receiver lines are used they are typically only 1.5 meters wide at most and may be effectively zero depending on what equipment is used. The geophones and cables are normally carried by the crew along these lines and the line needs only to be wide enough for one person to walk. In many cases, no cutting is required for these narrow lines since the crew can simply walk around the trees.

c) The character of seismic lines changes as 3D development seismic methods replace 2D exploration practices. In 2D, the source (dynamite shot holes or vibroseis points) and receiver (geophone) lines are normally the same – a single line is used for both. The width of the line is simply that required for whatever equipment is used as the signal source. However, in 3D - more commonly used for delineation of a known discovery, the source lines and receiver lines are normally at right angles to each other and are of different widths, as discussed in (b) above.

The Pembina report assumption of a uniform five metre line width is not, as is claimed, a conservative assumption, but in fact overestimates the width of lines by approximately 50% to 400%, compared to recent historical and proposed Yukon seismic activity.

3. Seismic Line Configuration

Virtually all seismic shot in the Yukon prior to devolution was done using simple straight cleared lines. However, the previous use of this practice was due to three limitations:

a) only visual survey methods were available and a clear line-of-sight was mandatory;

b) processing technology was not sophisticated enough to model an irregular grid; and

c) early equipment (pre-1980) was too large to move except over cat-cleared lines.

Since that earlier vintage of Yukon seismic, GPS survey technology, which does not require a straight line of sight between survey points, is now universal. Further, modern processing technology can handle immensely complicated geometries with no problems. Lastly, source equipment can be slung under helicopters or moved on low impact tracked vehicles over any kind of trail and receiver equipment carried by hand.

While there does not appear to be any specific input data related to the straight line character of seismic assumed in the report, repeated mention is made of the linear density of seismic lines[5]. It is acknowledged that extensive straight lines cut in forest can have related wildlife effects.

Emphasizing the negative effects of linear disturbances and relating it to future cumulative effects (i.e. proposed seismic lines) is largely irrelevant. Seismic practices in the 1970s do not reflect those in use today. Recent and future seismic programs in the Yukon have and will employ meandering lines as standard practice. This requires "jogging" the line at least one line width every few source points or curving the access line back and forth across the desired source line. These lines are and will be very difficult to see from the air and can be virtually undetectable from the ground if done correctly.

4. Seismic Line "Linear Footprint"

The report considers two kinds of footprint of developments – areal, with units of area, (e.g. km^2) and linear (with units of km/ km^2). While the areal component is straightforward, the linear portion is of questionable value. Ostensibly, it purports to measure the extent of linear features per unit area, e.g. kilometres of seismic per square kilometre. This parameter may be of some use in certain circumstances but it would seem to ignore the differences between various kinds of linear features. For example, a meandering seismic receiver line of maximum 1.5 metre width cut in the winter with sufficient snow or ice cover and used for two or three weeks, cut across a square kilometre, should have an entirely different effect on wildlife, vegetation, trappers, etc. than an all-weather road or pipeline right-of-way. In addition, different linear features will have different recovery rates – regeneration to a more natural state – which does not seem to be reflected in the "linear footprint" parameter. This is because of many factors: compaction, legacy use, presence of permafrost, etc.

B. Development

There are a number of assumptions in the Pembina report related to development that require examination.

1. Overlap of linear features

The report makes the apparent assumption that all linear features – seismic lines, roads and pipelines – are independent; specifically, there is the assumption that none of these features overlap[6]. The reality is almost always the exact opposite. It is current industry practice to intentionally overlap these activities: it is cheaper and easier to build a winter road along a seismic cut line; it is easier to convert a winter road to an all-weather road than to build a new road; it is much easier to lay flowlines alongside an existing trail or road than to construct a new right-of-way. Only in the case of truly large projects – a highway or major pipeline, for example – is it worthwhile to build a new route.

The Pembina report has ignored normal industry operating practices re: road and pipeline construction; the result is an exaggeration of the areal extent of these features.

2. Wells per Pad

This parameter is fundamental to the entire development methodology. The Pembina report states[7]:

> *"Most gas well sites in the southern parts of the NWT and Yukon and in southern Canada in general, are single well pads. Multi-well pads are economically feasible in the Mackenzie Delta because the reserves there contain a large amount of gas relative to the amount of surface land area, and there is also an extensive amount of surface water."*

The first sentence is generally true; however, the only development well in the Yukon in the last twenty-plus years, the 2004/05 L-38 well in Kotaneelee, was directionally drilled from a site adjoining an existing producing well precisely because of surface terrain, cost and environmental considerations. Most of the gas production in the southern NWT and Yukon, moreover, is from fairly productive reservoirs, e.g. the Nahanni carbonates, and these reservoirs have not required a large number of wells for commercial production rates. Furthermore, prior to about 1990, the drilling technology to reliably drill extended directional wells was simply not available.

The second sentence appears to be somewhat contradictory. If there is a large volume of gas per unit of area, then either the reservoir thickness or the porosity is high, in which case the productivity should also be high and the need for multiple wells therefore reduced. There are two main reasons for using multi-well pads: first, if there were multiple separate reservoirs. This would require multiple wells for recovery efficiency, since they should not be produced commingled. The second reason would be if there was limited surface access for vertical wells, which would require directional drilling to subsurface targets inaccessible to vertical wells. From the second sentence, it is difficult to tell if the authors of the Pembina report understand the rationale for single-well vs. multi-well drill pads.

The Pembina report concludes[8]:

> *"Based on the dispersed nature of the reserves for Colville Hills and Peel Plateau, a more traditional development has been assumed with a single well per pad."*

A review of the GSC work on the Peel Plateau reveals that the median pool area used for many of the play reserve estimates is five km^2. It should be remembered that the median is simply the 50^{th} percentile, and while there is certainly a minimum detectable pool size dictated by seismic resolution and economics, perhaps two km^2, the upper limit will be significantly larger, since the distribution of pool sizes is not symmetrical. Since the effective drainage area of a conventional gas well is approximately two km^2, it follows that the average pool will require at least two wells, and probably more, for effective drainage. The current state of industry construction practices and costs and directional drilling technology is such that we can expect for the foreseeable future that, as long as the overall wellbore trajectory does not exceed 45 degrees from the vertical, it will be cheaper to drill directionally to a subsurface target than to construct an access route and wellsite to allow vertical drilling to the same target. Prospective target zones in the Peel Plateau are sufficiently deep to allow an average of four development wells to be drilled from each production pad. Additionally, directional drilling makes it easier to complete wells horizontally, which offers potentially much higher productivity and recovery efficiency.

It is logical to assume that evolving environmental regulations will continue to place a burden of project assessment on proponents. It is also reasonable to expect them to minimize this burden by grouping wells and facilities into the minimum number of assessable sites.

While single-well pads and vertical wells are arguably more “traditional”, this is because of previous limitations in technology. Multi-well pads, directional wells and horizontal completions have become clearly more efficient in terms of resource recovered per unit of capital invested. It would be unreasonable to predicate that industry will ignore these efficiencies in favour of a “traditional development”.

In the great majority of field development scenarios in north Yukon, multi-well pads, directional wells and common facilities are anticipated to be the normal development method, rather than single-well pads with vertical wells. This means that the Pembina report exaggerates the number of well pads by a factor of approximately four.

3. Roads

While the Pembina report does appear to make a distinction between winter roads, (i.e., ice roads for single season use) and all-weather roads for semi-permanent use, it also states:

> *“…roads are built to access every well, whether dry or successful, whereas pipelines are only built to access successful wells”* [9]
>
> *“For wells on multi-well pads, such as is assumed for the Mackenzie Delta study area, the length of roads required is significantly reduced per well as most access is via air transport and most drilling equipment is hauled in over temporary ice and winter roads.”* [10]

It is accepted practice in areas of the north where winter drilling is the norm, including the Peel, to use ice roads for all exploratory drilling. Ice roads to unsuccessful wells are allowed to regenerate immediately unless needed for further access. It is not accepted practice to use air transport where road access exists, whether winter or all-weather. Only in the event of a commercial discovery would there be an all-weather road constructed and then only just prior to production, not before. The report also contains the statement:

> *“It is likely that, as more well pads get built, proponents will want to construct more permanent roads between well pads to avoid helicopter costs.”* [11]

In fact, the vast majority of oilfield equipment and tools are much too big and/or too heavy to be transported by helicopter and, where personnel transport is required, they follow the equipment. Therefore, this statement either directly contradicts the previous statement that there is a road to every well, thus obviating the need for helicopter access, or it ignores the fact that road travel in the oilfield is most often between a central facility and a well, not between wells themselves. Consequently, where the road network is constructed solely by and for industry, it will resemble a tree diagram rather than a spider web. The distances involved in the former are much, much lower than in the latter.

Lastly, the Pembina report assumes roads to be 30 metres wide[12]. While this may be the case for a major road such as the Dempster Highway, it is most definitely not the case in oil or gas field developments. For intra-field development, where access is restricted to the operator, a typical road would be a maximum of 10 meters. This assumes normal industry practice of radio-controlled traffic and limited access. In many cases, e.g. in the Fort Liard area at present, where construction is difficult and/or expensive, roads are commonly single-lane, i.e. a maximum of 6 meters wide, and radio control is used to avoid traffic conflicts.

The Pembina report clearly overestimates the magnitude of the likely road network and also overestimates the width of the vast majority of these roads by at least a factor of three.

4. Pipelines

The Pembina report should have made a distinction between flowlines and pipelines. In industry usage, flowlines are intra-field lines usually connecting wells or groups of wells and some other facility. The term flowline is commonly used to denote those lines carrying unprocessed products, e.g. any combination of oil, gas and water. Pipelines, in contrast, are generally larger and commonly carry a single phase fluid, normally post-processing of some kind. In oil field developments, the linear ratio of flowlines to pipelines as defined above is normally quite high, typically three or more to one. In gas field development, much the same ratio applies, except that in fields producing gas which contains hydrocarbon liquids or produced water, there is usually the need for wellsite separation and/or dehydration. This then dictates two flowlines to the next facility – one for gas and one for liquids. In either case, it is normal practice to lay flowlines from wellsites along the access road right-of-way, either on surface or buried.

Further, because the report assumes single well pads for the Peel basin, it assumes a single ‘pipeline’ from each producing well. Since in a gas prone basin such as the Peel, any primary processing such as liquids separation and/or dehydration will likely be done at the well pad, by assuming single well development the report therefore underestimates the length of ‘pipelines’ by as much as a factor of two. However, as it is highly likely that Peel development will be done by using multi-well pad drilling, the reality of the situation is that the Pembina report actually overestimates the length and number of ‘pipelines’ by at least a factor of two, assuming an average of at least four wells per pad. No matter what type of development, however, single-well or multi-well pads, flowlines will normally be laid alongside the access road, not in a separate right-of-way.

Finally, the report assumes a right-of-way width of 30 meters, and assumes these lines will be laid independently of any other feature. As discussed above, flowlines will normally be laid along the access road and will thus occupy no additional area.

Pipelines will be major lines only and while some of these may be laid in an independent right-of-way, the width of these should normally be a maximum of 10 to 15 meters, not the 30 meters assumed by the Pembina report.

The Pembina report erroneously considers all "pipelines" to be similar and to occupy 30 metre wide rights-of-way. In fact, the majority of "pipelines" will actually be flowlines – smaller diameter and laid along existing access routes. For true "pipelines" – larger diameter, single product lines – only in some cases will there need to be an independent right-of-way, and in these cases, the report overestimates the ROW width by a factor of approximately two to three.

5. Production Profile

The Pembina report makes a critical assumption regarding production profile[13]:

> *"All of the developments follow a production bell curve pattern over time similar in shape to that predicted by the GLJ Report for the anchor fields,[32] and similar to actual developments in the Chevron Ft. Liard and Pointed Mountain fields (see Figure 2).[32] Within the first ten years production rises quickly and then peaks, after which a steady decline continues until the field is depleted. As the model demonstrates,* ***the production profile is the key determinant of the pace of development for wells, pipelines, gas plants, roads and seismic lines.*** *(bold added)*
>
> *The production profiles generated by the model assume* ***that the capacity of the gas transmission line or the Inuvik gas processing facility (proposed in the Mackenzie Gas Project) does not curtail production from the individual field."*** *(bold added)*

The report specifically refers to the Ft. Liard and Pointed Mountain fields[14], both of which happened to be developed in close proximity to the Duke Energy Pointed Mountain pipeline to Ft. Nelson which had and still has abundant excess transmission capacity. In these cases, the gas production rate was limited only by the speed at which upstream production capacity could be developed. This is exactly the opposite of any reasonable development scenario in the Mackenzie Delta and the Peel basin. The economics of pipelines are such that the operator maximizes his return or minimizes his cost of operation by designing for approximately twenty years of life at full rated capacity. The probability that any possible consortium of pipeline operators would deliberately build excess capacity in such a pipeline is effectively zero. In fact, Yukon is a registered intervener in the Mackenzie Valley Pipeline hearings precisely to ensure that Yukon gas is allowed at least some guaranteed access to the limited capacity pipeline that has been proposed, in order to avoid stranding Yukon gas until excess capacity does exist at some time well in the future.

As mentioned, pipeline operators will, in general, require a twenty year production commitment at design capacity to construct a line of a given size. By definition, this means the line will run at full capacity; excess capacity costs money to construct for no return. A typical production profile for an unlimited pipeline capacity scenario will show a steep increase in capital expenditure, wells drilled and production rates up to a peak, followed by a normally slower exponential decline as fields are depleted. The shape of this production curve somewhat resembles a lognormal probability distribution. If, however, one assumes limited pipeline capacity, the only way to achieve twenty years of a full pipeline is to limit the fields' production before it would peak, typically at between 50% and 70% of the theoretical peak rate, and defer further development until field decline begins. This limits the amount of infrastructure required by the same proportion. The cost and magnitude of the infrastructure required to ship natural gas is to a great extent proportional to the peak rate. Therefore, if an unrealistically high peak rate is assumed, the infrastructure required will also be unrealistically high. This applies to inter-field pipelines, processing facilities, compressor facilities and the main pipeline to the Mackenzie Valley pipeline. By assuming unlimited pipeline capacity, and therefore production rates limited only by well and field capacity, the Pembina report overestimates, in its own words, "*the key determinant of the pace of development for wells, pipelines, gas plants, roads and seismic lines.*"[15]

There is, in addition, a secondary effect of the assumption of unlimited pipeline capacity and it also affects the number of producing wells and their expected recoveries. In general, the more slowly a reservoir is produced, the longer the production will continue. While this may seem intuitively obvious, the ultimate recovery from the reservoir – the product of rate and producing time - will normally also increase, and this is not intuitively obvious. If the production rate is decreased by a certain amount, the economic producing lifetime usually increases by more than that amount and vice versa. In other words, the production rate from a well and its ultimate recovery are usually inversely related; the higher the rate at which a well is produced, the less gas or oil it will ultimately produce. There can be exceptions to this reservoir engineering form of rate sensitivity but it remains generally true. By assuming unlimited pipeline capacity and therefore maximum rate production from every well, the recovery per well will generally be reduced and the number of wells required increased for a given quantity of reserves. It would be very difficult to quantify this "well efficiency" effect in this sort of hypothetical exercise but it exists nevertheless.

By erroneously assuming unlimited pipeline capacity, the report overestimates the total amount of all development infrastructure – inter-field pipelines, processing and compression facilities and the main transmission pipeline – by as much as 30% to 50%. In addition, assuming unlimited pipeline capacity will also increase to some lesser extent the number of wells required to produce the hypothetical reserves.

C. Other Issues:

1. Features – zone of influence

One important point about the ALCES model used in the Pembina report is that the various features – seismic lines, wells, etc. – all have their unique footprints. Wellpads are assumed to be two hectares, for example, and seismic lines are assumed to be five meters wide. Whatever these features are assumed to be, they also have an associated "zone of influence" or "affected zone". While only peripherally mentioned or discussed in the report, the rationale for this is not unreasonable. A particular feature may affect different flora and fauna beyond the strict extent of the feature itself.

However, an important qualification that must be applied to any zone of influence is the change in its size over its entire duration. As an example, a two hectare wellpad would have an effect for some distance around the site while the rig and equipment were on location. During operation, the noise and light during winter operations could be detectable for some kilometres. The next summer, however, assuming the rig was removed and the location properly cleaned up, the zone of influence would be far smaller.

It is not possible from reading the Pembina report to determine what the affected zones are – their size and their duration. Since the affected zones are an important measure of the impact of development activities, it is critical to model these realistically to achieve realistic results.

2. Reserves Forecast – Peel Plateau vs. Peel Plain

The report states:

> *"The number of wells that could be drilled in the future in the Peel Disturbed Belt area (332) is about three times that in the Peel Plains area (121) because there are roughly three times as many reserves in the Disturbed Belt."*[16]

These references are shown graphically on the map on page 37 of the report. The source of the reference to the relative proportion of the gas reserves, however, is difficult to identify; in Appendix A, *Study Area Data Sources and Maps*, p.32, the only reference for the Peel Plateau appears to be the Oil & Gas Management Branch, Department of Energy, Mines and Resources, Yukon Government.[17]

The most recent publication from the Oil & Gas Branch, "*Yukon Oil and Gas: A Northern Investment Opportunity"*, 2005, is a joint work by the Yukon Geological Survey and the Geological Survey of Canada. It attributes approximately 69% of the projected 2,945 BCF of gas in place to the Peel Plain area[18], instead of the 25% assumed by the Pembina report. Potential reserves figures are speculative at best at this very early stage of exploration since they are based on limited well data and probabilistic modelling. Nevertheless, it is difficult to understand why the Pembina report would present the relative potential of the Peel Plateau and Peel Plain areas as effectively the opposite of what is expected by the Yukon Geological Survey and the Geological Survey of Canada.

D. Graphical Representation of Peel Plateau Development

The final page in the report, page 38 in Appendix A, is a single page map of the Peel region purporting to show seismic lines, roads and wells 30 years from the start of development. There is a single note added, "Note – Map symbology not to scale".[19]

There are a number of notable misrepresentations in this graphical representation of the Pembina report's development scenario:

1. The ALCES model is a tabular model only; it does not and cannot model the spatial distribution of any feature – wells, seismic, roads, etc. The model simply calculates the quantity of development features and their regeneration over time. The graphical depiction of the development shown on this page is therefore totally fictional; it was not generated by ALCES.

2. The fictional spatial distribution of gas field development portrayed in the map clearly ignores the reality of hydrocarbon development and the Peel geology in particular. Hydrocarbons are not uniformly areally distributed. Large areas of the basin can be expected to be totally devoid of commercial hydrocarbons. The resultant development of what may be found, therefore, would concentrate in areas of success.

3. The character of the roads, wells and infrastructure shown on the map is unlike any real field development. In reality, these networks are developed as "tree" structures, with wells and surface facilities linked in a dendritic network to central facilities, not as a uniformly-distributed spiderweb across the entire area. There are roads and pipelines shown on the map which make no sense in any logical field development. This map, however, shows the features spread smoothly over the entire area of the Peel Plateau area and maximizes the apparent visual impact.

4. The scale of the map is approximately 1 to 1,400,000. The map note which reads, "symbology not to scale" is accurate; the features shown on the map are vastly exaggerated in size:

    a) The seismic lines displayed on the map are approximately 0.1 mm in width; this represents a 141 metre wide seismic line – approximately 50% greater than the length of a football field, or an exaggeration of approximately 100 to 1.

    b) The roads as shown are approximately 0.5 mm wide; this represents an actual width of over 700 meters, or just less than half a mile wide, an exaggeration of approximately 100 to 1.

    c) The well sites portrayed are approximately 1.3 mm square; this represents an area approximately 1800 meters square, an exaggeration of about 18 to 1 in linear dimensions or about 340 to 1 in area.

III. Conclusions

1. The input parameters for the ALCES model quoted in the report are consistently larger than those currently used in the industry, regarding road, right-of-way and seismic line widths. As a result the cumulative effect of these features is considerably overstated.
2. The assumption in the report of zero overlap for linear features and the assumption of only single well pads yield cumulative effects for these features that are greatly overstated.
3. The production profile used for the Peel Plateau scenario is used to schedule the quantity of roads, wells, seismic, etc. and it explicitly assumes unlimited capacity in the Mackenzie Valley pipeline. This is not the case; as a result, the amount of infrastructure associated with the Peel Plateau development scenario is overstated by approximately 30% to 50%.
4. The report does not clearly address the issue of regeneration of effects – the regeneration of disturbed areas and their return to a natural state. Much of the focus of industry efforts over the past 30 years to improve operating practices has been specifically to minimize both the initial impacts and the time for regeneration to the original state; these improvements have been ignored.
5. The map on page 38 which purports to show the impact of 30 years of development first hugely exaggerates the scale of the features shown. Second, the spatial distribution of those features is entirely fictional – it was not generated by the ALCES model since that software does not address the spatial distribution of features, only the quantity. Third, the features shown on the map – the distribution of wells, the extent and the layout of the road network and of the inter-field pipelines - bear no resemblance to real and current industry practices.

References

[1] The Pembina Institute. 2005. A *Peak* Into the Future. p. 2.
[2] ibid. p. 5.
[3] ibid. p. 13.
[4] ibid. p. 13.
[5] ibid. p. 23, 24, 25, 27, 28.
[6] ibid. p. 14, Table 8, p.27.
[7] ibid. p. 13.
[8] ibid. p. 13.
[9] ibid. p. 13.
[10] ibid. p. 13.
[11] ibid. p. 13, 14.
[12] ibid. p. 14.
[13] ibid. p. 22.
[14] ibid. p. 15, 16.
[15] ibid. p. 22.
[16] ibid. p.23.
[17] ibid. p. 32.
[18] Oil and Gas Management Branch, Department of Energy, Mines and Resources, Government of Yukon, *Yukon Oil and Gas: A Northern Investment Opportunity,* p. 35.
[19] The Pembina Institute. 2005. A *Peak* Into the Future. p. 38.