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Standardizing construction requirements for pipeline crossings: Interim report of survey responses

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COVER PHOTO

View of a pipeline crossing showing the use of logs and granular fill. Photo courtesy of Alberta-Pacific Forest Industries Inc.

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INTRODUCTION AND BACKGROUND

In many areas of the Prairie provinces (Alberta, Saskatchewan, and Manitoba) and northeastern B.C., the forest industry shares operating areas and resource roads with oil, gas, and pipeline companies. Many Alberta forest operations report that their resource road construction operations build hundreds of pipeline crossings per year and deal with up to 50 different pipeline owners. Written permission is required to cross various buried utilities. The Canadian Association of Petroleum Producers Agreement for Facility Crossings (CAPP 2001) often forms part of facility crossing agreements. These formal documents contain the legal requirements of both parties named in the agreements, and include the agreement itself, the location and plan profile, and specific and mutually agreed-to terms and conditions. Some of the clauses are specific to the construction of pipeline crossings, such as 72-hour notification before work starts, inspection of works, limits and distances from pipeline for construction-related activities, cover depth above pipeline, and other overarching requirements. Ground disturbance training, for both safe work procedures and an understanding of the relevant acts and regulations, provides a level of competency for those involved with pipeline crossings and is a requirement for work in Alberta.

Forest operations report that the approval process for these crossings can be costly, time-consuming, and frustrating because the crossing design requirements vary according to the pipeline owner and/or the arbitrary judgement of the site inspector from the pipeline company (many of these requirements are related to what has been done in the past). Over time, the concerns and constraints related to pipeline crossings have grown. The objective of this project is to develop a set of generic, cost-effective, and accepted pipeline crossing schematics for both permanent and temporary resource roads.

Standardized construction practices for building crossings for unpaved resource roads that cross existing pipelines will improve both the accuracy of planning costs and the deployment of equipment and material requirements; streamline the approval process and timelines for project completion; and promote coordinated land use. The designs would be useful to both the forestry and energy sectors as their companies build resource roads across pipelines.

APPROACH

In order to help establish an understanding of the various pipeline crossing construction methods and associated constraints, FPInnovations surveyed both forest and energy sector companies. The survey aimed to collect a representative sample of existing pipeline crossing requirements. Additional information collected included facility/master crossing agreements, the various planning phases for the construction of a crossing, construction and deactivation costs, and a vision for industry adoption of standard crossing schematics.

Prior to this interim report, a field study was conducted to gauge the importance of key factors (cover depth, vehicle load, soil compaction) regarding buried pipelines. The field study consisted of measuring pipe strains caused by heavy-industrial vehicles crossing over 20-m-long segments of unpressurized national pipeline that was 1.07 m (42 in.) in diameter. The pipeline segments were instrumented with strain gauges, and then buried with two different cover depths with the saturated clay fill compacted by two different methods (Thiam et al. 2015).

Figure 1 shows an actual stress response pattern recorded in a pipeline buried at 0.75 m as each axle of a 7-axle loaded lowbed travelled over top of the pipe. The top of the pipe went into compression (negative stress) as each axle approached, into tension (positive stress) when the axle was directly above, and then briefly into compression as the axle moved away. The results showed that strain was strongly influenced by cover depth and vehicle loading; increased soil compaction had little influence on pipe wall strains. A 50-t tracked excavator walking over the test pipes produced response pulses correlating to each pad, with the load concentrated under the drive and idler sprockets; the magnitude of which was almost as high as the drive group loading in Figure 1. Future testing is planned for this site using variations of typical and innovative crossing arrangements. The results from the field study will be utilized when evaluating the appropriateness of typical construction practices for crossings.

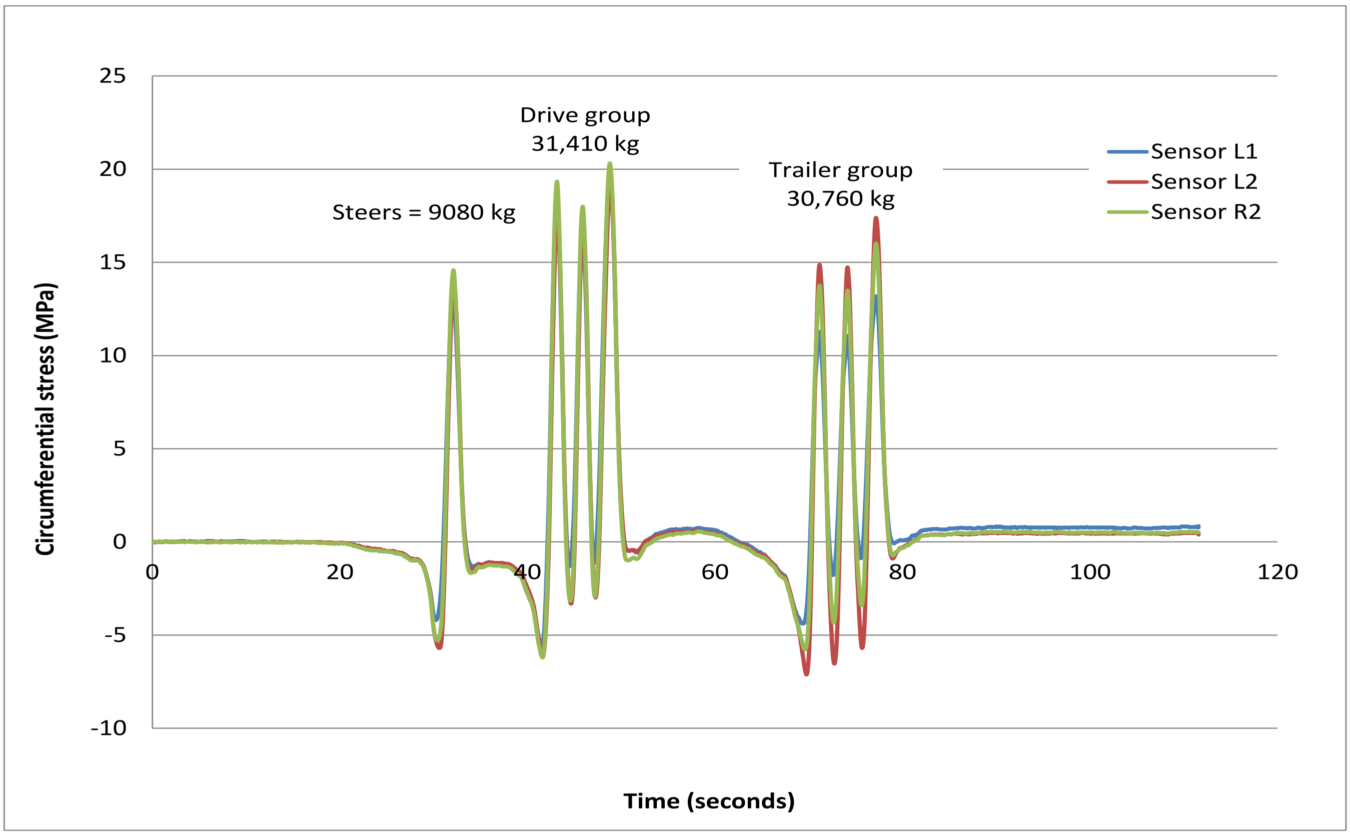

Figure 1. Stress in a national pipeline segment buried to 0.75 m cover and crossed over by a 71-tonne 7-axle lowbed (Thiam et al. 2015).

Beyond this interim report, a set of draft conceptual schematics will be produced to share with cooperators for comment. The general approval of these conceptual schematics will vary in formality. For example, two companies may agree amongst themselves to use them; a membership association may adopt and support their use and encourage its members to do the same; or, the schematics may be referenced by regulations and/or standards. The first phase towards the conceptual schematics being used by companies and gaining general approval will be facilitated by a pilot project. The pilot project will allow the conceptual schematics to be field-tested and revised if needed.

In April 2015, FPInnovations, in collaboration with the B.C. Oil and Gas Commission and B.C. Ministry of Forests, Lands, and Natural Resource Operations began a separate project to assess the feasibility of developing a set of pipeline crossing designs optimized for various classes of resource roads, and the feasibility of adopting a notification process (in lieu of the existing approval process) when using one of these designs in a crossing. Pipeline companies in B.C. will be surveyed to ascertain their willingness to support such a system before FPInnovations proceeds with preparing these optimized designs. Synergies between the project initiatives in BC and the initial work in Alberta will likely provide additional support towards optimized crossing designs for various site types (soil, moisture, topography, etc.).

RESULTS

A total of seven forest industry and five energy sector companies provided input during the survey. The topics of discussion in the survey were on pipeline crossing designs and considerations; the general concept of a standardized schematic; typical nuances and uncertainties of the current procedures for crossings; costs; and safety. The following points summarize the key and common responses:

- **Feasibility of adopting a standardized design concept:** Survey respondents were generally in support of using a standardized crossing schematic with the caveat that crossing requirements are site-specific and, therefore, the construction practices may not be appropriate under all conditions. Having a level of consistency for the construction crossing plans would improve the planning and construction phases. It was suggested that schematics should be prepared for a few common scenarios based on the season (winter and summer) and anticipated length of use (temporary and permanent). The predominant soils at a site are an example of a site-specific attribute that would not be captured in a standardized schematic.
- **Frequency of constructed crossings:** The number of crossings constructed in a year can range from 50 to 225; one company averaged 90 per year and dealt with 50 different pipeline owners. Many of the crossings are constructed in the winter. Most pipeline crossings are on provincial pipelines (i.e., 12- to 14-in.-diameter pipelines) that are used to transfer product to and from batteries. There are far fewer crossings over national pipelines (i.e., approximately 42-in.-diameter pipelines) which are used to transport large amounts of product to and from refineries.
- **Cover requirements for crossings:** During the construction of a pipeline crossing, survey respondents said that they are required to raise the road grade so that the road surface is 1.0 to 1.5 m above the original ground elevation for at least 5 m of either side of the pipeline. The typical cover depth for a pipeline below the ground surface is 1.2 to 1.5 m. The lift material may consist of native soil and granular material or a combination of soil and granular fill, over a layer of rig mats or corduroy (closely spaced logs) oriented transversely across the road. See Table 1 for a summary of typical cover depths for crossings. Note that the fill depths presented in Table 1 are typical and that shallower depths of fill are also encountered and agreed upon for crossing structures.

  Typical winter crossings use snow to provide the required lift. Raised road grades have also been constructed using wood chips frozen in place.

Table 1. Typical crossing cover requirements for pipeline crossings

Season of construction	Typical existing cover depth	Additional fill depth for resource road crossing	Frequency of use (by season)	Order of preference (by season)
Winter construction	1.2–1.5m	1.0–1.5 m snow and ice	1	1
Winter construction	1.2–1.5m	1.0–1.5 m gravel or native soil[a]	2	2
Summer construction: logs (corduroy) and fill	1.2–1.5m	1.0 m gravel or native soil over logs	1	1
Summer construction: granular fill only	1.2–1.5m	1.0–1.5 m gravel or native soil	2	2
Summer construction: mats and fill	1.2–1.5m	1.0 m gravel or native soil over rig or swamp mats	3	3

[a] One innovative solution when wood chips are available is to use them as a substitute for snow and freeze them in place.

- **Common location of a pipeline crossing:** The majority of constructed pipeline crossings are located within an existing road right-of-way between the ditch line and the edge of the forest. Very few are located within a cutblock or other opening away from an existing road right-of-way. When a pipeline is located within a cutblock, high stumps have been used to mark its location and to designate crossing locations for the harvesting equipment.
- **Concerns with crossing structures:** There were several common concerns regarding pipeline crossings:
    - Horizontal and vertical alignments of the crossing structure need to be planned on a site-specific basis. Many pipelines are located within the right-of-way adjacent to the road. In these cases, the horizontal alignment of the pipeline crossing has no tangent section and the trucks must complete their turn on the crossing. The road width through the crossing must be wide (e.g., 8+ m) to take into account the vehicles' off-tracking. The road width can be minimized by incorporating a flared approach and/or skewing the crossing in the predominant direction of travel (Figure 2).

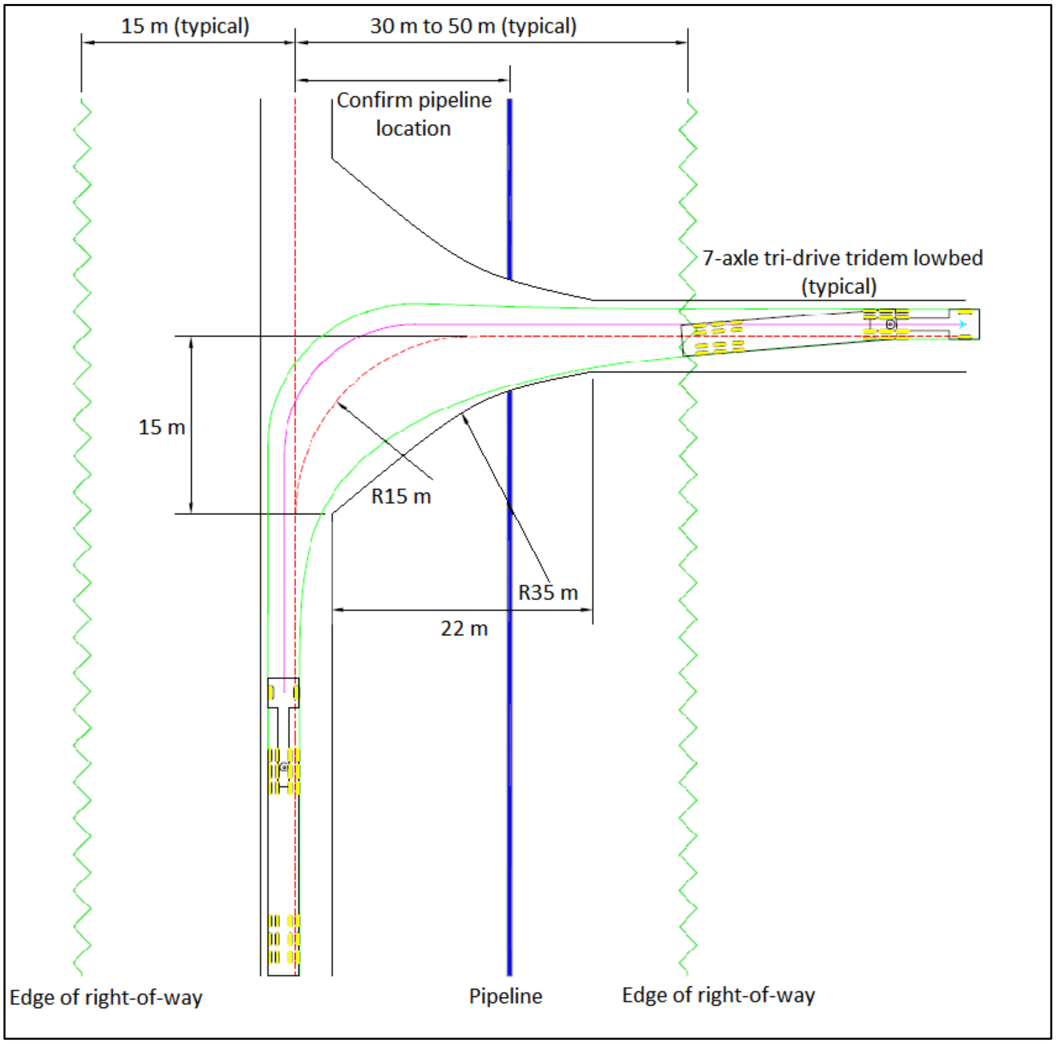

Figure 2. Plan view of travel path for 7-axle tri-drive tridem lowbed. Note that even with the truck aligned on the left-hand side of the approach and driving past the centreline of the crossing before turning, a flared crossing design is needed in order to navigate the turn across the pipeline crossing.

- The vertical curve of the approach needs to be gradual enough so the lowbed does not scrape the crossing surface; lowbeds can travel as close as 8 cm from the ground. Where power lines are present, the height of the crossing needs to be considered. A power line agreement will often specify a minimum 7-m clearance where the voltage in the line is unknown. Power lines sag, so the measurement should be at the lowest location of the sagging line. A level approach to the power line is preferred (Figure 3).

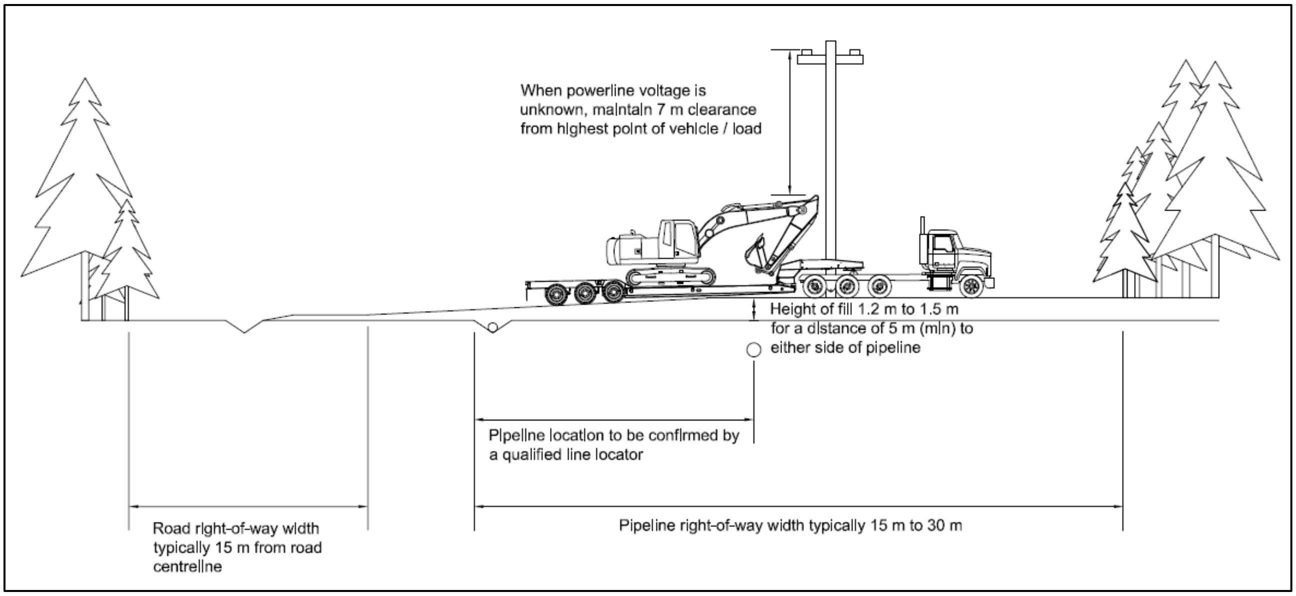

Figure 3. Profile view of 7-axle tri-drive tridem lowbed showing the additional height of fill above the existing pipeline and the gradual gradient required for the crossing in order for the lowbed to maintain clearance (not drag its deck along the crossing). Note the minimum distance to a powerline from the highest position of a load is shown for when the voltage is unknown.

  - During the winter there can be a concern with frost penetrating to the pipe depth where the freezing temperatures increase product viscosity and thus reduce its flow rate. A separation layer that provides thermal insulation was suggested as a solution to prevent the frost from reaching the vicinity of the pipeline. Snow on the surface of a road also helps insulate against frost penetration.
  - The cost of a crossing structure can vary significantly depending on the specified crossing design. Summer crossings with granular fill and/or logs are more cost-effective to construct and reclaim than a crossing that incorporates rig mats. Winter crossings made of snow and water are considered to be the most cost-effective type of crossing.
  - The permanency of a summer crossing structure was a concern for some because of the liability associated with its use by the public or others. Once a crossing is no longer needed, many companies elect to remove the structure. Many crossings are removed within 12 months, but 16–24 months is typically the maximum duration that a summer crossing is left in place.
- **Cost:** The costs associated with constructing or reclaiming a crossing are briefly summarized:
  - The construction cost for a summer crossing made of logs and fill can range from $500 to $1000 (average is $900). An excavator would be used for the majority of the work and a feller-buncher may be needed for up to one hour to cut the trees needed for the corduroy layer. An all-soil or soil/granular crossing would cost a similar amount; although the feller-buncher would not be needed, both an excavator and material delivery would be needed. Some crossings have been built by a crawler tractor and feller-buncher working together.

   - The construction cost of a summer crossing can increase significantly with the use of rig mats, and ranges from $5,000 to $10,000 per crossing depending on type of rig mat, number of rig mats, and transport distance. The cost for one all-wood, 2.45 x 4.9 m (8 x 16 ft.) rig mat is $800 to $850, and increases to $1800 for a heavy-duty steel frame rig mat. The number of rig mats used in a pipeline crossing will vary by site and may range from 4 to 8. The loading, transport, and unloading of rig mats add to the construction cost as well. The energy sector uses rig mats for various construction methods such as temporary road construction, weak soils and bearing improvements, and site levelling. Having a stockpile of rig mats drives the need for their continuous use.
   - The cost to reclaim a summer pipeline crossing ranges from $400 to $600, which is predominantly made up of excavator time. Where a layer of corduroy was used, there is no saw log or pulp value in the log due to contamination from the soil. There is, however, a value in the use of the logs as a source of on-site large woody debris. The cost of reclaiming a winter crossing made of snow is considered to be negligible compared to reclaiming a summer crossing.
- **Structural elements of a crossing:** The predominant structural elements of a pipeline crossing varied by season of use. For summer crossings they included granular fill and/or native soil (by volume and compaction), and a bridging or load-spreading layer (either logs or rig mats). Not as predominant was the use of a geotextile separation layer. For winter crossings they included the use of snow (natural and manmade), water/ice, granular fill, and wood chips. The technique for preparing a winter crossing includes the use of water to freeze the crossing which provides a stiff and rigid structure.
- **Status quo preference:** All companies surveyed acknowledged the importance and need for a crossing that maintains pipeline integrity and they would build accordingly to accomplish this. Both forestry and energy sector companies realized the benefit of using logs in the crossing because they are cost-effective and easily accessible. The layer of logs also played an important role during site reclamation because the equipment operator knew that anything below this layer was to be left undisturbed. Winter crossings were considered the most cost-effective. The use of snow and water to construct and freeze the crossing is a well-accepted technique.

KEY ELEMENTS OF STANDARD CROSSING DESIGNS

The survey identified a need and a desire for standardized construction practices for crossings of provincial pipelines. Existing crossing agreements lack explicit designs for these pipeline crossings and this leads to delays, frustration, and added costs. FPInnovations proposes the use of standardized schematics based on existing industry-proven crossing configurations. Table 2 summarizes the key elements of these proposed standard schematics.

Table 2. Key elements of proposed standard crossing schematics

Season of construction	Existing design cover depth	Additional fill depth for resource road crossing
Winter construction	1.2–1.5m	1.0–1.5 m snow and ice
Summer construction: logs (corduroy) and fill	1.2–1.5m	1.0 m gravel or native soil over logs
Summer construction: granular fill only	1.2–1.5m	1.0–1.5 m gravel or native soil

ROADMAP TO IMPLEMENTATION

The timeline associated with the proposed roadmap is somewhat related to additional pipeline crossing work which is continuing in Alberta. These recent trafficking trials will further enhance the knowledge of the strains reaching a buried pipe by both wheeled and tracked equipment. It is anticipated that the pilot trial utilizing the schematics of proposed crossing arrangements will be completed during 2016.

1. **Company review of proposed standard schematic elements:**
   Seek regulator and company approval of key elements of the proposed crossing arrangements, essentially to further verify the survey results. Once completed, FPInnovations will prepare schematics of crossing arrangements of provincial pipelines. Construction notes will also be incorporated onto the schematic to provide further details regarding the construction method and pertinent arrangement detail. Construction notes could also allow for reduced fill requirements where it has been an established practice and previously agreed upon.

2. **Identify cooperators for a pilot trial to showcase the use of standardized construction practices for crossings:**
   To be successful at introducing standardized construction practices for crossings for use in the natural resources sector, the proposed schematics and a streamlined method for their use should be piloted. FPInnovations will work with a member company and develop a set of proposed schematics to be used in a field trial with cooperation from the pipeline owner(s). The proposed schematic details will address the common and expected crossing scenarios encountered during the trial period. A temporary summer and temporary winter crossing would likely be developed before addressing permanent crossings.

3. **Development of optimized crossing designs and notification process:**
   If the B.C. pipeline crossing project finds that industry supports the development of optimized crossing designs and a notification process for their use, then FPInnovations will embark on a pilot trial of the new designs and the notification process—first in B.C. and then, possibly, in Alberta. It is anticipated that these designs will be suitable for a more limited set of site conditions than the standard set of conceptual schematics piloted in this project.

4. **Pilot trial report prepared with revisions to designs as needed:**
   FPInnovations will report on the construction, use, and reclamation of the standard crossing(s) based on the proposed construction practices. Any suggested revisions to the proposed construction practices would be included in the pilot project reporting. If the development of

optimized designs and a notification process is successful in a trial, the results from this work will be included in this report. Access to these findings will allow companies to utilize these new crossing arrangements regardless of their acceptance by a larger member association.

5. **Inclusion of the conceptual schematics in the CAPP Facility Crossing Agreement:**
   The Facility Crossing Agreement produced by CAPP is one of the more commonly used templates for an agreement. FPInnovations will provide CAPP with the schematics and pilot results, and will encourage CAPP to include the standard construction practices for crossings in the agreement document. The conceptual designs would gain widespread exposure and acceptance if included in the CAPP Facility Crossing Agreement.

6. **FPInnovations members lobby for the inclusion of the construction practices for crossings / schematics in regulations:**
   Further acceptance of the schematics, showing detailed arrangement of the crossings, by industry may lead to their reference or adoption in applicable regulations. This would be done if there was a clear benefit and support from current users (FPInnovations members and/or cooperators). This level of reference to the conceptual schematics would likely be industry-led.

CONCLUSIONS

In many areas of the Prairie provinces and northeastern B.C., the forest industry shares operating areas with oil, gas, and pipeline companies. The forest companies build hundreds of resource road crossings over pipelines each year and deal with up to 50 different pipeline owners. Approval process for these crossings can be costly, time consuming, and frustrating because the crossing design requirements vary according to the pipeline owner and/or the judgement of the site inspector from the pipeline company. The need for a standardized construction practices for resource road crossings of buried pipelines has been recognized and supported by industry; FPInnovations will develop a set of generic, cost-effective, and accepted pipeline crossing schematics for both permanent and temporary resource roads.

In order to help establish an understanding of the various pipeline-road crossing construction methods and associated constraints, FPInnovations surveyed both forestry and energy sector companies. The survey collected a representative sample of existing pipeline crossing requirements, as well as additional information included facility/master crossing agreements, the various planning phases for the construction of a crossing, costs, and a vision for industry adoption of a standard construction practices. The number of crossings constructed in a year ranged from 50 – 225 and, therefore, having a level of consistency for crossing designs would improve the planning and construction phases. A previous field study (Thiam et al. 2015) measured the effects of heavy-industrial vehicles crossing over sections of unpressurized pipeline. The test pipes were instrumented with strain gauges, placed at two different depths, and backfill compacted with two different methods. The results from the field study will be utilized when determining appropriate structural elements of standardized construction schematics.

A series of next steps has been prepared to help guide the development of standardized construction practices for crossings as well as the acceptance and dissemination of both the initial research and the standard schematics. The steps highlight the need for a pilot trial to showcase the use of the schematics in a Facility Crossing Agreement. The acceptance and promotion of the schematics by a membership association would enhance their implementation by both energy sector and forest industry companies. The inclusion of the standardized construction practices for crossings in regulations and/or standards will be pursued if there is support from current users.

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