Alien and Invasive Native Vascular Plants Along the Norman Wells Pipeline, District of Mackenzie, Northwest Territories

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Vegetation studies were carried out as part of a research and monitoring program to evaluate project effects and the performance of environmental mitigation along the Norman Wells to Zama Pipeline. This was the first fully buried oil pipeline and the largest and most extensive revegetation program to date in the boreal forest — discontinuous permafrost zone of the Northwest Territories. The pipeline owners (Interprovincial Pipe Line (NW) Ltd. (IPL), now Enbridge Pipelines Inc.) developed a special combination of seeds composed of predominantly native North American species from certified seed stocks to help reduce the risk of introduction of alien (non-North American) species. Monitoring, primarily focussed on the pipeline construction period, confirmed the initial presence of a limited number of alien species. The purpose of this paper is to update floristic data for the Continental Northwest Territories and document invasion of alien plants despite mitigative measures. Of the 34 alien taxa collected along the pipeline right-of-way, 15 are new to the flora of the mainland Northwest Territories including *Agrostis stolonifera*, *Alopecurus arundinaceus*, *Alopecurus pratensis*, *Bromus commutatus*, *Bromus hordeaceus*, *Bromus squarrosus*, *Festuca trachyphylla*, *Festuca valesiaca* ssp. *sulcata*, *Lolium perenne* ssp. *perenne*, *Lolium perenne* ssp. *multiflorum*, *Poa annua*, *Secale cereale*, *Triticum aestivum*, *Vulpia bromoides*, and *Corisperumum orientale* var. *emarginatum*. Nineteen alien taxa previously known from other areas of Continental Northwest Territories including the aggressive weedy grass known as Cheatgrass or Downy Brome are also reported. Thirteen native North American taxa of invasive habit, but uncommon in the Continental Northwest Territories were also detected along the pipeline.

Key Words: alien vascular plants, revegetation, Norman Wells Pipeline, District of Mackenzie, Northwest Territories, Mackenzie Valley.

The Norman Wells Pipeline Project involved the most extensive revegetation program to date in the mid-high boreal forest, including subarctic forest, of the western Northwest Territories (N.W.T.). The 869 km long (540 mi) pipeline is the first completely buried oil pipeline in the discontinuous permafrost zone in Northern Canada where it traverses erodible mineral and organic terrain, including both icy "thaw-sensitive" and "warming-sensitive" permafrost terrain from Norman Wells, N.W.T., to Zama, Alberta, (Figure 1a and b, 751 km in N.W.T.). Pipeline operations commenced in April 1985 (a 324 mm (12.7 inch) diameter pipe designed for ~30 000 barrels per day), following primarily winter construction in 1983-84 and 1984-85. Overland access for maintenance is seasonally limited. Vegetation assisted erosion control is necessary especially in the ice-rich permafrost terrain where ground thaw settlement causes surface elevation and subsequent drainage changes. The pipeline owner/operator, Interprovincial Pipe Line (NW) Ltd. (IPL) (now Enbridge Pipelines Inc.) has examined the success of revegetation from an erosion control perspective and undertook remedial work where necessary.

The project included major new, as well as standard, approaches to pipeline design and environmental impact mitigation such as minimizing the length of the pipeline in thaw-sensitive, or warming-sensitive, terrain; minimizing the energy input from the pipeline to ice-rich terrain; maximizing the length of the pipeline in previously cleared or disturbed areas; and, using primarily winter construction when much of the alignment was protected by frozen ground and snow or ice ground cover (ESSO and IPL 1980; MacInnes et al. 1989, 1990). One of the authors (K. L. MacInnes) was involved in evaluating the impacts and success of various mitigative measures, including the ecological implications of the revegetation program.

IPL's pipeline revegetation was undertaken primarily to reduce erosion by decreasing the velocity of surface water movement and by reducing volumes of subsurface water through evapotranspiration. Initial design plans for revegetation called for selection of basic seed mixes (Appendix 1) consisting of five to seven species of grasses known to do reasonably well under northern conditions and covering a range of soil and moisture conditions with

growth/development rates for short and long term ground cover establishment (Wishart and Fooks 1986; Wishart 1988).

The initial plans included seeding of mineral soils only (defined here as any soils where ditching exposed mineral soils) using a relatively conservative application of seed (compared to the trans-Alaska pipeline: Johnson 1981) depending on the erosion potential of the site (50 kg/ha or 30 kg/ha). Seedbed preparations and initial post-construction seeding took place in winter using hand and vehicle pulled cyclone seeders. Initial seeding was planned for a 10 m width strip centred over the pipe but because of additional disturbance the seeding was usually extended to the 20-25 m tree-cleared pipeline right-of-way. The areas of federal crown land in the Northwest Territories used under easement and temporary land use permits for the construction of the pipeline through September 1985 totalled 2597 hectares, of which the major portion consisted of right-of-way utilization (1797 ha).

The seeds to be used were specified by IPL, ordered in individual lots from a variety of North American and European producers, and put together into a specially designed mix for the Norman Wells Pipeline. Seeds were checked for purity and weed content as part of the Canadian seed certification program and IPL supplied Seed Certificates and reports, as required, on the revegetation programs. IPL monitored the success of their revegetation during and immediately after construction in erosion prone and other new maintenance areas. Additional remedial reseeding has taken place annually using the original "IPL mixes" as long as supplies lasted and more recently with commercially available seed mixes that included grasses that were known to grow well on the right-of-way. The observations discussed here focus on the 751 km of pipeline right-of-way in N.W.T. including areas which were reseeded in 1986-1988. Summer (thaw-season) monitoring was monthly from May to October in 1984-1986 primarily by helicopter. Stopping points for collections included revegetation trial areas established by the Department of Indian and Northern Affairs (DIAND) with IPL cooperation, study sites for the ground and pipe thermal monitoring, slopes, water crossings and other areas (settlement, erosion, pipe exposures, etc.) Regular but decreasingly frequent observations have continued through to September 1995. Following the initial finding of the aggressively weedy grass, Downy Brome (*Bromus tectorum*) and the disease head smut (*Ustilago bullata*) on the primary component of the seed mix, Slender Wheat grass (formerly *Agropyron trachycaulum*, now called *Elymus trachycaulus*), increased emphasis was placed on the collection of these species and diseased specimens (Cody and MacInnes 2000). The purpose of this paper is to update floristic data for the Continental Northwest Territories and document invasion of alien plants despite mitigative measures.

Annotated list by family

In this list the pipeline distance from Norman Wells is in **bold**, followed by the year in which the collection was made and the number or designator assigned to the individual specimen. Genera and species are listed alphabetically under families and nomenclatural synonyms are indicated in parentheses. Alien (non-North American) taxa new for the Continental Northwest Territories are marked with an asterisk (*).

All plant collections (1984-1989) and field observations (1983-1995) were made by Kaye MacInnes in connection with regular monitoring of the Norman Wells Pipeline Project area for the Department of Indian Affairs and Northern Development. All specimens cited were deposited at the Vascular Plant Herbarium of Agriculture and Agri-Food Canada, Ottawa (DAO). Location, date and habitat data of the Norman Wells Pipeline plant collections may be found in APPENDIX 2. In the list which follows the Kilometer Post (KP) is followed by the collection number.

POACEAE (GRAMINEAE) Grass Family

Agrostis scabra Willd., Rough Hair Grass — **0.3**: 85–55a; **150:** 84–59; **170:** 84–165; **192:** 85–72, 85–77; **287:** 89–53 **430:** 86–102; **527:** 85–94; **595:** 86–72; **636:** 89–21; **653:** 89–32.

This is a native species which frequently invades disturbed situations; in the Mackenzie River Valley known from as far north as Inuvik (Porsild and Cody 1980) where presumably introduced.

Agrostis stolonifera* L., Creeping Bent Grass — **287: 89–57.

This grass, has both native and introduced forms. It is widely distributed across Canada but has not previously been recorded as growing in the Continental Northwest Territories. Northern populations seem to be the result of introduction from further south (Dore and McNeill 1980), and could involve either native or introduced material.

Alopecurus aequalis Sobol, Water Foxtail — **430:** 86–106.

This is a native species widespread in the Continental Northwest Territories where it is found north to the limit of trees (Porsild and Cody 1980).

Alopecurus arundinaceus* Poir., Creeping Foxtail — **179: 84–175B; **192:** 85–66, 85–70b; **224:** 85–147; **287:** 89–59A; **306:** 86–124; **391:** 84–184; **527:** 85–106; **544:** 86–35b; **576:** 85–124; **579:** 86–46a, 86–46b; **595:** 86–65; **603:** 89–15; **628:** 86–52; **653:** 86–25; **678:** 89–41; **732:** 84–148.

This species, which was part of the seed mix applied in 1984, has not previously been recorded as growing in the Continental Northwest Territories. It

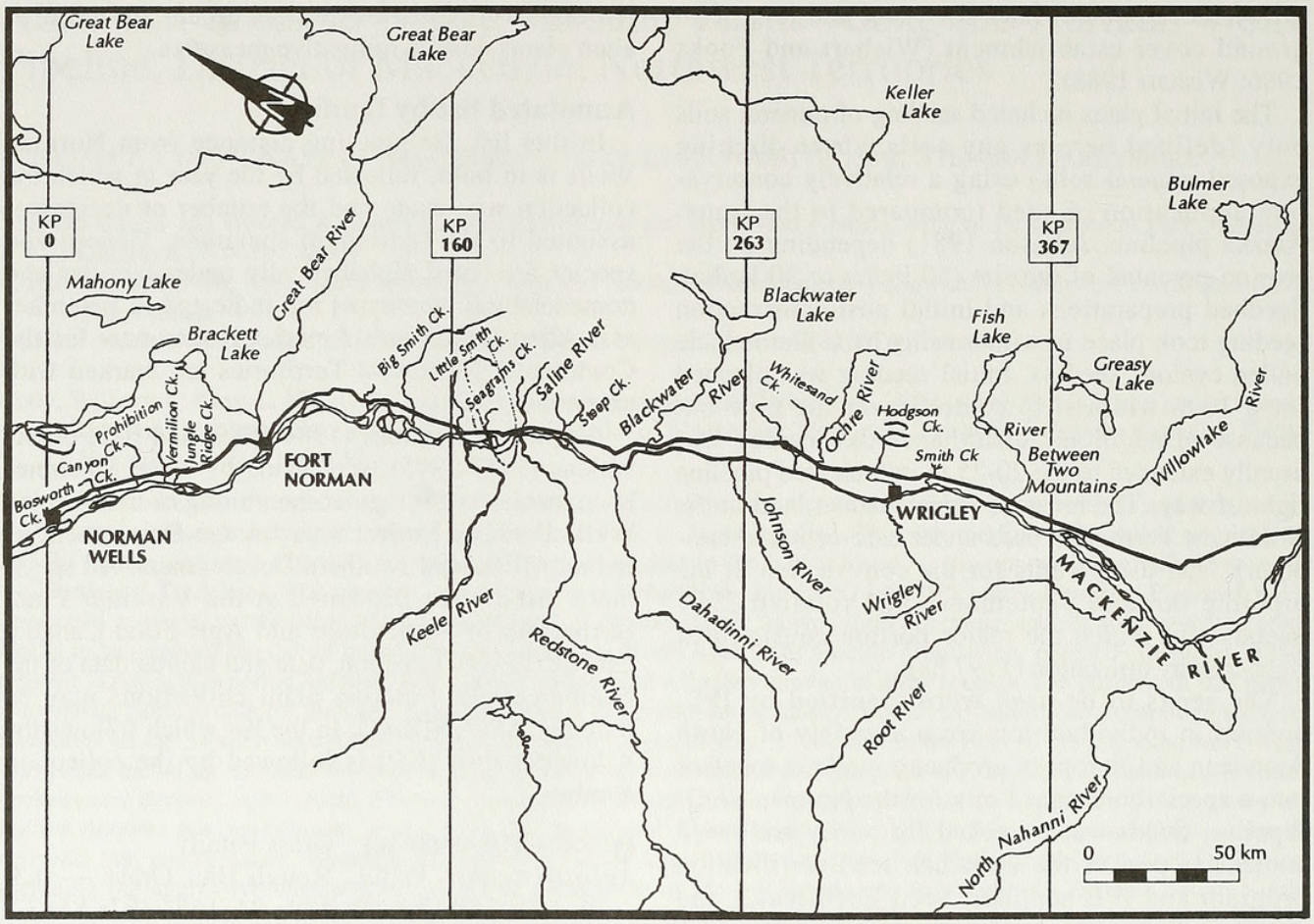

FIGURE 1a. Norman Wells Pipeline, northern part. KP = Kilometer Post

is a species native of Eurasia and apparently a recent introduction. It is being widely promoted in western North America as a forage. It differs from *A. pratensis* L. in having acute glumes with divergent tips, lemmas obliquely truncate or tapering abruptly, and lemma awns rarely or only slightly exserted from the spikelets. In *A. pratensis* the glume tips are parallel or convergent, the lemmas are acute and gradually tapering and the lemma awns are long and distinctly exserted from the spikelets.

Alopecurus pratensis* L., Meadow Foxtail — **0.02: 84–2A; **0.3:** 85–43; **18:** 86–130; **42:** 84–16; **65:** 84–35, 85–130; **240:** 85–80a; **391:** 84–183; **430:** 86–111; **529:** 85–110; **544:** 85–117.

This species has not previously been reported as growing in the Continental Northwest Territories. It is a species native of Eurasia that has been introduced widely across Canada and southward as a forage crop but has not done well for this purpose except on the Atlantic and Pacific coasts (Dore and McNeill 1980).

Avena fatua L., Wild Oats — **224:** 85–149a; **287:** 89–54.

Porsild and Cody (1980) reported this introduced species as an occasional weed in waste places in the Continental Northwest Territories.

Avena sativa L., Oats — **224:** 85–149.

Porsild and Cody (1980) reported this introduced widely cultivated species, as invading waste places in the Continental Northwest Territories.

Bromus commutatus* Schrader, Hairy Chess — **240: 85–141.

This is an annual weed of waste land which is introduced from Europe. To the south in Alberta it is rare along roadsides and in waste ground (Packer 1983). It has not previously been reported as occurring in the Continental Northwest Territories.

Bromus hordeaceus* L. (*B. mollis* L.), Soft Chess — **65: 84–34; **527:** 85–105; **529:** 85–111.

This species, which is naturalized from Eurasia, is found in Canada from the Maritime Provinces westward to southwestern Ontario and west of the Rocky Mountains through British Columbia to southern Alaska along roadsides, in old fields and in waste places (Pavlick 1995). It has not previously been reported from the Continental Northwest Territories.

Bromus squarrosus* L., Corn Brome — **65: 84–37B.

This introduced Eurasian species is known from southeastern British Columbia and eastern Washington to southern Manitoba and Kansas and

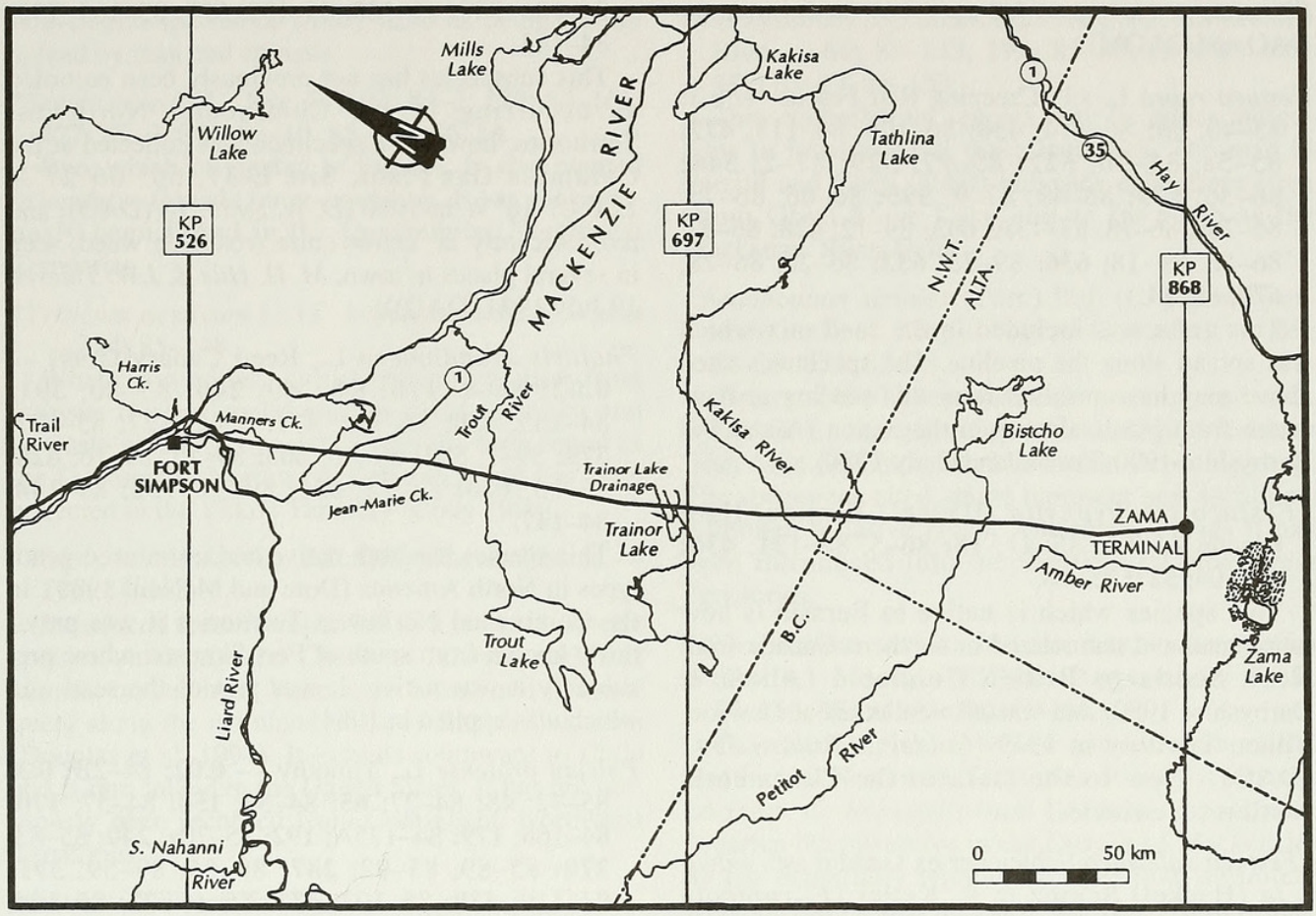

FIGURE 1b. Norman Wells Pipeline, southern part. KP = Kilometer Post

sporadically in southern Ontario and the New England States (Pavlick 1995). It is new to the Continental Northwest Territories.

Bromus tectorum L., Cheatgrass, Downy Chess, Downy Brome — **0.02:** 84–6; **19:** 86–138; **48:** 84–28; **65:** 84–37A; **170:** 84–168; **192:** 85–65; **240:** 85–78, 85–143; **287:** 89–50; **527:** 85–101; **557:** 85–19, 85–164; **732:** 84–149.

This species, which is introduced from Europe, is now found in disturbed situations throughout much of the United States and southern Canada. The invasion of this species into western North America was documented by Mack (1981). It is the only grass noted by Johnson (1981) in his survey of construction sites on the Trans-Alaska Pipeline. The map in Upadhyaya et al. (1986) gives the first record of this species occurring in the Continental Northwest Territories: Mackenzie River below Norman Wells (65° 40′N 128° 50′W, *W. Friesen 228*, 23 Sept. 1972, (SASK)). The Great Slave Lake locality indicated was however an unfortunate error in mapping (R. Turkington, personal communication 1991).

Elymus trachycaulus (Link) Gould ex Shinners s.l. (*Agropyron trachycaulum* (Link) Malte s.l.), Slender Wheat Grass — **0.05:** 84–1A (DAOM); **0.3:** 85–39; **19:** 85–58; **170:** 84–162 (DAOM); **179:** 84–176 (DAOM); **192:** 85–68; **224:** 85–150; **240:** 85–81; 85–142; **270:** 85–86; **287:** 89–49, 89–51, 89–58; **305:** 89–48; **306:** 85–144, 86–122; **380:** 86–91; **391:** 84–189 (DAOM) **403:** 85–33; **430:** 86–109; **477:** 85–3, 85–4; **527:** 85–95A, 85–107B; **529:** 84–12, 85–113, 87–3, 89–47; **544:** 85–13, 85–116, 85–118, 86–33, 87–1; 89–46; **557:** 85–166; **576:** 85–126; **579:** 86–45, 87–10, 89–2, 89–3; **595:** 86–76, 87–11, 89–9; **628:** 86–57, 86–58, 89–20; **653:** 89–37, 89–38; **678:** 89–43; **732:** 84–142 (DAOM).

This species formed 28% of the seed mix applied in 1984 and increased to 43% in 1985. Usually it was also a major component in remedial seeding work for the period up to 1996. It is a native species occurring throughout most of Canada northward to Alaska. Porsild and Cody (1980) reported it in the Mackenzie River drainage north to the Delta. After the initial finding of head smut (*Ustilago bullata* Berk.) on this species in the pipeline right-of-way in 1984, there was increased collection and documentation of the presence of diseased populations (see Cody and MacInnes 2000) in subsequent years. The disease was not new to the Northwest Territories but had only been rarely collected on *Hordeum jubatum* and ×*Elyhordeum macounii* (Vasey) Barkworth & Dewey (*Elymus trachycaulus* (Link) Gould ex

Shinners x *Hordeum jubatum* L.) (specimens at DAO and DAOM).

Festuca rubra L. s.l., Creeping Red Fescue — **0.3:** 85–40; **95:** 86–114; **430:** 86–105, 86–113; **477:** 85–5a, 85–5b; **527:** 85–97; **529:** 87–2; **544:** 86–36; **579:** 86–49, 87–9; **595:** 86–66, 86–75, 86–76a, 86–78; 87–13A; **603:** 89–12; **628:** 86–53, 86–56, 89–18; **636:** 89–23; **653:** 86–26, 86–28; **678:** 89–44.

This grass was included in the seed mix which was spread along the pipeline. The specimens cited above may have resulted from this seeding or have arisen from plants already in the region (Aiken and Darbyshire 1990; Porsild and Cody 1980).

Festuca trachyphylla* (Hackel) Krajina, Hard Fescue — **0.3: 85–41; **18:** 86–5, 86–131; **430:** 86–104; **527:** 85–98.

This species which is native to Eurasia is now introduced and naturalized in southern Canada from Nova Scotia to British Columbia (Aiken & Darbyshire 1980) and was also collected at Dawson, Yukon Territory in 1949 (*Calder & Billard 3547* (DAO)). New to the flora of the Continental Northwest Territories.

Festuca valesiaca* Schleicher ex Gaudin ssp. *sulcata* (Hackel) Schinz & R. Keller (*F. rupicola* Heuffel) — **595: 86–70.

This Eurasian grass has been sporadically introduced at scattered locations in North America. It has not been previously reported from the Continental Northwest Territories.

Hordeum jubatum L., Squirrel–tail Grass — **0.02:** 84–5; **65:** 84–159; **170:** 84–167; **391:** 84–188; **527:** 85–103; **557:** 85–556; **576:** 85–121; **579:** 87–8, 89–4; **653:** 89–34; **678:** 89–42; **732:** 84–146.

Porsild and Cody (1980) reported this species, which is native to North America and eastern Asia, as "Often a troublesome weed common in waste places near townsites north to the Mackenzie Delta".

Lolium perenne* L. ssp. *perenne*, Perennial Rye Grass — **0.02: 84–1C; **65:** 85–131; **192:** 85–74; **391:** 84–107.

This subspecies has not previously been recorded as occurring in the Continental Northwest Territories, however an earlier specimen was collected by the airstrip at Fisherman Lake, 60° 20′N 123° 48′W in 1973 (*Sheila M. Lamont FL339* (photo DAO)). A native of Europe, *Lolium perenne* is frequently included in seed mixes for revegetation because of its rapid germination and growth.

Lolium perenne* L. ssp. *multiflorum* (Lam.) Husnot (*L. multiflorum* Lam.), Italian Rye Grass — **0.02: 84–1B; **48:** 84–25; **65:** 84–33; **192:** 85–75; **240:** 85–84; **270:** 85–91; **287:** 89–52, 89–56; **391:** 84–106; **527:** 85–100, 85–102; **557:** 85–165; **732:** 84–143.

This subspecies has not previously been recorded as occurring in the Continental Northwest Territories, however a specimen was collected at the Columbia Gas Plant, Site E-37, 66° 06′27″N 124° 07′16″W in 1980 (*D. W. Smith 18* (DAO)) and more recently at Yellowknife (roadside weed, seen in several places in town, *M. H. Hils & J.W. Thieret*, 19 July 1994 (DAO)).

Phalaris arundinacea L., Reed Canary Grass — **0.02:** 84–4; **170:** 84–169; **240:** 85–80; **391:** 84–185; **430:** 86–112; **477:** 85–7; **527:** 85–107; **579:** 89–7; **597:** 89–10; **603:** 89–13, 89–16; **628:** 86–55; **636:** 89–22; **653:** 89–31; **732:** 84–144, 84–147.

This species has both native and introduced genotypes in North America (Dore and McNeill 1980). In the Continental Northwest Territories it was previously known from south of Fort Simpson where presumably it was native. It was part of the seed mix which was applied in 1984.

Phleum pratense L., Timothy — **0.02:** 84–2B; **0.3:** 85–42; **48:** 84–27; **65:** 84–36; **150:** 84–57; **170:** 84–166; **179:** 84–175A; **192:** 85–70a; **240:** 85–83; **270:** 85–89, 85–92; **287:** 89–55, 89–59; **391:** 84–110; **430:** 86–103; **477:** 85–1; **527:** 85–104; **529:** 85–109; **544:** 85–9, 85–116a, 86–33; **557:** 85–18, 85–162; **576:** 85–123; **579:** 89–5, 89–6; **595:** 86–71, 89–11; **603:** 89–14; **628:** 86–50, 89–19; **632:** 85–30, 85–31; **653:** 89–35, 89–36.

This species was previously known as an introduction from Eurasia about settlements in southwestern District of Mackenzie as far north as Fort Simpson on the Mackenzie River (Cody 1961). It was part of the seed mix which was applied in 1984.

Poa annua* L., Annual Blue Grass — **527: 85–99; **732:** 84–145.

This introduced weedy species which is new to the Continental Northwest Territories is expected to be found in the future around settlements in the Territory (Porsild and Cody 1980).

Poa pratensis L., Kentucky Blue Grass — **192:** 85–67b, 85–73.

This species, which was part of the seed mix applied in 1984, was known to Porsild and Cody (1980) in the District of Mackenzie north to Norman Wells where it was mainly restricted to settlements and roadsides and considered probably not indigenous. It is often confused with and difficult to separate from the mainly arctic *P. alpigena* (Fr.) Lindm. and there are both native and introduced forms in North America.

Puccinellia borealis Swallen — **192:** 85–71; **240:** 85–82; **576:** 85–125.

Porsild and Cody (1980) considered this native,

non–littoral species of weedy habit as being readily spread by man and animals.

Secale cereale* L., Rye — **0.02: 84–3; **170:** 84–161; **477:** 85–2; **544:** 85–10, 85–114, 86–34.

Rye, which originated in Eurasia, is also planted in southern Canada for revegetation. It has not previously been found in the Continental Northwest Territories.

Triticum aestivum* L. (*T. hybernum* auct.), Wheat — **224: 85–148.

Wheat is a widely cultivated introduction from Eurasia. It occasionally escapes along roadsides and in waste places. It has not previously been found in the Continental Northwest Territories, but has been collected in the Yukon Territory (Cody 1996).

Vulpia bromoides* (L.) S.F. Gray, Barren Fescue — **170: 84–163.

Introduced from Europe, this is a common weedy species on the Queen Charlotte Islands, the Gulf Islands, on southern Vancouver Island and is infrequent along the mainland coast of British Columbia (Douglas et al. 1994). It extends southward to Chile and is rare inland in the United States. It has not previously been recorded from Continental Northwest Territories.

JUNCACEAE Rush Family

Juncus bufonius L., Toad–rush — **150:** 84–71; **192:** 85–63.

This is a cosmopolitan, non–arctic, weedy species which has previously been recorded only from damp roadsides in and near settlements of the District of Mackenzie, north to the Mackenzie Delta (Porsild and Cody 1980).

POLYGONACEAE Buckwheat Family

Polygonum arenastrum Jord. ex Bor., Oval–leaved Knotweed — **26.5:** 84–155; **65:** 84–44; **579:** 86–40.

Introduced from Eurasia. Much of what Porsild and Cody (1980) mapped as *P. aviculare* L. in townsites north to the Mackenzie River Delta should be referred to as *P. arenastrum* (McNeill 1981).

CHENOPODIACEAE Goosefoot Family

Chenopodium album L., Lamb'-quarters — **65:** 84–38, 85–136a, 85–137; **557:** 85–159.

Introduced from Eurasia and reported by Porsild and Cody (1980) from as far north as the Mackenzie River Delta.

Chenopodium berlandieri Moq. ssp. *zschackei* (Murr.) Zobel, Net-seeded Lamb's-quarters — **0.02:** 84–7; **26.5:** 84–157B.

Possibly introduced at these localities. In western District of Mackenzie it is known as a native from a number of disturbed situations as far north as latitude 67° 22'N (Porsild and Cody 1980).

Chenopodium capitatum (L.) Aschers., Strawberry Blite — **65:** 85–133; **192:** 85–60; **529:** 85–108; **557:** 85–17, 85–158.

This circumboreal species may be either indigenous or introduced at these localities. The map in Porsild and Cody (1980) indicates collections from about Great Slave Lake and as far north as the Mackenzie River Delta.

Chenopodium simplex (Torr.) Raf. (*C. gigantospermum* Aellen), Maple–leaved Goosefoot — **65:** 84–39; **632:** 85–28.

Thieret (1961) reported this species under *C. hybridum* L. var. *gigantospermum* (Aellen) Rouleau from Mile 60 Enterprise-Mackenzie River highway. The specimens cited above represent new localities. Although a native North American species it has been introduced into the Continental Northwest Territories.

Corispermum orientale* Lam. var. *emarginatum* (Rydb.) Macbr., Villose Bugseed — **26.5: 84–156; **65:** 84–43; **192:** 85–61.

This weedy plant is a new introduction to the Continental Northwest Territories. It may be separated from *C. hyssopifolium* L., (native to North America but adventive in the District of Mackenzie) by the essentially wingless (rather than definitely winged) fruit which measures 2.5 to 3.0 mm (rather than 3.5 to 4.5 mm in length). The genus *Corispermum* is taxonomically complex and this specimen will be reexamined following the completion of monographic work currently underway (Mosyakin 1995).

BRASSICACEAE (CRUCIFERAE) Mustard Family

Brassica rapa L. (*B. campestris* L.), Bird Rape — **224:** 85–151; **557:** 85–15.

Porsild and Cody (1980) reported this widely introduced Eurasian species only from Yellowknife.

Capsella bursa-pastoris (L.) Medic., Shepherd's Purse — **65:** 85–132; **179:** 84–177; **632:** 85–29.

This widespread introduced Eurasian species is known from numerous disturbed situations as well as along roadsides and in townsites in the District of Mackenzie as far north as Inuvik.

Descurainea sophia (L.) Webb, Flixweed — **0.02:** 84–10; **26.5:** 84–157A; **42:** 84–22; **65:** 84–41; **557:** 85–157.

Porsild and Cody (1980) reported this species, which is introduced from Europe, as common in the southern parts of the Mackenzie Valley. A report from Norman Wells (Cody 1960) was based on a misidentification.

Lepidium bourgeauanum Thell., Bourgeau's Peppergrass — **557:** 85–154; **579:** 87–6.

Porsild and Cody (1980) reported that this prairie or grassland species was fairly common in the

upper Mackenzie Valley where it was thought to be native.

Thlaspi arvense L., Penny–cress — **0.02:** 84–14; **65:** 84–42, 85–138; **170:** 84–171; **224:** 85–152; **732:** 84–151.

This Eurasian species was described as an introduced weed by roadsides and in waste places by Porsild and Cody (1980). It was previously collected in the vicinity of Norman Wells (*Cody & Gutteridge 7609*, 27 July 1953 (DAO)).

ROSACEAE Rose Family

Potentilla norvegica L. s.l., Rough Cinquefoil — **65:** 85–139; **150:** 84–76; **224:** 86–17; **287:** 89–60; **595:** 86–60; **653:** 86–22, 89–25.

Porsild and Cody (1980) mapped this somewhat polymorphic circumpolar species which has both native and introduced forms northward in the Continental Northwest Territories to near the limit of trees. It is of weedy habit and readily invades areas of disturbed soil, clearings and burns.

FABACEAE (LEGUMINOSAE) Pea Family

Medicago sativa L., Alfalfa — **732:** 84–150.

This widely introduced species was reported by Porsild and Cody (1980) as occurring at Alexandra Falls on the Hay River and Fort Simpson in the District of Mackenzie. Wein et al. (1992) reported additional stations at Fort Smith and Lower Hay River.

Melilotus alba Desr., White Sweet Clover — **527:** 85–93; **529:** 86–30; **579:** 87–7, 89–8; **653:** 89–28.

Cody (1956, 1961) and Wein et al. (1992) reported this widely introduced Eurasian species from the southern District of Mackenzie at townsites north to Fort Simpson.

Melilotus officinalis (L.) Lam., Yellow Sweet Clover — **653:** 89–27.

Cody (1956, 1961) and Wein et al. (1992) reported this widely introduced Eurasian species from the southern District of Mackenzie north to Fort Simpson.

Trifolium hybridum L., Alsike Clover — **0.02:** 84–15; **65:** 85–136; **472:** 86–88.

Cody (1956, 1963) reported this widely introduced species from townsites in southern District of Mackenzie as far north as the Liard River.

BORAGINACEAE Borage Family

Lappula squarrosa (Retz.) Dumort. (*L. echinata* Gilib.), Bluebur — **579:** 86–39.

This introduced cosmopolitan weed was known to Porsild and Cody (1980) as occasional in the townsites of southwestern District of Mackenzie.

PLANTAGINACEAE Plantain Family

Plantago major L., Common Plantain — **65:** 84–160; **192:** 85–62.

Previously known in the Continental Northwest Territories as a roadside weed in settlements northward nearly to the Mackenzie River Delta (Porsild and Cody 1980).

ASTERACEAE (COMPOSITAE) Composite Family

Artemisia biennis Willd., Biennial Wormwood — **65:** 85–129.

Porsild and Cody (1980) knew this native and cosmopolitan weedy species in the District of Mackenzie where it was confined to waste places near human habitations along the Mackenzie River and its tributaries north to the Arctic Circle.

Crepis tectorum L., Narrow-leaved Hawk's-beard — **0.3:** 85–36; **65:** 85–134; **224:** 85–153; **306:** 86–119; **544:** 85–115; **557:** 85–16, 85–155; **576:** 85–119; **579:** 86–42.

Porsild and Cody (1980) knew this introduced cosmopolitan weedy species only from townsites and roadsides in the southwestern area of the Continental Northwest Territories.

Discussion

The foregoing includes 34 alien taxa of which 15 are new to the flora of the continental Northwest Territories. The mitigative measures taken did not prevent the invasion of alien nor were they necessarily expected to do so. It is to be noted that the purpose of the present work was not to evaluate mitigation or make recommendations, only to update floristic data. It is additionally important to note that the various alien taxa reported could have invaded the pipeline either by contaminated seed or by long distance dispersal using a number of vectors including vehicles used during pipeline construction as well as animals and wind.

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APPENDIX 1. Initial main broad-based seed mixes specifically developed and used by Interprovincial Pipe Line (NW) Ltd. for seeding the Norman Wells Pipeline right–of–way primarily in March of 1984 and 1985.[1]

Scientific names used	Common Name (Cultivar)	Percent by weight		Seed Sources Used
		1984	1985	
Agropyron trachycaulum (now *Elymus trachycaulus*)	Slender wheat grass (Revenue, Common) *North American*	28%	43%	Canada (AB)
Festuca rubra	Creeping Red Fescue (Boreal) *North American*	20%	27%	Canada (AB, BC), Germany
Festuca ovina	Hard Fescue (Durar, Sheep)	15%	0%	Canada (AB), Germany
Alopecurus arundinaceus	Creeping Foxtail (Common, Garrison)	15%	15/0%	Canada(BC), USA (Idaho)
Alopecurus pratensis	Meadow Foxtail (Common, Garrison)	0%	0/15%	USA (Oregon, Idaho)
Phalaris arundinacea	Reed Canary Grass (Vantage) *North American*	12%	9%	Canada (BC)
Phleum pratense	Timothy (Climax)	5%	6%	Canada (AB)
Poa pratensis	Kentucky Blue Grass (Common)	5%	0%	USA (Washington)

[1]Interprovincial Pipe Line (NW) Ltd. July 1985. Norman Wells to Zama Pipeline. Revegetation Activities. March–April 1984 and February–March 1985. Prepared by UMA.CANUCK. HARDY. Construction Services Manager. (Supplier: Dawson Seed Co. Ltd., West Vancouver, British Columbia.)

APPENDIX 2. Location, date and habitat data of Norman Wells Pipeline Plant Collections. KP = location along pipeline from north to south starting at Norman Wells. Terrain/soils as designated on terrain-typed pipeline alignment sheets.

KP	Location	Latitude/Longitude	Year
0.02	Norman Wells. Pump Station	65°17'N, 126°53'W	1984, 1986
	Hummocky silty clay lacustrine soils over bedrock. Black Spruce/Larch scrub. Elevation: 60 m. Ice–rich permafrost. Trees and shrubs cleared in 1983. Ditched January 1984. Seeded March 1984.		
0.3	Norman Wells	65°17'N, 126°52'W	1985
	300 m south of Pump Station. Hummocky silty clay lacustrine soils over bedrock. Black Spruce/Larch scrub. Elevation: 60 m. Ice-rich permafrost. Trees and shrubs cleared in 1983. Ditched January 1984. Seeded March 1984.		
18	North of Canyon Creek	65°14'N, 126°31'W	1986
	Hummocky till soils. Black Spruce-Labrador Tea scrub. Elevation: 120 m. Non ice-rich permafrost. Additional trees and shrubs cleared in 1983, widening older clearing. Ditched January 1984. Seeded March 1984.		
19	Canyon Creek	65°14'N, 126°30'W	1985, 1986
	Hummocky till soils. Mixed Black Spruce and White Spruce with Alder and Birch depending on aspect. Elevation: 90–120 m. Non ice-rich permafrost. Additional trees and shrubs cleared in 1983, widening older clearing. Ditched January 1984. Seeded March 1984.		
26.5	North of Christina Creek	65°13'N, 126°24'W	1985
	Hummocky colluvium. Black Spruce, White Spruce, Labrador Tea scrub. Elevation: 120 m. Ice-rich permafrost. Trees and shrubs cleared in 1983. Ditched January 1984. Seeded March 1984.		
42	Vermillion Creek North	65°06'N, 126°07'W	1984
	Hummocky silty clay lacustrine soils. Black Spruce/Larch scrub. Elevation: 120 m. Non ice-rich permafrost. Additional trees and shrubs cleared in 1983, widening older clearing. Ditched February 1984. Seeded March 1984.		
48	North of Jungle Ridge Creek	65°05'N, 126°02'W	1984
	Hummocky silty clay lacustrine soils with organic veneer. Black Spruce and Larch scrub. Elevation: 120 m. Ice-rich permafrost. Trees/shrubs cleared in 1983. Ditched February 1984. Seeded March 1984 and reseeded following thaw-settlement and ditchline erosion 1985.		
65	Norman Range	64°59'N, 125°44'W	1984, 1985
	12 km north of Tulita (Fort Norman). North of Bear Rock. Hummocky till veneer over bedrock. Spruce/Birch scrub on former burn area., Elevation: 150 m. Low ice permafrost. Trees and shrubs cleared in 1983. Ditched February 1984. Seeded March 1984.		
95	Northeast of Police Island	64°55'N, 125°15'W	1984, 1986
	Hummocky silty clay lacustrine plain. Black Spruce/Larch scrub. Elevation: 150 m. Ice-rich permafrost. Trees cleared in 1983. Ditched February 1984. Seeded March 1984.		
150	East of Mio Lake	64°31'N, 124°46'W	1984, 1985, 1986
	Hummocky sandy silt lacustrine plain. Black Spruce/Larch scrub. Elevation: 150 m. Non ice-rich permafrost. Former CNT landline clearing widened for pipeline right-of way in 1983. Ditched and seeded March 1984.		
170	South of Seagram Creek	64°22'N, 124°38'W	1984
	Hummocky silty sand lacustrine veneer over ground moraine. Black Spruce/Labrador Tea scrub. Elevation: 150 m. Non ice-rich permafrost. Trees cleared in 1983. Ditched and seeded March 1984.		
179	North of Saline River	64°18'N, 124°29W	1984
	Silty sand lacustrine veneer over ground moraine. Black Spruce/Labrador Tea scrub. Elevation: 135 m. Non ice-rich permafrost. Trees cleared in 1983. Ditched and seeded March 1984.		
192	North of Steep Creek	64°13'N, 124°23'W	1985
	Hummocky silty clay lacustrine plain. Black Spruce/Larch scrub. Elevation: 150 m. Ice-rich permafrost. Trees cleared in 1984. Ditched January 1985. Seeded March 1985.		
224	North of Blackwater River	63°47'N, 124°09'W	1985, 1986
	Hummocky silty colluvium of slope. Former burn-Spruce/Trembling Aspen/Alder forest. Elevation: 135 m. Ice-rich permafrost. Trees cleared 1984. Ditched January 1985. Seeded March 1985. Erosion and additional later seeding of non-woodchip insulated areas and west side-cut of slope.		
240	South of Blackwater River	63°47'N, 123°57'W	1985
	Silty clay lacustrine plain. Spruce/Aspen forest. Elevation: 185 m. Ice-rich permafrost. Trees cleared 1984. Ditched January 1985. Seeded March 1985.		
270	Southwest of Table Mountain	63°36'N, 123°39'W	1984, 1985
	10 km west of Table Mt., 50 km N of Wrigley. Hummocky silty clay lacustrine plain with 20–40 cm organic veneer. Black Spruce/Larch scrub. Elevation: 245 m. Icy permafrost. Additional trees and shrubs cleared in 1984, widening former seismic line tree clearing and including recent helipad clearing. Ditched January 1985. Seeded March 1985.		

(Continued)

APPENDIX 2. *(Continued)*

KP	Location	Latitude/Longitude	Year
287	South of Ochre River	63°27'N, 123°37'W	1989
	Sandy-gravel flood plain south of Ochre River. White Spruce forest. Elevation: 185 m. Trees cleared 1984. Ditched January 1985. Seeded March 1985. Eroded by major flood in July 1988. Pipe excavated, reburied and floodplain area reseeded February–March 1989.		
305	North of Hodgson Creek	63°18'N, 123°28'W	1989
	Sandy-gravel flood plain north of Hodgson Creek. White Spruce forest. Elevation: 215 m. Trees cleared 1984. Ditched January and seeded March 1985. Floodplain eroded by major floods in 1986 and in July 1988. Protective gravel berm constructed in 1987. Pipe excavated, reburied and area reseeded February-March 1989.		
306	Hodgson Valve Tower Area	63°18'N, 123°27'W	1985, 1986, 1989
	2 km south of Hodgson Creek. South of plain flooded in 1986 and 1988. Hummocky silty clay lacustrine plain Black Spruce/Labrador Tea forest. Elevation: 230 m. Ice-rich permafrost. Trees cleared in 1984. Ditched February 1985. Seeded March 1985. Additional fill added to ditchline due to settlement and erosion and reseeded winter 1986.		
353	River Between Two Mountains	62°57'N, 123°12'W	1984
	1 km south of river. Well-drained till. Boreal mixedwood-Spruce, Birch, Alder, Aspen. Elevation: 150 m. Trees cleared in 1983. Ditched March 1984. Seeded March 1984.		
380	Willowlake River winter road	62°43'N, 123°05'W	1986
	North side of Willowlake River. Area of road crossing and construction camp. 500 m west of pipeline. Sandy alluvial terrace. Boreal mixed woods. Elevation: 150 m. Non ice-rich permafrost. Seeding history, if any, unknown.		
391	South of Willowlake River	62°42'N, 123°05'W	1984, 1986
	11 km south of Willowlake River. Organic veneer over ground moraine. Boreal-Spruce/Larch. Elevation: 150 m. Non ice-rich permafrost. Area of former tree clearing for CNT landline. Additional trees/shrubs cleared 1983. Ditched February 1994. Seeded March 1984.		
403	Unnamed Creek area	62°30'N, 123°02'W	1985
	8 km east of Mackenzie River (Berry Island). Hummocky till-ground moraine. Boreal forest-White Spruce. Variable ground conditions from permafrost (ice-rich) to non-permafrost. Elevation: 150 m. Trees cleared 1983. Ditched February 1984. Seeded March 1984.		
430	West of Ebbutt Hills	62°19'N, 122°43'W	1984, 1986
	Thin organic veneer over ground moraine. Former forest fire area. Regrown boreal mixedwood: Trembling Aspen, Balsam Poplar, Alder, Willow, Spruce. Elevation: 150 m. Non ice-rich permafrost. Trees cleared 1983. Ditched February 1984. Seeded March 1984.		
472	South of Trail River	62°05'N, 122°04'W	1984, 1986
	6 km south of Trail River. Hummocky sandy silt lacustrine plain. Spruce forest. Elevation: 120 m. Non ice-rich permafrost. Trees cleared 1983. Ditched February 1984. Seeded March 1984.		
477	South of Trail River	62°05'N, 121°59'W	1985
	10 km south of Trail River. Sandy-eolian dune area. Jack Pine/Balsam Poplar forest. Elevation: 150 m. Non-permafrost site. Trees cleared 1983. Ditched February 1984. Seeded March 1984 (Seed mix included annual rye.)		
527	North of Mackenzie River	61°50'N, 121°10'W	1985
	Area includes old winter seismic line (trees/shrubs cleared), the newer pipeline right-of-way and the temporary pipeline construction camp site. Hummocky till-ground moraine. Boreal mixedwood. Elevation: 120 m. Non ice-rich permafrost. Trees/shrubs cleared for pipeline and camp in 1983. Ditched January 1984. Seeded March 1984.		
529	Mackenzie River south	61°49'N, 121°10'W	1985, 1987, 1989
	500 m south of the south bank of the river, near manual value site. Sandy silt lacustrine plain. Boreal mixedwood forest, White Spruce, Aspen. Elevation: 150 m. Non-permafrost site. Trees cleared 1984. Ditched February 1985. Seeded March 1985.		
544	Simpson Dunes	61°38'N, 121°10'W	1985, 1986, 1987, 1989
	10 km southeast of the Liard Ferry crossing. Sandy eolian dune. Mature Jack Pine. Elevation: 185 m. Non-permafrost site. Trees cleared 1984. Ditched February 1985. Seeded March 1985 (included annual rye in seed mix)		
557	Near Manners Creek	61°36'N, 121°06'W	1985
	Hummocky organic veneer over sandy silt lacustrine plain varying to peat plateau with collapse scars/fens/bogs. Mature White Spruce forest to boreal mixedwood to sedge fens and cattails. Elevation: 185 m. Thin permafrost with variable to high ice contents. Non-permafrost in peat plateau collapse scars. Trees cleared 1984. Ditched February 1985. Seeded March 1985.		

(Continued)

APPENDIX 2. *(Concluded)*

KP	Location	Latitude/Longitude	Year
559	Manners Creek	61°36'N, 121°05W	1989
	Organic terrain (fen, thick mat of floating vegetation to thick organic veneer with shrubs and scattered Black Spruce/Larch. Elevation: 150 m. Non-permafrost site (fen). Shrubs cleared in winter 1984 (after building up thick ice road). Ditched February 1985. Seeded March 1985.		
576	South of Jean Marie Creek	61°25'N, 120°56'W	1985
	Hummocky silty clay lacustrine plain. Boreal mixedwoods. Elevation: 185 m. Ice-rich permafrost. Trees cleared 1984. Ditched January 1985. Seeded March 1985. Additional seeding on eroded area summer 1985.		
579	North of Mackenzie Highway	61°23'N, 120°55'W	1985, 1986, 1987, 1989
	6 km north of pipeline/highway crossing. Hummocky sandy silt lacustrine plain. Boreal forest-White Spruce, Aspen. Elevation: 215 m. Permafrost with variable ice contents. Trees cleared 1984. Ditched January 1985. Seeded March 1985. Additional backfill placed in ditchline due to settlement and erosion and area reseeded 1986.		
585	Mackenzie Pump Station	61°22'N, 120°53'W	1984
	Adjacent to Highway. Ground moraine over bedrock. Jack Pine forest. Elevation: 215 m. Trees cleared 1983 and 1984. Non-permafrost site. Temporary camp site and permanent location of the Pump Station. Seeded March 1985.		
595	South of Mackenzie Highway	61°17'N, 120°56'W	1986, 1987, 1989
	10 km south of the Mackenzie Highway. Hummocky till ground moraine. Boreal mixedwoods. Elevation: 245 m. Non-permafrost site. Trees cleared 1984. Ditched January 1985. Seeded March 1985.		
603	Jean Marie Creek North	61°15'N, 120°45'W	1989
	Organic terrain. Peat plateau with collapse scars. Black Spruce/Larch scrub. Ice-rich permafrost in raised peaty areas. Elevation: 270 m. Scrub cleared 1984. Ditched February 1985. Seeded March 1985.		
628	North of Trout River	61°01'N, 120°35'W	1986, 1989
	43 km south of Mackenzie Highway. Till-ground moraine. Boreal mixedwoods. Elevation: 315 m. Non-permafrost site. Trees cleared 1984. Ditched January 1985. Seeded March 1985.		
632	Trout River south bank	60°59'N, 120°34'W	1985
	Till-ground moraine. Boreal mixedwoods. Elevation: 315 m. Non–permafrost site. Trees cleared 1984. Ditched January 1985. Seeded March 1985.		
636	South of Trout River	60°58'N, 120°34'W	1989
	Organic terrain. Peat plateau with collapse scars. Black Spruce/Larch. Elevation: 415 m. Ice-rich permafrost in raised peat. Trees and shrubs cleared 1984. Ditched January 1985. Seeded March 1985.		
653	Temporary Staging Site	60°48'N, 120°21'W	1986, 1989
	Tree cleared area adjacent to pipeline right-of-area. (Pipeline construction camp and summer equipment parking area in 1984. Some post-construction use as helicopter fuel cache or camp area.) Till-ground moraine. Boreal mixedwoods: Willow, Alder, Spruce. Elevation: 450 m. Non ice-rich permafrost site. Trees cleared 1983. Seeded March 1985.		
678	IPL(NW)Peat Trial area	60°35'N, 120°17'W	1989
	Organic terrain. Peat plateau ("bog") with collapse scars. Black Spruce/Larch. Elevation: 600 m. Ice-rich permafrost. Trees and shrubs cleared 1983. Ditched March 1984. Organic terrain not originally seeded. Following erosion of loose peat in ditchline, remedial work to limit ditchline erosion included experimental seeding 1988.		
732	Kakisa River bank	60°09'N, 119°52'W	1984
	South bank of the river at the pipeline crossing (cut slope). Till-moraine. Former forest fire burn area. Immature Jack Pine-mixedwood. Elevation: 450 m. Trees cleared 1983. Ditched February 1984. Seeded March 1984. Hand re-seeded in summer of 1984 following surface mud flow.		