APPENDIX A

North Nechako Neighbourhood Plan
L&M Engineering Limited

ENVIRONMENTAL OVERVIEW ASSESSMENT

Environmental Overview Assessment

North Nechako

Neighborhood Plan

Prepared for:

T.R. Projects Ltd & 406286 BC Ltd

Prepared by:

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12025 Russell Rd
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V3 – June 2019

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1 Introduction

Alces Environmental Ltd. (Alces) was retained by L&M Engineering (L&M) on behalf of T.R. Projects Ltd. (T.R.) and 406286 BC Ltd. to conduct an environmental overview assessment (EOA) in support of the North Nechako Road Neighborhood Plan and subsequent rezoning for their subdivision application (the Project). The purpose of this document is to provide L&M, T.R, 406286 BC Ltd. and the City of Prince George (CoPG) with a summary of environmental sensitivities and best management practices to mitigate or minimize the impact of the proposed developments.

2 Methodology

The EOA was conducted by Jonathan St. Jean, R.P.Bio of Alces Environmental. The assessment comprised of a desktop review of available environmental data for the project area, as well as two site visits with intensive systematic reconnaissance level ground surveys to determine existing aquatic and terrestrial habitat value.

2.1 Field Assessment

Surveys of the project footprint were conducted on October 30th, 2017 and May 28th, 2018. The surveys focused on all vegetated portions of the sites (within blue shaded areas of Map 1) and did not spend much time in the open gravel extraction areas as they provide little to no habitat value. However, all steep slopes and vertical banks within the gravel extraction areas were assessed as they could provide potential denning or nesting habitat.

2.2 Desktop Assessment

2.2.1 Historical Land Use

Orthophotos of the project footprint were reviewed for a general overview of historical land use (available from the CoPG: 1993, 1997, 2003, 2006, 2009, 2010 and 2014, Google Earth: 2018).

2.2.2 Rare/Endangered Species Database

The BC Conservation Data Centre (CDC) database was searched for potential rare or endangered plant species relevant to this site. Search criteria included:

- Prince George Forest District
    - Sub-Boreal-Spruce (SBS)
    - Sub-Boreal-Spruce dry/warm (SBSdw and SBSdw3), and
    - Sub-Boreal-Spruce dry/warm series 01 (SBSdw/01)

CDC search results identify species that can be expected to occur within the Forest District boundaries, and can be narrowed to specific biogeoclimatic zones. These status lists use a colour-coding system to rank the status and management priorities for species at risk:

Table 1: BC CDC Colour-Coding System

Red	**Endangered, or Threatened**: Endangered taxa are facing imminent extirpation or extinction. Threatened taxa are likely to become endangered if limiting factors are not reversed. Not all Red-listed taxa will necessarily become formally designated. Placing taxa on these lists flags them as being at risk and requiring investigation.
Blue	**Special Concern/Vulnerable:** Taxa of Special Concern have characteristics that make them particularly sensitive or vulnerable to human activities or natural events. Blue-listed taxa are at risk, but are not Extirpated, Endangered or Threatened.
Yellow	**Secure:** Includes species that are apparently secure and not at risk of extinction. Yellow-listed species may have red- or blue-listed subspecies. **Watch-List:** Yellow-listed species ranked 'S4' are considered to be of conservation concern because they have a small range or low abundance in the province, because they have shown provincial declines, or there are perceived long-term threats.

2.3 Recommendations

Recommendations have been developed based on a detailed review of accepted industry best management practices, guidance documents, and local, provincial and federal regulatory and policy frameworks.

3 Site Conditions

3.1 Overview

The majority of the project footprint is comprised of two historic gravel extraction areas, in Lot 1 and Lot 2. The gravel pits and surrounding areas were cleared to facilitate operations, with some of the cleared areas regenerating as second growth forest. The riparian area along the southern border has never been cleared (mature forest).

3.2 Project Location

The project footprint is located inside the CoPG and is situated between North Nechako Road, Foothills Boulevard and the Nechako River. There are three properties involved within the Neighborhood Plan, with a total area of 84.3 ha (the “project footprint”).

Table 2: North Nechako Neighbourhood Plan – Project Footprint

	Lot 1	Lot 2	Lot 3
Area:	27.1 ha	52.4 ha	4.8 ha
Civic:	4693 North Nechako Rd	2599 North Nechako Rd	4436 Craig Drive
Legal:	LT 1 DL 4050 PL 25854	LT DL 4051 PL REM	LT DL 4051 PL B3724

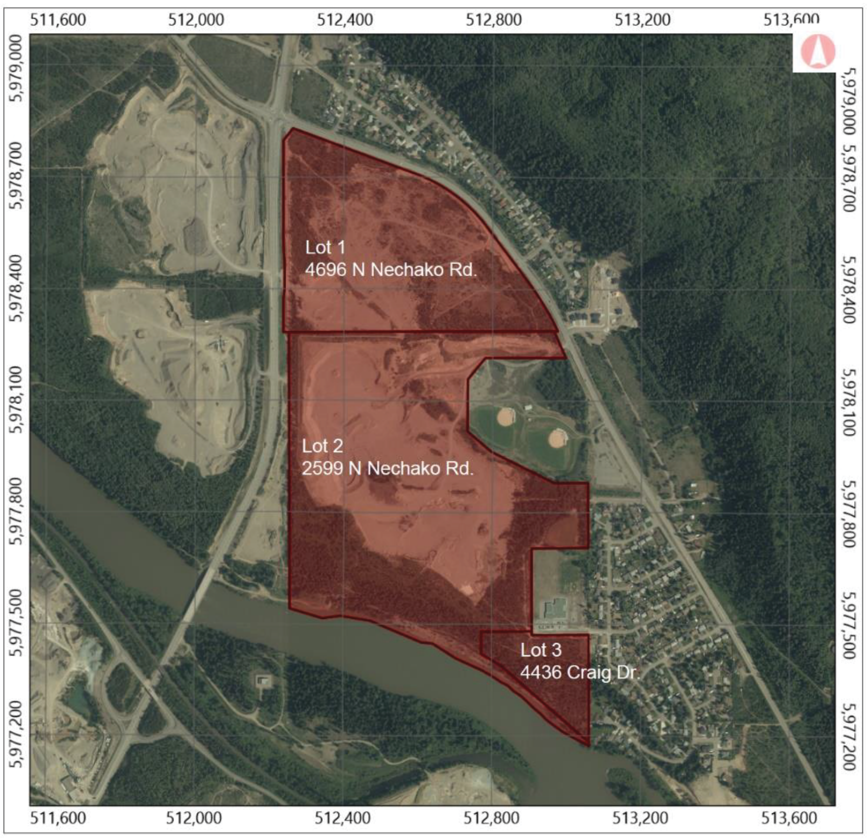

Figure 1: North Nechako Neighbourhood Plan – Lot Layout

3.3 Current Land Use

Current activities onsite include construction of Phase 1 of the Nechako Terrace subdivision (in Lot 1). There are currently no active gravel extraction activities within the project footprint. Abandoned gravel extraction pit areas remain bare, with natural regeneration occurring in peripheral areas that had been cleared.

The area is heavily used by recreationists by means of dirt biking, ATV riding, hiking and dog walking. The entire footprint is a network of roads and trails, which provides easy access throughout the entire project footprint. There is also the foundation of an old pumphouse located on the Craig Drive property.

3.4 Historical Land Use

Clearing and gravel extraction activities commenced in Lot 1 and Lot 2 around the 1970/80’s (per GeoNorth, 2017).

- Lot 1: Major clearing commenced around 1984, with most of the lot cleared by 1993 and some extraction over the years in small areas. Gravel extraction at a larger scale commenced around 2003, with the lot fully cleared and utilized for extraction by 2014.
- Lot 2: Steady expansion of the pit size over the years. Major clearing of around the pit occurred by 2003, in most of the lot area except for the Nechako riparian area and surrounding the Edgewood school. Lot 2’s pit appears to have become inactive around 2014.

No major clearing or development appears to have occurred in Lot 3 (Craig Drive), although the Pine Beetle impacts (of early 2000’s) appear to have impacted much of the forest and resulted in significant tree thinning.

3.5 Slope and Terrain

Most of the project footprint is level, and lower in elevation then the surrounding areas due to the gravel extraction activities.

The forested area along the Nechako River is predominantly comprised of steep fluvial benches. These steep benches are south facing and have slopes varying from 40-90%. As the benches are well drained and vegetated, they appear stable with no slumping or failures observed. The river bank shows some evidence of raveling material (Photo 3) but generally appears stable.

GeoNorth Engineering Ltd conducted a geotechnical assessment on the property (GeoNorth, 2017):

- “Other than the property having a moderate potential for erosion along the Nechako Riverbank, the proposed development is in an area with low risk of geological hazards. There is a low to negligible susceptibility of landslides provided final cut and fill slopes are constructed at appropriate gradients, negligible potential for sink holes from karst formations or piping, and no significant streams upslope of the development that might result in flooding from overland flow."

3.6 Vegetation

Most of project footprint was historically cleared for use as a large-scale open pit gravel extraction area (Photo 1). Within the stripped gravel extraction pit areas, there is no significant vegetation establishment, only sparse grasses, weeds and shrubs as observed in Photo 1. Previously cleared areas outside of the extraction areas are now covered in second growth lodgepole pine (*Pinus contorta*) dominated immature forest (Photo 2). The largest area of mature forest is a narrow band (50 – 75 m width) along the bank of the Nechako River.

3.6.1 Field Observations

The mature forest (riparian area) is dominated by hybrid white spruce (*Picea glauca x engelmannii*) and Douglas fir (*Pseudotsuga menziesii*). The sub-dominant species consists of trembling aspen (*Populus tremuloides*), paper birch (*Betula Papyrifera*), lodgepole pine (*Pinus contorta*) and black cottonwood (*Populus balsamifera*); trace amounts of sub-alpine fir (*Abies lasiocarpa*) was also observed. The dominant shrub species observed were birch-leaved spirea (*Spirea betulifolia*), Soopolallie (*Shepherdia canadensis*) and prickly rose (*Rosa acicularis*). Sub-dominant shrub species are saskatoon (*Amelanchier alnifolia*), highbush cranberry (*viburnum edule*), common juniper (*Juniperus communis*) and black twinberry (*Lonicera involucrate*).

Invasive plants are present on the site, and are also common along roadways around the perimeter of the project footprint.

3.6.2 Biogeoclimatic Ecosystem Classification (BEC)

The project site lies within the Sub-Boreal Spruce dry warm (Stuart Variant) (SBSdw3) BEC Zone (MFLNRO 2018, see Map 3). The field visits confirmed the mature forested areas of the site predominantly exhibited the characteristics of the SBSdw3 classification, site series 01: SxwFd – Pinegrass (**SBSdw3/01**).

The SBSdw3 occurs generally from Prince George to Vanderhoof, stretching along the Nechako River. The zone is warm relative to other biogeoclimatic units in this region, and winter precipitation is relatively low. Coniferous forests are dominated by lodgepole pine, Douglas-fir and hybrid white spruce. Deciduous forests are most commonly dominated by trembling aspen, with areas of paper birch. Black cottonwood is common along rivers and streams. Susceptible to pine beetle impacts and windthrow.

Pinegrass site series (SxwFd) is common and widespread, with an average soil moisture (4) and varied soil nutrient regime (poor – rich). Medium to fine-textured soils may have poor soil structure, leading to poor root growth.

3.6.3 Rare/Endangered Species

The BC Conservation Data Center (CDC) search for the Prince George Forest District identified one red-listed, six blue-listed plant and ten yellow-listed ecological communities (site series unit) in the SBSdw3 biogeoclimatic subzone (

Table 3). Some of these communities are only present in areas of low-gradient (slow moving) water features such as wetlands (not present within the study area), as noted.

Table 3: BC CDC Listed Ecological Communities within the Prince George Forest District, SBSdw3

BGC	Name	Status	Note
SBSdw3	tamarack / low birch / bluejoint reedgrass – sedges / peat-mosses	Red	Wetland
SBSdw3/02	Douglas-fir – lodgepole pine / clad lichens	Blue	
SBSdw3/05	lodgepole pine – black spruce / red-stemmed feathermoss	Blue	
SBSdw3/06	hybrid white spruce / hardhack – prickly rose	Blue	
SBSdw3/Wm02	swamp horsetail - beaked sedge	Blue	Wetland
SBSdw3/Wb12	scheuchzeria / peat-mosses	Blue	Wetland
SBSdw3/Fl05	Drummond's willow / bluejoint reedgrass	Blue	Wetland
SBSdw3/01	**Douglas-fir – hybrid white spruce / pinegrass**	**Yellow**	
SBSdw3/03	lodgepole pine / red-stemmed feathermoss – reindeer lichens	Yellow	
SBSdw3/04	Douglas-fir – hybrid white spruce / ricegrasses	Yellow	
SBSdw3/07	hybrid white spruce / black twinberry	Yellow	
SBSdw3/08	hybrid white spruce / oak fern	Yellow	
SBSdw3/09	hybrid white spruce / horsetails / glow moss	Yellow	
SBSdw3/10	black spruce / soft-leaved sedge / peat-mosses	Yellow	
SBSdw3/Wm01	beaked sedge – water sedge	Yellow	Wetland
SBSdw3/Wb09	black spruce / common horsetail / peat-mosses	Yellow	Wetland
SBSdw3/Wb05	black spruce / water sedge / peat-mosses	Yellow	Wetland

The dominant ecological community present at this site (SBSdw3/01) is listed as 'yellow' and ranked as 'S4', indicating that it may be limited in distribution or declining, but is not considered at-risk or endangered (see Section 2.2 for detailed description). Where there is limited representation (or substantial modification of existing areas) of mature natural examples of SBS subzones, most or all site series units in a subzone often appear on the CDC lists.

There are two blue-listed plant species within the SBSdw3 zone, detailed below.

Table 4: CDC listed plant species within the Prince George Forest District, SBSdw3 subzone

Name	Scientific Name	Type	Status
shinleaf wintergreen	*Pyrola elliptica*	Vascular Plant	Blue
pebbled paw	*Nephroma isidiosum*	Fungus	Blue

3.6.3.1 Shinleaf Wintergreen (Pyrola elliptica)

This evergreen perennial herb spreads via rhizomes and their feeding roots rely on a soil fungus for nutrient uptake. The flowers like most members of the Ericaceae family are hermaphrodite[1] (have both male and female organs), which makes the plant self-fertile, although it still relies on insects for pollination. Loss and degradation of forest environments due to logging and development are the major threats to the plants' survival.

Pyrola elliptica is a small plant with a cluster of waxy green leaves growing at ground level and a single flower bearing stem with clusters of white flowers veined pink or green. The Pyrola group of plants produce a substance closely related to aspirin. As a result the leaves have been used as a covering for bruises and wounds to help reduce pain, hence their common name 'Shinleaf'.

Although not observed, this plant is potentially present within the project footprint, however habitat on the site is not critical for Shinleaf and development activities should have negligible impacts on the species.

3.6.3.2 Pebbled Paw (Nephroma isidiosum)

Pebbled paw is a lichen, found on twigs and bark in mature, humid forests. The presence of this lichen is known as an indication of 'old age and pristine condition of the forest and its inhabitants'[2].

Although also not observed, this lichen is potentially present within the project footprint, in areas of mature forest; however on site habitat is also not critical for Pebbled Paw and development activities should also have negligible impacts on the species.

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[1] Watson, L., and Dallwitz, M.J. 1992 onwards. The families of Flowering Plants: descriptions, illustrations, identification, and information retrieval.
[2] Brodo et al, Lichens of North America, Canadian Museum of Nature, 2001

Figure 2: pebbled paw

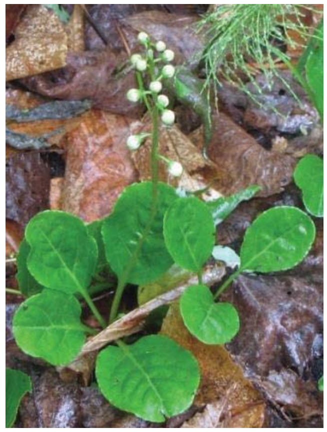

Figure 3: Shinleaf Wintergreen

3.7 Aquatics, Fisheries and Riparian Information

The project footprint is bordered to the south by the Nechako River. There are no other water features within the project footprint.

The Nechako River is a major waterway, and a principal tributary to the Fraser River. The Nechako is 516 km long, rises on the Nechako Plateau east of the Coast Mountains south of Burns Lake, flows north through Fort Fraser, then east through Vanderhoof to join the Fraser River at Prince George.

3.7.1 Field Observations

The riparian area within the project footprint is currently mature forest upland, which has not been previously impacted by historical land development (clearing), with a steep, poorly vegetated fluvial cut bank (Photo 3) along the edge of the Nechako River. The mature forest extends from the top of bank approximately 70-100m, with large trees and thick riparian vegetation. Pine trees throughout the project footprint have been impacted by pine beetle infestation.

There are no significant chronic erosion or stability concerns evident within the riparian area, though the cutbank to the Nechako River is poorly vegetated and will experience natural scour and sloughing during periods of water level fluctuation. The geotechnical assessment indicates that the project footprint is within a relatively stable reach of the river, with no significant changes to the shape of the shoreline since 1946, but experiences an on-going, slow rate of bank erosion (GeoNorth, 2017).

As the riparian habitat along the property is south facing, the vegetation within the riparian area does not provide a significant shade source; however, it will still provide a source of terrestrial invertebrates and nutrients to the Nechako River fisheries.

3.7.2 Rare/Endangered Species

The River provides habitat to numerous fish species, including the red-listed white sturgeon (Nechako and Upper Fraser populations), and blue-listed bull trout.

Table 5: CDC Listed Fish Species in Prince George Forest District, SBS zone

Common Name	*Scientific Name*	Status	Type
White Sturgeon (Upper Fraser River population)	*Acipenser transmontanus* pop. 5	Red	ray-finned fishes
Bull Trout	*Salvelinus confluentus*	Blue	ray-finned fishes

3.7.2.1 White Sturgeon

White sturgeon is the largest, longest-lived freshwater fish species in North America. Fish of over 6 m in length and over 100 years of age have been reported in the Fraser River. To complete their full life cycle, white sturgeon require sufficient suitable habitat, an abundant food base, and appropriate water conditions.

The white sturgeon has six populations in Canada (Lower Fraser River, Mid Fraser River, Nechako River, Upper Fraser River, Upper Columbia River, and Kootenay River). All populations are managed by the BC government, while four SARA-listed populations are under the responsibility of the federal government. Four populations of white sturgeon (Nechako River, Upper Fraser River, Upper Columbia River, and Kootenay River) were listed as Endangered under SARA in August 2006. In 2014, the “Recovery strategy for White Sturgeon (*Acipenser 79 transmontanus*) in Canada” was published by Fisheries and Oceans Canada.

The Upper Fraser and Nechako white sturgeon populations are Schedule 1 listed on the Species at Risk Public Registry, making it illegal to kill, harm, harass or capture individuals. Sturgeon habitat is further protected from degradation, disruption and destruction under the Federal Fisheries Act.

Although the project footprint is not located in an area along the River identified as ‘Critical Habitat’ within the Recovery Strategy (2014), significant alteration or disturbance to the riparian area of the Nechako River may trigger federal review.

3.7.2.2 Bull Trout

This trout is known from northern California to northern British Columbia, Alberta and parts of the Northwest Territories. Bull trout spawn in rivers and streams during the fall, often after an upstream migration. Bull trout remain abundant over much of the Province, but are in decline in parts of southern British Columbia, and are listed under the Endangered Species Act in the United States. They are highly vulnerable to angling and extremely sensitive to habitat and water quality degradation.

3.8 Wildlife

3.8.1 Field Observations

Numerous signs of wildlife utilization, including deer tracks, moose (*Alces alces*) and deer scat and browse on shrubs (Photos 4,5), were commonly observed across much of the project area. Two mule deer (*Odecoileus hemionus*) were observed during the site assessment. Anecdotal information from recreational users indicated black bears (*Ursus americanus*), coyotes (*Canis Latrans*) and red foxes (*Vulpes Vulpes*) are also common in the project footprint. A number of red squirrels (*Tamiasciurus hudsonicus*) and their middens were observed throughout much of the project, and showshoe hare (*Lepus americanus*) pellets were observed in the forested area adjacent to the Nechako River.

The mix of forest types and edge habitat within the project area provides good habitat for many bird species. Common ravens (*Corvus corax*), American robins (*Turdus migratorius*), black-capped chickadees (*Poecile atricapillus*), dark-eyed juncos (*Junco hyemalis*), song sparrows (*Melospiza melodia*), yellow-rumped warblers (*Setophaga coronata*) and two ruffed grouse (Bonasa umbellus) were observed during the course of the two assessments. One old stick nest (Photo 6) was observed within the Craig Drive property footprint; a number of old cup (Photo 7) and potential cavity nests were also observed during the assessment.

3.8.2 Biogeoclimatic Summary

The SBSdw3 zone supports a wide variety of wildlife. Douglas-fir stands provide important winter habitat for mule deer, and early spring habitat for black bear. South-facing slopes along the Nechako River may be used in the winter by a small population of elk. Riparian forests are used in the early spring by black bear and grizzly bear. White spruce - lodgepole pine forests are used by moose, grizzly bear, black bear, spruce grouse, northern goshawk, and furbearers, including wolverine, marten, and red squirrel.

3.8.3 Rare/Endangered Species

The BC Conservation Data Center (CDC) search for the Prince George Forest District in the SBS biogeoclimatic zone identified (Table *6*):

- Mammals: six blue-listed and one yellow-listed mammals,
- Amphibians: one yellow-listed amphibian, and
- Birds: one red-listed, 13 blue-listed, and one yellow-listed bird.

Table 6: Wildlife species of Management Concern in the Prince George Forest District, SBS zone.

Common Name	*Scientific Name*	Status	Type
Caribou (northern mountain population)	*Rangifer tarandus* pop. 15	Blue	mammals
Wolverine, *luscus* subspecies	*Gulo gulo luscus*	Blue	mammals

Mountain Goat	*Oreamnos americanus*	Blue	mammals
Fisher	*Pekania pennanti*	Blue	mammals
Grizzly Bear	*Ursus arctos*	Blue	mammals
Northern Myotis	*Myotis septentrionalis*	Blue	mammals
Little Brown Myotis	*Myotis lucifugus*	Yellow	mammals
Western Toad	*Anaxyrus boreas*	Yellow	amphibians
American White Pelican	*Pelecanus erythrorhynchos*	Red	birds
Sharp-tailed Grouse, *columbianus* subspecies	*Tympanuchus phasianellus columbianus*	Blue	birds
Black Swift	*Cypseloides niger*	Blue	birds
Great Blue Heron, *herodias* subspecies	*Ardea herodias herodias*	Blue	birds
Broad-winged Hawk	*Buteo platypterus*	Blue	birds
Bobolink	*Dolichonyx oryzivorus*	Blue	birds
Long-billed Curlew	*Numenius americanus*	Blue	birds
Eared Grebe	*Podiceps nigricollis*	Blue	birds
American Bittern	*Botaurus lentiginosus*	Blue	birds
Short-eared Owl	*Asio flammeus*	Blue	birds
Olive-sided Flycatcher	*Contopus cooperi*	Blue	birds
Rusty Blackbird	*Euphagus carolinus*	Blue	birds
Barn Swallow	*Hirundo rustica*	Blue	birds
Winter Wren	*Troglodytes hiemalis*	Blue	birds
Sandhill Crane	*Antigone canadensis*	Yellow	birds
Common Nighthawk	*Chordeiles minor*	Yellow	birds
Evening Grosbeak	*Coccothraustes vespertinus*	Yellow	birds

No critical habitats for red or blue listed species were observed within the study area.

This area is not identified as ungulate winter range (MFLNRO-RMO, 2018). The mature forest area present around the project area provide moderate levels of capability and suitability for mammals, birds, amphibians and reptiles, but not waterfowl or other species dominant in wetland/marshy areas.

3.8.3.1 Caribou (Northern Mountain)

Caribou are woodland subspecies of the deer family, and eat grasses, sedges and especially lichens. They require a mix of habitats containing old growth forest near more open habitat such as alpine, peatlands, or tundra. Population densities are naturally low and large areas are required to support herds. Fire or logging can displace caribou for decades. Habitat disturbance and roads and trails that increase abundance of other ungulate species and predators are also threats[3].

[3] Extracted from Species at Risk BC http://www.speciesatriskbc.ca/node/7933

The project footprint does not provide suitable habitat to support Caribou. This species is unlikely to be present within the project footprint or significantly affected by future development.

3.8.3.2 Wolverine

Wolverine are a wide-ranging species that occurs at low densities. They are solitary animals and males have territories as large as 200,000 ha; females about 40,000 to 50,000 ha. Wolverine are typically associated with remote wilderness areas and high elevation ecosystems.

The project footprint does not provide suitable habitat to support Wolverines. This species is unlikely to be present within the project footprint or significantly affected by future development.

3.8.3.3 Mountain Goat

Mountain goats live only in alpine areas of Western North America from Colorado to Alaska and the Yukon and Northwest Territories.

The project footprint does not provide suitable habitat to support Mountain Goats. This species is unlikely to be present within the project footprint or significantly affected by future development.

3.8.3.4 Fisher

The fisher is a member of the weasel family and are dependent on forests for all their life history needs. Female fishers require large diameter trees with cavities to birth and raise their young. They will only use cavities with entrance holes that are approximately 8 – 12 cm in diameter. Den trees also need to have other trees and shrubs around them to allow the female approach her den unseen. These specific requirements (along with the fact that females usually require multiple cavities to accommodate the growing kits) make fisher populations vulnerable to extirpation through loss of suitable denning habitat[4].

The project footprint contains larger trees along the southern perimeter, and may provide suitable habitat to support fishers. This species is potentially present within the project footprint and their habitat may be impacted by large tree removal. No dens were noted during the field assessment.

3.8.3.5 Grizzly Bear

Grizzly bears require large relatively undisturbed areas and are infrequently observed in proximity to Prince George. Grizzly bears are typically found at low to moderate densities

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[4] Extracted from Habitat Conservation Trust Foundation - https://hctf.ca/declining-den-sites-finding-cavities-fit-for-a-fisher/?gclid=EAIaIQobChMIyL73wNKv3wIVB6rsCh0_4AgjEAAYASAAEgIiDvD_BwE

in the SBS zone within the Prince George Forest District, and typically utilize riparian and wet forests throughout their range during summer. Important habitats include mature forests, avalanche chutes, subalpine meadows, riparian areas, floodplains, salmon-bearing streams, and habitats containing berry-producing shrubs.

The project footprint does not provide suitable habitat to support Grizzly Bears. This species is unlikely to be present within the project footprint or significantly affected by future development.

3.8.3.6 Northern Myotis and Little Brown Myotis

The northern myotis is a medium-sized bat with dark brown fur on its back and paler fur on its underside. It is very similar in colour and size to the little brown myotis, but the ears are longer. Both the northern myotis and little brown myotis sometimes use the same roosts or hibernacula and it is difficult to tell the species apart.

The northern myotis often forages for prey in cluttered areas such as forests, forest edges and overgrown trails. Little brown myotis hunt flying insects in a variety of habitats, often over water. Summer roost sites are most often in trees (in tree cavities and under loose bark), but can also be in man-made structures (e.g. under shingles). Winter hibernation sites (also called hibernacula) are usually in caves or mines.

The project footprint may have suitable habitat to support myotis in the summer months, but not for overwintering (hibernacula). This species is potentially present seasonally within the project footprint, and roosts may be impacted if land development activities occur during the breeding season.

3.8.3.7 Western Toad

The Western Toad is a large, stocky toad, ranging in colour from greenish to tan, brown or black with a light line along its mid-back. The Western Toad uses a wide variety of aquatic habitats for breeding and terrestrial habitats for foraging and hibernation. These habitats may be several kilometers apart, requiring Western Toads to move extensively, increasing their vulnerability to human developments and activities.

The project footprint does not contain suitable breeding habitat for Western toads (as per the BC CDC). This species is potentially present seasonally within the project footprint, but would not be significantly impacted by development activities. Western toad presence during construction may require an amphibian salvage and relocation effort to prevent harm to individual toads.

3.8.3.8 Birds

Several listed bird species are indicated to be present within the Prince George Forest District (Table 6). None were observed during field investigations, and the project footprint does not contain unique or rare avian habitat.

Raptor (stick) nests may be present within larger trees along the Nechako River. One stick nest was noted during the field assessment (inactive and dilapidated). Provincial laws provide legal protection for the active nests of all species of birds; however most unoccupied nests are not protected when not in use or outside the nesting season. Table 7 lists the species in which their inactive stick nests are protected.

Table 7: Protected Stick Nests under the BC Wildlife Act (34(b))

Common Name	***Scientific Name***
Bald Eagle	*Haliaeetus leucocephalus*
Golden Eagle	*Aquila chrysaetos*
Peregrine Falcon	*Falco peregrinus*
Gyrfalcon	*Falco rusticolus*
Osprey	*Pandion haliaetus*
Burrowing Owl	*Athene cunicularia*

3.8.4 Wildlife Summary

Overall, the majority of the habitat within the project area is poor as the footprint comprises mostly barren gravel extraction areas. The only area which offers any significant habitat potential is the southern boundary of the project along the Nechako River.

The generally south facing bench riparian habitat is generally important for many wildlife species, it provides early snow free areas for foraging wildlife such as song birds. However, this area receives heavy human and dog traffic along the extensive trail network throughout much of this area.

It is unlikely that this small forested area would be preferentially selected by wildlife, as it is a small island of heavily human-utilized forested habitat which is completely surrounded by busy roads and residential and industrial development. The forested riparian habitat within the project footprint also does not appear to contain a significant food source unavailable in the forested areas surrounding the adjacent neighborhoods.

No critical habitats for red or blue listed species were observed within the study area. This area is has not been identified as ungulate winter range.

4 Environmental Sensitive Areas

The following environmental sensitive areas (ESAs) identified during the site assessments should be considered during development planning as they pose the highest risk of environmental impacts during the development activities.

4.1 Nechako River Riparian Area

The riparian area of the Nechako River along the southern perimeter has a number fluvial benches with high gradient or steep slopes which terrace up from the river. Excavation of these slopes may cause slope instability or sediment transport depending on stripping, grubbing and excavation procedures. The riparian area is also linked to the red-listed Nechako white sturgeon population. Adverse impact to the riparian habitat, or addition of deleterious material (ie. excessive sediment) to the Nechako River, may trigger federal review under the *Fisheries Act*.

The Nechako River riparian area has also been designated as a Riparian Protection Development Permit Area (RPDPA) by the CoPG (see Section 5.1.1).

5 Guidelines and Recommendations

As all development projects will have some affect or impact to the environment it is imperative that sufficient time is spent on identifying constraints and impacts and then carefully planning and designing the development to exercise due diligence in attempting to minimize or mitigate potential harmful effects.

5.1 Leave Strip

5.1.1 CoPG Bylaw

The CoPG has identified a number of environmentally sensitive areas such as watercourses and wetlands within city limits that have been classified as Riparian Protection Development Permit Areas (RPDPAs). The Riparian Protection guidelines are outlined in Section 8.9 of the CoPG Zoning Bylaw:

City of Prince George, Zoning Bylaw 7850, 2007 (*relevant excerpts only, emphasis added)*:

> 8.9 Guidelines
>
> 8.9.2 Leave strips within riparian protection development permit areas must remain free of development, except in accordance with these guidelines, to ensure that natural features, function and conditions that support fish life processes are preserved, protected, restored or enhanced.
>
> Watercourses and water bodies shall have:
>
> 8.9.2 c) **30.0 m leave strips from the top of bank** of the Fraser River and Nechako River, except 50.0 m leave strips are required where the leave strip area is devoid of trees and there is evidence of active bank erosion;
>
> 8.9.2 e) lesser leave strips shall be considered where the size is determined on the basis of an assessment report provided by a qualified professional in respect of a development proposal.
>
> 8.9.3 Development within a leave strip shall not result in harmful alteration, disruption or destruction of natural features, functions and conditions that support fish life processes.
>
> 8.9.4 Subject to section 8.9.3, development within a leave strip may include pedestrian access, vegetation and trees, and training works or protection measures in accordance with these guidelines.

Definitions:

Leave Strip: an area of land where development is regulated to preserve, protect, restore or enhance the natural features, functions, and conditions that support fish life processes.

Top of Bank: the points closest to the boundary of the active floodplain of a watercourse or water body where a break in the slope of the land occurs such that the grade beyond the break is flatter than 3 (horizontal) to 1 (vertical) at any point* for a minimum distance of 15.0 meters measured perpendicularly from the break. Where banks are not well defined (as determined by a qualified professional) the top of bank is equivalent to the high water mark.

** Minor variations in elevation may be discounted where slope change greater than 3 (horizontal) to 1 (vertical) results in less than 1.0 metre elevation gain between the points where the slope is less than 3 (horizontal) to 1 (vertical).*

The riparian area of the Nechako River beyond the top-of-bank within the project footprint is well vegetated with mature forest, and would not meet the CoPG Bylaw requirement for an extended leave strip area (Bylaw 7850, Section 8.9.2(c)). There are no other environmental features at this location that would necessitate an increased riparian leave-strip area for increased environmental protection.

5.1.2 DFO Land Development Guidelines

The DFO Land Development Guidelines for the Protection of Aquatic Habitat recommends a 15m leave strip for residential and low-density areas, and 30 m for commercial and high-density areas.

5.1.3 Recommendation

A <u>30 m leave strip area</u> is deemed appropriate for this project area to preserve riparian habitat value, and also provide a larger shared habitat and may help minimize interactions between wildlife and humans along the walking trail.

Appropriate assessment within clearing boundaries for plant and wildlife features prior to any clearing outside of the leave strip is recommended to avoid contravention with the *Species at Risk Act* and/or *Wildlife Act.*

5.2 Erosion and Sediment Control

Development planning should ensure surface drainage is not directed toward the leave strip area, which may cause erosion, instability and/or vegetation loss within the riparian zone.

Erosion and sediment control plans (ESCPs) for construction should be prepared, with adequate mitigation measures to manage runoff and periodic monitoring of the leave strip area to ensure erosion is not occurring during construction.

5.3 Groundwater Protection

Similar to RPDPAs, the CoPG has Groundwater Protection Development Permit Areas (GPDPAs), these were developed in order to protect or minimize impacts to existing wells or local aquifers. The very southwest corner of the project area falls inside one of the GPDPAs (Appendix II). Residential developments pose a lesser risk to groundwater resources when compared to commercial and industrial developments; however residential developments do add to the cumulative effects on groundwater, because of this it is important to try to minimize any potential point source (spills) and nonpoint sources (sediment, salt and fertilizers) of pollution which could impact groundwater resources in the area.

5.4 Best Management Practices (BMPs)

The following BMPs have been provided as an overview and should not be considered comprehensive, they shall only provide general guidance that will help planners and developers adhere to Federal, Provincial and Municipal legislation and regulations. It is important to note that with all development activities there are more detailed BMPs associated with each specific activities.

5.4.1 Vegetation Clearing

Vegetation clearing conducted within the regionally appropriate songbird nesting window will require bird nesting surveys to ensure the protection of birds and avoid contravention of the *Migratory Birds Convention Act* and *Section 34 of the Wildlife Act*. A survey for raptor nests and wildlife den sites within clearing boundaries should also be performed.

5.4.2 Wildlife Avoidance

All project staff should be informed on human-wildlife interaction reduction techniques during their pre-work orientation. Recommended talking points:

- There shall be no feeding of wildlife;
- Any wildlife attractants such as garbage, food, oils and lubricants will be stored in vehicles or appropriate wildlife proof containers;
- Wildlife has the right-of-way, if wildlife is spotted on site, works will cease and the location and situation will be reported on the radio. Works will only continue once the site supervisor or EM has confirmed the animal has left the site.

At completion of development, homeowners should take steps to limit wildlife encounters. Not planting fruit trees and securing garbage reduce attractants for wildlife, particularly bears, and reduces the potential for attraction and habituation.

5.4.3 Invasive Plant Management

The following precautions will help ensure invasive species are not spread across the landscape:

- Minimize soil disturbance and promptly re-vegetate disturbed areas with a certified weed free seed mix.
- If straw is to be utilized onsite it shall be free of weeds.
- Ensure all equipment is cleaned of all soil, seeds, and plant parts prior to entering or exiting potential noxious weed infested areas. This is especially important for tracked vehicles.
- Do not unload, store, or park vehicles or equipment in infested areas

5.4.4 Pre-Construction Surveys

Prior to development activities Alces recommends a den and nesting survey be completed by a Qualified Environmental Professional.

6 Summary

The North Nechako Neighborhood Plan is located in a large, previously disturbed area adjacent to the Nechako River. Mature forest is present along the Nechako River perimeter to the south, and provides moderate habitat value for birds and mammals. Heavy recreational use of the area likely deters resident populations of large mammals, however attractants such as improperly stored garbage and other residential features (fruit trees, etc) may lead to increased habituation of wildlife.

No red or blue listed wildlife or plant species were noted within the project footprint during the field assessments, and no significantly unique habitat is present within the project footprint. The Nechako River is considered a critical habitat for the white sturgeon, and significant impacts to the watercourse due to development activities (water quality, riparian habitat value, etc) may trigger federal review.

A 30 metre leave strip along the Nechako River (measured from top-of-bank) is recommended to preserve riparian habitat value and reduce human-wildlife interaction. Geotechnical setback recommendations should also be followed to minimize potential for stability issues along the natural cutbank at the Nechako River.

Erosion and Sediment Control Plans are recommended prior to each development phase, with periodic environmental monitoring during construction. Pre-construction surveys should include: nesting activity, dens, protected stick nests, Western Toads and listed species.

7 References

Brodo et al, Lichens of North America, Canadian Museum of Nature, 2001

https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry/recovery-strategies/white-sturgeon/chapter-4.html

City of Prince George. 2007. Zoning Bylaw No. 7850. Updated April 16, 2018

Conservation Data Centre: http://maps.gov.bc.ca/ess/hm/cdc/ (Accessed Dec 2018)

Department of Fisheries and Oceans. 1993. Pg. 45. Land Development Guidelines for the Protection of Aquatic Habitat.

Environment and Climate Change Canada. 2016. Management Plan for the Western Toad (Anaxyrus boreas) in Canada [Proposed]. Species at Risk Act Management Plan Series. Environment and Climate Change Canada, Ottawa. iv + 38 pp.

Fisheries and Oceans Canada. 2014. Recovery strategy for White Sturgeon (Acipenser 79 transmontanus) in Canada [Final]

GeoNorth, Letter - September 25, 2017: Overview Geotechnical Assessment of Proposed Residential Development PID 014-402-207 and 014-702-240, North Nechako Area, Prince George, B.C.

https://www.for.gov.bc.ca/hre/becweb/resources/maps/FieldMaps.html

https://www2.gov.bc.ca/assets/gov/environment/natural-resource-stewardship/best-management-practices/develop-with-care/dwc-section-5-4-omineca-region.pdf

Guidelines for Raptor Conservation during Urban and Rural Land Development in British Columbia (2013)

https://www.kelownagardens.com/plants/pyrola-elliptica-shinleaf-white-wintergreen/

http://lichenportal.org/portal/taxa/index.php?taxon=55960

Ministry of Forests, Lands and Natural Resource Operations (Accessed July 2018)

MFLNRO, Develop with Care 2014: Environmental Guidelines for Urban and Rural Land Development in British Columbia

https://www.nechakowhitesturgeon.org

http://www.speciesatriskbc.ca/advancedsearch/?forestdistrict=DPG

Appendix I – Photos

Photo 1 – Example of one of the historical gravel extraction areas within the project area.

Photo 2 – Example of the immature Lodgepole Pine second growth forests which surrounds much of the gravel extraction areas.

Photo 3 – Nechako River banks with scarce vegetation and historical evidence of erosion.

Photo 4 – Deer tracks on one of the gravel extraction access roads.

Photo 5 – Typical browse on various species of shrubs.

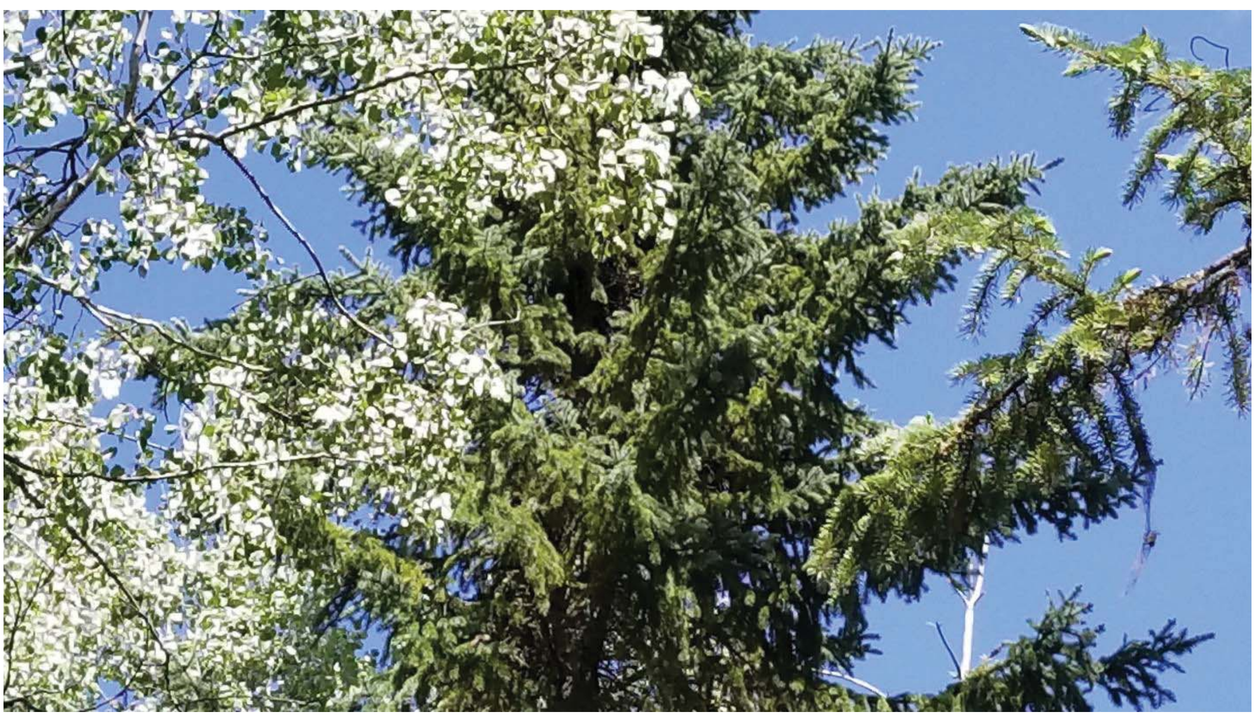


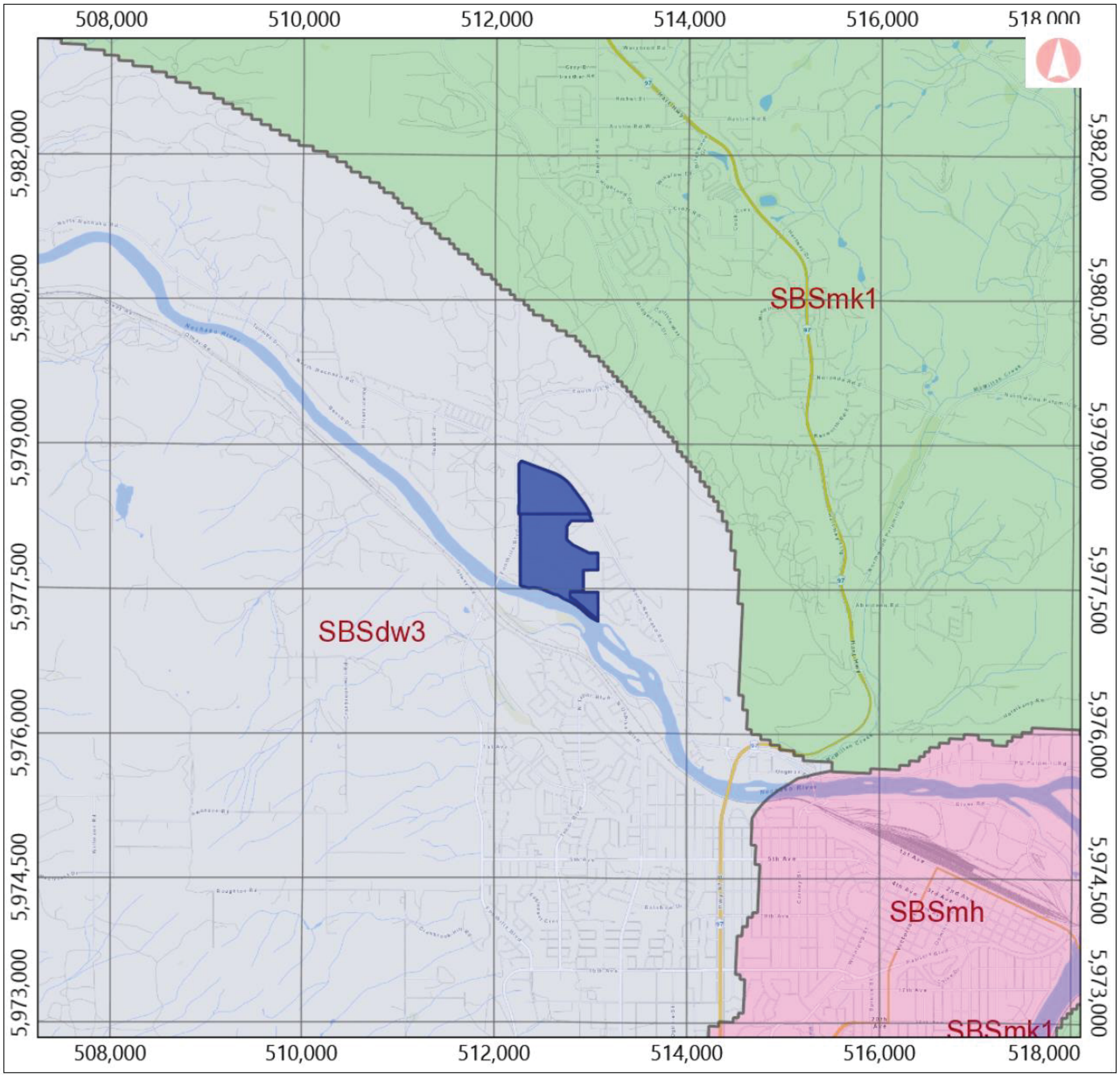
Photo 6 – Old stick nest 2/3 of the way up in a spruce tree.

Photo 7 – Example of one of the inactive (dilapidated) cup nests observed.

Appendix II – Maps and Figures

Map 1 - North Nechako Road Neighborhood Plan Overview Map

Map 2 – City of Prince George Development Permit Areas



Map 3 – Biogeoclimatic Zones near the Project Footprint

APPENDIX B

North Nechako Neighbourhood Plan
L&M Engineering Limited

GROUNDWATER ASSESSMENT

August 2, 2018

T.R. Projects Ltd. & 406286 BC Ltd. c/o L& M Engineering
205-6360 202nd Street
Langley, British Columbia, V2Y 1N2

E-mail: athandi@lmengineering.bc.ca

Attention: Ashley Thandi, BPI
Planner

Re: Groundwater Assessment Consulting Services
2599 and 4693 North Nechako Road and 4439 Craig Drive,
Prince George, British Columbia
Pinchin File: 221252.000

1.0 INTRODUCTION

Pinchin Ltd. (Pinchin) is pleased to provide the findings of our Groundwater Assessment Consulting Services (GACS) to T.R. Projects Ltd. & 406286 BC Ltd. c/o L& M Engineering (Client) for the property located at 2599 and 4693 North Nechako Road and 4439 Craig Drive in Prince George, British Columbia (hereafter referred to as the Site).

The Site consists of three parcels with a total area of 82.85 hectares (204.7 acres). The Site is partially cleared and is currently operated as a gravel pit with a portion of 4693 North Nechako Road to be developed as a future residential subdivision. As indicated on Figure 1 (Key Map), Site Parcel A is located between Foothills Boulevard and North Nechako Road, north of the Nechako River. Site Parcel B is located southeast of Parcel A. Site Parcel C is located on the southeast intersection of the Foothills Boulevard and North Nechako Road.

It is Pinchin's understanding that the Site has a proposed multi-phase development plan for residential dwellings, with a local commercial development proposed in the northeast corner of 4693 North Nechako Road. As indicated in the Official Community Plan (OCP) for the City of Prince George (Prince George), an area approximately 6.31 hectares (15.6 Acres) in size in the southwest portion of Site (on the property of 2599 North Nechako Road) is located within a Groundwater Protection Development Permit Area (Permit Area). The Client is currently in the process of conducting a Neighbourhood Plan for the proposed development, which requires a groundwater assessment to be completed for the Site.

This assessment aims to evaluate the potential impact of the proposed development to the Nechako River and the drinking water intake well locations.

2.0 SCOPE OF WORK

As per the Pinchin's proposal approved by the Client, dated March 26, 2018, the GACS scope of work completed are described below:

- Developed an understanding of the Site history and Site conditions by reviewing the 2017 Pinchin Phase I ESA Report;
- Reviewed the potential subdivision concept, proposed development plan and drainage-to-ground methods provided by the Client;
- Reviewed the current stormwater and sanitary drainage network of the Site and surrounding areas from the Prince George Geographic Information System (GIS);
- Reviewed Prince George city bylaws and current OCP for the Groundwater Protection Development Permit Area;
- Reviewed available literature and/or database to understand the regional and local subsurface stratigraphy and groundwater levels/zones;
- Conducted a conservative groundwater model of a potential worst-case spill at the Site and evaluate the potential impact to the Nechako River and the drinking water intake well locations; and
- Based on the outcome of the groundwater model, commented on any additional preventative measures that may be required in support of the proposed development.

Pinchin notes that the scope of work does not include an assessment of the form, function or size of the proposed riparian buffer along the Nechako River, with regards to erosion, habitat, or other riparian issues.

3.0 PREVIOUS REPORT

Pinchin reviewed the document entitled "Phase I Environmental Site Assessment, 2599 North Nechako Road and 4439 Craig Drive, Prince George, British Columbia", prepared by Pinchin Inc. (Pinchin) for TR Projects Ltd. and Lehigh Hanson Materials Ltd., dated September 25, 2017 (2017 Pinchin Phase I ESA Report).

The Phase I ESA consisted of historical reviews, a review of surrounding properties, a regulatory database search, and interviews as well as an exterior assessment of the Site.

The following summarizes the findings of the Pinchin Phase I ESA Report:

- The Phase I Report was completed for 2599 North Nechako Road (Parcel A) and 4439 Craig Drive (Parcel B) of the Site (i.e., the middle and southeast portions of the Site). Both parcels of land were free of any permanent structures and/or buildings. The north portion of the Site, parcel ID: 7558350, 4693 North Nechako Road, was not included in the 2017 Pinchin Phase I ESA;

- The Site and surrounding area were noted generally flat, with a steep slope adjacent to Nechako River at Parcel A;
- Based on iMapBC, the bedrock type for the Site was noted as interbedded black argillite, greywacke, siltstone, shale and minor limestone, minor ash tuff, tuffaceous argillite, basalt breccia and agglomerate in some localities;
- Based on the Surficial Geology, Map 3-1969, subsurface soils was indicated as Alluvial deposits; mainly sand and gravel forming terraces;
- Inferred Groundwater Flow Direction is to the south based on the location of Nechako River; and
- The Site was developed for gravel extraction in the early 1980's.

The results of the 2017 Pinchin Phase I ESA Report indicated that there were no significant potential environmental concerns associated with the current and historical use of the Site and adjacent properties and as such, no further environmental assessment work (i.e., Phase II ESA or subsurface investigation) was recommended.

4.0 REVIEW OF AVAILABLE INFORMATION

4.1 Municipal Water Supply

Pinchin reviewed water infrastructure on and around the Site, which indicated multiple water production (PW) wells near the Site. PW 607 located approximately 220 m north of the Site. PW 660 and PW 605 are located across the Nechako River approximately 190 m and 370 m south of the Site. PW 632 and PW 601 are located approximately 600 m and 1.4 km southeast of the Site. Refer to Figure 2 of this report for these PW locations. The maximum projected daily demand is 155,800 m^3/d (1804 L/s) for PW660, PW605 and PW601. PW607 is a back-up well that can supply the City with 9,219 m^3/d (106.7 L/s) (2015 Wells Protection Plan Report). The water from each well is pumped to the City's pump house at each respective well. The water is treated prior to distribution at the pump houses, which have chlorination and fluoridation facilities. The treated water is pumped either to a reservoir or directly pumped to individual homes and businesses (point of use). Protecting these water supply wells are important as they are highly vulnerable to potential pollution from land and/or water sources.

In order to identify the regional and local subsurface stratigraphy and groundwater levels, Pinchin conducted a well search and aquifer search in the area and reviewed available literature completed in the area.

4.2 British Columbia Ministry of the Environment Water Resource Atlas Search

A search of existing wells in the area on the British Columbia Ministry of the Environment and Climate Change Strategy (MOECCS) Water Resource Atlas well database indicated that there was one well located on the Site. A well (well tag number 25705) with unknown use was located on the south side of the Site along the Nechako River. The well was constructed in 1971 with a finished well depth of 26 m. The soil was described as fine to coarse sand, gravel and boulders from surface to 13 m and fine to coarse sand and gravel to 26 m.

MOECCS well database search indicated that multiple wells are located within 250 m of the Site. Pinchin reviewed the well detail log to obtain further information regarding the soil subsurface type and hydrogeology setting of the Site. The summary of the wells is as follows:

- A well (well tag number 103461) with unknown use (unlicensed) was located directly west of the Site. The well was constructed in 2009 with finished well depth of 23 m. The soil was described as dry brown dense medium to coarse sand & silt from surface to 12 m followed by moist brown dense sand and gravel to 20 m and moist brown dense fine to medium sand and silt to 23 m;
- A well (well tag number 29148) with unknown use (unlicensed) was located approximately 180 m north of the Site. The well was constructed in 1973 with a finished well depth of 78 m. The soil was described as sand and gravel from surface to 78 m. Static water level was noted as 37 m with estimated well yield of 1900 gallons per minute (GPM);
- A well (well tag number 75491) indicated as observation well (unlicensed) was located 150 m south of the Site, across the Nechako River. The well was constructed in 1998 with a finished well depth of 26 m. The soil was described as sand and gravel from surface to 26 m. Static water level was noted as 4.5 m; and
- A well (well tag number 21440) with unknown use (unlicensed) was located approximately 240 m east of the Site. The well was constructed in 1968 with a finished well depth of 86 m. The soil was described as silt with sand and gravel from sand and gravel from 83 m to 86 m. Static water level was noted as 37 m with estimated well yield of 8 GPM.

Based on the above MOECCS well information and Site Topography, inferred groundwater depth is within 30 m (areas closer to the Nechako River, south portion of the Site) to 37 m (closer to intersection of the north Nechako Road and Foothills Boulevard, north portion of the Site).

The search results are located in Appendix I.

4.3 Aquifer Search Results

The Site is located on the Nechako Aquifer. The Aquifer Classification System for Ground Water Management in British Columbia as defined by the Ministry of Environment classifies the Nechako Aquifer as IA. Productivity and vulnerability were indicated as high. In other words, it is heavily developed and highly productive while also being highly vulnerable to contamination from surface sources (iMapBC). Aquifer Description report and aquifer classification vulnerability to contamination on and near the Site are located in Appendix II.

4.4 Soil Type

Based on the MOECCS well information and the Surficial Geology, Map 3-1969 (Pinchin phase I ESA) subsurface soil at the side is mainly fine to coarse sand and gravel to approximately 30 meter below ground (mbg). It has been inferred that the subsurface solid at the Site is porous and permeable. Coarse permeable materials make the aquifer and the water supply vulnerable to infiltration of hazardous materials. This type of soil can hold a lot of water, and the water flows easily through the soil, which has effects on the potential for contamination migration.

4.5 Storm Water and Sanitary Drainage Network

Current storm infrastructure and sanitary infrastructure was obtained from the Prince George interactive map (PG Map), (Figure 3 and Figure 4). Pinchin has also reviewed the proposed drainage-to-ground method for the development, prepared by L & M Engineering Limited. The document indicated a recharge chamber pipe design. The perforated storm pipe surrounded with drain rock. Reportedly, all manholes and catch basins leading to the perforated pipe have sumps for sediment and debris. Within the Groundwater Protection Development Permit Area the storm water system design will be modified, such that the pipes will be sealed and direct any groundwater outside the area before infiltration occurs.

4.6 Other Available Literature Completed in the Area

Pinchin reviewed the document entitled "City of Prince George Wells Protection Plan: For CN related risks" dated March 2015, revised February 26, 2016, prepared by R. Radloff & Associates Inc., Summit Environmental Consultants, submitted for City of Prince George (2015 Wells Protection Plan Report).

This report reviewed the risks associated with Canadian National Railway (CN) operating within the Lower Nechako River Valley Aquifer (Nechako Aquifer). More specifically, risks evaluated related to the potential hazards adjacent to three of the City's water supply wells, PWs 660, 605 and 601/602. Protective measures were also reviewed. The following summarizes the findings of the 2015 Wells Protection Plan Report that were found relevant to the current GACS:

- The City of Prince George obtains approximately 95% of the water required for industrial and domestic use from three high-capacity wells: PW660, PW605 and PW602/601. In the past 20 years, two of the City wells in the Nechako Aquifer have been closed because of the contamination from spill-related accidents. A loss of well estimated as $6 million of capital lost;
- The soil in the area consisted of coarse materials, including sand and gravel, with only trace amounts of fine material (silt). The Nechako River Valley Aquifer is an unconfined aquifer comprised entirely of material from sand and gravel size up to cobble and boulders, with a very shallow water table (<5 m below ground);
- Capture Zone Analysis, containment inventory and preliminary groundwater monitoring plan were conducted as part of this assessment. Predictive contaminant model was also completed to evaluate the consequences of the long term or sudden release of the contaminants on the three City's water supply wells (PW660, PW601, and PW605). For example, one of the scenarios included the impact of a sudden release of methyl tert-butyl ether (MTBE) spill from a train derailment within the PW660 capture zone;
- The following are some of the actions recommended to be initiated by the City:
  - Remote pump shut-down capabilities and procedures (for the wells);
  - Emergency water quality monitoring plan (spill incident);
  - Remote operation capabilities and procedures (for the wells);
  - Additions to City's Groundwater Protection Areas (wellheads and Nechako River);
  - Installation of a ground seal (significantly reduces speed of infiltration) option to be determined based on additional studies; and
  - Installation of interceptor wells and trenches – option to be determined based on additional studies.

5.0 ENVIRONMANTAL GOVERNANCE AND GUIDANCE DOCUMENTS (CURRENT LEGISLATION)

No single document regarding the necessary procedures to protect the Nechako Aquifer, and its related potable water well systems, from contamination are available to review in respect to land development activities. City of Prince George has designated areas toward protecting the aquifer, which are referred to as 'Groundwater Protection Areas'. These areas are safeguarded with bylaws in the City of Prince George's Official Community Plan (OCP) Bylaw No. 8383, 2001, OCP Schedule D1. In Figure 2, the groundwater Protection Development Permit areas are presented. As indicated in the Figure 2, the southwest of the Site is located within the Groundwater Protection Development Permit area.

Section 6.2 of the OCP stated that the objective of the groundwater protection (objective 6.2.4) is to protect well heads and aquifers from incompatible development that may lead to contamination of the City's potable water supply. By regulating development within capture zones, the City may reduce the potential risk of contamination.

In Policy 6.2.2 of the OCP, the City defines a long list of threats from new developments including manufacture, processing, sale, storage, or distribution of wood waste, agricultural waste, petroleum products and snow storage. According to Policy 6.2.2, in Groundwater Protection Areas the City should not permit proposals for new development of the mentioned activities. Pinchin has reviewed the North Nechako Neighbourhood Plan proposed land use for the Site, which has been provided by the client. The Site predominantly consists of the proposed multifamily, single family, greenspace and parks land uses. The Single-family use is the proposed land use for the southwest portion of the Site, located within the Groundwater Protection Areas. The proposed single-family land use is considered a low risk land use, and is not considered likely to result in contamination. As such, the proposed land use is consistent with the restrictions and intentions of the OCP. Pinchin notes that the North Nechako Neighbourhood Plan proposed land use depicted proposed commercial land use for the northwest portion of the Site, which was located approximately 530 m from the Groundwater Protection Area and which would also be a low risk activity.

According to Policy 6.2.3 of the OCP "in groundwater protection areas the City should not allow any new effluent, stormwater runoff, or other contaminated discharges to ground. Where such discharges already exist the City may, if necessary, control the activity by enforcement of a bylaw." This bylaw currently apply to the Site, as the southwest portion of the Site is located on the groundwater protection areas. Pinchin recommends the following actions:

- Consideration should be given to the stormwater design on the southwest portion of the Site that is overlapping with Groundwater Protection Development Permit Area. This requires the stormwater drain away from this subdivision; and
- Consideration should be given to the stormwater system design within the Groundwater Protection Development Permit area in order to reduce the potential of migration of contaminants into the groundwater.

Pinchin has also reviewed Storm Sewer Bylaws No.2656, 1974, as the land development-related spill is the most significant threat to the City's water supply wells. Policy 2.7 of the Bylaws No.2656 indicated that no person shall discharge or cause or allow to be discharged into the storm sewer system (h) any gasoline, benzene, naphtha, solvent, fuel oil or other flammable or explosive liquids, solids or gas. As such an Environmental Management Plan (EMP) should be developed and implemented as part of the development activities for the Site. The EMP should include monitoring of Site activities in order to ensure the documentation, reporting and remediation of any spill that may occur during development.

Policy 2.9 Bylaws No.2656 also indicated that grease, oil and sand interceptors shall be provided for industries or commercial establishments when they are necessary for the proper handling of liquid waste containing grease or any flammable waste, sand, grit or other harmful ingredients except that such interceptors shall not be required if specifically exempted by permit issued by the Engineer. As North Nechako neighbourhood proposed land use plan depicted proposed commercial land use for the northwest portion of the Site, where required by the bylaw, interceptors should be installed. Interceptors shall be so located as to be readily and easily accessible for cleaning and inspection. All interceptors shall be maintained by the owner at his expense in continuously efficient operation at all times.

6.0 CONSERVATIVE GROUNDWATER MODEL

The threat of land development-related spills is viewed as the most significant threat to the City's water supply, because of the close proximity of the Site to the at-risk water supply wells. Conservative Groundwater Model of a potential worse case spill was used to assess potential impact to the Nechako River and the drinking water intake wells. As indicated in Figure 2, four PWs (PW 607, PW 660, PW 605 and PW 632) are located near the Site and the Nechako River is located directly south of the Site. Based on the type of development planned for the Site, the highest risk activity was considered to be the operation of motor vehicles on the roads of the Site. In order to evaluate the potential impacts, we considered three different spills scenarios, using the most common diesel/gasoline constituents. This includes naphthalene and methyl naphthalene, are known basic constituents of diesel, light extractable hydrocarbons (LEPH) and heavy extractable hydrocarbons (HEPH), and benzene, toluene, ethylbenzene and xylenes (collectively known as BTEX).

The Groundwater Protection Model (GPM), available from the British Columbia Ministry of Environment, was used as the Conservative Groundwater Model. "Technical Guidance on the Contaminated Sites-Groundwater Protection Model", dated November 1, 2017, provides guidance on using this model.

The GPM was calculated using the Screening Level Risk Assessment (SLRA) feature, in general accordance with the British Columbia (BC) Contaminated Sites regulation (CRS) "*Protocol 13 for Contaminated Sites – Screening Level Risk Assessment*", dated November 1, 2017.

Scenario 1: A gasoline spill, with approximate volume of around 100 L, on the asphalt or on the roads:

In this scenario, the release of fuel is a sudden release on the road from an on-Site vehicle (e.g. leaked motor fuel or fuel from a vehicle collision), which results in the gasoline spread into the stormwater catch basins. Areas potentially impacted by the gasoline fuel release are the asphalt and stormwater catch basins. It has been inferred that the asphalt surface underlying the gasoline fuel release (i.e. sheen) is in good condition with no significant cracks or pitting. It has also been inferred that the stormwater pipes are sealed within the Groundwater Protection Development Permit Area and the potential loss from the pipe within this area is negligible. Therefore, it is unlikely for the soil and groundwater to have been significantly impacted by the spill. Minor ingress through cracks in the road would not be sufficient to allow significant migration to reach the groundwater table, and therefore was not considered a completed pathway.

The GPM was not conducted in this scenario as the groundwater is not affected within the Groundwater Protection Development Permit Area, as a release within the area would be directed outside the area, and a release outside the area, would not have a mechanism to enter the area.

Pinchin notes that if this scenario occurred, recovery efforts and mitigation measures could be employed, and likely would be by emergency responders, in order to reduce the extent of migration to and through the storm sewer system.

Surface water quality falls under the jurisdiction of the Water Protection & Sustainability Branch of the BC Ministry of Environment (MOE), British Columbia approved water quality guideline: aquatic life, wildlife & agriculture (BCWQG), dated January 2017. As the water on-Site is not used for livestock watering or irrigation, only the aquatic life guidelines applies.

Scenario 2: A gasoline spill on the northwest portion of the Site.

In this scenario, the spill is a fuel sudden release on the parcel C during the development activities, i.e. excavation, or a fuel release from future activities that results in the soil contamination. Areas potentially impacted by gasoline fuel release are soil and groundwater. PW 607, Figure 2, is the closest PW to the Site and is located approximately 220 m north of the Site. GPM was completed to assess the potential impacts of the spill to this PW. For this purpose, the following input data has been used:

- Site-specific factor protective of groundwater use for drinking water;
- Distance to point of compliance (x) was set at 220 m. For the rest of the site specific parameters, default input data was used;
- Naphthalene (soil concentration at source (C_s): 1 µg/g to 50 µg/g, maximum measured groundwater concentration below source (C_{gwmax}) 1 µg/l to 500 µg/l), benzene (C_s: 1 µg/g to 70 µg/g, C_{gwmax} 1 µg/l to 3000 µg/l), toluene (C_s: 1 µg/g to 1,500 µg/g, C_{gwmax} 1 µg/l to 55,000 µg/l), ethylbenzene (C_s: 1 µg/g to 800 µg/g, C_{gwmax} 1 µg/l to 5,550 µg/l), and xylenes (C_s: 1 µg/g to 5,000 µg/g, C_{gwmax} 1 µg/l to 30,000 µg/l) and LEPH (C_s: 1 µg/g to 50 µg/g, C_{gwmax} 1 µg/l to 500 µg/l) were assessed with the GPM; and
- Methyl naphthalene and HEPH were not assessed as these substances were not selectable in the model and generally not a concern for groundwater impacts.

This SLRA was conducted using the information obtained from the detail site investigation at a former gas station located in British Columbia, to be conservative in term of choosing the upper concentrations. The predicted groundwater concentration at point of compliance (C_x) are presented in the Appendix III.

Drinking water use is currently considered for this model to apply the most conservative standards. Modelling results calculate that the above substances will not migrate to PW 607.

Scenario 3: A gasoline spill on the southwest portion of the Site.

In this scenario, the release of fuel is a sudden release on the parcel A during the development activities, i.e. excavation, or a fuel release from future activities that results in the soil contamination. Areas potentially impacted by a gasoline fuel release are soil and groundwater. PW 660, Figure 2, is the closest PW to the Site under this scenario and is located approximately 190 m south of the Site, across the Nechako River. GPM was completed to assess the potential impacts of the spill to PW 660. For this purpose, the following input data has been used:

- Site-specific factor protective of groundwater use for drinking water;
- Distance to the point of compliance (x) was set at 60 m. This is the distance from the potential spill to the Nechako River;
- The development area line is considered around 60 m north of Nechako River;
- The calculated C_x diluted by 10^3, as it was assumed that the contaminant of concern will be diluted as crossing the river and reaching PW660. The dilution factor that has been used is a conservative approach. The results were compared with the British Columbia approved water quality guideline: aquatic life, wildlife & agriculture (BCWQG), dated January 2017; and
- The site-specific parameters, C_s input concentrations were same as the scenario 2.

The predicted groundwater concentration at point of compliance (C_x) are presented in the Appendix IV. The GPM indicated that the predicted groundwater concentration C_x for benzene are exceeding the groundwater used for drinking water standard. By applying the dilution factor to C_x, the results are below the applicable BCWQG standards at PW 660. As such, it is unlikely for PW 660 to be significantly impacted by the spill.

7.0 RECOMMENDATION AND CONCLUSION

Based on the discussion and findings noted above, Pinchin recommends the following actions:

- The southwest portion of the Site that falls under the Groundwater Protection Development Permit Area be either undeveloped greenspace, parkland or residential development. These low risk activities are most protective of groundwater conditions;
- The stormwater system design on the southwest portion of the Site, that falls under Groundwater Protection Development Permit Area, should be configured in a manner that drains stormwater from roadways, and any potential releases from vehicles away from the

Groundwater Protection Development Permit Area. This will reduce the potential for any contamination to accumulate within the protected area;

- Consideration should be given to modifying the stormwater sewer design draining from roadways and vehicle parking areas within the Groundwater Protection Development Permit Area, to not include perforated pipes. This will mitigate the potential for any chemicals entering the sewer from migrating towards groundwater and thus further mitigate any potential concerns related to above discussed scenario 1 (Release from a vehicle accident);
- Stormsewer piping should be sealed at underground joints. If sealing of stormsewer connections is not feasible, consideration should be given to installing stormsewer lines above the water table (approximately 4.5 meters below ground surface) within the Groundwater Protection Development Permit Area, in order to further mitigate the potential for migration of chemicals to groundwater;
- Stormwater to ground recharge chambers, lift stations and sanitary sewer septic fields, septic tanks and lift stations should be kept out of the Groundwater Protection Development Permit Area; and
- An EMP should be developed and implemented as part of the development activities for the Site. The EMP should include monitoring of Site activities in order to ensure the documentation, reporting and remediation of any spill that may occur during development. A properly implemented EMP will address any potential concerns related to above discussed scenarios 2 and 3 (Releases during development activities).

8.0 TERMS AND LIMITATIONS

This GACS was performed for T.R. Projects Ltd. & 406286 BC Ltd. c/o L& M Engineering (Client) in order to identify potential issues of environmental concern in relation to the proposed development of the Site at 2599 and 4693 North Nechako Road and 4439 Craig Drive in Prince George, British Columbia (Site), based on information collected and provided by others. The term recognized environmental condition means the presence or likely presence of any hazardous substance on a property under conditions that indicate an existing release, past release, or a material threat of a release of a hazardous substance into structures on the property or into the ground, groundwater, or surface water of the property. This GACS does not quantify the extent of the current and/or recognized environmental condition or the cost of any remediation.

This letter was prepared for the exclusive use of the Client T.R. Projects Ltd. & 406286 BC Ltd. c/o L& M Engineering, subject to the terms, conditions and limitations contained within the duly authorized proposal for this project. Any use which a third party makes of this letter, or any reliance on or decisions to be made based on it, is the sole responsibility of such third parties. Pinchin accepts no responsibility for damages suffered by any third party as a result of decisions made or actions conducted.

If additional parties require reliance on this letter, written authorization from Pinchin will be required. Pinchin disclaims responsibility of consequential financial effects on transactions or property values, or requirements for follow-up actions and costs. No other warranties are implied or expressed. Furthermore, this letter should not be construed as legal advice. Pinchin will not provide results or information to any party unless disclosure by Pinchin is required by law.

This GACS was performed in general accordance with currently acceptable practices for environmental site investigations, as applicable to the Site. The information provided in this letter is based upon analysis of available documents, records and drawings and personal interviews. In evaluating the Site, Pinchin has relied in good faith on information provided by other individuals noted in this letter. Pinchin has assumed that the information provided is factual and accurate. In addition, the findings in this letter are based, to a large degree, upon information provided by the Site owner. Pinchin accepts no responsibility for any deficiency, misstatement or inaccuracy contained in this letter as a result of omissions, misinterpretations or fraudulent acts of persons interviewed or contacted.

Pinchin makes no other representations whatsoever, including those concerning the legal significance of its findings, or as to other legal matters touched on in this letter, including, but not limited to, ownership of any property, or the application of any law to the facts set forth herein. With respect to regulatory compliance issues, regulatory statutes are subject to interpretation and these interpretations may change over time.

9.0 CLOSING REMARKS

We trust that the foregoing information is satisfactory for your present needs. Should you have any questions or require additional information, please do not hesitate to contact the undersigned.

Pinchin Ltd.

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Encl.: Figures

Appendix I – British Columbia Ministry of the Environment and Climate Change Strategy (MOECCS) Water Resource Atlas search results

Appendix II – iMapBC aquifer search results

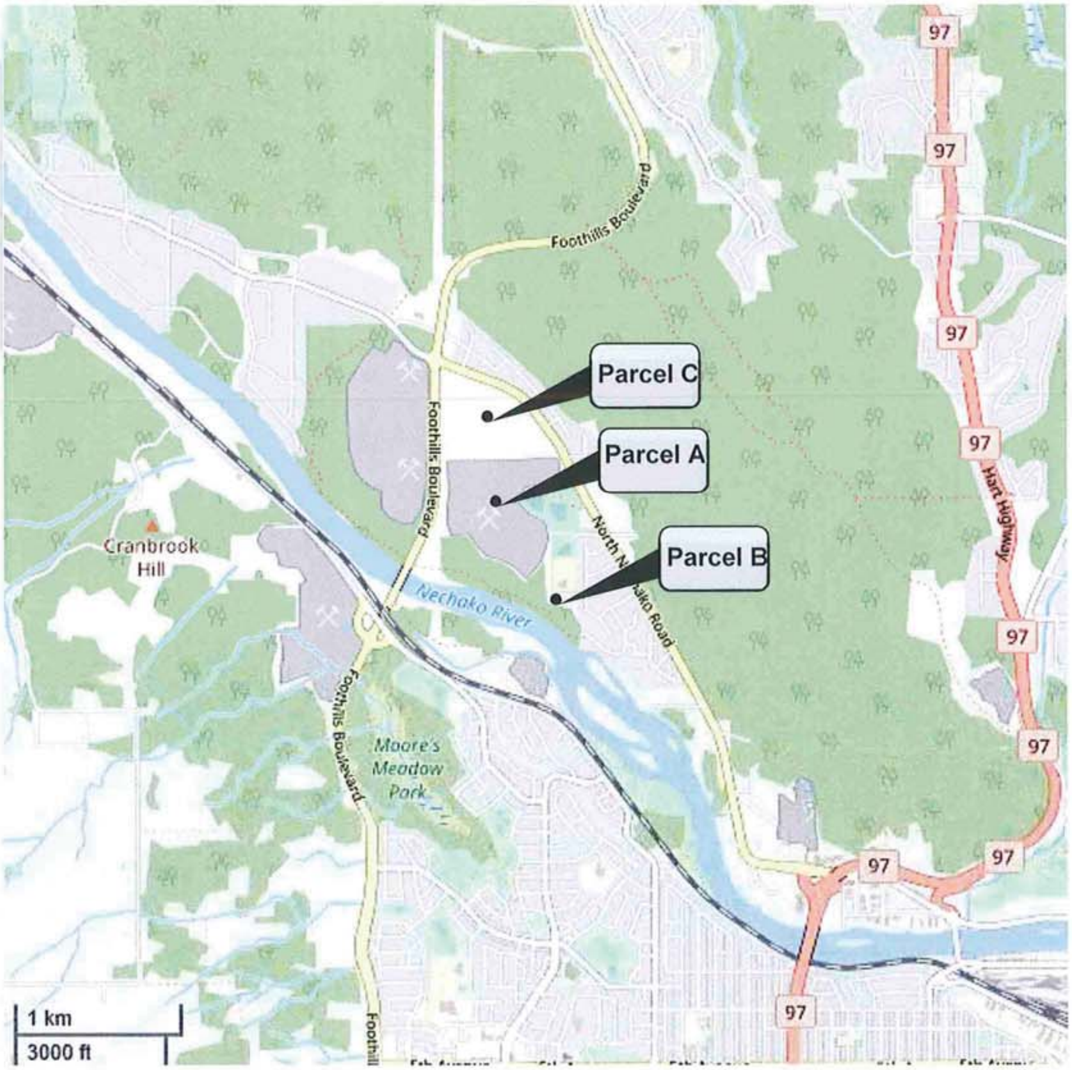
Appendix III – Groundwater Protection Model results

Appendix IV – Groundwater Protection Model results

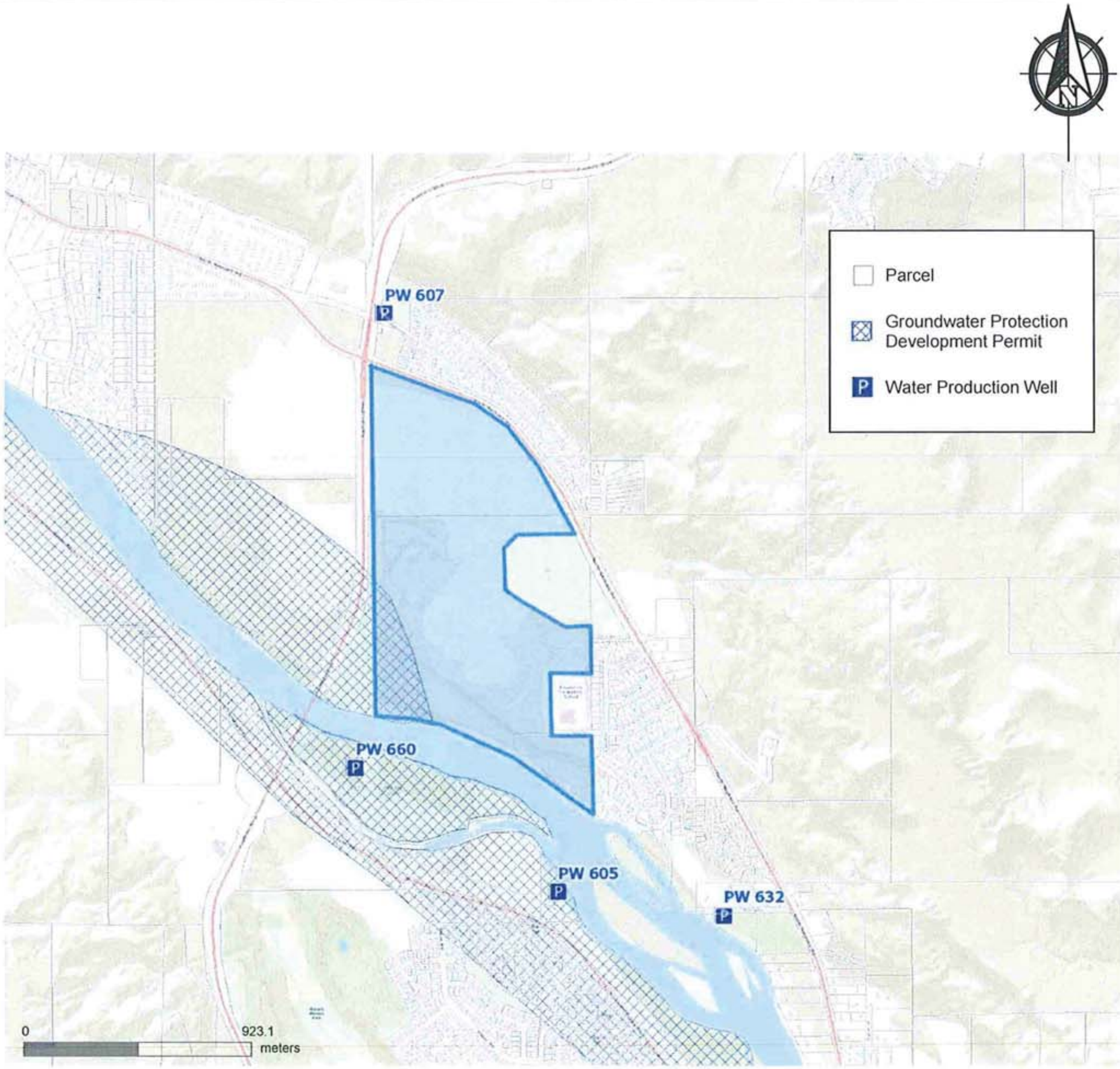
221252.000 FINAL Groundwater Assessment, 2599 N Nechako Rd, Prince George, BC, August 2 2018.docx

Template: Master Template for Peer Review Letter, EDR, May 3, 2018

FIGURES

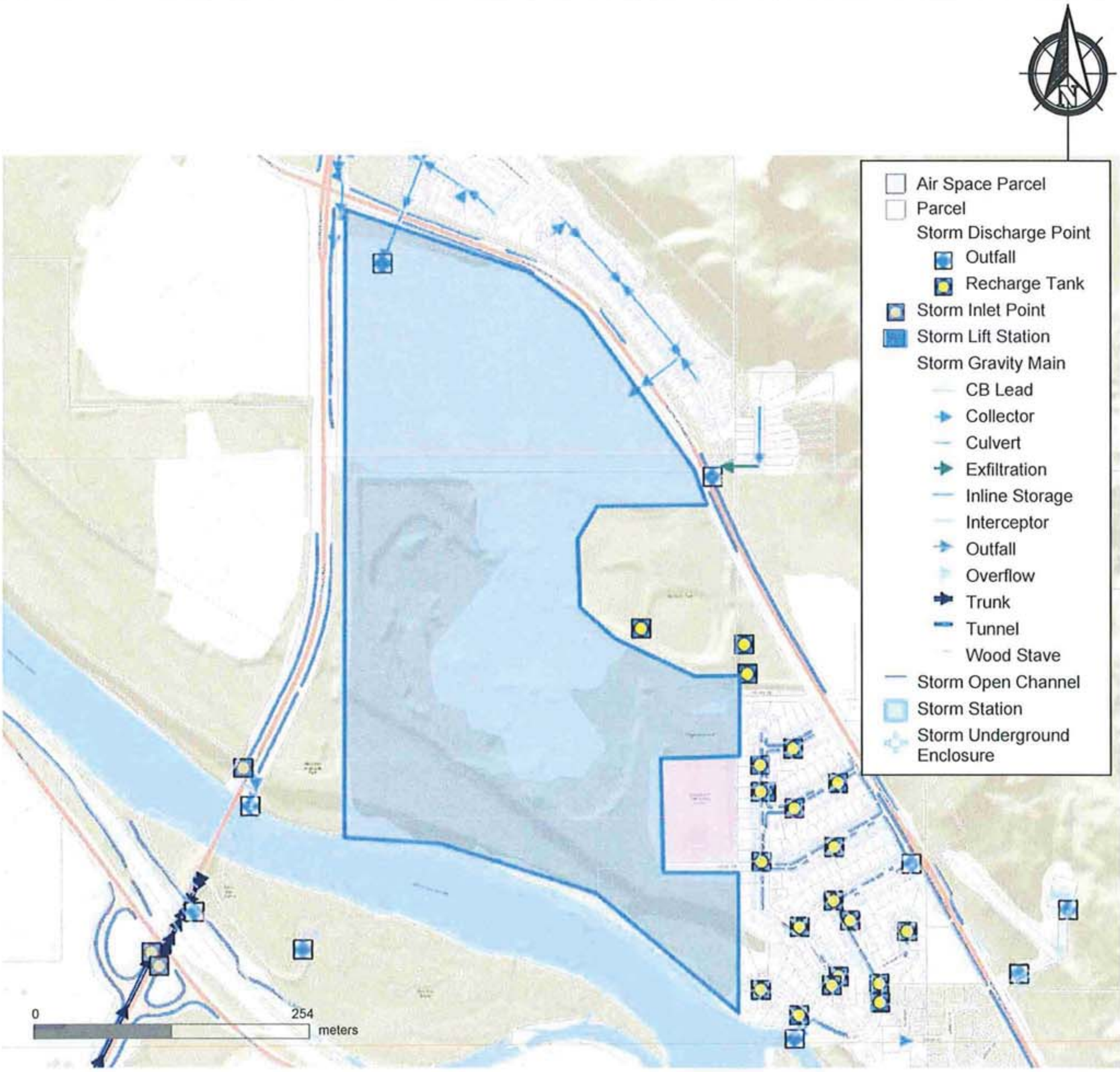


CLIENT NAME:	T.R. PROJECTS LTD & 406286 BC LTD. C/O L& M ENGINEERING				
PROJECT NAME:	GROUNDWATER ASSESSMENT CONSULTING SERVICES				
LOCATION:	2599 AND 4693 NORTH NECHAKO ROAD AND 4439 CRAIG DRIVE, PRINCE GEORGE, BRITISH COLUBIA				
TITLE:	KEY MAP				
DATE: July 2018	PROJECT #: 221252	IMAGE SOURCE: OPEN STREET MAPS	DRAWN BY: MK	CHECKED BY: KM	FIGURE NO.: 1

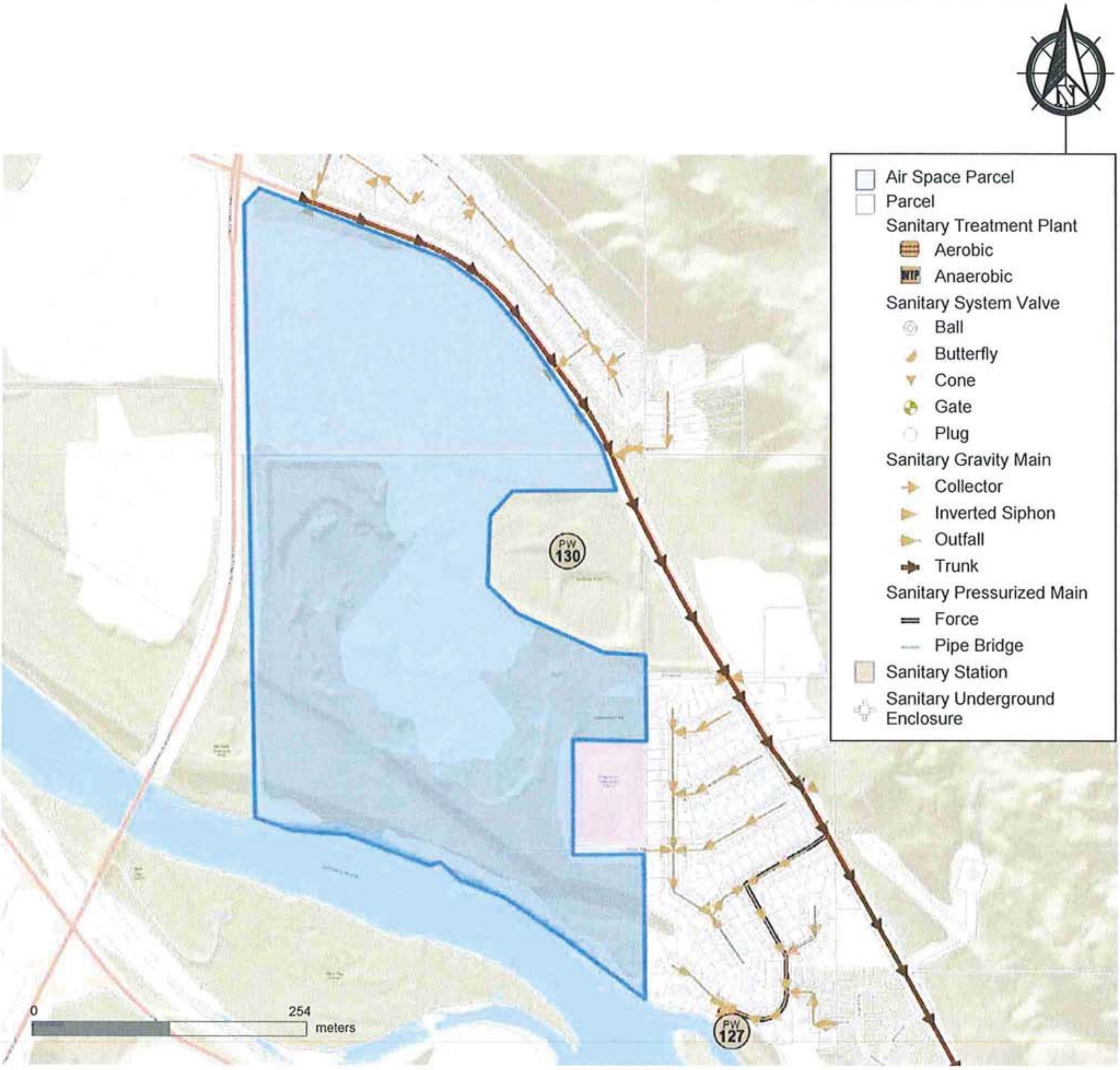


PINCHIN

CLIENT NAME:	T.R. PROJECTS LTD & 406286 BC LTD. C/O L& M ENGINEERING				
PROJECT NAME:	GROUNDWATER ASSESSMENT CONSULTING SERVICES				
LOCATION:	2599 AND 4693 NORTH NECHAKO ROAD AND 4439 CRAIG DRIVE, PRINCE GEORGE, BRITISH COLUBIA				
TITLE:	GROUNDWATER PROTECTION DEVELOPMENT PERMIT AREAS AND WATER PRODUCTION WELL LOCATIONS				
DATE: July 2018	PROJECT #: 221252	IMAGE SOURCE: PG MAP	DRAWN BY: MK	CHECKED BY: KM	FIGURE NO.: 2



PINCHIN	CLIENT NAME:	T.R. PROJECTS LTD & 406286 BC LTD. C/O L& M ENGINEERING			
	PROJECT NAME:	GROUNDWATER ASSESSMENT CONSULTING SERVICES			
	LOCATION:	2599 AND 4693 NORTH NECHAKO ROAD AND 4439 CRAIG DRIVE, PRINCE GEORGE, BRITISH COLUBIA			
	TITLE:	CURRENT STORM INFRASTRUCTURE			
DATE: July 2018	PROJECT #: 221252	IMAGE SOURCE: PG MAP	DRAWN BY: MK	CHECKED BY: KM	FIGURE NO.: 3



PINCHIN

CLIENT NAME:	T.R. PROJECTS LTD & 406286 BC LTD. C/O L& M ENGINEERING
PROJECT NAME:	GROUNDWATER ASSESSMENT CONSULTING SERVICES
LOCATION:	2599 AND 4693 NORTH NECHAKO ROAD AND 4439 CRAIG DRIVE, PRINCE GEORGE, BRITISH COLUBIA
TITLE:	CURRENT SANITARY INFRASTRUCTURE

DATE:	PROJECT #:	IMAGE SOURCE:	DRAWN BY:	CHECKED BY:	FIGURE NO.:
July 2018	221252	PG MAP	MK	KM	4

APPENDIX I

British Columbia Ministry of the Environment and Climate Change Strategy (MOECCS) Water Resource Atlas Search Results

[redacted] Groundwater Wells and Aquifers

Well Summary

Well Tag Number: 21440
Well Identification Plate Number:
Owner Name: BILL EASTLAND
Licenced Status: UNLICENSED

Well Status: NEW
Well Class:
Well Subclass:
Intended Water Use: Unknown Well Use

Observation Well Number:
Observation Well Status:
Environmental Monitoring System (EMS) ID:
Aquifer Number: 92
Alternative specs submitted (if required): No

Location Information

Street Address: N NECHAKO RD
Town/City:
Legal Description:

Lot	
Plan	
District Lot	7634
Block	
Section	
Township	
Range	
Land District	05 CARIBOO
Property Identification Description (PID)	

Description of Well Location:
BCGS Mapsheet Number: 093G097133

Leaflet | Powered by Esri | Government of British Columbia, DataBC, GeoBC

Geographic Coordinates - North American Datum of 1983 (NAD 83)

Latitude: 53.949607
UTM Northing: 5977934
Zone: 10
Longitude: -122.796933
UTM Easting: 513327
Location Accuracy Code: B

Well Activity

Construction Date (YYYY-MM-DD)	Alteration Date (YYYY-MM-DD)	Decommission Date (YYYY-MM-DD)	Drilling Company
1968-05-01			Pidherney, Bill

Well Completion Data

Total Depth Drilled:
Finished Well Depth: 285 feet
Final Casing Stick Up:
Depth to Bedrock:
Ground Elevation:
Elevation Determined By:

Static Water Level (BTOC): 120 feet
Estimated Well Yield: 8 GPH
Artesian Flow:
Artesian Pressure:

Well Cap:
Well Disinfected: No
Drilling Method: UNK
Orientation of Well: vertical

Lithology

From (feet)	To (feet)	Lithology Raw Data	Description	Material Description	Relative Hardness	Colour	Water-Bearing Estimated Flow	Observations
0	275	old drilled hole						
275	285	silt with sand and gravel						

Casing Details

From (feet)	To (feet)	Diameter (inches)	Casing Material	Wall Thickness (inches)	Drive Shoe
0	0	0		0	

[redacted] Groundwater Wells and Aquifers

Well Summary

Well Tag Number: 25705
Well Identification Plate Number:
Owner Name: CITY OF PRINCE GEORGE
Licenced Status: UNLICENSED

Well Status: NEW
Well Class:
Well Subclass:
Intended Water Use: Unknown Well Use

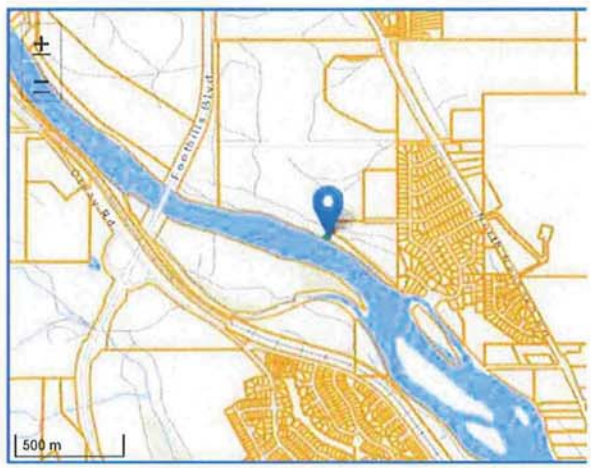
Observation Well Number:
Observation Well Status:
Environmental Monitoring System (EMS) ID:
Aquifer Number: 92
Alternative specs submitted (if required): No

Location Information

Street Address:
Town/City:
Legal Description:

Lot	
Plan	
District Lot	
Block	
Section	
Township	
Range	
Land District	05 CARIBOO
Property Identification Description (PID)	

Description of Well Location:
BCGS Mapsheet Number: 093G096244



Leaflet | Powered by Esri | Government of British Columbia, DataBC, GeoBC

Geographic Coordinates - North American Datum of 1983 (NAD 83)

Latitude: 53.944939
UTM Northing: 5977413
Zone: 10
Longitude: -122.805853
UTM Easting: 512743
Location Accuracy Code: B

Well Activity

Construction Date (YYYY-MM-DD)	Alteration Date (YYYY-MM-DD)	Decommission Date (YYYY-MM-DD)	Drilling Company
1971-12-01			Unknown

Well Completion Data

Total Depth Drilled:
Finished Well Depth: 88 feet
Final Casing Stick Up:
Depth to Bedrock:
Ground Elevation:
Elevation Determined By:

Static Water Level (BTOC):
Estimated Well Yield:
Artesian Flow:
Artesian Pressure:

Well Cap:
Well Disinfected: No
Drilling Method: UNK
Orientation of Well: vertical

Lithology

From (feet)	To (feet)	Lithology Raw Data	Description	Material Description	Relative Hardness	Colour	Water-Bearing Estimated Flow	Observations
0	45	fine to coarse sand and gravel and boulders						
45	88	fine to coarse sand and gravel						

Casing Details

From (feet)	To (feet)	Diameter (inches)	Casing Material	Wall Thickness (inches)	Drive Shoe
0	0	0		0	

[redacted] Groundwater Wells and Aquifers

Well Summary

Well Tag Number: 29148
Well Identification Plate Number:
Owner Name: NECHAKO IMP DIST
Licenced Status: UNLICENSED

Well Status: NEW
Well Class:
Well Subclass:
Intended Water Use: Unknown Well Use

Observation Well Number:
Observation Well Status:
Environmental Monitoring System (EMS) ID:
Aquifer Number: 92
Alternative specs submitted (if required): No

Location Information

Street Address:
Town/City:
Legal Description:

Lot	1
Plan	21495
District Lot	4050
Block	
Section	
Township	
Range	
Land District	05 CARIBOO
Property Identification Description (PID)	

Description of Well Location:
BCGS Mapsheet Number: 093G096422

Leaflet | Powered by Esri | Government of British Columbia, DataBC, GeoBC

Geographic Coordinates - North American Datum of 1983 (NAD 83)

Latitude: 53.959122
UTM Northing: 5978990
Zone: 10

Longitude: -122.811625
UTM Easting: 512360
Location Accuracy Code: B

Well Activity

Construction Date (YYYY-MM-DD)	Alteration Date (YYYY-MM-DD)	Decommission Date (YYYY-MM-DD)	Drilling Company
1973-11-01			Pacific Water Wells

Well Completion Data

Total Depth Drilled:		Static Water Level (BTOC):	123 feet	Well Cap:	
Finished Well Depth:	258 feet	Estimated Well Yield:	1900 GPM	Well Disinfected:	No
Final Casing Stick Up:		Artesian Flow:		Drilling Method:	UNK
Depth to Bedrock:		Artesian Pressure:		Orientation of Well:	vertical
Ground Elevation:					
Elevation Determined By:					

Lithology

From (feet)	To (feet)	Lithology Raw Data	Description	Material Description	Relative Hardness	Colour	Water-Bearing Estimated Flow	Observations
0	258	sand and gravel						

Casing Details

From (feet)	To (feet)	Diameter (inches)	Casing Material	Wall Thickness (inches)	Drive Shoe

Surface Seal and Backfill Details

Surface Seal Material: Other
Surface Seal Installation Method:
Surface Seal Thickness:
Surface Seal Length:

Backfill Material Above Surface Seal:
Backfill Depth:

Groundwater Wells and Aquifers

Well Summary

Well Tag Number: 75491
Well Identification Plate Number: 747
Owner Name: PRINCE GEORGE CITY
Licenced Status: UNLICENSED

Well Status: NEW
Well Class:
Well Subclass:
Intended Water Use: Observation Well

Observation Well Number: 342
Observation Well Status: Inactive
Environmental Monitoring System (EMS) ID: E243896
Aquifer Number: 92
Alternative specs submitted (if required): No

Location Information

Street Address: FISHTRAP ISLAND
Town/City: PRINCE GEORGE
Legal Description:

Lot	
Plan	
District Lot	2851
Block	
Section	
Township	
Range	
Land District	05 CARIBOO
Property Identification Description (PID)	

Description of Well Location:
BCGS Mapsheet Number: 093G096244

Leaflet | Powered by Esri | Government of British Columbia, DataBC, GeoBC

Geographic Coordinates - North American Datum of 1983 (NAD 83)

Latitude: 53.944844
UTM Northing: 5977401
Zone: 10
Longitude: -122.814218
UTM Easting: 512194
Location Accuracy Code: C

Well Activity

Construction Date (YYYY-MM-DD)	Alteration Date (YYYY-MM-DD)	Decommission Date (YYYY-MM-DD)	Drilling Company
1998-01-01			International Water Supply

Well Completion Data

Total Depth Drilled:
Finished Well Depth: 87 feet
Final Casing Stick Up:
Depth to Bedrock:
Ground Elevation:
Elevation Determined By:

Static Water Level (BTOC): 15 feet
Estimated Well Yield:
Artesian Flow:
Artesian Pressure:

Well Cap:
Well Disinfected: No
Drilling Method: UNK
Orientation of Well: vertical

Lithology

From (feet)	To (feet)	Lithology Raw Data	Description	Material Description	Relative Hardness	Colour	Water-Bearing Estimated Flow	Observations
0	87	sand and gravel						

Casing Details

From (feet)	To (feet)	Diameter (inches)	Casing Material	Wall Thickness (inches)	Drive Shoe
0	0	0		0	

Surface Seal and Backfill Details

Surface Seal Material: Other
Surface Seal Installation Method:
Surface Seal Thickness:
Surface Seal Length:

Backfill Material Above Surface Seal:
Backfill Depth:

Groundwater Wells and Aquifers

Well Summary

Well Tag Number: 103461
Well Identification Plate Number: 33628
Owner Name: CITY OF PRINCE GEORGE
Licenced Status: UNLICENSED

Well Status: NEW
Well Class: Monitoring
Well Subclass: Permanent
Intended Water Use:

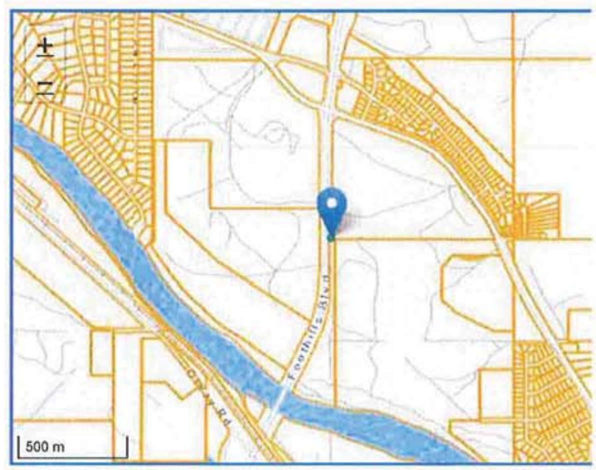
Observation Well Number:
Observation Well Status:
Environmental Monitoring System (EMS) ID:
Aquifer Number: 92
Alternative specs submitted (if required): No

Location Information

Street Address: FOOTHILLS BOULEVARD
Town/City: PRINCE GEORGE
Legal Description:

- Lot
- Plan
- District Lot
- Block
- Section
- Township
- Range
- Land District
- Property Identification Description (PID)

Description of Well Location: GRAVEL PIT NORTH OF NECHAKO RIVER
BCGS Mapsheet Number: 093G096422



Leaflet | Powered by Esri | Government of British Columbia, DataBC, GeoBC

Geographic Coordinates - North American Datum of 1983 (NAD 83)

Latitude: 53.952869
UTM Northing: 5978294
Zone: 10

Longitude: -122.813603
UTM Easting: 512232
Location Accuracy Code: G

Well Activity

Construction Date (YYYY-MM-DD)	Alteration Date (YYYY-MM-DD)	Decommission Date (YYYY-MM-DD)	Drilling Company
2009-06-19			Geotech Drilling Ser

Well Completion Data

Total Depth Drilled: 76 feet
Finished Well Depth: 76 feet
Final Casing Stick Up:
Depth to Bedrock:
Ground Elevation:
Elevation Determined By:

Static Water Level (BTOC):
Estimated Well Yield:
Artesian Flow:
Artesian Pressure:

Well Cap:
Well Disinfected: No
Drilling Method: AIR_ROTARY
Orientation of Well: vertical

Lithology

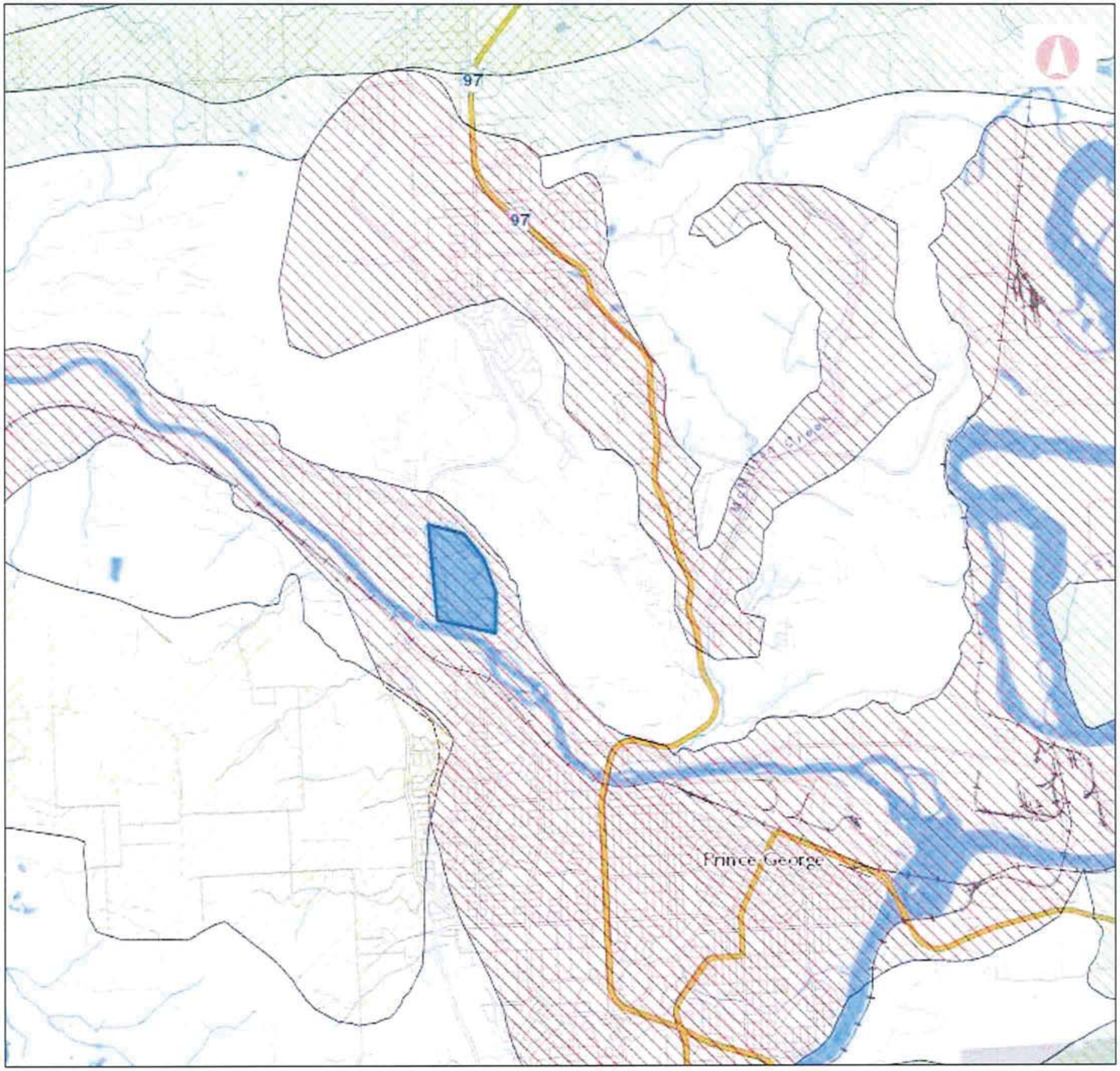
From (feet)	To (feet)	Lithology Raw Data	Description	Material Description	Relative Hardness	Colour	Water-Bearing Estimated Flow	Observations
0	13	SAND MED-COARSE			Dense	brown		DRY
13	39	SILT & SAND MED-COARSE			Dense	brown		DRY
39	66	SAND W/ GRAVEL			Dense	brown		MOIST
66	76	SILT & SAND FINE-MED			Dense	brown		MOIST

Casing Details

From (feet)	To (feet)	Diameter (inches)	Casing Material	Wall Thickness (inches)	Drive Shoe
0	76	4	Steel Pulled Out		No

APPENDIX II

iMapBC Aquifer Search Results



BRITISH COLUMBIA

iMapBC Mapping

Legend

Aquifers - Vulnerability - BC

VULNERABILITY_CODE

- Bedrock High Vulnerability
- Bedrock Moderate Vulnerability
- Bedrock Low Vulnerability
- Unconsolidated High Vulnerabili
- Unconsolidated Moderate Vulne
- Unconsolidated Low Vulnerabilit

TileCache

0 1.50 3.00 km

1: 73,819

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CAUTION: Maps obtained using this site are not designed to assist in navigation. These maps may be generalized and may not reflect current conditions. Uncharted hazards may exist. DO NOT USE THESE MAPS FOR NAVIGATIONAL PURPOSES.

Datum: NAD83
Projection: NAD_1983_BC_Environment_Albers

Key Map of British Columbia

AQUIFER CLASSIFICATION WORKSHEET

DATE: March 14, 2017 (Fresh Water Solutions Ltd.)

AQUIFER REFERENCE NUMBER: 0092

DESCRIPTIVE LOCATION OF AQUIFER: Fraser River plain between Old Summit Lake and Prince George, and Nechako River plain between Prince George and Chilako

NTS MAP SHEET: NTS Map: 093G / 15, 093J / 2

BCGS MAP SHEET: Trim Map: 093G.087, 093G.096, 093G.097, 093J.007

CLASSIFICATION: IA **RANKING: 15**

Aquifer Size: 93.6 km^2

Aquifer Boundaries:

This unconsolidated aquifer has been delineated on the basis of well development, topography and surface geology (Leaming and Armstrong, 1969; Tipper, 1961; 1971) and hydrogeology (McCallum, 1969). The aquifer coincides approximately with the fluvial terraces located along the shores of the Fraser River and Nechako River. The boundaries of this aquifer are to be considered uncertain, in light of the limited lithological information available.

Aquifer Sub-type: 1a

Aquifer Priority Rating for Observation Wells: 83.6

Geologic Formation (overlying materials):

Alluvial deposits comprising mainly sand and gravel, silt, minor muck and peat.

Geologic Formation (aquifer):

Alluvial deposits consisting mainly of sand and gravel forming terrace along the Fraser and Nechako River.

Confined/Partially Confined/Unconfined: Unconfined

Vulnerability: High (A)

Wells are completed in an aquifer that is unconfined. Groundwater levels are moderate to deep, with an average level of 20 m bgs and ranging from 2 to 174 m bgs. Well record lithology suggests that the alluvial aquifer is generally highly permeable.

Productivity: High - Average 4.1 L/s

Reported well yields range between less than 1 L/s and 315 L/s. The median well yield is 0.9 L/s and the arithmetic mean is 4.1 L/s. Well yields reported are estimated by the driller based on short-term bail or air- tests only and results obtained are often unreliable. The majority of wells have been completed simply as *open hole* into the sand and gravel and have not been completed with designed well screens for maximum hydraulic efficiency. Well yields could therefore be greater than well records suggest.

Depth to Water: Moderate - Average 20 m, Range 2 -174 m bgs

The deeper groundwater level records may be due to pumping interference of wells clusters.

Direction of Groundwater Flow:

Generally following the direction streamflow along the Fraser and Nechako River, but also away from the river along losing stretches (i.e. where river leakage occurs) and towards the river along gaining stretches (i.e. where the aquifer discharges into the river).

Recharge:

The main source of recharge is likely leakage from the Fraser River and precipitation recharge.

Well Density: Moderate – 4.1 wells/km^2

Well density of up to 11 wells per km^2 in the SW portion of the aquifer, where most wells are clustered.

Type of Water Use: Drinking / Multiple Water Use

The reported type of use for most of the wells located in the aquifer is Private Domestic, with fifteen wells designated for commercial and industrial use, four wells for irrigation, six wells for public water supply and one observation well.

Reliance on Source/Development:

Well water is a major source of water supply for domestic use, and to a lesser extent for commercial and industrial use, irrigation and for public water supply. Level of Development is High, given an estimated precipitation recharge of up to approximately 578 L/s (assuming 30% infiltration rate and an annual average precipitation of 630 mm/yr, based on Environment Canada records collected at the local meteorological station), with a likely significant additional contribution from river leakage, and the total groundwater withdrawal (based on the total reported well yield) of approximately 1574 L/s.

Conflicts between Users:

None documented.

Quantity Concerns:

None documented.

Quality Concerns:

None reported.

Comments:

None reported.

Water Budget:

No water budget calculations documented.

Groundwater model(s):

No groundwater models available for the aquifer.

Observation Wells:

One observation well (Well Tag 86618, also referred to as #378 in the BC Provincial Monitoring network) is located in the aquifer. Another well (Well Tag 75491) is reported as observation well, but it either no longer exists or was discontinued as monitoring well (verb. comm, MFLNRO, March 2017).

References:

Bernardinucci J. and K Ronneseth, 2002. Guide to Using the BC Aquifer Classification Maps for the Protection and Management of Groundwater. BC Ministry of Water, Land and Air Protection, Water Air and Climate Change Branch, Water Protection Section.

Leaming, S.P. and Armstrong, J.E. 1969. Surficial Geology, Prince George. G.S.C. Map 3 - 1969

McCallum, J.A. 1969. Groundwater and Geology of the Prince George Area, Central British Columbia. NTS 93/15 #17. A.R.D.A. Research Project No. 10014. Water Investigations Branch, Dept. of Lands, Forests and Water Resources. 45p.

Tipper, H.W. 1961. Geology, Prince George. GSC Map 49—1960.

Tipper, H.W. 1971. Surficial Geology, Prince George. GSC Map 1288A.

Wei, M., D. M. Allen, A. P. Kohut, S. Grasby, K. Ronneseth, and B. Turner. 2009. Understanding the Types of Aquifers in the Canadian Cordillera Hydrogeologic Region to Better Manage and Protect Groundwater. *Streamline Watershed Management Bulletin*, FORREX Forum for Research and Extension in Natural Resources.

Ranking

Ranking Component:	*Ranking Value:*
Productivity:	3
Vulnerability:	3
Size:	3
Demand*:	3
Type Of Use:	3
Quality:	0
Quantity:	0
Total:	**15**

** Demand was estimated based on the total yield of the wells located in the aquifer, and by assuming that the reported well capacity is the amount of water used. This is a conservative assumption, since reported well capacity is often higher than actual use.*

Statistical Summary of Well Data for Aquifer

Total number of wells available for statistical analysis: 388

	Depth to Bedrock (m bgs)	Well Depth (m bgs)	Depth to Water (m bgs)	Reported Est. Well Yield (L/s)	Est. Thickness of Confining Materials (m)
Number of Wells	15	385	273	388	129
Minimum	12	5	2	0.01	0
Maximum	166	195	174	315.5	83
Median	23	32	19	0.9	5
Average	40	36	20	4.1	11
Geometric Mean	29	-	-	-	5

Note: The geometric mean of the well depth, depth to water and well yield could not be calculated since the reported well depth, water depth and yield for some wells is zero.

APPENDIX III

Groundwater Protection Model Results

Groundwater Protection Transport Model

Site-specific Factors

- [x] Groundwater used for drinking water
- [ ] Groundwater flow to surface water used by aquatic life
- [ ] Groundwater used for livestock watering
- [ ] Groundwater used for irrigation

Substance Xylenes, total

Substance Properties

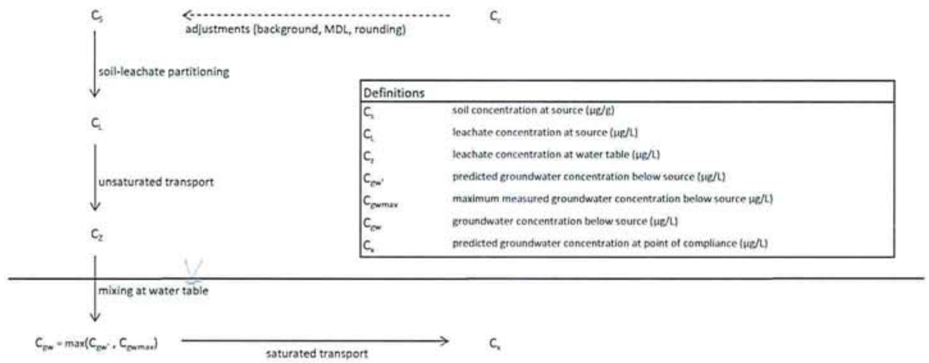
			Units	Source
K_{oc}	organic carbon partitioning coefficient	3.83E+02	L/kg	Lookup tables
K_d	distribution coefficient	1.92E+00	L/kg	Lookup tables
R_f	retardation factor in saturated zone	1.00E+01	[/]	$1 + (K_d \cdot \rho_b) / n$
R_u	retardation factor in unsaturated zone	2.84E+01	[/]	$1 + (K_d \cdot \rho_b) / n_w$
t_{hs}	half-life in saturated zone	290	days	Lookup tables
t_{hu}	half-life in unsaturated zone	145	days	Lookup tables
H'	dimensionless Henry's law constant	2.71E-01	[/]	Lookup tables
C_b	background concentration in soil	Not available	µg/g	Lookup tables
C_{dl}	analytical method detection limit	Not available	µg/g	Lookup tables
S	solubility limit	5.30E+01	mg/L	Lookup tables

Site-specific Parameters

			Units	Source	Defaults
X	source length	10	m	User input	10
Y	source width	30	m	User input	30
Z	source depth	3	m	User input	3
I	infiltration rate	0.55	m/yr	User input	0.55
f_{oc}	fraction of organic carbon	0.005	[/]	User input	0.005
n_w	water-filled porosity	0.119	[/]	User input	0.119
x	distance to point of compliance	220	m	User input	10
d_a	aquifer thickness	5	m	User input	5
d	depth to water table	3	m	User input	3
n	total porosity	0.36	[/]	User input	0.36
n_e	effective porosity	0.25	[/]	User input	0.25
K	hydraulic conductivity	3.00E-05	m/s	User input	3.00E-05
i	hydraulic gradient	0.008	[/]	User input	0.008
V	Darcy flux	7.57	m/yr	K·i	7.57
pH_{soil}	pH of soil	6.5	[/]	User input	6.5
pH_{water}	pH of groundwater	6.5	[/]	User input	6.5
ρ_b	dry bulk density of soil	1.7	g/cm^3	User input	1.7
H	water hardness	200	mg/L	User input	200
D_b	number of days of frozen ground	0	days	User input	0
n_a	air-filled porosity	0.241	[/]	$n - n_w$	0.241
∂_x	longitudinal dispersivity	22	[/]	0.1 x	1
∂_y	transverse dispersivity	2.2	[/]	$0.1\ \partial_x$	0.1
∂_u	dispersivity in unsaturated zone	0	[/]	0.1 b	0
v_u	leachate velocity in unsaturated zone	2.72	m/yr	I / n_w	2.72
v	average linear groundwater velocity in saturated zone	30.27	m/yr	V / n_e	30.27
d_m	mixing zone thickness	1.68	m	Protocol 28	1.68
DF	dilution factor	3.31	[/]	Protocol 28	3.31
b	vertical distance between base of source and water table	0	m	max (0, d-Z)	0

Conceptual Model

(arrows indicate order of calculations)



Definitions	
C_s	soil concentration at source (µg/g)
C_L	leachate concentration at source (µg/L)
C_Z	leachate concentration at water table (µg/L)
$C_{gw'}$	predicted groundwater concentration below source (µg/L)
C_{gwmax}	maximum measured groundwater concentration below source µg/L)
C_{gw}	groundwater concentration below source (µg/L)
C_x	predicted groundwater concentration at point of compliance (µg/L)

Model Type: ○ SSS ◉ SLRA

Site-specific Factors	C_s µg/g	C_L µg/L	C_Z µg/L	$C_{gw'}$ µg/L	C_{gwmax} µg/L	C_x µg/L
SLRA calculations:	5.00E+03	2.47E+06	2.47E+06	7.47E+05	3.00E+04	2.77E-04
Groundwater used for drinking water						9.00E+01
Groundwater flow to surface water used by aquatic life						
freshwater						
marine and/or estuarine						
any aquatic receiving environment						
Groundwater used for livestock watering						
Groundwater used for irrigation						

- [ ] Use leachate test data for CL

Site Details

Site ID	221252
Site Address	4693 North Nechako Road
User Name	<user name>
User Organization	Pinchin Inc.

Groundwater Protection Transport Model

Site-specific Factors

- [x] Groundwater used for drinking water
- [ ] Groundwater flow to surface water used by aquatic life
- [ ] Groundwater used for livestock watering
- [ ] Groundwater used for irrigation

Substance Toluene

Substance Properties

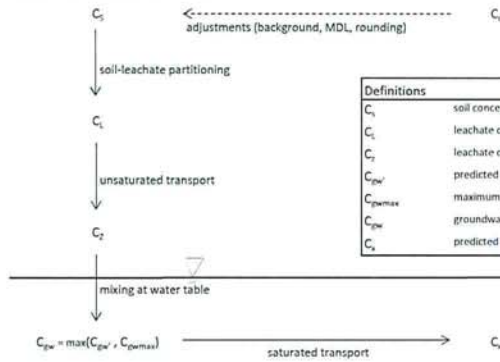
			Units	Source
K_{oc}	organic carbon partitioning coefficient	2.34E+02	L/kg	Lookup tables
K_d	distribution coefficient	1.17E+00	L/kg	Lookup tables
R_f	retardation factor in saturated zone	6.53E+00	[/]	$1 + (K_d \cdot \rho_b) / n$
R_u	retardation factor in unsaturated zone	1.77E+01	[/]	$1 + (K_d \cdot \rho_b) / n_w$
$t_{½s}$	half-life in saturated zone	130	days	Lookup tables
$t_{½u}$	half-life in unsaturated zone	65	days	Lookup tables
H'	dimensionless Henry's law constant	2.71E-01	[/]	Lookup tables
C_b	background concentration in soil	Not available	µg/g	Lookup tables
C_{dl}	analytical method detection limit	Not available	µg/g	Lookup tables
S	solubility limit	2.63E+02	mg/L	Lookup tables

Site-specific Parameters

			Units	Source	Defaults
X	source length	10	m	User input	10
Y	source width	30	m	User input	30
Z	source depth	3	m	User input	3
I	infiltration rate	0.55	m/yr	User input	0.55
f_{oc}	fraction of organic carbon	0.005	[/]	User input	0.005
n_w	water-filled porosity	0.119	[/]	User input	0.119
x	distance to point of compliance	220	m	User input	10
d_a	aquifer thickness	5	m	User input	5
d	depth to water table	3	m	User input	3
n	total porosity	0.36	[/]	User input	0.36
n_e	effective porosity	0.25	[/]	User input	0.25
K	hydraulic conductivity	3.00E-05	m/s	User input	3.00E-05
i	hydraulic gradient	0.008	[/]	User input	0.008
V	Darcy flux	7.57	m/yr	K·i	7.57
pH_{soil}	pH of soil	6.5	[/]	User input	6.5
pH_{water}	pH of groundwater	6.5	[/]	User input	6.5
ρ_b	dry bulk density of soil	1.7	g/cm^3	User input	1.7
H	water hardness	200	mg/L	User input	200
D_f	number of days of frozen ground	0	days	User input	0
n_a	air-filled porosity	0.241	[/]	$n - n_w$	0.241
∂_x	longitudinal dispersivity	22	[/]	0.1 x	1
∂_y	transverse dispersivity	2.2	[/]	$0.1\ \partial_x$	0.1
∂_u	dispersivity in unsaturated zone	0	[/]	0.1 b	0
v_u	leachate velocity in unsaturated zone	2.72	m/yr	I / n_w	2.72
v	average linear groundwater velocity in saturated zone	30.27	m/yr	V / n_e	30.27
d_m	mixing zone thickness	1.68	m	Protocol 28	1.68
DF	dilution factor	3.31	[/]	Protocol 28	3.31
b	vertical distance between base of source and water table	0	m	max (0, d-Z)	0

Conceptual Model

(arrows indicate order of calculations)



Definitions	
C_s	soil concentration at source (µg/g)
C_L	leachate concentration at source (µg/L)
C_Z	leachate concentration at water table (µg/L)
$C_{gw'}$	predicted groundwater concentration below source (µg/L)
C_{gwmax}	maximum measured groundwater concentration below source µg/L)
C_{gw}	groundwater concentration below source (µg/L)
C_x	predicted groundwater concentration at point of compliance (µg/L)

Model Type
( ) SSS (•) SLRA

Site-specific Factors	C_s µg/g	C_L µg/L	C_Z µg/L	$C_{gw'}$ µg/L	C_{gwmax} µg/L	C_x µg/L
SLRA calculations:	1.50E+03	1.17E+06	1.17E+06	3.55E+05	5.50E+04	8.31E-07
Groundwater used for drinking water						6.00E+01
Groundwater flow to surface water used by aquatic life						
freshwater						
marine and/or estuarine						
any aquatic receiving environment						
Groundwater used for livestock watering						
Groundwater used for irrigation						

- [ ] Use leachate test data for CL

Site Details

Site ID	221252
Site Address	4693 North Nechako Road
User Name	<user name>
User Organization	Pinchin Inc.

Groundwater Protection Transport Model

Site-specific Factors

- [x] Groundwater used for drinking water
- [ ] Groundwater flow to surface water used by aquatic life
- [ ] Groundwater used for livestock watering
- [ ] Groundwater used for irrigation

Substance Naphthalene

Substance Properties

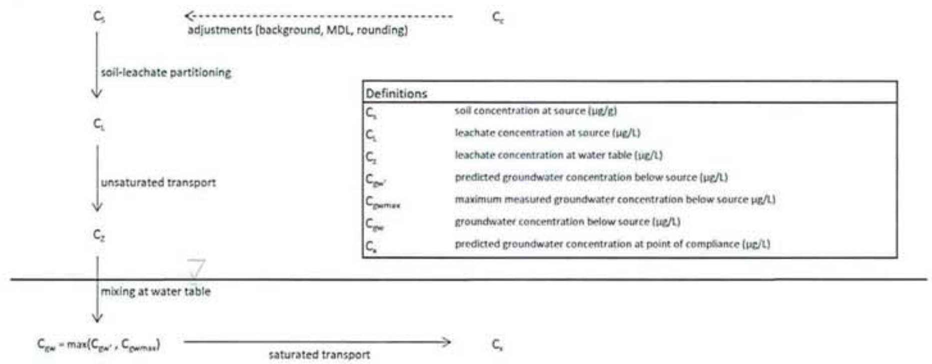
		Value	Units	Source
K_{oc}	organic carbon partitioning coefficient	1.54E+03	L/kg	Lookup tables
K_d	distribution coefficient	7.70E+00	L/kg	Lookup tables
R_f	retardation factor in saturated zone	3.74E+01	[/]	$1 + (K_d \cdot \rho_b) / n$
R_u	retardation factor in unsaturated zone	1.11E+02	[/]	$1 + (K_d \cdot \rho_b) / n_w$
$t_{½S}$	half-life in saturated zone	350	days	Lookup tables
$t_{½U}$	half-life in unsaturated zone	175	days	Lookup tables
H'	dimensionless Henry's law constant	1.80E-02	[/]	Lookup tables
C_b	background concentration in soil	Not available	µg/g	Lookup tables
C_{dl}	analytical method detection limit	Not available	µg/g	Lookup tables
S	solubility limit	1.55E+01	mg/L	Lookup tables

Site-specific Parameters

		Value	Units	Source	Defaults
X	source length	10	m	User input	10
Y	source width	30	m	User input	30
Z	source depth	3	m	User input	3
I	infiltration rate	0.55	m/yr	User input	0.55
f_{oc}	fraction of organic carbon	0.005	[/]	User input	0.005
n_w	water-filled porosity	0.119	[/]	User input	0.119
x	distance to point of compliance	220	m	User input	10
d_a	aquifer thickness	5	m	User input	5
d	depth to water table	3	m	User input	3
n	total porosity	0.36	[/]	User input	0.36
n_e	effective porosity	0.25	[/]	User input	0.25
K	hydraulic conductivity	3.00E-05	m/s	User input	3.00E-05
i	hydraulic gradient	0.008	[/]	User input	0.008
V	Darcy flux	7.57	m/yr	K·i	7.57
pH_{soil}	pH of soil	6.5	[/]	User input	6.5
pH_{water}	pH of groundwater	6.5	[/]	User input	6.5
ρ_b	dry bulk density of soil	1.7	g/cm^3	User input	1.7
H	water hardness	200	mg/L	User input	200
D_{fr}	number of days of frozen ground	0	days	User input	0
n_a	air-filled porosity	0.241	[/]	$n - n_w$	0.241
$ð_x$	longitudinal dispersivity	22	[/]	0.1 x	1
$ð_y$	transverse dispersivity	2.2	[/]	0.1 $ð_x$	0.1
$ð_u$	dispersivity in unsaturated zone	0	[/]	0.1 b	0
v_U	leachate velocity in unsaturated zone	2.72	m/yr	I / n_w	2.72
v	average linear groundwater velocity in saturated zone	30.27	m/yr	V / n_e	30.27
d_m	mixing zone thickness	1.68	m	Protocol 28	1.68
DF	dilution factor	3.31	[/]	Protocol 28	3.31
b	vertical distance between base of source and water table	0	m	max (0, d-Z)	0

Conceptual Model

(arrows indicate order of calculations)



Definitions	
C_s	soil concentration at source (µg/g)
C_L	leachate concentration at source (µg/L)
C_Z	leachate concentration at water table (µg/L)
$C_{gw'}$	predicted groundwater concentration below source (µg/L)
C_{gwmax}	maximum measured groundwater concentration below source µg/L)
C_{gw}	groundwater concentration below source (µg/L)
C_x	predicted groundwater concentration at point of compliance (µg/L)

Model Type: ○ SSS ◉ SLRA

Site-specific Factors	C_s µg/g	C_L µg/L	C_Z µg/L	$C_{gw'}$ µg/L	C_{gwmax} µg/L	C_x µg/L
SLRA calculations:	5.00E+01	6.43E+03	6.43E+03	1.95E+03	5.00E+02	4.65E-15
Groundwater used for drinking water						8.00E+01
Groundwater flow to surface water used by aquatic life						
freshwater						
marine and/or estuarine						
any aquatic receiving environment						
Groundwater used for livestock watering						
Groundwater used for irrigation						

- [ ] Use leachate test data for CL

Site Details

Site ID	221252
Site Address	4693 North Nechako Road
User Name	<user name>
User Organization	Pinchin Inc.

Groundwater Protection Transport Model

Site-specific Factors

- [x] Groundwater used for drinking water
- [ ] Groundwater flow to surface water used by aquatic life
- [ ] Groundwater used for livestock watering
- [ ] Groundwater used for irrigation

Substance LEPHs/LEPHw

Substance Properties

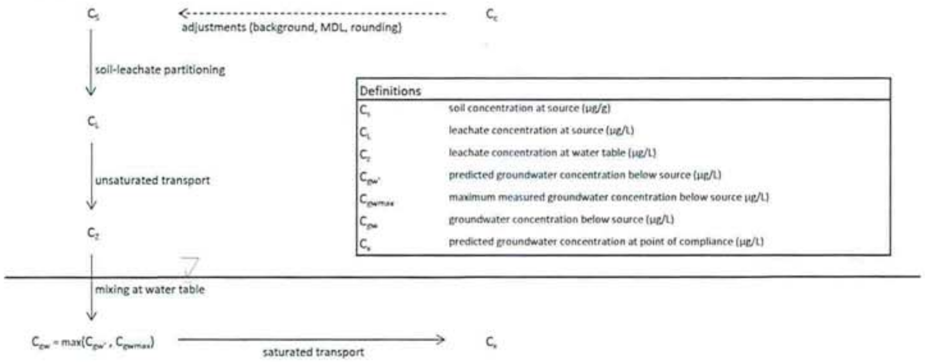
		Units		Source
K_{oc}	organic carbon partitioning coefficient	2.50E+03	L/kg	Lookup tables
K_d	distribution coefficient	1.25E+01	L/kg	Lookup tables
R_f	retardation factor in saturated zone	6.00E+01	[/]	$1 + (K_d \cdot \rho_b) / n$
R_u	retardation factor in unsaturated zone	1.80E+02	[/]	$1 + (K_d \cdot \rho_b) / n_w$
$t_{½S}$	half-life in saturated zone	350	days	Lookup tables
$t_{½U}$	half-life in unsaturated zone	175	days	Lookup tables
H'	dimensionless Henry's law constant	5.70E-02	[/]	Lookup tables
C_b	background concentration in soil	Not available	µg/g	Lookup tables
C_{dl}	analytical method detection limit	Not available	µg/g	Lookup tables
S	solubility limit	Not available	mg/L	Lookup tables

Site-specific Parameters

		Units		Source	Defaults
X	source length	10	m	User input	10
Y	source width	30	m	User input	30
Z	source depth	3	m	User input	3
I	infiltration rate	0.55	m/yr	User input	0.55
f_{oc}	fraction of organic carbon	0.005	[/]	User input	0.005
n_w	water-filled porosity	0.119	[/]	User input	0.119
x	distance to point of compliance	220	m	User input	10
d_a	aquifer thickness	5	m	User input	5
d	depth to water table	3	m	User input	3
n	total porosity	0.36	[/]	User input	0.36
n_e	effective porosity	0.25	[/]	User input	0.25
K	hydraulic conductivity	3.00E-05	m/s	User input	3.00E-05
i	hydraulic gradient	0.008	[/]	User input	0.008
V	Darcy flux	7.57	m/yr	K·i	7.57
pH_{soil}	pH of soil	6.5	[/]	User input	6.5
pH_{water}	pH of groundwater	6.5	[/]	User input	6.5
ρ_b	dry bulk density of soil	1.7	g/cm^3	User input	1.7
H	water hardness	200	mg/L	User input	200
D_{fr}	number of days of frozen ground	0	days	User input	0
n_a	air-filled porosity	0.241	[/]	$n - n_w$	0.241
∂_x	longitudinal dispersivity	22	[/]	0.1 x	1
∂_y	transverse dispersivity	2.2	[/]	$0.1\ \partial_x$	0.1
∂_u	dispersivity in unsaturated zone	0	[/]	0.1 b	0
v_U	leachate velocity in unsaturated zone	2.72	m/yr	I / n_w	2.72
v	average linear groundwater velocity in saturated zone	30.27	m/yr	V / n_e	30.27
d_m	mixing zone thickness	1.68	m	Protocol 28	1.68
DF	dilution factor	3.31	[/]	Protocol 28	3.31
b	vertical distance between base of source and water table	0	m	max (0, d-Z)	0

Conceptual Model

(arrows indicate order of calculations)



Definitions	
C_s	soil concentration at source (µg/g)
C_L	leachate concentration at source (µg/L)
C_z	leachate concentration at water table (µg/L)
$C_{gw'}$	predicted groundwater concentration below source (µg/L)
C_{gwmax}	maximum measured groundwater concentration below source µg/L)
C_{gw}	groundwater concentration below source (µg/L)
C_x	predicted groundwater concentration at point of compliance (µg/L)

Model Type: ○ SSS ◉ SLRA

Site-specific Factors	C_s µg/g	C_L µg/L	C_z µg/L	$C_{gw'}$ µg/L	C_{gwmax} µg/L	C_x µg/L
SLRA calculations:	3.00E+03	2.39E+05	2.39E+05	7.21E+04	4.00E+03	1.30E-18
Groundwater used for drinking water						
Groundwater flow to surface water used by aquatic life						
freshwater						
marine and/or estuarine						
any aquatic receiving environment						
Groundwater used for livestock watering						
Groundwater used for irrigation						

- [ ] Use leachate test data for CL

Site Details

Site ID	221252
Site Address	4693 North Nechako Road
User Name	<user name>
User Organization	Pinchin Inc.

Groundwater Protection Transport Model

Site-specific Factors

- [x] Groundwater used for drinking water
- [ ] Groundwater flow to surface water used by aquatic life
- [ ] Groundwater used for livestock watering
- [ ] Groundwater used for irrigation

Substance Ethylbenzene

Substance Properties

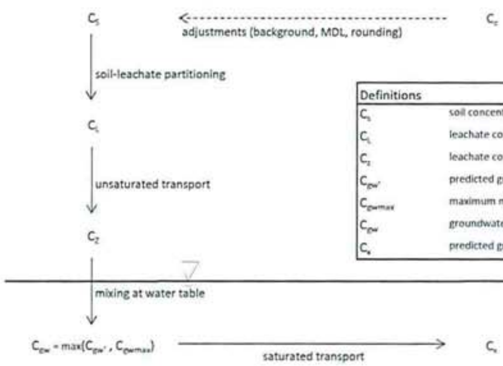
		Units		Source
K_{oc}	organic carbon partitioning coefficient	4.46E+02	L/kg	Lookup tables
K_d	distribution coefficient	2.23E+00	L/kg	Lookup tables
R_f	retardation factor in saturated zone	1.15E+01	[/]	$1 + (K_d \cdot \rho_b) / n$
R_u	retardation factor in unsaturated zone	3.29E+01	[/]	$1 + (K_d \cdot \rho_b) / n_w$
$t_{s(s)}$	half-life in saturated zone	290	days	Lookup tables
$t_{s(u)}$	half-life in unsaturated zone	145	days	Lookup tables
H'	dimensionless Henry's law constant	3.22E-01	[/]	Lookup tables
C_b	background concentration in soil	Not available	µg/g	Lookup tables
C_{dl}	analytical method detection limit	Not available	µg/g	Lookup tables
S	solubility limit	8.45E+01	mg/L	Lookup tables

Site-specific Parameters

		Units		Source	Defaults
X	source length	10	m	User input	10
Y	source width	30	m	User input	30
Z	source depth	3	m	User input	3
I	infiltration rate	0.55	m/yr	User input	0.55
f_{oc}	fraction of organic carbon	0.005	[/]	User input	0.005
n_w	water-filled porosity	0.119	[/]	User input	0.119
x	distance to point of compliance	220	m	User input	10
d_a	aquifer thickness	5	m	User input	5
d	depth to water table	3	m	User input	3
n	total porosity	0.36	[/]	User input	0.36
n_e	effective porosity	0.25	[/]	User input	0.25
K	hydraulic conductivity	3.00E-05	m/s	User input	3.00E-05
i	hydraulic gradient	0.008	[/]	User input	0.008
V	Darcy flux	7.57	m/yr	K·i	7.57
pH_{soil}	pH of soil	6.5	[/]	User input	6.5
pH_{water}	pH of groundwater	6.5	[/]	User input	6.5
ρ_b	dry bulk density of soil	1.7	g/cm^3	User input	1.7
H	water hardness	200	mg/L	User input	200
D_f	number of days of frozen ground	0	days	User input	0
n_a	air-filled porosity	0.241	[/]	$n - n_w$	0.241
∂_x	longitudinal dispersivity	22	[/]	0.1 x	1
∂_y	transverse dispersivity	2.2	[/]	$0.1\ \partial_x$	0.1
∂_u	dispersivity in unsaturated zone	0	[/]	0.1 b	0
v_u	leachate velocity in unsaturated zone	2.72	m/yr	I / n_w	2.72
v	average linear groundwater velocity in saturated zone	30.27	m/yr	V / n_e	30.27
d_m	mixing zone thickness	1.68	m	Protocol 28	1.68
DF	dilution factor	3.31	[/]	Protocol 28	3.31
b	vertical distance between base of source and water table	0	m	max (0, d-Z)	0

Conceptual Model

(arrows indicate order of calculations)



Definitions	
C_s	soil concentration at source (µg/g)
C_L	leachate concentration at source (µg/L)
C_z	leachate concentration at water table (µg/L)
$C_{gw'}$	predicted groundwater concentration below source (µg/L)
C_{gwmax}	maximum measured groundwater concentration below source µg/L)
C_{gw}	groundwater concentration below source (µg/L)
C_w	predicted groundwater concentration at point of compliance (µg/L)

Model Type
- ( ) SSS
- (•) SLRA

Site-specific Factors	C_s µg/g	C_L µg/L	C_z µg/L	$C_{gw'}$ µg/L	C_{gwmax} µg/L	C_w µg/L
SLRA calculations:	8.00E+02	3.41E+05	3.41E+05	1.03E+05	5.50E+03	6.49E-06
Groundwater used for drinking water						1.40E+02
Groundwater flow to surface water used by aquatic life						
freshwater						
marine and/or estuarine						
any aquatic receiving environment						
Groundwater used for livestock watering						
Groundwater used for irrigation						

- [ ] Use leachate test data for CL

Site Details

Site ID	221252
Site Address	4693 North Nechako Road
User Name	<user name>
User Organization	Pinchin Inc.

Groundwater Protection Transport Model

Site-specific Factors

- [x] Groundwater used for drinking water
- [ ] Groundwater flow to surface water used by aquatic life
- [ ] Groundwater used for livestock watering
- [ ] Groundwater used for irrigation

Substance Benzene

Substance Properties

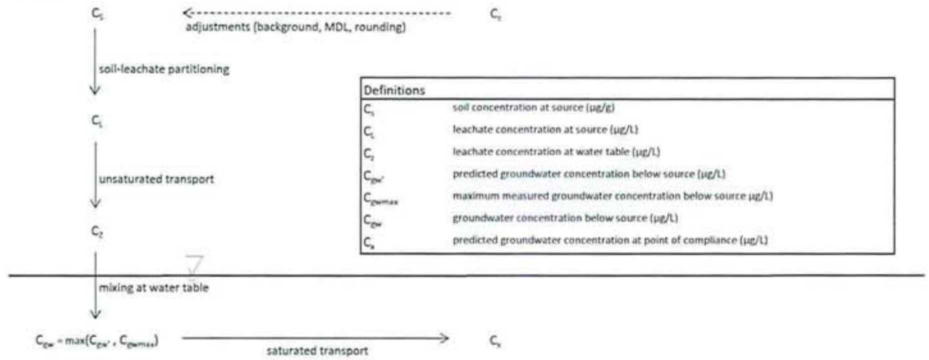
			Units	Source
K_{oc}	organic carbon partitioning coefficient	1.46E+02	L/kg	Lookup tables
K_d	distribution coefficient	7.30E-01	L/kg	Lookup tables
R_f	retardation factor in saturated zone	4.45E+00	[/]	$1 + (K_d \cdot \rho_b) / n$
R_u	retardation factor in unsaturated zone	1.14E+01	[/]	$1 + (K_d \cdot \rho_b) / n_w$
t_{sat}	half-life in saturated zone	390	days	Lookup tables
t_{unsat}	half-life in unsaturated zone	195	days	Lookup tables
H'	dimensionless Henry's law constant	2.27E-01	[/]	Lookup tables
C_b	background concentration in soil	Not available	µg/g	Lookup tables
C_{dl}	analytical method detection limit	5.00E-03	µg/g	Lookup tables
S	solubility limit	8.95E+02	mg/L	Lookup tables

Site-specific Parameters

			Units	Source	Defaults
X	source length	10	m	User input	10
Y	source width	30	m	User input	30
Z	source depth	3	m	User input	3
I	infiltration rate	0.55	m/yr	User input	0.55
f_{oc}	fraction of organic carbon	0.005	[/]	User input	0.005
n_w	water-filled porosity	0.119	[/]	User input	0.119
x	distance to point of compliance	220	m	User input	10
d_a	aquifer thickness	5	m	User input	5
d	depth to water table	3	m	User input	3
n	total porosity	0.36	[/]	User input	0.36
n_e	effective porosity	0.25	[/]	User input	0.25
K	hydraulic conductivity	3.00E-05	m/s	User input	3.00E-05
i	hydraulic gradient	0.008	[/]	User input	0.008
V	Darcy flux	7.57	m/yr	K·i	7.57
pH_{soil}	pH of soil	6.5	[/]	User input	6.5
pH_{water}	pH of groundwater	6.5	[/]	User input	6.5
ρ_b	dry bulk density of soil	1.7	g/cm^3	User input	1.7
H	water hardness	200	mg/L	User input	200
D_{fr}	number of days of frozen ground	0	days	User input	0
n_a	air-filled porosity	0.241	[/]	$n - n_w$	0.241
α_x	longitudinal dispersivity	22	[/]	0.1 x	1
α_y	transverse dispersivity	2.2	[/]	$0.1\ \alpha_x$	0.1
α_u	dispersivity in unsaturated zone	0	[/]	0.1 b	0
v_u	leachate velocity in unsaturated zone	2.72	m/yr	I / n_w	2.72
v	average linear groundwater velocity in saturated zone	30.27	m/yr	V / n_e	30.27
d_m	mixing zone thickness	1.68	m	Protocol 28	1.68
DF	dilution factor	3.31	[/]	Protocol 28	3.31
b	vertical distance between base of source and water table	0	m	max (0, d-Z)	0

Conceptual Model

(arrows indicate order of calculations)



Definitions	
C_s	soil concentration at source (µg/g)
C_L	leachate concentration at source (µg/L)
C_z	leachate concentration at water table (µg/L)
$C_{gw'}$	predicted groundwater concentration below source (µg/L)
C_{gwmax}	maximum measured groundwater concentration below source µg/L)
C_{gw}	groundwater concentration below source (µg/L)
C_x	predicted groundwater concentration at point of compliance (µg/L)

Model Type
- ( ) SSS
- (•) SLRA

Site-specific Factors	C_s µg/g	C_L µg/L	C_z µg/L	$C_{gw'}$ µg/L	C_{gwmax} µg/L	C_x µg/L
SLRA calculations:	7.00E+01	8.41E+04	8.41E+04	2.54E+04	3.00E+03	3.11E-01
Groundwater used for drinking water						5.00E+00
Groundwater flow to surface water used by aquatic life						
freshwater						
marine and/or estuarine						
any aquatic receiving environment						
Groundwater used for livestock watering						
Groundwater used for irrigation						

- [ ] Use leachate test data for CL

Site Details

Site ID	221252
Site Address	4693 North Nechako Road
User Name	<user name>
User Organization	Pinchin Inc.

APPENDIX IV

Groundwater Protection Model Results

Groundwater Protection Transport Model

Site-specific Factors

- [x] Groundwater used for drinking water
- [ ] Groundwater flow to surface water used by aquatic life
- [ ] Groundwater used for livestock watering
- [ ] Groundwater used for irrigation

Substance Xylenes, total

Substance Properties

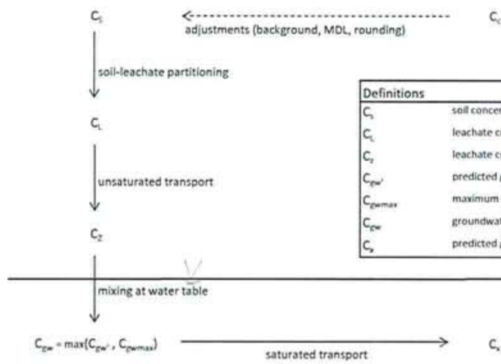
		Value	Units	Source
K_{oc}	organic carbon partitioning coefficient	3.83E+02	L/kg	Lookup tables
K_d	distribution coefficient	1.92E+00	L/kg	Lookup tables
R_f	retardation factor in saturated zone	1.00E+01	[/]	$1 + (K_d \cdot \rho_b) / n$
R_u	retardation factor in unsaturated zone	2.84E+01	[/]	$1 + (K_d \cdot \rho_b) / n_w$
$t_{s/2}$	half-life in saturated zone	290	days	Lookup tables
$t_{u/2}$	half-life in unsaturated zone	145	days	Lookup tables
H'	dimensionless Henry's law constant	2.71E-01	[/]	Lookup tables
C_b	background concentration in soil	Not available	µg/g	Lookup tables
C_{dl}	analytical method detection limit	Not available	µg/g	Lookup tables
S	solubility limit	5.30E+01	mg/L	Lookup tables

Site-specific Parameters

		Value	Units	Source	Defaults
X	source length	10	m	User input	10
Y	source width	30	m	User input	30
Z	source depth	3	m	User input	3
I	infiltration rate	0.55	m/yr	User input	0.55
f_{oc}	fraction of organic carbon	0.005	[/]	User input	0.005
n_w	water-filled porosity	0.119	[/]	User input	0.119
x	distance to point of compliance	60	m	User input	10
d_a	aquifer thickness	5	m	User input	5
d	depth to water table	3	m	User input	3
n	total porosity	0.36	[/]	User input	0.36
n_e	effective porosity	0.25	[/]	User input	0.25
K	hydraulic conductivity	3.00E-05	m/s	User input	3.00E-05
i	hydraulic gradient	0.008	[/]	User input	0.008
V	Darcy flux	7.57	m/yr	K·i	7.57
pH_{soil}	pH of soil	6.5	[/]	User input	6.5
pH_{water}	pH of groundwater	6.5	[/]	User input	6.5
ρ_b	dry bulk density of soil	1.7	g/cm^3	User input	1.7
H	water hardness	200	mg/L	User input	200
D_{fr}	number of days of frozen ground	0	days	User input	0
n_a	air-filled porosity	0.241	[/]	$n - n_w$	0.241
∂_x	longitudinal dispersivity	6	[/]	0.1 x	1
∂_y	transverse dispersivity	0.6	[/]	$0.1\ \partial_x$	0.1
∂_u	dispersivity in unsaturated zone	0	[/]	0.1 b	0
v_U	leachate velocity in unsaturated zone	2.72	m/yr	I / n_w	2.72
v	average linear groundwater velocity in saturated zone	30.27	m/yr	V / n_e	30.27
d_m	mixing zone thickness	1.68	m	Protocol 28	1.68
DF	dilution factor	3.31	[/]	Protocol 28	3.31
b	vertical distance between base of source and water table	0	m	max (0, d-Z)	0

Conceptual Model

(arrows indicate order of calculations)



Definitions	
C_s	soil concentration at source (µg/g)
C_L	leachate concentration at source (µg/L)
C_Z	leachate concentration at water table (µg/L)
$C_{gw'}$	predicted groundwater concentration below source (µg/L)
C_{gwmax}	maximum measured groundwater concentration below source µg/L)
C_{gw}	groundwater concentration below source (µg/L)
C_x	predicted groundwater concentration at point of compliance (µg/L)

Model Type

○ SSS ◉ SLRA

Site-specific Factors	C_s µg/g	C_L µg/L	C_Z µg/L	$C_{gw'}$ µg/L	C_{gwmax} µg/L	C_x µg/L
SLRA calculations:	5.00E+03	2.47E+06	2.47E+06	7.47E+05	3.00E+04	7.75E+01
Groundwater used for drinking water						9.00E+01
Groundwater flow to surface water used by aquatic life						
freshwater						
marine and/or estuarine						
any aquatic receiving environment						
Groundwater used for livestock watering						
Groundwater used for irrigation						

- [ ] Use leachate test data for CL

Site Details

Site ID	221252
Site Address	2599 North Nechako Road
User Name	<user name>
User Organization	Pinchin Inc.

Groundwater Protection Transport Model

Site-specific Factors

- [x] Groundwater used for drinking water
- [ ] Groundwater flow to surface water used by aquatic life
- [ ] Groundwater used for livestock watering
- [ ] Groundwater used for irrigation

Substance Toluene

Substance Properties

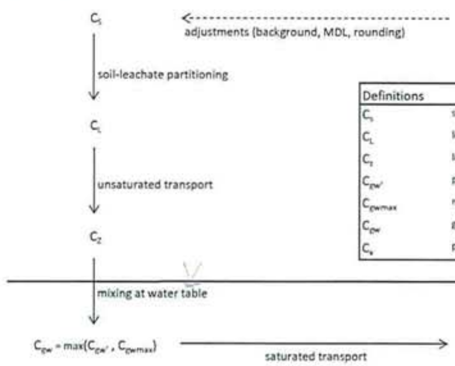
			Units	Source
K_{oc}	organic carbon partitioning coefficient	2.34E+02	L/kg	Lookup tables
K_d	distribution coefficient	1.17E+00	L/kg	Lookup tables
R_f	retardation factor in saturated zone	6.53E+00	[/]	$1 + (K_d \cdot \rho_b) / n$
R_u	retardation factor in unsaturated zone	1.77E+01	[/]	$1 + (K_d \cdot \rho_b) / n_w$
$t_{1/2s}$	half-life in saturated zone	130	days	Lookup tables
$t_{1/2u}$	half-life in unsaturated zone	65	days	Lookup tables
H'	dimensionless Henry's law constant	2.71E-01	[/]	Lookup tables
C_b	background concentration in soil	Not available	µg/g	Lookup tables
C_{dl}	analytical method detection limit	Not available	µg/g	Lookup tables
S	solubility limit	2.63E+02	mg/L	Lookup tables

Site-specific Parameters

			Units	Source	Defaults
X	source length	10	m	User input	10
Y	source width	30	m	User input	30
Z	source depth	3	m	User input	3
I	infiltration rate	0.55	m/yr	User input	0.55
f_{oc}	fraction of organic carbon	0.005	[/]	User input	0.005
n_w	water-filled porosity	0.119	[/]	User input	0.119
x	distance to point of compliance	60	m	User input	10
d_a	aquifer thickness	5	m	User input	5
d	depth to water table	3	m	User input	3
n	total porosity	0.36	[/]	User input	0.36
n_e	effective porosity	0.25	[/]	User input	0.25
K	hydraulic conductivity	3.00E-05	m/s	User input	3.00E-05
i	hydraulic gradient	0.008	[/]	User input	0.008
V	Darcy flux	7.57	m/yr	K·i	7.57
pH_{soil}	pH of soil	6.5	[/]	User input	6.5
pH_{water}	pH of groundwater	6.5	[/]	User input	6.5
ρ_b	dry bulk density of soil	1.7	g/cm^3	User input	1.7
H	water hardness	200	mg/L	User input	200
D_b	number of days of frozen ground	0	days	User input	0
n_a	air-filled porosity	0.241	[/]	$n - n_w$	0.241
∂_x	longitudinal dispersivity	6	[/]	0.1 x	1
∂_y	transverse dispersivity	0.6	[/]	$0.1\ \partial_x$	0.1
∂_u	dispersivity in unsaturated zone	0	[/]	0.1 b	0
v_{u}	leachate velocity in unsaturated zone	2.72	m/yr	I / n_w	2.72
v	average linear groundwater velocity in saturated zone	30.27	m/yr	V / n_e	30.27
d_m	mixing zone thickness	1.68	m	Protocol 28	1.68
DF	dilution factor	3.31	[/]	Protocol 28	3.31
b	vertical distance between base of source and water table	0	m	max (0, d-Z)	0

Conceptual Model

(arrows indicate order of calculations)



Definitions	
C_s	soil concentration at source (µg/g)
C_L	leachate concentration at source (µg/L)
C_z	leachate concentration at water table (µg/L)
$C_{gw'}$	predicted groundwater concentration below source (µg/L)
C_{gwmax}	maximum measured groundwater concentration below source µg/L)
C_{gw}	groundwater concentration below source (µg/L)
C_x	predicted groundwater concentration at point of compliance (µg/L)

Model Type
○ SSS ◉ SLRA

Site-specific Factors	C_s µg/g	C_L µg/L	C_z µg/L	$C_{gw'}$ µg/L	C_{gwmax} µg/L	C_x µg/L
SLRA calculations:	1.50E+03	1.17E+06	1.17E+06	3.55E+05	5.50E+04	2.90E+00
Groundwater used for drinking water						6.00E+01
Groundwater flow to surface water used by aquatic life						
freshwater						
marine and/or estuarine						
any aquatic receiving environment						
Groundwater used for livestock watering						
Groundwater used for irrigation						

- [ ] Use leachate test data for CL

Site Details

Site ID	221252
Site Address	2599 North Nechako Road
User Name	<user name>
User Organization	Pinchin Inc.

Groundwater Protection Transport Model

Site-specific Factors

- [x] Groundwater used for drinking water
- [ ] Groundwater flow to surface water used by aquatic life
- [ ] Groundwater used for livestock watering
- [ ] Groundwater used for irrigation

Substance Naphthalene

Substance Properties

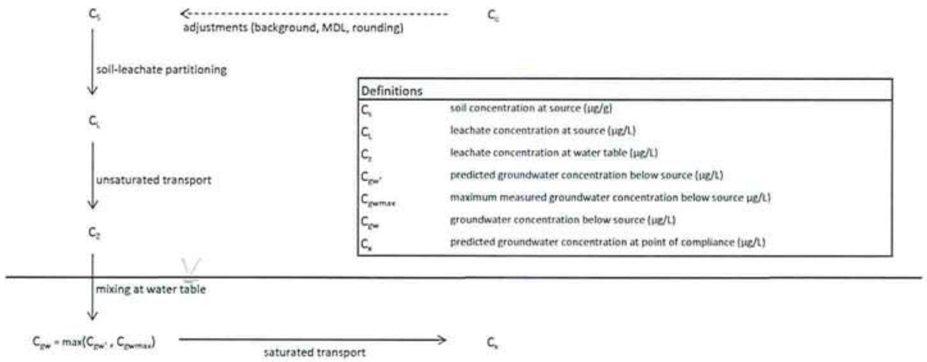
		Value	Units	Source
K_{oc}	organic carbon partitioning coefficient	1.54E+03	L/kg	Lookup tables
K_d	distribution coefficient	7.70E+00	L/kg	Lookup tables
R_s	retardation factor in saturated zone	3.74E+01	[/]	$1 + (K_d \cdot \rho_b) / n$
R_u	retardation factor in unsaturated zone	1.11E+02	[/]	$1 + (K_d \cdot \rho_b) / n_w$
$t_{½s}$	half-life in saturated zone	350	days	Lookup tables
$t_{½u}$	half-life in unsaturated zone	175	days	Lookup tables
H'	dimensionless Henry's law constant	1.80E-02	[/]	Lookup tables
C_b	background concentration in soil	Not available	μg/g	Lookup tables
C_{dl}	analytical method detection limit	Not available	μg/g	Lookup tables
S	solubility limit	1.55E+01	mg/L	Lookup tables

Site-specific Parameters

		Value	Units	Source	Defaults
X	source length	10	m	User input	10
Y	source width	30	m	User input	30
Z	source depth	3	m	User input	3
I	infiltration rate	0.55	m/yr	User input	0.55
f_{oc}	fraction of organic carbon	0.005	[/]	User input	0.005
n_w	water-filled porosity	0.119	[/]	User input	0.119
x	distance to point of compliance	60	m	User input	10
d_a	aquifer thickness	5	m	User input	5
d	depth to water table	3	m	User input	3
n	total porosity	0.36	[/]	User input	0.36
n_e	effective porosity	0.25	[/]	User input	0.25
K	hydraulic conductivity	3.00E-05	m/s	User input	3.00E-05
i	hydraulic gradient	0.008	[/]	User input	0.008
V	Darcy flux	7.57	m/yr	K·i	7.57
pH_{soil}	pH of soil	6.5	[/]	User input	6.5
pH_{water}	pH of groundwater	6.5	[/]	User input	6.5
ρ_b	dry bulk density of soil	1.7	g/cm^3	User input	1.7
H	water hardness	200	mg/L	User input	200
D_{fr}	number of days of frozen ground	0	days	User input	0
n_a	air-filled porosity	0.241	[/]	$n - n_w$	0.241
$ð_x$	longitudinal dispersivity	6	[/]	0.1 x	1
$ð_y$	transverse dispersivity	0.6	[/]	$0.1\ ð_x$	0.1
$ð_u$	dispersivity in unsaturated zone	0	[/]	0.1 b	0
v_u	leachate velocity in unsaturated zone	2.72	m/yr	I / n_w	2.72
v	average linear groundwater velocity in saturated zone	30.27	m/yr	V / n_e	30.27
d_m	mixing zone thickness	1.68	m	Protocol 28	1.68
DF	dilution factor	3.31	[/]	Protocol 28	3.31
b	vertical distance between base of source and water table	0	m	max (0, d-Z)	0

Conceptual Model

(arrows indicate order of calculations)



Definitions	
C_s	soil concentration at source (μg/g)
C_L	leachate concentration at source (μg/L)
C_z	leachate concentration at water table (μg/L)
$C_{gw'}$	predicted groundwater concentration below source (μg/L)
C_{gwmax}	maximum measured groundwater concentration below source μg/L)
C_{gw}	groundwater concentration below source (μg/L)
C_x	predicted groundwater concentration at point of compliance (μg/L)

Model Type
- ( ) SSS
- (•) SLRA

Site-specific Factors	C_s μg/g	C_L μg/L	C_z μg/L	$C_{gw'}$ μg/L	C_{gwmax} μg/L	C_x μg/L
SLRA calculations:	5.00E+01	6.43E+03	6.43E+03	1.95E+03	5.00E+02	1.40E-05
Groundwater used for drinking water						8.00E+01
Groundwater flow to surface water used by aquatic life						
freshwater						
marine and/or estuarine						
any aquatic receiving environment						
Groundwater used for livestock watering						
Groundwater used for irrigation						

- [ ] Use leachate test data for CL

Site Details

Site ID	221252
Site Address	2599 North Nechako Road
User Name	<user name>
User Organization	Pinchin Inc.

Groundwater Protection Transport Model

Site-specific Factors

- [x] Groundwater used for drinking water
- [ ] Groundwater flow to surface water used by aquatic life
- [ ] Groundwater used for livestock watering
- [ ] Groundwater used for irrigation

Substance LEPHs/LEPHw

Substance Properties

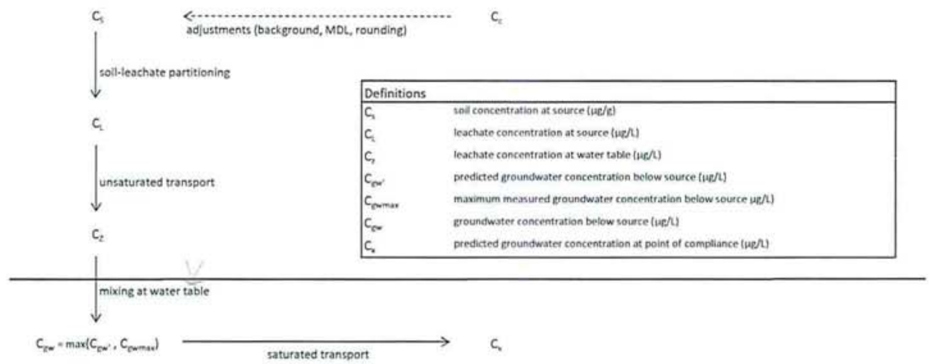
			Units	Source
K_{oc}	organic carbon partitioning coefficient	2.50E+03	L/kg	Lookup tables
K_d	distribution coefficient	1.25E+01	L/kg	Lookup tables
R_f	retardation factor in saturated zone	6.00E+01	[/]	$1 + (K_d \cdot \rho_b) / n$
R_u	retardation factor in unsaturated zone	1.80E+02	[/]	$1 + (K_d \cdot \rho_b) / n_w$
$t_{1/2 s}$	half-life in saturated zone	350	days	Lookup tables
$t_{1/2 u}$	half-life in unsaturated zone	175	days	Lookup tables
H'	dimensionless Henry's law constant	5.70E-02	[/]	Lookup tables
C_b	background concentration in soil	Not available	µg/g	Lookup tables
C_{dl}	analytical method detection limit	Not available	µg/g	Lookup tables
S	solubility limit	Not available	mg/L	Lookup tables

Site-specific Parameters

			Units	Source	Defaults
X	source length	10	m	User input	10
Y	source width	30	m	User input	30
Z	source depth	3	m	User input	3
I	infiltration rate	0.55	m/yr	User input	0.55
f_{oc}	fraction of organic carbon	0.005	[/]	User input	0.005
n_w	water-filled porosity	0.119	[/]	User input	0.119
x	distance to point of compliance	60	m	User input	10
d_a	aquifer thickness	5	m	User input	5
d	depth to water table	3	m	User input	3
n	total porosity	0.36	[/]	User input	0.36
n_e	effective porosity	0.25	[/]	User input	0.25
K	hydraulic conductivity	3.00E-05	m/s	User input	3.00E-05
i	hydraulic gradient	0.008	[/]	User input	0.008
V	Darcy flux	7.57	m/yr	K·i	7.57
pH_{soil}	pH of soil	6.5	[/]	User input	6.5
pH_{water}	pH of groundwater	6.5	[/]	User input	6.5
ρ_b	dry bulk density of soil	1.7	g/cm^3	User input	1.7
H	water hardness	200	mg/L	User input	200
D_f	number of days of frozen ground	0	days	User input	0
n_a	air-filled porosity	0.241	[/]	$n - n_w$	0.241
α_x	longitudinal dispersivity	6	[/]	0.1 x	1
α_y	transverse dispersivity	0.6	[/]	$0.1\ \alpha_x$	0.1
α_u	dispersivity in unsaturated zone	0	[/]	0.1 b	0
v_u	leachate velocity in unsaturated zone	2.72	m/yr	I / n_w	2.72
v	average linear groundwater velocity in saturated zone	30.27	m/yr	V / n_e	30.27
d_m	mixing zone thickness	1.68	m	Protocol 28	1.68
DF	dilution factor	3.31	[/]	Protocol 28	3.31
b	vertical distance between base of source and water table	0	m	max (0, d-Z)	0

Conceptual Model

(arrows indicate order of calculations)



Definitions	
C_s	soil concentration at source (µg/g)
C_L	leachate concentration at source (µg/L)
C_z	leachate concentration at water table (µg/L)
$C_{gw'}$	predicted groundwater concentration below source (µg/L)
C_{gwmax}	maximum measured groundwater concentration below source µg/L)
C_{gw}	groundwater concentration below source (µg/L)
C_x	predicted groundwater concentration at point of compliance (µg/L)

Model Type

○ SSS ◉ SLRA

Site-specific Factors	C_s µg/g	C_L µg/L	C_z µg/L	$C_{gw'}$ µg/L	C_{gwmax} µg/L	C_x µg/L
SLRA calculations:	5.00E+01	3.98E+03	3.98E+03	1.20E+03	5.00E+02	1.98E-08
Groundwater used for drinking water						
Groundwater flow to surface water used by aquatic life						
freshwater						
marine and/or estuarine						
any aquatic receiving environment						
Groundwater used for livestock watering						
Groundwater used for irrigation						

- [ ] Use leachate test data for CL

Site Details

Site ID	221252
Site Address	2599 North Nechako Road
User Name	<user name>
User Organization	Pinchin Inc.

Groundwater Protection Transport Model

Site-specific Factors

- ☑ Groundwater used for drinking water
- ☐ Groundwater flow to surface water used by aquatic life
- ☐ Groundwater used for livestock watering
- ☐ Groundwater used for irrigation

Substance Ethylbenzene

Substance Properties

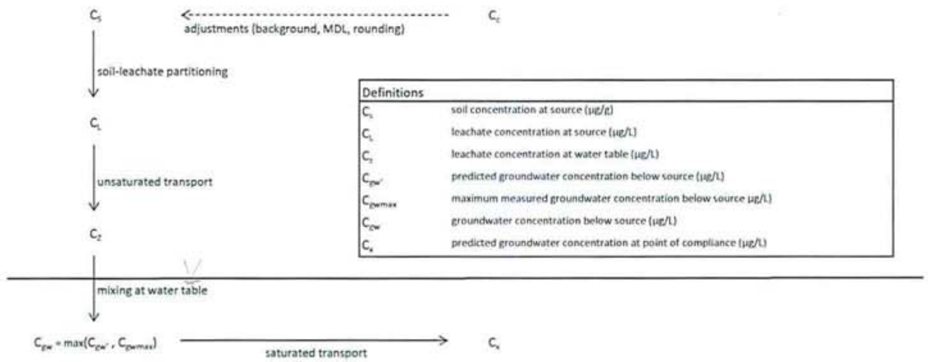
			Units	Source
K_{oc}	organic carbon partitioning coefficient	4.46E+02	L/kg	Lookup tables
K_d	distribution coefficient	2.23E+00	L/kg	Lookup tables
R_f	retardation factor in saturated zone	1.15E+01	[/]	$1 + (K_d \cdot \rho_b) / n$
R_u	retardation factor in unsaturated zone	3.29E+01	[/]	$1 + (K_d \cdot \rho_b) / n_w$
$t_{½s}$	half-life in saturated zone	290	days	Lookup tables
$t_{½u}$	half-life in unsaturated zone	145	days	Lookup tables
H'	dimensionless Henry's law constant	3.22E-01	[/]	Lookup tables
C_b	background concentration in soil	Not available	µg/g	Lookup tables
C_{dl}	analytical method detection limit	Not available	µg/g	Lookup tables
S	solubility limit	8.45E+01	mg/L	Lookup tables

Site-specific Parameters

			Units	Source	Defaults
X	source length	10	m	User input	10
Y	source width	30	m	User input	30
Z	source depth	3	m	User input	3
I	infiltration rate	0.55	m/yr	User input	0.55
f_{oc}	fraction of organic carbon	0.005	[/]	User input	0.005
n_w	water-filled porosity	0.119	[/]	User input	0.119
x	distance to point of compliance	60	m	User input	10
d_a	aquifer thickness	5	m	User input	5
d	depth to water table	3	m	User input	3
n	total porosity	0.36	[/]	User input	0.36
n_e	effective porosity	0.25	[/]	User input	0.25
K	hydraulic conductivity	3.00E-05	m/s	User input	3.00E-05
i	hydraulic gradient	0.008	[/]	User input	0.008
V	Darcy flux	7.57	m/yr	K·i	7.57
pH_{soil}	pH of soil	6.5	[/]	User input	6.5
pH_{water}	pH of groundwater	6.5	[/]	User input	6.5
ρ_b	dry bulk density of soil	1.7	g/cm^3	User input	1.7
H	water hardness	200	mg/L	User input	200
D_f	number of days of frozen ground	0	days	User input	0
n_a	air-filled porosity	0.241	[/]	$n - n_w$	0.241
α_x	longitudinal dispersivity	6	[/]	0.1 x	1
α_y	transverse dispersivity	0.6	[/]	$0.1\ \alpha_x$	0.1
α_u	dispersivity in unsaturated zone	0	[/]	0.1 b	0
v_u	leachate velocity in unsaturated zone	2.72	m/yr	I / n_w	2.72
v	average linear groundwater velocity in saturated zone	30.27	m/yr	V / n_e	30.27
d_m	mixing zone thickness	1.68	m	Protocol 28	1.68
DF	dilution factor	3.31	[/]	Protocol 28	3.31
b	vertical distance between base of source and water table	0	m	max (0, d-Z)	0

Conceptual Model

(arrows indicate order of calculations)



Definitions	
C_s	soil concentration at source (µg/g)
C_L	leachate concentration at source (µg/L)
C_z	leachate concentration at water table (µg/L)
$C_{gw'}$	predicted groundwater concentration below source (µg/L)
C_{gwmax}	maximum measured groundwater concentration below source µg/L)
C_{gw}	groundwater concentration below source (µg/L)
C_x	predicted groundwater concentration at point of compliance (µg/L)

Model Type
○ SSS ◉ SLRA

Site-specific Factors	C_s µg/g	C_L µg/L	C_z µg/L	$C_{gw'}$ µg/L	C_{gwmax} µg/L	C_x µg/L
SLRA calculations:	8.00E+02	3.41E+05	3.41E+05	1.03E+05	5.55E+03	4.41E+00
Groundwater used for drinking water						1.40E+02
Groundwater flow to surface water used by aquatic life						
freshwater						
marine and/or estuarine						
any aquatic receiving environment						
Groundwater used for livestock watering						
Groundwater used for irrigation						

☐ Use leachate test data for CL

Site Details

Site ID	221252
Site Address	2599 North Nechako Road
User Name	<user name>
User Organization	Pinchin Inc.

Groundwater Protection Transport Model

Site-specific Factors

- [x] Groundwater used for drinking water
- [ ] Groundwater flow to surface water used by aquatic life
- [ ] Groundwater used for livestock watering
- [ ] Groundwater used for irrigation

Substance Benzene

Substance Properties

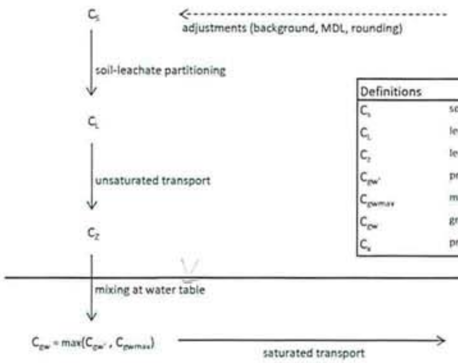
			Units	Source
K_{oc}	organic carbon partitioning coefficient	1.46E+02	L/kg	Lookup tables
K_d	distribution coefficient	7.30E-01	L/kg	Lookup tables
R_f	retardation factor in saturated zone	4.45E+00	[/]	$1 + (K_d \cdot \rho_b) / n$
R_u	retardation factor in unsaturated zone	1.14E+01	[/]	$1 + (K_d \cdot \rho_b) / n_w$
$t_{½S}$	half-life in saturated zone	390	days	Lookup tables
$t_{½U}$	half-life in unsaturated zone	195	days	Lookup tables
H'	dimensionless Henry's law constant	2.27E-01	[/]	Lookup tables
C_b	background concentration in soil	Not available	µg/g	Lookup tables
C_{dl}	analytical method detection limit	5.00E-03	µg/g	Lookup tables
S	solubility limit	8.95E+02	mg/L	Lookup tables

Site-specific Parameters

			Units	Source	Defaults
X	source length	10	m	User input	10
Y	source width	30	m	User input	30
Z	source depth	3	m	User input	3
I	infiltration rate	0.55	m/yr	User input	0.55
f_{oc}	fraction of organic carbon	0.005	[/]	User input	0.005
n_w	water-filled porosity	0.119	[/]	User input	0.119
x	distance to point of compliance	60	m	User input	10
d_a	aquifer thickness	5	m	User input	5
d	depth to water table	3	m	User input	3
n	total porosity	0.36	[/]	User input	0.36
n_e	effective porosity	0.25	[/]	User input	0.25
K	hydraulic conductivity	3.00E-05	m/s	User input	3.00E-05
i	hydraulic gradient	0.008	[/]	User input	0.008
V	Darcy flux	7.57	m/yr	K·i	7.57
pH_{soil}	pH of soil	6.5	[/]	User input	6.5
pH_{water}	pH of groundwater	6.5	[/]	User input	6.5
ρ_b	dry bulk density of soil	1.7	g/cm^3	User input	1.7
H	water hardness	200	mg/L	User input	200
D_f	number of days of frozen ground	0	days	User input	0
n_a	air-filled porosity	0.241	[/]	$n - n_w$	0.241
∂_x	longitudinal dispersivity	6	[/]	0.1 x	1
∂_y	transverse dispersivity	0.6	[/]	$0.1\ \partial_x$	0.1
∂_u	dispersivity in unsaturated zone	0	[/]	0.1 b	0
v_U	leachate velocity in unsaturated zone	2.72	m/yr	I / n_w	2.72
v	average linear groundwater velocity in saturated zone	30.27	m/yr	V / n_e	30.27
d_m	mixing zone thickness	1.68	m	Protocol 28	1.68
DF	dilution factor	3.31	[/]	Protocol 28	3.31
b	vertical distance between base of source and water table	0	m	max (0, d-Z)	0

Conceptual Model

(arrows indicate order of calculations)



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- (•) SLRA

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marine and/or estuarine						
any aquatic receiving environment						
Groundwater used for livestock watering						
Groundwater used for irrigation						

- [ ] Use leachate test data for CL

Site Details

Site ID	221252
Site Address	2599 North Nechako Road
User Name	<user name>
User Organization	Pinchin Inc.

APPENDIX C

North Nechako Neighbourhood Plan
L&M Engineering Limited

GEOTECHNICAL OVERVIEW ASSESSMENT

GEOTECHNICAL REPORT

OVERVIEW GEOTECHNICAL ASSESSMENT
NORTH NECHAKO NEIGHBOURHOOD
LAND USE PLAN

Prepared for

T.R. PROJECTS LTD. AND 406286 BC LTD.
c/o L&M ENGINEERING LIMITED

Prepared by

GEONORTH ENGINEERING LTD.
3975 18th AVENUE
PRINCE GEORGE, B.C., V2N 1B2
Phone: 250-564-4304   Fax: 250-564-9323

PROJECT No. K-4958

August 14, 2019

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APPENDICES

APPENDIX A

Site Plan	**Drawing 4958-A1**
Cross Section A-A	**Drawing 4958-A2**
Historical Photos	**Drawings 4958-A3 and A4**

1.0 INTRODUCTION

T.R. Projects Ltd. and 406286 BC Ltd. are planning a multi-phase residential development encompassing 84.42 hectares in the North Nechako area of Prince George. GeoNorth Engineering Ltd. was commissioned through L&M Engineering Limited (L&M), civil engineering design consultants for the project, to carry out an overview assessment of geotechnical conditions of the subdivision area to identify general geotechnical conditions in the area and potential geotechnical constraints to development.

The subdivision is located southeast of the intersection of Foothills Boulevard and North Nechako Road in Prince George, B.C. and includes parcels PID 007-558-350, 014-702-207 and 014-702-240. These parcels are bordered by Foothills Boulevard to the west, Nechako River to the south, North Nechako Road to the north, and baseball fields, Edgewood School and an established residential subdivision to the east. The proposed subdivision is within the Nechako River valley and is situated over glaciofluvial sand and gravel deposits that have been mined of gravel for about 50 years. Active gravel extraction is on-going and might continue depending on future development plans. A plan showing the site location is on Drawing 4958-A1, in Appendix A.

Our firm previously prepared an overview geotechnical assessment for Infinity Group of Companies, in care of L&M, for PID 014-702-207 and 014-702-240 in September 2017, our file number K-4755. The report provides general geotechnical recommendations for construction of a residential subdivision and includes a preliminary assessment of erosion and setback requirements for development along Nechako River.

Additionally, our firm carried out a geotechnical investigation for the proposed residential development at PID 007-558-350. We prepared a report, dated November 27, 2017, for Rolling Mix Concrete (B.C.) Ltd. in care of Nakib Construction Ltd., our file number K-4746. The report provides geotechnical recommendations for installation of buried utilities, storm water disposal, site preparation for buildings, and design and construction of building foundations, grade-supported slabs and roads.

This report presents an overview of geotechnical conditions and general constraints as they relate to the proposed development plans, and general recommendations for construction of a residential subdivision. It includes a preliminary assessment of erosion and setback requirements for development along the Nechako River. Our assessment is based on observations of surface conditions, and review of aerial photos, topographic maps and available geotechnical and published geological reports.

2.0 GEOLOGICAL BACKGROUND

2.1 Surficial Geology

Surficial geology of the Prince George area is described in Geological Survey of Canada Bulletin 196, accompanied by Map 1288A.[1] During the Pleistocene Epoch, between 2.6 million and 10,000 years ago British Columbia was episodically covered by glacial ice. During the climax of the most recent glaciation (the Fraser Glaciation), Prince George and surrounding area was covered by glacial ice to about 1400 m elevation. Drumlins and striations visible on higher elevation areas in the Prince George area indicate that glacial ice flowed in a northeasterly direction here.

At the end of the last glacial period, between about 12,000 and 10,000 years ago, the melting glacial ice formed a glacial lake that accumulated behind unmelted glacial ice and drift that filled the Fraser Valley at a location south of Prince George. The lake covered the Prince George area (Glacial Lake Prince George) to about 760 m elevation. Much of the area below the level of the lake is presently mantled in silt, clay and fine grained sand sediments of varying thickness deposited from the lake. When the blockage in the Fraser Valley was breached, the lake drained rapidly, eroding glacial lake sediments and till deposits, and creating the present-day major drainage courses such as the Nechako and Fraser Rivers. As the glacial meltwater cut through the accumulated sediments, it meandered across a broad flood plain and created gravel

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[1] Tipper, H.W., 1971, Geological Survey of Canada, Bulletin 196, “Glacial Geomorphology and Pleistocene History of Central British Columbia”

terraces along the channel walls through lateral migration and deposition of sediment from the stream. Map 1288A shows that the Nechako River valley was a major glacial meltwater channel. The adjacent slopes are mapped as glacial lake sediments and higher elevations are identified as glacial till. The sediment from glacial meltwater channels, called glaciofluvial deposits, are typically sand, gravel, and occasionally cobbles, with trace amounts of silt and clay size particles. The gradation is dependent on the source of the sediment and on the stream flow velocity at the time of deposition.

Water well records available on a website[2] maintained by the BC Geological Survey through the B.C. Ministry of Energy and Mines, show no well records on the property but several deep, reasonably well-documented well installations on nearby, adjacent properties. The lithology, or description of soil conditions encountered while drilling the well, varies widely between drillers but generally describes subsurface conditions as sand and gravel, occasionally with layers of cobbles or boulders, and occasionally as silty, to more than 60 m depth. Water levels reported in the wells generally coincides with the elevation of the river.

Geotechnical investigations by our firm and others in the vicinity have typically encountered layered, compact to dense sand and gravel, with varying amounts of silt and occasional layers of silt.

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2 http://www.mapplace.ca/

2.2 Site Conditions

The development property is at elevation 572 m along the south property boundary at the Nechako River bank, then rises across a 70% gradient slope to a triangular shaped, flat terrace at about elevation 594 m. The terrace is about 200 m wide at the west property line and narrows to 35 m at the east. Above this, the ground slopes up at a 25% to 30% gradient to the main, upper terrace level at between elevations 600 and 605 m. Ground contours show the undulating upper terrace level extends north of the property to the foot of moderately steep slopes that form the northeast side of the Nechako River valley. North Nechako Road at the north property boundary is at between elevations 600 and 606 m.

Gravel extraction has occurred from the level of the upper terrace. Ground contours on PGMap, an on-line geographic information application, available on the City of Prince George website, shows that most of the pit floor is presently at about 593 m elevation, but a small part of the gravel pit is as low as 591 m elevation. A 30 to 60 m wide area of fill, up to 9 m high, is present along the property boundary between PID 014-702-207 and PID 007-558-350. A cross section showing the variability in site topography from north to south is on Drawing 4958-A2, in Appendix A.

Provincial government aerial photos from our library and aerial photos available on PGMap, as well as the surface contours, show the progress of gravel extraction from the development area. Our earliest photos, dated 1946, show parts of the development area as harvested of trees but not in use for gravel extraction. Photos dated 1969 show the east parts of the property cleared of trees and stripped of vegetation, and gravel extraction in progress. A copy of these photos as well as photos dated 1984, 1988, 1993, 2003, 2010 and 2014 that show the progressive development of the gravel pit are shown on Drawings 4958-A3 and A4, in Appendix A.

The section of the Nechako River along the south property line is in a relatively stable reach of the river, adjacent to a gentle outside bend and downstream of the Foothill Boulevard bridge. Digital images available on PGMap as well as the photographs in our library both show no significant changes to the shoreline since 1946. There is variability in the amount of vegetation, and the loss of several trees along the river bank indicates an on-going, slow rate of bank erosion. Over the period in which aerial photos are available, Nechako River has experienced several significant flood events. Stream flow data at a Water Survey of Canada stream flow monitoring station on Nechako River at Isle Pierre[3] (Station 08JC002), about 50 km upstream of Prince George, show that maximum flows that exceeded 900 m^3/second occurred in 1964, 1972, 1976, 1997, 2007 and 2011. Of these high flow events, the most recent significant event was when the river sustained high flows over a two month period in 2007 which caused significant erosion of several riverbanks in and upstream of Prince George. Based on the aerial photos, the riverbank adjacent to the proposed development only sustained minor erosion following these events.

Flood plain mapping shows the Nechako River flood construction level, which is based on the 200 year return period flood level plus 600 mm of freeboard, is elevation 576.0 m at the east property line and elevation 577.0 m at the Foothills Boulevard bridge about 240 m upstream of the west property line.

2.3 Previous Investigation

Our firm previously conducted a geotechnical investigation at PID 007-558-350. The investigation included twelve test pits, excavated on August 28 and 29, 2017, and two drill holes, drilled on September 20, 2017.

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3 https://wateroffice.ec.gc.ca/report/statistics_e.html?stn=08JC002&mode=Table&type=stat&results_type=statistics&dataType=Monthly&parameterType=Flow&y1Max=1&y1Min=1

The test pits were excavated to between 3.0 and 3.7 m depth and generally encountered layered compact sandy gravel with a trace amount of fines, occasional cobbles and isolated boulders to the bottom of the holes. Several of the test pits encountered layers of loose, medium to coarse grained sand with a trace amount of fines.

Drill holes through North Nechako Road alignment to the development, encountered 90 mm of asphalt, over very dense sandy gravel fill with a trace of fines to about 1 m depth, over natural sandy gravel with a trace of fines to the bottom of the holes at 3.6 m depth. SPT "N" values in the natural, sandy gravel were between 42 and 75 in DH17-1 and between 19 and 42 in DH17-2, indicating dense to very dense condition in DH17-1 and compact to dense conditions in DH17-2.

Neither seepage nor bedrock were observed in the test pits or drill holes.

Laboratory tests indicate the natural sandy gravel has an average moisture content of 3% and an average gradation of 68% gravel, 31% sand, and 1% fines. The medium to coarse grained sand has an average moisture content of 5% and a gradation of 11% gravel, 89% sand, and less than 1% fines. The average gradation of the sandy gravel meets our gradation specification for Select Granular Subbase (SGSB) defined in Table 2 below. The results of the moisture density relationship test on the sandy gravel show the optimum moisture content is 6.5%. The sandy gravel, at an average moisture content of 3%, is therefore dry of optimum conditions for compaction.

The natural, sandy gravel and the medium to coarse grained sand encountered in the test pits were found to contain between 0.7% and 3.4% clay and silt sized particles. Material containing less than 5% silt and clay sized particles is considered to be free-draining. The discontinuous layer of sandy silt occasionally encountered in the top 0.2 m is not free-draining.

Large-scale infiltration tests were performed as part of the 2017 investigation. To carry out the tests the walls of several test pits were flattened to have side slopes between 1.25 and 1.5 horizontal to 1 vertical with a flat bottom 1 m square. A perforated plastic barrel and survey rod were set in the bottom of the excavation, then water was added to the test pit to a height of between 0.6 and 1 m. We recorded the rate at which the water level rose and subsequently dropped after pumping was stopped. Two trials were completed at each infiltration test pit. Approximately 15.1 m^3 of water was pumped into each test pit at a rate between 0.45 and 0.62 m^3 per minute. The infiltration rates during the tests were between 220 and 470 L/min and the water level dropped at between 2.5 and 10 cm/min. Results of the infiltration tests are presented in Table 1 below.

Table 1 - Infiltration Test Results

Infiltration Test Location	Average Infiltration Rate	Average Rate of Falling Water Level
TP17-1	380 L/min	7.5 cm/min
TP17-5	360 L/min	5.9 cm/min
TP17-8	470 L/min	9.7 cm/min
TP17-11	320 L/min	4.8 cm/min
TP17-12	220 L/min	2.6 cm/min

3.0 DISCUSSION

Geotechnical conditions at the proposed development properties are favourable. The granular deposits are typically compact to dense with moderate to high allowable bearing pressure and low susceptibility to settlement under typical building loads. The deposit is also relatively free draining, with a low to moderate susceptibility to frost heave. Groundwater levels likely vary seasonally and in response to water levels in Nechako River. Water levels at the site are likely to be slightly higher than river level, and could therefore be higher than the 200 year return period flood event but still well below the ground surface within the development area.

Other than the property having a moderate potential for erosion along the Nechako Riverbank, the proposed development is in an area with low risk of geological hazards. There is a low to negligible susceptibility of landslides provided final cut and fill slopes are constructed at appropriate gradients, negligible potential for sink holes from karst formations or piping, and no significant streams upslope of the development that might result in flooding from overland flow.

Development of a previously occupied, developed or mined property, such as the subject property, can have the risk of disturbed soil, buried debris or loosely placed materials, which if built over can cause settlement of buildings, roads and utilities. The available historic aerial photos and ground contours from PGMap provide some indication on the progress of the gravel pit development. A comparison of the historic and present ground contours show that other than an area at the boundary between PID 014-402-207 and 007-558-350 there does not appear to be significant fill placement on the property. Along the boundary there is an approximately 30 to 60 m wide strip of ground which appears to have been used as a disposal location for stripped materials and random fill. Ground contours on PGMap show the stripping and fill could be up to 9 m thick. Existing fill is not suitable for support of roads, buried utilities or building foundations and will need to be removed prior to subdivision development.

There will likely be significant cut and fill required to achieve suitable site grades to allow for efficient configuration of building lots and conveyance of storm and sanitary sewage. Soil conditions generally consist of layered sand and gravel that typically meet the gradation specifications for Select Granular Subbase (SGSB). We anticipate that most of the soil that will be cut from the property will be suitable for use as granular fill on civil projects in the area. There might be layers or zones within the property, however, that consist primarily of sand, or have a gradation that is either too fine or too coarse, for example, to meet the requirements of specific applications. Silty layers, if encountered, might not be suitable for structural fill but could be used as landscaping fill.

The following conceptual recommendations are based on the assumption that the conditions encountered in the investigation in PID 007-558-350, and those exposed in cut slopes at the gravel pit in PID 014-402-207 and 014-702-240, are representative of conditions elsewhere on the site. Please contact our office if conditions encountered during construction differ in any way from those described in this report.

4.0 CONCEPTUAL GEOTECHNICAL RECOMMENDATIONS FOR SUBDIVISION DEVELOPMENT

4.1 Site Preparation

1. Prior to placing fill to bring low areas to the design grade, have an experienced geotechnical engineer or their designate review the exposed surfaces to check for indications of existing fill or disturbed ground.

2. Bring low areas of the property to grade using clean granular fill that meets the gradation specifications for SGSB, described in Table 3, below.

3. Place the fill in uniform layers no more than 300 mm thick and compact each layer to at least 100% Standard Proctor Density (SPD) (ASTM D698) where the fill will support buildings, at least 98% SPD where the fill is used to support the pavement structures, and at least 95% SPD where the fill will be used in landscaped areas.

4. Use finished cut and fill slopes no steeper than 3.0 horizontal to 1 vertical (3.0H:1V).

4.2 Buried Utilities

1. Install buried utilities using the standard depth of cover specified in City of Prince George development bylaws.

2. Sand and gravel excavated from trenches and from borrow sources on the property will in general be suitable for use as trench fill above pipe bedding. Place the fill in uniform layers and compact each layer, as noted in Section 4.1 above.

3. Use trench excavation slopes in granular soil no steeper than 1H:1V, and as specified in the Worksafe BC Regulations. Slopes exposing dry sand might need to be cut at a flatter angle.

4. We do not anticipate seepage, but please contact an experienced geotechnical engineer if any signs of seepage or trench slope instability are noted.

4.3 Pavement Structures

1. Based on the available information, the on-site sandy gravel typically meets the gradation specifications for SGSB, and will be suitable for use as subbase fill in the road pavement structure.

2. For preliminary design, we recommend the following road pavement structures:

Table 2 - Road Structures

Pavement Component	Local Roads - 10 ESALs/day*	Collector Roads - 20 ESALs/day
Hot Mix Asphaltic Concrete	65 mm	75 mm
Intermediate Graded Base or Well Graded Base (IGB or WGB)	150 mm	250 mm
Select Granular Subbase (SGSB) / Prepared Subgrade	300 mm	500 mm
Prepared Subgrade	Local Granular Material	Local Granular Material

* ESAL = Equivalent Single Axle Load (8,000 kg)

3. Construct sidewalks using at least 100 mm of concrete placed on at least 80 mm of WGB over 500 mm of SGSB, over the prepared subgrade. Compact the top 300 mm of subgrade and the subbase and base fills to at least 100% SPD.

Table 3 - Gradation Specifications for Granular Fill

Sieve Size (mm)	Percentage Passing		
	Well Graded Base (WGB)	Intermediate Graded Base (IGB)	Select Granular Subbase (SGSB)
100	-	-	100
75	-	-	95-100
25	100	100	-
19	80-100	65-100	35-100
9.5	50-85	30-70	-
4.75	35-70	15-40	15-60
2.36	25-50	10-30	-
1.18	15-35	-	-
0.300	5-20	5-15	3-15
0.075	0-5	0-5	0-5

For IGB and WGB, use crushed and screened material that meets the requirements of B.C. Ministry of Transportation and Infrastructure (BCMoT) Standard Specifications. The Select Granular Subbase can be a pit run material that meets the above gradation. Use durable aggregate that will not degrade from exposure to water, freeze-thaw cycles or handling, spreading or compacting. It must not contain organic materials or an excess of flat or elongate stones. Do not place fill that is frozen and do not place fill on frozen ground.

4.4 Building Foundations

1. Building foundations may be supported on the natural compact to dense, layered sand and gravel or on compacted structural fill, as described in Section 4.1 placed on the natural sand and gravel.

2. Conventional strip or pad spread footings may be designed using an allowable bearing pressure of 150 kPa, and a factored bearing resistance of 225 kPa for limit states design.

3. Provide at least 1.2 m of soil cover over perimeter building foundations and at least 2.4 m of cover over foundations not warmed by building heat. Additional investigation and analysis might result in less cover being required if the natural granular soil is confirmed to be non-frost-susceptible.

4. Design basement and crawl space walls to withstand lateral earth pressures from soil, any surcharge, compaction and seismic loads. The natural sand and gravel at the site and structural fill meeting the gradation specifications for WGB, IGB and SGSB are considered to be free draining and adequate for below-grade drainage through ground infiltration. Foundation perimeter drains are not required from a geotechnical perspective.

4.5 Building Setback from Nechako Riverbank

1. For preliminary subdivision layout, use a setback for permanent structures of at least 60 m horizontal distance from the seasonal highwater mark of Nechako River and at least 45 m from the toe of the steep gradient slope adjacent to the river, whichever results in the greater setback.

4.6 Stormwater Infiltration

The lowest elevation of development on the property is 600 m, at the southwest corner. Flood plain mapping from PGMap shows the 200 year flood plain construction level in the area of the proposed development is 576 m elevation, so infiltration capacity is unlikely to be affected by flood events.

The results of the grain size distribution analyses performed on the natural, sandy gravel and the medium to coarse grained sand encountered during the investigation have less than 5% fines, and is considered to be free-draining. The discontinuous layer of sandy silt occasionally encountered in the top 0.2 m is not free-draining.

The software GeoStudio 2018 Seep/W Version 9.0 was used to simulate the 2017 infiltration test results to determine hydraulic conductivity. These results were compared to those from hand calculations and from correlations to grain size distribution. The results indicate that storm water disposal to ground through an infiltration system is feasible. We recommend the infiltration system be designed using a range in hydraulic conductivity between 5.0×10^{-4} and 1.0×10^{-3} m/s.

The infiltration rate, or hydraulic flux (Q), is calculated as $Q = K \cdot I \cdot A$, where K is the hydraulic conductivity, I is the hydraulic gradient and A is the cross sectional area perpendicular to the direction of flow.

To reduce the potential for freezing, we recommend the bottom of infiltration systems be installed at least 3.0 m below the final design grade, measured perpendicular to the ground surface.

5.0 CONSTRUCTION REVIEW

We recommend that an experienced geotechnical engineer or their representative, or a Building Official review the following:

- Proposed building foundation plans to confirm building plans meet the intent of our recommendations.

- Foundation excavations to confirm that ground conditions are as expected or to provide additional recommendations if necessary to suit actual site conditions.

- Compaction of structural fill that will support building foundations.

We also recommend that an experienced geotechnical technician review placement and compaction of structural fill that will support utilities and paved road structures, starting with the first layer, to confirm that the fill materials and soil densities meet the project specifications.

6.0 CLOSURE

This report was prepared by GeoNorth Engineering Ltd. for the use of T.R. Projects Ltd., 406286 BC Ltd., L&M Engineering Limited, City of Prince George, and their consultants. The material in it reflects GeoNorth Engineering's judgement in light of the information available to us at the time of preparation. Any use which Third Parties make of this report, or any reliance on decisions to be made based on it, are the responsibility of such Third Parties. GeoNorth Engineering Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

Please call the writers if you have any questions or require additional information.

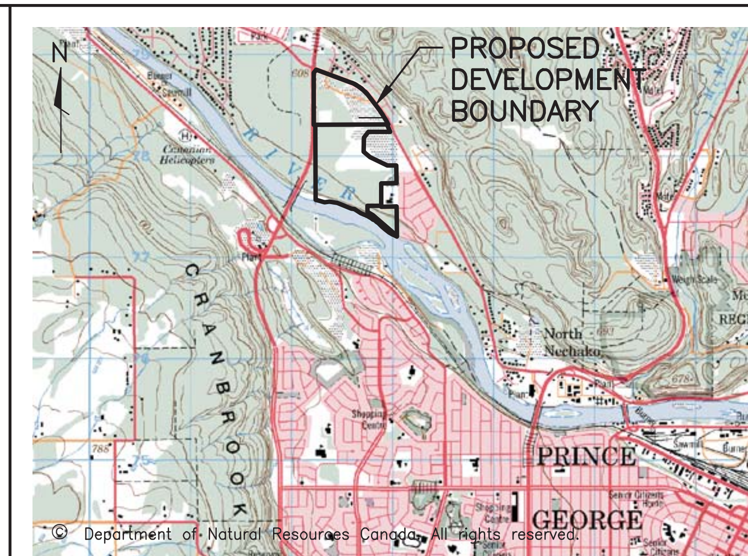
Yours truly,
GeoNorth Engineering Ltd.

Per: W.J. Lanenga, P.Eng.

Reviewed by,
GeoNorth Engineering Ltd.

Per: D.J. McDougall, M.Eng., P.Eng.

APPENDIX A



KEY MAP

NTS Map – 93 G/15 Scale – 1:75,000

NOTES:

1. SITE PLAN BASED ON DIGITAL INFORMATION PROVIDED BY L&M ENGINEERING LIMITED.
2. ORTHOPHOTO FROM CITY OF PRINCE GEORGE WEBSITE, DATED SPRING 2014. ACCURACY CANNOT BE GUARANTEED.

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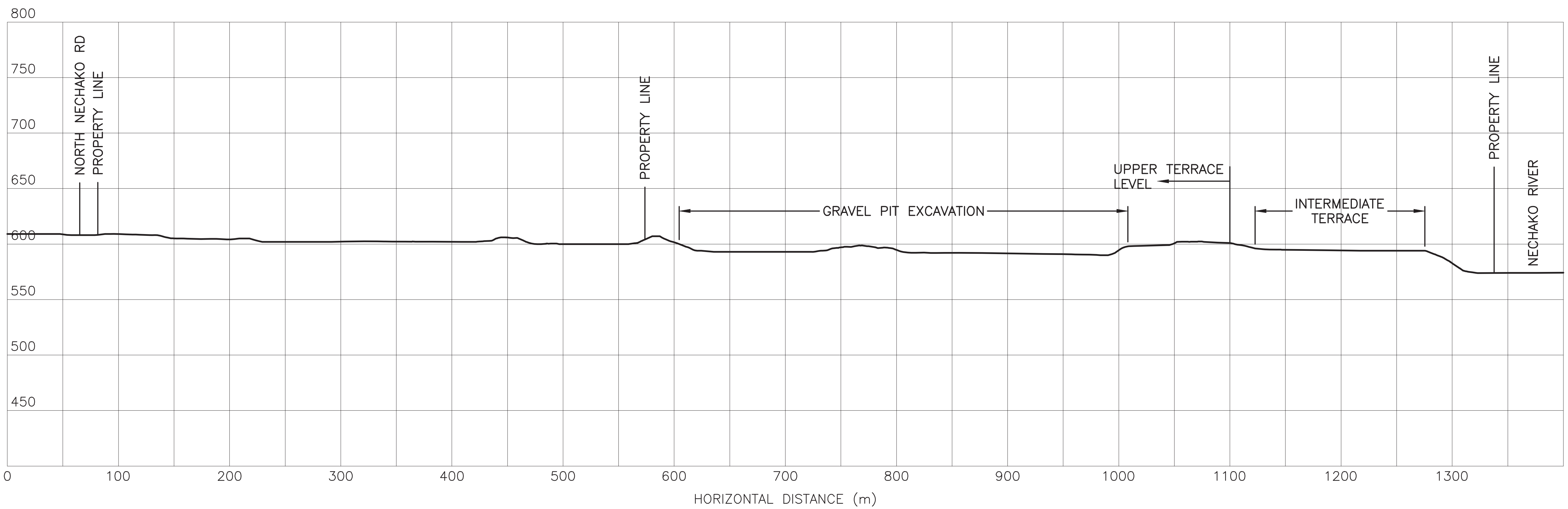
T.R. PROJECTS AND 406286 BC LTD.
c/o L&M ENGINEERING LIMITED
OVERVIEW GEOTECHNICAL ASSESSMENT
NORTH NECHAKO NEIGHBOURHOOD LAND USE PLAN
PRINCE GEORGE, B.C.
SITE PLAN

SCALE:	1:7500
DATE:	2019/08/14
DWN BY:	LU
MAP REF:	–
DWG NO.	4958-A1
APPROVED:	
PROJECT NO:	K-4958
REV.	–

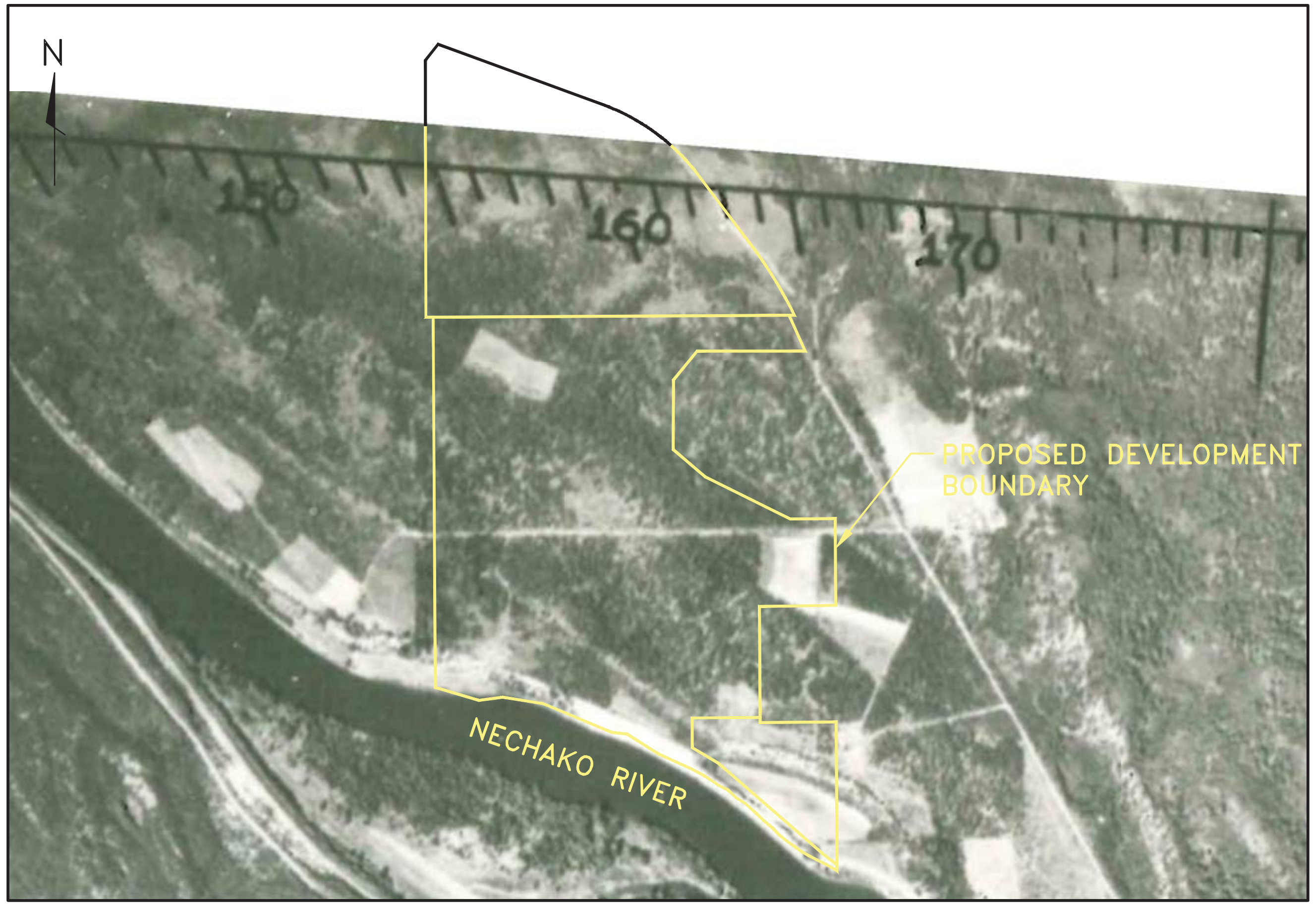


Cross Section A–A

GEONORTH ENGINEERING LTD
3975 18th Avenue
Prince George, B.C. V2N 1B2
Tel. 250-564-4304 Fax 250-564-9323

T.R. PROJECTS AND 406286 BC LTD.
c/o L&M ENGINEERING LIMITED
OVERVIEW GEOTECHNICAL ASSESSMENT
NORTH NECHAKO NEIGHBOURHOOD LAND USE PLAN
PRINCE GEORGE, B.C.
CROSS SECTION A–A

SCALE: 1:4000
DATE: 2019/08/14
DWN BY: LU
MAP REF: –
DWG NO. 4958-A2
APPROVED:
REV. –
PROJECT NO: K-4958



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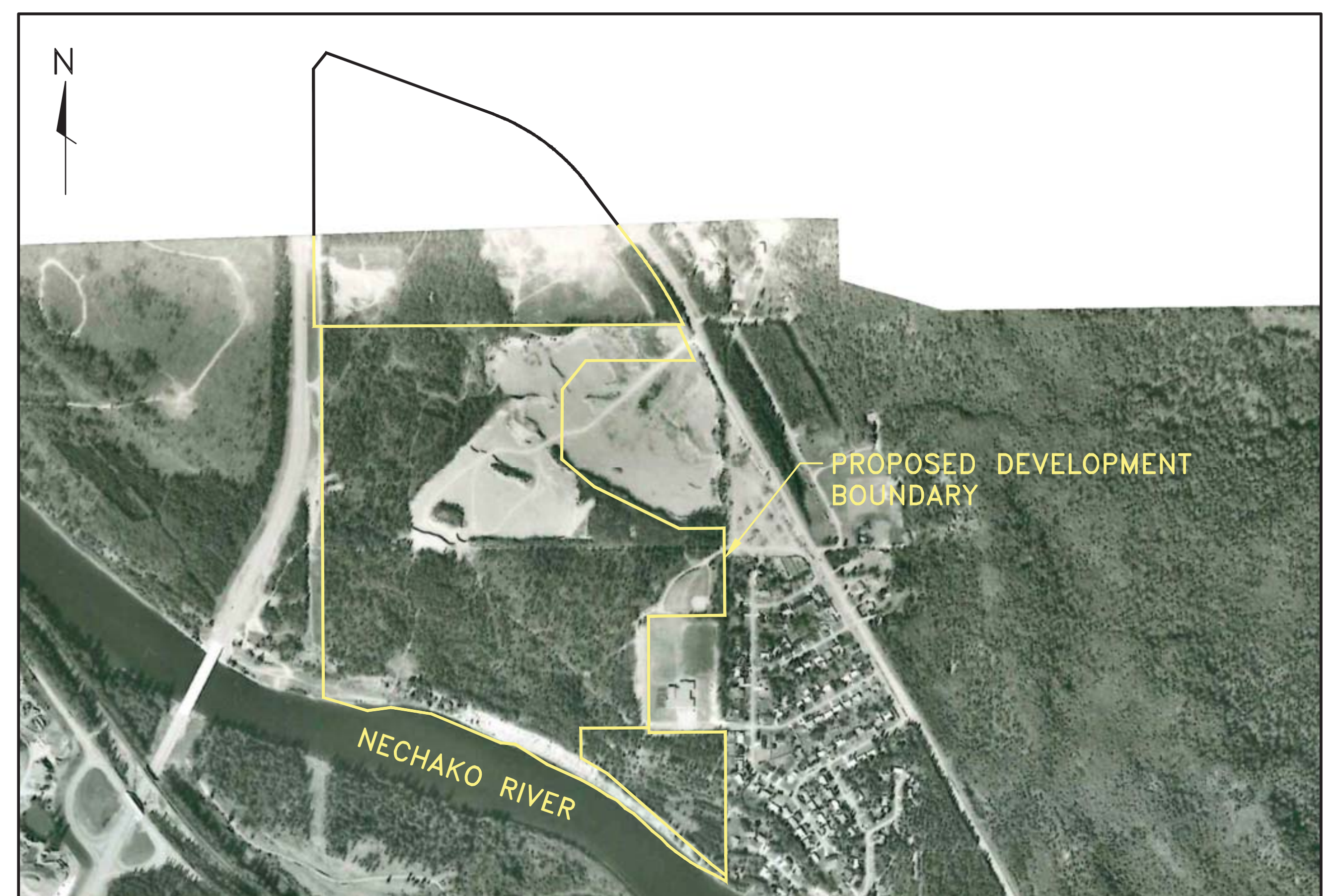

1988

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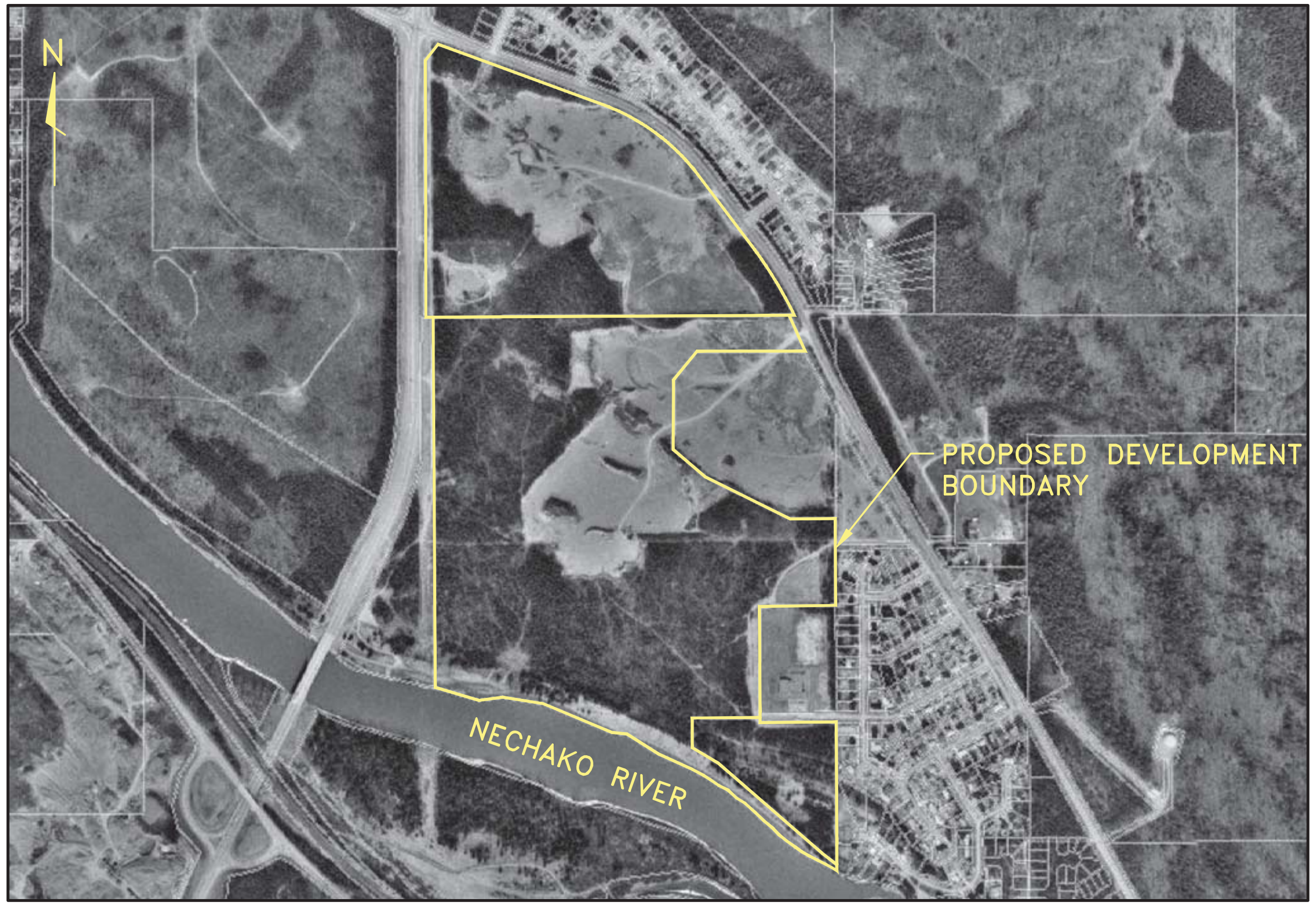
OVERVIEW GEOTECHNICAL ASSESSMENT
NORTH NECHAKO NEIGHBOURHOOD LAND USE PLAN
PRINCE GEORGE, B.C.
HISTORICAL PHOTOS

SCALE:	1:150
DATE:	2019/08/14
DWN BY:	LU
MAP REF:	–
DWG NO.	4958-A3
APPROVED:	
PROJECT NO:	K-4958
REV.	–



1993

2003

2010

2014

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NORTH NECHAKO NEIGHBOURHOOD LAND USE PLAN
PRINCE GEORGE, B.C.
HISTORICAL PHOTOS

SCALE:	1:150
DATE:	2019/08/14
DWN BY:	LU
MAP REF:	–
DWG NO.	4958-A4
APPROVED:	
PROJECT NO:	K-4958
REV.	–

APPENDIX D

North Nechako Neighbourhood Plan
L&M Engineering Limited

ARCHAEOLOGICAL OVERVIEW & ARCHAEOLOGICAL IMPACT ASSESSMENT

1877 Queensway
Prince George, BC
V2L 1L9
1-250-614-1653
info@norcanc.com
www.norcanc.com

Attn: Josh Turner

May 18, 2018

Infinity Properties

205 – 6360 202nd Street
Langley BC, V2Y 1N2

RE: AN ARCHAEOLOGICAL OVERVIEW OF NEW DEVELOPMENT WITH THE CITY OF PRINCE GEORGE WITHIN DISTRICT LOTS 4050 AND 4051

Dear Sir,

This letter has been developed to assist Infinity Properties in determining the risk of altering a heritage site as defined by the Heritage Conservation Act. This assessment is not an Archaeological Impact Assessment as defined by the Heritage Conservation Act. However, the results of this assessment will provide sufficient information for Infinity Properties to assess its risk in relation to possible archaeological or cultural heritage resources within the project area, and to establish its next course of action.

Under the Heritage Conservation Act, a person may not destroy, alter or remove heritage objects from a heritage site. A heritage site is defined as consisting of cultural materials created, deposited, or constructed prior to 1846. For the purpose of this report, all pre-1846 sites are considered archaeological resources. All post-1846 sites are considered traditional use sites.

This overview entails a review of historical documents, maps, archaeological databases, topographic maps, orthographic photos, project development plans and other relevant data. Information obtained from these documents assists the archaeologist in determining the potential for archaeological sites to occur within the boundaries of the proposed development area.

The area under question, a portion of District Lot 4050 and 5051 within the City of Prince George (as outlined on the attached map) consists currently of gravel pit and treed area adjacent to the Nechako River. Application has been made to redevelopment the area between Foothills Blvd, North Nechako road and the Nechako River.

Norcan Consulting Ltd. has assessed the proposed development area and has deemed to be broken into two sections the first being heavily disturbed area, the gravel pit, and an area of high archaeological potential along the Nechako River.

Archaeological Potential Ratings

Currently, rezoning applications in Fraser-Fort George requiring archaeological assessments are identified by the City of Prince George through the application of the Prince George City Archaeological Risk Management Tool, developed by Normand Canuel in the year 2017. A preliminary archaeological impact assessment consists of a detailed pre-field review of the predictions of the relevant archaeological predictive model, followed by a pedestrian field survey. Only the portions of a given potential development area that overlap with the high archaeological potential zones, as identified by the Risk Management Tool, require a preliminary archaeological impact assessment.

The criteria used by the predictive model to determine archaeological potential include the proximity of the proposed development area to lakes, rivers, streams, and wetlands, the degree of slope, land features, and the proximity of the proposed development to known archaeological sites and heritage trails.

Recommendations for DISTRICT LOTS 4050 AND 4051 (described and outlined on the attached map)

The Prince George Archaeological Risk Management Tool rates district lots 4050 and 4051 (as outlined and described on the attached map) as having areas of high archaeological potential due to the proximity of the Nechako River to the south. Such features, especially lakes and rivers, were important resources of food and water for First Nations peoples, and the banks of these features were attractive locations for temporary or permanent settlement. Therefore, areas within approximately 200 m of water, especially where the terrain is flat, dry and elevated, are considered to have high archaeological potential. In addition, elevated benches and terraces along major water routes such as the Nechako River are also considered to be areas of high potential for heritage trails or hunting sites. However, in the case of the surveyed area outlined in the attached map of the development area, a more thorough on-site review of the predictive model outcomes by Norcan Consulting Ltd. found that the model's predictions do reflect the true archaeological potential of this area. Finally, provincial records indicate a previously known archaeological site is across the River within 300 m of the within the proposed development area. On the south side of the River, parallel with this development is an area know as Fish Trap Island, this was an important fish harvesting area used by the local First Nations. Knowing that an archaeological site and Fish Nations traditional use site is along the same section of River plays heavily into the high Archaeological rating along the Nechako River.

There is a heavily used walking path along the Nechako River, it was community build not sanctioned by the city. There is clear continual use of this area, with walking trails, motor bike paths, ATV use, old broken-down cars and even a pet graveyard. The walking path along the upper slope of the river is modern however according to historical documents a First Nations trail did fallow along the north side of the Nechako River. This intersects the trail adds to the high archaeological potential for this development.

On May 8, 2018 a two-person Norcan crew surveyed the proposed development area (see hatched area on attached map) and found that the terrain in the undisturbed treed area along the River had three fluvial terraces, the terraces are flat, dry with well-draining soil. In addition, the majority of the sediments within the gravel pit were heavily disturbed. Any indications of sites or cultural materials have been previously destroyed or lost with the gravel pit. The terraced river terrain within the gravel pit was heavily distributed leading to this sectioning being reclassified as having low potential compared to the treed terraces area the River being deemed high.

Northwest view of Gravel Pit, looking towards Foothills Blvd.

Walking path along river, facing East.

Within the gravel pit little to no portion of the area's sediments and vegetation are left undisturbed. The area along the River was young trees comprised of fir, spruce, aspen and pine. The understory contains soopolallie, reindeer lichen, juniper, Oregon grape, and prince's pine, among other dry site indicators. There are slope breaks that define the three fluvial terraces when moderately to moderately-steep slopes.

North View of Flat upper terrace

Throughout the survey archaeological indicators were encountered. Therefore, the part of the proposed development area that had been previously identified as having high archaeological potential will retain its potential (approximately 200 m from the Nechako River). Due to the above assessment, the existing gravel pit area within the proposed development is reclassified as having low archaeological potential.

South View of River, from lower terrace

Norcan Consulting Ltd. recommends that no further archaeological investigation is required for this proposed development located within the existing gravel pit, The area with the development that presently have forest over will require an archaeological impact assessment prior to any alterations by development.

However, the developer should be aware that even the most thorough archaeological investigation could fail to locate all archaeological remains. In the event that archaeological remains are encountered during development, all ground-disturbing activities in the vicinity of the archaeological remains must be suspended immediately. It is the developer's responsibility to inform The City of Prince George and the Archaeology Branch of the presence of archaeological remains within the proposed development area as soon as possible upon their discovery.

Sincerely,

Normand Canuel

The present study was designed solely as an archaeological review and was not intended to evaluate traditional aboriginal use of the areas in which development is proposed. The results of this study should not be considered valid for that purpose. We recommend that the appropriate First Nation Group be contacted in an effort to locate any known cultural resource or use of that area.

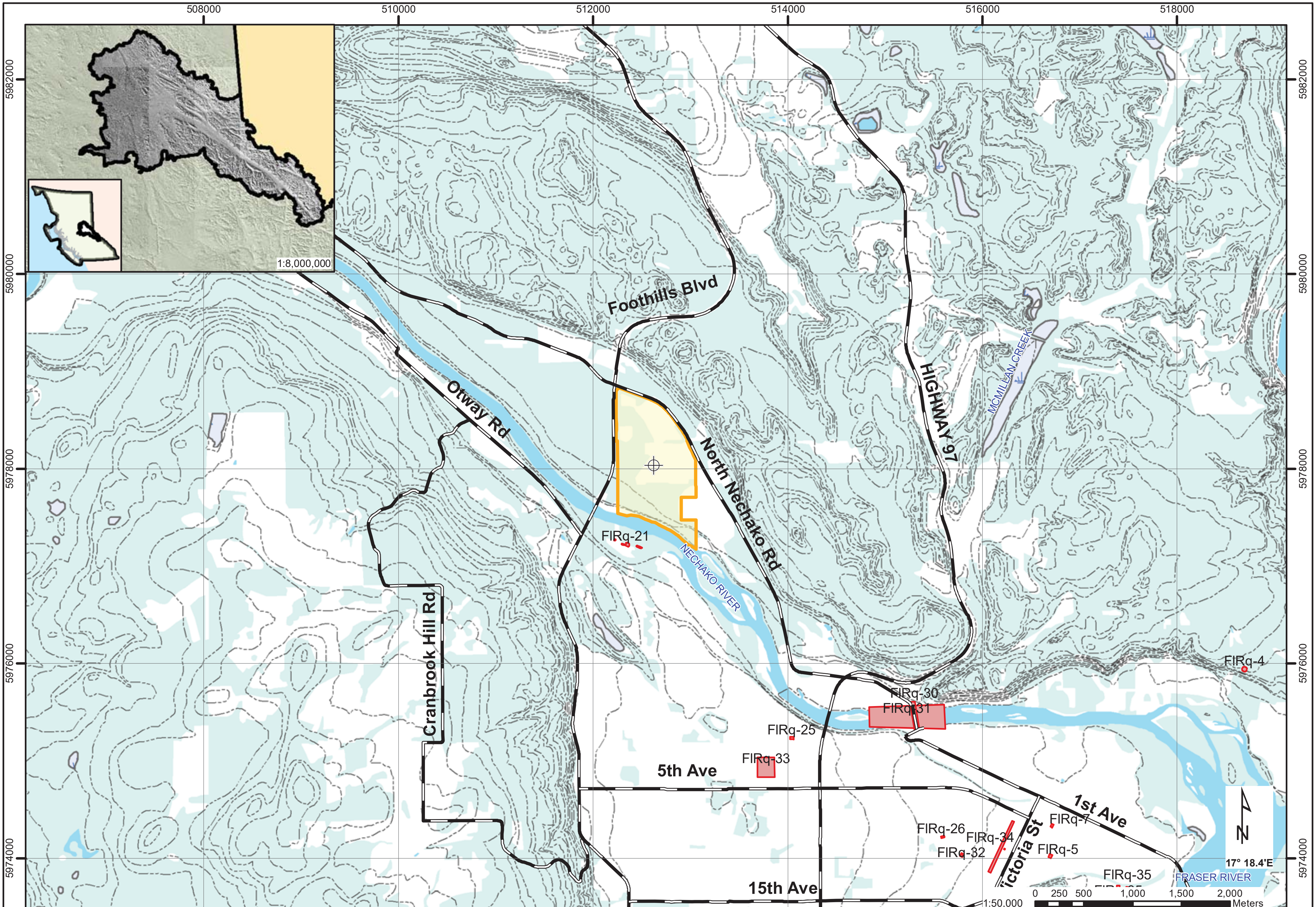

FIG: 1 NORTH NECHAKO DEVELOPMENT PERMIT OVERVIEW MAP

Base Map: NTS Map 093G/15
UTM Point: UTM 10 512622 E 5978038 N
NTS: 093G/15
Client: City pf Prince George
Development Area: 93 ha.

Natural Resource District: Prince George
Date Surveyed: 05/08/2018

Date Mapped: 05/17/2018

NORCAN CONSULTING LTD

Legend

- Development
- UTM Point
- Built Road
- Proposed Road
- Blaze Line
- Water Body
- Wetland
- Contour
- Waterway
- Trail
- Existing Arch Site >1000 m²
- Existing Arch Site <1000 m²
- New Arch Site
- Traditional Use Site
- Shovel Test Area
- Untested Area of Potential

FIG: 2 NORTH NECHAKO DEVELOPMENT PERMIT OVERVIEW MAP

Base Map: Google Earth Image
UTM Point: UTM 10 512622 E 5978038 N
NTS: 093G/15
Client: City pf Prince George
Development Area: 93 ha.

HIP: 18A0134
Licence:
Natural Resource District: Prince George

Date Mapped: 05/17/2018

NORCAN CONSULTING LTD

Legend

Development

UTM Point

ARCHAEOLOGICAL IMPACT ASSESSMENT CONDUCTED ON PROPOSED RESIDENTIAL SUBDIVISION 2259 NORTH NECHAKO ROAD AND 4439 CRAIG DRIVE WITHIN THE CITY OF PRINCE GEORGE

Heritage Inspection Permit 2019-0044

Prepared By:

Norcan Consulting Ltd.
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Prince George, BC, V2L 1L9
Phone: 250-614-1653
Fax: 250-614-1655

Prepared For:

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Langley, BC, V2Y 1N2
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Attn: Sebastian Blackthorne
PO Box 9816 Stn Prov Govt
Victoria, BC, V8W 9W3

Ministry of Forests, Lands, Natural Resource Operations & Rural Development
(Prince George District)
2000 South Ospika Boulevard
Prince George, BC, V2N 4W5

Lheidli-T'enneh Band
1041 Whenun Road
Prince George, BC, V2N 5X8

Nak'azdli First Nation
PO Box 1329
Fort St. James, BC, V0J 1P0

Grant of License

*I, **Normand Canuel,** confirm that I am the copyright owner (or a copyright owner) of this report and, for good and valuable consideration, I irrevocably grant a non-exclusive license to the Province of British Columbia, for a term equal to the life of the copyright commencing on the date of execution below, to make copies of the reports, including all appendices and photos, and to provide such copies to anyone, at the discretion of the Province, either at no charge or at the cost incurred by the Province or the proponent in making and distributing the copies. All parties, except the party for whom the report was prepared, acknowledge that any use or interpretation of this report is at the sole risk and liability of the subsequent user(s).*

Normand Canuel
Norcan Consulting Ltd.
Friday, June 14, 2019

Acknowledgements

Norcan Consulting Ltd. would like to thank T.R. Projects Ltd. for the opportunity to conduct this Heritage Inspection Permit, and Lheidli-T'enneh Band and Nak'azdli Band for their input and support of this project. We also thank Norcan staff for their participation, Mr. John Smith of Prince George for his assistance with photographic and verbal evidence of disturbance, and Archaeology Branch Officer Sebastian Blackthorne for their management guidance.

Management Summary

This project was carried out within the City of Prince George under Heritage Inspection Permit (HIP) 2019-0044. This permit was granted to Normand Canuel of Norcan Consulting Ltd. (Norcan) to conduct an Archaeological Impact Assessment of proposed residential subdivision 2259 North Nechako Road and 4439 Craig Drive. Norcan received the single development from proponent, T.R. Projects Ltd.

In May of 2018, the development was subjected to a Preliminary Field Reconnaissance (PFR) assessment and a Detailed Archaeological Review, including the application of the *Archaeological Risk Framework Tool* developed for the City of Prince George by Norcan (Canuel & Pritchard, 2018). This review determined High Potential Areas (HPA's) which would require subsurface testing. Upon issuance of HIP 2019-0044, subsurface testing began in May of 2019.

During this assessment, two HPA's tested positive for archaeological resources. The development contained 84 ha of total land area, of which 24 ha consisted of gravel pits, 5 ha contained slopes in excess of 50 %, and 3 ha has been excluded as a reserve. Of the total land area, 20 ha was surveyed (includes both high potential and low potential survey) and 8.2 ha was determined to have high archaeological potential. Of the development area surveyed, 3.538 ha was subjected to subsurface testing. Of the total area subjected to subsurface testing, Norcan recommended that .0358 ha covering two protected archaeological sites be managed for impacts by the proponent.

Archaeological sites are protected under the *Heritage Conservation Act* (HCA), and it was recommended that sites TSN19-NorthNechakoDevelopments-SSL1 and TSN19-NorthNechakoDevelopments-SSL2 be excluded from the development area, or a Section 12 Site Alteration Permit (SAP) will be required prior to the commencement of development activities.

General considerations and recommendations are as follows:

- 30 meter wide reserve area along the embankment of the Nechako River (Figure 2).
- Under the *Heritage Conservation Act* (HCA), altering a (known) archaeological site on private or Crown land without having undertaken an archaeological assessment is illegal and punishable by up to a $50,000 fine and two year's imprisonment.
- Minimally, all workers on all project, regardless of whether they are located within or outside HPA's, should always follow a Chance Find Protocol (CFP) in case archaeological materials are inadvertently encountered during development activities. This applies

whether an archaeological assessment has been performed or not, as even the most thorough assessment may fail to recover archaeological materials that may be present. Under a CFP, operations within the vicinity of a find should cease immediately and the Archaeology Branch should be notified. The Archaeology Branch will then advise an appropriate course of action.

- Any archaeological site identified during an archaeological assessment or through a CFP during development activities that may be impacted by a project will require a Site Alteration Permit pursuant to section 12 of the HCA prior to commencement, or continuation, of work.
- Protect archaeological site TSN19-NorthNechakoDevelopments-SSL1 and exclude from future developmental impacts with covenants placed on the appropriate lot(s).
- We recommend that archaeological site TSN19-NorthNechakoDevelopments-SSL2 be considered fully mitigated with no further work or covenants placed on the property.

Credits

Permit Holder

Normand Canuel (MA)

Report Author

Brett Nuttall (BA)

Report Editor

Normand Canuel (MA)

Alisha Deutsch (BA)

Field Technicians

Howie Alexis

Eddie Antoine

Field Supervisors

Brett Nuttall (BA)

Joel Trask

Archaeologists

Charlotte Bailey (BA)

Claire Bauer (BA)

Gabrielle Janicki (BSc)

Rebecca Lewthwaite (BSc)

Cheryl McCullough (BA)

Nikolai Rambo (BA)

Shenaya Setah (BA)

GIS

Mary Reyers (BSc)

Administration

Alisha Deutsch (BA)

Alicia Elzinga (BCom)

Odai Mansour (BA)

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Glossary of Terms

AIA Archaeological Impact Assessment – an assessment performed under a HIP that attempts to gauge a proposed project's impact on known and potential cultural heritage resources located within a project's footprint and makes recommendations on how to avoid or mitigate any resources or archaeological concerns identified during the assessment. An AIA may or may not include exploration of subsurface materials through shovel testing, augering or probing.

CMT Culturally Modified Tree.

CFP Chance Find Protocol - a set of stop-work and reporting guidelines for workers to follow if archaeological materials are inadvertently encountered during on-site development activities.

DEM Digital Elevation Model.

GIS Geographic Information System.

HCA Heritage Conservation Act.

HIP A Heritage Inspection or Heritage Investigation Permit issued under section 14 of the HCA by the Archaeology Branch to conduct AIAs.

HPA High Potential Area – an area determined by the predictive model to have high potential to contain cultural heritage resources.

LIDAR Light Detection and Ranging.

OSM On-Site Monitoring involves monitoring of on-site development activities and operations for unearthed archaeological materials. OSM may or may not be performed under a HIP.

SAP Site Alteration Permit issued under section 12 of the HCA by the Archaeology Branch to mitigate known archaeological sites. SAPs are typically applied for when a project cannot be redesigned to avoid or exclude an archaeological site area from being impacted during development.

TRIM Terrain Resource Information Management.

1. Introduction

Heritage Inspection Permit (HIP) 2019-0044 is a single development permit authorizing an Archaeological Impact Assessment (AIA) to be performed on proposed residential subdivision 2259 North Nechako Road and 4439 Craig Drive within the City of Prince George (Figure 1). This HIP Final Report provides background information concerning the natural and cultural setting of the general development area and summarizes the project's methodology, results and recommendations.

As outlined in the British Columbia Archaeological Impact Assessment Guidelines (Apland & Kenny, 1998), an AIA attempts to:

- Identify and evaluate archaeological resources within the project area
- Identify and assess all impacts on archaeological resources that might result from development
- Recommend viable alternatives for managing unavoidable adverse impacts

The primary objective of this project was to assess a specific proposed residential subdivision to ensure that any archaeological resources present would not be impacted, directly or indirectly, by residential development activities. This objective was met through a combination of comprehensive pre-field research and systematic field survey methods. Residential development activities may include road extensions, pipeline implementation (i.e. sanitation, hydro, etc.) and the construction of housing units. Sources of potential impacts on archaeological resources may include gravel pit excavation, grading and levelling for road and housing construction, subsurface disturbance through pipeline implementation, and post developmental activities such as private homeowners land alterations (i.e. secondary construction and additions to housing, gardening, lawn maintenance, etc.).

Under this permit an AIA was performed on proposed residential subdivision 2259 North Nechako Road and 4439 Craig Drive between April 24th and May 24th, 2019 (Figures 1 & 2; Table 1). All First Nations with claims or title to the proposed development area were sent a referral letter (either by fax, email, or online portal) that included maps, coordinates, and a description of the development. A minimum of 30 days was provided to allow for any questions or concerns to be brought to the Archaeology Branch or Norcan prior to the start of the AIA. AIA's are designed to discover and address potential impacts to archaeological resources, they are not intended to speculate on aboriginal rights or traditional use territories.

1.1. Provincial Legislation

The Heritage Conservation Act, RSBC 1996, c.187, is the primary legislation governing the management of cultural heritage resources on private and Crown land within the province of BC. Cultural heritage resources can be designated as protected or non-protected. Protected resources are objects and areas that contain evidence of past human activity, and they are classified according to site type, subtype and descriptor. As protected resources, archaeological sites cannot be damaged, altered or moved as a result of impacts from development without a Site Alteration Permit issued pursuant to section 12 of the HCA. Under the HCA, altering a (known) archaeological site on private or Crown Land without having undertaken an archaeological assessment is illegal and punishable by up to a $50,000 fine and two year's imprisonment. In contrast, non-protected cultural heritage resources are usually recent historic Euro-Canadian sites or locales that have value to First Nations communities and attest to their meaningful ties to a place. Heritage buildings and aboriginal traditional use sites such as traplines, trails and CMT's that post-date AD 1846, are typical examples of non-protected cultural heritage.

Table 1 Project Personnel & Roles

Survey Dates	Field Director	FD On Site?	Supervisor(s)
April 24;	Normand Canuel;	Yes;	Brett Nuttall;
April 25;	Normand Canuel;	Yes;	Brett Nuttall;
April 29;	Normand Canuel;	No;	Brett Nuttall;
April 30;	Normand Canuel;	No;	Brett Nuttall;
May 1;	Normand Canuel;	No;	Brett Nuttall;
May 2;	Normand Canuel;	No;	Brett Nuttall;
May 9;	Normand Canuel;	No;	Brett Nuttall;
May 10;	Normand Canuel;	No;	Brett Nuttall, Joel Trask;
May 14;	Normand Canuel;	No;	Brett Nuttall, Joel Trask;
May 15;	Normand Canuel;	No;	Brett Nuttall;
May 16;	Normand Canuel;	Yes;	Brett Nuttall;
May 17;	Normand Canuel;	No;	Brett Nuttall, Joel Trask;
May 21;	Normand Canuel;	No;	Brett Nuttall;
May 22;	Normand Canuel;	Yes;	Brett Nuttall;
May 23;	Normand Canuel;	No;	Brett Nuttall;
May 24	Normand Canuel	No	Brett Nuttall

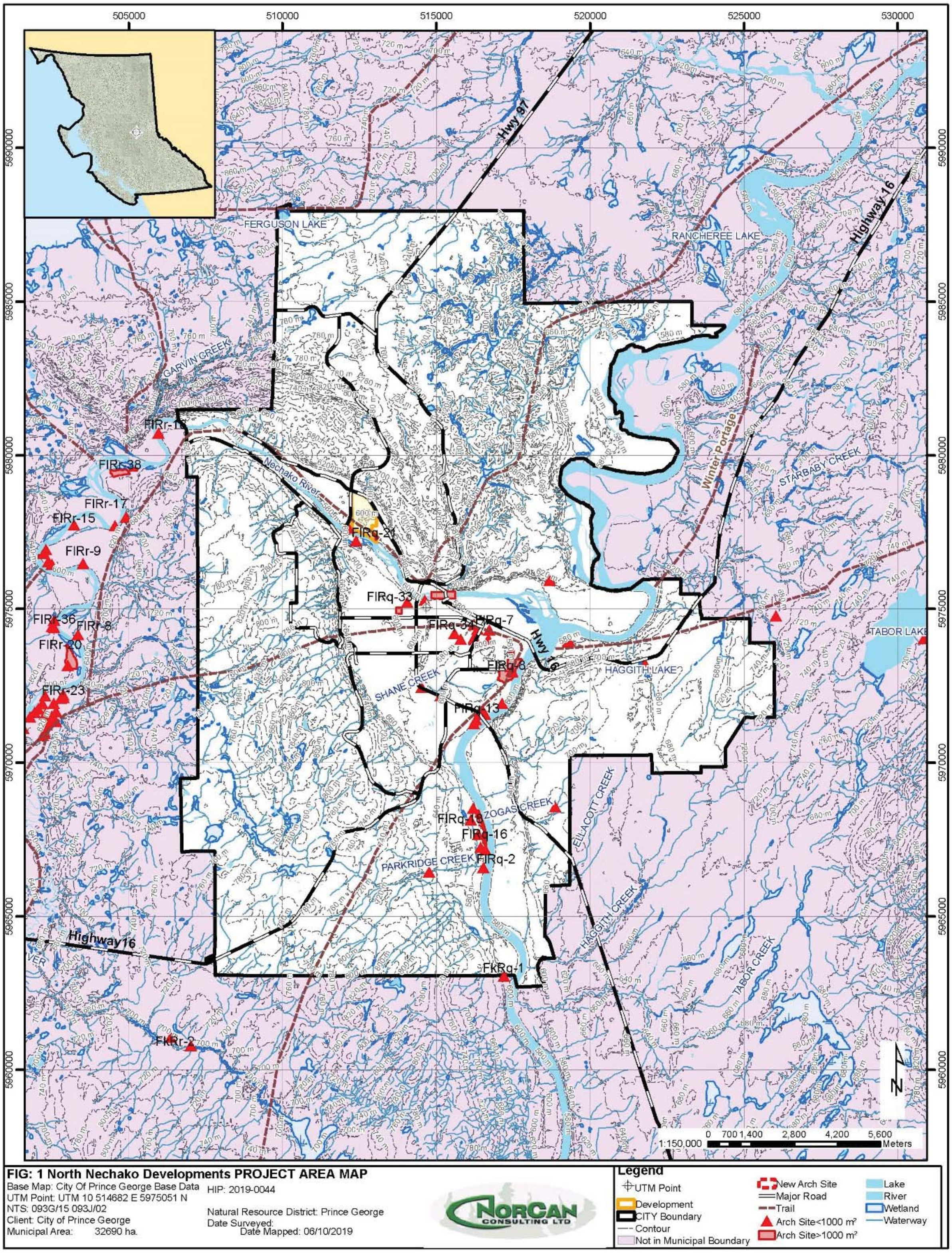

Figure 1 North Nechako Developments Project Area Map

2. Study Area

The study area encompasses the proposed residential subdivision 2259 North Nechako Road and 4439 Craig Drive and is located within the municipal boundaries of the City of Prince George and covers 84 ha of total land area (Figure 1 & 2). A description of the biophysical characteristics of the landscape in and around Prince George, and a summary of local ethnographic cultures and previous archaeological work can be found in Canuel & Pritchard (2018). Additional information not available in that report is provided below.

2.1. Geomorphology of Prince George and Surrounding Area

Prince George is situated within the Fraser Basin physiographic region, which is characterized by thick drift mostly deposited during the glacial and deglacial phases of the Fraser Glaciation (Clague, 1988; Clague, Hebda, & Mathewes, 1990; Holland, 1976; Sacco, 2012; Tipper, 1971a). During the glacial advance and maximum, glaciers sourced from the Cariboo and Coast mountains eroded existing surficial deposits and bedrock, deposited thick, extensive till blankets, and streamlined landforms. During deglaciation, ice retreated to the west and south. Glaciers retreating south within the Fraser River valley impeded drainage causing the formation of Glacial Lake Fraser, which occupied much of the Fraser Basin. The region was mantled by clayey to sandy glaciolacustrine sediments that are thickest (>100 m) at lower elevations, and thin to veneers in upland areas. The configuration of Glacial Lake Fraser changed as glaciers continued to retreat from the region. These changes are best preserved on hillsides as successive glacial lake shorelines that record a gradual lowering of the lake level. When drainage to the south was re-established, glacial meltwater flowed through the pre-existing Nechako and Fraser river valleys, cut terraces into the glaciolacustrine sediments, and deposited sand and gravel in braided channels that spanned the valley bottoms.

During the early Holocene, when glaciers had retreated from the region but before the establishment of vegetation, the land surface was particularly unstable, and erosion and sedimentation rates were high. Glaciolacustrine deposits gullied and failed, creating a complex of plateaus, steep slopes and colluvial deposits. Some of this material was carried by streams to the lower valleys where glaciolacustrine and glaciofluvial deposits continued to be incised, creating terraces above present-day river levels but below the glaciofluvial terraces. By the mid to late Holocene, vegetation had largely colonized the region, which helped stabilize the land surface and reduced the sediment supply to the rivers. The rivers were reduced to single thread, smaller channels that continued to incise the land surface. Eventually, a baseline was reached, and these channels migrated along valley bottoms, cut abrupt scarps at the valley edges and periodically flooded their banks. During the modern period, continued, gradual incision of rivers into alluvial valley fills created low fluvial terraces and inactive sections of floodplain, while erosion continued along river scarps and colluviation was restricted to the steepest, highest-relief slopes.

Within the study area, there is a general correlation between the age of landform assemblages and elevation. The oldest landforms from the glacial period (late Pleistocene), consisting of streamlined till and till-veneered bedrock, occur at the highest elevations, above the maximum elevation of Glacial Lake Fraser. The most widespread landform assemblages are from the deglacial period (late Pleistocene) and associated with Glacial Lake Fraser. At higher elevations, these include shoreline and subaqueous fan deposits composed of coarser material (e.g., sand and gravel), with lesser amounts of fine-grained materials. At lower elevations, where the water was deeper, the deposits are generally fine-grained (e.g., silt and clay), and form thick mantles or plains over the underlying material. High elevation terraces were created when large volumes of meltwater cut wide channels into the glaciolacustrine material, and deposited outwash on braided plains. Early Holocene landforms were dominantly formed by erosion and colluviation that occurred prior to the colonization of vegetation. These features generally occur in the north where sandy deltaic deposits were incised, or along large glaciolacustrine scarps originally cut by meltwater flowing through the Fraser and Nechako river valleys. These extensive, unvegetated deposits provided significant sediment sources for eolian activity. Mid to late Holocene fluvial landforms are generally confined to the large valley systems below the glaciofluvial terraces, but above the active fluvial plains, and these features were built up by overbank flooding events. Modern landforms include active fluvial and colluvial features.

2.2. Past Land Use - Dakelh (Carrier) Culture and Lifeways

Prince George falls within the traditional territory of the Lheidli-T'enneh First Nation, who are a branch of the Dakelh (Carrier) people, a Northern Athapaskan (Dene) speaking language group to which many other contemporary First Nation groups in the Central Interior trace their heritage. The following summarizes aspects of Dakelh lifeways from documentary sources with a focus on past behaviours and land use activities that are most likely to be reflected and encountered in the archaeological record (Bishop, 1983; Blacklaws, 1980; Bond & Russell, 1992; Borden, 1951; 1952; Carlson A., 1995; Carlson R., 1996; Cassidy & Cassidy, 1981; Clark-Giesbrecht, 1994; Cole & Lockner, 1989; Donahue, 1976; Duff, 1951; Fladmark, 1976, 1986, 1999; Fraser, 1960; Furniss, 1993;Hall, 1992; Harmon, 1820; Helmer, 1977; Hooper, 1978; Hudson, 1972, 1983; Jenness, 1943; Klippenstein, 1992; MacKenzie, 1970; Morice, 1893, 1905; Tobey, 1981). Appendix A contains an official Historical Timeline provided by the Lheidli-T'enneh Band.

The Dakelh were semi-nomadic hunters, fishers and gatherers who moved around the landscape following a seasonal round of resource exploitation and were organized around matrilineal-based extended households and clans. People spent the winter in multi-household villages near major lakes and rivers, living in semi-subterranean (pit) houses. Remains of semi-subterranean pit houses are common features in the archaeological record, and they are recognized as distinctive, large and deep depressions, often found in clusters located near major waterbodies and waterways. During fairer weather, and increasingly after contact with Europeans, the Dakelh also inhabited aboveground lodges, which were generally square or oblong pole-framed structures covered with hides, bark or matting. In addition to household dwellings, fish lodges, ceremonial lodges used for feasting, and other structures used for rites of passage were constructed. In contrast to winter pithouses, remains of aboveground structures are only rarely identified in the archaeological record as evidence for them comes in the form of postholes and central hearth features, which are usually not visible on the ground surface and require subsurface testing to expose.

From spring through fall, households fragmented into smaller family groups to hunt, fish and collect a variety of plants and berries, including pine cambium, within their territories (*Keyoh*). Game and freshwater fish were sought, usually at nearby lakes and streams and in the surrounding forests. Caribou, elk, moose, deer, goats and bear were among the large game animals taken. People also hunted and trapped groundhog (marmot), beaver, muskrat, lynx, rabbit and other small game. These animals were hunted for both meat and fur. Pine cambium was collected in the late spring as an additional and sometimes necessary food source. Cambium collection creates distinctive scars on lodgepole pine trees, where the bark has been stripped away in order to scrape the cambium from the tree. Tool marks, if present on the scar face or surrounding bark, also indicate a cultural rather than natural origin of scarring. This practice of cambium collection persisted well into the 1900s. During the late summer, families would coalesce in large camps near primary fishing spots for large- scale salmon harvesting and processing for storage, trade and winter consumption; these important and productive locales were usually returned to each year.

A large variety of implements and practices were used for hunting, trapping, fishing and gathering plant food. Stone tools (points, knives, scrapers and modified flaking debris) are the most common objects recovered archaeologically. Many kinds of traps, snares and hunting blinds were also used to procure resources. As salmon was highly valued and heavily relied upon, large weirs were built across the inlets and outlets of lakes and mouths of rivers to catch salmon in slow moving currents. Where currents were deeper and faster; movable latticework traps were constructed along the shorelines. These were used in conjunction with basket traps at the top of narrow waterfalls where the migrating salmon could be caught as they attempted to jump the falls. Dip nets, leisters and harpoons were used from rocky outcrops overlooking rapids where salmon gathered in large numbers. Many tools were made of wood, bark and bone. These organic materials do not preserve well in the acidic soils of coniferous forests and are therefore not commonly recovered.

The sharing of food through feasting ceremonies such as the potlatch, and trading goods with neighbouring communities and outsiders were vital to Dakelh lifeways. Households were often not entirely self-sufficient, and they relied upon resources and access to the territories of others secured through inter-household and inter-clan trade and relationships (e.g. marriage). Feasts (*Bah'lats*) were used to maintain the social order of households, and to commemorate deaths, acknowledge name succession and validate the right of hereditary chiefs (*Deneza*) to govern and settle disputes or breaches of law and custom. In order to store large amounts of food for trade and consumption, it was dried or smoked then placed into pits, layered between pieces of bark, then covered with brush and earth. These cache pits are common features of the archaeological record and are recognized as distinctive small circular to oval depressions, often with a discernable berm or rim around them. They are usually found in easily excavated and well-drained soils (sandy or silty loams, fine gravels) in association with hunting trails, islands, river confluences and berry patches or in large aggregates near village sites.

Processed salmon and, increasingly after contact, fur, were traded for valued items such as eulachon grease/oil, raw materials (e.g. obsidian) and European trade items and foodstuffs. Trails were the primary means of moving overland to access geographically dispersed resources and facilitated short and long-distance trade. Although most trails were localized and trips were short, people sometimes traveled upwards of 300 km and spent weeks along trail networks, gathering and trading resources along the way. Heritage trails are recognizable on the landscape by the presence of an exposed trail bed, associations with blazed trees or culturally modified trees (CMT's), and often close proximity to other types of archaeological sites.

2.3. Past Land Use – Historical Development of Prince George

Driven by resource exploration and funded by the North West Company, Alexander Mackenzie first reached the present-day location of Prince George during his second expedition between 1792 and 1793. He was followed by Simon Fraser, who arrived at the confluence of the Nechako and Fraser Rivers on July 11, 1806. By autumn of the following year, the Fort George trading post had been established (Diaz, 1992; Runnalls, 1946). Ownership of the post passed to the Hudson's Bay Company in 1821, and it remained operational until its closure in 1915 (Runnalls, 1946). The establishment of Fort Alexander in 1821 and the "Tete Jaune" or "Yellowhead" pass in 1827 expedited the movement of people and supplies from the south and turned Fort George into an important staging area for central and northern BC (Runnalls, 1946). However, it remained only of secondary importance to other posts in the New Caledonia region such as Fort St. James and Fort McLeod over the course of the 19th century.

The Fort George Indian Reserve #1 (FGIR1) was established in 1892 in what is now downtown Prince George and was originally inhabited by 124 residents living in 29 houses (Figure 1). Although food was cultivated and livestock raised, residents relied heavily on hunting, trapping and gathering wild resources to supplement their diet and livelihood (Vogt & Gamble, 2010). Until the early 20th century, the expansion of Fort George was modest, but the construction of the Grand Trunk Pacific Railway, which began in 1906 and became operational in 1914, and extensive promotion of the area by the Federal and Provincial governments, various clubs, boards, associations and land holding companies including the Northern Development Company (South Fort George), the Natural Resources Security Company (Fort George and Central Fort George), and the Grand Trunk Development Corporation, ushered in greater settlement and commercial development (Diaz, 1992; Runnalls, 1946). Between 1909 and 1911 a significant number of settlers arrived, which greatly expanded the required agricultural land base, and a new steamship dock, general store, bank, schoolhouse, hospital, newspaper and mission were established (Diaz, 1992; Runnalls, 1946). By 1911, mounting pressure from settlers and the Indian Affairs agent for the area forced the Lheidli-T'enneh from FGIR1 and relocated them to Indian Reserve #2, located north of Fort George in Shelley, where it remains today. In response to this pressure, Chief Louise of the Lheidli-T'enneh said "[F]or more than 200 years...we live here, we die here, we bury here, we fish and hunt and trap here, by and by we make gardens here, we like this place" (Vogt & Gamble, 2010).

In 1913, the Grand Trunk Pacific Development Company began clearing a location for a new town site, and in 1915 the Provincial government granted the incorporation of Prince George (Runnalls, 1946).

2.4. Cultural Heritage Sites

The *Heritage Conservation Act* (HCA) requires the maintenance of a Provincial Heritage Register to keep records about archaeological and historic sites in BC. The Archaeology Branch administers several systems including the HRIA (Heritage Resource Inventory Application), APTS (Archaeological Permit Tracking System), PARL (Provincial Archaeological Report Library) and RAAD (Remote Access to Archaeological Data) that collectively form this register. Prior to 2001, information on non-protected cultural heritage sites (e.g. traditional use sites) were entered into this register and assigned permanent site numbers (Borden numbers). Since 2001, only protected archaeological sites have been entered and assigned permanent site numbers.

A review of RAAD shows 1050 cultural heritage sites located within a 100 km radius of Prince George, including 24 (pre and post-contact) sites within City limits (British Columbia Archaeology Branch, 2016). Archaeological sites found within the City consist of cultural depressions (house pits, cache pits or roasting pits) and lithic scatters, and indicate the area has been occupied since at least 9700 BP (before present) (Burford, Jackman, & Cogswell, 2008). Given the nature of occupation by First Nations, and the probability that sites were both destroyed and unrecorded during the historical development of the City, the provincial register likely underrepresents the extent of past indigenous land use and cultural heritage resources within the City. Sites located beyond City limits are more representative of the range and extent of past land use, and include lithic scatters, cultural depressions, CMTs, trails, buildings, human remains or burials and earthworks. The 24 cultural heritage sites located within the City are listed in Table 2, and a summary of sites located within 100 km of Prince George can be found in Table 3.

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Table 2 Cultural Heritage Sites in Prince George

Borden Number	Site Context	Site Type	HIP Number
FlRq-1	Precontact	Habitation Feature, Cultural Depression, House Pit	1973-0028
FlRq-2	Precontact & Historic	Subsistence Feature, Cultural Depression, Cache Pit	ASAB 1976
FlRq-3	Historic	Habitation Feature, Cultural Depression; Building, Commercial, Trading Post (Fort George)	1977-0017; 1998-0218
FlRq-4	Precontact	Subsistence Feature, Cultural Depression, Cache Pit	1981-0028
FlRq-5	Historic	Building, Commercial, Liquor Store	N/A
FlRq-6	Historic	Habitation, Single Dwelling (Prince George Dept. of Highways Bungalow)	N/A
FlRq-7	Historic	Building, Governmental/Communications, Post Office (Federal Government Building*)*	N/A
FlRq-8	Precontact &Postcontact	Human Remains, Grave/Burial (Lheidli T'enneh Traditional Burial Ground)	2005-0382
FlRq-9	Precontact	Subsistence Feature, Cultural Depression, Cache Pit; Cultural Material, Subsurface, Lithics	2006-0209; 2007-0290
FlRq-10	Precontact	Cultural Material, Subsurface, Lithics	2006-0209
FlRq-11	Precontact	Cultural Material, Subsurface, Lithics	2006-0209
FlRq-12	Precontact	Cultural Material, Subsurface, Lithics	2006-0209
FlRq-13	Precontact	Subsistence Feature, Cultural Depression, Cache Pit; Subsistence Feature, Cultural Depression, Roasting Pit; Cultural Material, Subsurface, Lithics; Cultural Material, Surface, Lithics	2006-0209; 2006-0416
FlRq-14	Precontact	Cultural Material, Subsurface, Lithics	2007-0339; 2008-0188
FlRq-15	Precontact	Subsistence Feature, Cultural Depression, Cache Pit; Cultural Material, Subsurface, Lithics	2007-0339; 2013-0174
FlRq-16	Precontact	Subsistence Feature, Cultural Depression, Cache Pit, Cultural Material, Subsurface, Faunal & Lithics	2007-0339; 2008-0277; 2013-0174
FlRq-17	Precontact	Cultural Material, Subsurface, Lithics; Cultural Material, Surface, Lithics	2007-0339; 2008-0188
FlRq-18	Precontact	Subsistence Feature, Cultural Depression, Cache Pit	2007-0339; 2008-0277
FlRq-19	Precontact	Subsistence Feature, Cultural Depression, Cache Pit; Cultural Material, Subsurface, Lithics	2008-0277; 2009-0112; 2009-0341
FlRq-20	Precontact	Cultural Material, Subsurface, Lithics	2009-0129
FlRq-21	Precontact	Cultural Material, Subsurface, Lithics	2015-0155
FlRq-22	Precontact	Cultural Material, Subsurface, Lithics	2014-0099
FlRq-23	Precontact & Postcontact	Cultural Material, Subsurface, Lithics & Refuse	2014-0099
FlRq-24	Precontact	Cultural Material, Subsurface, Lithics	2016-0106

Table 3 Cultural Heritage Sites within 100 km of Prince George.

Site Context*	Frequency
Pre-Contact	854
Traditional Use	154
Historic & Post-Contact	41
Unknown	1

*Pre-contact sites that also have historic or post-contact components are identified as pre-contact.

3. Project Methodology

3.1. Pre-Field Potential Assessment

In 1978, Normand Canuel and Wayne Hanson assessed the area as part of an ASAB project along the Nechako River. The proposed development was assessed for previous land altering activities which included farming and housing, pre-1960, and gravel extraction until the mid-eighties (Plate 1). For additional photos providing evidence of past land altering activities, see Appendix B.

Plate 1 STA 1N and TSN19-NorthNechakoDevelopments-SSL1 c.1978 (Photo courtesy of Mr. John Smith of Prince George)

Prior to the commencement of field work, the proposed development was subjected to a detailed archaeological review (DAR), which determined specific areas within the proposed development that have archaeological potential and require further assessment. During the DAR, Norcan assessed archaeological potential by applying *The Archaeological Risk Framework Tool (ARFT)*, a predictive model developed for the City of Prince George by Normand Canuel and Brian Pritchard in May of 2018. After completing the DAR, a preliminary field reconnaissance (PFR) was conducted within the development in May of 2018.

3.1.1. Predictive Modelling

The Archaeological Risk Framework Tool (ARFT) (Canuel & Pritchard, 2018) is an objective areal predictive model that uses predominantly inductive procedures and logic and equal weighting of variables. In this model, known archaeological sites within and around Prince George comprise the sample data from which the relationship between independent (environmental) and dependant (site presence/absence) variables are analyzed and projected onto the development area to make predictions about the potential of these areas to contain an archaeological site(s). Quantifying the spatial relationship between the factors that indicate the presence of known sites and then partially explaining this relationship in terms of past human behaviour is primarily an inductive process (Altschul, 1988).

The strength and utility of objective predictive models lies in how they explicitly operationalize the relationships between the dependant and independent variables that constitute them, and the interrelationships between multiple independent variables (Altschul, 1988). For example, dry soils are associated with certain landforms and types of vegetation, and while all three of these variables may indicate the presence of a site on their own, the three variables together are likely an even more powerful indicator of site location. However, in order to use all three variables each one must be tested independently and in combination with the other variables.

Environmental variables related to landforms, or terrain, are commonly included in archaeological predictive models both within and outside of BC because of their ability to predict site locations. In this model, independent environmental variables related to terrain (elevation, slope, solar incidence, ruggedness and proximity to water) are the inputs and dependant variables (high or not high archaeological potential) the outcomes. When statistically analyzing the terrain variables, the dependant variables were the archaeological events that have occurred (known sites) or have not occurred (no sites). For more details on this predictive model see Canuel & Pritchard (2018).

3.1.2. Detailed Archaeological Review

After the development was received by Norcan, a DAR was conducted. In addition to applying Canuel & Pritchard (2018), this review analyzed data from multiple sources to further refine the archaeological potential within the development and helped to determine survey strategy. The margins along the Nechako River, well-defined terrace landforms and areas near known archaeological sites, were assessed at this stage as having high archaeological potential and were the main focus of field survey. In contrast, areas within the development with no significant hydrological features nearby, low-lying and wet terrain, and steeply sloping or irregular terrain were assessed as having low archaeological potential, these areas were surveyed with this assessment in mind. Among the sources examined include NTS (1:50,000) and TRIM-based (1:20,000) maps, Prince George City Lidar, Prince George City High Resolution Aerial Photography, RAAD, and Norcan's proprietary heritage trail database (Canuel, 2008). Occasionally and as circumstances dictate, published and unpublished sources concerning local and regional history, archaeology, ethnography, and the physical environment were reviewed (Smith, 2019).

3.1.3. Preliminary Field Reconnaissance

In May 2018, a DAR and a PFR were completed by Norcan Consulting Ltd. on the proposed development. During the PFR, areas of high and low archaeological potential were subjected to a stratified pedestrian survey to further refine high potential areas (HPA's) into what would become subsurface test areas (STA's). As a result of this assessment, three areas: an upper, middle and lower paleo-terraces were determined to have high potential for subsurface archaeological materials and would require subsurface testing.

3.1.4. Survey Instruction and Guidance

Prior to the commencement of any fieldwork, detailed work instructions were outlined. This includes but is not limited to determining development access (e.g. by truck and foot), preferred crew size and transect and or subsurface test spacing, highlighting areas of high archaeological potential requiring survey and or subsurface testing, outlining anticipated low potential survey areas, and anticipating additional considerations and directions (e.g. disturbance anticipated from previous development, extraordinary or uncommon safety concerns, etc.). These work instructions were outlined following the completion of the DAR and were written down by the permit holder on Norcan 'field envelopes' including highlighted orthographic and topographic maps of the development. These instructions were also verbally communicated to field directors and supervisors prior to departure to the field.

3.2. In Field Potential Assessment

The project methodology was designed to meet the criteria outlined in the British Columbia Archaeological Impact Assessment Guidelines (Apland & Kenny, 1998). As part of Norcan's daily work and safety awareness program, the survey instructions given to field directors and supervisors were relayed to field assistants upon arrival at the development. During this time safety concerns and AIA protocols matched to field conditions were also discussed and determined. All surveys were carried out under snow free conditions to allow for maximum visibility of archaeological and cultural heritage resources and transects were spaced 10 m (in high potential areas) to 40 m (in low potential areas) apart.

During field survey, crews assessed the development for CMT's, testable HPA's, cultural depressions, heritage trails, surface lithic and faunal materials, and historic structures and features (e.g. root cellars, quarry test pits, etc.). Crews also assessed for landscape features with potential culturally or ecologically significant values. In addition to assessing the landscape, exposed banks, road cuts, tree throws, excavator skidder trails and animal burrows were visually examined for cultural materials. Notes and photographs were taken on vegetation (under and overstory), terrain and hydrology, sediments and strata, and all archaeological and cultural heritage resources encountered.

3.2.1. Crews

Field crews typically consisted of one to two experienced supervisors with one to five field assistants. On occasion, the permit holder was on site to provide guidance to supervisors; however, an experienced field director was always available either in person, or by phone (cell) to instruct supervisors and crew.

3.2.2. HPA Identification

During field survey, landforms were assessed for their potential to contain subsurface archaeological materials. HPA's are locations that are assessed areas determined to be suitable for temporary or permanent habitation, and their identification takes into consideration several variables including slope gradient and aspect, sediment type and moisture content, presence of dry-indicator plant species, proximity to hydrological features, fish and wildlife habitat, and other food and raw material sources. During field assessment, 3 HPA's were identified within the lower, middle and upper terrace portions of the development (Figure 2).

3.2.3. Subsurface Testing

Norcan refers to HPA's that have been evaluated through shovel testing and/or excavator testing as subsurface test areas (STA's). All subsurface testing was completed in accordance with the methodology outlined in HIP 2019-0044. Norcan's subsurface testing methodology included a minimum individual test area of 0.123 m^2 (35 x 35 cm) when conducting shovel tests (ST's), and a minimum individual test area of 0.750 m^2 (50 x 150 cm) when conducting excavator tests (ET's). In addition to shovel testing and excavator testing, an evaluative unit (EU) was placed within STA3 E and within STA1 N, each evaluative unit had an individual test area of 1.000 m² (100 x 100 cm). A total of 7 STA's were evaluated within the 3 previously identified HPA's under HIP 2019-0044. Table 4 lists all STA's and the total number of shovel tests, excavator tests and evaluative units conducted within each, for more details on stratigraphy and sediments descriptions please see Table 5 & 6.

Table 4 Summary of STA's

STA #	# ST's	# ET's	# EU	STA Shape	STA Size m²
STA1	42	43	-	O	6,375
STA1 N	95	-	1	O	6,120
STA2	98	-	-	R	2,784
STA3 E	181	-	1	E	3,636
STA3 W	32	24	-	R	2,880
STA3 NW	49	-	-	E	3,760
STA4	40	41	-	O	9,828
Totals: 7 STA's	**537**	**108**	**2**	**N/A**	**35,383**

Table 5 Subsurface Test Log

STA#	ST/ET #	Depth (cm)	Results	Stratigraphy and Sediment Description (dbs cm)
STA-1	ST 1	80	Negative	0-5 humic; 5-15 brown black silty loam with no inclusions; 15-40 black brown silty clay with no inclusions; 40-75 orange brown silty clay with no inclusions; 75-80+ orange brown sandy silt with 20% rounded gravel and cobble inclusions.
STA-1	ST 11	47	Negative	0-6 humic; 6-8 brown black silty loam with no inclusions; 8-38 orange brown sandy silt with 10% rounded gravel and cobble inclusions; 38-47+ compact orange brown silt with 40% rounded gravel and cobble inclusions.
STA-1	ST 14	31	Negative	0-5 humic; 5-10 brown black silty loam; 10-28 orange brown silty clay with less than 5%; 28-31+ coarse orange brown sand with 40% rounded gravel and cobbles
STA-1	ST 39	40	Negative	0-6 humic; 6-8 brown black silty loam; 8-30 orange brown silty clay with less than 5% rounded inclusions; 30-40+ orange brown sandy silt with 40% rounded gravel and cobble inclusions.
STA-1	ET 2	80	Negative	0-8 humic; 8-16 brown black silty loam with no inclusions; 16-65 orange brown sandy silt with no inclusions; 65-80+ coarse orange brown sand with 70% rounded gravel and cobble inclusions.
STA-1	ET 15	110	Negative	0-10 humic; 10-100 orange brown sandy silt with no inclusions; 100-110+ compact orange brown silty clay with no inclusions.

STA-1	ET 34	90	Negative	0-8 humic; 8-14 brown black silty loam with no inclusions; 14-85 orange brown sandy silt with no inclusions; 85-90+ coarse orange brown sand with 70% rounded gravel and cobble inclusions.
STA-1	ET 43	120	Negative	0-10 humic; 10-20 brown black sandy loam with 20% rounded gravel and cobble inclusions; 20-120+ orange brown sandy silt with 80% gravel and cobble inclusions.
STA-1-North	ST 20	40	Negative	0-5 humic; 5-8 brown black silty loam with no inclusions; 8-35 orange brown sandy silt with no inclusions; 35-40+ orange grey silty sand with no inclusions.
STA-1-North	ST 50	50	Negative	0-3 humic; 3-5 brown black silty loam with no inclusions; 5-23 orange brown sandy silt with no inclusions; 23-50+ orange grey silty sand with no inclusions.
STA-1-North	ST 72	50	Negative	0-6 humic; 6-10 brown black silty loam with no inclusions; 10-27 orange brown silt with no inclusions; 27-50+ orange brown silty clay with no inclusions.
STA-1-North	ST 84	49	Negative	0-8 humic; 8-11 brown black silty loam with no inclusions; 11-30 orange brown silt with no inclusions; 30-49+ orange brown silty clay with no inclusions.
STA-1-North	ST 95	47	Negative	0-6 humic; 6-8 brown black silty loam with no inclusions; 8-30 orange brown silt with no inclusions; 30-47+ orange brown silty clay with no inclusions.
STA-2	ST 10	35	Negative	0-8 humic; 8-35+ orange brown silty sand with 70% rounded and sub-rounded gravel and cobble inclusions.
STA-2	ST 22	40	Negative	0-14 humic; 14-18 brown black sandy loam; 18-40+ orange brown silty sand with 70% rounded and sub-rounded gravel and cobble inclusions.
STA-2	ST 34	38	Negative	0-12 humic; 12-38+ orange brown silty sand with 70% rounded and sub-rounded gravel and cobble inclusions.
STA-2	ST 50	32	Negative	0-10 humic; 10-32+ orange brown silty sand with 70% rounded and sub-rounded gravel and cobble inclusions.
STA-2	ST 52	30	Negative	0-10 humic; 10-30+ orange brown silty sand with 70% rounded and sub-rounded gravel and cobble inclusions.
STA-2	ST 68	36	Negative	0-12 humic; 12-14 brown black silty loam with no inclusions; 14-36+ orange brown silty sand with

				70% rounded and sub-rounded gravel and cobble inclusions.
STA-2	ST 75	35	Negative	0-12 humic; 12-13 brown black silty loam with no inclusions; 13-35+ orange brown silty sand with 70% rounded and sub-rounded gravel and cobble inclusions.
STA-2	ST 90	33	Negative	0-10 humic; 10-33+ orange brown silty sand with 70% rounded and sub-rounded gravel and cobble inclusions.
STA-2	ST 93	31	Negative	0-8 humic; 8-31+ orange brown silty sand with 70% rounded and sub-rounded gravel and cobble inclusions.
STA-3-East	ST 1	37	Negative	0-13 humic; 13-37+ orange brown silty sand with 70% rounded and sub-rounded gravel and cobble inclusions.
STA-3-East	ST 16	37	Negative	0-11 humic; 11-37+ orange brown silty sand with 70% rounded and sub-rounded gravel and cobble inclusions.
STA-3-East	ST 31	38	Negative	0-14 humic; 14-38+ orange brown silty sand with 70% rounded and sub-rounded gravel and cobble inclusions.
STA-3-East	ST 46	30	Negative	0-7 humic; 7-30+ orange brown silty sand with 70% rounded and sub-rounded gravel and cobble inclusions.
STA-3-East	ST 47	35	Negative	0-6 humic; 6-14 brown black silty loam with no inclusions; 14-35+ orange brown silty sand with 70% rounded and sub-rounded gravel and cobble inclusions.
STA-3-East	ST 51	31	Negative	0-10 humic; 10-31+ orange brown silty sand with 70% rounded and sub-rounded gravel and cobble inclusions.
STA-3-East	ST 63	35	Negative	0-6 humic; 6-15 brown black sandy loam with no inclusions; 15-35+ coarse orange brown sand with 70% rounded and sub-rounded gravel and cobble inclusions.
STA-3-East	ST 93	32	Negative	0-6 humic; 6-17 brown black sandy loam with 20% rounded and sub-rounded gravel and cobble inclusions; 17-32+ coarse orange brown sand with 70% rounded and sub-rounded gravel and cobble inclusions.
STA-3-East	ST 116	57	Negative	0-8 humic; 8-17 brown black sandy loam with 20% rounded and sub-rounded gravel and cobble inclusions; 17-57+ coarse orange brown sand with 80% rounded and sub-rounded gravel and cobble inclusions.
STA-3-East	ST 131	34	Negative	0-6 humic; 6-8 brown black sandy loam with 20% rounded and sub-rounded gravel and cobble inclusions; 8-26 orange brown silty sand with 60% rounded and sub-rounded gravel and cobble inclusions; 26-34+ coarse orange brown sand with

				80% rounded and sub-rounded gravel and cobble inclusions.
STA-3-East	ST 141	35	Negative	0-5 humic; 5-7 brown black sandy loam with 20% rounded and sub-rounded gravel and cobble inclusions; 7-23 orange brown silty sand with 60% rounded and sub-rounded gravel and cobble inclusions; 23-35+ coarse orange brown sand with 80% rounded and sub-rounded gravel and cobble inclusions.
STA-3-East	ST 151	25	Negative	0-4 humic; 4-6 brown black sandy loam with 20% rounded and sub-rounded gravel and cobble inclusions; 6-23 orange brown silty sand with 60% rounded and sub-rounded gravel and cobble inclusions; 23-25+ coarse orange brown sand with 80% rounded and sub-rounded gravel and cobble inclusions.
STA-3-East	ST 162	34	Negative	0-6 humic; 6-10 brown black sandy loam with 20% rounded and sub-rounded gravel and cobble inclusions; 10-24 orange brown silty sand with 60% rounded and sub-rounded gravel and cobble inclusions; 24-34+ coarse orange brown sand with 80% rounded and sub-rounded gravel and cobble inclusions.
STA-3-East	ST 167	26	Negative	0-6 humic; 6-9 brown black sandy loam with 20% rounded and sub-rounded gravel and cobble inclusions; 9-22 orange brown silty sand with 60% rounded and sub-rounded gravel and cobble inclusions; 22-26+ coarse orange brown sand with 80% rounded and sub-rounded gravel and cobble inclusions.
STA-3-West	ST 1	35	Negative	0-7 humic; 7-18 orange brown silty sand with 70% rounded and sub-rounded gravel and cobble inclusions; 18-35+ coarse orange brown sand with 80% rounded and sub-rounded gravel and cobble inclusions.
STA-3-West	ST 32	29	Negative	0-7 humic; 7-17 orange brown silty sand with 70% rounded and sub-rounded gravel and cobble inclusions; 17-29+ coarse orange brown sand with 80% rounded and sub-rounded gravel and cobble inclusions.
STA-3-West	ET 1	91	Negative	0-9 humic; 9-20 orange brown silty sand with 70% rounded and sub-rounded gravel and cobble inclusions; 20-78 coarse orange brown sand with 80% rounded and sub-rounded gravel and cobble inclusions; 78-91+ coarse orange grey sand with 80% gravel inclusions.
STA-3-West	ET 24	115	Negative	0-10 humic; 10-22 orange brown silty sand with 70% rounded and sub-rounded gravel and cobble inclusions; 22-65 coarse orange brown sand with 80% rounded and sub-rounded gravel and cobble inclusions; 65-115+ coarse orange grey sand with 80% gravel inclusions.

STA-3-Northwest	ST 1	38	Negative	0-10 humic; 10-30 orange brown silty sand with 50% rounded and sub-rounded gravel and cobble inclusions; 30-38+ coarse orange grey sand with 60% rounded and sub-rounded gravel inclusions.
STA-3-Northwest	ST 16	37	Negative	0-10 humic; 10-30 orange brown silty sand with 50% rounded and sub-rounded gravel and cobble inclusions; 30-37+ coarse orange grey sand with 60% rounded and sub-rounded gravel inclusions.
STA-3-Northwest	ST 28	30	Negative	0-10 humic; 10-28 orange brown silty sand with 50% rounded and sub-rounded gravel and cobble inclusions; 28-30+ coarse orange grey sand with 60% rounded and sub-rounded gravel inclusions.
STA-3-Northwest	ST 33	40	Negative	0-10 humic; 10-30 orange brown silty sand with 50% rounded and sub-rounded gravel and cobble inclusions; 30-40+ coarse orange grey sand with 60% rounded and sub-rounded gravel inclusions.
STA-3-Northwest	ST 43	35	Negative	0-10 humic; 10-30 orange brown silty sand with 50% rounded and sub-rounded gravel and cobble inclusions; 30-35+ coarse orange grey sand with 60% rounded and sub-rounded gravel inclusions.
STA-4	ST 1	40	Negative	0-9 humic; 9-16 brown black silty loam with no inclusions; 16-38 orange brown sandy silt with 70% rounded and sub-rounded gravel and cobble inclusions; 38-40+ coarse orange grey sand with 80% rounded and sub-rounded gravel inclusions.
STA-4	ST 16	45	Negative	0-10 humic; 10-13 brown black silty loam with no inclusions; 13-35 orange brown sandy silt with 70% rounded and sub-rounded gravel and cobble inclusions; 35-45+ coarse orange grey sand with 80% rounded and sub-rounded gravel and cobble inclusions.
STA-4	ST 30	48	Negative	0-7 humic; 7-10 brown black silty loam with no inclusions; 10-27 orange brown sandy silt with 50% rounded and sub-rounded gravel and cobble inclusions; 35-48+ coarse orange grey sand with 80% rounded and sub-rounded gravel and cobble inclusions.
STA-4	ST 37	50	Negative	0-8 humic; 8-16 brown black silty loam with no inclusions; 16-50+ orange brown sandy silt with 50% rounded and sub-rounded gravel and cobble inclusions.
STA-4	ET 1	120	Negative	0-8 humic; 8-12 brown black silty loam with no inclusions; 12-45 orange brown sandy silt with 40% rounded and sub-rounded gravel, cobble and boulder inclusions; 45-120+ coarse orange grey sand with 70% rounded and sub-rounded gravel and cobble inclusions.

STA-4	ET 19	120	Negative	0-10 humic; 10-13 brown black silty loam with no inclusions; 13-30 orange brown sandy silt with 30% rounded and sub-rounded gravel, cobble and boulder inclusions; 30-88 coarse orange grey sand with 70% rounded and sub-rounded gravel and cobble inclusions; 88-120+ coarse orange grey sand with 30% rounded and sub-rounded gravel inclusions.
STA-4	ET 24	157	Negative	0-10 humic; 10-13 brown black silty loam with no inclusions; 13-49 orange brown sandy silt with 30% rounded and sub-rounded gravel, cobble and boulder inclusions; 49-71 coarse orange grey sand with 15% rounded and sub-rounded gravel and cobble inclusions; 71-157+ coarse orange grey sand with no inclusions.
STA-4	ET 40	130	Negative	0-10 humic; 10-14 brown black silty loam with no inclusions; 14-52 orange brown sandy silt with 30% rounded and sub-rounded gravel, cobble and boulder inclusions; 52-130+ coarse orange grey sand with no inclusions.
STA-4	ET 41	118	Negative	0-10 humic; 10-17 brown black silty loam with no inclusions; 17-67 orange brown sandy silt with 70% rounded and sub-rounded gravel, cobble and boulder inclusions; 67-118+ coarse orange grey sand with 80% rounded and sub-rounded gravel and cobble inclusions.

Table 6 Evaluative Test Log

TSN#	EU #	Depth (cm)	Results	Stratigraphy and Sediment Description (dbd cm)
TSN19-NorthNechako Developments -SSL2	EU1	37-50	Negative	0-10 humic; 10-22 brown black sandy loam with 30% rounded and sub-rounded gravel and cobble inclusions; 22-50+ coarse orange brown sand with 70% rounded and sub-rounded gravel and cobble inclusions. No additional lithics were collected during EU testing.

* Datum 10 cm above surface.

The amount, spacing, and patterning of ST's and ET's were determined based on the size, shape, and characteristics of an STA (Figure 2). For instance, the linear landforms such as a terrace edge, are generally more suited to a systematic testing pattern where ST's and ET's are placed in two or more (parallel) rows and spaced at regular intervals across the STA. Heavy blowdown or significant tree cover within an STA may prohibit a systematic testing pattern from being followed as it prevents access to subsurface deposits at regular intervals. The inaccessibility caused by blowdown also effectively decreases the size of a testable area. Depending on these and other factors, sometimes a combined systematic and judgmental testing pattern may be warranted.

Mechanical excavations were conducted using an excavator whenever possible due to the amount of displaced disturbed potential cultural deposits, obscured potential cultural deposits, and excessive depths of potential cultural deposits. During excavator testing, 100% of potentially cultural bearing deposits were screened by hand, and minimally 25% of displaced disturbed potential cultural deposits were sample screened/raked by hand. In order to collect precise artifact provenience, sediments were removed using a small toothed bucket due to the large amounts of boulder and cobble inclusions, in maximum 10 cm lifts. All mechanical excavations were directed by a qualified archaeologist (ie. Permit holder, supervisor).

ST's measured at least 35 cm x 35 cm and ET's measured at least 50 cm x 150 cm with variable depths depending on the nature of sediments, depth of culturally sterile subsoil, and if significant impediments (e.g. large roots, boulders, etc.) were encountered. All excavated sediments were passed through ¼-inch mesh screen. ST's and ET's were labeled with consecutive numbers (e.g. ST1, ST2, ET1, ET2, etc.), and their locations were plotted on a field map created to scale by hand on graph paper using a compass, ruler and tape measure. Stratigraphic profiles of all positive and a sample of negative ST's and ET's were recorded and photographed. All EU's were recorded with a GPS unit, photographed and mapped by level/layer (10 cm increments), excavated in quadrants (50 cm x 50 cm) and a stratigraphic profile drawing was completed on each. All positive ST's and all EU's were also recorded with a GPS unit via an averaging waypoint function, to obtain a precise location.

3.2.4. Analysis of Archaeological Materials

When archaeological (e.g. lithic) materials were recovered they were analyzed according to morphological and functional variables and catalogued following a nested typology beginning with two main categories: tools and debitage. The tool category includes implements such as unifaces, bifaces, projectile points, hammerstones, etc., whereas the debitage category includes primary, secondary and tertiary waste flakes and cores resulting as a by-product of stone tool manufacture. Only debitage was recovered under this permit and it was examined for utilization (i.e. use-wear) and retouch and described according to raw material type and flake typology. Metric attributes such as weight, length, width and thickness were not recorded as this data is reserved for tools.

3.2.5. Archaeological Site Recording

Effective evaluation of an archaeological site requires that its content, size and location be carefully recorded. The extent of lithic site TSN19-NorthNechakoDevelopments-SSL1, was delineated through systematic shovel testing whereby ST's were placed radiating from positive ST's. Delineation of the northern, western and southern margins of the site was accomplished following a 2.5 to 5 meter interval subsurface testing pattern until three or more negative tests were encountered in each direction. Delineation of the eastern margin of the site was not accomplished due to the encroachment of private property. The eastern margin is arbitrary, and it is reasonable to assume the site could extend in this direction.

The extent of lithic site TSN19-NorthNechakoDevelopments-SSL2, was delineated through a combined systematic and judgemental testing pattern whereby tests were placed systematically radiating from positive ST's, and judgementally following the edge of the terrace landform. Delineation of the site was accomplished following a 1 to 2.5 meter interval testing pattern until three or more negative ST's were encountered in each direction, or, until the edge of the landform was reached.

All positive ST's and the positive EU were photographed, recorded with a GPS unit, and had their stratigraphic profiles recorded. A sample of negative ST's and ET's were also photographed and had their stratigraphic profiles recorded (Tables 5 & 6). The landforms containing the sites and general site areas were also photographed and recorded. The site areas, including all positive and negative ST locations, landform features, and margins, were mapped to scale by hand on graph paper using a compass, ruler and tape measure. The site boundaries were recorded using a GPS unit and flagged with yellow and red 'Special Management Zone' ribbon. Each piece of flagging had the temporary site name, company affiliation, date and supervisor's initials written on them with permanent marker. GPS data was uploaded into ArcMap 10.3.1 and combined with the hand-drawn maps to produce detailed digital site maps.

4. Impact Assessment Results

4.1. Proposed Development

A summary of the results from the AIA performed under HIP 2019-0044 is listed below and provided in Table 7. More detailed information, including maps showing areas surveyed within the development, and the locations of STA's, and archaeological sites, can be found within Figures 1, 2, 3, 4 & 5, and Tables 2, 3, 4 & 7.

- Two protected archaeological sites (TSN19-NorthNechakoDevelopments-SSL1 and TSN19-NorthNechakoDevelopments-SSL2) located within STA1 North and STA3 East.

- Seven STA's (five negative and two positive)

- T.R. Projects Ltd. elected to exclude a 30 meter wide reserve along the edge of the Nechako River to reduce costs with covenants placed on the appropriate lots.

Table 7 2019-0044 Project Result Summary

STA's	STA (ha)	Arch Sites	Arch Site (ha)
7	3.5383	2	.0358

4.2. Archaeological Sites

TSN19-NorthNechakoDevelopments-SSL1 is a subsurface lithic site within STA1 N located on a plain of the lower terrace approximately 100 m north of the margin of the Nechako River, along the eastern boundary of the proposed development (Figures 2, 3 & 4). A total of 95 ST's ranging in depth from 30 cm to 60 cm (dbs)and one evaluative unit ranging in depth from 48 cm to 55 cm (dbd) were placed at STA1 N. The site area measures approximately 19.5 m by 24 m and contains 24 ST's, six of which produced positive results for lithic debitage. One evaluative unit was also placed within the site's boundaries with positive results. All site data and shapefiles were sent to T.R. Projects Ltd. and the Archaeology Branch.

TSN19-NorthNechakoDevelopments-SSL2 is a subsurface lithic site (isolated find) within STA3 E located on the upper terrace feature approximately 145 m north of the margin of the Nechako River, within the eastern portion of the proposed development (Figures 2, 4 & 5). A total of 181 ST's ranging in depth from 21 cm to 74 cm (dbs) and one evaluative unit ranging in depth from 38 cm to 50 cm (dbd) were placed at STA3 E. The site area measures 5 m by 5 m and contains seven ST's, one of which produced a single primary proximal lithic flake debitage. One evaluative unit was also placed within the site's boundaries with negative results. All site data and shapefiles were sent to T.R. Projects Ltd.

and the Archaeology Branch.

4.3. Archaeological Site Significance

Following the British Columbia Archaeological Impact Assessment Guidelines (Apland & Kenny, 1998), archaeological sites are assigned a value to represent their overall significance to the people, economy and scientific community of British Columbia. This value is a recommendation that takes into consideration a site's scientific, public, historic, ethnic and economic significance, and is considered by the Archaeology Branch when determining an appropriate management strategy for a site.

The overall significance of site TSN19-NorthNechakoDevelopments-SSL1 is considered low. The ethnic significance of archaeological sites is always considered moderate to high by the concerned First Nations in whose territory a site is located. However, the site itself is a small subsurface lithic scatter, has a low density of artifacts, lacks formal and diagnostic tools, and has been thoroughly tested. As such, the site offers only minimal public, scientific, historical, and economic value.

The overall significance of site TSN19-NorthNechakoDevelopments-SSL2 is considered low. The ethnic significance of archaeological sites is always considered moderate to high by the concerned First Nations in whose territory a site is located. However, the site itself is an isolated lithic find, lacks formal and diagnostic tools, and has been thoroughly tested. As such, the site offers only minimal public, scientific, historical, and economic value.

Figure 3 Detailed Site Map TSN19-NorthNechakoDevelopments-SSL1

REDCATED

Figure 5 Detailed Site Map TSN19-NorthNechakoDevelopments-SSL2

5. Impact Management Recommendations

The primary objective of this project was to assess the proposed residential subdivision 2259 North Nechako Road and 4439 Craig Drive to ensure that any archaeological resources present would not be impacted by development activities. A summary of Norcan's management recommendations and proponent mitigation strategies for all archaeological and cultural heritage concerns identified within the development, assessed under HIP 2019-0044, is listed below.

- It was recommended that site TSN19-NorthNechakoDevelopments-SSL1 and TSN19-NorthNechakoDevelopments-SSL2 be excluded from the development area through project redesign, or if avoidance is not feasible, then an SAP pursuant to Section 12 of the HCA would be required to further assess the site prior to development activities. The sites may be avoided by excluding site boundaries from the development area and leaving a wind-firm buffer around the sites.

- T.R. Projects Ltd. has agreed to a minimum 30 meter reserve to be added to the landforms located along the margins of the Nechako River to avoid any potential subsurface archaeological materials that may be located within these areas and reduce costs (Figure 2 & 4).

- Assuming boundary alterations to avoid sites, the 30 meter reserve is adhered to by T.R. Projects Ltd. and no further changes to the development are made, no further archaeological investigations were recommended.

- T.R. Projects Ltd. was made aware that even the most thorough AIA may fail to locate all archaeological resources. If hitherto unidentified archaeological resources are encountered during development activities, it was recommended that all ground disturbance operations within the vicinity of the find(s) should be suspended immediately, and the Ministry of Forests, Lands, and Natural Resource Operations and the Archaeology Branch should be informed as soon as possible.

6. Project Evaluation

6.1. Predicted vs. Confirmed Archaeological Potential

In this project, the gap between archaeological potential predicted during the DAR and realized during field surveys was quite minimal, the areas subjected to subsurface testing corresponded with HPA's identified during pre-field assessment, and two archaeological sites were located within these HPA's. By design, predictive models and the DAR process over-predict archaeological potential to capture as many resources as possible. Surveys, in turn, are required to confirm or downgrade this potential based on in-field observations.

During this project only one of the areas of high archaeological potential identified (Middle Terrace portion and STA4) during the DAR was subsequently reclassified as having low archaeological potential. Negative results from subsurface testing, poorly draining to low-lying and wet terrain, slopes exceeding 15 %, a 30 meter reserve effectively excluding any HPA's located along the margins of the terrace edge and a high level of past disturbances (i.e. farming, housing development, quarry operations, etc.) were the main reasons for downgrading archaeological potential.

6.2. Suitability of Survey Techniques and Results

The most likely areas to contain archaeological and cultural heritage resources are found along the margins of hydrological features, and this criterion carries the most weight when predicting archaeological potential. During this project, the margins of the Nechako River have been given a significant reserve that effectively excludes any HPA's located along the margins of this hydrological resource. Given our understanding of the relationship between past land use patterns and archaeological potential, we believe the survey coverage and methodology adhered to during this project was more than sufficient to ensure that any archaeological and cultural heritage resources present in the assessed development were properly identified and managed.

6.3. Recommendations for Improvement

The abundance, types and locations of archaeological sites found to date are, to a large extent, a product of (past and present) survey and testing strategies employed in response to industry and development. Recommendations for narrowing this gap and establishing a more varied and comprehensive archaeological record that better represents past indigenous lifeways are as follows:

- Surveying and testing in high potential areas near major waterbodies, rather than excluding them from development areas, may result in the identification of larger, and more significant sites and site types (e.g. villages, major hunting camps, etc.).

- Surveying and testing in non-high potential areas may result in the identification of a greater quantity of sites and variety of site types in surprising areas.
- Sites found in non-high potential areas may elicit unknown, or under-utilized, variables for determining archaeological potential.
- There is often a substantial lag between the time archaeological sites are found and when site information is available to consultants through either RAAD or PARL. Having new site information available more quickly may increase the efficacy of pre-field predictions concerning archaeological potential.
- Although TUS's represent the lifeways of First Nations peoples during the recent past, they indirectly inform us about indigenous lifeways in the more distant past as well. However, unlike data on archaeological sites that are widely accessible in RAAD and PARL, information on TUS's is not easily or widely available to consultants. Making TUS data more available may increase the efficacy of pre-field predictions concerning archaeological potential.

References

Altschul, J. (1988). Models and the Modeling Process. In J. Judge, & L. Sebastian, *Qunatifying the Present and Predicting the Past: Theory, Method, and Application of Archaeological Predictive Modeling* (pp. 61-96). Denver: U.S. Department of the Interior, Bureau of Land Management Service Center.

Apland, B., & Kenny, R. (1998). British Columbia Archaeological Impact Assessment Guidelines. Victoria, BC. British Columbia Archaeology Branch

Bishop, C. (1983). Limiting Access to Limited Goods: The Origins of Stratification in Interior British Columbia. In E. Tooker, *The Development of Political Organization in Native North America.* 1979 Proceedings of the American Ethnological Society.

Blacklaws, R. (1980). *Kluskus Oral History Program and Preliminary Grease Trail Impact Statement.* Victoria, BC: British Columbia Archaeology Branch.

Bond, L., & Russell, S. (1992). *The Carrier of Long Ago.* Prince George, BC: Canadian Cateloging Publication Data.

Borden, C. (1951). *Results of a Preliminary Survey of the Nechako Reservoir in West Central, BC.* Victoria, BC: British Columbia Archaeology Branch.

Borden, C. (1952). Results of Archaeological Investigations in Central British Columbia. In W. Duff, *Anthropology in British Columbia Volume 3* (pp. 31-43). Victoria, BC: British Columbia Provincial Museum.

British Columbia Archaeology Branch. (2009). *Archaeological Overview Assessments as General Land Use Planning Tools - Provincial Standards and Guidelines.* Victoria, BC: Ministry of Forests, Lands and Natural Resource Operations: Archaeology Branch.

British Columbia Archaeology Branch. (2016). Remote Access to Archaeological Data (RAAD). Victoria, BC.

Burford, A., Jackman, N., & Cogswell, A. (2008). *Archaeological Investigations at Site FlRq-13 on the Fraser River in Prince George, BC.* Victoria, BC: British Columbia Archaeology Branch.

Canuel, N. (2008). Trail Database for Central and Northern British Columbia. Prince George, BC. Norcan Consulting Ltd.

Canuel, N., & Pritchard, B. (2018). Managing Cultural Heritage Resources within the City of Prince George: The Archaeological Risk Framework Tool. Prince George, BC. Norcan Consulting Ltd.

Carlson, A. (1995). *Archaeological Sites of the Nechako Canyon, Cheslatta Falls and Vicinity, Central Interior BC.* Victoria, BC: British Columbia Archaeology Branch.

Carlson, R. (1996). The First British Columbians. In H. Johnston, *The Pacific Province: A History of British Columbia*. Burnaby, BC: Department of History, Simon Fraser University.

Cassidy, M., & Cassidy, F. (1981). *Proud Past: a history of the Wet'suwet'en of Moricetown, B.C.* Victoria, BC: Ministry of Small Business, Tourism and Culture.

Clague, J. (1988). Quaternary stratigraphy and history, Quesnel, British Columbia. Geographie physique et Quaternaire 42, 279-288.

Clague, J., Hebda, R., & Mathewes, R. (1990). Stratigraphy and paleoecology of Pleistocene interstadial sediments, central British Columbia. Quaternary Research 34, 208-226.

Clark-Giesbrecht, J. (1994). Heritage Lost A People's History of the Ootsa Lake Region 1905-1955. Likely, BC: Quesnel Lake Publishing.

Cole, D., & Lockner, B. (. (1989). The Journals of George Dawson: British Columbia, 1875-1878. Vol. 1, 1875-1876. Vancouver, BC: University of BC Press.

Diaz, R. (1992). An Environmental History of Prince George, British Columbia. London, Ontario: M.A. Thesis, Department of History, University of Western Ontario.

Donahue, P. (1976). Excavations at Algatcho and Tezli on the Central Interior Plateau of British Columbia. Wisconsin: University of Wisconsin.

Duff, W. (1952). Notes on Carrier Social Organization. Anthropology in BC 2, 28-34.

Fladmark, K. (1976). Punchaw Village: A Preliminary Report. Burnaby: Department of Archaeology, Simon Fraser University.

Fladmark, K. (1986). British Columbia Prehistory. Ottawa, ON: Archaeological Survey of Canada. National Museum of Man.

Fladmark, K. (1999). The Prehistory of Northern Interior British Columbia. Canadian Journal of Archaeology.

Fraser, S. (1960). The Letters and Journals of Simon Fraser, 1806-1818. (W. Lamb, Ed.) Toronto: Macmillan.

Furniss, E. (1993). Dakelh Keyoh: the Southern Carrier in Earlier Times. Quesnel, BC: Quesnel School District.

Hall, L. (1992). The Carrier My People. Cloverdale, BC: Friesen Printers.

Harmon, D. (1820). Journal of Voyages and Travels in the Interior of North America. Andover: Flag and Gould.

Helmer, J. (1977). Points, People and Prehistory: A Preliminary Synthesis of Culture History in North Central British Columbia. Edmonton, AB: Unpublished PhD Dissertation, Department of Anthropology, University of Alberta.

Holland, S. (1976). Landforms of British Columbia, a Physiographic Outline. Victoria, BC: British Columbia Department of Mines and Petroleum Resources.

Hooper, C. (1978). In the Footsteps of Their Ancestors: Aboriginal Trails as a Cultural Heritage Resource. Victoria, BC: Ministry of Forests, Vanderhoof Forest District.

Hudson, D. (1972). The Historical Determinants of Carrier Social Organization: A Study of Northwest Athabascan Matriliny. Hamilton: Unpublished MA Thesis, Department of Anthropology, McMaster University .

Hudson, D. (1983). Traplines and Timber: Social and Economic Change Among the Carrier Indians of Northern BC. Edmonton, AB: Unplublished PhD Dissertation, University of Alberta.

Jenness, D. (1943). The Carrier Indians of the Bulkey River: Their Social and Religious Life. Bureau of American Ethnology, Bulletin 133, Anthropology Paper 25, 469-586.

Klippenstein, F. E. (1992). The role of the carrier Indians in the fur trade at Fort St. James, 1806-1915 : a report from historical and anthropological sources. Fort St. James, BC: Canadian Heritage, Parks Canada.

MacKenzie, A. (1970). The Journals and Letters of Sir Alexander MacKenzie. (W. Lamb, Ed.) Cambridge: Hakluyt Society at the University Press.

Morice, A. (1893). Notes: Archaeological, Industrial, Sociological, on the Western Denes, with an Ethnographical Sketch of the Same. In Transactions of the Canadian Institute, Sessions 1892-1893.

Morice, A. (1905). The History of the Northern Interior of British Columbia (formerly New Caledonia), (1660-1880). Toronto: William Briggs.

Runnalls, F. (1946). A History of Prince George. Vancouver, BC: Wrigley Printing Company Ltd.

Sacco, D. (2012). Quaternary geology in part of the McLeod Lake map area (NTS 093J), central British Columbia. Burnaby: Unpublished M.Sc thesis, Department of Earth Sciences, Simon Fraser University.

Smith, J. (2019) Personal interviews by B. Nuttall (oral) between April and May 2019 regarding past disturbances in the project area.

Tipper, H. (1971a). Glacial geomorphology and Pleistocene history of central British Columbia. Ottawa: Geological Survey of Canada, Bulletin 196.

Tobey, M. (1981). Carrier. In J. Helm, & W. Sturtevant, Handbook of North American Indians, Vol. 6: Subarctic (pp. 413-432). Washington DC: Smithsonian Institution Scholarly Press.

Vogt, D., & Gamble, D. (2010). "You Don't Suppose the Dominion Government Wants to Cheat the indians?": The Grand Trunk Pacific Railway and the Fort George Reserve, 1908-12. BC Studies 166, 55-72.

Appendices

Appendix A: Lheidli-T'enneh Historical Timeline

Appendix B: Project Photos

Appendix C: 2019-0044 Permit

Lheidli T'enneh

Appendix A. Lheidli T'enneh Historical Timeline

5487 BC

Lithic evidence supports the conclusion that indigenous peoples occupied the area between 7500 and 9000 years ago. There were two digs in the last forty years that uncovered artifacts that have been scientifically dated.

The governance system in the past was originally conducted by extended family heads, but by the time of European contact was through the Bahtlats. This community involved process provided for participatory decision making. It was also utilized for specific purposes such as coming of age, marriage, death, sharing of wealth and food. There are several clan and sub-clans and each had a male (dene zah) and a female (tseke zah) head person. The Lheidli T'enneh clans were frog (lasilyoo), grouse ('utsut), beaver (tsa) and bear (Sus). There was also a medicine person who was held in high standing within the community. This person dealt with the physical, mental, emotional and spiritual well-being of the community members.

The roles in the community centered on the gathering, preparation and storage of caribou, salmon, berries, plants and medicines. Each member had a role and a responsibility; the lives of all the community members depended on it.

Oral history was the means of transferring knowledge. The use of legends was very important to express past occurrences and to pass on information.

1763 Royal Proclamation of King George III. The document provides for commitments to the Indians of Canada. One of the commitments was to enter into Treaties.

1793 Alexander Mackenzie travels through Lheidli territory and follows ancient Grease trail to Nuxalk territory. First contact with Lheidli T'enneh was probably at Fort George canyon on June 19.

1807 Simon Fraser establishes an advanced camp at Lheidli to explore Fraser River to the ocean.

1808 For the next 50 years the fur trade would be dependent on the Indians to supply labor for building and hauling but more importantly for dried salmon for food. This compromised the fur trader's ability to only exchange trade goods for furs, forcing them to supply credit and at times cash purchases.

1820 Hudson Bay Company (HBC) establishes temporary trading post at confluence of Chilako and Nechako rivers.

1821 HBC and Northwest Trading Company amalgamate.

1823 HBC establishes trading post at Lheidli.

1824 HBC closes trading post at Lheidli.

1829 HBC re-opens trading post at Lheidli till 1915.

1836 Small Pox epidemic in northern British Columbia.

1839 First census of Lheidli village: 75 men, 50 women and 62 children for a total of 187.

1850 Measles epidemic.

1861 *Country Land Act* set the value of unsurveyed and auctioned land in the colony of British Columbia at "four shillings and twopence" per acre.
1861 *Pre-emption Purchase Act* and *Pre-emption Consolidation Act* refined the system of granting land to settlers, even though most of the land had not yet been subject to treaty negotiations
1861 Colonial policy for the establishment of Reserve lands.
1862 Peak of the Cariboo gold rush
1867 Canada confederates as a nation under the *British North American Act* (BNA) which serves as the base document for the Canadian constitution. The BNA set out the rules for the government of the new federal nation. It established a British style parliament with a House of Commons and Senate and set out the division of powers between the federal and provincial governments.*s.91 (24)* gives the Federal Government of Canada exclusive legislative responsibility for "Indians and lands reserved for the Indians".
1867 St. Joseph's mission established at Williams Lake.
1867 HBC establishes Barkerville fur trading post.
1870 Economic depression in B.C.
1871 Indians not allowed to fish commercially.
1871 British Columbia enters confederation. Article 13 of the Terms of Union transfers to Canada jurisdiction over Indians and all Indian Reserves (surveyed) in the Province of B.C.
1872 Small pox epidemic in B.C.
1872 The right to vote in BC elections withdrawn from Indians.
1875 Revised *BC Land Act* provides for Indian reserves (s. 60).
1875 Land available to settlers free of charge.
1876 First Federal *Indian Act* passed, consolidates all previous legislation concerning Indians.
1876 Order in Council proclaims that the *Fisheries Act* of Canada extends to B.C.
1876 Indian people excluded from voting in Municipal elections.
1877 Federal *Fisheries Act* takes effect.
1877 Federal Minister of Public Works presents order in council 486 to utilize Fort George as a route for proposed Pacific Railway line.
1880 *Indian Act* amendment prohibits Indians from assembling. In effect to 1927.
1885 *Indian Act* amendment prohibits Indians from holding Potlatch's. In effect to 1951.
1885 Father Morice active in Northern B.C. He handed out titles to Indians as "church chiefs" and watchman, while the trading posts had "fur trade chief" and Indian agents had native police, all claiming to be leader. This led to factionalism within the bands and to the demise of the traditional hereditary and community chief system.
1886 HBC establishes trading post at Stoney Creek.
1888 Federal policy creates Indian food fishery; Indians not allowed to fish commercially.
1888 Small pox epidemic.
1890 Indian Reserve Commissioner O'Reilly directed to not allot fishing privileges.
1891 Federal government grants BC railways 100 foot rights of way through crown lands.
1892 O'Reilly surveys Fort George Indian reserves.
1893 Economic Depression.
1893 On April 14th Fort George reserves approved.
1895 *Indian Act* amended to create current Chief and Council election system.
1897 Indian fishing devices destroyed by federal officials.
1901 Largest sock eye run on the Fraser River recorded to date.

1903 Incorporation of Grand Trunk Pacific Railway.
1906 Delegation of BC Chiefs meets with King Edward to discuss the Indian Land Question.
1906 *Railway Belt Act* approved.
1906 Barricade (fishing) Agreements signed with Lake Babine.
1907 Economic recession.
1907 Negotiations begin for the sale of Ft. George I.R. #1.
1908 Lheidli members reject offer for sale of I.R. #1.
1909 Lheidli members reject second offer for the sale of I.R. #1.
1911 Barricade (fishing) Agreements signed with Fort Fraser and Fort St James Bands.
1911 Controversial sale of IR #1 on November 18. This sale is currently a specific claim in the federal specific claims resolution process. The Band was not paid the market value of the land. There are questions in regards to why two other offers were rejected by the federal government. There is the issue of the Grand Trunk Pacific Railway only requiring eighteen acres of land to build their rail lines and station. The remainder of the 1466 acres were sold the next year for over one million dollars.
1912 Economic depression.
1912 Pacific Great Eastern Railway is incorporated.
1913 On September 7^{th} remaining members of Lheidli were forced off the village site against their will, removed from homes and village was burnt to the ground.
1913 As part of the sale of Lheidli village, contractors constructed approximately 20 new houses and St. Pius X church at Khas T'an Lhe Ghulgh, Reserve No.2, (Bundle of Fireweed), and 4 houses at Hlez Ba Nee Chek, Reserve No.3, (Lake Behind the Dirt). While the new homes looked nice, they were constructed from poorly seasoned lumber that continued to shrink, making the houses drafty, cold and unsuitable for the winters in this area.
1914 Grand Trunk Pacific Railway completes construction in Northern B.C.
1917 Federal Government imposes further fishing restriction.
1917 Mission residential school established in fort St. James, for Indian children from north central BC. It was decided that the Nakazlie reserve was too close and that the parents were interfering with the re-education of their children.
1918 First World War ends.
1918 Spanish Flu kills many Indians in B.C.
1920 B.C. Indian population reaches lowest point on record.
1922 A site considered removed enough from Indian reserves and villages was chosen for the new Lejac Residential School on the South shore of Fraser Lake. Many natives helped with the construction in hopes that conditions would be much better for their children, but it soon became clear that little had changed. (Closed in 1976)
1922 Grand Trunk Pacific Railway and Canadian Northern Railway merge to form Canadian National Railway.
1922 Lejac residential school was established at Fraser Lake. (Closed in 1976)
1927 *Indian Act* amended to make it illegal to obtain funds or legal counsel to pursue land claims.
1939 Second World War begins, four Lheidli T'enneh men join: Alec Paul, Jack Alexander, Charlie Brasie and Max Pius.
1945 Last Lheidli T'enneh Hereditary chief George Jael dies and is buried at IR#2.
1949 Right to vote in provincial elections restored to Indians in British Columbia.
1949 West Coast Transmission Co. incorporated.

1951 *Indian Act* revised repealing prohibition for First Nations to pursue land claims and the potlatch.

1953 Pacific Great Eastern Railway extended to Prince George.

1960 Indian people were given the right to vote in the Federal Elections.

1964 BC Hydro erects high voltage power transmission lines through Fort George IR #2.

1968 Indian Homemakers Association formed. Mary Pius involved.

1969 Federal government introduces the "White Paper "(Statement of Government of Canada on Indian Policy), which seeks to eliminate certain "privileges" of Aboriginal people, by abolishing the *Indian Act* and the federal obligation to Aboriginal people. First Nations respond with a "Red Paper" that effectively ends the federal initiative.

1969 Chief Ronald Seymour represents Lheidli in the establishment of Union of BC Indian Chiefs.

1973 Punchaw Lake archeology site dig conducted by Dr. Landmark of Simon Fraser University. Findings identified 43 house platforms and 57 cache pits. Evidence indicates that there was 4000 years of habitation and the site has been utilized for 8000 to 9000 years. The 5,400 square meter site has an ancient east-west trail running across it. When Alexander Mackenzie passed through the area in 1793, he mentions in his journal that the natives already had European trade goods from ships on the coast. The ancient trail is now referred to as the Nuxalk-Carrier grease trail.

1982 Canadian Constitution amended and repatriated from England, and re-named as *Constitution Acts*. Section 35 of the *Constitution Act, 1982* "recognizes and affirms" the aboriginal and treaty rights of the aboriginal peoples of Canada, who are defined as "the Indian, Inuit and Metis peoples of Canada".

1985 Bill C-31 legislation approved. This amendment to the *Indian Act* restored the status to Aboriginal women who lost their status due to marrying non-Aboriginal men or other reasons. Also, the first generation of children received their status.

1992 Band administers property taxes on reserve through section 83 of *the Indian Act*.

2000 Members approve Bill C-49 Land Code; this provides the Band the jurisdiction to manage reserve lands.

1993 Entered the BC Treaty Negotiation Process with Canada and province of BC:

Stage 1	Statement of Intent accepted by the BC Treaty Commission on December 12, 1993
Stage 2	Readiness declared for the three parties on November 02, 1995
Stage 3	Framework Agreement signed by three parties on August 26, 1996
Stage 4	Agreement in Principle signed by three parties on August 01, 2003
Stage 5	Final Agreement completed on November 29, 2006 Community vote held in March 2007. The Constitution was successfully passed, the Final agreement was rejected.

1996 Became a partner in the McGregor Model Forest Association. Developed working relationships with the Indigenous peoples from the Cree from Montreal Lake and the Nania from the far east Russia.

1997 Established LTN Contracting Ltd. This company is a partnership that specializes in timber harvesting.

1999 Protocols signed for information sharing and economic exchange with the Nisga'a Tribal Council and the Snuneymuxw First Nation.

2002 Memorandums of Understanding on Cooperation and Communication signed with the City of Prince George and the Regional District of Fraser-Fort George.

Lheidli T'enneh Timeline – June 18, 2013 Version

2010 Fraser River Bridge Archeology dig finds an extensive collection of lithic items covering many thousand years of occupation and some of the lithic items were dated to 7500 +/- 40 years ago.

2012 Band accepted into Fiscal Management Authority (FMA). The self-government initiative provides the jurisdiction to manage the property tax system.

2012 Federal Government approves Bill C-3; this amendment to the *Indian Act* adds a third generation of disenfranchised members to the membership list.

2013 Band becomes a co-host for the 2015 Canada Winter games.

2013 Band is the host of the 37^{th} annual Elder's Gathering.

2015 Band is the Host First Nation for the 2015 Canada Winter Games.

Appendix B: Project Photos

Slope defining lower terrace edge along the Nechako River (NW).

Slope defining middle terrace edge along the Nechako River (SE).

Douglas fir dominant forest cover within the western portion of the middle terrace (N).

Trembling aspen stand within the upper terrace (SW).

Immature lodgepole pine and second growth forest cover within the lower terrace (NW).

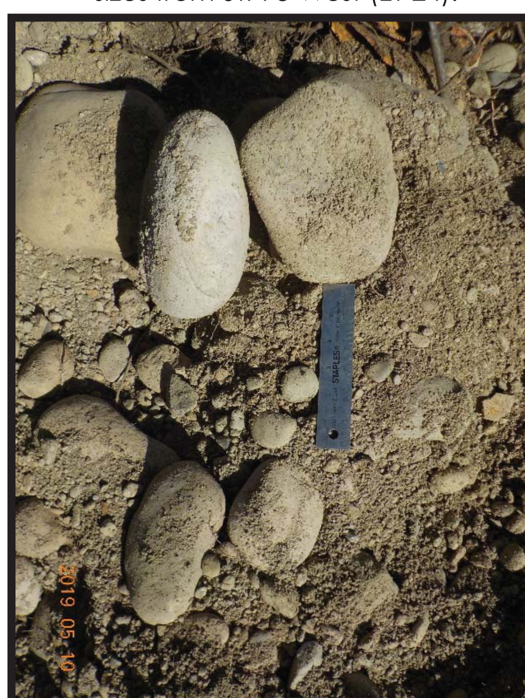
Common soil profile within STA-1 (ST 11).

Common soil profile within STA-1-North/TSN19-NorthNechakoDevelopment-SSL1 (EU1).

Common soil profile within STA-2 (ST 68).

Common soil profile within STA-3-East /TSN19-NorthNechakoDevelopment-SSL2 (EU 1).

Common soil profile and varying inclusion sizes from STA-3-West (ET 24).



Common soil profile within STA-3-Northwest (ST 33).

Common soil profile and varying inclusion sizes from STA-4 (ET 24).

TSN19-NorthNechakoDevelopment-SSL1 terrain, P2 on detailed site map (SW).

Low-lying and poorly draining section north of STA-1, west of STA-1-North and southwest of TSN19-NorthNechakoDevelopment-SSL1 (W).

Historical photo c. 1978 from Mr. John Smith. Note the area immediately west of the fence is the current location of TSN19-NorthNechakoDevelopment-SSL1 (NW).

Historical photo c. 1978 from Mr. John Smith. Overlooking what was then a field with regen growth. Note this photo is showing what is now STA-1 and part of STA-1-North (SW).

Plate 17. Old root cellar within the central portion of STA-4 (NW).

Plate 18. Old quarry test within the western portion of STA-4 (S).

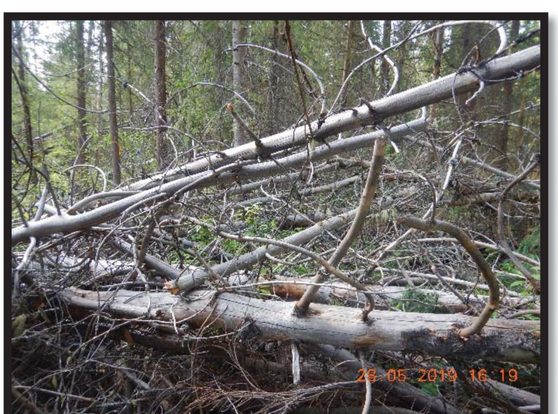
Modern recreational trail bisecting TSN19-NorthNechakoDevelopment-SSL2 (NW).

STA-1-North view of TSN19-NorthNechakoDevelopment-SSL1 (N).

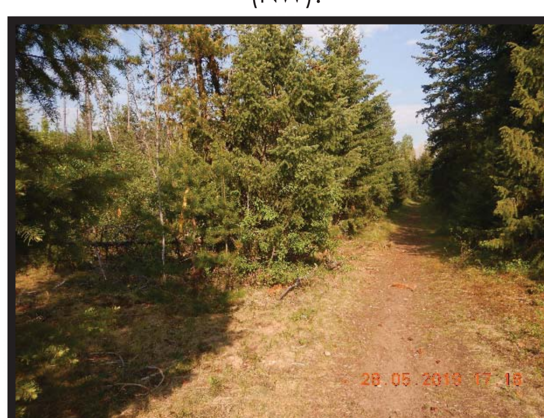
Disturbance within testable area of TSN19-NorthNechakoDevelopment-SSL1, P1 on detailed site map (W).

Arbitrary eastern boundary of TSN19-NorthNechakoDevelopment-SSL1, P3 on detailed site map (S).

Blowdown within testable area of TSN19-NorthNechakoDevelopment-SSL1 (NW).



Modern recreational trail bisecting TSN19-NorthNechakoDevelopment-SSL2 and western boundary, P1 on detailed site map (NW).



Blowdown within testable area of TSN19-NorthNechakoDevelopment-SSL2 (W).

Defining terrace edge and natural boundary of TSN19-NorthNechakoDevelopment-SSL2 (SE).

TSN19-NorthNechakoDevelopment-SSL2 observed boundary, P2 on detailed site map (N).

Defining terrace edge within STA-3-Northwest (SW).

Appendix C: 2019-0044 Permit

Permit No. **2019-0044**

BRITISH COLUMBIA

HERITAGE CONSERVATION ACT

HERITAGE INSPECTION PERMIT

THIS IS TO CERTIFY that **Normand Canuel** of **Norcan Consulting Limited**, is hereby authorized to conduct inspections as described below, subject to the terms and conditions on the back hereof.

Type of inspection and location:

Archaeological Impact Assessment for proposed residential subdivision 2259 North Nechako Road (District Lot 4051 Cariboo District Except: Firstly; plan B3724, Secondly; Plan 22731, Thirdly; Plan BCP4470, Fourthly; Plan BCP4772, Fifthly; Plan BCP20972) and 4439 Craig Drive (Block A (plan B3724) Disttict lot 4051 Cariboo District Except Plan 22731) Prince George.

All work is to conform with the "Application for Permit" dated September 7, 2018.

Disposition of materials collected: **The Exploration Place Science Centre & Museum**

Issued **March 6, 2019**

Expires **October 30, 2019**

Minister of Forests, Lands, Natural Resource Operations and Rural Development

Per ______________________________

(See back for *Conditions*)

APPENDIX E

North Nechako Neighbourhood Plan
L&M Engineering Limited

TRAFFIC IMPACT STUDY

ENGINEERING LIMITED

June 14th, 2019

TRAFFIC IMPACT STUDY

NORTH NECHAKO

Client: T.R. Projects & 406286 BC Ltd.

L&M Project No.: 1600-02

L&M ENGINEERING LIMITED

1210 Fourth Avenue, Prince George, BC V2L 3J4

Phone: (250) 562-1977

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APPENDICES

1.0 INTRODUCTION

On behalf of T.R. Projects Ltd. and 406286 BC Ltd., L&M Engineering is pleased to submit a Traffic Impact Study in support of the North Nechako Neighbourhood Plan. The two businesses own adjacent parcels of land located between Foothills Boulevard, North Nechako Road and the Nechako River. Over the past few decades, both properties have been used primarily for gravel extraction, as they are both designated as soil removal areas within the City of Prince George. The proposed plan for both properties is to continue extracting gravel until the land is lowered to a suitable grade for residential development. The gravel extraction and residential construction will take place simultaneously until the Neighbourhood Plan area is fully developed.

It is proposed that the future site will consist of single-family homes, multiple family homes, and commercial development. This TIS report has been requested by City of Prince George to determine the potential impact on the surrounding road network and to provide guidance to future detailed design works for this development.

2.0 SCOPE OF STUDY

A scope development meeting was held on March 9th 2018 with the City of Prince George.

2.1 Study Intersection(s)

- Foothills Boulevard & North Nechako Road
- Churchill Road & North Nechako Road
- Craig Drive & Churchill Road
- Proposed Site Access near Dever Road & North Nechako
- *1st Avenue / Foothills Boulevard
- *North Nechako Road & Parkhill Center Access

*After trip generations are calculated, review to determine if Synchro analysis is required

2.2 Study Horizons

- Existing Background
- Projected Background
- Phasing horizons will be summarized in pre-submission letter

2.3 Peak Study Periods

- Weekday AM peak 6:00am to 9:00am
- Weekday PM peak 3:00pm to 6:00pm

2.4 Background Traffic Growth Rates

- L&M has reviewed the MoTI permanent count stations to determine historic growth rates on several recent projects. The growth is negative. L&M to include this in the study and use a 1.0% linear growth rate.

2.5 Seasonal Adjustment

- The majority of the traffic using the study intersections are local commuters; therefore no seasonal adjustment is required.

2.6 Trip Generation

- The Institute of Traffic Engineers (ITE) Trip Generation rates will be used.

2.7 Trip Distribution

- Determine the trip distribution based upon the proposed land use and local traffic patterns.

2.8 Pre-Submission

- Trip generation, distribution, background growth rate and the study horizons to be submitted to CoPG for approval prior to the analysis and completion of the TIS.

2.9 Analysis

- Analysis to be prepared using Trafficware Synchro software.
- Review Signal Warrants.
- Determine thresholds for infrastructure improvements.
- Use 95th percentile for queue lengths. Compare to TAC equation queue lengths.
- 15 min intervals.

2.10 Geometrics

- Review intersection geometry
- Sight Distances
- Left Turn Queue Lengths
- Deceleration Lanes.

2.11 Active Transportation (Pedestrians)

- Estimate pedestrian volumes.
- Evaluate need for pedestrian connectivity across North Nechako Road.
- Review locations for crosswalks in conjunction with potential transit stops.

2.12 Transit Connectivity

- Determine if internal bus route is required.

2.13 Report

- Summarize findings in a report to be submitted to the CoPG.

3.0 EXISTING BACKGROUND TRAFFIC

The following background traffic counts were conducted for the Weekday AM and PM Peak Hours:

- Foothills Boulevard & North Nechako Road
- Churchill Road & North Nechako Road
- Churchill Road & Craig Drive
- North Meadow Road & North Nechako
- Fairburn Road & North Nechako Road

The counts were conducted from 6:00am to 9:00am (AM Peak) and 3:00pm to 6:00pm (PM Peak). The counts were conducted in 15-minute increments and were categorized by vehicle class (see Appendix A).
The existing background volumes for the peak study periods are shown in Figure 2.

4.0 PROJECTED BACKGROUND TRAFFIC

A review of the Annual Average Daily Traffic data from the permanent Count Station P-42NS indicates that there is not a consistent trend of population growth in the Prince George area. The annual growth rates over the past eight years have fluctuated up and down, but the average annual population growth over that period has been -0.31%. To be conservative, a background growth rate of 1.0% was chosen for the analysis. This rate is used to project the 2019 existing background traffic 15 years into the future to the year 2034. This growth represents general background development and population increase. This growth rate is conservative and, if applied to Prince George, would represent the current population increasing from 74,000 (Source: Statistics Canada 2016 Census Data) to 86,580 by the year 2034. The projected background traffic is illustrated in Figure 3.

5.0 DEVELOPMENT TRAFFIC

The peak hour trip generation for the development site was established using the published Institute of Traffic Engineers (ITE) trip generation rates, using the maximum traffic generating uses allowable under the proposed zone.

5.1. Trip Generation

L&M Engineering has developed a conceptual layout plan (as shown in Figure 1) to determine the appropriate density for the analysis. Based on the proposed zoning for the site, the site can yield up to 547 single-family and 309 multiple-family dwellings. The developers have expressed an interest in incorporating duplex lots amongst the single-family lots, therefore the density of the single-family zoning was increased from the typical 8 lots/ha to 10 lots/ha to account for this. The remaining portion of the property will be designated for commercial development. The developer has not yet decided which commercial uses will be developed on the site, and as such assumptions were made to develop commercial trip generation. It was assumed that the commercial site would be occupied by a convenience store/gas station, a high turnover sit down restaurant, and a specialty retail centre (strip-mall). The gas station and the restaurant land uses generate high trip generation volumes compared to other uses allowed under the commercial zoning. These uses were chosen to ensure that the study was using conservative generation volumes. The specialty retail centre generates average trip generation volumes for the zoning and allows for a wide variety of retail stores and other commercial amenities. The mixture of high and medium traffic generating land uses will ensure that the study analyses a realistic scenario. The trip generation rates and volumes are summarized in Table 1 and Table 2.

Table 1 – Opening Day Peak Hour Generation Rates										
Land Use	ITE #	Peak Period	Units	Traffic Generation Variable (x)	Trip Gen. Rate	In %	Out %	Total Trip Gen.	Entry (vph)	Exit (vph)
Single Residential	210	AM	64	Dwelling Units	T=0.71(x)+4.8	25	75	**50**	12	38
		PM	64	Dwelling Units	Ln(T)=0.96Ln(x)+0.2	63	37	**66**	42	24

Table 2 - Total Traffic Peak Hour Generation Rates																
LAND USE	ITE CODE	AREA	VARIABLE	UNIT	AM PEAK						PM PEAK					
					RATE	%	%	TRIP GENERATION			RATE	%	%	TRIP GENERATION		
		ft^2				IN	OUT	TOTAL	IN	OUT		IN	OUT	TOTAL	IN	OUT
Single Family Residential	210		Per unit	547	T=0.71(x)+4.8	25	75	393	98	295	Ln(T)=0.96Ln(x)+0.2	63	37	519	327	192
Multi Family Housing Low-Rise	220		Per unit	309	Ln(T)=0.95Ln(x)-0.51	23	77	139	32	107	Ln(T)=0.89Ln(x)-0.02	63	37	161	101	60
Convenience Market with Gasoline Pumps	853		Per Fueling Position	8	20.76	50	50	166	83	83	23.04	50	50	184	92	92
High TurnOver Sit Down Restaurant	932	5000	Per 1000 ft^2	5	9.94	55	45	50	28	23	9.77	59	41	49	29	20
Specialty Retail Centre	814	70000	Per 1000 ft^2	70	0	0	0	0	0	0	2.71	44	56	190	84	106
								748	**241**	**508**				**1103**	**633**	**470**
					RESIDENTIAL			532	130	402				680	428	252
					INSITUTIONAL											
					COMMERCIAL			216	111	106				423	205	218
					TOTAL			**748**	**241**	**508**				**1103**	**633**	**470**

*Trip Generations are calculated using the equation or the average rate, outlined in the ITE Trip Generation Manual 10th Edition (Specialty Retail Centre – 8th Edition).

5.2. Trip Distribution

To obtain specific development traffic volumes, the traffic distribution in and out of the proposed development site must be established. This is accomplished by examining the existing traffic counts and adding the new ingress and egress trip generation traffic in the appropriate percentage distribution to each of the movements. The distribution percentages shown are a percentage of the total development traffic during the peak hour. The trip distribution for the Opening Day and Total Traffic scenarios were developed separately to account the differing number of site accesses and land uses. The Opening Day scenario only includes the development of Phase 1 on the northern parcel, owned by 406286BC Ltd. Construction of Phase 1 commenced in the summer of 2018.

The trip distribution percentages for the ingress and egress movements are illustrated in Figures 4 and 5.

5.3. Trip Assignment Volumes

Based on the trip distribution percentages and utilizing the trip generation volumes illustrated in Tables 1 and 2, the Trip Assignment volumes can be calculated. The Trip Assignment volumes for the site are shown in Figures 6 and 7.

5.4. Pass-By Trip Adjustment

The ITE Trip Generation Handbook defines a pass-by trip as a trip made with an immediate stop on the way from an origin to a primary destination without a route diversion. An example of a pass-by trip that relates to this study would be a vehicle that is travelling from the Prince George City Center to the Hart via North Nechako Road that stops to use the commercial amenities before completing its trip to the Hart. This vehicle is already travelling to the Hart; therefore, another vehicle does not need to be added to the trip generation as the vehicle was already in the traffic stream. The ITE Trip Generation Handbook provides pass-by percentages to estimate the number of pass-by trips generated by various land uses. An adjustment was made to account for pass-by trips during the 2034 Total Traffic scenario. Refer to Table 3 for a full breakdown of the commercial pass-by trips. The pass-by trips are shown in Figure 8.

5.5. 2019 Opening Day Volumes

Adding the Opening Day trip assignment traffic (Figure 6) to the Existing Background traffic (Figure 2) results in the 2019 Opening Day Traffic shown in Figure 9.

5.6. 2034 Total Traffic Volumes

Adding the Total Traffic trip assignment traffic (Figure 7) to the Projected Background traffic (Figure 3) and subtracting the Pass-By Trips (Figure 8) from the through traffic results in the 2034 Total Traffic shown in Figure 10.

Table 3 – Pass-By Trips (2034 Total Traffic)

Commercial Use	Pass-By % ITE Average	Pass-By % Used	Peak Period	Pass-By Trips Total	Pass-By Trips Enter	Pass-By Trips Exit
Convenience Market with Gasoline Pumps	63%	50%	AM	84	42	42
	66%	50%	PM	92	46	46
High Turnover Sit-Down Restaurant	No Data	0%	AM	0	0	0
	43%	40%	PM	20	12	8
Shopping Centre*	No Data	0%	AM	0	0	0
	34%	30%	PM	57	25	32

*No data is provided for a Specialty Retail Centre; a Shopping Centre is a similar land use, therefore the pass-by % was generated using the Shopping Centre data.

6.0 HEAVY VEHICLE PERCENTAGE

The percentage of heavy vehicles on the municipal roads was calculated using the existing percentage of heavy vehicle traffic obtained from the 2017 and 2018 traffic counts. Where the heavy vehicle volumes were zero, a default level of 2% was entered into the Synchro model (see Appendix A).

7.0 CAPACITY ANALYSIS

7.1. Method of Analysis

To analyze the performance of the study intersections and calculate the capacity and "level of service" (LOS) of each intersection, the Synchro Studio Software has been used. This software was developed by Trafficware Ltd. and is based on the methods and procedures in the Highway Capacity Manual. Computer printouts showing the detailed calculation for each individual movement at each study intersection are provided in Appendix B.

The concept of "Level of Service" is defined as a qualitative measure describing operational conditions within a traffic stream, and their perception by motorists. A level of service definition generally describes these conditions in terms of such factors as speed and travel time, freedom to maneuver, traffic interruptions, comfort and convenience, and safety.

The six levels of service are defined in the Highway Capacity Manual as follows:

- **Level of Service A** represents free flow. Individual users are virtually unaffected by the presence of others in the traffic stream. Freedom to select desired speeds and to maneuver within the traffic stream is extremely high. The general level of comfort and convenience provided to the motorist is excellent.
- **Level of Service B** is in the range of stable flow, but the presence of other users in the traffic stream begins to be noticeable. Freedom to select desired speeds is relatively unaffected, but there is a slight decline in the freedom to maneuver within the traffic stream from Level of Service A. The level of comfort and convenience provided is somewhat less than at Level of Service A, because the presence of others in the traffic stream begins to affect individual behavior.
- **Level of Service C** is the range of stable flow, but marks the beginning of the range of flow in which the operation of individual users becomes significantly affected by interaction with others in the traffic stream. The selection of speed is now affected by the presence of others, and maneuvering within the traffic stream requires substantial vigilance on the part of the user. The general level of comfort and convenience declines noticeably at this level.
- **Level of Service D** represents high-density, but stable, traffic flow. Speed and freedom to maneuver are severally restricted, and the driver experiences a generally poor level of comfort and convenience. Small increases in traffic flow will generally cause operational problems at this level.
- **Level of Service E** represents operating conditions at, or near, the capacity level. All speeds are reduced to a low, but relatively uniform value. Freedom to maneuver within the traffic stream is extremely

difficult, and is generally accomplished by forcing a vehicle to "give way" to accommodate such maneuvers. Comfort and convenience levels are extremely poor, and driver or pedestrian frustration is generally high. Operations at this level are usually unstable, because small increases in flow and minor perturbations within the traffic stream will cause breakdowns.

- **Level of Service F** is used to define forced or breakdown flow. This condition exists wherever the amount of traffic approaching a point exceeds the amount which can traverse the point. Queues form behind such locations. Operations within the queues are characterized by stop-and-go waves, and they are extremely unstable. Vehicles may progress at reasonable speeds for several hundred feet or more, and then be required to stop in a cyclic fashion. The Level of Service F is used to describe the operating conditions within the queue, as well as the point of the breakdown.

Levels of Service Criteria, as defined by the Highway Capacity Manual, are illustrated in Table 4.

Table 4 – Level of Service Definitions

Level of Service	Impact on Street Traffic	Unsignalized Intersection Delay(s)	Signalized Intersection Delay(s)
A	Little or no delays	0 – 10	0 – 10
B	Minor delays	10 – 15	10 – 20
C	Average delays	15 – 25	20 – 35
D	Long delays	25 – 35	35 – 55
E	Very long delays	35 – 50	55 – 80
F	Undesirable	> 50	> 80

For this study North Nechako Road was displayed and analyzed as an east/west road.

7.2. Foothills Boulevard and North Nechako Road

The Foothills Boulevard and North Nechako Road intersection is a signalized four-way intersection. Foothills Boulevard is a four-lane arterial highway at this location with a speed limit of 70 km/hr and North Nechako Road is a two-lane arterial road with a speed limit of 60 km/hr. The northbound and southbound (Foothills Boulevard) approaches each have two free through lanes, as well as left turn lanes with protected/permissive control and channelized right turn lanes. The westbound and eastbound approaches (North Nechako Road) each have a single free through lane, a left turn lane with permissive control and a channelized right turn lane.

A separate traffic count was conducted during the AM peak hour (7:30–8:30) on September 8, 2017 to determine if the traffic signal for the westbound left turning traffic was operating efficiently. The count included a total of 49 westbound vehicles turning left from North Nechako Road onto Foothills Boulevard. Of those 49 vehicles only one had to wait at the light for more than 1 full cycle length. The largest observed queue was 3 vehicles.

A summary of the Synchro analysis for this intersection is shown in Table 5. The analysis for all design scenarios shows that during the Weekday AM and PM Peaks for all intersection movements operate at LOS C or better (average delays).

Table 5 – N. Nechako & Foothills Blvd.								
	N. Nechako				Foothills Blvd.			
Approach	Eastbound		Westbound		Northbound		Southbound	
	EBL|EBT|EBR		WBL|WBT|WBR|		NBL|NBT|NBR		SBL|SBT|SBR	
	LOS	Delay(s)	LOS	Delay(s)	LOS	Delay(s)	LOS	Delay(s)
AM PEAK								
2019 Existing Background	C|C|C	21.8|26.2|21.4	C|C|C|	23.1|22.0|21.1	A|B|B	8.7|10.9|10.5	A|B|A	8.1|10.1|8.69
2019 Opening Day	C|C|C	21.8|26.2|21.4	C|C|C	23.3|22.0|21.1	A|B|B	8.7|10.9|10.5	A|B|A	8.2|10.1|8.9
2034 Projected Background	C|C|C	21.6|27.9|21.3	C|C|C	23.8|21.9|20.9	A|B|B	9.0|11.3|10.9	A|B|A	10.0|10.6|9.2
2034 Total Traffic	C|C|C	21.4|28.9|21.1	C|C|C	24.0|21.7|21.1	A|B|B	9.2|11.6|11.1	B|B|A	10.9|11.0|9.4
PM PEAK								
2019 Existing Background	C|C|B	20.5|21.0|19.9	C|C|C	21.0|22.0|20.3	A|B|A	7.8|10.8|9.9	A|B|A	7.6|10.4|9.5
2019 Opening Day	C|C|B	20.5|21.0|19.9	C|C|C	20.9|22.1|20.3	A|B|A	7.8|10.8|9.9	A|B|A	7.7|10.4|9.5
2034 Projected Background	C|C|B	20.5|21.1|19.8	C|C|C	21.0|22.3|20.2	A|B|B	8.1|11.4|10.2	A|B|A	8.0|10.9|9.7
2034 Total Traffic	C|C|C	21.4|22.3|20.7	C|C|C	22.0|23.6|21.4	A|B|B	8.8|12.3|10.8	A|B|A	7.8|10.9|9.6

7.3. Dever Road and North Nechako Road

The Dever Road and North Nechako Road intersection is an unsignalized three-way intersection. North Nechako is a two-lane arterial road at this location with a speed limit of 60 km/hr. The eastbound and westbound approaches each have a free through lane. The southbound approach (Dever Road) is stop controlled and permits both left and rights turning movements.

It is proposed to install a new three-way intersection approximately 50m west of the existing intersection, which will be used to access the proposed development. The road accessing the development will be located near south end of the Edgewood Park parking lot and the existing berm. The new intersection alignment will intersect North Nechako Road at a highpoint which enhances the available sight distances for vehicles leaving the subject site. Installing the access in the proposed location will also allow the existing lane-way on the south side of North Nechako, directly across from the existing Dever Road, to remain. If the access is constructed directly across from Dever Road, then the lane-way would need to be removed which in turn, eliminates accesses to the homes backing onto the lane-way. The proposed intersection will likely be constructed as a part of T.R. Projects (southern parcel) Phase 1. The access could be the primary access point for a large majority of the proposed single-family dwelling units.

In the interim both the existing and proposed intersections will act as offsetting T-intersections. In the future when the property to the south of Sturgeon Road is developed, the existing Dever Road should be relocated to align with the southern leg of the proposed intersection to create a four-way intersection.

The Dever Road intersection that will be used to access the proposed development will likely be constructed as a part of T.R. Projects (southern parcel) Phase 1. The access could be the primary access point for a large majority of the proposed single-family dwelling units.

A summary of the Synchro analysis for this intersection is shown in Table 6. The analysis shows that during the Weekday AM and PM Peaks all intersection movements operate at LOS C or better (average delays).

Table 6 – Dever Rd. & N. Nechako Rd.						
	N. Nechako				Dever Road	
Approach	Eastbound		Westbound		Northbound	
	LOS	Delay(s)	LOS	Delay(s)	LOS	Delay(s)
AM PEAK						
2034 Total Traffic	-	0.0	A	2.4	C	22.9
PM PEAK						
2034 Total Traffic	-	0.0	A	4.2	C	17.5

7.4. Churchill Road and North Nechako Road

The Churchill Road and North Nechako Road intersection is an unsignalized three-way intersection. North Nechako Road is a two-lane arterial at this location with a speed limit of 60 km/hr. The eastbound approach has a single free through lane and allows right turns. The westbound approach has a single free through lane and a left turn lane. The northbound approach (Churchill Road) is stop-controlled with access to North Nechako Road with allowable left and right turn movement.

The Synchro analysis shows that this intersection is operating at a LOS F (undesirable delay) for the 2034 Total Traffic AM Peak scenario. An additional scenario was analysed in which a dedicated northbound right turn lane was added to Churchill Road. The intersection still operates at a LOS F during the 2034 Total Traffic scenario, even with the right turn lane, but the control delay improves drastically from 243 seconds to 76 seconds. It was determined that the right turn lane should be installed once the intersection reaches a LOS F. This occurs when the eastbound through traffic on North Nechako reaches 650 veh/hr in the peak hour, which can be equated to approximately 250 new dwelling units combined between the two subject properties.

The intersection was also analyzed to determine if the traffic volumes warrant the installation of a traffic light. Despite the LOS F, it was determined that none of the design horizons, including the 2034 Total Traffic scenario warranted the signalization of the intersection.

Table 7 – N. Nechako Rd. & Churchill Rd.						
	N. Nechako				Churchill Rd.	
Approach	Eastbound		Westbound		Northbound	
	EBT|EBR		WBL|WBT		NBL|NBR	
	LOS	Delay(s)	LOS	Delay(s)	LOS	Delay(s)
AM PEAK						
2019 Existing Background	-	0.0	A|-	9.3|0.0	C	19.8
2019 Opening Day	-	0.0	A|-	9.4|0.0	C	21.0
2034 Projected Background	-	0.0	A|-	9.8|0.0	D	26.7
2034 Total Traffic	-	0.0	B|-	11.3|0.0	F	242.6
2034 Total Traffic **	-	0.0	B|-	11.3|0.0	F|F	52.4|75.6
PM PEAK						
2019 Existing Background	-	0.0	A|-	7.9|0.0	B	14.2
2019 Opening Day	-	0.0	A|-	8.0|0.0	B	14.9
2034 Projected Background	-	0.0	A|-	8.1|0.0	C	16.6
2034 Total Traffic	-	0.0	A|-	8.9|0.0	E	38.6

** Northbound right turn lane was added to Churchill Road to improve the movements control delay.

7.5. Churchill Road and Craig Drive

The Churchill Road and Craig Drive intersection is an unsignalized four-way intersection. Both roads have a 50km/hr speed limit. Churchill Road and Craig Drive are both two-lane local roads that allow full movements. Craig Drive is stop-controlled.

The extension of Craig Drive will likely be constructed within T.R. projects first two phases. This access is essential to the development for a variety of reasons. From a safety stand point, the access would provide an additional egress point for residents of the Edgewood Terrace neighbourhood to use in the event of an emergency. The extension would also provide emergency vehicles with multiple access points to the school during such events. During weekdays the access would be used primarily by residents that are dropping off or picking up children from Edgewood Elementary School. The access would also provide efficient traffic connectivity between the new and existing subdivisions.

A summary of the Synchro analysis for this intersection is shown in Table 8. The analysis shows that during the Weekday AM and PM Peaks all intersection movements operate at LOS B or better (minor delays).

Table 8 –Churchill Rd. & Craig Dr.

	Craig Dr.				Churchill Rd.			
Approach	Eastbound		Westbound		Northbound		Southbound	
	LOS	Delay(s)	LOS	Delay(s)	LOS	Delay(s)	LOS	Delay(s)
Am PEAK								
2019 Existing Background	A	8.9	B	11.1	A	6.8	A	0.2
2019 Opening Day	A	8.9	B	11.4	A	6.9	A	0.2
2034 Projected Background	A	9.0	B	11.6	A	6.8	A	0.2
2034 Total Traffic	A	9.7	B	12.3	A	6.9	A	0.2
PM Peak								
2019 Existing Background	A	8.8	A	9.3	A	4.5	A	1.5
2019 Opening Day	A	8.8	A	9.3	A	4.5	A	1.5
2034 Projected Background	A	8.8	A	9.4	A	4.5	A	1.3
2034 Total Traffic	A	9.0	A	10.0	A	6.1	A	1.3

7.6. Foothills Boulevard and Road A

The proposed Foothills Boulevard and Road A intersection will be an unsignalized three-way intersection. Foothills is a four-lane arterial highway with design speed limit of 70km/hr. Road A will be a two-lane collector road with a design speed limit of 50km/hr. The intersection will allow full movements and Road A will be stop controlled.

A summary of the Synchro analysis for this intersection is shown in Table 9. The analysis shows that during the Weekday AM and PM Peaks all intersection movements operate at LOS C or better (average delays).

Table 9 – Foothills Boulevard & Road A						
	Foothills				Road A	
Approach	Northbound		Southbound		Westbound	
	NBT|NBR		SBL|SBT		NBL|NBR	
	LOS	Delay(s)	LOS	Delay(s)	LOS	Delay(s)
AM PEAK						
2034 Total Traffic	-	0.0	A	2.3	C	16.5
PM PEAK						
2034 Total Traffic	-	0.0	A	2.9	C	22.3

7.7. Fairburn Road and North Nechako Road

The Fairburn Road and North Nechako Road intersection was not identified as a study intersection for this report. The intersection was analyzed in a recent TIS conducted by L&M and the Synchro analysis for this intersection showed that all intersection movements operate at a LOS C or better for all design horizons, except the northbound movement on Fairburn Road, which operates at a LOS E during the 2032 Total Traffic PM Peak scenario. Since North Nechako Road is classified as an arterial highway and its main purpose is to transport traffic from local roads and collector roads to urban centres, there is a possibility that the road will need to be upgraded to a four-lane arterial in the future. If North Nechako Road is four-laned or if the westbound left turn lane at Foothills Boulevard is extended, the Fairburn and North Nechako intersection's northbound leg may be restricted to right in and right out movements only.

8.0 GEOMETRICS

8.1. Sight Distance

The concept of sight distance applies both to vehicles approaching a potential conflict point (typically an intersection) and vehicles departing from a stop at the intersection.

Sufficient sight distance should be provided in the design of roads so that drivers can perceive potential conflicts and respond by maneuvering appropriately. The proposed available sight distances were reviewed to determine if they meet current standards.

A combination of PGMAP and field analysis were used to approximate the available vehicle sightline distances for the existing and proposed intersection locations. Table 10 illustrates a summary of the survey findings:

TABLE 10 – AVAILABLE SIGHT DISTANCE (SITE ACCESSES)			
Intersection (Speed Limit 70km/hr)	**Measured From**	**Measured Sight Distance (m)**	
		*Looking North**	*Looking South**
Foothills & North Nechako (WB)	Right-Turn Lane	N/A	>275
Foothills & North Nechako (EB)	Right-Turn Lane	>275	N/A
Foothills & Road A (WB)	3m from Road Edge	>275	>275
Intersection (Speed Limit 60km/hr)		**Measured Sight Distance (m)**	
		*Looking West**	*Looking East**
Foothills & North Nechako (NB)	Right-Turn Lane	>235	N/A
Foothills & North Nechako (SB)	Right-Turn Lane	N/A	>235
Dever & North Nechako (NB)	3m from Road Edge	>235	140
Churchill & North Nechako	3m from Bike Lane	>235	>235
Intersection (Speed Limit 50km/hr)		**Measured Sight Distance (m)**	
		*Looking North**	*Looking South**
Craig & Churchill (EB)	Stop Sign	30	30
	3m from Road Edge	>195	≈85
Craig & Churchill (WB)	Stop Sign	30	30
	3m from Road Edge	>195	≈90

**From the perspective of a driver stopped on the intersection minor road. Rounded to nearest 1m.*

The *Transportation Association of Canada (TAC) Geometric Design Guide* outlines the criteria for several different types of sight distance, including *stopping sight distance*, *crossing sight distance*, *turning sight distance, passing sight distance,* and *decision sight distance*. When these criteria apply depends on the specific vehicle maneuvers being considered. At a *minimum*, sufficient stopping sight distance should be provided so that drivers can perceive, react, and bring the vehicle to a stop or avoid conflicts.

The sight distance criteria are outlined in Table 11 for a range of speeds:

TABLE 11 – SIGHT DISTANCE CRITERIA			
	Design Speed (Major Road)		
	50km/hr	*60 km/hr*	*70 km/hr*
Sight Distance Type	*Minimum Distance Required (m)*		
Stopping Sight Distance	65	85	110
Crossing Sight Distance (SU) (1)	129	155	n/a
Turning Sight Distance	120	160	200
Passing Sight Distance (2)	n/a	n/a	n/a
Minimum Decision Sight Distance	135	165	200
Desirable Decision Sight Distance	195	235	275

(1) *Based on a medium single-unit truck (10.0m long), crossing 2-lanes.*

(2) *Not applicable to urban or multi-lane roads.*

8.1.1. Foothills Boulevard and North Nechako Road

The Foothills Boulevard and North Nechako Road intersection has been reviewed to determine the available sight distances when looking north and south along Foothills and looking west and east along North Nechako.

At a design speed of 60km/hr and 70km/hr, TAC Guidelines recommend a minimum sight distance for turning movements from a stop condition of 160m and 200m, respectively. The site distances for this intersection were measured from the crosswalks within the right turn lanes. All four movements have available site distances in excess of TAC Guideline recommendations.

8.1.2. Dever Road and North Nechako Road

The Dever Road and North Nechako Road intersection has been reviewed to determine the available sight distances when looking east and west along North Nechako Road.

At a design speed of 60km/hr, the TAC Guidelines recommend a minimum sight distance for turning movements from a stop condition of 160m. A northbound vehicle stopped 1m from the edge of North Nechako Road has available site distances of 140m looking east and in excess of 235m looking west.

Both directions meet the stopping sight distance requirements. The sight distance looking west is 20m shorter than the recommended turning sight distance, but deemed to be acceptable. Vehicles approaching from the east may have to slow slightly to accommodate left turning vehicles.

8.1.3. Churchill Road and North Nechako Road

The Churchill Road and North Nechako Road intersection has been reviewed to determine the available sight distances when looking east and west along North Nechako Road.

At a design speed of 60km/hr, the TAC Guidelines recommend a minimum sight distance for turning movements from a stop condition of 160m. A northbound vehicle stopped at the stop sign has available site distances in excess of 235m looking west, but the sight lines looking east are limited by a fence when looking east. When the driver advances slightly, while remaining out of the traffic stream on North Nechako Road, the available sight distance increases to greater than 235m. The sight distances exceed the recommendations outlined in the TAC Guide.

8.1.4. Churchill Road and Craig Drive

The Churchill Road and Craig Drive intersection has been reviewed to determine the available sight distances when looking north and south along Churchill Road.

At a design speed of 50 km/hr, TAC Guidelines recommend a minimum sight distance for turning movements from a stop condition of 120m. When looking south the sight distance is only 90m, which meets stopping sight distance but not turning sight distance. During the traffic counts (both AM and PM counts), only one vehicle made an eastbound left turn, therefore the sight distances are sufficient without any improvements.

9.0 AUXILIARY LANES

Auxiliary lanes, as defined by the Transportation Association of Canada (TAC), "serve as storage lanes, deceleration lanes, or a combination of the two." They can be used to minimize hazard and inconvenience, to increase capacity, and to promote operating efficiency where vehicles exit or enter the roadway.

9.1. Left Turn Warrants

Each of the left turn scenarios were first plotted on the "Harmelink" charts to determine if a warrant for a left turn lane is met. The warrants were evaluated utilizing the currently posted 60 and 70km/hr design speeds on North Nechako Road and Foothills Boulevard, respectively. A summary of the left-turn warrants is listed in Table 12.

Table 12 – Left Turn Warrants

Movement	Volume Advancing (vph)	Volume Opposing (vph)	Percent Left Turns	Scenario Warrant is Met
North Nechako @ North Meadow (WBL)	593	332	11 %	2034 Total Traffic (PM)
North Nechako @ Fairburn (WBL)	505	330	19%	2034 Total Traffic (PM)
North Nechako @ Dever (WBL)	256	743	16%	2034 Total Traffic (AM)
	651	365	23%	2034 Total Traffic (PM)
Foothills @ Road A (SBL)	521	328	50	2034 Total Traffic (AM)
	409	828	39	2034 Total Traffic (PM)

9.2. Required Left Turn Storage

To analyze the left turn storage length, the available (existing) length was first measured from an aerial map. The distance was then compared with the computed Synchro 95th percentile queue storage lengths in addition to the published TAC calculation guidelines. The following TAC equations were utilized:

Unsignalized: $S = N*L/30$

Where: S= Storage Length (m)
N= Left Turn Volumes (veh/hr)
L= Average Vehicle Length (7.5m)

Signalized: *S = (N*L*SF*C)/3600*

Where: S= Storage Length (m)
N= Left Turn Volumes (veh/hr)
L= Average Vehicle Length (7.5m)
SF=Safety Factor. Used 2 for > 60km/hr

Table 13A – Foothills Blvd. & North Nechako Road Left Turn Storage												
Left Turn Storage Length												
Design Year	NBL			SBL			WBL			EBL		
	LT VOL (vph)	SYN (m)	TAC (m)	LT VOL (vph)	SYN (m)	TAC (m)	LT VOL (vph)	SYN (m)	TAC (m)	LT VOL (vph)	SYN (m)	TAC (m)
Weekday AM Peak												
2019 Existing Background	40	*<8*	*11*	*311*	*33*	*83*	*43*	*11*	*9*	*26*	*<8*	*<8*
2019 Opening Day	40	*<8*	*11*	358	33	84	46	12	*9*	26	*<8*	*<8*
2034 Projected Background	46	*<8*	*12*	314	*39*	95	49	13	*10*	29	8	*<8*
2034 Total Traffic	46	*<8*	*12*	368	44	98	49	13	*10*	29	8	*<8*
Weekday PM Peak												
2019 Existing Background	119	*13*	32	93	*10*	25	46	12	9	27	8	*<8*
2019 Opening Day	137	*13*	37	107	11	27	44	12	9	27	8	*<8*
2034 Projected Background	119	*15*	32	102	12	29	53	14	11	30	9	*<8*
2034 Total Traffic	143	*15*	38	158	16	42	53	14	11	30	9	*<8*

Table 13B – North Nechako Left Turn Storage @ Fairburn			
Design Year	WB Left Turn		
	LT VOL (vph)	SYN (m)	TAC (m)
Weekday AM Peak			
2034 Total Traffic	16	<8	<8
Weekday PM Peak			
2034 Total Traffic	95	<8	25
Result: Use the minimum **Storage Length of 30m for WBL**			

Table 13C– North Nechako Left Turn Storage @ North Meadow			
Design Year	WB Left Turn		
	LT VOL (vph)	SYN (m)	TAC (m)
Weekday AM Peak			
2019 Opening Day	8	<8	<8

2034 Total Traffic	18	<8	<8
Weekday PM Peak			
2019 Opening Day	29	<8	<8
2034 Total Traffic	65	<8	17
Result: Use the minimum **Storage Length of 30m for WBL**			

Table 13D – North Nechako Left Turn Storage @ Dever			
Design Year	**WB Left Turn**		
	LT VOL (vph)	SYN (m)	TAC (m)
Weekday AM Peak			
2034 Total Traffic	42	<8	11
Weekday PM Peak			
2034 Total Traffic	183	<8	49
Result: Use a **Storage Length of 50m for WBL**			

Table 13E – North Nechako Left Turn Storage @ Churchill			
Design Year	**WB Left Turn**		
	LT VOL (vph)	SYN (m)	TAC (m)
Weekday AM Peak			
2019 Existing Traffic	36	<8	10
2019 Opening Day	36	<8	10
2034 Projected Background	41	<8	11
2034 Total Traffic	47	<8	13
Weekday PM Peak			
2019 Existing Traffic	53	<8	14
2019 Opening Day	53	8	14
2034 Projected Background	61	8	16
2034 Total Traffic	90	9	24
Result: Use the minimum **Storage Length of 30m for WBL**			

Table 13F – Foothills Left Turn Storage @ Road A			
Design Year	**SB Left Turn**		
	LT VOL (vph)	SYN (m)	TAC (m)
Weekday AM Peak			
2034 Total Traffic	50	<8	13
Weekday PM Peak			
2034 Total Traffic	39	<8	11
Result: Use the minimum **Storage Length of 30m for SBL**			

Tables 13A to 13F illustrate the results of the modelled and calculated left turn storage lengths. It is recommended to utilize the more conservative TAC value.

The storage length for the proposed left turn lanes should be constructed to the standard minimum of 30m, with the exception of the WBL movement onto the proposed Dever Road, where 50m of storage should be provided.

In addition, the SBL at the Foothills Boulevard and North Nechako Road intersection does not meet the TAC's storage length recommendation. The existing lane has a storage length of approximately 60m and the TAC recommends a storage length of 98m. The TAC equation can be slightly misleading when calculating storage lengths for signalized left turn lanes with permissive phasing. The equation does not account for the left turning vehicles having their own signal phase, which means the equation calculates the storage length as if the turning movement was operating under permissive control. Under these conditions it is good practice to use the Synchro queue length results to determine the required left turn storage length instead of the TAC equation. The Synchro results determined that during the 2034 Total Traffic AM scenario the required storage length is 44m.

Multiple visual observations have been made at this intersection during the peak hours of the day and the consensus is that the SBL movement does not have an operational issue. It is recommended that the SBL turn lane continue to use the 60m storage length.

10.0 RIGHT TURN DECELERATION LANE WARRANTS

All of the right turn movements into the subject site were analyzed to determine if a right turn taper or full right turn deceleration lane is warranted for any of the design horizons. The warrant can only be triggered if the right turning volume is greater than 20 vehicles per hour. For the design horizons in this study, the Fairburn intersection (eastbound) was the only intersection to generate greater than 20 right turning vehicles in the peak hour. This occurred in both the AM and PM peak hours during the 2034 Total Traffic scenario. In the AM peak a right turn taper was warranted and in the PM peak a full-width right turn lane is warranted. See Appendix C for the right turn warrant plot.

The Ministry of Transportation's Supplement to the TAC Geometric Design Guide provides recommendations for ideal right turn lane lengths. For 60km/hr design speeds the guide recommends an arterial road to have a 50m taper and a 40m parallel lane. North Nechako Road is an arterial road but due to the limited spacing between the Fairburn intersection and the Foothills intersection (approximately 120m), the deceleration lane may need to be constructed to collector road standards. The guide recommends a collector road to have a 50m taper and a 20m parallel lane. The dimensions for the deceleration lane should be determined during the detailed design phase.

11.0 TRANSIT CONNECTIVITY

The City of Prince George's Transit Future Plan indicates that bus stops should be located within 400m of 90 percent of residents. There are currently four bus stops and two separate bus routes along North Nechako Road that border the subject development (Shown in Exhibit 1). A large majority of the future development will be located further than 400m away from the nearest existing bus stop and some of the residents will have over a 1400m walk to an existing bus stop. In order to remain consistent with the City of Prince George's transit policies it is recommended that an internal bus route through the development be installed.

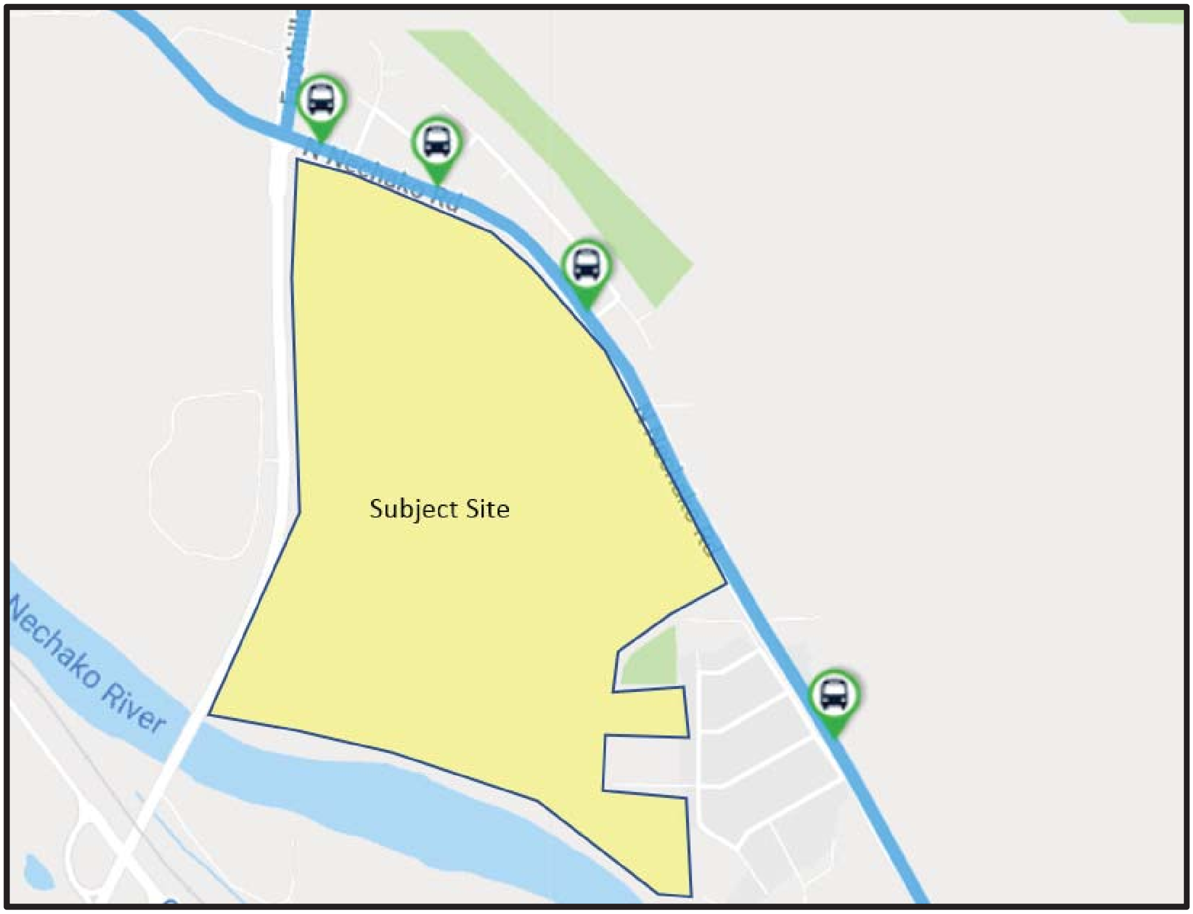

Exhibit 1: Public Transit Stops

12.0 PEDESTRIAN CONNECTIVITY

The roads within the proposed development will be built to City of Prince George's urban road standards which include concrete sidewalks on every road. This will provide a safe and efficient pedestrian network through the entirety of the subdivision. The sidewalks were designed primarily on the north and east sides of the roads to maximize sun exposure. However, some exceptions were made to enhance the sidewalk continuity and reduce the number of pedestrian road crossings. In addition to having an internal pedestrian network, the site will be surrounded by a rustic trail network which will connect the North Meadow and Edgewood Terrace subdivisions to the Edgewood Elementary School and the Nechako Riverfront Park. The trail network is proposed to cross Dever Road in order to connect the linear neighbourhood park located on either side of Dever Road. Since Dever Road is a collector road and the road crossing is not located at an intersection, it is recommended that a "zebra" crosswalk be installed at this location.

The Pedestrian Crossing Control Manual for British Columbia was used to determine if crosswalks were warranted across North Nechako Road at any of the study intersections. It was determined that during the 2034 Total Traffic scenario, marked and signed crosswalks will be required at the Churchill Road & North Nechako Road intersection and the Dever Road and North Nechako Road intersection. The crosswalk warrant at Churchill Road is not triggered until the sum of the eastbound and westbound traffic (along North Nechako Road) reaches 850 vehicles/hr during the peak hour. The crosswalk warrant at Dever Road is not triggered until the sum of the eastbound and westbound traffic reaches 850 vehicles/hr during the peak hour and approximately 150 dwelling units are constructed on T.R. Projects' property. The Dever Road crosswalk warrant was triggered under the assumption that a future bus stop will be installed at the intersection. If the intersection does not receive a bus stop, then the pedestrian volumes will be too low to warrant a crosswalk. This is also true if the City of Prince George decides to create a bus route through the proposed development in lieu of only keeping the bus route on North Nechako Road. This would reduce the number of pedestrians that need to cross North Nechako Road at the Dever Road intersection, as they will use the developments internal bus stops instead.

The warrants also showed that crosswalks are not required at the Fairburn or North Meadow intersections. See Exhibit 2 for the crosswalk warrant results and calculations.

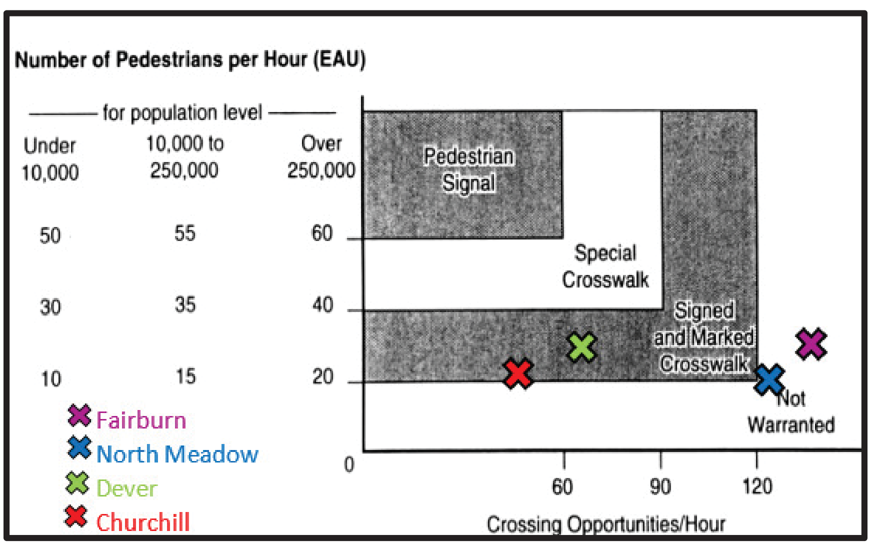

Exhibit 2: Crosswalk Warrants (See Appendix C for Full Results)

The warrants were compared against the TAC's Pedestrian Crossing Control Guide's (Third Edition - June 2018) Decision Support Tool. It was determined that no additional crosswalks will be required at any of the intersections on North Nechako Road. Refer to Appendix C for the full pedestrian warrant calculations.

13.0 TRAFFIC CALMING MEASURES

The proposed internal collector road that connects the Fairburn Road intersection to the Dever Road intersection should include traffic calming measures to deter drivers from speeding and short-cutting through the development. At the time of detailed design, one or more of the intersections along the collector road should be considered as candidates for traffic circles. Traffic circles help reduce vehicle speeds and accidents in residential areas, without requiring vehicles to come to a complete stop. This results in safer, more pedestrian friendly neighbourhoods. A typical traffic circle is shown in Exhibit 3.

Exhibit 3: Traffic Circle Example

14.0 CONCLUSIONS AND RECOMMENDATIONS

This traffic study was conducted using cautious parameters to simulate a practical worst-case, and thus illustrate the potential impacts to the road network. Although optimistic, the full build-out of the residential development has been assumed to be constructed by 2034. Two theoretical design horizons were considered: “Opening Day” (2019) and “Total Traffic” (2034). The actual expected impacts are unlikely to be as severe or occur as soon as identified in the report.

Foothills Boulevard & North Nechako Road

1. The Foothills Boulevard & North Nechako Road intersection operates at a LOS C (average delays) or better for all design horizons.
2. All of the available sight distances at the Foothills & North Nechako intersection meet or exceed the minimum standards recommended in the TAC Geometric Design Guide.
3. The TAC Guide equation for left turn storage determined that the southbound left turn lane should have a minimum storage length of 98m. The existing lane has a storage length of 60m. As discussed in the report, the Synchro analysis provides more accurate results than the TAC equation for protected left turn lanes at signalized intersections. The Synchro analysis determined the minimum storage to be 44m. It is recommended that the southbound left turn lane continue to use the existing 60m of storage length.

North Nechako Road & Dever Road

1. The Dever Road & North Nechako Road intersection operates at a LOS C (average delays) or better for the 2034 Total Traffic AM and PM horizons.
2. The northbound sight line looking east is approximately 140m and the TAC recommendation for turning sight distance on a road with a 60km/hr speed limit is 160m. The available sight distance does however exceed the stopping sight distance of 85m.
3. The left turn warrant is met for the westbound left movement on North Nechako at the proposed Dever Road site access during the 2034 Total Traffic scenario. It was determined that the left turn warrant is not triggered until approximately 80 dwelling units are developed on T.R. Projects property. The left turn lane should have a minimum storage length of 50m.

4. The Signed and Marked Pedestrian Crosswalk Warrant was met for pedestrians crossing North Nechako Road during the 2034 Total Traffic scenario. The crosswalk is triggered once the sum of the westbound and eastbound traffic on North Nechako Road reaches 850 veh/hr in the peak hour and the development consists of 150 dwelling units on the T.R. Projects property.
5. The southbound leg of the offset intersection should be realigned to be directly across from the proposed Dever Road alignment once the land on the north side of North Nechako Road is developed.

Churchill Road & North Nechako Road

1. The Churchill Road & North Nechako Road intersections northbound movement operates at a LOS E and F (very long and undesirable delays) during the 2034 Total Traffic horizons. A separate Synchro analysis was conducted, where a designated right turn lane was added to the northbound movement. The movement continued to operate at a LOS F, but the control delay was reduced from 242 seconds to 76 seconds. It is recommended that a northbound right turn lane be installed once the combined number of dwelling units between the two properties reaches 250 units.
2. The available sight distances looking east and west along North Nechako exceed all of the TAC Guideline requirements when the driver advances to the edge of North Nechako Road.
3. The TAC Guideline equation for left turn storage determined that the northbound left turn lane should have a minimum storage length of 30m. The existing storage length is approximately 40m in length, therefore no improvements are required.
4. The Signed and Marked Pedestrian Crosswalk Warrant was met for pedestrians crossing North Nechako Road during the 2034 Total Traffic scenario. The traffic along North Nechako Road is to low to trigger the warrant during the 2019 Opening Day scenario. The crosswalk should be installed once the sum of the westbound and eastbound traffic on North Nechako Road reaches 850 veh/hr in the peak hour.

Churchill Road & Craig Drive

1. The Churchill Road & Craig Drive intersection operates at a LOS B (minor delays) or better for all design horizons.

2. The available sight distance looking north exceeds the TAC Guides turning sight distance requirements. The sight distance looking south is approximately 90m which does not meet the turning sight distance requirements. The sight distance does however meet the stopping sight distance of 85m.

North Meadow Road & North Nechako Road

1. The left turn warrant is met for the westbound left turn movement on North Nechako at the proposed North Meadow Road site access during the 2034 Total Traffic scenario. It was determined that the left turn warrant is not triggered until approximately 80 dwelling units are developed on the 406286BC Ltd. property. The TAC equation determined that the left turn lane should have a minimum storage length of 30m.

Fairburn Road & North Nechako Road

1. The left turn warrant is met for the westbound left turn movement on North Nechako at the proposed Fairburn Road site access during the 2034 Total Traffic scenario. The left turn lane is required during the first phase of commercial construction in the northwest corner of the site. The left turn lane should have a minimum storage length of 30m.
2. The right turn deceleration warrant was met during both the AM and PM peak hour scenarios for the 2034 Total Traffic scenario. The AM scenario warranted a full-width turn lane and taper, while the PM scenario only warranted a taper. The right turn lane should be installed during the first phase of commercial construction in the northwest corner of the site.
3. The northbound approach may be restricted to right in and right out movements only if one or both of the following upgrades occur:
    i. North Nechako Road is expanded to a four-lane arterial highway.
    ii. The westbound left turn lane at the Foothills Boulevard and North Nechako Road is extended to the east.

Foothills Boulevard & Road A

1. The Foothills Boulevard and Road A intersections operates at a LOS C (average delays) or better during all design horizon scenarios.

2. The available sight distances for all movements meet or exceed the recommendations outlined in the TAC Guide.
3. The left turn warrant is met for the southbound left turn movement on Foothills Boulevard at the proposed site access location during the 2034 Total Traffic scenario. The left turn lane should be constructed at the same time that the site access is installed. The left turn lane should have a minimum storage length of 30m.

Traffic Calming Measures

1. Traffic circles should be installed at one or more of the internal intersections along the collector that connects the Fairburn Road intersection to the Dever Road intersection.

15.0 CLOSURE

This Traffic Impact Study has been prepared for the exclusive use of T.R. Projects Ltd., 406286BC Ltd., and the City of Prince George. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it are the responsibility of such third parties. L&M Engineering Limited accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this study. The information and data contained within this document represents L&M Engineering Limited's professional judgment in accordance with the knowledge and information available to L&M Engineering Limited at the time of the report preparation. No other warranty, expressed or implied, is made.

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JUNE 14 2019

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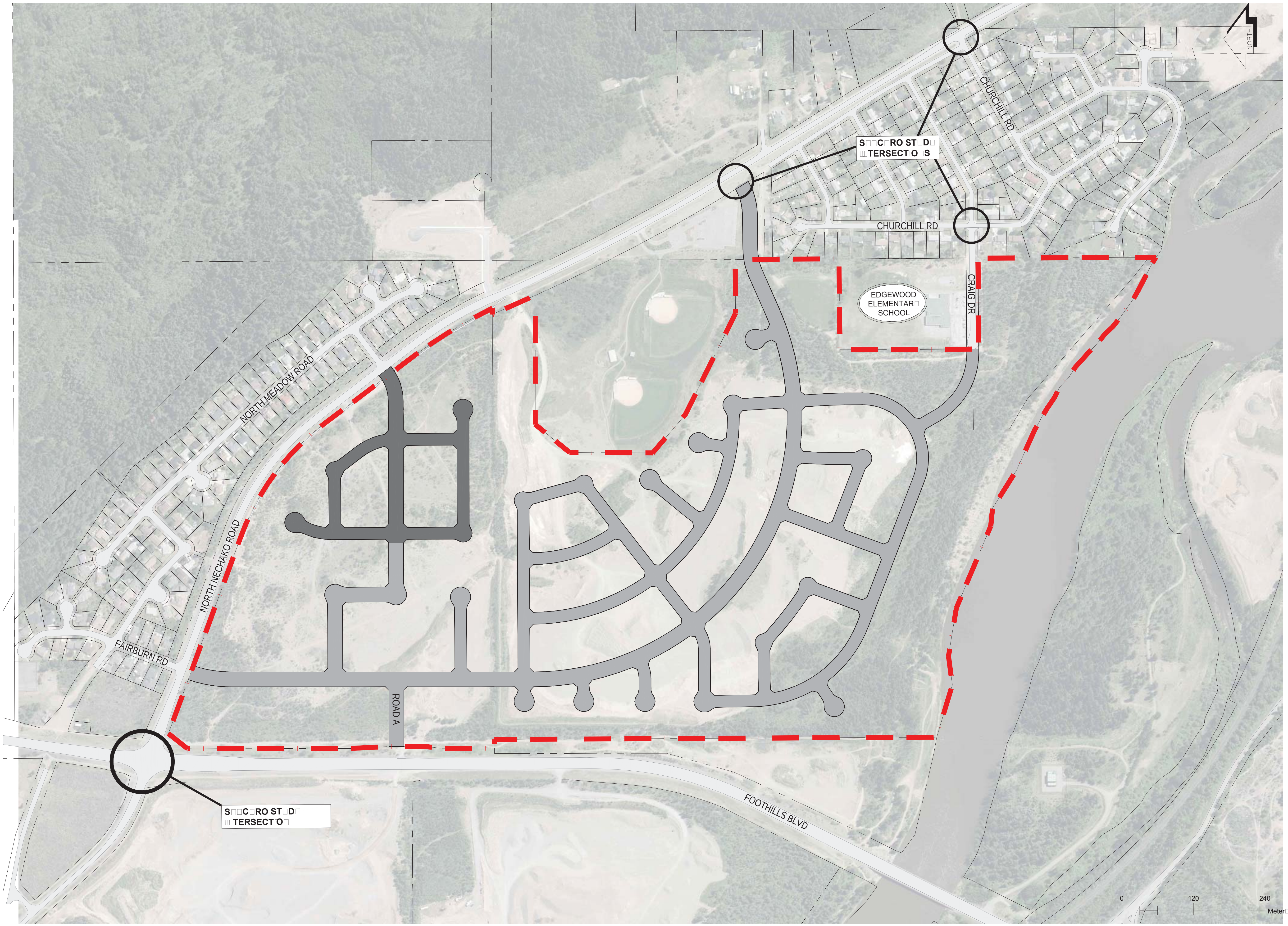
Figures



LEGEND

DEVELOPMENT BOUNDARY

2019 OPENING DAY ROAD NETWORK

2034 TOTAL TRAFFIC ROAD NETWORK

NO.	DATE	REVISION	DR.

L&M ENGINEERING LIMITED

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CHECKED:	TF
ENGINEER:	TAF
SURVEY FILE:	
DRAWING FILE:	C3D18 1600-02 TIS Base.dwg
CORRESPONDENCE:	CoT
GRID:	
DATE:	NOV 2018
SCALES:	1:600

NORTH NECHAKO
NEIGHBOURHOOD PLAN
TRAFFIC IMPACT STUDY

OVERALL SITE PLAN

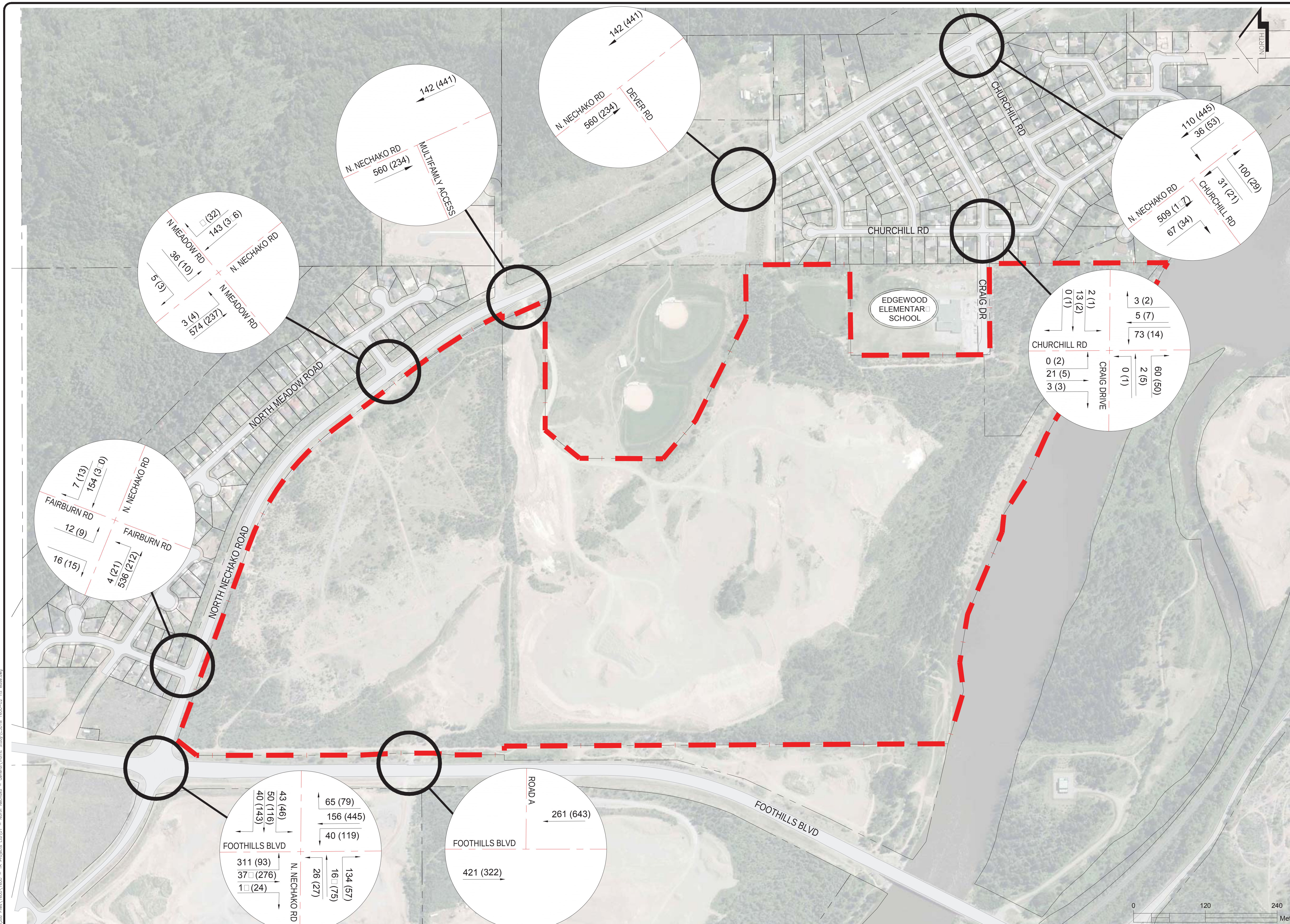
CONSULTANTS PROJECT No.

1600-02

DRAWING No.

FIG 1

SHEET No.	REV. No.
1 OF 10	0



LEGEND

DEVELOPMENT BOUNDARY

xxx AM TRAFFIC
(xxx) PM TRAFFIC

NO.	DATE	REVISION	DR.

L&M ENGINEERING LIMITED

1210 FOURTH AVENUE
PRINCE GEORGE, B.C.
V2L 3J4
TEL. (250) 562-1977
FAX (250) 562-1967

DRAWN:	KP
CHECKED:	TF
ENGINEER:	TAF
SURVEY FILE:	
DRAWING FILE:	C3018 1600-02 TIS Base.dwg
CORRESPONDENCE:	CoT
GRID:	
DATE:	NOV 2018
SCALES:	1:600

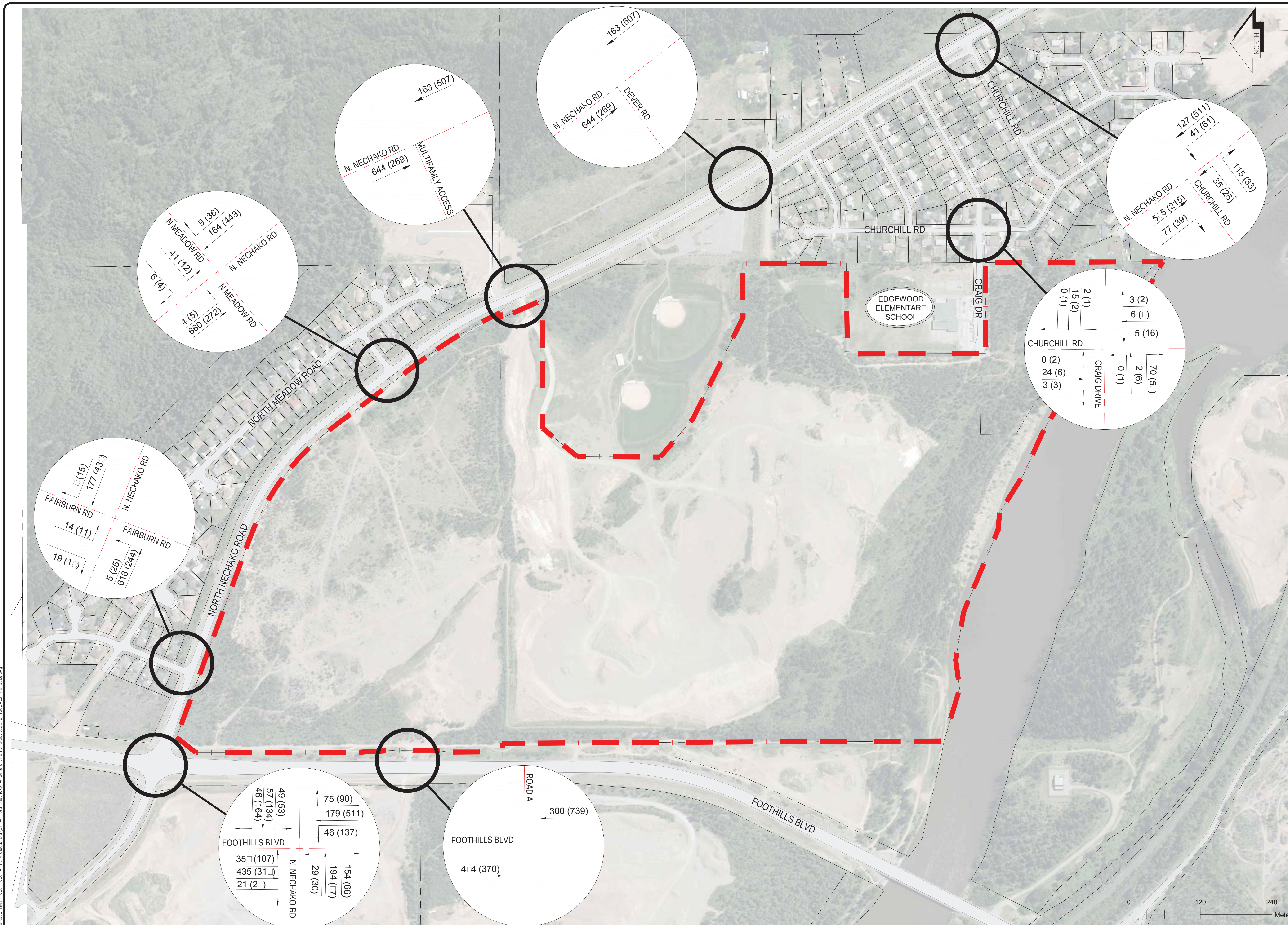
NORTH NECHAKO NEIGHBOURHOOD PLAN
TRAFFIC IMPACT STUDY

2019 EXISTING BACKGROUND

CONSULTANTS PROJECT No.
1600-02

DRAWING No.
FIG 2

SHEET No. 2 OF 10
REV. No. 0



LEGEND

DEVELOPMENT BOUNDARY

xxx AM TRAFFIC
(xxx) PM TRAFFIC

NO.	DATE	REVISION	DR.

L&M ENGINEERING LIMITED

1210 FOURTH AVENUE
PRINCE GEORGE, B.C.
V2L 3J4
TEL. (250) 562-1977
FAX (250) 562-1967

DRAWN:	KP
CHECKED:	TF
ENGINEER:	TAF
SURVEY FILE:	
DRAWING FILE:	C3018 1600-02 TIS Base.dwg
CORRESPONDENCE:	CoT
GRID:	
DATE:	NOV 2018
SCALES:	1:600

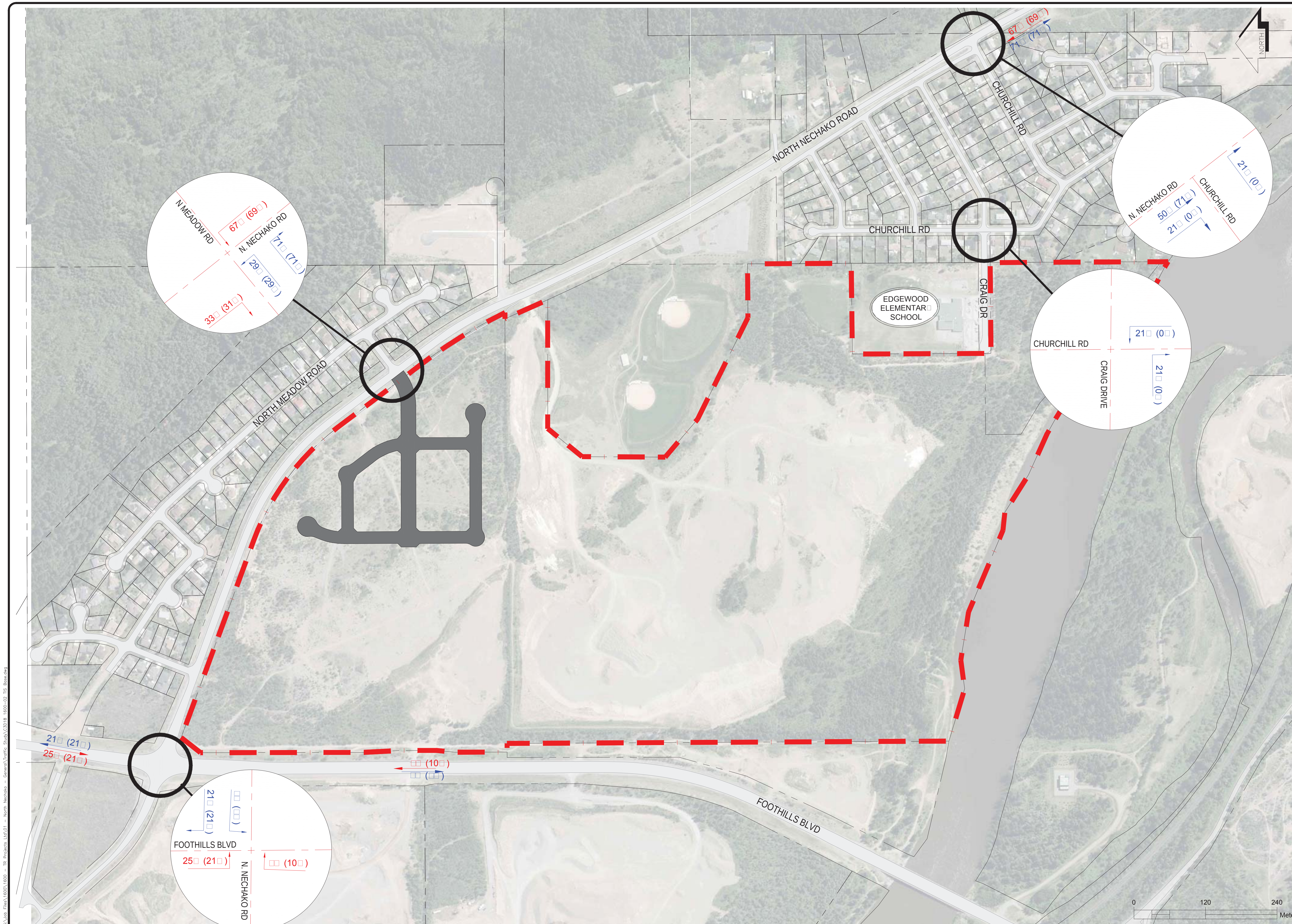
NORTH NECHAKO
NEIGHBOURHOOD PLAN
TRAFFIC IMPACT STUDY

2034 PROJECTED BACKGROUND

CONSULTANTS PROJECT No.
1600-02

DRAWING No.
FIG 3

SHEET No. 3 OF 10
REV. No. 0



LEGEND

DEVELOPMENT BOUNDARY

INGRESS
xxx AM TRAFFIC %
(xxx) PM TRAFFIC %

EGRESS
xxx AM TRAFFIC %
(xxx) PM TRAFFIC %

NO.	DATE	REVISION	DR.

L&M ENGINEERING LIMITED

1210 FOURTH AVENUE
PRINCE GEORGE, B.C.
V2L 3J4
TEL (250) 562-1977
FA□ (250) 562-1967

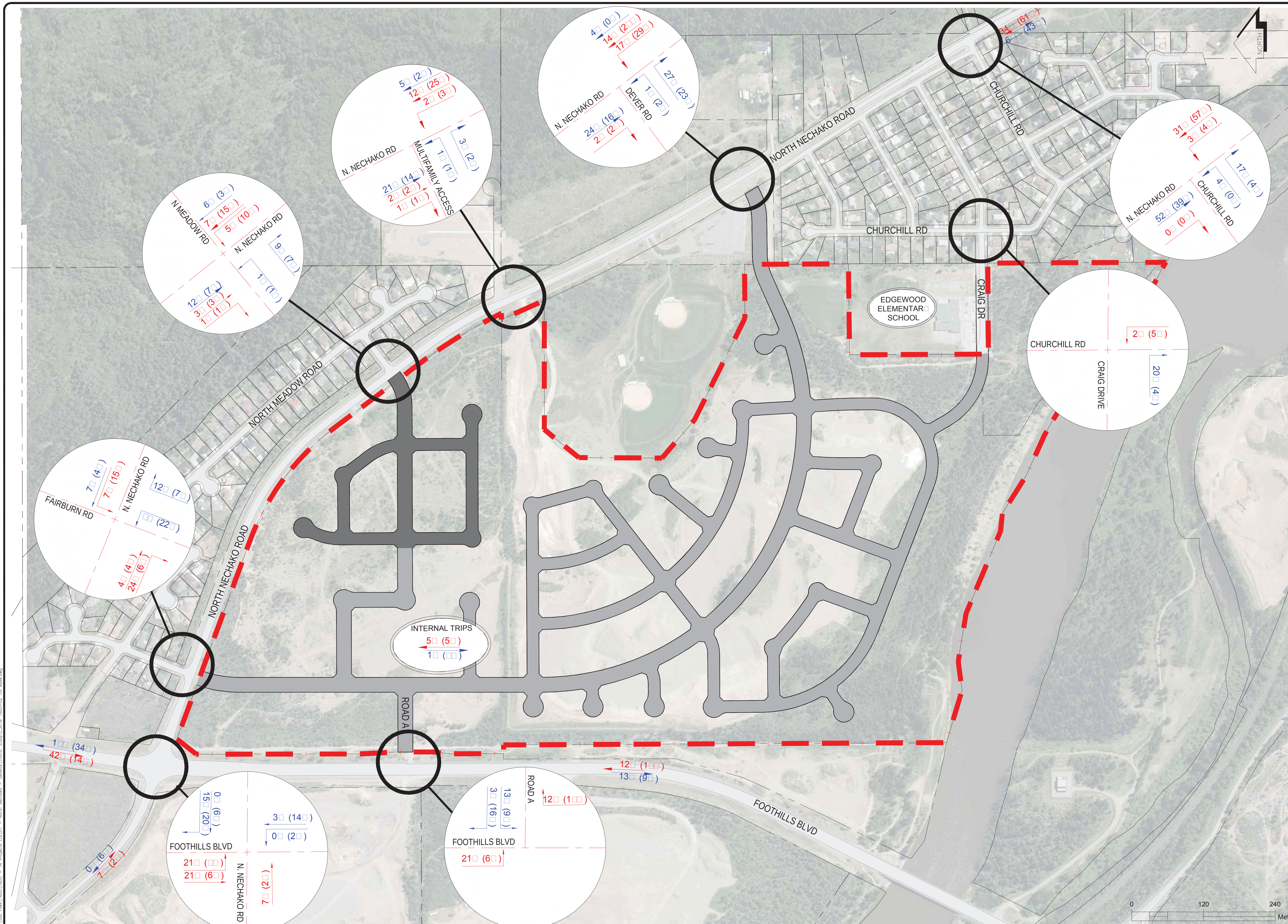
DRAWN:	KP
CHECKED:	TF
ENGINEER:	TAF
SURVEY FILE:	
DRAWING FILE:	C3D18 1600-02 TIS Base.dwg
CORRESPONDENCE:	CoT
GRID:	
DATE:	NOV 2018
SCALES:	1:600

NORTH NECHAKO NEIGHBOURHOOD PLAN
TRAFFIC IMPACT STUDY
TRIP DISTRIBUTION – OPENING DAY

CONSULTANTS PROJECT No.
1600–02

DRAWING No.
FIG 4

SHEET No. 7 OF 10
REV. No. 0



LEGEND

DEVELOPMENT BOUNDARY

INGRESS
xxx AM TRAFFIC %
(xxx) PM TRAFFIC %

EGRESS
xxx AM TRAFFIC %
(xxx) PM TRAFFIC %

NO.	DATE	REVISION	DR.

L&M ENGINEERING LIMITED

1210 FOURTH AVENUE
PRINCE GEORGE, B.C.
V2L 3J4
TEL. (250) 562-1977
FAX (250) 562-1967

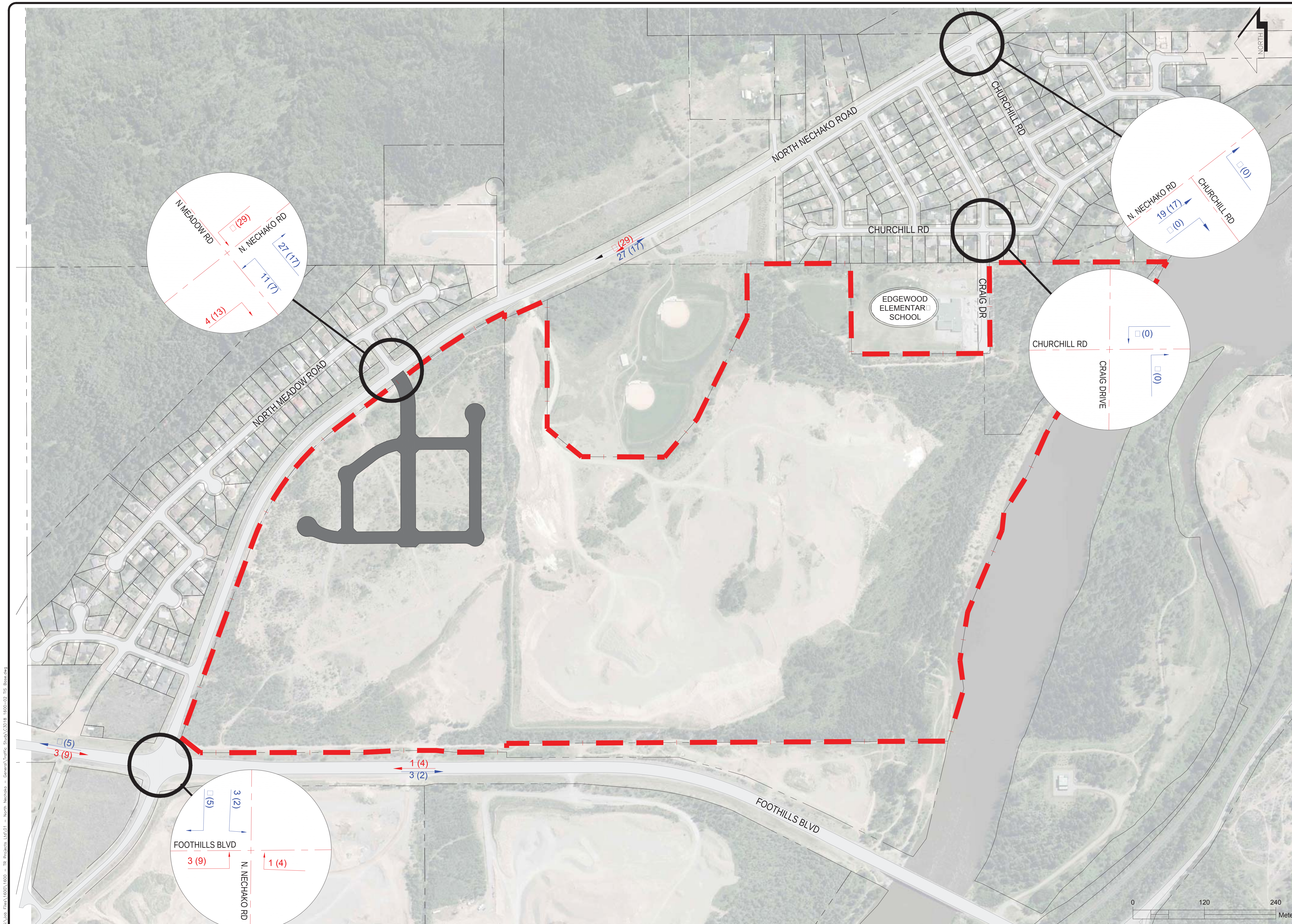
DRAWN:	KP
CHECKED:	TF
ENGINEER:	TAF
SURVEY FILE:	
DRAWING FILE:	C3018 1600-02 TIS Base.dwg
CORRESPONDENCE:	CoT
GRID:	
DATE:	NOV 2018
SCALES:	1:600

NORTH NECHAKO NEIGHBOURHOOD PLAN
TRAFFIC IMPACT STUDY
TRIP DISTRIBUTION – TOTAL TRAFFIC

CONSULTANTS PROJECT No.
1600-02

DRAWING No.
FIG 5

SHEET No.	REV. No.
7 OF 10	0



LEGEND

DEVELOPMENT BOUNDARY

INGRESS
xxx AM TRAFFIC %
(xxx) PM TRAFFIC %

EGRESS
xxx AM TRAFFIC %
(xxx) PM TRAFFIC %

NO.	DATE	REVISION	DR.

L&M ENGINEERING LIMITED
1210 FOURTH AVENUE
PRINCE GEORGE, B.C.
V2L 3J4
TEL. (250) 562-1977
FAX (250) 562-1967

DRAWN:	KP
CHECKED:	TF
ENGINEER:	TAF
SURVEY FILE:	
DRAWING FILE:	C3D18 1600-02 TIS Base.dwg
CORRESPONDENCE:	CoT
GRID:	
DATE:	NOV 2018
SCALES:	1:600

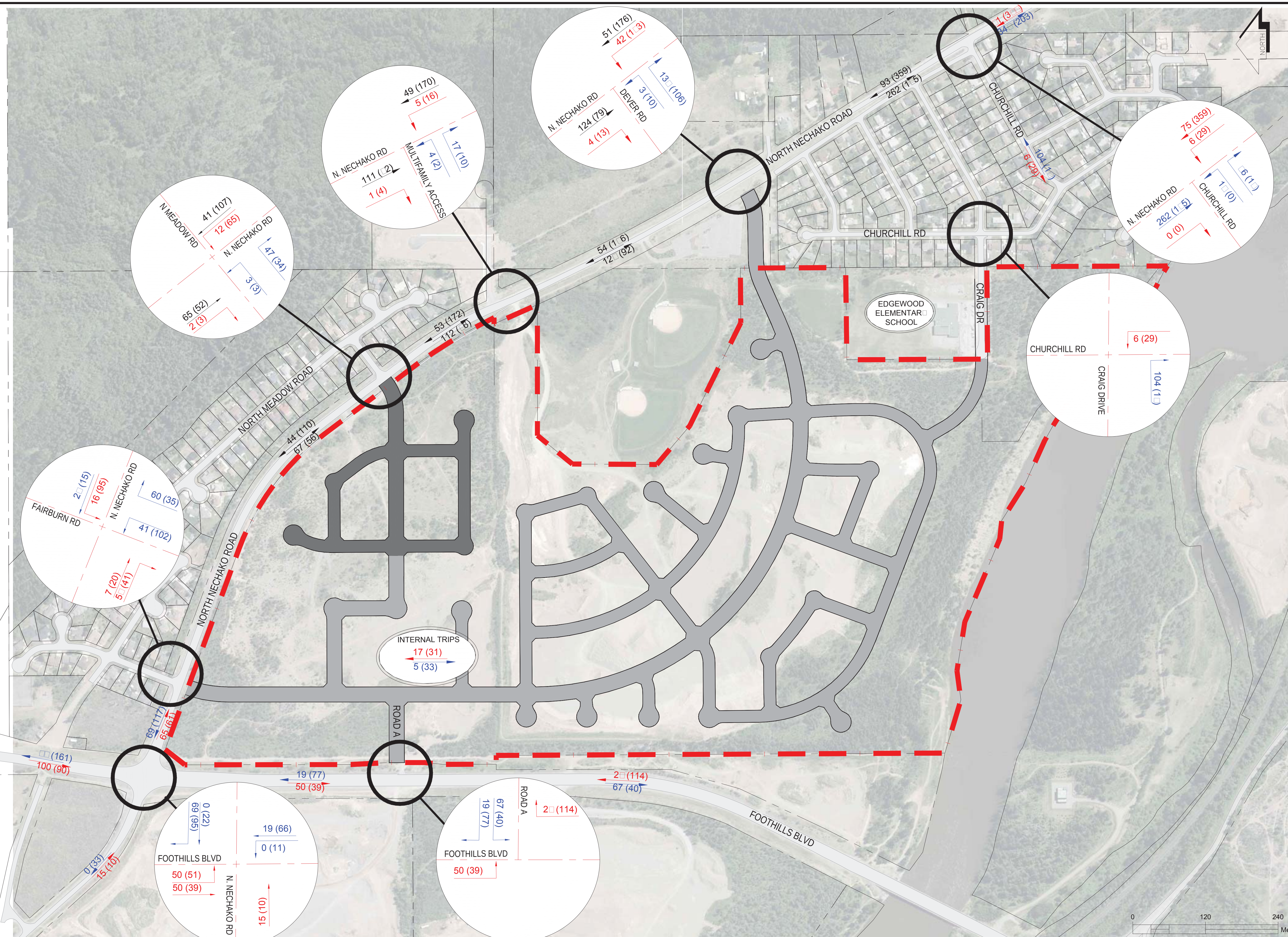
NORTH NECHAKO NEIGHBOURHOOD PLAN
TRAFFIC IMPACT STUDY
TRIP ASSIGNMENT – OPENING DAY

CONSULTANTS PROJECT No.
1600–02

DRAWING No.
FIG 6

SHEET No.	REV. No.
7 OF 10	0

G:\Job_Files\1600\1600 - TR Projects Ltd\01 - North Nechako - General\Traffic Study\C3D18 1600-02 TIS Base.dwg



LEGEND

DEVELOPMENT BOUNDARY

INGRESS
xxx AM TRAFFIC %
(xxx) PM TRAFFIC %

EGRESS
xxx AM TRAFFIC %
(xxx) PM TRAFFIC %

NO.	DATE	REVISION	DR.

L&M ENGINEERING LIMITED
1210 FOURTH AVENUE
PRINCE GEORGE, B.C.
V2L 3J4
TEL. (250) 562-1977
FAX (250) 562-1967

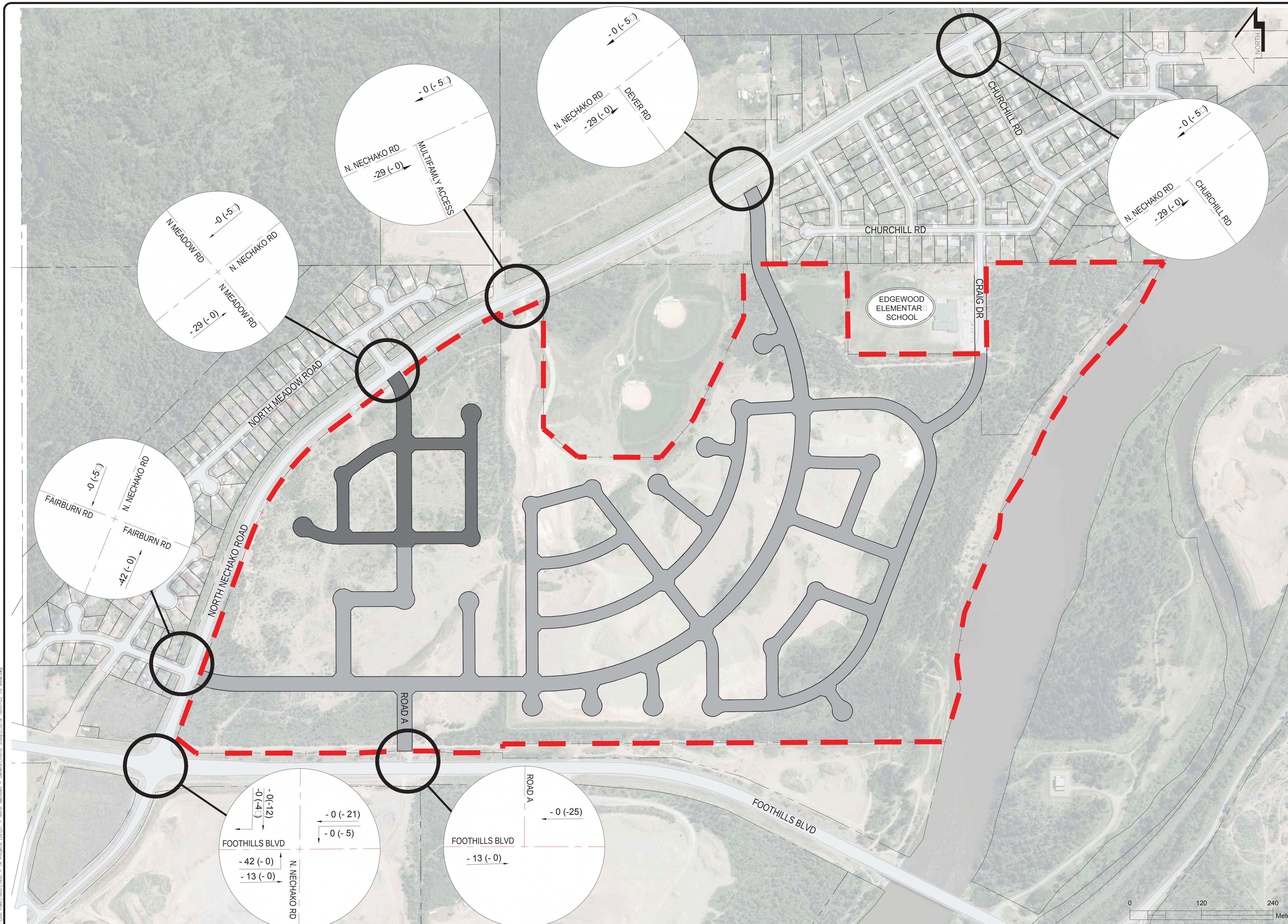
DRAWN:	KP
CHECKED:	TF
ENGINEER:	TAF
SURVEY FILE:	
DRAWING FILE:	C3D18 1600-02 TIS Base.dwg
CORRESPONDENCE:	CoT
GRID:	
DATE:	NOV 2018
SCALES:	1:600

NORTH NECHAKO NEIGHBOURHOOD PLAN
TRAFFIC IMPACT STUDY
TRIP ASSIGNMENT – TOTAL TRAFFIC

CONSULTANTS PROJECT No.
1600-02

DRAWING No.
FIG 7

SHEET No. 7 OF 10
REV. No. 0



LEGEND

DEVELOPMENT BOUNDARY

xxx AM TRAFFIC
(xxx) PM TRAFFIC

NO.	DATE	REVISION	DR.

L&M ENGINEERING LIMITED
1210 FOURTH AVENUE
PRINCE GEORGE, B.C.
V2L 3J4
TEL. (250) 562-1977
FAX (250) 562-1967

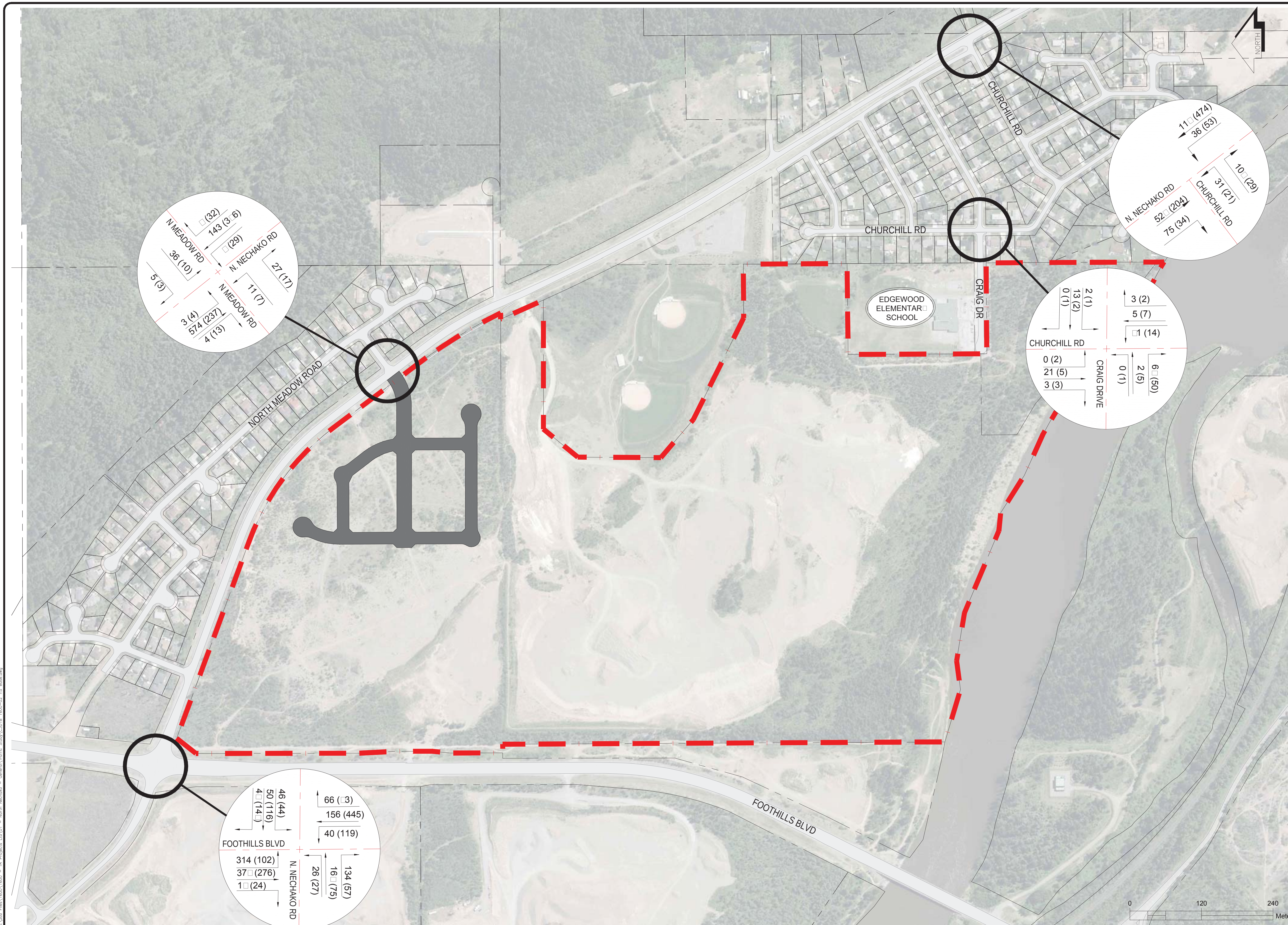
DRAWN:	KP
CHECKED:	TF
ENGINEER:	TAF
SURVEY FILE:	
DRAWING FILE:	C3018 1600-02 TIS Base.dwg
CORRESPONDENCE:	CoT
GRID:	
DATE:	NOV 2018
SCALES:	1:600

NORTH NECHAKO NEIGHBOURHOOD PLAN
TRAFFIC STUDY
PASS-BY TRIPS – TOTAL TRAFFIC

CONSULTANTS PROJECT No. 1600-02

DRAWING No. FIG 8

SHEET No.	REV. No.
8 OF 10	0



LEGEND

DEVELOPMENT BOUNDARY

xxx AM TRAFFIC
(xxx) PM TRAFFIC

NO.	DATE	REVISION	DR.

L&M ENGINEERING LIMITED

1210 FOURTH AVENUE
PRINCE GEORGE, B.C.
V2L 3J4
TEL. (250) 562-1977
FA (250) 562-1967

DRAWN:	KP
CHECKED:	TF
ENGINEER:	TAF
SURVEY FILE:	
DRAWING FILE:	C3018 1600-02 TIS Base.dwg
CORRESPONDENCE:	CoT
GRID:	
DATE:	NOV 2018
SCALES:	1:600

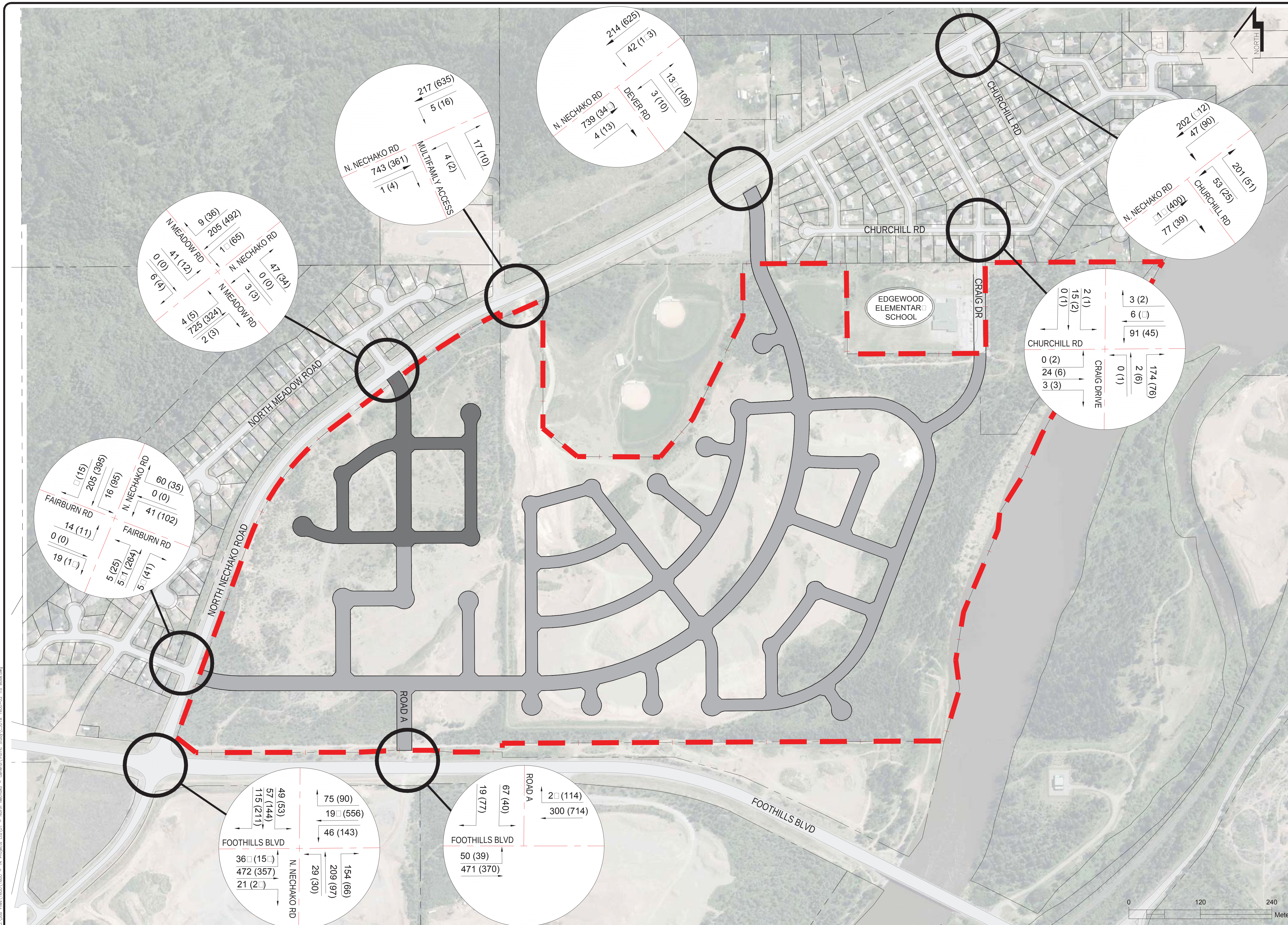
NORTH NECHAKO NEIGHBOURHOOD PLAN
TRAFFIC IMPACT STUDY

2019 OPENING DAY

CONSULTANTS PROJECT No.
1600-02

DRAWING No.
FIG 9

SHEET No.	REV. No.
9 OF 10	0



LEGEND

DEVELOPMENT BOUNDARY

xxx AM TRAFFIC
(xxx) PM TRAFFIC

NO.	DATE	REVISION	DR.

L&M ENGINEERING LIMITED

1210 FOURTH AVENUE
PRINCE GEORGE, B.C.
V2L 3J4
TEL. (250) 562-1977
FAX (250) 562-1967

DRAWN:	KP
CHECKED:	TF
ENGINEER:	TAF
SURVEY FILE:	
DRAWING FILE:	C3018 1600-02 TIS Base.dwg
CORRESPONDENCE:	CoT
GRID:	
DATE:	NOV 2018
SCALES:	1:600

NORTH NECHAKO NEIGHBOURHOOD PLAN TRAFFIC IMPACT STUDY

2034 TOTAL TRAFFIC

CONSULTANTS PROJECT No. 1600-02

DRAWING No. FIG 10

SHEET No.	REV. No.
10 OF 10	0

Appendix A
Traffic Counts

Vehicle Turning Movement Survey

PASSENGER VEHICLES

N/S Street: ***Foothills Blvd.***

E/W Street: ***North Nechako Rd.***

LOCATION: ***Prince George***

DATE: ***June 23, 2017***

WEATHER: ***Enter Weather***

TOTAL HOURS= ***HRS***

Observer: ***Enter Name***

Notes: ***N/A***

Speed Limit Major Street	***Speed***
Speed Limit Minor Street	***Speed***

	SOUTHBOUND (North Approach)			NORTHBOUND (South Approach)			WESTBOUND (East Approach)			EASTBOUND (West Approach)			Total	Hourly
TIME	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	Volume	Volume
6:00 - 6:15	6	18		4	10	3			4		9	7	61	
6:15 - 6:30	9	30		3	3	4		1	2		7	9	68	
6:30 - 6:45	30	46	1		7	1	6	1	1	1	15	7	116	
6:45 - 7:00	20	42	1	5	19	4	4	4	2	2	15	11	129	374
7:00 - 7:15	22	49	2	3	9	6	4	8	6		13	15	137	450
7:15 - 7:30	36	65	1	1	17	6	4	5	6	2	15	17	175	557
7:30 - 7:45	82	100	4	9	27	8	2	8	7	4	26	37	314	755
7:45 - 8:00	68	80	8	11	34	18	9	9	5	5	31	33	311	937
8:00 - 8:15	76	83	3	11	49	14	7	10	11	9	50	24	347	1147
8:15 - 8:30	74	94	1	6	36	21	15	9	12	6	51	35	360	1332
8:30 - 8:45	49	100	5	8	43	7	10	10	12	11	28	16	299	1317
8:45 -9:00	36	65	5	12	31	10	4	8	15	1	20	21	228	1234
SUB TOTAL	**508**	**772**	**31**	**73**	**285**	**102**	**65**	**73**	**83**	**41**	**280**	**232**	**2545**	

14:30 - 14:45														
14:45 - 15:00														
15:00 - 15:15	24	69	4	20	66	10	7	20	17	4	16	23	280	
15:15 - 15:30	15	50	6	21	98	13	17	25	16	2	14	19	296	576
15:30 - 15:45	16	72	13	23	85	20		26	24	6	17	17	319	895
15:45 - 16:00	14	69	3	28	97	27	14	31	27	8	8	8	334	1229
16:00 - 16:15	19	52	5	34	89	11	8	24	29	8	11	16	306	1255
16:15 - 16:30	24	57	6	25	92	13	11	27	25	10	7	14	311	1270
16:30 - 16:45	24	79	6	23	84	8	15	18	43	8	15	24	347	1298
16:45 - 17:00	15	82	1	29	102	18	11	34	33	6	21	10	362	1326
17:00 - 17:15	24	50	5	21	110	18	11	27	36	4	15	16	337	1357
17:15 - 17:30	23	71	6	34	103	15	13	30	44	7	13	15	374	1420
17:30 - 17:45	28	54	8	32	110	21	9	21	23	8	21	13	348	1421
17:45 - 18:00	23	75	6	26	104	18	8	16	25	8	27	9	345	1404
SUB TOTAL	**249**	**780**	**69**	**316**	**1140**	**192**	**124**	**299**	**342**	**79**	**185**	**184**	**3959**	

Vehicle Turning Movement Survey

LT + Bus + RV

N/S Street: Foothills Blvd.

E/W Street: North Nechako Rd.

LOCATION: Prince George

DATE: June 23, 2017

WEATHER: Enter Weather

TOTAL HOURS= HRS

Observer: Enter Name

Notes: N/A

Speed Limit Major Street	Speed
Speed Limit Minor Street	Speed

	SOUTHBOUND (North Approach)			NORTHBOUND (South Approach)			WESTBOUND (East Approach)			EASTBOUND (West Approach)			Total	Hourly
TIME	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	Volume	Volume
6:00 - 6:15	2	1		1							1	2	7	
6:15 - 6:30		1									1		2	
6:30 - 6:45		2			1				1		1		5	
6:45 - 7:00	1	1	1		1						1		5	19
7:00 - 7:15	1	2			1			1					5	17
7:15 - 7:30	2	2	1		3			1		2		1	12	27
7:30 - 7:45							3	3					6	28
7:45 - 8:00	3	3	1	1	1			2			5	1	17	40
8:00 - 8:15		1			2			6		1	1	1	12	47
8:15 - 8:30			1								1		2	37
8:30 - 8:45	2	2	1		1	2						1	9	40
8:45 -9:00		3	1		2				1		1		8	31
SUB TOTAL	**11**	**18**	**6**	**2**	**12**	**2**	**3**	**13**	**2**	**3**	**12**	**6**	**90**	

14:30 - 14:45														
14:45 - 15:00														
15:00 - 15:15	4	1		3	3		1	2					14	
15:15 - 15:30	3	1	1	1	2	2	1			1			12	26
15:30 - 15:45		1			4		1	1	1		1		9	35
15:45 - 16:00	2	1	2		1		2				4		12	47
16:00 - 16:15	1			2	1						1		5	38
16:15 - 16:30		3			1	1		2			3		10	36
16:30 - 16:45		3	1		3					1			8	35
16:45 - 17:00		3	1		4	2						1	11	34
17:00 - 17:15		1	2		2	1					1	1	8	37
17:15 - 17:30		1		1	4			1		1	3		11	38
17:30 - 17:45	1	5	1		1		1		4				13	43
17:45 - 18:00		2	1	1	1				2				7	39
SUB TOTAL	**11**	**22**	**9**	**8**	**27**	**6**	**6**	**6**	**7**	**3**	**13**	**2**	**120**	

Vehicle Turning Movement Survey

HEAVY TRUCKS

N/S Street: Foothills Blvd.

E/W Street: North Nechako Rd.

LOCATION: Prince George

DATE: June 23, 2017

WEATHER: Enter Weather

TOTAL HOURS= HRS

Observer: Enter Name

Notes: N/A

Speed Limit Major Street	Speed
Speed Limit Minor Street	Speed

	SOUTHBOUND (North Approach)			NORTHBOUND (South Approach)			WESTBOUND (East Approach)			EASTBOUND (West Approach)			Total	Hourly
TIME	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	Volume	Volume
6:00 - 6:15														
6:15 - 6:30					1								1	
6:30 - 6:45														
6:45 - 7:00					1								1	2
7:00 - 7:15	1	2					1		1				5	7
7:15 - 7:30		2					1						3	9
7:30 - 7:45	1				1	1			1				4	13
7:45 - 8:00		4		1	3		5						13	25
8:00 - 8:15		6					1	2	1				10	30
8:15 - 8:30	1					2			2				5	32
8:30 - 8:45	1	1			9	1	1						13	41
8:45 -9:00		5				1	1		1				8	36
SUB TOTAL	**4**	**20**		**1**	**15**	**5**	**10**	**2**	**6**				**63**	

14:30 - 14:45														
14:45 - 15:00														
15:00 - 15:15	1	4			1						1		7	
15:15 - 15:30		2			1		2				2	1	8	15
15:30 - 15:45		3			1	1		1					6	21
15:45 - 16:00		2				1					1		4	25
16:00 - 16:15	2	1			1	2	1						7	25
16:15 - 16:30		1			3	1			4				9	26
16:30 - 16:45		2			1	1			1				5	25
16:45 - 17:00		1				2							3	24
17:00 - 17:15		2						1					3	20
17:15 - 17:30		1											1	12
17:30 - 17:45														7
17:45 - 18:00														4
SUB TOTAL	**3**	**19**			**8**	**8**	**3**	**2**	**5**		**4**	**1**	**53**	

Vehicle Turning Movement Survey **PEDESTRIAN**

N/S Street: Foothills Blvd.
E/W Street: North Nechako Rd.
LOCATION: Prince George
DATE: June 23, 2017
WEATHER: Enter Weather
TOTAL HOURS= HRS

Observer: Enter Name
Notes: N/A

Speed Limit Major Street	Speed
Speed Limit Minor Street	Speed

TIME	SOUTHBOUND (North Approach)	NORTHBOUND (South Approach)	WESTBOUND (East Approach)	EASTBOUND (West Approach)	Total Volume	Hourly Volume
6:00 - 6:15	1				1	
6:15 - 6:30						
6:30 - 6:45						
6:45 - 7:00						1
7:00 - 7:15						
7:15 - 7:30		2			2	2
7:30 - 7:45	2				2	4
7:45 - 8:00		3			3	7
8:00 - 8:15		2		2	4	11
8:15 - 8:30						9
8:30 - 8:45				1	1	8
8:45 -9:00		1		1	2	7
SUB TOTAL	**3**	**8**		**4**	**15**	

TIME	SOUTHBOUND (North Approach)	NORTHBOUND (South Approach)	WESTBOUND (East Approach)	EASTBOUND (West Approach)	Total Volume	Hourly Volume
14:30 - 14:45						
14:45 - 15:00						
15:00 - 15:15			1		1	
15:15 - 15:30			1		1	2
15:30 - 15:45						2
15:45 - 16:00			2		2	4
16:00 - 16:15		1	2	1	4	7
16:15 - 16:30						6
16:30 - 16:45			4		4	10
16:45 - 17:00			1	1	2	10
17:00 - 17:15		1			1	7
17:15 - 17:30				3	3	10
17:30 - 17:45				1	1	7
17:45 - 18:00		3			3	8
SUB TOTAL		**5**	**11**	**6**	**22**	

Vehicle Turning Movement Survey **TOTAL**

N/S Street: Foothills Blvd.
E/W Street: North Nechako Rd.
LOCATION: Prince George
DATE: June 23, 2017
WEATHER: Enter Weather

TOTAL HOURS = HRS

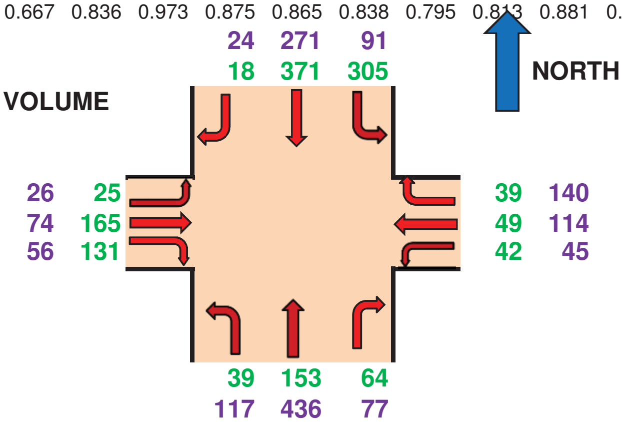
Observer: Enter Name
Notes: N/A

Speed Limit Major Street	Speed
Speed Limit Minor Street	Speed

	SOUTHBOUND (North Approach)			NORTHBOUND (South Approach)			WESTBOUND (East Approach)			EASTBOUND (West Approach)			Total	Hourly	Pedestrian			
TIME	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	Volume	Volume	N	S	E	W
6:00 - 6:15	8	19		5	10	3			4		10	9	68		1			
6:15 - 6:30	9	31		3	4	4		1	2		8	9	71					
6:30 - 6:45	30	48	1		8	1	6	1	2	1	16	7	121					
6:45 - 7:00	21	43	2	5	21	4	4	4	2	2	16	11	135	395				
7:00 - 7:15	24	53	2	3	10	6	5	9	7		13	15	147	474				
7:15 - 7:30	38	69	2	1	20	6	5	6	6	4	15	18	190	593		2		
7:30 - 7:45	83	100	4	9	28	9	5	11	8	4	26	37	324	796	2			
7:45 - 8:00	71	87	9	13	38	18	14	11	5	5	36	34	341	1002		3		
8:00 - 8:15	76	90	3	11	51	14	8	18	12	10	51	25	369	1224		2		2
8:15 - 8:30	75	94	2	6	36	23	15	9	14	6	52	35	367	**1401**				
8:30 - 8:45	52	103	6	8	53	10	11	10	12	11	28	17	321	1398				1
8:45 -9:00	36	73	6	12	33	11	5	8	17	1	21	21	244	**1301**		1		1
SUB TOTAL	**523**	**810**	**37**	**76**	**312**	**109**	**78**	**88**	**91**	**44**	**292**	**238**	**2698**		3	8		4
PEAK HOUR	**305**	**371**	**18**	**39**	**153**	**64**	**42**	**49**	**39**	**25**	**165**	**131**	**1401**		2	5		2
PHF	0.9187	0.928	0.5	0.75	0.75	0.696	0.7	0.681	0.696	0.625	0.793	0.885						
14:30 - 14:45																		
14:45 - 15:00																		
15:00 - 15:15	29	74	4	23	70	10	8	22	17	4	17	23	301				1	
15:15 - 15:30	18	53	7	22	101	15	20	25	16	3	16	20	316	617			1	
15:30 - 15:45	16	76	13	23	90	21	1	28	25	6	18	17	334	951				
15:45 - 16:00	16	72	5	28	98	28	16	31	27	8	13	8	350	1301			2	
16:00 - 16:15	22	53	5	36	91	13	9	24	29	8	12	16	318	1318		1	2	1
16:15 - 16:30	24	61	6	25	96	15	11	29	29	10	10	14	330	1332				
16:30 - 16:45	24	84	7	23	88	9	15	18	44	9	15	24	360	1358			4	
16:45 - 17:00	15	86	2	29	106	22	11	34	33	6	21	11	376	**1384**			1	1
17:00 - 17:15	24	53	7	21	112	19	11	28	36	4	16	17	348	1414		1		
17:15 - 17:30	23	73	6	35	107	15	13	31	44	8	16	15	386	1470				3
17:30 - 17:45	29	59	9	32	111	21	10	21	27	8	21	13	361	**1471**				1
17:45 - 18:00	23	77	7	27	105	18	8	16	27	8	27	9	352	1447		3		
SUB TOTAL	**263**	**821**	**78**	**324**	**1175**	**206**	**133**	**307**	**354**	**82**	**202**	**187**	**4132**			5		6
PEAK HOUR	**91**	**271**	**24**	**117**	**436**	**77**	**45**	**114**	**140**	**26**	**74**	**56**	**1471**			1	1	5
PHF	0.7845	0.788	0.667	0.836	0.973	0.875	0.865	0.838	0.795	0.813	0.881	0.824						

PEAK HOUR VOLUME

AM PEAK
PM PEAK



Vehicle Turning Movement Survey

PASSENGER VEHICLES

N/S Street: ***FairburnRd.***
E/W Street: ***North Nechako Road***
LOCATION: ***Prince George***
DATE: ***June 23, 2017***
WEATHER: ***Enter Weather***
TOTAL HOURS= ***HRS***

Observer: ***Enter Name***
Notes: ***N/A***

Speed Limit Major Street	***Speed***
Speed Limit Minor Street	***Speed***

	SOUTHBOUND (North Approach)			NORTHBOUND (South Approach)			WESTBOUND (East Approach)			EASTBOUND (West Approach)			Total	Hourly
TIME	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	Volume	Volume
6:00 - 6:15								4			22		26	
6:15 - 6:30	4							3	1		24		32	
6:30 - 6:45	1		2					8	1		45		57	
6:45 - 7:00	1		1					10	1	1	39		53	168
7:00 - 7:15	2		1					17		1	34		55	197
7:15 - 7:30			5					14		2	61		82	247
7:30 - 7:45	2		1					14	1	1	93		112	302
7:45 - 8:00	2		5					23		2	129		161	410
8:00 - 8:15	3		4					31	3	1	148		190	545
8:15 - 8:30	3		7					39		1	147		197	660
8:30 - 8:45	3							36	3		84		126	674
8:45 -9:00	5		3					28	2	1	87		126	639
SUB TOTAL	**26**		**29**					**227**	**12**	**10**	**913**		**1217**	

14:30 - 14:45														
14:45 - 15:00														
15:00 - 15:15	2		2					51	2	1	56		114	
15:15 - 15:30			4					72	2	4	47		129	243
15:30 - 15:45	3		1					61	3	3	51		122	365
15:45 - 16:00	1		3					75		1	38		118	483
16:00 - 16:15			1					61	2	6	40		110	479
16:15 - 16:30	1		7					59	4	3	46		120	470
16:30 - 16:45	2		4					85	5	1	41		138	486
16:45 - 17:00	2		5					119	5	5	75		211	579
17:00 - 17:15	1		2					80		7	42		132	601
17:15 - 17:30	4		4					86	3	8	46		151	632
17:30 - 17:45	1		5					61		2	67		136	630
17:45 - 18:00	3		1					51	3	3	65		126	545
SUB TOTAL	**20**		**39**					**861**	**29**	**44**	**614**		**1607**	

Vehicle Turning Movement Survey

LT + Bus + RV

N/S Street: FairburnRd.

E/W Street: North Nechako Road

LOCATION: Prince George

DATE: June 23, 2017

WEATHER: Enter Weather

TOTAL HOURS= HRS

Observer: Enter Name

Notes: N/A

Speed Limit Major Street	Speed
Speed Limit Minor Street	Speed

	SOUTHBOUND (North Approach)			NORTHBOUND (South Approach)			WESTBOUND (East Approach)			EASTBOUND (West Approach)			Total	Hourly
TIME	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	Volume	Volume
6:00 - 6:15														
6:15 - 6:30														
6:30 - 6:45											1		1	
6:45 - 7:00								1			1		2	3
7:00 - 7:15														3
7:15 - 7:30								2					2	5
7:30 - 7:45								4					4	8
7:45 - 8:00								2			2		4	10
8:00 - 8:15	1							5	1		3		10	20
8:15 - 8:30								1			1		2	20
8:30 - 8:45											3		3	19
8:45 -9:00								1			1		2	17
SUB TOTAL	**1**							**16**	**1**		**12**		**30**	

14:30 - 14:45														
14:45 - 15:00														
15:00 - 15:15								2			3		5	
15:15 - 15:30								5		1	5		11	16
15:30 - 15:45								1			2		3	19
15:45 - 16:00										1	5		6	25
16:00 - 16:15														20
16:15 - 16:30								1			5		6	15
16:30 - 16:45														12
16:45 - 17:00											1		1	7
17:00 - 17:15														7
17:15 - 17:30								1					1	2
17:30 - 17:45											1		1	3
17:45 - 18:00											1		1	3
SUB TOTAL								**10**		**2**	**23**		**35**	

Vehicle Turning Movement Survey

HEAVY TRUCKS

N/S Street: FairburnRd.
E/W Street: North Nechako Road
LOCATION: Prince George
DATE: June 23, 2017
WEATHER: Enter Weather
TOTAL HOURS= HRS

Observer: Enter Name
Notes: N/A

Speed Limit Major Street	Speed
Speed Limit Minor Street	Speed

	SOUTHBOUND (North Approach)			NORTHBOUND (South Approach)			WESTBOUND (East Approach)			EASTBOUND (West Approach)			Total	Hourly
TIME	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	Volume	Volume
6:00 - 6:15														
6:15 - 6:30														
6:30 - 6:45														
6:45 - 7:00														
7:00 - 7:15								2			1		3	3
7:15 - 7:30	1							1			1		3	6
7:30 - 7:45								1			2		3	9
7:45 - 8:00								4			1		5	14
8:00 - 8:15								6			2		8	19
8:15 - 8:30								1			3		4	20
8:30 - 8:45								3			2		5	22
8:45 -9:00								2			2		4	21
SUB TOTAL	**1**							**20**			**14**		**35**	

14:30 - 14:45														
14:45 - 15:00														
15:00 - 15:15										2			2	
15:15 - 15:30								1					1	3
15:30 - 15:45								1			2		3	6
15:45 - 16:00											2		2	8
16:00 - 16:15								1			3		4	10
16:15 - 16:30								2			1		3	12
16:30 - 16:45											1		1	10
16:45 - 17:00								1			2		3	11
17:00 - 17:15								1					1	8
17:15 - 17:30														5
17:30 - 17:45														4
17:45 - 18:00														1
SUB TOTAL								**7**		**2**	**11**		**20**	

Vehicle Turning Movement Survey

PEDESTRIAN

N/S Street: FairburnRd.
E/W Street: North Nechako Road
LOCATION: Prince George
DATE: June 23, 2017
WEATHER: Enter Weather

TOTAL HOURS= HRS

Observer: Enter Name
Notes: N/A

Speed Limit Major Street	Speed
Speed Limit Minor Street	Speed

TIME	SOUTHBOUND (North Approach)	NORTHBOUND (South Approach)	WESTBOUND (East Approach)	EASTBOUND (West Approach)	Total Volume	Hourly Volume
6:00 - 6:15						
6:15 - 6:30						
6:30 - 6:45			1	1	2	
6:45 - 7:00			1	1	2	4
7:00 - 7:15						4
7:15 - 7:30				1	1	5
7:30 - 7:45						3
7:45 - 8:00			1	3	4	5
8:00 - 8:15				3	3	8
8:15 - 8:30						7
8:30 - 8:45						7
8:45 -9:00				2	2	5
SUB TOTAL			**3**	**11**	**14**	

14:30 - 14:45						
14:45 - 15:00						
15:00 - 15:15				1	1	
15:15 - 15:30				1	1	2
15:30 - 15:45						2
15:45 - 16:00			2		2	4
16:00 - 16:15			2	3	5	8
16:15 - 16:30						7
16:30 - 16:45			4		4	11
16:45 - 17:00			1	1	2	11
17:00 - 17:15				1	1	7
17:15 - 17:30			2	2	4	11
17:30 - 17:45						7
17:45 - 18:00						5
SUB TOTAL			**11**	**9**	**20**	

Vehicle Turning Movement Survey **TOTAL**

N/S Street: FairburnRd.
E/W Street: North Nechako Road
LOCATION: Prince George
DATE: June 23, 2017
WEATHER: Enter Weather
TOTAL HOURS = HRS

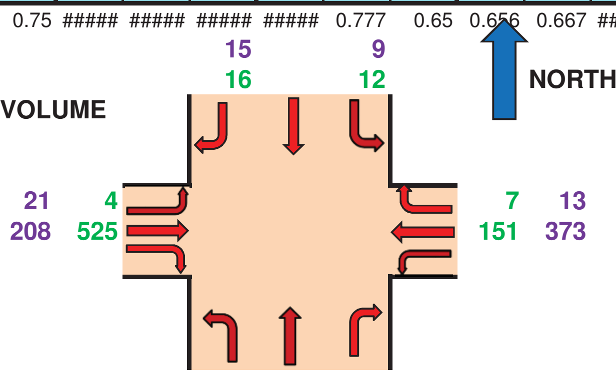
Observer: Enter Name
Notes: N/A

Speed Limit Major Street	Speed
Speed Limit Minor Street	Speed

	SOUTHBOUND (North Approach)			NORTHBOUND (South Approach)			WESTBOUND (East Approach)			EASTBOUND (West Approach)			Total	Hourly	Pedestrian			
TIME	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	Volume	Volume	N	S	E	W
6:00 - 6:15								4			22		26					
6:15 - 6:30	4							3	1		24		32					
6:30 - 6:45	1		2					8	1		46		58				1	1
6:45 - 7:00	1		1					11	1	1	40		55	171			1	1
7:00 - 7:15	2		1					19		1	35		58	203				
7:15 - 7:30	1		5					17		2	62		87	258				1
7:30 - 7:45	2		1					19	1	1	95		119	319				
7:45 - 8:00	2		5					29		2	132		170	434			1	3
8:00 - 8:15	4		4					42	4	1	153		208	584				3
8:15 - 8:30	3		7					41		1	151		203	700				
8:30 - 8:45	3							39	3		89		134	**715**				
8:45 -9:00	5		3					31	2	1	90		132	**677**				2
SUB TOTAL	**28**		**29**					**263**	**13**	**10**	**939**		**1282**				3	11
PEAK HOUR	**12**		**16**					**151**	**7**	**4**	**525**		**715**				1	6
PHF	0.75	#####	0.571	#####	#####	#####	#####	0.899	0.438	0.5	0.858	#####						
14:30 - 14:45																		
14:45 - 15:00																		
15:00 - 15:15	2		2					53	2	3	59		121					1
15:15 - 15:30			4					78	2	5	52		141	262				1
15:30 - 15:45	3		1					63	3	3	55		128	390				
15:45 - 16:00	1		3					75		2	45		126	516			2	
16:00 - 16:15			1					62	2	6	43		114	509			2	3
16:15 - 16:30	1		7					62	4	3	52		129	497				
16:30 - 16:45	2		4					85	5	1	42		139	508			4	
16:45 - 17:00	2		5					120	5	5	78		215	**597**			1	1
17:00 - 17:15	1		2					81		7	42		133	616				1
17:15 - 17:30	4		4					87	3	8	46		152	**639**			2	2
17:30 - 17:45	1		5					61		2	68		137	637				
17:45 - 18:00	3		1					51	3	3	66		127	549				
SUB TOTAL	**20**		**39**					**878**	**29**	**48**	**648**		**1662**					9
PEAK HOUR	**9**		**15**					**373**	**13**	**21**	**208**		**639**				7	4
PHF	0.5625	#####	0.75	#####	#####	#####	#####	0.777	0.65	0.656	0.667	#####						

PEAK HOUR VOLUME

AM PEAK
PM PEAK



Vehicle Turning Movement Survey

PASSENGER VEHICLES

N/S Street: ***North Meadow Rd.***

E/W Street: ***North Nechako Rd.***

LOCATION: ***Prince George***

DATE: ***June 23, 2017***

WEATHER: ***Enter Weather***

TOTAL HOURS= ***HRS***

Observer: ***Enter Name***

Notes: ***N/A***

Speed Limit Major Street	***60km/hr***
Speed Limit Minor Street	***50km/hr***

	SOUTHBOUND *(North Approach)*			NORTHBOUND *(South Approach)*			WESTBOUND *(East Approach)*			EASTBOUND *(West Approach)*			Total	Hourly
TIME	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	Volume	Volume
6:00 - 6:15								2			18		20	
6:15 - 6:30	2							6	1		23		32	
6:30 - 6:45	2							8			49		59	
6:45 - 7:00	4							10	1		35		50	161
7:00 - 7:15	1		2					19	1		42		65	206
7:15 - 7:30	1		1					11			56		69	243
7:30 - 7:45	6		1					16	2	2	111		138	322
7:45 - 8:00	9		2					19	1	1	127		159	431
8:00 - 8:15	10		1					27	1		158		197	563
8:15 - 8:30	9		1					46	3		146		205	699
8:30 - 8:45	4			8				31	2		79		124	685
8:45 -9:00	2							24	1	1	82		110	636
SUB TOTAL	**50**		**8**	**8**				**219**	**13**	**4**	**926**		**1228**	

14:30 - 14:45														
14:45 - 15:00														
15:00 - 15:15	6							53	6	2	41		108	
15:15 - 15:30	1		1					69	3	1	39		114	222
15:30 - 15:45	5		1					72	8	1	54		141	363
15:45 - 16:00	1		1					63	7	1	33		106	469
16:00 - 16:15	3							72	2		38		115	476
16:15 - 16:30	2							65	6		42		115	477
16:30 - 16:45	3							89	4	2	48		146	482
16:45 - 17:00	3		1					114	6	1	68		193	569
17:00 - 17:15	1							87	12		47		147	601
17:15 - 17:30	3		2					77	9	1	54		146	632
17:30 - 17:45	3							52	2	2	60		119	605
17:45 - 18:00	3		1					47	4	2	65		122	534
SUB TOTAL	**34**		**7**					**860**	**69**	**13**	**589**		**1572**	

Vehicle Turning Movement Survey

LT + Bus + RV

N/S Street: North Meadow Rd.

E/W Street: North Nechako Rd.

LOCATION: Prince George

DATE: June 23, 2017

WEATHER: Enter Weather

TOTAL HOURS= HRS

Observer: Enter Name

Notes: N/A

Speed Limit Major Street	60km/hr
Speed Limit Minor Street	50km/hr

	SOUTHBOUND (North Approach)			NORTHBOUND (South Approach)			WESTBOUND (East Approach)			EASTBOUND (West Approach)			Total	Hourly
TIME	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	Volume	Volume
6:00 - 6:15											2		2	
6:15 - 6:30	1										2		3	
6:30 - 6:45								2			3		5	
6:45 - 7:00			1								1		2	12
7:00 - 7:15								1			2		3	13
7:15 - 7:30	1							1			2		4	14
7:30 - 7:45								7					7	16
7:45 - 8:00								2	1		6		9	23
8:00 - 8:15								9			2		11	31
8:15 - 8:30											4		4	31
8:30 - 8:45											5		5	29
8:45 -9:00								2			1		3	23
SUB TOTAL	**2**		**1**					**24**	**1**		**30**		**58**	

14:30 - 14:45														
14:45 - 15:00														
15:00 - 15:15								3			4		7	
15:15 - 15:30								3			6		9	16
15:30 - 15:45								3			5		8	24
15:45 - 16:00								2			7		9	33
16:00 - 16:15								2	1		4		7	33
16:15 - 16:30								4			7		11	35
16:30 - 16:45								1			4		5	32
16:45 - 17:00								1			4		5	28
17:00 - 17:15								4			4		8	29
17:15 - 17:30								4					4	22
17:30 - 17:45								5			3		8	25
17:45 - 18:00								2	1		2		5	25
SUB TOTAL								**34**	**2**		**50**		**86**	

Vehicle Turning Movement Survey

HEAVY TRUCKS

N/S Street: North Meadow Rd.
E/W Street: North Nechako Rd.
LOCATION: Prince George
DATE: June 23, 2017
WEATHER: Enter Weather
TOTAL HOURS= HRS

Observer: Enter Name
Notes: N/A

Speed Limit Major Street	60km/hr
Speed Limit Minor Street	50km/hr

	SOUTHBOUND (North Approach)			NORTHBOUND (South Approach)			WESTBOUND (East Approach)			EASTBOUND (West Approach)			Total	Hourly
TIME	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	Volume	Volume
6:00 - 6:15														
6:15 - 6:30														
6:30 - 6:45														
6:45 - 7:00								1					1	1
7:00 - 7:15								2			1		3	4
7:15 - 7:30														4
7:30 - 7:45								3			2		5	9
7:45 - 8:00							5	5			1		11	19
8:00 - 8:15								3			1		4	20
8:15 - 8:30	1							3			5		9	29
8:30 - 8:45								2			3		5	29
8:45 -9:00								2			1		3	21
SUB TOTAL	**1**						**5**	**21**			**14**		**41**	

14:30 - 14:45														
14:45 - 15:00														
15:00 - 15:15											1		1	
15:15 - 15:30								2					2	3
15:30 - 15:45								1			3		4	7
15:45 - 16:00											1		1	8
16:00 - 16:15											3		3	10
16:15 - 16:30								3					3	11
16:30 - 16:45								1			1		2	9
16:45 - 17:00											2		2	10
17:00 - 17:15														7
17:15 - 17:30														4
17:30 - 17:45														2
17:45 - 18:00														
SUB TOTAL								**7**			**11**		**18**	

Vehicle Turning Movement Survey

PEDESTRIAN

N/S Street: North Meadow Rd.
E/W Street: North Nechako Rd.
LOCATION: Prince George
DATE: June 23, 2017
WEATHER: Enter Weather
TOTAL HOURS= HRS

Observer: Enter Name
Notes: N/A

Speed Limit Major Street	60km/hr
Speed Limit Minor Street	50km/hr

TIME	SOUTHBOUND (North Approach)	NORTHBOUND (South Approach)	WESTBOUND (East Approach)	EASTBOUND (West Approach)	Total Volume	Hourly Volume
6:00 - 6:15				1	1	
6:15 - 6:30			1		1	
6:30 - 6:45				1	1	
6:45 - 7:00				1	1	4
7:00 - 7:15						3
7:15 - 7:30			1	2	3	5
7:30 - 7:45				1	1	5
7:45 - 8:00				3	3	7
8:00 - 8:15	1			3	4	11
8:15 - 8:30						8
8:30 - 8:45						7
8:45 -9:00				2	2	6
SUB TOTAL	**1**		**2**	**14**	**17**	

14:30 - 14:45						
14:45 - 15:00						
15:00 - 15:15						
15:15 - 15:30						
15:30 - 15:45						
15:45 - 16:00	3				3	3
16:00 - 16:15	1		1	1	3	6
16:15 - 16:30	1				1	7
16:30 - 16:45	2				2	9
16:45 - 17:00	1		2	1	4	10
17:00 - 17:15				1	1	8
17:15 - 17:30	2				2	9
17:30 - 17:45						7
17:45 - 18:00						3
SUB TOTAL	**10**		**3**	**3**	**16**	

Vehicle Turning Movement Survey

TOTAL

N/S Street: North Meadow Rd.
E/W Street: North Nechako Rd.
LOCATION: Prince George
DATE: June 23, 2017
WEATHER: Enter Weather

TOTAL HOURS = HRS

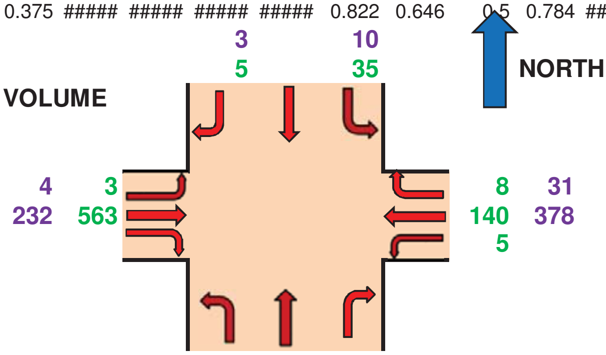
Observer: Enter Name
Notes: N/A

Speed Limit Major Street	60km/hr
Speed Limit Minor Street	50km/hr

	SOUTHBOUND (North Approach)			NORTHBOUND (South Approach)			WESTBOUND (East Approach)			EASTBOUND (West Approach)			Total	Hourly	Pedestrian			
TIME	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	Volume	Volume	N	S	E	W
6:00 - 6:15								2			20		22					1
6:15 - 6:30	3							6	1		25		35				1	
6:30 - 6:45	2							10			52		64					1
6:45 - 7:00	4		1					11	1		36		53	174				1
7:00 - 7:15	1		2					22	1		45		71	223				
7:15 - 7:30	2		1					12			58		73	261			1	2
7:30 - 7:45	6		1					26	2	2	113		150	347				1
7:45 - 8:00	9		2				5	26	2	1	134		179	473				3
8:00 - 8:15	10		1					39	1		161		212	614	1			3
8:15 - 8:30	10		1					49	3		155		218	**759**				
8:30 - 8:45	4			8				33	2		87		134	743				
8:45 -9:00	2							28	1	1	84		116	**680**				2
SUB TOTAL	**53**		**9**	**8**			**5**	**264**	**14**	**4**	**970**		**1327**		1		2	14
PEAK HOUR	**35**		**5**				**5**	**140**	**8**	**3**	**563**		**759**		**1**			**7**
PHF	0.875	#####	0.625	#####	#####	#####	0.25	0.714	0.667	0.375	0.874	#####	0.87041		0.25	#####	#####	0.583
14:30 - 14:45																		
14:45 - 15:00																		
15:00 - 15:15	6							56	6	2	46		116					
15:15 - 15:30	1		1					74	3	1	45		125	241				
15:30 - 15:45	5		1					76	8	1	62		153	394				
15:45 - 16:00	1		1					65	7	1	41		116	510	3			
16:00 - 16:15	3							74	3		45		125	519	1		1	1
16:15 - 16:30	2							72	6		49		129	523	1			
16:30 - 16:45	3							91	4	2	53		153	523	2			
16:45 - 17:00	3		1					115	6	1	74		200	**607**	1		2	1
17:00 - 17:15	1							91	12		51		155	637				1
17:15 - 17:30	3		2					81	9	1	54		150	**658**	2			
17:30 - 17:45	3							57	2	2	63		127	632				
17:45 - 18:00	3		1					49	5	2	67		127	559				
SUB TOTAL	**34**		**7**					**901**	**71**	**13**	**650**		**1676**		10			3
PEAK HOUR	**10**		**3**					**378**	**31**	**4**	**232**		**658**		**5**		**2**	**2**
PHF	0.8333	#####	0.375	#####	#####	#####	#####	0.822	0.646	0.5	0.784	#####	0.8225		0.63	#####	0.25	0.5

PEAK HOUR VOLUME

AM PEAK
PM PEAK



Vehicle Turning Movement Survey

PASSENGER VEHICLES

N/S Street: ***North Nechako Rd.***

E/W Street: ***Churchill Rd.***

LOCATION: ***Prince George***

DATE: ***June 22, 2017***

WEATHER: ***Enter Weather***

TOTAL HOURS= ***HRS***

Observer: ***Enter Name***

Notes: ***N/A***

Speed Limit Major Street	***60km/hr***
Speed Limit Minor Street	***50km/hr***

	SOUTHBOUND (North Approach)			NORTHBOUND (South Approach)			WESTBOUND (East Approach)			EASTBOUND (West Approach)			Total	Hourly
TIME	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	Volume	Volume
6:00 - 6:15		23	1		3							1	28	
6:15 - 6:30		31	1		2					1		2	37	
6:30 - 6:45		80	1		10					1		7	99	
6:45 - 7:00		63			5							6	74	238
7:00 - 7:15		38		4	12					1		6	61	271
7:15 - 7:30		63	1	2	12							4	82	316
7:30 - 7:45		103	1	3	8					5		10	130	347
7:45 - 8:00		128	8	6	16					3		16	177	450
8:00 - 8:15		127	19	11	26					4		27	214	603
8:15 - 8:30		147	32	10	23					12		37	261	782
8:30 - 8:45		77	2	8	28					8		15	138	790
8:45 -9:00		110	1	8	24					2		14	159	772
SUB TOTAL		**990**	**67**	**52**	**169**					**37**		**145**	**1460**	

14:30 - 14:45														
14:45 - 15:00														
15:00 - 15:15		33	6	5	53					2		6	105	
15:15 - 15:30		36	7	7	61					5		8	124	229
15:30 - 15:45		36	4	9	61					7		9	126	355
15:45 - 16:00		30	3	10	56					2		5	106	461
16:00 - 16:15		34	4	7	59					4		2	110	466
16:15 - 16:30		43	1	14	73					2		7	140	482
16:30 - 16:45		55	2	5	71					4		6	143	499
16:45 - 17:00		47	8	20	111					3		10	199	592
17:00 - 17:15		31	5	13	107					9		4	169	651
17:15 - 17:30		49	9	7	122					4		8	199	710
17:30 - 17:45		46	10	11	83					4		5	159	726
17:45 - 18:00		33	3	8	60					1		6	111	638
SUB TOTAL		**473**	**62**	**116**	**917**					**47**		**76**	**1691**	

Vehicle Turning Movement Survey

LT + Bus + RV

N/S Street: North Nechako Rd.

E/W Street: Churchill Rd.

LOCATION: Prince George

DATE: June 22, 2017

WEATHER: Enter Weather

TOTAL HOURS= HRS

Observer: Enter Name

Notes: N/A

Speed Limit Major Street	60km/hr
Speed Limit Minor Street	50km/hr

	SOUTHBOUND *(North Approach)*			**NORTHBOUND** *(South Approach)*			**WESTBOUND** *(East Approach)*			**EASTBOUND** *(West Approach)*			Total	Hourly
TIME	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	Volume	Volume
6:00 - 6:15		1											1	
6:15 - 6:30		3											3	
6:30 - 6:45		1			2								3	
6:45 - 7:00		1											1	8
7:00 - 7:15		1			1								2	9
7:15 - 7:30				1	1								2	8
7:30 - 7:45		2		1	4					1			8	13
7:45 - 8:00		4			2							1	7	19
8:00 - 8:15		1	4							3		1	9	26
8:15 - 8:30		3	1		2							1	7	31
8:30 - 8:45		5											5	28
8:45 -9:00		4			1							1	6	27
SUB TOTAL		**26**	**5**	**2**	**13**					**4**		**4**	**54**	

14:30 - 14:45														
14:45 - 15:00														
15:00 - 15:15				3	1								4	
15:15 - 15:30		3			1								4	8
15:30 - 15:45		2			2								4	12
15:45 - 16:00		7			1								8	20
16:00 - 16:15		1		1	1							1	4	20
16:15 - 16:30		2			2								4	20
16:30 - 16:45		2	1		4								7	23
16:45 - 17:00		4			1								5	20
17:00 - 17:15		1			3							1	5	21
17:15 - 17:30		1			1					1			3	20
17:30 - 17:45		1	1	1	2								5	18
17:45 - 18:00		2		1	1							1	5	18
SUB TOTAL		**26**	**2**	**6**	**20**					**1**		**3**	**58**	

Vehicle Turning Movement Survey

HEAVY TRUCKS

N/S Street: North Nechako Rd.
E/W Street: Churchill Rd.
LOCATION: Prince George
DATE: June 22, 2017
WEATHER: Enter Weather

TOTAL HOURS= HRS

Observer: Enter Name
Notes: N/A

Speed Limit Major Street	60km/hr
Speed Limit Minor Street	50km/hr

	SOUTHBOUND (North Approach)			NORTHBOUND (South Approach)			WESTBOUND (East Approach)			EASTBOUND (West Approach)			Total	Hourly
TIME	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	Volume	Volume
6:00 - 6:15														
6:15 - 6:30					1								1	
6:30 - 6:45				2								1	3	
6:45 - 7:00					2								2	6
7:00 - 7:15		1											1	7
7:15 - 7:30		1											1	7
7:30 - 7:45		2			3								5	9
7:45 - 8:00					4								4	11
8:00 - 8:15		4							1				5	15
8:15 - 8:30		3			4								7	21
8:30 - 8:45					3								3	19
8:45 -9:00		3			3					1			7	22
SUB TOTAL		**14**		**2**	**20**				**1**	**1**		**1**	**39**	

14:30 - 14:45														
14:45 - 15:00														
15:00 - 15:15		2			1								3	
15:15 - 15:30		3			3								6	9
15:30 - 15:45		3			3								6	15
15:45 - 16:00		1	1		1								3	18
16:00 - 16:15		3			1								4	19
16:15 - 16:30		1			3								4	17
16:30 - 16:45		6			1								7	18
16:45 - 17:00					3								3	18
17:00 - 17:15		1											1	15
17:15 - 17:30		2			2								4	15
17:30 - 17:45					1								1	9
17:45 - 18:00		2			1								3	9
SUB TOTAL		**24**	**1**		**20**								**45**	

Vehicle Turning Movement Survey

PEDESTRIAN

N/S Street: North Nechako Rd.
E/W Street: Churchill Rd.
LOCATION: Prince George
DATE: June 22, 2017
WEATHER: Enter Weather
TOTAL HOURS= HRS

Observer: Enter Name
Notes: N/A

Speed Limit Major Street	60km/hr
Speed Limit Minor Street	50km/hr

TIME	SOUTHBOUND (North Approach)	NORTHBOUND (South Approach)	WESTBOUND (East Approach)	EASTBOUND (West Approach)	Total Volume	Hourly Volume
6:00 - 6:15						
6:15 - 6:30	2				2	
6:30 - 6:45						
6:45 - 7:00						2
7:00 - 7:15	1	1			2	4
7:15 - 7:30	5				5	7
7:30 - 7:45	2				2	9
7:45 - 8:00	7			3	10	19
8:00 - 8:15	1				1	18
8:15 - 8:30	1	2			3	16
8:30 - 8:45						14
8:45 -9:00	2				2	6
SUB TOTAL	**21**	**3**		**3**	**27**	

14:30 - 14:45						
14:45 - 15:00						
15:00 - 15:15	1	1			2	
15:15 - 15:30	1	1			2	4
15:30 - 15:45		3			3	7
15:45 - 16:00	1	1			2	9
16:00 - 16:15		1		1	2	9
16:15 - 16:30		2			2	9
16:30 - 16:45	1	1			2	8
16:45 - 17:00		3			3	9
17:00 - 17:15		2			2	9
17:15 - 17:30		4			4	11
17:30 - 17:45	1	1			2	11
17:45 - 18:00						8
SUB TOTAL	**5**	**20**		**1**	**26**	

Vehicle Turning Movement Survey

TOTAL

N/S Street: North Nechako Rd.
E/W Street: Churchill Rd.
LOCATION: Prince George
DATE: June 22, 2017
WEATHER: Enter Weather

TOTAL HOURS = HRS

Observer: Enter Name
Notes: N/A

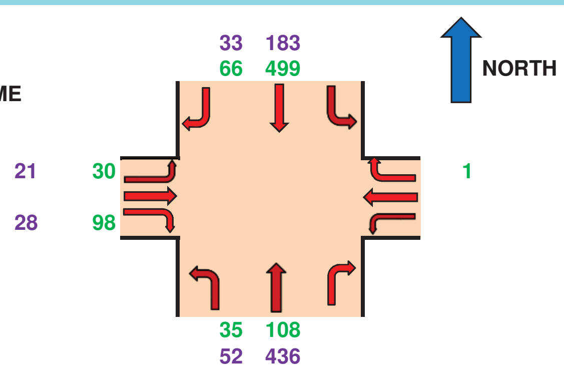
Speed Limit Major Street	60km/hr
Speed Limit Minor Street	50km/hr

	SOUTHBOUND (North Approach)			NORTHBOUND (South Approach)			WESTBOUND (East Approach)			EASTBOUND (West Approach)			Total	Hourly	Pedestrian			
TIME	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	Volume	Volume	N	S	E	W
6:00 - 6:15		24	1		3							1	29					
6:15 - 6:30		34	1		3					1		2	41		2			
6:30 - 6:45		81	1	2	12					1		8	105					
6:45 - 7:00		64			7							6	77	252				
7:00 - 7:15		40		4	13					1		6	64	287	1	1		
7:15 - 7:30		64	1	3	13							4	85	331	5			
7:30 - 7:45		107	1	4	15					6		10	143	369	2			
7:45 - 8:00		132	8	6	22					3		17	188	480	7			3
8:00 - 8:15		132	23	11	26				1	7		28	228	644	1			
8:15 - 8:30		153	33	10	29					12		38	275	834	1	2		
8:30 - 8:45		82	2	8	31					8		15	146	**837**				
8:45 -9:00		117	1	8	28					3		15	172	**821**	2			
SUB TOTAL		**1030**	**72**	**56**	**202**				**1**	**42**		**150**	**1553**		21	3		3
PEAK HOUR		**499**	**66**	**35**	**108**				**1**	**30**		**98**	**837**		**9**	**2**		**3**
PHF	**#DIV/0!**	**0.82**	**0.50**	**0.80**	**0.87**	**#DIV/0!**	**#####**	**#####**	**0.25**	**0.63**	**#####**	**0.64**						

TIME	SB LEFT	SB THRU	SB RIGHT	NB LEFT	NB THRU	NB RIGHT	WB LEFT	WB THRU	WB RIGHT	EB LEFT	EB THRU	EB RIGHT	Total Volume	Hourly Volume	N	S	E	W
14:30 - 14:45																		
14:45 - 15:00																		
15:00 - 15:15		35	6	8	55					2		6	112		1	1		
15:15 - 15:30		42	7	7	65					5		8	134	246	1	1		
15:30 - 15:45		41	4	9	66					7		9	136	382		3		
15:45 - 16:00		38	4	10	58					2		5	117	499	1	1		
16:00 - 16:15		38	4	8	61					4		3	118	505		1		1
16:15 - 16:30		46	1	14	78					2		7	148	519		2		
16:30 - 16:45		63	3	5	76					4		6	157	540	1	1		
16:45 - 17:00		51	8	20	115					3		10	207	**630**		3		
17:00 - 17:15		33	5	13	110					9		5	175	687		2		
17:15 - 17:30		52	9	7	125					5		8	206	745		4		
17:30 - 17:45		47	11	12	86					4		5	165	**753**	1	1		
17:45 - 18:00		37	3	9	62					1		7	119	665				
SUB TOTAL		**523**	**65**	**122**	**957**					**48**		**79**	**1794**		5	20		1
PEAK HOUR		**183**	**33**	**52**	**436**					**21**		**28**	**753**		**1**	**10**		
PHF	**#DIV/0!**	**0.88**	**0.75**	**0.65**	**0.87**	**#DIV/0!**	**#####**	**#####**	**#####**	**0.58**	**#####**	**0.70**						

PEAK HOUR VOLUME

AM PEAK
PM PEAK



Vehicle Turning Movement Survey

PASSENGER VEHICLES

N/S Street: ***Churchill Rd***

E/W Street: ***Craig Drive***

LOCATION: ***Enter Location***

DATE: ***4/4/2018***

WEATHER: ***Sunny***

TOTAL HOURS= ***HRS***

Observer: ***Diane Allen***

Notes: ***Enter Notes***

Speed Limit Major Street	***50***
Speed Limit Minor Street	***50***

	SOUTHBOUND (North Approach)			NORTHBOUND (South Approach)			WESTBOUND (East Approach)			EASTBOUND (West Approach)			Total	Hourly
TIME	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	Volume	Volume
6:00 - 6:15				1									1	
6:15 - 6:30		1											1	
6:30 - 6:45	1								1				2	
6:45 - 7:00		1											1	5
7:00 - 7:15		1											1	5
7:15 - 7:30		1		2		1							4	8
7:30 - 7:45		4		2	2		2						10	16
7:45 - 8:00		3		8	2	1		2				3	19	34
8:00 - 8:15		7	2	33	1	1		8				25	77	110
8:15 - 8:30		6	1	26		1		3			1	29	67	173
8:30 - 8:45		2		1							1	3	7	170
8:45 -9:00		1			1							1	3	154
SUB TOTAL	**1**	**27**	**3**	**73**	**6**	**4**	**2**	**13**	**1**		**2**	**61**	**193**	

14:30 - 14:45	1	1	1	20	3	1		1	1			1	30	
14:45 - 15:00		1	2	13	1	1		1		1	1	29	50	
15:00 - 15:15											2	12	14	
15:15 - 15:30	1	3		1	3		1					3	12	106
15:30 - 15:45				1		1						3	5	81
15:45 - 16:00		2									2	5	9	40
16:00 - 16:15						1			1			3	5	31
16:15 - 16:30		1			1							1	3	22
16:30 - 16:45		1			2		1		1			1	6	23
16:45 - 17:00					2		1		1			2	6	20
17:00 - 17:15		1			1	1			1				4	19
17:15 - 17:30		1		1			2		1				5	21
17:30 - 17:45					1								1	16
17:45 - 18:00		1			1				1				3	13
SUB TOTAL	**2**	**12**	**3**	**36**	**15**	**5**	**5**	**2**	**7**	**1**	**5**	**60**	**153**	

Vehicle Turning Movement Survey

LT + Bus + RV

N/S Street: Churchill Rd

E/W Street: Craig Drive

LOCATION: Enter Location

DATE: 43194

WEATHER: Sunny

TOTAL HOURS= HRS

Observer: Diane Allen

Notes: Enter Notes

Speed Limit Major Street	50
Speed Limit Minor Street	50

	SOUTHBOUND (North Approach)			NORTHBOUND (South Approach)			WESTBOUND (East Approach)			EASTBOUND (West Approach)			Total	Hourly
TIME	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	Volume	Volume
6:00 - 6:15														
6:15 - 6:30														
6:30 - 6:45														
6:45 - 7:00														
7:00 - 7:15														
7:15 - 7:30														
7:30 - 7:45		1											1	1
7:45 - 8:00				1									1	2
8:00 - 8:15				2								3	5	7
8:15 - 8:30				1							1		2	9
8:30 - 8:45														8
8:45 -9:00														7
SUB TOTAL		**1**		**4**							**1**	**3**	**9**	

14:30 - 14:45				4									4	
14:45 - 15:00											1	1	2	
15:00 - 15:15											1	3	4	
15:15 - 15:30												1	1	11
15:30 - 15:45														7
15:45 - 16:00														5
16:00 - 16:15							1						1	2
16:15 - 16:30														1
16:30 - 16:45		1											1	2
16:45 - 17:00														2
17:00 - 17:15						1							1	2
17:15 - 17:30														2
17:30 - 17:45														1
17:45 - 18:00														1
SUB TOTAL		**1**		**4**		**1**	**1**				**2**	**5**	**14**	

Vehicle Turning Movement Survey

HEAVY TRUCKS

N/S Street: Churchill Rd
E/W Street: Craig Drive
LOCATION: Enter Location
DATE: 43194
WEATHER: Sunny
TOTAL HOURS= HRS

Observer: Diane Allen
Notes: Enter Notes

Speed Limit Major Street	50
Speed Limit Minor Street	50

	SOUTHBOUND (North Approach)			NORTHBOUND (South Approach)			WESTBOUND (East Approach)			EASTBOUND (West Approach)			Total	Hourly
TIME	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	Volume	Volume
6:00 - 6:15														
6:15 - 6:30														
6:30 - 6:45														
6:45 - 7:00														
7:00 - 7:15														
7:15 - 7:30														
7:30 - 7:45														
7:45 - 8:00														
8:00 - 8:15														
8:15 - 8:30														
8:30 - 8:45														
8:45 -9:00														
SUB TOTAL														

14:30 - 14:45														
14:45 - 15:00														
15:00 - 15:15														
15:15 - 15:30														
15:30 - 15:45														
15:45 - 16:00														
16:00 - 16:15														
16:15 - 16:30														
16:30 - 16:45														
16:45 - 17:00														
17:00 - 17:15														
17:15 - 17:30														
17:30 - 17:45														
17:45 - 18:00														
SUB TOTAL														

Vehicle Turning Movement Survey

PEDESTRIAN

N/S Street: Churchill Rd
E/W Street: Craig Drive
LOCATION: Enter Location
DATE: 43194
WEATHER: Sunny
TOTAL HOURS= HRS

Observer: Diane Allen
Notes: Enter Notes

Speed Limit Major Street	50
Speed Limit Minor Street	50

TIME	SOUTHBOUND (North Approach)	NORTHBOUND (South Approach)	WESTBOUND (East Approach)	EASTBOUND (West Approach)	Total Volume	Hourly Volume
6:00 - 6:15				1	1	
6:15 - 6:30						
6:30 - 6:45						
6:45 - 7:00						1
7:00 - 7:15						
7:15 - 7:30						
7:30 - 7:45						
7:45 - 8:00	3		1	1	5	5
8:00 - 8:15	6		6	4	16	21
8:15 - 8:30	10		8	2	20	41
8:30 - 8:45	1			1	2	43
8:45 -9:00						38
SUB TOTAL	**20**		**15**	**9**	**44**	

14:30 - 14:45				3	3	
14:45 - 15:00	7	1	3	4	15	
15:00 - 15:15	1			7	8	
15:15 - 15:30	1			7	8	34
15:30 - 15:45	1			2	3	34
15:45 - 16:00			2		2	21
16:00 - 16:15		3		3	6	19
16:15 - 16:30			4	1	5	16
16:30 - 16:45			2	5	7	20
16:45 - 17:00			5	1	6	24
17:00 - 17:15				3	3	21
17:15 - 17:30				1	1	17
17:30 - 17:45	3		3	4	10	20
17:45 - 18:00	1			1	2	16
SUB TOTAL	**14**	**4**	**19**	**42**	**79**	

Vehicle Turning Movement Survey

TOTAL

N/S Street: Churchill Rd
E/W Street: Craig Drive
LOCATION: Enter Location
DATE: 43194
WEATHER: Sunny
TOTAL HOURS = HRS

Observer: Diane Allen
Notes: Enter Notes

Speed Limit Major Street	50
Speed Limit Minor Street	50

	SOUTHBOUND (North Approach)			NORTHBOUND (South Approach)			WESTBOUND (East Approach)			EASTBOUND (West Approach)			Total	Hourly	Pedestrian			
TIME	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	LEFT	THRU	RIGHT	Volume	Volume	N	S	E	W
6:00 - 6:15				1									1					1
6:15 - 6:30		1											1					
6:30 - 6:45	1								1				2					
6:45 - 7:00		1											1	5				
7:00 - 7:15		1											1	5				
7:15 - 7:30		1		2		1							4	8				
7:30 - 7:45		5		2	2		2						11	17				
7:45 - 8:00		3		9	2	1		2				3	20	36	3		1	1
8:00 - 8:15		7	2	35	1	1		8				28	82	117	6		6	4
8:15 - 8:30		6	1	27		1		3			2	29	69	**182**	10		8	2
8:30 - 8:45		2		1							1	3	7	178	1			1
8:45 -9:00		1			1							1	3	**161**				
SUB TOTAL	**1**	**28**	**3**	**77**	**6**	**4**	**2**	**13**	**1**		**3**	**64**	**202**		20		15	9
PEAK HOUR		**21**	**3**	**73**	**5**	**3**	**2**	**13**			**2**	**60**	**182**		**19**		**15**	**7**
PHF	**#DIV/0!**	**0.75**	**0.375**	**0.521**	**0.625**	**0.75**	**0.25**	**0.406**	**#####**	**#####**	**0.25**	**0.517**						

TIME	SB LEFT	SB THRU	SB RIGHT	NB LEFT	NB THRU	NB RIGHT	WB LEFT	WB THRU	WB RIGHT	EB LEFT	EB THRU	EB RIGHT	Total Volume	Hourly Volume	N	S	E	W
14:00 - 14:15	1	1	1		3	1		1	1			1	10					3
14:15 - 14:30		1	2	13	1	1		1		1	2	30	52		7	1	3	4
14:30 - 14:45											3	15	18		1			7
14:45 - 15:00	1	3		1	3		1					4	13	**93**	1			7
15:00 - 15:15				1		1						3	5	88	1			2
15:15 - 15:30		2									2	5	9	45			2	
15:30 - 15:45						1	1		1			3	6	33		3		3
15:45 - 16:00		1			1							1	3	23			4	1
16:00 - 16:15		2			2		1		1			1	7	25			2	5
16:15 - 16:30					2		1		1			2	6	**22**			5	1
16:30 - 16:45		1			1	2			1				5	21				3
16:45 - 17:00		1		1			2		1				5	23				1
17:00 - 17:15					1								1	17	3		3	4
17:15 - 17:30		1			1				1				3	14	1			1
SUB TOTAL	**2**	**13**	**3**	**16**	**15**	**6**	**6**	**2**	**7**	**1**	**7**	**65**	**143**		14	4		42
PEAK HOUR	**2**	**5**	**3**	**14**	**7**	**2**	**1**	**2**	**1**	**1**	**5**	**50**	**93**		**9**	**1**	**3**	**21**

Appendix B
Synchro Reports

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	26	168	134	43	50	39	40	156	65	311	378	18
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.95	1.00	1.00	0.95	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1789	1883	1601	1706	1883	1601	1789	3544	1601	1789	3544	1601
Flt Permitted	0.71	1.00	1.00	0.58	1.00	1.00	0.51	1.00	1.00	0.57	1.00	1.00
Satd. Flow (perm)	1339	1883	1601	1036	1883	1601	967	3544	1601	1073	3544	1601
Peak-hour factor, PHF	0.70	0.79	0.89	0.70	0.70	0.70	0.75	0.75	0.70	0.92	0.93	0.70
Adj. Flow (vph)	37	213	151	61	71	56	53	208	93	338	406	26
RTOR Reduction (vph)	0	0	122	0	0	45	0	0	53	0	0	14
Lane Group Flow (vph)	37	213	29	61	71	11	53	208	40	338	406	12
Heavy Vehicles (%)	2%	2%	2%	7%	2%	2%	2%	3%	2%	2%	3%	2%
Turn Type	Perm		Perm	Perm		Perm	pm+pt		Perm	pm+pt		Perm
Protected Phases		4			8		5	2		1	6	
Permitted Phases	4		4	8		8	2		2	6		6
Actuated Green, G (s)	12.1	12.1	12.1	12.1	12.1	12.1	31.1	27.6	27.6	36.1	30.1	30.1
Effective Green, g (s)	12.1	12.1	12.1	12.1	12.1	12.1	31.1	27.6	27.6	36.1	30.1	30.1
Actuated g/C Ratio	0.19	0.19	0.19	0.19	0.19	0.19	0.49	0.43	0.43	0.57	0.47	0.47
Clearance Time (s)	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	254	358	304	197	358	304	517	1536	694	676	1675	757
v/s Ratio Prot		c0.11			0.04		0.01	0.06		c0.05	0.11	
v/s Ratio Perm	0.03		0.02	0.06		0.01	0.04		0.03	c0.24		0.01
v/c Ratio	0.15	0.59	0.09	0.31	0.20	0.03	0.10	0.14	0.06	0.50	0.24	0.02
Uniform Delay, d1	21.5	23.6	21.3	22.2	21.7	21.0	8.6	10.9	10.5	7.5	10.0	8.9
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.3	2.6	0.1	0.9	0.3	0.0	0.1	0.0	0.0	0.6	0.1	0.0
Delay (s)	21.8	26.2	21.4	23.1	22.0	21.1	8.7	10.9	10.5	8.1	10.1	8.9
Level of Service	C	C	C	C	C	C	A	B	B	A	B	A
Approach Delay (s)		24.0			22.1			10.5			9.2	
Approach LOS		C			C			B			A	

Intersection Summary			
HCM Average Control Delay	14.3	HCM Level of Service	B
HCM Volume to Capacity ratio	0.49		
Actuated Cycle Length (s)	63.7	Sum of lost time (s)	12.0
Intersection Capacity Utilization	73.6%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	26	168	134	46	50	48	40	156	66	314	378	18
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.95	1.00	1.00	0.95	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1789	1883	1601	1706	1883	1601	1789	3544	1601	1789	3544	1601
Flt Permitted	0.71	1.00	1.00	0.58	1.00	1.00	0.51	1.00	1.00	0.57	1.00	1.00
Satd. Flow (perm)	1339	1883	1601	1036	1883	1601	967	3544	1601	1073	3544	1601
Peak-hour factor, PHF	0.70	0.79	0.89	0.70	0.70	0.70	0.75	0.75	0.70	0.92	0.93	0.70
Adj. Flow (vph)	37	213	151	66	71	69	53	208	94	341	406	26
RTOR Reduction (vph)	0	0	122	0	0	56	0	0	53	0	0	14
Lane Group Flow (vph)	37	213	29	66	71	13	53	208	41	341	406	12
Heavy Vehicles (%)	2%	2%	2%	7%	2%	2%	2%	3%	2%	2%	3%	2%
Turn Type	Perm		Perm	Perm		Perm	pm+pt		Perm	pm+pt		Perm
Protected Phases		4			8		5	2		1	6	
Permitted Phases	4		4	8		8	2		2	6		6
Actuated Green, G (s)	12.1	12.1	12.1	12.1	12.1	12.1	31.1	27.6	27.6	36.1	30.1	30.1
Effective Green, g (s)	12.1	12.1	12.1	12.1	12.1	12.1	31.1	27.6	27.6	36.1	30.1	30.1
Actuated g/C Ratio	0.19	0.19	0.19	0.19	0.19	0.19	0.49	0.43	0.43	0.57	0.47	0.47
Clearance Time (s)	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	254	358	304	197	358	304	517	1536	694	676	1675	757
v/s Ratio Prot		c0.11			0.04		0.01	0.06		c0.05	0.11	
v/s Ratio Perm	0.03		0.02	0.06		0.01	0.04		0.03	c0.24		0.01
v/c Ratio	0.15	0.59	0.09	0.34	0.20	0.04	0.10	0.14	0.06	0.50	0.24	0.02
Uniform Delay, d1	21.5	23.6	21.3	22.3	21.7	21.1	8.6	10.9	10.5	7.6	10.0	8.9
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.3	2.6	0.1	1.0	0.3	0.1	0.1	0.0	0.0	0.6	0.1	0.0
Delay (s)	21.8	26.2	21.4	23.3	22.0	21.1	8.7	10.9	10.5	8.2	10.1	8.9
Level of Service	C	C	C	C	C	C	A	B	B	A	B	A
Approach Delay (s)		24.0			22.1			10.5			9.2	
Approach LOS		C			C			B			A	

Intersection Summary			
HCM Average Control Delay	14.4	HCM Level of Service	B
HCM Volume to Capacity ratio	0.49		
Actuated Cycle Length (s)	63.7	Sum of lost time (s)	12.0
Intersection Capacity Utilization	73.7%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	29	194	154	49	57	46	46	179	75	358	435	21
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.95	1.00	1.00	0.95	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1789	1883	1601	1706	1883	1601	1789	3544	1601	1789	3544	1601
Flt Permitted	0.70	1.00	1.00	0.50	1.00	1.00	0.48	1.00	1.00	0.55	1.00	1.00
Satd. Flow (perm)	1327	1883	1601	904	1883	1601	911	3544	1601	1042	3544	1601
Peak-hour factor, PHF	0.70	0.79	0.89	0.70	0.70	0.70	0.75	0.75	0.70	0.92	0.93	0.70
Adj. Flow (vph)	41	246	173	70	81	66	61	239	107	389	468	30
RTOR Reduction (vph)	0	0	139	0	0	53	0	0	61	0	0	16
Lane Group Flow (vph)	41	246	34	70	81	13	61	239	46	389	468	14
Heavy Vehicles (%)	2%	2%	2%	7%	2%	2%	2%	3%	2%	2%	3%	2%
Turn Type	Perm		Perm	Perm		Perm	pm+pt		Perm	pm+pt		Perm
Protected Phases		4			8		5	2		1	6	
Permitted Phases	4		4	8		8	2		2	6		6
Actuated Green, G (s)	12.8	12.8	12.8	12.8	12.8	12.8	31.1	27.6	27.6	36.1	30.1	30.1
Effective Green, g (s)	12.8	12.8	12.8	12.8	12.8	12.8	31.1	27.6	27.6	36.1	30.1	30.1
Actuated g/C Ratio	0.20	0.20	0.20	0.20	0.20	0.20	0.48	0.43	0.43	0.56	0.47	0.47
Clearance Time (s)	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	264	374	318	180	374	318	488	1519	686	654	1656	748
v/s Ratio Prot		c0.13			0.04		0.01	0.07		c0.06	0.13	
v/s Ratio Perm	0.03		0.02	0.08		0.01	0.05		0.03	c0.28		0.01
v/c Ratio	0.16	0.66	0.11	0.39	0.22	0.04	0.12	0.16	0.07	0.59	0.28	0.02
Uniform Delay, d1	21.3	23.8	21.1	22.4	21.6	20.8	8.9	11.3	10.8	8.5	10.5	9.2
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.3	4.1	0.2	1.4	0.3	0.1	0.1	0.0	0.0	1.5	0.1	0.0
Delay (s)	21.6	27.9	21.3	23.8	21.9	20.9	9.0	11.3	10.9	10.0	10.6	9.2
Level of Service	C	C	C	C	C	C	A	B	B	A	B	A
Approach Delay (s)		24.9			22.2			10.9			10.3	
Approach LOS		C			C			B			B	

Intersection Summary			
HCM Average Control Delay	15.1	HCM Level of Service	B
HCM Volume to Capacity ratio	0.57		
Actuated Cycle Length (s)	64.4	Sum of lost time (s)	12.0
Intersection Capacity Utilization	77.5%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	29	209	154	49	57	115	46	198	75	368	472	21
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.95	1.00	1.00	0.95	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1789	1883	1601	1706	1883	1601	1789	3544	1601	1789	3544	1601
Flt Permitted	0.70	1.00	1.00	0.47	1.00	1.00	0.47	1.00	1.00	0.54	1.00	1.00
Satd. Flow (perm)	1327	1883	1601	836	1883	1601	876	3544	1601	1017	3544	1601
Peak-hour factor, PHF	0.70	0.79	0.89	0.70	0.70	0.70	0.75	0.75	0.70	0.92	0.93	0.70
Adj. Flow (vph)	41	265	173	70	81	164	61	264	107	400	508	30
RTOR Reduction (vph)	0	0	138	0	0	130	0	0	61	0	0	16
Lane Group Flow (vph)	41	265	35	70	81	34	61	264	46	400	508	14
Heavy Vehicles (%)	2%	2%	2%	7%	2%	2%	2%	3%	2%	2%	3%	2%
Turn Type	Perm		Perm	Perm		Perm	pm+pt		Perm	pm+pt		Perm
Protected Phases		4			8		5	2		1	6	
Permitted Phases	4		4	8		8	2		2	6		6
Actuated Green, G (s)	13.3	13.3	13.3	13.3	13.3	13.3	31.1	27.6	27.6	36.1	30.1	30.1
Effective Green, g (s)	13.3	13.3	13.3	13.3	13.3	13.3	31.1	27.6	27.6	36.1	30.1	30.1
Actuated g/C Ratio	0.20	0.20	0.20	0.20	0.20	0.20	0.48	0.43	0.43	0.56	0.46	0.46
Clearance Time (s)	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	272	386	328	171	386	328	469	1507	681	637	1644	743
v/s Ratio Prot		c0.14			0.04		0.01	0.07		c0.06	0.14	
v/s Ratio Perm	0.03		0.02	0.08		0.02	0.06		0.03	c0.29		0.01
v/c Ratio	0.15	0.69	0.11	0.41	0.21	0.10	0.13	0.18	0.07	0.63	0.31	0.02
Uniform Delay, d1	21.2	23.9	21.0	22.4	21.4	21.0	9.1	11.6	11.0	8.9	10.9	9.4
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.3	5.0	0.1	1.6	0.3	0.1	0.1	0.1	0.0	1.9	0.1	0.0
Delay (s)	21.4	28.9	21.1	24.0	21.7	21.1	9.2	11.6	11.1	10.9	11.0	9.4
Level of Service	C	C	C	C	C	C	A	B	B	B	B	A
Approach Delay (s)		25.4			21.9			11.2			10.9	
Approach LOS		C			C			B			B	

Intersection Summary			
HCM Average Control Delay	15.8	HCM Level of Service	B
HCM Volume to Capacity ratio	0.60		
Actuated Cycle Length (s)	64.9	Sum of lost time (s)	12.0
Intersection Capacity Utilization	78.9%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	27	75	57	46	116	143	119	445	79	93	276	24
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.95	1.00	1.00	0.95	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1789	1883	1601	1789	1883	1601	1789	3579	923	1789	3579	1601
Flt Permitted	0.67	1.00	1.00	0.70	1.00	1.00	0.54	1.00	1.00	0.49	1.00	1.00
Satd. Flow (perm)	1260	1883	1601	1322	1883	1601	1022	3579	923	919	3579	1601
Peak-hour factor, PHF	0.81	0.88	0.82	0.87	0.84	0.80	0.84	0.97	0.88	0.78	0.79	0.70
Adj. Flow (vph)	33	85	70	53	138	179	142	459	90	119	349	34
RTOR Reduction (vph)	0	0	57	0	0	147	0	0	51	0	0	19
Lane Group Flow (vph)	33	85	13	53	138	32	142	459	39	119	349	15
Heavy Vehicles (%)	2%	2%	2%	2%	2%	2%	2%	2%	77%	2%	2%	2%
Turn Type	Perm		Perm	Perm		Perm	pm+pt		Perm	pm+pt		Perm
Protected Phases		4			8		5	2		1	6	
Permitted Phases	4		4	8		8	2		2	6		6
Actuated Green, G (s)	10.5	10.5	10.5	10.5	10.5	10.5	30.0	25.4	25.4	30.0	25.4	25.4
Effective Green, g (s)	10.5	10.5	10.5	10.5	10.5	10.5	30.0	25.4	25.4	30.0	25.4	25.4
Actuated g/C Ratio	0.18	0.18	0.18	0.18	0.18	0.18	0.51	0.43	0.43	0.51	0.43	0.43
Clearance Time (s)	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	226	338	287	237	338	287	584	1554	401	540	1554	695
v/s Ratio Prot		0.05			c0.07		c0.02	c0.13		0.02	0.10	
v/s Ratio Perm	0.03		0.01	0.04		0.02	0.11		0.04	0.10		0.01
v/c Ratio	0.15	0.25	0.04	0.22	0.41	0.11	0.24	0.30	0.10	0.22	0.22	0.02
Uniform Delay, d1	20.2	20.6	19.8	20.5	21.2	20.1	7.5	10.7	9.8	7.4	10.4	9.5
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.3	0.4	0.1	0.5	0.8	0.2	0.2	0.1	0.1	0.2	0.1	0.0
Delay (s)	20.5	21.0	19.9	21.0	22.1	20.3	7.8	10.8	9.9	7.6	10.4	9.5
Level of Service	C	C	B	C	C	C	A	B	A	A	B	A
Approach Delay (s)		20.5			21.0			10.1			9.7	
Approach LOS		C			C			B			A	

Intersection Summary			
HCM Average Control Delay	13.4	HCM Level of Service	B
HCM Volume to Capacity ratio	0.32		
Actuated Cycle Length (s)	58.5	Sum of lost time (s)	18.0
Intersection Capacity Utilization	51.6%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	27	75	57	44	116	148	119	445	83	102	276	24
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.95	1.00	1.00	0.95	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1789	1883	1601	1789	1883	1601	1789	3579	923	1789	3579	1601
Flt Permitted	0.67	1.00	1.00	0.70	1.00	1.00	0.54	1.00	1.00	0.49	1.00	1.00
Satd. Flow (perm)	1260	1883	1601	1322	1883	1601	1022	3579	923	919	3579	1601
Peak-hour factor, PHF	0.81	0.88	0.82	0.87	0.84	0.80	0.84	0.97	0.88	0.78	0.79	0.70
Adj. Flow (vph)	33	85	70	51	138	185	142	459	94	131	349	34
RTOR Reduction (vph)	0	0	57	0	0	152	0	0	53	0	0	19
Lane Group Flow (vph)	33	85	13	51	138	33	142	459	41	131	349	15
Heavy Vehicles (%)	2%	2%	2%	2%	2%	2%	2%	2%	77%	2%	2%	2%
Turn Type	Perm		Perm	Perm		Perm	pm+pt		Perm	pm+pt		Perm
Protected Phases		4			8		5	2		1	6	
Permitted Phases	4		4	8		8	2		2	6		6
Actuated Green, G (s)	10.5	10.5	10.5	10.5	10.5	10.5	30.0	25.4	25.4	30.0	25.4	25.4
Effective Green, g (s)	10.5	10.5	10.5	10.5	10.5	10.5	30.0	25.4	25.4	30.0	25.4	25.4
Actuated g/C Ratio	0.18	0.18	0.18	0.18	0.18	0.18	0.51	0.43	0.43	0.51	0.43	0.43
Clearance Time (s)	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	226	338	287	237	338	287	584	1554	401	540	1554	695
v/s Ratio Prot		0.05			c0.07		c0.02	c0.13		0.02	0.10	
v/s Ratio Perm	0.03		0.01	0.04		0.02	0.11		0.04	0.11		0.01
v/c Ratio	0.15	0.25	0.04	0.22	0.41	0.12	0.24	0.30	0.10	0.24	0.22	0.02
Uniform Delay, d1	20.2	20.6	19.8	20.5	21.2	20.1	7.5	10.7	9.8	7.5	10.4	9.5
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.3	0.4	0.1	0.5	0.8	0.2	0.2	0.1	0.1	0.2	0.1	0.0
Delay (s)	20.5	21.0	19.9	20.9	22.1	20.3	7.8	10.8	9.9	7.7	10.4	9.5
Level of Service	C	C	B	C	C	C	A	B	A	A	B	A
Approach Delay (s)		20.5			21.0			10.1			9.7	
Approach LOS		C			C			B			A	

Intersection Summary			
HCM Average Control Delay	13.4	HCM Level of Service	B
HCM Volume to Capacity ratio	0.32		
Actuated Cycle Length (s)	58.5	Sum of lost time (s)	18.0
Intersection Capacity Utilization	51.7%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	30	87	66	53	134	164	137	511	90	107	318	28
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.95	1.00	1.00	0.95	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1789	1883	1601	1789	1883	1601	1789	3579	923	1789	3579	1601
Flt Permitted	0.66	1.00	1.00	0.69	1.00	1.00	0.51	1.00	1.00	0.45	1.00	1.00
Satd. Flow (perm)	1235	1883	1601	1305	1883	1601	970	3579	923	856	3579	1601
Peak-hour factor, PHF	0.81	0.88	0.82	0.87	0.84	0.80	0.84	0.97	0.88	0.78	0.79	0.70
Adj. Flow (vph)	37	99	80	61	160	205	163	527	102	137	403	40
RTOR Reduction (vph)	0	0	65	0	0	167	0	0	58	0	0	23
Lane Group Flow (vph)	37	99	15	61	160	38	163	527	44	137	403	17
Heavy Vehicles (%)	2%	2%	2%	2%	2%	2%	2%	2%	77%	2%	2%	2%
Turn Type	Perm		Perm	Perm		Perm	pm+pt		Perm	pm+pt		Perm
Protected Phases		4			8		5	2		1	6	
Permitted Phases	4		4	8		8	2		2	6		6
Actuated Green, G (s)	11.0	11.0	11.0	11.0	11.0	11.0	30.0	25.4	25.4	30.0	25.4	25.4
Effective Green, g (s)	11.0	11.0	11.0	11.0	11.0	11.0	30.0	25.4	25.4	30.0	25.4	25.4
Actuated g/C Ratio	0.19	0.19	0.19	0.19	0.19	0.19	0.51	0.43	0.43	0.51	0.43	0.43
Clearance Time (s)	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	230	351	298	243	351	298	557	1541	397	508	1541	689
v/s Ratio Prot		0.05			c0.08		c0.02	c0.15		0.02	0.11	
v/s Ratio Perm	0.03		0.01	0.05		0.02	0.13		0.05	0.12		0.01
v/c Ratio	0.16	0.28	0.05	0.25	0.46	0.13	0.29	0.34	0.11	0.27	0.26	0.02
Uniform Delay, d1	20.1	20.6	19.7	20.5	21.3	20.0	7.8	11.2	10.0	7.7	10.8	9.7
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.3	0.4	0.1	0.5	0.9	0.2	0.3	0.1	0.1	0.3	0.1	0.0
Delay (s)	20.5	21.1	19.8	21.0	22.3	20.2	8.1	11.4	10.2	8.0	10.9	9.7
Level of Service	C	C	B	C	C	C	A	B	B	A	B	A
Approach Delay (s)		20.5			21.1			10.5			10.1	
Approach LOS		C			C			B			B	

Intersection Summary			
HCM Average Control Delay	13.7	HCM Level of Service	B
HCM Volume to Capacity ratio	0.37		
Actuated Cycle Length (s)	59.0	Sum of lost time (s)	18.0
Intersection Capacity Utilization	62.1%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	30	97	66	53	144	211	143	556	90	158	357	28
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.95	1.00	1.00	0.95	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1789	1883	1601	1789	1883	1601	1789	3579	923	1789	3579	1601
Flt Permitted	0.65	1.00	1.00	0.69	1.00	1.00	0.49	1.00	1.00	0.40	1.00	1.00
Satd. Flow (perm)	1223	1883	1601	1292	1883	1601	925	3579	923	749	3579	1601
Peak-hour factor, PHF	0.81	0.88	0.82	0.87	0.84	0.80	0.84	0.97	0.88	0.78	0.79	0.70
Adj. Flow (vph)	37	110	80	61	171	264	170	573	102	203	452	40
RTOR Reduction (vph)	0	0	65	0	0	215	0	0	59	0	0	22
Lane Group Flow (vph)	37	110	15	61	171	49	170	573	43	203	452	18
Heavy Vehicles (%)	2%	2%	2%	2%	2%	2%	2%	2%	77%	2%	2%	2%
Turn Type	Perm		Perm	Perm		Perm	pm+pt		Perm	pm+pt		Perm
Protected Phases		4			8		5	2		1	6	
Permitted Phases	4		4	8		8	2		2	6		6
Actuated Green, G (s)	11.5	11.5	11.5	11.5	11.5	11.5	31.0	26.3	26.3	33.6	27.6	27.6
Effective Green, g (s)	11.5	11.5	11.5	11.5	11.5	11.5	31.0	26.3	26.3	33.6	27.6	27.6
Actuated g/C Ratio	0.19	0.19	0.19	0.19	0.19	0.19	0.50	0.43	0.43	0.54	0.45	0.45
Clearance Time (s)	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	228	350	298	240	350	298	530	1523	393	508	1598	715
v/s Ratio Prot		0.06			c0.09		0.02	0.16		c0.04	0.13	
v/s Ratio Perm	0.03		0.01	0.05		0.03	0.14		0.05	c0.18		0.01
v/c Ratio	0.16	0.31	0.05	0.25	0.49	0.16	0.32	0.38	0.11	0.40	0.28	0.02
Uniform Delay, d1	21.1	21.7	20.7	21.5	22.5	21.1	8.5	12.1	10.7	7.3	10.8	9.6
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.3	0.5	0.1	0.6	1.1	0.3	0.4	0.2	0.1	0.5	0.1	0.0
Delay (s)	21.4	22.3	20.7	22.0	23.6	21.4	8.8	12.3	10.8	7.8	10.9	9.6
Level of Service	C	C	C	C	C	C	A	B	B	A	B	A
Approach Delay (s)		21.6			22.2			11.4			9.9	
Approach LOS		C			C			B			A	

Intersection Summary			
HCM Average Control Delay	14.4	HCM Level of Service	B
HCM Volume to Capacity ratio	0.38		
Actuated Cycle Length (s)	61.8	Sum of lost time (s)	12.0
Intersection Capacity Utilization	63.8%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Group Flow (vph)	37	213	151	61	71	56	53	208	93	338	406	26
v/c Ratio	0.14	0.57	0.34	0.30	0.19	0.15	0.09	0.14	0.13	0.51	0.23	0.03
Control Delay	21.0	28.5	6.5	24.6	21.3	7.5	6.5	12.4	4.0	11.1	11.5	5.8
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	21.0	28.5	6.5	24.6	21.3	7.5	6.5	12.4	4.0	11.1	11.5	5.8
Queue Length 50th (m)	3.5	21.8	0.0	5.9	6.7	0.0	2.1	7.3	0.0	15.8	15.2	0.0
Queue Length 95th (m)	7.5	33.7	11.5	11.2	11.8	4.5	5.3	11.8	4.1	32.9	26.6	2.6
Internal Link Dist (m)		159.5			151.5			157.3			291.3	
Turn Bay Length (m)	30.0		60.0	35.0		45.0	45.0		120.0	64.0		87.0
Base Capacity (vph)	351	493	531	271	493	461	571	1450	710	659	1743	801
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.11	0.43	0.28	0.23	0.14	0.12	0.09	0.14	0.13	0.51	0.23	0.03

Intersection Summary

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Group Flow (vph)	37	213	151	66	71	69	53	208	94	341	406	26
v/c Ratio	0.14	0.57	0.34	0.32	0.19	0.19	0.09	0.14	0.13	0.52	0.23	0.03
Control Delay	21.0	28.5	6.5	25.2	21.3	7.2	6.5	12.4	4.0	11.2	11.5	5.8
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	21.0	28.5	6.5	25.2	21.3	7.2	6.5	12.4	4.0	11.2	11.5	5.8
Queue Length 50th (m)	3.5	21.8	0.0	6.4	6.7	0.0	2.1	7.3	0.0	16.0	15.2	0.0
Queue Length 95th (m)	7.5	33.7	11.5	11.9	11.8	4.8	5.3	11.8	4.1	33.1	26.6	2.6
Internal Link Dist (m)		159.5			151.5			157.3			291.3	
Turn Bay Length (m)	30.0		60.0	35.0		45.0	45.0		120.0	64.0		87.0
Base Capacity (vph)	351	493	531	271	493	470	571	1450	711	659	1743	801
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.11	0.43	0.28	0.24	0.14	0.15	0.09	0.14	0.13	0.52	0.23	0.03

Intersection Summary

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Group Flow (vph)	41	246	173	70	81	66	61	239	107	389	468	30
v/c Ratio	0.15	0.63	0.37	0.37	0.21	0.17	0.11	0.17	0.15	0.61	0.27	0.04
Control Delay	21.0	30.1	6.3	27.0	21.3	7.2	6.8	12.8	3.9	14.1	12.1	5.5
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	21.0	30.1	6.3	27.0	21.3	7.2	6.8	12.8	3.9	14.1	12.1	5.5
Queue Length 50th (m)	3.8	25.7	0.0	6.9	7.7	0.0	2.6	8.8	0.0	20.3	18.6	0.0
Queue Length 95th (m)	8.0	38.5	12.2	12.6	13.1	4.7	5.9	13.3	4.3	#38.9	30.6	2.8
Internal Link Dist (m)		159.5			151.5			157.3			291.3	
Turn Bay Length (m)	30.0		60.0	35.0		45.0	45.0		120.0	64.0		87.0
Base Capacity (vph)	343	488	543	235	488	464	542	1435	712	638	1725	794
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.12	0.50	0.32	0.30	0.17	0.14	0.11	0.17	0.15	0.61	0.27	0.04

Intersection Summary

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Group Flow (vph)	41	265	173	70	81	164	61	264	107	400	508	30
v/c Ratio	0.14	0.66	0.36	0.39	0.20	0.35	0.12	0.19	0.15	0.64	0.30	0.04
Control Delay	20.8	30.9	6.2	27.9	21.1	6.3	6.9	13.1	3.9	15.7	12.4	5.5
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	20.8	30.9	6.2	27.9	21.1	6.3	6.9	13.1	3.9	15.7	12.4	5.5
Queue Length 50th (m)	3.8	28.0	0.0	6.9	7.7	0.0	2.8	10.4	0.0	22.8	21.6	0.0
Queue Length 95th (m)	8.0	41.4	12.2	12.7	13.1	5.8	5.9	14.5	4.3	#44.1	33.3	2.8
Internal Link Dist (m)		159.5			151.5			157.3			291.3	
Turn Bay Length (m)	30.0		60.0	35.0		45.0	45.0		120.0	64.0		87.0
Base Capacity (vph)	340	484	540	215	484	533	524	1423	707	622	1711	788
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.12	0.55	0.32	0.33	0.17	0.31	0.12	0.19	0.15	0.64	0.30	0.04

Intersection Summary

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Group Flow (vph)	33	85	70	53	138	179	142	459	90	119	349	34
v/c Ratio	0.14	0.25	0.20	0.22	0.40	0.41	0.23	0.29	0.20	0.21	0.22	0.05
Control Delay	21.7	22.7	7.6	23.0	25.2	7.1	6.6	12.2	4.6	6.5	11.8	5.1
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	21.7	22.7	7.6	23.0	25.2	7.1	6.6	12.2	4.6	6.5	11.8	5.1
Queue Length 50th (m)	3.1	8.1	0.0	5.0	13.5	0.0	5.1	16.1	0.0	4.2	11.8	0.0
Queue Length 95th (m)	8.2	17.4	6.9	12.4	24.8	9.3	12.7	29.4	7.2	10.0	19.3	2.9
Internal Link Dist (m)		159.5			151.5			157.3			291.3	
Turn Bay Length (m)	30.0		60.0	35.0		45.0	45.0		120.0	64.0		87.0
Base Capacity (vph)	358	535	505	376	535	583	617	1589	460	574	1589	730
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.09	0.16	0.14	0.14	0.26	0.31	0.23	0.29	0.20	0.21	0.22	0.05

Intersection Summary

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Group Flow (vph)	33	85	70	51	138	185	142	459	94	131	349	34
v/c Ratio	0.14	0.25	0.20	0.21	0.40	0.42	0.23	0.29	0.20	0.23	0.22	0.05
Control Delay	21.7	22.7	7.6	22.8	25.2	7.1	6.6	12.2	4.6	6.7	11.8	5.1
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	21.7	22.7	7.6	22.8	25.2	7.1	6.6	12.2	4.6	6.7	11.8	5.1
Queue Length 50th (m)	3.1	8.1	0.0	4.8	13.5	0.0	5.1	16.1	0.0	4.6	11.8	0.0
Queue Length 95th (m)	8.2	17.4	6.9	12.1	24.8	9.4	12.7	29.4	7.3	10.8	19.3	2.9
Internal Link Dist (m)		159.5			151.5			157.3			291.3	
Turn Bay Length (m)	30.0		60.0	35.0		45.0	45.0		120.0	64.0		87.0
Base Capacity (vph)	358	535	505	376	535	587	617	1589	462	574	1589	730
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.09	0.16	0.14	0.14	0.26	0.32	0.23	0.29	0.20	0.23	0.22	0.05

Intersection Summary

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Group Flow (vph)	37	99	80	61	160	205	163	527	102	137	403	40
v/c Ratio	0.16	0.28	0.22	0.24	0.44	0.43	0.28	0.33	0.22	0.25	0.26	0.06
Control Delay	21.7	22.8	7.2	23.2	25.7	6.9	7.2	12.8	4.7	7.1	12.3	4.9
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	21.7	22.8	7.2	23.2	25.7	6.9	7.2	12.8	4.7	7.1	12.3	4.9
Queue Length 50th (m)	3.5	9.5	0.0	5.8	15.9	0.0	6.2	19.4	0.0	5.1	14.2	0.0
Queue Length 95th (m)	8.8	19.6	7.2	13.9	28.0	9.6	14.7	34.4	7.8	11.5	22.6	3.1
Internal Link Dist (m)		159.5			151.5			157.3			291.3	
Turn Bay Length (m)	30.0		60.0	35.0		45.0	45.0		120.0	64.0		87.0
Base Capacity (vph)	348	530	508	367	530	598	590	1574	463	542	1574	726
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.11	0.19	0.16	0.17	0.30	0.34	0.28	0.33	0.22	0.25	0.26	0.06

Intersection Summary

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Group Flow (vph)	37	110	80	61	171	264	170	573	102	203	452	40
v/c Ratio	0.16	0.31	0.22	0.25	0.48	0.51	0.30	0.39	0.23	0.40	0.28	0.05
Control Delay	21.7	23.2	7.2	23.2	26.4	7.1	7.6	13.9	4.8	8.9	12.5	4.9
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	21.7	23.2	7.2	23.2	26.4	7.1	7.6	13.9	4.8	8.9	12.5	4.9
Queue Length 50th (m)	3.5	10.6	0.0	5.8	17.1	0.0	7.0	22.4	0.0	8.5	17.0	0.0
Queue Length 95th (m)	8.8	21.4	7.2	13.9	29.6	10.3	15.2	37.6	7.8	16.4	25.2	3.1
Internal Link Dist (m)		159.5			151.5			157.3			291.3	
Turn Bay Length (m)	30.0		60.0	35.0		45.0	45.0		120.0	64.0		87.0
Base Capacity (vph)	324	499	483	342	499	618	560	1480	442	504	1631	751
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.11	0.22	0.17	0.18	0.34	0.43	0.30	0.39	0.23	0.40	0.28	0.05

Intersection Summary

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (veh/h)	67	19	300	28	50	471
Sign Control	Stop		Free			Free
Grade	0%		0%			0%
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	73	21	326	30	54	512
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type			None			None
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	706	178			357	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	706	178			357	
tC, single (s)	6.8	6.9			4.1	
tC, 2 stage (s)						
tF (s)	3.5	3.3			2.2	
p0 queue free %	79	98			95	
cM capacity (veh/h)	353	834			1199	

Direction, Lane #	WB 1	NB 1	NB 2	SB 1	SB 2
Volume Total	93	217	139	225	341
Volume Left	73	0	0	54	0
Volume Right	21	0	30	0	0
cSH	405	1700	1700	1199	1700
Volume to Capacity	0.23	0.13	0.08	0.05	0.20
Queue Length 95th (m)	6.7	0.0	0.0	1.1	0.0
Control Delay (s)	16.5	0.0	0.0	2.3	0.0
Lane LOS	C			A	
Approach Delay (s)	16.5	0.0		0.9	
Approach LOS	C				

Intersection Summary			
Average Delay	2.0		
Intersection Capacity Utilization	38.5%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (veh/h)	40	77	714	114	39	370
Sign Control	Stop		Free			Free
Grade	0%		0%			0%
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	43	84	776	124	42	402
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type			None			None
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	1124	450			900	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1124	450			900	
tC, single (s)	6.8	6.9			4.1	
tC, 2 stage (s)						
tF (s)	3.5	3.3			2.2	
p0 queue free %	77	85			94	
cM capacity (veh/h)	188	556			751	

Direction, Lane #	WB 1	NB 1	NB 2	SB 1	SB 2
Volume Total	127	517	383	176	268
Volume Left	43	0	0	42	0
Volume Right	84	0	124	0	0
cSH	333	1700	1700	751	1700
Volume to Capacity	0.38	0.30	0.23	0.06	0.16
Queue Length 95th (m)	13.2	0.0	0.0	1.4	0.0
Control Delay (s)	22.3	0.0	0.0	2.9	0.0
Lane LOS	C			A	
Approach Delay (s)	22.3	0.0		1.1	
Approach LOS	C				

Intersection Summary			
Average Delay	2.3		
Intersection Capacity Utilization	51.7%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	739	4	42	214	3	138
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.87	0.92	0.70	0.71	0.92	0.92
Hourly flow rate (vph)	849	4	60	301	3	150
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume			854		1273	852
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			854		1273	852
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			92		98	58
cM capacity (veh/h)			786		171	360

Direction, Lane #	EB 1	WB 1	NB 1
Volume Total	854	361	153
Volume Left	0	60	3
Volume Right	4	0	150
cSH	1700	786	351
Volume to Capacity	0.50	0.08	0.44
Queue Length 95th (m)	0.0	1.9	16.2
Control Delay (s)	0.0	2.4	22.9
Lane LOS		A	C
Approach Delay (s)	0.0	2.4	22.9
Approach LOS			C

Intersection Summary			
Average Delay	3.2		
Intersection Capacity Utilization	62.5%	ICU Level of Service	B
Analysis Period (min)	15		

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	348	13	183	625	10	106
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.78	0.92	0.92	0.82	0.92	0.92
Hourly flow rate (vph)	446	14	199	762	11	115
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume			460		1613	453
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			460		1613	453
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			82		88	81
cM capacity (veh/h)			1101		94	607

Direction, Lane #	EB 1	WB 1	NB 1
Volume Total	460	961	126
Volume Left	0	199	11
Volume Right	14	0	115
cSH	1700	1101	412
Volume to Capacity	0.27	0.18	0.31
Queue Length 95th (m)	0.0	5.0	9.7
Control Delay (s)	0.0	4.2	17.5
Lane LOS		A	C
Approach Delay (s)	0.0	4.2	17.5
Approach LOS			C

Intersection Summary			
Average Delay	4.0		
Intersection Capacity Utilization	79.2%	ICU Level of Service	D
Analysis Period (min)	15		

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	509	67	36	110	31	100
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.82	0.70	0.80	0.87	0.80	0.80
Hourly flow rate (vph)	621	96	45	126	39	125
Pedestrians	2			2		
Lane Width (m)	3.7			3.7		
Walking Speed (m/s)	1.2			1.2		
Percent Blockage	0			0		
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume			716		887	671
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			716		887	671
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			95		87	73
cM capacity (veh/h)			884		298	456

Direction, Lane #	EB 1	WB 1	WB 2	NB 1
Volume Total	716	45	126	164
Volume Left	0	45	0	39
Volume Right	96	0	0	125
cSH	1700	884	1700	405
Volume to Capacity	0.42	0.05	0.07	0.40
Queue Length 95th (m)	0.0	1.2	0.0	14.5
Control Delay (s)	0.0	9.3	0.0	19.8
Lane LOS		A		C
Approach Delay (s)	0.0	2.4		19.8
Approach LOS				C

Intersection Summary			
Average Delay	3.5		
Intersection Capacity Utilization	45.9%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	536	67	36	118	31	100
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.82	0.70	0.80	0.87	0.80	0.80
Hourly flow rate (vph)	654	96	45	136	39	125
Pedestrians	2			2		
Lane Width (m)	3.7			3.7		
Walking Speed (m/s)	1.2			1.2		
Percent Blockage	0			0		
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume			749		929	704
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			749		929	704
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			95		86	71
cM capacity (veh/h)			860		281	437

Direction, Lane #	EB 1	WB 1	WB 2	NB 1
Volume Total	749	45	136	164
Volume Left	0	45	0	39
Volume Right	96	0	0	125
cSH	1700	860	1700	386
Volume to Capacity	0.44	0.05	0.08	0.42
Queue Length 95th (m)	0.0	1.3	0.0	15.6
Control Delay (s)	0.0	9.4	0.0	21.0
Lane LOS		A		C
Approach Delay (s)	0.0	2.3		21.0
Approach LOS				C

Intersection Summary			
Average Delay	3.5		
Intersection Capacity Utilization	47.3%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	585	77	41	127	35	115
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.82	0.70	0.80	0.87	0.80	0.80
Hourly flow rate (vph)	713	110	51	146	44	144
Pedestrians	2			2		
Lane Width (m)	3.7			3.7		
Walking Speed (m/s)	1.2			1.2		
Percent Blockage	0			0		
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume			823		1019	770
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			823		1019	770
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			94		82	64
cM capacity (veh/h)			806		245	400

Direction, Lane #	EB 1	WB 1	WB 2	NB 1
Volume Total	823	51	146	188
Volume Left	0	51	0	44
Volume Right	110	0	0	144
cSH	1700	806	1700	349
Volume to Capacity	0.48	0.06	0.09	0.54
Queue Length 95th (m)	0.0	1.5	0.0	23.1
Control Delay (s)	0.0	9.8	0.0	26.7
Lane LOS		A		D
Approach Delay (s)	0.0	2.5		26.7
Approach LOS				D

Intersection Summary			
Average Delay	4.6		
Intersection Capacity Utilization	51.6%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	818	77	47	202	53	201
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.82	0.70	0.80	0.87	0.80	0.80
Hourly flow rate (vph)	998	110	59	232	66	251
Pedestrians	2			2		
Lane Width (m)	3.7			3.7		
Walking Speed (m/s)	1.2			1.2		
Percent Blockage	0			0		
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume			1108		1404	1055
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			1108		1404	1055
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			91		52	8
cM capacity (veh/h)			630		139	274

Direction, Lane #	EB 1	WB 1	WB 2	NB 1
Volume Total	1108	59	232	318
Volume Left	0	59	0	66
Volume Right	110	0	0	251
cSH	1700	630	1700	228
Volume to Capacity	0.65	0.09	0.14	1.39
Queue Length 95th (m)	0.0	2.3	0.0	135.8
Control Delay (s)	0.0	11.3	0.0	242.6
Lane LOS		B		F
Approach Delay (s)	0.0	2.3		242.6
Approach LOS				F

Intersection Summary			
Average Delay	45.3		
Intersection Capacity Utilization	69.9%	ICU Level of Service	C
Analysis Period (min)	15		

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	818	77	47	202	53	201
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.82	0.70	0.80	0.87	0.80	0.80
Hourly flow rate (vph)	998	110	59	232	66	251
Pedestrians	2			2		
Lane Width (m)	3.7			3.7		
Walking Speed (m/s)	1.2			1.2		
Percent Blockage	0			0		
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume			1108		1404	1055
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			1108		1404	1055
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			91		52	8
cM capacity (veh/h)			630		139	274

Direction, Lane #	EB 1	WB 1	WB 2	NB 1	NB 2
Volume Total	1108	59	232	66	251
Volume Left	0	59	0	66	0
Volume Right	110	0	0	0	251
cSH	1700	630	1700	139	274
Volume to Capacity	0.65	0.09	0.14	0.48	0.92
Queue Length 95th (m)	0.0	2.3	0.0	16.7	63.8
Control Delay (s)	0.0	11.3	0.0	52.4	75.6
Lane LOS		B		F	F
Approach Delay (s)	0.0	2.3		70.7	
Approach LOS				F	

Intersection Summary			
Average Delay	13.5		
Intersection Capacity Utilization	67.1%	ICU Level of Service	C
Analysis Period (min)	15		

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	187	34	53	445	21	29
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.88	0.75	0.70	0.87	0.70	0.70
Hourly flow rate (vph)	212	45	76	511	30	41
Pedestrians	2			2		
Lane Width (m)	3.7			3.7		
Walking Speed (m/s)	1.2			1.2		
Percent Blockage	0			0		
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume			258		900	237
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			258		900	237
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			94		90	95
cM capacity (veh/h)			1307		291	800

Direction, Lane #	EB 1	WB 1	WB 2	NB 1
Volume Total	258	76	511	71
Volume Left	0	76	0	30
Volume Right	45	0	0	41
cSH	1700	1307	1700	461
Volume to Capacity	0.15	0.06	0.30	0.15
Queue Length 95th (m)	0.0	1.4	0.0	4.1
Control Delay (s)	0.0	7.9	0.0	14.2
Lane LOS		A		B
Approach Delay (s)	0.0	1.0		14.2
Approach LOS				B

Intersection Summary			
Average Delay	1.8		
Intersection Capacity Utilization	34.1%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	204	34	53	474	21	29
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.88	0.75	0.70	0.87	0.70	0.70
Hourly flow rate (vph)	232	45	76	545	30	41
Pedestrians	2			2		
Lane Width (m)	3.7			3.7		
Walking Speed (m/s)	1.2			1.2		
Percent Blockage	0			0		
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume			277		953	256
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			277		953	256
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			94		89	95
cM capacity (veh/h)			1286		270	781

Direction, Lane #	EB 1	WB 1	WB 2	NB 1
Volume Total	277	76	545	71
Volume Left	0	76	0	30
Volume Right	45	0	0	41
cSH	1700	1286	1700	435
Volume to Capacity	0.16	0.06	0.32	0.16
Queue Length 95th (m)	0.0	1.4	0.0	4.4
Control Delay (s)	0.0	8.0	0.0	14.9
Lane LOS		A		B
Approach Delay (s)	0.0	1.0		14.9
Approach LOS				B

Intersection Summary			
Average Delay	1.7		
Intersection Capacity Utilization	35.6%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	215	39	61	511	25	33
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.88	0.75	0.70	0.87	0.70	0.70
Hourly flow rate (vph)	244	52	87	587	36	47
Pedestrians	2			2		
Lane Width (m)	3.7			3.7		
Walking Speed (m/s)	1.2			1.2		
Percent Blockage	0			0		
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume			296		1034	272
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			296		1034	272
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			93		85	94
cM capacity (veh/h)			1265		239	765

Direction, Lane #	EB 1	WB 1	WB 2	NB 1
Volume Total	296	87	587	83
Volume Left	0	87	0	36
Volume Right	52	0	0	47
cSH	1700	1265	1700	393
Volume to Capacity	0.17	0.07	0.35	0.21
Queue Length 95th (m)	0.0	1.7	0.0	6.0
Control Delay (s)	0.0	8.1	0.0	16.6
Lane LOS		A		C
Approach Delay (s)	0.0	1.0		16.6
Approach LOS				C

Intersection Summary			
Average Delay	2.0		
Intersection Capacity Utilization	37.7%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	400	39	90	812	25	51
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.88	0.75	0.70	0.87	0.70	0.70
Hourly flow rate (vph)	455	52	129	933	36	73
Pedestrians	2			2		
Lane Width (m)	3.7			3.7		
Walking Speed (m/s)	1.2			1.2		
Percent Blockage	0			0		
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume			507		1673	483
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			507		1673	483
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			88		61	88
cM capacity (veh/h)			1058		92	583

Direction, Lane #	EB 1	WB 1	WB 2	NB 1
Volume Total	507	129	933	109
Volume Left	0	129	0	36
Volume Right	52	0	0	73
cSH	1700	1058	1700	212
Volume to Capacity	0.30	0.12	0.55	0.51
Queue Length 95th (m)	0.0	3.1	0.0	19.9
Control Delay (s)	0.0	8.9	0.0	38.6
Lane LOS		A		E
Approach Delay (s)	0.0	1.1		38.6
Approach LOS				E

Intersection Summary			
Average Delay	3.2		
Intersection Capacity Utilization	54.6%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	400	39	90	812	25	51
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.88	0.75	0.70	0.87	0.70	0.70
Hourly flow rate (vph)	455	52	129	933	36	73
Pedestrians	2			2		
Lane Width (m)	3.7			3.7		
Walking Speed (m/s)	1.2			1.2		
Percent Blockage	0			0		
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume			507		1673	483
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			507		1673	483
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			88		61	88
cM capacity (veh/h)			1058		92	583

Direction, Lane #	EB 1	WB 1	WB 2	NB 1	NB 2
Volume Total	507	129	933	36	73
Volume Left	0	129	0	36	0
Volume Right	52	0	0	0	73
cSH	1700	1058	1700	92	583
Volume to Capacity	0.30	0.12	0.55	0.39	0.12
Queue Length 95th (m)	0.0	3.1	0.0	11.8	3.2
Control Delay (s)	0.0	8.9	0.0	66.8	12.1
Lane LOS		A		F	B
Approach Delay (s)	0.0	1.1		30.1	
Approach LOS				D	

Intersection Summary			
Average Delay	2.6		
Intersection Capacity Utilization	53.4%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	1	2	63	2	13	1	73	5	3	1	21	3
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.70	0.70	0.70	0.70	0.92	0.70	0.70	0.75	0.92	0.75	0.70
Hourly flow rate (vph)	1	3	90	3	19	1	104	7	4	1	28	4
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	260	252	30	341	252	9	32			11		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	260	252	30	341	252	9	32			11		
tC, single (s)	7.1	6.5	6.2	7.1	6.5	6.2	4.1			4.1		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	100	100	91	99	97	100	93			100		
cM capacity (veh/h)	641	608	1044	529	608	1072	1580			1608		

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	94	23	115	33
Volume Left	1	3	104	1
Volume Right	90	1	4	4
cSH	1015	609	1580	1608
Volume to Capacity	0.09	0.04	0.07	0.00
Queue Length 95th (m)	2.3	0.9	1.6	0.0
Control Delay (s)	8.9	11.1	6.8	0.2
Lane LOS	A	B	A	A
Approach Delay (s)	8.9	11.1	6.8	0.2
Approach LOS	A	B		

Intersection Summary			
Average Delay	7.1		
Intersection Capacity Utilization	22.0%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	1	2	68	2	13	1	81	5	3	1	21	3
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.70	0.70	0.70	0.70	0.92	0.70	0.70	0.75	0.92	0.75	0.70
Hourly flow rate (vph)	1	3	97	3	19	1	116	7	4	1	28	4
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	283	275	30	371	275	9	32			11		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	283	275	30	371	275	9	32			11		
tC, single (s)	7.1	6.5	6.2	7.1	6.5	6.2	4.1			4.1		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	100	100	91	99	97	100	93			100		
cM capacity (veh/h)	615	586	1044	499	586	1072	1580			1608		

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	101	23	127	33
Volume Left	1	3	116	1
Volume Right	97	1	4	4
cSH	1014	586	1580	1608
Volume to Capacity	0.10	0.04	0.07	0.00
Queue Length 95th (m)	2.5	0.9	1.8	0.0
Control Delay (s)	8.9	11.4	6.9	0.2
Lane LOS	A	B	A	A
Approach Delay (s)	8.9	11.4	6.9	0.2
Approach LOS	A	B		

Intersection Summary			
Average Delay	7.2		
Intersection Capacity Utilization	22.8%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	1	2	70	2	15	1	85	6	3	1	24	3
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.70	0.70	0.70	0.70	0.92	0.70	0.70	0.75	0.92	0.75	0.70
Hourly flow rate (vph)	1	3	100	3	21	1	121	9	4	1	32	4
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	302	292	34	391	292	11	36			13		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	302	292	34	391	292	11	36			13		
tC, single (s)	7.1	6.5	6.2	7.1	6.5	6.2	4.1			4.1		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	100	99	90	99	96	100	92			100		
cM capacity (veh/h)	594	571	1039	481	571	1071	1575			1606		

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	104	25	134	37
Volume Left	1	3	121	1
Volume Right	100	1	4	4
cSH	1008	570	1575	1606
Volume to Capacity	0.10	0.04	0.08	0.00
Queue Length 95th (m)	2.6	1.1	1.9	0.0
Control Delay (s)	9.0	11.6	6.8	0.2
Lane LOS	A	B	A	A
Approach Delay (s)	9.0	11.6	6.8	0.2
Approach LOS	A	B		

Intersection Summary			
Average Delay	7.2		
Intersection Capacity Utilization	23.2%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	1	2	174	2	15	1	91	6	3	1	24	3
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.70	0.70	0.70	0.70	0.92	0.70	0.70	0.75	0.92	0.75	0.70
Hourly flow rate (vph)	1	3	249	3	21	1	130	9	4	1	32	4
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	319	309	34	557	309	11	36			13		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	319	309	34	557	309	11	36			13		
tC, single (s)	7.1	6.5	6.2	7.1	6.5	6.2	4.1			4.1		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	100	99	76	99	96	100	92			100		
cM capacity (veh/h)	576	555	1039	313	555	1071	1575			1606		

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	253	25	143	37
Volume Left	1	3	130	1
Volume Right	249	1	4	4
cSH	1025	520	1575	1606
Volume to Capacity	0.25	0.05	0.08	0.00
Queue Length 95th (m)	7.4	1.2	2.0	0.0
Control Delay (s)	9.7	12.3	6.9	0.2
Lane LOS	A	B	A	A
Approach Delay (s)	9.7	12.3	6.9	0.2
Approach LOS	A	B		

Intersection Summary			
Average Delay	8.2		
Intersection Capacity Utilization	30.0%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	1	5	50	1	2	1	14	7	2	2	5	3
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
Hourly flow rate (vph)	1	7	71	1	3	1	20	10	3	3	7	4
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	69	68	9	141	69	11	11			13		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	69	68	9	141	69	11	11			13		
tC, single (s)	7.1	6.5	6.2	7.1	6.5	6.2	4.1			4.1		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	100	99	93	100	100	100	99			100		
cM capacity (veh/h)	909	811	1072	760	810	1069	1608			1606		

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	80	6	33	14
Volume Left	1	1	20	3
Volume Right	71	1	3	4
cSH	1039	848	1608	1606
Volume to Capacity	0.08	0.01	0.01	0.00
Queue Length 95th (m)	1.9	0.2	0.3	0.0
Control Delay (s)	8.8	9.3	4.5	1.5
Lane LOS	A	A	A	A
Approach Delay (s)	8.8	9.3	4.5	1.5
Approach LOS	A	A		

Intersection Summary			
Average Delay	6.9		
Intersection Capacity Utilization	13.5%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	1	5	50	1	2	1	14	7	2	2	5	3
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
Hourly flow rate (vph)	1	7	71	1	3	1	20	10	3	3	7	4
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	69	68	9	141	69	11	11			13		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	69	68	9	141	69	11	11			13		
tC, single (s)	7.1	6.5	6.2	7.1	6.5	6.2	4.1			4.1		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	100	99	93	100	100	100	99			100		
cM capacity (veh/h)	909	811	1072	760	810	1069	1608			1606		

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	80	6	33	14
Volume Left	1	1	20	3
Volume Right	71	1	3	4
cSH	1039	848	1608	1606
Volume to Capacity	0.08	0.01	0.01	0.00
Queue Length 95th (m)	1.9	0.2	0.3	0.0
Control Delay (s)	8.8	9.3	4.5	1.5
Lane LOS	A	A	A	A
Approach Delay (s)	8.8	9.3	4.5	1.5
Approach LOS	A	A		

Intersection Summary			
Average Delay	6.9		
Intersection Capacity Utilization	13.5%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	1	6	58	1	2	1	16	8	2	2	6	3
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
Hourly flow rate (vph)	1	9	83	1	3	1	23	11	3	3	9	4
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	78	76	11	162	77	13	13			14		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	78	76	11	162	77	13	13			14		
tC, single (s)	7.1	6.5	6.2	7.1	6.5	6.2	4.1			4.1		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	100	99	92	100	100	100	99			100		
cM capacity (veh/h)	896	801	1070	726	800	1067	1606			1604		

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	93	6	37	16
Volume Left	1	1	23	3
Volume Right	83	1	3	4
cSH	1035	831	1606	1604
Volume to Capacity	0.09	0.01	0.01	0.00
Queue Length 95th (m)	2.2	0.2	0.3	0.0
Control Delay (s)	8.8	9.4	4.5	1.3
Lane LOS	A	A	A	A
Approach Delay (s)	8.8	9.4	4.5	1.3
Approach LOS	A	A		

Intersection Summary			
Average Delay	7.0		
Intersection Capacity Utilization	14.5%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	1	6	76	1	2	1	45	8	2	2	6	3
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
Hourly flow rate (vph)	1	9	109	1	3	1	64	11	3	3	9	4
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	161	159	11	271	160	13	13			14		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	161	159	11	271	160	13	13			14		
tC, single (s)	7.1	6.5	6.2	7.1	6.5	6.2	4.1			4.1		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	100	99	90	100	100	100	96			100		
cM capacity (veh/h)	776	702	1070	588	702	1067	1606			1604		

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	119	6	79	16
Volume Left	1	1	64	3
Volume Right	109	1	3	4
cSH	1027	729	1606	1604
Volume to Capacity	0.12	0.01	0.04	0.00
Queue Length 95th (m)	3.0	0.2	1.0	0.0
Control Delay (s)	9.0	10.0	6.1	1.3
Lane LOS	A	A	A	A
Approach Delay (s)	9.0	10.0	6.1	1.3
Approach LOS	A	A		

Intersection Summary			
Average Delay	7.4		
Intersection Capacity Utilization	21.5%	ICU Level of Service	A
Analysis Period (min)	15		

Appendix C
Calculations

Crosswalk Warrants

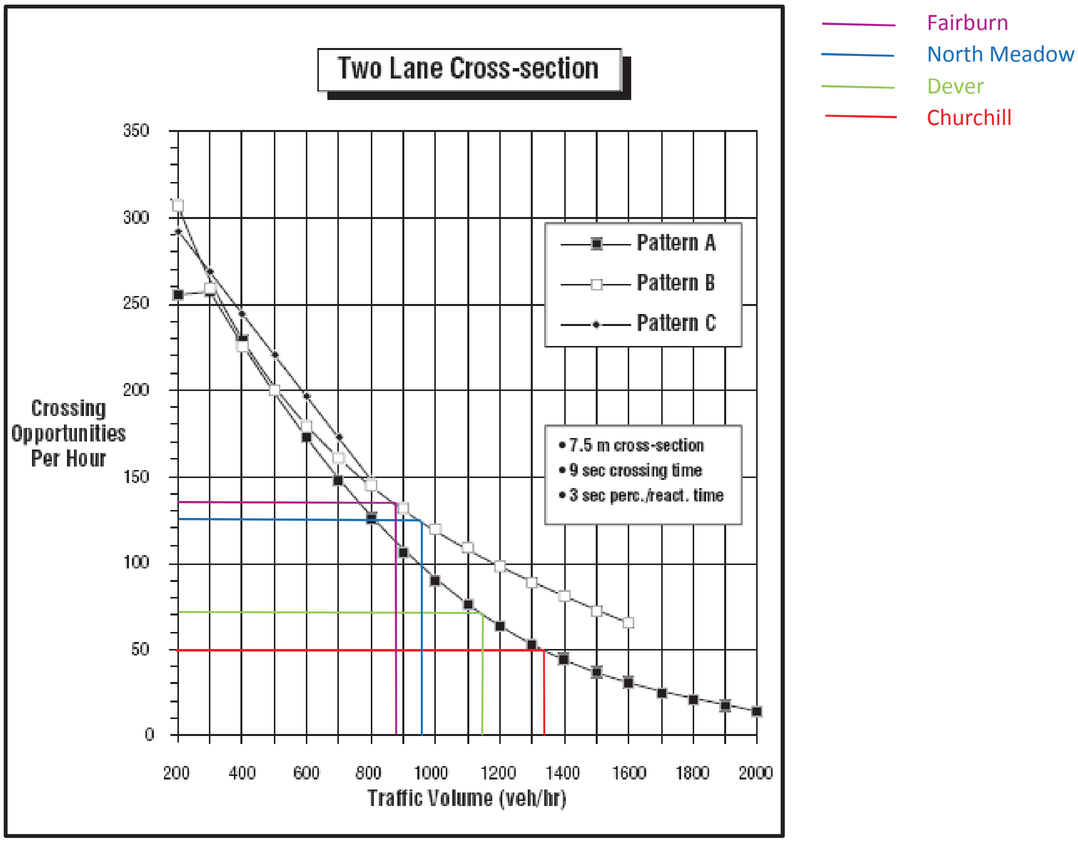


Figure 1

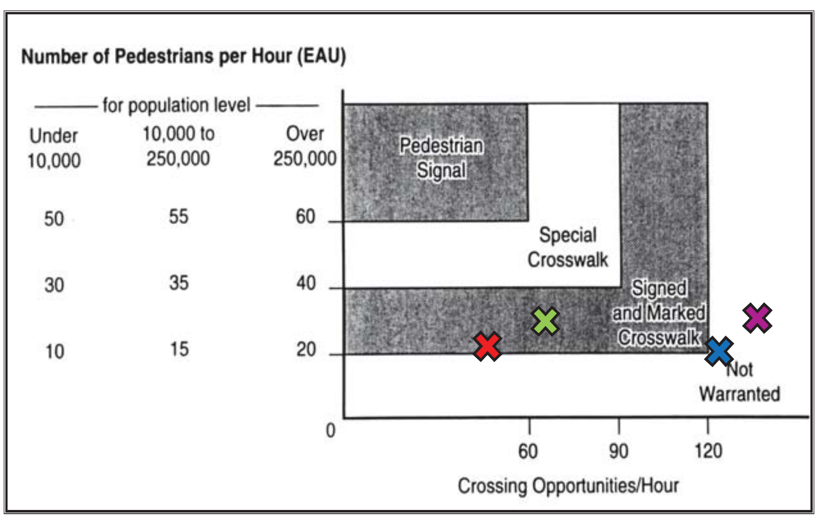


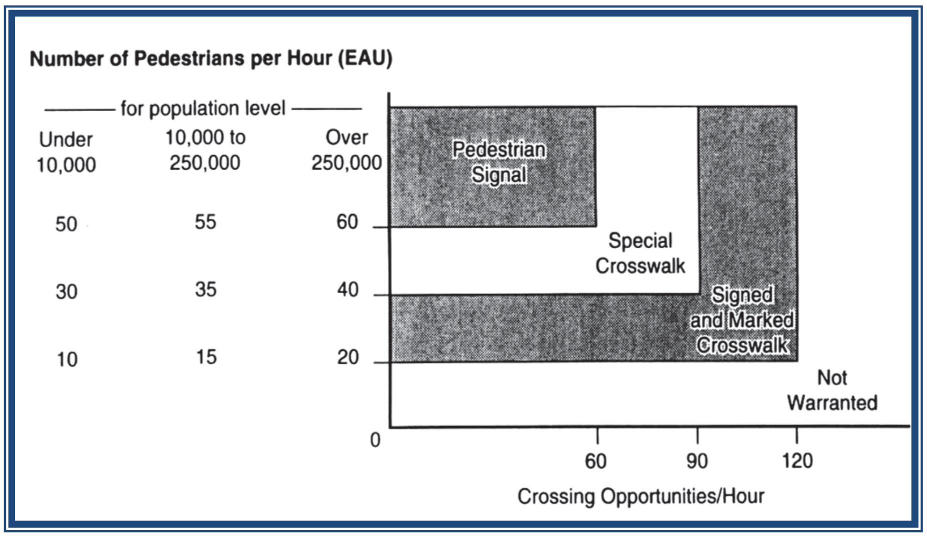
Figure 2

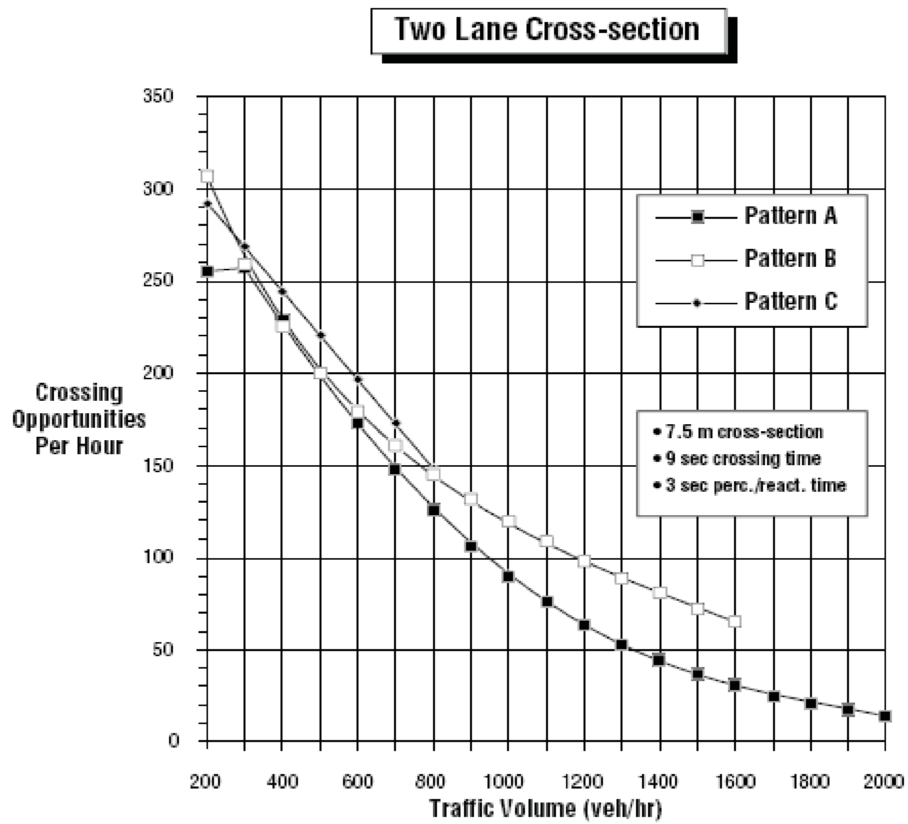
Pedestrian Crossing Warrant Model
Pedestrian Crossing North Nechako & Fairburn (AM)

	Actual Count	EAU
Adults crossing	10	10
Children Crossing	7	14
Elderly Crossing	0	0
Total	17	24

Traffic Volume	837	vehicles per hour
Pedestrian Count	17	
Roadway Cross Section	12	metres
Signal Progression	none	
Speed Limit	50	km/hr
population	80,000	

Not Warranted



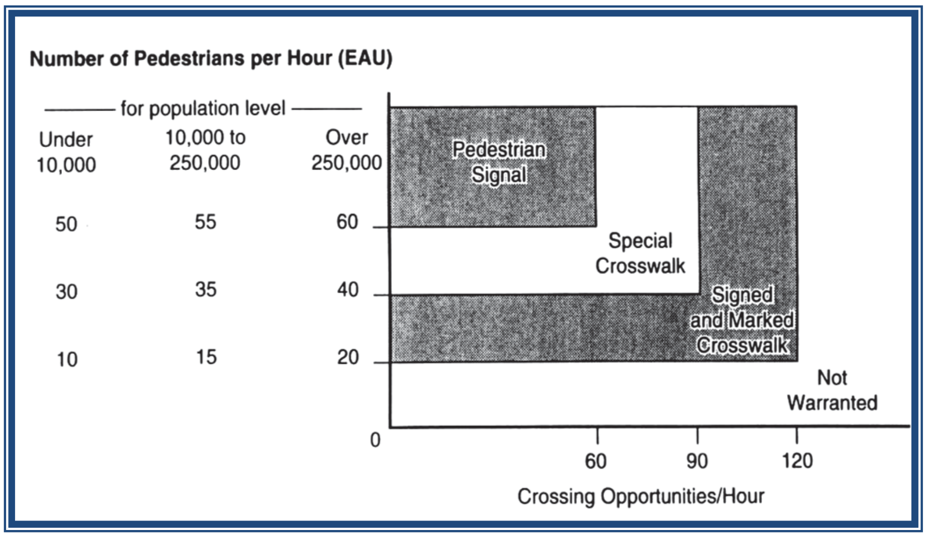


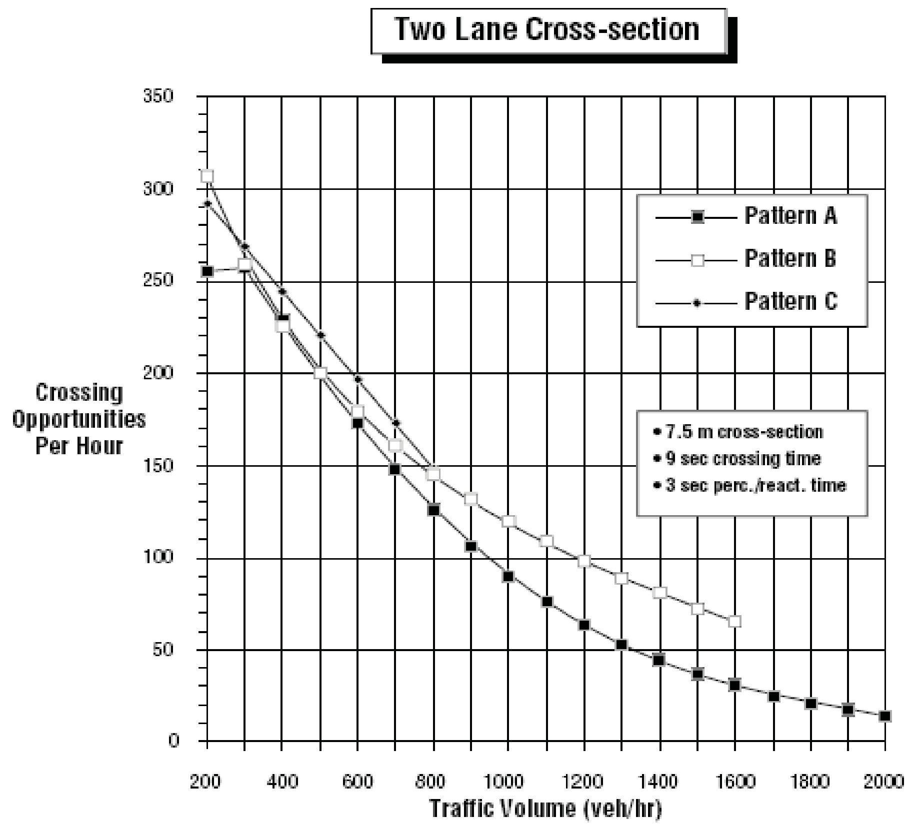
Pedestrian Crossing Warrant Model
Pedestrian Crossing North Nechako & North Meadow (AM)

	Actual Count	EAU
Adults crossing	6	6
Children Crossing	4	8
Elderly Crossing	0	0
Total	10	14

Traffic Volume	963	vehicles per hour
Pedestrian Count	10	
Roadway Cross Section	12	metres
Signal Progression	none	
Speed Limit	50	km/hr
population	80,000	

Not Warranted



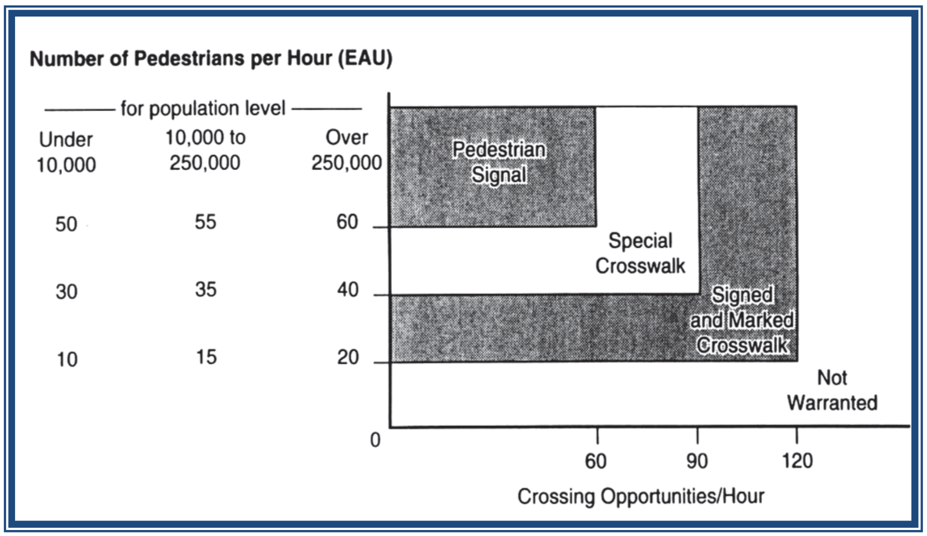


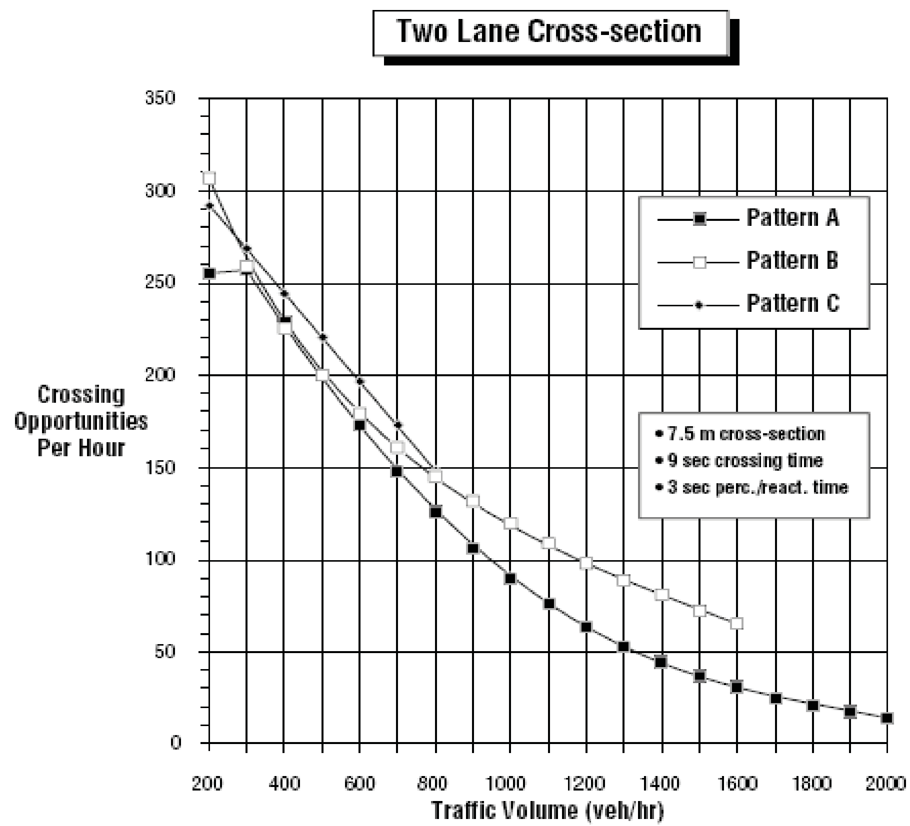
Pedestrian Crossing Warrant Model
Pedestrian Crossing North Nechako & Dever (PM)

	Actual Count	EAU
Adults crossing	10	10
Children Crossing	5	10
Elderly Crossing	0	0
Total	15	20

Traffic Volume	1169	vehicles per hour
Pedestrian Count	15	
Roadway Cross Section	12	metres
Signal Progression	none	
Speed Limit	50	km/hr
population	80,000	

SIGNED & MARKED CROSSWALK



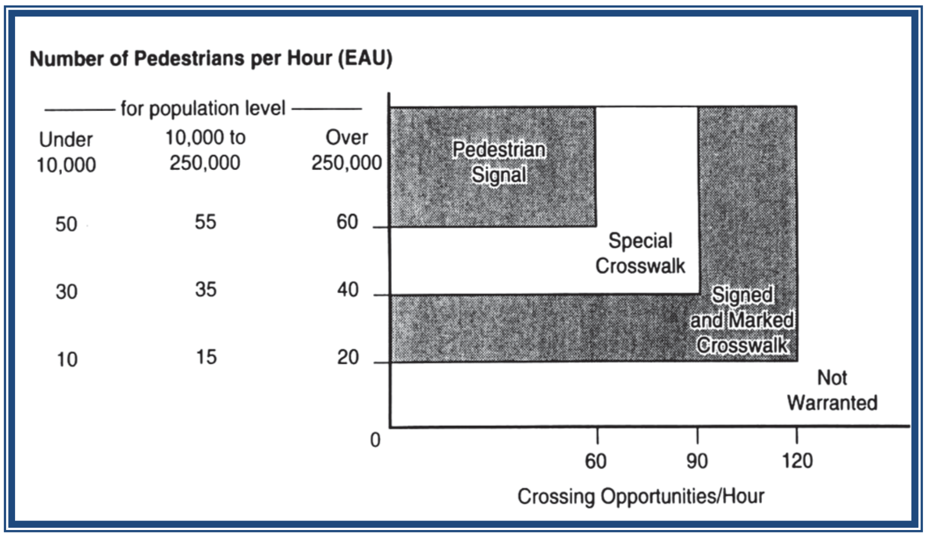


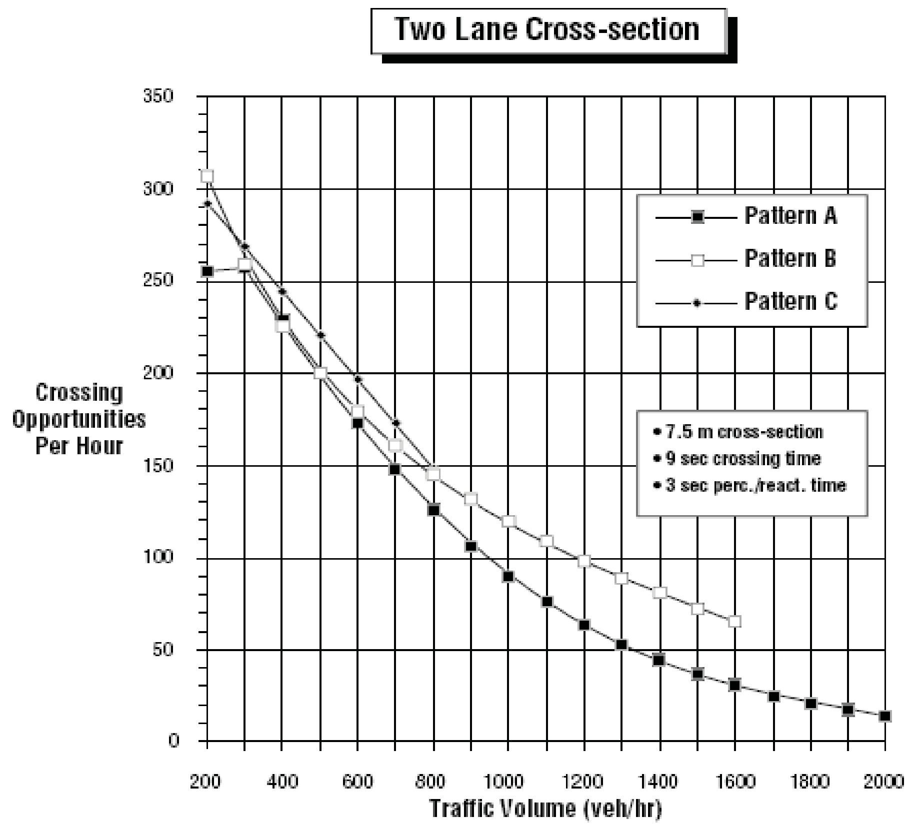
Pedestrian Crossing Warrant Model
Pedestrian Crossing North Nechako & Churchill (PM)

	Actual Count	EAU
Adults crossing	7	7
Children Crossing	4	8
Elderly Crossing	0	0
Total	11	15

Traffic Volume	1348	vehicles per hour
Pedestrian Count	11	
Roadway Cross Section	12	metres
Signal Progression	none	
Speed Limit	60	km/hr
population	80,000	

SIGNED & MARKED CROSSWALK





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Fax. (250) 562-1967

PROJECT NO.	PAGE
DRAWING BY	DATE
REFER TO	DRAWING NO.

TAC PEDESTRIAN CROSSING CONTROL GUIDE - 3RD EDITION (JUNE 2018) CALCULATIONS

EAU's → Equivalent Adult Units *** 7-hour average
↳ NOTE THAT L&M COUNTS WILL BE A 6 HOUR AVERAGE

① NORTH NECHAKO & CHURCHILL

TOTAL PEDESTRIANS (PEDs) = 49 over 6 hrs
6 HOUR AVG. = 49/6 ≈ 8
CHILDREN = 6 x 2 = 12
ADULTS = 2 x 1 = 2
(EAUS)
= **14 EAU's**

①, ② & ④ ASSUMPTION - 3/4 children - 1/4 adult
MOSTLY SCHOOL PEDESTRIANS

② NORTH NECHAKO & NORTH MEADOW

TOTAL PED's = 22 over 6 hrs
6 hr AVG = 22/6 ≈ 4
CHILDREN = 3x2=6
ADULTS = 1x1=1
7 EAU's

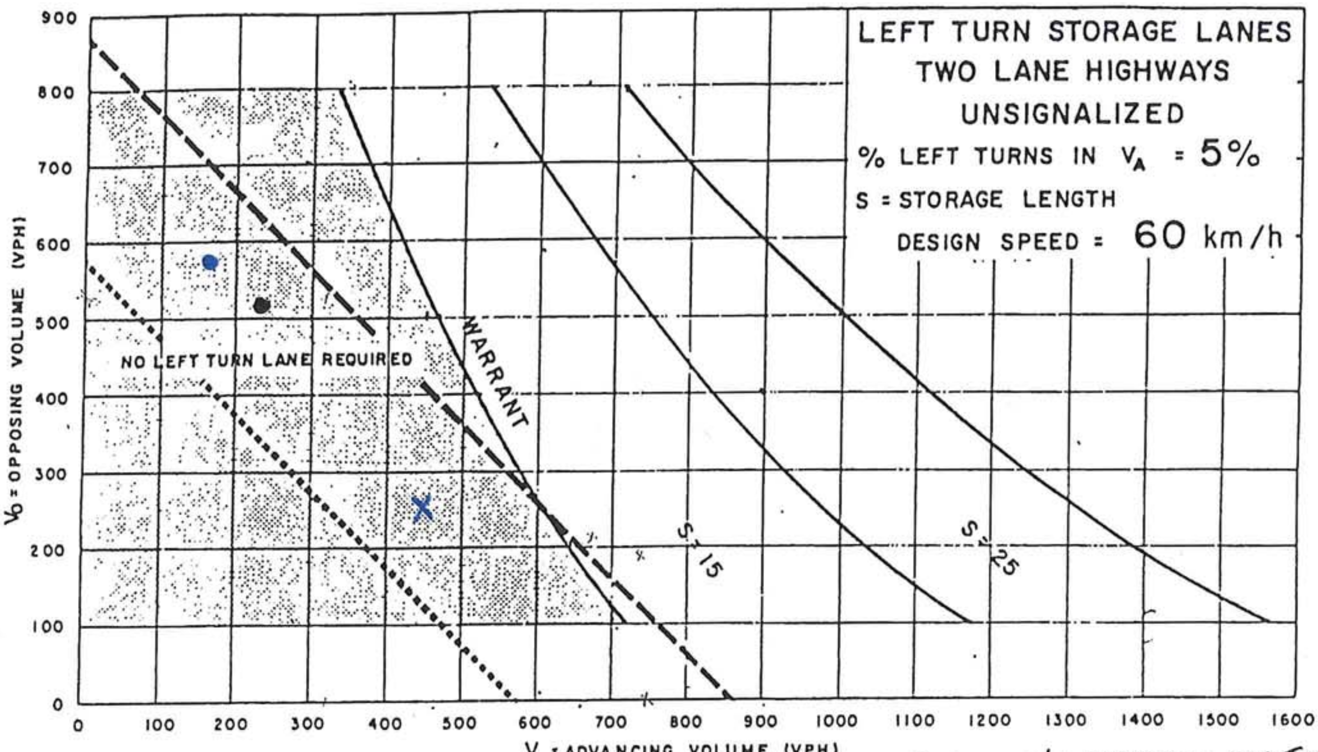
③ NORTH NECHAKO & FAIRBURN

TOTAL PED's = 34 + 20
↳ ASSUMED INCREASE DUE TO COMMERCIAL DEVELOPMENT
6 HR AVG = 54/6 = 9
CHILDREN = 5 x 2 = 10
ADULTS = 4 x 1 = 4
= 14 EAU's

③ ASSUMED → 1/2 CHILDREN 1/2 ADULT
SPLIT OF STUDENT / SHOPPING PEDESTRIANS

④ NORTH NECHAKO & DEVER

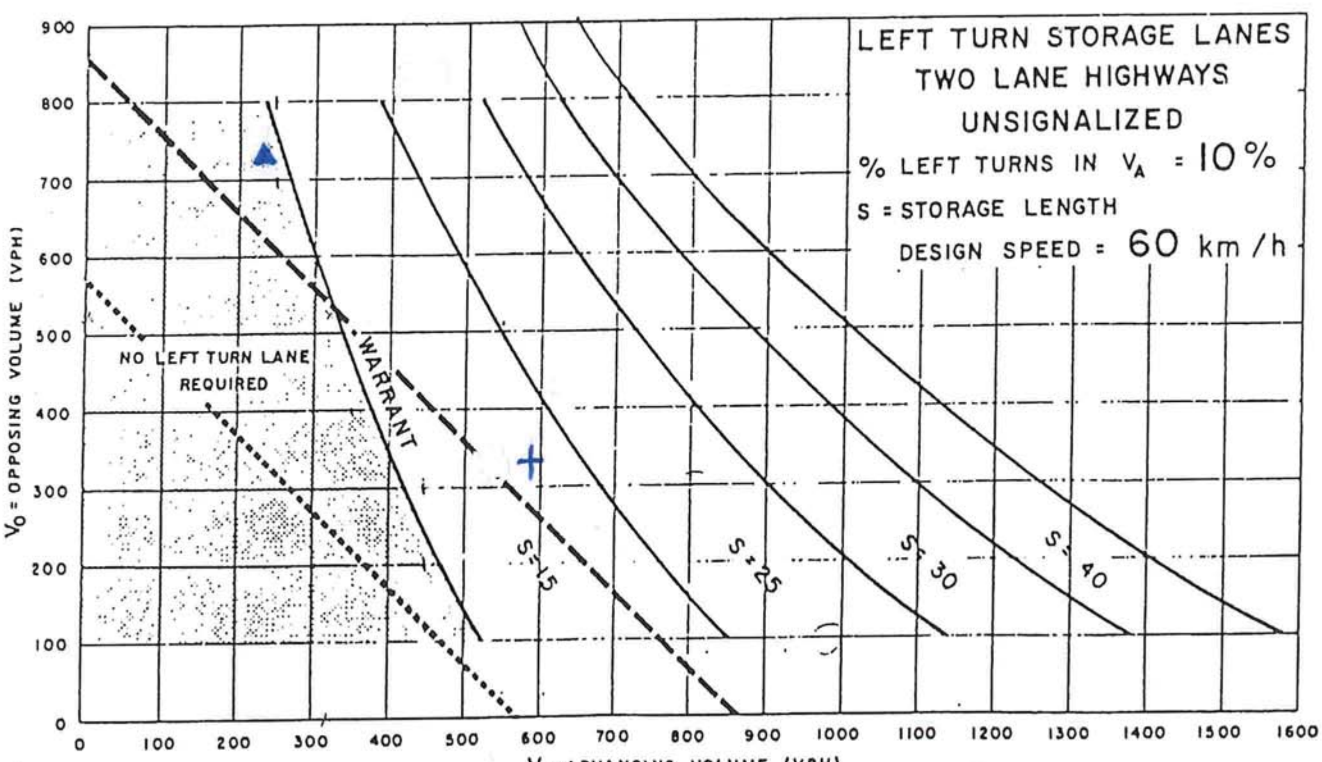
TOTAL PED's = 40 over 6 hrs → ASSUMED TO BE BETWEEN CHURCHILL & N. MEADOW PED VOLUMES
6 HR AVG = 40/6 ≈ 7
CHILDREN = 5 x 2 = 10
ADULTS = 2 x 1 = 2
= 12 EAU's

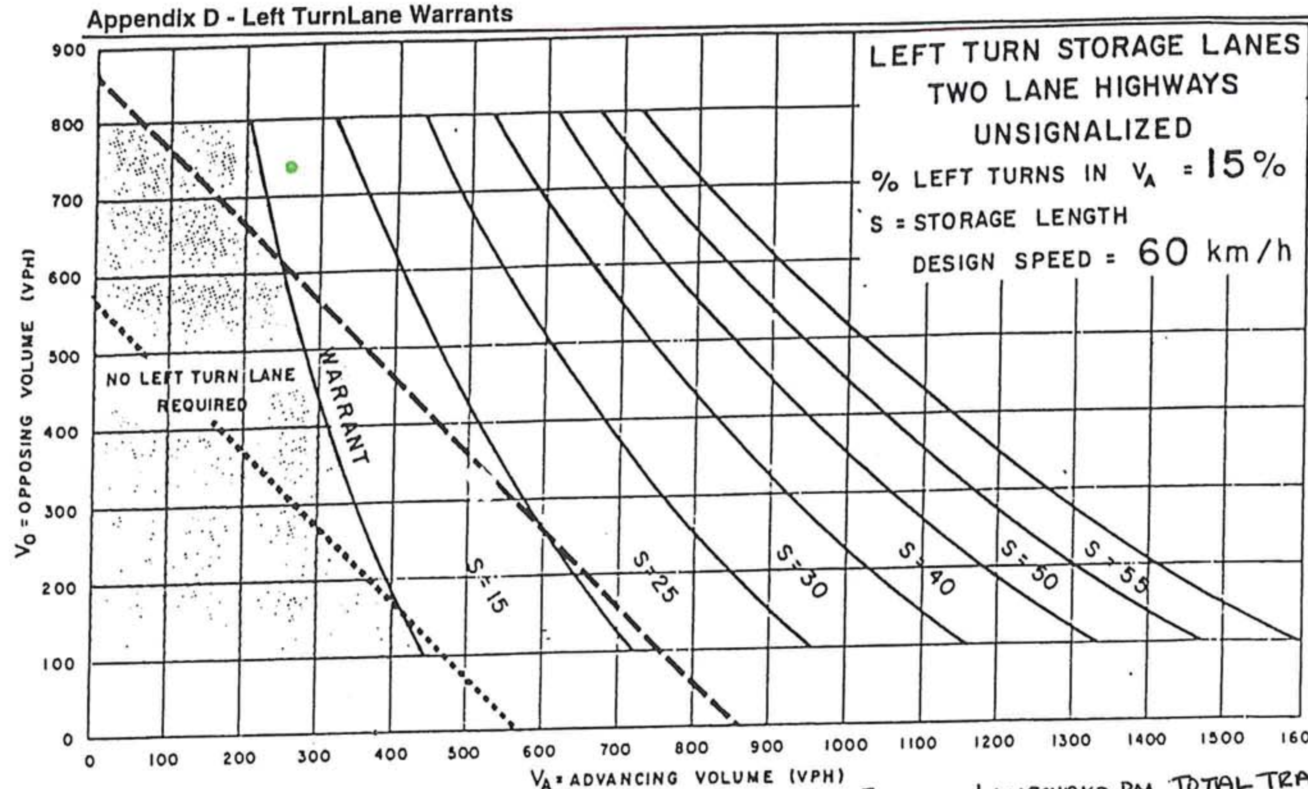


● FAIRBURN/N. NECHAKO AM TOTAL TRAFFIC
● N. MEADOW/N. NECHAKO AM OPENING DAY
X N. MEADOW/N. NECHAKO PM OPENING DAY
▲ N. MEADOW/N. NECHAKO AM TOTAL TRAFFIC
+ N. MEADOW/N. NECHAKO PM TOTAL TRAFFIC

– – – – TRAFFIC SIGNALS MAY BE WARRANTED IN RURAL AREAS OR URBAN AREAS WITH RESTRICTED FLOW

•••••••• TRAFFIC SIGNALS MAY BE WARRANTED IN "FREE FLOW" URBAN AREAS

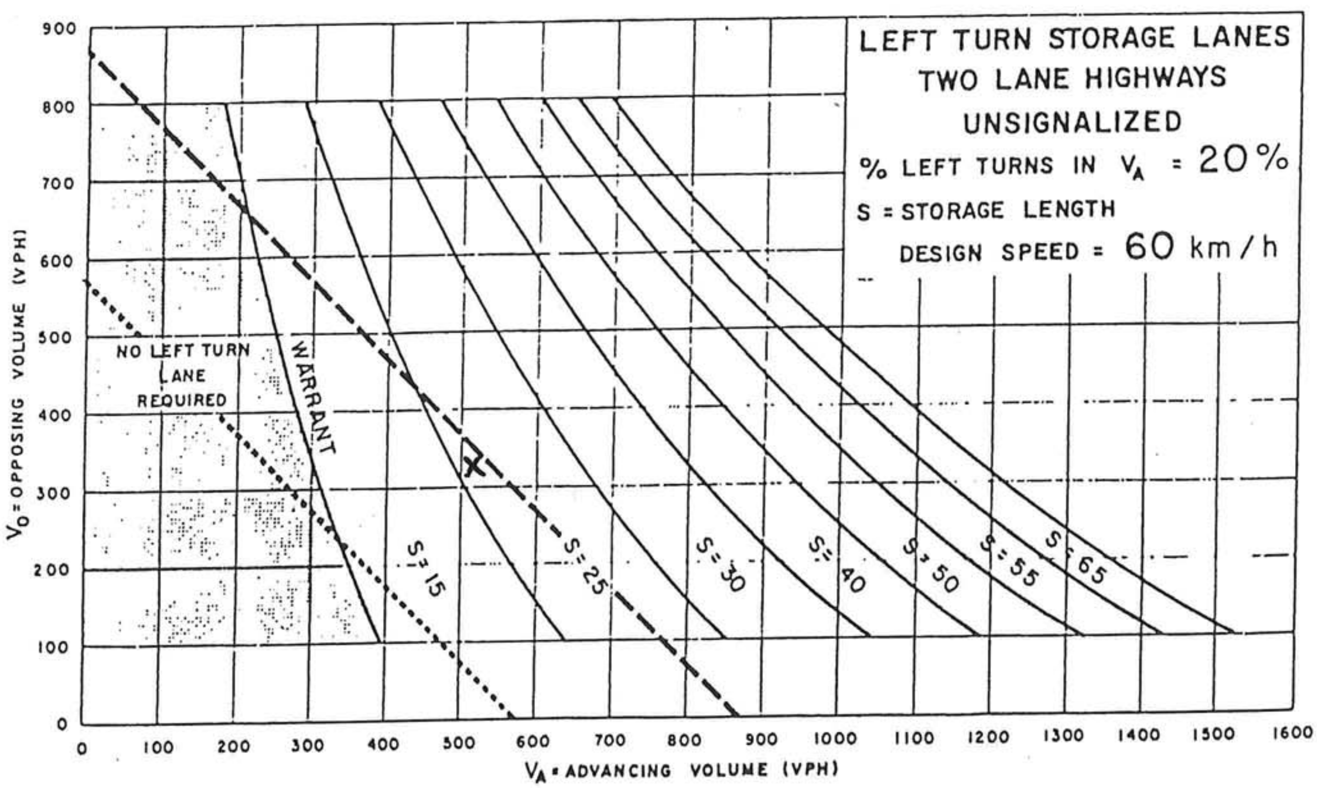


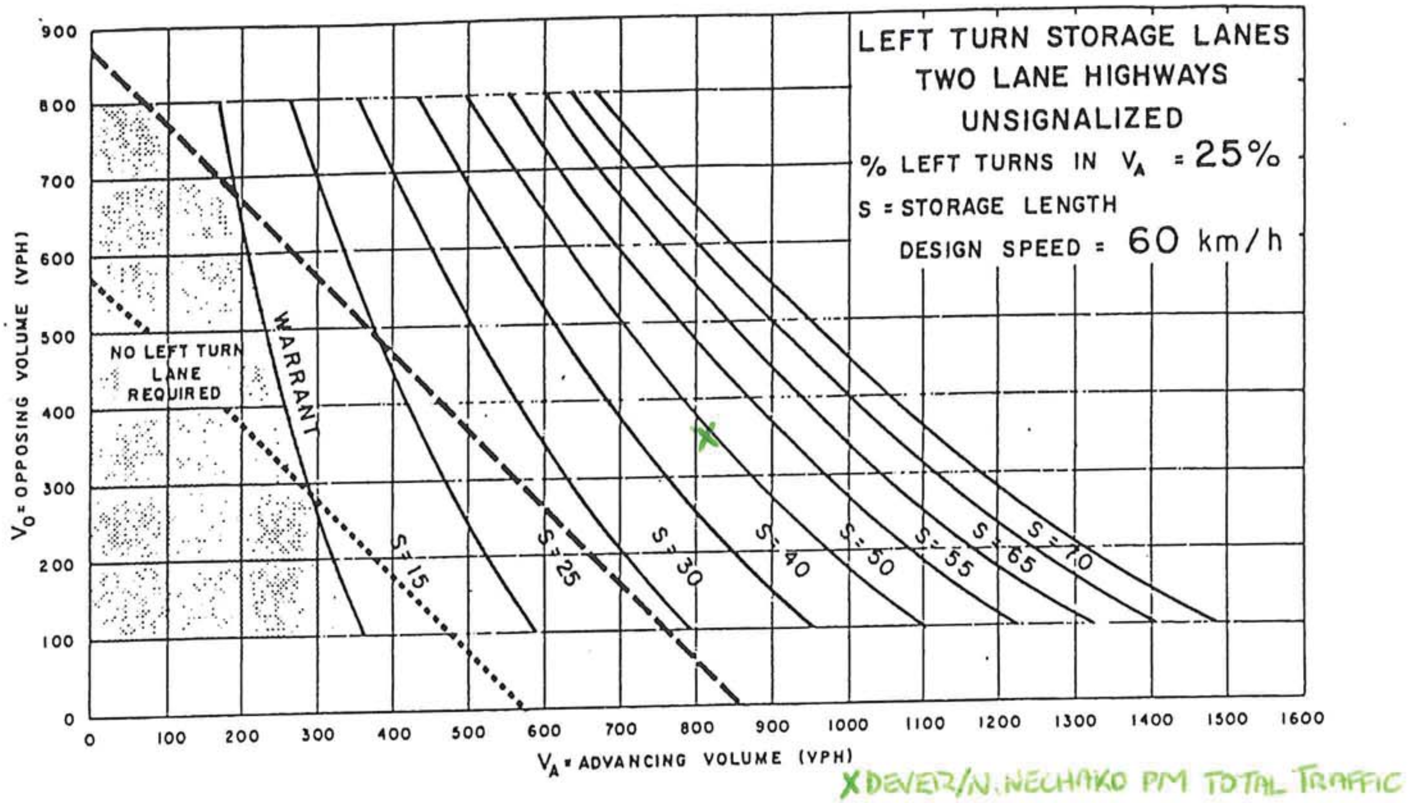


X FAIRBURN/N.NECHAKO PM TOTAL TRAFFIC
• DEVER/N.NECHAKO AM TOTAL TRAFFIC

— — — — TRAFFIC SIGNALS MAY BE WARRANTED IN RURAL AREAS OR URBAN AREAS WITH RESTRICTED FLOW

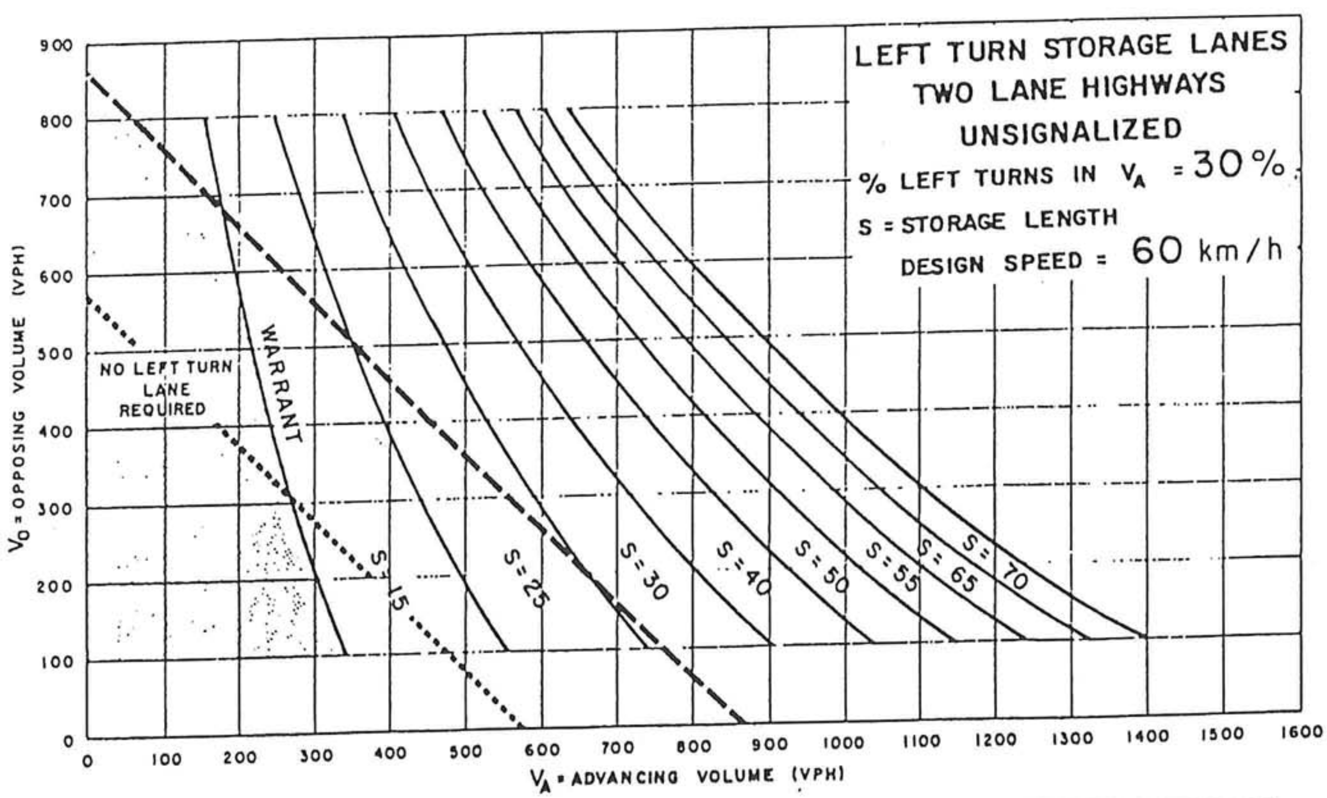
•••••••••• TRAFFIC SIGNALS MAY BE WARRANTED IN "FREE FLOW" URBAN AREAS

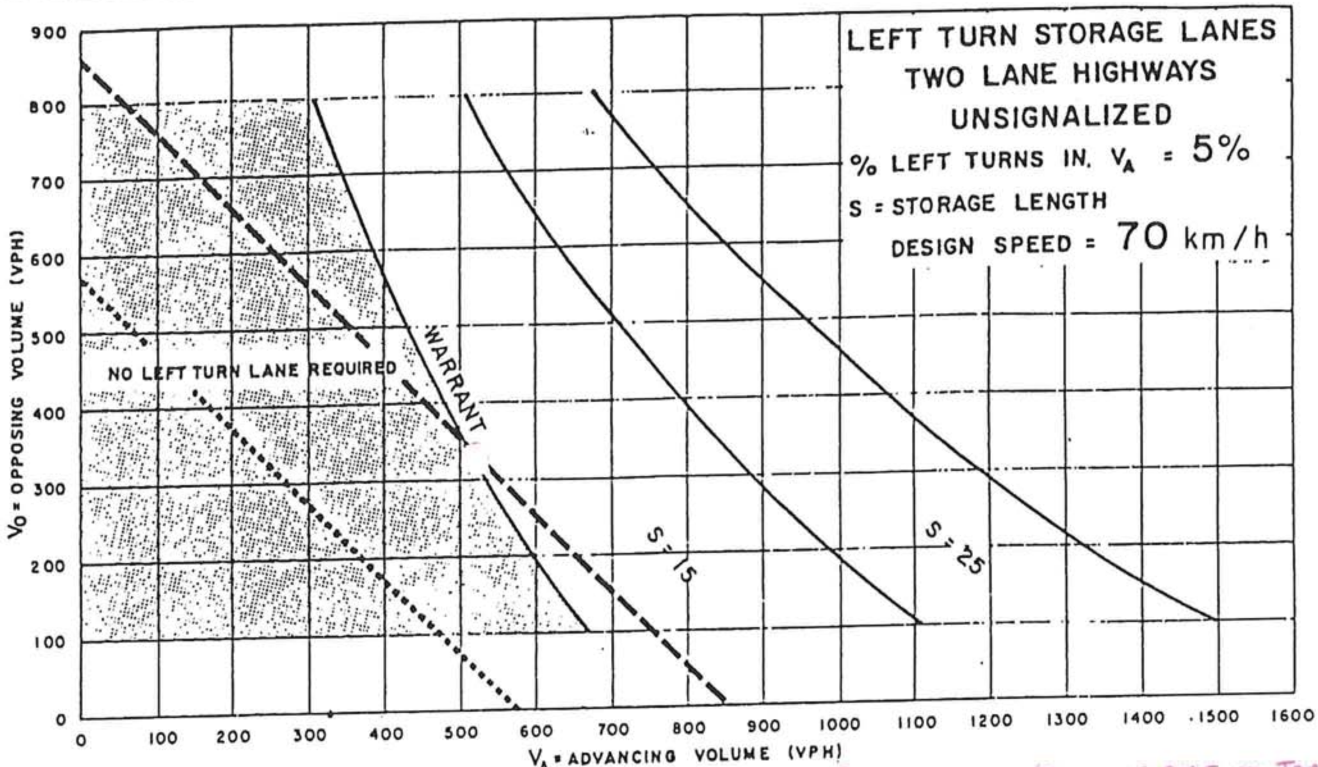




TRAFFIC SIGNALS MAY BE WARRANTED IN RURAL AREAS OR URBAN AREAS WITH RESTRICTED FLOW

TRAFFIC SIGNALS MAY BE WARRANTED IN "FREE FLOW" URBAN AREAS

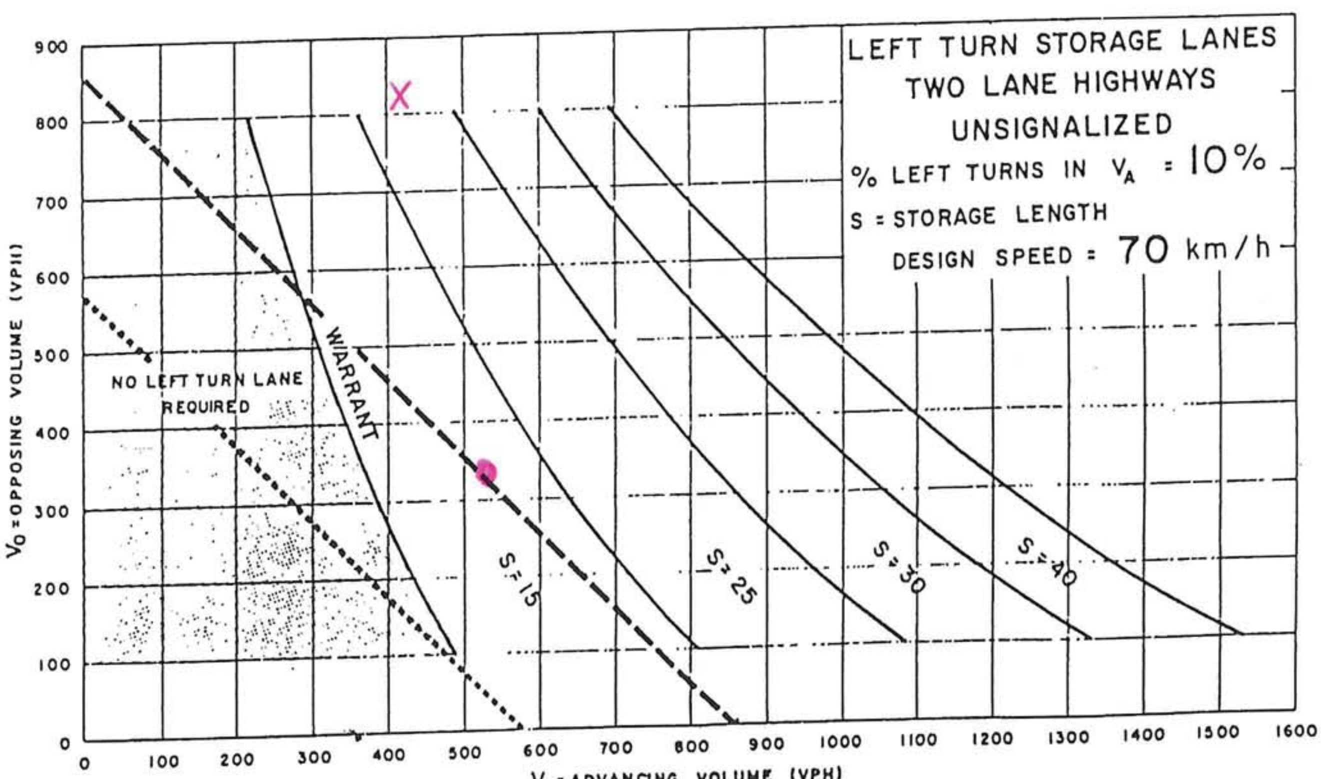




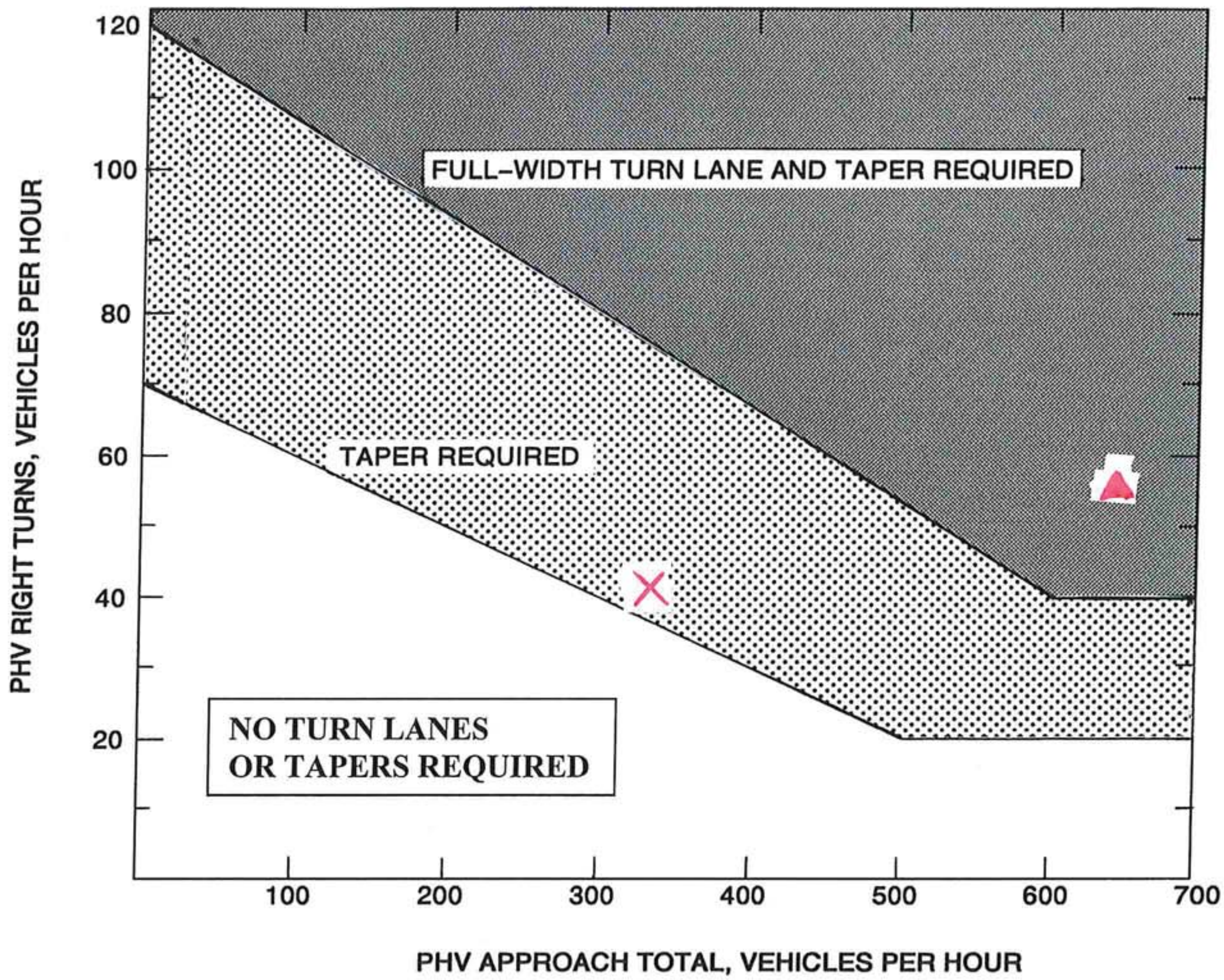
● FOOTHILLS ACCESS / FOOTHILLS AM TOTAL TRAFFIC
X FOOTHILLS ACCESS / FOOTHILLS PM TOTAL TRAFFIC

— — — — TRAFFIC SIGNALS MAY BE WARRANTED IN RURAL AREAS OR URBAN AREAS WITH RESTRICTED FLOW

••••••••• TRAFFIC SIGNALS MAY BE WARRANTED IN "FREE FLOW" URBAN AREAS



North Nechako EB Right Turn Lane @ Fairburn



Appropriate Radius required at all Intersections and Entrances (Commercial or Private).

LEGEND

PHV - Peak Hour Volume (also Design Hourly Volume equivalent)

Adjustment for Right Turns

For posted speeds at or under 45 mph, PHV right turns > 40, and
PHV total < 300.
Adjusted right turns = PHV Right Turns - 20
If PHV is not known use formula: PHV = ADT x K x D

K = the percent of AADT occurring in the peak hour
D = the percent of traffic in the peak direction of flow

Note: An average of 11% for K x D will suffice.

FIGURE 3-23 GUIDELINES FOR RIGHT TURN TREATMENT (2-LANE HIGHWAY)

▲ - 2034 Total Traffic PM Peak

X - 2034 Total Traffic AM Peak

APPENDIX F

North Nechako Neighbourhood Plan
L&M Engineering Limited

SERVICING BRIEF

L&M ENGINEERING LIMITED
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January 2019

NORTH NECHAKO NEIGHBOURHOOD PLAN SERVICING BRIEF

Client: TR Projects Ltd. / 406286 BC Ltd.
L&M Project No.: 1600-01

L&M ENGINEERING LIMITED
1210 Fourth Avenue, Prince George, BC V2L 3J4
Phone: (250) 562-1977

TABLE OF CONTENTS

Page No.

1.0 INTRODUCTION

L&M Engineering is pleased to provide you with this Servicing Brief for the development of the North Nechako Neighbourhood Plan Area, which is located at the southeast corner of the North Nechako Road and Foothills Boulevard intersection. The land consists of three properties, herein referred to as the subject area, which are currently owned by 406286 BC Ltd. and T.R. Projects Ltd. All of these properties are located adjacent to one another and once developed they will all require similar servicing requirements.

This Servicing Brief has been prepared to summarize the existing utilities in the surrounding area and demonstrate how each property can be serviced with municipal water, sanitary, and storm sewer servicing.

2.0 BACKGROUND DATA AND REPORTS

L&M Engineering has reviewed the following reports in relation to the development of the subject area:

- City of Prince George – 2017 Sanitary Sewer Services Master Plan prepared by AECOM;
- City of Prince George – 2014 Water Service Network Plan prepared by Opus Dayton Knight;
- City of Prince George – Development Services Department: Design Guidelines;
- City of Prince George – Zoning Bylaw No. 7850, 2007;
- City of Prince George – Official Community Plan Bylaw No. 8383, 2011.;
- PG Map – Zoning and Land Use;
- GeoNorth Geotechnical Report (PR# K-4958, August 21, 2018); and
- Pinchin Groundwater Assessment (PR# 221252.000, August 2, 2018).

3.0 SUBJECT PROPERTIES

T.R. Projects Ltd. Lands

a) **PID: 014-702-207:** This property is approximately 52.4 hectares in size and is entirely contained within the North Nechako Neighbourhood Plan. The property is presently zoned AG: Greenbelt, P1: Parks and Recreation, U1: Minor Utilities, and AF: Agriculture and Forestry within the *City of Prince George Zoning Bylaw No. 7850, 2007* and is designated for future Neighbourhood Residential, Rural, Utility, and Parks & Open Space land uses in the *City of Prince George Official Community Plan Bylaw No. 8383, 2011.*

b) **PID: 014-702-240:** This property is approximately 4.84 hectares in size and is entirely contained within the North Nechako Neighbourhood Plan. The property is presently zoned AG: Greenbelt and AF: Agriculture and Forestry within the *City of Prince George Zoning Bylaw No. 7850, 2007* and is designated for future Neighbourhood Residential and Rural land uses in the *City of Prince George Official Community Plan Bylaw No. 8383, 2011.*

406286 BC Ltd. Lands

a) **PID: 007-558-350:** This property is approximately 27.2 hectares in size and is entirely contained within the North Nechako Neighbourhood Plan. The property is presently zoned AG: Greenbelt, RS2: Single Residential, U1: Minor Utilities, and AF: Agriculture and Forestry within the *City of Prince George Zoning Bylaw No. 7850, 2007*. This property is designated for future Neighbourhood Residential, Rural and Utility land uses in the *City of Prince George Official Community Plan Bylaw No. 8383, 2011.*

For an overview of the properties contained within the North Nechako Neighbourhood Plan Area and the respective relation to each other please refer to Appendix A for the Land Ownership Drawing.

4.0 TOPOGRAPHY

The subject area's terrain includes a number of sloped ridges combined with rolling topography. As a result, the site experiences significant changes in elevation with a high point of 612m and a low point of 584m. The majority of the lands are active gravel pits with exposed aggregates with the exception of the south east parcel PID: 014-702-240.

5.0 DESIGN POPULATION

The North Nechako Neighbourhood Plan will act as a guide for future land use amendments that will be required prior to development. In broad terms the North Nechako Neighbourhood Plan Area is envisioned to be comprised of a planned mix of compatible residential and commercial land uses. For the purpose of this Servicing Brief, the design populations for the Single Residential, Multiple Residential, and Commercial developments were calculated using the Design Population by Household Size table (Table 2.10.1) in the City of Prince Georges Draft Design Guidelines:

Single Family Residential

- *The area is 54.7 hectares;*
- *Density = 10 units/ha, which yields 547 units*
- Using a factor of 3.0 people/unit (Hart/Nechako Sector, per *CoPG Draft Design Guidelines*), this yields a design population of **1,641 people.**

Multiple Residential

- *The area is 10.3 hectares;*
- *Density = 30 units/ha, which yields 309 units*
- Using a factor of 3.0 people/unit (Hart/Nechako Sector, per *CoPG Draft Design Guidelines*), this yields a design population of **926 people.**

Commercial

- *The area is 3.7 hectares;*
- *Density = 60 people/ha, which yields* **222 people**

6.0 WATER DISTRIBUTION SYSTEM

6.1 Existing System

L&M conducted a review of the existing municipal watermain infrastructure in the vicinity of the subject properties. Watermains exist adjacent to the site as follows:

- Fairburn Road — Ex. 250mm diameter watermain stub, PVC
- North Meadow Road — Ex. 250mm diameter watermain stub, PVC
- Dever Drive — Pr. 200mm diameter watermain, PVC
- Craig Drive — Ex. 150mm diameter watermain stub, PVC

The system is part of Pressure Zone 8 which obtains its static pressure from the Edgewood Reservoir (PW832) at a Top Water Elevation (TWL) = 649.9m.

6.2 Future Domestic Water Demands

The domestic water demands have been calculated utilizing rates published in the City of Prince George Draft Design Guidelines. Table 6.1 below outlines the calculation of the anticipated domestic water demand for the development of the North Nechako Neighbourhood Plan Area based on the location, size, number of units, and population. The domestic water demands calculated include Average Day Demand (ADD), Max Day Demand (MDD), and Peak Hour Demand (PHD).

PHASE 1							
Location	Hectares	No. of Units	Population*	ADD	MDD	PHD	Node Elevation
1-A	3.8	21	64	0.35	1.09	1.50	605.9
1-B	3.8	21	64	0.35	1.09	1.50	605.3
1-C	3.8	22	66	0.36	1.12	1.54	603.6

PHASE 2A							
Location	Hectares	No. of Units	Population*	ADD	MDD	PHD	Node Elevation
2A-A (Multi-Family)	1.1	33	99	0.54	1.69	2.31	604.9
2A-B (Commercial)	3.69	N/A	222	1.22	3.78	5.18	604.2
2A-C (Multi-Family)	3.5	105	315	1.73	5.37	7.36	603.0
2A-D	4.1	41	123	0.68	2.10	2.87	602.7
PHASE 2B							
Location	Hectares	No. of Units	Population*	ADD	MDD	PHD	Node Elevation
2B-A (Multi-Family)	3.57	107.1	321.3	1.77	5.48	7.51	605.4
2B-B	3.0	30	90	0.49	1.53	2.10	599.7
2B-C	3.0	30	90	0.49	1.53	2.10	604.5
2B-D	3.0	30	90	0.49	1.53	2.10	598.2
PHASE 3							
Location	Hectares	No. of Units	Population*	ADD	MDD	PHD	Node Elevation
3-A	1.8	18	53.25	0.29	0.91	1.24	604.1
3-B	1.8	18	53.25	0.29	0.91	1.24	602.1
3-C	1.8	18	53.25	0.29	0.91	1.24	598.9
3-D	1.8	18	53.25	0.29	0.91	1.24	593.9
PHASE 4							
Location	Hectares	No. of Units	Population*	ADD	MDD	PHD	Node Elevation
4-A	2.2	22	66	0.36	1.12	1.54	598.4
4-B	2.2	22	66	0.36	1.12	1.54	599.4
PHASE 5							
Location	Hectares	No. of Units	Population*	ADD	MDD	PHD	Node Elevation
5-A	1.6	16	49	0.27	0.84	1.14	597.4
5-B	1.6	16	49	0.27	0.84	1.14	595.4
5-C	1.6	16	49	0.27	0.84	1.14	593.1
PHASE 6							
Location	Hectares	No. of Units	Population*	ADD	MDD	PHD	Node Elevation
6-A	2.1	21	62	0.34	1.06	1.45	609.8
6-B	2.1	21	62	0.34	1.06	1.45	602.1
6-C	2.1	21	62	0.34	1.06	1.45	598.5
PHASE 7							
Location	Hectares	No. of Units	Population*	ADD	MDD	PHD	Node Elevation
7-A	2.6	26	76.5	0.42	1.30	1.79	599.7
7-B	2.6	26	76.5	0.42	1.30	1.79	603.4
PHASE 8							
Location	Hectares	No. of Units	Population*	ADD	MDD	PHD	Node Elevation
8-A	2.8	28	84	0.46	1.43	1.96	602.2

PHASE 9							
Location	Hectares	No. of Units	Population*	ADD	MDD	PHD	Node Elevation
9-A	2.0	20	61	0.34	1.04	1.43	592.3
9-B	2.0	20	61	0.34	1.04	1.43	594.6
9-C	2.0	20	61	0.34	1.04	1.43	594.1
PHASE 10							
Location	Hectares	No. of Units	Population*	ADD	MDD	PHD	Node Elevation
10-A	1.0	10	30	0.16	0.51	0.70	597.1
10-B	1.0	10	30	0.16	0.51	0.70	595.8
10-C (Multi-Family)	2.1	63	189	1.04	3.22	4.42	607.4

**Population was calculated using # of dwelling units/ha per Development Regulations found in the CoPG Zoning Bylaw*

6.3 Fire Protection Demands

In addition to the domestic water demand, an allowance for fire protection must be made. The City of Prince George Draft Design Guidelines recommends minimum fire protection design flows based on land use. Table 6.2 below summarizes the fire flow requirements outlined in Table 3.2.2 of the City of Prince George Draft Design Guidelines.

Table 6.2: Fire Flow Requirements	
Land Use	**Required Fire Flow (L/s)**
Single Family Residential	60
Apartments / Townhouses	125
Commercial	150

The reference document titled *Water Supply for Public Fire Protection*, produced by the Fire Underwriters Survey is the de-facto standard throughout Canada for establishing fire protection requirements when designing municipal water works system design. This document presents a fire flow estimate that accounts for factors such as building construction, total floor area, material combustibility, automatic sprinkling, building separation, and occupancy. The design fire flow requirements for each development will need to be calculated at the time of detailed design to ensure an adequate design fire flow is utilized for each individual site.

6.4 Water Modelling Results and Proposed Servicing

L&M Engineering submitted design parameters to the City of Prince George for water modelling. The City's Water Model was analyzed under Average Day Demand (ADD), Maximum Day Demand (MDD) and Peak Hour Demand (PHD) conditions. Maximum Day conditions represent the highest recorded daily demand on the water system and Peak Hour flow conditions represent the highest demand on the system during the course of any given day.

The objective of the water modelling was to determine how much of the subject area could be serviced via the Edgewood Reservoir (PW832). The results of the City's water modelling indicated that the entirety of the subject area could be serviced via PW832 and that with a 200mm water main the available fire flow during the MDD scenario is sufficient for the proposed land uses. With exception to a Node 10C where a 250mm main will be required to provide sufficient fire flow. The lowest available fire flows for the lands was found to be 136 L/s at node 10C and 144 L/s at node 1B. Both of which are greater than the required 125 L/s for multifamily development. Node 2A-B has an available fire flow of 232 L/s which is greater than the required 150 L/s for commercial development.

Refer to Appendix B for the full Water Modelling Report prepared by the City of Prince George. Further modelling or adjustments will be required at the time of the detailed design stage for each project to account for the site specific building elevations and friction losses.

Based on the modelling results, the provision of adequate and reliable municipal water (Fire flow + MDD) can be achieved at this site without any additional offsite improvements.

7.0 SANITARY COLLECTION SYSTEM

7.1 Existing System

There are two existing sanitary catchment areas in the vicinity of the subject area which are outlined below as catchment 1 and catchment 2.

Catchment 1:

Catchment 1 consists of the northern area of the subject area as show in Appendix C. The existing sanitary system in the vicinity of the subject area for catchment 1 consists of a 525mm diameter gravity trunk main on North Nechako Road, which flows southeast from the Foothills-North Nechako intersection. City manhole (Asset ID 1465) located to the southeast of the North Nechako Road – North Meadow Road intersection will collect the flows via gravity for the proposed catchment 1.

Catchment 2:

Catchment 2 consists of the southern area of the subject area as show in Appendix C. The existing sanitary system in the vicinity of the subject area for catchment 2 consists of a 200mm diameter gravity main on Stevens Drive, which flows southeast into a City lift station (Asset ID PW127). City manhole (Asset ID 1550) located in the cul-de-sac at the west end of Stevens Drive will collect the flows via gravity for the proposed catchment 2. A right-of-way through 4385 Stevens Drive has been provided to allow connection from the subject properties to the Stevens Drive sanitary system.

7.2 Sanitary Design Flows

The City of Prince George Draft Design Guidelines (Section 4.2) outline the procedure required to determine the sanitary sewer design flows. The calculations for the Full Build-Out design flows from catchment 1 that discharge into the sanitary network on North Nechako Road via gravity are summarized in Table 7.2 below:

Table 7.2 Sanitary Sewage Flow Calculations		
Catchment 1		
No of Dwelling Units	263	
People per Dwelling Unit	3	
Population	789	people
Domestic Avg Daily per Capita	380	L/d
Peak Factor	3.86	
Development Area (ha)	19.08	ha
People per ha (Commercial)	60	
Area (Commercial)	3.69	ha
Population Commercial	222	
Peak Factor (Commercial)	4.13	
Flows Based Upon Total Development Area		
Sewage Flow Qs	384180	L/d
Infiltration Qi	255031	L/d
Average Flow (Qs + Qi)	**639211**	**L/d**
Peak Flow	**1762043**	**L/d**
Peak Flow	**20.39**	**L/s**

The calculations for the Full Build-Out design flows from catchment 2 that discharge into the sanitary network on North Nechako Road via force main are summarized in Table 7.3 below:

Table 7.3: Sanitary Sewage Flow Calculations		
Catchment 2		
Number of Dwelling Units	594	
People per Dwelling Unit	3	
Population	1782	people
Domestic Avg Daily per Capita	380	L/d
Peak Factor	3.62	
Development Area (ha)	45.91	ha
Flows Based Upon Total Development Area		
Sewage Flow Qs	677160	L/d
Infiltration Qi	514209	L/d
Average Flow (Qs + Qi)	**1191369**	**L/d**
Peak Flow	**2968387**	**L/d**
Peak Flow	**34.36**	**L/s**

7.3 Existing Capacity

L&M Engineering reviewed the *City of Prince George 2017 Sanitary Sewer Services Master Plan (prepared by AECOM)* for information related to the capacity of the existing sanitary system. Table 7.1 below illustrates the available downstream sanitary flows.

Table 7.1 Available Downstream Sanitary Flows						
Pipe: Asset ID	Location	Diameter (mm)	Total Capacity (L/s)	Available Capacity (L/s)	Zone Flow (L/s)	Zoning Available Flow (L/s)
Catchment 1						
7988	N. Nechako	525	239	203.15	40.3	162.9
7984	N. Nechako	525	228	193.8	40.6	153.2
7933	N. Nechako	525	227	192.95	35.3	157.65
7924	N. Nechako	525	236	200.6	35.3	165.3
7850	N. Nechako	525	248	210.8	35.3	175.5
7848	N. Nechako	525	229	194.65	35.4	159.25
7847	N. Nechako	525	276	234.6	189.5	45.1
7846	N. Nechako	525	177	150.45	41.4	109.05
7845	N. Nechako	525	221	187.85	35.7	152.15
7640	N. Nechako	525	259	220.15	54.6	165.55
7634	N. Nechako	525	511	434.35	37	397.35
7921	N. Nechako	525	1001	850.85	55.5	795.35
7915	N. Nechako	525	397	337.45	37.6	299.85
7910	N. Nechako	525	421	357.85	57.3	300.55
7902	N. Nechako	525	957	813.45	38.5	774.95
7886	N. Nechako	525	543	461.55	60.1	401.45
7874	N. Nechako	525	762	647.7	40	607.7
7867	N. Nechako	525	901	765.85	40.3	725.55
7857	N. Nechako	500	621	527.85	40.8	487.05
6799	N. Nechako	500	656	557.6	41.1	516.5
6791	N. Nechako	600	187	158.95	64.8	94.15
6789	N. Nechako	600	180	153	44.8	108.2
6788	N. Nechako	600	182	154.7	18.9	135.8
6787	N. Nechako	500	163	138.55	51.4	87.15
6781	N. Nechako	600	303	257.55	69.9	187.65
7856	N. Nechako	600	568	482.8	70.1	412.7
7836	N. Nechako	600	345	293.25	70.2	223.05
7831	Tomlin	600	267	226.95	54.9	172.05
10920	Tomlin	600	341	289.85	58.3	231.55
Catchment 2						
7927	Stevens	200	38	32.3	0.5	31.8
7926	Stevens	200	33	28.05	0.5	27.6
10613	To lift station	200	114	96.9	5.5	91.4
7853	To lift station	200	120	102	5.5	96.5
7851	To lift station	200	65	55.25	5.5	49.8
10287	To lift station	200	22	18.7	7.5	11.2

Catchment 1:

The downstream sanitary flow assessment reviewed the existing zoning and OCP model scenarios and indicated that for all scenarios there are no apparent capacity issues in the 525mm diameter sanitary main from the Foothills Boulevard and North Nechako

Road intersection to the sanitary lift station (PW117) near the John Hart Bridge. The entire main is currently below 50% capacity. The City's web mapping service (PG Map) indicates the minimum available zone flow is 87 L/s for the sanitary main between the subject properties and the sanitary lift station (PW117). Therefore, the sanitary main will have sufficient capacity to service the development.

Catchment 2:

The downstream sanitary flow assessment reviewed the existing zoning and OCP model scenarios. The study indicated that for the full development build-out scenario, the 200mm diameter sanitary main would be undersized at multiple locations from the Stevens Drive cul-de-sac to the sanitary lift station (PW127). The undersized pipe asset ID's are 7927, 7926, and 10287.

7.4 Proposed Sanitary Servicing

Based on the design flows and the required cover for the sanitary main (2.25m), it appears that a 250mm diameter service running at minimum grade will be required to service catchment 1 and catchment 2. Using a 200mm diameter main at the minimum permitted grade does not provide sufficient capacity for the entire proposed onsite sanitary network.

For catchment 1, the proposed sanitary main tie-in location is a sanitary manhole (Asset ID 1465) at the proposed site entrance which is located at the intersection of North Nechako Road and North Meadow Road. The invert of the existing sanitary stub at the manhole has an elevation of 600.28m. This tie-in location provides a sufficient amount of cover for the 250mm diameter on-site sanitary main for catchment 1. A 250mm diameter main at a minimum slope of 0.3% will have sufficient capacity to service the peak flow of catchment 1.

The proposed plan for catchment 2 is to mine the gravel in the area before any future development takes place. Due to the lower elevation and future gravel extraction, the use of the existing sanitary lift station (PW 127) will be required to pump the sewage to the trunk main on North Nechako Road.

Catchment 2 flows will be directed to the 200mm diameter gravity main on Stevens Drive, which flows southeast into a City lift station (Asset ID PW127). A 250mm diameter main at a minimum slope of 0.3% will have sufficient capacity to service the peak flow of catchment 2. Portions of the 200mm gravity main on Stevens Drive and lift station PW127 are under sized for the full build-out of catchment 2.

Four pipe segments are undersized from the Stevens Road tie-in point to PW127, which are pipe asset ID's 7927, 7926, and 10287. Pipe asset ID 10287 has the lowest available capacity and is therefore the trigger for future upgrades. The additional sanitary flows produced by the proposed development (34.36 L/s) are greater than the available zoning flow of 11.2 L/s. Pipe asset ID 10287 will be able to service approximately 180 new dwelling units before any upgrades are required.

The OCP states that PW127 has a Peak Wet Weather Flow (PWWF) of 7.4 L/s and has a capacity of 13 L/s. Therefore, the pump station is undersized for the total additional sanitary flows produced by the proposed development (34.36 L/s). PW127 will be able to service approximately 90 new dwelling units before any upgrades are required. Table 7.4 below outlines the number of constructed dwellings units that will trigger an upgrade to the existing downstream sanitary system.

Table 7.4 Offsite Sanitary Upgrades

Pipe: Asset ID	Location	Existing Diameter (mm)	Existing Capacity (L/s)	Existing Flow (L/s)	Development Flow (L/s)	Remaining Capacity (L/s)	Remaining Capacity (Dwelling Units)	Proposed Diameter (mm)	Existing Pipe Grade	Proposed Flow Capacity (L/s)
7927	Stevens	200	32.3	0.5	34.36	31.8	545	250	1.3%	80.1
7926	Stevens	200	28.05	0.5	34.36	27.55	470	250	1.0%	70.3
10287	To Lift Station	200	18.7	7.5	34.36	11.2	180	250	0.4%	44.4
PW127	Lift Station	2 x2.2 HP	13	7.5	34.36	5.5	90	TBD	TBD	TBD

8.0 STORM WATER SYSTEM

8.1 Existing System

The existing storm system in the vicinity of the subject area consists of two 600mm storm mains that extend onto the subject properties. One of the mains (PG Map AssetID: 3427) extends 118m from a manhole located at the intersection of North Nechako Road and Fairburn Road. The end of the main is exposed and the storm water dissipates into the gravel soils. The other main (PG Map AssetID: 1340) extends 30m from a manhole located at the intersection of North Nechako Road and North Meadow Road. Based on the PG Map data it appears that the main is discharging into the gravels below the surface. Both of the storm mains are discharging water from the residential subdivisions located on the north side of North Nechako Road.

8.2 Proposed Storm Servicing

The proposed storm servicing plan will include disposal of storm water runoff into the native gravel soils via on-site storm water disposal systems, consisting of multiple exfiltration pipe trenches. All of the storm water runoff from the proposed development will remain onsite and infiltrate into the gravel soils. The exact size and location of the storm infrastructure have not yet been confirmed. The lowest elevation on the property is 600m at the southwest corner. Floodplain mapping indicates the 200 year flood plain in the area is 576m; therefore the infiltration capacity will not be affected by flood events.

The ground water assessment completed by Pinchin identified that no infiltration may occur within the Groundwater Protection Development Permit Area. This area is illustrated on the GRD-WAT drawing in Appendix E. Additionally it was indicated that grease, oil, and sand interceptors shall be provided for the commercial development within the Neighbourhood Plan Area. Pinchin recommended that an Environmental Management Plan (EMP) should be developed for the site which includes monitoring site activities, document reporting, and remediation of potential spills.

As part of the geotechnical report, GeoNorth completed five infiltration tests at various locations throughout the site. The results are shown in Table 8.1 below:

Table 8.1: Infiltration Test Results

Infiltration Test Location	Average Infiltration Rate (L/min)	Average Rate of Falling Water Level (m^3/min)
TP17-1	380	7.5
TP17-5	360	5.9
TP17-8	470	9.7
TP17-11	320	4.8
TP17-12	220	2.6

Based on the test results, it was recommended by GeoNorth that the infiltration system should be designed using a range in hydraulic conductivity between 5.0 x 10^{-4} and 1.0 x 10^{-3} m/s. The geotechnical report indicated that storm water disposal to ground through an infiltration system is feasible.

9.0 SUMMARY

In summary, the subject area located at the southeast corner of the North Nechako Road – Foothills Boulevard intersection, in Prince George, BC appears to be situated such a way that it can be adequately serviced with the nearby municipal water, sanitary and onsite storm sewer infrastructure. The proposed water infrastructure will be tying into the existing system at Fairburn Road, North Meadow Road, Dever Road, and Craig Drive. The onsite gravity fed sanitary system will tie into a manhole located to the southeast of the North Nechako Road and North Meadow Road intersection and the manhole and lift station at the northwest end of Stevens Drive. The storm runoff generated by the proposed development will be managed by a series of onsite exfiltration system. As noted, site investigation and design calculations should be conducted at the beginning of future detailed design processes to confirm the presence and condition of existing services as well as confirm that the actual design demands can be met by utilizing the nearby municipal servicing.

10.0 CLOSURE

This Servicing Brief has been prepared for the City of Prince George, T.R. Projects Ltd., and 406286 B.C. Ltd. as an intended user. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it are the responsibility of such third parties. L&M Engineering Limited accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this study. The information and data contained within this document represents L&M Engineering Limited's professional judgement in accordance with the knowledge and information available to L&M Engineering Limited at the time of the report preparation. No other warranty, expressed or implied, is made.

Sincerely,

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Jan 22, 2019

Jason R. Boyes, P.Eng.
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Appendix A
Land Ownership Drawing

L&M ENGINEERING LIMITED PLANNING CENTRE 1210 Fourth Avenue Prince George, B.C. V2L 3J4 Tel. (250) 562-1977 Fax (250) 562-1967	JOB No: 1600-02 DATE: OCT 2018 DRAWN BY: MM SCALE: 1:3,000	NORTH NECHAKO NEIGHBOURHOOD PLAN LAND OWNERSHIP	DWG No F2

Appendix B
Water Modelling