EUB/AGS Geo-Note 2003-43

Inventory of Holocene Landslides, Peace River Area, Alberta (NTS 84C)

Alberta Energy and Utilities Board

Alberta Geological Survey

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Inventory of Holocene Landslides, Peace River Area, Alberta (NTS 84C)

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Cover photo: A typical scene in the Peace River Valley

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Contents

Figures

Maps

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Abstract

The Peace River Lowlands of Alberta and British Columbia are one of the most historically active mass movement areas in western Canada. At the town of Peace River, Alberta, the Peace River has incised through approximately 120 m of Quaternary sediments and 30 m into the underlying bedrock. Failures of varying types have occurred in both the Quaternary sediments and the underlying shale bedrock during incision and valley widening processes. Numerous failures continue to cause infrastructure problems for the town of Peace River and impacts roads and rail lines in the area. Valleys containing tributaries of the Peace River, such as the Smoky River, Heart River, Whitemud Creek, Cadotte River and Buchanan Creek valleys have also been actively failing during the Holocene.

The Alberta Geological Survey has recently completed a large surficial mapping program in the Peace River map-area (NTS 84C). Relevant information such as colluvium polygons, landslide symbols and sediments of known higher activity levels (i.e. glaciolacustrine sediments) were filtered in a geographical information system (GIS) to produce a landslide inventory map. The landslides represented by point and line symbols were then examined using air photograph stereo pairs and crudely classified and subsequently tagged in the GIS. This process created a derivative digital product from existing surficial maps with active digital layers of various surficial materials, landslide types and areas affected by existing landslides. A total of 157 landslide features are contained in the inventory and were classified according to material type, movement type and mode of movement. The scale of the air photos used allowed the identification of landslides with minimum length and width dimensions of 240 m.

This regional inventory provides an overview of landslide data for the Peace River map sheet that may be incorporated into future landslide hazard investigations in the area, and provides a framework for the development of similar inventories from other maps created through the surficial mapping initiative.

1 Introduction

Infrastructure development, urban growth and public health and safety are some of the issues that are the drivers behind geological hazard mapping in Alberta. As a result, there is increasing need to provide stakeholders with reliable information to assist with land use planning, development and maintenance. The purpose of this report is to provide an inventory of historic and active mass movements in the Peace River map area (NTS 84C, Figure 1). There is a high incidence of failures along the Peace River (Cruden et al., 1990); therefore there is a need for an accurate inventory. Most of the landslides documented here are prehistoric slides that despite a present state of inactivity must be considered geoindicators of potential problems due to reactivation or new failure development (e.g. Thompson and Hayley, 1975; Williams et al., 1983; Brooker and Peck, 1993). The inventory is derived from surficial geology maps produced as part of the Alberta Geological Survey's ongoing surficial mapping program (Paulen, 2004a,b; Paulen et al., 2004a,b).

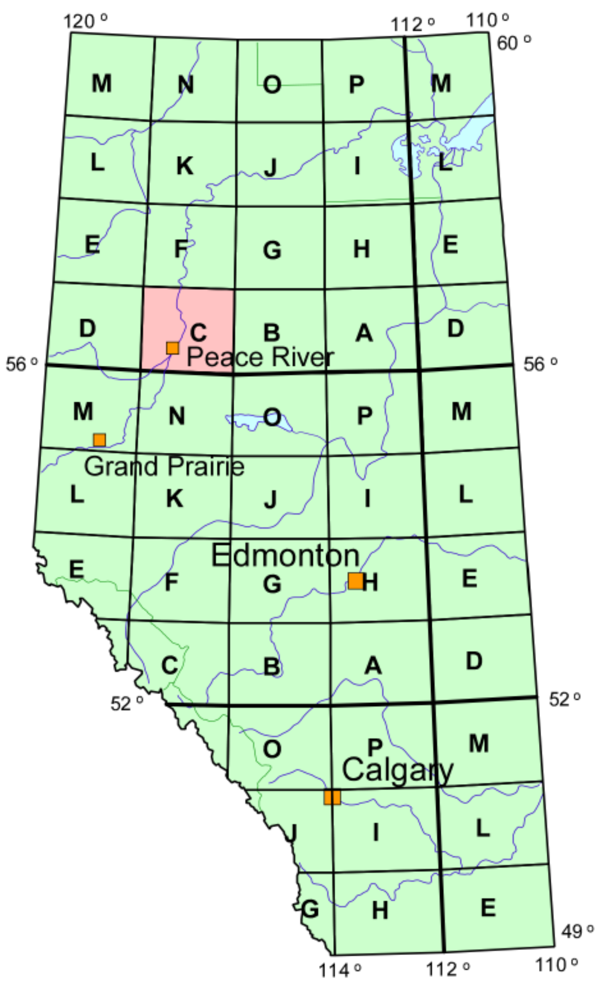

Figure 1. Location of the study area; the Peace River map area (NTS 84C) is highlighted.

The Peace River map area lies in the Interior Plains of Canada (Bostock, 1981), within the Peace River Lowlands physiographic zone (Pettapiece, 1986). Much of the surface morphology in the area is the result of processes associated with the last glacial event (late Wisconsin) and Holocene erosion. The Peace River valley is the dominant geomorphic feature of the region and was developed from incision of the Peace River through the Quaternary sediments and into the Cretaceous bedrock following deglaciation (Figure 2). The river valley is an important transportation corridor and includes highways and a railway line. The Peace River Lowlands separates the Buffalo Head Hills to the east and the Whitemud and Clear Hills to the west. The Peace River District is mainly fertile farmland characterized by flat topography and stone-free fields developed on sediments of the former lake bottom of Glacial Lake Peace, which inundated most of the region below 610 m asl (Mathews, 1980; Leslie and Fenton, 2001; Paulen et al., 2003a). Elevation ranges from 326 m at the bottom of the Peace River valley to a maximum of 838 m in the easternmost Clear Hills.

Figure 2. Peace River valley at the town of Peace River, looking northwest. The hummocky topography seen on the opposite side of the valley is the result of landslide processes.

This inventory is a derivative product (e.g. Brardinoni et al., 2003; Hylland et al., 2003; Duk-Rodkin and Hood, 2004) that is based on surficial geology mapping of the Peace River map sheet. This surficial geology map was produced through extensive air photo interpretation and fieldwork, and identifies a number of surficial deposits and landforms. These include extensive colluvial deposits and numerous large and small landslide scars. These features were examined in further detail to produce a digital landslide inventory for this area (Paulen et al., 2003b). The inventory is incorporated in a Geographic Information System (GIS) and the data are presented in shapefile format. The interactive map can be displayed using ArcExplorer™ (included). A copy of the inventory map is also included in Adobe® Portable Document Format (PDF) and all landslide data that are in the digital files are listed in Appendix I. The remainder of this report briefly outlines: 1) the geology and slope instability in the Peace River area; 2) the production of the inventory and its layout; and 3) gives an overview of the content of the inventory.

2 Geology and Slope Stability

2.1 Geology of the Peace River Lowland

The geology of the Peace River lowland is described in three sections; bedrock geology, Quaternary stratigraphy and surficial geology.

2.1.1 Bedrock Geology

The study area is within the Western Canada Sedimentary Basin. The stratigraphic units relevant to landslide processes in the Peace River area occur within to the Cretaceous Fort St. John Group deposited in the active foreland basin adjacent to the tectonically active hinterland (Hayes et al., 1994, Figure 3). The Fort St. John Group consists of the Sprit River and Peace River formations overlain by sandstone of the Dunvegan Formation. The Smoky Group, which west of the Peace River consists of Kaskapau and Puskaskau formations, is stratigraphically above the Dunvegan sandstone, however they are generally not susceptible to mass movement processes in the Peace River area (do not occur along the Peace River valley or its tributaries), and therefore they will receive no further attention in this report.

The stratigraphically lowest formation relevant to this study is the Peace River Formation of the Fort St. John Group. The Peace River Formation (Lower Cretaceous) occurs along the bottom of the Peace River valley with the exception of the reach south of the town of Peace River. This formation consists of the Harmon, the Cadotte and the Paddy members (Reinson et al., 1994). The oldest, the Harmon Member, is an offshore marine shale. The Cadotte Member is composed primarily of sandstone (nearshore sediments and basin equivalents). The contact between these members is locally gradational, showing a coarsening upwards profile with an erosional unconformity separating the members. The Paddy member primarily consists of estuarine valley deposits, fluvial channel and coastal plain facies. The Shaftesbury Formation is an upper Lower Cretaceous unit that occurs in the central portion of the map area and outcrops along the Peace River in the reach south of the town of Peace River (Hamilton et al., 1999). This formation consists of dark grey marine shale with bentonite partings and occasional sandy and silty interbeds. The upper contact is gradational into the regionally extensive Dunvegan Formation. The Dunvegan Formation shows numerous cycles of wave, fluvial and mixed-influence delta sedimentation, and includes shales, sandstones and conglomerates (Leckie et al., 1994).

2.1.2 Quaternary Geology

2.1.2.1 Quaternary Stratigraphy

The Peace River region of Alberta is historically characterized by a stratigraphy in which only one Laurentide glacial event, the Lostwood Glaciation (Fenton, 1984), affected west-central Alberta (cf. Bayrock, 1969; Liverman et al., 1989). However, older ice-proximal glaciofluvial sediments and an older till were documented recently by Fenton et al. (2003) and the discovery of older oxidized till in the southwest Buffalo Head Hills to the east indicates that early Wisconsin ice of the Burke Lake Glaciation (Fenton, 1984) advanced into the Peace River Valley. Stratigraphic drilling results also suggests that multiple glacial events may have affected the region (Pawlowicz et al., 1996; Leslie and Fenton, 2001). Recent work by Leslie and Fenton (2001) described the surface stratigraphy and overall distribution of the surficial deposits. Stratigraphic correlations with sediments documented in the Peace River District of British Columbia (Bobrowsky et al., 1991) have been suggested by Miller and Cruden (2002). The Quaternary stratigraphy in the study area consists of preglacial gravels, Burke Lake glacial deposits and Lostwood glacial deposits capped by Holocene sediments.

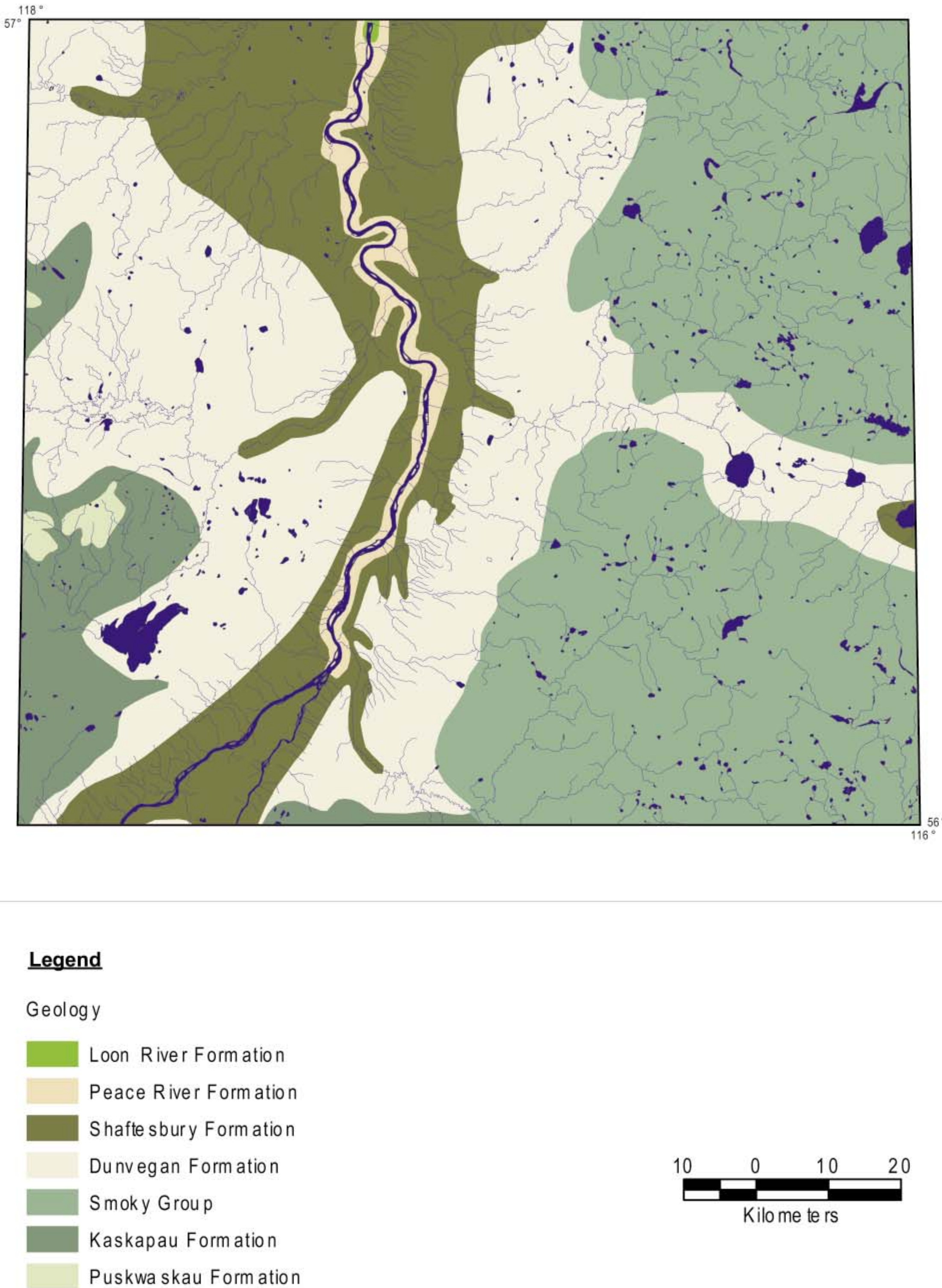

Figure 3. Bedrock geology of the Peace River area, NTS 84C (modified from Hamilton et al. 1999).

Preglacial Gravels

These sediments are preserved in preglacial valleys and on the upland west of Peace River near the town of Grimshaw (Paulen, 2004a). The age of these sediments has yet to be confirmed but they are interpreted to be sediments reworked from Paleogene (Tertiary) quartzite gravels that occur in Clear Hills to the northwest and deposited in an nonglacial Peace River drainage system during the Sangamon or possibly earlier (Churcher and Wilson, 1979). We suggest these gravels may be correlative to the well-documented sediments at Watino and Simonette (Liverman et al., 1989).

Burke Lake Glacial Deposits

Deposits associated with early Wisconsin ice advance were observed at two sites in the Peace River area (Leslie and Fenton, 2001). They are preliminarily correlated with the oxidized tills recently discovered near Cadotte Lake, approximately 50 km east of the town of Peace River on the southwest flank of the Buffalo Head Hills (Paulen et al., 2003a). The relationship of these older tills to the Early Wisconsin glacial deposits observed in the Fort Assiniboine Region (St-Onge, 1972) is unknown.

Lostwood Glacial Deposits

A complete late Wisconsin glacial cycle is preserved in various exposures and within overburden drill core for the Peace River region. Late Wisconsin ice advanced into the region 22,000 years BP (Dyke et al., 2002). Regional deglaciation is estimated to have occurred sometime after 11,000 ± 200 years BP (Lowdon and Blake, 1968; Lowdon et al., 1977; Dyke, 2004). The Laurentide Ice Sheet flowed southwesterly across the Peace River Valley at glacial maximum but later, as ice thickness decreased, topographically controlled ice flowed southward between the Buffalo Head Hills and the Clear Hills (Paulen and McClenaghan, 2005). During early deglaciation, the Laurentide Ice Sheet retreated northward and down-drainage, essentially blocking drainage and ponding the glacial meltwaters at the ice margin. Glacial Lake Peace was one of the larger glacial lakes that developed (Mathews, 1980). It extended into British Columbia to the west and reached as far north as High Level. The Lostwood Glacial deposits include proglacial lacustrine sediments that developed as the advancing ice dammed drainage (Bobrowsky et al., 1991; Catto et al., 1996), advance outwash glaciofluvial sediments (Leslie and Fenton, 2001), till and glacial Lake Peace sediments (Taylor, 1960; Mathews, 1980).

Holocene Deposits

Glacial Lake Peace drained in the early Holocene and the Peace River immediately began incising through the Quaternary sediments. There are several terrace levels that record the rapid rate of incision. Landslides also occurred throughout the Holocene and continue to affect the region. Holocene deposits include organic sediments, fluvial terraces from river incisions, eolian dunes and loess deposits and colluvial deposits from landslide processes.

2.1.2.2 Surficial Geology

Surficial geology of the study area is summarized from 1:100 000 scale maps of Paulen (2004a, b) and Paulen et al. (2004a, b). Above 610 m asl, the dominant sediment is till of varying genesis and thickness. Till is ubiquitous throughout the study area and forms a thick (2 to >25 m) continuous blanket over large parts of the region. It is grey-brown, carbonaceous clayey silt till with 1 to 5% clast content by volume and averages 10% carbonate in the matrix. The till at surface is dissected by numerous meltwater channels and locally capped by veneers of glaciolacustrine silt, eolian sand, alluvium and organic sediments.

Below 610 m asl, Glacial Lake Peace silt, clay and minor sand of varying thickness blankets the area. These glaciolacustrine sediments commonly consist of a fining upwards sequence of stratified sand, silt and massive clay with lenses of ice-rafted diamicton. Discontinuous deposits of loess, bogs and fluvial sediments cap these deposits. Along the Peace River and its tributaries, slope failure and mass movement has resulted in thick accumulations of colluvium.

2.2 Slope Stability

Landslide activity in the Peace River area since deglaciation has been extensive (Bobrowsky et al., 1991). Surficial mapping in the eastern Peace River Region of British Columbia (NTS 94A) identifies similar geology and physiology as noted in this study and documents extensive colluvium deposits and landslide features (Catto, 1991). Common failure types included earth flows caused by sudden saturation of the surficial material and large landslides on the walls of river valleys. Mass movement processes remain active (Figure 4) and recent events have been documented in northeastern British Columbia (Bobrowsky and Smith, 1992), in the vicinity of the town of Peace River (Hardy, 1957; Alberta Transportation, 1985; Cruden et al., 1990) and in the western Peace River Lowlands of Alberta (Miller and Cruden, 2002). The primary influence on slope stability along the Peace River is lithology and previous work has identified the shales of the Shaftesbury Formations as very susceptible to sliding in contrast to the competent sandstone of the Dunvegan Formation (Cruden et al., 1990). The low-strength glaciolacustrine clays and silts of Glacial Lake Peace are also largely responsible for slope stability problems and are typically the major lithologic component of the extensive colluvial deposits along the Peace River (Paulen, 2004a,b; Paulen et al., 2004b,c). Failure also occurs in over-consolidated glaciolacustrine sediments which were deposited proximal to the advancing Late Wisconsin glaciers and subsequently overridden by the Laurentide Ice Sheet. These deeply buried glaciolacustrine sediments are present throughout the western Peace River Lowlands of Alberta.

Figure 4. The 1984 earth flow (slide number 86) on the east Peace River hill (Highway 2) that partly dammed the Heart River (photo courtesy of Alberta Transportation 1985).

3 Map Production

This landslide inventory map is a derivative product of surficial geology maps (Paulen, 2004a, b; Paulen et al., 2004a,b). The digital files produced from the surficial maps containing glaciolacustrine and colluvial polygons as well as large and small landslide scar locations were extracted from the original GIS surficial maps. Landslide features on the original surficial maps are simply located and no characteristics are reported. The landslide inventory map provides additional details about each mapped slide as determined from additional detailed airphoto interpretation.

3.1 Airphoto Interpretation

The 1:60 000 airphotos used for the production of the surficial maps were also used for landslide classification. Each landslide feature was examined and some basic details were determined. These details include the type of material, mode of movement and type of movement as described by Cruden and Varnes (1996) and the overall length and width of the landslide. When any attribute could not be determined the entry in the inventory was left blank. Two fields were established for the mode, material and movement type for complex slides attributes to describe the first and second movements.

Mode of Movement

Rotational and translational slides were identified in the Peace River landslide inventory. Rotational slides move along a concave curved rupture surface, while translational slides occur along a planar rupture surface (Cruden and Varnes, 1996). The mode of movement was determined by examining the features of each slide. Rotational movements were identified by backward rotated displaced material (Figure 5) or perched ponds at the head of the slide (Figure 6). In some cases, erosion has exposed the sides of a landslide and the shape of the displaced mass is visible. This provides the opportunity to identify a slide as rotational or translational. Translational movements were distinguished from rotational slides by the lack of backward rotation of the displaced material or the absence of sag ponds at the head of the slide.

Mode of movement label: Mode _1 and Mode _2.

Material Type

Material type follows Cruden and Varnes (1996) classification and includes: earth, debris and rock. Earth describes material that contains 80 percent or higher particles <2 mm; debris describes material that contains 20 to 80 percent particles >2 mm, with the remainder <2 mm; and rock describes a hard firm mass that was intact and in place before movement. Material type was estimated in the landslide inventory based on the apparent depth of the slide, knowledge of local bedrock and Quaternary geology, and the surficial geology polygons in the vicinity of the landslide.

Material type label: Mat _1 and Mat _2

Type of Movement

The type of movement associated with a failure was identified on airphotos by the shape and texture of the displaced material. Two mechanisms for movement were identified in the Peace River area. These include slides and flows. Slide movement occurs when displaced material moves along failure planes or zones and remains essentially undeformed. In slides, the displaced material remains largely intact or is

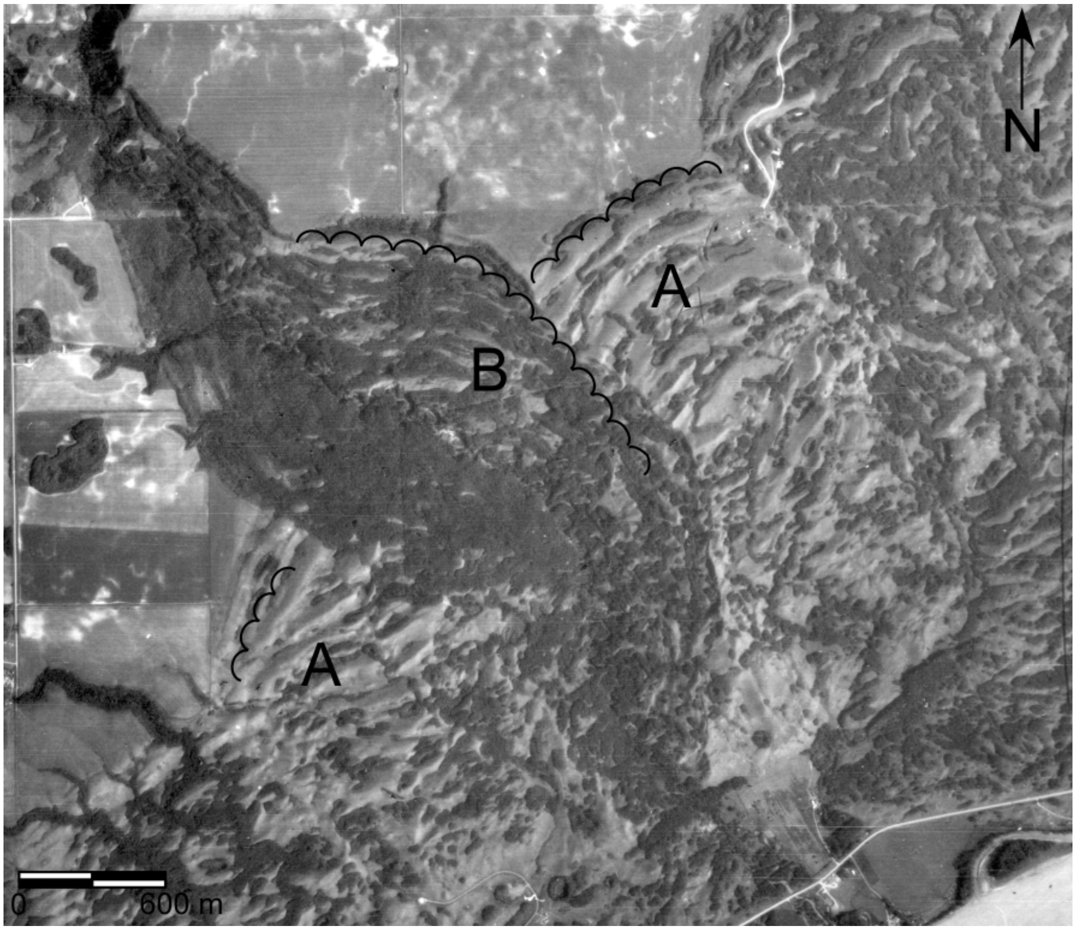

Figure 5. Example of a rotational slide (A) dissected by more recent sliding (B). Note backward tilted displaced material (Air Photograph 84-102P LN 83 3057 32, 1:60 000, ©Alberta Sustainable Resource Development, Air Photo Distribution).

Figure 6. Sag pond developed near the scarp of a landslide. Highway 744 can be seen to the south.

broken into blocks, with little evidence of materials behaving as a fluid. In a flow, the displaced material moves in a manner similar to a viscous fluid leaving a bowl shaped depression (Figure 7). The displaced material often shows an undulating surface with few intact blocks. The material often forms lobes at the base of the slide or flows along channels or gullies. In some cases the failures are complex and require more than one movement type designator such a sliding near the head of the failure and flowing near the toe.

Movement type label: Move _1 and Move _2.

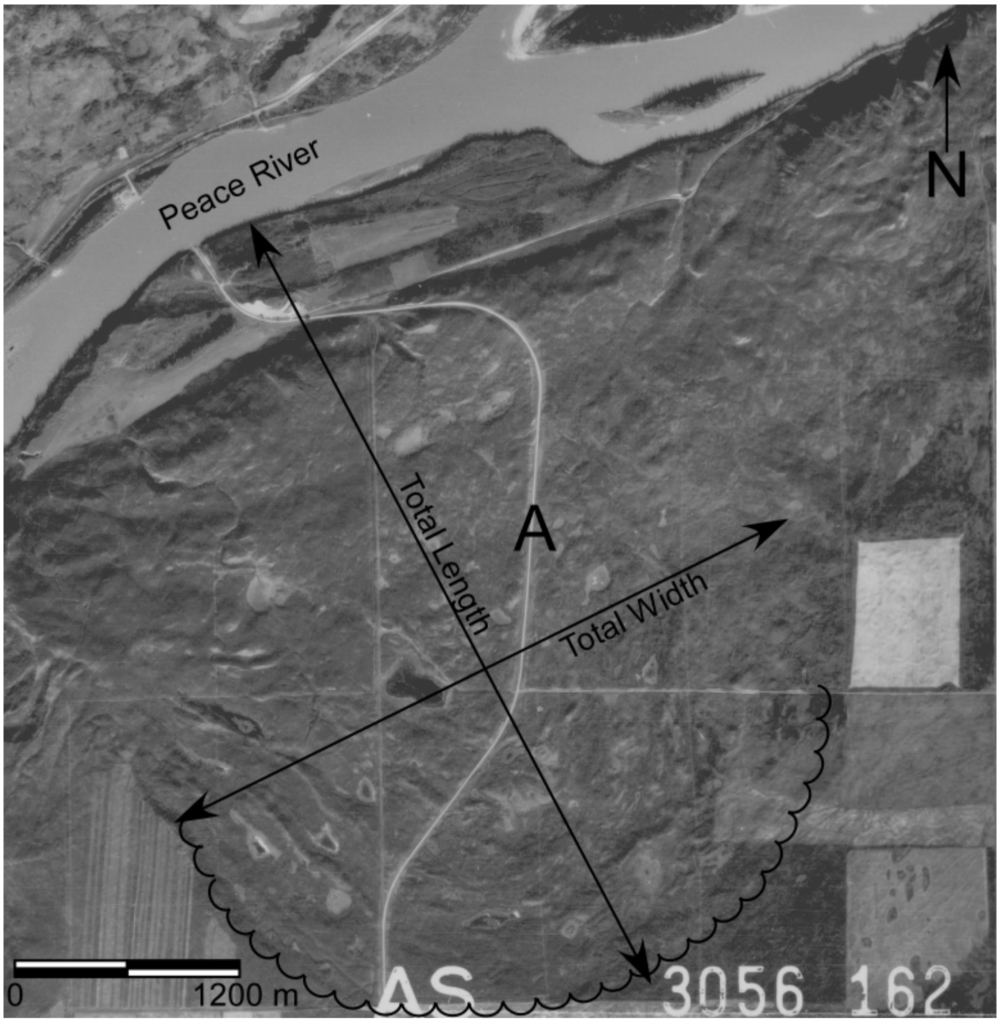

Figure 7. Example of an inactive-old earth flow. A bowl shaped depression (A) formed when the material flowed as a viscous fluid. The Peace River has shifted toward the opposite side of the valley and drainage is established on the slide mass, common features of slide described as Inactive-Old. Length and width measurements are shown. (Air Photograph 84-102P LN 82 3056 162 1:60000, ©Alberta Sustainable Resource Development, Air Photo Distribution).

Size of Slide Area

The total length and width of the slide areas were estimated using the 1:60 000 scale air photographs. The length value was measured from the slide scarp to the toe of the slide debris and the width value was measured at the widest part of the slide (Figures 8 and 9).

Size labels: Tot_Length and Tot_Width.

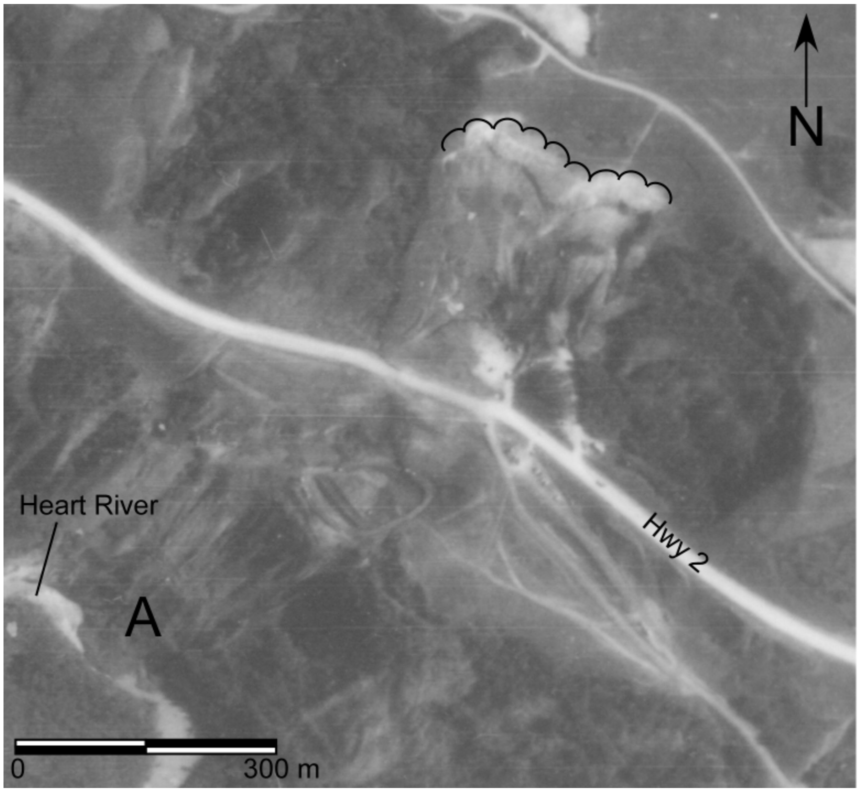

Figure 8. The 1984 earth flow above the Heart River along Highway 2 (inventory slide number 86) provides an example of a slide feature classified as active. Note the original slide topography and slopes that are bare of vegetation (see also Figure 4). The slide debris deposited in the Heart River is visible (A) (Air Photograph 84-102P LN 83 3056 36, 1:60 000, ©Alberta Sustainable Resource Development, Air Photo Distribution).

Figure 9. The 1984 earth flow, photographed in 2002 from across the Heart River. Highway 2 has been rebuilt across the landslide.

Aspect

The approximate aspect of the slide (direction the scarp or failure plane is facing) was estimated using air photos, and is given in cardinal directions as north, northeast, northwest, east, west, south, southeast or southwest.

Aspect label: Aspect.

Age of Slide Feature

The McCalpin (1994) classification system of age classification was used to describe the relative age of landslides in the Peace area. This classification does not give an absolute age but describes a qualitative description of the state of activity and age of a slide. A slide may be described as active or inactive. An active slide retains the original slide topography and has fresh scarps bare of vegetation. Pre-slide drainage is blocked by the slide margins and depressions, commonly with perched (sag) ponds present on the displaced material. An inactive slide shows no recent record of movement, and the slide topography is modified by erosion and deposition. There are three sub-categories of inactive slides, young, mature and old. Young slides have incomplete revegetated scarps, and drainage has begun to entrench upslope and becomes poorly developed on the slide area. The displaced mass has begun to be eroded if it extends into a stream or river. Mature slides have completely revegetated scarps, drainage has begun to develop on the slide area, and the slide toe is incised if it extends into a stream or river. Old slides have an integrated drainage network throughout the slide mass and any streams crossing the toe of the slide may have swung to the opposite valley side (Figure 7). The displaced material is largely eroded but the scarp still remains and is recognizable.

Age label: Age.

3.2 Inventory Map Format

The inventory map shows the location of the mass movement features identified in this study. These failures are first classified by size based on the original surficial mapping. Descriptions are recorded in two separate attribute tables for large and small slides respectively. The attribute tables contain the characteristics described earlier, as well as the location and a unique identifying number for each failure. The small failures are point features, where the point represents the location of the centre of the slide. The large failures are line features, with lines approximating the location of the scarp. Location information in the attribute tables is given in UTM coordinates (Zone 11) using NAD 83 as a datum. For the small features, the northing and easting values are a single point on the map whereas larger landslides are represented by a northing and easting value that approximates the centre of the landslide area. The inventory map also shows surficial deposits of colluvium and glaciolacustrine sediments as these deposits consistently host most failures in the project area. Nearshore and littoral glaciolacustrine silts and sands are differentiated, outlining the edge of glacial Lake Peace. In some areas a discontinuous layer of loess or organic sediments cover these sediments; which are also shown on the map.

4 Inventory Results

A total of 157 failures are classified in the inventory of the Peace River area. Surficial geology mapping identified 86 features that are classified as small landslides (represented as points) and 71 features classified as large landslides (scarp delineated by lines). It is these failures that are described in detail in this project.

4.1 Landslide Distribution

The large landslides are restricted to valley of the Peace River and its tributaries. The occurrence of these failures results from river valley development, which through incision, has removed lateral confining pressures and created relief. Consequently, slopes are subject to the influence of gravitational processes that under certain conditions may fail (e.g. high pore pressure due to water saturation). These types of failures are particularly common in low strength clays and with perched water tables in glaciolacustrine deposits (cf. Kenney, 1976; West, 1995). As might be expected, the landslide features recorded in this inventory occur predominately in colluvial polygons. However, most of the notable failures are adjacent to glaciolacustrine polygons, suggesting that the sediments of Glacial Lake Peace are related to much of the mass movement activity in the Peace River map sheet (Figure 10). Of the tributaries, the Heart and Smoky Rivers show the most landslide activity. Unlike the main Peace River Valley, Shaftesbury Formation shale outcrops along the subordinate drainages. We suggest the physical properties of the shale in this formation may be responsible for the increased landslide occurrence (Figure 11). The remainder of the map area has relatively low relief and therefore little or no slope in which to fail.

Figure 10. A recent landslide in glacial Lake Peace sediments.

Figure 11. A recent landslide on the Smoky River occurring in Shaftesbury Formation shale.

4.2 Inventory Limitations

The scale of the air photographs used in the inventory limits both the minimum sized landslide that was identified and the confidence with which individual slides were classified. The smallest slide dimension identified using the 1:60 000 air photos was 240 m; however, smaller slides have been documented in the area, including landslides within the town of Peace River (Cruden et al., 1990; Hardy, 1957). The scale of the photos also limits the ability to confidently classify the slide features. The material type given is based on the apparent depth of the slide and its relation to the surficial and bedrock geology units mapped in the vicinity. Detailed work in areas of interest must be considered for confirmation of failure type, mechanism and sedimentology.

5 Conclusions

The landslide inventory map for the Peace River area (NTS 84C) shows 157 landslide features and extensive colluvial deposits that represent areas of significant mass movement processes. The larger

failures are most common in the glaciolacustrine deposits that occur in the Peace River valley and shales of the Shaftesbury Formation that are present along tributaries of the Peace River.
A digital landslide inventory map was created using existing digital surficial geology maps with additional air photo analysis. This process identified landslides with a maximum dimension larger than 240 m.
The digital version of this map allows the display of the characteristics of an individual slide, as well as a summary of the location and characteristics of all failures identified on the map. These features may facilitate further studies of landslide distribution and hazards throughout the region. This inventory also establishes a cost effective process for producing derivative maps that can augment the Alberta Geological Survey's surficial mapping program.

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Appendix I – Table of Landslide Data

Slide numbers in this appendix correspond to landslides identified in the ArcExplorer™ project and the map provided in Adobe® Portable Document Format (PDF). UTM coordinates are provided in NAD83 Datum, for UTM Zone 11. Dimensions (slide width and length) are measured in metres; a zero value in these fields indicates that the dimensions are less than 240 m and not accurately measurable from 1:60,000 air photographs.

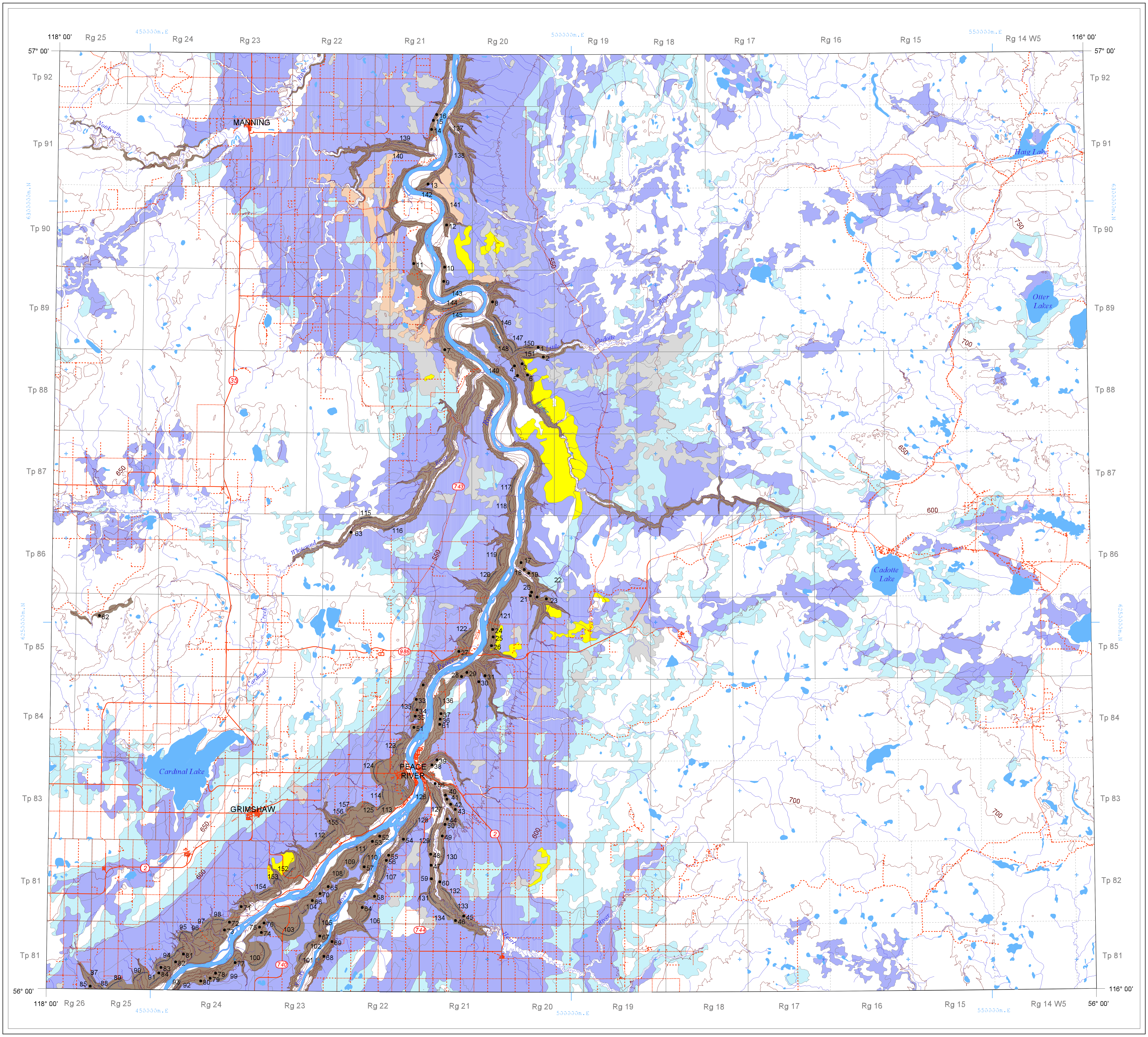
SLIDE_ID	NORTHING	EASTING	MODE_1	MAT_1	MOVE_1	MODE_2	MAT_2	MOVE_2	TOT_WIDTH	TOT_LENGTH	AGE	ASPECT
1	6282645	496073							0	0	Inactive-Old	S
2	6281491	496702							0	0	Inactive-Old	N
3	6280694	494171							780	0	Inactive-Old	W
4	6280445	493261							360	0	Inactive-Old	E
5	6279296	493624							300	0	Inactive-Old	NE
6	6279351	494816							600	0	Inactive-Old	SW
7	6282374	484977	rotational	earth	slide		earth	flow	1500	540	Inactive-Old	NE
8	6288030	490655	translational		slide				660	1020	Inactive-Old	W
9	6290463	484864	translational	earth	slide			(flow)	1500	720	Inactive-Old	W
10	6292175	484972		earth	flow				600	600	Inactive-Old	W
11	6292581	481293		earth	flow				300	780	Inactive-Old	E
12	6297164	485194		earth	slide		earth	flow	480	360	Inactive-Old	W
13	6302024	482989		earth	flow				600	900	Inactive-Old	NW
14	6308504	483412	rotational		slide			flow	480	720	Inactive-Mature	E
15	6309587	483639	rotational		slide				480	600	Inactive-Mature	E
16	6310270	484029	rotational		slide				360	540	Inactive-Mature	E
17	6257090	494052			slide			flow	660	900	Inactive-Old	NW
18	6256259	494437	translational		slide				480	600	Inactive-Old	SW
19	6255843	494954	translational		slide				540	600	Inactive-Old	S
20	6253583	495305			slide				300	540	Inactive-Old	E
21	6253147	495145			slide				540	480	Inactive-Old	E
22	6253006	495942			slide				480	540	Inactive-Old	W
23	6252802	497044			slide				600	540	Inactive-Old	S
24	6249142	490678		earth	flow				780	900	Inactive-Old	W
25	6248265	490740		earth	flow				660	1020	Inactive-Old	W
26	6247227	490525		earth	flow				420	1020	Inactive-Old	W
27	6246551	486654			slide				720	900	Inactive-Mature	SE
28	6243561	486971	rotational		slide			flow	900	900	Inactive-Old	NW
29	6244052	487614							600	900	Inactive-Old	NW
30	6242947	489036	translational		slide				720	720	Inactive-Mature	W
31	6243678	489777			slide				540	360	Inactive-Old	NE
32	6242562	482431	rotational	earth	slide		earth	flow	540	600	Inactive-Mature	SE

SLIDE_ID	NORTH-ING	EASTING	MODE_1	MAT_1	MOVE_1	MODE_2	MAT_2	MOVE_2	TOT_WIDTH	TOT_LENGTH	AGE	AS-PECT
33	6240853	481602		earth	slide				420	360	Inactive-Mature	E
34	6239610	481689							360	540	Inactive-Old	E
35	6238868	481471	rotational	earth	slide				540	360	Inactive-Old	E
36	6238512	484445		earth	flow				300	1200	Inactive-Mature	W
37	6239152	484539	rotational	earth	slide		earth	flow	1140	1200	Inactive-Old	W
38	6233056	483467							540	1140	Inactive-Old	NW
39	6233674	484063							540	600	Inactive-Old	NW
40	6229497	485070							360	360	Inactive-Old	W
41	6228995	485244							420	360	Inactive-Old	W
42	6228399	485695							420	540	Inactive-Old	SW
43	6227803	486240							600	540	Inactive-Old	SW
44	6226647	485281			flow				360	720	Inactive-Old	W
45	6215137	487240							420	300	Inactive-Old	SW
46	6214606	486265							420	480	Inactive-Old	NE
47	6221165	483349		earth	flow				600	360	Inactive-Mature	E
48	6222483	483322	rotational		slide				780	480	Inactive-Old	E
49	6224648	484696	rotational		slide				540	420	Inactive-Old	W
50	6226022	485018			flow				360	660	Inactive-Young	W
51	6237538	481329	rotational	earth	slide				840	720	Inactive-Mature	S
52	6224613	477254		earth	flow				480	720	Inactive-Old	NW
53	6224011	476385		earth	slide		earth	flow	960	1320	Inactive-Mature	NW
54	6224250	480072		earth	flow				660	1080	Inactive-Old	NW
55	6222359	478324		earth	slide		earth	flow	540	900	Inactive-Old	NW
56	6221729	478038		earth	flow				360	780	Inactive-Old	NW
57	6220984	475421							420	1080	Inactive-Old	NE
58	6217494	476648							780	1380	Inactive-Old	W
59	6219551	483389	rotational		slide				720	420	Inactive-Old	E
60	6219190	484401	rotational		slide				240	360	Inactive-Old	W
61	6237898	484392		earth	flow				600	900	Inactive-Old	W
62	6250810	443988	rotational	earth	slide				420	360	Inactive-Old	N
63	6260682	473856	rotational		slide				300	300	Inactive-Old	NW
64	6216158	475176							360	1440	Inactive-Mature	W
65	6218626	471148			slide			flow	1080	1440	Inactive-Mature	NW

SLIDE _ID	NORTH-ING	EASTING	MODE_1	MAT_ 1	MOVE_ 1	MODE_ 2	MAT_ 2	MOVE_2	TOT_ WIDTH	TOT _LENGTH	AGE	AS-PECT
66	6216966	469267							1080	1200	Inactive-Mature	NW
67	6212774	470144		earth	flow				600	1200	Inactive-Mature	E
68	6210354	470626	rotational		slide				600	420	Inactive-Mature	W
69	6212107	471591	rotational		slide				360	480	Inactive-Young	W
70	6217794	470170	rotational		slide				960	1500	Inactive-Mature	NW
71	6216256	460823	rotational		slide				1200	600	Inactive-Old	E
72	6214417	459423	rotational	earth	slide				600	1200	Inactive-Mature	E
73	6213478	458829	translational	earth	slide				420	600	Inactive-Mature	SE
74	6213185	463197		earth	slide		earth	flow	600	2200	Inactive-Mature	W
75	6213816	462985		earth	flow				300	660	Inactive-Old	W
76	6214307	463513		earth	flow				480	960	Inactive-Old	NW
77	6209610	460095	rotational		slide			flow	480	900	Inactive-Old	W
78	6208357	457760	rotational		slide		earth	flow	300	900	Inactive-Mature	NW
79	6207740	457124		earth	flow				540	900	Inactive-Old	NW
80	6207436	456013		earth	flow				1020	1500	Inactive-Mature	NW
81	6210630	453953		earth	flow				900	1080	Inactive-Old	SE
82	6209700	453032		earth	flow				660	780	Inactive-Old	SE
83	6209033	451282							540	600	Inactive-Old	SE
84	6208374	451032							600	600	Inactive-Mature	E
85	6206812	442874	rotational		slide				600	360	Inactive-Old	NW
86	6230855	483851		earth	flow				240	240	Active	SW
87	6207496	443148	rotational	debris	slide				480	900	Inactive-Old	SE
88	6206660	444024	rotational	debris	slide				360	1020	Inactive-Old	SE
89	6206957	445737		earth	flow				2100	3000	Inactive-Old	SE
90	6207577	448864							1920	900	Inactive-Old	SE
91	6207092	450684	rotational		slide				1800	780	Inactive-Old	SE
92	6206781	452936	rotational	debris	slide				1800	600	Inactive-Old	NW
93	6206552	453111		debris	slide				1800	780	Inactive-Old	NW
94	6209720	452895	rotational	debris	slide				4200	1680	Inactive-Old	SE
95	6212363	454405	rotational	debris	slide				1740	1500	Inactive-Old	SE
96	6212848	455901	rotational	debris	slide				900	1320	Inactive-Old	SE

SLIDE _ID	NORTH-ING	EASTING	MODE_1	MAT_ 1	MOVE_ 1	MODE_ 2	MAT_ 2	MOVE_2	TOT_ WIDTH	TOT _LENGTH	AGE	AS-PECT
97	6213778	456953	rotational	debris	slide				1200	1080	Inactive-Old	SE
98	6214196	458085	rotational	debris	slide				900	1200	Inactive-Old	S
99	6208143	458490		earth	flow				1560	1800	Inactive-Old	NW
100	6210570	462561		earth	flow				2400	3900	Inactive-Old	W
101	6210044	468062	rotational	debris	slide				1020	1860	Inactive-Old	SE
102	6211527	468992	rotational	debris	slide				1500	1320	Inactive-Mature	SE
103	6214412	466269		earth	flow				3180	1800	Inactive-Old	N
104	6215929	467974	rotational	earth	slide				720	1200	Inactive-Old	NW
105	6214601	470744	rotational	debris	slide				2400	1500	Inactive-Young	E
106	6215571	474924	rotational	debris	slide				2040	2700	Inactive-Mature	NW
107	6220411	477242	rotational		slide				2100	720	Inactive-Old	NW
108	6220344	472214			slide				1620	1620	Inactive-Old	NW
109	6221962	473778	rotational		slide			flow	1500	2400	Inactive-Old	NW
110	6221719	475881	translational	debris	slide		earth	flow	1440	900	Inactive-Old	SE
111	6223256	475032	translational	earth	slide				1200	1200	Inactive-Old	NW
112	6223849	471095	rotational	debris	slide		earth	flow	3900	2160	Inactive-Old	SE
113	6227664	477741	rotational		slide			flow	1500	1500	Inactive-Old	SE
114	6229659	478186		earth	flow				1380	1980	Inactive-Old	E
115	6262122	475571	rotational	earth	slide				1500	720	Inactive-Old	S
116	6261300	478348			slide				1200	300	Inactive-Old	N
117	6266423	493312	translational		slide				2040	660	Inactive-Old	E
118	6263862	493043	translational		slide				1500	1020	Inactive-Old	E
119	6257768	492274	rotational		slide				2400	1560	Inactive-Old	E
120	6254883	490791	rotational/ trans		slide				2400	1500	Inactive-Old	SE
121	6250960	490697			slide				1380	900	Inactive-Old	W
122	6248250	487771	rotational		slide				1800	1500	Inactive-Old	SE
123	6234917	479885							0	600	Inactive-Old	E
124	6232194	478200	rotational	debris	slide		earth	flow	3000	3600	Inactive-Old	E
125	6227866	475733	rotational		slide				2400	2700	Inactive-Old	SW
126	6229161	482595							1500	600	Inactive-Old	W
127	6229120	483956	rotational		slide				2520	1080	Inactive-Old	E
128	6225831	480842							1860	900	Inactive-Old	NW
129	6224402	483592	rotational	debris	slide				2200	840	Inactive-Old	E
130	6222218	484536	rotational	debris	slide				2100	900	Inactive-Old	W

SLIDE _ID	NORTH-ING	EASTING	MODE_1	MAT_1	MOVE_1	MODE_2	MAT_2	MOVE_2	TOT_WIDTH	TOT_LENGTH	AGE	AS-PECT
131	6217755	483646	rotational	debris	slide				2220	1020	Inactive-Old	E
132	6217688	484819	transla-tional	debris	slide				1620	760	Inactive-Old	SW
133	6216084	486235	rotational	debris	slide				1200	600	Inactive-Old	SW
134	6215787	485223	rotational	debris	slide				2040	900	Inactive-Old	NE
135	6239905	481745	rotational		slide				900	780	Inactive-Old	E
136	6240458	483997	rotational	earth	slide		earth	flow	960	1140	Inactive-Old	W
137	6308337	485965	rotational						1020	600	Inactive-Old	NE
138	6305748	485466	rotational		slide			multiple flows	2100	600	Inactive-Old	W
139	6306813	480181	transla-tional		slide				1680	540	Inactive-Old	S
140	6306153	479939	transla-tional		slide				1860	720	Inactive-Old	N
141	6299655	484940	rotational		slide				1980	660	Inactive-Old	W
142	6301124	482810	rotational		slide				1560	780	Inactive-Old	S
143	6289193	485817	transla-tional		slide				1980	600	Inactive-Old	SE
144	6287791	485911	transla-tional		slide				2520	780	Inactive-Old	N
145	6286820	486288	transla-tional		slide				2400	460	Inactive-Old	S
146	6285351	491061	rotational						2700	780	Inactive-Old	W
147	6283032	492786	rotational		slide				1320	540	Inactive-Old	SW
148	6282371	492611	rotational		slide				780	240	Inactive-Old	SW
149	6282142	493730							780	600	Inactive-Old	SE
150	6282371	494890	rotational		slide				1200	840	Inactive-Old	S
151	6281738	494836	rotational		slide				1260	480	Inactive-Old	N
152	6219966	466862	rotational	debris	slide				1800	0	Inactive-Old	SE
153	6219050	465163			slide		earth	flow	1620	2400	Inactive-Old	S
154	6217647	463815	rotational		slide				2220	1500	Inactive-Old	SE
155	6226356	472214	rotational		slide				0	0	Inactive-Old	SW
156	6226666	473252	rotational		slide				0	0	Inactive-Old	SE
157	6227502	473899			flow				0	0	Inactive-Old	SE



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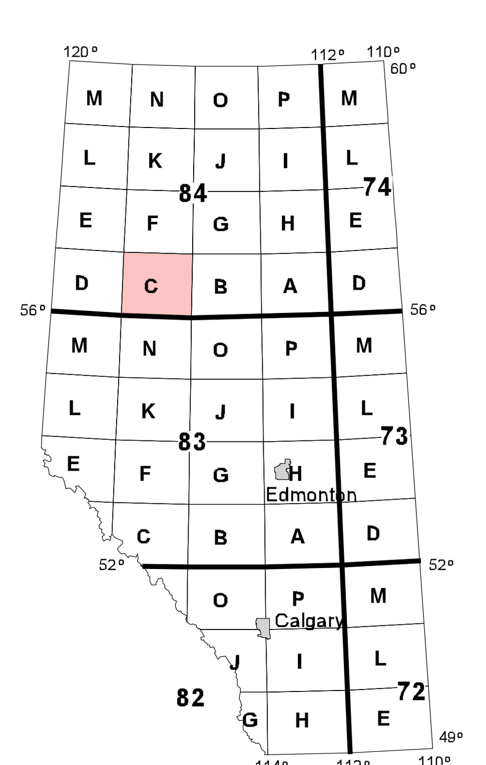

Scale 1:250 000

5 0 5 10 15 20 25 30 kilometres

5 0 5 10 15 20 miles

Projection: Universal Transverse Mercator, Zone 11
Datum: North American Datum, 1983

Legend

- Organic veneer overlying glaciolacustrine deposits
- Fluvial veneer overlying glaciolacustrine deposits
- Eolian veneer overlying glaciolacustrine deposits
- Colluvial deposits
- Glaciolacustrine deposits
  - Deep water glaciolacustrine deposits
  - Littoral and nearshore glaciolacustrine deposits

- Small landslide and active layer failure scar • 4
- Large landslide and active failure scar 103
- Road paved
- Road unimproved
- Road gravel
- Township/range - surveyed
- Township/range - unsurveyed
- UTM zone 11 grid
- Contour 50m interval
- River
- Lake

Landslide Inventory of the Peace River Area, Alberta (NTS 84C)

Compiled by: M.R. Davies, R.C. Paulen and A.S. Hickin

Geo-Note 2003-43

Digital base data provided by:
Spatial Data Warehouse
Alberta Environment
Alberta Infrastructure

Surficial geology modified from Paulen et. al., (2005)
GIS/Cartography by: N.L. Clarke

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AGS Alberta Geological Survey