TOTAL E&P CANADA LTD

Environmental Baseline Study:

Hydrology

Total E&P Canada Ltd.
Calgary, Alberta

TOTAL

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Acronyms and Abbreviations

IDF ..... intensity–duration–frequency
LSA ..... local study area
LSD ..... legal subdivision
NSWA ..... North Saskatchewan Watershed Alliance
NTS ..... National Topographic Service
RSA ..... regional study area
TOTAL ..... TOTAL E&P Canada Ltd.

1 Introduction

1.1 Background

TOTAL E&P Canada Ltd. (TOTAL) owns a parcel of land in Alberta's Industrial Heartland near Fort Saskatchewan, Alberta (see Figure 1.1-1). The parcel is situated in the following portions of Township 55, Range 21, West of the 4th Meridian:

- Section 18:
  - portions of legal subdivisions (LSDs) 11, 12
  - all of LSDs 13 and 14
- Section 19
- Section 20:
  - portion of LSD 3
  - all of LSDs 4, 5 and 6
  - northwest quarter

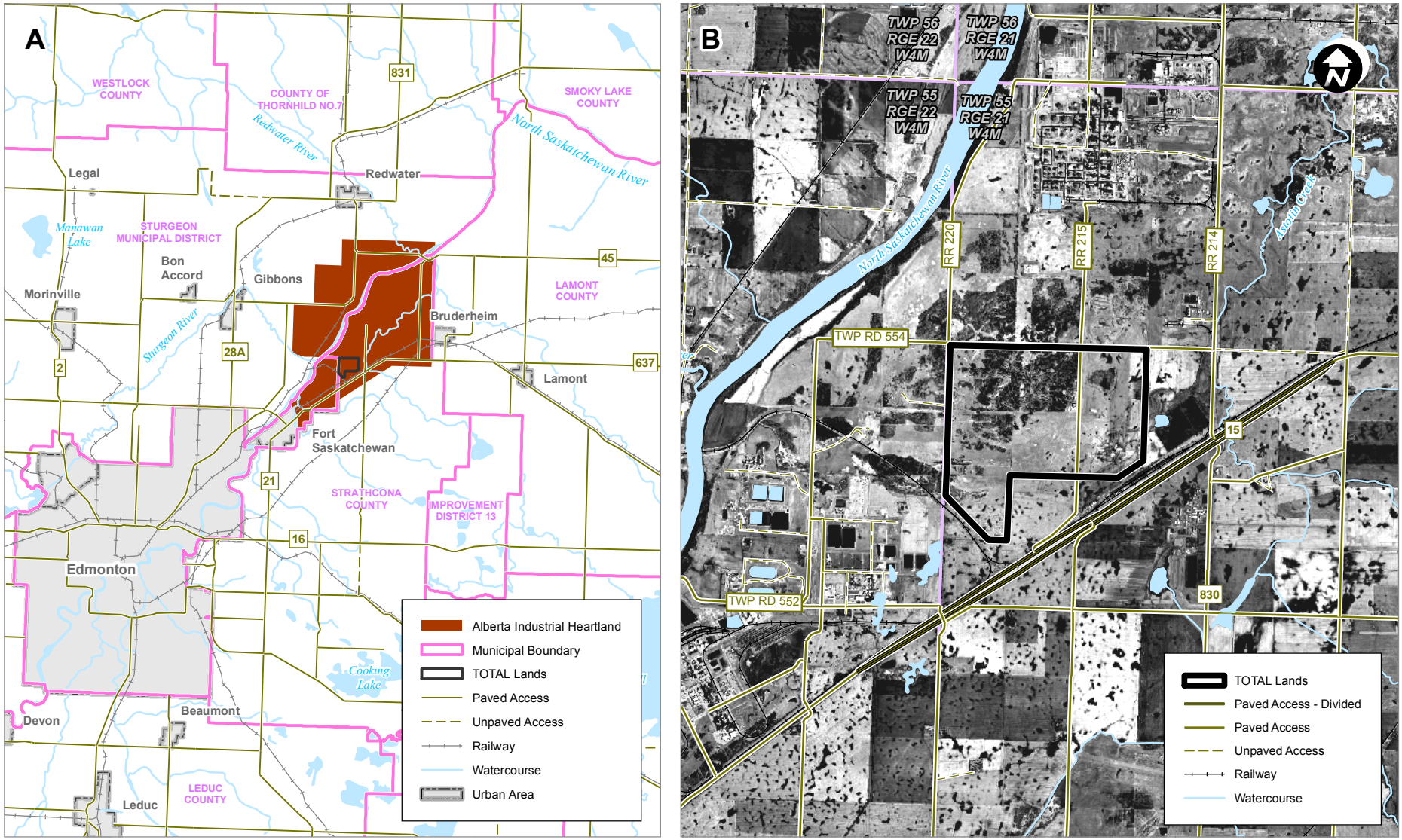
Throughout this document, this land (including small inholdings that TOTAL is intending to acquire) is referred to as the TOTAL lands.

This report is one of a series of studies prepared to document the environmental baseline conditions of the TOTAL lands and surrounding area.

1.2 Focus of Baseline Investigations

The hydrology baseline investigation included collection, compilation and analysis of data to characterize local and regional hydrological characteristics of the TOTAL lands and downstream waterbodies. This included:

- drainage patterns and waterbodies in the local study area (LSA)
- flows in the LSA waterbodies and the North Saskatchewan River, which is included in the regional study area (RSA)



TOTAL

TITLE

FIGURE 1.1-1
TOTAL LANDS*

*includes small inholdings TOTAL intends to acquire

SCALE

A 5 0 5 10 15 Distance in Kilometres

B 500 0 500 1,000 1,500 Distance in Metres

1.3 Study Areas

1.3.1 Local Study Area

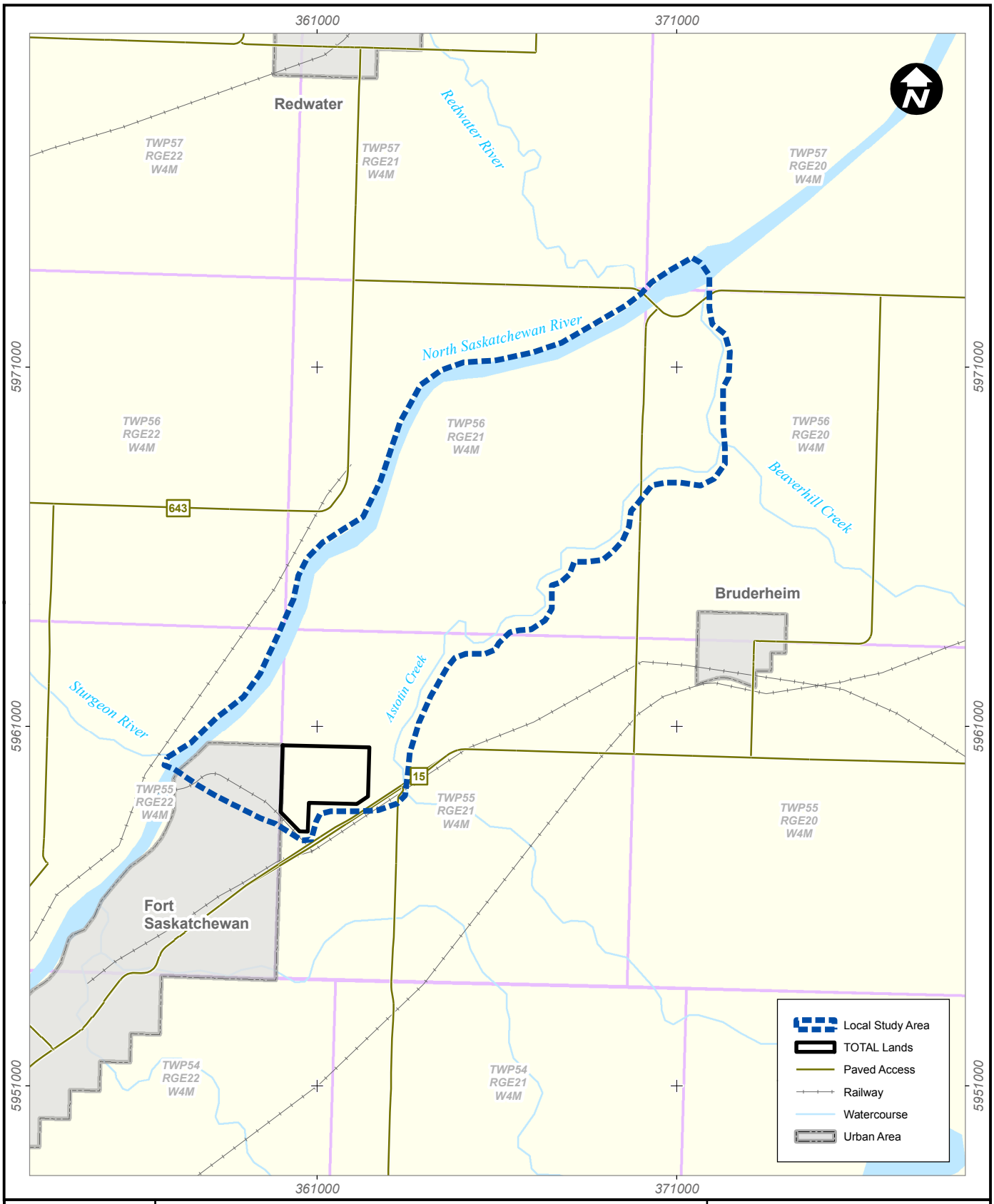
The LSA for the project (see Figure 1.3-1) includes:

- all TOTAL lands
- downstream watercourses that convey natural site drainage to the North Saskatchewan River, specifically:
  - local watercourses east of the TOTAL lands that drain to Astotin Creek and the reaches of Astotin and Beaverhill creeks
  - local watercourses west and northwest of the TOTAL lands that drain to the North Saskatchewan River
- the reach of the North Saskatchewan River from the Sturgeon River (upstream) to the Redwater River

There are no lakes in the LSA and ponded water is limited to wetland areas in topographic lows.

1.3.2 Regional Study Area

The RSA for the project (see Figure 1.3-2) includes the LSA and an extended reach of the North Saskatchewan River. This was specified to be consistent with that of other aquatic disciplines (i.e., water quality). The downstream limit of the RSA is at Pakan. The upstream limit of the RSA is the Town of Devon, which is approximately the existing limit of urban development upstream of Edmonton.



TOTAL

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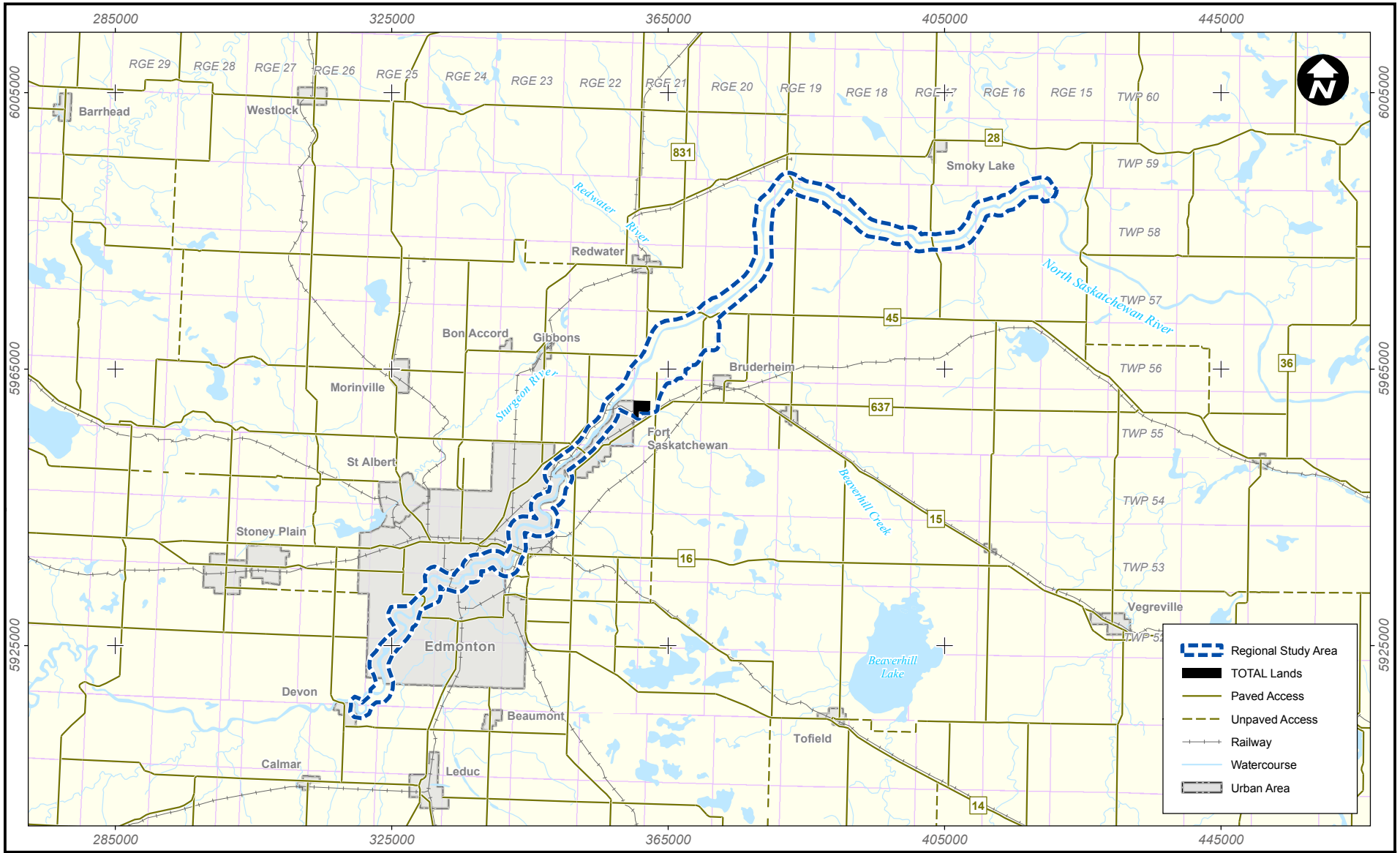
FIGURE 1.3-1
HYDROLOGY LOCAL STUDY AREA

SCALE

1.5 0 1.5 3 4.5

Distance in Kilometres



TOTAL

TITLE

FIGURE 1.3-2
HYDROLOGY REGIONAL STUDY AREA

SCALE

8 0 8 16 24

Distance in Kilometres

2 Methods

2.1 Local Study Area

2.1.1 Review of Historical Data

Data used to characterize baseline conditions in the LSA included the following:

- **Long-duration precipitation** was characterized using data from the Environment Canada climate station at Fort Saskatchewan (Station 3012710). This station has a period of record from 1958 to 2006 (Environment Canada 2006a).
- **Short-duration precipitation** was characterized by intensity–duration–frequency (IDF) curves that are based on measurements of short-duration rainfall (5 minutes to 10 days). Environment Canada only generates IDF curves for selected climate stations, and they are unavailable for Fort Saskatchewan. Short-duration precipitation was characterized using data from the Edmonton City Centre Airport (Station 3012208). This station is located approximately 35 km southwest of the TOTAL lands, and was used as a basis for drainage engineering design by Strathcona County (2003).
- **Local streamflow regimes** were characterized using long-term regional data for streams located in the White Zone south of Lac la Biche (Environment Canada 2006b). For gauged streams in the LSA, data from that station were used to characterize the flow regime. For ungauged streams, a regional hydrological analysis was used.
- **North Saskatchewan River flow regime** was characterized using data from Environment Canada hydrometric Station 05DF001 (North Saskatchewan River at Edmonton), which is located at the Low Level Bridge in Edmonton. Flows in the North Saskatchewan River are regulated at two upstream locations, including the Brazeau Dam on the Brazeau River (since 1961) and the Bighorn Dam on the North Saskatchewan River (since 1972). These impoundments reduce flood peaks and increase low flows on the North Saskatchewan River but have little effect on mean annual flows. Derived naturalized flows for the North Saskatchewan River in Alberta are available for the period of record 1912 to 2002 on a weekly time step (AENV 2005).
- **Drainage patterns and waterbodies** on the TOTAL lands were characterized using 1:50,000-scale National Topographic Service (NTS) mapsheet 83H/14 (Redwater). The NTS map permits an assessment of drainage patterns at a relatively coarse scale. Finer-scale information was generated using publicly available digital elevation data on a 100-m grid (GeoBase 2007).

2.1.2 Evaluation of Precipitation, Runoff and Drainage Patterns and Waterbodies

2.1.2.1 Precipitation

Long-term precipitation characteristics in the LSA were characterized using data from the Environment Canada climate station at Fort Saskatchewan (Station 3012710). This station has a period of record from 1958 to 2006 (Environment Canada 2006a).

Monthly and annual mean and daily extreme values for rainfall, snowfall and total precipitation were calculated. Monthly and annual total precipitation values for wet and dry conditions were derived using a frequency analysis of these data.

Short-duration precipitation was characterized using published data from the Environment Canada climate station at Edmonton City Centre Airport (Station 3012208).

2.1.2.2 Runoff

Flow characteristics of local watercourses were examined using local and regional hydrometric data published by Environment Canada (2006b). For the long-term hydrometric stations that collected the data used to generate statistics for floods and low flows and to calculate mean annual water yields, see Table 2.1-1.

Table 2.1-1 Hydrometric Stations for Regional Analysis

Station Number	Station Name	Location	Drainage Area (km^2)	Period of Record
05EA001	Sturgeon River near Fort Saskatchewan	53°47'14" N 113°13'23" W	3350 Gross 2490 Effective	1914–2005
05EB015	Beaverhill Creek near the mouth	53°53'21" N 112°56'57" W	2930 Gross – Effective[1]	1975–1986
06AA002	Amisk River at Highway 36	54°28'20" N 112°1'0" W	2510 Gross 1890 Effective	1971–2005
05EC005	Redwater River near the mouth	53°53'49" N 112°59'46" W	1550 Gross 1110 Effective	1978–2005
07CA005	Pine Creek near Grassland	54°49'12" N 112°46'34" W	1450 Gross 933 Effective	1966–2005
05EC004	Namepi Creek near the mouth	54°1'47" N 112°50'44" W	720 Gross 506 Effective	1975–1995
07CA008	Babette Creek near Colinton	54°39'10" N 113°4'45" W	222 Gross – Effective[1]	1978–2005
07CA003	Flat Creek near Boyle	54°35'15" N 112°54'20" W	184 Gross 88.1 Effective	1919–2005
05EB902	Pointe-Aux-Pins Creek near Ardrossan	53°35'58" N 113°9'49" W	106 Gross – Effective[1]	1979–2005

NOTE:
[1]Effective drainage area not reported by Environment Canada.

2.1.2.3 Drainage Patterns

LSA topography, drainage patterns and watercourses were initially characterized using available NTS mapping (1:50,000 scale) followed by site reconnaissance on April 13, May 28 and September 1, 2007. The first site reconnaissance was during spring runoff for observation of flow directions, the second after the study area was expanded and the third to determine the flow path from the TOTAL lands to Astotin Creek. Pre-development site conditions were photographed and notes on watercourse characteristics were recorded.

Drainage patterns were also examined by generating ground elevation contours from the publicly available digital elevation data for the area (GeoBase 2007).

2.1.3 North Saskatchewan River Flow Regime

The North Saskatchewan River flow regime was characterized using data from Environment Canada hydrometric Station 05DF001 (North Saskatchewan River at Edmonton). Available data included monitoring data from Environment Canada (2006b) and naturalized weekly data from Alberta Environment (AENV 2005). Naturalized data were calculated to remove man-made effects, including those due to dams and water withdrawals. Three analyses were performed, based on:

- post-dam recorded flows from 1973 to 2002
- post-dam naturalized flows from 1973 to 2002
- the complete record of naturalized flows from 1912 to 2002

The naturalized flow record ends in 2002, so a period end of 2002 was selected to allow concurrent values to be examined using measured and naturalized flow data, even though the post-dam flow record is currently available to the end of 2005. Mean, minimum and maximum monthly and annual discharges were calculated for each of these cases.

Pre-dam (1912 to 1960) and post-dam (1973 to 2005) flood and low-flow discharges were calculated using measured flow data. The 7-day 10-year low flow (7Q10) values for the North Saskatchewan River were also calculated for the pre-dam and post-dam periods, based on the lowest 7-day mean flow for each year.

2.2 Regional Study Area

2.2.1 Review of Historical Data

The RSA includes the LSA as well as an extended reach of the North Saskatchewan River from Devon to Pakan. Because the North Saskatchewan River flow regime in the RSA is adequately characterized by the analysis for the LSA, no additional analyses related to the flow regime were required. Existing water licence information was requested from Alberta Environment to allow approved water withdrawals to be evaluated.

2.2.2 Licensed Withdrawals from the North Saskatchewan River

Details of existing water licences for water withdrawals from the North Saskatchewan River and tributaries in the RSA were compiled using Alberta Environment data. Data related to each licence included:

- approval and water allocation identification numbers
- filing number
- geographical location (legal subdivision [LSD], latitude and longitude)
- licensed annual withdrawal quantity and maximum withdrawal rate
- consumptive use, losses and return flow
- industry activity code
- priority, effective licence and expiry dates

2.3 Quality Assurance and Quality Control

The hydrology baseline relied heavily on data published by Environment Canada and Alberta Environment, which are subject to the internal QA/QC procedures of those agencies.

Data collected during field investigations included only reconnaissance-level observations of drainage pattern and direction. These observations were made according to specific work instructions issued by the task manager and observations were compared with available contour mapping and aerial photography.

3 Results

3.1 Local Study Area

3.1.1 Evaluation of Precipitation, Runoff, Drainage Patterns and Waterbodies

3.1.1.1 Precipitation Regime

Long-duration precipitation was characterized using data from the Environment Canada climate station at Fort Saskatchewan (Station 3012710). This station has a period of record from 1958 to 2006 (Environment Canada 2006a). For monthly precipitation summaries for this station, see Table 3.1-1 and Figure 3.1-1, and for derived monthly and annual precipitation statistics for this station, see Table 3.1-2.

Table 3.1-1 Monthly Precipitation Summary for the Fort Saskatchewan Climate Station 3012710 (1958–2006)

Month	Rainfall (mm)		Snowfall (mm)		Precipitation (mm)			
	Monthly	Daily	Monthly	Daily	Monthly			Daily
	Mean	Extreme	Mean	Extreme	Minimum	Mean[1]	Maximum	Extreme
January	1	7	22	33	1	23	138	33
February	1	12	14	25	0	15	52	25
March	1	10	15	21	1	16	96	21
April	13	16	7	35	0	21	60	37
May	40	48	2	24	5	42	125	48
June	79	78	0	0	4	79	172	78
July	81	62	0	0	17	81	173	62
August	62	53	0	0	4	62	156	53
September	41	77	0	6	0	42	154	77
October	13	15	5	19	1	18	66	23
November	2	11	18	25	0	21	142	25
December	1	6	21	23	3	21	59	23
Annual	337	78	104	35	238	441	698	78

NOTE:
[1]Due to rounding, mean monthly rainfall plus snowfall might not appear to equal total precipitation in all cases.

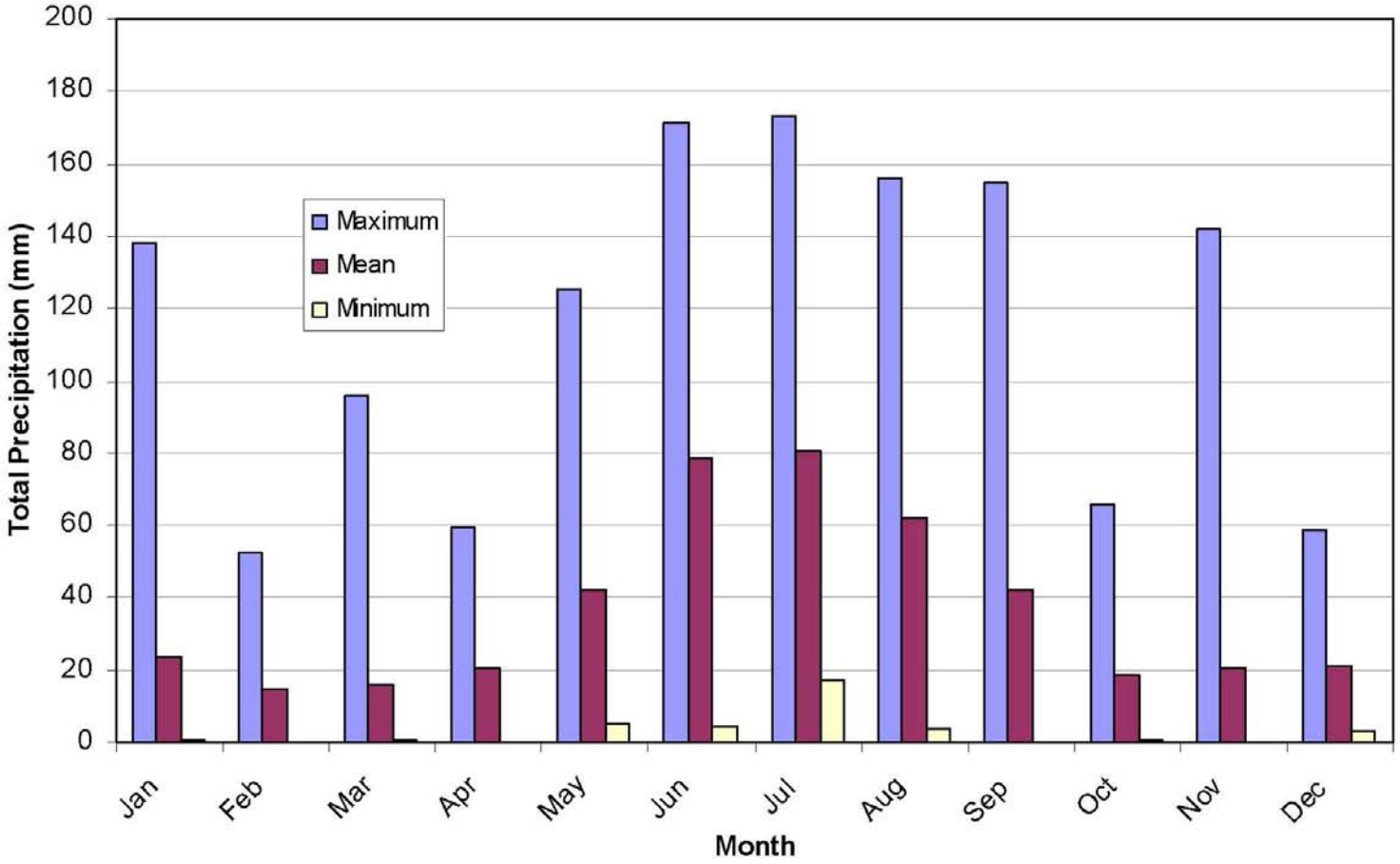


Figure 3.1-1 Monthly Precipitation Summary for Fort Saskatchewan Climate Station 3012710 (1958–2006)

Table 3.1-2 Derived Monthly and Annual Precipitation Statistics for the Fort Saskatchewan Climate Station 3012710 (1958–2006)

Month	Total Precipitation (mm)				
	100 Year Dry	10 Year Dry	Average	10 Year Wet	100 Year Wet
January	0.3	3.7	23.4	53.0	138.0
February	0.0	3.5	15.0	30.7	62.3
March	0.9	3.0	16.0	35.4	93.0
April	0.0	2.8	20.7	40.2	64.4
May	3.9	14.3	41.9	76.8	133.3
June	4.3	27.1	78.7	136.3	190.4
July	9.7	35.5	80.6	132.4	175.1
August	3.0	22.9	62.2	106.2	156.3
September	1.2	7.8	41.9	86.0	173.2
October	0.9	5.2	18.4	35.7	67.3
November	0.0	1.8	20.6	42.5	141.7
December	2.5	4.5	21.3	40.8	73.0
Annual	**253**	**349**	**441**	**587**	**698**

Short-duration precipitation was characterized by IDF curves generated by Environment Canada for Edmonton City Centre Airport (Station 3012208). For short-duration rainfall intensities for return periods from 2 to 100 years and durations of 5 minutes to 10 days, see Table 3.1-3, and for IDF curves, see Figure 3.1-2.

Table 3.1-3 Short-Duration Rainfall Intensities for Edmonton City Centre Airport Climate Station 3012208 (1914–1995)

Duration	Rainfall Rate (mm/h)					
	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year
5 min	79.4	118.9	144.8	177.9	202.6	226.9
10 min	50.7	75.5	91.8	112.7	128.2	143.5
15 min	39.0	57.9	70.4	86.3	98.1	109.8
30 min	24.9	36.8	44.6	54.6	62.1	69.4
1 hr	15.9	23.4	28.3	34.6	39.3	43.9
2 hr	10.2	14.9	17.9	21.9	24.9	27.8
6 hr	5.0	7.2	8.7	10.6	12.0	13.4
12 hr	3.2	4.6	5.5	6.7	7.6	8.5
24 hr	2.0	2.9	3.5	4.3	4.8	5.4
2 days	1.3	1.9	2.2	2.7	3.1	3.4
5 days	0.7	1.0	1.2	1.5	1.7	1.9
10 days	0.5	0.6	0.8	0.9	1.1	1.2

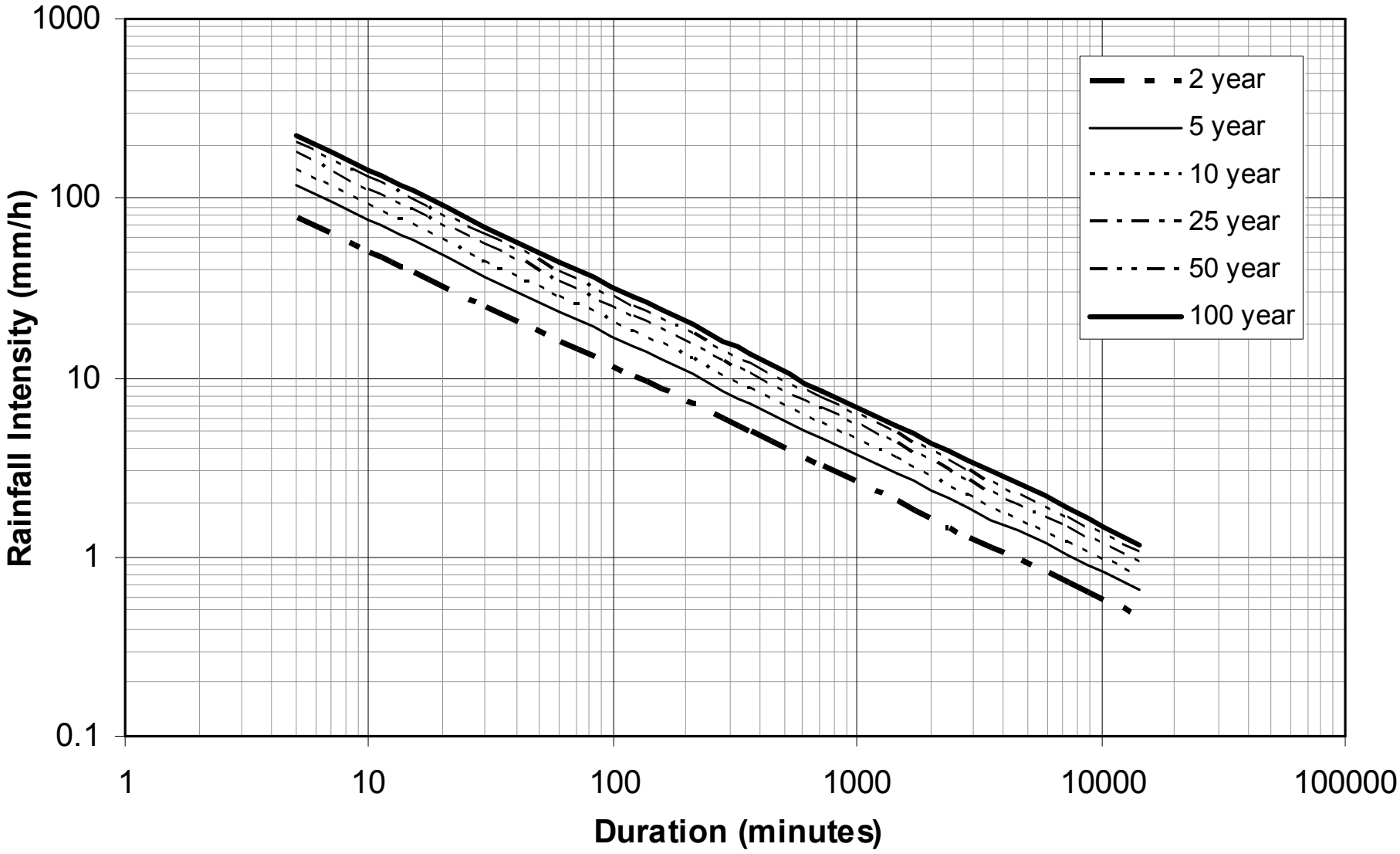


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FIGURE 3.1-2
SHORT-DURATION RAINFALL INTENSITIES FOR EDMONTON CITY CENTRE AIRPORT CLIMATE STATION 3012208 (1914-1995)

TOTAL

3.1.1.2 Runoff

Flow characteristics of local watercourses were examined using hydrometric data from local and regional Environment Canada stations (Environment Canada 2006b). Data for the selected long-term stations listed in Table 2.1-1 were used to generate frequency analyses for floods and mean annual water yields. For derived flood discharges for return periods of 2, 10 and 100 years, see Table 3.1-4 and Figure 3.1-3. Regional equations that can be applied to ungauged streams for floods of these return periods are as follows:

- 100-year Maximum Instantaneous Discharge (m^3/s) = $0.5955\ A^{0.6774}$
- 10-year Maximum Instantaneous Discharge (m^3/s) = $0.3494\ A^{0.6219}$
- 2-year Maximum Instantaneous Discharge (m^3/s) = $0.1464\ A^{0.5756}$

Based on the derived regional relationships and a gross drainage area of 126 km^2, Astotin Creek in the LSA is estimated to have a two-year flood discharge of 2.37 m^3/s, a 10-year flood discharge of 7.07 m^3/s and a 100-year flood discharge of 15.8 m^3/s. For a description of the flood regime of Beaverhill Creek in the LSA, see Table 3.1-4.

Table 3.1-4 Derived Flood Discharges for Regional Hydrometric Stations

Station Number	Station Name	Gross Drainage Area (km^2)	Maximum Instantaneous Discharge (m^3/s)		
			2-Year	10-Year	100-Year
05EA001	Sturgeon River near Fort Saskatchewan	3350	21.6	55.1	109
05EB015	Beaverhill Creek near the mouth	2930	12.4	49.4	154
06AA002	Amisk River at Highway 36	2510	9.46	40.6	128
05EC005	Redwater River near the mouth	1550	8.03	30.9	62.9
07CA005	Pine Creek near Grassland	1450	12.1	31.3	90.3
05EC004	Namepi Creek near the mouth	720	11.0	35.5	92
07CA008	Babette Creek near Colinton	222	1.63	6.62	19.7
07CA003	Flat Creek near Boyle	184	2.82	8.44	16.9
05EB902	Pointe-Aux-Pins Creek near Ardrossan	106	3.13	7.60	14.9

Low flows on streams in the region with drainage areas smaller than several hundred square kilometres are typically zero, due to summer low flows or winter frozen conditions. Even larger watersheds can stop flowing during the year, depending on conditions in the upper watershed.

Beaverhill Creek has a gross drainage area of 2930 km^2 at the Environment Canada hydrometric station located near its mouth, and has reported discharges of zero in each of the 12 years of its period of record. Astotin Creek, with a gross drainage area of 126 km^2 near its confluence with Beaverhill Creek, is ungauged. However, it is a tributary of Beaverhill Creek and therefore must also have annual discharges of zero for that period.

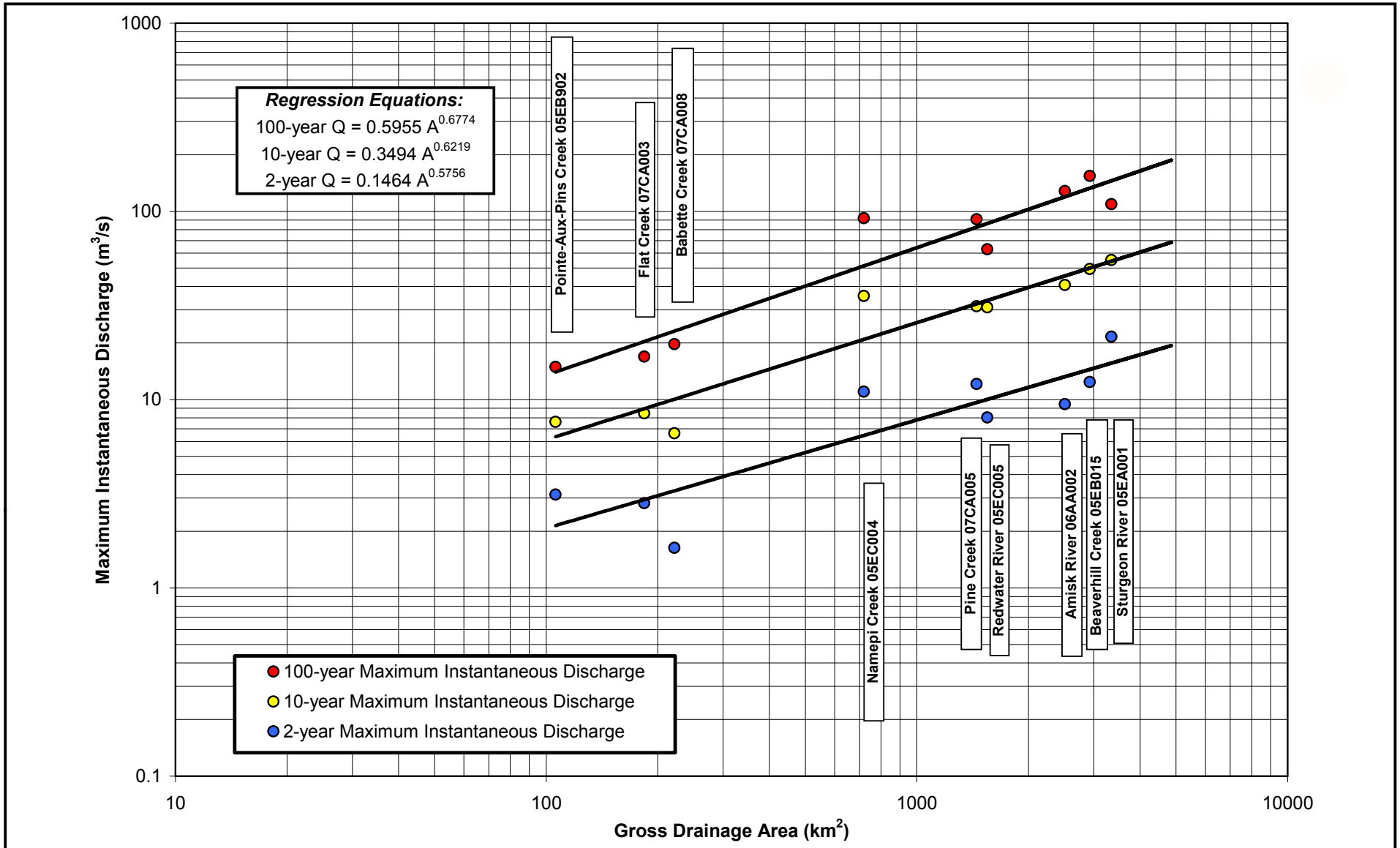

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FIGURE 3.1-3
REGIONAL RUNOFF RELATIONSHIPS FOR 2, 10 AND 100-YEAR FLOODS

TOTAL

Flow records from the Sturgeon and Redwater rivers show that during most years, the low flow is greater than zero. However, flows on both rivers fall to zero often enough that the calculated 7Q10 value is zero.

For mean annual water yields, defined as mean annual stream discharge volume divided by gross drainage area, see Table 3.1-5. Mean annual water yields vary from 4 mm for Beaverhill Creek, which includes Beaverhill Lake in the upper watershed and is dominated by storage and evaporation, to 51 mm for Flat Creek. Based on regional data, a mean annual water yield of approximately 20 mm could be expected for Astotin Creek.

Table 3.1-5 Derived Mean Annual Water Yields for Regional Hydrometric Stations

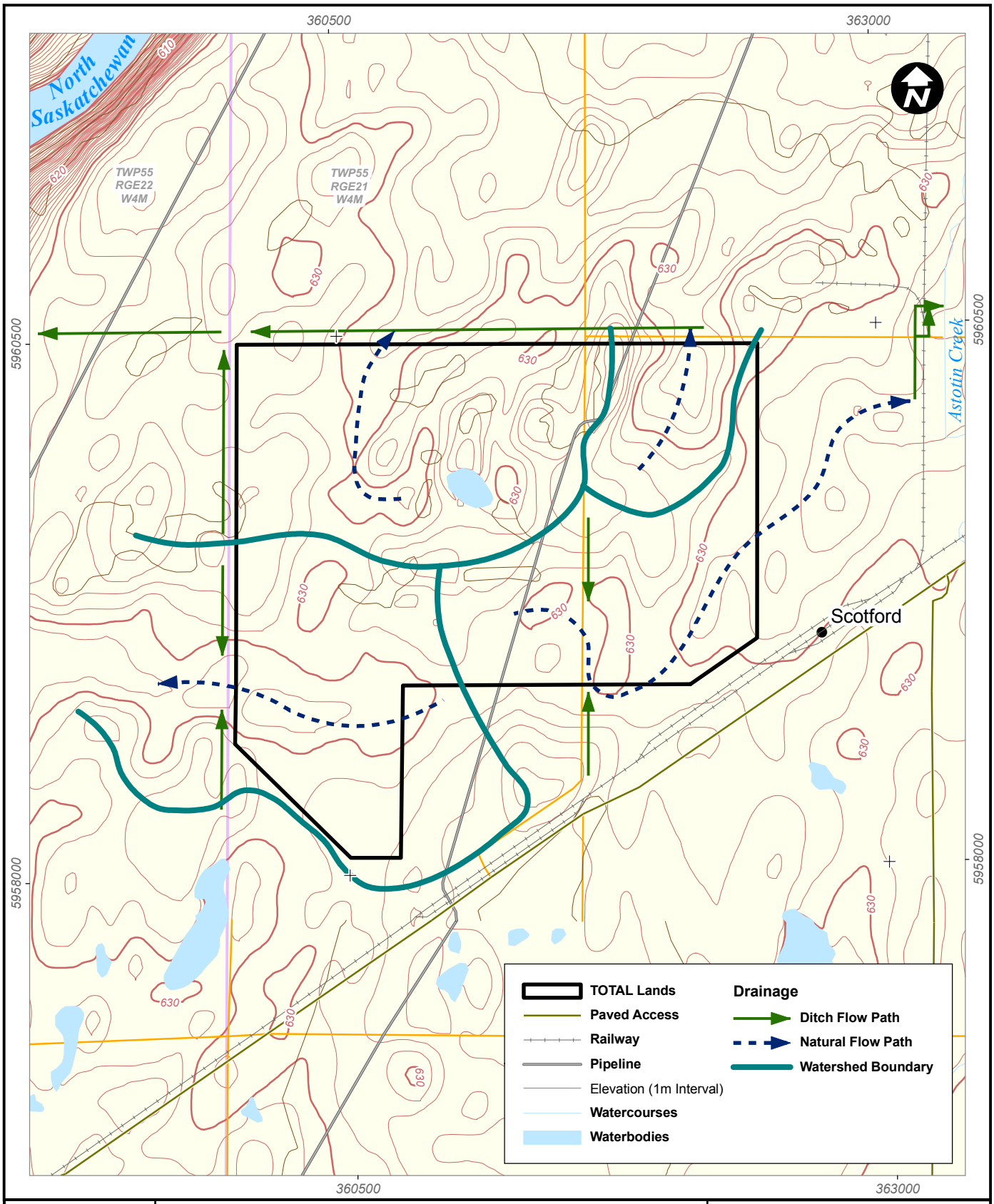
Station Number	Station Name	Gross Drainage Area (km^2)	Mean Annual Discharge (m^3/s)	Mean Annual Water Yield (mm)
05EA001	Sturgeon River near Fort Saskatchewan	3350	3.88	37
05EB015	Beaverhill Creek near the mouth	2930	0.409	4
06AA002	Amisk River at Hwy 36	2510	2.51	32
05EC005	Redwater River near the mouth	1550	0.877	18
07CA005	Pine Creek near Grassland	1450	1.93	42
05EC004	Namepi Creek near the mouth	720	0.381	17
07CA008	Babette Creek near Colinton	222	0.114	16
07CA003	Flat Creek near Boyle	184	0.298	51
05EB902	Pointe-Aux-Pins Creek near Ardrossan	106	0.101	30
05DF001	North Saskatchewan River at Edmonton	28,000	195	220

3.1.1.3 Waterbodies and Drainage Patterns

The TOTAL lands are located in the North Saskatchewan River tablelands on the south side of the river, in a low-relief area consisting of pasture and cultivated fields, with stands of shrubs in some locations and denser, treed areas in the northern part. Some wetland vegetation was observed in local depressions. Runoff from some areas of the TOTAL lands flows to lower Astotin Creek, a tributary of Beaverhill Creek, which flows to the North Saskatchewan River.

Surface flow patterns away from the TOTAL lands are strongly influenced by ditches associated with existing public roadways. Drainage patterns at the TOTAL lands and adjacent areas were determined from site reconnaissance and available digital elevation model (DEM) data (see Figure 3.1-4).

The TOTAL lands are centred on a local high, where the natural drainage pattern conveys runoff from eastern areas to Astotin Creek, from western areas to the North Saskatchewan River via a small, unnamed watercourse and from northern areas to the North Saskatchewan River via roadside ditches. Drainage to local swales is typically over land slopes of approximately 1% and swale slopes at the TOTAL lands are 0.25% or less, with depression storage in some local lows.



TOTAL

TITLE

FIGURE 3.1-4
DRAINAGE PATTERNS AND WATERCOURSES OF THE TOTAL LANDS

SCALE

250 0 250 500 750

Distance in Metres

3.1.2 North Saskatchewan River Flow Regime

Long-term streamflow data from the Environment Canada hydrometric station on the North Saskatchewan River at Edmonton (Station 05DF001) were used to generate statistics to characterize the flow regime of the North Saskatchewan River (Environment Canada 2006b).

The North Saskatchewan River at Edmonton has a gross drainage area of 28,000 km^2 and an effective drainage area of 27,300 km^2. The North Saskatchewan River in the LSA has a gross drainage area of 33,000 km^2, or 18% greater than at the upstream hydrometric station. Additional drainage area between the two is provided by tributaries, including:

- Sturgeon River (gross drainage area of 3350 km^2 and effective drainage area of 2490 km^2)
- Ross Creek (gross drainage area of 111 km^2)
- Pointe-aux-Pins Creek (gross drainage area of 141 km^2)
- Oldman Creek (gross drainage area of 130 km^2)

These minor tributaries have low water yields compared with the upper North Saskatchewan River watershed and flow in the RSA originates mainly in the upper watershed. Under natural flow conditions, mean annual flow of the North Saskatchewan River increases by only 4% between Devon and the Elk Point Bridge (AENV 2005). North Saskatchewan River flows in the reach near the LSA can be characterized by the historical record from Station 05DF001.

Flow in the North Saskatchewan River is regulated at two locations: the Brazeau Dam on the Brazeau River (since 1961) and the Bighorn Dam on the North Saskatchewan River (since 1972). These are hydroelectric facilities operated by TransAlta Utilities. The dams are operated to meet peak power demands and cause fluctuations in the North Saskatchewan River flow rate over the course of a day. They have also caused mean winter flows to increase substantially and have reduced peak flood flows on the North Saskatchewan River (NSWA 2006). Alberta Environment (AENV 2005) presented results of a study to derive naturalized flows on the North Saskatchewan River for the period 1912 to 2002.

For long-term monthly flow statistics for the North Saskatchewan River at Edmonton, see Table 3.1-6, which includes the results of the analysis of naturalized flows for the period 1912 to 2002, naturalized flows for the post-dam period 1973 to 2002 and recorded flows for the concurrent period 1973 to 2002. Table 3.1-6 also shows that mean flows during the winter months (November through March) are substantially higher in the post-dam period, and mean flows in the adjacent months of October and April are also marginally greater. Mean flows during the open-water months of May through September are currently smaller than if the dams had not been constructed, due to storage and release during the winter months. Annual flows are only slightly affected by the dams.

Table 3.1-6 Monthly Discharges for Station 05DF001 North Saskatchewan River at Edmonton (1912–2002)

Month	Minimum			Mean			Maximum		
	Naturalized (1912–2002)	Naturalized (1973–2002)	Recorded (1973–2002)	Naturalized (1912–2002)	Naturalized (1973–2002)	Recorded (1973–2002)	Naturalized (1912–2002)	Naturalized (1973–2002)	Recorded (1973–2002)
January	15.7	15.7	82.2	35.9	31.8	114	70.5	69.3	160
February	16.8	16.8	82.6	34.8	33.1	116	65.6	57.0	153
March	14.7	14.7	90.8	46.1	54.9	133	111	111	192
April	67.4	89.7	149	156	160	228	407	407	432
May	102	128	135	290	265	246	1100	429	431
June	240	266	188	547	485	327	1080	1030	857
July	288	322	138	560	552	365	1210	1030	851
August	225	225	134	390	365	231	820	601	479
September	126	126	108	250	227	182	738	371	298
October	49.2	49.2	91.1	135	128	152	293	273	260
November	25.1	25.1	79.2	65.4	57.4	128	130	127	188
December	16.9	16.9	76.0	37.1	30.8	120	83.8	83.8	192
Annual	136	136	140	214	201	195	365	299	293

The naturalized flow study did not provide the daily data required to examine flood peak discharges. For results of analysis of minimum and maximum annual mean daily flows, considering the pre- and post-dam periods, see Table 3.1-7. Existing and future conditions are represented by the post-dam streamflow regime.

Table 3.1-7 Extreme Flood and Low Flow Discharges for Station 05DF001 North Saskatchewan River at Edmonton (1912–2005)

Return Period (years)	Minimum Mean Daily Discharge (m^3/s)		Maximum Mean Daily Discharge (m^3/s)		Maximum Instantaneous Discharge (m^3/s)	
	Pre-Dam (1912–1960)	Post-Dam (1973–2005)	Pre-Dam (1911–1960)	Post-Dam (1973–2005)	Pre-Dam (1911–1960)	Post-Dam (1973–2005)
2	20.9	64.9	1080	731	1250	832
5	15.1	50.2	1700	1250	1920	1380
10	12.0	41.6	2250	1740	2510	1900
20	9.61	34.2	2900	2350	3230	2580
50	7.09	25.6	3990	3420	4430	3790
100	5.56	19.9	5040	4500	5590	5050
7Q10	15.4	59.1	n/a	n/a	n/a	n/a

3.1.3 Regional Study Area

The RSA includes the LSA and extended reaches of the North Saskatchewan River, upstream from the Sturgeon River confluence to Devon, and downstream from the Redwater River confluence to Pakan. Because the North Saskatchewan River flow regime in the RSA is adequately characterized by the analysis for the LSA, no RSA flow regime analysis was required.

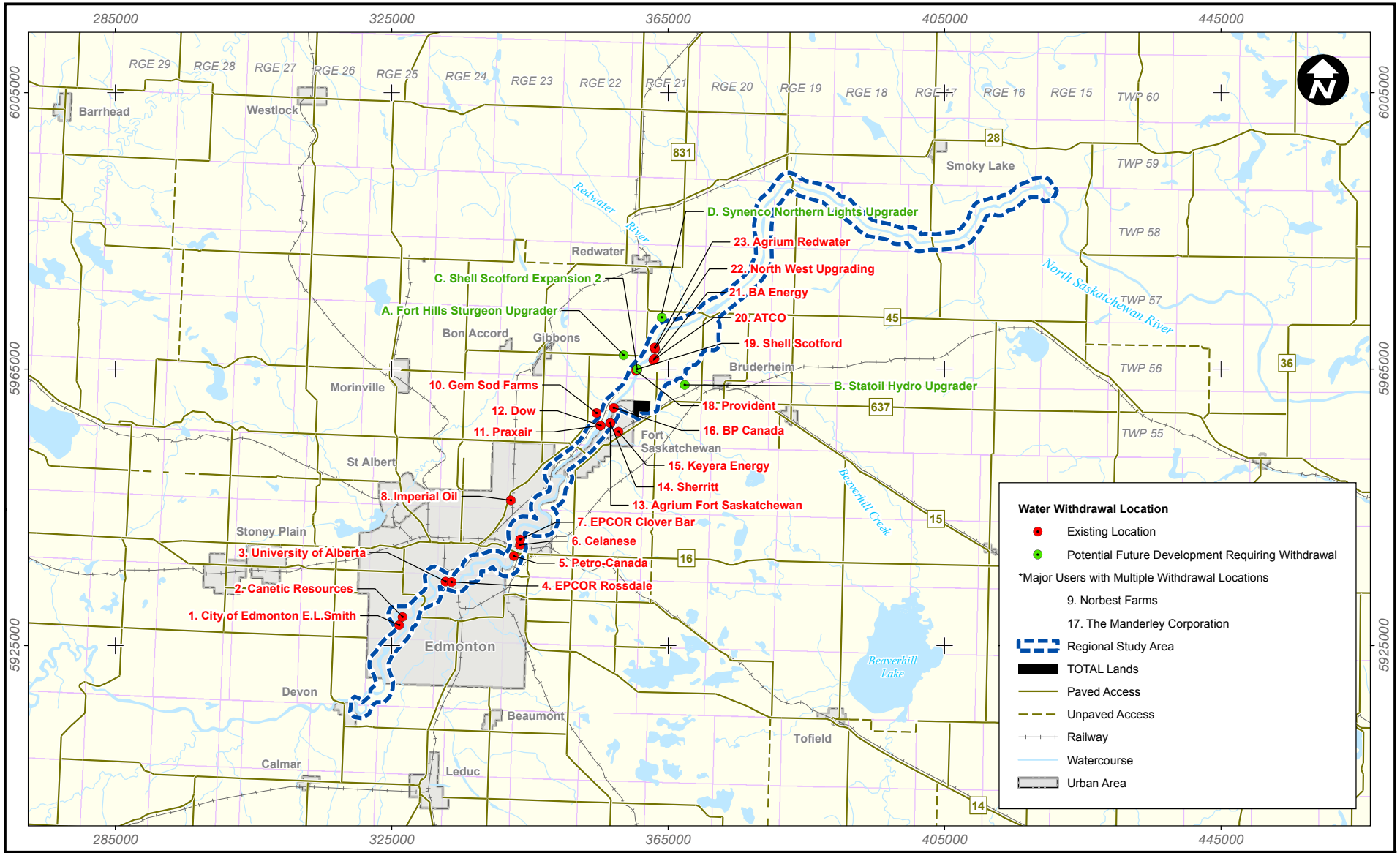
3.1.3.1 Licensed Withdrawals from the North Saskatchewan River

There are 433 surface water withdrawal licences in the North Saskatchewan River watershed (AENV 2005), including those from North Saskatchewan River tributaries. Water consumed was allocated as follows:

- 70% allocated to 14 licences
- 80% allocated to 23 licences
- 90% allocated to 44 licences
- 10% allocated to remaining 90% of licences

An updated list of water licences (AENV 2007) was used to examine water withdrawals in the RSA. For the locations of users with licensed water withdrawals greater than 1,000,000 m^3/a (annual mean withdrawal rate of 32 L/s) in the RSA, see Figure 3.1-5. For a list of major licensed withdrawal values, see Table 3.1-8.

The 23 licensees responsible for the 60 licensed withdrawals listed in Table 3.1-8 comprise 97% of the licensed consumptive use in the RSA. Major water uses covered by the licences include cooling water for thermal power plants, oil and gas processing, and well injection. Many of the licences with purposes designated as “other” are chemical processing facilities. Other common water uses include hydropower, agricultural (crop and garden irrigation and stock watering), aggregate washing, lake, wetland and fishery enhancement, urban water supply and park and golf course irrigation.



TOTAL

TITLE

FIGURE 3.1-5
MAJOR WATER WITHDRAWAL LOCATIONS WITHIN THE REGIONAL STUDY AREA

SCALE

8 0 8 16 24

Distance in Kilometres

Table 3.1-8 Major Water Withdrawals in the Regional Study Area

Intake No.[1]	Permit Holder	Approval Name	Industry Activity	Location (LSD)	Licence Priority Date	Licensed Withdrawal (m^3/a)	Return Flow (m^3/a)	Consumptive Use		
								(m^3/a)	(% of 7Q10)	(% of MAF)[2]
1	City of Edmonton	Edmonton/Municipal/Edmonton City – F00219A	URBAN	SE-9-52-25-W4M	29-Oct-14	23,239,500	16,902,090	6,337,410	0.34	0.10
			URBAN	SE-9-52-25-W4M	07-Jun-54	112,562,960	81,867,050	30,695,910	1.65	0.50
2	Canetic Resources Inc.	Edmonton/Injection/Acclaim Processing Co Ltd – F09581	INJECTN	NE-9-52-25-W4M	13-Sep-56	1,356,830	0	1,356,830	0.07	0.02
			INJECTN	NE-9-52-25-W4M	11-Feb-80	313,300	0	313,300	0.02	0.01
			INJECTN	NE-9-52-25-W4M	17-Feb-88	883,180	16,040	867,140	0.05	0.01
			INJECTN	NE-9-52-25-W4M	09-May-89	2,269,610	0	2,269,610	0.12	0.04
3	University of Alberta	Edmonton/Cooling/University of Alta, WR, 11990	COOLING	SE-31-52-24-W4M	28-Sep-65	21,585,940	20,506,640	1,079,300	0.06	0.02
			COOLING	SE-31-52-24-W4M	23-Apr-79	21,585,910	20,506,610	1,079,300	0.06	0.02
4	EPCOR Power Development Corporation	Edmonton/Cooling/Edmonton Power – F27455	COOLING	SW-32-52-25-W4M	23-Aug-37	53,017,280	37,907,360	15,109,920	0.81	0.25
			COOLING	SW-32-52-25-W4M	07-Jun-54	35,871,600	25,648,200	10,223,400	0.55	0.17
			COOLING	SW-32-52-25-W4M	04-Feb-75	149,382,720	106,808,650	42,574,070	2.28	0.69
5	Petro-Canada Products Inc.	Petro-Canada Products, WR, 08806	GAS/PTRO	NE-7-53-23-W4M	14-Sep-50	3,535,160	875,770	2,659,390	0.14	0.04
			GAS/PTRO	NE-7-53-23-W4M	04-Apr-85	2,253,580	562,470	1,691,110	0.09	0.03
6	Celanese Canada Inc.	Celanese Canada Inc., WR, 09024	OTHR	NW-17-53-23-W4M	13-Nov-51	10,484,600	6,605,300	3,879,300	0.21	0.06
		Edmonton/Industrial Processing/Celanese Canada	OTHR	NW-17-53-23-W4M	19-May-94	5,553,000	1,943,550	3,609,450	0.19	0.06
7	EPCOR Power Development Corporation	Edmonton Power Inc, WR, 12258	COOLING	SW-20-53-23-W4M	18-Jul-67	234,361,200	222,643,140	11,718,060	0.63	0.19
			COOLING	SW-20-53-23-W4M	19-Oct-71	215,859,000	205,066,050	10,792,950	0.58	0.18
8	Imperial Oil Resources Ltd.	Imperial Oil Resources Ltd, WR, 08109	GAS/PTRO	NW-6-53-23-W4M	25-Feb-48	3,583,260	1,453,040	2,130,220	0.11	0.03
			GAS/PTRO	NW-6-53-23-W4M	12-Mar-73	5,667,850	2,299,210	3,368,640	0.18	0.05
9	Norbest Farms Ltd.	Norbest Farms Ltd, WR, 25230	CROP	SW-15-55-22-W4M	01-Feb-91	404,580	0	404,580	0.02	0.01
		Norbest Farms Ltd, WR, 27157	CROP	SW-14-54-23-W4M	16-Mar-95	141,850	0	141,850	0.01	0.00
		Fort Saskatchewan/Crop/Norbest Farms Limited	GRDN	SE-9-55-22-W4M	18-Feb-03	153,000	0	153,000	0.01	0.00
		Fort Saskatchewan/Crops/Norbest Farms Ltd.	CROP	NE-31-54-22-W4M	18-Mar-03	154,200	0	154,200	0.01	0.00
			CROP	SW-25-55-22-W4M	27-Feb-06	403,000	0	403,000	0.02	0.01

Table 3.1-8 Major Water Withdrawals in the Regional Study Area (cont'd)

Intake No.	Permit Holder	Approval Name	Industry Activity	Location (LSD)	Licence Priority Date	Licensed Withdrawal (m^3/a)	Return Flow (m^3/a)	Consumptive Use		
								(m^3/a)	(% of 7Q10)	(% of MAF)
10	Gem Sod Farms Inc.	Fort Saskatchewan/Sod/Gem Sod Farms Inc. – F14960	GRDN	NE-16-55-22-W4M	24-Oct-72	243,000	0	243,000	0.01	0.00
			GRDN	NE-16-55-22-W4M	09-Apr-75	214,630	0	214,630	0.01	0.00
			GRDN	NE-16-55-22-W4M	21-Jun-76	638,940	0	638,940	0.03	0.01
		Fort Saskatchewan/Sod/Gem Sod Farms Inc. – F20903	GRDN	-55-22-W4M	03-Aug-83	346,600	0	346,600	0.02	0.01
11	Praxair Canada Inc.	Praxair Canada Inc, WR, 18236	COOLING	NW-10-55-22-W4M	08-May-78	696,920	87,580	609,340	0.03	0.01
		Fort Saskatchewan/Cooling/Praxair Canada Inc – F18236	COOLING	NW-10-55-22-W4M	16-Oct-06	736,738	0	736,738	0.04	0.01
12	Dow Chemical Canada Inc.	Dow Chemical Canada Inc., WR, 16434	OTHR	NW-10-55-22-W4M	07-Jun-74	21,493,390	0	21,493,390	1.15	0.35
13	Agrium Products Inc.	Fort Saskatchewan/Processing/ Agrium Products Inc – F09094	OTHR	NE-10-55-22-W4M	24-Oct-52	1,518,510	531,480	987,030	0.05	0.02
			OTHR	NE-10-55-22-W4M	11-Feb-65	790,120	276,540	513,580	0.03	0.01
			OTHR	NE-10-55-22-W4M	11-Jul-91	1,500,000	525,000	975,000	0.05	0.02
14	Sherritt International Corporation	Fort Saskatchewan/Processing/ Sherritt International – F27640	OTHR	NE-10-55-22-W4M	24-Oct-52	2,061,720	721,190	1,340,530	0.07	0.02
			OTHR	NE-10-55-22-W4M	11-Feb-65	1,061,720	371,390	690,330	0.04	0.01
			OTHR	NE-10-55-22-W4M	11-Jul-91	2,030,860	710,400	1,320,460	0.07	0.02
15	Keyera Energy Facilities Ltd.	Chevron Canada Resources, WR, 13501	OTHR	SE-11-55-22-W4M	07-Dec-82	995,420	0	995,420	0.05	0.02
16	BP Canada Energy Company	Amoco Canada Petroleum Co Ltd, WR, 15813	OTHR	SW-23-55-22-W4M	21-Aug-81	2,047,580	0	2,047,580	0.11	0.03
			OTHR	SW-23-55-22-W4M	17-Sep-76	49,340	0	49,340	0.00	0.00
			OTHR	SW-23-55-22-W4M	02-Nov-73	49,340	0	49,340	0.00	0.00
17	The Manderley Corporation	Fort Saskatchewan/Sod/The Manderley Corporation	CROP	SE-26-55-22-W4M	16-Jan-78	405,810	0	405,810	0.02	0.01
		Fort Saskatchewan/Sod/The Manderley Corporation – F26323	GRDN	SE-15-55-22-W4M	19-Mar-93	65,300	0	65,300	0.00	0.00
		Fort Saskatchewan/Irrigation/The Manderley Corporation – F26522	GRDN	SE-26-55-22-W4M	14-Sep-93	388,710	0	388,710	0.02	0.01
		Fort Saskatchewan/Sod/The Manderley Corporation	GRDN	NW-25-55-22-W4M	24-Mar-03	265,000	0	265,000	0.01	0.00
			GRDN	NE-36-44-22-W4M	04-Apr-03	755,208	0	755,208	0.04	0.01

Table 3.1-8 Major Water Withdrawals in the Regional Study Area (cont'd)

Intake No.	Permit Holder	Approval Name	Industry Activity	Location (LSD)	Licence Priority Date	Licensed Withdrawal (m^3/a)	Return Flow (m^3/a)	Consumptive Use		
								(m^3/a)	(% of 7Q10)	(% of MAF)
18	Provident Energy Ltd.	Redwater/Washing/Procor Limited – F16821	OTHR	NW-6-56-21-W4M	30-Oct-74	123,350	0	123,350	0.01	0.00
			OTHR	NW-6-56-21-W4M	06-Mar-80	874,540	0	874,540	0.05	0.01
		Bruderheim/Washing/Novagas – F16821	GAS/PTRO	NW-6-56-21-W4M	23-Jun-98	123,400	0	123,400	0.01	0.00
		Redwater/Washing Salt Caverns/Provident Energy Ltd – F16821	OTHR	NW-6-56-21-W4M	01-May-07	2,250,000	0	2,250,000	0.12	0.04
		Fort Saskatchewan/Other/Provident Energy Ltd – F16821	OTHR	NW-6-56-21-W4M	–	1,200,000	0	1,200,000	0.06	0.02
19	Shell Canada Products Ltd.	Shell Canada Resources Ltd, WR, 14675	OTHR	NW-6-56-21-W4M	16-Apr-81	8,243,120	3,763,700	4,479,420	0.24	0.07
		Beamer/Industrial Processing/Shell Chemicals – F14675	GAS/PTRO	NW-6-56-21-W4M	04-Feb-98	5,059,400	0	5,059,400	0.27	0.08
	Shell Canada Ltd.	Fort Saskatchewan/Oil Extraction/Shell Scotford Upgrader	GAS/PTRO	NW-6-56-21-W4M	12-Mar-98	8,146,800	1,944,720	6,202,080	0.33	0.10
		Shell Canada Scotford Expansion 1[3]	N/A	NW-6-56-21-W4M	N/A	7,358,400	2,785, 680	4,572,720	0.25	0.07
20	ATCO Gas and Pipelines Ltd.	Northwestern Utilities Ltd, WR, 20375	OTHR	NE-8-56-21-W4M	11-Jun-82	3,700,440	0	3,700,440	0.20	0.06
21	BA Energy Inc.	Fort Saskatchewan/Upgrader Facility/BA Energy – F00208953	GAS/PTRO	NE-8-56-21-W4M	19-Oct-05	3,703,200	0	3,703,200	0.20	0.06
22	North West Upgrading Inc.	Northwest Upgrading[4]	N/A	NE-17-56-21-W4M	N/A	6,570,000	0	6,570,000	0.35	0.11
23	Agrium Products Inc.	Viridian Inc, WR,12290	OTHR	NE-17-56-21-W4M	22-Nov-67	7,959,007	795,600	7,163,407	0.38	0.12
			OTHR	NE-17-56-21-W4M	29-Oct-80	7,687,537	768,460	6,919,077	0.37	0.11
152 Smaller Licences (Consumptive Use Less Than 1 Mm^3/a)						13,106,773	4,473,840	8,632,933	0.46	0.14
Total Existing and Approved						**1,019,083,933**	**766,581,070**	**249,717,183**	**13.4**	**4.06**

Table 3.1-8 Major Water Withdrawals in the Regional Study Area (cont'd)

Intake No.	Permit Holder	Approval Name	Industry Activity	Location (LSD)	Licence Priority Date	Licensed Withdrawal (m^3/a)	Return Flow (m^3/a)	Consumptive Use		
								(m^3/a)	(% of 7Q10)	(% of MAF)
A	Petro-Canada	Sturgeon Upgrader[5]	N/A	-7-56-22-W4M	N/A	14,454,000	2,628,000	11,826,000	0.6	0.19
B	North American Oil Sands	North American Oil Sands Upgrader[6]	N/A	N/A	N/A	10,000,000	0	10,000,000	0.5	0.16
C	Shell Canada Ltd.	Scotford Expansion 2[7]	N/A	NW-6-56-21-W4M	N/A	39,420,000	13,140,000	26,280,000	1.4	0.43
D	Synenco	Northern Lights Upgrader[8]	N/A	-56-21-W4M	N/A	10,300,000	0	10,300,000	0.6	0.17
					Total Future Projects	**74,174,000**	**15,768,000**	**58,406,000**	**3.13**	**0.95**
					Total All Projects	**1,093,257,933**	**782,349,070**	**308,123,183**	**16.53**	**5.01**

NOTES:
N/A not applicable
[1]See Figure 3.1-5
[2]MAF mean annual flow
[3]Shell (2005)
[4]North West Upgrading (2006)
[5]Petro-Canada (2006)
[6]Values estimated based on other similar projects
[7]Shell (2007)
[8]Synenco (2006)

Some facilities have multiple licences that reflect past expansions or other changes, and these have been added together where appropriate. Calculated values of consumptive use as a percentage of 7Q10 and mean annual flow are based on the post-dam 7Q10 value of 59.1 m^3/s and post-dam mean annual flow of 195 m^3/s. Existing and future licensed consumptive use in the RSA are 16.5% of post-dam 7Q10 and 5.0% of post-dam mean annual flow.

There are 140 licensed water withdrawals on the North Saskatchewan River between the downstream limit of the RSA and the Saskatchewan border. The total licensed withdrawal is 50.2 Mm^3/a, and the total licensed consumptive use is 26.4 Mm^3/a. The total licensed consumptive use is equal to 1.4% of the post-dam 7Q10 and 0.4% of the post-dam mean annual flow.

3.2 Summary

3.2.1 Local Study Area

Key hydrology findings in the LSA can be summarized as follows:

- Long-duration precipitation for the LSA is based on data from the Environment Canada climate station at Fort Saskatchewan. Mean annual precipitation in the LSA is 441 mm, including 337 mm of rainfall and 104 mm of snowfall (expressed as a snow–water equivalent).
- Short-duration rainfall for the LSA is based on data from the Environment Canada climate station at Edmonton City Centre Airport. The 10-year, 24-hour rainfall in the LSA is 84 mm (3.5 mm/h) and the 100-year, 24-hour rainfall in the LSA is 130 mm (5.4 mm/h).
- Flood and low-flow discharges and annual water yields in the LSA can be estimated from site-specific and regional data. Beaverhill Creek, with a gross drainage area of 2930 km^2, was monitored by Environment Canada from 1975 to 1986. It has a 100-year maximum instantaneous flood discharge of 154 m^3/s, a 2-year maximum instantaneous flood discharge of 12.4 m^3/s and a mean annual discharge of 0.409 m^3/s. Low flows typically fall to zero, even during the open-water season, and its mean annual water yield is 4 mm. The hydrology of Beaverhill Creek is greatly influenced by storage and evaporation at Beaverhill Lake in the upper watershed.
- Flow estimates for Astotin Creek, which has a gross drainage area of 126 km^2, were based on a regional hydrological analysis. Astotin Creek is estimated to have a 100-year maximum instantaneous flood discharge of 15.8 m^3/s, a two-year maximum instantaneous flood discharge of 2.37 m^3/s and a mean annual discharge of 0.08 m^3/s. Because Astotin Creek is a tributary of Beaverhill Creek, low flows are expected to fall to zero, even during the open water season, and its mean annual water yield is estimated to be approximately 20 mm.

- The TOTAL lands are located on a local high, where the natural drainage pattern conveys runoff from eastern areas to Astotin Creek, from western areas to the North Saskatchewan River via a small, unnamed watercourse and from northern areas to the North Saskatchewan River via roadside ditches.
- The North Saskatchewan River near the LSA has a gross drainage area of approximately 33,000 km^2 and its flow regime is adequately described using data from the Environment Canada hydrometric station on the North Saskatchewan River at Edmonton. Its flow is regulated by two upstream dams, which reduce peak flows and increase low flows from the hydrological regime that existed before regulation. Based on the post-dam period 1973 to 2005, the North Saskatchewan River has a 100-year maximum instantaneous flood discharge of 5050 m^3/s and a two-year maximum instantaneous flood discharge of 832 m^3/s. The mean annual discharge for the period 1973 to 2002 was 195 m^3/s. Low flows typically occur under winter ice-covered conditions. Based on the post-dam period 1973 to 2005, the 10-year low-flow discharge is 41.6 m^3/s and the 100-year low-flow discharge is 19.9 m^3/s. Mean annual water yield at Edmonton is 220 mm (based on gross drainage area).

3.2.2 Regional Study Area

Key hydrology findings in the RSA can be summarized as follows:

- The RSA includes the LSA as well as an extended reach of the North Saskatchewan River from Devon to Pakan.
- The North Saskatchewan River flow regime throughout the RSA is similar to that described for the LSA (see Section 3.2.1).
- Total licensed consumptive use of the North Saskatchewan River for existing and approved projects in the RSA is 250 Mm^3/a. This quantity averaged over the year is equal to 13.4% of the 7Q10 low flow. Total licensed withdrawals from the North Saskatchewan River for future projects equal 58.4 Mm^3/a. This quantity averaged over the year is equal to 3.1% of the 7Q10 low flow.

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