# Design Flood Hydrology in the Resource Sector
# Northern B.C. Case Studies


ONSITE Engineering Ltd.

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June 23, 2020

FPInnovations

British Columbia | Ministry of Forests, Lands, Natural Resource Operations and Rural Development

# Acknowledgements


- Jean-Guy Bernat, P.Eng., OEL
- Lee Deslauriers, P.Eng., RPF, StoneCroft
- Matt Kurowski, EIT, FPInnovations
- Jason Olmsted, P.Eng., MFLNRORD
- Eric Hannula, RPF, Babine Forest Products

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        2. Environmental Considerations
        3. Materials and Structures Available
    2. Site Survey
    3. Geotechnical Investigation
        1. Rarely subsurface
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    5. Road Design
    6. Foundation Design
    7. Substructure Selection (MFLNRORD Standard Drawings)
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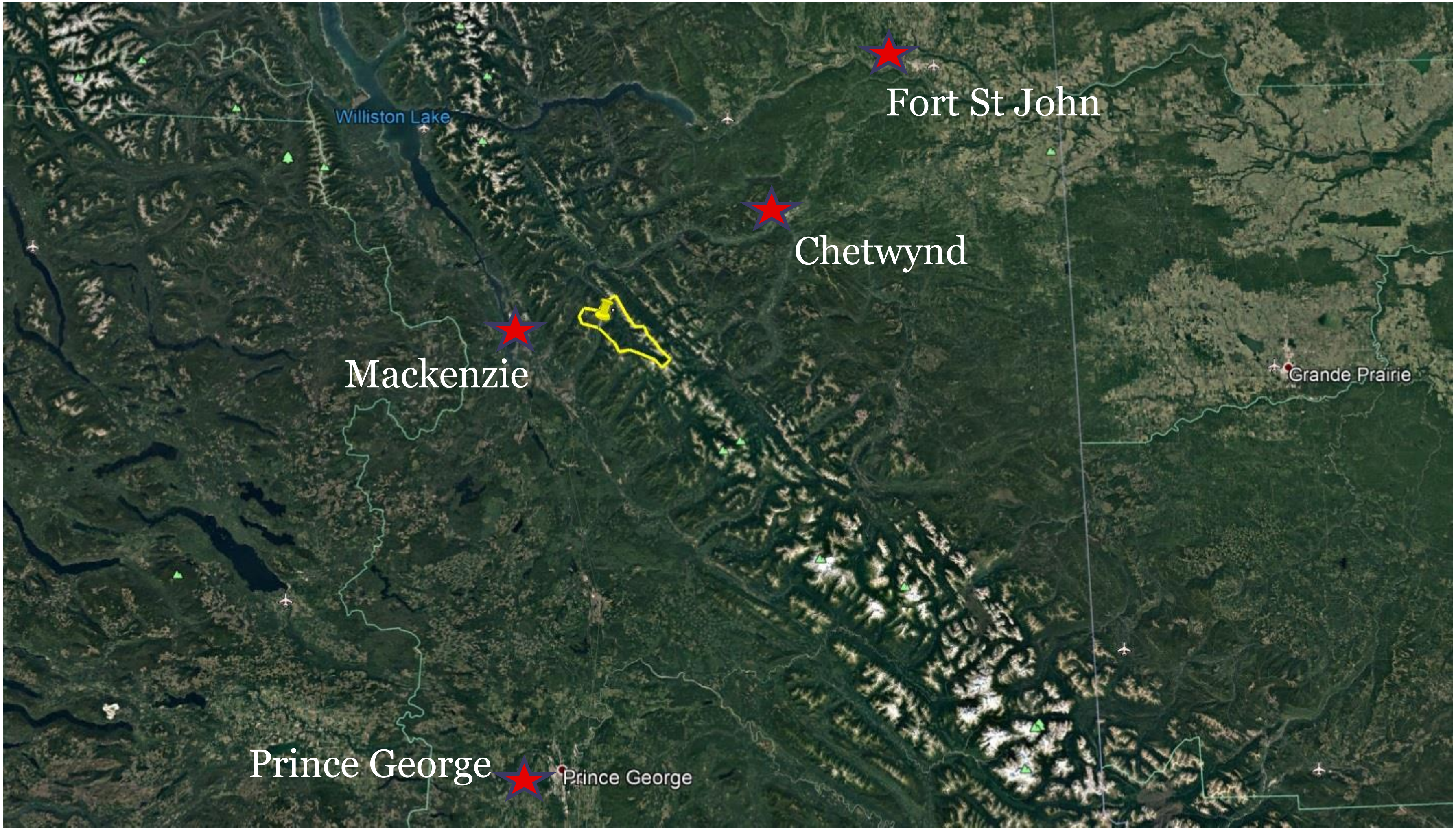
    9. Hydraulic Design
    10. Riprap Design
    11. Overall Constructability & Timing
3. 50-100 + Designs a Year
4. Typical Time Available for Hydrology: 1-4 hours

# 2. Misinchinka River (320 km$^2$)



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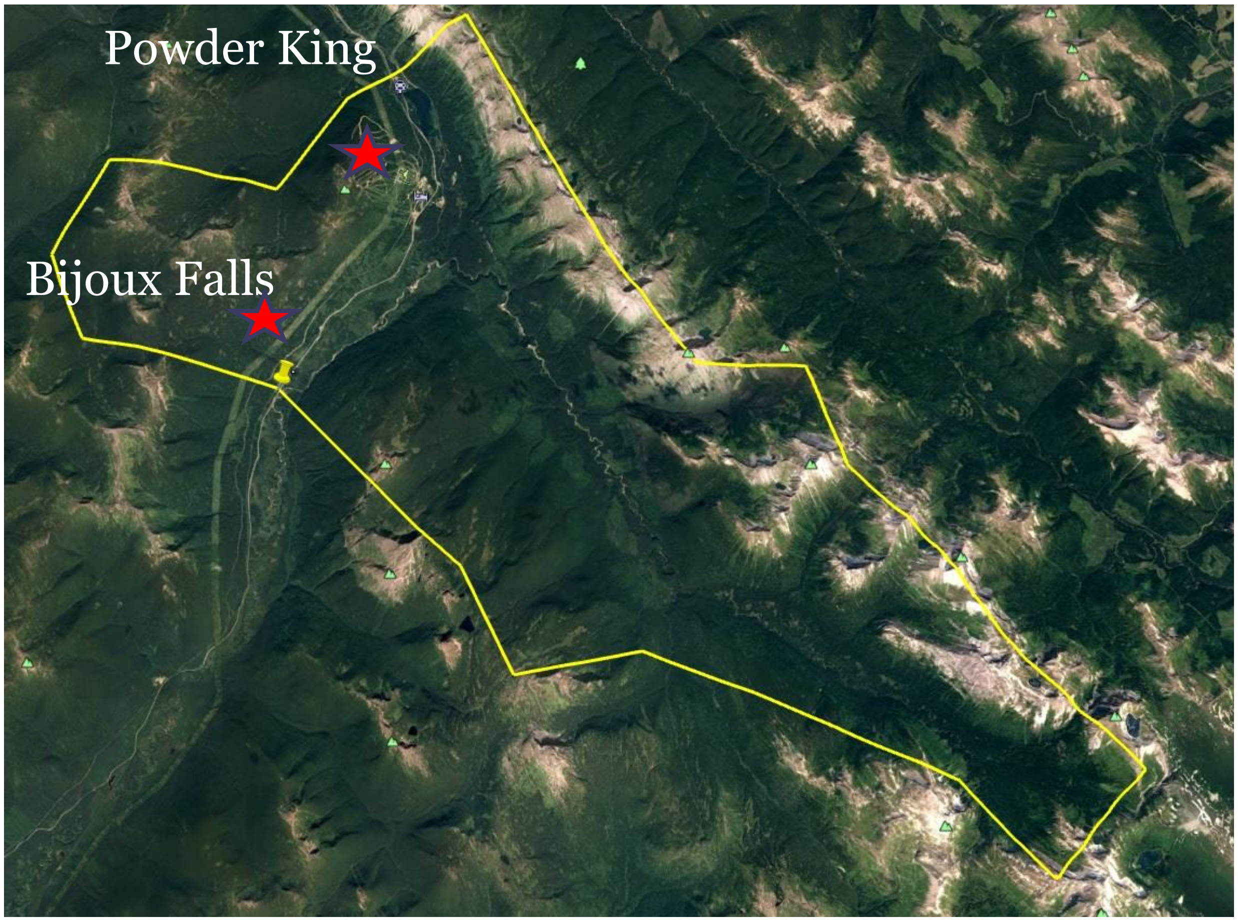



- 55°18' 04.1"N,
- 122°40' 30.8"W

- Beside Highway 97
- 2 hours North of PG

- Area: 320 km2
- Length: 40km
- Peak Elevation: 1960m
- Crossing Elevation: 750m
- Watershed Slope: 3%

- Stream Gradient at Site: 0.4%

# 2. Misinchinka River (320 km$^2$)

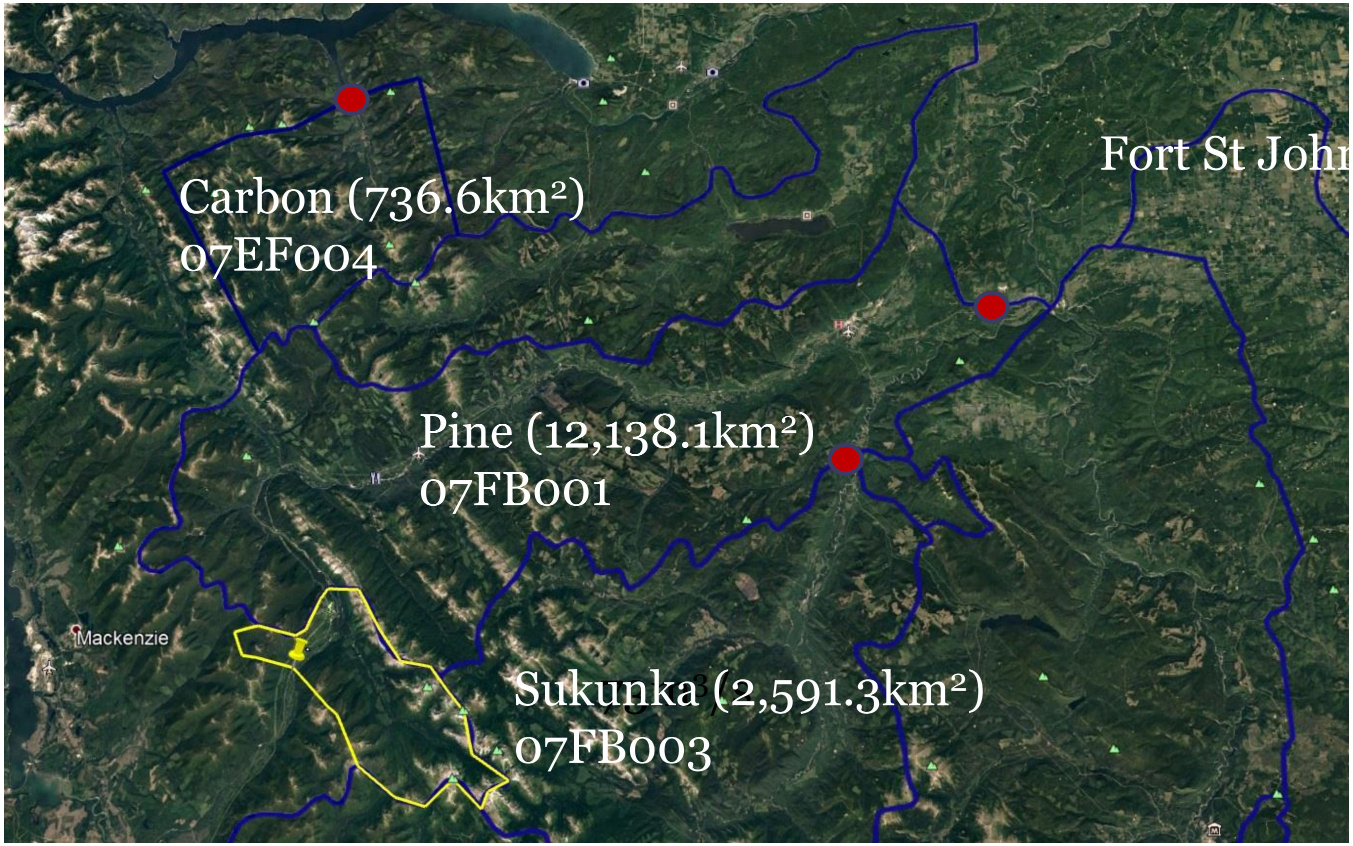
Upstream
Sept 6
2017


Upstream
Sept 14
2017

Woods to
Town
Sept 6
2017


Downstream
Sept 14
2017

# 2. Misinchinka River (320 $km^2$)




- Regional Analysis with check with channel capacity
- Similar Type and Size Gauged Watersheds in the Same Hydrologic Zone & Subzone (7)
- Pine (50 years data)
- Sukunka (33 years data)
- Carbon (14 years data)

# 2. Misinchinka River (320 km$^2$)

**Inventory of Streamflow in the Omineca and Northeast Regions**

**February 2015**

Ashfaque Ahmed, P.Eng.
Knowledge Management Branch

BRITISH COLUMBIA
Ministry of Environment

Inventory of Streamflow in the Omineca and Northeast Regions
A. Ahmed, BC MOE, February 2015

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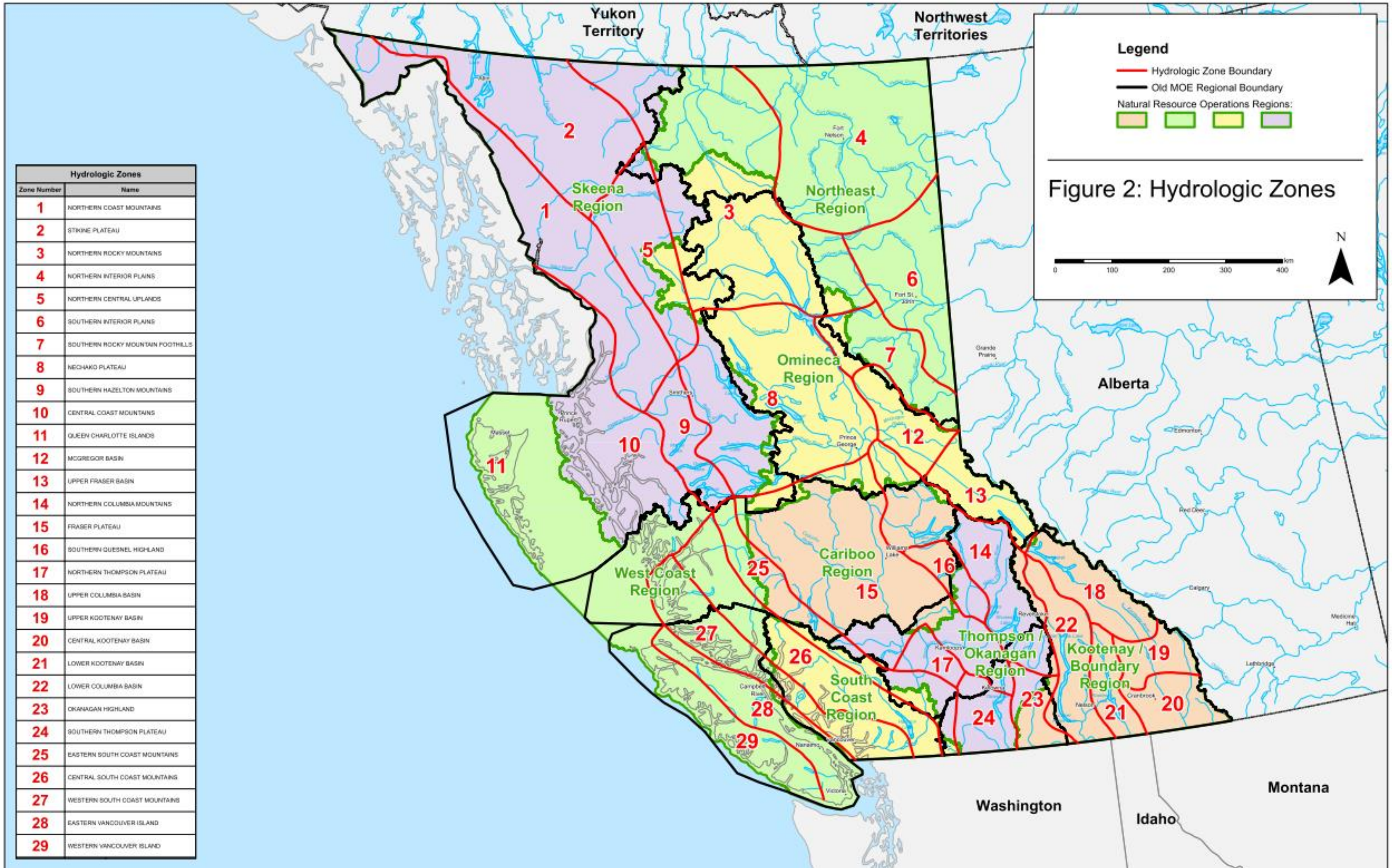


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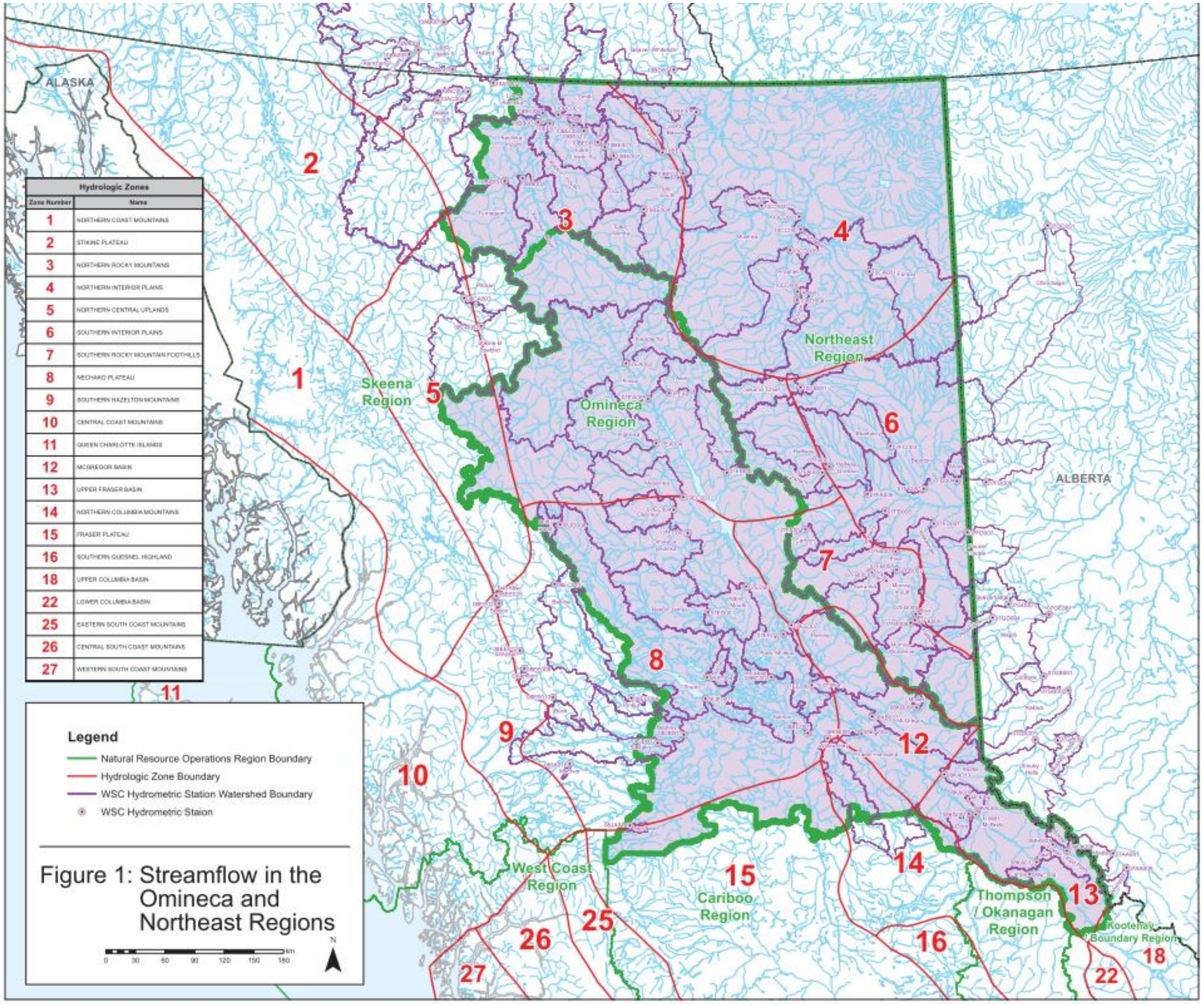


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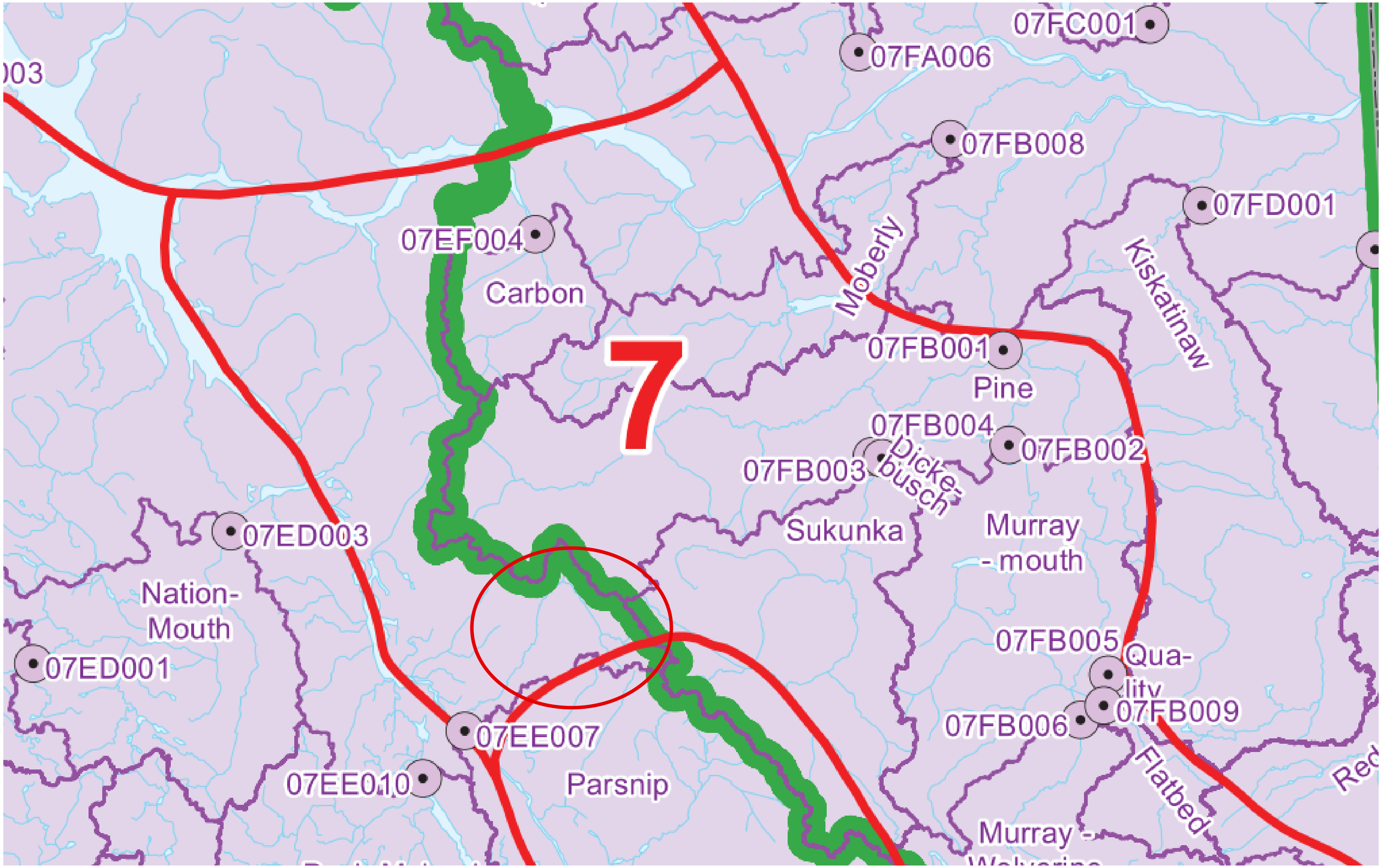


Inventory of Streamflow in the Omineca and Northeast Regions

A. Ahmed, BC MOE, February 2015

# 2. Misinchinka River (320 km$^2$)

BRITISH COLUMBIA

Ministry of Environment, Lands & Parks

**Streamflow in the Omineca-Peace Region**

**W. Obedkoff, P.Eng.**

**Water Inventory Section**
**Resources Inventory Branch**

**September 2000**

- Previous Report & Method

Peak flow from an ungauged watershed in the Omineca-Peace region can be estimated by use of the regionalized information presented in this report. The general procedure would consist of locating the topic watershed on a map (Figure 1), identifying the subzone and its design curve and then estimating its peak flow from Figure 3. If the basin of interest is located near or within one of the observed watersheds more weight would be given to this point and a parallel line would be drawn through it (or close by) in the graph to the projected area of the basin. If the basin straddles a subzone boundary the point would be located between the subzone curves in proportion to the areas within each subzone. Peak flow estimates based on the above procedure would be for a 10-year recurrence interval; estimates for other recurrence intervals could be made by reference to the frequency relationships in relevant data sheets of the BCSI report.

Streamflow in the Omineca-Peace Region
W. Obedkoff, BC MOE, September 2000

# 2. Misinchinka River (320 km$^2$)

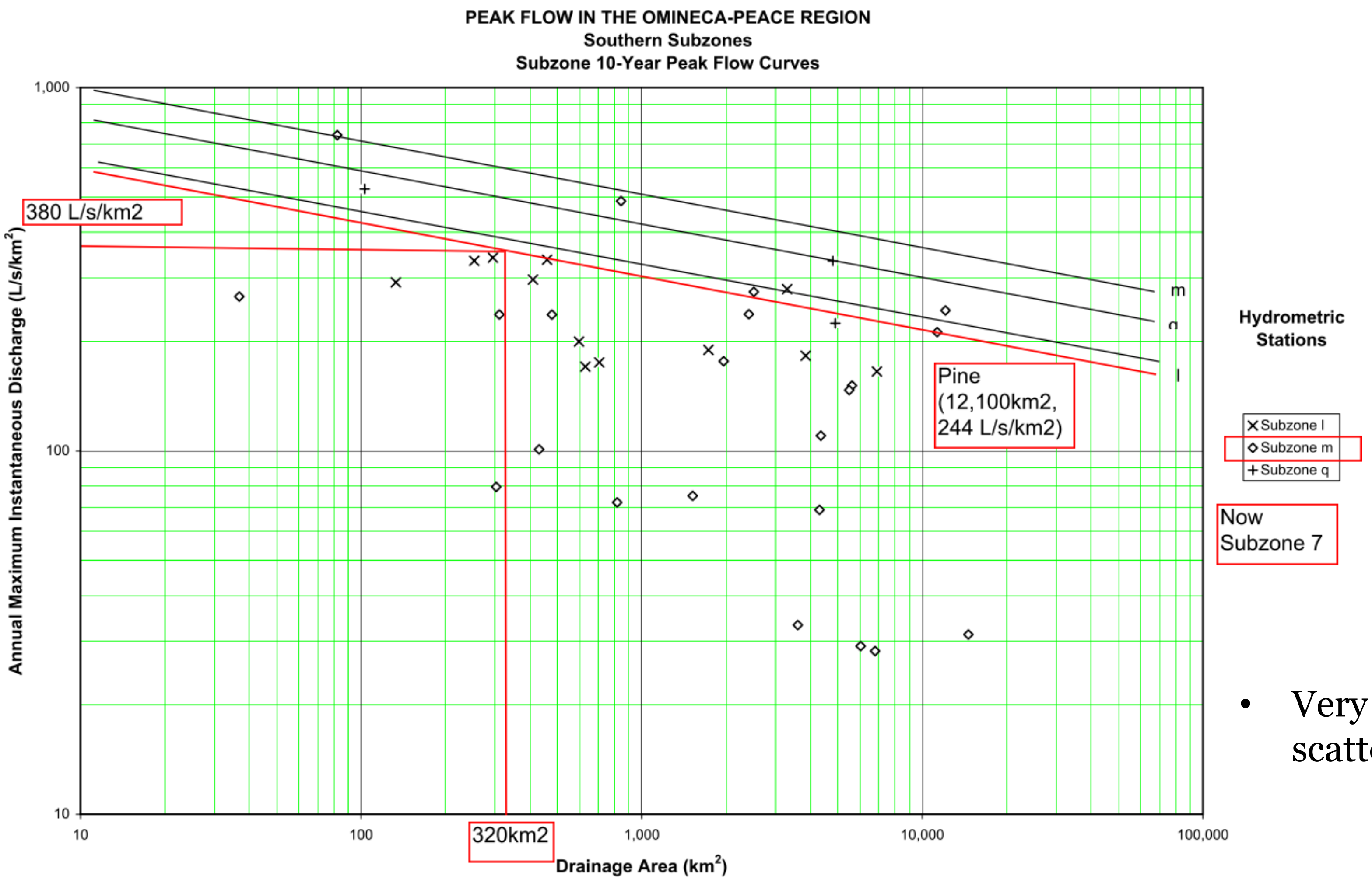


Figure 3 Watershed Peak Flow (continued)

- Very large scatter zone m

Streamflow in the Omineca-Peace Region

W. Obedkoff, BC MOE, September 2000

# 2. Misinchinka River (320 $km^2$)

From Pine Gauged Watershed:

- $Q10 = 380\ L/s/km^2 * 320\ km^2$
- $Q10 = 121{,}600\ L/s/km^2$
- $Q10 = 121.6\ m^3/s$

- Q100:Q10 Ratio for Pine River = 2.1

- $Q100 = 255 m^3/s$

- Assumption:
    - Similar Style Watershed
    - It is reasonable to scale off that watershed
    - Q2:Q10:Q100 multipliers are valid for design watershed
        - Is this reasonable going from 12,100$km^2$ to 320$km^2$ watersheds?

- However…

Streamflow in the Omineca-Peace Region

W. Obedkoff, BC MOE, September 2000

# 2. Misinchinka River (320 km$^2$)

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Ashfaque Ahmed, P.Eng.
Knowledge Management Branch

British Columbia
Ministry of Environment

In contrast to the previous version of this report, hydrologic zone design curves are not included for the various streamflow indices. Despite the substantial effort that went into delineating zones with similar streamflow characteristics, significant variability still exists within each zone. In many cases when using this report, professional judgment is required to decide which stations are most representative of the ungauged watershed in

question. In addition, because the frequency analyses in this iteration used all available data, the record period is not the same for all stations. Therefore, the relative position of a particular station's streamflow metric (e.g., peak flow) on the plots is influenced in part by the length of the record period analyzed, and so all stations are not necessarily directly comparable. Finally, several stations included in the original report have been decommissioned, resulting in fewer data points from which to draw a regional curve.

In short:

- Previous method is no longer valid for Omineca and Northeast Regions

- Carbon (14 years) vs Pine (50 years)

Inventory of Streamflow in the Omineca and Northeast Regions
A. Ahmed, BC MOE, February 2015

# 2. Misinchinka River (320 km$^2$)

- How scale from gauged watershed?
- $Q_2 = Q_1 (A_2/A_1)^n$
- RTAC Drainage Manual Volume 1, n =0.6 to 0.75 (1982)
- n = 0.6 to 1.0 (linear), 0.75 on average in BC – Eaton et al (2002)

| Hydro-logic Zone | Watershed Stream | Hydrometric Station | Drainage Area (km$^2$) | Median Elevation (m) | Normal Annual Runoff[1] (mm) | Normal Annual Runoff[1] (m$^3$/s) | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual Flow Ratio 10-Year : Avg Year High | Annual Flow Ratio 10-Year : Avg Year Low | Peak Flow 10 - Year (m$^3$/s) | Peak Flow Ratio 100-Yr:10-Yr |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 | Carbon | 07EF004 | 736.6 | 1345 | 525 | 12.25 | 1 | 1 | 1 | 2 | 26 | 36 | 13 | 4 | 5 | 5 | 3 | 2 | 1.44 | 0.62 | 255.06 | 1.96 |
| 7 | Cutbank | 07GB001 | 840.8 | 1138 | | | | | | | | | | | | | | | | | 326.43 | 2.94 |
| 7 | Dickebusch | 07FB004 | 84.8 | 1053 | 215 | 0.58 | 1 | 0 | 1 | 8 | 27 | 21 | 20 | 9 | 6 | 4 | 2 | 1 | 1.62 | 0.43 | 57.71 | 6.43 |
| 7 | Flatbed | 07FB009 | 478.7 | 1129 | 270 | 4.09 | 1 | 1 | 1 | 10 | 31 | 22 | 15 | 7 | 6 | 4 | 3 | 2 | 1.43 | 0.61 | 141.51 | 3.09 |
| 7 | Moberly | 07FB008 | 1521.7 | 938 | 235 | 11.34 | 1 | 1 | 1 | 5 | 24 | 32 | 16 | 7 | 4 | 4 | 3 | 2 | 1.38 | 0.63 | 122.10 | 1.79 |
| 7 | Murray - mouth | 07FB002 | 5554.3 | 1162 | 471 | 82.96 | 2 | 1 | 2 | 5 | 22 | 26 | 15 | 7 | 6 | 7 | 4 | 2 | 1.25 | 0.75 | 959.18 | 1.53 |
| 7 | Murray - Wolverine | 07FB006 | 2385.4 | 1303 | 755 | 57.07 | 2 | 1 | 2 | 5 | 21 | 27 | 15 | 7 | 7 | 7 | 4 | 2 | 1.21 | 0.78 | 615.93 | 1.63 |
| 7 | Pine | 07FB001 | 12138.1 | 1125 | 475 | 182.66 | 2 | 1 | 2 | 5 | 25 | 27 | 13 | 6 | 5 | 6 | 4 | 2 | 1.24 | 0.76 | 2664.47 | 1.91 |
| 7 | Quality | 07FB005 | 26.3 | 1087 | 233 | 0.19 | 1 | 1 | 1 | 14 | 23 | 17 | 17 | 9 | 6 | 4 | 2 | 1 | 1.66 | 0.43 | 11.26 | 3.86 |
| 7 | Sukunka | 07FB003 | 2591.3 | 1198 | 671 | 55.08 | 1 | 1 | 2 | 6 | 29 | 27 | 12 | 4 | 5 | 7 | 4 | 2 | 1.22 | 0.78 | 730.82 | 1.36 |

- Using n = 1.0 , n=0.75, 0.6,
- Carbon: Q100 = 217 : 267 : 303 m$^3$/s (737km$^2$, 14 yrs)
- Pine: Q100 = 78 : 333 : 574 m$^3$/s ... before 255 m$^3$/s (12,138km$^2$, 50 yrs)
- Sukunka: Q100 =127 : 207 : 283 m$^3$/s ... before 187 m$^3$/s (2,591km$^2$, 33 yrs)

- Range: 207 to 574 m$^3$/s or even 78 to 574 m$^3$/s

- ... is equation valid ... are n values even reasonable .... Previously n = 0.85?

Inventory of Streamflow in the Omineca and Northeast Regions

A. Ahmed, BC MOE, February 2015

# 2. Misinchinka River (320 km$^2$)

- Either Sukunka or Pine for Q100
  - Primarily Sukunka as closer in watershed size and potential scaling issues
  - Q100 = 250 m$^3$/s
    - Unit Q100 = 0.78m$^3$/s per km$^2$

In B.C. there are 675 hydrometric stations with maximum daily discharge records (excluding large river, multizone stations) and 285 maximum instantaneous discharge records with adequate lengths for frequency analysis. These station totals (tallied in 1984) include at least eight years record but stations with at least five years have been used for short recurrence interval estimates. The criteria arbitrarily adopted for extending the recurrence interval of frequency estimates beyond the sample record length are listed in Table 2. These criteria are used in the regionalization procedures described in Section 7.4.

TABLE 2. Recurrence Interval Extension Criteria

From: Manual of Operational Hydrology in BC 2nd Ed. 1991

| MAXIMUM RECURRENCE INTERVAL USED IN PEAK FLOW REGIONALIZATION (yrs.) | | | |
|---|---|---|---|
| Simplified Procedure | | Preliminary Design | |
| Record Length | Estimate Limit | Record Length | Estimate Limit |
| | | 5-7 | 10 |
| 8-14 | 25 | 8-10 | 25 |
| 15-20 | 50 | 11-15 | 50 |
| 21-50 | 100 | 16-19 | 100 |
| > 50 | 200 | > 19 | 200 |

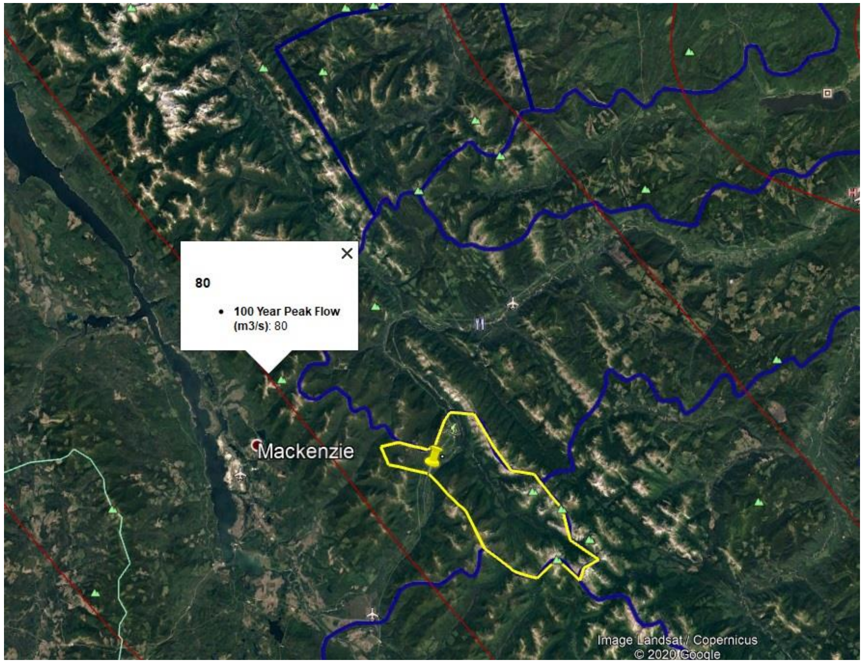
Manual of Operational Hydrology in British Columbia

Coulson, C.H. (& W. Obedkoff for Peak Flow Studies), 1991

# 2. Misinchinka River (320 km$^2$)

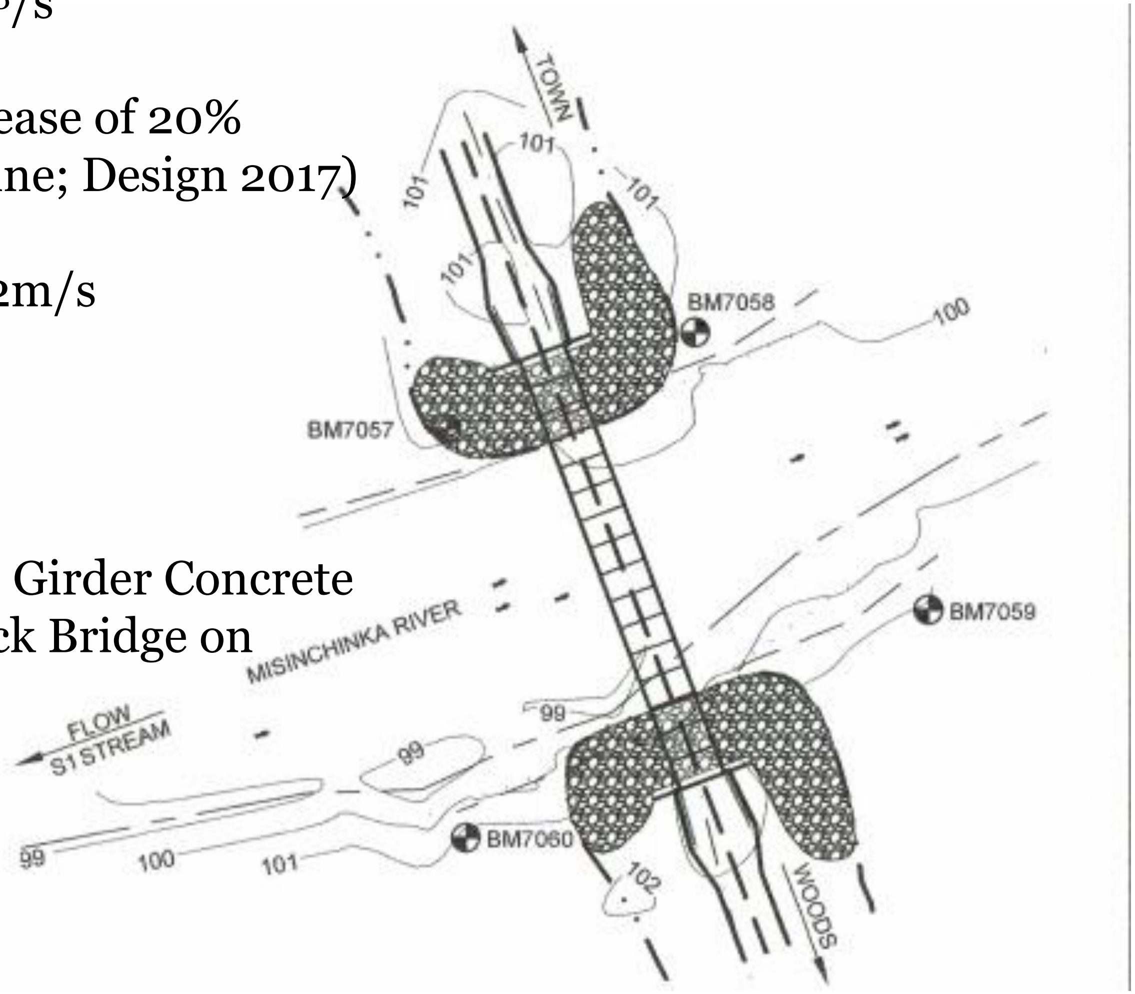
- Alternative Q100 Calculations
  - Download stream data from gauged stations and perform own statistical analysis
  - World of statistics is complex, none of us at OEL are experts in the field and we typically rely on procedures established by others

- Isolines
  - 80 m$^3$/s/100km * 320 km = 256 m$^3$/s



# 2. Misinchinka River (320 km$^2$)

- Initial Q100 = 250m$^3$/s
- Climate Change increase of 20%
  (EGBC Guideline; Design 2017)
- Q100 = 300m$^3$/s @ 2m/s
- 1.5m Q100 clearance
- 48.768m (160') Steel Girder Concrete
  Composite Deck Bridge on
  Driven Piles



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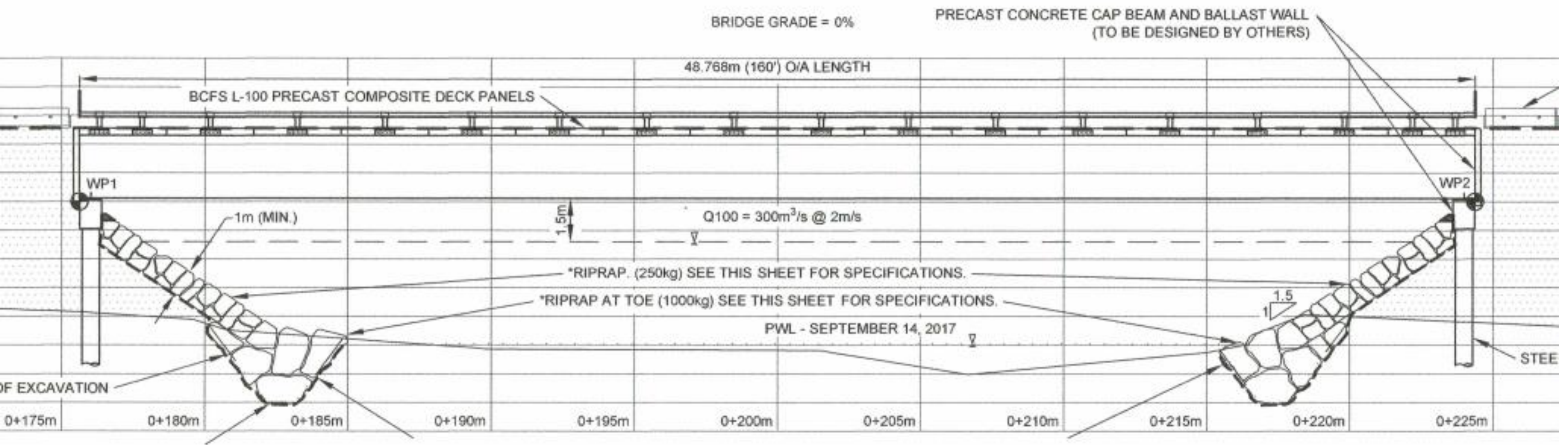
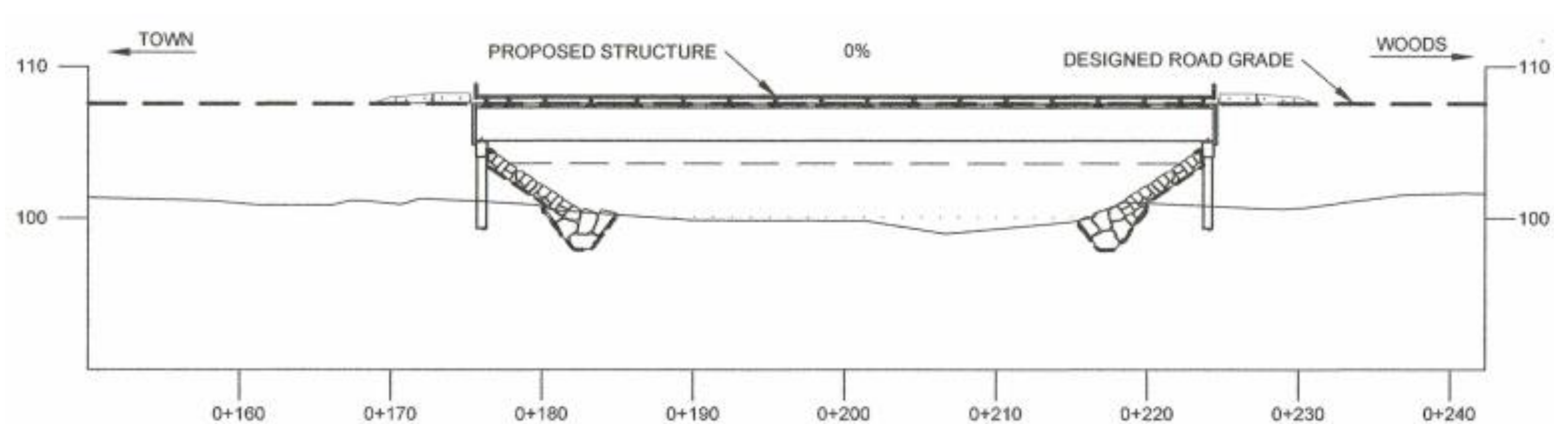


# 2. Misinchinka River (320 $km^2$)

- Average Design Velocity can be as critical as Q100
- Used Manning's formula for uniform flow within open channels

$$Q = AV = \frac{1}{n} A \, {R_h}^{2/3} \sqrt{S_e}$$

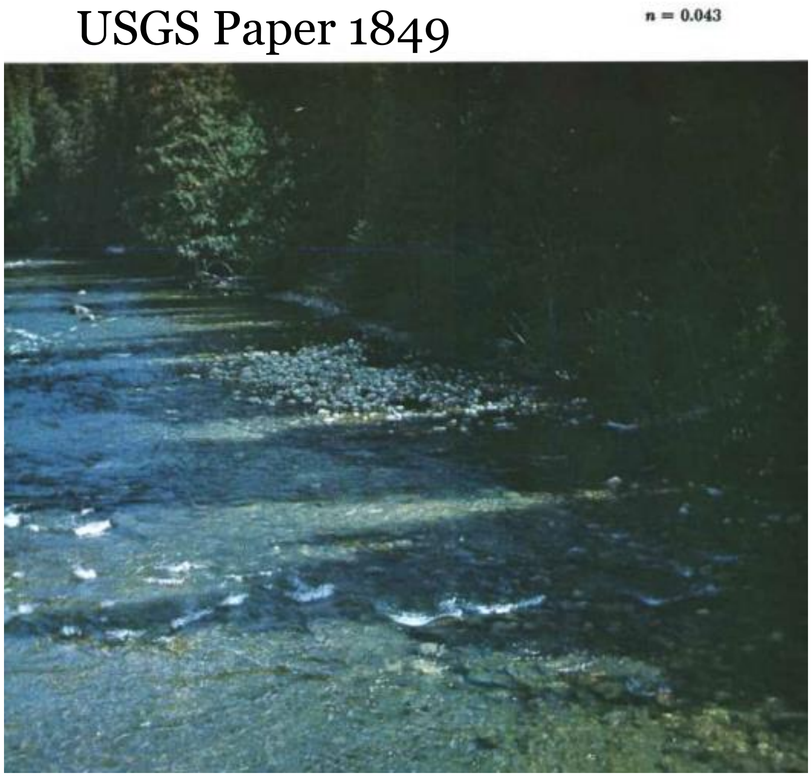
| | |
|---|---|
| Q = | flow in $m^3/s$ |
| V = | velocity in m/s |
| A = | water area in $m^2$ |
| $R_h$= | Hydraulic Radius in m = Water area (a) / wetted perimeter (P) |
| Se = | Slope of the energy grade line which can be assumed to be $S_o$ = slope of channel for uniform flow |
| n = | Manning's roughness coefficient |

- Can use design cross section for geometry

- For n:
- If there was more flow at time of survey, back calculate & solve
- Comparison with calculated streams
  - USGS Paper 1849
  - Hicks and Mason Roughness Characteristics of New Zealand Streams (1991)
- Equations (Cowan, 1955; Jarrett, 1985 USGS Report 4004)

# 2. Misinchinka River (320 km$^2$)

USGS Paper 1849

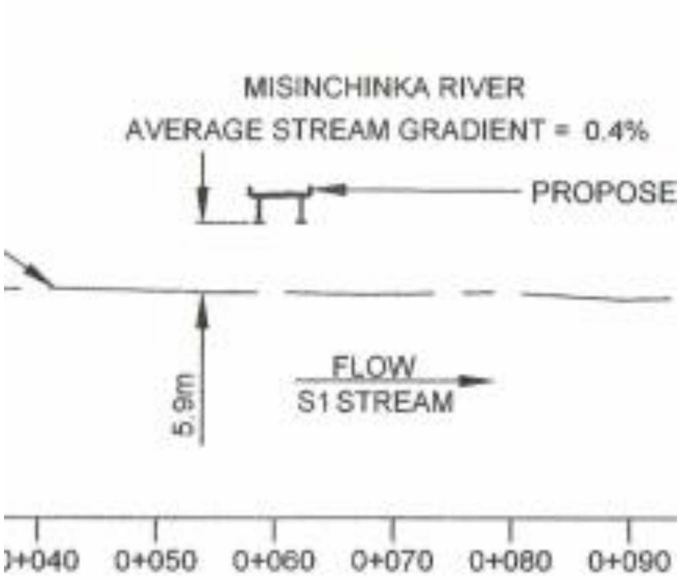



Misinchinka Sept 6, 2017

- n = 0.04, velocity = 2.8 m/s
- n = 0.06, velocity = 2.2 m/s
- n = 0.08, velocity = 1.8 m/s

- n expected to be closer to 0.04 to 0.06,
- v = 2.0 m/s is conservative – debris, obstructions in river
  - V=2.8m/s - 2.5m clearance above Q100

# 2. Misinchinka River (320 km$^2$)




Design Check:

- Highway is approximately 6m above stream bottom – see truck for scale
- BCMOTI – river has never overtopped highway at this location
- Even when Bijoux Falls falling directly onto highway
- Frequent flooding, washouts in Pine Pass

# 2. Misinchinka River (320 km$^2$)

Design Check

- Oct 25, 2017
- At top of Woods Bank
- Flow Area = 48.6m$^2$ (from Survey)
- Velocity = 1.5 m/s (From Approximate Surface Velocity Measured from Highway)
- Solved for:
- Flow = 73m$^3$/s
- Manning's n = 0.058

- Peak Flow in Pine River during event = 1,500m$^3$/s (https://wateroffice.ec.gc.ca/search/real_time_e.html)
- Pine River Q2 = 1,449 (Streamflow in Region 7)
- Pine Q100:Q2 = 3.54
- Misinchinka Q100 = 263 m$^3$/s

# 2. Misinchinka River (320 $km^2$)

Summary

- Estimate Design Flood using 3 very different sized streams/rivers
  - Pine (12,138$km^2$, 50 years data)
  - Sukunka (2,591$km^2$, 33 years data)
  - Carbon (737$km^2$, 14 years data)

- Is the method reasonable?
  - Very subjective

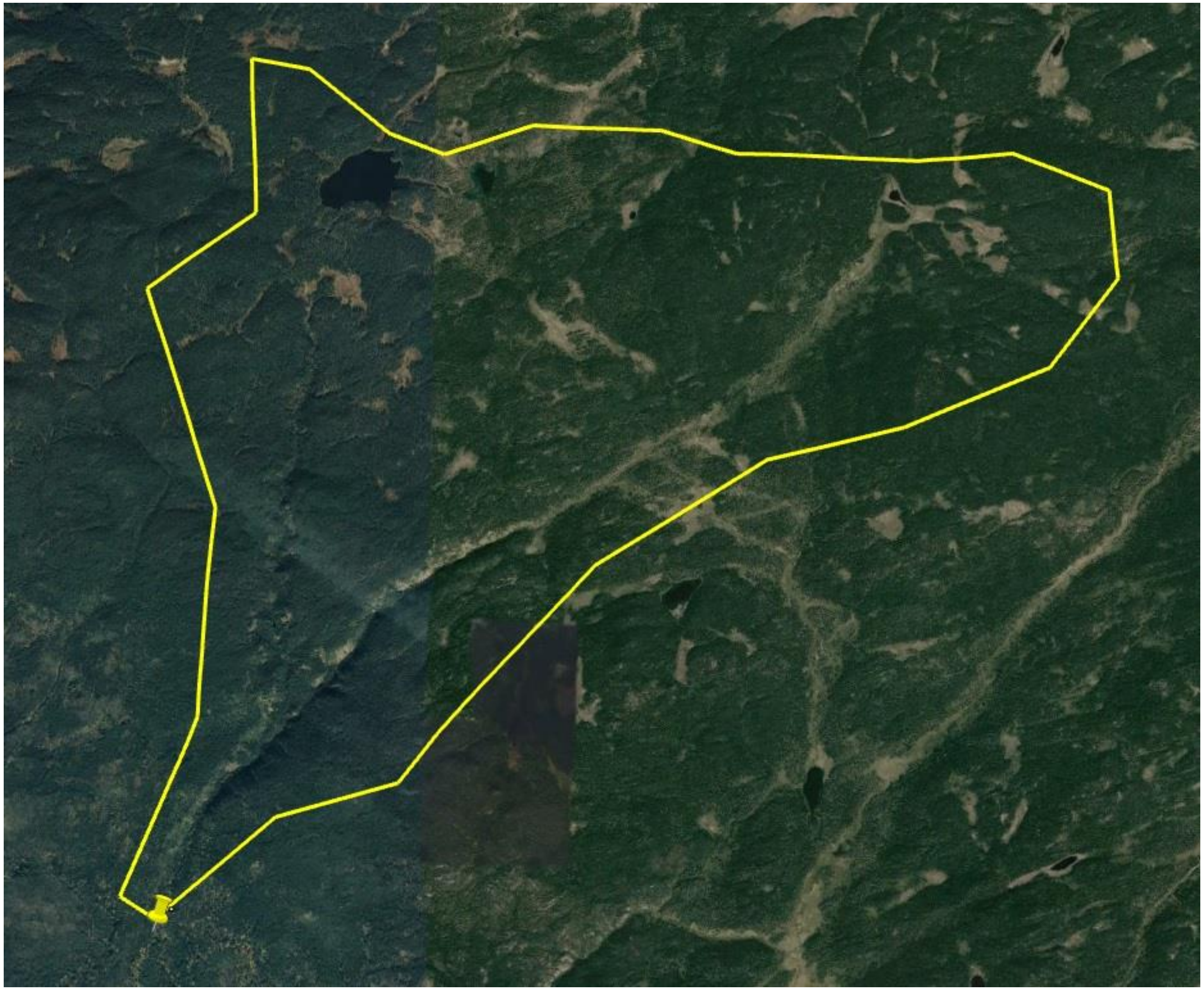
- Q100 Range 207 to 574 $m^3/s$

- Velocity Range 1.8 to 2.8 m/s (for chosen Q100)
  - Based on Manning's Formula

- How take Climate change into account?
  - IDF_CC Curves?
    - For a large watershed?
  - Average or extreme daily/monthly increase in rainfall?
  - Other?

# 3. North AllPort Creek (18.8 km$^2$)

# 3. North AllPort Creek (18.8 km$^2$)



54°30'10.3"N,
126° 9'10.9"W

Area: 18.8 km2
Length: 10.2km
Centroid-Site: 4.7km
Peak Elevation: 1400m
Crossing Elevation: 890m
Watershed Slope: 5%

Swamp/Lakes: 1.3km$^2$

Stream Gradient at Site: 0.4%

# 3. North AllPort Creek (18.8 $km^2$)

Nov 13, 2018

From Upstream Looking Down To Crossing

Nov 13, 2018

From Crossing Looking Upstream

Nov 13, 2018

From Crossing Looking Downstream

Nov 13, 2018

From Woods to Town

# 3. North AllPort Creek (18.8 km$^2$)

- Regional Analysis:

- 08EE009 Richfield (173km$^2$): Q100 = 5.2m$^3$/s
- 08EE004 Bulkley (7,360km$^2$): Q100 = 9.6m$^3$/s
- 08EE008 Goathorn (149km$^2$): Q100 = 11.7m$^3$/s

- Rational Method
  - RTAC Drainage Manual Volume 1 (1982)
    - Rural areas up to 25 km$^2$
    - Urban Drainage up to 13 km$^2$
  - Manual of Operational Hydrology in BC (1991)
    - Up to 25 km$^2$
  - BCMOTI BC Supplement to TAC Geometric Road Design (2019)
    - Under 10km$^2$

$$Q=0.28CIA$$

Where:
Q = peak discharge in m$^3$/s
C = runoff coefficient
I = rainfall intensity in mm/hr
A = drainage area in km$^2$

# 3. North AllPort Creek (18.8 km$^2$)

- Runoff Coefficient C
  - Interior Watersheds: 0.25 to 0.45
    - Local Experience
    - RTAC Drainage Manual Volume 1 (1982)
  - 5 Options (0.25, 0.30, 0.35, 0.40, 0.45)
  - 3 Consistently (0.30, 0.35, 0.40)

**Table 2.4.1 — Typical rural runoff coefficients**

| Soil description | Land use | | |
|---|---|---|---|
| | Crops | Pasture | Wooded |
| Tight clayey soils, good surface drainage | 0.55 | 0.45 | 0.40 |
| Medium textured loams, well drained | 0.40 | 0.35 | 0.30 |
| Shallow medium textured loams overlying limestone bedrock; open loams and sand loams | 0.30 | 0.25 | 0.20 |
| Coarse well drained sands and gravels | 0.25 | 0.15 | 0.05(–) |

b) For storms having return period of more than 10 years, increase the listed values as follows, up to a maximum coefficient of 0.95.

25-yr. — add 10%
50-yr. — add 20%
100-yr. — add 25%

# 3. North AllPort Creek (18.8 km$^2$)

- Time of Concentration Tc
  - Needed to get rainfall intensity

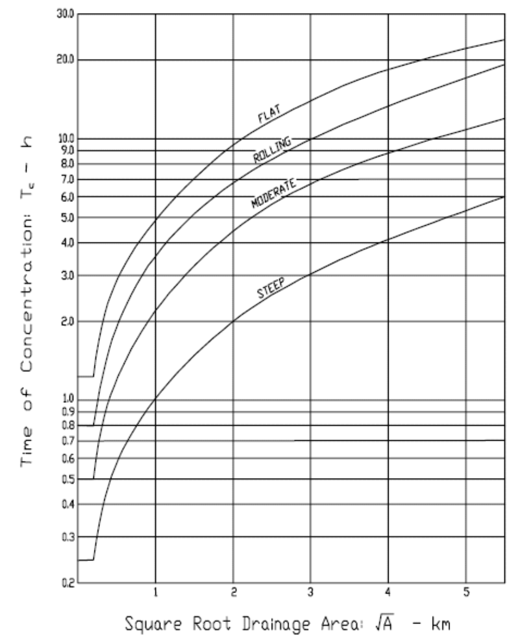
  - Loukas (Modified Snyder) = 2.24 hours
  - Modified Snyder = 2.37 hours
  - SCS Curve Number = 1.40 hours
  - Hathaway Method = 3.05 hours
  - MOE (Coulson Graphical) = 9 hours

  - Total travel time = 3.7 hours
    - Overland Flow (0.6 hours)
    - Stream Flow (3.1 hours)

  - 6 Options: 1.40 to 9.0 hours

  - BCMOTI BC Supplement to TAC Geometric Road Design (2019) example shows average

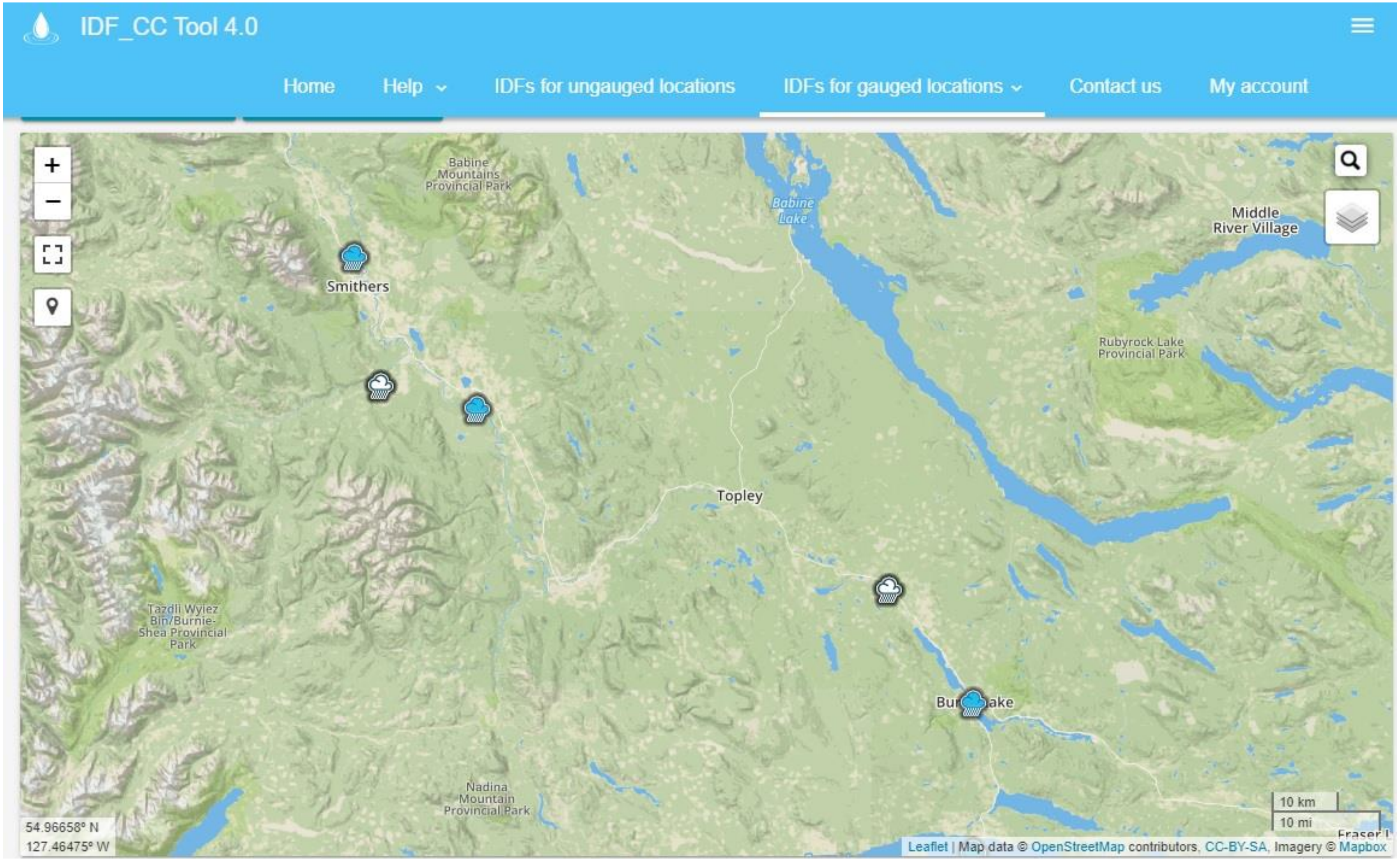
  - Prefer selecting one for a specific reason



# 3. North AllPort Creek (18.8 km$^2$)


- IDF1077500 Smithers
  Last Data: 2002
  Years Data: 31
- IDF1076638 Quick
  Last Data: 1994
  Years Data: 13
- IDF1091169 Burns Lake
  Last Data: 1990
  Years Data: 21
- IDF Ungauged at Site

# 3. North AllPort Creek (18.8 km$^2$)



# 3. North AllPort Creek (18.8 $km^2$)

## IDF for: BURNS LAKE ID:1091169

Station Info | IDF historical data | IDF under climate change

Station name: **BURNS LAKE**

ID: **1091169**

Latitude: **54.23**

Longitude: **-125.77**

Starting year: **1969**

Ending year: **1990**

Number of years (with data): **21**

## IDF for: BURNS LAKE ID:1091169

Station Info | IDF historical data | IDF under climate change

GEV | Gumbel

Tables | Plots | Interpolation Equations

The table below provides coefficients for the interpolation equations fitted to the IDF curve using the GEV distribution.

| T (years) | Coefficient A | Coefficient B | Coefficient $t_0$ |
|---|---|---|---|
| 2 | 8.3 | -0.670 | 0.028 |
| 5 | 12.4 | -0.717 | 0.035 |
| 10 | 15.9 | -0.758 | 0.044 |
| 20 | 19.9 | -0.801 | 0.056 |
| 25 | 21.3 | -0.816 | 0.059 |
| 50 | 26.2 | -0.864 | 0.072 |
| 100 | 31.7 | -0.909 | 0.082 |

Use the coefficients provided in the table above with the following equation:

$$i\left(\frac{mm}{h}\right) = A \cdot (t + t_0)^B$$

Where:

- $i$ is the precipitation intensity rate in $\frac{mm}{h}$
- $A$, $B$ and $t_0$, are the coefficients for each return period (T) in years
- $t$, the time (duration) of the precipitation event in hours (h)

# 3. North AllPort Creek (18.8 $km^2$)

- IDF Curves
  - 4 Possible Options
    - Burns Lake – Nearby, similar area – but 21 years data, 30 years old
    - Smithers has most data and most recent (2002!) – but surrounded by mountains
    - Quick is closest – but only 13 years data
    - Ungauged – at location, but how is it interpolated?

- Also Rainfall Atlas of Canada (1986)
  - But is data actually that much older?
  - Still referenced BCMOTI

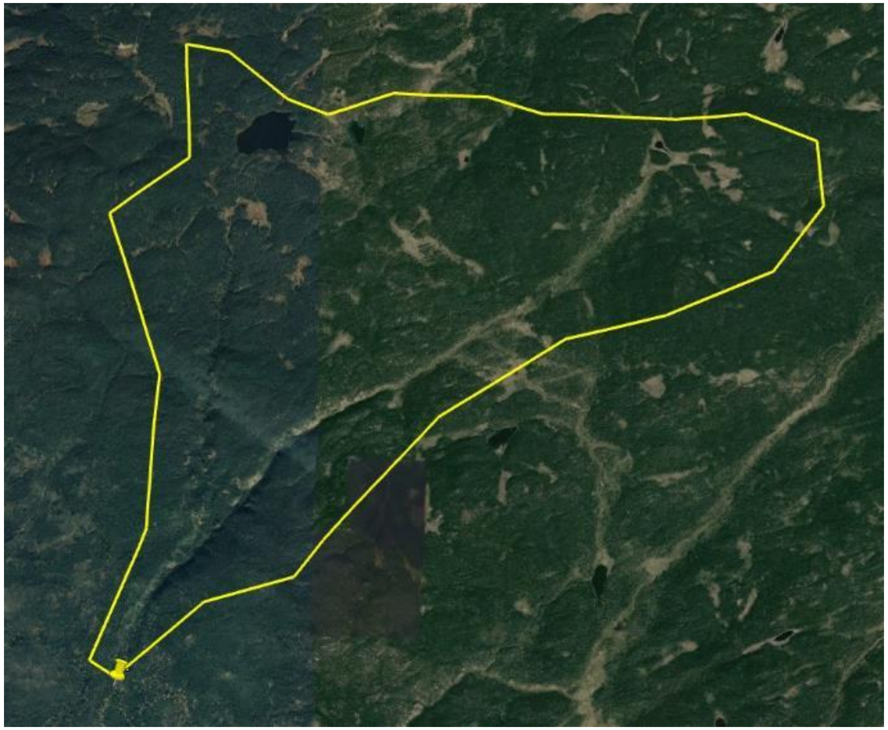
- Rational Method – 120 possible combinations (5 Cs x 6 Is (from Tc) x 4 IDF Curves)

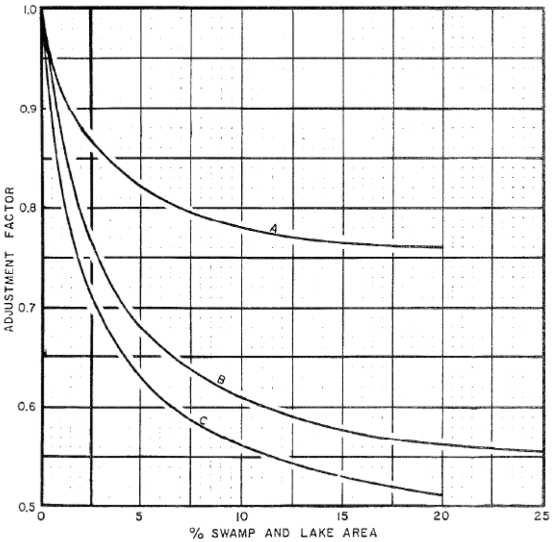
- Selected:
  - C= 0.30
  - Tc = 3.7 hours (total flow, it is mainly streamflow)
  - I = 9.5 mm/hr from Burns Lake (close and similar)
    - Burns Lake = 9.5 mm/hr
    - Smithers = 9.2 mm/hr
    - Quick = 38.3 mm/hr
    - Ungauged = 11.0 mm/hr

# 3. North AllPort Creek (18.8 km$^2$)

- Rational Flow = 15.0 m$^3$/s
  - Reduction factor of 0.80 due to 7% lake/swamp area in upper portion of basin

- Q100 = 12.0 m$^3$/s






Curve A — significant portion of flow passes through storage areas in upper basin only.

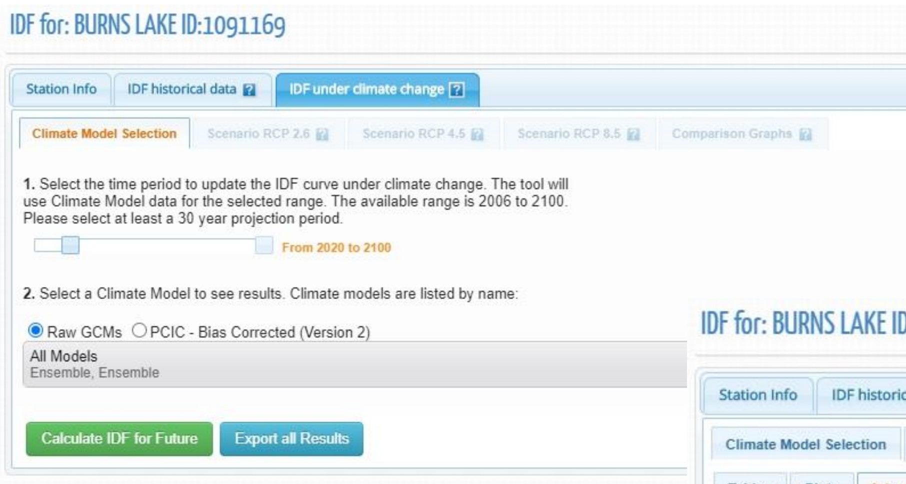
Curve B — significant portion of flow passes through storage areas distributed across basin.

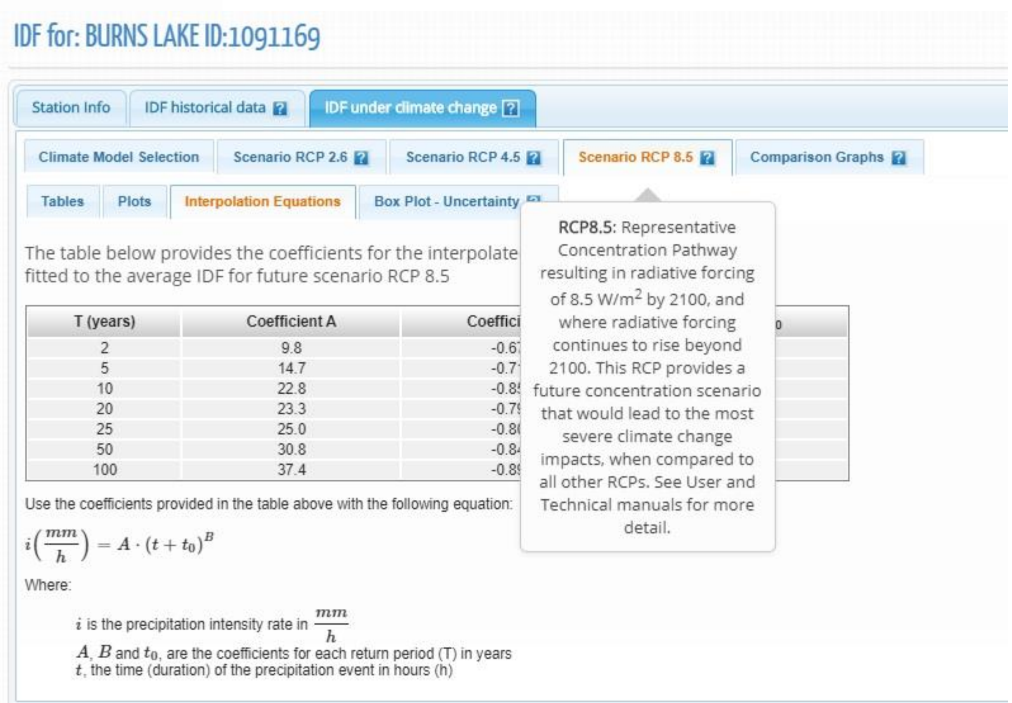
Curve C — storage is located in path of flow at lower end of basin.

**Figure 2.4.6 — Peak discharge adjustment for storage** (10)

# 3. North AllPort Creek (18.8 km$^2$)

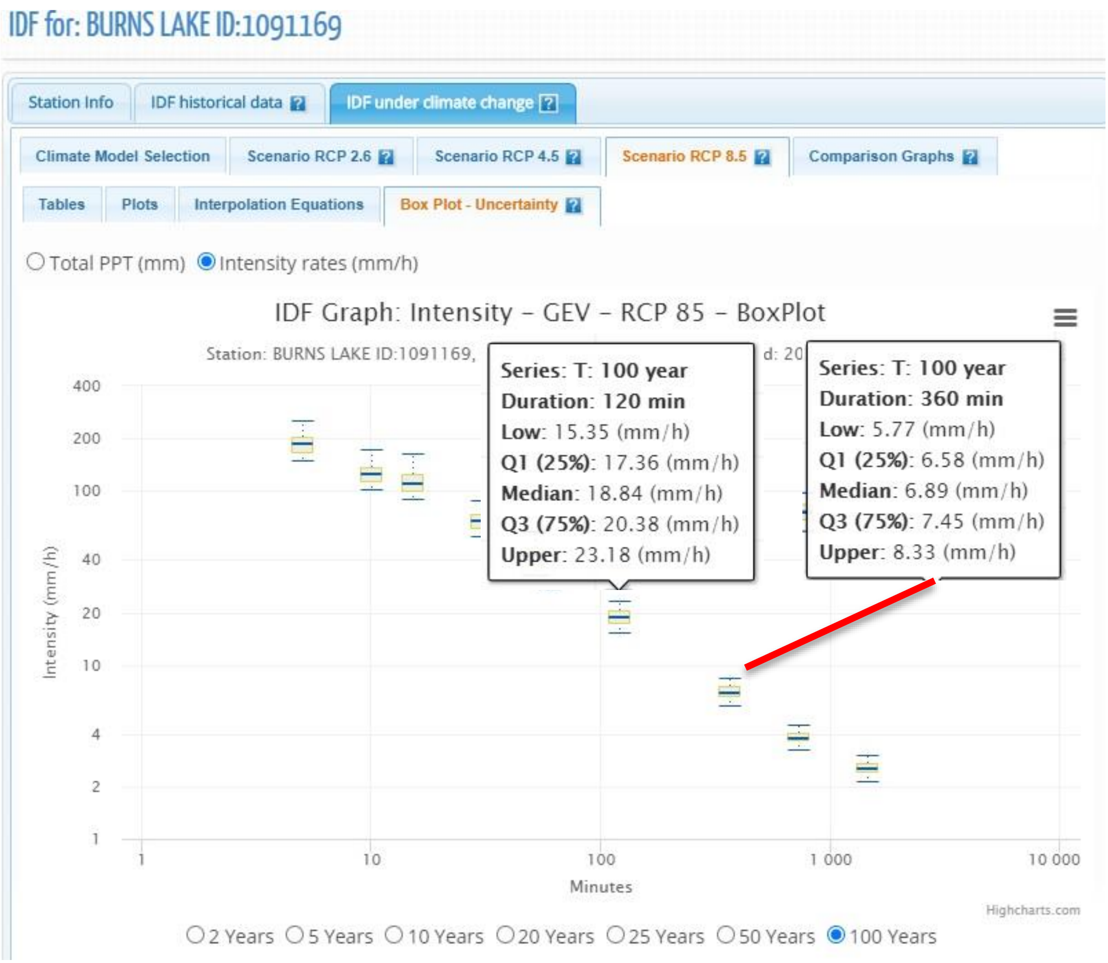
- Climate Change from IDF_CC Curves



# 3. North AllPort Creek (18.8 $km^2$)

- Climate Change from IDF_CC Curves
- From Interpolation Equations, I = 11.4mm/hour (T= 3.7 hours, 222 minutes)
- But there is a large range



# 3. North AllPort Creek (18.8 $km^2$)

- Q100 with Climate Change:
  - C= 0.30
  - Tc = 3.7 hours
  - I = 11.4 mm/hr from Burns Lake (close and similar)
    - Increase of 20% (vs 9.5mm)

- Rational Flow = 18.1 $m^3/s$
  - Reduction factor of 0.80 due to 7% lake/swamp area in upper portion of basin

- Q100 = 14.5 $m^3/s$ … used original 15.0 $m^3/s$ to be slightly conservative

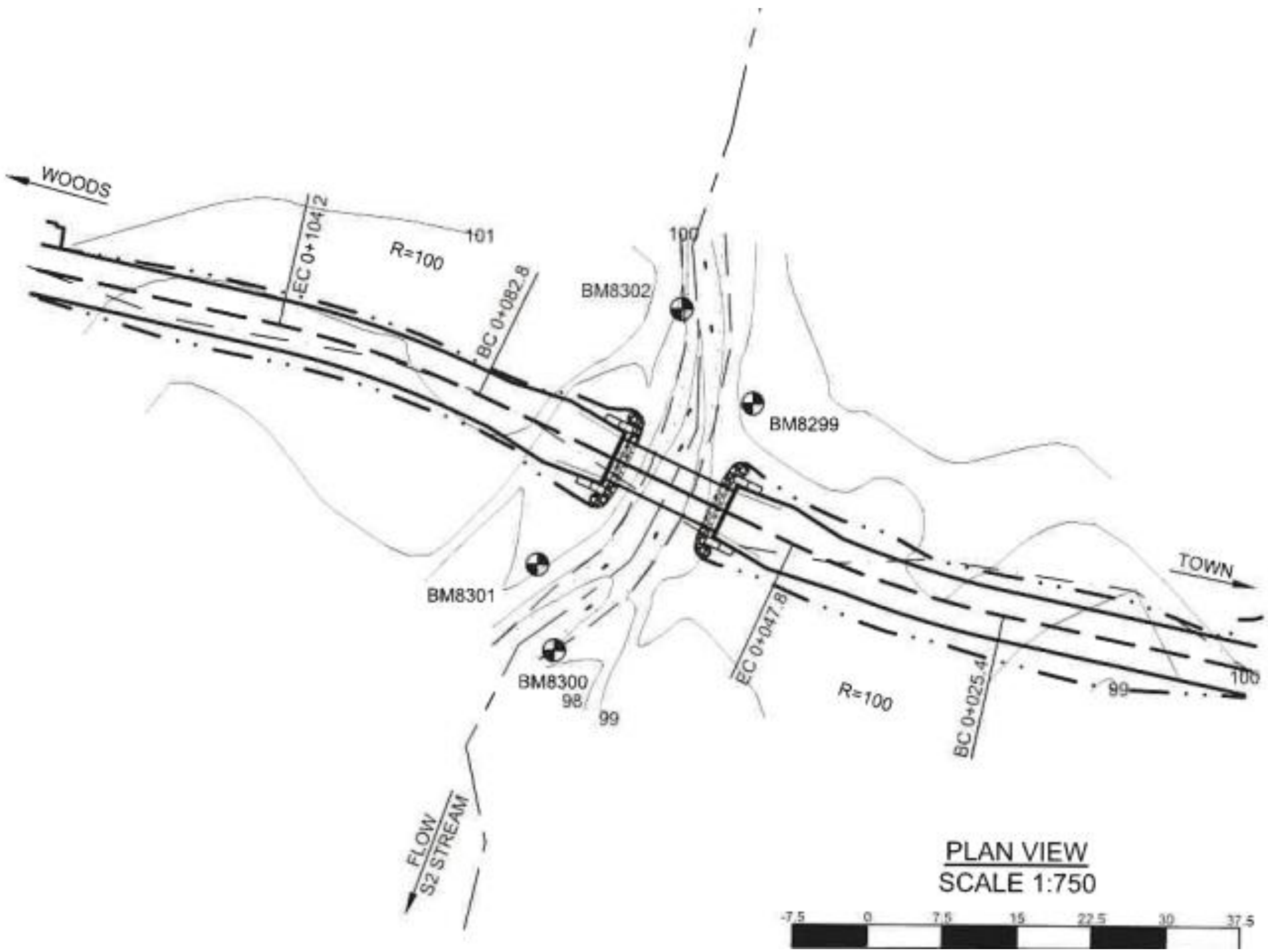
- Unit flow = 0.80 $m^3/s$

# 3. North AllPort Creek (18.8 $km^2$)

- Q100 range from Rational (120 combinations)
  - Extreme & Unrealistic (no reduction)
    - C = 0.25, tc = 9.0 hours, I = 5.2mm from Smithers
      - Q100 = 6.9 $m^3/s$
    - C = 0.50, tc = 1.40, I = 44.7mm from Quick
      - Q100 = 75.7 $m^3/s$
  - Reasonable Range
    - C = 0.30 to 0.40
    - Tc = 3.0 to 5.0
    - I from Burns Lake (8.8 mm/hr) & Ungauged (13.1 mm/hr)
    - Q100 = 13.9 $m^3/s$ * 0.80
      - Q100 = 11.1 $m^3/s$
    - Q100 = 27.5 m3/s * 0.80
      - Q100 = 22.0 $m^3/s$
- Selected Q100 prior to Climate Change = 12.5 m3/s
  - Reasonable Range = 11.1 $m^3/s$ to 22.0 $m^3/s$

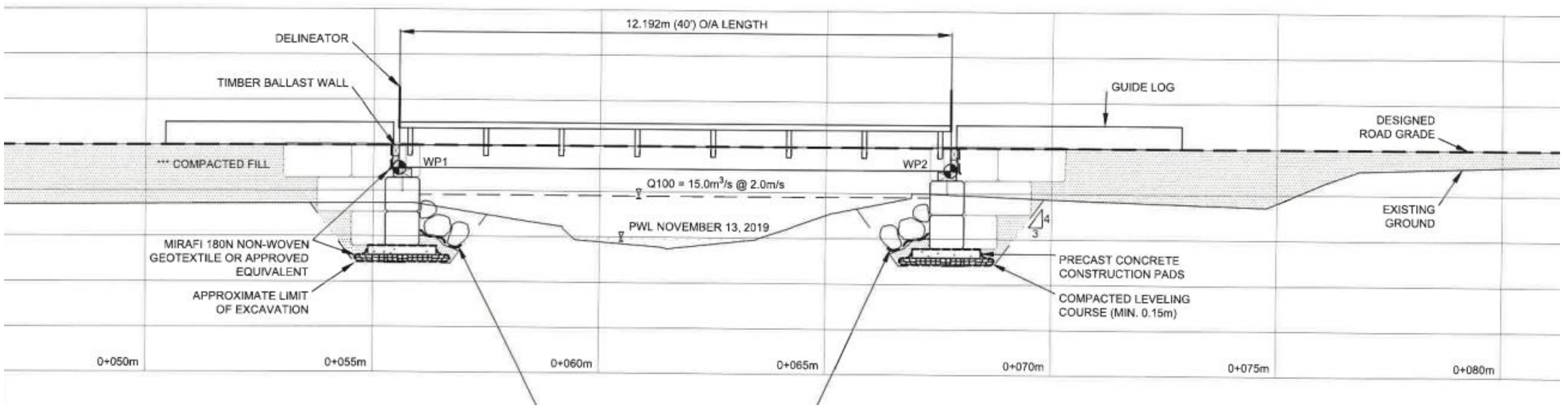
# 3. North AllPort Creek (18.8 $km^2$)

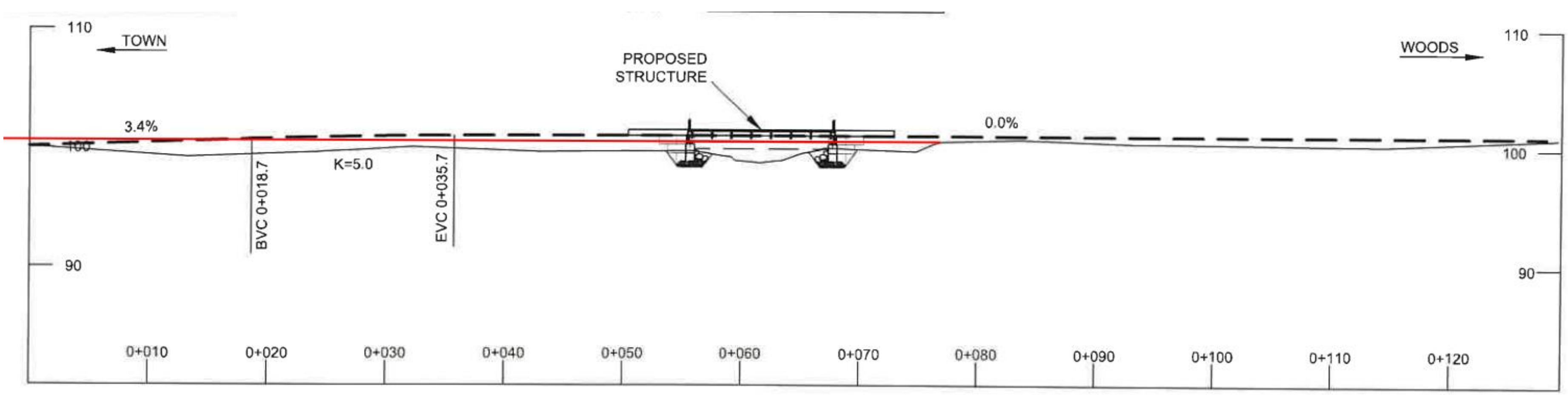
- 12.192m (40') All Steel Portable Bridge on 2 High Lock Block Abutments



# 3. North AllPort Creek (18.8 km$^2$)

- Bottom of girders above ground on town side



# 3. North AllPort Creek (18.8 $km^2$)

Summary

- Estimated Design Flood using rational method due to size
- Q100 = 12.5 $m^3/s$

- Reasonable Range = 11.1 $m^3/s$ to 22.0 $m^3/s$ (100%)

- Did not discuss design checks, channel & site characteristics.

- Regional Analysis:
  - 08EE009 Richfield (173$km^2$): Q100 = 5.2$m^3/s$
  - 08EE004 Bulkley (7,360$km^2$): Q100 = 9.6$m^3/s$
  - 08EE008 Goathorn (149$km^2$): Q100 = 11.7$m^3/s$

- Used IDF_CC Tool for Climate Change (20% increase)
- Q100 = 14.5 $m^3/s$ (used 15.0 $m^3/s$)

- Assumes increase in streamflow due to climate change is directly correlated to increase in Rainfall calculated by IDF_CC Curves

# 4. Summary

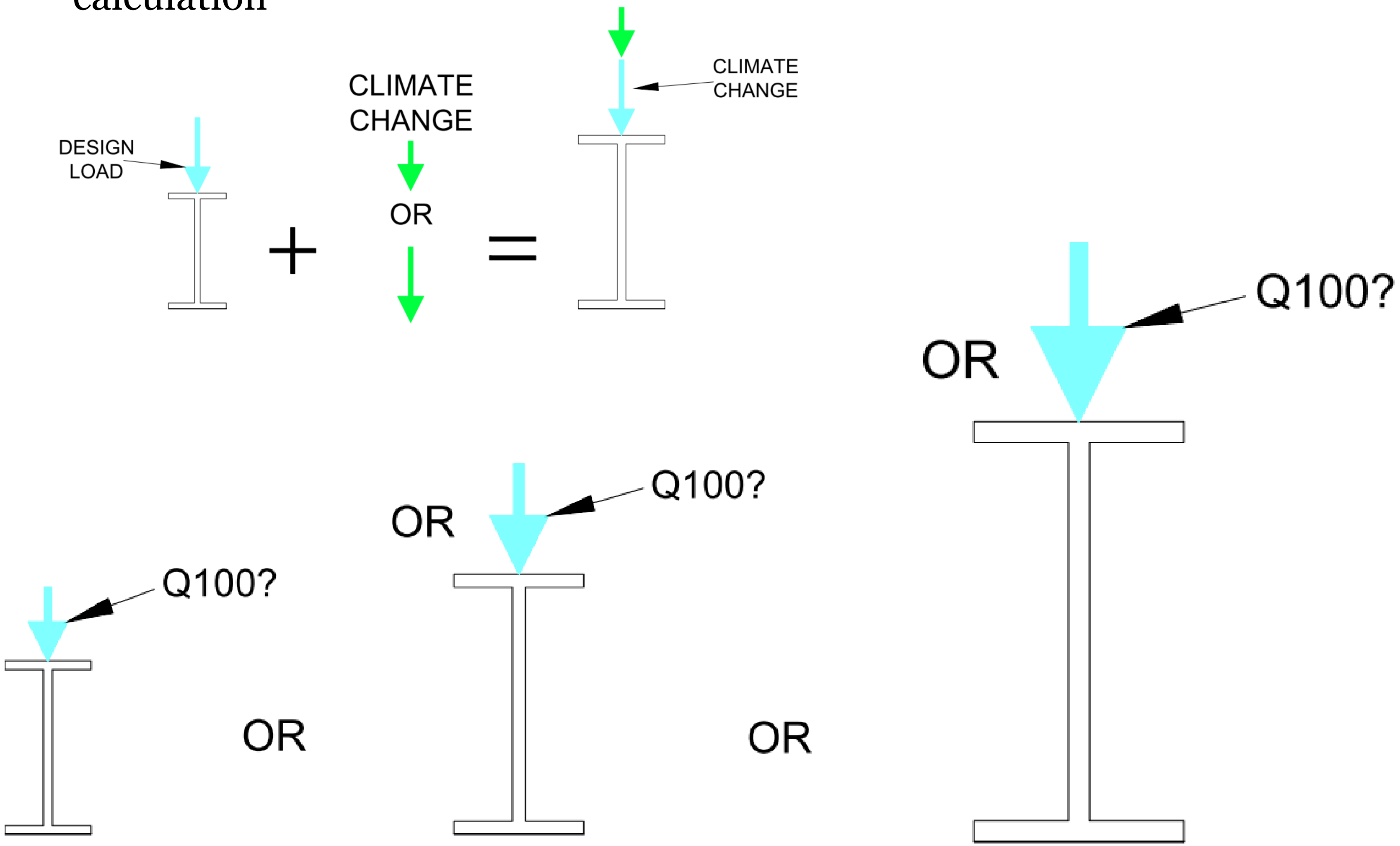
- Design Flood Hydrology is complex with possible wide range of calculated flows

- Site & stream characteristics can be as important as “standard” design flow calculations

- In remote resource applications there is limited data available
  - Gauged watersheds
    - Similarity (size and characteristics)
    - Proximity
  - IDF Curves
    - Old, limited data
    - Proximity

# 4. Summary

- Climate change is not being added to a very defined calculation



# 5. Questions/Comments

"The person who should take responsibility for the calculated design flow should absolutely be the most experienced, knowledgeable, and skilled engineer … who has yet to be sued"

Dr. Rollin Hotchkiss, P.E., D.WRE, F.ASCE