An Analysis of the Heavy Rain Event:

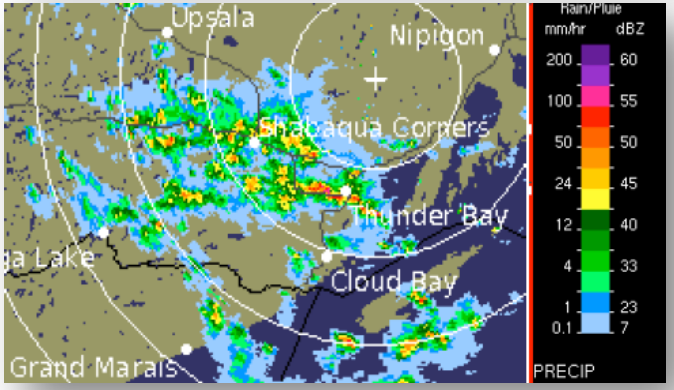
Thunder Bay , May 28, 2012

Graham Saunders

Outline

- Weather conditions of evening of May 27
- Summary of heavy rain event – May 28
- Antecedent moisture conditions and overland flow
- 50 -100-year events (IDF curves)
- Rainfall measurement: potential errors
- Historical Storms
- CIMA Report
- Discussion

Thunder Bay – Extreme Precipitation (May 28, 2012)



The total estimated cost of the Flood Event is $100 million CAD

- A rainstorm on May 28, 2012 **caused flash flooding** in and around the city of Thunder Bay.
- Rain showers associated with a thunderstorm began around **midnight on May 28, 2012**.
- Thunder and heavy/moderate rain showers occurred **for two hours**, with **70 mm recorded at the Airport** and **77 mm at the LRCA station** next to the Neebing River.
- The heavy rains and flooding of May 28 **closely followed another heavy rain event** on May 24 of 51.5 mm.
  - The **landscape in and around the City was saturated** and subsequent days with more rain continued very wet ground conditions with **a high water table**.
- Available records suggest that the May 28 situation **reached 100-year status more quickly than any other historical storm.**

G. Saunders (201

Weather conditions late evening on May 27

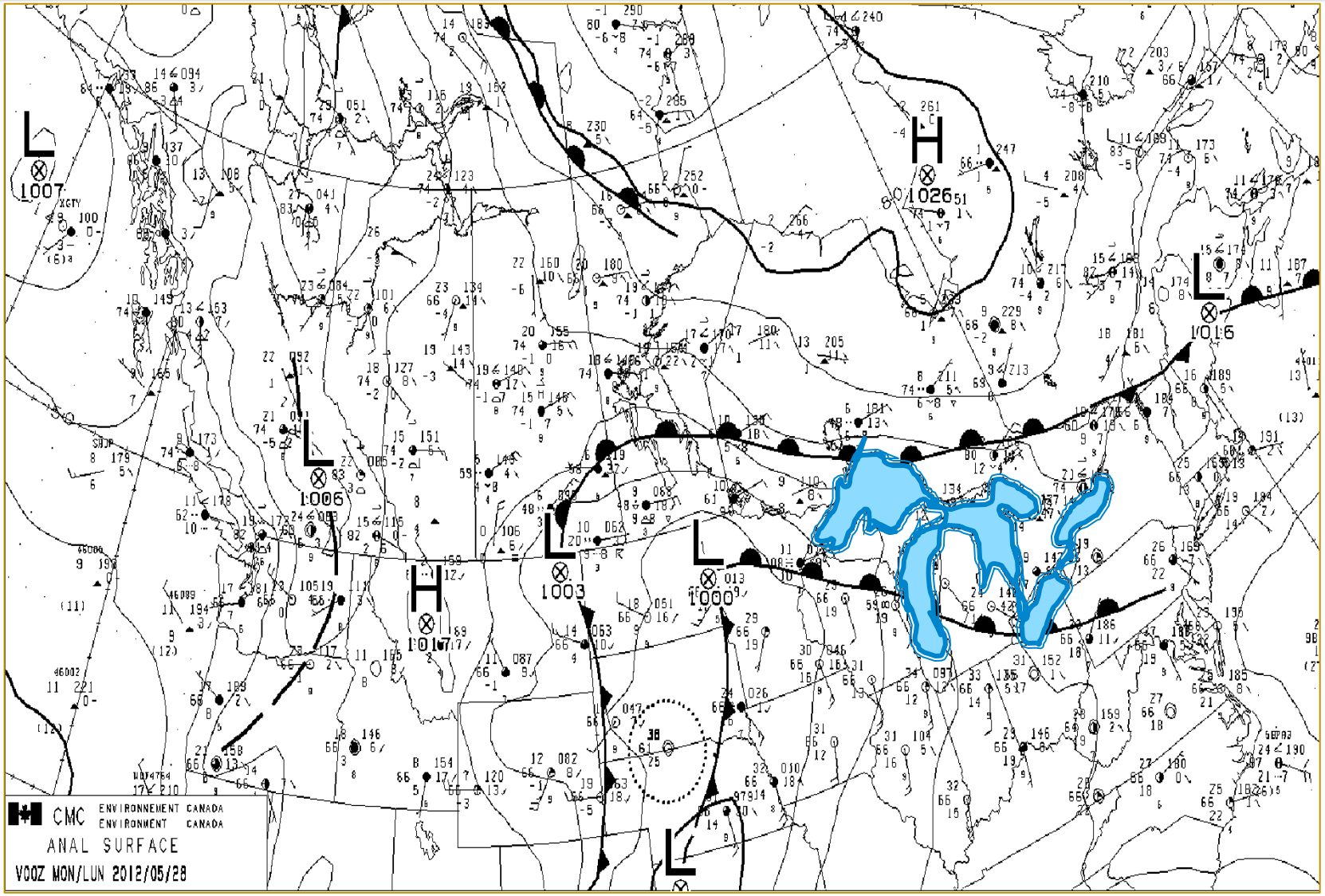
A low-pressure system and associated warm front moved from western Minnesota to southwest of Thunder Bay.

Environment Canada Forecast at 4 PM

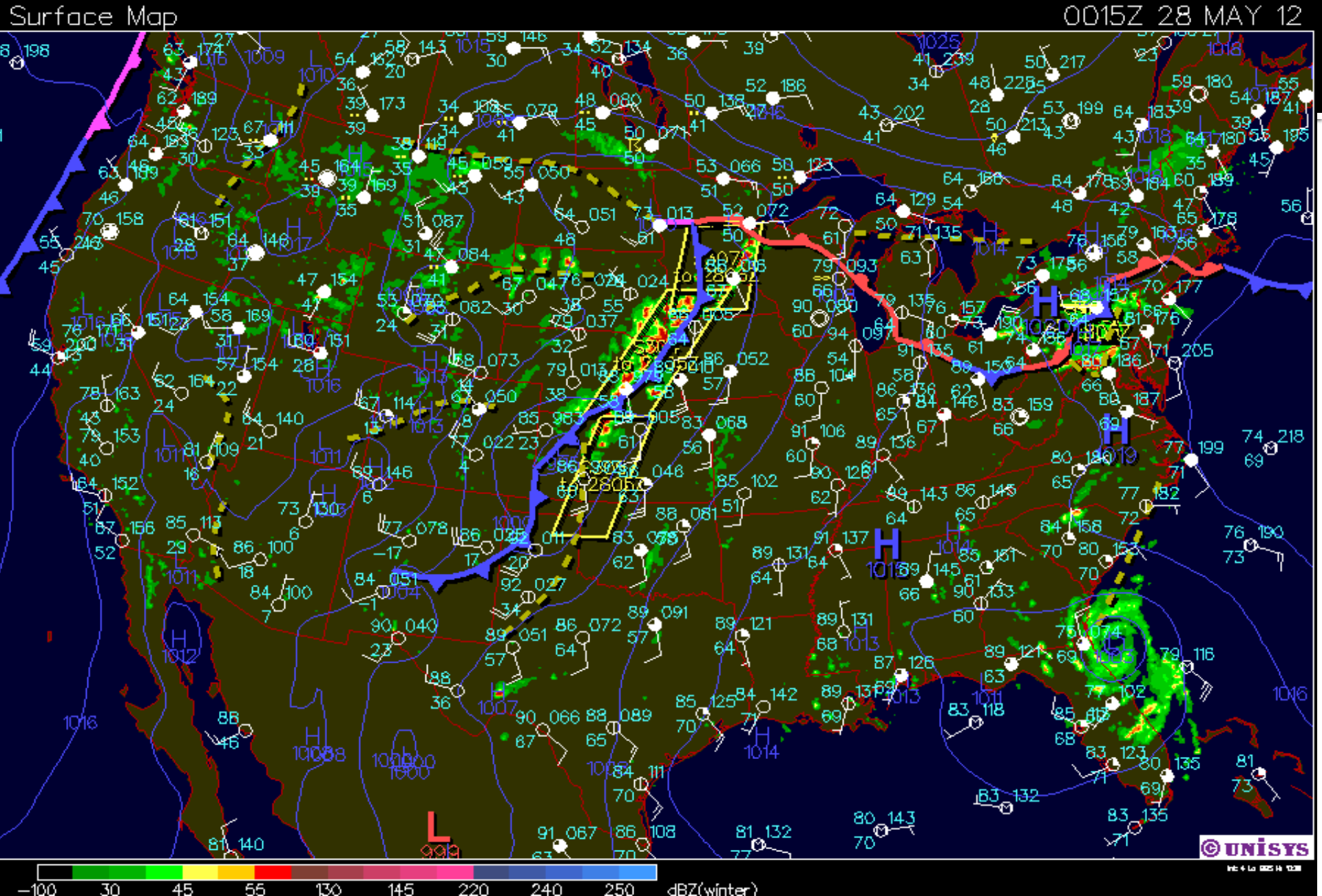
SUNDAY 27 MAY 2012

TONIGHT..SHOWERS WITH RISK OF A THUNDERSTORM. AMOUNT 10 TO 15 MM . . .

Surface analysis: May 27 at 2000 (8 p.m.)



Surface Analysis: May 27 at 2015 (8:15 p.m.)



Defining Rain Events

Light rain: to 2.5 mm per hour

Moderate rain: 2.6 mm to 7.5 mm per hour

Heavy rain: more than 7 mm per hour

≥ 50 mm in 24 hours = a **heavy rain** day

Some Rain Statistics for Thunder Bay – May 28, 2012

Rain began in Thunder Bay on May 28 at midnight

- **50 mm** was recorded between
  00:15 - 01:15 a.m. (1-hour record)
- **70 mm** in two hours (2-hour record)
- **100 mm** in 24-hour

- **65 mm:** average precipitation for the month of May
- May rain total: **201 mm** (monthly record for May)

Radar display of precipitation type

Colour	Precipitation Intensity	Weather Description
Blue	Light	Rain or snow
Cyan	Moderate	Rain or snow
Green	Heavy	Light thunderstorms and/or moderate rain showers
Yellow	Very Heavy	Moderate thunderstorms
Red	Intense	Potential flooding rains and severe thunderstorms
Magenta / Purple	Extreme	Flooding rains with severe thunderstorms

Making Sense of Radar Charts

Rainfall intensity

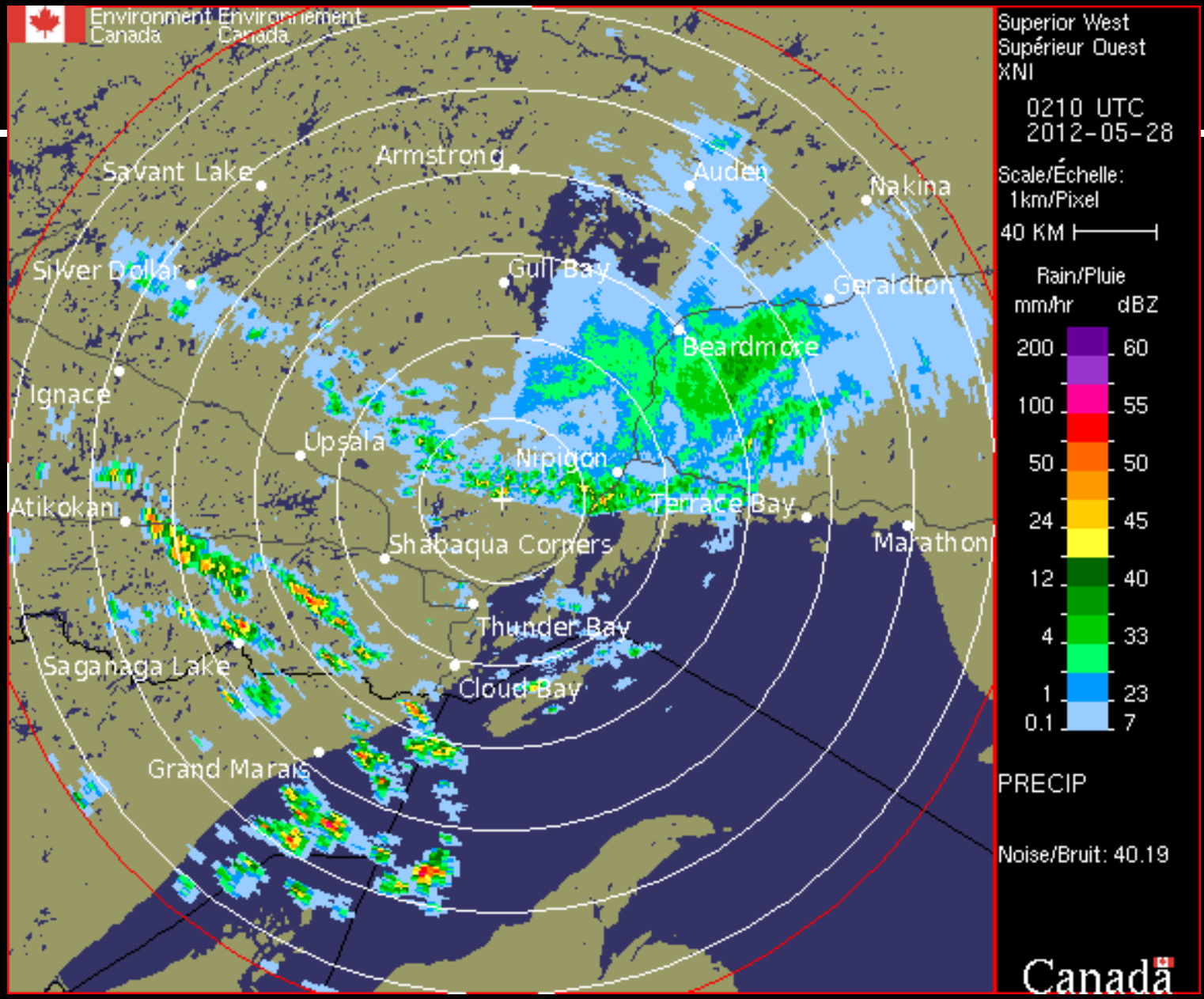
Radar displays spot estimates of rain amounts per hour
Example: Red has a range of 75 to 100 mm/hr

- Isolated thunderstorms
- Lines of thunderstorms

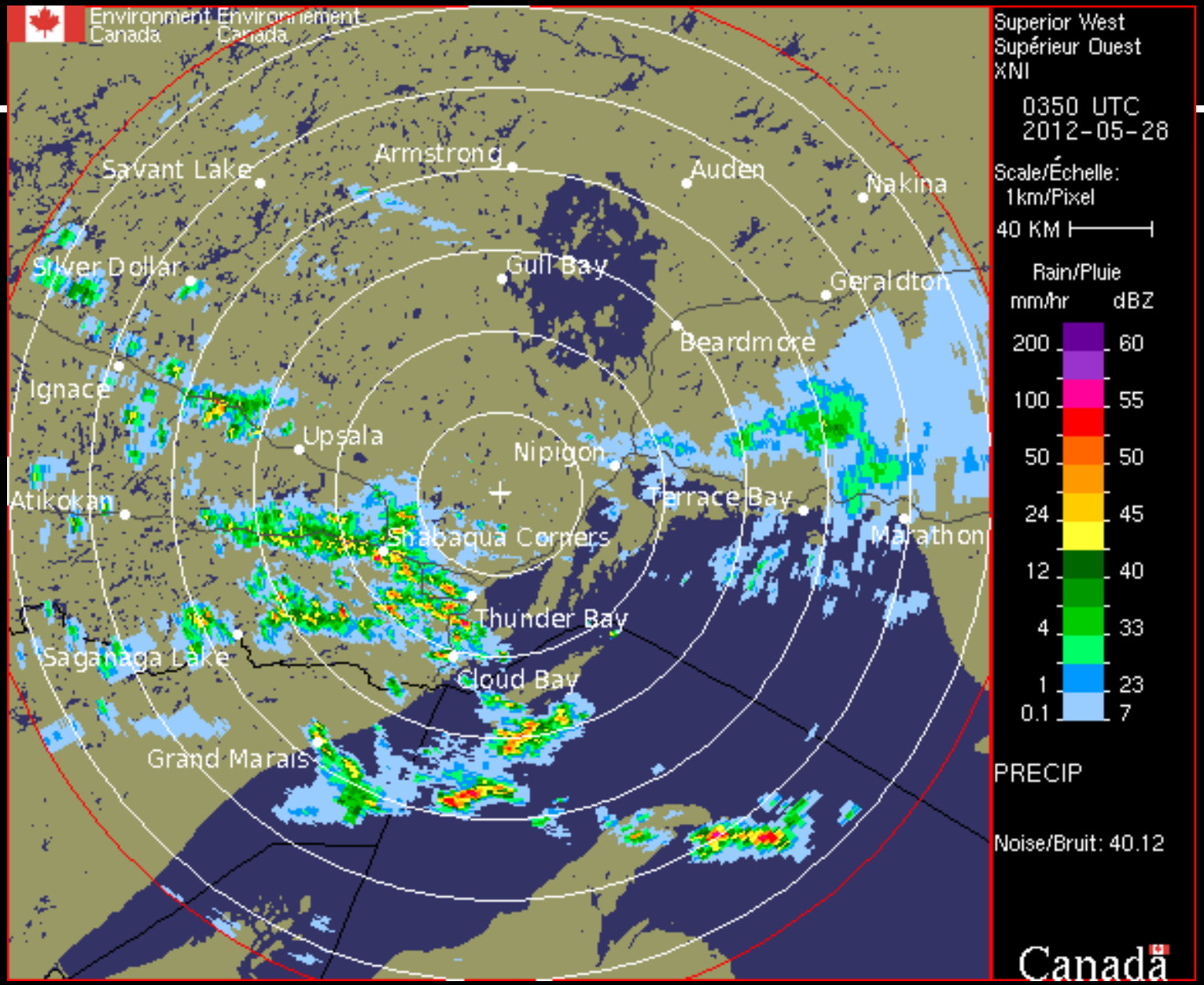
Typically, these pass over a location moderately quickly

In the following we see this feature, also thunderstorms that are stationary or re-form

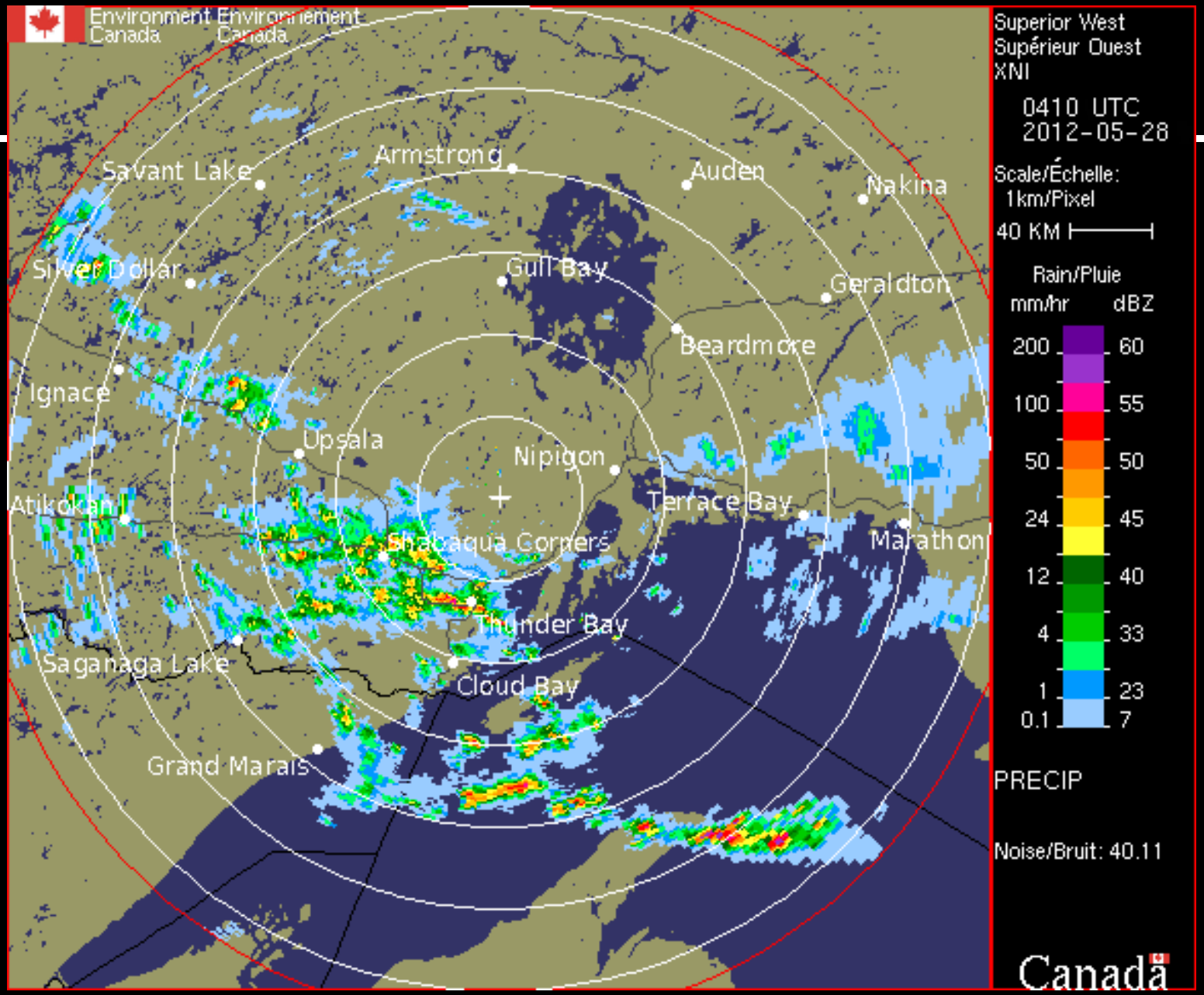
Radar: May 27 at 2210 (10:10 p.m.) Thunder Bay and area



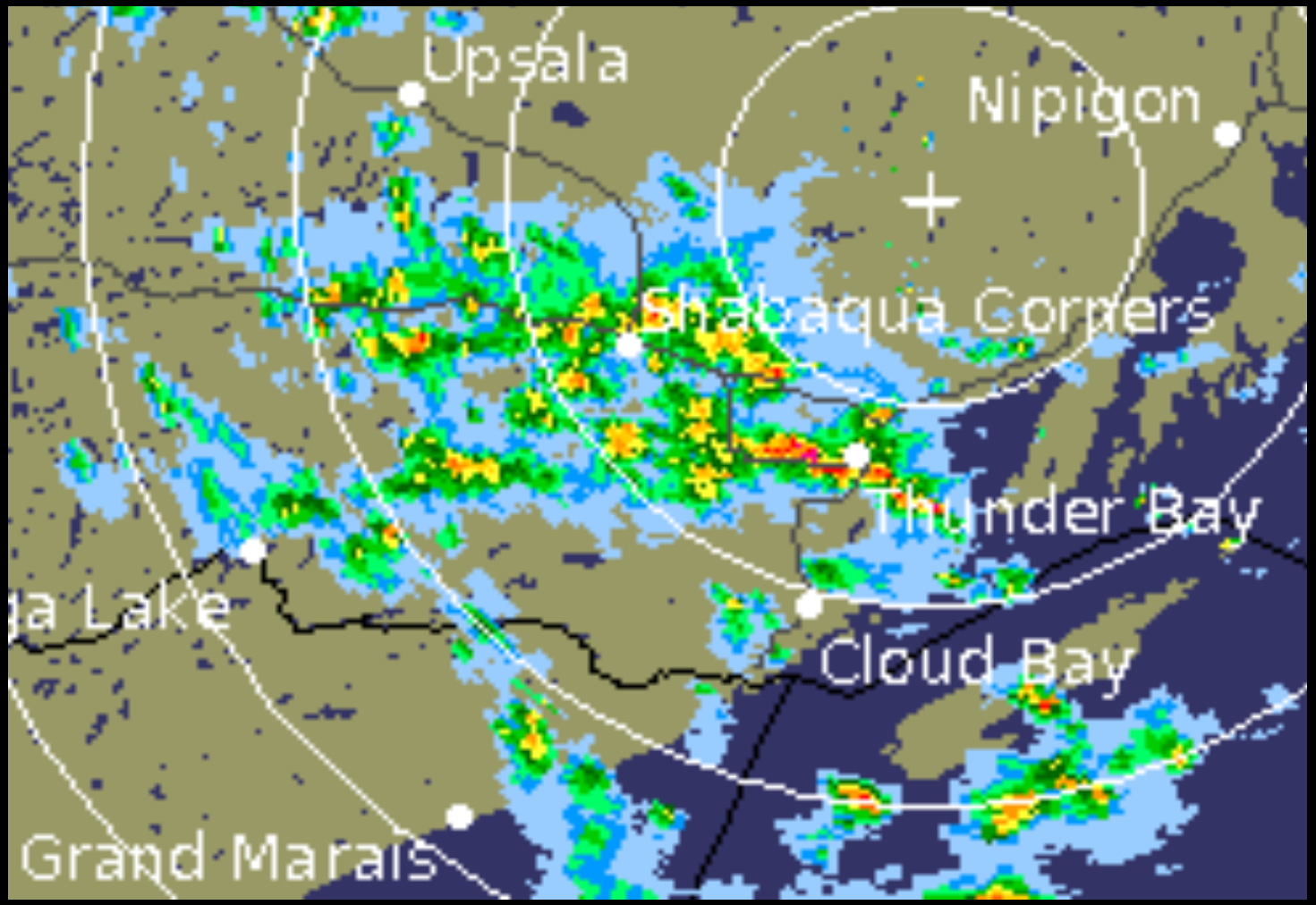
Radar May 27 at 2350 (11:50 p.m.)



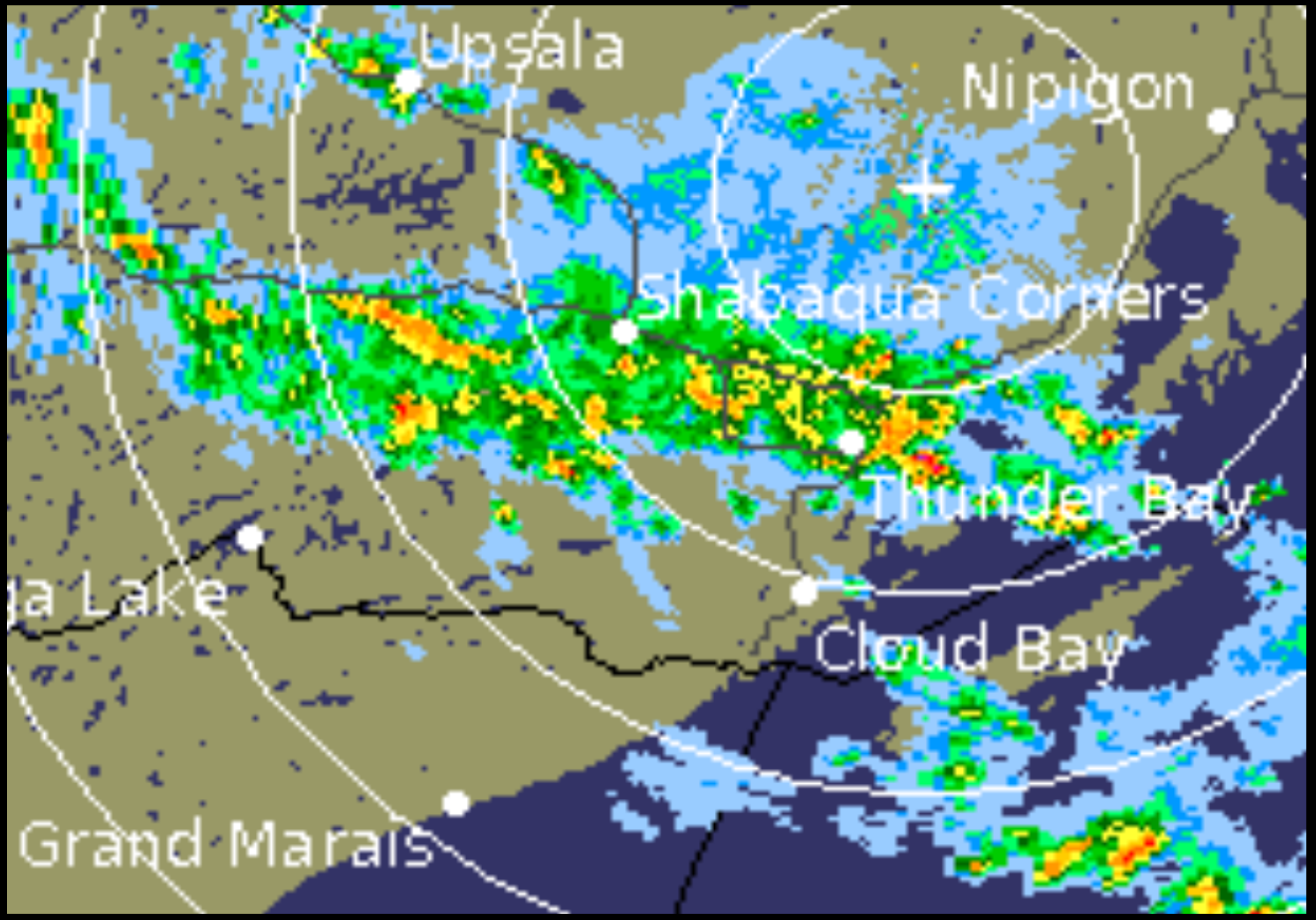
Radar: May 28 at 0010 (00:10 a.m.)

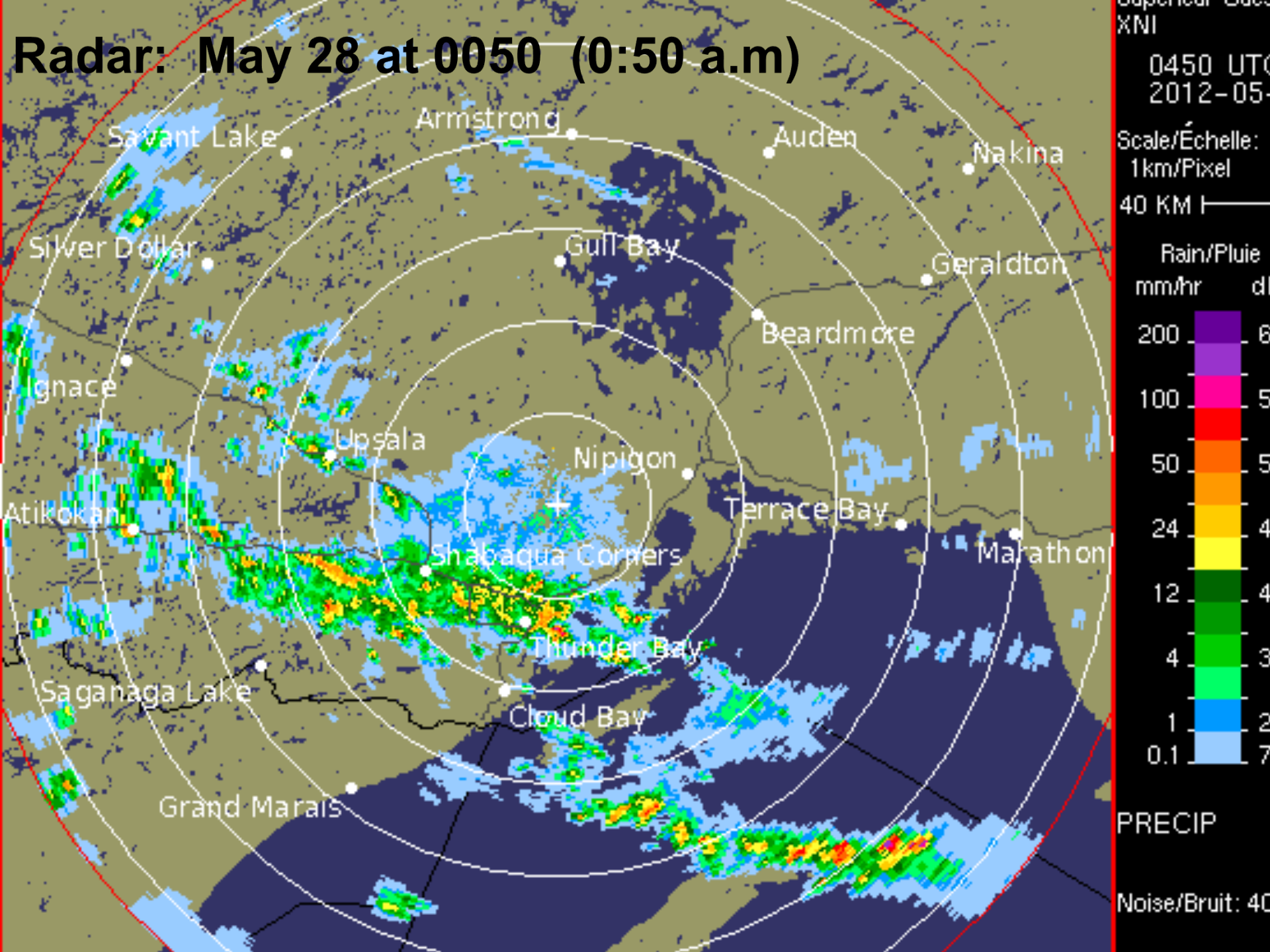


Radar: May 28 at 0010 (00:10 a.m.)



Radar: May 28 at 0030 (00:30 a.m.)




Radar: May 28 at 0050 (0:50 a.m)
Savant Lake
Armstrong
Auden
Nakina
Silver Dollar
Gull Bay
Geraldton
Beardmore
Ignace
Upsala
Nipigon
Atikokan
Terrace Bay
Marathon
Shabaqua Corners
Thunder Bay
Saganaga Lake
Cloud Bay
Grand Marais
XNI
0450 UTC
2012-05-
Scale/Échelle:
1km/Pixel
40 KM
Rain/Pluie
mm/hr
200
100
50
24
12
4
1
0.1
PRECIP
Noise/Bruit: 40

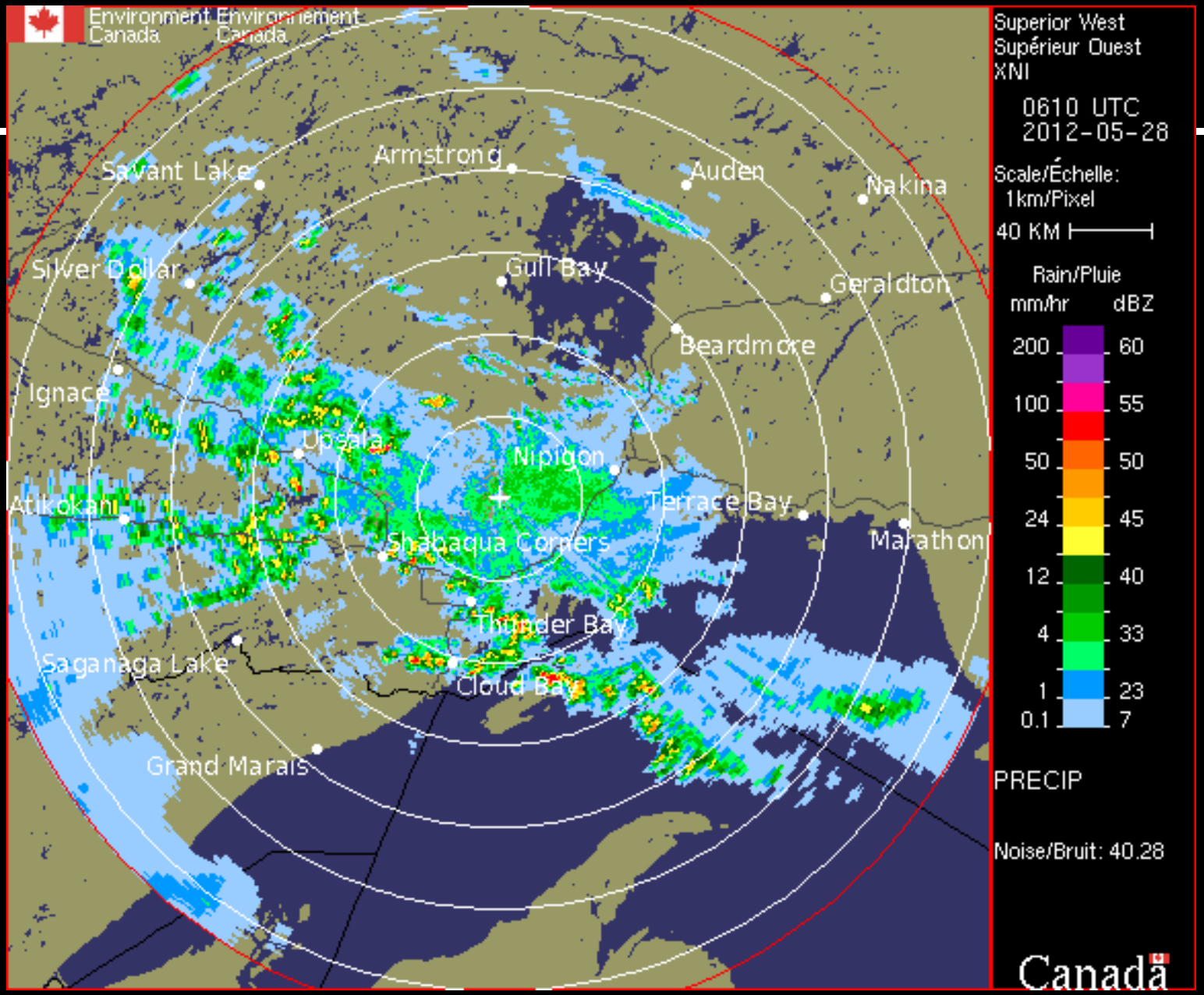
Environment Canada Warning: Severe Thunderstorms

SEVERE THUNDERSTORM WARNING, ISSUED BY ENVIRONMENT CANADA
AT 1:27 AM EDT MONDAY 28 MAY 2012.

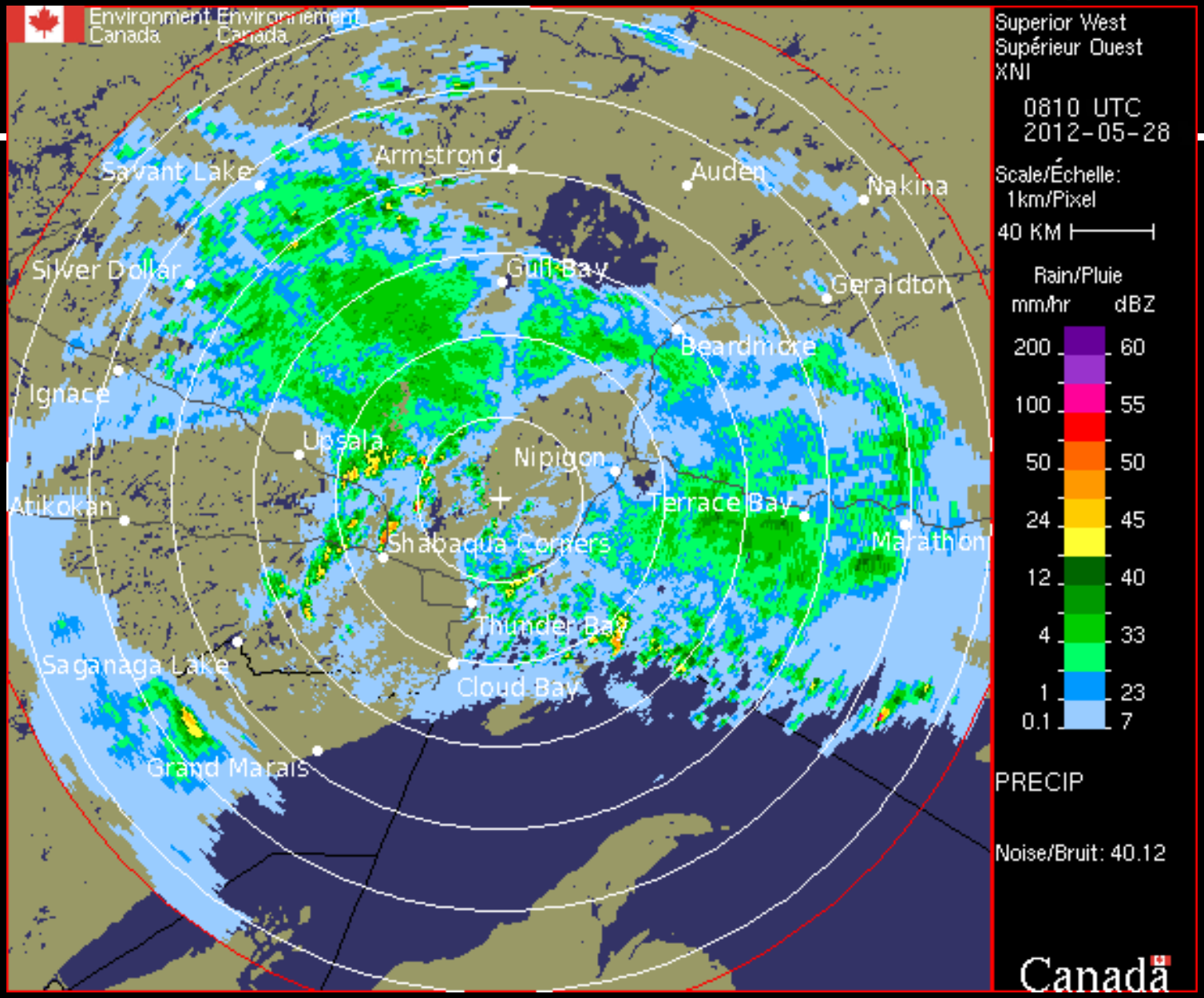
SEVERE THUNDERSTORM WARNING FOR:
=NEW= CITY OF THUNDER BAY
=NEW= ATIKOKAN - SHEBANDOWAN - QUETICO PARK =NEW= SUPERIOR WEST.

==DISCUSSION==
A LINE OF NEARLY STATIONARY THUNDERSTORMS STRETCHES ALONG HIGHWAY 11 TO THE WEST TO THUNDER BAY INTO THE CITY OF THUNDER BAY ITSELF.
LOCAL RAINFALL AMOUNTS OVER 50 MM ARE EXPECTED BEFORE THE HEAVIEST RAIN TAPERS OFF IN THE NEXT HOUR OR TWO. HOWEVER, MORE RAIN IS STILL EXPECTED DURING THE NIGHT AND MONDAY. …

Radar: May 28 at 0210 (2:10 a.m)



Radar: May 28 at 0410 (4:10 a.m.)



Antecedent Moisture Conditions

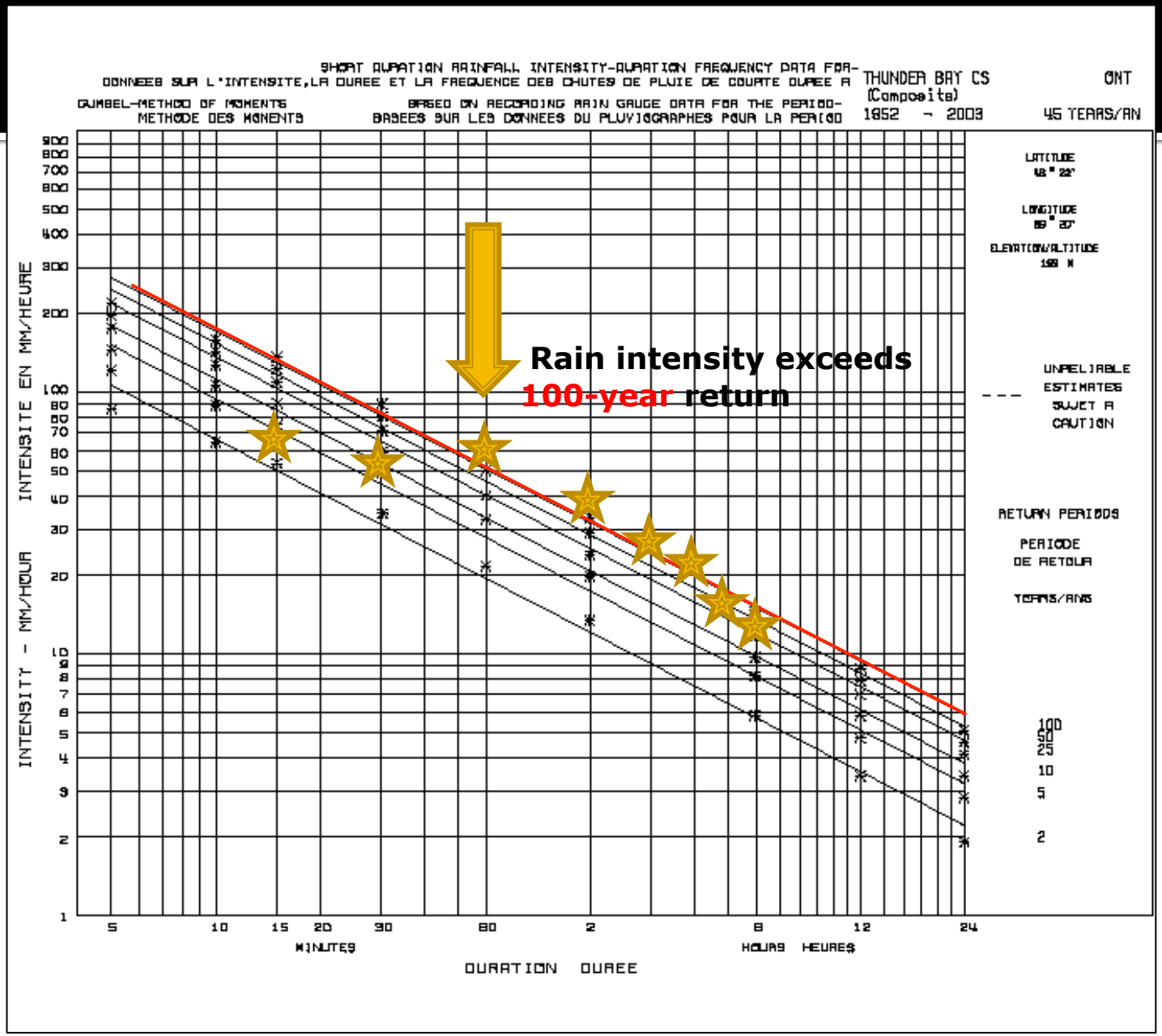
May 1 to 22: featured average rainfall

May 24: Heavy rain day
(50 to 60 mm measured)

May 25 to 27: 5 to 25 mm

Overland (surface) water flow

Thunder Bay Airport Intensity Duration Frequency



Rainfall Measurements

Problems and potential errors especially with heavy rain events equal to or greater than 75 millimetres.

- Rain gauge location
- Wind
- Mechanical errors

Rain totals tend to under report actual amounts.

Thunder Bay Historical Storms

Date	24 Hour Total (mm)	Average Rate (mm/ hour)	Antecedent (mm)
Sept. 10, 1961	98.0	4.4	12.0
May 24, 1971	76.2	3.2	54.1
Sept. 26, 1973	87.1	5.8	4.9
Sept. 8, 1977	131.2	5.5	3.7
June 28, 1996	87.7	8.0	2.0
July 2, 1997	80.4	4.0	25.6
June 6, 2008	78.8	6.1	8.0
May 28, 2012	91.3	20.3	66.4

Average hourly rate: Total divided by storm duration (see page 22)

Atlantic Avenue WPCP Flooding Assessment

December 3, 2012

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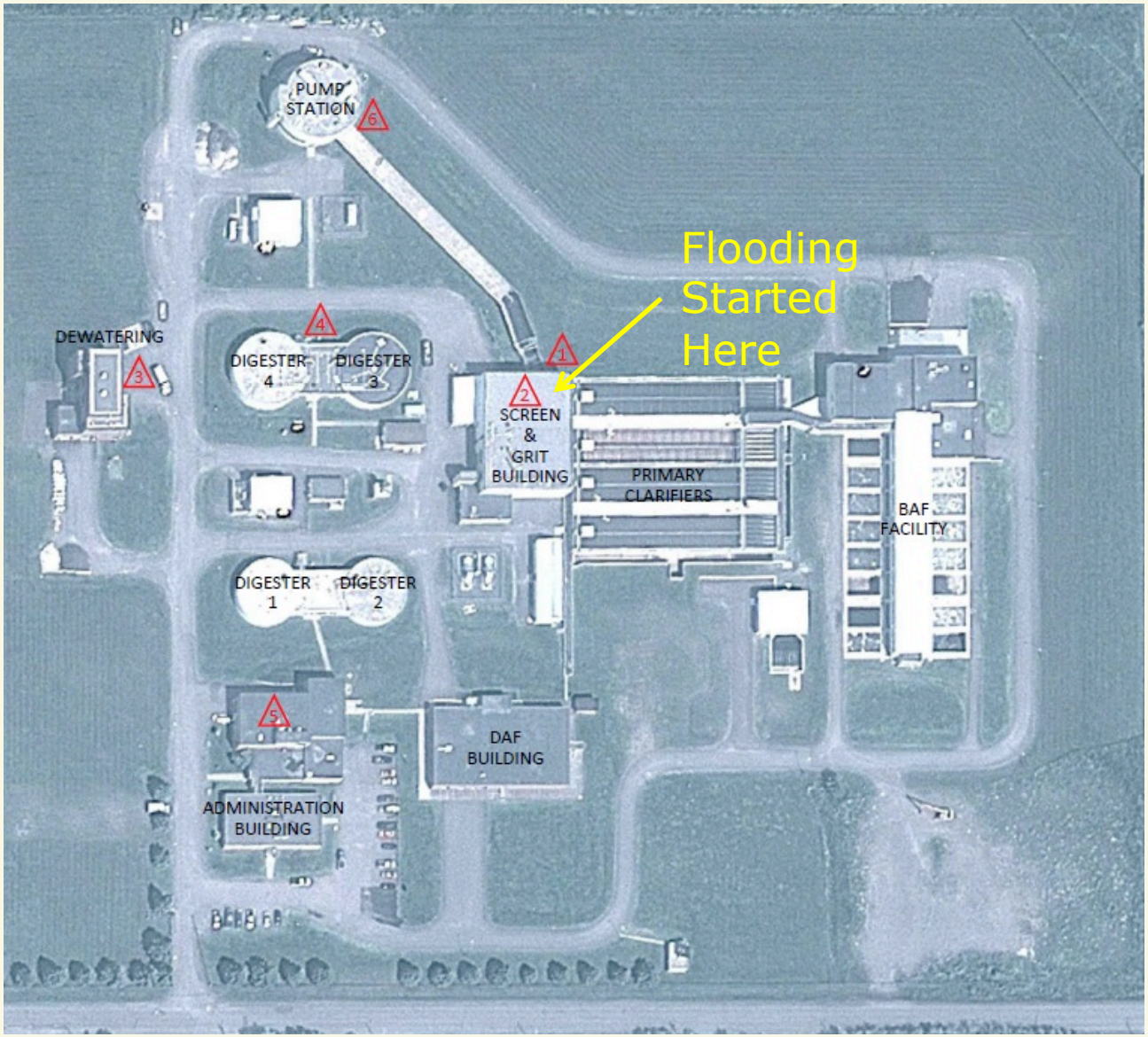
Source of Flooding



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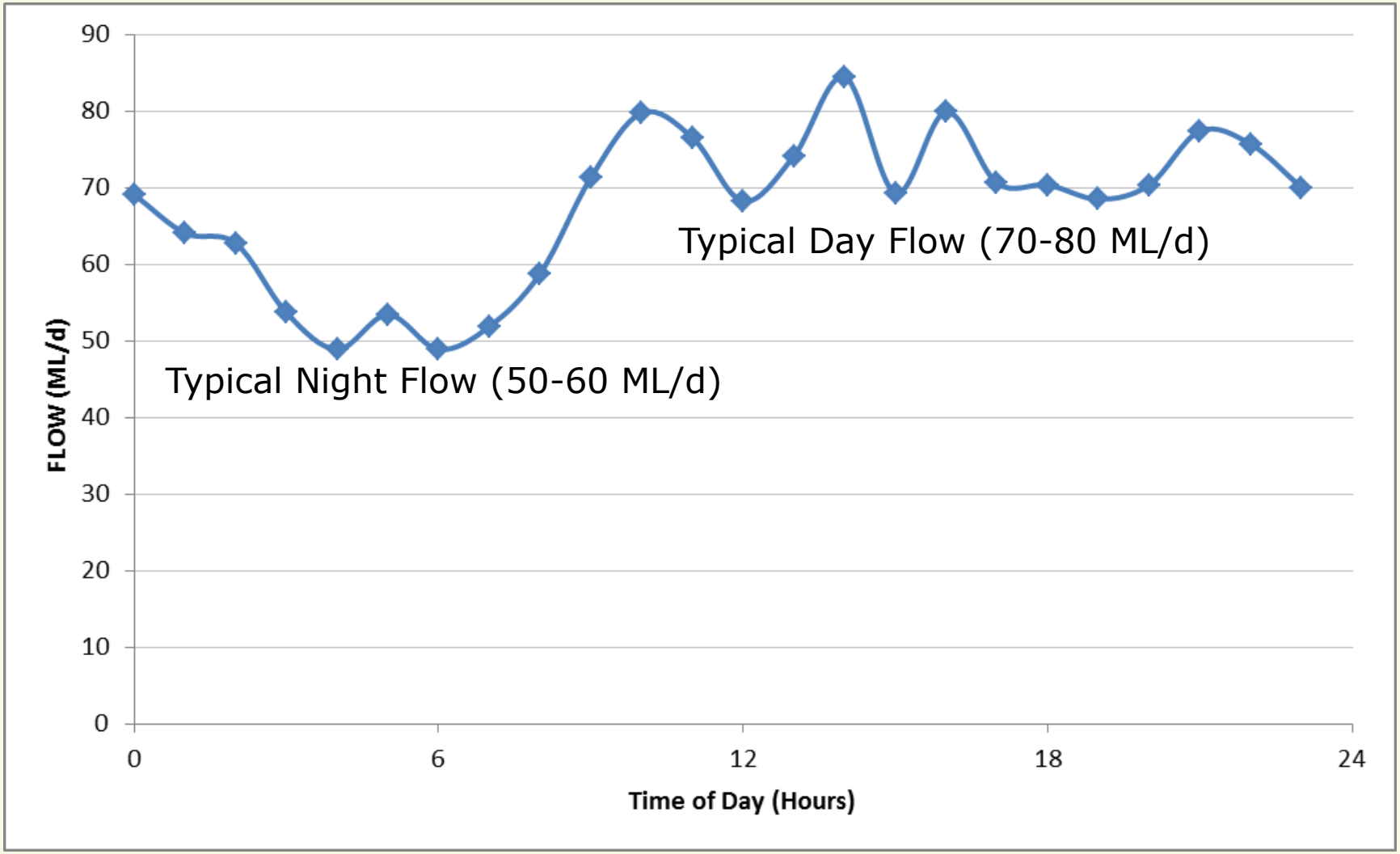
Source of Flooding

- Flooding started in Preliminary Treatment Building and progressed to all other tunnels around the plant including ultimately pump station dry well
  - Suggests excessive plugging and headloss across influent screens
  - Direction of door buckling confirms flooding from main level in Headworks down into tunnel

Estimated Plant Flows

- All flow to plant is through an on-site pumping station
  - Design capacity 766 ML/d
  - Equipped with 5 pumps (4 duty)
- Plant flow meter is calibrated to a maximum of 668 ML/d
- Applied first principles engineering approach using wet well level and manufacturer pump data to estimate flow from station

Normal Dry Weather Plant Flow



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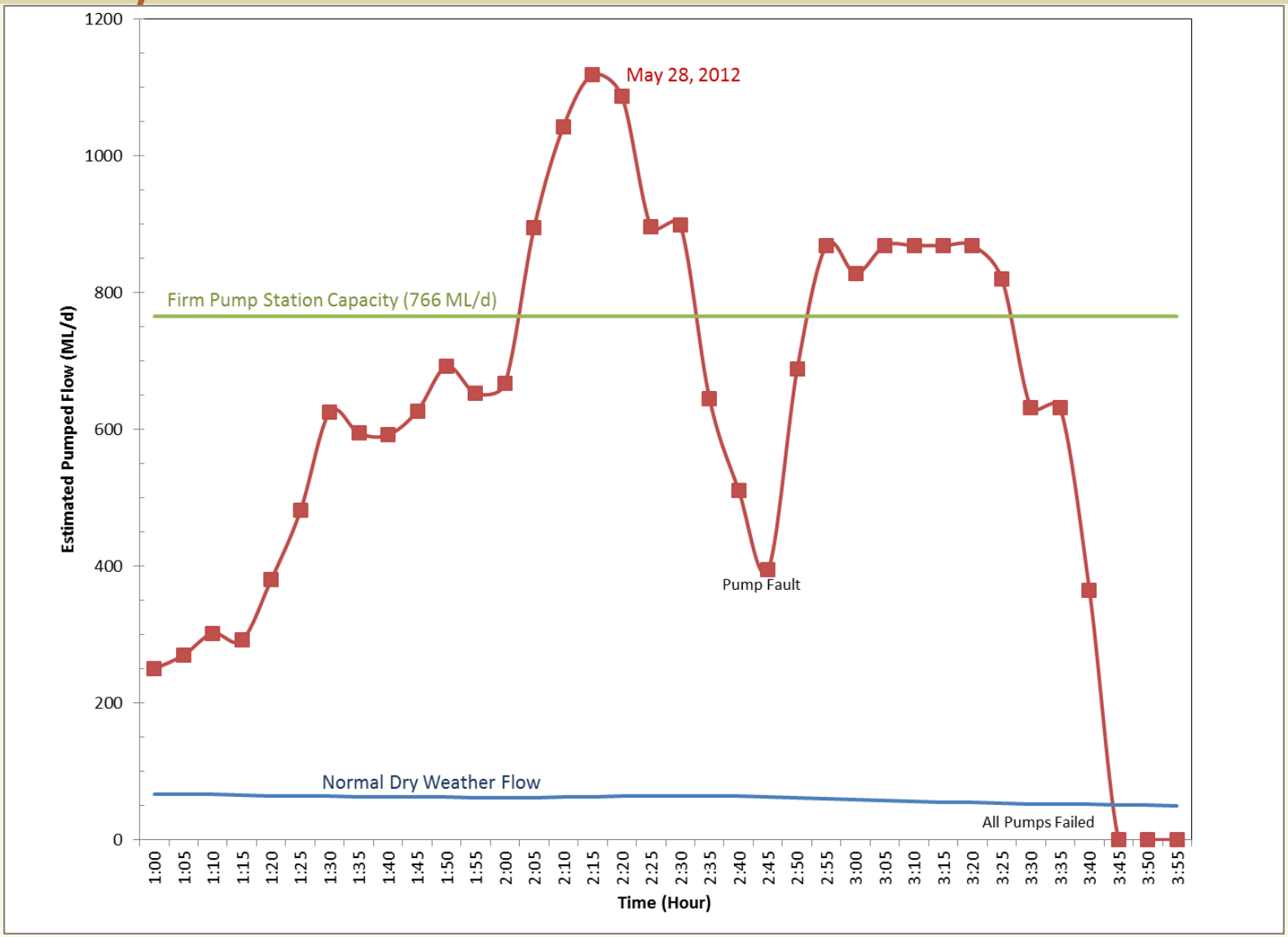
Plant Flow During Flooding (May 28, 2012)



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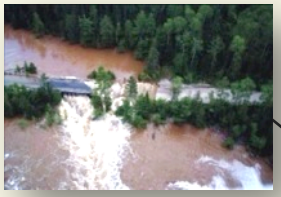
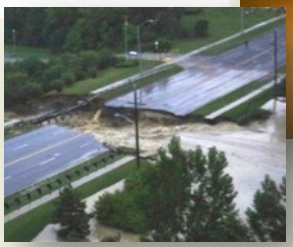
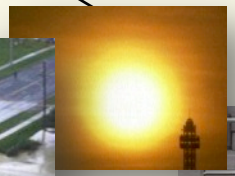
May 28th Plant Flow

- Estimated flow to the plant exceeded 1000 ML/d (more than 30% greater than station firm capacity)
- Average pump station output from 2 am to 3:30 am (before drywell flooding) approximately 800 ML/d
  - Greater than station design capacity
  - Unable to maintain normal pump station operating level due to incoming flow exceeding station capacity

Climate Change Impacts in Ontario







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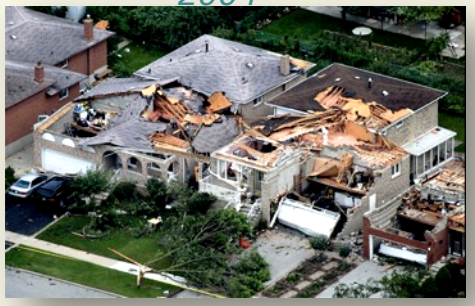
Weather Extremes!!!

Sudbury, Extreme Rain, 2009

Wawa, Extreme Rain, 2012

Peterborough, Extreme Rain, 2004

Georgian Bay, Low Water Levels, 2012



Vaughn, Tornado, 2009

Southern Ontario, Wind Storm, 2011

Toronto, Extreme Rain, 2005

Toronto, Extreme Rain, 2013

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Implications for Municipal Infrastructure

Transportation:
Road
Highway
Bridge
Walkway
Rail line

Building:
Residential
Institutional
Private

Stormwater/ wastewater:
Sewer line
Waste treatment facility
Catch basin
Settling pond

Drinking water:
Source water intake
Treatment facility
Pumping facility
Transportation/ Distribution

IT and communication:
Cell tower
Phone line
Cable line
Fiber optic

Energy:
Power generation
Power distribution
Power transmission

Shoreline (if applicable):
Dock
Berm
Port
Harbour
Flood control

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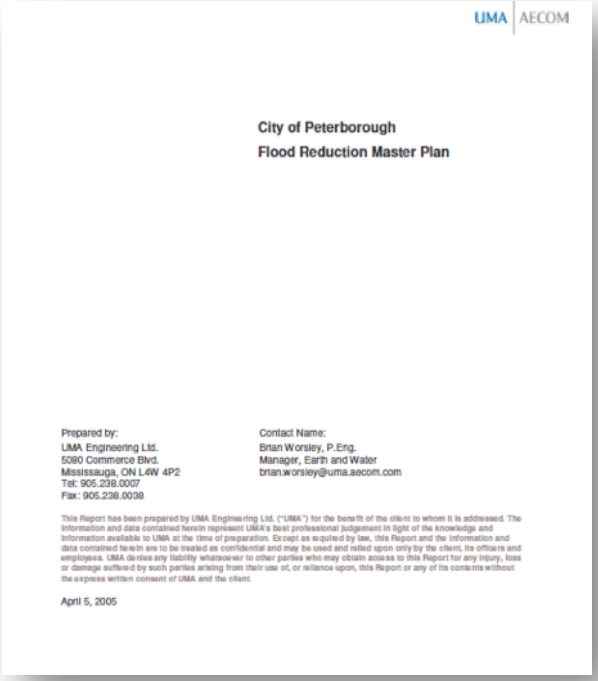
Adapting to Floods in Peterborough



UMA | AECOM

City of Peterborough
Flood Reduction Master Plan

Prepared by:
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Tel: 905.238.0007
Fax: 905.238.0038

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Manager, Earth and Water
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April 5, 2005

- In response to flooding from a few extreme precipitation events, the City of Peterborough developed their **Flood Reduction Master Plan** in May 2005.
- **Examples of the proposed actions include:**
  - **Diverting creeks** which run through the downtown core;
  - **Retrofitting storm sewer systems** to add more capacity and steer excess water away from developments;
  - **Culvert replacements**;
  - **Upgrading overland flow channels** and re-directing them to avoid development.
- In addition to infrastructure upgrades, the City has offered **financial incentives** to encourage the **disconnection of foundation drains** from the sanitary sewer system, use of **rain barrels** and the installation of **backwater valves** in previously affected areas.

Questions and Discussion