RISK ASSESSMENT OF THREE NEWFOUNDLAND AND LABRADOR INFRASTRUCTURE CASE STUDIES

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CASE STUDY #1
CORNER BROOK BRIDGE

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Case Study #1 – Corner Brook General Description

- Main Street Bridge
  - Original bridge probably built in 1920's as part of the Bowater Pulp & Paper Mill
  - Reconstructed in 1950's as a two lane bridge in (more or less) it's present form
  - Two lane concrete bridge (arterial road) with one centre pier crossing Corner Brook Stream
  - Presently in need of rehabilitation or replacement
  - Closed a number of times in 2013 due to high water and ice floes in the stream
  - Classified as a collector road

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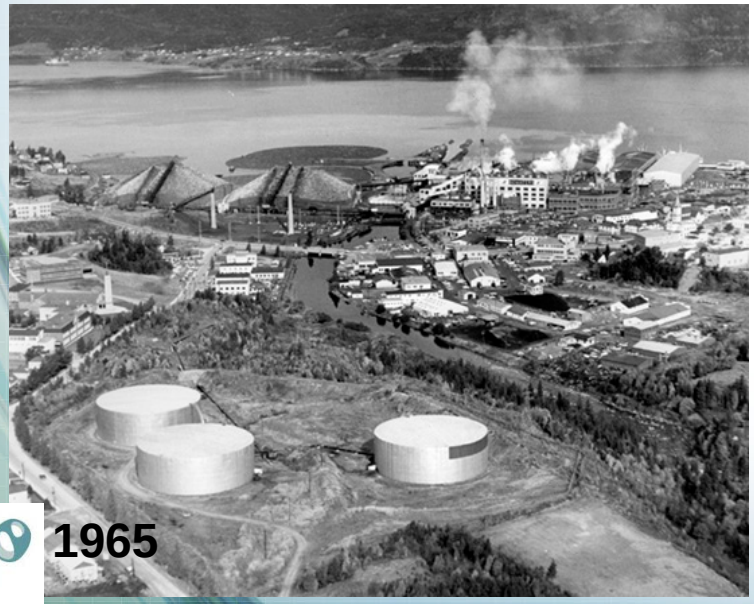
Case Study #1 – Corner Brook History

1938

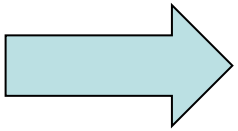
1956


1965

2011

Case Study #1 – Corner Brook Infrastructure Components

- Bridge



- Foundation
- Support pier
- Abutments
- Girders
- Bridge deck
- Drainage system
- Operations and Maintenance

Case Study #1 – Corner Brook Climate Variables – Long List

- High/Low Temperature
- Heat & Cold Waves
- Extreme Diurnal Temperature Variability
- Freeze Thaw Cycles
- Heavy Rain
- Daily Total Rainfall
- Winter Rain
- Freezing Rain
- Ice Storm
- Coastal Erosion
- Snow Accumulation
- Blowing Snow/Blizzard
- Lightning
- Hail Storm
- Hurricane/Tropical Storm
- High Winds
- Tornado
- Drought/Dry Period
- Heavy Fog
- Sea Level
- Winter Rain

Case Study #1 – Corner Brook Climate Variables – Short List

- High/Low Temperature
- Heat & Cold Waves
- Frost
- Freeze Thaw Cycles
- Heavy & Winter Rain
- Freezing Rain
- Ice cover/Thickness
- Flooding
- Sea Level
- Wind
- Snow

Case Study #1 – Corner Brook Infrastructure and Climate

Climate Scoring:

PIEVC Score	Method A	Range of Occurrences (per Year)
0	Negligible or not applicable	0
1	Improbable / highly unlikely	>0 to 0.05
2	Remote	>0.05 to 0.1
3	Occasional	>0.1 to 0.25
4	Moderate / possible	>0.25 to 0.75
5	Often	>0.75 to 1.25
6	Probable	>1.25 to 2
7	Certain / highly probable	>2

Case Study #1 – Corner Brook Infrastructure and Climate

High Temperature:

- # of days where the maximum daily temperature is greater than 30°C.
- The maximum temperature recorded for Corner Brook was 35°C in June 2003
- Average of 58.5 days a year with temperatures greater than 20°C and an average of 0.69 days per year had temperatures greater than 30°C
- Projections indicate largest increase during winter with temperatures increasing an average of 2.4°C … summer months increase is 2.1°C

Description	Days/Year	
	Historic	2050
> 20°C	58.5	increasing
> 30°C	0.69	increasing
Score	2	3
	remote	occasional

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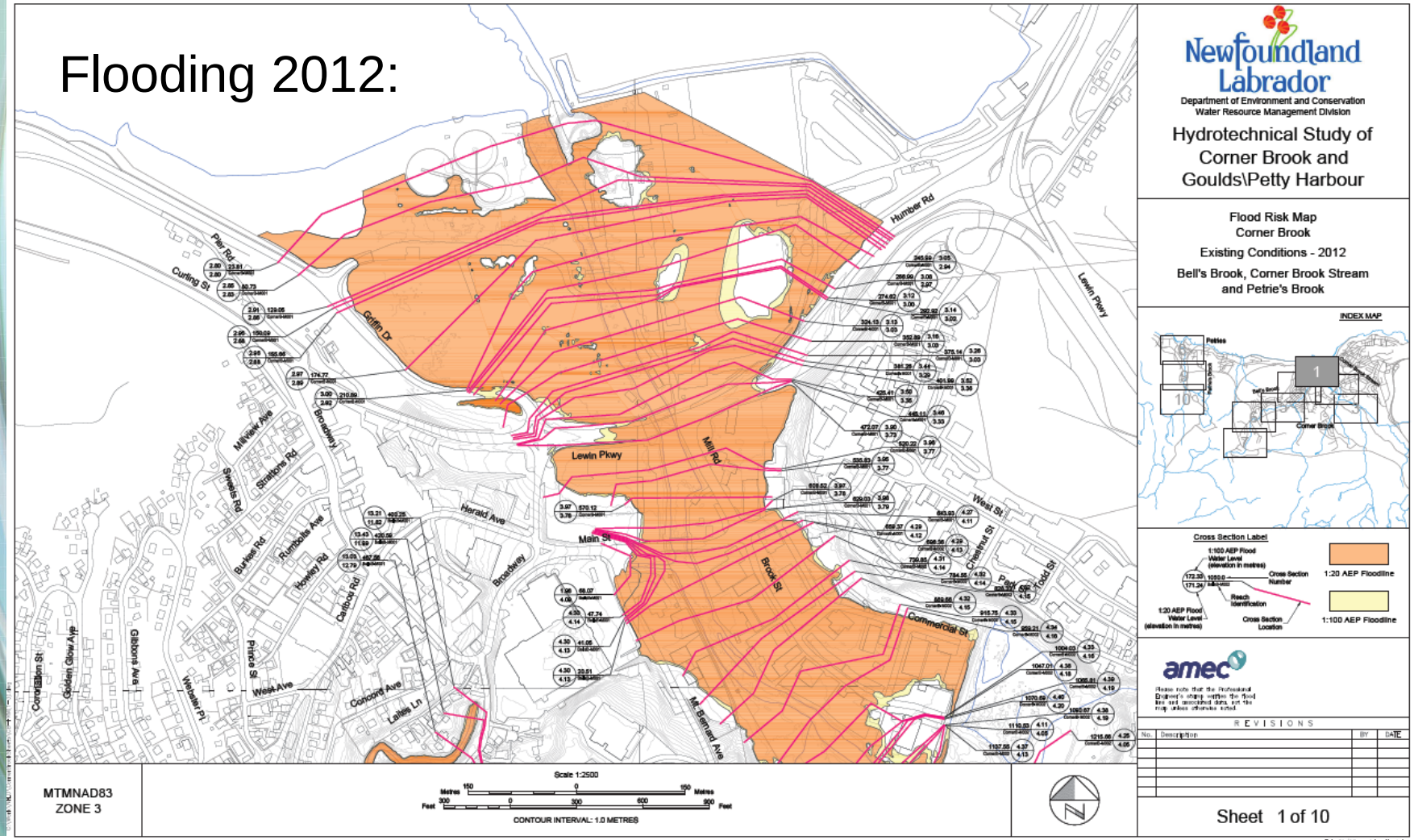
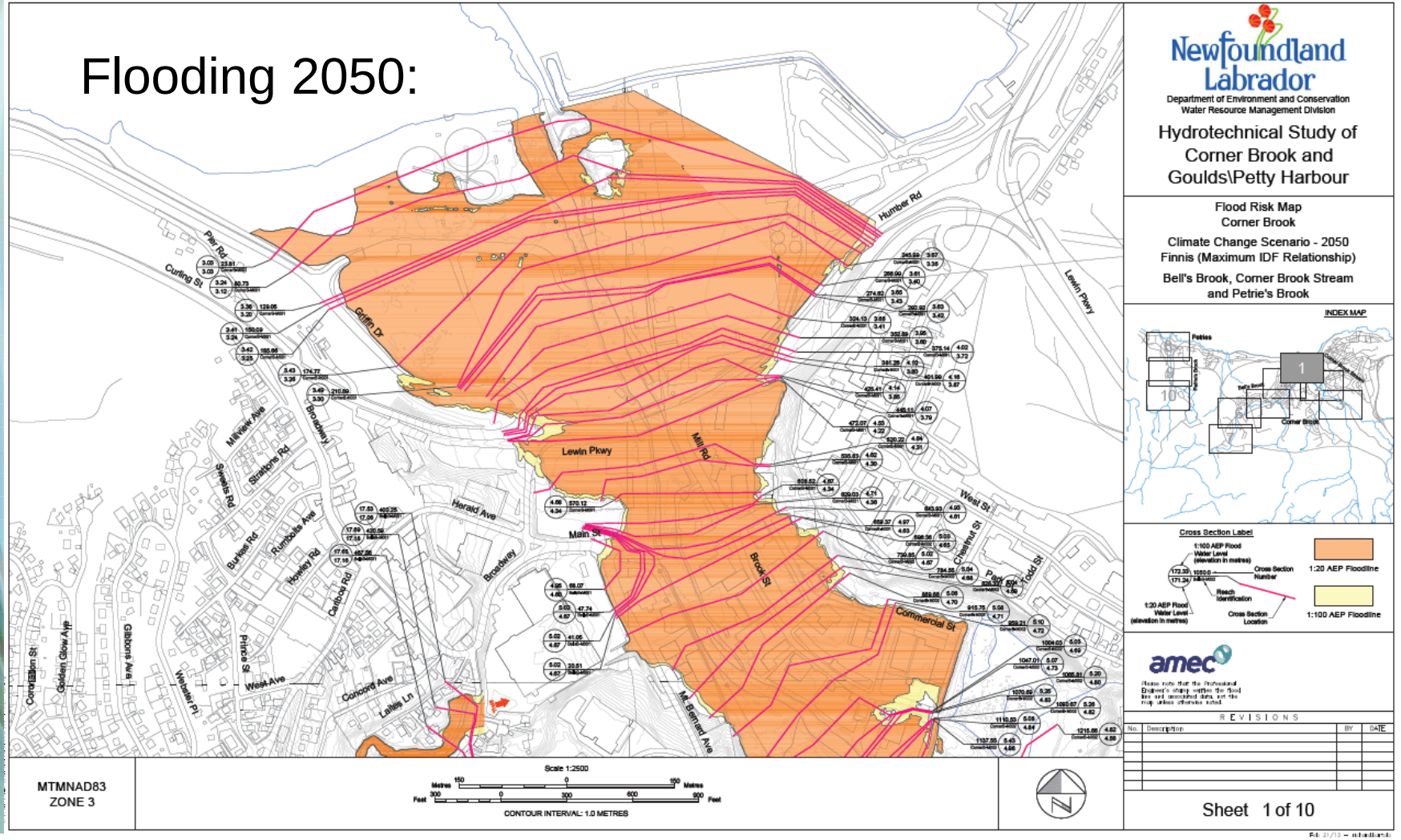
Case Study #1 – Corner Brook Infrastructure and Climate



Case Study #1 – Corner Brook Infrastructure and Climate



Case Study #1 – Corner Brook Return Period Policy

- Corner Brook Bridge designated as a collector road
- Return Period Policy requires minimum 50 year return period water level to top of pier or obvert of bridge opening
- Top of bridge deck = 2.3 m
- Obvert of bridge deck = 3.32 m
- 20 year flood level (current) = 4.11 m
- 100 year flood level (current) = 4.27 m
- 20 year flood level (2050) = 4.61 m
- 100 year flood level (2050) = 4.93 m

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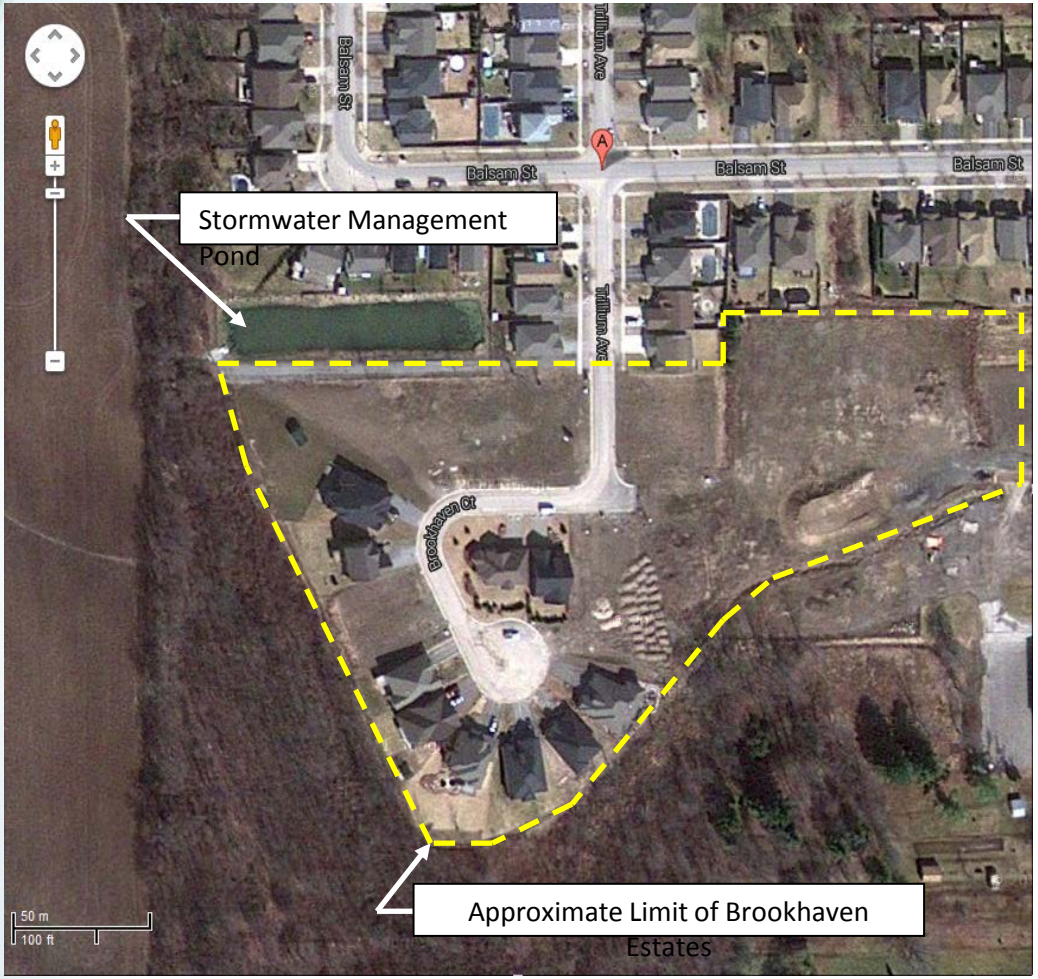
Case Study #1 – Corner Brook Risk Assessment

- Temperature variation (freeze/thaw, high/low, hot and cold waves) will effect bridge movement through expansion/contraction;
- Frost not expected to effect the bridge as it is founded on timber piles
- Bridge subject to closure due to flooding impacts (heavy rain, winter rain, hurricane/tropical storm, ice floes, sea level [plus storm surge], etc.) … increases in flood risk anticipated on Corner Brook Stream

Case Study #1 – Corner Brook Risk Assessment (cont'd)

- Potentially more frequent use of snowplows and other de-icing measures may result in more rapid degradation of the wearing surface
- Winter driving hazards may increase, along with more likelihood of delays in clearing snow off driving surface
- Deck may be vulnerable to winter rain as it is assumed that snow/ice has blocked surface drains.
- Extreme climate effects may affect O&M's ability to function (in current configuration), increasing emergency response risk, public health and safety.



Case Study #2 – Goulds Stormwater Management

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Case Study #2 – Goulds General Description

- Stormwater Infrastructure
  - Proposed residential development
  - Stormwater infrastructure includes quantity control facility (pond) and storm sewer network (separated)
  - Designed to current St. John's municipal IDF relationship
  - Performance and design evaluated using projected Intensity-Duration-Frequency relationship for 2050 as one means of identifying vulnerability

Case Study #2 – Goulds Infrastructure

Infrastructure Components

- Stormwater Management Pond
- Storm Sewer Collection Network

Administration / Operations
Personnel
Stormwater Management Pond
Inlet
Quantity Controls
Volume
Freeboard
Outlet
Quality Controls
Volume
Outlet
Containment / Embankment
Storm Sewer Network
Catchbasins
Pipes
Manholes
Outlets
Communications
Telephone, Telemetry
Others

Case Study #2 – Goulds Climate Variables

Climate Parameters

- High/Low Temperatures
- Heat/Cold Waves
- Heavy Rain
- Daily Total Rain
- Winter Rain
- Hurricane/Tropical Storm
- Drought/Dry Period

Case Study #2 – Goulds Infrastructure and Climate

Storm Sewer Design Rainfall:

- Current St. John's design rainfall for storm sewers is 77.2 mm/hr (~ 5 year design criteria, T_c ~ 5 minutes)
- Current - 5 year 6 hour design rainfall is 57.7 mm
- 2050 - 5 year 6 hour design rainfall is 68.0 mm

Stormwater Management Design Rainfall:

- Current 100 year 24 hour design rainfall is 132.0 mm
- 2050 100 year 24 hour design rainfall is 141.2 mm

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Case Study #2 – Goulds Infrastructure and Climate

Comparison of SWM Pond Designs based on Alternate Design Rainfall						
IDF	Peak Flows (m^3/s)		SWM Pond Metrics			
	Post No Controls	Post with Controls	Level (m)	Total Volume Required (m^3)	Additional Volume Required	
					(m^3)	(%)
Current Design	1.583	0.421	184.08	1831.6	----	----
2050 - Maximum	1.932	0.424	184.08	3455.3	1623.7	89%
2050 - Mean	1.676	0.423	184.08	2532.2	700.6	38%

Comparison of SWM Pond Costs based on Alternate Design Rainfall									
IDF	Pond Bottom Area (m^2)	Pond Top					Approximate Additional Cost		
		Width (m)	Length (m)	Land Required (m^2)	Additional Land Required		Land[1] $$$	Construction[2] $$$	Total $$$
					(m^2)	(%)			
Current Design	1537	24.4	103.7	2530.8	--	--	---	--	---
2050 - Maximum	2950	24.4	189.9	4633.0	2102.3	83%	$315,340	$105,540	$420,880
2050 - Mean	2150	24.4	141.1	3442.8	912.0	36%	$136,804	$45,538	$182,342

NOTES:

1. The cost of the additional land required is based $150 per square metre.
2. Construction costs estimated as $65 per cubic metre including excavation through to landscaping and surface treatment.

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Case Study #2 – Goulds Infrastructure and Climate

Storm Sewer Design Summary – Brookhaven Estates									
Pipe #	Current Design IDF	EC IDF	EC IDF	Maximum IDF	90th Percentile IDF	Mean IDF	Maximum IDF	90th Percentile IDF	Mean IDF
	1963	2010	2012	2020			2050		
	Pipe Sizes (mm) and Costs based on a 2 Year Design Rainfall								
1	450	450	450	525	450	450	525	450	450
2	450	450	450	525	450	450	525	450	450
3	525	525	525	600	525	525	600	525	525
4	300	300	300	300	300	300	300	300	300
5	525	525	525	600	525	525	600	600	525
6	525	525	525	600	525	525	600	600	525
Total Pipe Cost	*$28,352*	*$28,352*	*$28,352*	*$35,102*	*$28,352*	*$28,352*	*$35,102*	*$31,360*	*$28,352*
% of Original Cost	*100%*	*100%*	*100%*	*124%*	*100%*	*100%*	*124%*	*111%*	*100%*
	Pipe Sizes (mm) and Costs based on a 5 Year Design Rainfall								
1	525	525	525	525	525	525	525	525	525
2	525	525	525	525	525	525	525	525	525
3	525	525	525	600	600	525	600	600	600
4	300	300	300	300	300	300	300	300	300
5	600	600	600	600	600	600	600	600	600
6	600	600	600	600	600	600	600	600	600
Total Pipe Cost	*$32,069*	*$32,069*	*$32,069*	*$35,102*	*$35,102*	*$32,069*	*$35,102*	*$35,102*	*$35,102*
% of Original Cost	*113%*	*113%*	*113%*	*124%*	*124%*	*113%*	*124%*	*124%*	*124%*
	Pipe Sizes (mm) and Costs based on a 10 Year Design Rainfall								
1	525	525	525	525	525	525	525	525	525
2	525	525	525	525	525	525	525	525	525
3	600	600	600	600	600	600	600	600	600
4	300	300	300	300	300	300	300	300	300
5	600	600	600	600	600	600	600	600	600
6	600	600	600	600	600	600	600	600	600
Total Pipe Cost	*$35,102*	*$35,102*	*$35,102*	*$35,102*	*$35,102*	*$35,102*	*$35,102*	*$35,102*	*$35,102*
% of Original Cost	*124%*	*124%*	*124%*	*124%*	*124%*	*124%*	*124%*	*124%*	*124%*
	Pipe Sizes (mm) and Costs based on a 25 Year Design Rainfall								
1	525	525	525	600	525	525	600	525	525
2	525	525	525	600	525	525	600	525	525
3	600	600	600	600	600	600	600	600	600
4	300	300	300	450	300	300	450	450	300
5	600	600	600	675	675	600	675	675	675
6	600	600	600	675	675	600	675	675	675
Total Pipe Cost	*$35,102*	*$35,102*	*$35,102*	*$45,144*	*$41,310*	*$35,102*	*$45,144*	*$42,142*	*$41,310*
% of Original Cost	*124%*	*124%*	*124%*	*159%*	*146%*	*124%*	*159%*	*149%*	*146%*

Colour coded cells	Approved Design Cells colour coded where the storm sewer design is the same

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Case Study #2 – Goulds Risk Assessment

Stormwater Management Pond

- Extended high temperatures and/or drought/dry period could evaporate the permanent pool negating stormwater quality controls resulting in degraded downstream aquatic habitat
- Extended low temperatures could freeze the permanent pool negating stormwater quality controls resulting in degraded downstream aquatic habitat
- More extreme summer rains could exceed the capacity of the pond control outlet resulting in overflow of the containment embankment which could result in failure
- Winter/early spring rains on frozen ground may result in significant runoff which may exceed the capacity of the facility
- Hurricane/tropical storms result in significant runoff and debris runoff which may exceed the capacity of the facility or compromise the functionality of the control outlet

Case Study #2 – Goulds Risk Assessment

Storm Sewer Collection System

- Temperature variability not a significant issue
- Rainfall events generating higher than design runoff will result in degraded performance, more frequent surcharging and increased frequency of overland flow and/or flooding.
- More frequent surcharging conditions may also lead to increased flow velocity of point of discharge to the stormwater management pond potentially resulting in increased erosion at the outfall.

CASE STUDY #3 – PLACENTIA HIGH SCHOOL

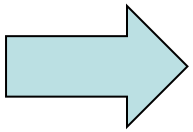
Case Study #3 – Placentia General Description

- High School
  - New school opened in 2010
  - 4,780 square meter, two storey school accommodates grades 7 to 12
  - Constructed to LEED standards, using a concrete foundation and structural steel frame

Case Study #3 – Placentia Infrastructure

Infrastructure Components

- Building Envelope
- Exterior Elements
- Structural Elements
- Mechanical Systems
- Electrical Systems
- Water and Wastewater Handling Systems
- Supporting Infrastructure
- Emergency Response



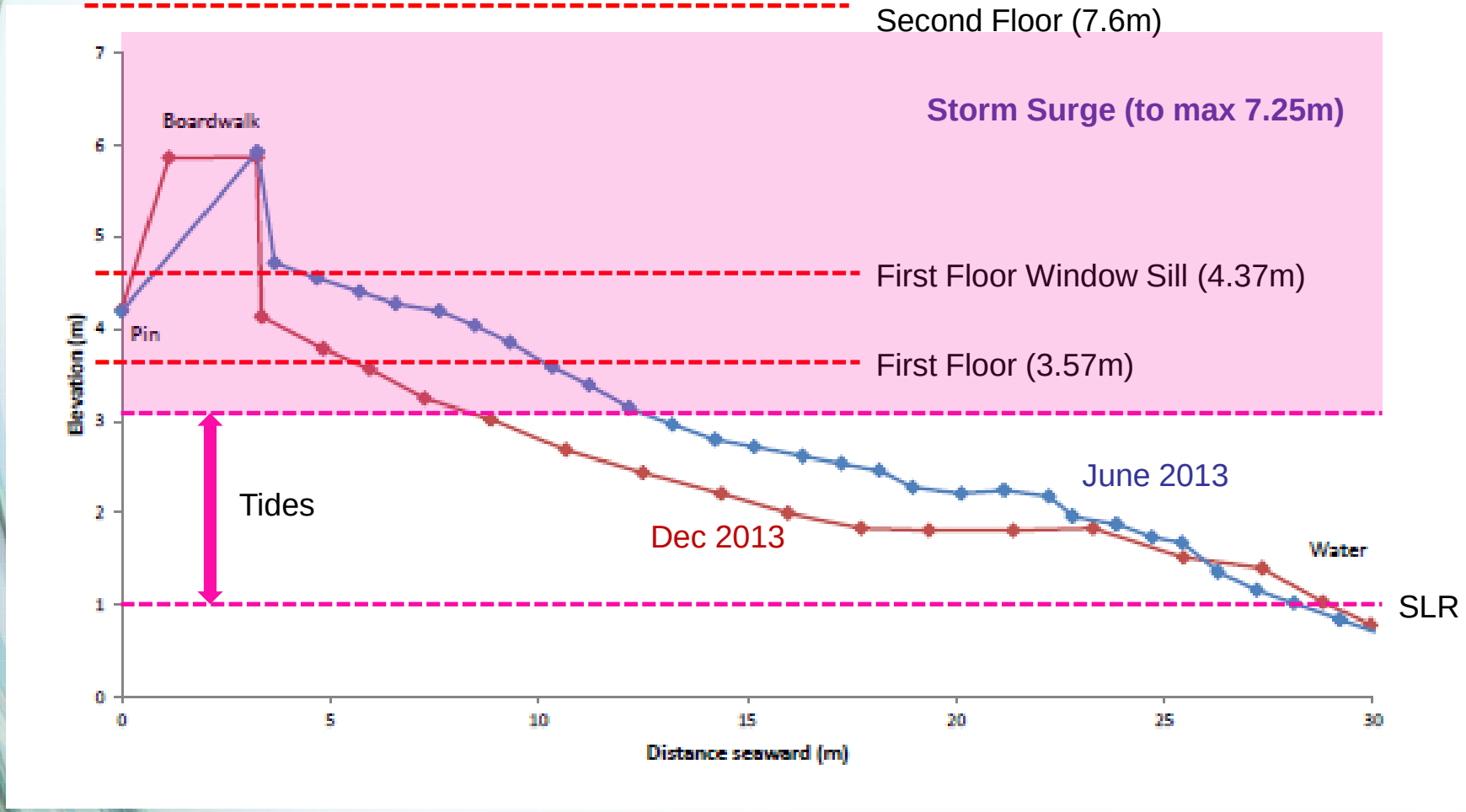
Administration / Operations
Personnel
Building Envelope
Roofing
Windows
Insulation
Cladding
Weather Sealing
Exterior Elements
Landscaping
Pavement
Walkways
Stormwater Management / Drainage
Accessibility
Structural
Roof / Floor Framing / Slabs
Lateral Load Resisting System
Walls
Foundation
Mechanical Systems
HVAC / Boilers / Chillers
Air Handling Units
Building Automation
Electrical Systems
Distribution / Lighting
Emergency Power / Alarms
Water / Wastewater Systems
Domestic Water System
Wastewater System
Supporting Infrastructrue
Municipal Services
Sea Wall / Barrier
Communications
Telephone, Telemetry
Others

Case Study #3 – Placentia Climate Parameters

Climate Parameters

- High/Low Temperature
- Heat & Cold Waves
- Snow Accumulation
- Freeze Thaw Cycles
- Heavy Rain
- Winter Rain
- Coastal Erosion
- Hurricane/Tropical Storm
- High Winds
- Flooding
- Sea Level

Case Study #3 – Placentia Infrastructure and Climate



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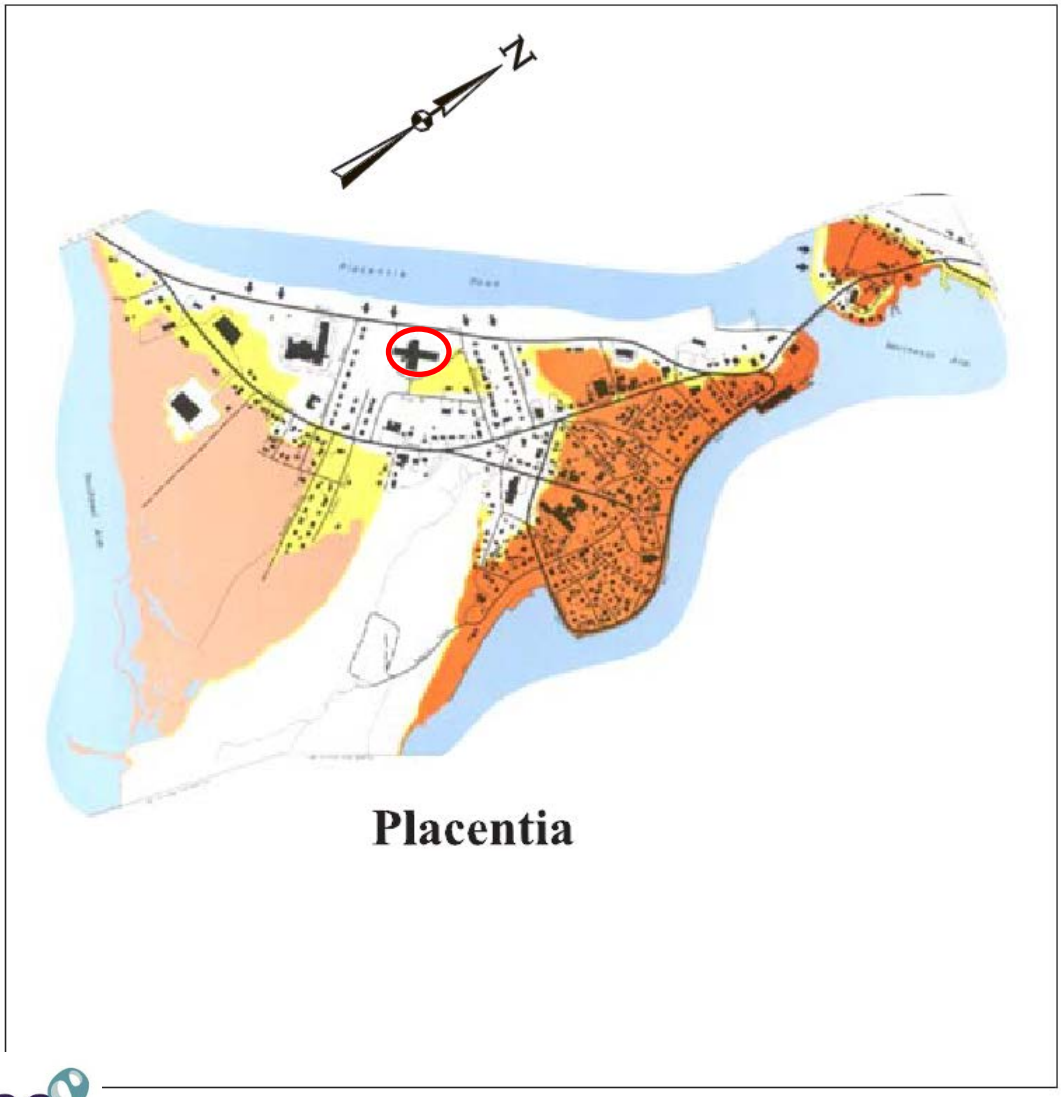
Case Study #3 – Placentia Infrastructure and Climate



"If projected amounts of sea level rise occur, many of the zones designated as the 1:100 year flood zone will be within the 1:20 year levels."

Batterson & Liverman, 2010