



**PROVINCE OF NEWFOUNDLAND AND LABRADOR
OFFICE OF CLIMATE CHANGE AND ENERGY EFFICIENCY
IMPROVING RESILIENCE TO CLIMATE CHANGE IMPACTS
CASE STUDY REPORT : LAVAL HIGH SCHOOL, PLACENTIA**

Report No.: TP114024-001

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EXECUTIVE SUMMARY

Infrastructure, whether built, human or natural, is critically important to individuals and communities. The purpose of infrastructure is to protect the life, health, and social welfare of all of its inhabitants from the weather elements, to host economic activities and to sustain aesthetic and cultural values. When infrastructure fails under extreme weather conditions and can no longer provide services to communities, the result is often a disaster. As the climate changes, it is likely that risks for infrastructure failure will increase as weather patterns shift and extreme weather conditions become more variable and regionally more intense. Since infrastructure underpins so many economic activities of societies, these impacts will be significant and will require adaptation measures. Even though municipalities share responsibilities associated with infrastructure with other levels of government, any effect of climate change is ultimately experienced locally, even if its origins are outside local jurisdictions, such as disruption of electrical power or fuel supply.

The degree to which a municipality is able to deal with the impact of climate change is often referred to as “adaptive capacity” or “the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with consequences” (Intergovernmental Panel on Climate Change, 2001). The vulnerability of infrastructure systems needs to be assessed as part of municipal risk management and decision making. Understanding the level of vulnerability also contributes to better, more informed decision-making and policy development by providing a basis for establishing priorities.

A key aspect of the Government of Newfoundland and Labrador’s 2011 Climate Change Action Plan was to establish the Office of Climate Change and Energy Efficiency (CCEE) as a central agency located in Executive Council to lead policy and strategy development on issues relating to climate change and energy efficiency. The Office works collaboratively with other departments and agencies to ensure the subjects of climate change and energy efficiency are effectively integrated into policy development and decision making. The CCEE assists with development and better use of climate change data for the Province and consideration of how climate change will impact infrastructure. The Province has been and continues to make efforts towards maximizing the use of the available data sets, covering areas of climate variable projections, flood risk mapping, coastal vulnerability and sea level rise, to inform better planning and decision making, ultimately increasing the Province’s resilience to the potential impacts of climate change.

Engineers Canada established the Public Infrastructure Engineering Vulnerability Committee (PIEVC) to oversee a national engineering assessment of the vulnerability of Canadian public infrastructure to changing climate conditions. PIEVC developed a protocol in 2005 to guide vulnerability assessments. The Protocol is a procedure to systematically gather and examine

available data in order to develop an understanding of the relevant climate effects and associated interactions with infrastructure.

This project was developed by the CCEE, with funding support from the Province of Newfoundland and Labrador, Department of Environment and Conservation, to support the demonstration of the PIEVC Protocol towards a better understanding of potential vulnerabilities of Provincial infrastructure from climate change and to develop educational material to support two climate change workshops held in June 2014 in St. John's. These workshops were attended by about 120 government decisions makers, engineers, planners, municipal staff and other stakeholders.

The climate change vulnerability assessments which have been completed are founded on version 10 of the PIEVC Protocol and Provincial climate change datasets and targeted three (3) case study sites in Newfoundland, namely:

- Corner Brook – Main Street Bridge over Corner Brook Stream
- Goulds – Stormwater management and storm sewer design
- Placentia – Laval High School

These climate change risk assessments have been developed as demonstration projects / case studies and as such do not apply all aspects of the PIEVC Protocol. These assessments have focused only on Steps 1, 2 and 3 of the Protocol, although some recommendations (Step 5) stemming from the assessment are offered. Step 4 (Engineering Analysis) was not included in these assessments.

This report constitutes the final documentation regarding the climate change vulnerability assessment of the Laval High School in the Town of Placentia.

Recommendations stemming from the application of the PIEVC Protocol to the Laval High School in the Town of Placentia to assess risks and vulnerabilities to projected changes in climate phenomenon in the future are outlined below.

- It is recommended that this scoped climate change vulnerability assessment be completed in full for all components (referring to Steps 1 to 5) of the PIEVC protocol.¹
- It is recommended that periodic shoreline monitoring on the seaward side of the breakwater/boardwalk be continued.
- It is recommended that the flood inundation mapping for the Town of Placentia be updated.
- It is recommended that near term changes in the expected frequency of freeze thaw cycles be evaluated to determine the effects of potential increased cycles on the roof of the school.

-
- It is recommended that the capacity of the HVAC systems to perform as designed with future anticipated temperatures be evaluated.
 - It is recommended that the data referenced in the applicable design codes and guidelines be updated to reflect current information. Alternatively, a mechanism to require completion of a site-specific climate assessment to determine whether in-depth analysis is necessary for infrastructure being designed or evaluated be developed.
 - It is recommended that recording of climatic events specific to the subject infrastructure be a regular procedure in the administration of the infrastructure.
 - It is recommended that the climate change projections available from the Province be augmented such that the time series upon which the projections are based are made available such that more in-depth interrogation of the datasets is possible.

General recommendations regarding climate change risk assessment of infrastructure stemming from the workshops included:

- The Province should develop procedures and/or policies for incorporating risk assessment into infrastructure planning and development practices.
- The development of climate change datasets by the Province is a great step forward in breaking down perceived barriers to climate change risk assessments. However, barriers that still exist as a consequence of the lack of coordination among departments and lack of understanding of the “do nothing” scenario still need to be addressed. As such, better Government interdepartmental coordination should be advanced towards a consistent view of the requirements for incorporating risk assessment into infrastructure planning and development practices.
- The workshops clearly demonstrated value in advancing understanding of climate change issues affecting infrastructure in the Province. Further opportunities for training/education about climate change and the potential impacts to the Province should be continued for all levels of government and the private sector.
- The climate change datasets developed by the Province can generally support climate change risk assessment. However, the Province should not view these datasets as static. Examples of gaps in the datasets have already been noted (i.e., short duration IDF data). With changing science and data collection new projections are being developed around the world. The Province should develop a review cycle for its datasets. Further, the Province should also allow for new datasets to be analysed and incorporated into the larger suite of datasets.

¹ Adoption of this recommendation would encompass some of the other recommendations itemized in the list.



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SECTION 1

INTRODUCTION



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1 INTRODUCTION

It has been projected that Newfoundland and Labrador (the “Province”) may, in the future, experience changes in the frequency and/or severity of extreme weather as well as changes to average climate over several decades or more as a result of climate changes. These changes are expected to affect natural, social and built infrastructure, potentially having significant socio-economic consequences. The climate change assessment focus has most often been directed towards a range of mitigation options related to energy use. These have been targeted at reducing greenhouse gas emissions, encouraging public transport and increasing energy efficiency at all scales in the community. However, more recently, the focus has shifted toward adaptation measures recognizing that communities must adapt to changing climatic conditions.

The Government of Newfoundland and Labrador has recognized the potential for change in the Province and has charted a course for the Province with the 2011 Climate Change Action Plan which establishes the provincial Government’s strategic approach to climate change. As a component of this strategy the Office of Climate Change and Energy Efficiency (CCEE) was initiated as a central agency located in Executive Council to lead policy and strategy development on issues relating to climate change and energy efficiency. As a key part of this mandate, the Office works collaboratively with other departments and agencies to ensure the subjects of climate change and energy efficiency are effectively integrated into policy development and decision making.²

A component of the CCEE’s mandate is directed towards development and better use of climate change data available for the Province and consideration of how climate change will impact infrastructure. The Province has been and continues to make efforts towards maximizing the use of the data sets that have been developed, covering areas of projections, flood risk mapping, coastal vulnerability and sea level rise, to inform better planning and decision making, ultimately increasing the Province’s resilience to the potential impacts of climate change.

Engineers Canada, the business name of the Canadian Council of Professional Engineers, established the Public Infrastructure Engineering Vulnerability Committee (PIEVC) to oversee a national engineering assessment of the vulnerability of Canadian public infrastructure to changing climate conditions. PIEVC developed a protocol in 2005 to guide vulnerability assessments. The Protocol is a procedure to gather and examine available data in order to develop an understanding of the relevant climate effects and their interactions with infrastructure.

This project was developed by the CCEE to support the demonstration of the PIEVC Protocol towards a better understanding of potential vulnerabilities of Provincial infrastructure from

² From <http://www.exec.gov.nl.ca/exec/ccee/>

climate change and to develop educational material to support two climate change workshops held in June 2014 in St. John's, namely:

- One (1) - ½ day workshop for Decision-Makers on Integrating Climate Risk into Infrastructure Decisions in Newfoundland and Labrador, held on June 3rd, 2014, and,
- Two (2) - one (1) day workshops for Engineers, Planners and Municipal staff on Integrating Climate Risk into Infrastructure Decisions in Newfoundland and Labrador, was held on June 4th, 2014. The second one day workshop was held on June 5th, 2014.

These climate change vulnerability assessments are founded on version 10 of the PIEVC Protocol and Provincial climate change datasets and targeted three (3) case study sites in Newfoundland, namely:

- Corner Brook – Main Street Bridge over Corner Brook Stream
- Goulds – Stormwater management and storm sewer design
- Placentia – Laval High School

As noted above, these climate change risk assessments have been developed as demonstration projects and as such do not apply all steps of the PIEVC Protocol.

Separate reports have been developed for each of the climate change vulnerability assessments completed for the infrastructure sites noted above. This report constitutes the final documentation regarding the climate change vulnerability assessment of the Laval High School located in the Town of Placentia.

1.1 PROJECT OBJECTIVES

The principal objective of this study is to identify those components of the Laval High School that are at risk of failure, damage and/or deterioration from extreme climatic events or significant changes to baseline climate design values. The nature and relative levels of risk are to be determined in order to establish priorities for remedial action. The assessment of vulnerability was based on the May 2012 (v10) PIEVC Protocol, premised on potentially three (3) future time frames, namely: 2020, 2050 and 2080 where data was available.

The outcomes of all of the assessments are expected to drive possible remedial action at the study-specific infrastructure locations and to support CCEE efforts to engage the engineering community and advance risk based design for infrastructure in the Province. Further, the results of this assessment will be incorporated into the national knowledge base which has been formed as a basis for analysis and development of recommendations for review of codes, standards and engineering practices.

1.2 PROJECT SCOPE

This scoped climate change vulnerability assessment will review climate change and infrastructure datasets and will apply the PIEVC Protocol specifically Steps 1 and 2, and a preliminary, independent application of Step 3 of the Protocol. This vulnerability assessment will use version 10 of the Protocol.

The intent of this assessment is to provide an overview of the PIEVC Protocol and, through an example, how its application to infrastructure can assist in understanding risks in the face of a changing climate. Further, this report provides only a preliminary risk assessment of the Laval High School in the Town of Placentia, in essence a starting point. As a starting point, it does not touch on all aspects of the infrastructure or all potential climatic influences. Full applications of the PIEVC Protocol have been completed for similar infrastructure elsewhere in Canada. These reports are available at the PIEVC website (www.pievc.ca) and it is encouraged that these be reviewed in advance of a more in-depth risk assessment of the high school in the future.



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SECTION 2

PIEVC PROTOCOL STEP 1

PROJECT DEFINITION



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2 STEP 1 - PROJECT DEFINITION

2.1 OVERVIEW

Step 1 of the PIEVC Protocol focuses on the development of a general description for the following aspects of the project:

- location of the vulnerability assessment;
- infrastructure of concern;
- historic climate;
- existing loads on the subject infrastructure;
- age of the subject infrastructure;
- other relevant factors;
- identification of major documents and information sources.

The outcome from this step is a definition of the boundary conditions for the vulnerability assessment.

2.2 STUDY LOCATION

The Town of Placentia (“Placentia”) lies on the south-eastern portion of the island of Newfoundland (ref. Figures 2-1, 2-2 and 2-3) on the Avalon Peninsula about 100 km south-west of St John’s. Placentia lies on the east side of Placentia Bay which is bounded by the Burin Peninsula to the west and the Avalon Peninsula to the east.

The community encompasses Dunville, which forms the north-western section of the town and is connected to downtown by a lift bridge. The Placentia area is subject to frequent storms, which have caused serious flooding in low-lying locations.

The population of Placentia was 3,643 in 2011, representing a decrease from 2001 of about 17%. There has been a general decline in the population of the community since 2001.

Placentia’s low-lying location on a flood plain adjacent to the sea has contributed to the town historically having to deal with serious flooding. In response to this threat, two pieces of infrastructure were built to hold back seawater. A stone and timber breakwater – begun in the 1960’s and extended in the 1990’s – was built. To prevent flooding by water diverted by the breakwater, a sheet-steel pile floodwall was constructed in 1993 along the inside (northeast) face of the downtown peninsula.

Placentia-area infrastructure located in low-lying sites in communities and along roadways is vulnerable to flooding. For example, in August 2007, heavy rain from the post-tropical storm

Chantal washed out bridges and submerged roads, basements and parking lots. One road collapsed under a car's weight when a culvert beneath the pavement washed away, creating a gap six meters wide and six meters deep. In 2007, Dunville experienced flooding related to Chantal but downtown Placentia escaped flooding.

Eastern Newfoundland's climate is mid-boreal, marked by cool summers and winters. Communities fringing Placentia Bay, like Newfoundland and Labrador in general, currently are subject to a wide range of climatic events, including mid-latitude storms, hurricanes and tropical storms, snowfall and frost, plus summer drought. Recent trends suggest that such events are becoming more frequent and intense.

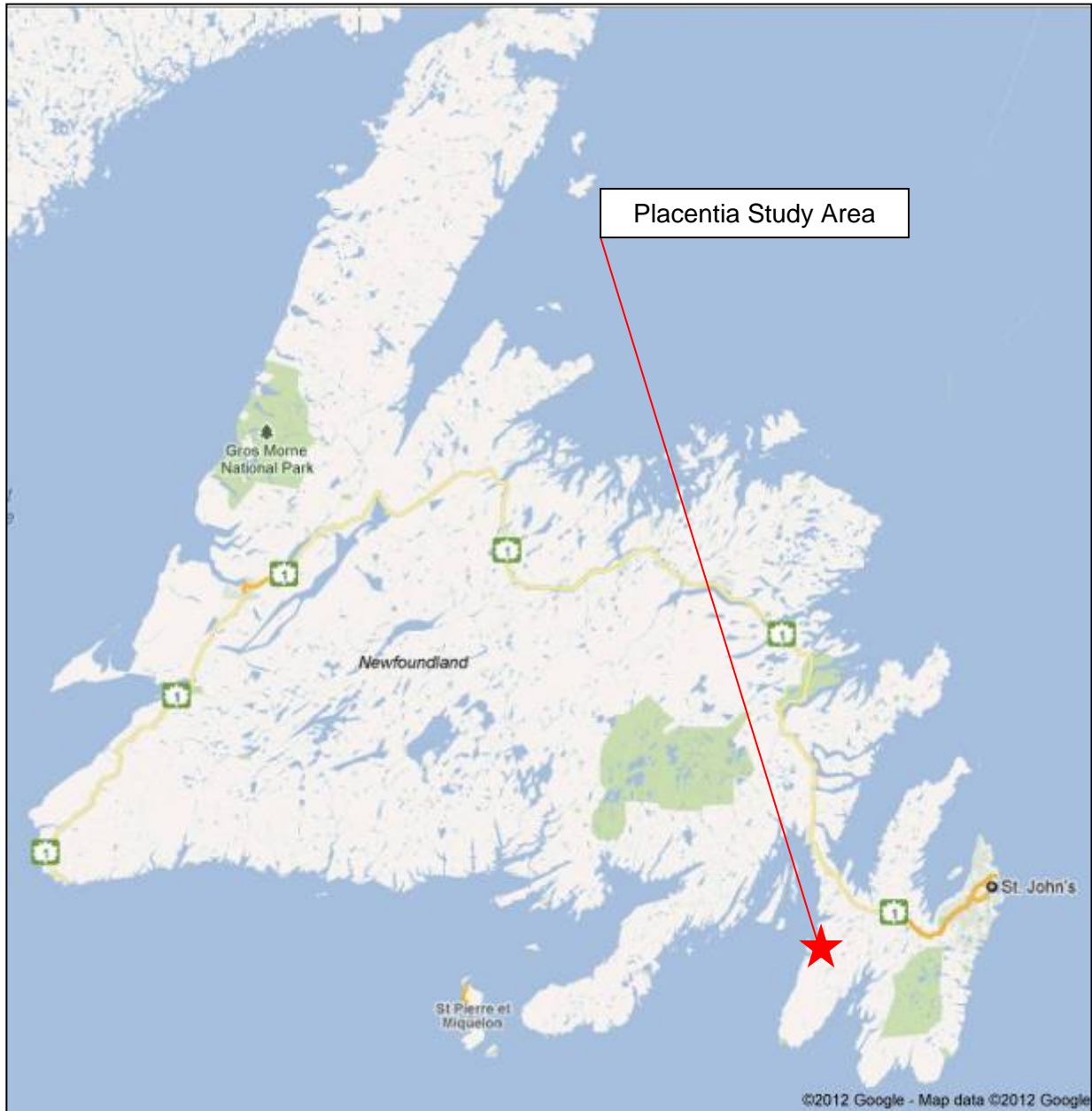


Figure 2-1 : Study Location - Regional Context



Figure 2-2 : Study Location – Local Overview



Figure 2-3 : Study Location – Local Context

(Please note the image above depicts the old school location, although the new school has been constructed immediately beside the old school)

2.3 STUDY INFRASTRUCTURE

The study infrastructure for this climate change vulnerability assessment is the Laval High School in the Town of Placentia. The school is located in the core of the Town at the following co-ordinates:

Latitude	47° 14' 31.9"
Longitude	53° 57' 59.0"

at address: 67-91 Beach Rd, Placentia, NL A0B 2Y0.



Figure 2-4 : Laval High School³

Completed in 2010, the school is a 4,780 square meter, two storey building which accommodates grades 7 to 12⁴. It was a design-build project and was constructed to Leadership in Energy and Environmental Design (LEED) standards, using a concrete foundation and structural steel frame. The exterior cladding is a combination of metal siding, hardi-plank siding, and split face architectural block, while the roof is a two-ply modified bitumen system. Interior walls are a mixture of masonry and steel stud drywall, while ceilings are acoustic and T-Bar system. Floors feature a combination of sheet vinyl and vinyl and ceramic tile. The large gymnasium has a telescopic bleacher system. The building is heated and ventilated with

³ From: <https://www.nlesd.ca/schools/schoolprofile.jsp?id=87>

⁴ From: <http://www.marcogroup.ca/portfolio/past/laval-high-school>

individual water and source heat pumps. Work for this project also involved the complete landscaping of the site with new sidewalks, curbs, and asphalt paving.

Laval High School has a student population of approximately 310 and 32 staff members. Students attending this school come from the surrounding communities of Ship Harbour, Fox Harbour, Dunville, Jerseyside, Ferndale, Freshwater, Placentia, Southeast, Bond's Path, Point Verde and Big Barasway.⁵

2.4 STUDY AREA CLIMATE

(from Cameron et al, 2008)

“The climate of Eastern Newfoundland is classified as mid-boreal, marked by relatively cool conditions and seasonally consistent precipitation, with humid and per-humid moisture regimes. Newfoundland lies within the Boreal Eco-climatic Province of Canada. The climate is controlled by the dominant westerly winds of the mid-latitude Northern Hemisphere, and the proximity of the relatively cold waters of the Labrador Current system of the Atlantic Ocean. Mean February sea surface temperatures are less than 0°C along the majority of the coastline. Local factors, such as topography and the prevalence of onshore and offshore breezes, create distinct mesoclimatic and microclimatic regimes in many locations.

Within the Avalon Peninsula, summers are short, cool, and wet (normally, the driest and hottest month is August). Winters are moderately mild and wet. Long springs (March through June) and relatively short autumns (September through mid-October) are normal. The Avalon zone, influenced by southwesterly winds blowing landward, is considered to be the area of Newfoundland showing the most marked maritime influence. At shoreline sites, daily mean temperatures in February vary from -2.5°C to -6°C. Interior areas are 1 to 2 C° colder than adjacent coastal sites.

August daily mean temperatures vary from 14°C to 16°C, with sites exposed to maritime conditions associated with south-westerly winds being cooler than sites on the north-east coast. On local scales, summer temperature values vary with aspect. Sites in these areas that are exposed to direct south-westerly winds are somewhat more variable in temperature than are sheltered areas. Freeze-thaw cycles are generally numerous from mid-December to early April, and frost events may occur at any time from early September to June. In exposed coastal headlands, several freeze-thaw cycles may occur daily during the early and late winter.

The mean annual precipitation throughout the Avalon varies from 1500 to 1650 mm. Local variations between adjacent stations indicate that wind effects are significant in causing the amount of precipitation to be under-estimated. Individual storms (notably Gabrielle in September

⁵ <http://www.laval.k12.nf.ca/>

2001) may bring more than 100 mm of rainfall within 24 hours. Some north-east facing slopes on the north-east Avalon received more than 200 mm of rain during Gabrielle.

Additional variations are due to aspect and differences in the proportion of precipitation types. Areas marked by larger proportions or amounts of snowfall also generally receive less total precipitation. Shoreline areas receive less snowfall and more freezing rain and drizzle than do interior locations, although rainfall events in coastal areas may be associated with freezing precipitation events inland.

In coastal sites, typically 15 to 25% of the precipitation falls as snow, although in exposed regions subject to onshore winds the proportion of snowfall may be less than 10%. Large annual variations are common.

Fog is common along the Placentia Bay shore. Argentia, the foggiest weather station in Canada, averages 206 days with at least 1 hour of fog. Ice foot development is commonly a major factor in the geomorphic development of the Conception Bay shoreline north of Spaniards Bay, and along the Trinity Bay shoreline.

Formation of an ice foot largely precludes winter erosion of beach sediments. The southerly extent of persistent ice foot development coincides with the position of the -0.5° C February SST⁶ isotherm, confining the phenomenon to the northern and central parts of the shoreline surrounding the Avalon Peninsula. Ice foot development is less common along Placentia Bay than along Trinity and Conception Bays, and is generally associated with strong positive NAO⁷ conditions.

Wind patterns vary seasonally, and local topographical effects are extremely significant in many embayments. Westerly and south-westerly winds are more prevalent throughout the year, although winds may originate from any point of the compass at any time of the year.

The south-westerly winds generally bring warm, moist air to the region from the warmer ocean surface waters south of the Burin Peninsula.

Along the open shorelines of Placentia Bay, the extensive fetch allows the south-westerly winds to be effective agents driving the evolution of coastal geomorphology. Strong south-westerly winds are associated with many of the major storms and hurricanes during the summer and autumn, which generally pass over the region from south-west to north-east. Wind patterns show some seasonal variation, with easterly and south-westerly winds alternating during the summer, and south-westerly's dominating during the winter. Diurnal onshore and offshore winds are common in most embayments.

⁶ SST - Sea Surface Temperature

⁷ North Atlantic oscillation

Strong southerly winds associated with late autumn and winter storms also are effective agents at modifying coastlines, if they arrive prior to the formation of pack or landfast ice.”
The statistical summaries in Table 2-1 provide a general overview of the study area climate. It is interesting to note the significant increase in average annual precipitation over the 1971-2000 and 1981-2010 periods noted in Table 2-1.

A complete listing of the climate normals for Placentia, for each of the periods noted in Table 2-1, is available via the Environment Canada website.

Table 2-1 : Climate Information for Placentia⁸

Climate Parameter	Colinet ¹		North Harbour ¹
	1961-1990	1971-2000	1981-2010
Precipitation			
Average annual precipitation	1391.0 mm	1392.1 mm	1571.7 mm
Average annual rainfall	1225.2 mm	1229.2 mm	1395.0 mm
Average annual snowfall	165.7 cm	162.9 cm	176.7 cm
Extreme daily rainfall	104.6 mm September 1948		142.0 mm June 1988
Extreme daily snowfall	101.6 cm February 1943		
Extreme snow depth	n/a	104 cm February 1975	
Annual occurrence of daily rainfall events (with totals >25 mm)	n/a	11.3 events per year generally between June and November	12.4 events per year generally between March and November
Temperature			
Daily average minimum temperature	-8.7 °C	-9.2 °C	-8.0 °C
Daily average maximum temperature	19.1 °C	19.2 °C	20.1 °C
Extreme minimum temperature	-28.9 °C February 1975		
Extreme maximum temperature	29.4 °C July 1947		
Frost			
Average date of last spring frost	n/a	n/a	June 7 th
Average data of first autumn frost	n/a	n/a	October 18 th
Average frost free season	n/a	n/a	132 days
Notes:			
1. The weather station at Colinet was discontinued in 1996.			

⁸ Source: Environment Canada Climate Normals 1981-2010 for the Colinet and North Harbour weather stations (#8401200 and #8402874), Environment Canada website at http://climate.weather.gc.ca/climate_normals/index_e.html

2.5 OTHER RELEVANT FACTORS

No specific other relevant factors have been identified for this assessment.

2.6 ASSESSMENT TIME FRAMES

2.6.1 Historical

The time frame used for this assessment for representation of historical information is the period 1981-2010. This 30-year period matches the most recent climate normal period available from Environment Canada. Where independent data analyses were completed for this assessment, the 1981-2010 time frame was used unless otherwise indicated.

2.6.2 Future

It had been planned to complete the vulnerability assessment for three future periods, namely 2020, 2050 and 2080. These future periods reflect the tri-decade periods of 2005-2034, representing 2020, 2035 to 2064, representing 2050, and 2065 to 2094, representing 2080. Gaps in the available climate datasets are noted where they have been identified.

However, vulnerability assessment beyond the 2050 time frame was not completed in consideration of the design life of the subject infrastructure and availability of climate projections. That is, significant reconstruction and/or rehabilitation of the infrastructure would likely occur beyond 2050. It is also understood that the uncertainty associated with climate projections increases moving farther into the future which would limit or question the validity and/or usability of any results.

2.7 MAJOR DOCUMENTS AND INFORMATION SOURCES

Major documents and other information sources used to support this climate change vulnerability assessment are referenced, as appropriate, throughout this report.

SECTION 3

PIEVC PROTOCOL STEP 2

DATA GATHERING AND SUFFICIENCY



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3 STEP 2 - DATA GATHERING AND SUFFICIENCY

3.1 OVERVIEW

Step 2 of the PIEVC Protocol focuses on describing aspects of the subject infrastructure that will be assessed with relevant climate change parameters. Identification of the infrastructure components to be considered for evaluation has focused on:

- what are the infrastructure components of interest to be evaluated?
- number of physical elements and location(s)
- other potential engineering / technical considerations
- operations and maintenance practices and performance goals

The second part of this task focused on identification of relevant climate information. Climatic and meteorological data (both existing/historic data, as well as, future projected climate data) has been identified and collected. The objectives of the climate analysis and projections component of this assessment are to:

- establish a set of climate parameters describing climatic and meteorological phenomena relevant to the Town of Placentia, and;
- establish a general probability of occurrence of each climate phenomena, both historically and in the future.

As noted in Section 2, for the purposes of this assessment the term “historical” is defined as comprising both the existing climate and the climate from the recent past, while the “future” climate is defined as representing three timeframes, namely 2020, 2050 and 2080, where data is available.

Given the scoping level nature of this vulnerability assessment, the AMEC Team identified features of the subject infrastructure to be considered in the assessment using the climate information gathered for this study. The development of this assessment framework is typically a collaborative effort between the consultant and infrastructure owner/operator. The infrastructure component data and the climatic data form the foundation of the risk assessment matrix which is a fundamental aspect of the Protocol.

3.2 INFRASTRUCTURE OF INTEREST

As noted previously, the infrastructure of interest for this climate change vulnerability assessment is the Laval High School in the Town of Placentia in the Province of Newfoundland and Labrador.

3.2.1 Laval High School

(source: Design Development Report, Grade 7-12 School, Placentia, NL⁹)

The Laval High School project involved the construction of a new two storey facility to accommodate grades 7-12 students in the Placentia and Dunville area. The school was constructed on a relatively flat building site on Beach Road adjacent to the existing Laval School in Placentia. The existing school was demolished after construction of the new school. The project included an increase in floor areas of the Gymnasium, Change Rooms, Stage and Music Room beyond Department of Education standards. The increased areas are based on additional funding provided to the Town of Placentia by INCO.

The gross area of the ground floor of the school building is approximately 3,450 square meters and the gross floor area of the second floor is approximately 1,330 square meters. The total gross floor area of the building is approximately 4,780 square meters. The gross floor area attributed to Department of Education Standards is approximately 4,187 square meters and the gross floor area attributed to the INCO funds is approximately 593 square meters.

The project was designed with a sustainable development review based on the LEED scorecard guidelines. A Green Building Workshop was held and attended by the Department of Transportation and Works, Department of Education, and the consultant team. The project team developed the design to achieve the LEED points necessary for minimum Silver level.

The school is a two storey steel frame structure with infill masonry exterior walls. Exterior siding materials include coloured concrete masonry, metal siding, and cement siding.

The school is heated and ventilated with individual water source heat pumps in each room. A geothermal energy field provides the energy storage for this heat pump based system. This field consists of approximately 16 boreholes, each 150 meters deep. This field is sized for half of the peak load. Fresh air would be provided to all spaces as required based on carbon dioxide levels.

A selection of drawings of the school made available from the Province for this assessment are provided in Appendix A.

3.3 EXISTING LOADS AND COMPONENTS

3.3.1 Structure

Details on all aspects of the design loads and other design characteristics are provided in the

⁹ Design Development Report, Grade 7-12 School, Placentia, NL, Report Prepared for Government of Newfoundland and Labrador, Department of Transportation & Works, Design and Construction Division PHB Project #2661-02, Revised 27 Feb 2009, 17 September 2008.

Design Development Report. Some aspects of the project are outlined below:

- The finished floor elevation of the school has been set at 3.57 m (above sea level).
- A 200 mm (8") PVC water main provides service for the school. PVC was used due to the high ground water level underlying the site that is understood to be brackish.
- An existing 200 mm sanitary sewer is located near the southern property boundary. A 200 mm PVC pipe services the building from the last manhole on this system. Sanitary sewers were constructed to standards of the Canadian Standards Association and the National Plumbing Code.
- There is no piped underground storm sewer system on the site or present in any of the streets that border the property. Neither is there an open ditch storm drainage system. It was noted that the Town is built on coarse, beach rock type material with a ground water level that is located approximately 2.0 m below surface. The ground water is brackish and its elevation is controlled by sea level. Soils in the area support excellent percolation rates and that there has never been a drainage problem at the school site. The Town uses bottomless catchbasins to permit percolation to the ground water level. The Department of Transportation & Works own and maintain similar type catchbasins along Beach Road. Exfiltration trenches are used for storm drainage disposal. Storm sewers are constructed of PVC to Canadian Standards Association and the National Plumbing Code. The roof drains are "full flow" type with a size of 300 mm.
- Standard sanitary manholes are used that are in accordance with the Municipal Water, Sewer and Road Specifications.
- The foundation system consists of a strip footing and foundation wall with interior piers and footings at column locations resting on undisturbed sand & gravel or structural fill. Footings were designed for an allowable bearing capacity of between 135 kPa and 250 kPa depending on the footing size. The exterior and interior footings were placed 1.2 m below finished grade. The foundation wall is 200 to 250 mm thick reinforced concrete. The concrete strength was designed for 25 MPa at 28 days reinforced with grade 400 steel.
- The floor system consists of a 100 mm slab on grade with wire mesh reinforcing, 10 mil (thousandth of an inch) poly vapour barrier, 125 mm stone over compacted fill or undisturbed till. Concrete strength was designed as 20 MPa at 28 days.
- The second level floor system consists of 64 mm concrete topping over metal deck supported on open web steel joists and steel beams and columns. Concrete strength was designed as 25 MPa at 28 days.
- The roof structure over the classroom and administration wing consists of a metal deck on a structural steel joist, beam & column system with grid spacing in the 7.5 m to 10.0 m range. The roof structure is sloped to provide positive drainage to roof drains.

Design loads (see below) for the new school were based on the 2005 National Building Code of Canada (NBCC) for a building such as a school to be used as a post-disaster shelter and having an Importance Factor of 1.15 for snow and wind loads and 1.3 for earthquake loads.

Roof Load:	Snow Load: Snow + rain load based on ground snow load of 2.4 kPa and rain load of 0.7 kPa as per NBC 2005 for Argentia, NL (S = 3.01 kPa.). Increased loading adjacent to higher roof levels and projections in accordance with the NBC 2005 structural commentaries.
Dead Load:	Total = 1.10 kPa including: Mech. & Elect. 0.24 kPa, Roofing & Deck 0.27 kPa, Ceiling System 0.24 kPa, Structure 0.35 kPa
Floor Loads Upper Floor	Live Load: 4.8 kPa Corridors, 2.4 kPa Classrooms Dead Load = 3.88 kPa including: Mech. & Elect. 0.24 kPa, Ceiling 0.24 kPa, Flooring 0.10 kPa, Concrete Slab 1.9 kPa, Structure 0.4 kPa, Partitions 1.0 kPa
Wind Load	Calculated using a basic wind load of $Q\ 1/50 = 0.75\ \text{kPa}$ and an Importance Factor of 1.15.
Earthquake Load	Calculated using the NBC 2005 Seismic Data for Argentia, NL and an Importance Factor of 1.3.
Deflection Limits	<ul style="list-style-type: none"> • Roof Structure L/300 • Walls with Brick L/720 • Lateral Drift L/400 • Walls without Brick L/240
Thermal and Moisture Protection	The building thermal envelope exceeds the minimum resistant values as specified under the Model National Energy Code of Canada for Buildings. Minimum Values: Roof -RSI 4.0 m ² /W (K) / -U 0.25 W/m ² (K) Walls -RSI 3.7 m ² /W (K) / -U 0.270 W/m ² (K) Actual Values: Roof -RSI 5.6 m ² /W (K) / -U 0.2184 W/m ² (K) Wall - RSI 3.8 m ² /W (K) / - U 0.2694 W/m ² (K)
Outdoor Design Conditions	HVAC systems will be capable of providing design output under the following ambient conditions as per the NBCC: Minimum outdoor dry bulb temperature (1%) - -16°C Maximum outside dry bulb temperature (2.5%) - 23°C Minimum outside winter relative humidity - 70.0% Coincident winter design wind velocity - 15.0 m/s
Indoor Design Conditions	With the exception of gymnasium, maintenance, storage and shop areas, HVAC will be designed to maintain the following indoor design criteria: Summer maximum temperature - 24°C Summer maximum relative humidity - 60.0% Winter minimum temperature - 22.0°C Winter minimum relative humidity - 30.0%

Additional information regarding the design of the building is provided in the Design Development Report.

In addition to the school building itself, the sea wall provides protection from storm surge and sea level rise. As such, information regarding the sea wall has also been compiled from the vulnerability assessment completed in 2008¹⁰ as outlined below. No new information was available regarding the sea wall for this vulnerability assessment.

The Breakwater is constructed of a heavy timber cribbing network filled with stone. The heavy timber includes creosoted wood in the original section and green pressure treated wood in the part constructed in 1993. The breakwater is parallel to the main beach along Placentia Road. It separates the active beach from Beach Road, which forms the western limit of development for the downtown peninsula section of the Town of Placentia. The breakwater is capped by a publicly accessible boardwalk, built and maintained for resident and tourist use.

Owned and operated by the Town of Placentia, the Breakwater was originally built with Government of Canada resources in the early 1990's. Construction was a response to flooding between 1960 and 1989. There has been no flooding of downtown Placentia since the breakwater was built.

Some relevant measurements, dimensions, and elevations are:

- 0 m is mean sea level and 0 m is used as a geodetic elevation
- 1.2 m is the typical high tide level (1992) under calm conditions. Similar tidal ranges are indicated by the available data from Argentina
- 2.2 m: This is the typical elevation above sea level of pebble and cobble gravel accumulated by wave action at the base of the Breakwater. However, the amount of sediment varies both along the length of the Breakwater and over time. The typical elevation of exposed beach sand at the toe is 2.6 m. Along the breakwater, beach sand typically reaches elevations of 3.2 m
- 4.1 – 4.4 m is the typical elevation of stone on the beach side of the Breakwater
- 5.8 m is a typical top elevation of a typical Breakwater section.

3.3.2 Infrastructure Support Systems

- *Power Sources:* Power was deemed to be a direct element of the subject infrastructure and, therefore, was considered for this assessment. This aspect of the school infrastructure is embodied within the electrical system.
- *Communications:* Consideration was given to modes of communication include telephone, two-way radio, e-mail, Internet, and telemetry. This aspect of the school infrastructure is embodied within the emergency preparedness system.

¹⁰ Water Resources Public Infrastructure Vulnerability Assessment for Placentia, Newfoundland, Cameron Consulting, Dr. Norm Catto, AMEC, April 2008.

- *Transportation*: Transportation refers to the road and driving conditions that can affect operations and staff response time, as well as, adverse conditions that might disrupt normal traffic flow.
- *Personnel*: Consideration was given to staffing situations relevant to operations and maintenance of the subject infrastructure.

3.3.3 Infrastructure Components for Assessment

The study infrastructure has been segregated into the following elemental components for the purposes of assessment:

- Building Envelope – roofing, windows, insulation, cladding, weather sealing.
- Exterior Elements – landscaping, pavement, walkways, drainage and accessibility.
- Structural – roof and floor framing, lateral load resisting system, roof and floor deck/slabs, walls, and foundation.
- Mechanical Systems – HVAC, boilers, chillers, air handling units and building automation system.
- Electrical Systems – electrical power distribution system, emergency (life safety) power system, lighting, fire alarm and communication systems.
- Water and Wastewater Handling Systems – domestic water service, wastewater and rainwater management systems.
- Supporting Infrastructure – municipal services, roads and other infrastructure outside of the facility’s boundary but having an impact on facility operations.
- Emergency Preparedness
- Transportation
- Personnel

3.4 CURRENT DESIGN STANDARDS

The design of the school is founded upon a long list of standards. Each of these should be reviewed to establish the current vintage of the standard to establish if elements of the school building would be designed differently using today’s standards. An example of a standard that has changed is the National Building Code of Canada. The design of the school is based on the 2005 edition of the NBCC. The current version of the NBCC was published in 2010.

3.5 JURISDICTIONAL OVERVIEW

The Laval High School is owned and managed by the Newfoundland and Labrador English School District.

3.6 CLIMATE ANALYSIS

3.6.1 Overview

The objectives of this component of the report are to:

- Establish a set of climate parameters describing the climatic and meteorological phenomena relevant to the case study
- Establish a general probability of occurrence of each climate parameter both historically and in the future.

As noted previously, the term “historical” relates to climate from the current time frame and recent past while “future” relates to the future time frames previously noted as 2020, 2050 and 2080. However, data for all climate variables/phenomena were not available for these periods.

It should also be noted that this climate analysis is not meant to be exhaustive. The climate information presented in the following sections is not based on new science or analyses generated through this project but a review of readily available information from other sources. It is clear that climate science is advancing rapidly and this review should not be construed as a comprehensive characterization of the historic climate or future projections of the case study.

For this study, the climate change datasets developed by the Province were the primary source of climate data for this assessment. These datasets are described in Section 3.6.3.

As well, uncertainties in the climate projections are clearly demonstrated in the results (Finnis, 2013). The information developed and used for this project is adequate to meet the stated objectives of the case study; however, other potential users of the information should consider it in the proper context.

3.6.2 The “Long” and “Short” List of Climate Variables

A preliminary “long” list of climate parameters was developed based on climate events and change factors identified in Appendix A of the Protocol as indicated below:

- | | |
|---|----------------------------|
| • High and Low Temperature | • Snow Accumulation |
| • Heat and Cold Waves | • Blowing Snow/Blizzard |
| • Extreme Diurnal Temperature Variability | • Frost |
| • Freeze Thaw Cycles | • Hail Storm |
| • Heavy Rain / Daily Total Rain | • Hurricane/Tropical Storm |
| • Winter Rain / Freezing Rain | • High Winds |
| • Ice cover/Thickness | • Heavy Fog |
| • Coastal Erosion | • Drought/Dry Periods |
| • Sea Level and Storm Surge | • Flooding |

The list was refined by AMEC¹¹ based on climatic and meteorological phenomena deemed relevant to the Laval High School in Placentia. Further refinement was needed for rainfall oriented parameters to “dovetail” with the available climate projections.

Justification for selection of a climate parameter was based on the parameter’s potential to affect vulnerability to the infrastructure and its components as a result of either an extreme or persistent occurrence.

The short list of climate variables that would be considered relevant for assessment are outlined below:

- High and Low Temperature
- Heat Waves
- Frost and Freeze Thaw Cycles
- Sea Level and Storm Surge
- Extreme Precipitation Return Periods
- High Winds

Due to the scoped nature of the present vulnerability assessment, only High and Low Temperature and Sea Level have been assessed.

3.6.3 Climate Data Sources

3.6.3.1 Historical

The basic analysis of historical data for the study area was based on data from a variety of sources including:

- Environment Canada’s Climate Normals
 (available at http://climate.weatheroffice.gc.ca/climate_normals/index_e.html)
- Environment Canada’s Climate Data Online
 (available at http://climate.weatheroffice.gc.ca/climateData/canada_e.html)
- Environment Canada’s Canadian Daily Climate Data (CDCD v1.02)
 (available at <ftp://arcdm20.tor.ec.gc.ca/pub/dist/CDCD/>)

The Argentia, NL weather station (#8400104 at 47°17'38.000" N by 53°59'36.000" W) was used where available from the above noted data sources. Where data for the Argentia station were not available in the databases above, as was the case for certain climate parameters (i.e., ice storms and hurricanes), data for a nearby station or information in the literature based on a regional context was used. Any other data sources, when used, are documented in the climate parameter specific sections that follow.

3.6.3.2 Future

To date, the Province has collected four (4) datasets with a view to establishing a basis for the Province’s approach to improving resilience to climate change impacts. These data sets are:

¹¹ The refinement exercise is typically done in collaboration with the infrastructure owner/operator

- Climate Projections for the Province

Projected Impacts of Climate Change for the Province of Newfoundland & Labrador
 Dr. Joel Finnis, Department of Geography Memorial University of Newfoundland
 March 22, 2013

This study down-scaled four internationally recognized global models to develop projections for the Province. The main projections for temperature and precipitation use regional data from twelve (12) weather stations in Newfoundland and six (6) stations in Labrador, ensuring that local conditions were included in the study.

- Flood risk mapping incorporating potential climate change influences

Flooding is a natural process and the conditions that result in floods are often predictable and usually occur in the same areas, known as flood plains. Flooding and erosion processes are quite difficult to control and avoid. As such, the best and most cost effective method of minimizing their impact is proper management and planning of known flood plains. Flood plain management usually involves the adoption of land use regulations that limit human exposure to areas prone to flooding events. The Department of Environment and Conservation has undertaken hydro-technical studies, identifying and mapping regular and climate change flood risk zones and then implementing policies to limit future flood susceptible development in those areas. Climate change flood risk maps have been developed for seven (7) communities.

Two examples:

- *Flood Risk Mapping Project, Corner Brook Stream and Petrie's Brook*
 Government of Newfoundland and Labrador
 Water Resources Management Division
 Department of Environment and Conservation
 Prepared by AMEC Environment & Infrastructure, February 2013
- *Flood Risk Mapping Project, Goulds and Petty Harbour Area*
 Government of Newfoundland and Labrador
 Water Resources Management Division
 Department of Environment and Conservation
 Prepared by AMEC Environment & Infrastructure, March 2013
- Coastal Vulnerability Assessment (2011 – on-going)
 A Coastal Vulnerability Assessment program was established in 2011-12 to monitor the impact of coastal erosion in select sites. Data is now available for 104 sites around the Province, including 34 sites previously established by the Geological Survey of Canada and the Geological Survey of Newfoundland and Labrador.

This dataset is comprised of the following:

- *Coastal Monitoring in Newfoundland and Labrador: 2012 Update*
M. Irvine, Geochemistry, Geophysics and Terrain Sciences, Memorial University Current Research (2013) Newfoundland and Labrador Department of Natural Resources, Geological Survey, Report 13-1, pages 43-54
- *Coastal Monitoring in Newfoundland and Labrador*
M.L. Irvine, Geochemistry, Geophysics and Terrain Sciences, Memorial University Current Research (2012) Newfoundland and Labrador Department of Natural Resources, Geological Survey, Report 12-1, pages 191-197
- A Microsoft Excel™ spreadsheet (Coastalmonitoring_sites.xlsx¹²) identifying the monitoring sites.
- Surveyed field data and associated GIS data layers.
- Predictions of Future Sea Level Rise (2010)

Understanding the direction and magnitude of future sea-level change is important in planning and regulating development in coastal zones. Estimates of sea level rise change leading up to 2050 and 2100 are provided for four zones covering the Province in the following reference:

- *Past and Future Sea Level Change in Newfoundland and Labrador: Guidelines for Policy and Planning*, Martin Batterson, Geochemistry, Geophysics and Terrain Sciences, Memorial University and David Liverman, Geological Survey of Newfoundland and Labrador, Current Research (2010) Newfoundland and Labrador Department of Natural Resources, Geological Survey, Report 10-1, page 129-141

This dataset was used to support definition of ocean water level boundary conditions for the two flood plain mapping studies previously noted.

Other readily available literature as documented in the specific climate parameter sections that follow was also reviewed.

3.6.4 Climate Variable Probability of Occurrence

The process of assessing the probability of a climate parameter's chance of occurrence was conducted by first identifying historical frequency. In some instances the relevant data were presented in a format that could be directly related to probability. In other instances a directly comparable format was either unintelligible or unattainable. A scoring system was used whereby a score between 0 and 7 was assigned to each parameter by subjectively relating the known or calculated frequency to one of the descriptive terms. Method A from Figure 3 of the Protocol, Probability Score Definitions, was adopted for use for this study. Figure 3, specific to Method A, is reproduced in part as Table 3-1 below.

¹² Provided by the Province

Table 3-1 : Risk Assessment Probability Score Definitions – Method A

(source: PIEVC, 2012)

PIEVC Probability 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

In many instances, though, the characterization of a climate parameter is descriptive rather than numeric. In these cases a definable means may be required to relate the available descriptive terms to that required for numeric probabilities. This process is outlined below and follows the same process used for a recent PIEVC based vulnerability assessment of flood control dams completed by the Toronto and Region Conservation Authority (TRCA, 2010).

The process is initiated with the question “what is the likelihood that an event will occur in a given year?” For example, a climate parameter having a historical annual frequency of 0.5 would be considered to mean that the climate event would occur, on average, once every two years. In consideration of the available descriptive terms, the term “moderate/possible” best represented the likelihood of its occurrence in a given year. In other words, it is by no means certain that it will occur every year.

Following the same rationale as above, parameters with known or calculated probability scores of greater than 2 were considered very likely to occur in a given year based simply on the historical record. Therefore, any probability scores greater than 2 were considered best represented by the term “certain/highly probable”. Method A (ref. Table 3-1) relates the term “certain/highly probable” to a Probability Score of 7.

The above three rationales provide the relational benchmarks considered for this assessment. Consistency was maintained throughout the assessment process by using a suite of frequency ranges as described in Table 3-1 which related frequency ranges to PIEVC scores. Using this mechanism, where frequencies were available, the matching probability score was assigned.

3.6.4.1 High Temperature

Definition

The maximum temperature currently recorded for Argientia is 26.1°C, which occurred on August 15th, 1949 (Environment Canada, 2011b). As a reflection of the recorded high temperature, a threshold temperature of 20°C has been selected as representative of the measure of high

temperatures for this report. This definition is consistent with other PIEVC protocols based climate change vulnerability assessments (e.g., TRCA, 2010; AMEC 2012).

Historical Climate

Climate normals for St Mary’s, obtained from Environment Canada Data Online (Environment Canada, 2011b) for the period from 1981 to 2010, indicate an average of 18.5 days a year with temperatures greater than 20°C and an average of 0.0 days per year had temperatures greater than 30°C.

The findings for ‘number of days with a maximum temperature >20°C’ outlined in Table 3-2 were compared with the established ranges in Table 3-1, resulting in a recommended probability scale of “remote” (or “2”).

Trends

In a study by Zhang et al. (2000), trends in temperature change over Canada were analyzed during the 20th century. Over southern Canada, the mean annual temperature was found to have increased between 0.5 and 1.5°C (between 1900 and 1998), with the greatest warming found in the Prairie Provinces. It was found that the change was due largely to warmer overnight temperatures, meaning that the region was becoming less cold but not hotter. Specific temperature elements included in the analysis were the minimum, maximum, and mean temperature. For southern Canada, trends were computed for the period 1900-1998 and for the rest of Canada for the period 1950-1998.

The trend in increasing overnight temperatures was statistically significant over all of southern Canada. Easterling et al. (2000) discuss a similar finding in studies on the trends of temperatures in the United States over the period 1910-1998.

Table 3-2 : Summary of High Temperature Occurrence (°C)

Description	Days/Year	
	Historic ¹	2050 ²
> 20°C	18.5	increasing
> 30°C	0	increasing
Probability Score	3 occasional	4 Moderate / possible
Notes:		
1. Source: Environment Canada, 2011b		
2. Source: Finnis, 2013		

Climate Projections

Findings

As documented in the *Projected Impacts of Climate Change for the Province of Newfoundland & Labrador* report (Finnis, 2013) daily maximum temperatures are projected to increase throughout the Province. This report indicated the largest increase, for Bay D'Espoir (nearest available data point to Placentia), during the winter with temperatures increasing an average of 2.3°C with an ensemble uncertainty of 0.6. Finnis also estimated the projected increase in daily maximum temperature during the summer months (June, July, and August) to be 2.0°C, having an ensemble uncertainty of 0.4. It should be noted that Finnis' daily maximum temperatures are projected for 2038-2070. Furthermore Finnis' findings, similar to historic trends, show greater increases in overnight temperatures than daytime temperatures. The Finnis report does not provide data to compute projected daily occurrence of temperatures above 30°C.

Probability Scoring

Data for the average number of days having high temperatures in Newfoundland is not currently available in the Province's climate change datasets. As such, a quantitative estimate of the projected probability score for High Temperature can only be approximated from the available data.

Given that the findings of the Finnis report suggest an increase in daily maximum temperature it is inferred that the 'number of days with a maximum temperature >20°C' also has the potential to increase with climate change. As such, a probability score of '4' or 'moderate/possible has been assigned (ref. Table 3-2).

3.6.4.2 Low Temperature

Definition

The minimum temperature currently recorded for Argentia is -20.0°C, which occurred on January 29th, 1957 (Environment Canada, 2011b). Other recorded low temperatures from nearby stations are identified in Table 2-1. As a reflection of these recorded low temperatures, a threshold of -20°C was considered a representative and the threshold for low temperature for this assessment. This definition is consistent with other PIEVC protocols based climate change vulnerability assessments (e.g., TRCA, 2010; AMEC, 2012).

Historical Climate

Climate normals for St Mary's, obtained from Environment Canada Data Online (Environment Canada 2011b) for the period from 1981 to 2010 indicate an average of 0.2 days per year with temperatures less than -20°C and 0 days per year with temperatures less than -30°C (ref. Table 3-3).

Probability Scoring

The findings for ‘number of days with a minimum temperature < -20°C’ were compared with the established ranges in Table 3-1, resulting in a recommended probability score of “Remote” (or “2”).

Climate Projections

Findings

Daily minimum temperatures are projected to increase approximately 3.5°C across Newfoundland over the period 2038-2070 (Finnis, 2013). The greatest increase would appear in Labrador (Finnis, 2010). Finnis reported that daily minimum temperatures during the winter months would increase by an average of 3.2°C in the Bay D’Espoir area, with an average ensemble uncertainty of 1.4.

Probability Scoring

The upward movement in daily minimum temperatures into the future 2038-2070 time frame suggests the probability score of “Improbable / highly unlikely” (or “1”).

Table 3-3 : Summary of Low Temperature Occurrence (°C)

Description	Days/Year	
	Historic ¹	2050 ²
< -20°C	0.2	decreasing
< -30°C	0	n/a
Probability Score	2 Remote	1 Improbable / highly unlikely
Notes:		
1. Source: Environment Canada, 2011b		
2. Source: Finnis, 2013		

3.6.4.3 Sea Level and Storm Surge

The estimates of sea level rise were abstracted from Tables 3 and 4, and Figure 4 in Batterson and Liverman (2010) using Zone 1 information to reflect conditions at Placentia. This document is presently the approved reference for sea level rise estimates in the Province. A summary of key values from this document, relevant to the current assessment, are outlined in Table 3-4.

Table 3-4 : Summary of Sea Level Rise

Period	Sea Level Rise Estimate
2020	0.05 m
2050	0.40 m
2080	1.00 m

With regard to probability scoring, a score of ‘3’ or ‘occasional’ was assigned to reflect the current expectation of occurrence as a means of establishing a trend into the future. A probability score of ‘5’ or ‘often’ was assigned to 2050 to reflect the increasing trend with regard to expectation of flooding.

Table 3-5 : Summary of Sea Level Rise and Storm Surge

Definition	Days/Year	
	Historic	2050 ¹
Sea Level Rise and Storm Surge	0	increasing
Probability Score	3 occasional	5 Often
Notes: 1. Source: Finnis, 2013		

Associated with sea level rise and flood risk is storm surge. A rise in a potential wind assisted storm surge wave elevation by 0.25 m from the current potential wave height elevation of 7.00 m to 7.25 m was used for the Breakwater in the previous case study (Cameron et al, 2008) and has also been adopted for the current assessment. This is the mean significant wave height under current conditions offshore of the Avalon Peninsula, and has been used in the assessment of coastal sensitivity to sea level rise along the Placentia Bay shoreline. Catto *et al.* (2003) and Catto (2006a) discusses the relationship between wind speed, duration, and incremental increase in wave height - above tidal and storm surge elevations.

3.6.4.4 Extreme Precipitation Return Periods

Definition

An Intensity-Duration Frequency (IDF) Curve is a tool that characterizes an area’s rainfall pattern. By analyzing past rainfall events, statistics about rainfall reoccurrence can be determined for various standard return periods; for example, the depth and duration of the rainfall event that statistically occurs once every 10 years.

Historical Climate

A weather station with published IDF data is not available specifically for the Town of Placentia. IDF data is available, however, for the weather station at Argentia (#8400104 with a period of record from 1980 – 2009, although data for the period 1987 to 2003 is missing) to the north of this study area. The current IDF reports/data available for this stations is dated February 9, 2012.

The following comments stem from a general review of the applicability of the data from these stations to support this assessment:

- The Argentina station, relative to the Placentia, lies about 7 km north from the Laval High School.
- Figure 3-1 illustrates the Public Forecast Warning Areas used by Environment Canada. The Public Forecast Warning Area boundaries were developed by Environment Canada several decades ago based on rigorous climate studies and considerable public consultation. The Towns of Placentia of Argentia lie entirely within the Avalon Peninsula South Warning Area.

The 1:20 year precipitation amounts were estimated by interpolation (using the Logarithmic trending option in Microsoft Excel™) from the 1:10 year and 1:25 year amounts. The IDF estimates for the project area are provided in Table 3-6.

Table 3-6: Return Period Rainfall Amounts for Argentia (mm)

Duration	Frequency				
	10 year	20 year	25 year	50 year	100 year
10 min	12.8	14.4	15.1	16.7	18.4
30 min	21.5	23.9	24.8	27.3	29.8
1 h	29.0	32.6	34.0	37.7	41.4
2 h	42.5	48.4	50.7	56.8	62.8
6 h	90.8	107.8	114.5	132.2	149.6
12 h	119.5	145.2	151.3	174.9	198.3
24 h	131.4	155.5	163.1	186.7	210.0

The historical extreme precipitation return periods are provided below in Table 3-7. Historical extreme precipitation return period data for Argentia was obtained from the *Projected Impacts of Climate Change for the Province of Newfoundland & Labrador* report. These data were accrued and analysed by Dr. Finnis from the Adjusted & Homogenized Canadian Climate Data (AHCCD) using the same methods used by Environment Canada for their IDF curves.

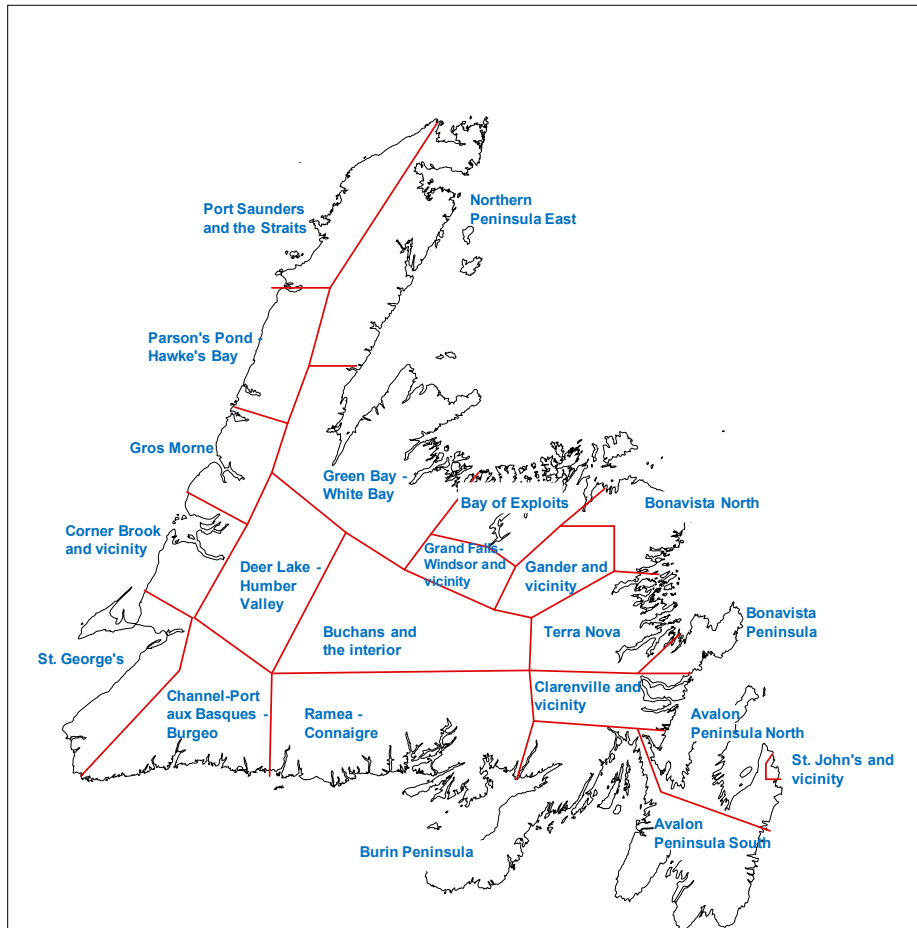


Figure 3-1 : Public Weather Warning Regions for Newfoundland
 (Based on http://www.weatheroffice.gc.ca/warnings/nl_e.html)

Table 3-7 : Summary of AHCCD-Derived Results for Extreme Precipitation Return Periods for Argentina (24 hour duration)

Description	Historic ¹	Projected Mean ¹	Projected Maximum ¹
20 year	155.5	166.5	184.2
50 year	186.7	198.7	220.4
100 year	210.0	222.7	247.6

Notes:
 1. Source: Finnis, 2010

Probability Scoring

For this climate parameter, a probability score of ‘4’ or ‘Moderate / possible’ was assigned to reflect that return period precipitation values are typical in any given year and the probability score reflects the current expectation of occurrence as a means of establishing a trend into the future (ref. Table 3-8).

Climate Projections

Findings

As reported in the *Projected Impacts of Climate Change for the Province of Newfoundland & Labrador* report, precipitation levels for extreme precipitation return periods for the Argentia area are projected to increase. The greatest increase in the projected precipitation levels for Argentia is noted for the 100 year event; an increase of 37.6 mm or 18% over the historic value.

Probability Scoring

A probability score of ‘6’ or ‘Probable’ was assigned to reflect the significance of the increases in projected return period rainfall amounts (ref. Table 3-8).

Table 3-8 : Summary of Probability Scoring for Return Period Rainfall (mm)

Definition	Days/Year	
	Historic ¹	2050 ²
Return Period Rainfall – 100 Year 24 Hour Duration	210.0	222.7 (mean) 247.6 (maximum)
Probability Score	4 Moderate / possible	6 Probable
Notes:		
1. Source: Environment Canada, 2011b		
2. Source: Finnis, 2013		

3.6.4.5 Climate Parameters Summary

A summary of the historical and future climate parameter probability scores is provided in Table 3-9.

Table 3-9 : Climate Parameters Summary

Climate Parameter	Anticipated Changes	
	Historic	Future
		2050
Increasing		
High Temperature	3	4
Sea Level and Storm Surge	3	5
Extreme Precipitation	4	6
Decreasing		
Low Temperature	2	1
Not included in this Assessment		
Heat Waves		
High Winds		
Freeze Thaw Cycles		



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SECTION 4

PIEVC PROTOCOL STEP 3

RISK ASSESSMENT



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4 STEP 3 - RISK ASSESSMENT

4.1 OVERVIEW

An engineering vulnerability exists when the total load effects on infrastructure exceed the total capacity to withstand them, while meeting the desired performance criteria. Where the total loads or effects do not exceed the total capacity, adaptive capacity exists.

Step 3 of the PIEVC Protocol involves the identification of infrastructure components which are likely to be sensitive to changes in specific climate parameters (ref. Section 3). This step focuses on qualitative assessments as a means of prioritizing more detailed Evaluation Assessments or Engineering Analyses, if required, in Step 4 of the Protocol. In other words, professional judgment and experience are used to determine the likely effect of individual climate events on individual components of the infrastructure. To achieve this objective, the Protocol uses an assessment matrix process to assign an estimated probability and an estimated severity to each potential interaction.

As noted in Section 3.6.4, the Protocol specifies that a scaling system with values ranging from 0 to 7 be applied to rank both the potential climate events and the estimated response severity. For this project, Method A (climate probability scores) and Method E (response severity scores) have been selected as being the most appropriate based on the available data. The climate probability scores identified for use in the risk assessment are documented in Section 3.6.4 of this report.

An evaluation of this type is usually completed during a Risk Assessment Workshop which brings together representatives of the infrastructure owner/operator plus other stakeholders.

The objectives of a risk assessment workshop would include:

- learning more about interactions between infrastructure components and weather events;
- identifying anecdotal evidence of infrastructure responses to weather events;
- discussing other factors that may affect infrastructure capacity;
- identifying actions that could address climate effects,
- Identifying and documenting the local perspective relevant to the subject infrastructure.

Given the nature of this climate change vulnerability assessment (ref. Section 1.2), AMEC completed the risk assessment of the Laval High School independently.

4.2 RISK ASSESSMENT RESULTS

4.2.1 Methodology

The complete Risk Assessment Matrix for this project is included in Figure 4-1 of this report. Under each *climate effect* column heading, there are four sub-headings, as follows:

1. **Y/N (Yes/No)**. This field is marked “Y” if there is an expected interaction between the infrastructure component and the climate effect, and “N” if not. This was triggered by reviewing potential *performance responses* in light of the climate variable. For example, would or could any of the following issues be affected by the anticipated changes in a climate variable:

- Structural Design (Design)
 - Safety
 - Load carrying capacity
 - Overturning
 - Sliding
 - Fracture
 - Fatigue
 - Serviceability
 - Deflection
 - Permanent deformation
 - Cracking and deterioration
 - Vibration
 - Foundation Design Considerations
- Infrastructure Functionality (Functionality)
 - Level of Effective Capacity (short, medium, long-term)
 - Equipment (component selection, design, process and capacity considerations)
- Infrastructure Performance (Performance)
 - Level of Service, Serviceability, Reliability
 - Materials performance
- Watershed, Surface Water and Groundwater (Environment)
 - Erosion along watercourses
 - Erosion scour of associated/supporting earthworks
 - Sediment transport and sedimentation
 - Channel re-alignment / meandering
 - Change in water quantity
 - Change in water quality (Water Quality)
 - Change in water resources demands
 - Change in groundwater recharge
 - Change in thermal characteristics of water resource
- Operations and/or Maintenance
 - Structural aspects
 - Equipment aspects

- Functionality and effective capacity
- Emergency Response (Emergencies)
 - Storm, flood, ice, water damage
- Insurance Considerations (Insurance)
- Municipal Considerations (Policies)
 - Codes
 - Public sector policy
 - Land use planning
 - Guidelines
 - Inter-government communications
- Social Effects (Social Effects)
- Economic considerations (Economic)

A general ‘Other’ category was also included to allow capture of issues not covered by the aforementioned considerations.

2. **P (Climate Probability Score Factor)**. This value reflects the expectation of a change in a climate variable under the influence of climate change as outlined in Section 3.6.4.
3. **S (Response Severity Score Factor)**. This value reflects the expected severity of the interaction between the climate phenomena and the infrastructure component. As such, different climate phenomena may lead to varying response severities.
4. **R (Priority of Climate Effect)**. This is calculated as P multiplied by S. This priority value is used to determine how the interaction will be assessed in the next steps of the protocol. Since this is a qualitative assessment, the R should not be used to prioritize recommended actions.

At the end of this assessment, three categories of infrastructure-climate interactions emerge:

1. **R > 36**. “High” possibility of a severe effect. Interactions in this range should lead to recommendations in Step 5 of the Protocol.
2. **12 < R ≤ 36**. “Medium” possibility of a major effect. These effects are considered to be in a “grey area”, where it is uncertain whether the impact is sufficient to cause the need for recommendations. Step 4 of the protocol, which involves a quantitative analysis, can be used to determine which effects to leave aside and which to discuss further.
3. **R ≤ 12**. “Low” possibility of an effect. These infrastructure-climate interactions are typically left aside without further analysis or recommendations.

A summary of the results of the risk assessment are provided in Figure 4-1, at the end of this section. The colour coding in the Figure relates to the Priority of Climate Effect ranges (i.e., “high” (red), “medium” (yellow) and “low” (green)).

A major outcome of the risk assessment workshop was that only a few infrastructure-climate interactions were identified in the “High” category. The highest Priority of Climate Effect value was calculated as 42, associated with extreme rainfall, with a number of other infrastructure interactions with sea level rise and potential for increased storm surge climate parameters also ranking as significant vulnerabilities.

4.2.2 Results

This section provides some insight to the matrix values resulting from the Risk Assessment documented in Table 4-1.

a) Laval High School

As expected, the highest severity ratings are linked to performance responses that contribute to risks to public safety (namely, flooding). The climate parameters triggering these responses were all related to increased expectation of sea level rise and potential for increased storm surge and extreme precipitation events which, by extension, is linked to potential flooding of the Laval High School and related issues of emergency preparedness and evacuation.

The most recent hydrotechnical study of the community of Placentia was completed in 1985 (Shawmont Newfoundland Limited, 1985). The flood inundation map for the community (ref Figure 4-1) shows a community built on a beach-ridge complex, very close to sea-level. Almost all the built-up area is in the 20-year flood zone, including the historic town centre. Floods here are caused by a combination of high tides, a storm surge and high wind and waves. As a result the water in South-East Arm backs up (the flood inundation map does not show that the Arm extends from the bridge on Highway 100 to around the back of the town). To reduce flood damage an embankment was built along the Placentia Bay shore, and a sea-wall along the harbour (the narrow part of the Arm next to the town centre, southeast of the bridge). If one of the effects of global warming is a rise in sea-level, then it will be increasingly difficult to protect Placentia from floods.¹³

The existing 1 in 100 year flood zone for Placentia may well be effectively, by 2050, the 1 in 20 year flood zone with areas formerly outside the 100 year zone now prone to flooding. This may include the new Laval High School. The flood protection/mitigation measures, including the sea wall and berm, be designed based on protection from the 100 year predicted flood. These are likely to be inadequate by 2050. (Batterson and Liverman, 2010)

¹³ From <http://www.heritage.nf.ca/environment/floods.html>

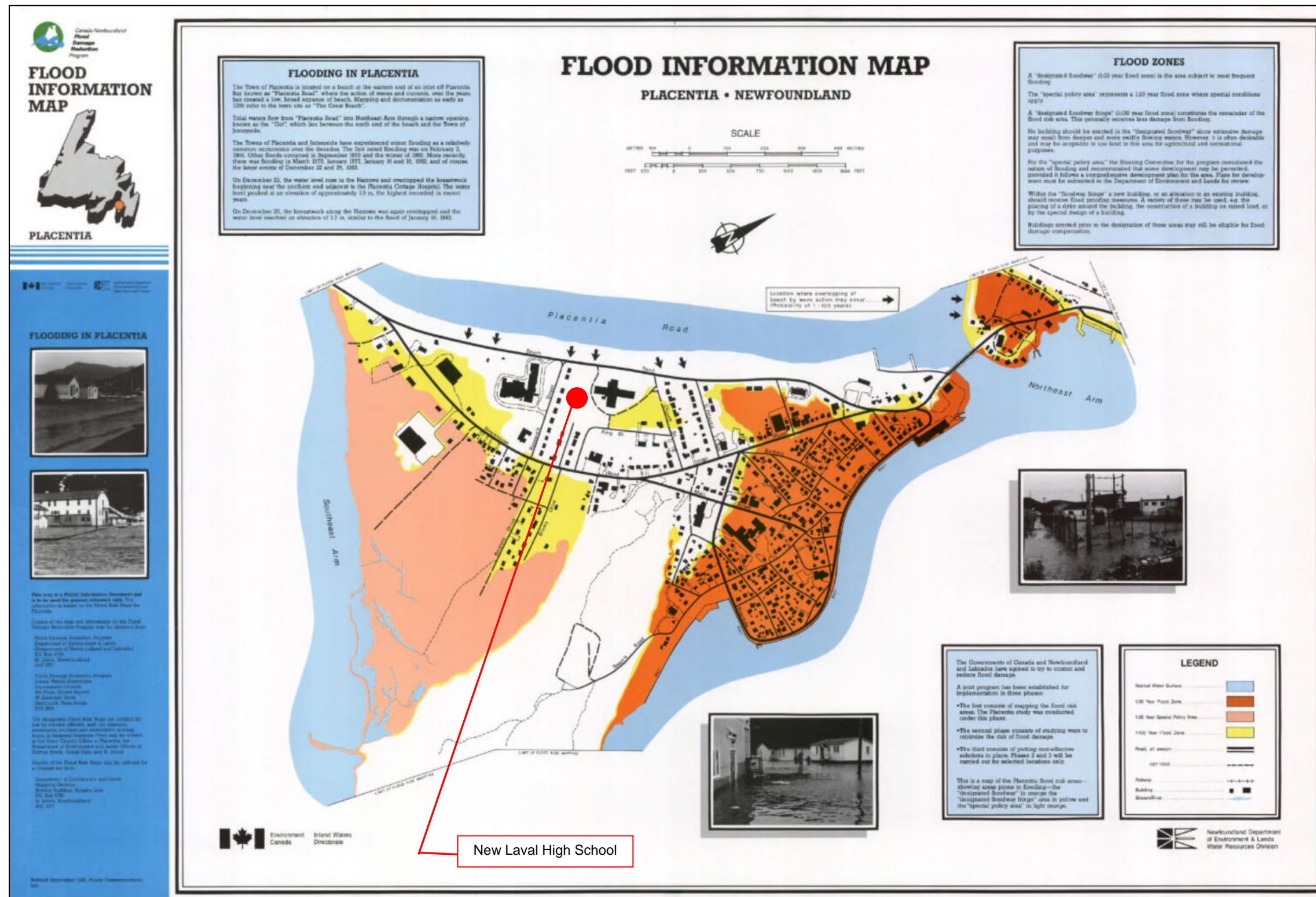


Figure 4-1 : Placentia Flood Inundation Map



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Storm surges and wave run-up can cause erosion and flooding of low-lying areas, heavy rain can trigger landslides, and waves can undercut the base of slopes, causing rock falls or other types of slope movement. As noted previously, sea level is projected to rise during the next century, and climate-change projections suggest an increase in the intensity of storms, heavy precipitation events and a greater number of freeze–thaw cycles, which has the potential to further increase the risk from flooding and/or erosion. To assist communities in the development long-term planning and policy decisions, the Geological Survey of Newfoundland and Labrador initiated a multi-year coastal monitoring program in 2011. This program aims to assess rates of shoreline migration, changes in beach profiles, delineate areas of high vulnerability to coastal flooding and/or erosion, and to assess the connectivity between coastal stability and anthropogenic, climatic, oceanographic and geographical factors. (Irvine, 2012)

The coastal monitoring program has been collecting shoreline data for Placentia in the area of the beach near the boardwalk/breakwater. Two shoreline profiles were collected during 2013 as illustrated in Figure 4-2; one in June and one in December. The difference between the two profiles reflecting the storm surge event that occurred between December 4 and 5, 2013. A Newfoundland TV news cast indicated that “there was devastating damage in Placentia overnight as a storm surge ripped through the heart of the town. Much of the town’s iconic boardwalk was damaged or destroyed”.¹⁴ Laval High School can be seen in the video report available at the Newfoundland TV website.

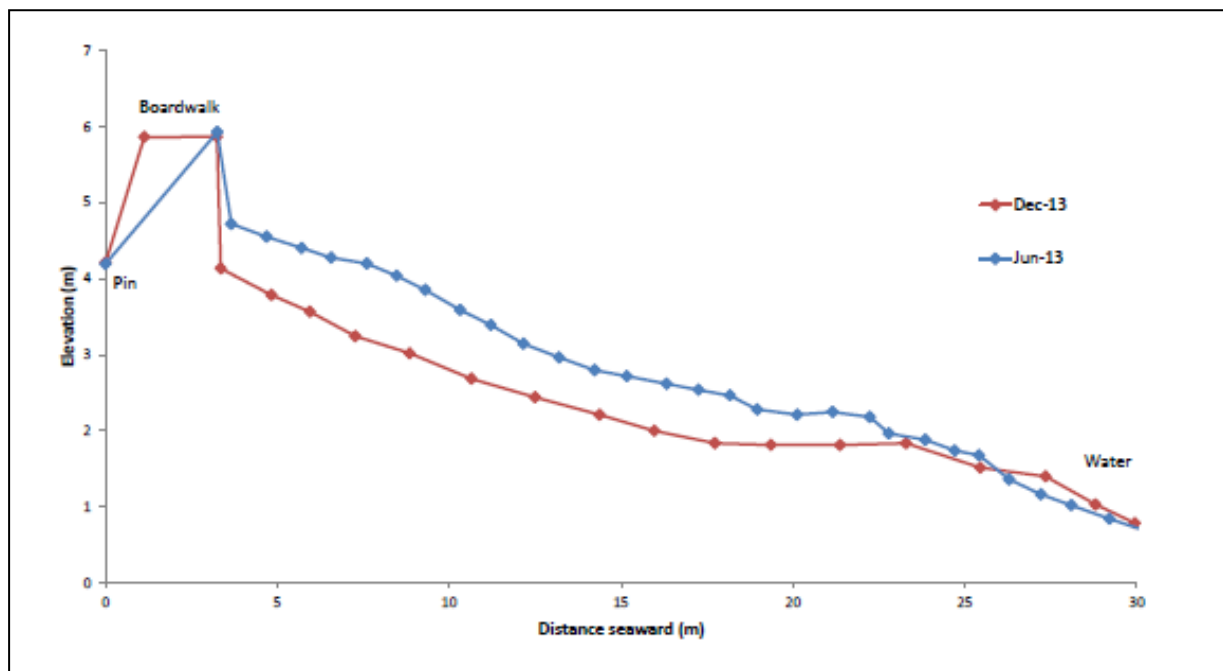


Figure 4-2 : Placentia Coastal Monitoring - 2013

¹⁴ Source: <http://ntv.ca/storm-surge-causes-severe-damage-in-placentia/>

As can be seen from Figure 4-2, this one event resulted in significant erosion of about 1 m vertical of the beach area on the seaward side of the boardwalk.

Figure 4-3 relates the boardwalk and beach area information from Figure 4-2 to include data relating to sea level rise, storm surge and key elevation details from Laval High School.

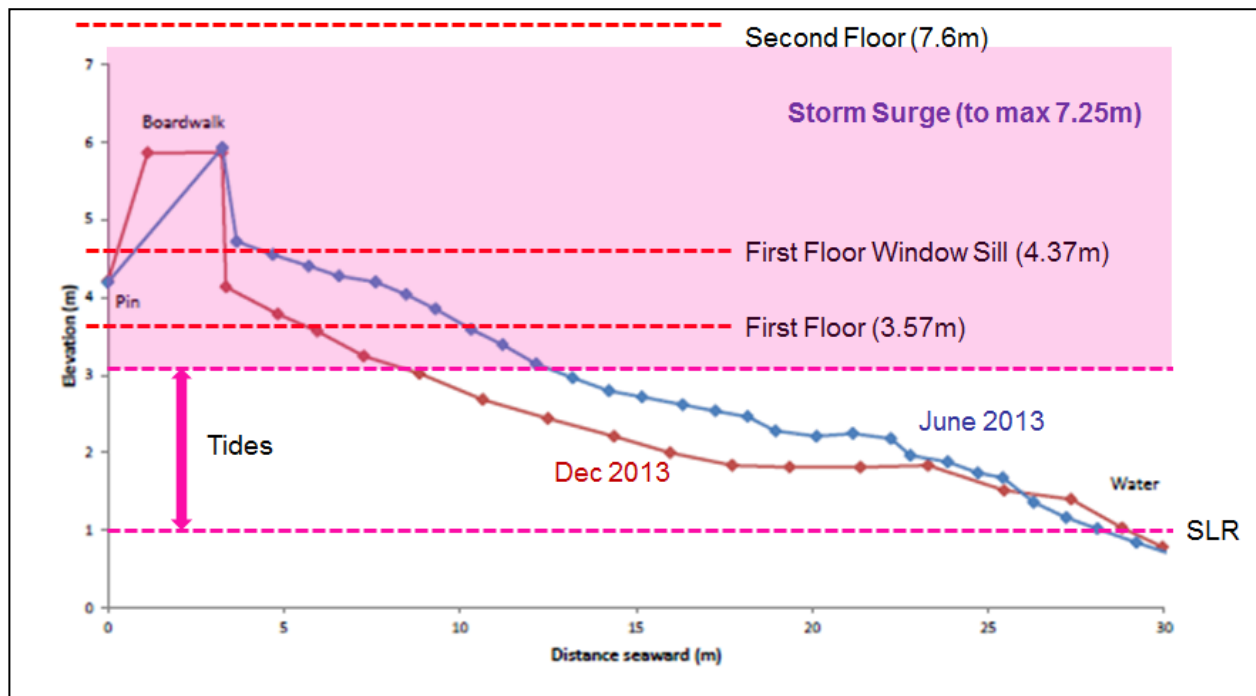


Figure 4-3 : Cumulative Effects - Potential Risk from Seaward Flooding

In addition to issues relating to potential flooding, sea level rise and storm surge, the following potential vulnerabilities were also identified.

- The flat roof systems will be particularly vulnerable to climate change due to increase freeze-thaw cycles and summer temperatures. Roof deterioration is likely to be accelerated.
- The potential increased spring, summer and fall temperatures due to climate change can have a direct effect on all the buildings cooling systems.
- Work should begin with the local electrical utility to study and plan for the cumulative effects on electricity loads, demand, consumption, etc. during spring, summer and fall for the community.

- All walkways, stairs, and parking areas be kept clear of snow and ice in the winter in accordance with current building management practices.

Generally codes and guidelines used for a current school design are based on climate data are quite dated. Some may be as old as 50 or 60 years. As it is clear that the climate is changing, and will continue to change, it is recommended that the data referenced in the applicable design codes and guidelines be updated to reflect current information. An alternate approach, completing a site-specific climate assessment to determine whether in-depth analysis is necessary for the infrastructure being designed or evaluated may be prudent.

4.3 DATA SUFFICIENCY

The Risk Assessment step of the evaluation required judgments on significance, likelihood, response and uncertainty in the context of the probability of climate effects and the severity of infrastructure responses to the effects. Some judgments could be fairly easily made based on available information, however, others required use of “indirect” information. This complicated the assessment of the response severity of climate effects on infrastructure operations, and, more specifically, introduced additional uncertainty into the assessment.

In general, the data available were sufficient for the non-numerical (qualitative), engineering judgment-based screening purposes of this risk assessment.

It is again noted that this scoped climate change vulnerability assessment reviewed climate change and infrastructure datasets as applicable to the PIEVC Protocol; specifically Steps 1 and 2, and a preliminary, independent application of Step 3 of the Protocol only.

Infrastructure Component	Performance Response (✓ if yes)											Climate Events																											
	Structural Design	Functionality	Watershed, Surface Water and Groundwater	Operations, Maintenance, Materials Performance	Emergency Response	Insurance Considerations	Policy Considerations	Social Effects	Water Quality	Economic Considerations	Other	High Temperature (3 to 4)				Low Temperature (2 to 1)				Sea Level and Storm Surge (3 to 4)				Extreme Precipitation Return Periods (4 to 6)				Heat Waves (not included in this assessment)				Freeze Thaw Cycles (not included in this assessment)				High Winds (not included in this assessment)			
												Y/N	P	S	R	Y/N	P	S	R	Y/N	P	S	R	Y/N	P	S	R	Y/N	P	S	R	Y/N	P	S	R	Y/N	P	S	R
												4				1				5				6															
<i>Operations and Maintenance</i>																																							
Personnel	Y			Y		Y	Y	Y			Y	4	3	12	N				Y	5	6	30	Y	6	6	36	N				N				N				
Transportation	Y			Y	Y	Y			Y		N				Y	1	4	4	Y	5	6	30	Y	6	6	36	N				N				N				
<i>Laval High School</i>																																			N				
Building Envelope	Y	Y		Y		Y					Y	4	3	12	Y	1	5	5	N				N				N				N				N				
Exterior Elements	Y	Y		Y		Y					Y	4	3	12	Y	1	5	5	N				Y	6	5	30	N				N				N				
Structural	Y	Y		Y							N				N				Y	5	3	15	N				N				N				N				
Mechanical Systems	Y	Y	Y	Y							Y	4	3	12	N				N				Y	6	5	30	N				N				N				
Electrical Systems	Y	Y		Y		Y					Y	4	3	12	N				Y	5	4	20	Y	6	5	30	N				N				N				
Water & Wastewater Handling Systems	Y	Y	Y	Y		Y					N				N				Y	5	3	15	Y	6	4	24	N				N				N				
Supporting Infrastructure	Y	Y		Y	Y		Y	Y			Y	4	3	12	Y	1	5	5	Y	5	7	35	Y	6	6	36	N				N				N				
Emergency Preparedness					Y	Y	Y	Y		Y	N				Y	1	4	4	Y	5	7	35	Y	6	7	42	N				N				N				

The highlighted values depicted in this Figure are the 'Priority of Climate Effect' or 'R' values resulting from the Risk Assessment.

Priority of Climate Effect		
R > 36	High	
12 < R ≤ 36	Medium	
R ≤ 12	Low	

Table 4-1 : Risk Assessment Results



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SECTION 5

PIEVC PROTOCOL STEP 4

ENGINEERING ANALYSIS



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5 STEP 4 - ENGINEERING ANALYSIS

Step 4 of the PIEVC Protocol focuses on the determination of adaptive capacity. Specifically, if the climate changes as described in Step 2, does the infrastructure of interest have adaptive capacity available to meet the desired performance criterion? If the adaptive capacity is determined not to exist, this evaluation determines the additional capacity required to meet the desired performance criteria, again if the climate changes as described in Step 2.

The engineering analysis step requires the assessment of the various factors that affect load and capacity of the subject infrastructure. Based on this assessment, indicators or factors are determined in order to relatively rank the potential vulnerability of the infrastructure elements to various climate effects.

As noted in the Protocol, much of the data required for Engineering Analysis may not exist or may be very difficult to acquire and this analysis requires the application of multi-disciplinary professional judgment. Thus, even though numerical analysis is applied, the practitioner is cautioned to avoid the perception that the analysis is definitively quantitative or based on measured parameters. The results of the analysis yield a set of parameters that can be ranked relative to each other, based on the professional judgment of the practitioner. The results can also be used to rank the relative vulnerability or resiliency of the infrastructure.

A PIEVC Protocol based engineering analysis is driven by the following steps:

1. Determine the existing load on the subject infrastructure
2. Determine the anticipated climate change load
3. Determine other change loads
4. Determine the total load
5. Determine the existing capacity
6. Calculate the projected change in existing capacity arising from aging/use of the infrastructure
7. Determine additional capacity
8. Determine the project total capacity
9. Determine the vulnerability ratio
10. Determine the capacity deficit

The mechanism by which each of these loads and capacities are computed is outlined in detail in the PIEVC Protocol.

Given the scoped approach for this climate change vulnerability assessment, this step of the Protocol was not completed for this case study.



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SECTION 6

PIEVC PROTOCOL STEP 5

CONCLUSIONS AND RECOMMENDATIONS



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6 CONCLUSIONS AND RECOMMENDATIONS

6.1 LIMITATIONS

The uncertainty in the assessment of the likelihood and magnitude of climate - infrastructure interactions is a limitation of this study. The judgment of likelihood and magnitude were unique to the individuals who took part in the risk assessment. The probability and risk values documented from the risk assessment are consensus views of likelihood and magnitude and the range of opinions contributes to uncertainty.

Overall, the results of this study are based on applying professional judgment to the assessment of the most current information available within the scope of the PIEVC protocol and can, therefore, be used as a guide for future action on the part of the Town of Placentia and other governmental organizations.

6.2 OVERVIEW

Where vulnerability is identified, options to negate vulnerability have been assessed including reductions in load effects, changes in the performance criteria or additional capacity building. As a general rule, systems with high adaptive capacity are better able to deal with climate change impacts. Step 5 details infrastructure-specific recommendations on adaptive measures, such that the desired performance criteria are met in those circumstances where Steps 3 has indicated insufficient adaptive capacity.

As noted previously, this scoped risk assessment was limited to the application of Steps 1 and 2 of the PIEVC Protocol and a preliminary, independent application, by AMEC, of Step 3 of the Protocol.

The recommendation categories, based on the PIEVC protocol, are as follows:

- *Remedial engineering or operations action required*
- *Management action required*
- *Additional study or data required*
- *No further action required.*

The climate factors identified as potentially contributing to infrastructure vulnerability will be evidenced as gradual changes. However, often the extremes (such as extreme rainfall), even if uncommon, have a far greater impact on public perception of risk. Under climate change scenarios, some of these phenomena are anticipated to occur more frequently.

6.2.1 Laval High School

The vulnerabilities judged to be of the highest priority for the building are those associated with performance responses that contribute risks to public health and safety (namely, flood related). Specifically, sea level rise, the potential for increased storm surge and extreme rainfall as catalysts for increased flood risk were identified as triggers for these vulnerabilities.

6.3 RECOMMENDATIONS

As noted previously, the intent of this assessment is to provide an overview of the PIEVC Protocol and, through an example, how its application to infrastructure can assist in understanding risks in the face of a changing climate. This preliminary assessment does not touch on all aspects of the infrastructure or all potential climatic influences. As such, the first recommendation is for the assessment to be expanded/completed, such that it includes all aspects of the PIEVC Protocol and all relevant components of the subject infrastructure and climate reflecting all available information and experiences of, and input from, municipal staff. Full applications of the PIEVC Protocol have been completed for similar infrastructure elsewhere in Canada and these reports are available at the PIEVC website (www.pievc.ca). It is encouraged that these be reviewed in advance of a more in-depth risk assessment of the Laval High School in the future.

Other recommendations stemming from the application of the PIEVC Protocol to the Laval High School in the Town of Placentia to assess risks and vulnerabilities to projected changes in climate phenomenon in the future are outlined below.

- It is recommended that this scoped climate change vulnerability assessment be completed in full for all components of the PIEVC protocol.¹⁵
- It is recommended that periodic shoreline monitoring on the seaward side of the breakwater/boardwalk be continued.
- It is recommended that the flood inundation mapping for the Town of Placentia be updated.
- It is recommended that near term changes in the expected frequency of freeze thaw cycles be evaluated to determine the effects of potential increased cycles on the roof of the school.
- It is recommended that the capacity of the HVAC systems to perform as designed with future anticipated temperatures be evaluated.
- It is recommended that the data referenced in the applicable design codes and guidelines be updated to reflect current information. Alternatively, a mechanism to require completion of a site-specific climate assessment to determine whether in-depth analysis is necessary for infrastructure being designed or evaluated be developed.

¹⁵ Adoption of this recommendation would encompass some of the other recommendations itemized in the list.

- It is recommended that recording of climatic events specific to the subject infrastructure be a regular procedure in the administration of the infrastructure.
- It is recommended that the climate change projections available from the Province be augmented such that the time series upon which the projections are based are made available such that more in-depth interrogation of the datasets is possible.

General recommendations regarding climate change risk assessment of infrastructure stemming from the workshops included:

- The Province should develop procedures and/or policies for incorporating risk assessment into infrastructure planning and development practices.
- The development of climate change datasets by the Province is a great step forward in breaking down perceived barriers to climate change risk assessments. However, barriers that still exist as a consequence of the lack of coordination among departments and lack of understanding of the “do nothing” scenario still need to be addressed. As such, better Government interdepartmental coordination should be advanced towards a consistent view of the requirements for incorporating risk assessment into infrastructure planning and development practices.
- The workshops clearly demonstrated value in advancing understanding of climate change issues affecting infrastructure in the Province. Further opportunities for training/education about climate change and the potential impacts to the Province should be continued for all levels of government and the private sector.
- The climate change datasets developed by the Province can generally support climate change risk assessment. However, the Province should not view these datasets as static. Examples of gaps in the datasets have already been noted (i.e., short duration IDF data). With changing science and data collection new projections are being developed around the world. The Province should develop a review cycle for its datasets. Further, the Province should also allow for new datasets to be analysed and incorporated into the larger suite of datasets.



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SECTION 7

REFERENCES



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7 REFERENCES

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APPENDICES

APPENDIX A - Project Documentation



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APPENDIX A

Project Documentation

A selection of drawings of the school made available from the Province for this assessment.



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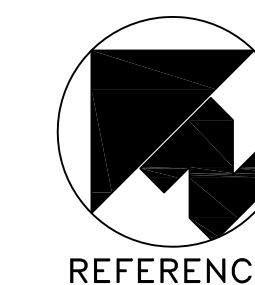
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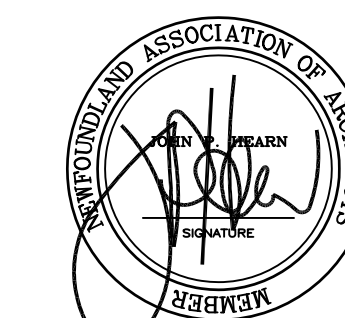
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B	ISSUED FOR FINAL SUBMISSION	07 OCT .09	T.P.
A	ISSUED FOR INTERIM SUBMISSION	07 AUG .09	T.P.

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DRAWING
CODE CONFORMANCE AND FIRE SEPARATIONS PLANS

DRAWN BY	CHECKED BY	APPROVED BY
-	J. P. HEARN	J. P. HEARN
PROJECT NO.	DWG. FILE NO.	DTW PROJECT NO.
JHA-09-16		400936001
DATE	SCALE	DRAWING NO.
JULY 2009	AS SHOWN	WA100
		REV.
		0

FIRE SEPARATION SCHEMATIC NOTES

FIRE RESISTANCE RATINGS FOR WALL ASSEMBLIES

• USE LEGEND BELOW AND DRAWINGS TO IDENTIFY LOCATION OF FIRE SEPARATIONS.

	120 min
	60 min
	45 min
	NON-RATED

NOTE: RATINGS SHOWN ARE THE MINIMUM REQUIRED

FIRE RESISTANCE RATINGS FOR FLOOR ASSEMBLIES

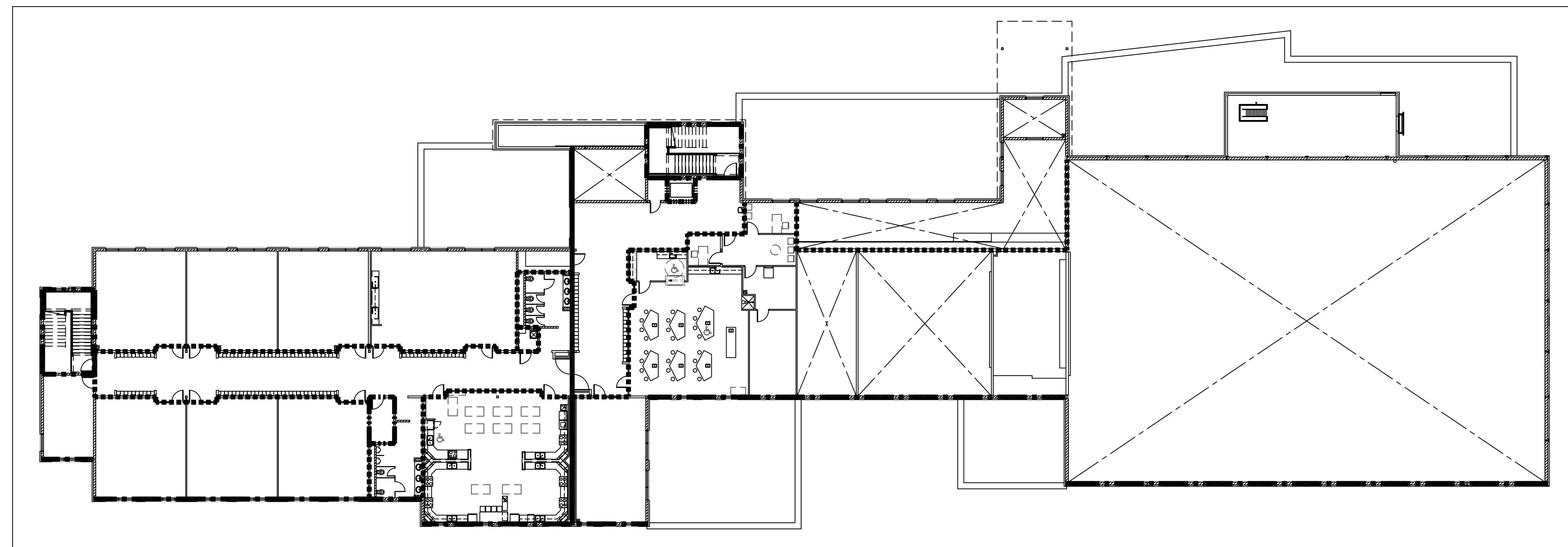
• USE LEGEND BELOW AND DRAWINGS TO IDENTIFY LOCATION OF FIRE SEPARATIONS FOR FLOOR ABOVE LEVEL INDICATED.

	DENOTES NON-RATED FIRE RATED FLOOR / ROOF SEPARATION ABOVE
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FIRE SEPARATION SCHEMATIC NOTES

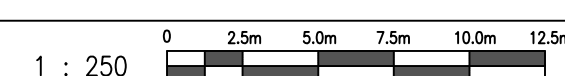
- REPORT TO ENGINEER ANY DISCREPANCY BETWEEN THE RATINGS SHOWN IN THE FIRE SEPARATION SCHEMATIC AND THOSE GIVEN IN ASSEMBLY DESCRIPTIONS.
- FIRE STOP PENETRATIONS AND JOINTS IN EACH ASSEMBLY IDENTIFIED ANYWHERE IN DRAWINGS OR SCHEDULES AS BEING A FIRE SEPARATION.

NOT USED

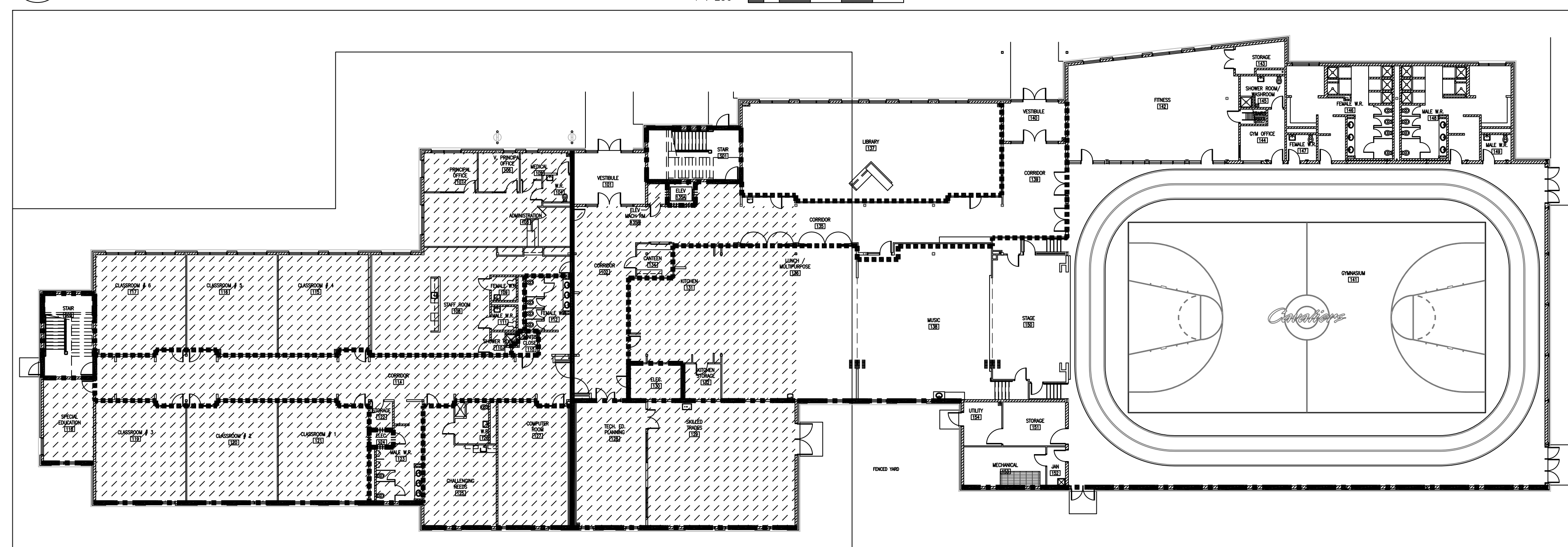


2 SECOND FLOOR FIRE SEPARATION PLAN

WA100

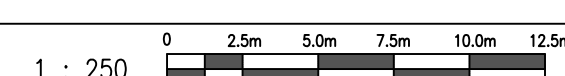


NOT USED



1 GROUND FLOOR FIRE SEPARATION PLAN

WA100

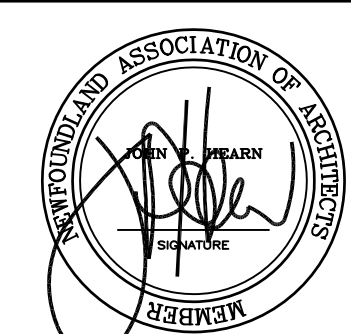


General Notes:

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REVISIONS			
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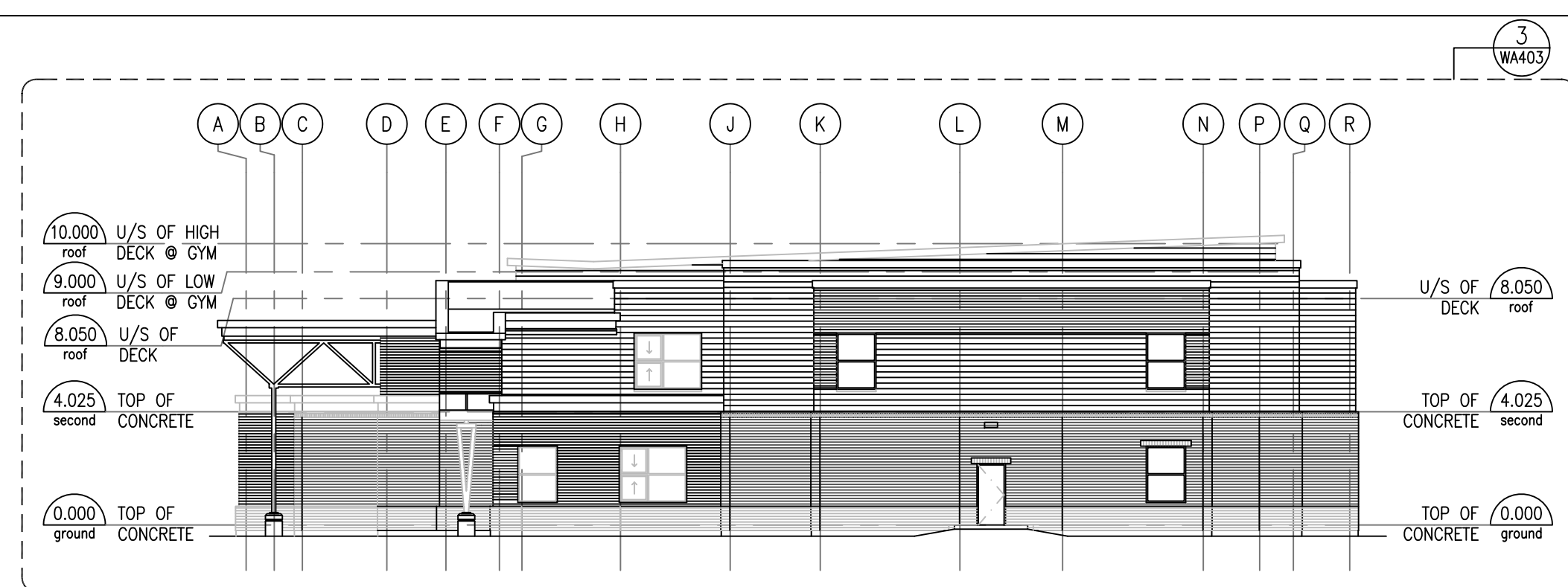
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PROJECT
NEW 7-12 PLACENTIA SCHOOL
PLACENTIA NEWFOUNDLAND AND LABRADOR

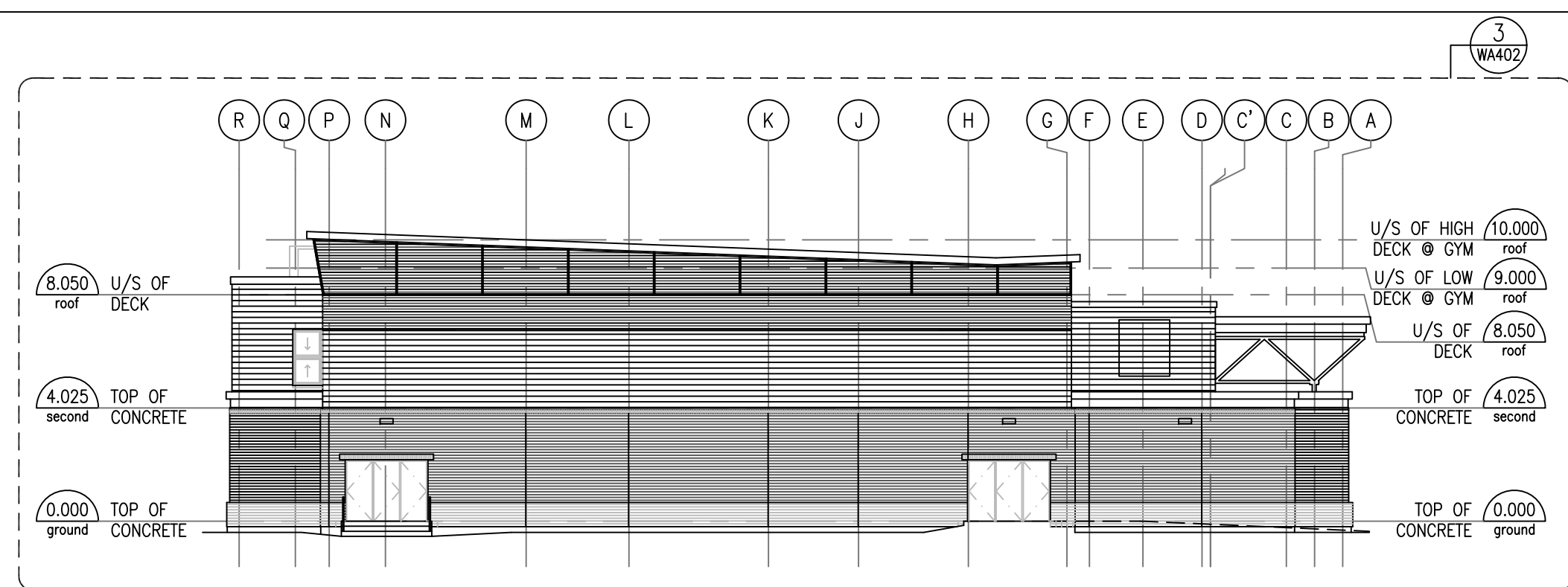
DRAWING
BUILDING ELEVATIONS 1

DRAWN BY	CHECKED BY	APPROVED BY
-	J. P. HEARN	J. P. HEARN
PROJECT NO.	DWG. FILE NO.	DTW PROJECT NO.
JHA-09-16		400936001
DATE	SCALE	DRAWING NO.
JULY 2009	AS SHOWN	WA401
		REV. 0



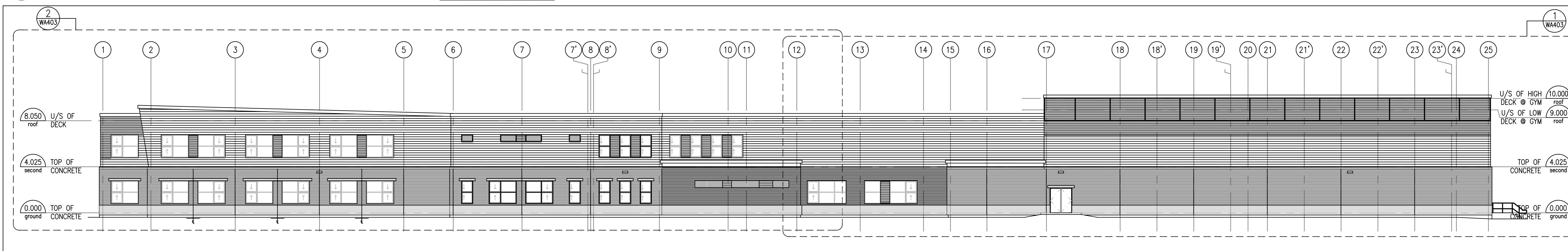
4 WEST BUILDING ELEVATION

WA401



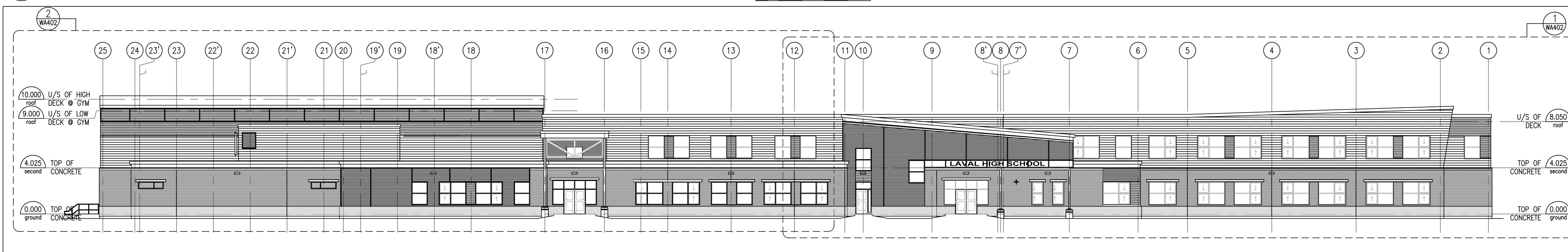
3 EAST BUILDING ELEVATION

WA401



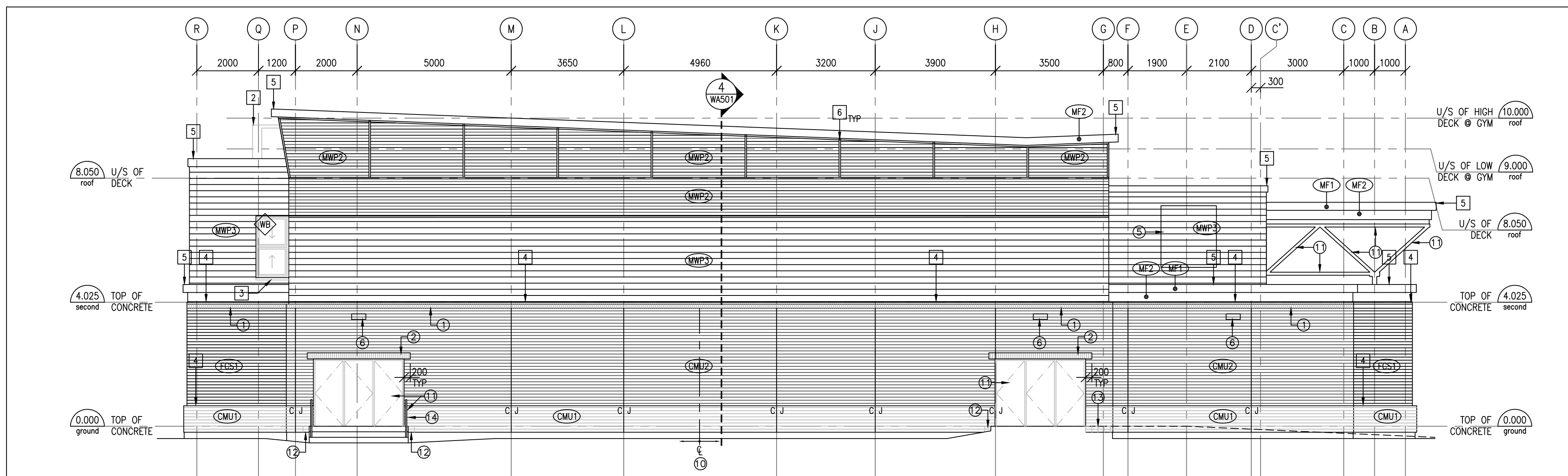
2 SOUTH BUILDING ELEVATION

WA401



1 NORTH BUILDING ELEVATION

WA401



3 EAST BUILDING ELEVATION
WA402

ELEVATIONS LEGEND

WINDOW TAGS

WA DENOTES WINDOW TYPE. SEE ARCHITECTURAL PROJECT NOTES AND LEGENDS SHEET.

ELEVATION TAGS

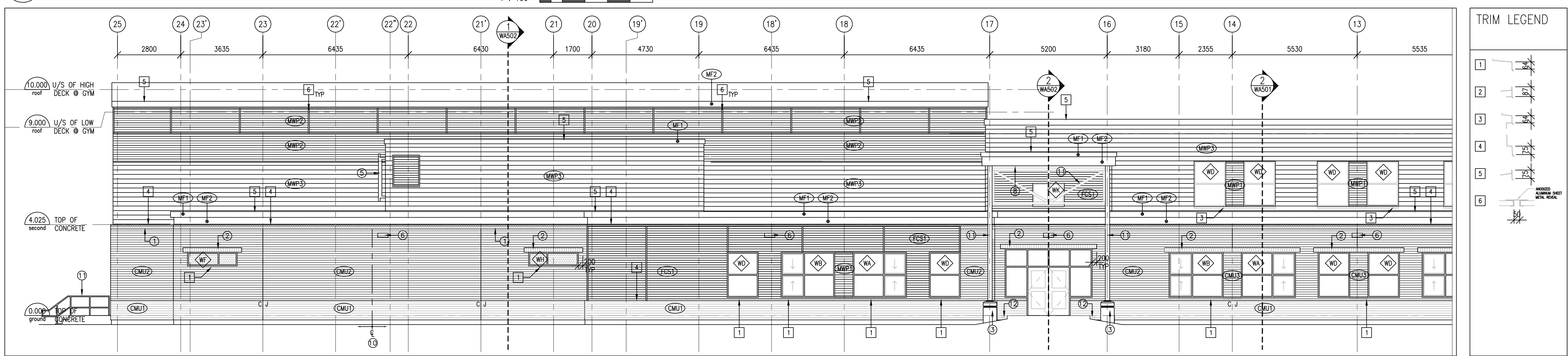
TEXT DENOTES EXTERIOR FINISH TYPE. SEE ARCHITECTURAL PROJECT NOTES AND LEGENDS SHEET.

ELEVATION MATERIALS AND FINISHES

SEE EXTERIOR FINISHES LEGEND ON ARCHITECTURAL PROJECT NOTES AND LEGENDS SHEET FOR MATERIAL AND FINISH DESCRIPTIONS.

	DENOTES CMU1
	DENOTES CMU2
	DENOTES MWP1 & MWP2
	DENOTES MWP3
	DENOTES FCS1

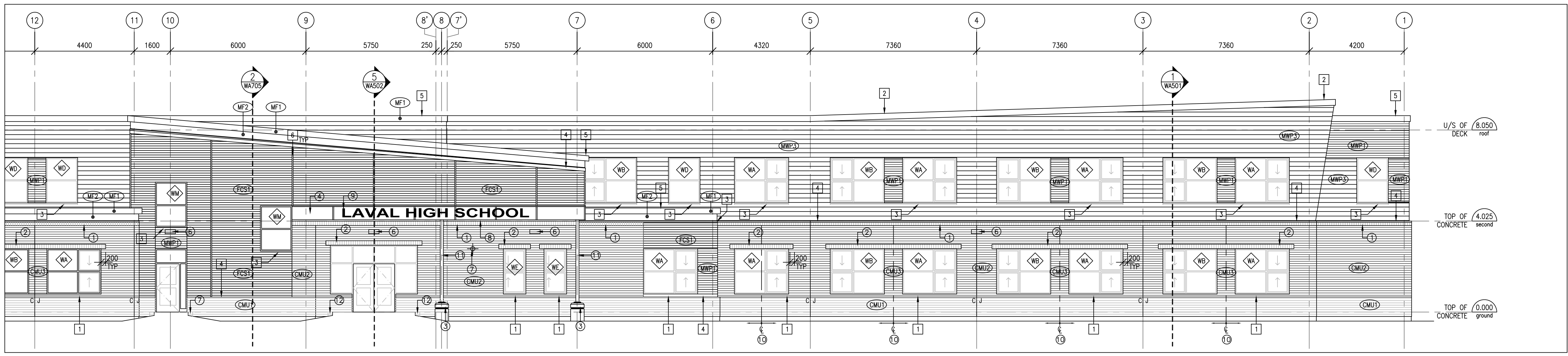
- ### SHEET KEYNOTES
- THESE NOTES APPLY ONLY TO PARTICULAR WORK IDENTIFIED BY KEYNOTE MARKERS.
- PROVIDE CONTINUOUS 200MM HIGH CMU2 SOLDIER COURSE.
 - PROVIDE 200MM HIGH CMU1 SOLDIER COURSE ABOVE OPENINGS.
 - ARCHITECTURAL CONCRETE, SEALER FINISH.
 - COMPOSITE METAL PANEL, SILVER METALLIC, WITH DRY JOINTS.
 - PROVIDE SNOW Baffle IN STEEL FRAMING WITH MWP3 FINISH.
 - EXTERIOR LIGHT FIXTURE, SEAL FIXTURE AT EXTERIOR SIDING.
 - AMBER STROBE LIGHT, SEAL FIXTURE AT EXTERIOR SIDING.
 - PROVIDE MWP2 FOR SOFFIT TO CANOPY.
 - 400MM HIGH LETTER SIGNAGE, VERIFY TITLE AND TEXT STYLE WITH OWNER.
 - USE CENTERLINE OF EACH GRID BAY FOR MASONRY SETTING OUT FOR THAT BAY, INTERIOR AND EXTERIOR MASONRY (TYPICAL).
 - PT16 PAINT FINISH.
 - EXTEND SMOOTH FACE CMU 200MM BEYOND THE EDGE OF THE CONCRETE.
 - EXTEND SMOOTH FACE CMU TO EDGE OF BUILDING.
 - PAINTED STEEL EXTERIOR HANDRAIL/GUARD.



2 PARTIAL NORTH BUILDING ELEVATION 2
WA402

TRIM LEGEND

1	
2	
3	
4	
5	
6	



1 PARTIAL NORTH BUILDING ELEVATION 1
WA402



Department of Transportation and Works
Government of Newfoundland and Labrador

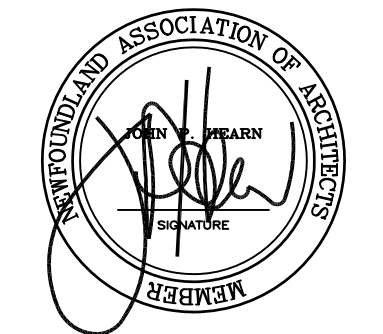
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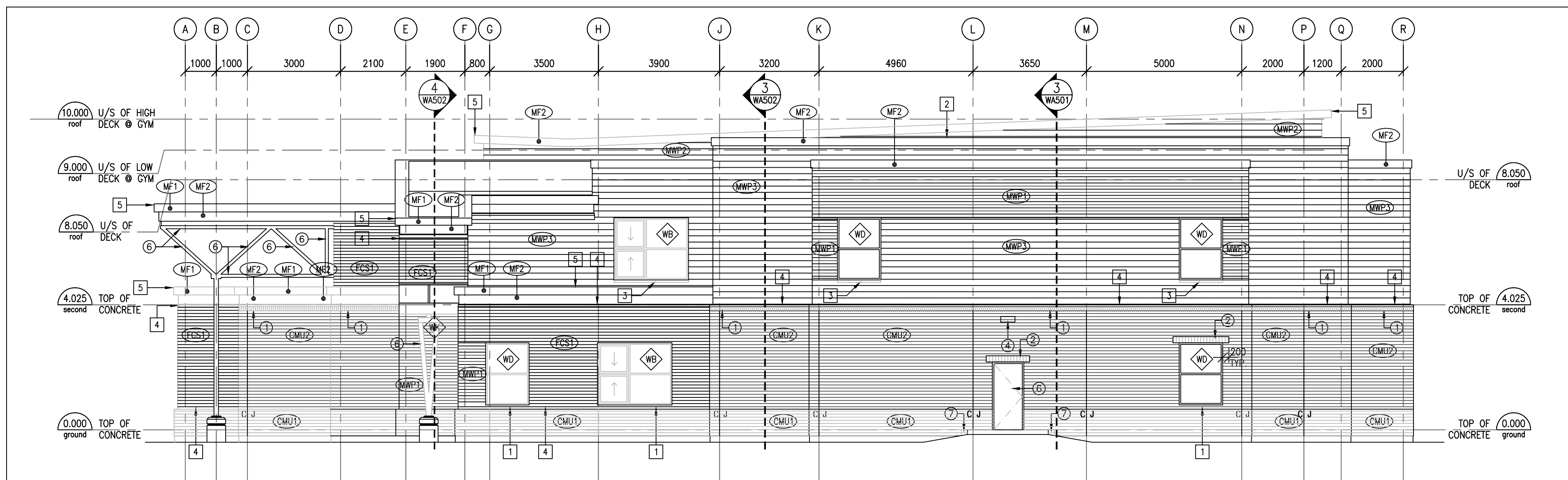
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PROJECT
NEW 7-12 PLACENTIA SCHOOL

PLACENTIA NEWFOUNDLAND AND LABRADOR

DRAWING
BUILDING ELEVATIONS 2

DRAWN BY	CHECKED BY	APPROVED BY
	J. P. HEARN	J. P. HEARN
PROJECT NO.	DWG. FILE NO.	DTW PROJECT NO.
JHA-09-16		400936001
DATE	SCALE	DRAWING NO.
JULY 2009	AS SHOWN	WA402
		REV.
		0



3 WEST BUILDING ELEVATION
WA403

ELEVATIONS LEGEND

WINDOW TAGS
 WA DENOTES WINDOW TYPE. SEE ARCHITECTURAL PROJECT NOTES AND LEGENDS SHEET.

ELEVATION TAGS
 TEXT DENOTES EXTERIOR FINISH TYPE. SEE ARCHITECTURAL PROJECT NOTES AND LEGENDS SHEET.

ELEVATION MATERIALS AND FINISHES
 SEE EXTERIOR FINISHES LEGEND ON ARCHITECTURAL PROJECT NOTES AND LEGENDS SHEET FOR MATERIAL AND FINISH DESCRIPTIONS.

DENOTES CMU1

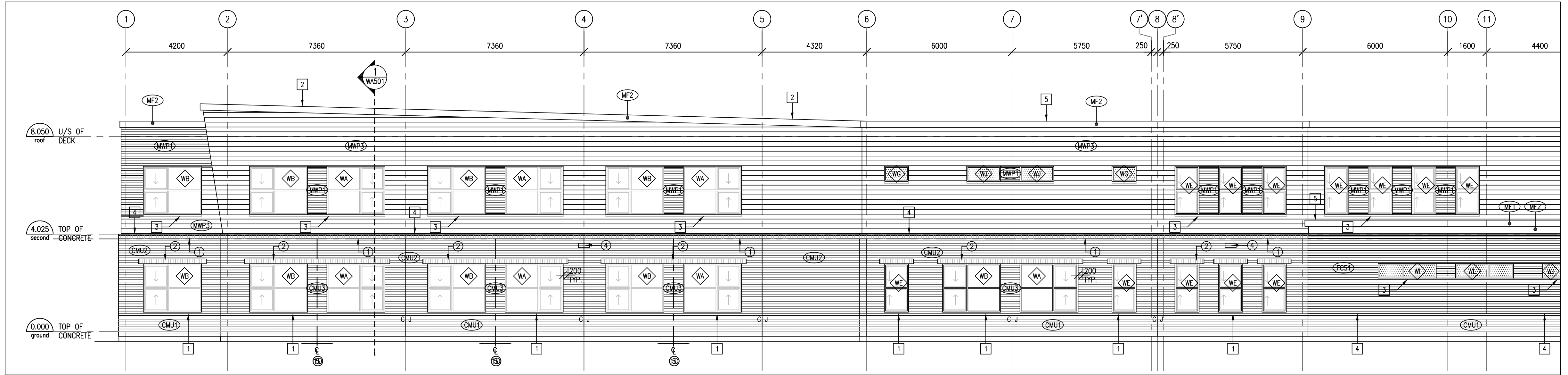
DENOTES CMU2

DENOTES MWP1 & MWP2

DENOTES MWP3

DENOTES FCS1

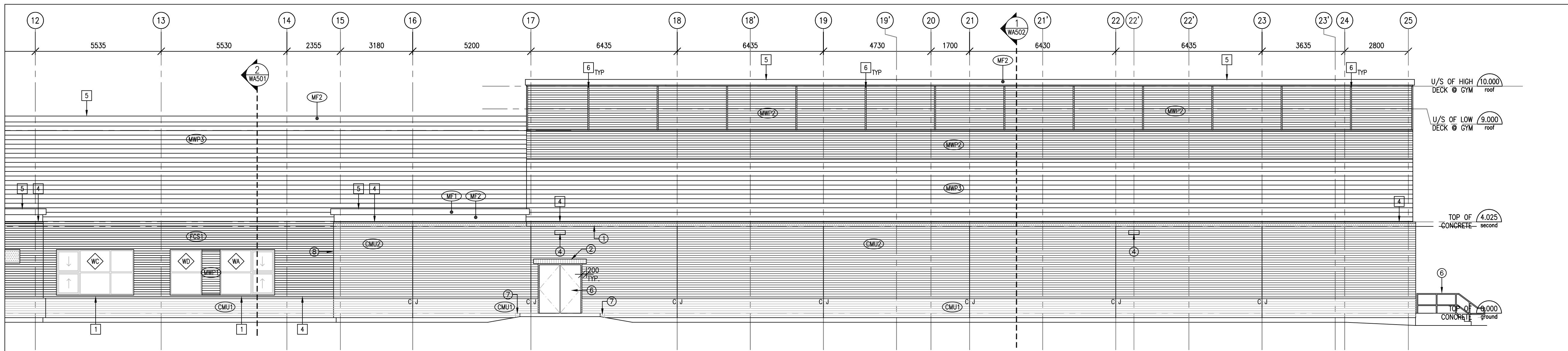
- ⊗ SHEET KEYNOTES**
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- PROVIDE CONTINUOUS 200MM HIGH CMU2 SOLDIER COURSE.
 - PROVIDE 200MM HIGH CMU1 SOLDIER COURSE ABOVE OPENINGS.
 - ARCHITECTURAL CONCRETE, SEALER FINISH.
 - EXTERIOR LIGHT FIXTURE, SEAL FIXTURE AT EXTERIOR SIDING.
 - USE CENTERLINE OF EACH GRID BAY FOR MASONRY SETTING OUT FOR THAT BAY, INTERIOR AND EXTERIOR MASONRY (TYPICAL).
 - P16 PAINT FINISH.
 - EXTEND SMOOTH FACE CMU 200MM BEYOND THE EDGE OF THE CONCRETE.
 - CONTINUE CMU2 FINISH AROUND CORNER TO ADJACENT EXTERIOR WALL SURFACE.



2 PARTIAL SOUTH BUILDING ELEVATION 2
WA403

TRIM LEGEND

-
-
-
-
-
-



1 PARTIAL SOUTH BUILDING ELEVATION 1
WA403



Department of Transportation and Works
Government of Newfoundland and Labrador

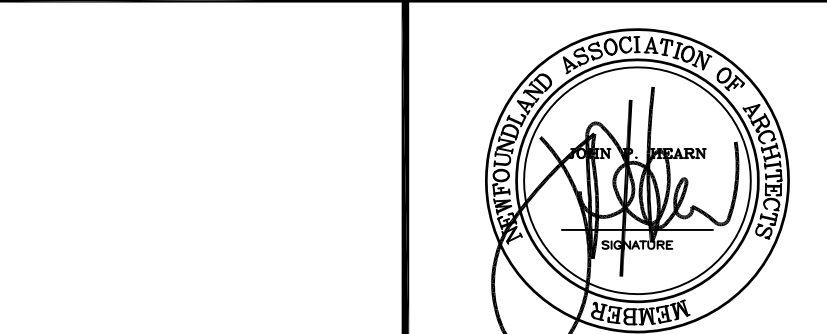
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PROJECT
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 PLACENTIA NEWFOUNDLAND AND LABRADOR

DRAWING
BUILDING ELEVATIONS 3

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