From: pharrington@nalcorenergy.com
To: ktucker@nalcorenergy.com
Cc: briancrawley@nalcorenergy.com
Subject: Wind/Ice loadings updates -Top Priority
Date: Tuesday, October 23, 2012 2:21:18 PM
Attachments: .png
Meteorological Loads and cost increase factors - REv x.pptx

Kyle

Pls find attached the deck you sent with the adjustments made to slides 15,20 and 21 - where the Nalcor wind load is the same as the 150yr as we discussed in the meeting recently .

Can you update the slide 5 to show the percentage increase this gives and also produce a graph similar to that shown in the MHI report - showing the Ice loadings CSA 150 yr and what nalcor has used for design - also add a the 500 yr CSA so we have both references.

This is top priority -pls make every effort to turn this around asap

Thanks Paul

Meteorological Loads and cost increase factors - REv x.pptx

Paul Harrington
Project Director
LC Mgmt & Support
Nalcor Energy - Lower Churchill Project
t. **709 737-1907** c. **709 682-1460**
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Kyle Tucker---10/17/2012 03:13:51 PM---Hi Paul, I have attached the newly revised presentation to this email based on your request. Please

From: Kyle Tucker/NLHydro

To: Paul Harrington/NLHydro@NLHydro

Cc: Paul Humphries/NLHydro@NLHydro, Jason Kean/NLHydro@NLHydro, Ron Power/NLHydro@NLHydro, Brian Crawley/NLHydro@NLHYDRO, Gilbert Bennett/NLHydro@NLHydro

Date: 10/17/2012 03:13 PM

Subject: Re: Presentation for Mr. Martin - revised

Hi Paul,

I have attached the newly revised presentation to this email based on your request. Please let me know if you have any further additions.

Thanks,

Kyle

[attachment "Meteorological Loads and cost increase factors - rev 3.pptx" deleted by Paul Harrington/NLHydro]

Kyle B. Tucker, M.Eng., P.Eng.
Project Manager - Overland Transmission
Nalcor Energy - Lower Churchill Project
t. **709 737-1449** c. **709 687-0884**
e. **ktucker@nalcorenergy.com**
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Paul Harrington---10/16/2012 03:16:54 PM---Paul I have asked Kyle to sit in on that meeting to make sure we have covered all the bases

From: Paul Harrington/NLHydro

To: Paul Humphries/NLHydro@NLHydro

Cc: Kyle Tucker/NLHydro@NLHydro, Jason Kean/NLHydro@NLHydro, Ron Power/NLHydro@NLHydro, Brian Crawley/NLHydro@NLHYDRO, Gilbert Bennett/NLHydro@NLHydro

Date: 10/16/2012 03:16 PM

Subject: Re: Presentation for Mr. Martin

Paul

I have asked Kyle to sit in on that meeting to make sure we have covered all the bases

Paul Harrington
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Paul Humphries---10/16/2012 02:18:26 PM---Kyle: Once you finalize you presentation could you provide me a copy. As I am suppose to be discussi

From: Paul Humphries/NLHydro

To: Paul Harrington/NLHydro@NLHydro

Cc: Kyle Tucker/NLHydro@NLHydro, Jason Kean/NLHydro@NLHydro, Ron Power/NLHydro@NLHydro, Brian Crawley/NLHydro@NLHYDRO, Gilbert Bennett/NLHydro@NLHydro

Date: 10/16/2012 02:18 PM

Subject: Re: Presentation for Mr. Martin

Kyle: Once you finalize you presentation could you provide me a copy. As I am suppose to be discussing reliability with Ed on Thursday I would like to insure that we are aligned.

Thanks

Paul

Paul Humphries
Manager System Planning
Project Execution & Technical Services
Newfoundland and Labrador Hydro - a Nalcor Energy company
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Paul Harrington---10/16/2012 01:39:17 PM---Kyle This is very good- one suggestion - could you add a slide that explains why we exceed the CSA

From: Paul Harrington/NLHydro

To: Kyle Tucker/NLHydro@NLHydro

Cc: Jason Kean/NLHydro@NLHydro, Ron Power/NLHydro@NLHydro, Brian Crawley/NLHydro@NLHYDRO, Gilbert Bennett/NLHydro@NLHydro, Paul Humphries/NLHydro@NLHydro

Date: 10/16/2012 01:39 PM

Subject: Re: Presentation for Mr. Martin

Kyle

This is very good- one suggestion - could you add a slide that explains why we exceed the CSA standards by such a wide margin. To address the folks who might say that Nalcor over designed- I am of the understanding that the meteorological conditions that we have experienced in the 50 years of data gathering require us to go well beyond what CSA recommends - if that is correct we should clearly state that

Regards Paul

Jason

can you take a look at the last few slides to make sure they are aligned with the RAP and FLG slides we have already presented and if we need to be consistent in language and content then propose some rewording

Thanks Paul

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Kyle Tucker---10/16/2012 01:20:13 PM---Hi Paul, Based on our discussion this morning, I have attached a first draft of the presentation for

From: Kyle Tucker/NLHydro

To: Paul Harrington/NLHydro@NLHydro

Cc: Ron Power/NLHydro@NLHydro, Jason Kean/NLHydro@NLHydro

Date: 10/16/2012 01:20 PM

Subject: Presentation for Mr. Martin

Hi Paul,

Based on our discussion this morning, I have attached a first draft of the presentation for your review. Please provide feedback as to additions or changes.

Thanks,

Kyle

[attachment "Meteorological Loads and cost increase factors - rev 1.pptx" deleted by Paul Harrington/NLHydro]

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Meteorological Load Cases and Cost Drivers between DG2 and DG3

Boundless Energy

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LOWER CHURCHILL PROJECT

History of Meteorological Assessment

- Historical documents and references
  - 1973 MRI report – 20 years of data, and formed the basis for the 1998 Teshmont report and 2008 RSW report
  - 2010 assessment by Kathy Jones (CRREL – US Army Corp of Engineers) – 50 years of data
  - Hydro experience and assessments by A. Haldar
  - CSA Standard load cases
  - Rime Ice assessment by Landsvirkjun Power

CSA Standards

- Analysis Basis: CSA 60826-06 – Design Criteria of Overhead Transmission Lines

Executive Summary – Meteorological Loads

- Line length (ac and dc) = 1576 km
  - 315 kV HVac – 247 km x 2 lines
  - 350 kV HVdc – 1082 km
- Number of ac and dc meteorological zones and sub zones = 17
  - 315 kV HVac – 1
  - 350 kV HVdc – 16

Executive Summary – Meteorological Loads

- Number of zones that meet or exceed the CSA:
  - 150-year ice loading = 17 of 17 (100%)
  - 150-year wind loading = 12 of 17 (71%)
- Length of line that meet or exceeds the CSA:
  - 150-year ice loading = 1576 km of 1576 km (100%)
  - 500-year ice loading = 1398 km of 1576 km (89%)
  - 150-year wind loading = 1008 km of 1576 km (64%)
  - 500-year wind loading = 166 km of 1576 km (11%)

Meteorological Loading – 315 kV HVac

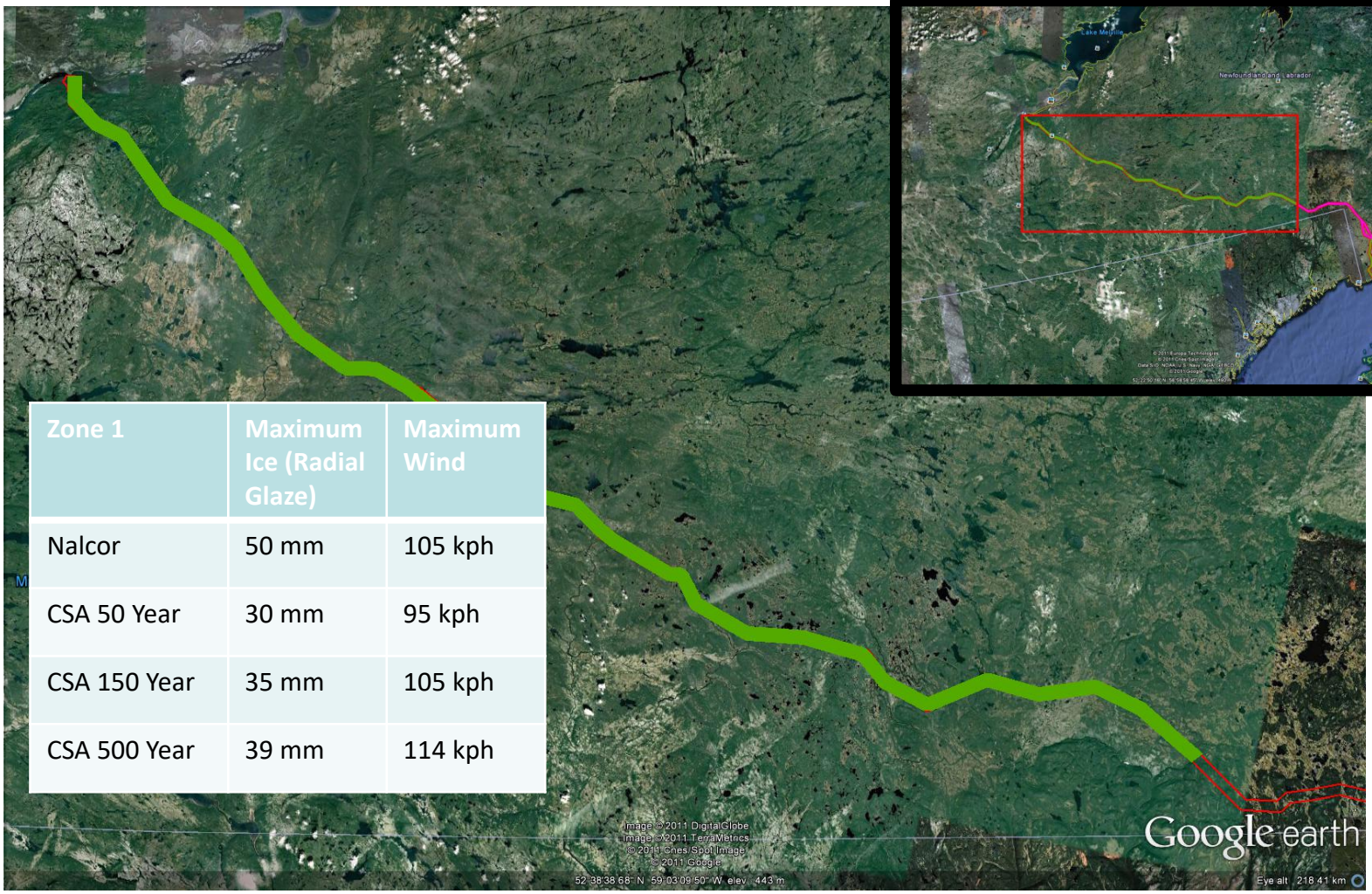
Nalcor Selected Load Cases

- Maximum Ice – 35 mm radial glaze
- Maximum Wind – 105 kph

CSA Load Cases

- Maximum Ice
  - 50 year = 23 mm
  - 150 year = 26 mm
  - 500 year = 29 mm
- Maximum Wind
  - 50 year = 95 kph
  - 150 year = 105 kph
  - 500 year = 114 kph

Meteorological Loading – HVdc Line

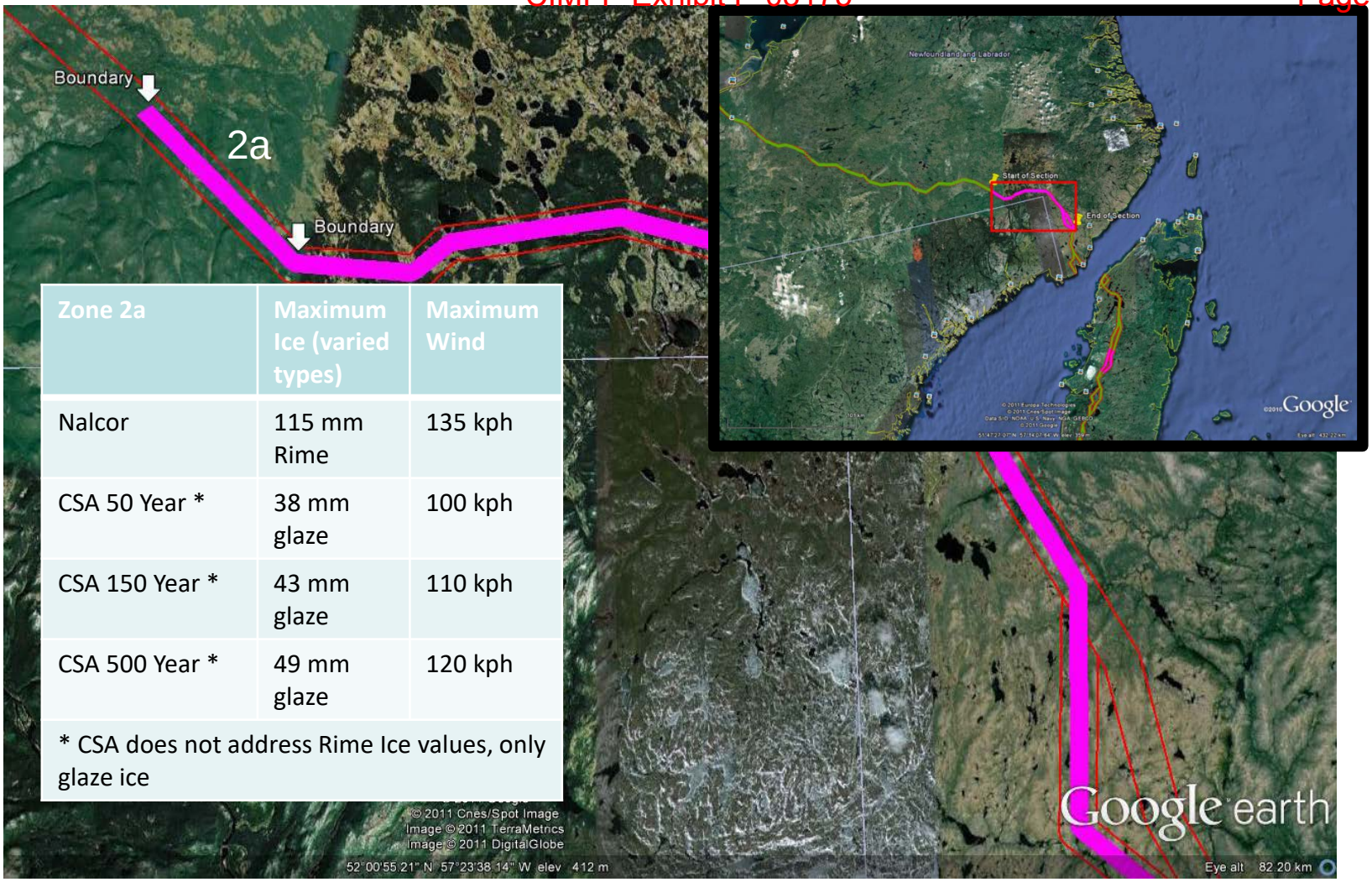


Zone 1	Maximum Ice (Radial Glaze)	Maximum Wind
Nalcor	50 mm	105 kph
CSA 50 Year	30 mm	95 kph
CSA 150 Year	35 mm	105 kph
CSA 500 Year	39 mm	114 kph

Zone 1 – Inner Labrador

Average Meteorological Loading Zone

Maximum Ice: 50 mm glaze, Maximum Wind: 105 km/h, Combined Ice and Wind: 25 mm glaze and 60 km/h



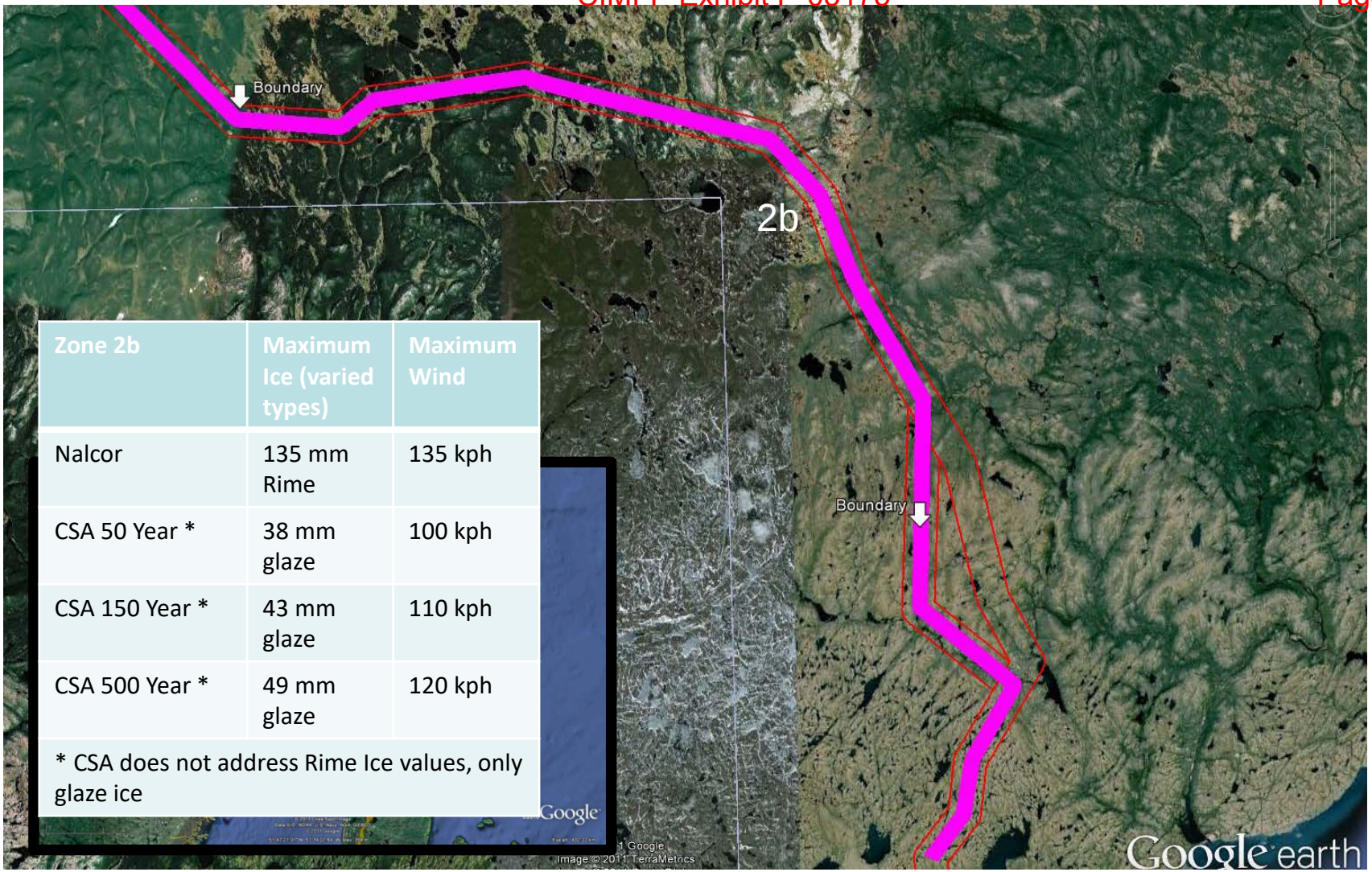
Zone 2a	Maximum Ice (varied types)	Maximum Wind
Nalcor	115 mm Rime	135 kph
CSA 50 Year *	38 mm glaze	100 kph
CSA 150 Year *	43 mm glaze	110 kph
CSA 500 Year *	49 mm glaze	120 kph

* CSA does not address Rime Ice values, only glaze ice

Zone 2a – Alpine Labrador

High Alpine Meteorological Loading Zone

Maximum Ice: 115 mm (Rime), Maximum Wind: 135 km/h, Combined Ice and Wind: 60 mm (Rime) and 95 km/h

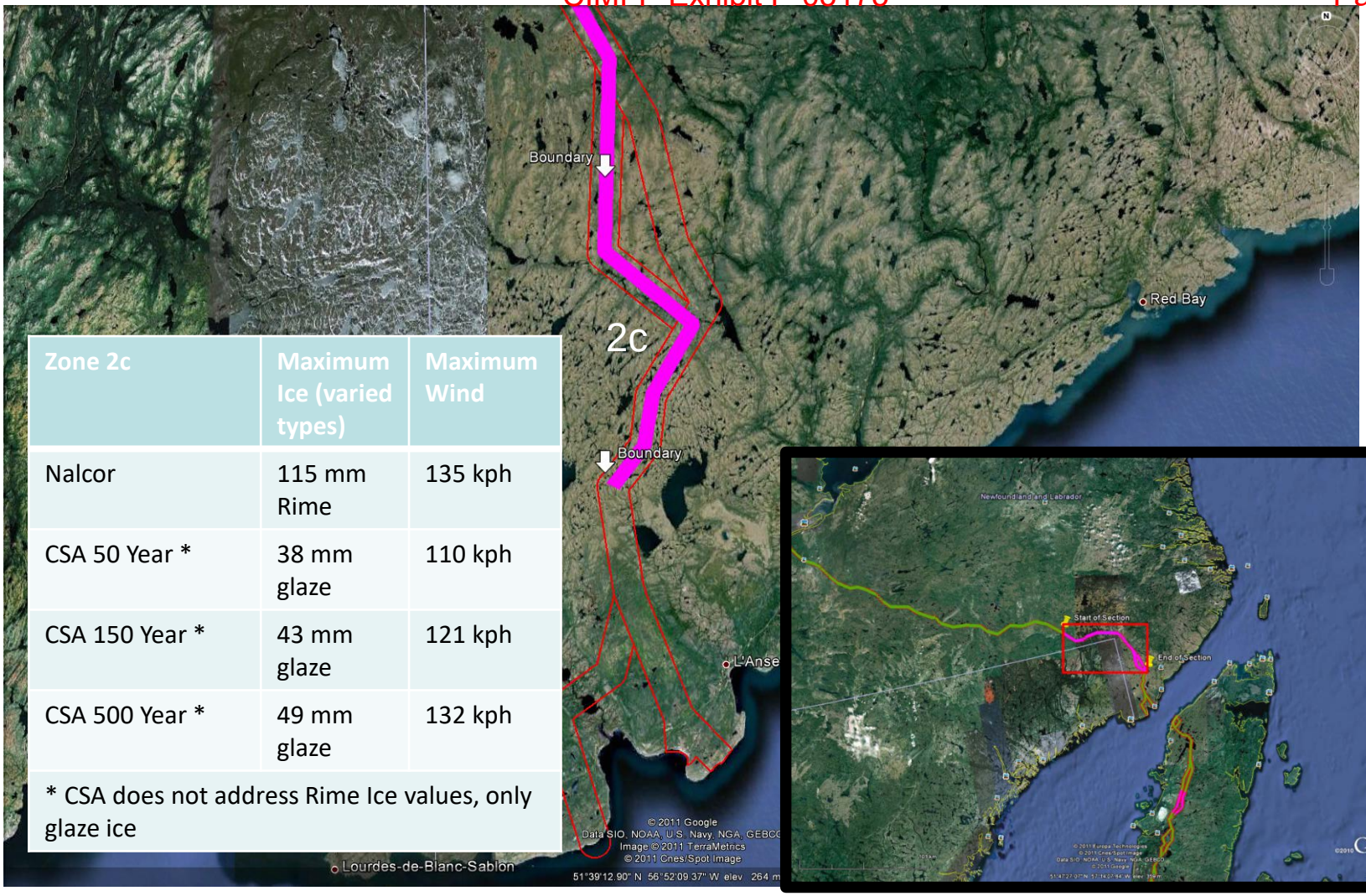


Zone 2b	Maximum Ice (varied types)	Maximum Wind
Nalcor	135 mm Rime	135 kph
CSA 50 Year *	38 mm glaze	100 kph
CSA 150 Year *	43 mm glaze	110 kph
CSA 500 Year *	49 mm glaze	120 kph
* CSA does not address Rime Ice values, only glaze ice		

Zone 2b – Alpine Labrador

Extreme Alpine Meteorological Loading Zone

Maximum Ice: 135 mm (Rime), Maximum Wind: 135 km/h, Combined Ice and Wind: 70 mm (Rime) and 95 km/h

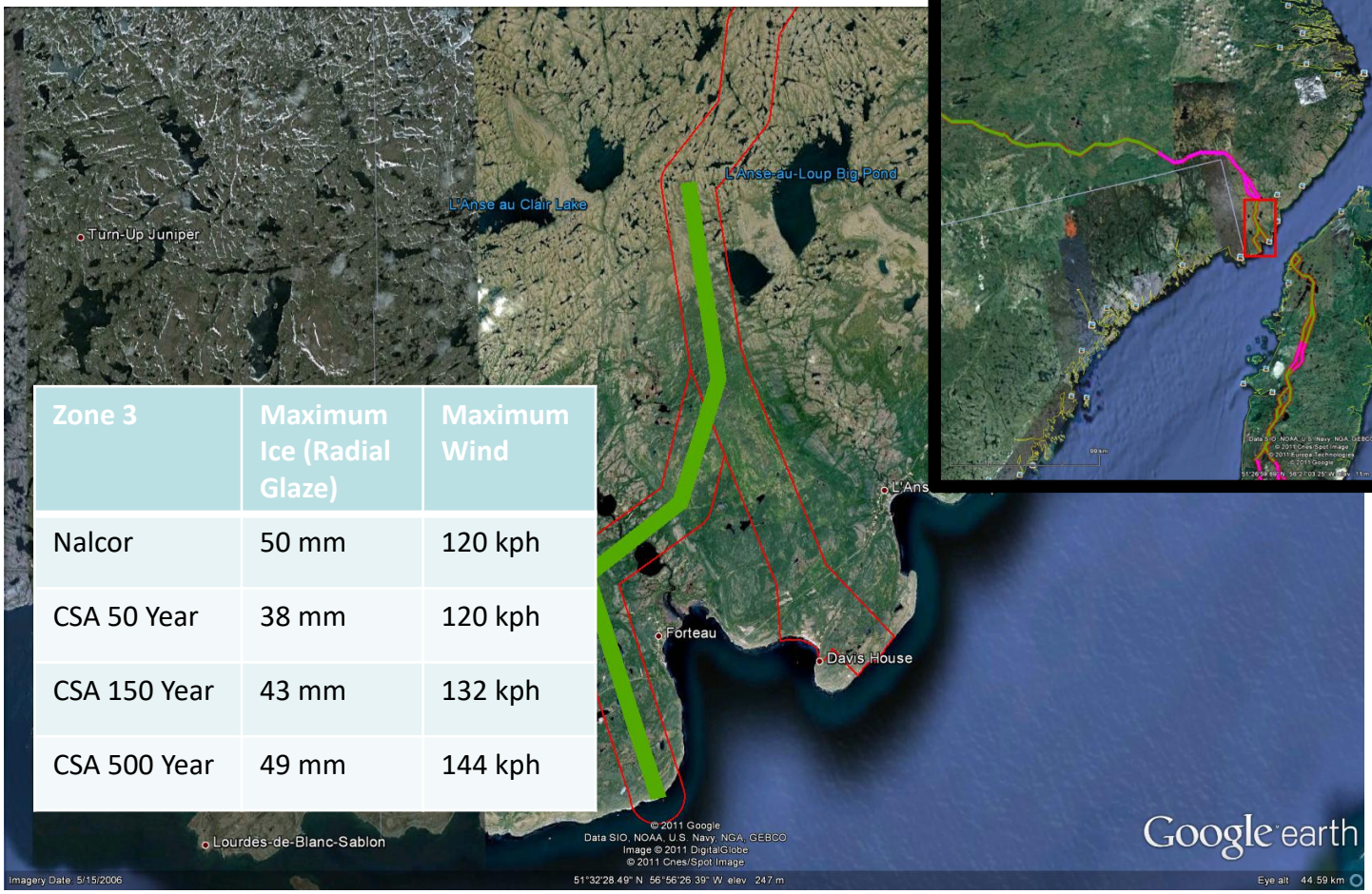


Zone 2c	Maximum Ice (varied types)	Maximum Wind
Nalcor	115 mm Rime	135 kph
CSA 50 Year *	38 mm glaze	110 kph
CSA 150 Year *	43 mm glaze	121 kph
CSA 500 Year *	49 mm glaze	132 kph
* CSA does not address Rime Ice values, only glaze ice		

Zone 2c – Alpine Labrador

High Alpine Meteorological Loading Zone (Western Corridor Alternative Only)

Maximum Ice: 115 mm (Rime), Maximum Wind: 135 km/h, Combined Ice and Wind: 60 mm (Rime) and 95 km/h

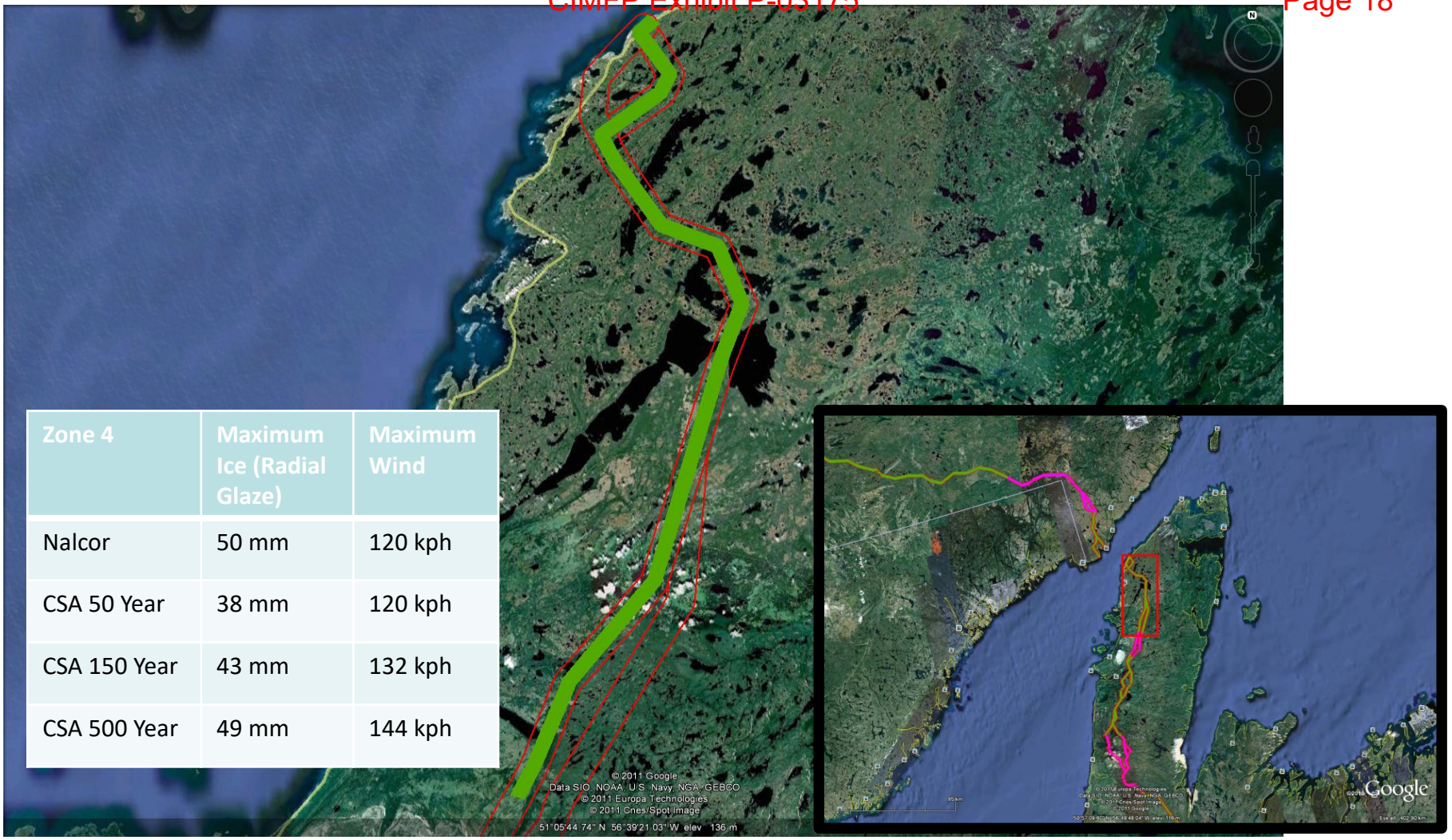


Zone 3	Maximum Ice (Radial Glaze)	Maximum Wind
Nalcor	50 mm	120 kph
CSA 50 Year	38 mm	120 kph
CSA 150 Year	43 mm	132 kph
CSA 500 Year	49 mm	144 kph

Zone 3 – Labrador Coast

Average Meteorological Loading Zone

Maximum Ice: 50 mm (Glaze), Maximum Wind: 120 km/h, Combined Ice and Wind: 25 mm (Glaze) and 60 km/h



Zone 4	Maximum Ice (Radial Glaze)	Maximum Wind
Nalcor	50 mm	120 kph
CSA 50 Year	38 mm	120 kph
CSA 150 Year	43 mm	132 kph
CSA 500 Year	49 mm	144 kph

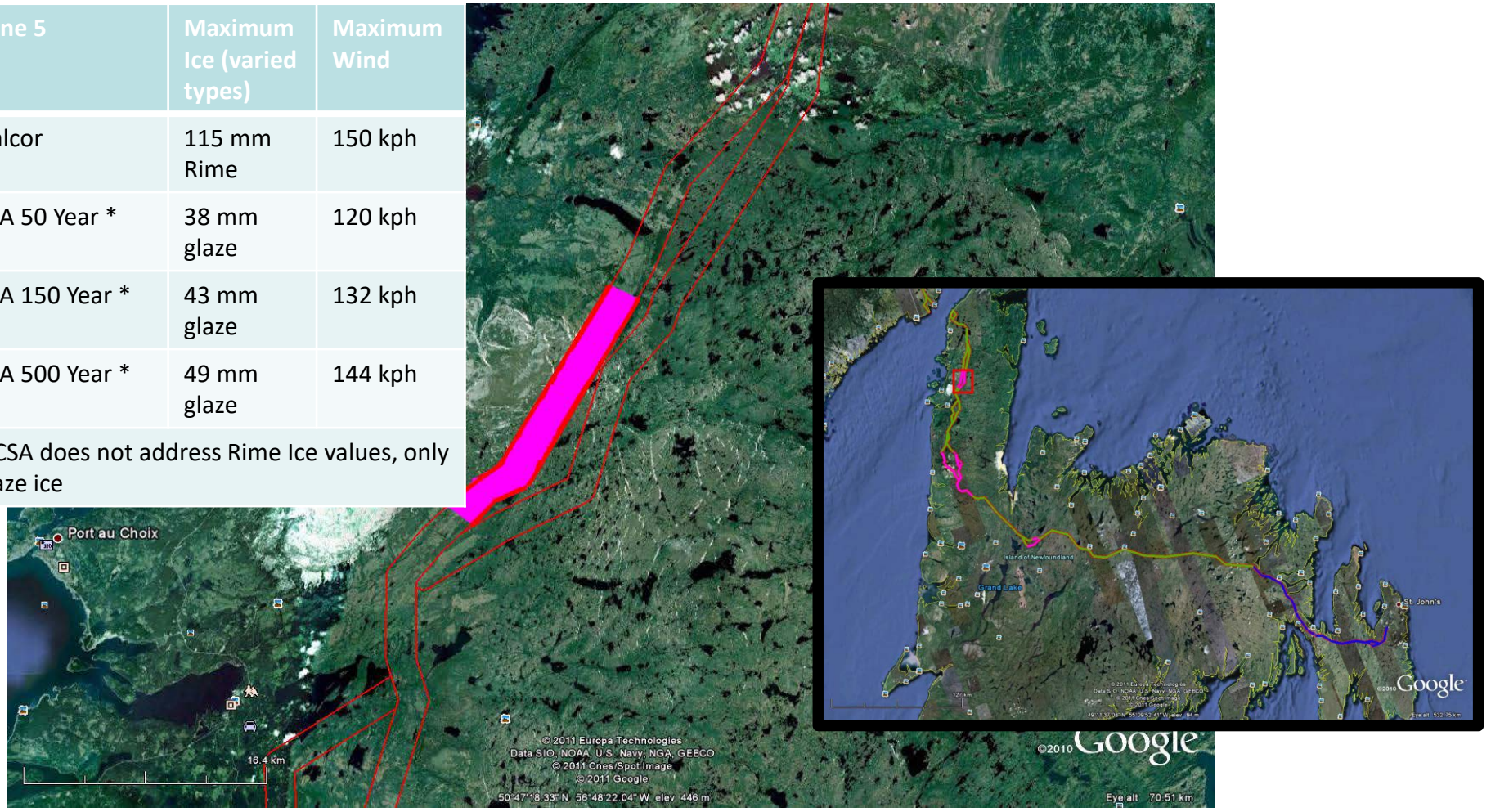
Zone 4 – Northern Peninsula Coast

Average Meteorological Loading Zone

Maximum Ice: 50 mm (Glaze), Maximum Wind: 120 km/h, Combined Ice and Wind: 25 mm (Glaze) and 60 km/h

Zone 5	Maximum Ice (varied types)	Maximum Wind
Nalcor	115 mm Rime	150 kph
CSA 50 Year *	38 mm glaze	120 kph
CSA 150 Year *	43 mm glaze	132 kph
CSA 500 Year *	49 mm glaze	144 kph

* CSA does not address Rime Ice values, only glaze ice

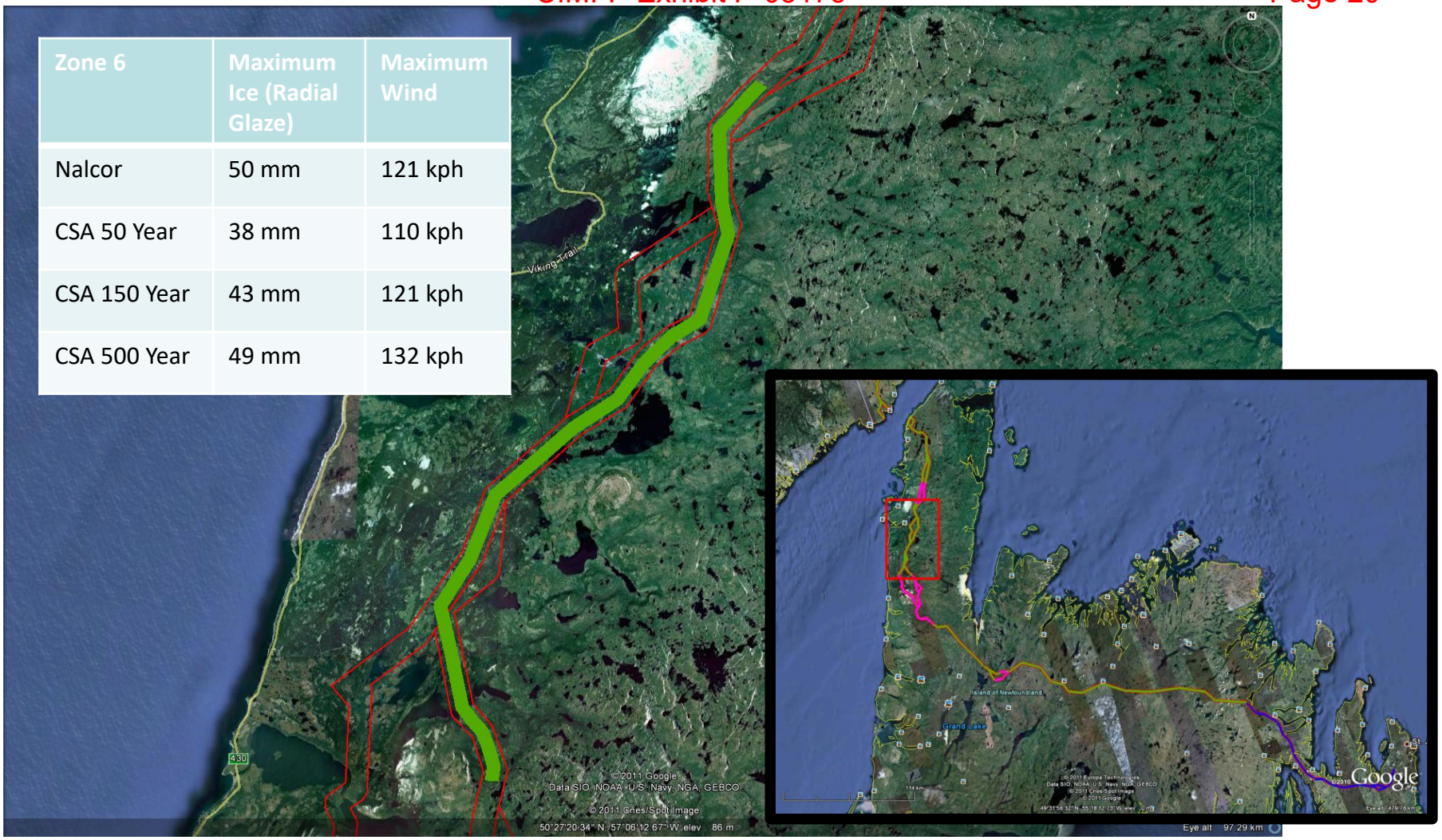


Zone 5 – Highlands of St. John

High Alpine Meteorological Loading Zone (Western Corridor Alternative Only)

Maximum Ice: 115 mm (Rime), Maximum Wind: 150 km/h, Combined Ice and Wind: 60 mm (Rime) and 105 km/h

Zone 6	Maximum Ice (Radial Glaze)	Maximum Wind
Nalcor	50 mm	121 kph
CSA 50 Year	38 mm	110 kph
CSA 150 Year	43 mm	121 kph
CSA 500 Year	49 mm	132 kph



Zone 6 –Northern Peninsula

Average Meteorological Loading Zone

Maximum Ice: 50 mm (Glaze), Maximum Wind: 120 km/h, Combined Ice and Wind: 25 mm (Glaze) and 60 km/h

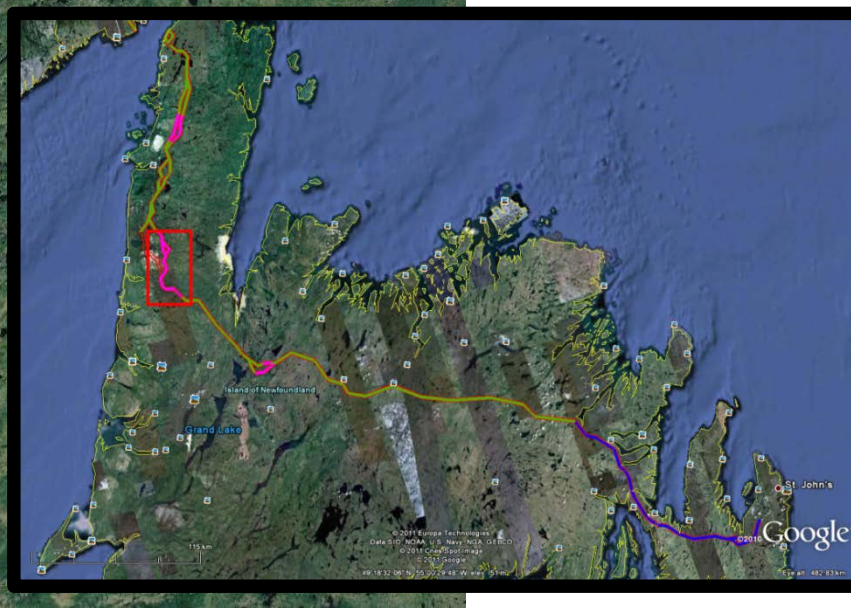
Boundary

7a

Boundary

Zone 7a	Maximum Ice (varied types)	Maximum Wind
Nalcor	115 mm Rime	180 kph
CSA 50 Year *	38 mm glaze	110 kph
CSA 150 Year *	43 mm glaze	121 kph
CSA 500 Year *	49 mm glaze	132 kph

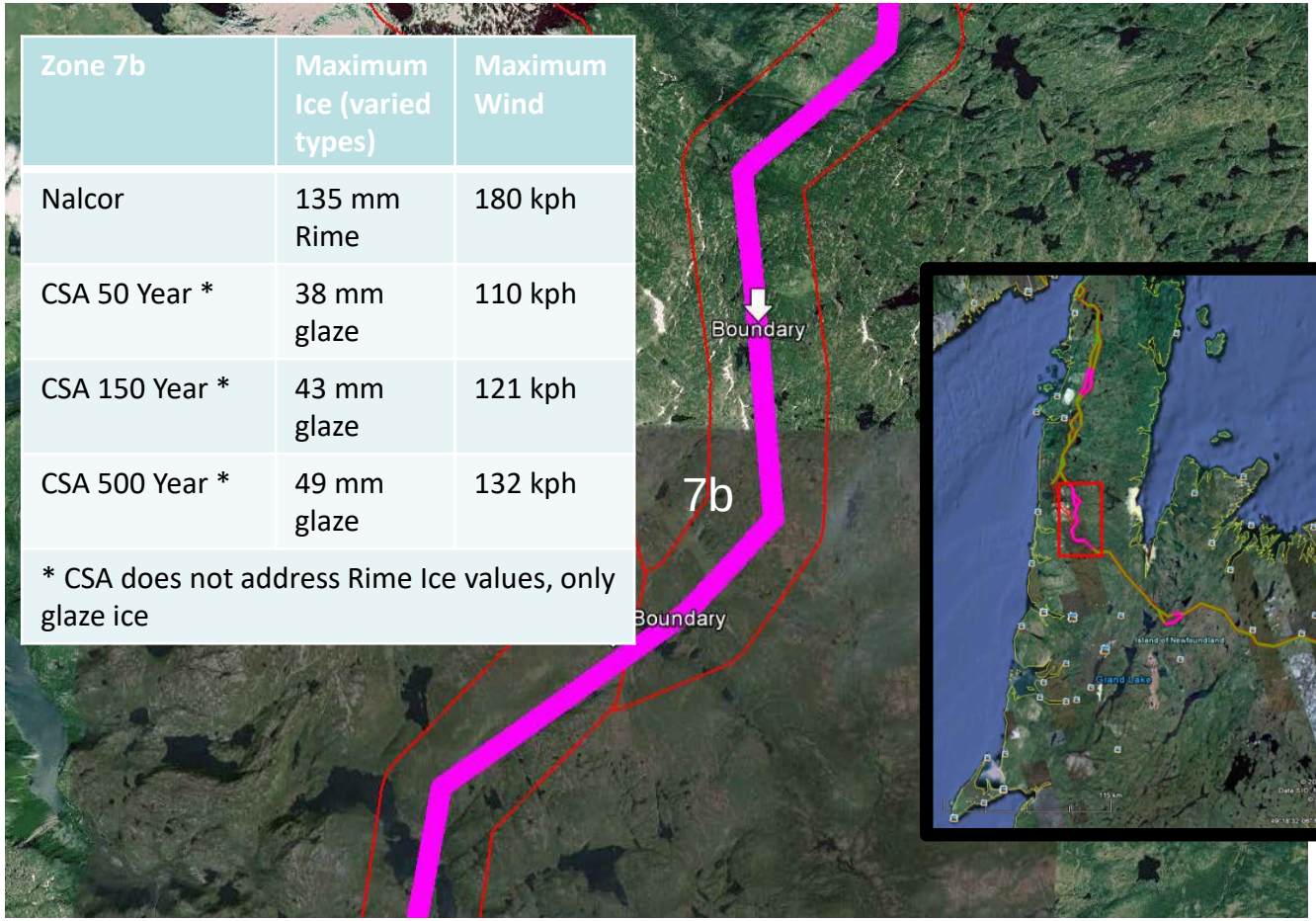
* CSA does not address Rime Ice values, only glaze ice

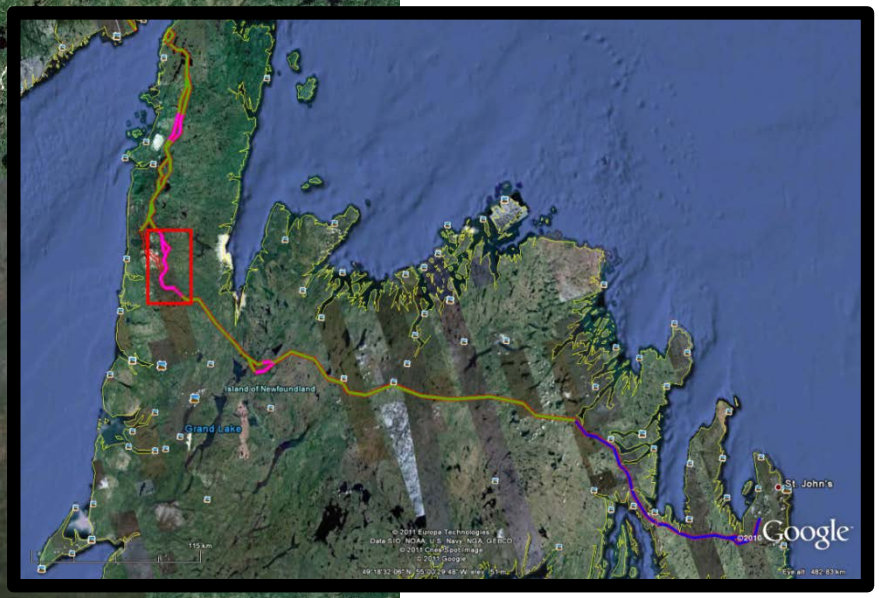


Zone 7a – Long Range Mountains Crossing

Zone 7b	Maximum Ice (varied types)	Maximum Wind
Nalcor	135 mm Rime	180 kph
CSA 50 Year *	38 mm glaze	110 kph
CSA 150 Year *	43 mm glaze	121 kph
CSA 500 Year *	49 mm glaze	132 kph

* CSA does not address Rime Ice values, only glaze ice



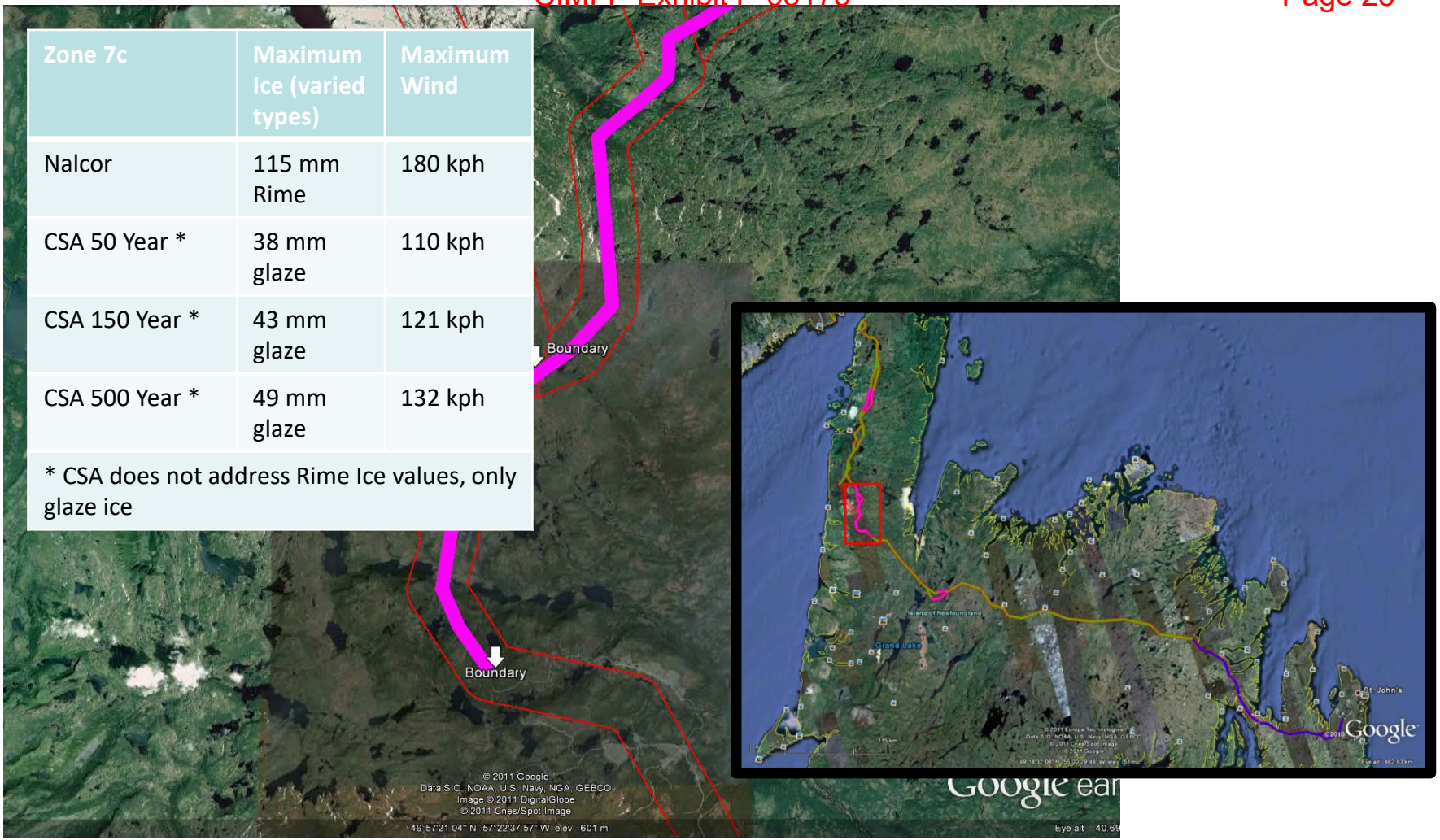


Zone 7b – Long Range Mountains Crossing

Extreme Alpine Meteorological Loading Zone (Eastern Corridor Alternative Only)

Maximum Ice: 135 mm (Rime), Maximum Wind: 180 km/h, Combined Ice and Wind: 70 mm (Rime) and 125 km/h

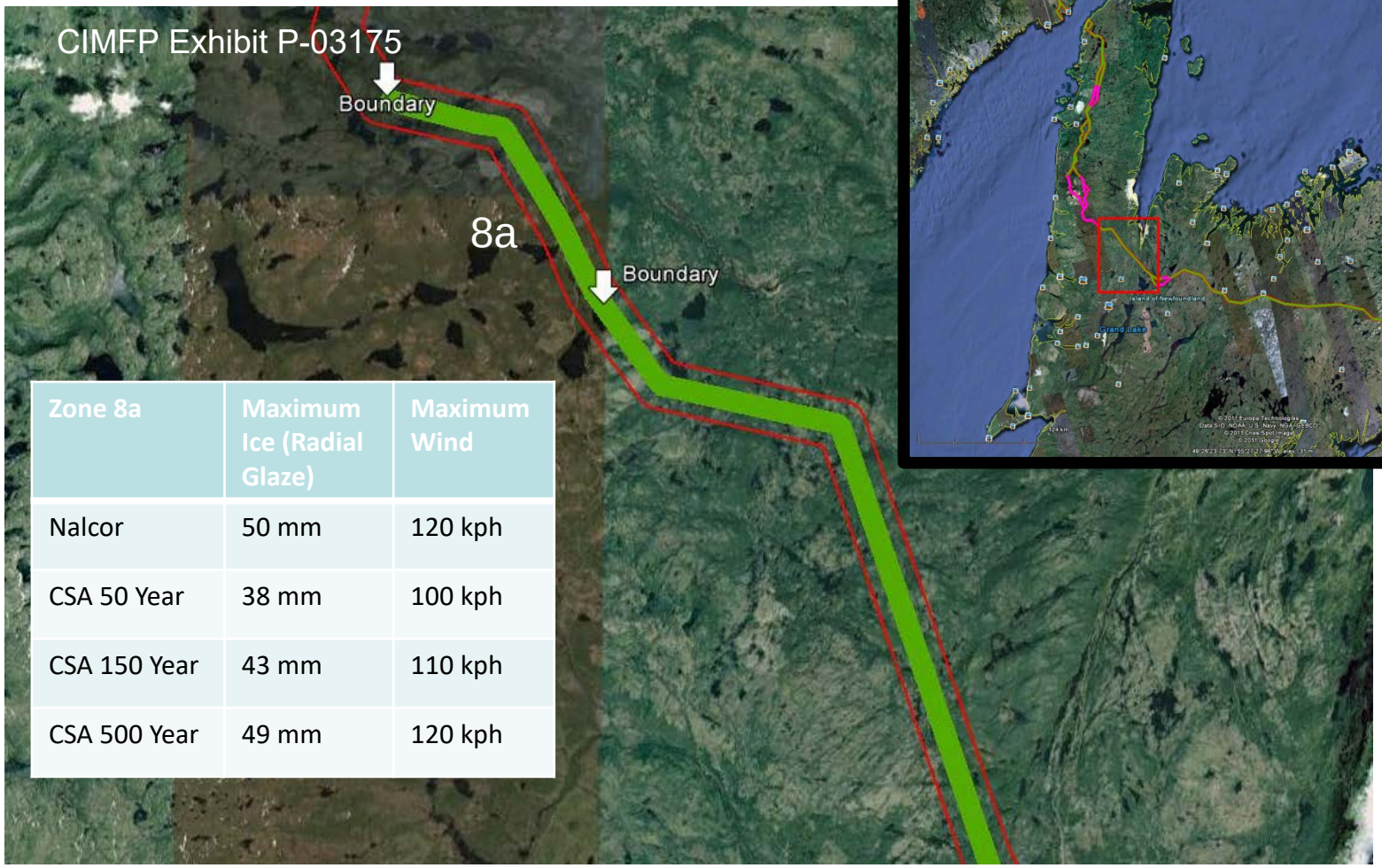
Zone 7c	Maximum Ice (varied types)	Maximum Wind
Nalcor	115 mm Rime	180 kph
CSA 50 Year *	38 mm glaze	110 kph
CSA 150 Year *	43 mm glaze	121 kph
CSA 500 Year *	49 mm glaze	132 kph
* CSA does not address Rime Ice values, only glaze ice		



Zone 7c – Long Range Mountains Crossing

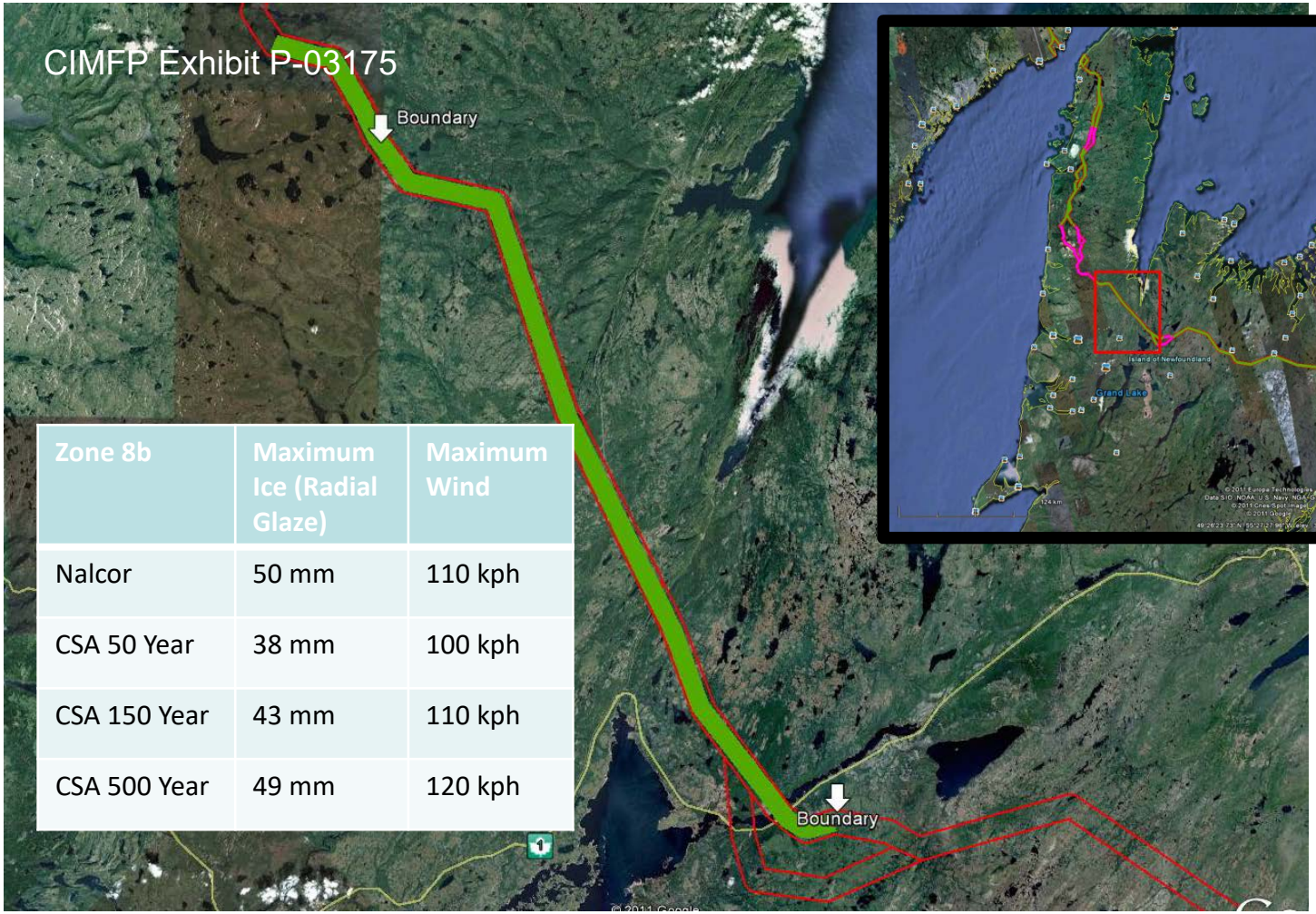
High Alpine Meteorological Loading Zone

Maximum Ice: 115 mm (Rime), Maximum Wind: 180 km/h, Combined Ice and Wind: 60 mm (Rime) and 125 km/h



Zone 8a	Maximum Ice (Radial Glaze)	Maximum Wind
Nalcor	50 mm	120 kph
CSA 50 Year	38 mm	100 kph
CSA 150 Year	43 mm	110 kph
CSA 500 Year	49 mm	120 kph

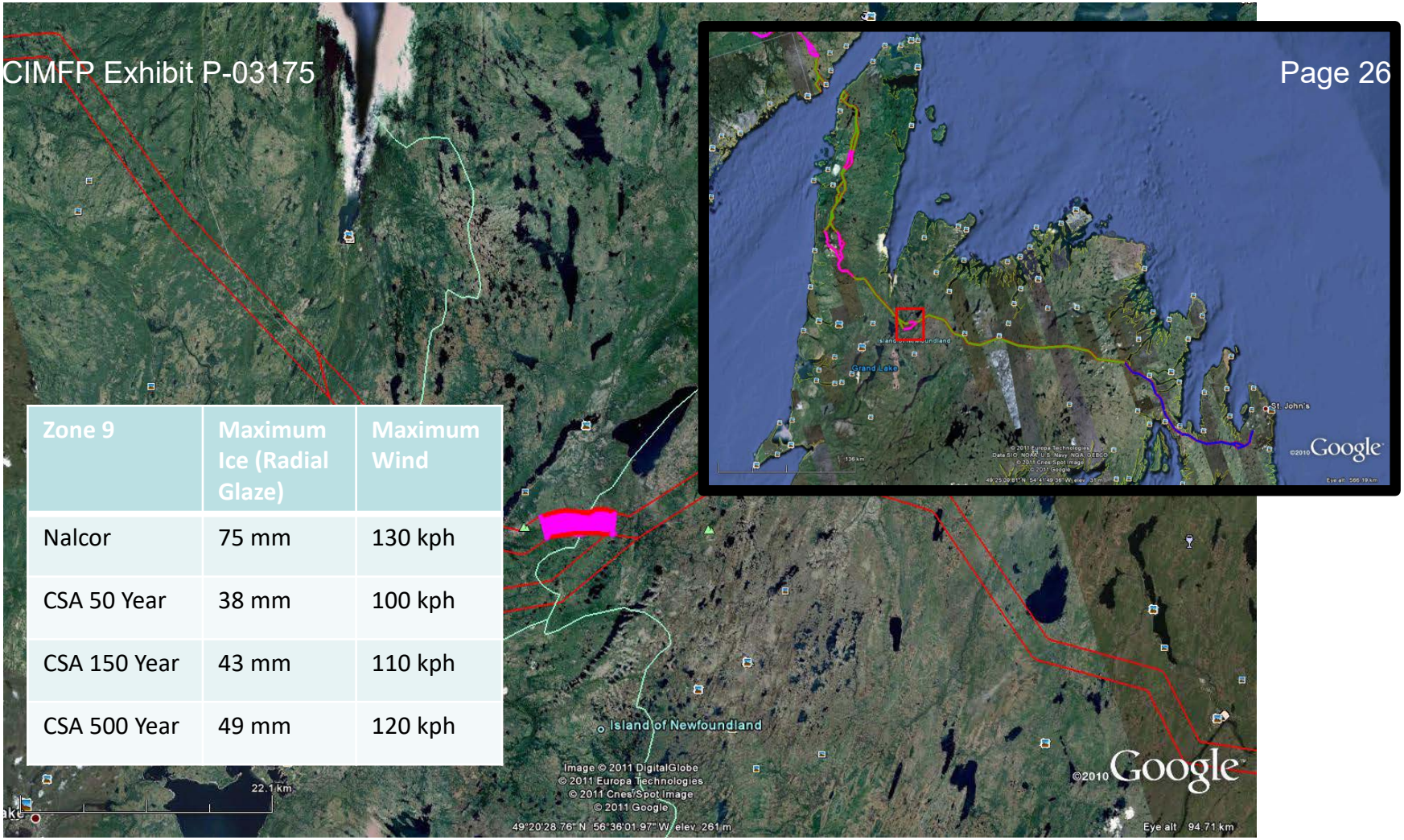
Zone 8a – Central-West Newfoundland



Zone 8b	Maximum Ice (Radial Glaze)	Maximum Wind
Nalcor	50 mm	110 kph
CSA 50 Year	38 mm	100 kph
CSA 150 Year	43 mm	110 kph
CSA 500 Year	49 mm	120 kph

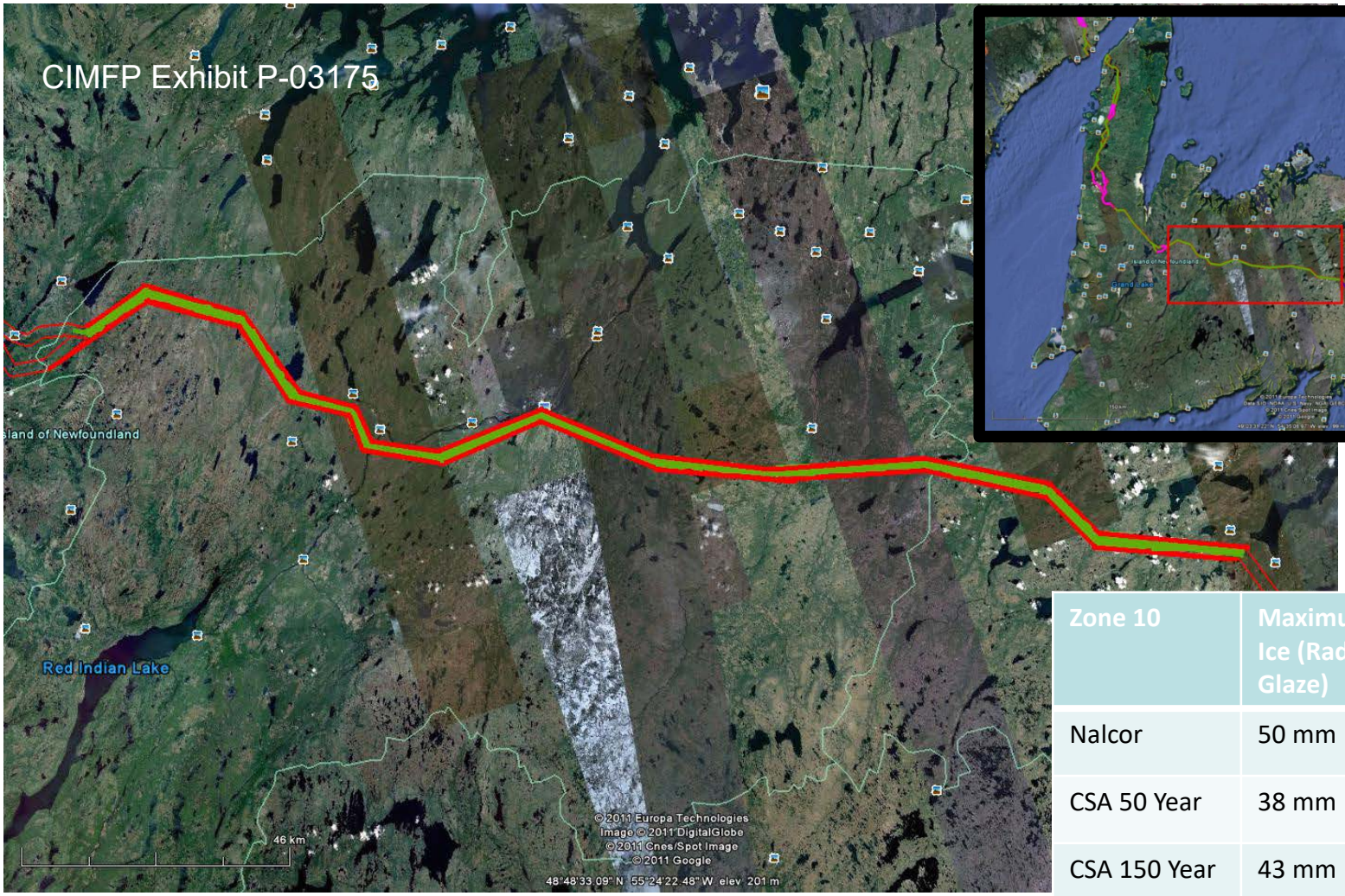
Average Meteorological Loading Zone

Maximum Ice: 50 mm (Glaze), Maximum Wind: 105 km/h, Combined Ice and Wind: 25 mm (Glaze) and 60 km/h



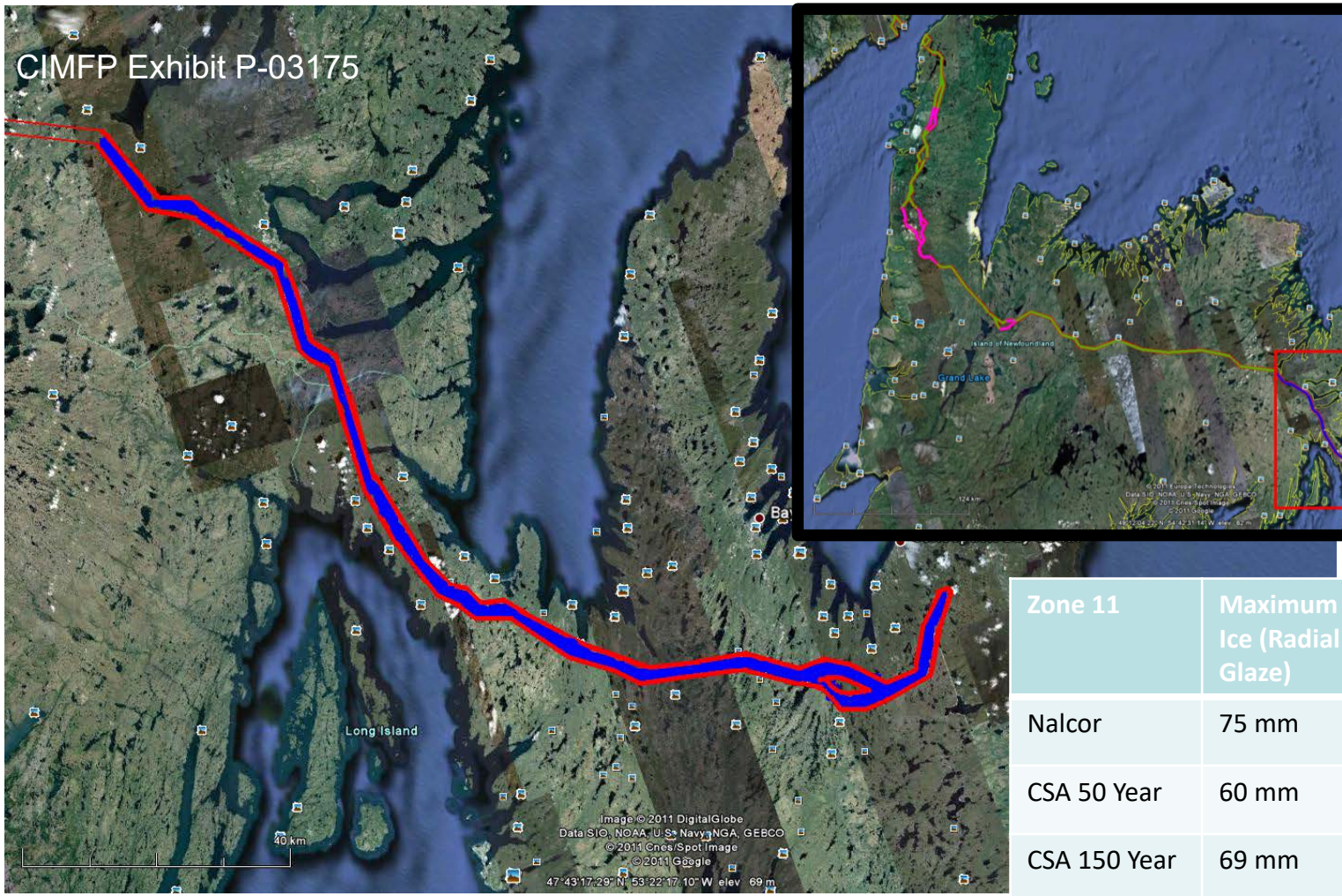
Zone 9	Maximum Ice (Radial Glaze)	Maximum Wind
Nalcor	75 mm	130 kph
CSA 50 Year	38 mm	100 kph
CSA 150 Year	43 mm	110 kph
CSA 500 Year	49 mm	120 kph

Zone 9 – The Birchy Narrows



Zone 10	Maximum Ice (Radial Glaze)	Maximum Wind
Nalcor	50 mm	110 kph
CSA 50 Year	38 mm	100 kph
CSA 150 Year	43 mm	110 kph
CSA 500 Year	49 mm	120 kph

Zone 10 – Central-East Newfoundland



Zone 11	Maximum Ice (Radial Glaze)	Maximum Wind
Nalcor	75 mm	130 kph
CSA 50 Year	60 mm	130 kph
CSA 150 Year	69 mm	143 kph
CSA 500 Year	78 mm	156 kph

Zone 11 – Eastern Newfoundland

Overall Evaluation

- Load selection was a balance between many sources, including uncertainty due to lack of data (ie. central Labrador appears over designed vs Eastern which appears to be on target for CSA 500-year loads)
- The unique nature of a large conductor allowed for increased ice loads in some areas without penalty, as is the case with central Labrador

Overall Evaluation

- Comparison between the CSA glaze loads and Nalcor Rime ice loads in the Alpine zones is not a fair relationship due to the different formation mechanisms; however, CSA data for Rime ice does not exist
- Alpine zones were extensively studied, and are also inaccessible, so failure in these areas was taken into account in load selection as it would be difficult to repair expeditiously

Cost Drivers from DG2 to DG3

- DG2 based on:
  - Used empirical formulae to estimate tower weighs and quantities due to lack of engineering analysis meaning incomplete tower design
  - Utilized typical Hydro transmission construction costs factored from analysis using 230 kV guyed-V tower construction during Avalon Upgrade
  - Typical 50/50 mix of materials vs construction utilized used to verify estimate

Cost Drivers from DG2 to DG3

- DG3 added:
  - More detailed tower models based on final meteorological loading and PLS CADD models meant increased weight and quantity
  - Significantly better understanding of the lack of access along some sections of the line, and the quantification of the additional road construction requirements and the likely use of heavy lift helicopters

Cost Drivers from DG2 to DG3 (cont'd)

- DG3 added (cont'd):
  - Some significant river crossings identified, requiring large bridges or ice bridges
  - New cost based on the national norms and the requirement to attract national and international contractors given project size and complexity
  - Materials vs Construction balance shifted to approximately 30/70 from historical 50/50
  - Significantly higher camp costs incorporated

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