NL WATER RESOURCES MANAGEMENT DIVISION

WSP 2023 HURRICANE SEASON FLOOD ALERT SYSTEM

END-OF-SEASON REPORT

2023-06-01 TO 2023-12-31

MAY 15, 2024

CONFIDENTIAL

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IMPORTANT NOTICE

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1 FLOOD ALERTS SUMMARY

The WSP Hurricane Season Flood Alert System (HSFAS) Product is a combination of professionally trained meteorologists applying their full knowledge of atmospheric science to Newfoundland and Labrador's weather patterns and combining these patterns with existing trends, known observations, and weather prediction models. Examining maximum precipitation predictions from many different dynamic models allows forecasters to produce a better forecast of the maximum precipitation potential based on the strength of different models in handling the atmospheric physics of differing weather patterns.

From June 2023 to December 2023, 96 alerts were issued. In the table below, only the greatest threshold is highlighted. In cases where both the 12-h and 24-h 100-year flood limits were met, the cell was only filled with the 12-h colour. No missed alerts were found.

Table 1 Summary of Flood Alerts

	Site location	Issue Date	12-hourly Precipitation Forecast (mm)	24-hourly Precipitation Forecast (mm)
1	Mary's Harbour (Mary's Harbour Airport)	06-05-2023	51.9	75.2
2	Battle Harbour (Battle Harbour Lor)	06-05-2023	57.4	79
3	Wabush (Wabush Lake Airport)	06-27-2023	53.6	78.1
4	Corner Brook	07-02-2023	47.8	65.6
5	Stephenville Crossing, Black Duck Siding	07-02-2023	72.5	117.7
6	Stephenville	07-02-2023	72.5	117.7
7	Cold Brook, Kippens (Gaudon's Brook)	07-02-2023	72.5	117.7
8	Corner Brook	07-02-2023	48.9	78
9	Deer Lake, Steady Brook	07-02-2023	57.9	84.5
10	Appleton/Glenwood	07-02-2023	55.6	91.1
11	Gander (Gander Airport CS)	07-02-2023	59.6	92.7
12	Corner Brook	07-03-2023	55.4	68.7
13	La Scie	07-03-2023	74.6	78.1
14	Channel-Port aux Basques (Port Aux Basques)	07-22-2023	100	120
15	Burgeo	07-22-2023	100	115
16	Corner Brook	08-14-2023	68.9	70.7
17	Wabush (Wabush Lake Airport)	08-24-2023	34.9	54.8
18	Corner Brook	08-28-2023	55.8	61.9
19	Burgeo	08-28-2023	128.7	183.3
20	La Scie	08-28-2023	74.8	79.7
21	Burgeo	08-28-2023	97.7	149
22	Happy Valley-Goose Bay (Goose Airport)	08-29-2023	118.1	163.1
23	Happy Valley-Goose Bay (Goose Airport)	08-29-2023	46.2	64.1
24	Trout River	08-29-2023	85.7	90.9
25	Burgeo	08-29-2023	84.1	108.7
26	St. Alban's	08-29-2023	93.5	134.7
27	Churchill Falls	09-12-2023	56.9	60.9

	Site location	Issue Date	12-hourly Precipitation Forecast (mm)	24-hourly Precipitation Forecast (mm)
28	Churchill Falls	09-12-2023	70.5	81.7
29	St. Anthony	09-15-2023	62.3	67.3
30	Deer Lake, Steady Brook	10-12-2023	42.4	78.4
31	Deer Lake, Steady Brook	10-13-2023	44.5	71.7
32	Corner Brook	10-20-2023	42.1	64.1
33	Burgeo	10-20-2023	85.1	109.8
34	Burgeo	10-21-2023	83.9	108.8
35	Deer Lake, Steady Brook	10-21-2023	49.4	74.8
36	Channel-Port aux Basques (Port Aux Basques)	11-16-2023	128.3	138.9
37	Great Codroy (Codroy Valley)	11-16-2023	98.6	105.4
38	Stephenville	11-16-2023	86.1	117
39	Cold Brook, Kippens (Gaudon's Brook)	11-16-2023	86.1	120.5
40	Stephenville Crossing, Black Duck Siding	11-16-2023	86.1	117
41	Corner Brook	11-16-2023	74.3	91.6
42	Burgeo	11-16-2023	100.5	117
43	Deer Lake, Steady Brook	11-16-2023	67.6	82.5
44	Channel-Port aux Basques (Port Aux Basques)	11-16-2023	125.1	146.5
45	Great Codroy (Codroy Valley)	11-16-2023	86.3	105.3
46	Stephenville	11-16-2023	101.4	116.1
47	Cold Brook, Kippens (Gaudon's Brook)	11-16-2023	101.4	116.1
48	Stephenville Crossing, Black Duck Siding	11-16-2023	101.4	116.1
49	Corner Brook	11-16-2023	80.1	92.4
50	Burgeo	11-16-2023	97.9	111.6
51	Channel-Port aux Basques (Port Aux Basques)	11-18-2023	91.2	93.6
52	Burgeo	11-18-2023	92	95
53	Channel-Port aux Basques (Port Aux Basques)	11-18-2023	91.7	92.3
54	Burgeo	11-18-2023	90.7	91.9
55	Churchill Falls	12-16-2023	64.5	92.5
56	Churchill Falls	12-17-2023	66.1	93.1
57	Channel-Port aux Basques (Port Aux Basques)	12-17-2023	91.7	146.1
58	Stephenville	12-17-2023	99.3	134.5
59	Cold Brook, Kippens (Gaudon's Brook)	12-17-2023	99.3	139.6
60	Stephenville Crossing, Black Duck Siding	12-17-2023	99.3	135.3
61	Corner Brook	12-17-2023	46.1	75.8
62	Burgeo	12-17-2023	100.8	136
63	Churchill Falls	12-17-2023	74.8	99.4
64	Channel-Port aux Basques (Port Aux Basques)	12-17-2023	100.2	170.2
65	Stephenville	12-17-2023	88.5	159.5
66	Cold Brook, Kippens (Gaudon's Brook)	12-17-2023	103.3	168.2

	Site location	Issue Date	12-hourly Precipitation Forecast (mm)	24-hourly Precipitation Forecast (mm)
67	Trout River	12-17-2023	63.7	102.4
68	Stephenville Crossing, Black Duck Siding	12-17-2023	103.3	162.4
69	Corner Brook	12-17-2023	57.4	71.4
70	Burgeo	12-17-2023	108.3	168.9
71	Corner Brook	12-18-2023	46.1	64
72	Burgeo	12-18-2023	89	154
73	Cold Brook, Kippens (Gaudon's Brook)	12-18-2023	66	103
74	Stephenville Crossing, Black Duck Siding	12-18-2023	77	104
75	Burgeo	12-18-2023	92	152
76	Great Codroy (Codroy Valley)	12-19-2023	66.5	120
77	Stephenville	12-19-2023	71.4	105
78	Stephenville Crossing, Black Duck Siding	12-19-2023	71.4	105
79	Corner Brook	12-19-2023	45	80
80	Channel-Port aux Basques (Port Aux Basques)	12-19-2023	80	140
81	Burgeo	12-19-2023	95	150
82	Deer Lake, Steady Brook	12-19-2023	54.2	86.5
83	Cold Brook, Kippens (Gaudon's Brook)	12-19-2023	68.8	105.6
84	Corner Brook	12-19-2023	55	90.3
85	Stephenville	12-19-2023	66.7	102.5
86	Burgeo	12-19-2023	110	165
87	Deer Lake, Steady Brook	12-19-2023	47	86
88	Channel-Port aux Basques (Port Aux Basques)	12-20-2023	91.5	117.1
89	Corner Brook	12-20-2023	60.3	89.4
90	Burgeo	12-20-2023	126.9	203.8
91	Deer Lake, Steady Brook	12-20-2023	56.3	80.6
92	Channel-Port aux Basques (Port Aux Basques)	12-20-2023	88.4	111.7
93	Corner Brook	12-20-2023	63.7	107.2
94	Burgeo	12-20-2023	132.5	204.5
95	Deer Lake, Steady Brook	12-20-2023	60.4	99.5

Legend (WRMD or EC Exceeded flood limit)

Exceeded 12-Hourly 20-yr flood limit

Exceeded 12-Hourly 100-yr flood limit

Exceeded 24-Hourly 20-yr flood limit

Exceeded 24-Hourly 100-yr flood limit

The 2023 season was more active than the 2022 season, with 95 alerts in 2023 vs 39 alerts in 2022. Most of the alerts were associated with five significant rainfall events through the season: one in July in western and central Newfoundland, one in August in western and southern Newfoundland, one in October in western and southern Newfoundland, one in November in western and southern Newfoundland, and one in December in western and southern Newfoundland and Labrador. The December forecasted rainfall event was by far the biggest

of the season, with 41 alerts issued for 10 different sites in three regions. Five sites during this event were forecasted to exceed 12-hourly 100-year flood limits, and eight sites were forecasted to exceed 24-hourly 100-year flood limits.

Table 2 Monthly Analysis of Flood Alerts

Month	Total Alerts	12-hourly 20-yr alerts	12-hourly 100-yr alerts	24-hourly 20-yr alerts	24-hourly 100-yr alerts
June	3	1	1	1	0
July	12	5	0	6	1
August	11	4	3	3	1
September	3	1	2	0	0
October	6	0	0	6	0
November	19	13	6	0	0
December	41	5	9	13	14
Total:	95	29	21	29	16

Of the 95 alerts issued, 29 were 12-hourly, 20-year alerts, 21 were 12-hourly 100-year alerts, 29 were 24-hourly 20-year alerts, and 16 were 24-hourly 100-year alerts. Most of the alerts (60) were issued in November and December.

One alert for Burgeo was confirmed by the ECCC rain gauge in December.

Table 3 Community Analysis of Flood Alerts

Community	Region	Total Number of Alerts
Churchill Falls	Labrador	5
Channel-Port-aux-Basques	Western	10
Cold Brook, Kippens (Gaudon's Brook)	Western	5
Corner Brook	Western	14
Great Codroy (Codroy Valley)	Western	3
Deer Lake, Steady Brook	Western	9
Stephenville (both sites)	Western	14
Burgeo	Southern	18

The above table highlights communities that received more than two alerts. This table is provided to help understand the potential impact at the community level.

From a regional perspective, the graph below provides a breakdown of the alerts by geography. There was a significant concentration of rainfall alerts for western Labrador, given a relatively persistent storm track and a favourable pattern for excessive rainfall. Rainfall was well below normal in northern Labrador and eastern Newfoundland. The Atlantic Hurricane Season was active in the Atlantic Basin, but its effects were much less in Newfoundland and Labrador than in the previous season. Heavy rainfall was observed in eastern Newfoundland as the remnants of Hurricane Franklin tracked by to the southeast in early September, but flooding wasn't observed, and alerts were not triggered.

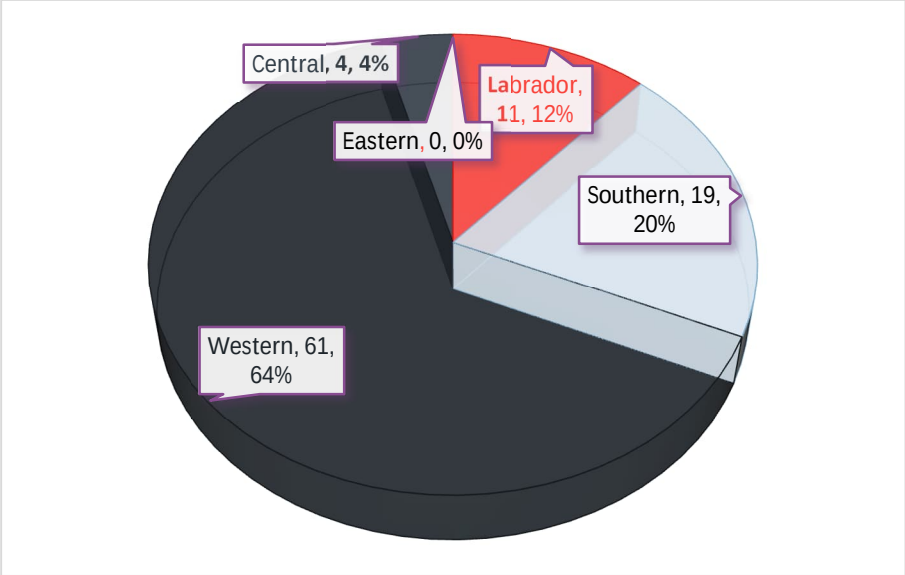

Figure 1. Alerts by Region

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2 VERIFICATION OF ALERTS

The flood alerts were verified using three data sources/methods to compare with the forecasted values. These data sources include ECCC rain gauge data, WRMD rain gauge data, and qualitative community-based reports. However, some significant challenges remain with verification. Rainfall has very high spatial variability, meaning that stations only a few kilometres apart may record vastly different values. Nearby gauge comparison is a limited verification method due to the intense variability of precipitation over the changing terrain and within small (meso-) scale atmospheric features. Specifically, we find that many of the heavy rain events forecasted in Burgeo will fall over the higher terrain north of the town, while the town reports lower totals.

Also, due to the risk involved with missed alerts, the implemented forecasting approach represents a worst-case scenario. The forecast is essentially the highest possible rainfall based on the current conditions instead of the most likely scenario rainfall. Every season, by design, there are many alerts issued that are not required. As such, any issued alert will overestimate what is observed, creating alerts that will not verify. The system was designed to avoid missing an alert, as the consequence for missed alerts is very serious for the people and resources involved.

2.1 COMMUNITY BASED FLOOD REPORTS

WSP works with Fire & Emergency Services – NL (FES-NL) whenever there are reports of flooding that may not have been forecasted. The concept was to create a qualitative field verification measurement that could further validate the statistical methods. Following a forecasted flood event, the intention was for local officials to classify the event as having no, minor, or catastrophic flooding, and these eyewitness reports would be noted on the verification. In the absence of community accounts, local newspapers and social media were scanned to verify the alerts qualitatively.

Beothuck Lake reached maximum capacity due to heavy rain in western Newfoundland from December 19th through December 21st, which closed Rushy Pond Brook Bridge on the Trans-Canada Highway.

2.2 POTENTIAL MISSED ALERTS

There was no evidence of missed alerts this season.

2.3 CLIMATE NORMALS

Airport reports of rainfall across NL were examined to determine how the 2023 HSFAS season compared to the climatological normals. The 2023 months are colour-coded in red if they were substantially above normal and blue if they were substantially below normal. Deer Lake was consistently above normal through the second half of 2023, which is consistent with the abundant alerts issued by WSP for western Newfoundland.

Table 4 Monthly Rainfall Totals (in millimetres) compared to climate normals

Location	Jun 2023	Jun Norm	Jul 2023	Jul Norm	Aug 2023	Aug Norm	Sep 2023	Sep Norm	Oct 2023	Oct Norm	Nov 2023	Nov Norm	Dec 2023	Dec Norm
St. John's*	132.7	97.5	81.6	91.6	130.8	100.0	90.5	129.6	122.2	153.7	147.2	124.8	29.4	102.9
Gander**	122.8	89.8	77.4	107.2	80.9	106.5	78.2	121.1	84.8	116.0	39.2	80.4	13.6	54.7
Deer Lake*	120.1	81.0	120.8	95.1	111.0	109.6	77.6	99.9	169.9	84.9	83.8	60.2	85.7	27.6
Goose Bay**	110.6	86.9	78.8	111.8	111.5	107.2	127.8	85.8	66.8	67.2	1.8	26.3	1.8	6.6

Notes:
*Climate normals available from 1981-2010
**Climate normals available from 1991-2020

2.4 SUMMARY

The Western Region had above-normal rainfall in 5 of the 6 months of the season, which was consistent with all the alerts issued during the season. Most of the other regions had below-normal to near-normal precipitation throughout the season.

Table 6 Forecast Regions and Rainfall Observed Compared to Normals

Month	Eastern Region	Central Region	Western Region	Southern Region	Labrador
June	Above normal	Above normal	Above normal	Near normal	Above normal
July	Below normal	Below normal	Above normal	Above normal	Near normal
August	Above normal	Below normal	Above normal	Above normal	Above normal
September	Below normal	Below normal	Below normal	Below normal	Near normal
October	Above normal	Below normal	Above normal	Above normal	Near normal
November	Above normal	Below normal	Above normal	Near normal	Below normal
December	Below normal	Near normal	Above normal	Above normal	Near normal

*Rainfall from climate sites and spatial rainfall anomaly data from the NCEP/NCAR Reanalysis were used to categorize

3 LESSONS LEARNED

The Western Region and Southern Region received the bulk of anomalous rainfall this season. As individual seasons continue to depart further from climate normals, customized alerting services such as this become more critical. Record-breaking dry or wet spells emphasize the growing importance of nowcasting and advanced weather monitoring on a very local scale.

Flooding is a complex phenomenon and can occur with amounts significantly less than the 20-year or 100-year thresholds and vice versa – no flooding may occur with amounts significantly higher than those. The HSFAS product, along with the services provided by WRMD, such as water level monitoring and reporting, are key components that work well together to help provide advance warnings to communities to better prepare for potential flooding.

Validation and incremental improvements to the HSFAS service are aided by having a network of observations. While a product such as the ECCC Canadian Precipitation Analysis (CaPA) would help, this still represents a precipitation model which could vary significantly from true observations. As we have indicated in the past, the best solution would be to fill the gaps in the available monitoring networks. Using only the ECCC and WRMD gauge data limits our ability to verify the forecasts in some areas. Many communities require additional measurements, access, and/or studies. Without adequate instrumentation for measuring precipitation, it can be almost impossible to know for certain in high terrain areas whether the forecasted precipitation was accurate. Attempts have been made to fill these gaps through community-based flood reports and the use of local media sources to try to collaborate sparse gauge data.

4 CONCLUSION

It would be beneficial to pursue additional improvements to the data sources:

1. Additional rain gauges could be installed, particularly in the regions that generated significant alerts.
2. Flood Risk Mapping Studies could be considered for the communities that triggered alerts based on Intensity-Duration-Frequency (IDF) curves.
3. Consider longer duration alerting for longer duration events (48-h and 72-h)
4. Consider adding forecaster-generated precipitation amounts in addition to the maximum probable precipitation amounts to give the users details on the most likely scenario as well as the current worst-case scenario.

5 CLOSURE

We trust that this report meets your needs. Please do not hesitate to contact the undersigned if you have any questions or comments regarding the outlook for the hurricane season.

Yours sincerely,

WSP Canada Inc.

Prepared by:

Nick Camizzi
Weather and Climate Consultant

Reviewed by:

J. Chris Innes
Discipline Lead