BRITISH COLUMBIA **ENERGY REGULATOR**

Disposal and Injection Fracture Gradient Maps & Reference Material

January 2024

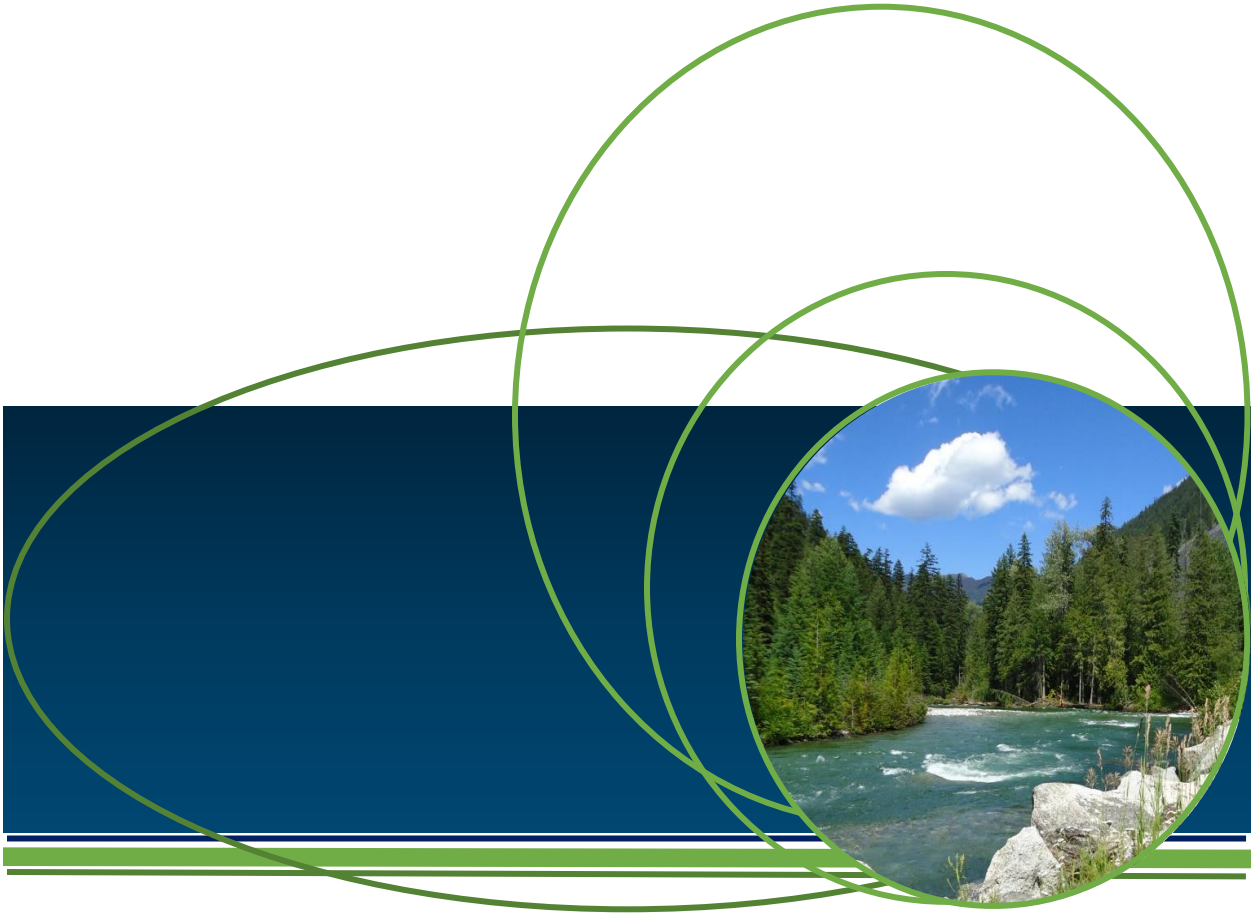

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Table of Revisions

The Regulator is committed to continuous improvement of its documentation. The table below summarizes revisions to the Fracture Gradient Maps. Revisions are posted to the documentation section of the Regulator's website at the beginning of each month and are effective one month after posting, unless otherwise noted. For more information about the Regulator's monthly revisions, and for details of this month's revisions, please visit the documentation section of the Regulator's website. Stakeholders who would like to provide input or feedback on Regulator documentation may send comments to servicedesk@bc-er.ca.

Posted Date	Chapter	Summary of Revisions (s)
September 16th, 2019	All	This document has added approved fracture gradients for disposal wells to the Fracture Gradients Maps. Contours of hydraulic fracture data points were removed.

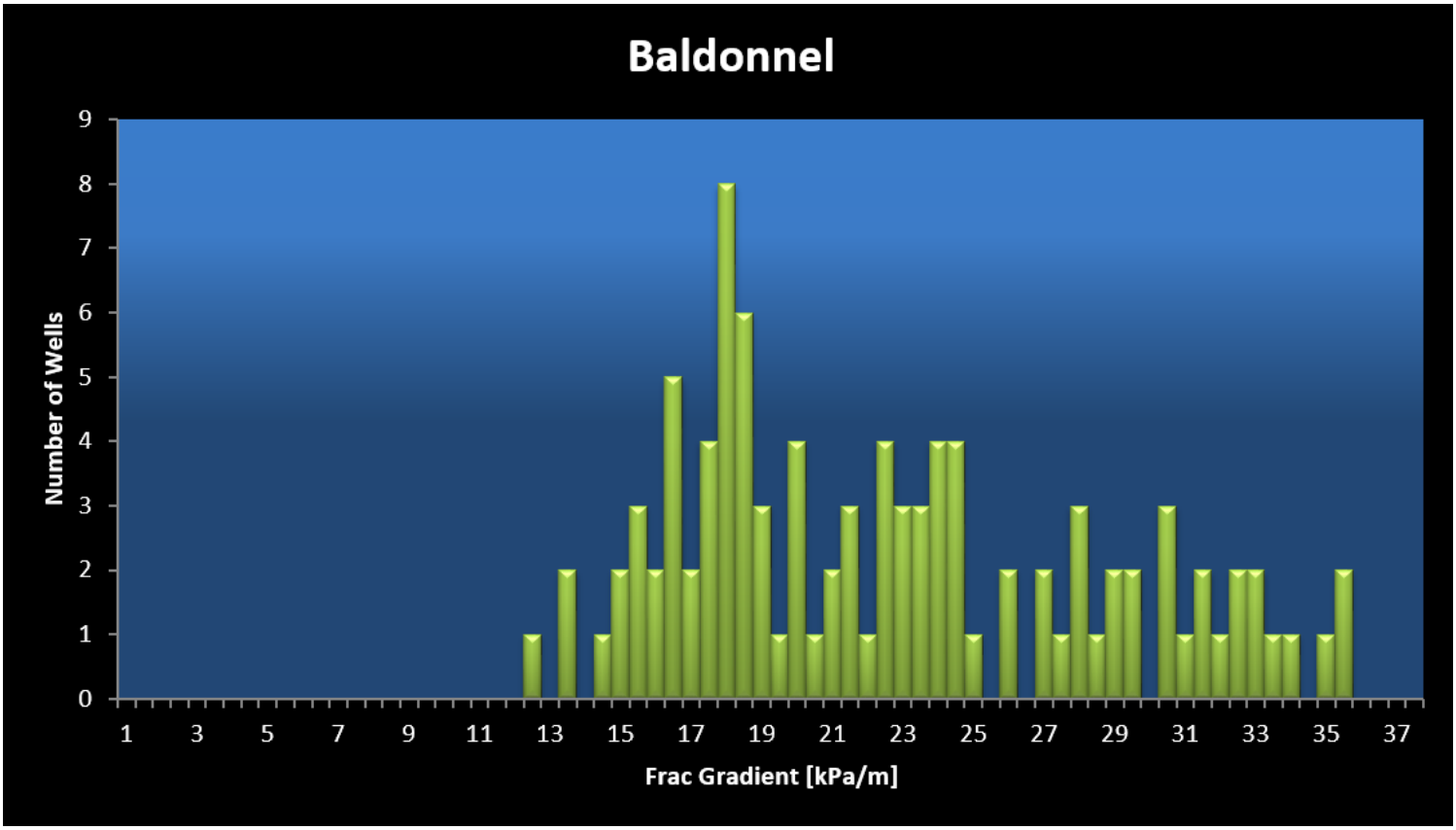
Executive Summary

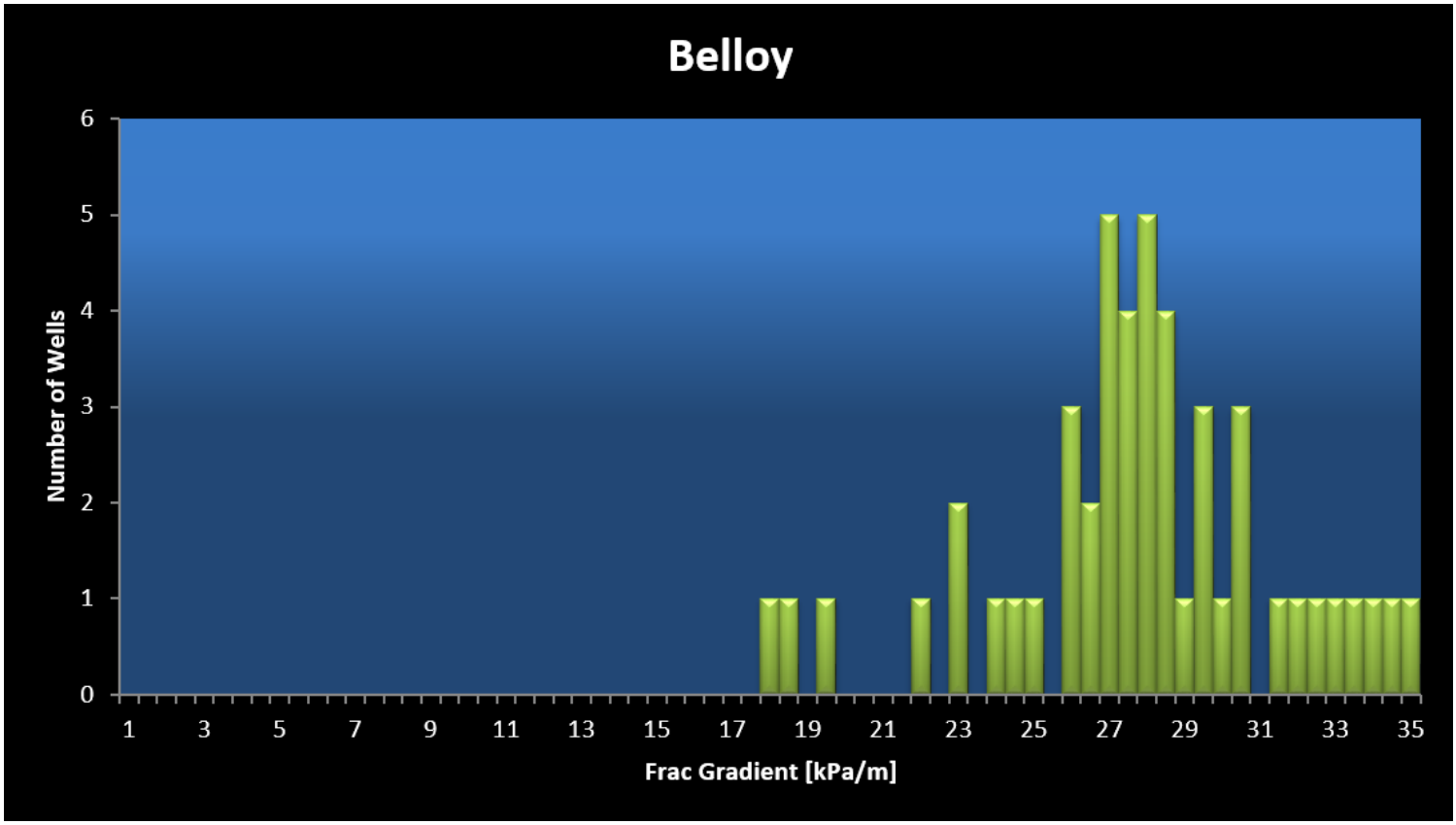
The maps in this document are intended as a reference to aid in determining the appropriate maximum wellhead injection pressures for deep disposal and injection wells. The maps include two sets of data, for seven disposal target formations: Baldonnel, Belloy, Bluesky, Cadomin-Nikanassin, Debolt, Halfway, and Paddy-Cadotte.

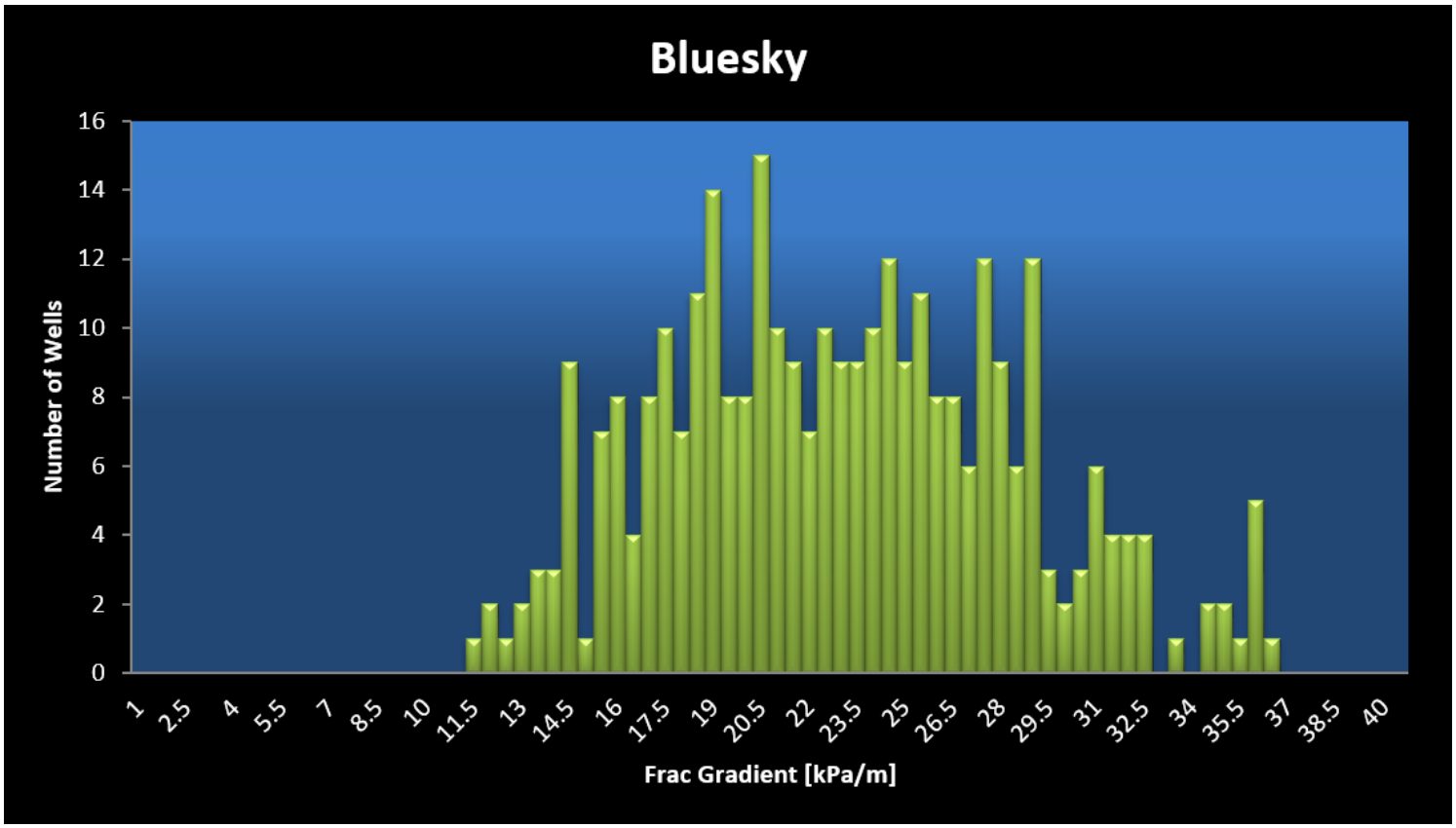
The first set, shown as red data points, were generated from ISIP values (a proxy of fracture propagation pressure) from hydraulic fracture stimulations. Maps utilizing this data were originally published by the Oil & Gas Commission in 2013. For this update, data points from subsequent hydraulic fracture stimulations have been added and previous data points included as before.

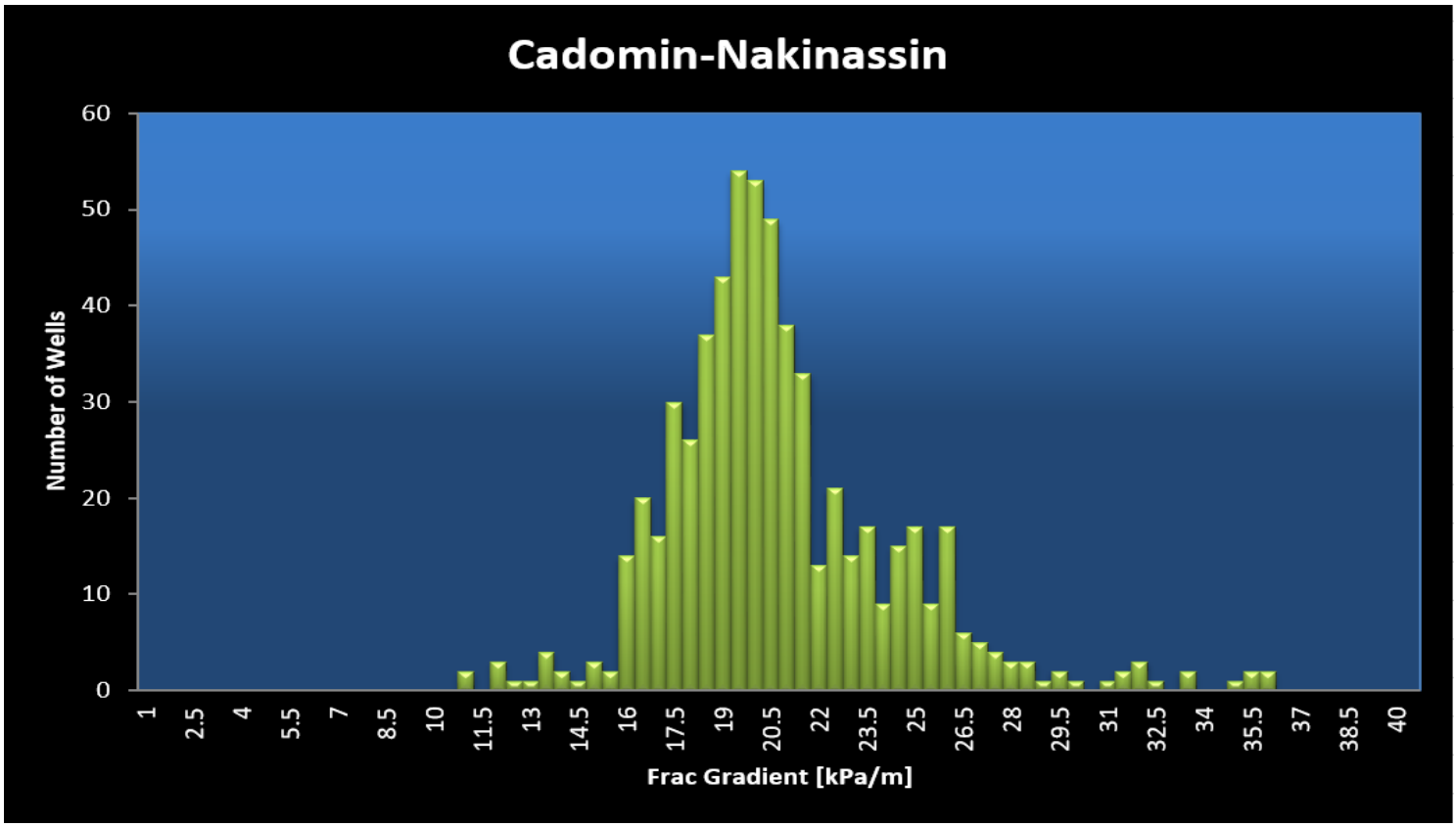
The second set of data, shown as blue points, are fracture gradients based on the approved maximum wellhead injection pressure for disposal wells. In total, 76 disposal and injection well approval applications were evaluated. These values were generally determined using ISIP and fracture propagation pressure values from DFITs and Injection Step Rate Tests on the injection or disposal well. Final approved values were determined with consideration of the quality of the tests and resulting data, results from analogous nearby injection or disposal wells, as well as mapped fracture gradient values.

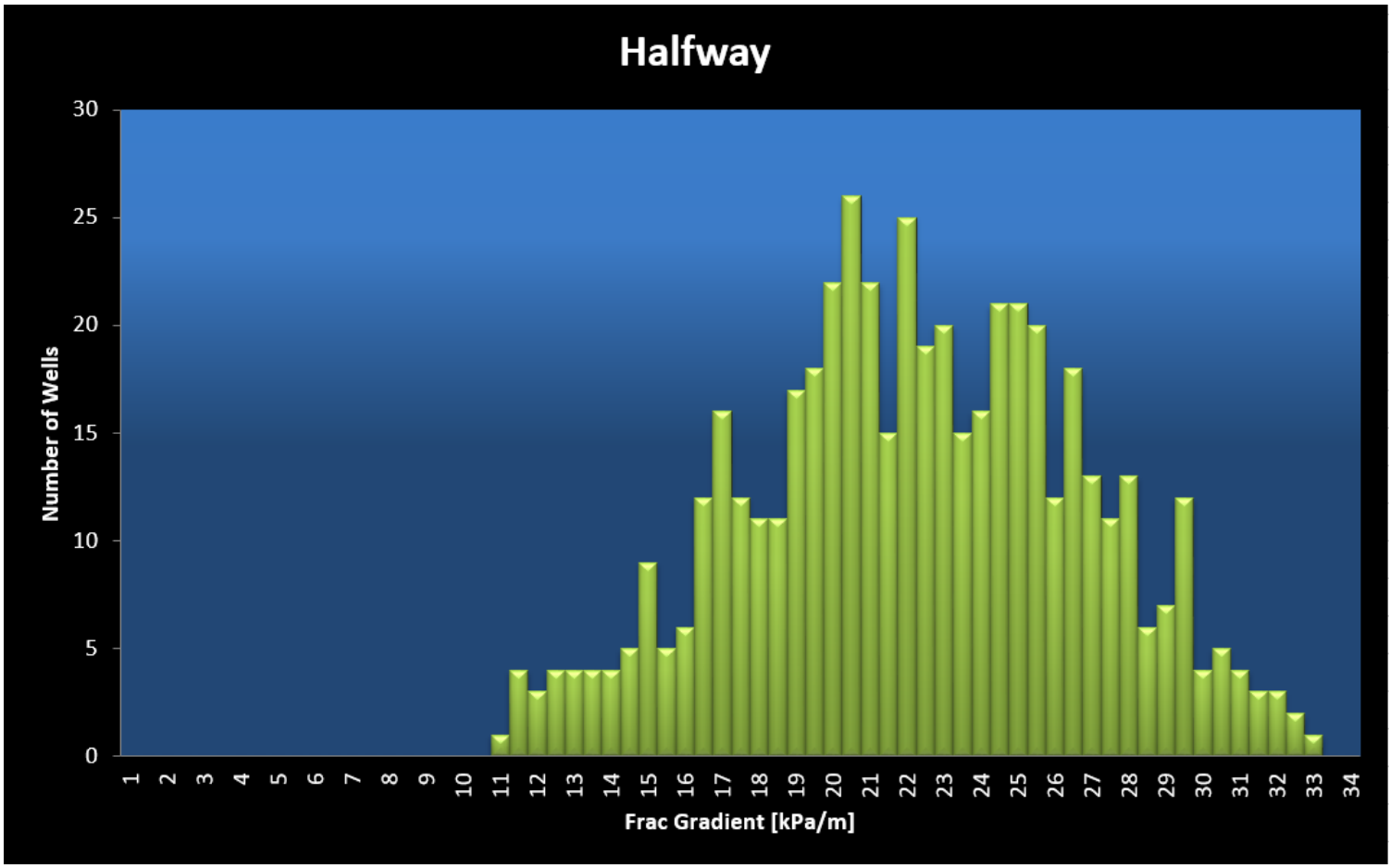
In general, a quality test with a more conservative value is given the highest weighting in determining an approved value. In some cases, the approved maximum wellhead pressure (and resulting displayed gradient) was based on the maximum value requested by the well permit holder and may be lower than the maximum value that might be normally approved. Also, lower values may reflect limits associated with surface equipment or the condition of the well.


Baldonnel
Number of Wells
0
1
2
3
4
5
6
7
8
9
1
3
5
7
9
11
13
15
17
19
21
23
25
27
29
31
33
35
37
Frac Gradient [kPa/m]


Belloy
Number of Wells
0
1
2
3
4
5
6
1
3
5
7
9
11
13
15
17
19
21
23
25
27
29
31
33
35
Frac Gradient [kPa/m]


Bluesky
Number of Wells
0
2
4
6
8
10
12
14
16
1
2.5
4
5.5
7
8.5
10
11.5
13
14.5
16
17.5
19
20.5
22
23.5
25
26.5
28
29.5
31
32.5
34
35.5
37
38.5
40
Frac Gradient [kPa/m]


Cadomin-Nakinassin
Number of Wells
0
10
20
30
40
50
60
1
2.5
4
5.5
7
8.5
10
11.5
13
14.5
16
17.5
19
20.5
22
23.5
25
26.5
28
29.5
31
32.5
34
35.5
37
38.5
40
Frac Gradient [kPa/m]


Halfway
Number of Wells
0
5
10
15
20
25
30
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34
Frac Gradient [kPa/m]

BRITISH COLUMBIA ENERGY REGULATOR

Oil and Gas Commission

Baldonnel Fracture Gradients

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By :	Date : 2019/09/06
Scale = 1:231500	Project : SRT and DFIT Frac Grad

Kilometres 0 5 10 15

Miles 0 5 10

Datum: NAD 83 Spheroid: GRS 80
Projection: 6 degrees TM (Transverse Mercator)

Legend

Approved Fracture Gradient from Disposal Wells (kPa/m)	Fracture Gradient from Hydraulic Fracture Stimulation (kPa/m)
20.0	20.0

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Oil and Gas Commission

Belloy Fracture Gradients

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By :	Date : 2019/09/10
Scale = 1:125000	Project : SRT and DFIT Frac Grad

geoSCOUT
www.geologic.com

Kilometres
0 1 2 3 4 5 6
Miles
0 1 2 3 4

Datum: NAD 83 Spheroid: GRS 80
Projection: 6 degrees TM (Transverse Mercator)

94-H-4 94-H-3 94-H-2 94-H-1

94-A-13 94-A-16

94-A-9

T88 T87 T86 T85 T84 T83 T82 T81 T80 T79

R24 R23 R22 R21 R20 R19 R18 R17 R16 R15 R14 R13W6

19.1 26.6 19.2 27.7 28.3 24.8 29.2 26.4 30.4 27.2 25.7 27.9 26.6 28.1 27.1 26.7 28.6 26.6 27.2 27.9 29.6 30.1 34.5 33.3 30.0 26.9 31.7 33.6 25.9 27.7 26.0 32.7 29.4 29.3 24.3 22.7 23.9 24.2 18.1 28.5 27.2 22.8 26.3 20.6 19.1 20.5

Legend

Approved Fracture Gradient from Disposal Wells (kPa/m)	Fracture Gradient from Hydraulic Fracture Stimulation (kPa/m)
20.0	20.0

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Bluesky Fracture Gradients

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geoSCOUT www.geologic.com	By :	Date : 2019/09/10
	Scale = 1:389500	Project : SRT and DFIT Frac Grad

Kilometres
0 10 20 30
0 10 20
Miles

Datum: NAD 83 Spheroid: GRS 80
Projection: 6 degrees TM (Transverse Mercator)

Legend

Approved Fracture Gradient from Disposal Wells (kPa/m)	Fracture Gradient from Hydraulic Fracture Stimulation (kPa/m)
20.0	20.0

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94-G-7 94-G-8 94-H-5 94-H-6 94-H-7 94-H-8 R13W6

94-G-7 94-G-2 94-B-15 94-B-10 94-B-7 94-B-2 93-O-15 93-O-10 93-O-7 93-O-2

94-H-8 94-H-1 94-A-16 T88 T87 T86 T85 T84 T83 T82 T81 T80 T79 T78 T77 93-P-9 93-P-8 93-P-1

Oil and Gas Commission

Cadomin-Nikinassin Fracture Gradients

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geoSCOUT www.geologic.com

By :	Date : 2019/09/10
Scale = 1:224500	Project : SRT and DFIT Frac Grad

Kilometres 0 5 10 15

0 5 10 Miles

Datum: NAD 83 Spheroid: GRS 80
Projection: 6 degrees TM (Transverse Mercator)

Legend

Approved Fracture Gradient from Disposal Wells (kPa/m)	Fracture Gradient from Hydraulic Fracture Stimulation (kPa/m)
20.0	20.0

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93-O-2 93-O-1 93-P-4 93-P-3 93-P-2 93-P-1 R13W6

Oil and Gas Commission

Debolt Fracture Gradients

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geoSCOUT www.geologic.com	By :	Date : 2019/09/06
	Scale = 1:362000	Project : SRT and DFIT Frac Grad

Kilometres
0 5 10 15
0 5 10
Miles
Datum: NAD 83 Spheroid: GRS 80
Projection: 6 degrees TM (Transverse Mercator)

94-O-13 94-O-14 94-O-15 94-O-16 94-P-13 94-P-14 94-P-15 94-P-16

94-O-12 94-O-5 94-O-4 94-J-13 94-J-12 94-J-5 94-J-4 94-G-13 94-G-12 94-G-5 94-G-4 94-B-13 94-B-12 94-B-5 94-B-4

94-P-9 94-P-8 94-P-1 94-I-16 94-I-9 94-I-8 94-I-1 94-H-16 94-H-9 94-H-8 94-H-1 94-A-16

22.8 20.5 25.9 25.3 18.0 22.6 22.5 20.7 21.3 20.0 21.0 27.5 19.1 16.9

T88 T87 T86 T85 T84 T83 T82

94-B-4 94-B-3 94-B-2 94-B-1 R26 R25 R24 R23 R22 R21 R20 R19 R18 R17 R16W6

Legend

Approved Fracture Gradient from Disposal Wells (kPa/m)	Fracture Gradient from Hydraulic Fracture Stimulation (kPa/m)
20.0	20.0

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Halfway Fracture Gradients

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geoSCOUT www.geologic.com	By :	Date : 2019/09/10
	Scale = 1:227500	Project : SRT and DFIT Frac Grad

Kilometres
0 5 10 15
0 5 10
Miles
Datum: NAD 83 Spheroid: GRS 80
Projection: 6 degrees TM (Transverse Mercator)

Legend

Approved Fracture Gradient from Disposal Wells (kPa/m)	Fracture Gradient from Hydraulic Fracture Stimulation (kPa/m)
20.0	20.0

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94-G-14 94-G-15 94-G-16 94-H-13 94-H-14 94-H-15 94-H-16 R13W6
94-G-11 94-H-9
94-G-6 94-H-8
94-G-3 94-H-1
94-B-14 94-A-16
94-B-11 T88
T87
94-B-6 T86
T85
T84
94-B-3 T83
T82
T81
T80
93-O-14 T79
T78
93-O-11 T77
93-P-9
93-O-6 93-P-8
93-O-6 93-O-7 93-O-8 93-P-5 93-P-6 93-P-7 93-P-8 R13W6

R21 R20 R19 R18 R17 R16 R15 R14 R13W6

T80 T79 T78 T77

93-P-11 93-P-9 93-P-6 93-P-8

93-P-6 93-P-7 93-P-8 R13W6

Oil and Gas Commission

Paddy-Cadotte Fracture Gradients

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geoSCOUT www.geologic.com

By :	Date : 2019/09/10
Scale = 1:132500	Project : SRT and DFIT Frac Grad

28.0 27.7 28.0 28.0 28.0 28.4 28.4 22.2 25.0

27.8 27.0 28.0

A B C D E F G H

Legend

Approved Fracture Gradient from Disposal Wells (kPa/m)	Fracture Gradient from Hydraulic Fracture Stimulation (kPa/m)
20.0	20.0

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Kilometres
0 1 2 3 4 5 6
0 1 2 3 4
Miles

Datum: NAD 83 Spheroid: GRS 80
Projection: 6 degrees TM (Transverse Mercator)

93-P

end

Calculating Maximum Wellhead Injection Pressure

$$P_{Wellhead} = P_{(ISIP\ or\ FPP)} \times 0.9 - P_{hyd} + P_{friction}$$