

*Updated*  
*FS2020 Dual Mode*  
*Performance Evaluation*

Version 0.2

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*Pacific States Marine Fisheries Commission*

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PIT Tag Information System  
Columbia Basin | [ptagis.org](http://ptagis.org)

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## 1. INTRODUCTION

### 1.1 *Background*

Since the recent introduction of the FS2020 transceiver, there have been queries from the fisheries community as to whether this transceiver will work with an orifice or slot antenna in dual mode (FDXB and HDX) operation. The current installed base of transceivers only supports FDX decoding. HDX decoding would be beneficial to allow for the interrogation of Lamprey, which are currently being tagged with HDX tags.

Although the FS2020 transceiver does add the capability of reading HDX tags, there is a potential for performance degradation reading FDXB tags. This is due to the requirement of HDX tags having a cycle time of energizing the tag of 50 msec and de-energizing/reading of 20 msec. This gives a total cycle time of 70 msec. The FDXB tag continuously sends out a tag telegram every 30.5 msec while it is energized. However, due to the HDX operational mode, this is now limited to every 70 msec. Because of this, factors such as antenna read range, fish speed, and external noise sources will have a greater negative impact on tag readability.

To test the possible performance degradation in HDX operational mode, PSMFC has performed lab testing in its Kennewick office to simulate reading tags at different speeds and read ranges.

### 1.2 *Document Revision 9/14/2018*

Since the original publishing of this document, field testing of dual mode operation has been performed. Sites tested and reading efficiency results have been added in section 3.3.

### 1.3 *Purpose of Document*

To determine the theoretical impact on FDXB tag detection when running the FS2020 in dual detection mode.

## 1.4 ***Acronyms***

This section provides the acronyms used in the document.

### 1.4.1 **Acronyms**

- |          |  |
|----------|--|
| 1) A     | Amps   |
| 2) FDXB  | Full Duplex B                                  |
| 3) Ft    | Feet   |
| 4) HDX   | Half Duplex                                    |
| 5) Msec  | Milliseconds                                   |
| 6) Mv    | Millivolts                                     |
| 7) P-P   | Peak to peak                                   |
| 8) PSMFC | Pacific States Marine and Fisheries Commission |
| 9) RF    | Radio Frequency                                |
| 10) Sec  | Second   |

## 2. **TEST SETUP**

A FS2020 transceiver was connected to a shielded 24" orifice antenna. This antenna is in an RF shielded room to eliminate external RF noise sources which could skew the results. A belt driven by a PLC controlled variable speed motor runs through the center of the antenna. A TX1400BE, TX1400SST, TX1408, and HDX tags are placed on the belt with sufficient spacing to ensure that no 2 tags are in the antenna activation field at the same time. A laptop computer running Minimon is connected to the transceiver to monitor the tag reading.

### 2.1 ***Test Protocol***

Baseline 100% read efficiency read ranges were taken for each tag. Transceiver current and noise floor measurements were taken before testing.

The belt was run for 100 loops at speeds of 10, 12, 14, 16, 18, and 20 ft/sec. Data was taken for the number of reads per tag and the number of unique reads per tag. This test was run in HDX/FDXB operational mode and FDXB only operational mode.

## 2.1.1 Belt Test Results

FS2020  
Exciter current: 1.9A P-P      Signal level : 80mV  
24" orifice with shield

	TX1408	HDX	TX1400SST-1	TX1400BE
Read Range	20"	42"	44"	28"

## Unique Reads per 100 loops

Speed (ft/sec)	TX1408	HDX	TX1400SST-1	TX1400BE
10	100	100	100	100
12	100	100	100	100
14	100	100	100	100
16	100	100	100	100
18	100	100	100	100
20	97	100	100	100

## Unique Reads per 100 loops HDX Off

Speed (ft/sec)	TX1408	HDX	TX1400SST-1	TX1400BE
10	100	100	100	100
12	100	100	100	100
14	100	100	100	100
16	100	100	100	100
18	100	100	100	100
20	100	100	100	100

## Reads per pass - 100 loops HDX on - Unique off

Speed (ft/sec)	TX1408	HDX	TX1400SST-1	TX1400BE
10	2.10	6.50	4.60	3.02
12	1.93	5.54	4.13	2.75
14	1.57	4.73	3.47	2.25
16	1.34	3.96	2.98	1.91
18	1.14	3.47	2.60	1.70
20	1.08	3.20	2.47	1.63

## Reads per pass - 100 loops HDX off - Unique off

Speed (ft/sec)	TX1408	HDX	TX1400SST-1	TX1400BE
10	5.50	Na	11.39	7.30
12	4.48	Na	9.23	5.89
14	3.74	Na	8.07	5.25
16	3.07	Na	6.98	4.86
18	2.52	Na	6.13	4.35
20	2.23	Na	5.68	3.90

### 2.1.2 Belt Test Observations

From the data, it is apparent that the number of reads per tag is substantially less when the transceiver is run in FDXB/HDX mode. The unique tag readability was not impacted with the exception of the TX1408 tag at 20 ft/sec. However, this antenna/transceiver combination has a substantially greater read distance than the typical current installed base of systems in the field. This may be due to the FS2020 transceiver having better performance, the antenna not being representative of the current installed systems, or because it is not being tested in water. From lab testing, we do know that the FS2020 transceiver has better read distance than the current FS1001A and FS1001B transceivers. We do not know the performance increase when attached to currently installed antennas in the field. Therefore, in order to get a better simulation against the current installed base, the antenna current was turned down to decrease the read range. Because of the obvious reduction of read range, the test was only run at 10 ft/sec. The following tests show that with the reduced read range, the TX1400SST and HDX tags still have a 100% read performance. The TX1408 and TX1400BE tags take a significant performance hit.

### 2.1.3 Reduced Read Range Belt Test

Exciter current: 1.2A P-P HDX On				
	TX1408	HDX	TX1400SST-1	TX1400BE
Read Range	6"	38"	32"	16"
Unique reads per 100 loops 10 ft/sec HDX on				
TX1408	HDX	TX1400SST-1	TX1400BE	
2	100	100	82	

Exciter current: 0.66A P-P				
	TX1408	HDX	TX1400SST-1	TX1400BE
Read Range	NR	26"	24"	9"
Unique reads per 100 loops 10 ft/sec HDX on				
TX1408	HDX	TX1400SST-1	TX1400BE	
0	100	100	4	

### 2.1.4 Belt Test Summary

HDX mode does affect the number of reads per tag.

Actual performance will be unknown until field trials are performed.

TX1408 and TX1400BE tags will have a greater negative impact.

Other factors such as tag orientation, fish speed, and external noise sources will also have an impact on the reading efficiency.

Other antenna configurations such as the 18" orifice and the slot antennas have less read range than the 24" antenna used for lab testing. Therefore, the read efficiency on those antennas would be at a lesser value. Without testing, the performance on those antennas is unknown.

## 3. PERFORMANCE ESTIMATES

With the new PTAGIS database, it was possible to pull reads per tag information from multiple sites. With this information it is possible to estimate the performance impact of running the FS2020 in dual mode.

From past testing and theoretical reading speed of a FDXB tag when running the FS2020 in dual detection mode, it is known that tags that are only read once or twice in FDXB only detection mode will not be read in dual detection mode.

Reports were generated from the sites TD1, TD2, MC1, and MC2 to show a histogram of the reads per tag for each transceiver.

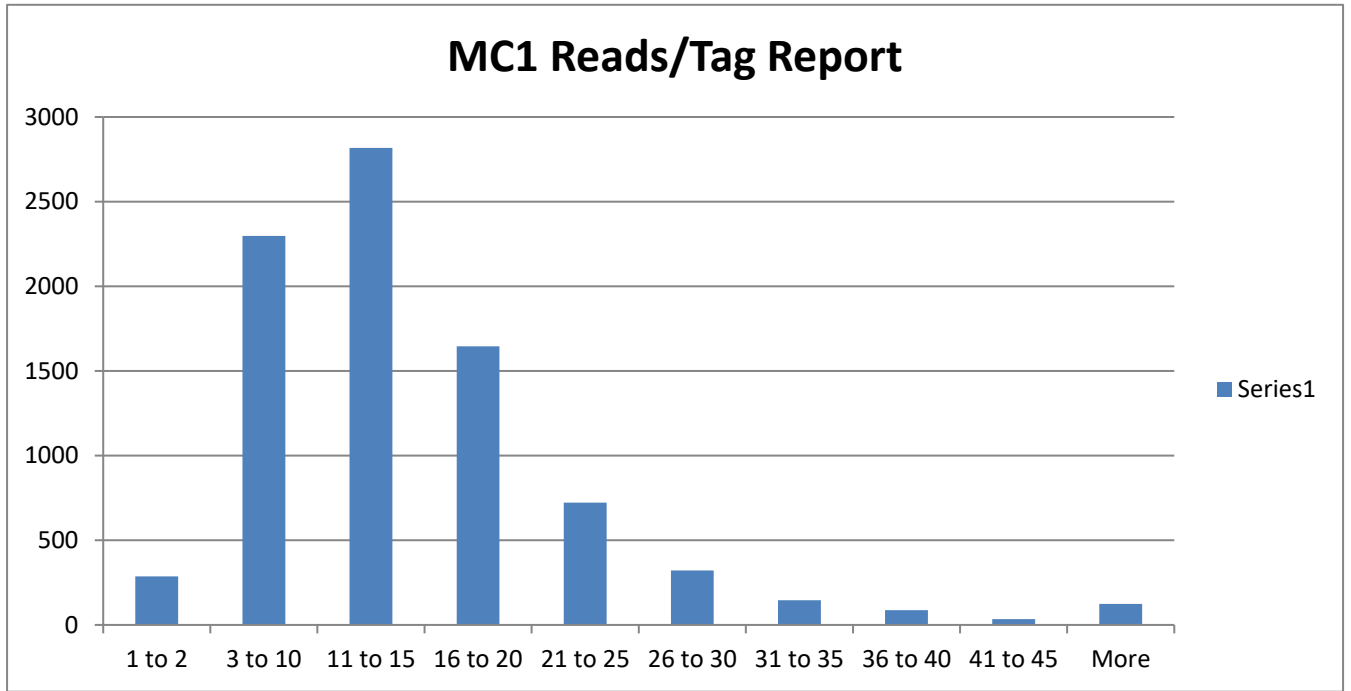
### 3.1 *Site Data*

The following is the data with graphs for the sites TD1, TD2, MC1, and MC2. Graphs and data are shown for each antenna.

FS2020 transceivers were installed at MC1 and MC2 on 9/11/2013. Therefore, data for those sites was taken from that day until 11/25/2013 when the report was run.



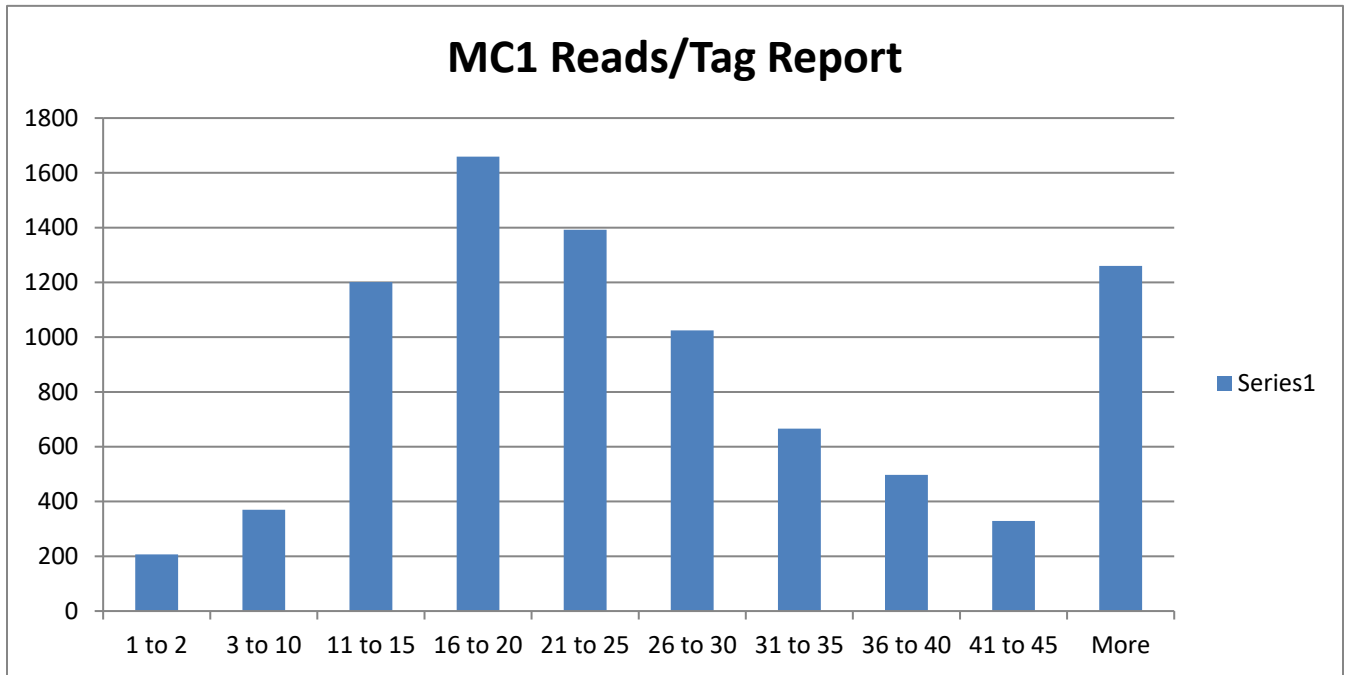
3.1.1 MC1 Antenna 01



Bin Val	Reads/tag	Tag count	Percent
2	1 to 2	287	3.4
10	3 to 10	2298	27.1
15	11 to 15	2817	33.2
20	16 to 20	1646	19.4
25	21 to 25	722	8.5
30	26 to 30	322	3.8
35	31 to 35	146	1.7
40	36 to 40	87	1.0
45	41 to 45	34	0.4
	More	124	1.5
	<b>Total</b>	<b>8483</b>	

**Antenna 01**  
**9/11/2013 through 12/13/2013**

3.1.2 MC1 Antenna 02

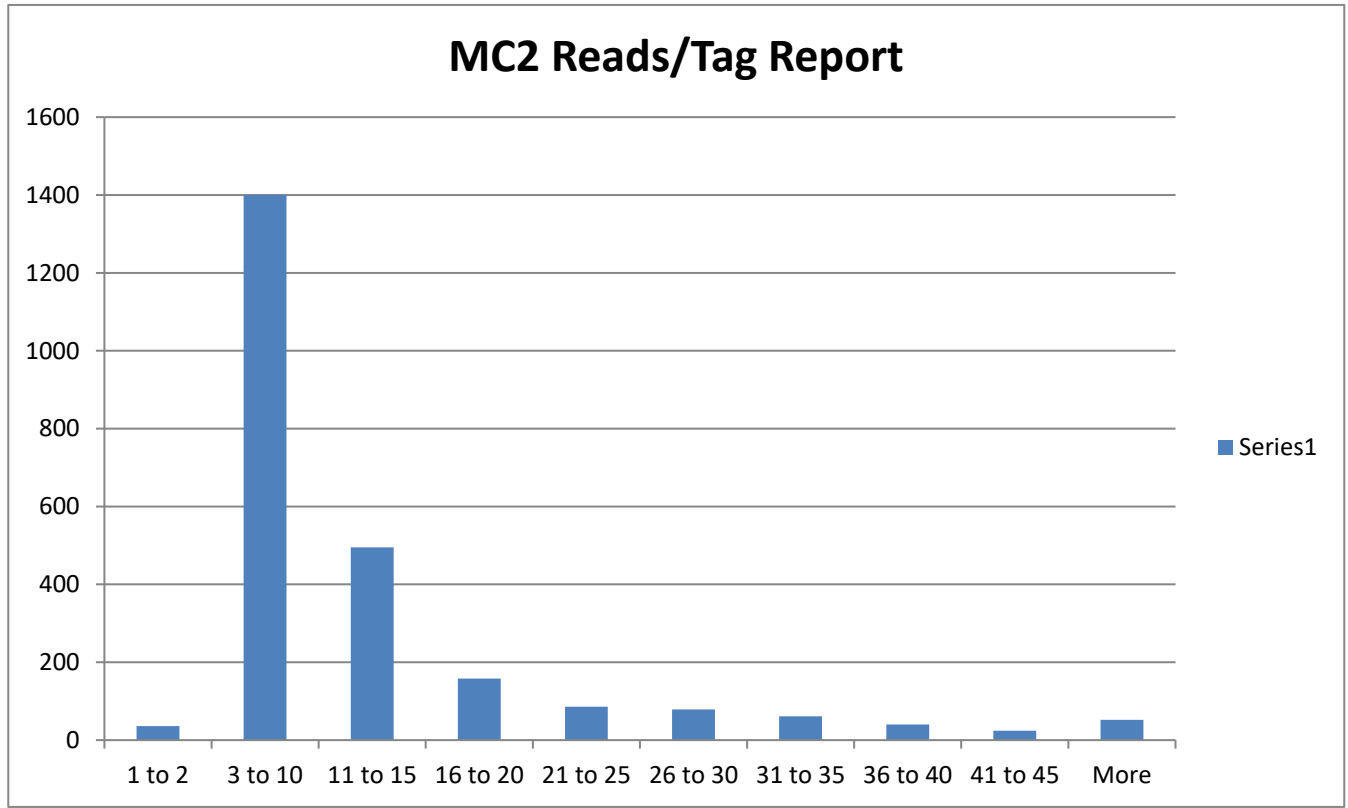


Bin Val	Reads/tag	Tag count	Percent
2	1 to 2	207	2.4
10	3 to 10	370	4.3
15	11 to 15	1201	14.0
20	16 to 20	1659	19.3
25	21 to 25	1392	16.2
30	26 to 30	1025	11.9
35	31 to 35	666	7.7
40	36 to 40	497	5.8
45	41 to 45	329	3.8
	More	1260	14.6
	<b>Total</b>	8606	

**Antenna 02**

9/11/2013 through 12/13/2013

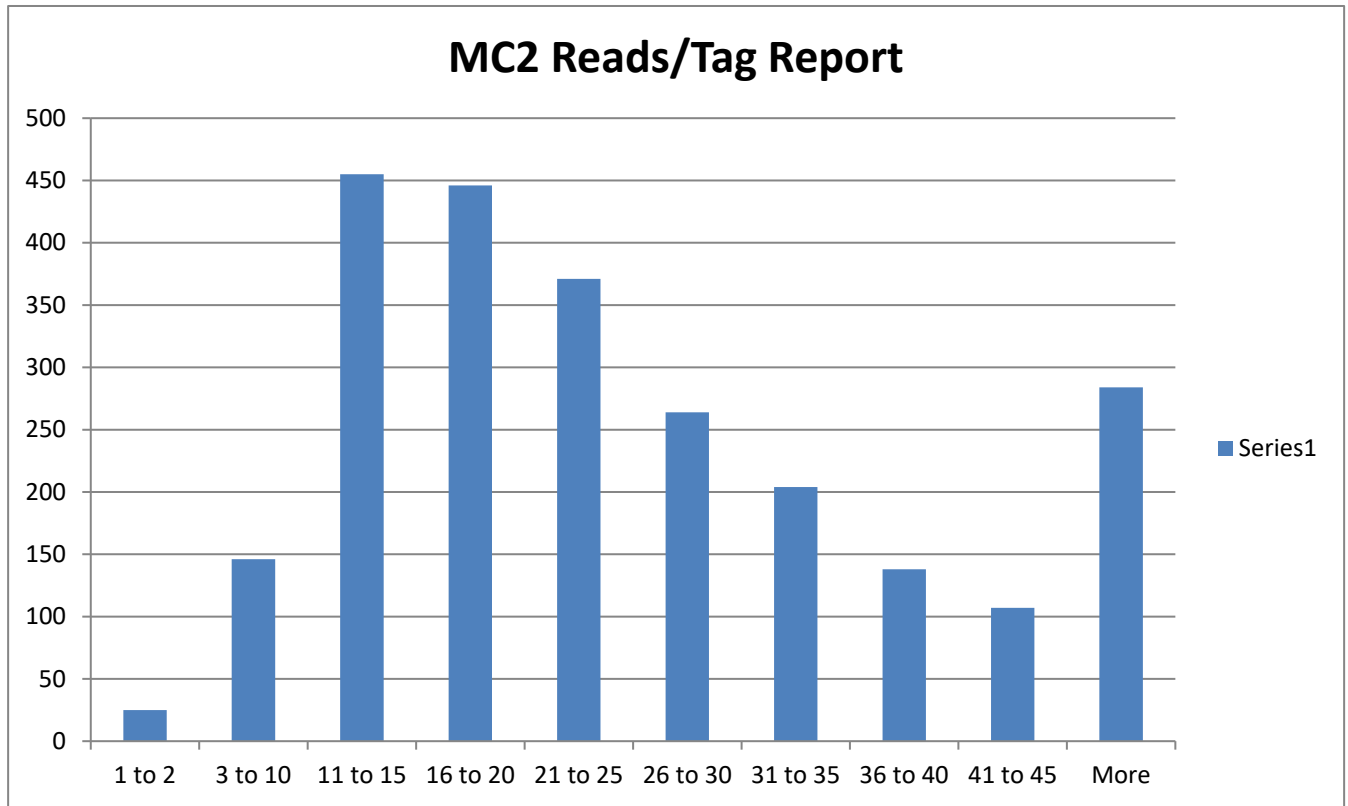
3.1.3 MC2 Antenna 01



Bin Val	Reads/tag	Tag Count	Percent
2	1 to 2	36	1.5
10	3 to 10	1400	57.6
15	11 to 15	495	20.4
20	16 to 20	158	6.5
25	21 to 25	86	3.5
30	26 to 30	79	3.2
35	31 to 35	61	2.5
40	36 to 40	40	1.6
45	41 to 45	24	1.0
	More	52	2.1
<b>Total</b>		<b>2431</b>	

Antenna 01  
 9/11/2013 through  
 12/13/2013

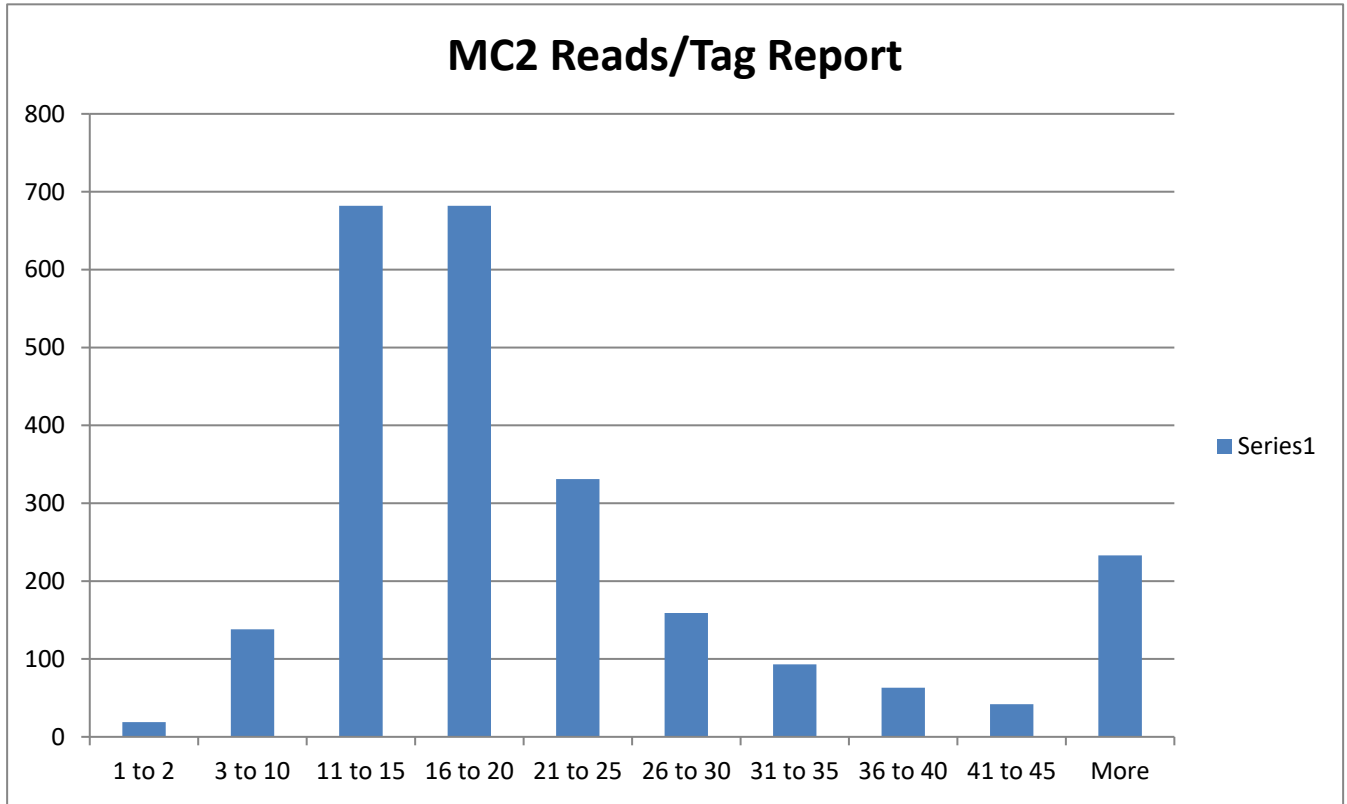
3.1.4 MC2 Antenna 02



Bin Val	Reads/tag	Tag Count	Percent
2	1 to 2	25	1.0
10	3 to 10	146	6.0
15	11 to 15	455	18.6
20	16 to 20	446	18.3
25	21 to 25	371	15.2
30	26 to 30	264	10.8
35	31 to 35	204	8.4
40	36 to 40	138	5.7
45	41 to 45	107	4.4
	More	284	11.6
	<b>Total</b>	<b>2440</b>	

Antenna 02  
 9/11/2013 through  
 12/13/2013

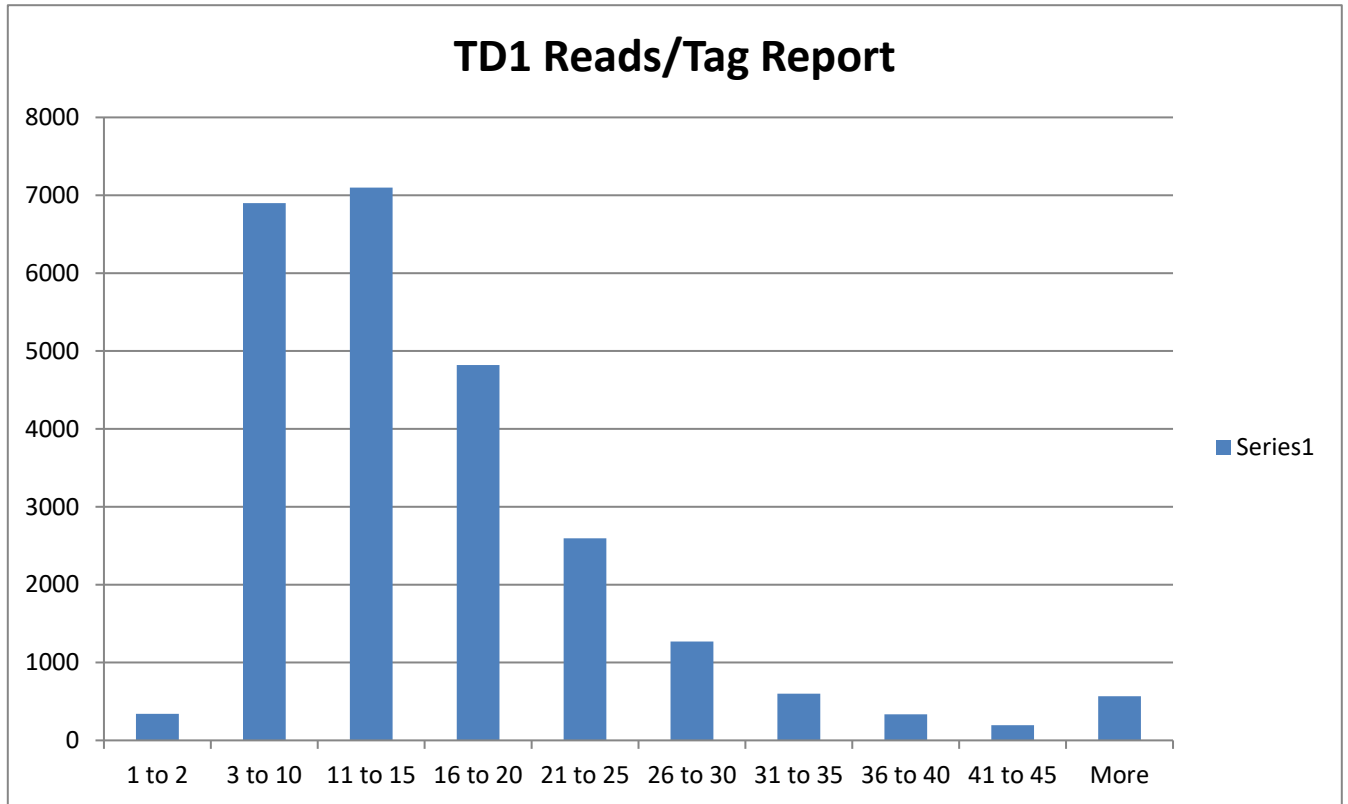
3.1.5 MC2 Antenna 03



Bin Val	Reads/tag	Tag Count	Percent
2	1 to 2	19	0.8
10	3 to 10	138	5.7
15	11 to 15	682	27.9
20	16 to 20	682	27.9
25	21 to 25	331	13.6
30	26 to 30	159	6.5
35	31 to 35	93	3.8
40	36 to 40	63	2.6
45	41 to 45	42	1.7
	More	233	9.5
	<b>Total</b>	<b>2442</b>	

Antenna 03  
 9/11/2013 through  
 12/13/2013

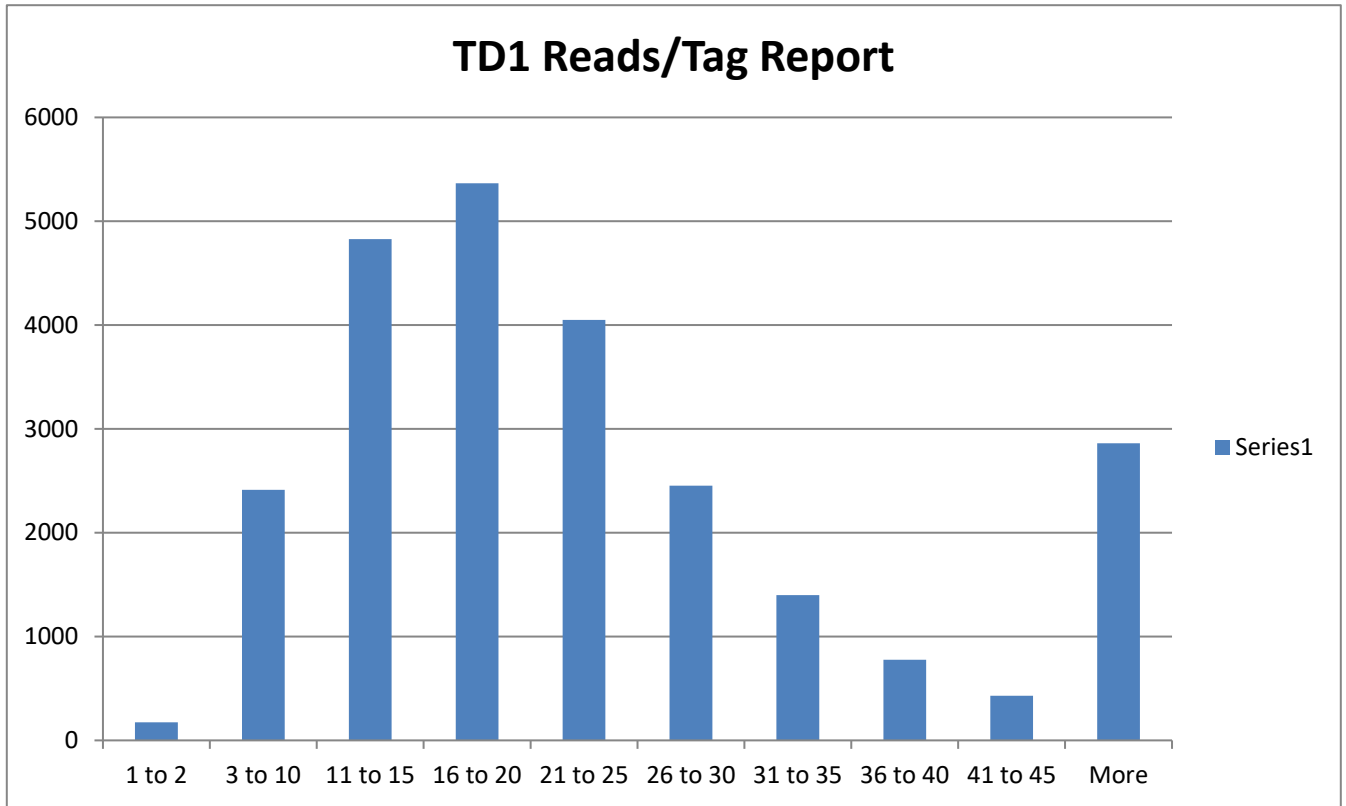
3.1.6 TD1 Antenna 01



Bin Val	Reads/tag	Tag count	Percent
2	1 to 2	340	1.4
10	3 to 10	6899	27.9
15	11 to 15	7099	28.7
20	16 to 20	4820	19.5
25	21 to 25	2594	10.5
30	26 to 30	1269	5.1
35	31 to 35	600	2.4
40	36 to 40	334	1.4
45	41 to 45	196	0.8
	More	566	2.3
	<b>Total</b>	<b>24717</b>	

**Antenna 01**  
 YTD  
 as of 11/25/2013

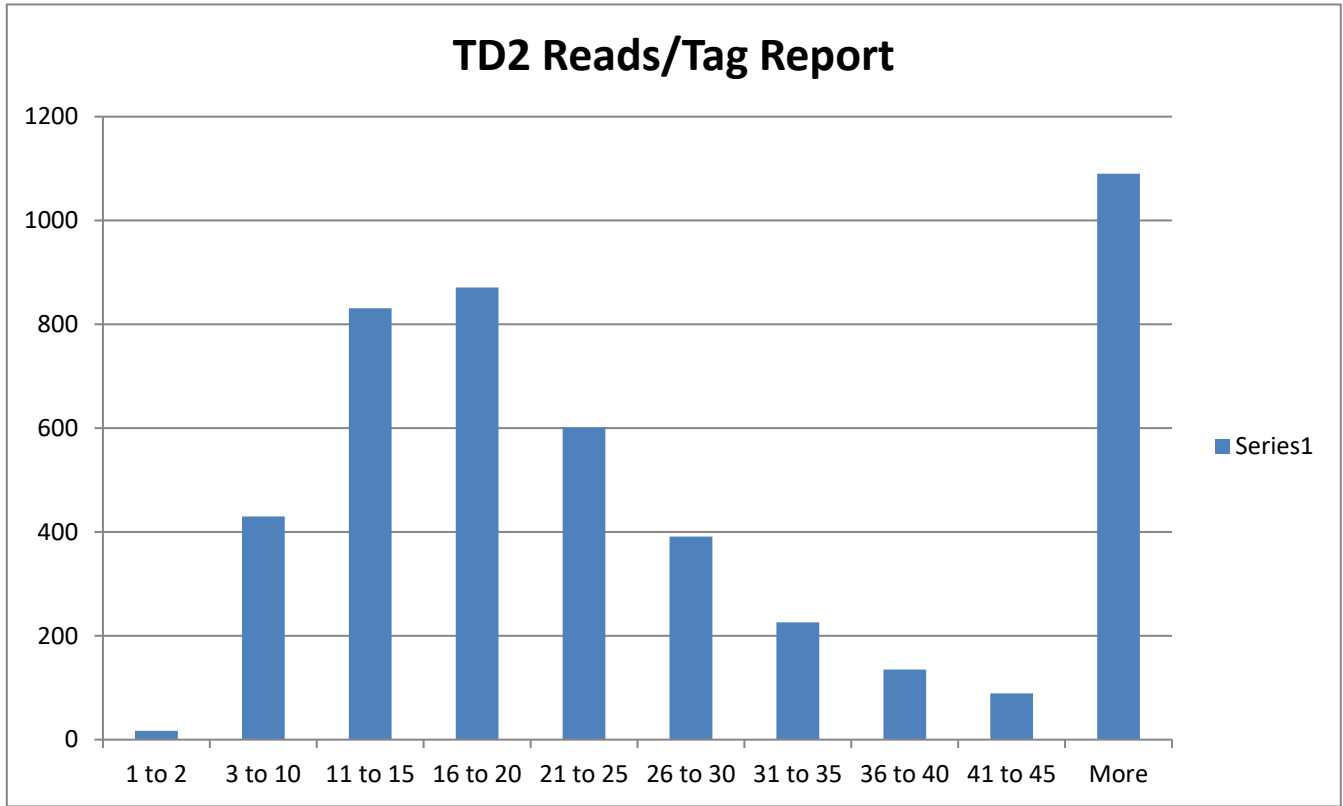
3.1.7 TD1 Antenna 02



Bin Val	Reads/tag	Tag count	Percent
2	1 to 2	174	0.7
10	3 to 10	2413	9.8
15	11 to 15	4827	19.5
20	16 to 20	5365	21.7
25	21 to 25	4049	16.4
30	26 to 30	2453	9.9
35	31 to 35	1399	5.7
40	36 to 40	777	3.1
45	41 to 45	430	1.7
	More	2861	11.6
	<b>Total</b>	24748	

**Antenna 02**  
 YTD  
 as of 11/25/2013

3.1.8 TD2 Antenna 01

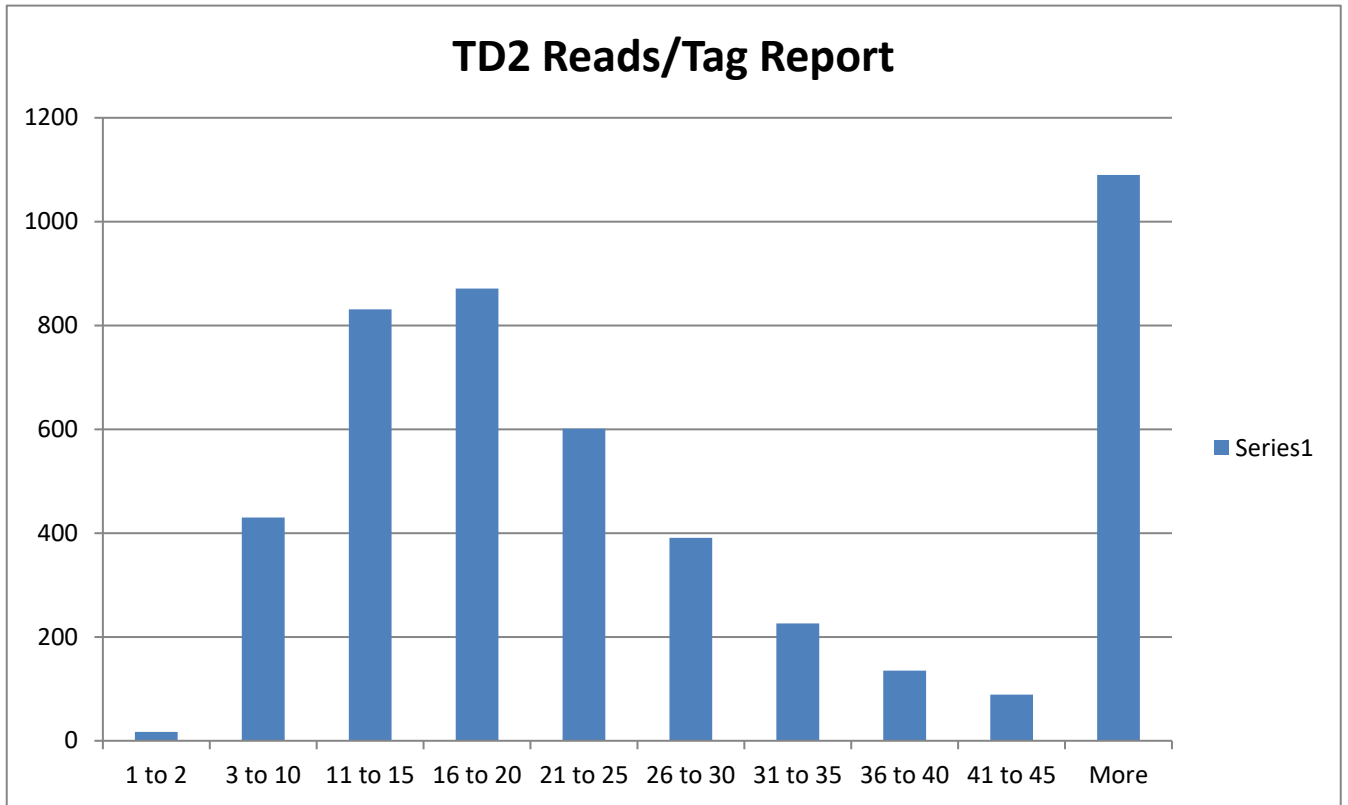


Bin Val	Reads/tag	Tag count	Percent
2	1 to 2	78	1.7
10	3 to 10	965	20.7
15	11 to 15	901	19.3
20	16 to 20	856	18.4
25	21 to 25	678	14.5
30	26 to 30	464	10.0
35	31 to 35	299	6.4
40	36 to 40	160	3.4
45	41 to 45	95	2.0
	More	165	3.5
	<b>Total</b>	4661	

**Antenna 01**  
 YTD  
 as of 11/25/2013



3.1.9 TD2 Antenna 02



Bin Val	Reads/tag	Tag count	Percent
2	1 to 2	17	0.4
10	3 to 10	430	9.2
15	11 to 15	831	17.8
20	16 to 20	871	18.6
25	21 to 25	601	12.8
30	26 to 30	391	8.4
35	31 to 35	226	4.8
40	36 to 40	135	2.9
45	41 to 45	89	1.9
	More	1090	23.3
	<b>Total</b>	<b>4681</b>	

**Antenna 02**  
 YTD  
 as of 11/25/2013

### 3.2 **Summary Detection Loss**

The following is a chart of the percentages of fish that are currently read once or twice for the viewing window antenna at each site for the year 2013.

Less than 3 reads/tag				
Site	Antenna	Total Fish	tags < 3 reads	Percent
MC1	01	8483	287	3.4
MC1	02	8606	207	2.4
MC2	01	2431	36	1.5
MC2	02	2440	25	1
MC2	03	2442	19	0.8
TD1	01	24717	340	1.4
TD1	02	24748	174	0.7
TD2	01	4661	78	1.7
TD2	02	4681	17	0.4

The percent shown would be an estimated loss in detection efficiency per antenna if the FS2020 transceiver is put in dual detection mode.

### 3.3 **Field Testing**

On 8/29/2017 Dual mode was enabled at TD1 and TD2 to determine read mode impact on reading efficiencies. Efficiencies were monitored with no measureable negative impact. Due to the positive results, additional sites had dual mode detection enabled throughout the year.

#### 3.3.1 **Dual Mode Detection Enable Dates**

TD1 since 8/29/17

TD2 since 8/29/17

BO1 since 3/30/18

BO4 since 3/30/18

MC1 since 4/2/18

PRO since 4/5/18

ROZ since 4/5/18

LFF since 8/16/18

#### 3.3.2 **Dual Mode Field Results**

Adult ladder efficiency tests were monitored and statistical analysis was performed by PSMFC and NOAA to ensure that detection efficiency wasn't impacted. Reports show no statistical degradation in reading efficiency.

**3.3.3 Adult Ladder Efficiency (12 month rolling average)**

Adult ladder efficiency 12 month rolling average

	BON	MCN	TDA
9/14/2017	99.8	99.1	99.2
9/13/2018	99.2	99.2	99.4
% Gain/Loss	-0.6	0.1	0.2

### 3.3.4 Adult Ladder Weir To Weir Efficiency

## TDA Fish Ladders

Subsite	Date Range	Antenna	Unique Tags Detected by Subsite	Unique Tags Detected by Antenna Group	Unique Tags Detected by Antenna	Tags Missed per Antenna	Percent Tags Detected by Antenna
TD1	8/30/16 to 8/28/17	01	10,166	10,166	10,130	36	99.65%
	9/29/17 to 8/28/18	01	7,444	7,444	7,419	25	99.66%
% Gain/Loss							0.01%

Subsite	Date Range	Antenna	Unique Tags Detected by Subsite	Unique Tags Detected by Antenna Group	Unique Tags Detected by Antenna	Tags Missed per Antenna	Percent Tags Detected by Antenna
TD1	8/30/16 to 8/28/17	02	10,166	10,166	10,152	14	99.86%
	9/29/17 to 8/28/18	02	7,444	7,444	7,431	13	99.83%
% Gain/Loss							-0.03%

Subsite	Date Range	Antenna	Unique Tags Detected by Subsite	Unique Tags Detected by Antenna Group	Unique Tags Detected by Antenna	Tags Missed per Antenna	Percent Tags Detected by Antenna
TD2	8/30/16 to 8/28/17	01	1,432	1,432	1,430	2	99.86%
	9/29/17 to 8/28/18	01	1,024	1,024	1,024	0	100.00%
% Gain/Loss							0.14%

Subsite	Date Range	Antenna	Unique Tags Detected by Subsite	Unique Tags Detected by Antenna Group	Unique Tags Detected by Antenna	Tags Missed per Antenna	Percent Tags Detected by Antenna
TD2	8/30/16 to 8/28/17	02	1,432	1,432	1,431	1	99.93%
	9/29/17 to 8/28/18	02	1,024	1,024	1,021	3	99.71%
% Gain/Loss							-0.22%

### 3.4 Conclusion

From past testing and theoretical reading speed of a FDXB tag when running the FS2020 in dual detection mode, it is known that tags that are only read once or twice in FDXB only detection mode will not be read in dual detection mode.

FS2020 transceivers were installed at MC1 and MC2 on 9/11/2013. Therefore, data for those sites was taken from that day until 11/25/2013 when the report was run. The data for TD1 and TD2 is YTD through 12/13/13.

The database report data shows that we could have a detection efficiency loss per antenna of between 0.4% and 3.4% if the FS2020 dual mode is enabled. This is the percentage of fish that were read only once or twice in the FDXB only detection mode.

Overall loss of detection efficiency per antenna group would be less than individual antennas due to the redundancy. The overall theoretical detection efficiency loss per antenna group has not been calculated and is unknown at this time.

### 3.5 ***Recommendations***

Due to the positive results of the field testing performed, the following sites will be phased into dual mode detection.

ICH, LMA, GOA, GRA, JO1, and JO2

Ongoing monitoring of detection efficiency will be performed and any negative impact will be assessed.