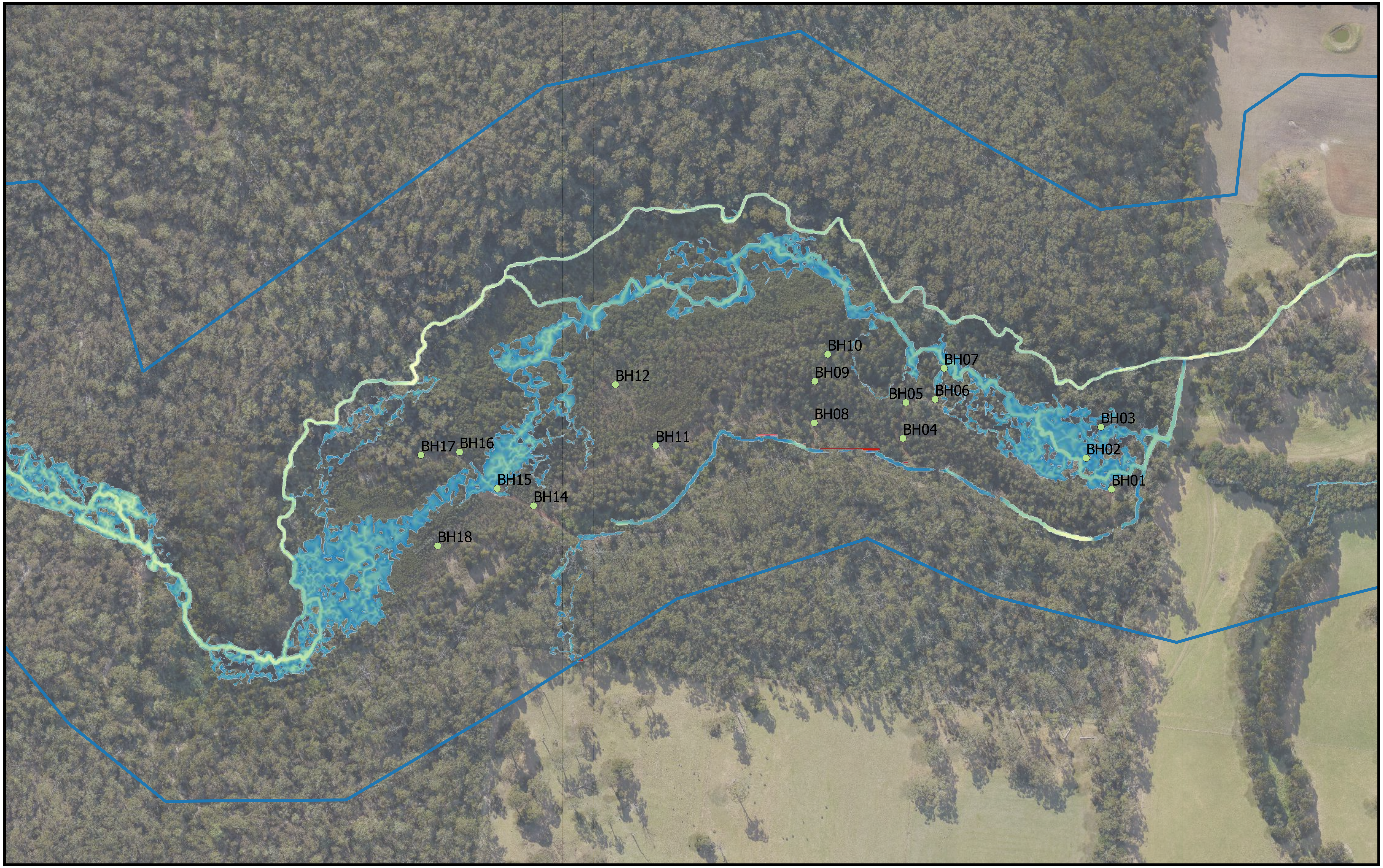
Appendices

Appendix A – Additional TUFLOW Outputs



Legend

Water Depth (m)

- 0
- 0.2
- 0.4
- 0.6
- 0.8
- 1
- 1.2

Tufow model boundary

Borehole locations

Paper Size ISO A3

0 50 100 m

Map Projection: Mercator Grid
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

Barwon Water
Big Swamp Modelling for Detailed Design

Existing conditions
Wet period water depths (August 2019)

Project No. **12536659**
Revision No. **A**
Date. **24/12/2020**

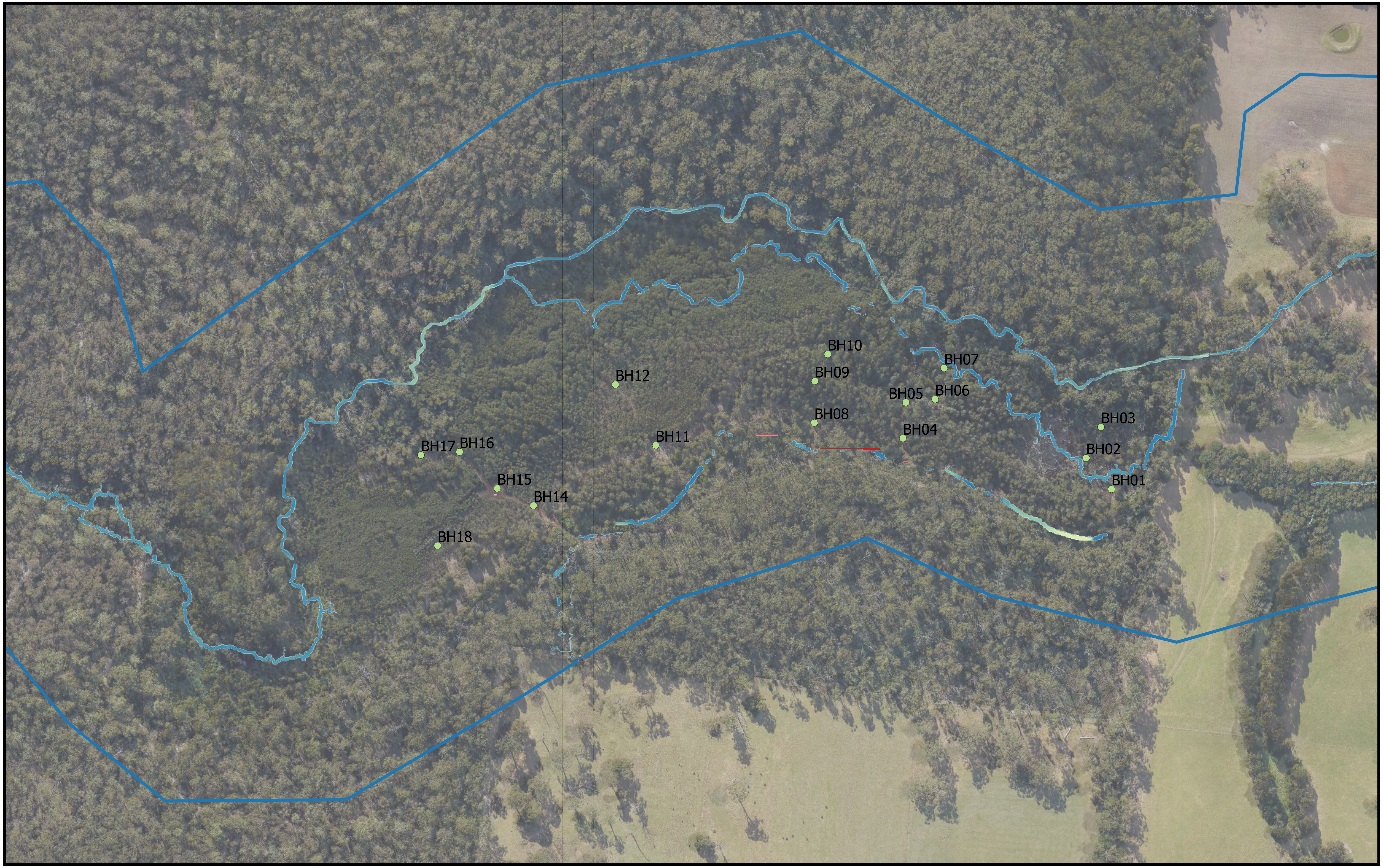
FIGURE SW-01

Document Path: \\ghdnet\ghd\AU\Melbourne\Projects\31\12536659\Tech\06_TUFLOW\TUFLOW\GIS workspaces\results_sensitivity.qgz

Data Source: Barwon Water, Imagery, 2019; Jacobs, Bore Locations, 2019; GHD, bore details, 2020;

Print Date:

Created By: Ellie Denson



Legend

Water Depth (m)

- 0
- 0.2
- 0.4
- 0.6
- 0.8
- 1
- 1.2

Tufow model boundary

Borehole locations

Paper Size ISO A3

0 50 100 m

Map Projection: Mercator Grid
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Barwon Water
Big Swamp Modelling for Detailed Design

Existing conditions
Dry period water depths (March 2020)

Project No. **12536659**
Revision No. **A**
Date. **24/12/2020**

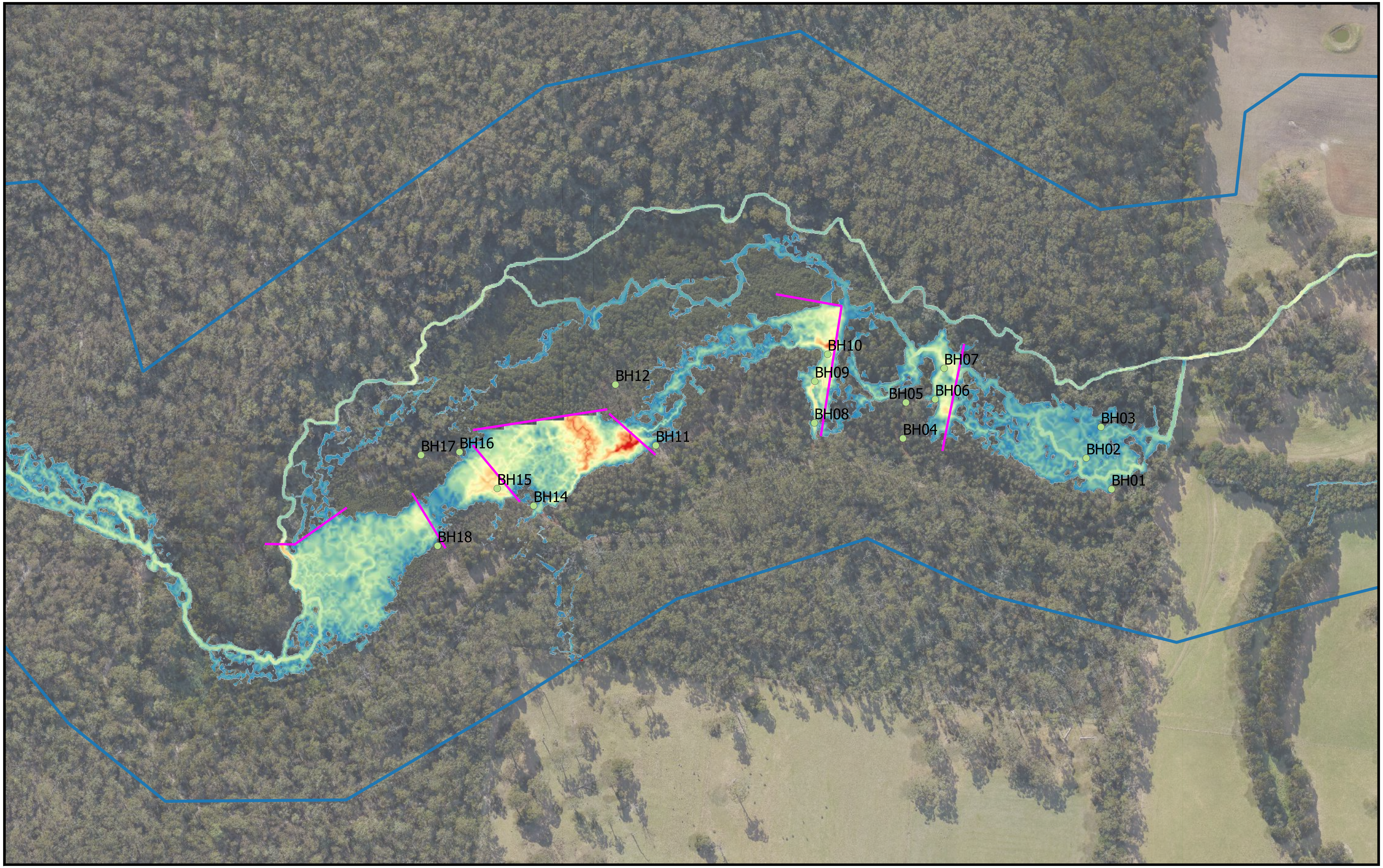
FIGURE SW-02

Document Path: \\ghdnet\ghd\AU\Melbourne\Projects\31\12536659\Tech\06_TUFLOW\TUFLOW\GIS workspaces\results_sensitivity.qgz

Data Source: Barwon Water, Imagery, 2019; Jacobs, Bore Locations, 2019; GHD, bore details, 2020;

Print Date:

Created By: Ellie Denson



Legend

Water Depth (m)		
0	0.6	Borehole locations
0.2	0.8	Barriers
0.4	1	
	1.2	
	Tufow model boundary	

Paper Size ISO A3

0 50 100 m

N

Map Projection: Mercator Grid
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

GHD

Barwon Water
Big Swamp Modelling for Detailed Design

Proposed Barrier Scenario (Group 12)
Wet period water depths (August 2019)

Project No. 12536659
Revision No. A
Date. 24/12/2020

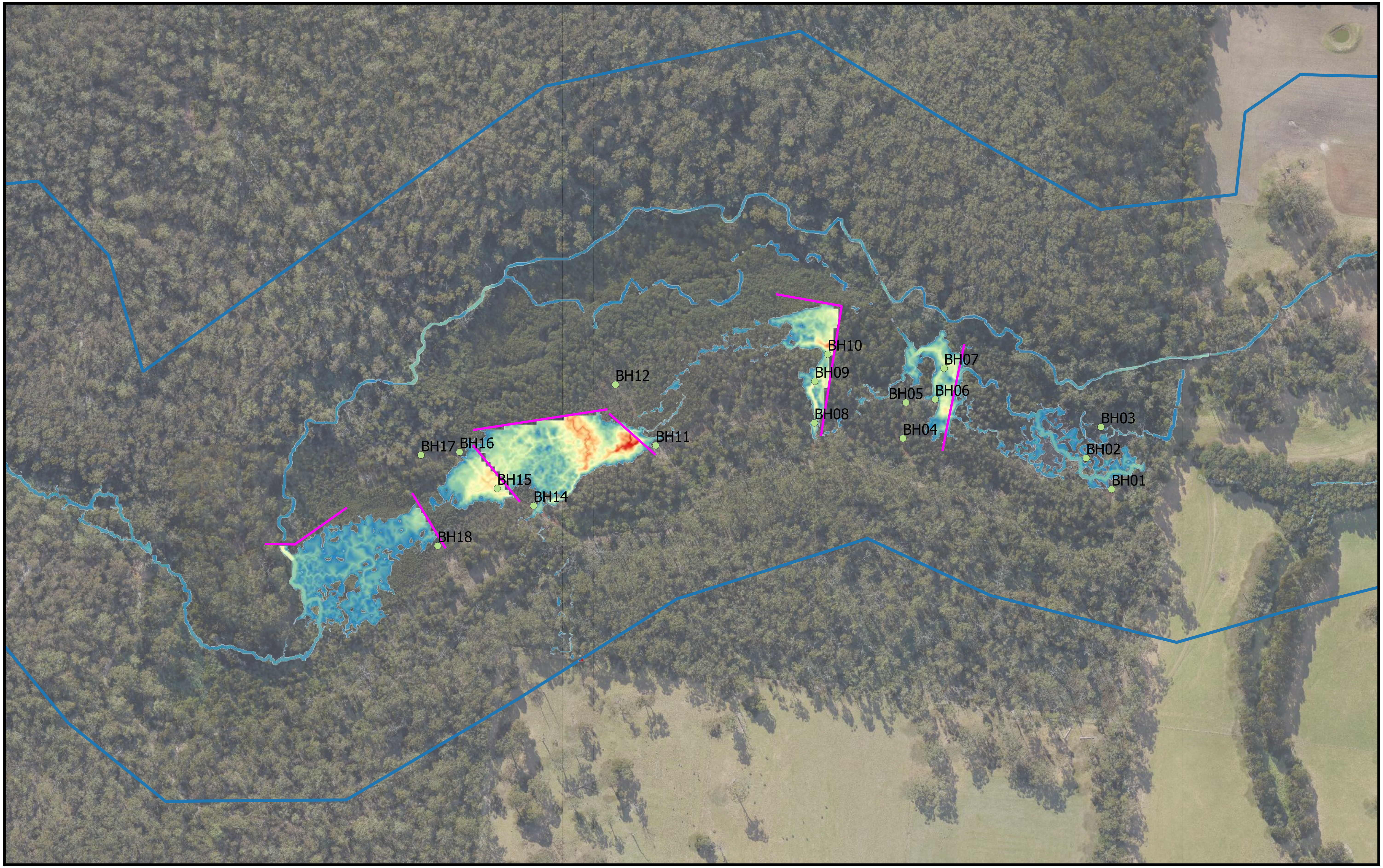
FIGURE SW-03

Document Path: \\ghdnet\ghd\AU\Melbourne\Projects\31\12536659\Tech\06_TUFLOW\TUFLOW\GIS workspaces\results_sensitivity.qgz

Data Source: Barwon Water, Imagery, 2019; Jacobs, Bore Locations, 2019; GHD, bore details, 2020;

Print Date:

Created By: Ellie Denson



Legend

Water Depth (m)
- 0
- 0.2
- 0.4
- 0.6
- 0.8
- 1
- 1.2
- Tufow model boundary
- Borehole locations
- Barriers

Paper Size ISO A3

0 50 100 m

Map Projection: Mercator Grid
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

GHD

Barwon Water
Big Swamp Modelling for Detailed Design

Proposed Barrier Scenario (Group 12)
Dry period water depths (March 2020)

Project No. **12536659**
Revision No. **A**
Date. **24/12/2020**

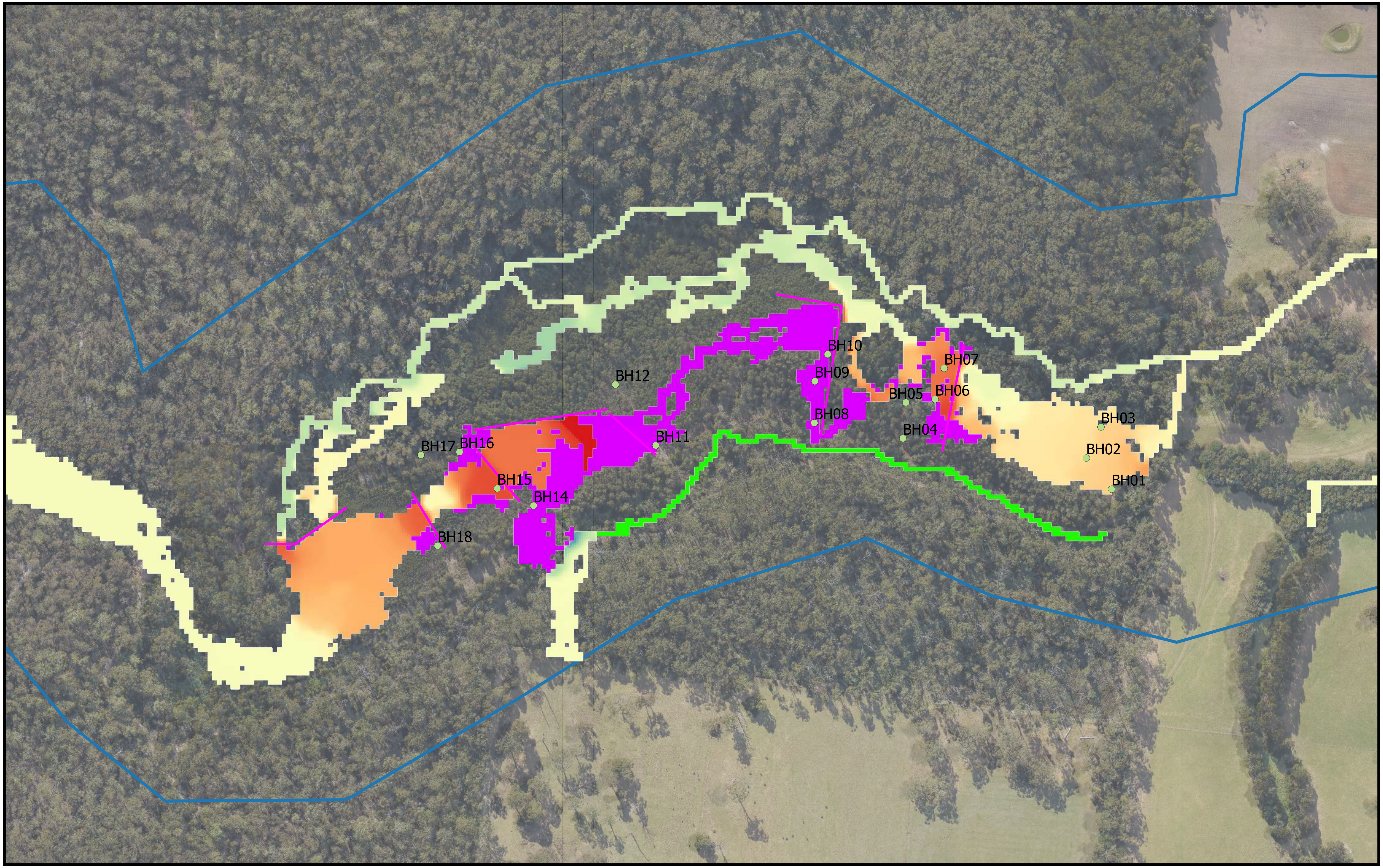
FIGURE SW-04

Document Path: \\ghdnet\ghd\AU\Melbourne\Projects\31\12536659\Tech\06_TUFLOW\TUFLOW\GIS workspaces\results_sensitivity.qgz

Data Source: Barwon Water, Imagery, 2019; Jacobs, Bore Locations, 2019; GHD, bore details, 2020;

Print Date:

Created By: Ellie Denson



Legend

Depth afflux (m)
- -0.8
- -0.5
- -0.3
- -0.2
- -0.1
- -0.05
- 0
- 0.05
- 0.1
- 0.2
- 0.3
- 0.5
- 0.8
- > 0.8
- Was Wet Now Dry
- Was Dry Now Wet
- Tuflow Model Boundary
- Borehole Locations
- Barriers

Paper Size ISO A3

0 50 100 m

Map Projection: Mercator Grid
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Barwon Water
Big Swamp Modelling for Detailed Design

Proposed Barrier Scenario (Group 12)
Wet period depth afflux (August 2019)

Project No. **12536659**
Revision No. **A**
Date. **24/12/2020**

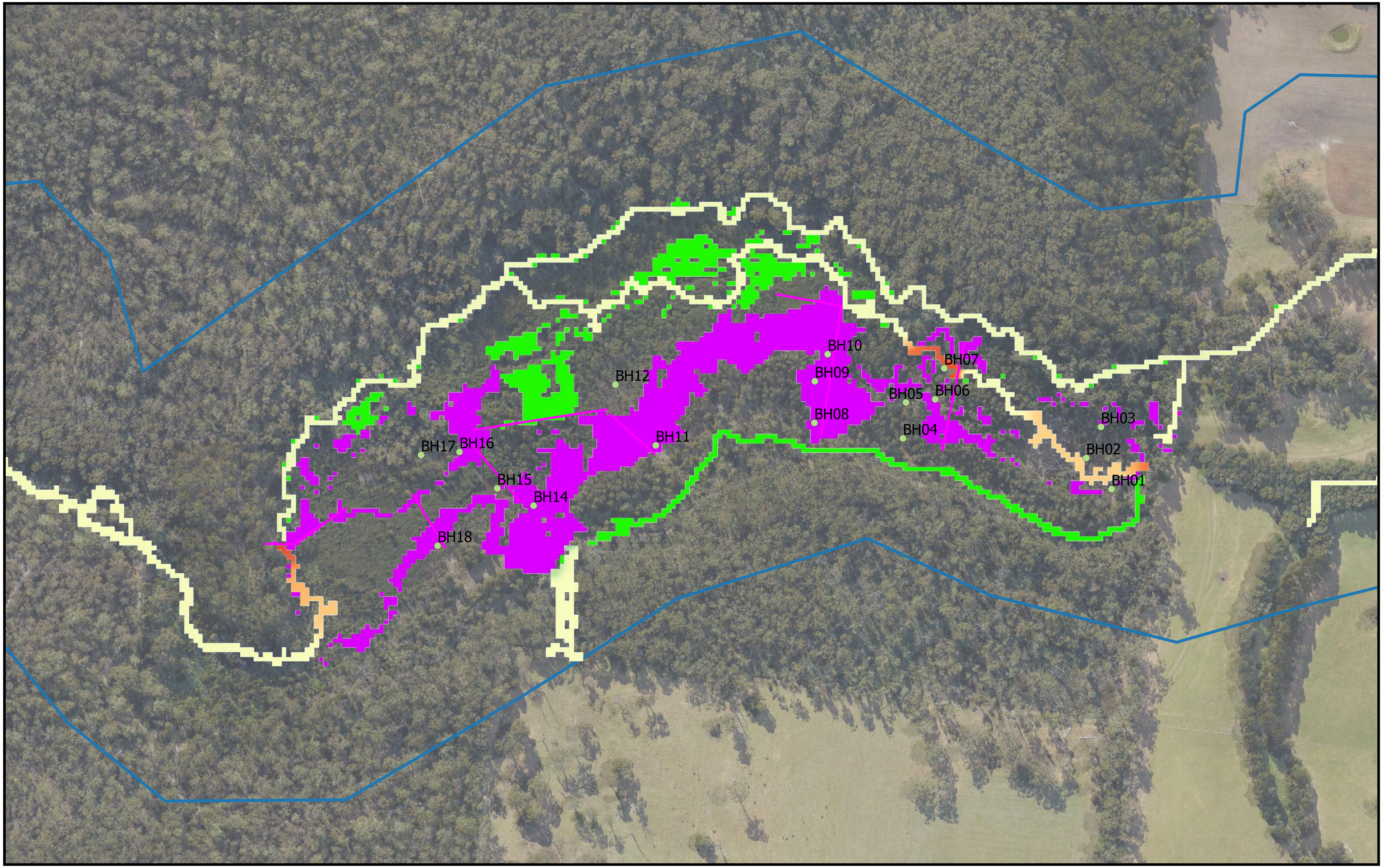
FIGURE SW-05

Document Path: \\ghdnet\ghd\AU\Melbourne\Projects\31\12536659\Tech\06_TUFLOW\TUFLOW\GIS workspaces\results_sensitivity.qgz

Data Source: Barwon Water, Imagery, 2019; Jacobs, Bore Locations, 2019; GHD, bore details, 2020;

Print Date:

Created By: Ellie Denson



Legend

Depth afflux (m)			
-0.8	-0.05	0.5	Borehole Locations
-0.5	0	0.8	Barriers
-0.3	0.05	> 0.8	
-0.2	0.1	Was Wet Now Dry	
-0.1	0.2	Was Dry Now Wet	
	0.3	Tuflow Model Boundary	

Paper Size ISO A3

0 50 100 m

Map Projection: Mercator Grid
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Barwon Water
Big Swamp Modelling for Detailed Design

Proposed Barrier Scenario (Group 12)
Dry period depth afflux (March 2020)

Project No. **12536659**
Revision No. **A**
Date. **24/12/2020**

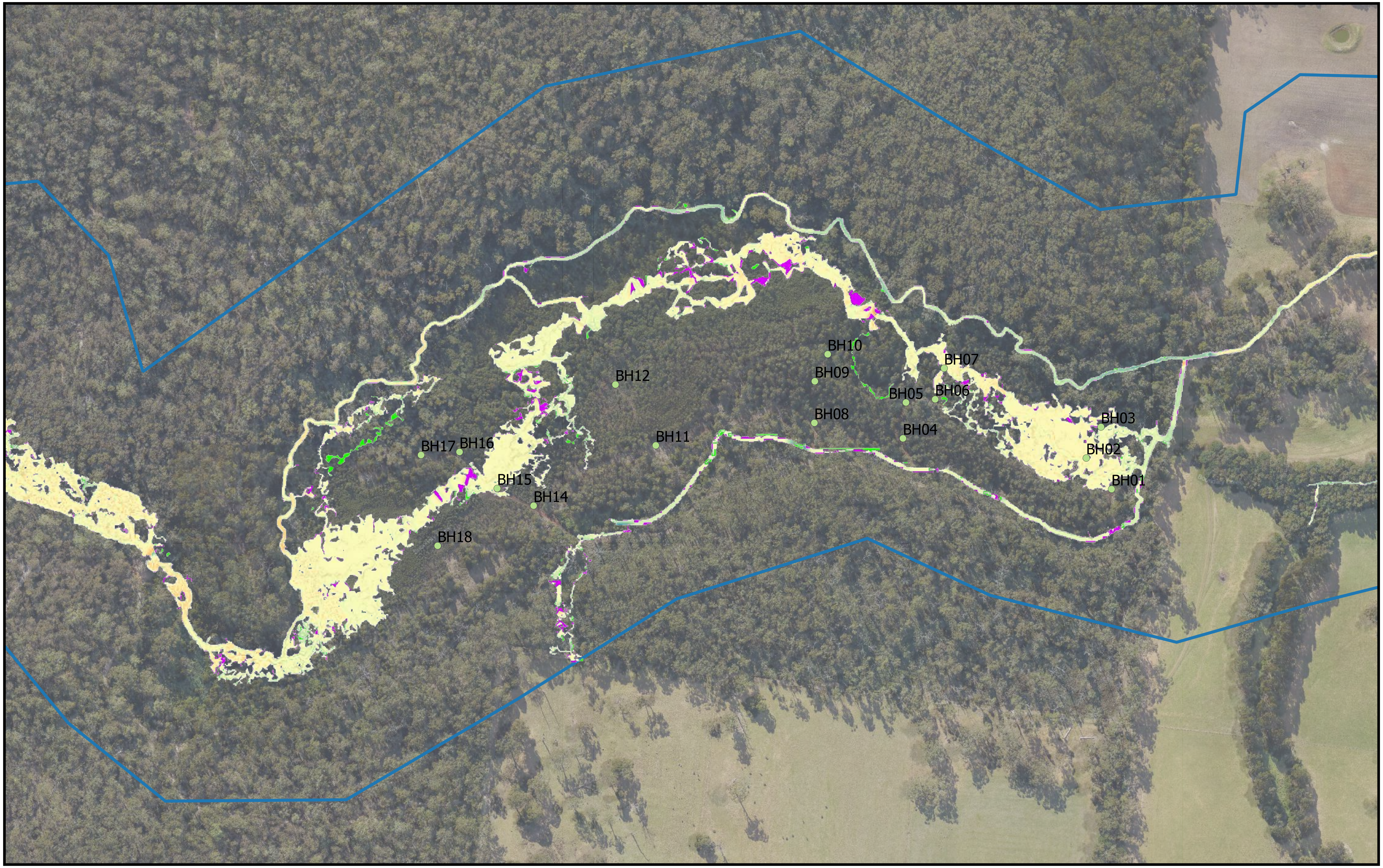
FIGURE SW-06

Document Path: \\ghdnet\ghd\AU\Melbourne\Projects\31\12536659\Tech\06_TUFLOW\TUFLOW\GIS workspaces\results_sensitivity.qgz

Data Source: Barwon Water, Imagery, 2019; Jacobs, Bore Locations, 2019; GHD, bore details, 2020;

Print Date:

Created By: Ellie Denson



Legend

Depth afflux (m)
- -0.5
- -0.3
- -0.2
- -0.1
- -0.05
- -0.02
- 0
- 0.02
- 0.05
- 0.1
- 0.2
- 0.3
- 0.5
- > 0.5
- Was Wet Now Dry
- Was Dry Now Wet
- Tuflow Model Boundary
- Borehole Locations
- Barriers

Paper Size ISO A3

0 50 100 m

Map Projection: Mercator Grid
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

GHD

Barwon Water
Big Swamp Modelling for Detailed Design

Sensitivity run - 1 m grid cell size
Wet period depth afflux (August 2019)

Project No. **12536659**
Revision No. **A**
Date. **24/12/2020**

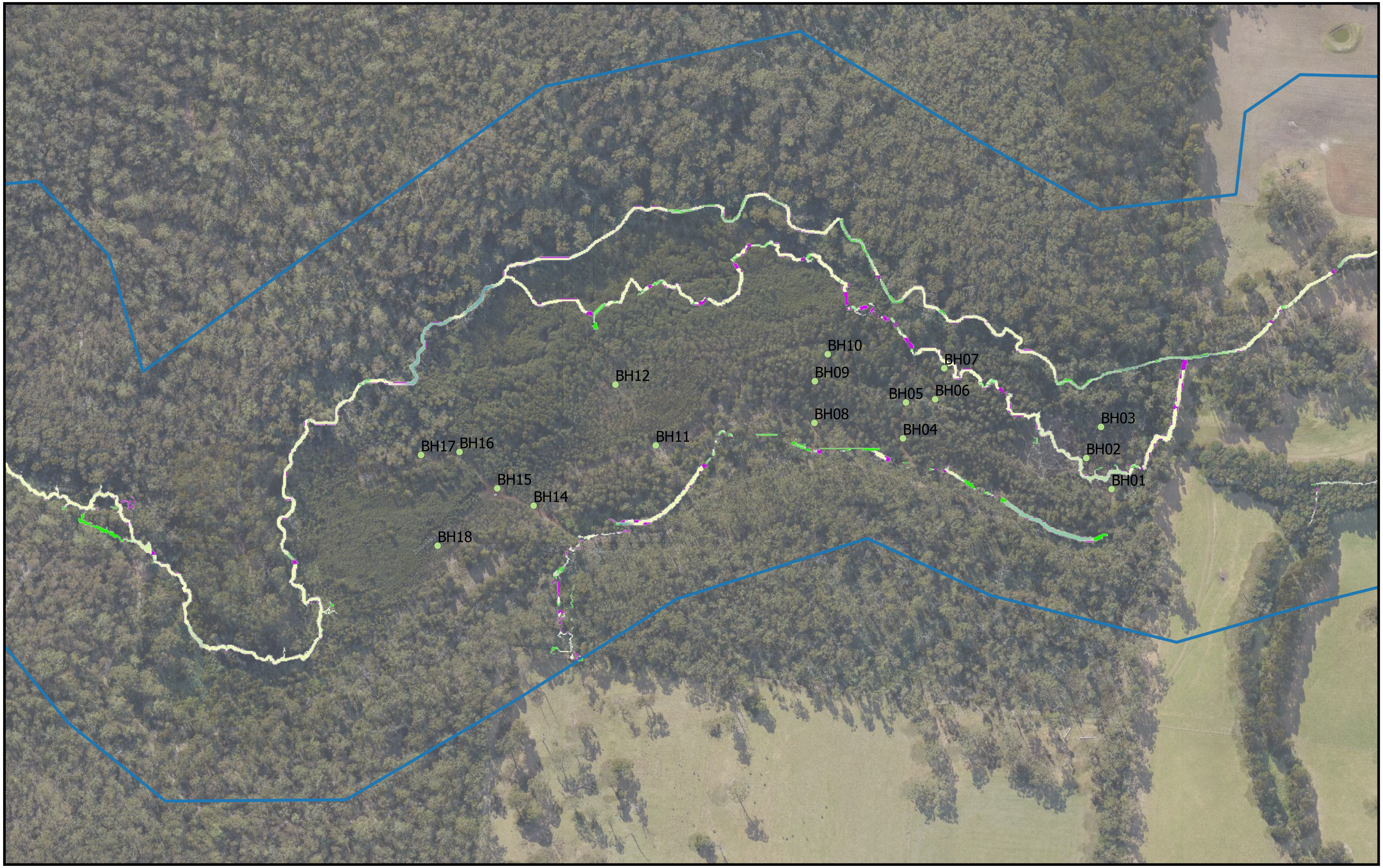
FIGURE SW-07

Document Path: \\ghdnet\ghd\AU\Melbourne\Projects\31\12536659\Tech\06_TUFLOW\TUFLOW\GIS workspaces\results_sensitivity.qgz

Print Date:

Data Source: Barwon Water, Imagery, 2019; Jacobs, Bore Locations, 2019; GHD, bore details, 2020;

Created By: Ellie Denson



Legend

Depth afflux (m)
- -0.5
- -0.3
- -0.2
- -0.1
- -0.05
- -0.02
- 0
- 0.02
- 0.05
- 0.1
- 0.2
- 0.3
- 0.5
- > 0.5
- Was Wet Now Dry
- Was Dry Now Wet
- Tuflow Model Boundary
- Borehole Locations
- Barriers

Paper Size ISO A3

0 50 100 m

Map Projection: Mercator Grid
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Barwon Water

Big Swamp Modelling for Detailed Design

Sensitivity run - 1 m grid cell size
Dry period depth afflux (March 2020)

Project No. **12536659**
Revision No. **A**
Date. **24/12/2020**

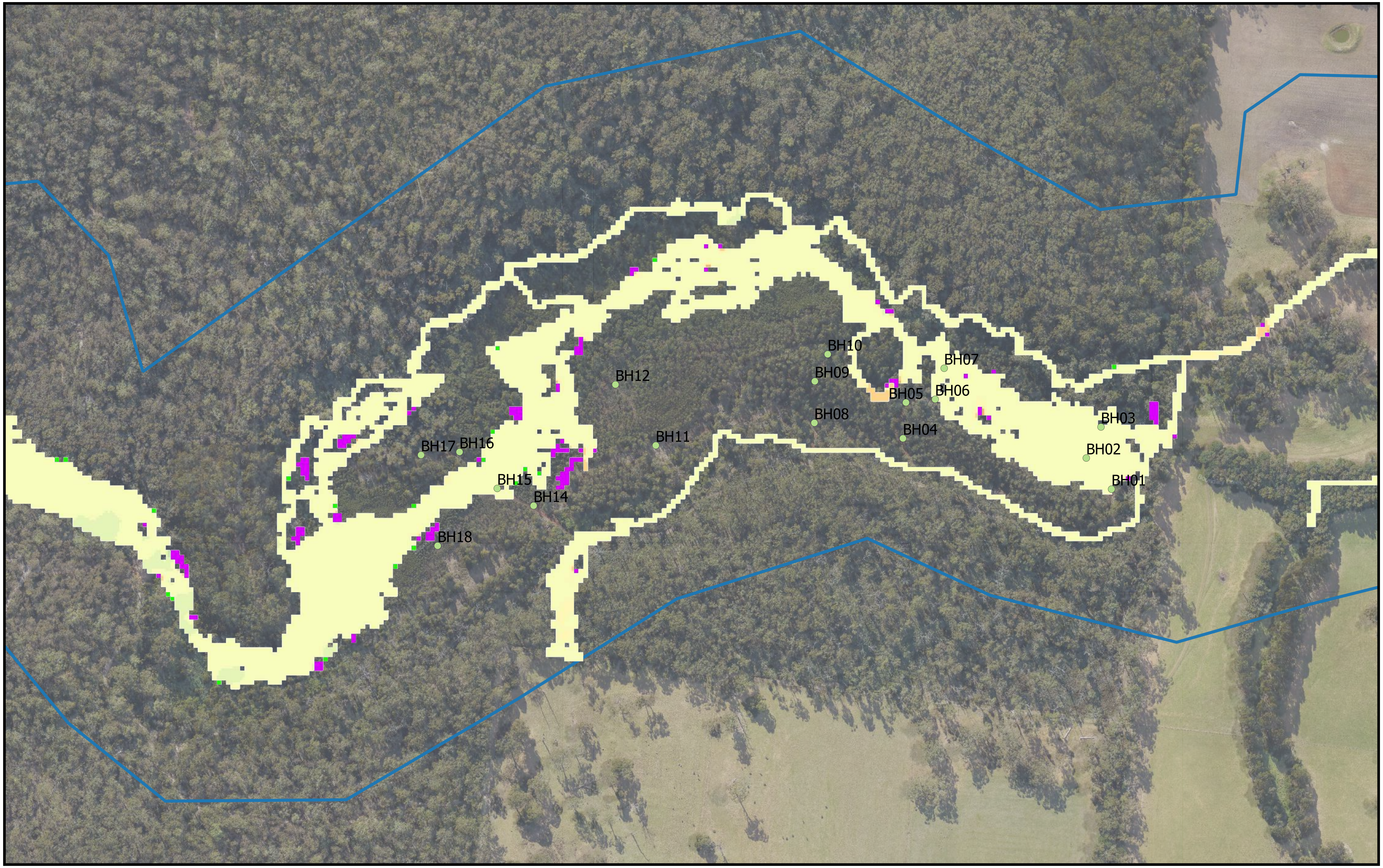
FIGURE SW-08

Document Path: \\ghdnet\ghd\AU\Melbourne\Projects\31\12536659\Tech\06_TUFLOW\TUFLOW\GIS workspaces\results_sensitivity.qgz

Data Source: Barwon Water, Imagery, 2019; Jacobs, Bore Locations, 2019; GHD, bore details, 2020;

Print Date:

Created By: Ellie Denson



Legend

Depth afflux (m)			
-0.5	-0.02	0.3	Borehole Locations
-0.3	0	0.5	Barriers
-0.2	0.02	> 0.5	
-0.1	0.05	Was Wet Now Dry	
-0.05	0.1	Was Dry Now Wet	
	0.2	Tuflow Model Boundary	

Paper Size ISO A3

0 50 100 m

Map Projection: Mercator Grid
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Barwon Water
Big Swamp Modelling for Detailed Design

Sensitivity run - 15 minute timestep on upstream inflow
Wet period depth afflux (August 2019)

Project No. **12536659**
Revision No. **A**
Date. **24/12/2020**

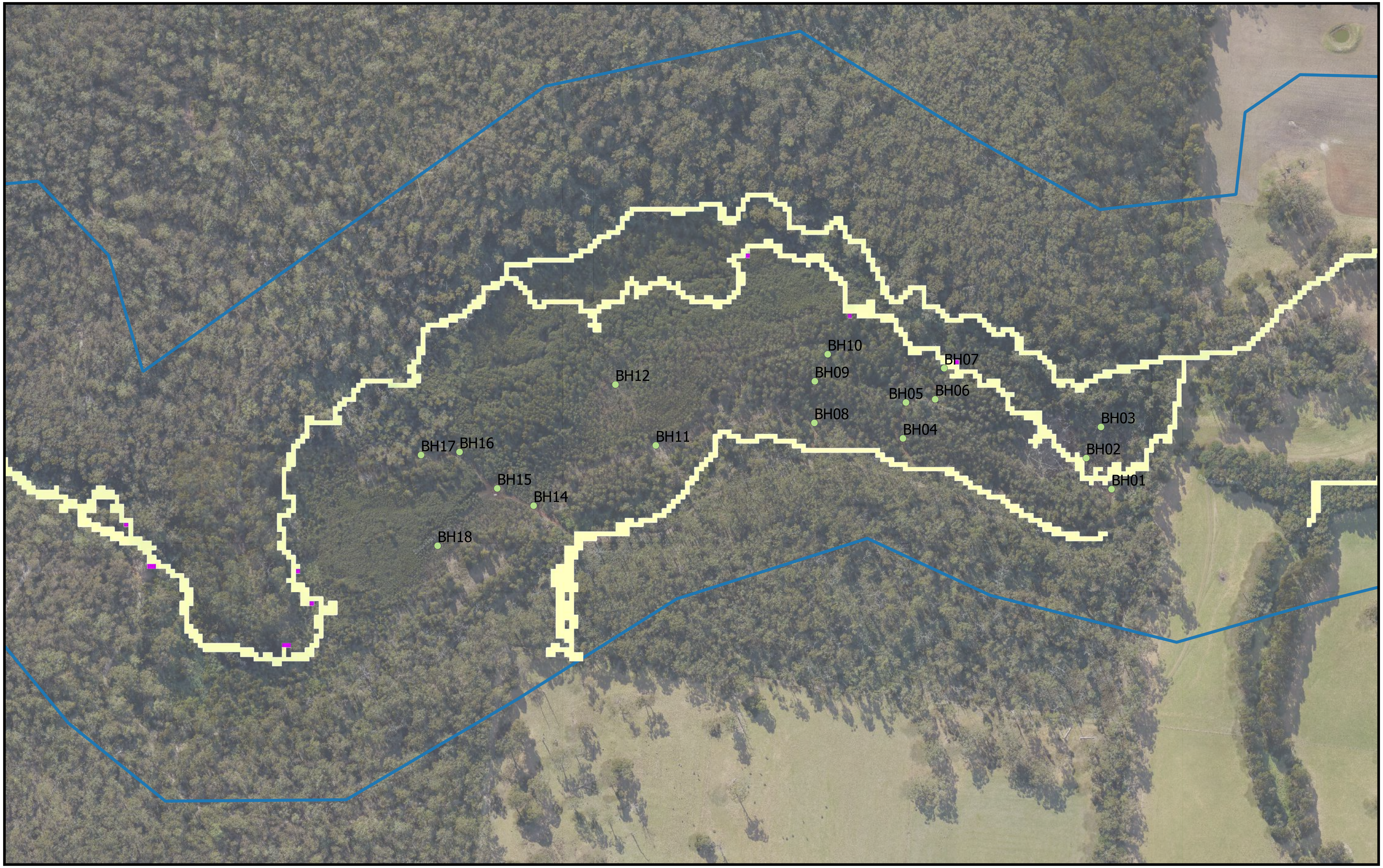
FIGURE SW-09

Document Path: \\ghdnet\ghd\AU\Melbourne\Projects\31\12536659\Tech\06_TUFLOW\TUFLOW\GIS workspaces\results_sensitivity.qgz

Data Source: Barwon Water, Imagery, 2019; Jacobs, Bore Locations, 2019; GHD, bore details, 2020;

Print Date:

Created By: Ellie Denson



Legend

Depth afflux (m)			
-0.5	-0.02	0.3	Borehole Locations
-0.3	0	0.5	Barriers
-0.2	0.02	> 0.5	
-0.1	0.05	Was Wet Now Dry	
-0.05	0.1	Was Dry Now Wet	
	0.2	Tuflow Model Boundary	

Paper Size ISO A3

0 50 100 m

Map Projection: Mercator Grid
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Barwon Water
Big Swamp Modelling for Detailed Design

Sensitivity run - 15 minute timestep on upstream inflow
Dry period depth afflux (March 2020)

Project No. **12536659**
Revision No. **A**
Date. **24/12/2020**

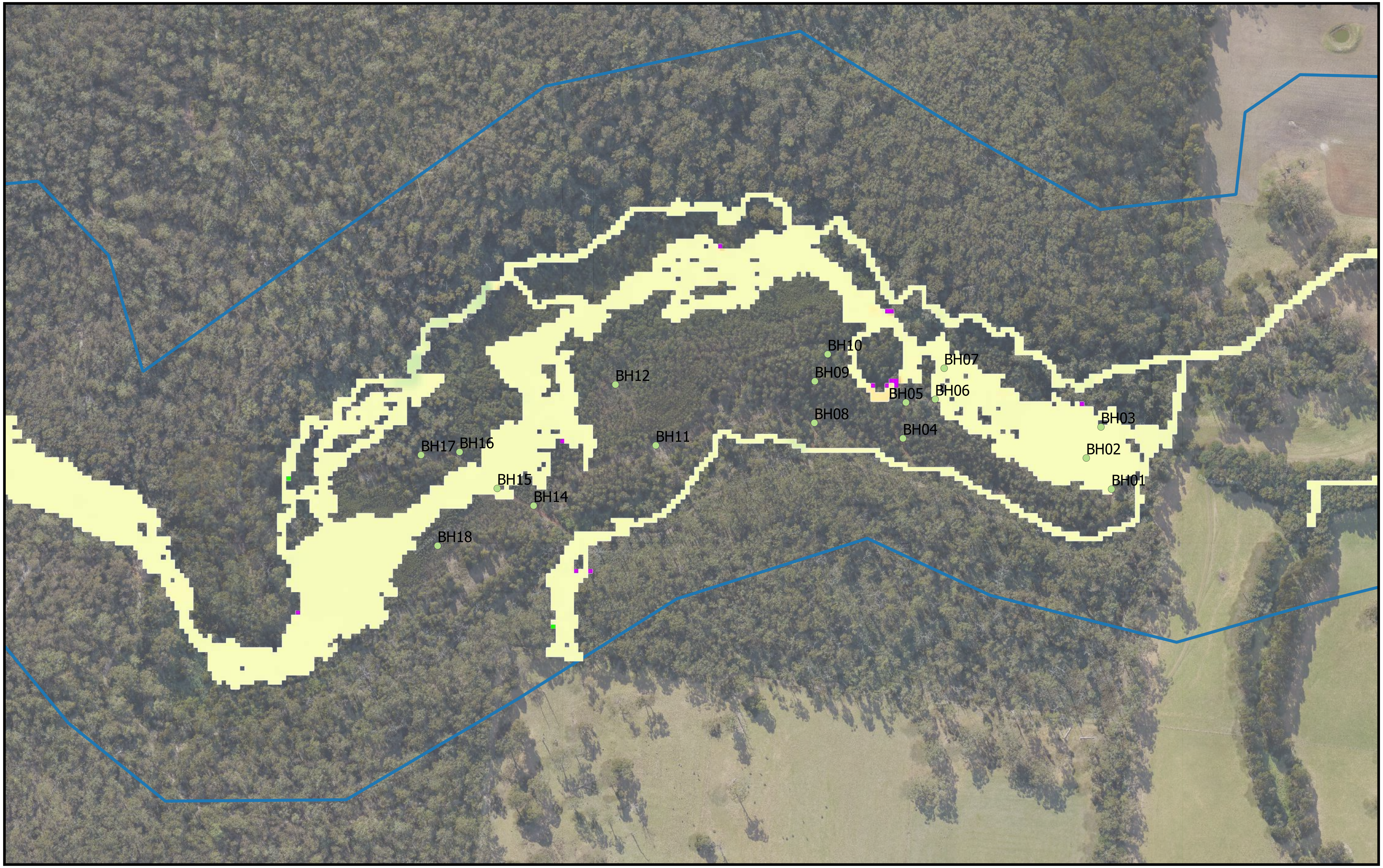
FIGURE SW-10

Document Path: \\ghdnet\ghd\AU\Melbourne\Projects\31\12536659\Tech\06_TUFLOW\TUFLOW\GIS workspaces\results_sensitivity.qgz

Data Source: Barwon Water, Imagery, 2019; Jacobs, Bore Locations, 2019; GHD, bore details, 2020;

Print Date:

Created By: Ellie Denson



Legend

Depth afflux (m)			
-0.5	-0.02	0.3	Borehole Locations
-0.3	0	0.5	Barriers
-0.2	0.02	> 0.5	
-0.1	0.05	Was Wet Now Dry	
-0.05	0.1	Was Dry Now Wet	
	0.2	Tuflow Model Boundary	

Paper Size ISO A3

0 50 100 m

Map Projection: Mercator Grid
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

GHD

Barwon Water
Big Swamp Modelling for Detailed Design

Sensitivity run - Double Precision
Wet period depth afflux (August 2019)

Project No. **12536659**
Revision No. **A**
Date. **24/12/2020**

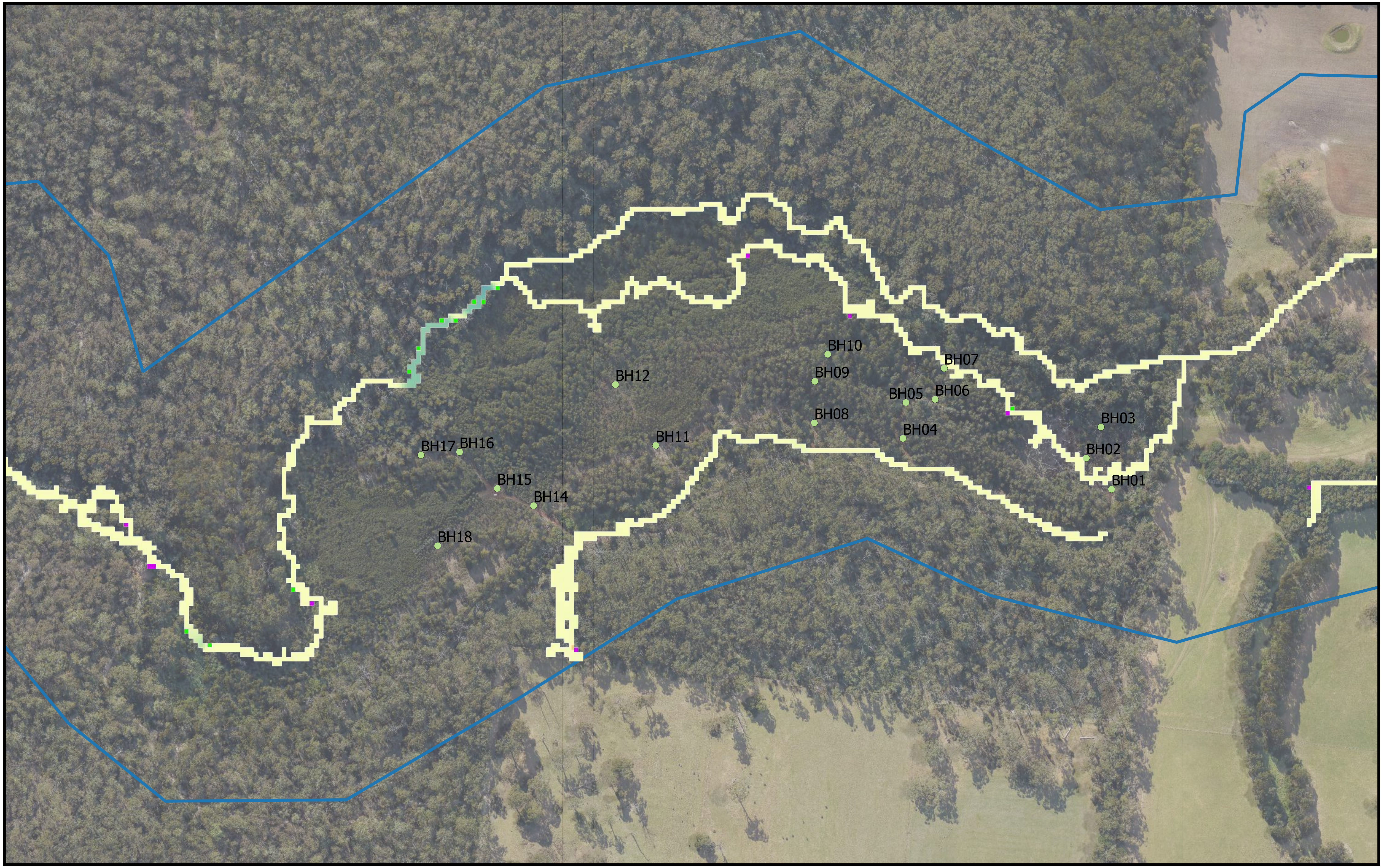
FIGURE SW-11

Document Path: \\ghdnet\ghd\AU\Melbourne\Projects\31\12536659\Tech\06_TUFLOW\TUFLOW\GIS workspaces\results_sensitivity.qgz

Data Source: Barwon Water, Imagery, 2019; Jacobs, Bore Locations, 2019; GHD, bore details, 2020;

Created By: Ellie Denson

Print Date:



Legend

Depth afflux (m)

-0.5	-0.02	0.3	Borehole Locations
-0.3	0	0.5	Barriers
-0.2	0.02	> 0.5	
-0.1	0.05	Was Wet Now Dry	
-0.05	0.1	Was Dry Now Wet	
	0.2	Tuflow Model Boundary	

Paper Size ISO A3

0 50 100 m

Map Projection: Mercator Grid
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Barwon Water
Big Swamp Modelling for Detailed Design

Sensitivity run - Double Precision
Dry period depth afflux (March 2020)

Project No. **12536659**
Revision No. **A**
Date. **24/12/2020**

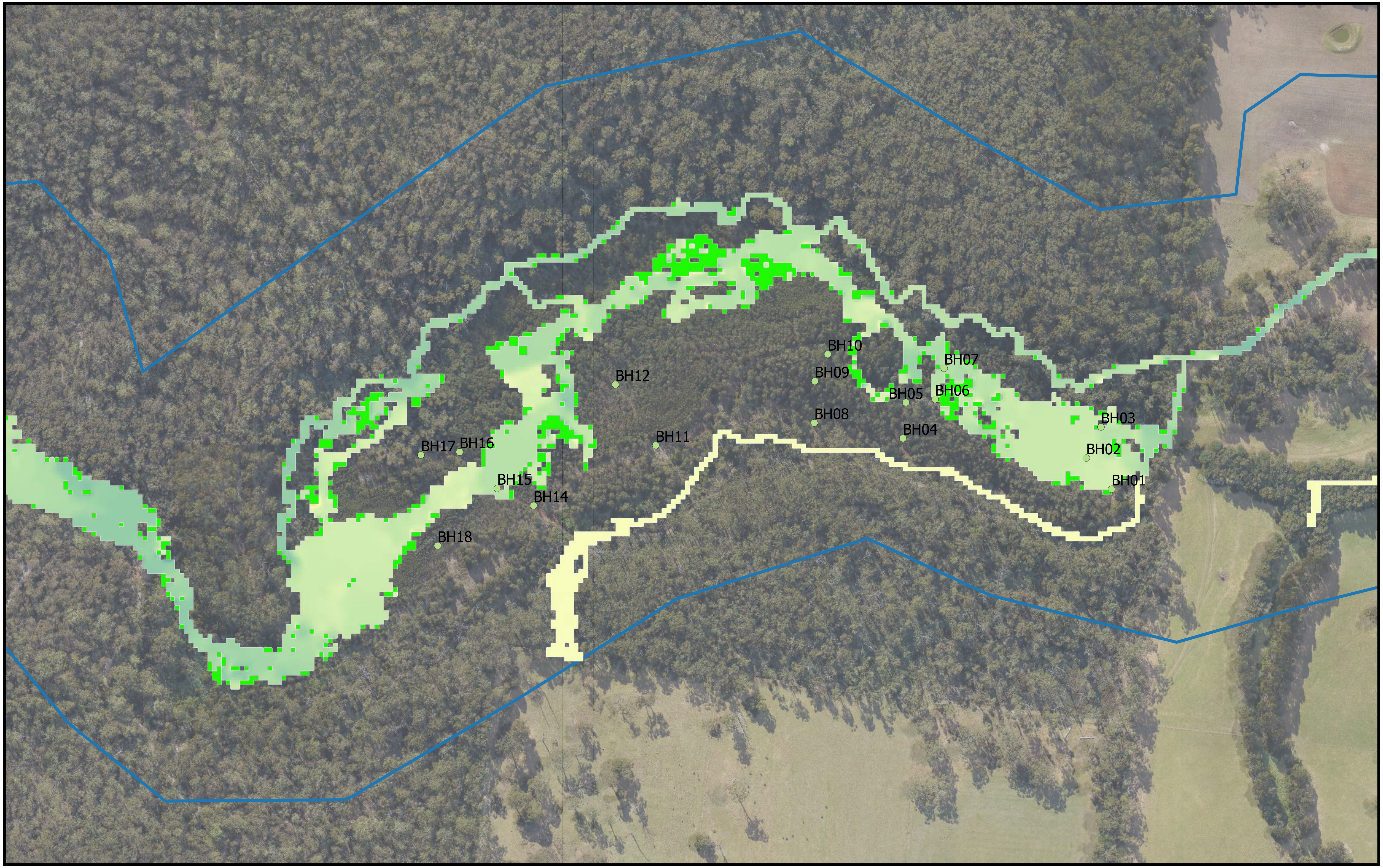
FIGURE SW-12

Document Path: \\ghdnet\ghd\AU\Melbourne\Projects\31\12536659\Tech\06_TUFLOW\TUFLOW\GIS workspaces\results_sensitivity.qgz

Data Source: Barwon Water, Imagery, 2019; Jacobs, Bore Locations, 2019; GHD, bore details, 2020;

Print Date:

Created By: Ellie Denson



Legend

Depth afflux (m)			
-0.5	-0.02	0.3	Borehole Locations
-0.3	0	0.5	Barriers
-0.2	0.02	> 0.5	
-0.1	0.05	Was Wet Now Dry	
-0.05	0.1	Was Dry Now Wet	
	0.2	Tuflow Model Boundary	

Paper Size ISO A3

0 50 100 m

Map Projection: Mercator Grid
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Barwon Water
Big Swamp Modelling for Detailed Design

Sensitivity run - Inflow from GR4J Wet period depth afflux (August 2019)

Project No. **12536659**
Revision No. **A**
Date. **24/12/2020**

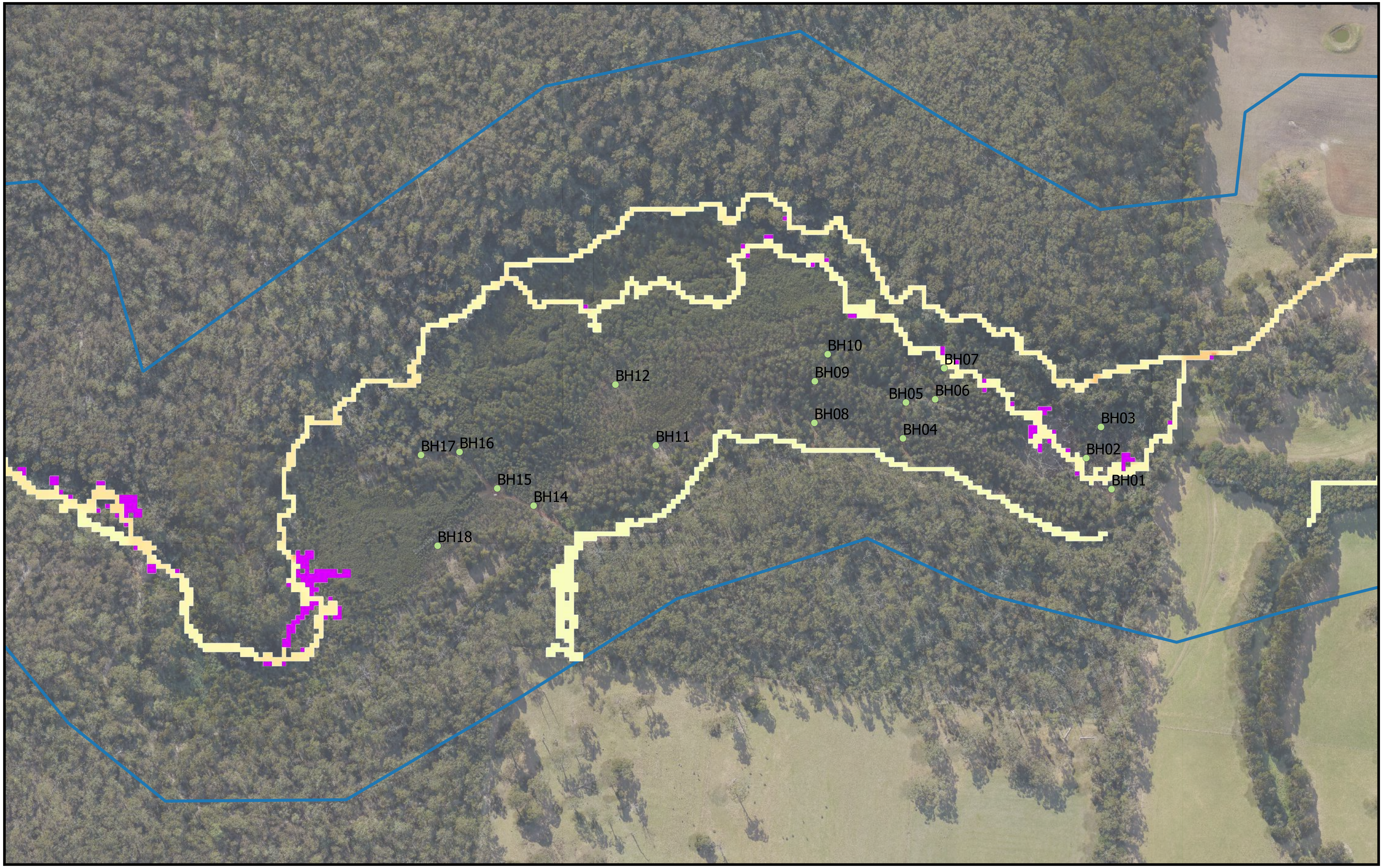
FIGURE SW-13

Document Path: \\ghdnet\ghd\AU\Melbourne\Projects\31\12536659\Tech\06_TUFLOW\TUFLOW\GIS workspaces\results_sensitivity.qgz

Data Source: Barwon Water, Imagery, 2019; Jacobs, Bore Locations, 2019; GHD, bore details, 2020;

Print Date:

Created By: Ellie Denson



Legend

Depth afflux (m)
- -0.5
- -0.3
- -0.2
- -0.1
- -0.05
- -0.02
- 0
- 0.02
- 0.05
- 0.1
- 0.2
- 0.3
- 0.5
- > 0.5
- Was Wet Now Dry
- Was Dry Now Wet
- Tuflow Model Boundary
- Borehole Locations
- Barriers

Paper Size ISO A3

0 50 100 m

Map Projection: Mercator Grid
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Barwon Water
Big Swamp Modelling for Detailed Design

Sensitivity run - Inflow from GR4J
Dry period depth afflux (March 2020)

Project No. **12536659**
Revision No. **A**
Date. **24/12/2020**

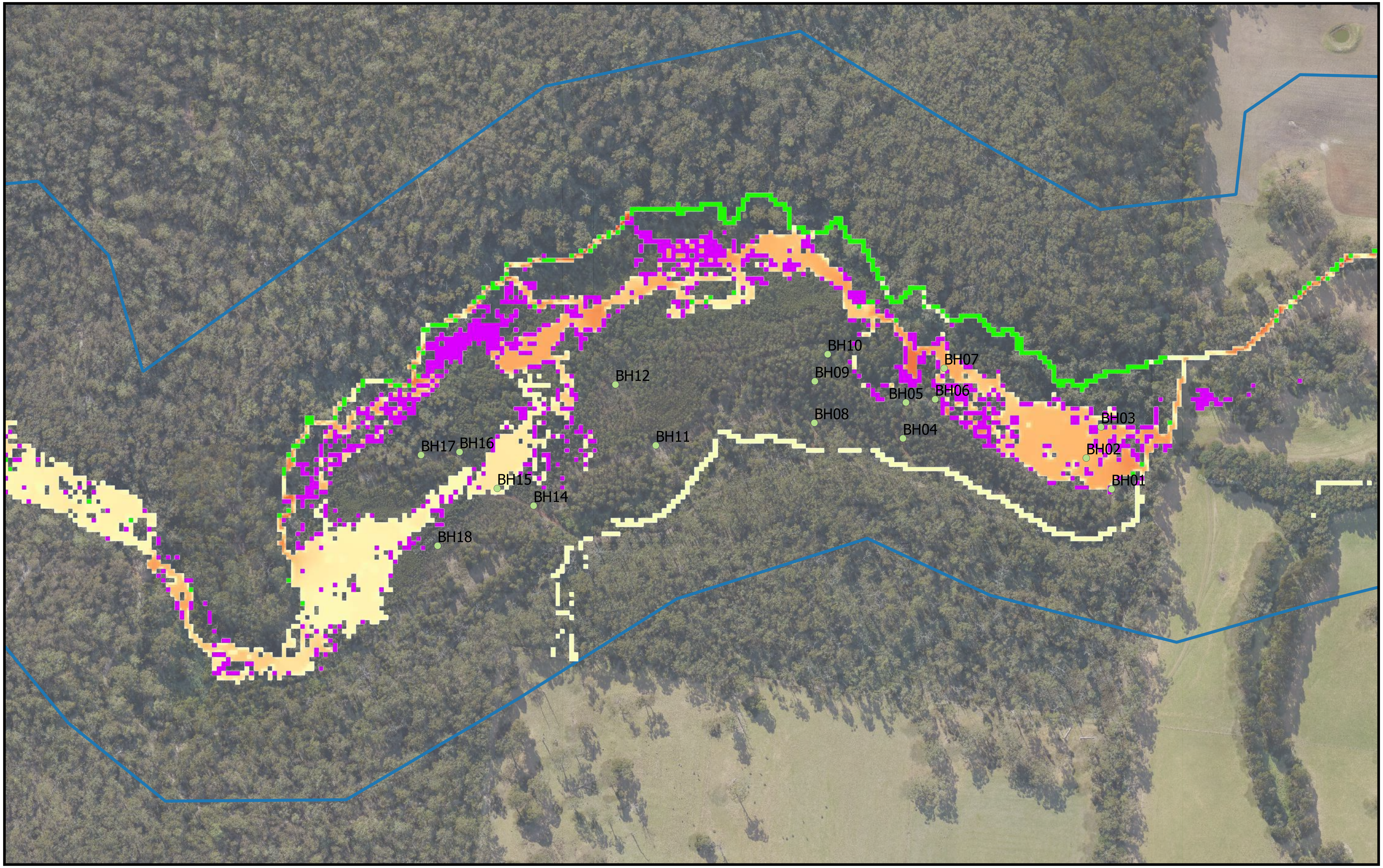
FIGURE SW-14

Document Path: \\ghdnet\ghd\AU\Melbourne\Projects\31\12536659\Tech\06_TUFLOW\TUFLOW\GIS workspaces\results_sensitivity.qgz

Data Source: Barwon Water, Imagery, 2019; Jacobs, Bore Locations, 2019; GHD, bore details, 2020;

Print Date:

Created By: Ellie Denson



Legend

Depth afflux (m)			
-0.5	-0.02	0.3	Borehole Locations
-0.3	0	0.5	Barriers
-0.2	0.02	> 0.5	
-0.1	0.05	Was Wet Now Dry	
-0.05	0.1	Was Dry Now Wet	
	0.2	Tuflow Model Boundary	

Paper Size ISO A3

0 50 100 m

Map Projection: Mercator Grid
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

GHD

Barwon Water
Big Swamp Modelling for Detailed Design

Sensitivity run - No stream gully shaping
Wet period depth afflux (August 2019)

Project No. 12536659
Revision No. A
Date. 24/12/2020

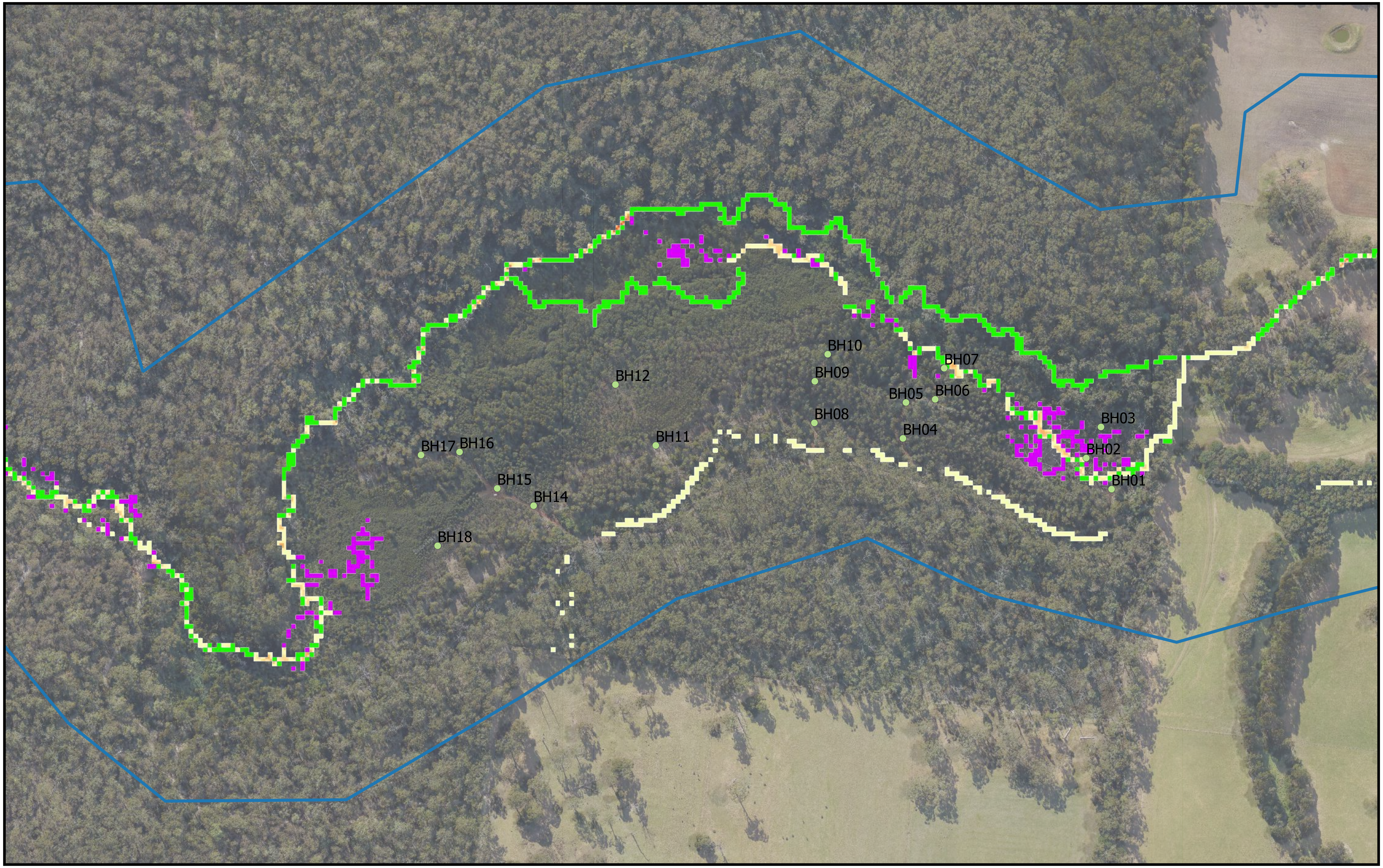
FIGURE SW-15

Document Path: \\ghdnet\ghd\AU\Melbourne\Projects\31\12536659\Tech\06_TUFLOW\TUFLOW\GIS workspaces\results_sensitivity.qgz

Data Source: Barwon Water, Imagery, 2019; Jacobs, Bore Locations, 2019; GHD, bore details, 2020;

Print Date:

Created By: Ellie Denson



Legend

Depth afflux (m)

- -0.5
- -0.3
- -0.2
- -0.1
- -0.05
- -0.02
- 0
- 0.02
- 0.05
- 0.1
- 0.2
- 0.3
- 0.5
- > 0.5
- Was Wet Now Dry
- Was Dry Now Wet
- Tuflow Model Boundary
- Borehole Locations
- Barriers

Paper Size ISO A3

0 50 100 m

Map Projection: Mercator Grid
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Barwon Water
Big Swamp Modelling for Detailed Design

Sensitivity run - No stream gully shaping
Dry period depth afflux (March 2020)

Project No. **12536659**
Revision No. **A**
Date. **24/12/2020**

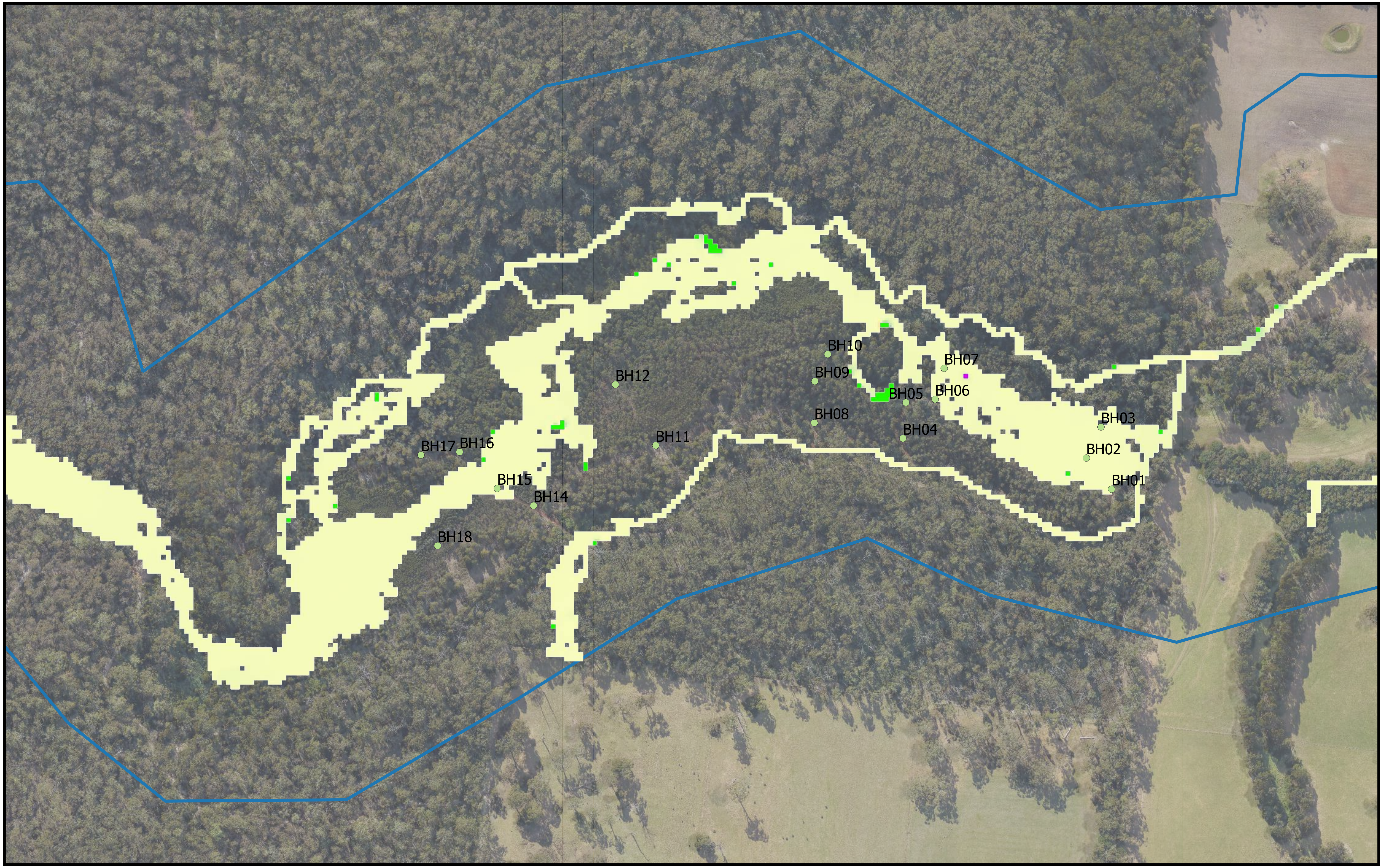
FIGURE SW-16

Document Path: \\ghdnet\ghd\AU\Melbourne\Projects\31\12536659\Tech\06_TUFLOW\TUFLOW\GIS workspaces\results_sensitivity.qgz

Data Source: Barwon Water, Imagery, 2019; Jacobs, Bore Locations, 2019; GHD, bore details, 2020;

Print Date:

Created By: Ellie Denson



Legend

Depth afflux (m)			
-0.5	-0.02	0.3	Borehole Locations
-0.3	0	0.5	Barriers
-0.2	0.02	> 0.5	
-0.1	0.05	Was Wet Now Dry	
-0.05	0.1	Was Dry Now Wet	
	0.2	Tuflow Model Boundary	

Paper Size ISO A3

0 50 100 m

Map Projection: Mercator Grid
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Barwon Water
Big Swamp Modelling for Detailed Design

Sensitivity run - High infiltration Wet period depth afflux (August 2019)

Project No. **12536659**
Revision No. **A**
Date. **24/12/2020**

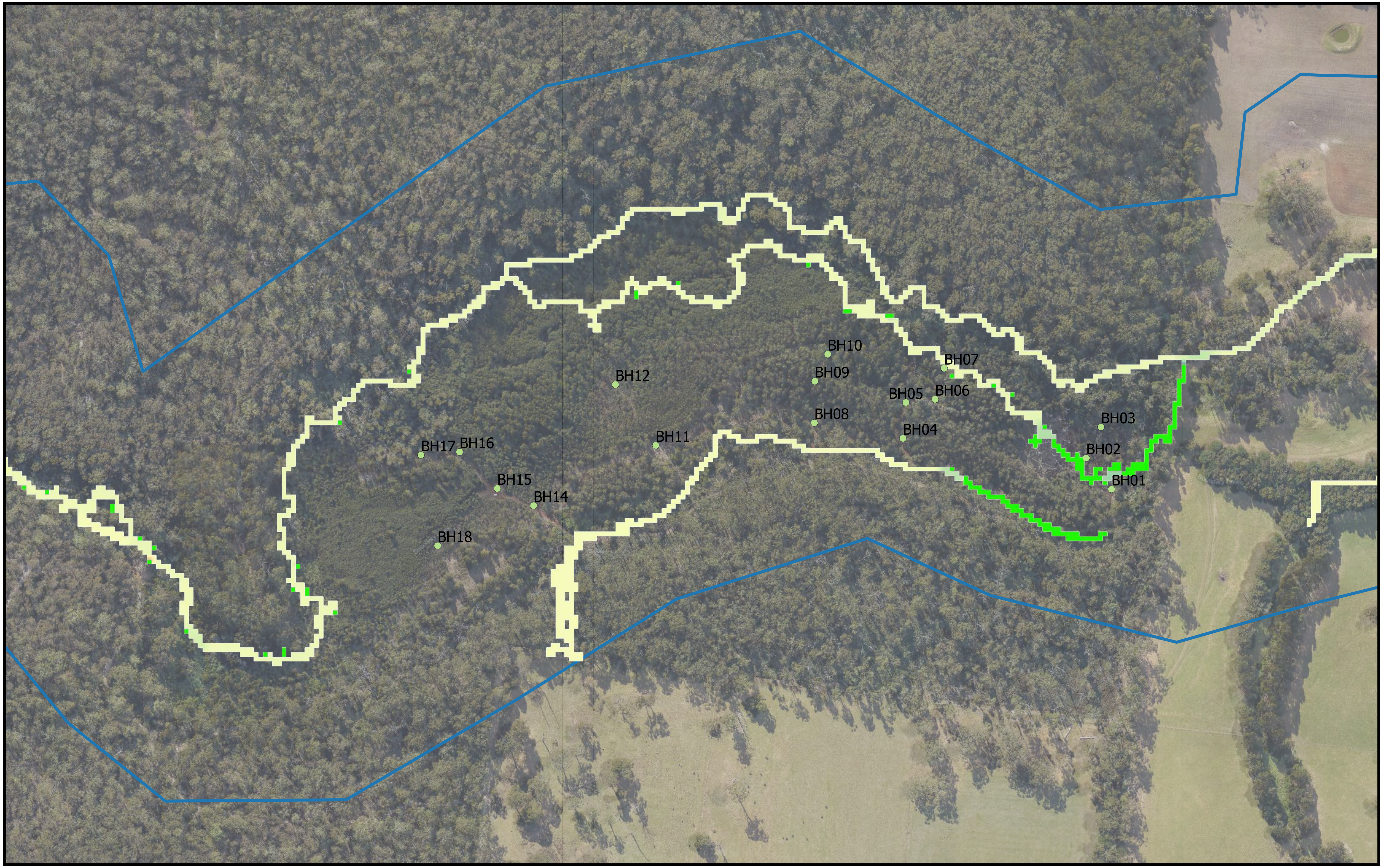
FIGURE SW-17

Document Path: \\ghdnet\ghd\AU\Melbourne\Projects\31\12536659\Tech\06_TUFLOW\TUFLOW\GIS workspaces\results_sensitivity.qgz

Data Source: Barwon Water, Imagery, 2019; Jacobs, Bore Locations, 2019; GHD, bore details, 2020;

Print Date:

Created By: Ellie Denson



Legend

Depth afflux (m)
- -0.5
- -0.3
- -0.2
- -0.1
- -0.05
- -0.02
- 0
- 0.02
- 0.05
- 0.1
- 0.2
- 0.3
- 0.5
- > 0.5
- Was Wet Now Dry
- Was Dry Now Wet
- Tuflow Model Boundary
- Borehole Locations
- Barriers

Paper Size ISO A3

0 50 100 m

Map Projection: Mercator Grid
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Barwon Water
Big Swamp Modelling for Detailed Design

Sensitivity run - High infiltration
Dry period depth afflux (March 2020)

Project No. 12536659
Revision No. A
Date. 24/12/2020

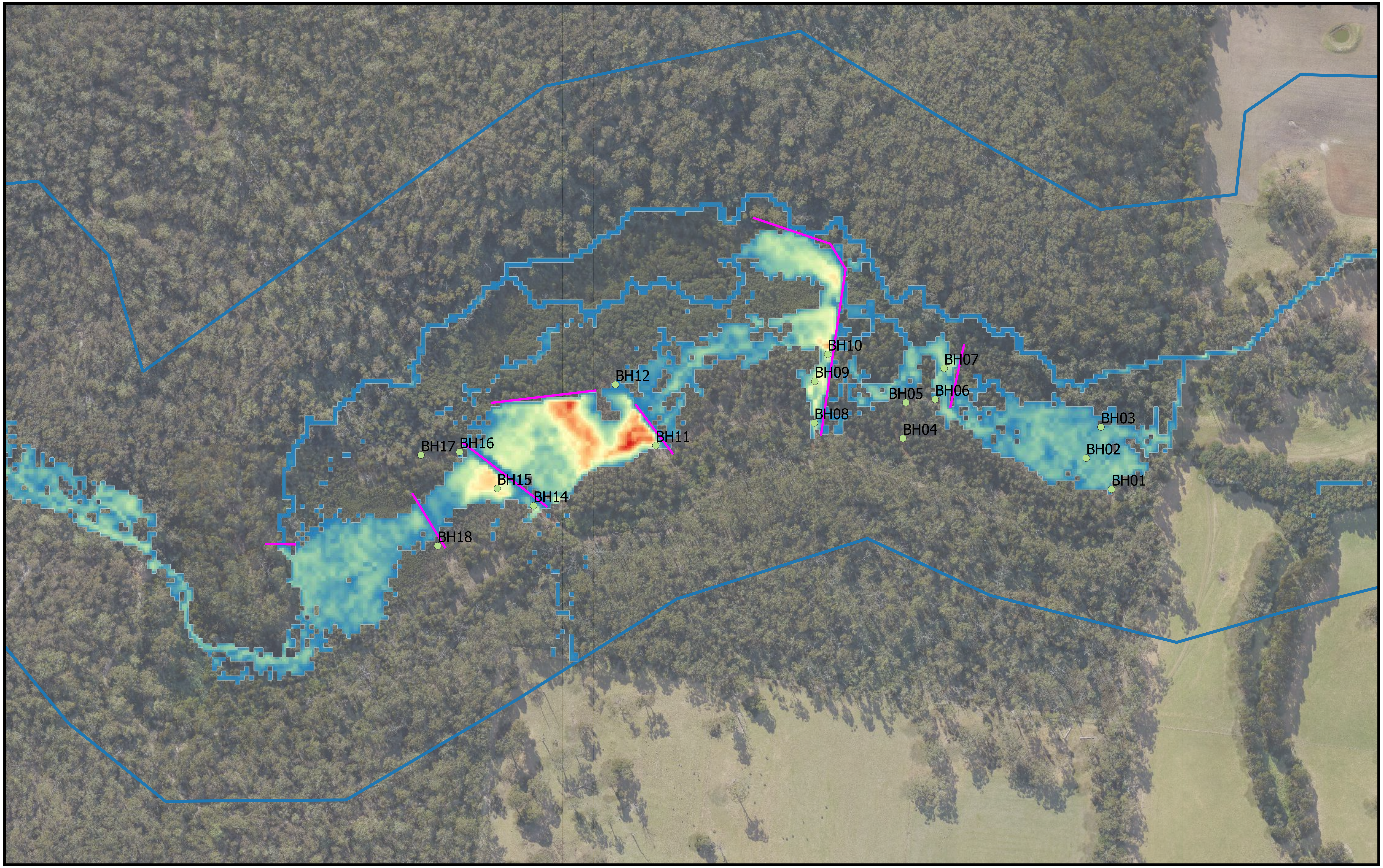
FIGURE SW-18

Document Path: \\ghdnet\ghd\AU\Melbourne\Projects\31\12536659\Tech\06_TUFLOW\TUFLOW\GIS workspaces\results_sensitivity.qgz

Data Source: Barwon Water, Imagery, 2019; Jacobs, Bore Locations, 2019; GHD, bore details, 2020;

Print Date:

Created By: Ellie Denson



Legend

Water Depth (m)

- 0
- 0.2
- 0.4
- 0.6
- 0.8
- 1
- 1.2
- Tufow model boundary
- Borehole locations
- Barriers

Paper Size ISO A3

0 50 100 m

Map Projection: Mercator Grid
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Barwon Water
Big Swamp Modelling for Detailed Design

Barrier group 3 version 2 results
Wet period water depths (August 2019)

Project No. **12536659**
Revision No. **A**
Date. **24/12/2020**

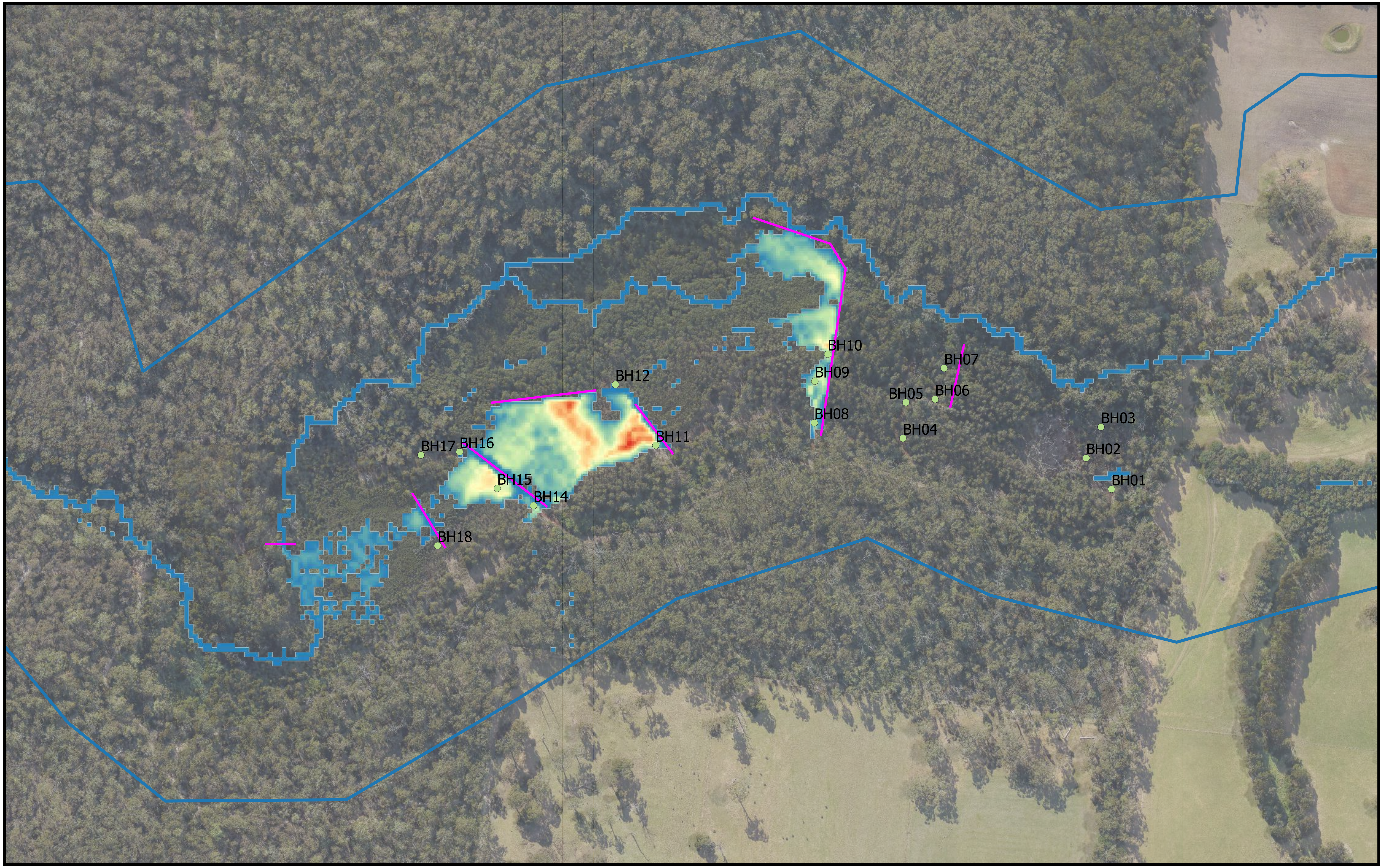
FIGURE SW-19

Document Path: \\ghdnet\ghd\AU\Melbourne\Projects\31\12536659\Tech\06_TUFLOW\TUFLOW\GIS workspaces\results_sensitivity.qgz

Data Source: Barwon Water, Imagery, 2019; Jacobs, Bore Locations, 2019; GHD, bore details, 2020;

Print Date:

Created By: Ellie Denson



Legend

Water Depth (m)

0	0.6	Borehole locations
0.2	0.8	Barriers
0.4	1	
	1.2	
	Tufow model boundary	

Paper Size ISO A3

0 50 100 m

Map Projection: Mercator Grid
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

GHD

Barwon Water
Big Swamp Modelling for Detailed Design

Barrier group 3 version 2 results
Dry period water depths (March 2020)

Project No. 12536659
Revision No. A
Date. 24/12/2020

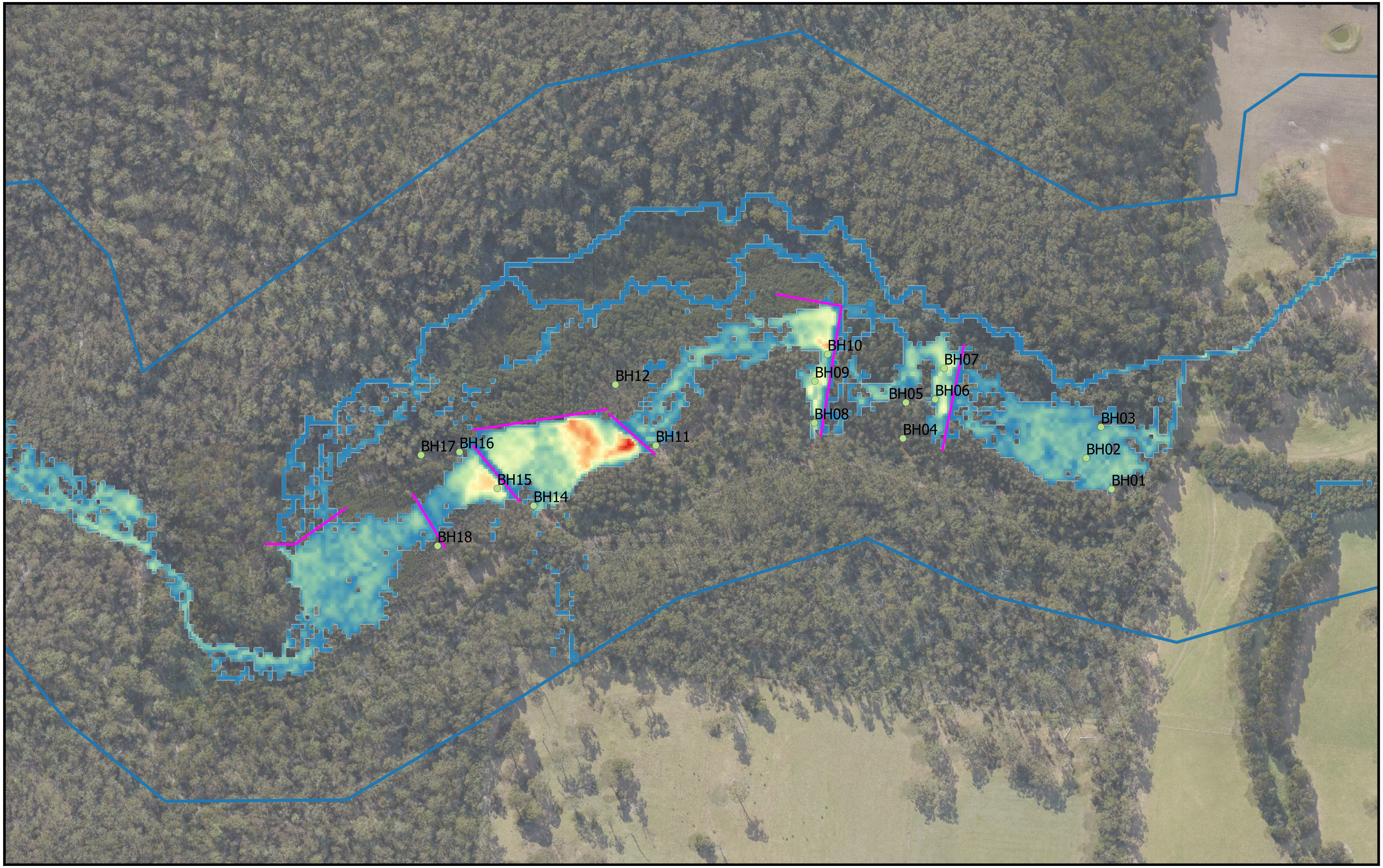
FIGURE SW-20

Document Path: \\ghdnet\ghd\AU\Melbourne\Projects\31\12536659\Tech\06_TUFLOW\TUFLOW\GIS workspaces\results_sensitivity.qgz

Data Source: Barwon Water, Imagery, 2019; Jacobs, Bore Locations, 2019; GHD, bore details, 2020;

Print Date:

Created By: Ellie Denson



Legend

Water Depth (m)

- 0
- 0.2
- 0.4
- 0.6
- 0.8
- 1
- 1.2
- Tufow model boundary
- Borehole locations
- Barriers

Paper Size ISO A3

0 50 100 m

Map Projection: Mercator Grid
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Barwon Water
Big Swamp Modelling for Detailed Design

Barrier group 5 results
Wet period water depths (August 2019)

Project No. **12536659**
Revision No. **A**
Date. **24/12/2020**

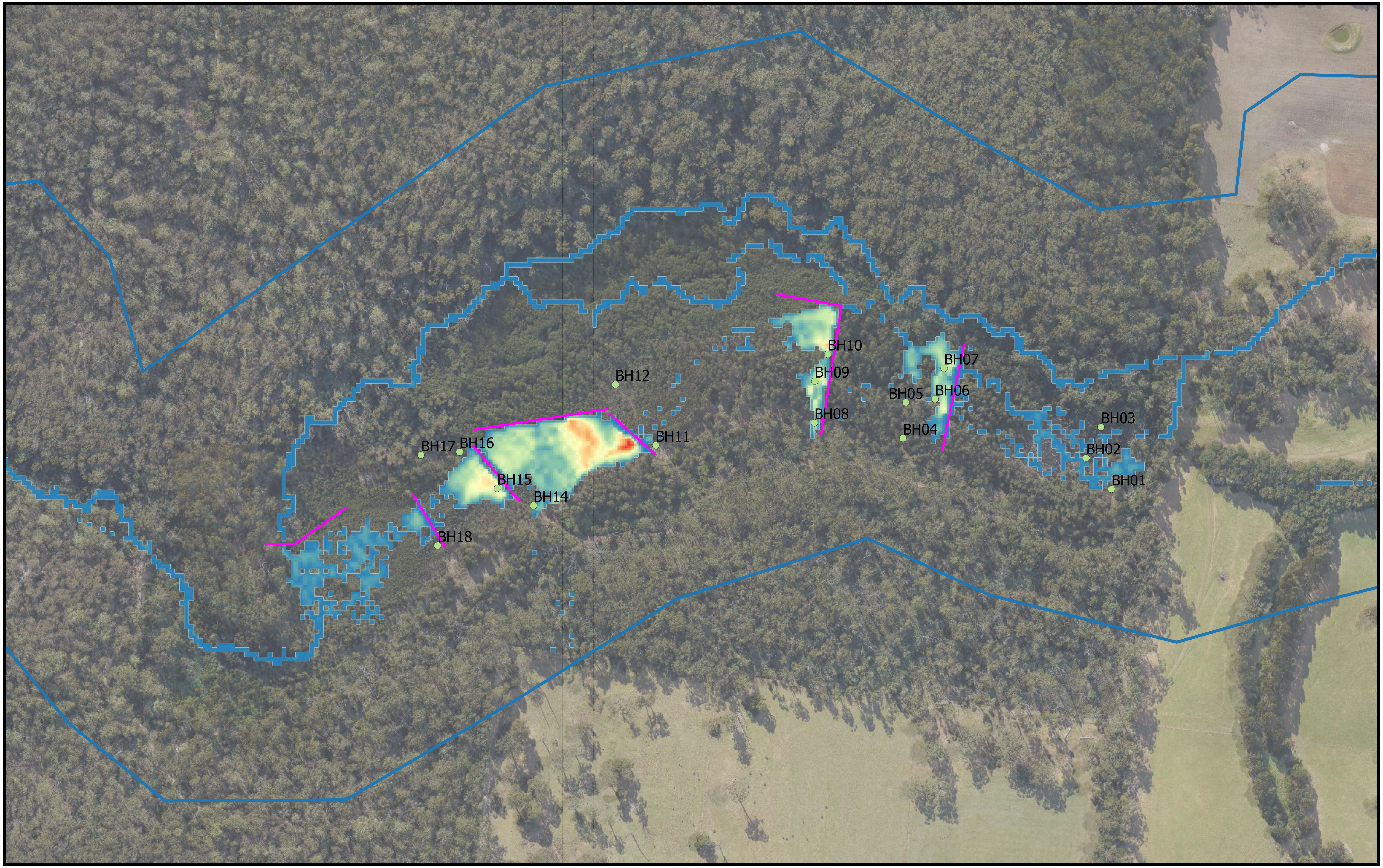
FIGURE SW-21

Document Path: \\ghdnet\ghd\AU\Melbourne\Projects\31\12536659\Tech\06_TUFLOW\TUFLOW\GIS workspaces\results_sensitivity.qgz

Data Source: Barwon Water, Imagery, 2019; Jacobs, Bore Locations, 2019; GHD, bore details, 2020;

Print Date:

Created By: Ellie Denson



Legend

Water Depth (m)
- 0
- 0.2
- 0.4
- 0.6
- 0.8
- 1
- 1.2
- Tufow model boundary
- Borehole locations
- Barriers

Paper Size ISO A3

0 50 100 m

Map Projection: Mercator Grid
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

GHD

Barwon Water
Big Swamp Modelling for Detailed Design

Barrier group 5 results
Dry period water depths (March 2020)

Project No. 12536659
Revision No. A
Date. 24/12/2020

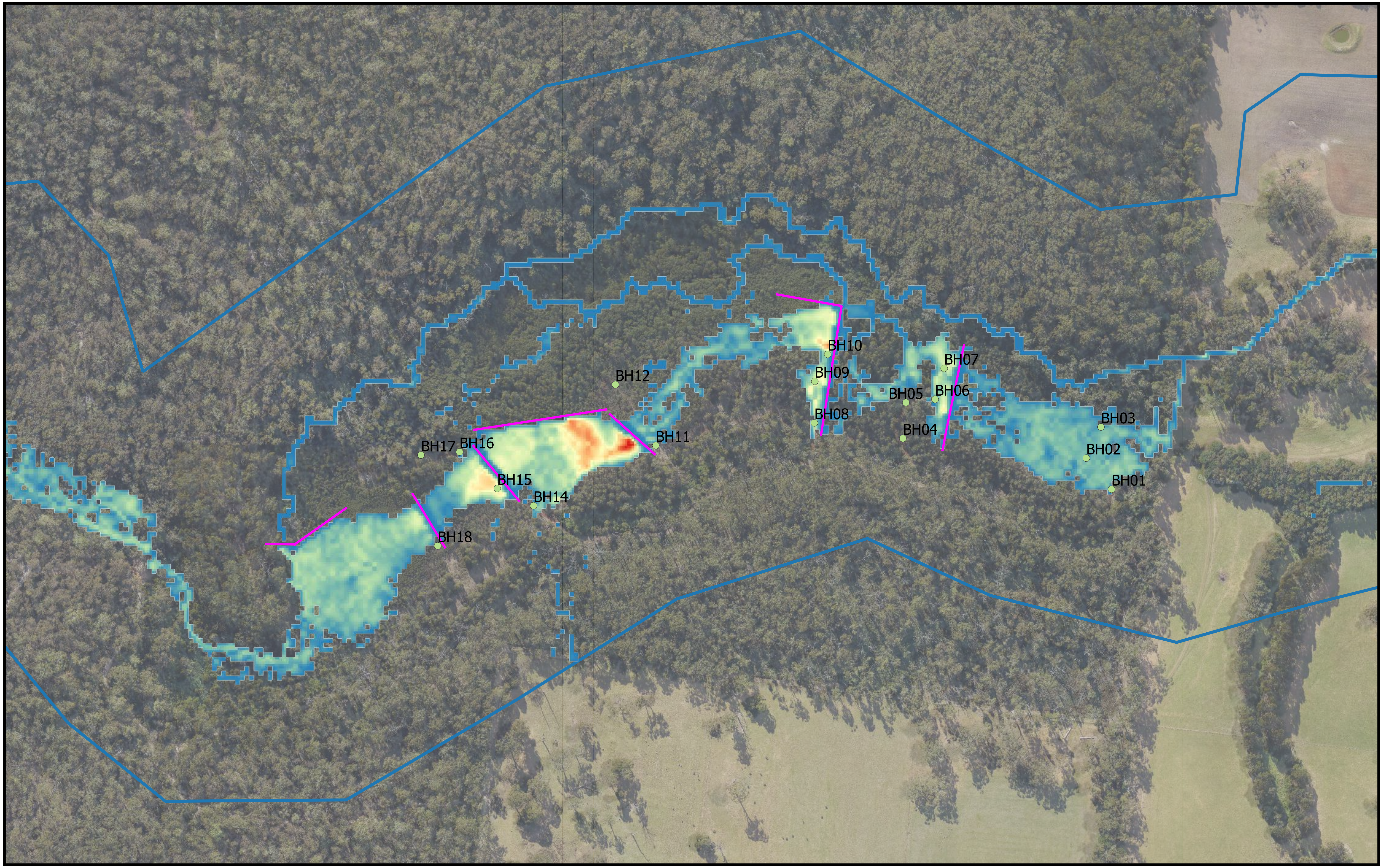
FIGURE SW-22

Document Path: \\ghdnet\ghd\AU\Melbourne\Projects\31\12536659\Tech\06_TUFLOW\TUFLOW\GIS workspaces\results_sensitivity.qgz

Data Source: Barwon Water, Imagery, 2019; Jacobs, Bore Locations, 2019; GHD, bore details, 2020;

Print Date:

Created By: Ellie Denson



Legend

Water Depth (m)

- 0
- 0.2
- 0.4
- 0.6
- 0.8
- 1
- 1.2
- Tufow model boundary
- Borehole locations
- Barriers

Paper Size ISO A3

0 50 100 m

Map Projection: Mercator Grid
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Barwon Water
Big Swamp Modelling for Detailed Design

Barrier group 8 results
Wet period water depths (August 2019)

Project No. **12536659**
Revision No. **A**
Date. **24/12/2020**

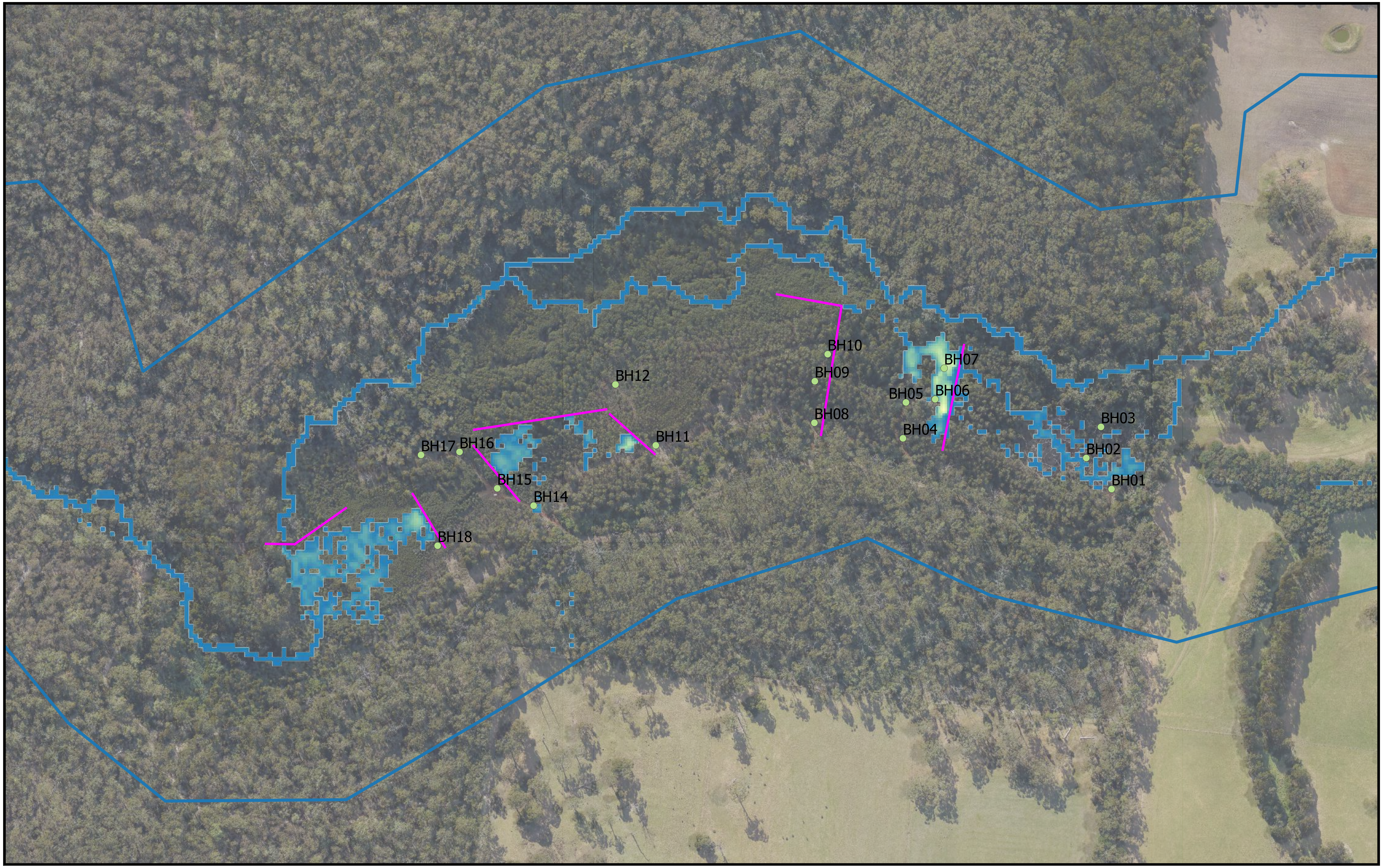
FIGURE SW-23

Document Path: \\ghdnet\ghd\AU\Melbourne\Projects\31\12536659\Tech\06_TUFLOW\TUFLOW\GIS workspaces\results_sensitivity.qgz

Data Source: Barwon Water, Imagery, 2019; Jacobs, Bore Locations, 2019; GHD, bore details, 2020;

Print Date:

Created By: Ellie Denson



Legend

Water Depth (m)			
0	0.6	Borehole locations	
0.2	0.8	Barriers	
0.4	1		
	1.2		
	Tufow model boundary		

Paper Size ISO A3

0 50 100 m

Map Projection: Mercator Grid
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Barwon Water

Big Swamp Modelling for Detailed Design

Barrier group 8 results
Dry period water depths (March 2020)

Project No. **12536659**
Revision No. **A**
Date. **24/12/2020**

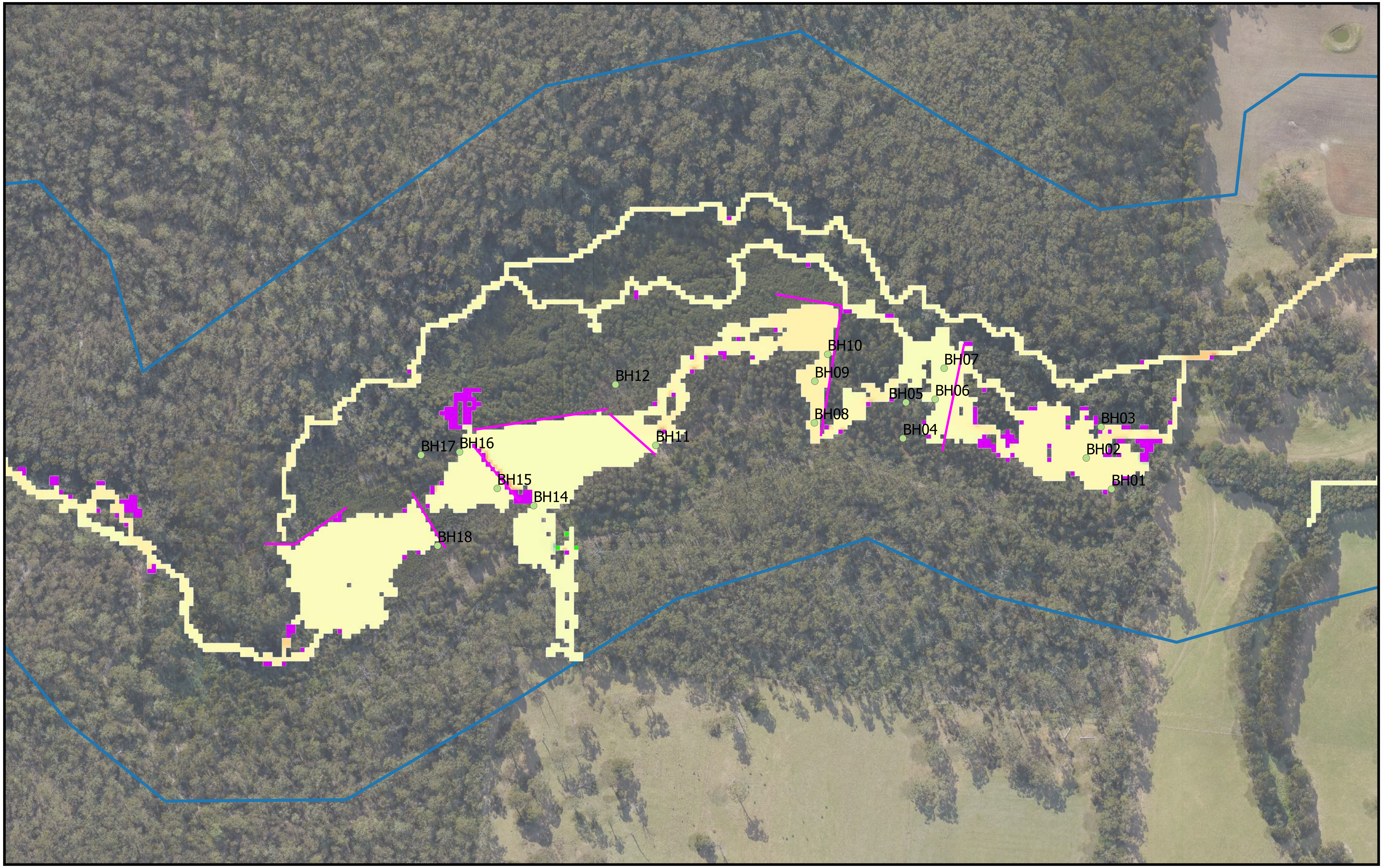
FIGURE SW-24

Document Path: \\ghdnet\ghd\AU\Melbourne\Projects\31\12536659\Tech\06_TUFLOW\TUFLOW\GIS workspaces\results_sensitivity.qgz

Data Source: Barwon Water, Imagery, 2019; Jacobs, Bore Locations, 2019; GHD, bore details, 2020;

Print Date:

Created By: Ellie Denson



Legend

Depth afflux (m)
- -0.5
- -0.3
- -0.2
- -0.1
- -0.05
- -0.02
- 0
- 0.02
- 0.05
- 0.1
- 0.2
- 0.3
- 0.5
- > 0.5
- Was Wet Now Dry
- Was Dry Now Wet
- Tuflow Model Boundary
- Borehole Locations
- Barriers

Paper Size ISO A3

0 50 100 m

Map Projection: Mercator Grid
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Barwon Water

Big Swamp Modelling for Detailed Design

Proposed barriers with 3ML/day supplimentary flow

Dry period depth afflux compared to 2ML/day

Project No. **12536659**
Revision No. **A**
Date. **24/12/2020**

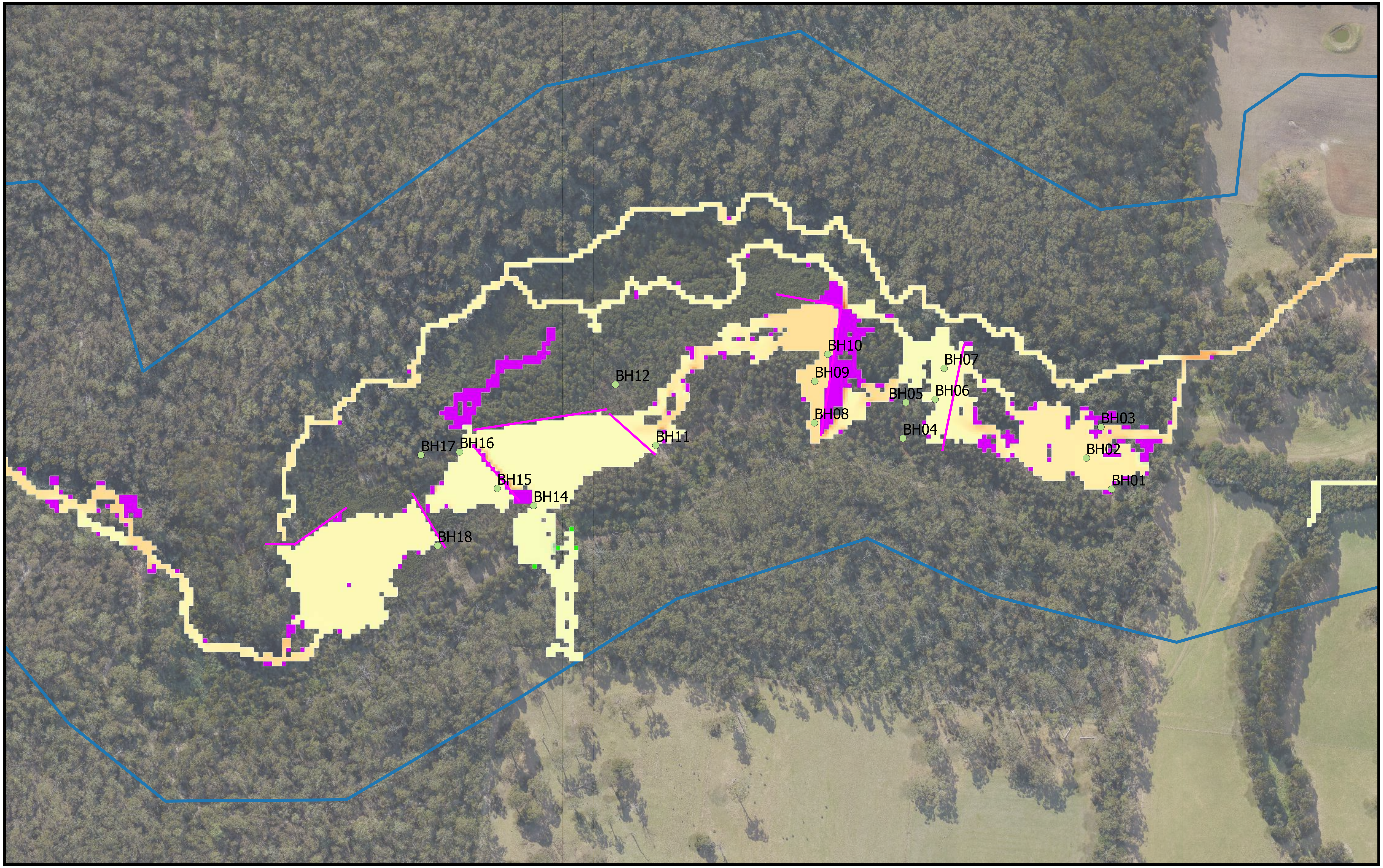
FIGURE SW-25

Document Path: \\ghdnet\ghd\AU\Melbourne\Projects\31\12536659\Tech\06_TUFLOW\TUFLOW\GIS workspaces\results_sensitivity.qgz

Data Source: Barwon Water, Imagery, 2019; Jacobs, Bore Locations, 2019; GHD, bore details, 2020;

Print Date:

Created By: Ellie Denson



Legend

Depth afflux (m)

-0.5	-0.02	0.3	Borehole Locations
-0.3	0	0.5	Barriers
-0.2	0.02	> 0.5	
-0.1	0.05	Was Wet Now Dry	
-0.05	0.1	Was Dry Now Wet	
	0.2	Tuflow Model Boundary	

Paper Size ISO A3

0 50 100 m

Map Projection: Mercator Grid
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

GHD

Barwon Water

Big Swamp Modelling for Detailed Design

Proposed barriers with 4ML/day supplimentary flow

Dry period depth afflux compared to 2ML/day

Project No. 12536659
Revision No. A
Date. 24/12/2020

FIGURE SW-26

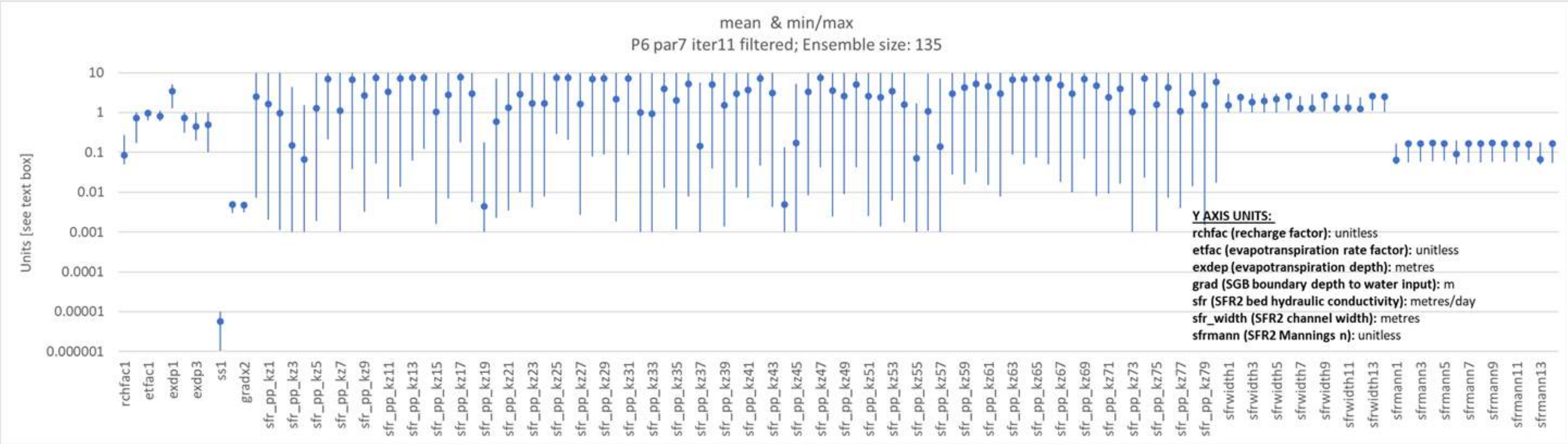
Document Path: \\ghdnet\ghd\AU\Melbourne\Projects\31\12536659\Tech\06_TUFLOW\TUFLOW\GIS workspaces\results_sensitivity.qgz

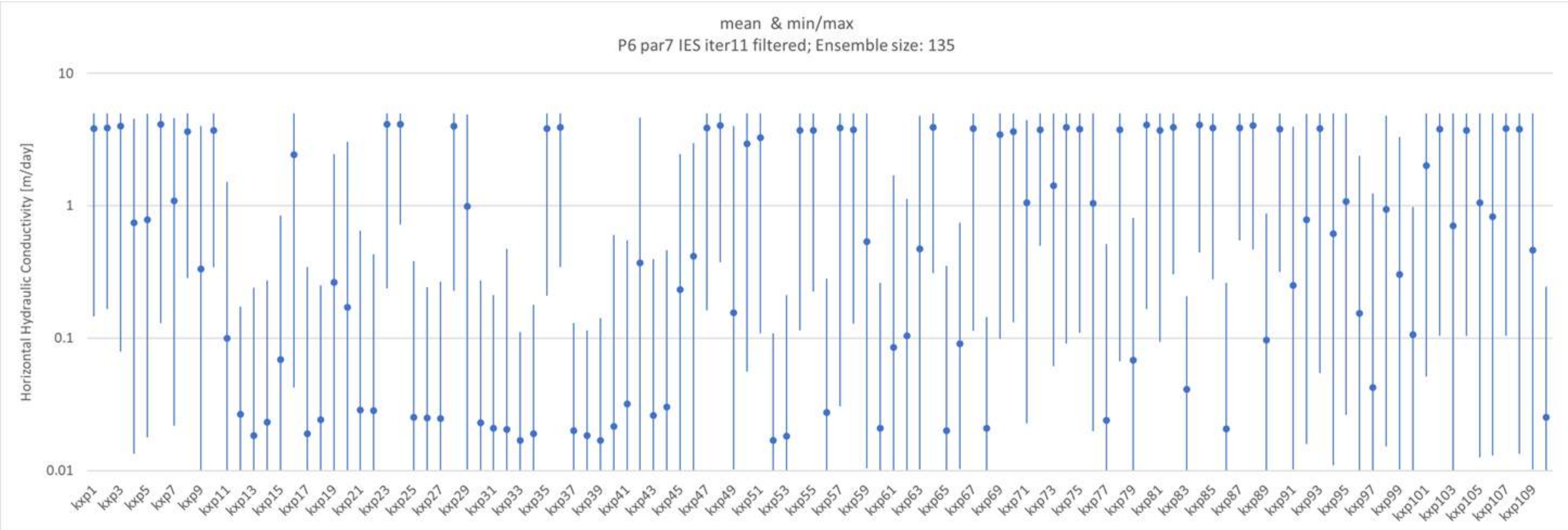
Data Source: Barwon Water, Imagery, 2019; Jacobs, Bore Locations, 2019; GHD, bore details, 2020;

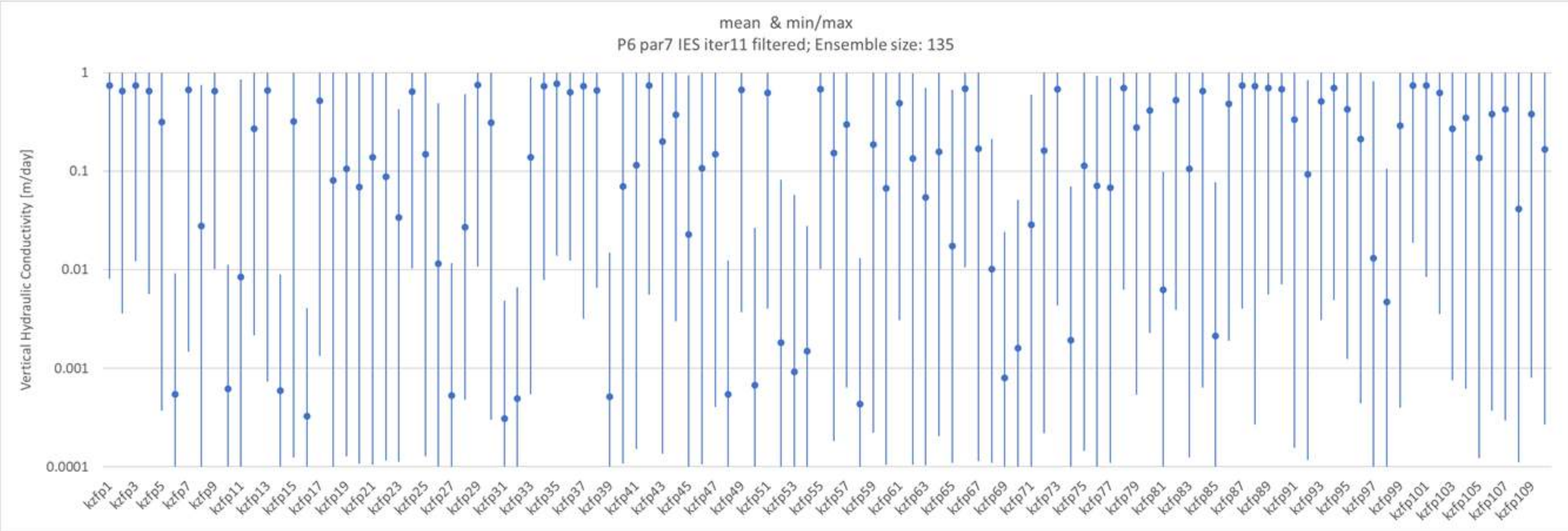
Print Date:

Created By: Ellie Denson

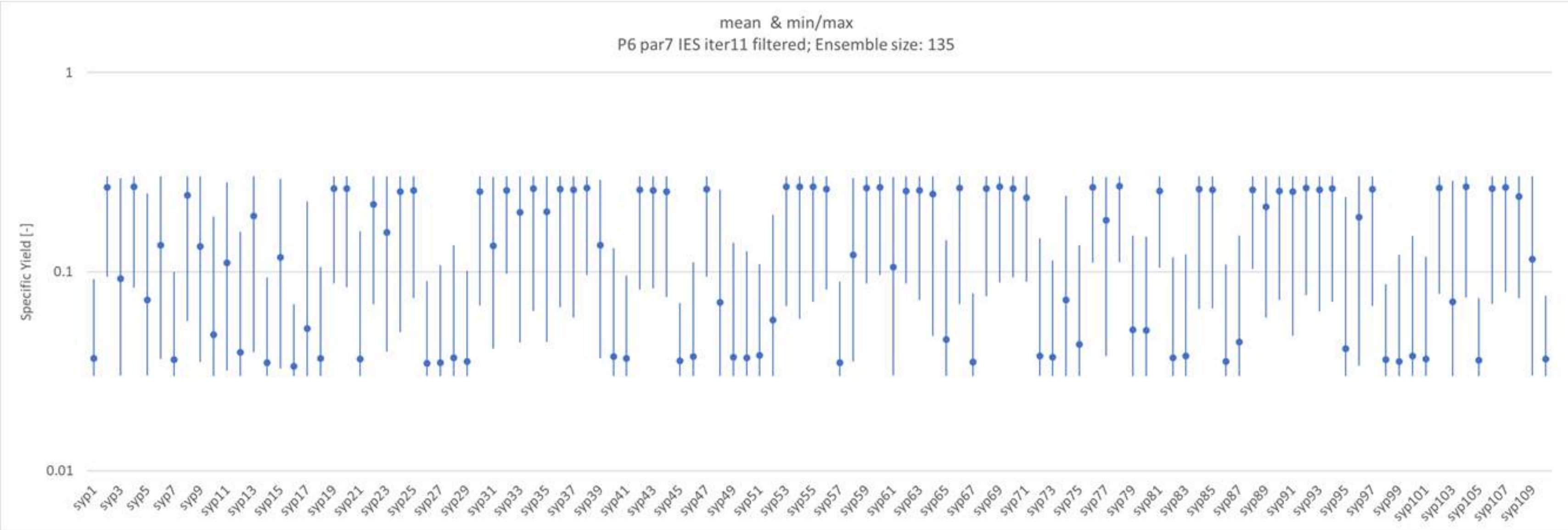
Appendix B – Stochastic history-matched parameter ranges


mean & min/max
P6 par7 iter11 filtered; Ensemble size: 135
Units [see text box]
Y AXIS UNITS:
rchfac (recharge factor): unitless
etfac (evapotranspiration rate factor): unitless
exdep (evapotranspiration depth): metres
grad (SGB boundary depth to water input): m
sfr (SFR2 bed hydraulic conductivity): metres/day
sfr_width (SFR2 channel width): metres
sfrmann (SFR2 Mannings n): unitless


mean & min/max
P6 par7 IES iter11 filtered; Ensemble size: 135
Horizontal Hydraulic Conductivity [m/day]



mean & min/max
P6 par7 IES iter11 filtered; Ensemble size: 135
Vertical Hydraulic Conductivity [m/day]
1
0.1
0.01
0.001
0.0001
kzfp1
kzfp3
kzfp5
kzfp7
kzfp9
kzfp11
kzfp13
kzfp15
kzfp17
kzfp19
kzfp21
kzfp23
kzfp25
kzfp27
kzfp29
kzfp31
kzfp33
kzfp35
kzfp37
kzfp39
kzfp41
kzfp43
kzfp45
kzfp47
kzfp49
kzfp51
kzfp53
kzfp55
kzfp57
kzfp59
kzfp61
kzfp63
kzfp65
kzfp67
kzfp69
kzfp71
kzfp73
kzfp75
kzfp77
kzfp79
kzfp81
kzfp83
kzfp85
kzfp87
kzfp89
kzfp91
kzfp93
kzfp95
kzfp97
kzfp99
kzfp101
kzfp103
kzfp105
kzfp107
kzfp109



mean & min/max
P6 par7 IES iter11 filtered; Ensemble size: 135
Specific Yield [-]
1
0.1
0.01
syp1
syp3
syp5
syp7
syp9
syp11
syp13
syp15
syp17
syp19
syp21
syp23
syp25
syp27
syp29
syp31
syp33
syp35
syp37
syp39
syp41
syp43
syp45
syp47
syp49
syp51
syp53
syp55
syp57
syp59
syp61
syp63
syp65
syp67
syp69
syp71
syp73
syp75
syp77
syp79
syp81
syp83
syp85
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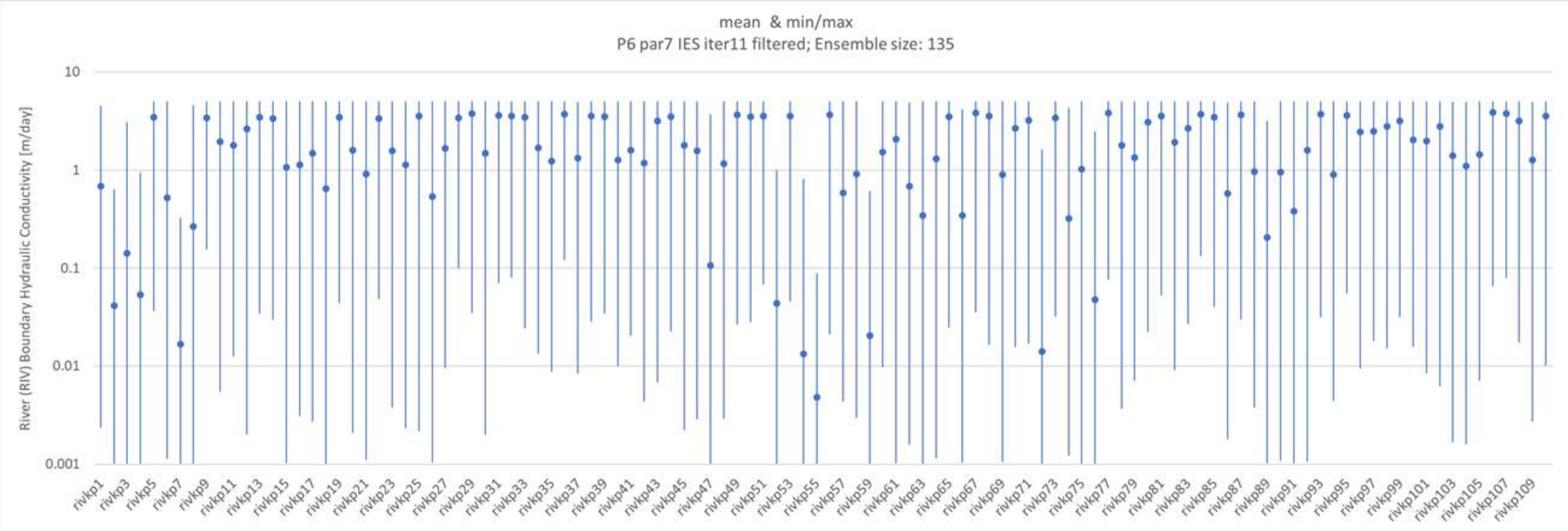
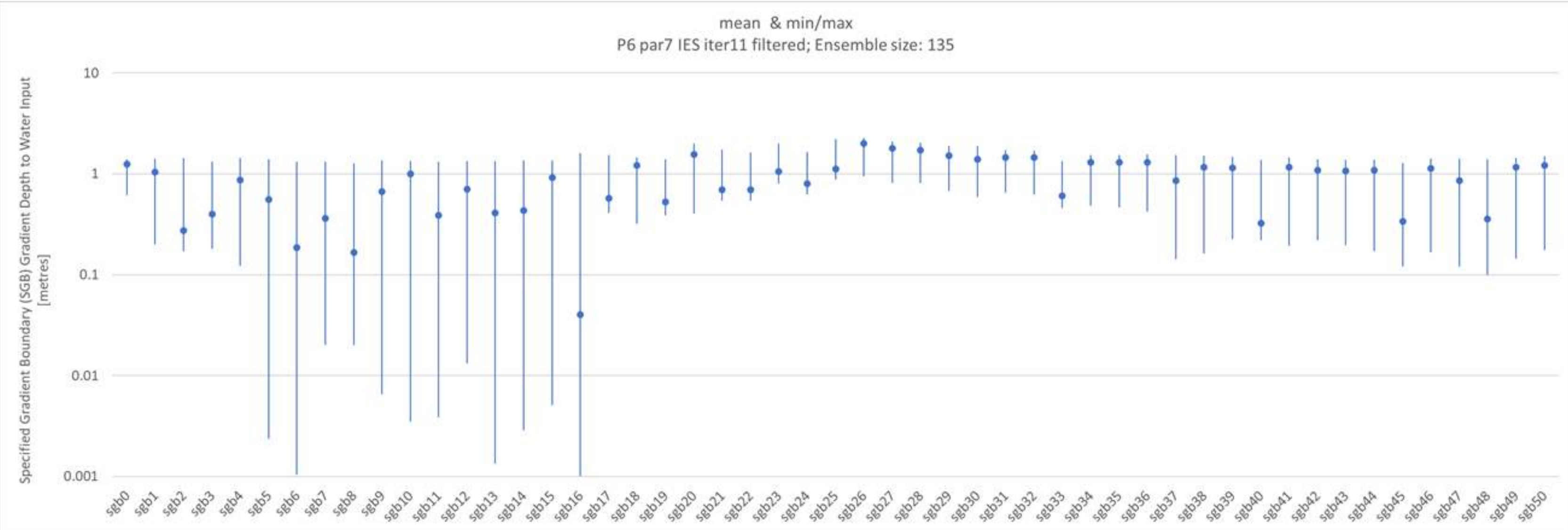
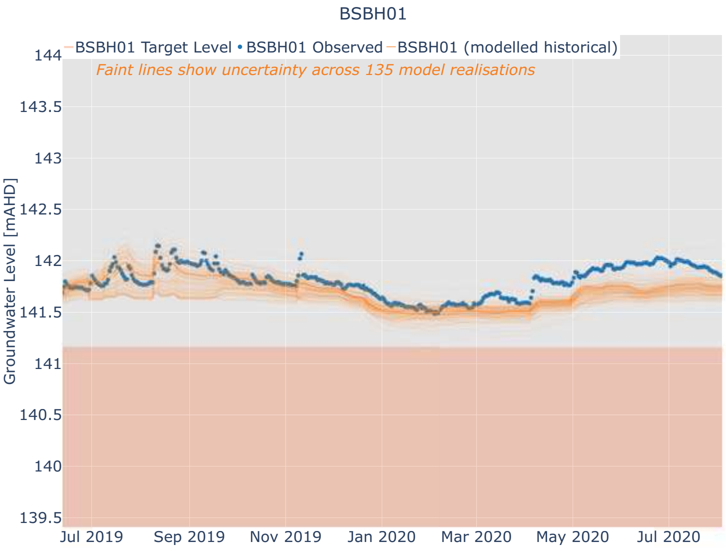
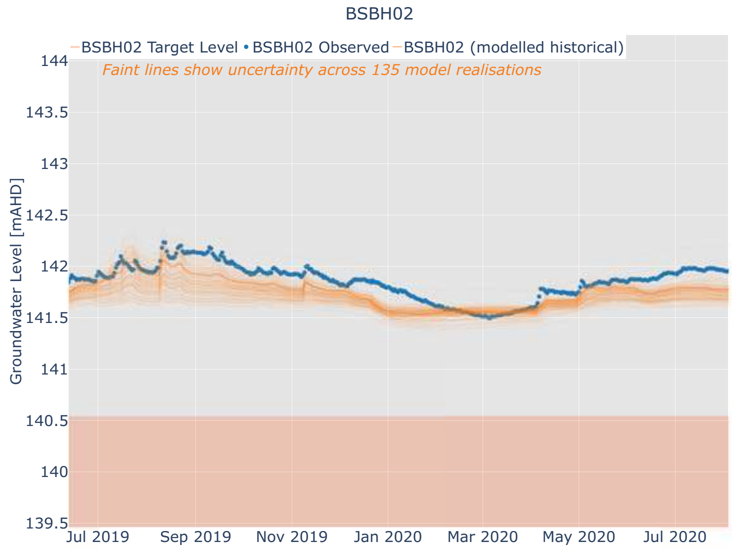
syp103
syp105
syp107
syp109

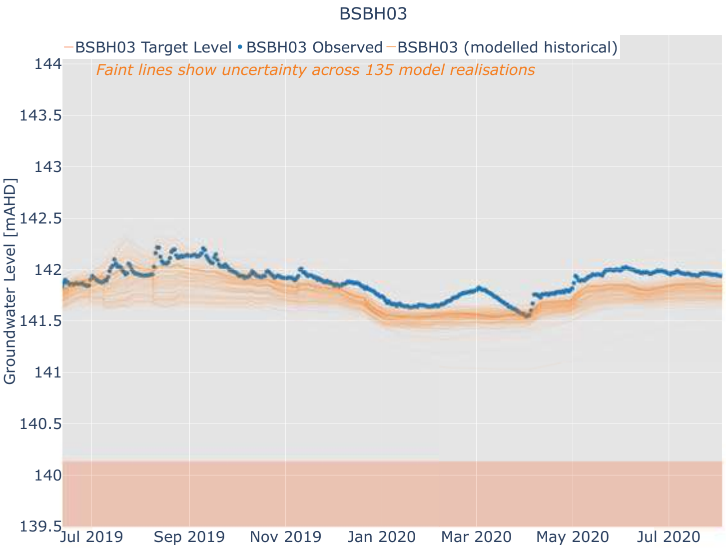

mean & min/max
P6 par7 IES iter11 filtered; Ensemble size: 135
River (RIV) Boundary Hydraulic Conductivity [m/day]
10
1
0.1
0.01
0.001

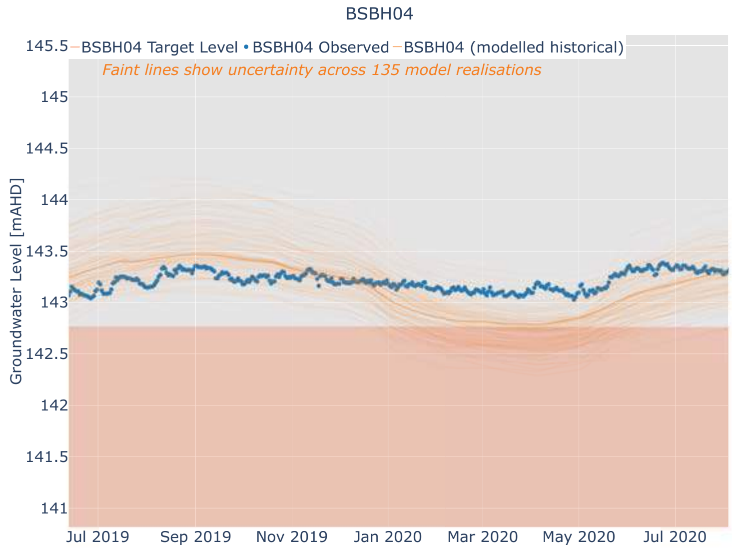

mean & min/max
P6 par7 IES iter11 filtered; Ensemble size: 135
Specified Gradient Boundary (SGB) Gradient Depth to Water Input [metres]
10
1
0.1
0.01
0.001

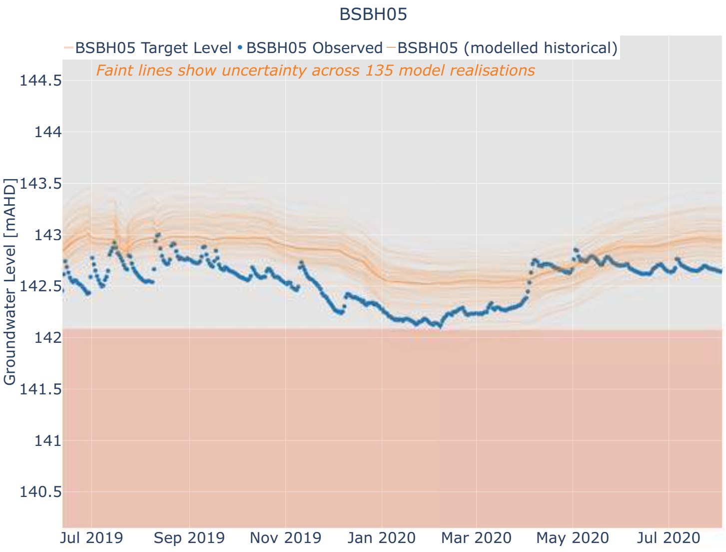
Appendix C – Stochastic history matching – groundwater level hydrographs

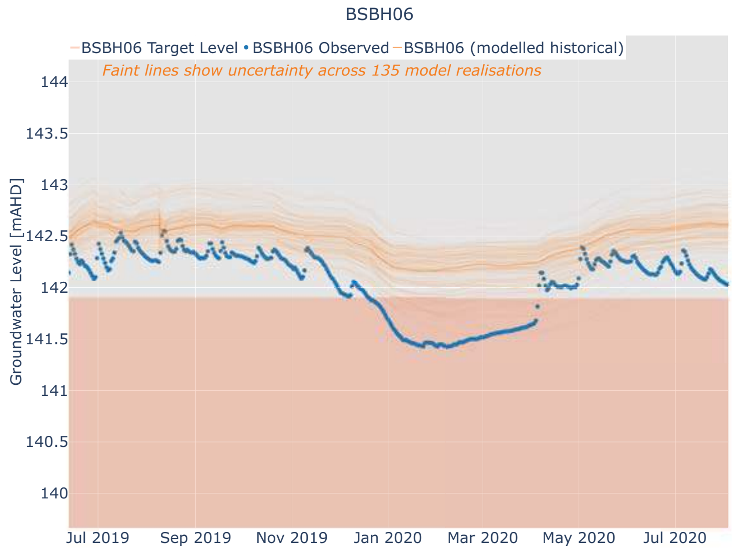

BSBH01
BSBH01 Target Level
BSBH01 Observed
BSBH01 (modelled historical)
Faint lines show uncertainty across 135 model realisations
Groundwater Level [mAHD]
144
143.5
143
142.5
142
141.5
141
140.5
140
139.5
Jul 2019
Sep 2019
Nov 2019
Jan 2020
Mar 2020
May 2020
Jul 2020


BSBH02
BSBH02 Target Level
BSBH02 Observed
BSBH02 (modelled historical)
Faint lines show uncertainty across 135 model realisations
Groundwater Level [mAHD]
144
143.5
143
142.5
142
141.5
141
140.5
140
139.5
Jul 2019
Sep 2019
Nov 2019
Jan 2020
Mar 2020
May 2020
Jul 2020

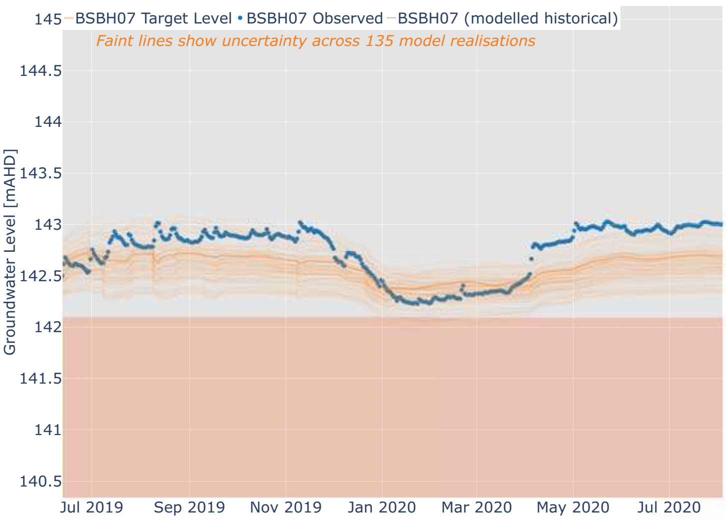

BSBH03
BSBH03 Target Level
BSBH03 Observed
BSBH03 (modelled historical)
Faint lines show uncertainty across 135 model realisations
Groundwater Level [mAHD]
144
143.5
143
142.5
142
141.5
141
140.5
140
139.5
Jul 2019
Sep 2019
Nov 2019
Jan 2020
Mar 2020
May 2020
Jul 2020


BSBH04
BSBH04 Target Level
BSBH04 Observed
BSBH04 (modelled historical)
Faint lines show uncertainty across 135 model realisations
Groundwater Level [mAHD]
145.5
145
144.5
144
143.5
143
142.5
142
141.5
141
Jul 2019
Sep 2019
Nov 2019
Jan 2020
Mar 2020
May 2020
Jul 2020

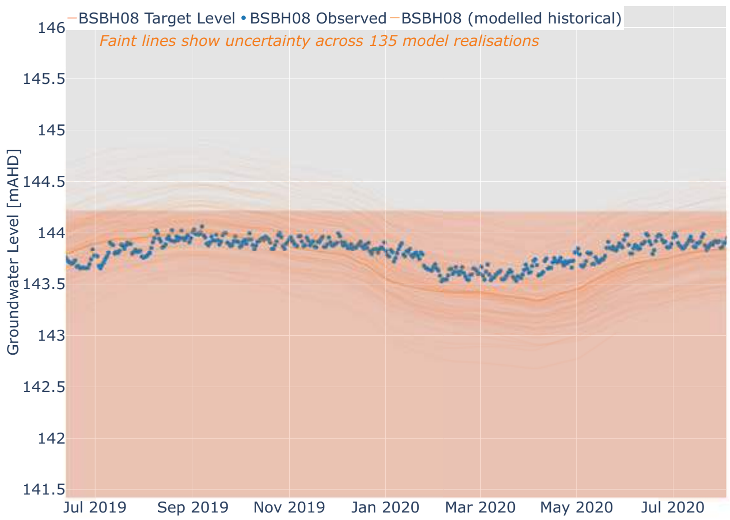

BSBH05
BSBH05 Target Level
BSBH05 Observed
BSBH05 (modelled historical)
Faint lines show uncertainty across 135 model realisations
Groundwater Level [mAHD]
144.5
144
143.5
143
142.5
142
141.5
141
140.5
Jul 2019
Sep 2019
Nov 2019
Jan 2020
Mar 2020
May 2020
Jul 2020


BSBH06
BSBH06 Target Level
BSBH06 Observed
BSBH06 (modelled historical)
Faint lines show uncertainty across 135 model realisations
Groundwater Level [mAHD]
144
143.5
143
142.5
142
141.5
141
140.5
140
Jul 2019
Sep 2019
Nov 2019
Jan 2020
Mar 2020
May 2020
Jul 2020

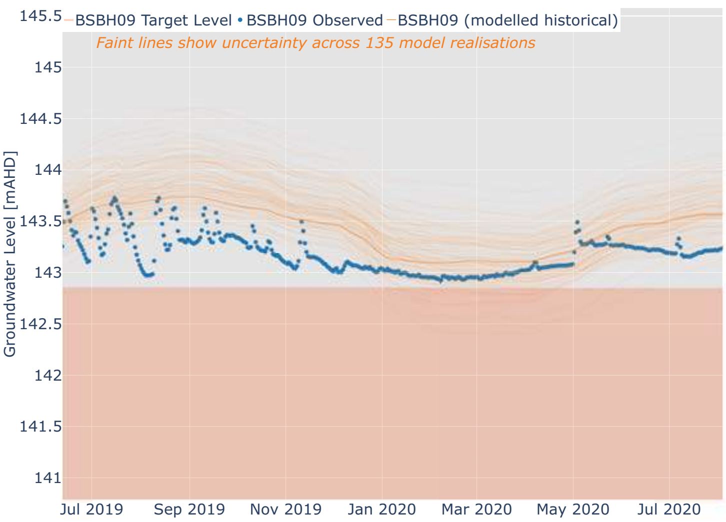
BSBH07



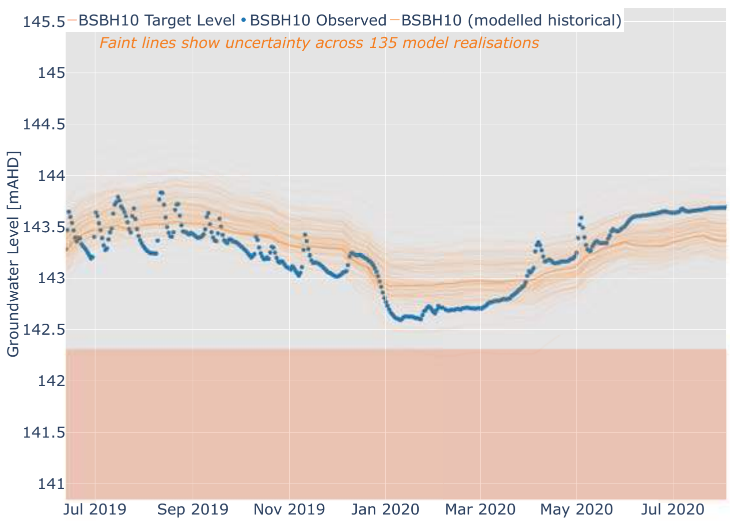
BSBH08



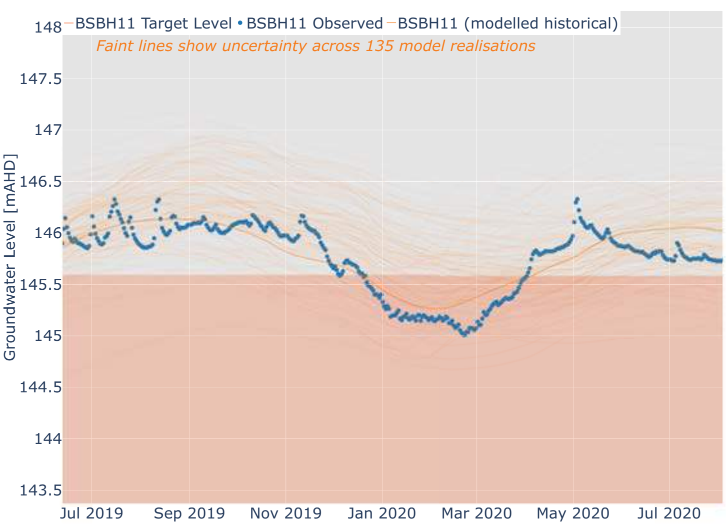
BSBH09



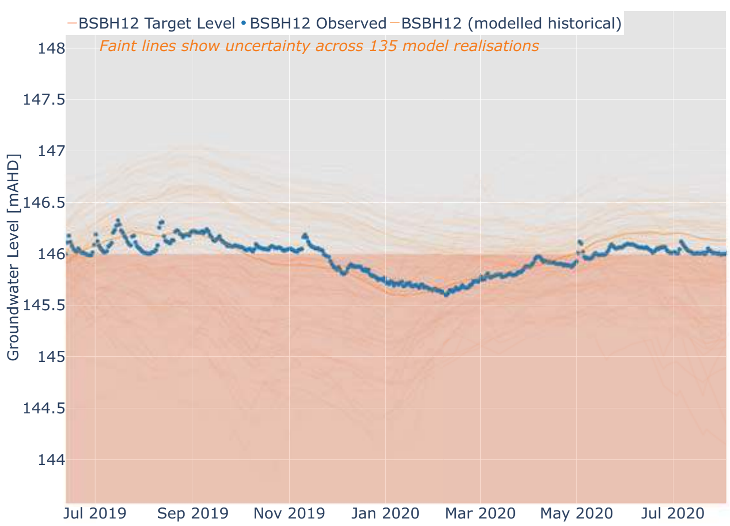
BSBH10

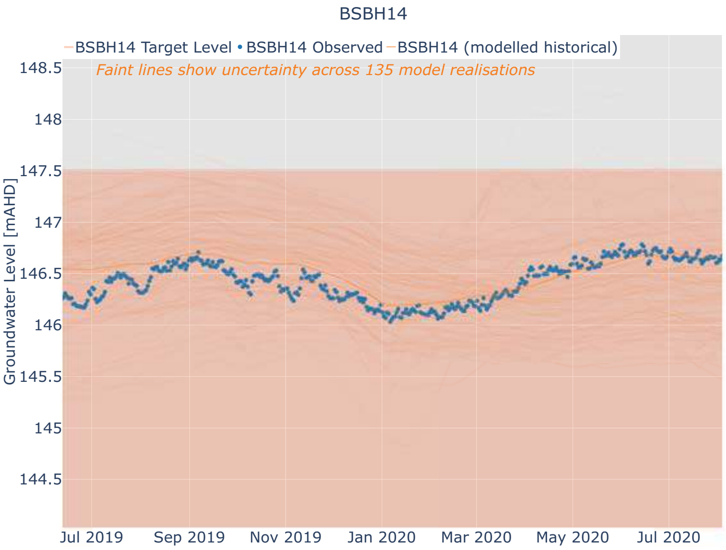


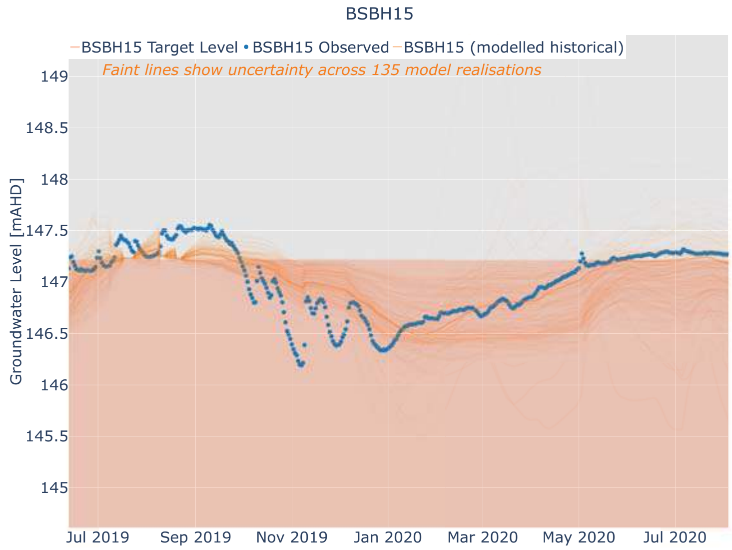
BSBH11

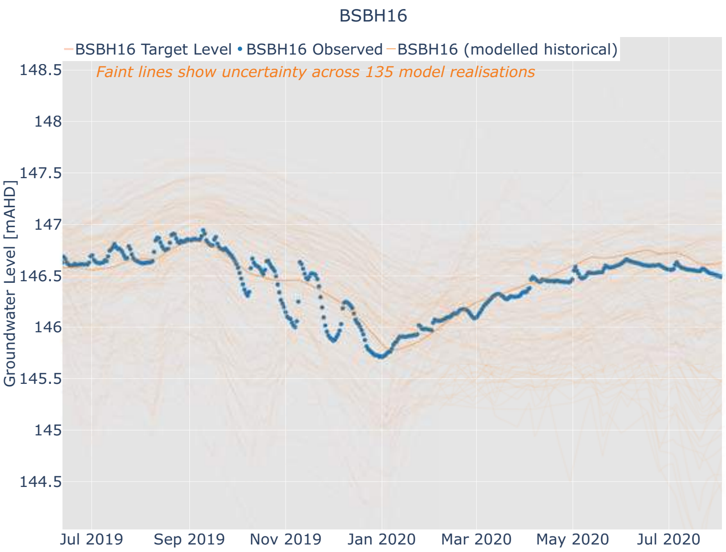


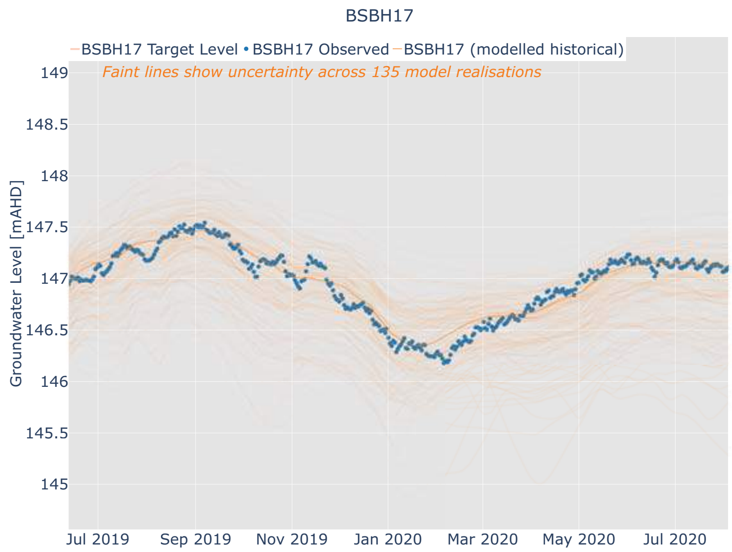
BSBH12

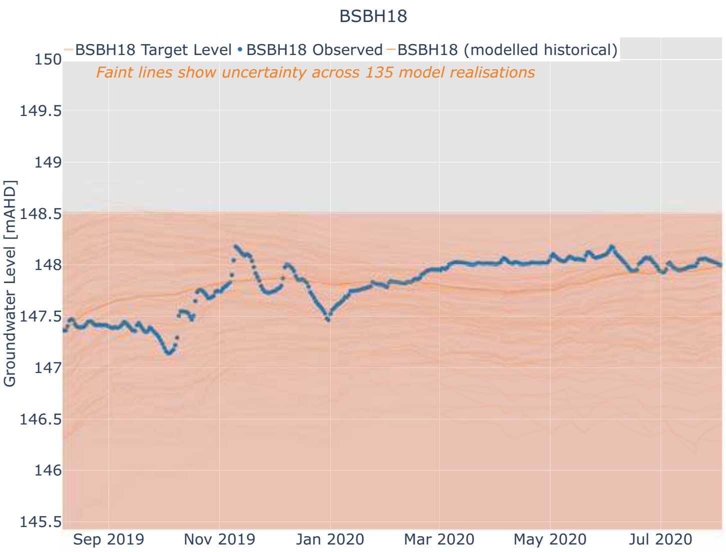


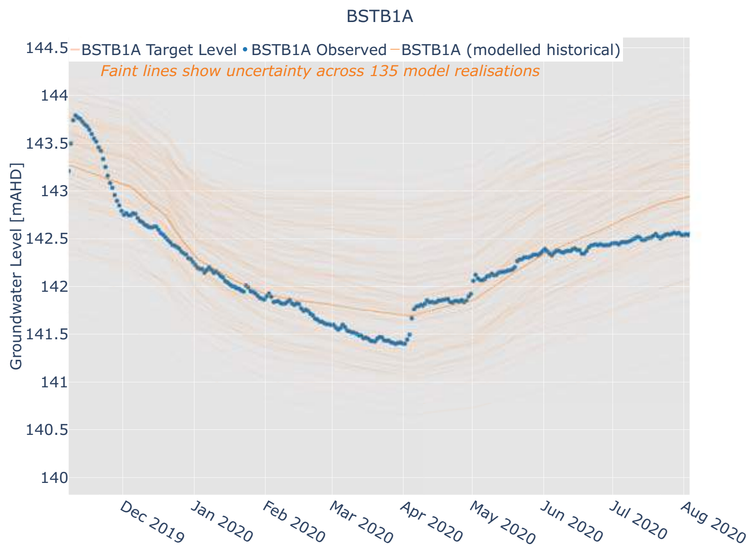

BSBH14
BSBH14 Target Level
BSBH14 Observed
BSBH14 (modelled historical)
Faint lines show uncertainty across 135 model realisations
Groundwater Level [mAHD]
Jul 2019
Sep 2019
Nov 2019
Jan 2020
Mar 2020
May 2020
Jul 2020


BSBH15
BSBH15 Target Level
BSBH15 Observed
BSBH15 (modelled historical)
Faint lines show uncertainty across 135 model realisations
Groundwater Level [mAHD]
Jul 2019
Sep 2019
Nov 2019
Jan 2020
Mar 2020
May 2020
Jul 2020

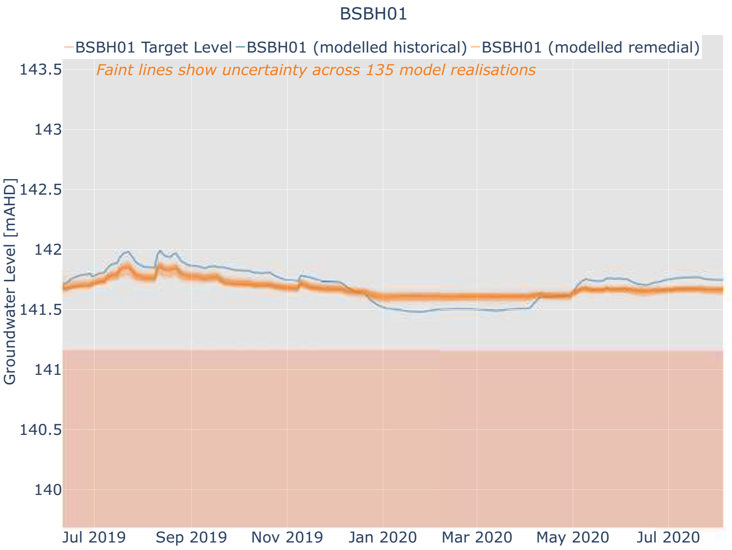

BSBH16
BSBH16 Target Level
BSBH16 Observed
BSBH16 (modelled historical)
Faint lines show uncertainty across 135 model realisations
Groundwater Level [mAHD]
Jul 2019
Sep 2019
Nov 2019
Jan 2020
Mar 2020
May 2020
Jul 2020

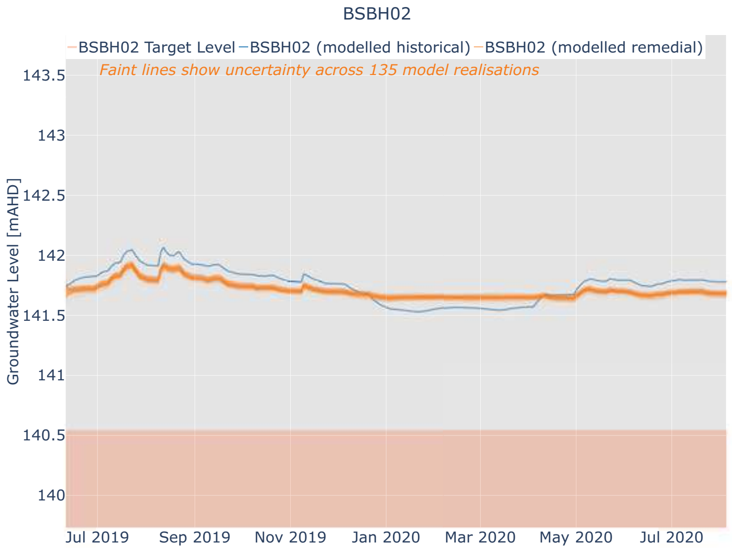

BSBH17
BSBH17 Target Level
BSBH17 Observed
BSBH17 (modelled historical)
Faint lines show uncertainty across 135 model realisations
Groundwater Level [mAHD]
Jul 2019
Sep 2019
Nov 2019
Jan 2020
Mar 2020
May 2020
Jul 2020

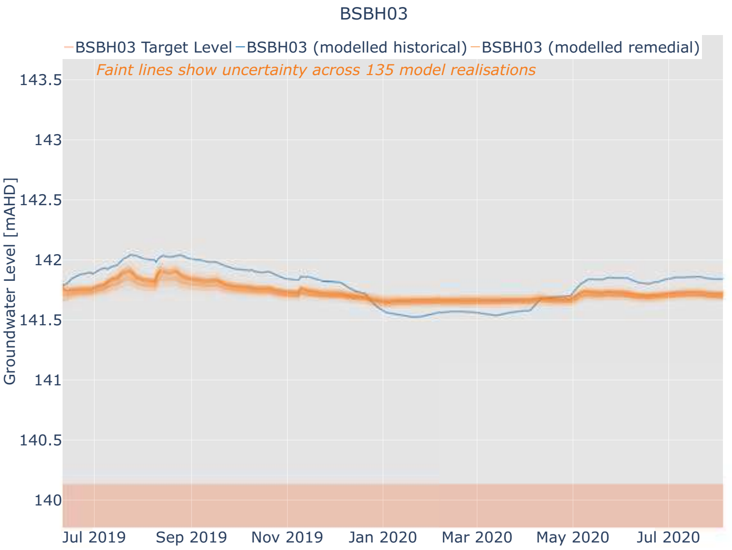

BSBH18
BSBH18 Target Level
BSBH18 Observed
BSBH18 (modelled historical)
Faint lines show uncertainty across 135 model realisations
Groundwater Level [mAHD]
Sep 2019
Nov 2019
Jan 2020
Mar 2020
May 2020
Jul 2020


BSTB1A
BSTB1A Target Level
BSTB1A Observed
BSTB1A (modelled historical)
Faint lines show uncertainty across 135 model realisations
Groundwater Level [mAHD]
Dec 2019
Jan 2020
Feb 2020
Mar 2020
Apr 2020
May 2020
Jun 2020
Jul 2020
Aug 2020

Appendix D – Stochastic remedial forecasting – groundwater level hydrographs


BSBH01
BSBH01 Target Level
BSBH01 (modelled historical)
BSBH01 (modelled remedial)
Faint lines show uncertainty across 135 model realisations
Groundwater Level [mAHD]
143.5
143
142.5
142
141.5
141
140.5
140
Jul 2019
Sep 2019
Nov 2019
Jan 2020
Mar 2020
May 2020
Jul 2020


BSBH02
BSBH02 Target Level
BSBH02 (modelled historical)
BSBH02 (modelled remedial)
Faint lines show uncertainty across 135 model realisations
Groundwater Level [mAHD]
143.5
143
142.5
142
141.5
141
140.5
140
Jul 2019
Sep 2019
Nov 2019
Jan 2020
Mar 2020
May 2020
Jul 2020


BSBH03
BSBH03 Target Level
BSBH03 (modelled historical)
BSBH03 (modelled remedial)
Faint lines show uncertainty across 135 model realisations
Groundwater Level [mAHD]
143.5
143
142.5
142
141.5
141
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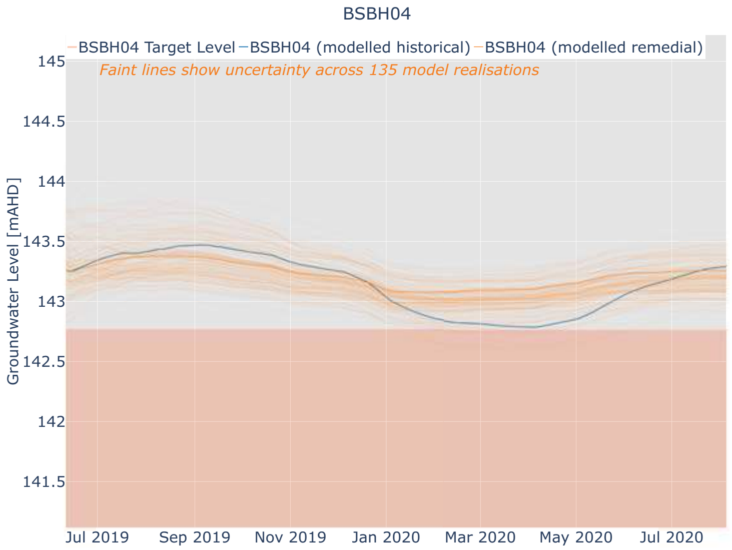
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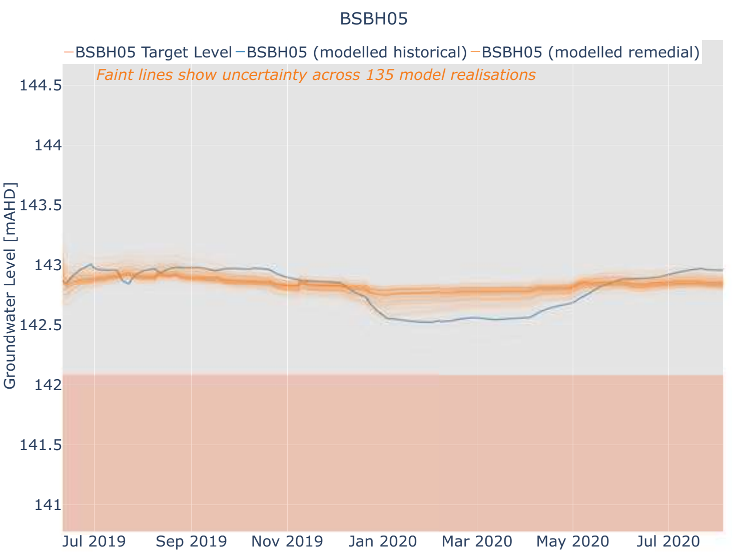
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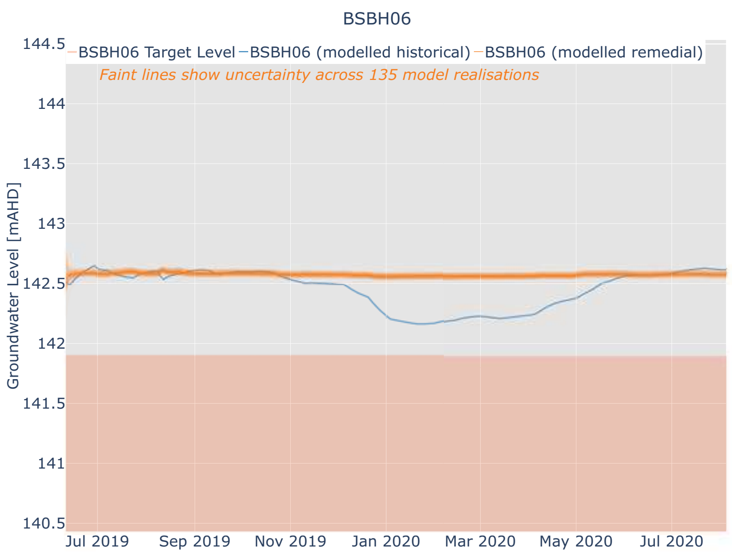
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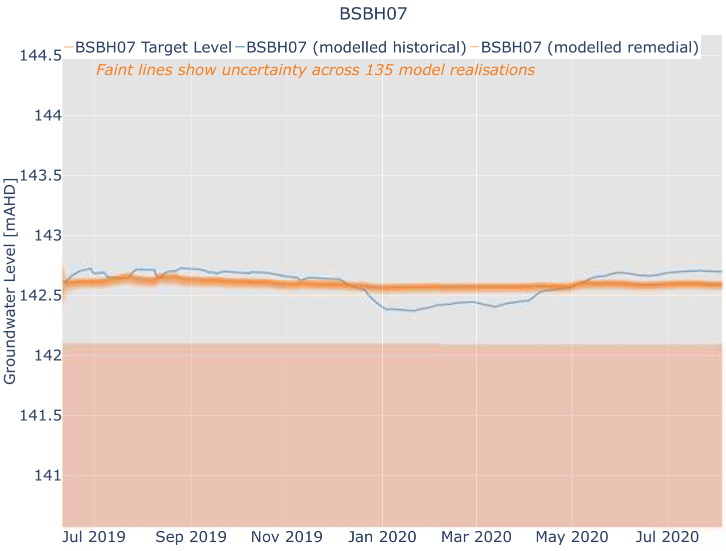
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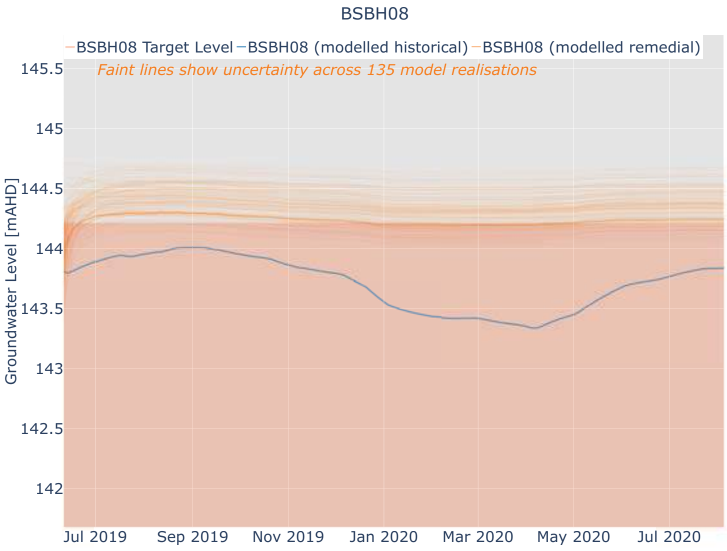
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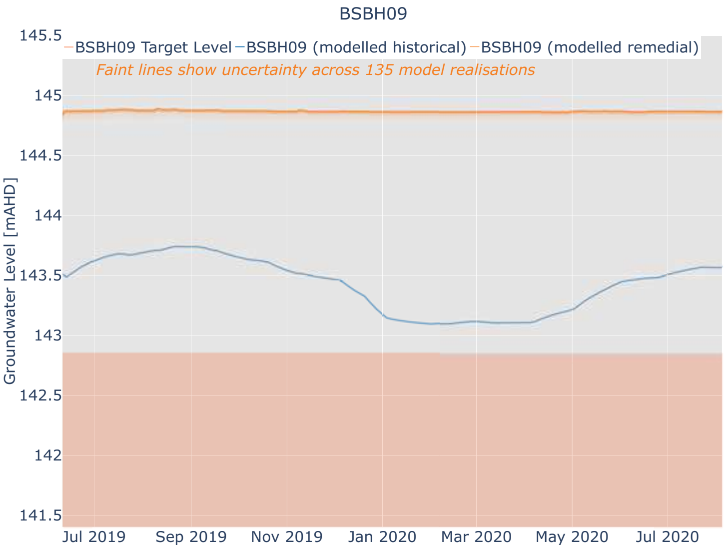
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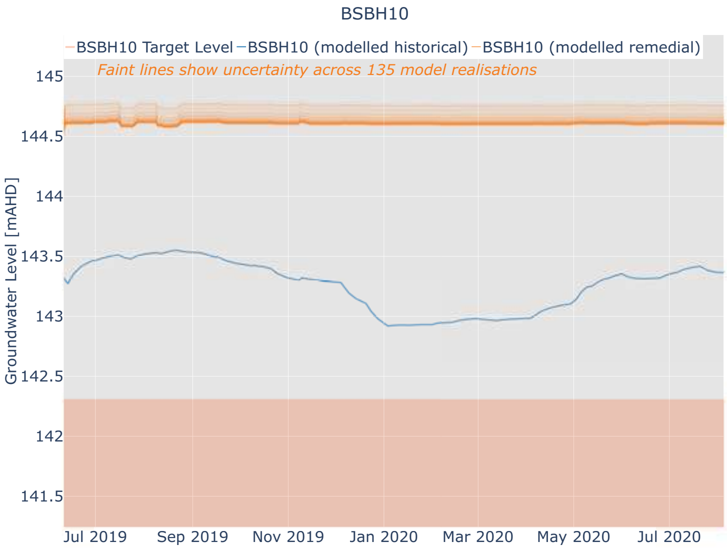
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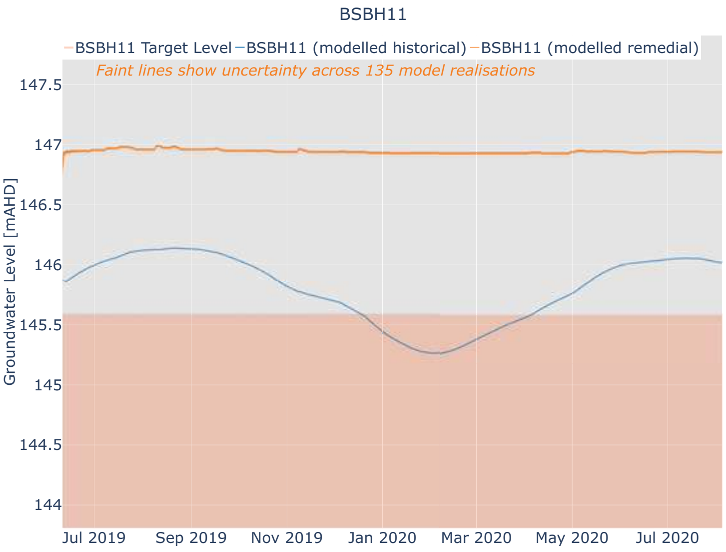
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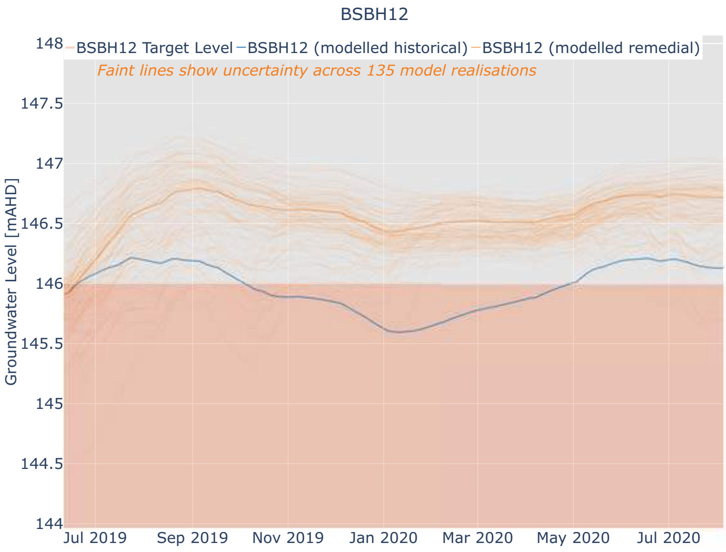
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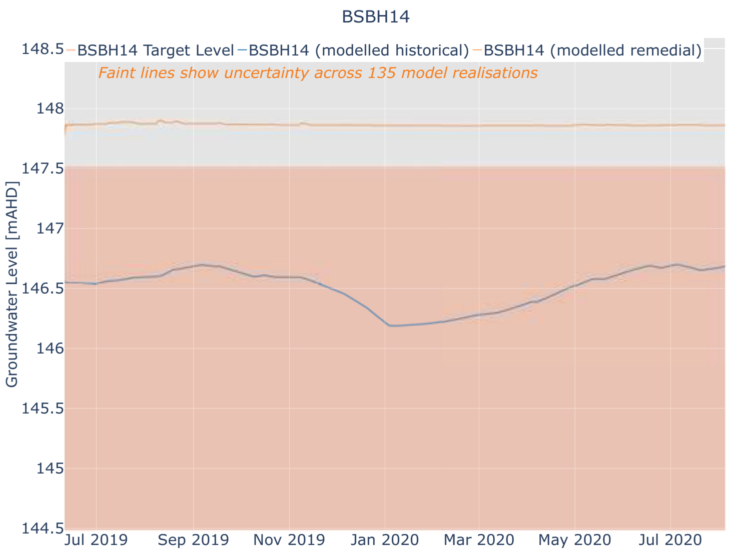
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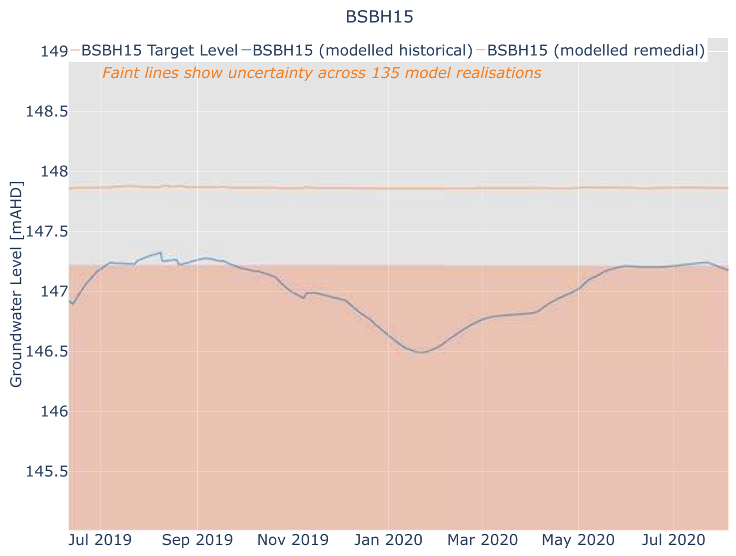
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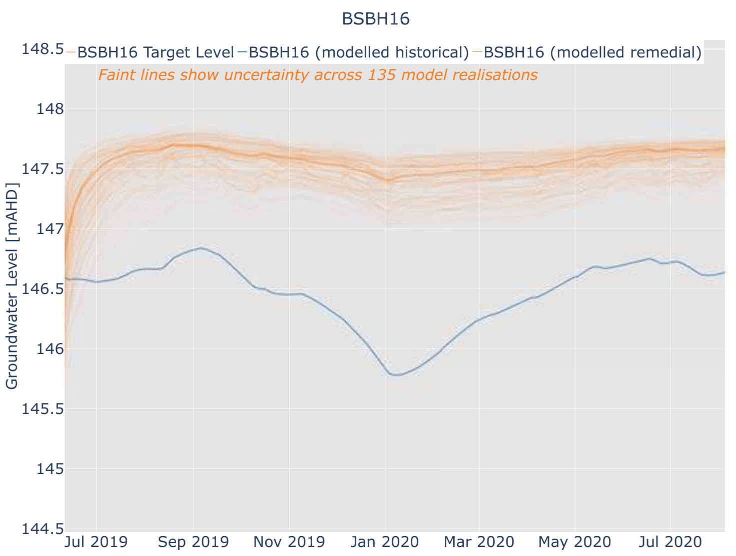
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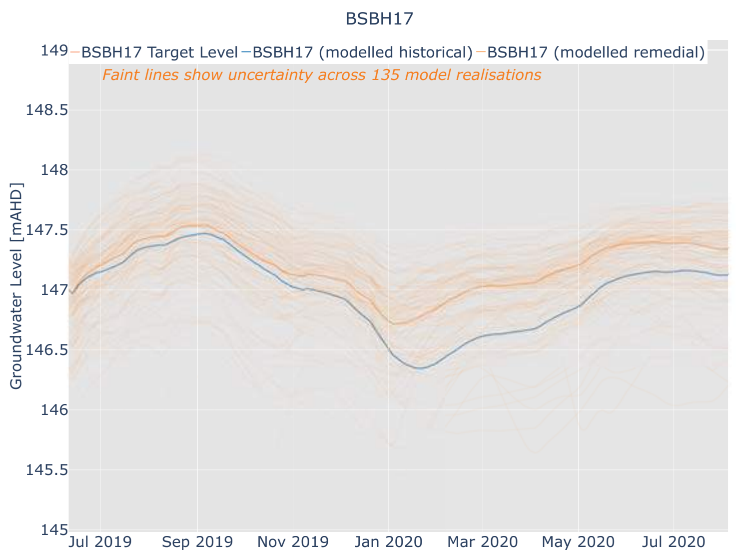
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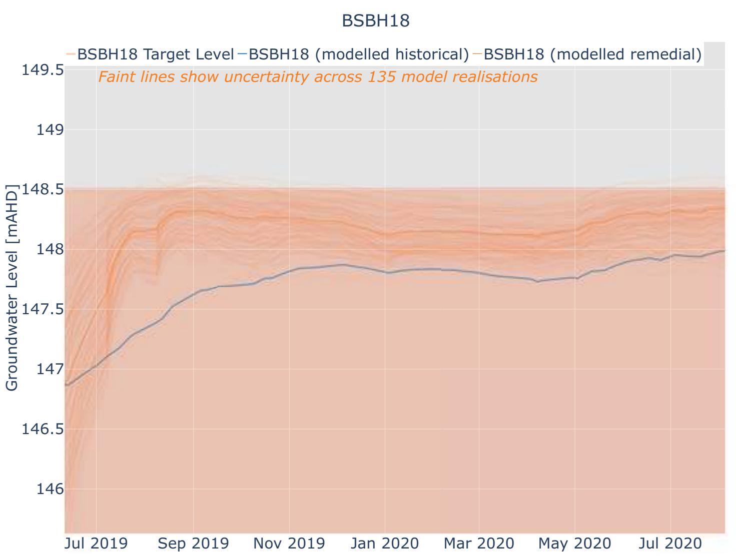
Jul 2019 Sep 2019 Nov 2019 Jan 2020 Mar 2020 May 2020 Jul 2020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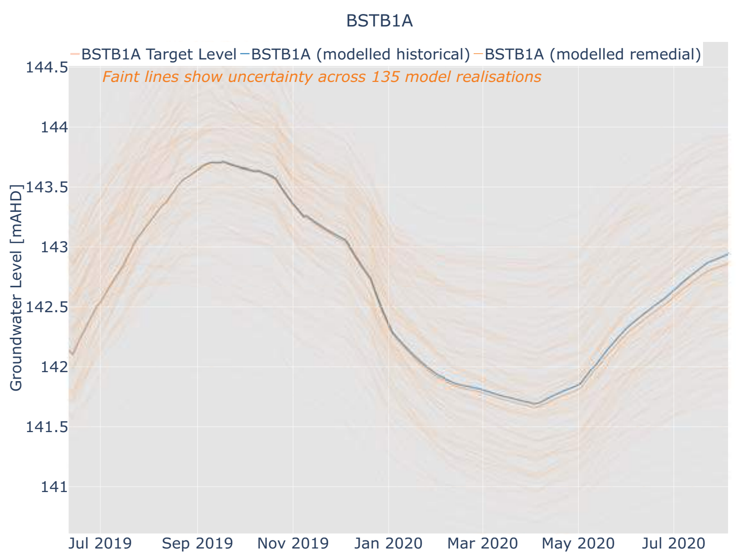
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144.5 144 143.5 143 142.5 142 141.5 141
Jul 2019 Sep 2019 Nov 2019 Jan 2020 Mar 2020 May 2020 Jul 2020

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12536659-15234-2/https://projectsportal.ghd.com/sites/pp17_01/bigswampgroundwaters/ProjectDocs/Completion_Report_Final/12536659-REP_BigSwamp_GW_SW_Model.docx

Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
Final	R. Gresswell E. Denson M.Medwell-Squire C.Nicol	J. Morgan		J. Morgan		09/04/21

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To:	Jarred Scott (Barwon Water)	cc: Jeff Morgan (GHD)
From:	Stuart Brown	
Subject:	**Independent Peer Review: Groundwater-Surface Water Modelling of Big Swamp for Detailed Design. Final report**	
Date:	15 April 2021	**Ref:** D21136

Stuart Brown of HGEO Pty Ltd was engaged to provide independent peer review of numerical groundwater-surface water modelling being carried out by consultants GHD to inform detailed design of remediation strategies at Big Swamp. Big Swamp is a peat swamp located along Boundary Creek, which forms a tributary of Barwon River, Victoria. Reduced flow along Boundary Creek in recent years has resulted in lowering of the water table in Big Swamp and activation of acid sulfate soils. Remediation options being considered by Barwon Water include controlled release of supplementary flow and construction of a series of hydraulic barriers to increase net recharge and groundwater levels across the swamp. Modelling was carried out by GDH to assess hydraulic barrier designs under different rainfall and flow regimes.

This memo presents the findings of a peer review of a final draft of the modelling report by consultants GHD, entitled:

- Big Swamp Integrated Groundwater-Surface Water Modelling for Detailed Design Technical Modelling Report. December 2020.

The report was supplied as a pdf file: 12536659-REP_BigSwamp_GW_SW_Model_DraftA.pdf. In keeping with best practice, regular milestone meetings were held (and attended by the reviewer) to discuss the modelling approach and progress. Model files were not inspected in full by the reviewer; however relevant excerpts of files were viewed through MS Teams.

The review was carried out with reference to principles and concepts outlined in the Australian Groundwater Modelling Guidelines (AGMG) (Barnett *et al.* 2012), and guidelines on uncertainty analysis and decision support modelling (Middlemis and Peeters 2018; Doherty and Moore 2019).

Summary: In my opinion, the adopted modelling approach is appropriate for assessment of groundwater levels and recharge processes within the swamp and the assessment of remediation options. The model is fit for the purpose of informing the remediation strategies to address groundwater quality in Big Swamp. The results address the project objectives and provide significant insights into the hydrogeology of Big Swamp. The confidence level classification of Class 2 (with some attributes of Class 3, as defined in the AGMG) is considered appropriate.

A number of minor comments and recommendations were communicated to the modellers via meetings and subsequent emails which were incorporated into the final report. I have no further significant recommendations in relation to the final draft.

The modelling report is presented to a high standard with clear explanations of the modelling approach and the report structure conforms to best practice as recommended in the AGMG. The modellers should be commended on the standard of work and the outcome.

1. Review

Table 1 below summarises the findings of this review with respect to the AGMG model compliance checklist. The model and modelling report were produced to a high standard and found to be compliant with the guideline and in line with best practice.

Table 1. Numerical model compliance checklist (AGMG 2012)

Item	Model aspect	Comments	Yes/No
1a	Model objectives clearly stated?	Modelling objectives are clearly stated in Section 1.2 of the report	Yes
1b	Model confidence level stated?	Model confidence level is assessed as Class 2 (with some attributes of Class 3, as defined in the AGMG) in Section 7.2, based on attributes summarised in Table 7.1. I agree with the classification.	Yes
2	Are objectives satisfied?	The model provides an effective tool for assessing remediation options. Results are clearly articulated and presented in the report, satisfying the model objectives.	Yes
3	Conceptualisation consistent with objectives and confidence level?	Section 2 of the report develops a detailed conceptual model for the swamp, including aquifer characteristics, groundwater-surface-water interactions, and interactions with underlying aquifers.	Yes
4	Conceptualisation clearly presented and reviewed?	The conceptual model is clearly presented in Section2; earlier drafts of the conceptual model were presented in progress meetings and reviewed by relevant specialists in Barwon Water and the peer reviewer (Stuart Brown)	Yes
5	Does model design conform to best practice?	The modelling approach is consistent with modelling best practice and in terms of effective decision support (e.g. Doherty & Moore, 2019 and the GMDSI)	Yes
6	Model calibration (history matching) satisfactory?	Yes. History matching of the groundwater model was carried out using PEST and PESTPP-IES. Calibration statistics are satisfactory.	Yes
7a	Parameter values and model fluxes plausible?	The initial (prior) parameter values (Table 5) are plausible based on the site conceptualisation and data, and relevant literature values. The calibrated parameters are also reasonable.	Yes
8	Predictions conform to best practice	The model assessed changes in surface water inundation and groundwater response for several barrier options for the same period as used for history matching. The predictive scenarios were similar to natural baseline in terms of aquifer stress. Predictions assessed against clear management thresholds and presented clearly.	Yes
9	Uncertainty associated with predictions reported?	Model uncertainty is rigorously explored through the application of PESTPP-EIS following model calibration. Section 6 of the report presents the results of a thorough uncertainty analysis which conforms with best practice.	Yes
10	Is the model fit for purpose?	The model is fit for the purpose of informing the remediation strategies to address groundwater quality in Big Swamp. The results address the project objectives and provide significant insights into the hydrogeology of Big Swamp.	Yes

2. General comments

Reporting: The modelling report is presented to a high standard with clear explanations of the modelling approach and results. Maps, graphics, and data plots are also of a high standard. The conceptual diagrams and modelling flow diagrams are particularly effective. The report structure conforms to that recommended in the AGMG.

Conceptualisation: A conceptual model for the swamp groundwater system is presented in Section 2 of the report. The conceptualisation and supporting data provide a sound basis for numerical model design and calibration.

The swamp is underlain by Quaternary alluvium valley fill (QA) which is itself underlain by Tertiary aquifers and aquitards. Groundwater levels within the swamp are sustained by aquifer though-flow (QA and Tertiary), surface water infiltration from Boundary Creek and periodic inundation of the swamp floodplain, as well as distributed rainfall recharge. Discharge is via aquifer throughflow, seepage loss to the Tertiary formations and evapotranspiration (EVT). The conceptualisation draws of

previous hydrogeological studies, including drilling, and is supported by high quality observational data including regional groundwater monitoring bores, a dense groundwater monitoring network within the swamp and several surface water gauging stations.

A key area of uncertainty that arises from the conceptual model is the groundwater level in the underlying Tertiary deposits and its role in maintaining groundwater levels within the swamp. However, this aspect is addressed in the model by allowing for a range of possible levels during model history matching and uncertainty analysis. This approach provided insights into the role of the Tertiary deposits in the groundwater level recovery within the swamp during the dry period.

Model approach and design: Model design and approach are presented in Section 3 of the report. The objectives of the project and conceptual model of the swamp require that the model needs to include a mechanism for flood inundation of the swamp, surface water groundwater exchanges and inter-aquifer exchanges. As the modellers point out in Section 3, this can be done in several ways, ranging from fully coupled surface-groundwater models to groundwater model (only) with simplifying assumptions. Fully coupled models present a considerable challenge due to the difference in time-scales between surface water and groundwater flow processes and events (hours versus weeks to months). They can be numerically unstable and have very long run times making them unsuitable for assessment of system behaviour over long periods (months to years). The modellers proposed a loosely coupled (“middle”) approach whereby a surface water runoff model (TUFLOW) provides surface water flow and inundation areas as input to a 3D groundwater model (Modflow-USG). I agree that this is the most pragmatic approach and provides a good balance with respect to model runtime and stability, and realistic representation of the surface water inundation.

The modelling approach uses multiple models and pre- and post-processors, coupled together using a Microsoft Windows batch file. The architecture is clearly depicted in Figure 4-6. A surface runoff model (GR4J through eWater Source) is used to generate surface water flow and level data. Those flows and levels were calibrated against stream gauges. TUFLOW was used to simulate flood inundation. Groundwater recharge and evapotranspiration were estimated using the program LUMPREM, a 1D soil water balance model. Outputs from these “external” models were then used to generate input files for the MODFLOW-USG groundwater model using a number of pre-processing utilities. Importantly, the TUFLOW output provided flood extents and depths which were represented in the groundwater model as MODFLOW RIV boundaries.

The groundwater model uses the control-volume finite difference code MODFLOW-USG (Transport) and includes boundary conditions to simulate flood inundation (RIV), stream flow and leakage (SFR) and inter-aquifer exchange (SGB). The SFR (stream) boundary was used in addition to the RIV boundary so that the stream losses could be verified against stream gauges.

The groundwater model uses an unstructured mesh, refined near the stream channels and in the areas of frequent inundation The model mesh refinement is appropriate for the coupling of TUFLOW outputs with groundwater infiltration (through MODFLOW-USG RIV boundaries). The model consists of two layers, although the second layer was included simply to aid simulation of partially penetrating barriers, if required. The use of few layers is justified by the shallow depth of the water table, meaning that vertical infiltration time is negligible compared with the length of the stress periods. Groundwater exchange with the underlying Tertiary aquifer was simulated using Specified Gradient Boundaries (SGB). This allows direct control and assessment of lateral groundwater flow components while avoiding the need to simulate the regional aquifer. The relatively simple model structure results in relatively short runtimes and allows rigorous assessment of parameter sensitivities and prediction uncertainty.

In my opinion, the adopted modelling approach is appropriate for assessment of groundwater levels and recharge processes within the swamp and the assessment of remediation options. The use of a conceptual model to identify and represent the most important hydrological features and the proposed use of advanced tools to explore parameter and predictive uncertainty is in line with current best practice.

History matching: For the groundwater model, the modellers employed a combination of automated techniques to derive parameter values with the least error variance. PEST-HP was used with Singular Value Decomposition (SVD) for initial history matching and “fine-tuning” while PESTPP-IES was used to generate an ensemble of parameter values, all of which produce an acceptable fit with observation data. History matching used a combination of head, flow and gradient (bore head difference) targets which were grouped and weighted to assist in the automated procedure.

The surface water models (GR4J and TUFLOW) were calibrated separately against gauge data and observations of inundation. Due to the loosely coupled nature of the surface water and groundwater models, a certain amount of iteration was required to endure that infiltration rates were consistent. Figure 4-12 shows that there is a good agreement between modelled and observed heads and flow at the downstream gauge.

The methods of history matching are considered appropriate for a highly parameterised model, loosely coupled with the output from surface water models. The Scaled Root Mean Squared (SRMS) error is around 3% and the Root Mean Squared (SRMS) error is around 0.2 m. Hydrographs shown in Figures 4-8 and 4-9 indicate a close match between modelled and observed groundwater heads within the swamp. At most bores, the model closely simulates both the absolute head and range over wet and dry periods. As such, the model provides an excellent basis for predicting groundwater response to changed surface water inundation conditions. Small or localised variations between modelled and observed conditions are to be expected due to uncertainties in ground conditions across the site.

Table 5 summarises the key hydraulic parameters in the groundwater flow model. The initial values are reasonable based on the site conceptualisation, and the ranges provide appropriate bounds for history matching and uncertainty analysis. Similarly, calibrated values (Section 4.4.5) are reasonable, noting that some of the calibrated stream parameter values are at their max/min bounds. PESTPP tools are used to carry out a thorough sensitivity analysis (Section 4), which provide important insights into groundwater processes, particularly around the importance of exchange between the Tertiary and Quaternary aquifers.

Predictions: Model predictions are presented in Section 5, relating to the stated objectives. Results are presented to show the effect of barriers on surface flow inundation (and preferred option), flow diversion and the effect of various barrier options on groundwater levels within the swamp. The hydrographs, contour maps and difference maps are an effective way of presenting the results. Predictive runs were carried out over the same 14-month period as the history-matching baseline, with aquifer stress conditions that are of a similar order of magnitude to the baseline conditions. This approach reduces predictive uncertainty related to future climatic conditions and increases the level of confidence. It is noted that the predicted heads in monitoring bores BH09, BH10, BH11, BH14 and BH15 are significantly higher than the baseline (as was the objective) and display little seasonal variability. This is presumably because those bores are close to the proposed barriers where ponding is predicted to be nearly continuous.

Uncertainty analysis: Predictive uncertainty analysis was carried out using PESTPP-IES, a non-linear approach appropriate for highly parameterised models. An ensemble of 135 calibrated parameter sets was used to run the predictive scenarios (using PESTPP-SWP) such that multiple predicted hydrographs could be generated for each monitoring bore. This provided an estimate of the predictive uncertainty at each location. The sources of uncertainty are discussed. Results are presented in a manner that clearly shows the range of predictive uncertainty.

Because of the loosely coupled nature of the model, the uncertainty associated with estimated creek flows and flood inundation are not fully integrated in the PEST workflow. However, the sensitivities of those aspects are thoroughly explored in Section 6.1.2, with the gully shaping (topography) assumptions in TUFLOW found to be most sensitive. The model results are therefore contingent on the accuracy of topographical data (LiDAR).

I hope you find these comments useful. If you have any further questions, please contact me using the details above.

Regards

Stuart

Dr. Stuart Brown

Principal Hydrogeologist

References

Barnett, B., Townley, L.R., et al. 2012. *Australian Groundwater Modelling Guidelines*. Waterlines Report Series.

Doherty, J. and Moore, C. 2019. Decision Support Modeling: Data Assimilation, Uncertainty Quantification, and Strategic Abstraction. *Groundwater*, **n/a**, https://doi.org/10.1111/gwat.12969.

Middlemis, H. and Peeters, L.J.M. 2018. *Uncertainty Analysis—Guidance for Groundwater Modelling within a Risk Management Framework*. Information Guidelines explanatory note.