Cardno
Shaping the Future

Appendix E

Eastern Lakes Concept Design

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1 Introduction

Cardno has been engaged by Penrith Lakes Development Corporation (PLDC) to undertake flood modelling and preliminary design of the eastern lakes of the Penrith Lakes Scheme. This report details the analysis of the eastern lakes, which was primarily concerned with managing flooding impacts in the 100yr and 200yr events within the PLDC site, and east of the site on neighbouring properties. Preliminary costings are provided for the discussed options.

2 Eastern Lakes – v13d option 4 design

2.1 Terrain

The eastern lakes area is comprised of a series of lakes located between Main Lake and Castlereagh Road (refer **Figure 1**). The northern most lake, Allawah Lake, is connected to Main Lake via a 50m wide flowpath, with a crest at 19mAHD. There is a spillway that connects Allawah Lake to Duralia Lake, with its crest set at 24.5mAHD. North Pond is connected to Duralia Lake by a spillway at 21mAHD, and to Regatta Lake by a spillway at 24.4mAHD. Finally, Regatta Lake and Final Basin are separated by a crest at 19mAHD.

On the eastern side of Castlereagh Rd, adjacent to the southern end of Duralia Lake is an existing lake, Cranebrook Lake. It is not directly connected to the eastern lake system via overland flow, but has a 900mm piped connection to Duralia Lake (refer **Figure 1**).

Castlereagh Road runs along the eastern side of all the lakes at an approximate height of 24-25mAHD. Flow is able to pass under Castlereagh Road at 3 locations. The first is via 3 bebo arches (9m x 3m) which connects the Stilling Basin to North pond. The second location is at Nepean St, which passes under Castlereagh Rd through a single bebo arch (9m x 3m). The third connection is a 900mm pipe connecting Cranebrook Lake and Duralia Lake.

There is a creek system which runs along the eastern side of Castlereagh Road. South of Andrews Rd it is a formalised channel, which passes under Andrews Rd via six 900mm pipes and five 2700x1500 box culverts. Between Andrews Rd and Nepean St the area has been redeveloped as part of the Waterside Green development which has constructed a series of small lakes and channels. North of Nepean Street, Waterside Green feeds into a small grass channel which ultimately empties into the Stilling Basin, where the 3 bebo arches are located (refer **Figure 2**).

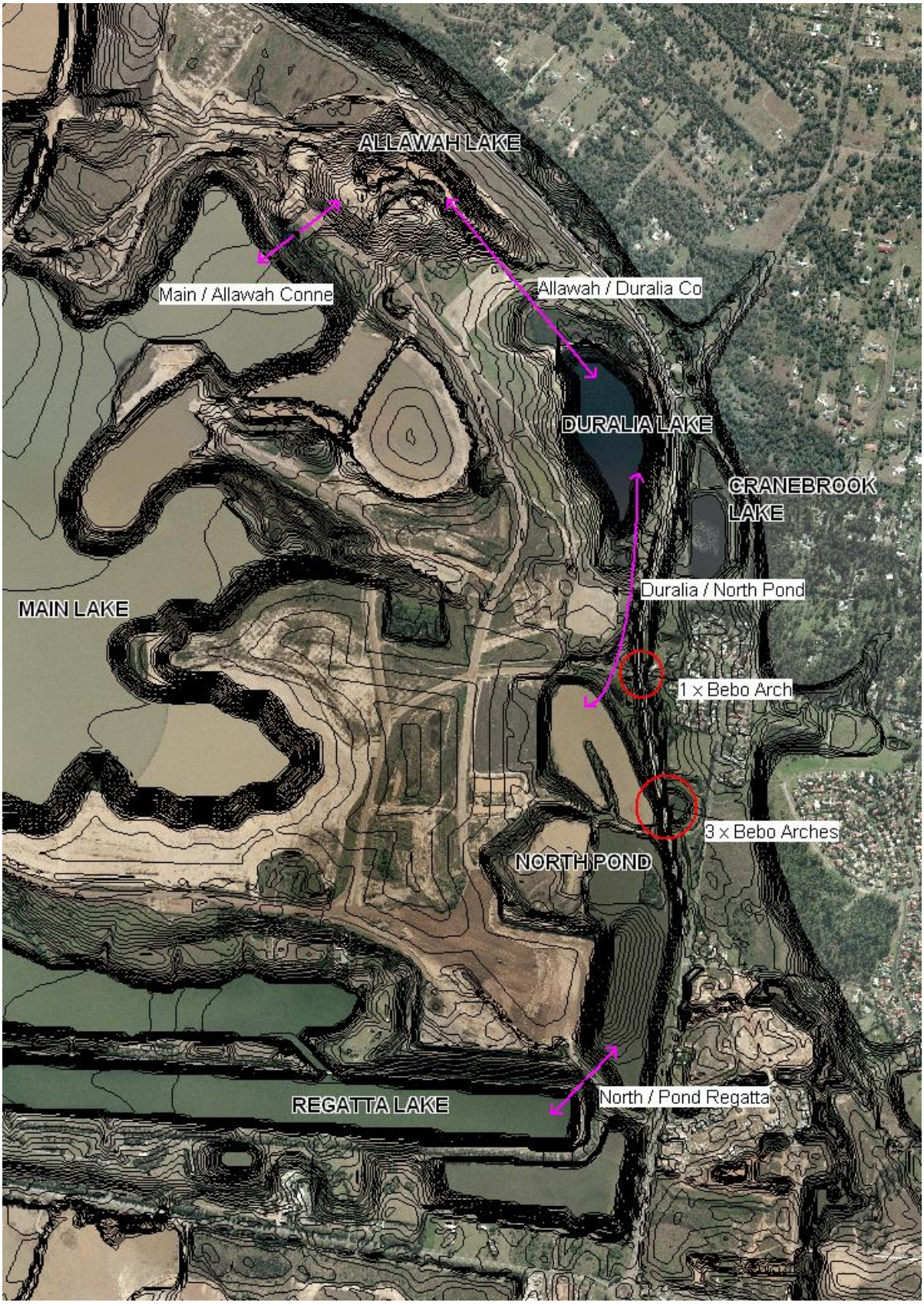

Figure 1: Eastern Lake Details – v13d opt4

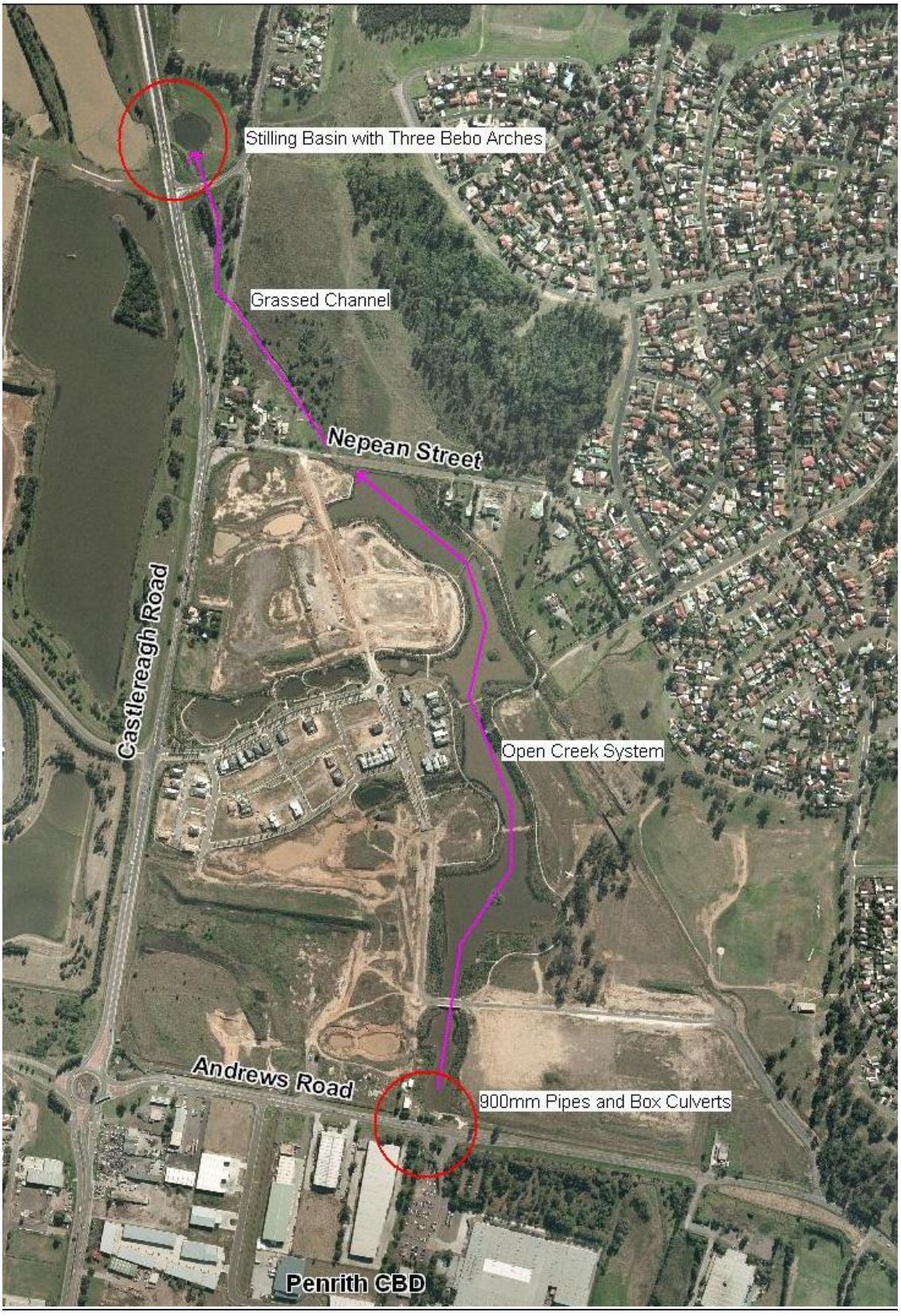

Figure 2: Flowpath East of Castlereagh Road

2.2 Impacts

In the 100yr event, there are no negative impacts outside of the PLDC site boundary in the vicinity of the eastern lakes. The design actually improves flood levels in the 100yr event for many properties along Castlereagh Road. However, there are significant increases in the eastern lakes area for the 200yr event. These increases are in the order of 0.9m to 1.5m (refer **Figures 3 & 4**).

The reason that the 200yr has such severe impacts, whilst the 100yr shows improvements, is due to flow entering from the south via Penrith CBD and the Waterside Green development. In the 100yr event, only a small amount of flow progresses past Andrews Rd. Meanwhile, the high level connections between the eastern lakes and Main Lake prevent backwater from the Main Lake. In the 200yr event however, significantly more flow enters from the south-east. The high level connections prevent efficient drainage of this area, resulting in elevated water levels.

The aim of this investigation was to remove, or at least improve, these impacts on surrounding properties. As part of the investigation, 3 options were modelled:

- Low weir connection – connecting the eastern lakes with weirs set at 19mAHD
- High weir connection – connecting the eastern lakes with weirs at the 100yr water level
- Bund wall at 200yr level – placing a bund wall along the Nepean River, west of Penrith CBD, set at the 200yr flood level

All models utilised a 15m grid.

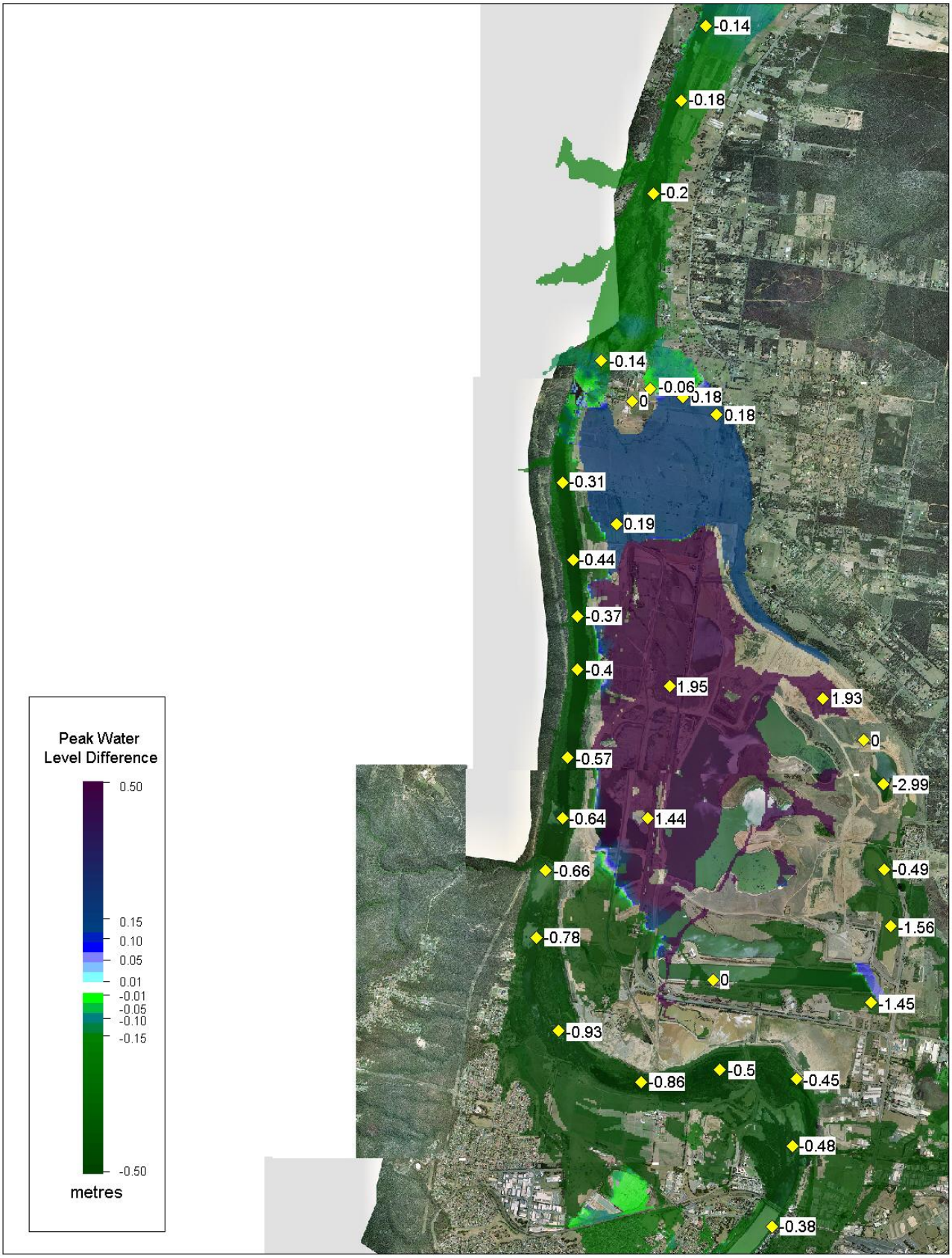

Figure 3: 100yr Impacts (v13d opt4 less Existing v6)

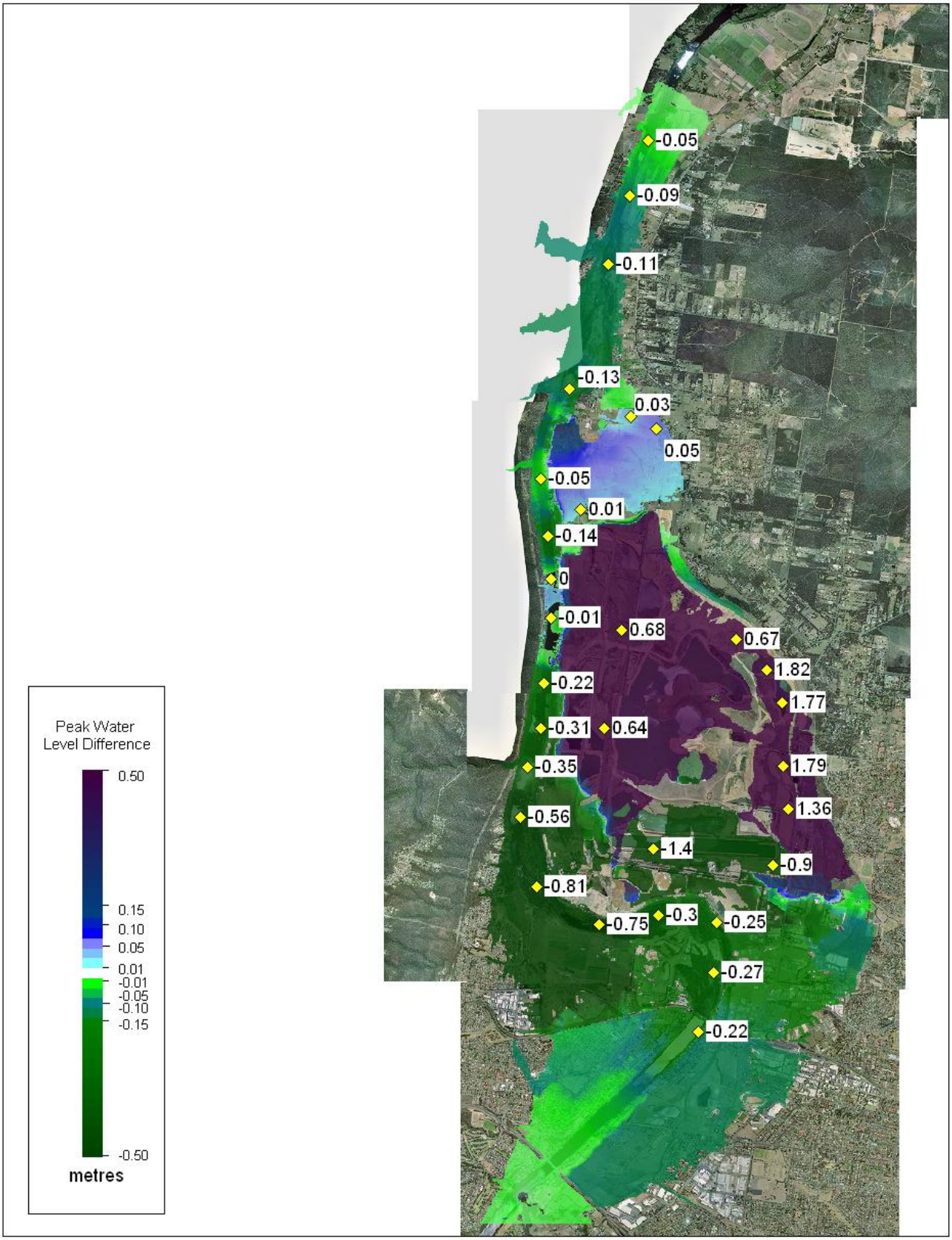

Figure 4: 200yr Impacts (v13d opt4 less Existing v6)

3 Design Options

3.1 Option 1 – Low Weir Connection

The first option investigated involved connecting all of the eastern lakes with channels set at 19mAHD. This is the level of the channel that currently connects the Main Lake to Allawah Lake. The aim of these connections was to equalise the levels of the eastern lakes with Main Lake. The peak level of Main Lake is lower than the existing flood level for the affected properties in the 200yr event, so the channels may allow the eastern lakes to equalise with Main Lake, reducing impacts east of Castlereagh Rd.

The channels had a base width of 50m wide, with batters at 1 in 6 to the current design surface, and were modelled as 1D connections.

The 50m wide channels significantly reduced flood levels east of Castlereagh Rd in the 200yr event, although there were still some impacts. The levels are summarised in **Table 1**.

Table 1: Comparison of Peak Levels for Option 1 – 100yr & 200yr events

	100yr v13d opt4	100yr Opt 1	100yr Existing	200yr v13d opt4	200yr Opt 1	200yr Existing
Main Lake	22.54	22.53	20.67	23.41	23.42	22.76
Allawah Lake	22.54	22.54	20.69	23.41	23.42	22.74
Duralia Lake	18.00	22.54	20.98	24.60	23.63	22.82
North Pond	20.66	22.54	22.20	24.71	23.80	23.20
Regatta Lake	22.54	22.54	23.37	23.45	23.44	23.96
Cranebrook Lake	19.98	22.56	22.41	24.72	23.93	23.56
Properties	20.48	22.56	22.41	24.72	23.93	23.56

3.2 Option 2 - High Weir Connection

This option is identical to option 1, but the crest of the weirs is set at the 100yr flood level of 22.55mAHD. This option aimed to combine the desirable aspects of the existing design (v13d opt4) in the 100yr, and the low weir option (option 1) in the 200yr.

The levels are summarised in **Table 2**.

Table 2: Comparison of Peak Levels for Option 2A – 100yr & 200yr events

	100yr v13d opt4	100yr Opt 2A	100yr Existing	200yr v13d opt4	200yr Opt 2A	200yr Existing
Main Lake	22.54	22.54	20.67	23.41	23.41	22.76
Allawah Lake	22.54	22.54	20.69	23.41	23.41	22.74
Duralia Lake	18.00	18.00	20.98	24.60	24.50	22.82
North Pond	20.66	20.66	22.20	24.71	24.55	23.20
Regatta Lake	22.54	22.54	23.37	23.45	23.44	23.96
Cranebrook Lake	19.98	19.98	22.41	24.72	24.57	23.56
Properties	20.48	20.48	22.41	24.72	24.57	23.56

3.3 Option 3 – Bund Wall at 200yr Level

The third option that was examined was the creation of a bund wall along the Nepean River, west of Penrith CBD, running from the PLDC site boundary to Boundary Creek and raising some levels adjacent to the railway line in the CBD to prevent the 200yr flows from entering (refer Figure).

This option was first investigated as early as July 2008 to improve evacuation times in the PMF. However, it was removed from subsequent models based on advice from PLDC.

The levels are summarised in **Table 3**.

Table 3: Comparison of Peak Levels for Option 3 – 100yr & 200yr events

	100yr v13d opt4	100yr Opt 3	100yr Existing	200yr v13d opt4	200yr Opt 3	200yr Existing
Main Lake	22.54	22.55	20.67	23.41	23.40	22.76
Allawah Lake	22.54	22.55	20.69	23.41	23.40	22.74
Duralia Lake	18.00	18.00	20.98	24.60	18.00	22.82
North Pond	20.66	18.07	22.20	24.71	18.00	23.20
Regatta Lake	22.54	22.55	23.37	23.45	23.42	23.96
Cranebrook Lake	19.98	18.00	22.41	24.72	18.00	23.56
Properties	20.48	-	22.41	24.72	-	23.56

As the bund prevented any water entering from the south, it removed any impacts in the 200yr event, and reduced flood levels below currently existing flood levels in the area around the eastern lakes.

Increases did occur upstream of the bund wall, in Penrith itself. This has implications for the approval of this option with Council. However, it is noted that the bund has significant benefits for the northern areas of Penrith.

3.4 Option 4 – PLDC Extents

Following consultation with PLDC, outlines were provided for preferred channel geometries between Allawah and Duralia (100315_mwz_floodway extents.dwg, received 15 March 2010). These outlines were incorporated into the 2D grid. The Allawah to Duralia flowpath had a width of 380m

The levels are summarised in **Table 4**.

Table 4: Comparison of Peak Levels for Option 4 – 100yr & 200yr events

	100yr v13d opt4	100yr Opt 4	100yr Existing	200yr v13d opt4	200yr Opt 4	200yr Existing
Main Lake	22.54	22.54	20.67	23.41	23.41	22.76
Allawah Lake	22.54	22.54	20.69	23.41	23.41	22.74
Duralia Lake	18.00	18.00	20.98	24.60	23.58	22.82
North Pond	20.66	20.66	22.20	24.71	24.63	23.20
Regatta Lake	22.54	22.54	23.37	23.45	23.45	23.96
Cranebrook Lake	19.98	19.98	22.41	24.72	24.65	23.56
Properties	20.48	20.48	22.41	24.72	24.65	23.56

3.5 Option 5 – PLDC Extents with low connection between North Pond and Duralia

An analysis of the results showed that water was building up in North Pond and was not being conveyed in sufficient volume to Duralia Lake. To improve this flow, a 50m wide channel set at 19mAHD was incorporated between North Pond and Duralia Lake.

The levels are summarised in **Table 5**.

Table 5: Comparison of Peak Levels for Option 5 – 100yr & 200yr events

	100yr v13d opt4	100yr Opt 5	100yr Existing	200yr v13d opt4	200yr Opt 5	200yr Existing
Main Lake	22.54	22.54	20.67	23.41	23.41	22.76
Allawah Lake	22.54	22.54	20.69	23.41	23.41	22.74
Duralia Lake	18.00	18.00	20.98	24.60	23.77	22.82
North Pond	20.66	20.66	22.20	24.71	24.25	23.20
Regatta Lake	22.54	22.54	23.37	23.45	23.45	23.96
Cranebrook Lake	19.98	19.98	22.41	24.72	24.30	23.56
Properties	20.48	20.48	22.41	24.72	24.30	23.56

3.6 Option 6 – Maximum Extents with low connection between North Pond and Duralia

Although Option 5 further improved impacts on the eastern properties, the flood levels were still 0.55m above existing levels. The flowpath between Allawah and Duralia was already at a maximum width, but an examination of the terrain of North Pond – Duralia Link suggested that extra width could be used. The flowpath width of the North Pond to Duralia link was increased to 150m.

The levels are summarised in **Table 6**.

Table 6: Comparison of Peak Levels for Option 6 – 100yr & 200yr events

	100yr v13d opt4	100yr Opt 3	100yr Existing	200yr v13d opt4	200yr Opt 4	200yr Existing
Main Lake	22.54	22.54	20.67	23.41	23.42	22.76
Allawah Lake	22.54	22.54	20.69	23.41	23.42	22.74
Duralia Lake	18.00	18.00	20.98	24.60	23.85	22.82
North Pond	20.66	20.66	22.20	24.71	23.91	23.20
Regatta Lake	22.54	22.54	23.37	23.45	23.45	23.96
Cranebrook Lake	19.98	19.98	22.41	24.72	24.02	23.56
Properties	20.48	20.48	22.41	24.72	24.02	23.56

3.7 Options Summary

A summary of the effectiveness of the options in reducing flood levels east of Castlereagh Road is shown in **Table 7**. Note that the high connection options preventing any flooding in the 100 and the bund wall option prevented any flooding in both the 100yr and 200yr events; the level difference in brackets is the difference between the existing flood level and the natural surface.

Table 7: Peak water Level changes for properties east of Castlereagh Rd due to investigated options

	Description	100yr Peak Water Level Change	200yr Peak Water Level Change
13d opt4	Preliminary Design Scenario	(-1.93)	+1.16
Option 1	Low weir connection	0.15	+0.36
Option 2	High weir connection, 50m flowpath	(-1.93)	+0.99
Option 3	Bund wall	(-1.93)	(-2.10)
Option 4	PLDC Extents	(-1.93)	+1.09
Option 5	PLDC Extents with a low North Pond to Duralia Connection	(-1.93)	+0.74
Option 6	Maximised flowpath widths with a low North Pond to Duralia Connection	(-1.93)	+0.46

4 Cost Considerations

The factor that governs the relative cost of these options will be the earthworks required. Given this, those options with high weirs will be cheaper than those with low weirs. Also, those options with wider flowpaths will be more costly than those with narrower flowpaths. The bund wall option will be the most expensive option, by a considerable margin.

5 Eastern Lakes Recommendations

Of the options investigated, Option 6 is recommended as the preferred option.

It was selected for a number of reasons, including:

- Removing flooding impacts on the eastern properties in the 100yr event
- Reducing the 200yr impact significantly below the design case
- No need for a link between Main Lake and North Pond which allows for a single flood free zone in this area which is important if the area is to be used for residential properties

6 Qualifications

The following qualifications apply to this report:

- The attached sketches are concept designs only, and would require detailed design at a later stage.
- No geotechnical analysis has been consulted in the preparation of this report. Only a broad appreciation of the soil types has been considered.
- The design of the Weir has been based on the 100 year and 200 year ARI design events. No other design events have been modelled. No sensitivity analysis has been undertaken but it is recommended that this be undertaken prior to the detailed design phase.
- The results presented in this report are based on the current design for the Penrith Lakes Development. Any changes to this design may result in different flow behaviour across the Regatta Lake weir and therefore may require different options for energy dissipation and scour protection.

7 References

Cardno Lawson Treloar (2009). *Penrith Lakes Flood Modelling: Model Calibration and Verification*, December, prepared for Penrith Lakes Development Corporation, Final.

Cardno Lawson Treloar (2009). *Concept Design of Weir 6 (Letter)*, April, prepared for Penrith Lakes Development Corporation.

Construction Industry Research and Information Association [CIRIA] (1985). *Reinforcement of Steep Grassed Waterways: Review and Preliminary Design Recommendations*, Technical Note 120, London.