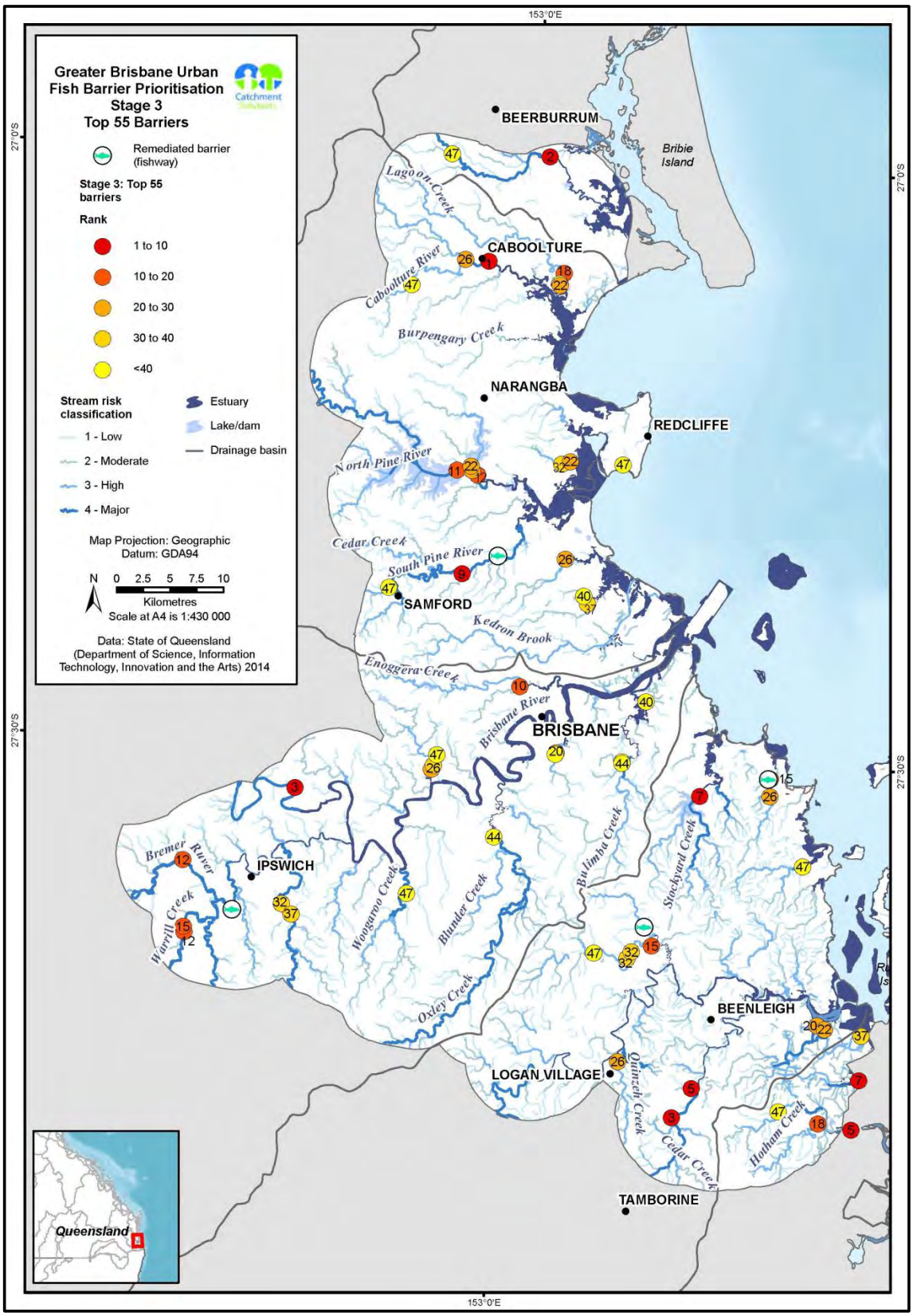

Figure 18. Location and overall priority rank of the top 50 barriers to fish passage in the GB region.

Discussion

The desktop study of the Greater Brisbane region identified a total 13,629 potential barriers at a density of 3.8 potential barriers per km² (total catchment area). Potential barriers located on first ordered waterways that didn't discharge directly into estuarine environments were removed from further assessment in stage 1. These waterways are generally typified as ephemeral headwater streams and are deemed to be low risk in terms of fish passage requirements (Fisheries QLD, 2013). Although some fish may intermittently utilise these habitats during periods of elevated stream flow, the expected species possess good swimming and/or unique climbing abilities (eel sp., cox's and striped gudgeon). Some upper catchment specialists have evolved an ability to climb wet surfaces and negotiate faster velocities to enable them to ascend natural barriers such as waterfalls and steep rock riffles which are commonly encountered in upper catchment headwater streams (Pusey, Kennard and Arthington 2004; Allen, Midgley and Allen 2002). Therefore, the small size and ephemeral nature of these waterways combined with the climbing abilities of the fish that commonly occur in these habitats meant that potential barriers in these locations were a low priority. Although these potential barriers were removed prior to stage 1 scoring and assessment, they remain on file for any potential future assessment.

Following the removal of all potential barriers which occurred on first order waterways (and did not discharge directly into estuarine waters), a total of 4,916 potential barriers remained. These barriers were assessed and ranked in accordance with the spatial and temporal habitat characteristic criteria set out in stage 1. This was achieved using the analytical GIS stream network processing tool; RivEX. 522 high ranking potential barriers were visited in the field in line with the prioritisation list. Of the 522 ground-truthed potential barriers, 264 were determined to be barriers that prevent, delay or obstruct fish migration. The remaining 258 potential barriers were assessed as not affecting fish passage (Figure 16). These generally consisted of bridges, logs and full width culverts installed below bed level and/or with a low flow channel and wall baffles (Figure 19). All waterway barrier works (culverts, pipes, weirs, causeways) in QLD are regulated under the Fisheries Act 1994. Minor works or those deemed low risk due to the waterway type (stream classification), can be completed via self-assessment (Accepted Development). In this situation, works can be completed by adhering to the standards and requirements of Fisheries QLD *Accepted Development requirements for operational work that is construction or raising waterway barrier work* without having to gain Development Approval. A high number of potential barriers visited in the field comprised culvert crossings which appeared to conform to the Accepted Development requirements and therefore deemed not to be barriers (Figure 19).

Figure 19. Culvert crossing conforming to Accepted Development requirements. Note: Low flow channel and wall roughening.

Through the prioritisation process, barriers were ranked according to the impact they have on Greater Brisbane fish communities and the cost and technical feasibility of rehabilitation of fish passage at the site. From this process a list of top priority barriers has been developed. This list (See Appendix 1) provides a prioritised guide to the most important places that targeted rehabilitation of fish passage will have the greatest benefit to fish communities of the region. The list also contains a number of structures that have fishways installed on them, however it should be recognised that some of these are older 'salmon' fishways, and due to their poor design, block fish passage.

Overall, the top three highest priority ranked barriers in the GB region were (1) Caboolture River Barrage, (2) Elimbah Creek Tidal Causeway, and equal third, Luscombe Weir on the Albert River and Mt. Crosby Weir on the Brisbane River. The reason these barriers scored so highly in the prioritisation process, along with many other barriers ranked in the top 50, was due to a combination of critical criteria these barriers met in terms of potential for fish community impacts. Generally these barriers were on high ordered streams, situated on, or in close proximity to the estuary, had minimal to no barriers downstream and blocked access to large areas of available habitat upstream. This combination of factors meant that these barriers, and barriers with similar traits, present the biggest overall impacts to fish community condition and overall aquatic ecosystem health, and thus, ranked highest in priority for remediation works.

With the prioritisation now completed and a list of potential sites for rehabilitation of fish passage recommended, investment and funding is required to remediate the various options outlined for each structure in the priority list (Appendix 1). It should be recognised that the list is a guide only and some unforeseeable scenarios may make some sites more or less practical. In all cases, rehabilitation of a site should be further investigated to ensure circumstances have not changed and investment expenditure is being spent at the most beneficial site.

Conclusion

13,629 potential barriers within the GB region were identified and refined to a list of the highest priority sites within the region. The priority ranked sites represent the greatest return in terms of ecological restoration with the least financial expenditure. By remediating fish passage at these sites, extensive areas of fish habitat will become accessible to many socio-economically important migratory fish species. This will ensure the sustainability of fish populations and improve aquatic ecosystem health in many of the region's waterways, while investing rehabilitation funds in the most efficient manner.

"Access to habitat is just as important as habitat itself"

Recommendations

- Development of individual council and relevant state government agency investment strategies for a fish migration barrier remediation program targeting the top 5-10 barriers identified in each LGA area within this report. This program would include:
    - Preparation of an investment strategy for the highest priority sites based on information in this report
    - Undertake Fish Passage Options Assessment to determine most appropriate remediation option at each site
    - Detailed survey of the sites and production of design documents for suitable fishways
    - Construction of agreed fishway designs
    - Monitoring of the rehabilitated sites to ensure proper operation of the fishway
    - Pre and post barrier remediation fishway and fish community sampling to determine the effectiveness of providing fish passage past the barrier.
- A SEQ wide fish barrier remediation project targeting the top 5-10 barriers identified in this report.
- Fish monitoring of potential and/or actual barriers to determine the degree of impact the structure is having on fish communities i.e. if you're unsure if it's a barrier to fish passage, then quantify through barrier monitoring the number, type and size of species able to ascend past (See Slacks Creek Case Study 1 in Appendix 2).
- Further fishway monitoring to better understand fish communities and their migration requirements.

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Appendix 1- Top 50 Barriers and Associated Information

Overall Priority	1	
LGA/LGA Priority	MBRC	1
Barrier ID	13941	
Stream Name	Caboolture River	
Location	-27.086745°	152.957708°
Barrier Type	Redundant Tidal Barrage	
Barrier Name	Caboolture Weir	
Fishway Type Needed	Bypass R.Ramp/Retrofit Cone	
Approx. Cost of Fishway	$180 - $250k	

Overall Priority	2	
LGA/LGA Priority	MBRC	2
Barrier ID	3728	
Stream Name	Elimbah Creek	
Location	-26.996403°	153.010241°
Barrier Type	Tidal Causeway	
Barrier Name/Info	Within Forestry Area	
Fishway Type Needed	Removal/Bed Lvl Xing/R.Ramp	
Approx. Cost of Fishway	$60 -$100k	

Overall Priority	3	
LGA/LGA Priority	GCCC & LCC	1* & 1*
Barrier ID	10352	
Stream Name	Albert River	
Location	-27.800196°	153.169262°
Barrier Type	Redundant Weir	
Barrier Name	Luscombe Weir	
Fishway Type Needed	Removal	
Approx. Cost of Fishway	$1.3 million	

Overall Priority	3	
LGA/LGA Priority	BCC	1
Barrier ID	12850	
Stream Name	Brisbane River	
Location	-27.537293°	152.797935°
Barrier Type	Weir	
Barrier Name	Mt Crosby Weir	
Fishway Type Needed	Concrete Cone	
Approx. Cost of Fishway	$800 k - $1 .1 million	

Overall Priority	5	
LGA/LGA Priority	GCCC	2
Barrier ID	13801	
Stream Name	Pimpama River	
Location	-27.802888°	153.339623°
Barrier Type	Tidal Floodgate	
Barrier Name	Kerkin Road North	
Fishway Type Needed	Fish Friendly Auto-tidal Gates	
Approx. Cost of Fishway	*$25 - $150k	

Overall Priority	5	
LGA/LGA Priority	GCCC & LCC	3 & 2
Barrier ID	10351	
Stream Name	Albert River	
Location	-27.775037°	153.186256°
Barrier Type	Tidal Pipe Causeway	
Barrier Name	Stanmore Road	
Fishway Type Needed	Bridge/Culverts	R.Ramp/Cone
Approx. Cost of Fishway	$100-$300 k	$50-$90 k

Overall Priority	7	
LGA/LGA Priority	RCC	1
Barrier ID	4374	
Stream Name	Tingalpa Creek	
Location	-27.528354°	153.180559°
Barrier Type	Dam	
Barrier Name	Leslie Harrison Dam	
Fishway Type Needed	Fish Lift/Cone	
Approx. Cost of Fishway	$1-2 million	

Overall Priority	7	
LGA/LGA Priority	GCCC	4
Barrier ID	13800	
Stream Name	Behm Creek	
Location	-27.760848°	153.344678°
Barrier Type	Tidal Floodgate	
Barrier Name	Stapylton-Jacobs Well Rd	
Fishway Type Needed	Fish Friendly Auto Tidal Gate	
Approx. Cost of Fishway	*$25 - $75 k	

Overall Priority	9	
LGA/LGA Priority	MBRC	3
Barrier ID	218	
Stream Name	South Pine River	
Location	-27.350244°	152.946384°
Barrier Type	Culvert Causeway	
Barrier Name	Bunya Crossing	
Fishway Type Needed	Rock Ramp	
Approx. Cost of Fishway	$25 -$40 k	

Overall Priority	10	
LGA/LGA Priority	BCC	2
Barrier ID	12199	
Stream Name	Enoggera Creek	
Location	-27.443336°	153.005675°
Barrier Type	Tidal Weir	
Barrier Name	Bancroft Park (Hulme St)	
Fishway Type Needed	Full-width or partial Rock Ramp	
Approx. Cost of Fishway	$80 -$100 k	

Overall Priority	11	
LGA/LGA Priority	MBRC	4
Barrier ID	2279	
Stream Name	North Pine River	
Location	-27.263543°	152.937002°
Barrier Type	Dam	
Barrier Name	North Pine Dam	
Fishway Type Needed	Fish Lift	
Approx. Cost of Fishway	$1 - 2 million	

Overall Priority	12	
LGA/LGA Priority	ICC	1
Barrier ID	8231	
Stream Name	Warrill Creek	
Location	-27.659011°	152.698957°
Barrier Type	DNRM V-notch Gauging Weir	
Barrier Name	DNRM Weir	
Fishway Type Needed	Cone (1st ridge) &/or R.Ramp	
Approx. Cost of Fishway	$70 - $100 k	

Overall Priority	12	
LGA/LGA Priority	ICC	1
Barrier ID	8933	
Stream Name	Bremer River	
Location	-27.602753°	152.695117°
Barrier Type	DNRM V-notch Gauging Weir	
Barrier Name	DNRM Weir	
Fishway Type Needed	Cone (1st ridge) &/or R.Ramp	
Approx. Cost of Fishway	$50 - $80 k	

Overall Priority	12	
LGA/LGA Priority	MBRC	5
Barrier ID	2252	
Stream Name	North Pine River	
Location	-27.266964°	152.956523°
Barrier Type	Culvert Causeway	
Barrier Name	Youngs Crossing	
Fishway Type Needed	Rock Ramp + Vertical Baffles	
Approx. Cost of Fishway	$25 - $40 k	

Overall Priority	15	
LGA/LGA Priority	RCC	2
Barrier ID	4876	
Stream Name	Hilliards Creek	
Location	-27.511266°	153.246640°
Barrier Type	Causeway (pedestrian)	
Barrier Name	Fellmonger Park	
Fishway Type Needed	New Culverts + Rock Ramp	
Approx. Cost of Fishway	$60 - $100 k	

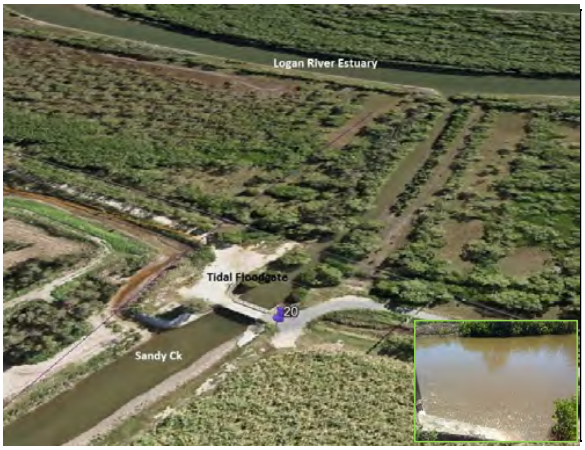
Overall Priority	15	
LGA/LGA Priority	ICC	3
Barrier ID	13807	
Stream Name	Warrill Creek	
Location	-27.602485°	152.695277°
Barrier Type	Weir - Sheet Pile & Gab. Bask.	
Barrier Name	200 m U/S Cunningham Hwy	
Fishway Type Needed	Removal/Full-width R.Ramp	
Approx. Cost of Fishway	$50 - $80 k	

Overall Priority	15	
LGA/LGA Priority	LCC	3
Barrier ID	4170	
Stream Name	Scrubby Creek	
Location	-27.656718°	153.142060°
Barrier Type	Culvert Causeway + Ap. Drop	
Barrier Name	Queens Rd	
Fishway Type Needed	Removal + Bridge	
Approx. Cost of Fishway	$70 - $90 k	

Overall Priority	18	
LGA/LGA Priority	GCCC	5
Barrier ID	13911	
Stream Name	Hotham Creek	
Location	-27.799051°	153.307883°
Barrier Type	Tidal Causeway	
Barrier Name	Sugar Cane Crossing	
Fishway Type Needed	Removal/Rock Ramp	
Approx. Cost of Fishway	$30 - $40 k	

Overall Priority	18	
LGA/LGA Priority	MBRC	6
Barrier ID	10719	
Stream Name	King John Creek	
Location	-27.093888°	153.028851°
Barrier Type	Pipe Causeway	
Barrier Name	Estuary diverted	
Fishway Type Needed	Bed Level Xing &/or R.Ramp	
Approx. Cost of Fishway	$15 - $25 k	

Overall Priority	20	
LGA/LGA Priority	GCCC	6
Barrier ID	5810	
Stream Name	Sandy Creek	
Location	-27.716465°	153.302614°
Barrier Type	New Tidal Floodgate	
Barrier Name	Loves Rd (main west arm)	
Fishway Type Needed	Fish Friendly Auto Tidal Gate	
Approx. Cost of Fishway	*$25 - $75 k	



Overall Priority	20	
LGA/LGA Priority	BCC	3
Barrier ID	11864	
Stream Name	Norman Creek	
Location	-27.497907°	153.043011°
Barrier Type	Tidal Culvert Apron Drop ~300mm	
Barrier Name	Logan Road - Hanlon Park	
Fishway Type Needed	R.Ramp/Cone + horizontal baffles	
Approx. Cost of Fishway	$20 - $40 k	

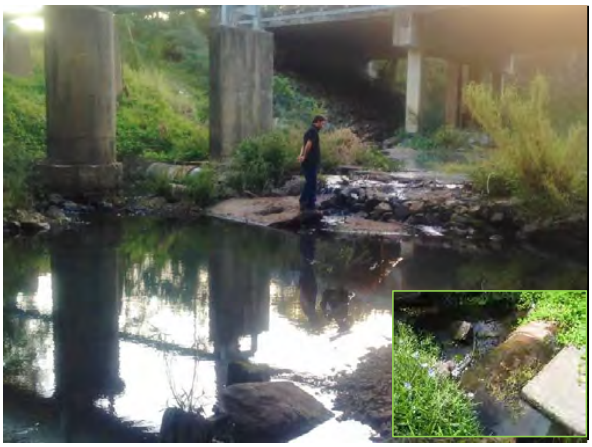
Overall Priority	22	
LGA/LGA Priority	MBRC	7
Barrier ID	2107	
Stream Name	Freshwater Creek	
Location	-27.252072°	153.043054°
Barrier Type	Tidal Bund	
Barrier Name	Hays Inlet FHA	
Fishway Type Needed	Removal/Rock Ramp	
Approx. Cost of Fishway	$5 - $30 k	

Overall Priority	22	
LGA/LGA Priority	MBRC	7
Barrier ID	13992	
Stream Name	King John Creek	
Location	-27.104366°	153.025763°
Barrier Type	Tidal Pipe Causeway	
Barrier Name	Tidal causeway adj FHA	
Fishway Type Needed	Removal/Bed level Crossing	
Approx. Cost of Fishway	$5 - $25 k	

Overall Priority	22	
LGA/LGA Priority	MBRC	7
Barrier ID	2278	
Stream Name	North Pine River	
Location	-27.259740°	152.950767°
Barrier Type	Weir ~2.5 m high	
Barrier Name	Seqwater @ Petrie Town	
Fishway Type Needed	Rock Ramp	
Approx. Cost of Fishway	$60 - $90 k	

Overall Priority	22	
LGA/LGA Priority	GCCC	7
Barrier ID	5807	
Stream Name	Sandy Creek East	
Location	-27.719208°	153.309700°
Barrier Type	Tidal Floodgate	
Barrier Name	School Rd	
Fishway Type Needed	Fish Friendly Auto Tidal Gate	
Approx. Cost of Fishway	*$25 -$75 k	

Overall Priority	26	
LGA/LGA Priority	BCC	4
Barrier ID	12433	
Stream Name	Moggill Creek	
Location	-27.516509°	152.925948°
Barrier Type	Concrete & Pipe Weir ~1m high	
Barrier Name	Under Moggill Rd	
Fishway Type Needed	Removal and/or Rock Ramp	
Approx. Cost of Fishway	$40 - $70 k	



Overall Priority	26	
LGA/LGA Priority	RCC	3
Barrier ID	4890	
Stream Name	Hilliards Creek	
Location	-27.525889°	153.246758°
Barrier Type	Box Culvert Causeway	
Barrier Name	QLD Gov.(DAF) Research Stn.	
Fishway Type Needed	Rock Ramp + Culverts	
Approx. Cost of Fishway	$60 - $90 k	

Overall Priority	26	
LGA/LGA Priority	BCC	4
Barrier ID	13996	
Stream Name	Cabbage Tree Creek	
Location	-27.334655°	153.043116°
Barrier Type	Rock Weir	
Barrier Name	Lemke Rd - adj AFL Club	
Fishway Type Needed	Removal/Rock Ramp	
Approx. Cost of Fishway	$5 - $10 k	

Overall Priority	26	
LGA/LGA Priority	LCC	4
Barrier ID	7083	
Stream Name	Quinzeh Creek	
Location	-27.755147°	153.115479°
Barrier Type	Causeway	
Barrier Name	D/S Waterford-Tamborine Rd	
Fishway Type Needed	Removal + Bd Level Xing/R.Ramp	
Approx. Cost of Fishway	$25 - $60 k	

Overall Priority	26	
LGA/LGA Priority	MBRC	10
Barrier ID	13992	
Stream Name	North Pine River	
Location	-27.263190°	152.951383°
Barrier Type	Pipe Culvert Causeway	
Barrier Name	Opposite Old Petrie Town	
Fishway Type Needed	Bed Level Xing/New Culverts	
Approx. Cost of Fishway	$20 - $50 k	

Overall Priority	26	
LGA/LGA Priority	MBRC	10
Barrier ID	13942	
Stream Name	Waraba Creek	
Location	-27.086080°	152.935456°
Barrier Type	Weir	
Barrier Name	Waraba Weir - Caboolture	
Fishway Type Needed	Cone/V-Slot/Bypass R.Ramp	
Approx. Cost of Fishway	$80 - $200 k	

Overall Priority	32	
LGA/LGA Priority	BCC	6
Barrier ID	12435	
Stream Name	Moggill Creek	
Location	-27.513516°	152.927873°
Barrier Type	Pipe Culvert Causeway	
Barrier Name	Kilkivan Avenue	
Fishway Type Needed	Low Flow & High Flow Rock Ramp	
Approx. Cost of Fishway	$20 - $80 k	

Overall Priority	32	
LGA/LGA Priority	LCC	5
Barrier ID	6387	
Stream Name	Scrubby Creek	
Location	-27.662613°	153.123738°
Barrier Type	Pipe Culvert Causeway	
Barrier Name	Gould Adams Prk - Kingston Rd	
Fishway Type Needed	Full-width Rock Ramp	
Approx. Cost of Fishway	$60- $100 k	

Overall Priority	32	
LGA/LGA Priority	MBRC	12
Barrier ID	2106	
Stream Name	Freshwater Creek	
Location	-27.668090°	153.119794°
Barrier Type	Earthern Bund	
Barrier Name	Upstream Hays Inlet FHA	
Fishway Type Needed	Removal/Rock Ramp	
Approx. Cost of Fishway	$5 - $30 k	

Image courtesy MBRC

Overall Priority	32	
LGA/LGA Priority	LCC	5
Barrier ID	6388	
Stream Name	Scrubby Creek	
Location	-27.668090°	153.119794°
Barrier Type	Pipe Culvert Causeway	
Barrier Name	D/S Logan Motorway	
Fishway Type Needed	Removal/Bed Level Xing + R.Ramp	
Approx. Cost of Fishway	$30 k - $60 k	

Overall Priority	32	
LGA/LGA Priority	ICC	4
Barrier ID	9649	
Stream Name	Bundamba Creek	
Location	-27.635605°	152.790513°
Barrier Type	Rock Weir	
Barrier Name	Worley Park	
Fishway Type Needed	Rock Ramp	
Approx. Cost of Fishway	$5 - $8 k	

Overall Priority	37	
LGA/LGA Priority	BCC	7
Barrier ID	665	
Stream Name	Downfall Creek	
Location	-27.371446°	153.065862°
Barrier Type	Weir	
Barrier Name	Virginia Golf Course	
Fishway Type Needed	Removal & or RRamp/Cone	
Approx. Cost of Fishway	$30 k - $80 k	

Overall Priority	37	
LGA/LGA Priority	ICC	8
Barrier ID	9748	
Stream Name	Bundamba Creek	
Location	-27.644044°	152.800083°
Barrier Type	Pipe Causeway	
Barrier Name	East Owen Street	
Fishway Type Needed	New Box Culverts &/or Rock Ramp	
Approx. Cost of Fishway	$20 - $90 k	

Overall Priority	37	
LGA/LGA Priority	GCCC	8
Barrier ID	5525	
Stream Name	Cabbage Tree Point Creek	
Location	-27.722999°	153.344490°
Barrier Type	Tidal Floodgate - Pipe	
Barrier Name	Cabbage Tree Point	
Fishway Type Needed	Fish Friendly Auto-tidal Gates	
Approx. Cost of Fishway	$10 - $15 k	

Overall Priority	40	
LGA/LGA Priority	BCC	8
Barrier ID	343	
Stream Name	Zillmere Waterholes	
Location	-27.364832°	153.061926°
Barrier Type	Culvert Causeway	
Barrier Name	Sandgate Road	
Fishway Type Needed	Rock Ramp + Nib wall & Baffles	
Approx. Cost of Fishway	$30 - $50 k	

Overall Priority	40	
LGA/LGA Priority	BCC	8
Barrier ID	13828	
Stream Name	Hemmant Creek	
Location	-27.451713°	153.125205°
Barrier Type	Tidal Floodgate	
Barrier Name	Hemmant Tingalpa Rd	
Fishway Type Needed	Fish Friendly Auto-tidal Gates	
Approx. Cost of Fishway	$25 - $35	

Overall Priority	40	
LGA/LGA Priority	MBRC	13
Barrier ID	13940	
Stream Name	King John Creek	
Location	-27.102760°	153.025381°
Barrier Type	Earthern Bund	
Barrier Name	Deception Bay FHA	
Fishway Type Needed	Removal/Bed Level Crossing	
Approx. Cost of Fishway	$5 - $15 k	

Overall Priority	40	
LGA/LGA Priority	BCC	8
Barrier ID	11865	
Stream Name	Norman Creek	
Location	-27.499142°	153.042516°
Barrier Type	Concrete lined drain	
Barrier Name	Hanlon Park	
Fishway Type Needed	Horizontal Culvert Baffles	
Approx. Cost of Fishway	$40 - $90 k	

Overall Priority	44	
LGA/LGA Priority	BCC	11
Barrier ID	11647	
Stream Name	Bulimba Creek	
Location	-27.502643°	153.105451°
Barrier Type	Culvert Causeway	
Barrier Name	Opposite Carindale Shop. Cntr	
Fishway Type Needed	Rock Ramp	
Approx. Cost of Fishway	$15 - $25	

Overall Priority	44	
LGA/LGA Priority	BCC	11
Barrier ID	13943	
Stream Name	Blunder Creek	
Location	-27.571258°	152.987956°
Barrier Type	Causeway	
Barrier Name	Oxley Creek Junction	
Fishway Type Needed	Removal/Bed Level Xing	
Approx. Cost of Fishway	$3 -$5 k	

Overall Priority	44	
LGA/LGA Priority	BCC	11
Barrier ID	11648	
Stream Name	Bulimba Creek	
Location	-27.504079°	153.105604°
Barrier Type	Culvert Causeway	
Barrier Name	Opposite Carindale Shop. Cntr	
Fishway Type Needed	Removal	
Approx. Cost of Fishway	$3 - $5 k	

Overall Priority	47	
LGA/LGA Priority	ICC	9
Barrier ID	12970	
Stream Name	Woogaroo Creek	
Location	-27.622268°	152.908130°
Barrier Type	Rock Weir	
Barrier Name	Newman St Easement	
Fishway Type Needed	Rock Ramp	
Approx. Cost of Fishway	$30 - $50 k	

Overall Priority	47	
LGA/LGA Priority	MBRC	14
Barrier ID	1523	
Stream Name	South Pine River	
Location	-27.365176°	152.877745°
Barrier Type	Culvert Causeway	
Barrier Name	Cannington Crt - Samford	
Fishway Type Needed	Rock Ramp + Baffles/Culverts	
Approx. Cost of Fishway	$40 k - $80 k	

Overall Priority	47	
LGA/LGA Priority	BCC	14
Barrier ID	12461	
Stream Name	Moggill Creek	
Location	-27.504555°	152.930528°
Barrier Type	Pipe Causeway	
Barrier Name	Branton Street	
Fishway Type Needed	Removal/Rock Ramp	
Approx. Cost of Fishway	$20 k - $80 k	

Overall Priority	47	
LGA/LGA Priority	MBRC	15
Barrier ID	11071	
Stream Name	Caboolture River	
Location	-27.109714°	152.885927°
Barrier Type	Culvert Causeway	
Barrier Name	Litherland Road	
Fishway Type Needed	Rock Ramp + Baffles	
Approx. Cost of Fishway	$30 - $50 k	

Overall Priority	47	
LGA/LGA Priority	LCC	14
Barrier ID	13407	
Stream Name	Scrubby Creek	
Location	-27.664953°	153.087981°
Barrier Type	Weir	
Barrier Name	Demeio Park	
Fishway Type Needed	Full-width Rock Ramp	
Approx. Cost of Fishway	$50 k - $80 k	

Overall Priority	47	
LGA/LGA Priority	MBRC	14
Barrier ID	3953	
Stream Name	Six Mile (Elimbah) Creek	
Location	-26.997845°	152.918202°
Barrier Type	Relic Causeway	
Barrier Name	Beerburrum West State Forest	
Fishway Type Needed	Removal	
Approx. Cost of Fishway	$4 - 8 k	

Overall Priority	47	
LGA/LGA Priority	GCCC	9
Barrier ID	7749	
Stream Name	Pimpama River	
Location	-27.790614°	153.269688°
Barrier Type	Pipe Causeway	
Barrier Name	Relic barrier in GC train corridor	
Fishway Type Needed	Removal	
Approx. Cost of Fishway	$5 - $15 k	

Overall Priority	47	
LGA/LGA Priority	MBRC	14
Barrier ID	2417	
Stream Name	Bells Creek	
Location	-27.252733°	153.092914°
Barrier Type	Culverts + Concrete lined drain	
Barrier Name	Bells Paddock Reserve	
Fishway Type Needed	Horizontal & Vertical Baffles	
Approx. Cost of Fishway	$15 - $50 k	

Overall Priority	47	
LGA/LGA Priority	RCC	4
Barrier ID	5071	
Stream Name	Eprapah Creek	
Location	-27.583315°	153.281349°
Barrier Type	Culvert Causeway	
Barrier Name	Redland Bay Road	
Fishway Type Needed	Culvert Baffles	
Approx. Cost of Fishway	$15 - $40 k	

Overall Priority	56	
LGA/LGA Priority	ICC	10
Barrier ID	3953	
Stream Name	Six Mile Creek	
Location	-27.606753°	152.859900°
Barrier Type	Rock Weir	
Barrier Name	Urban Utilities Pipeline barrier	
Fishway Type Needed	Removal/Rock Ramp	
Approx. Cost of Fishway	$10 - $40 k	

Overall Priority	56	
LGA/LGA Priority	MBRC	18
Barrier ID	1264	
Stream Name	Cedar Creek	
Location	-27.338880°	152.882218°
Barrier Type	Perched Culvert Causeway	
Barrier Name	Hanson Road	
Fishway Type Needed	New culverts/ Rock Ramp	
Approx. Cost of Fishway	$40 - $80 k	

Overall Priority	56	
LGA/LGA Priority	LCC	15
Barrier ID	10540	
Stream Name	Oxley Creek	
Location	-27.728289°	152.948461°
Barrier Type	Perched Culvert Causeway	
Barrier Name	Roberts Road	
Fishway Type Needed	New culverts/Rock Ramp	
Approx. Cost of Fishway	$40 - $80 k	

Overall Priority	56	
LGA/LGA Priority	RCC	5
Barrier ID	4850	
Stream Name	Tarradarrapin Creek	
Location	-27.490879°	153.220676°
Barrier Type	Culvert Apron Drop	
Barrier Name	Dorsal Drive	
Fishway Type Needed	Retro-fit Cone/Rock Ramp	
Approx. Cost of Fishway	$50 - $80 k	

Overall Priority	56	
LGA/LGA Priority	BCC	15
Barrier ID	4256	
Stream Name	Wynnum Creek	
Location	-27.440850°	153.169327°
Barrier Type	Tidal Weir	
Barrier Name	Adjacent Tingal Rd	
Fishway Type Needed	Removal/Rock Ramp	
Approx. Cost of Fishway	$4 - $30 k	

Overall Priority	56	
LGA/LGA Priority	BCC	15
Barrier ID	13995	
Stream Name	Bulimba Creek	
Location	-27.514289°	153.108399°
Barrier Type	Rock Weir	
Barrier Name	Pacific Golf Course	
Fishway Type Needed	Removal	
Approx. Cost of Fishway	$2 - $5 k	

Overall Priority	56	
LGA/LGA Priority	GCCC	10
Barrier ID	7811	
Stream Name	Pimpama River	
Location	-27.787995°	153.268460°
Barrier Type	Culvert Causeway	
Barrier Name	Stewarts Road	
Fishway Type Needed	Rock Ramp + Baffles/Box Culverts	
Approx. Cost of Fishway	$30 - $70 k	

Appendix 2 - Greater Brisbane Fish Barrier Remediation Case Studies

Case Study 1 - Paradise Road Overpass, Slacks Creek

Introduction

The remediation of the Paradise Road overpass barrier in Slacks Creek was undertaken in partnership between Logan City Council and Catchment Solutions. The Paradise Road overpass was ranked the 36th highest priority barrier in the GB region. A fish passage options assessment was undertaken to determine the most appropriate fish passage solution at this site. The investigation determined that a combination of two fishway designs would provide suitable fish passage; rock-ramp fishway to assist fish ascending the concrete culvert apron drop, and a series of horizontal concrete baffles retrofitted to the base of the culverts to assist fish passage through the 50 m long culverts (500 mm head loss).

Barrier Ranking	36th in the Greater Brisbane region
Barrier Type(s)	Surface drop, water depth and flow velocity
Total Surface Drop (head loss)	1.8 m, consisting of 0.5 m through culverts and 1.3 m off culvert apron
Best Remediation Method	Combination of nature-like partial-width rock-ramp and horizontal culvert baffle fishways
Length of Fishway	91 m
Number of Ridges	17 ridges in rock-ramp, 10 horizontal culvert baffle ridges
Drops Between Pools	80 mm for rock-ramp & 50 mm for the horizontal baffles
Slots (number & type)	4 slots, consisting 2 x high flow and 2 x low flow
Total Construction Time	3 weeks
Total Rock Used	783 t – predominantly consisting of large rock: 1.2 - 3 m (up to 11 t)
Total Overall Cost	$ 124 000

Figure 20. Left; showing the 1.3 m surface drop barrier off the downstream face of the culvert apron. Right; showing stream flow spread out across all four box culverts creating a shallow water surface barrier along the entire 50 m length of the structure. During stream flow events the culverts also created a flow velocity barrier.

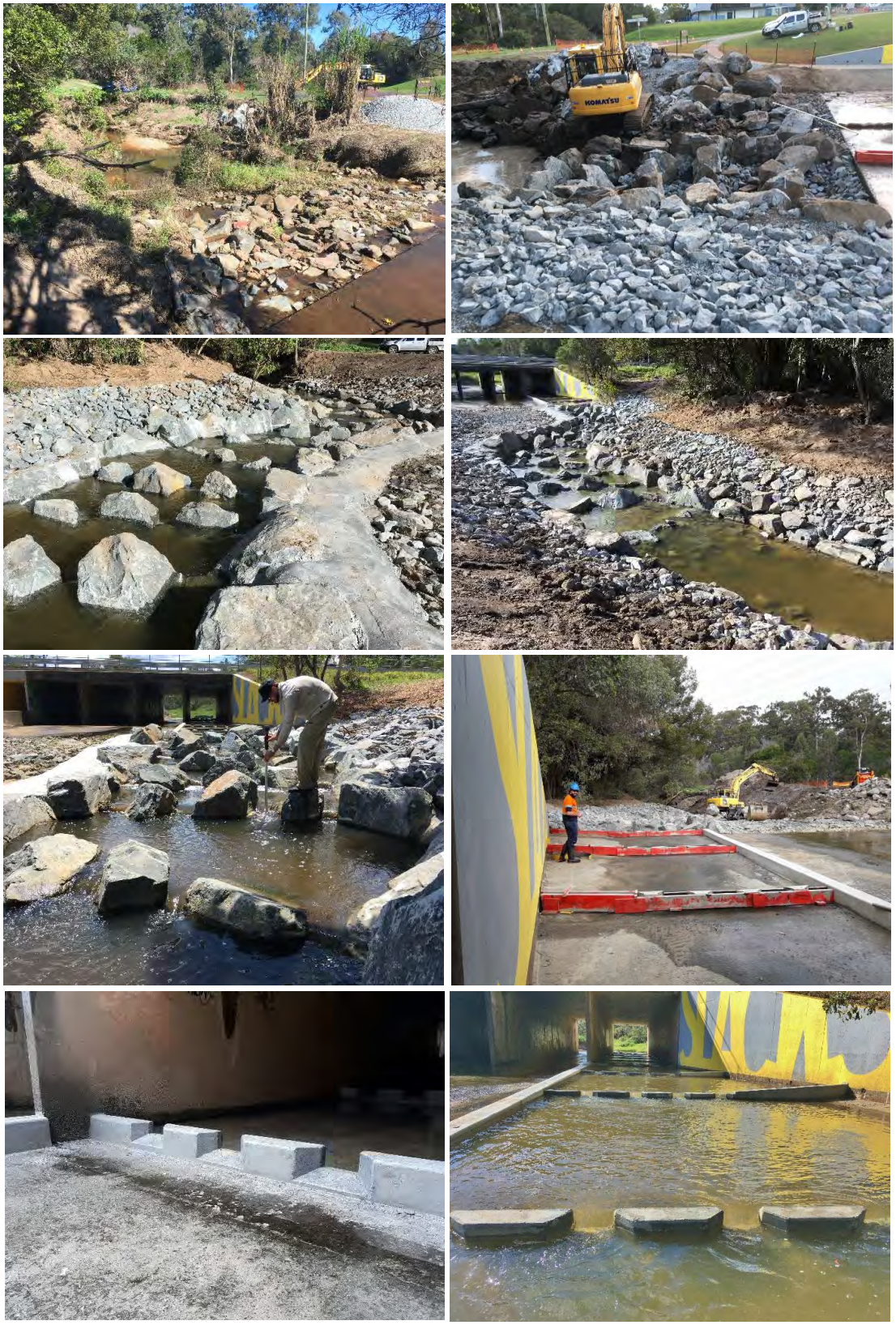


Figure 21. Showing during and post construction of the rock-ramp and horizontal culvert baffle fishways

Pre Fishway Construction Monitoring

Prior to fishway construction works, the barrier was monitored for one week to evaluate the overall impacts to the fish communities of Slacks Creek and determine how many, and what species, were making it past the barrier. Over almost five days of monitoring, six species were surveyed ascending the barrier, at an overall catch rate of 4.12 individual fish per day. Two of the fish species recorded in the trap; striped gudgeon and long-finned eel, possess an ability to climb vertical wet surfaces (barriers).

Migration Classification	Common Name	Species Name	Size Range (mm)	CPUE (Fish/day)
Diadromous	Empire gudgeon	*Hypseleotris compressa*	21- 64	0.62
	Long-finned eel	*Anguilla reinhardtii*	19- 56	0.82
	Striped gudgeon	*Gobiomorphus australis*	19- 69	0.82
Potamodromous	Hypseleotris sp.	*Hypseleotris species*	17	0.21
	Firetail gudgeon	*Hypseleotris galii*	31- 46	0.62
	Western carp gudgeon	*Hypseleotris klunzingeri*	16- 20	1.03
		Total Species and Overall CPUE	**6**	**4.12**

Post Remediation Works

Following the construction of the rock-ramp and horizontal baffle fishway, monitoring was again carried out to assess the success of the fishways at passing the full suite of fish species and size classes expected to occur within Slacks Creek. Over almost five days of monitoring, 6,546 fish representing 11 species were surveyed successfully ascending the fishways, at an overall catch rate of 1,384.18 fish per day. This is a substantial increase from pre-construction monitoring results of only 4.12 fish per day able to ascend the barrier, and highlights the numbers of fish which were previously trying to move past the Paradise Road overpass barrier, however were unable to do so. Significantly, juvenile diadromous fish species were recorded at the highest catch rates, with striped gudgeon captured at a rate of 812 fish per day, followed by empire gudgeon and sea mullet with 272 and 258 fish per day respectively. Native fish comprised 98.9% of the total catch (individuals), which again emphasises the importance of this remediated fish barrier.

Migration Classification	Common Name	Species Name	Size Range (mm)	CPUE (Fish/day)
Diadromous	Empire gudgeon	*Hypseleotris compressa*	16- 72	272.14
	Long-finned eel	*Anguilla reinhardtii*	40- 300	4.65
	Sea mullet	*Mugil cephalus*	24- 51	257.76
	Striped gudgeon	*Gobiomorphus australis*	14- 112	812.62
Potamodromous	Firetail gudgeon	*Hypseleotris galii*	31- 36	0.85
	Flathead gudgeon	*Philypnodon grandiceps*	19- 62	12.69
	Western carp gudgeon	*Hypseleotris klunzingeri*	18- 34	8.88
Pest Fish	Mosquito fish	*Gambusia holbrooki*	12- 44	12.26
	Platy	*Xiphophorus maculatus*	31- 33	0.85
	Swordtail	*Xiphophorus helleri*	38	0.42
	Tilapia	*Oreochromis mossambicus*	125- 390	1.06
		Total Species and Overall CPUE	**11**	**1384.18**

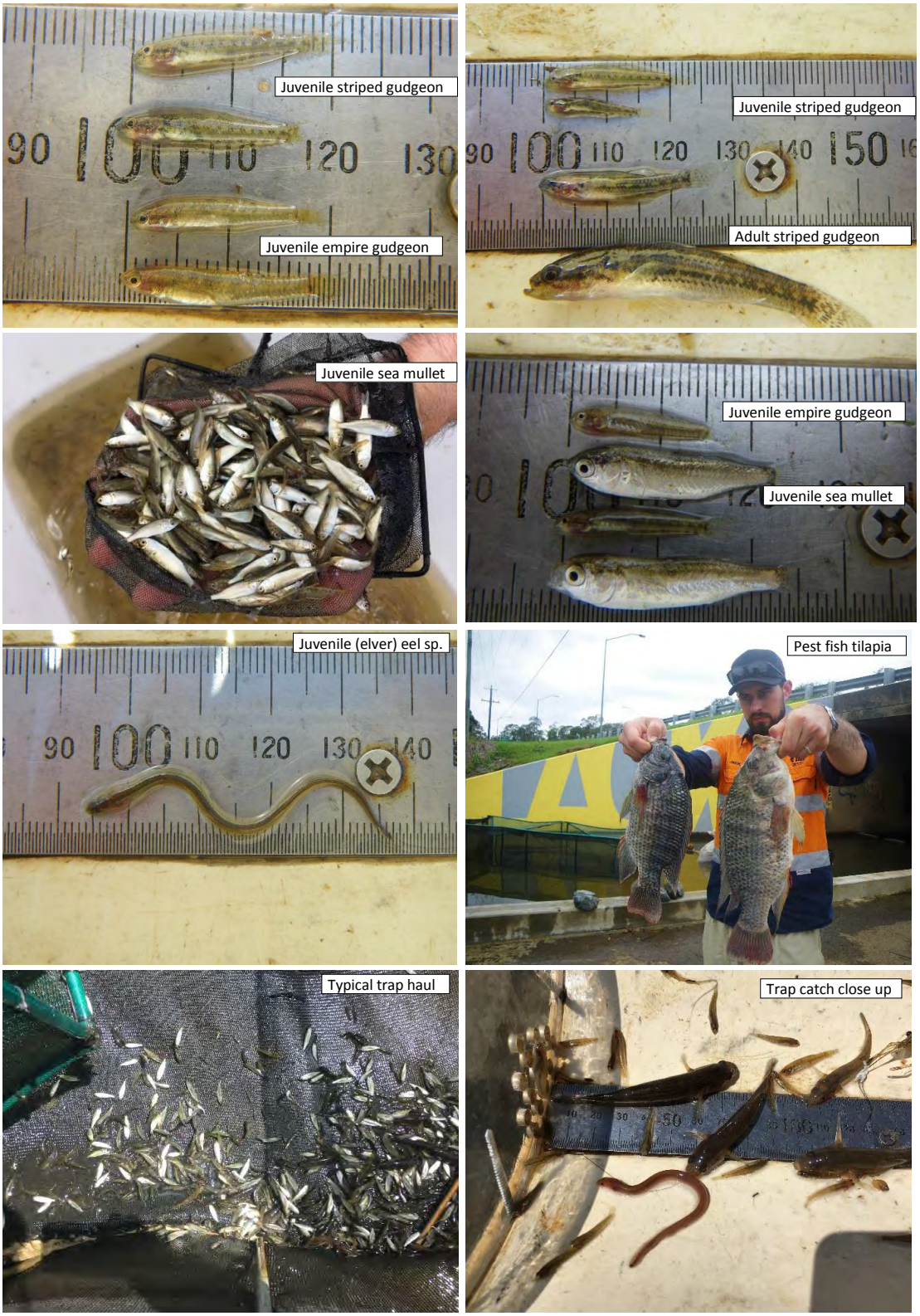


Figure 22. Fish captured successfully ascending the Slacks Creek fishways during assessment monitoring

Case Study 2- Berrys Weir, Bremer River

Introduction

The remediation of Berrys Weir with rock-ramp fishway on the Bremer River was undertaken in partnership between Ipswich City Council and Catchment Solutions in 2016. Berrys Weir was the 7th highest priority ranked fish barrier in the Greater Brisbane region. The 2.4 m high weir was constructed in the 1960's to impound water for power generation (Stanwell). A fish passage options assessment determined that a partial width rock-ramp fishway would be the best remediation option at this site.

Barrier Ranking	7th in Greater Brisbane region
Barrier Type(s)	Surface drop
Total Surface Drop	2.4 m
Best Remediation Method	1:33 Partial- width rock-ramp fishway + 1:15 full width
Length of Fishway	90 m
Number of Ridges	33
Drops Between Pools	75 mm
Total Construction Time	3 weeks
Total Rock Used	480 t
Total Overall Cost	$ 96 000

Figure 23. Berrys Weir fish barrier before remediation works, with relict north- American style fish ladder visible down left side of weir

Fishway Construction Works

Figure 24. Berrys Weir fishway construction images

Fishway Monitoring

Following fishway construction, two separate rounds of monitoring were carried out in December 2016 and December 2017 to assess the capabilities of the fishway at passing the full suite of fish species and size classes expected to occur within Bremer River. On both occasions, the fishway trap was set at the exit of the fishway on the upstream side of the weir, to show the numbers and species of fish that were able to ascend the rock-ramp fishway. In 2016, a total of 19 different species were captured at a rate of 690.4 fish per trapping day, whilst in 2017, 16 species were captured at a rate of 4,075.5 fish per day. Significantly, four 'new' native species were captured successfully ascending the fishway that had not been recorded in over 14 years of EHMP fish surveys within the Bremer River, including freshwater mullet, speckled goby, yellowfin bream and fork-tailed catfish. These results highlight the impact that barriers close to the estuarine interface have on the health of freshwater fish communities. Other notable fishway monitoring results (2017) include the capture of 1,073 juvenile freshwater mullet at a catch rate of 267 fish per day, and 1,273 sea mullet at a catch rate of 316 fish per day.

Migration Classification	**Common Name**	**Species Name**	**Size Range** (mm)		**CPUE** (Fish/day)	
			2016	**2017**	**2016**	**2017**
Marine Vagrant	Yellowfin bream	*Acanthopagrus australis*	254	-	0.2	-
Diadromous	Empire gudgeon	*Hypseleotris compressa*	19- 52	21- 64	114.1	2020.5
	Long-finned eel	*Anguilla reinhardtii*	70- 550	400- 1200	2.8	1.5
	Bullrout	*Notesthes robusta*	35- 58	28- 165	1.6	27.8
	Eel sp.	*Anguilla species*	-	50- 65	-	1
	Freshwater mullet	*Trachystoma petardi*	-	51- 79	-	266.6
	Sea mullet	*Mugil cephalus*	38 72	34- 234	38.9	316.3
	Striped gudgeon	*Gobiomorphus australis*	21- 52	21- 83	80	1283.7
Potamodromous	Firetail gudgeon	*Hypseleotris galii*	31- 33	28- 42	1	12.7
	Flathead gudgeon	*Philypnodon grandiceps*	20- 51	19- 25	10.2	0.5
	Crimson-spotted rainbowfish	*Melanotaenia duboulayi*	18- 74	36- 41	177.4	0.5
	Hypseleotris sp.	*Hypseleotris species*	15- 41	-	248.1	-
	Bony bream	*Nematalosa erebi*	110- 254	39- 204	1.2	21.1
	Speckled goby	*Redigobius bikolanus*	25- 33	-	2.4	-
	Australian smelt	*Retropinna semoni*	24- 40	22- 54	2	121
	Fork-tailed catfish	*Arius graeffei*	230- 350	-	1.2	-
	Pacific blue-eye	*Pseudomugil signifer*	32	-	0.2	-
	Eel-tailed catfish	*Tandanus tandanus*	34	-	0.2	-
	Agassiz's glassfish	*Ambassis agassizii*	40- 53	-	0.4	-
	Banded grunter	*Amniataba percoides*	-	110	-	0.2
	Spangled perch	*Leiopotherapon unicolor*	-	165- 195	-	0.5
	Unspecked hardyhead	*Craterocephalus fulvus*	-	35- 56	-	1.2
Pest Fish	Platy	*Xiphophorus maculatus*	25	-	0.2	-
	Tilapia	*Oreochromis mossambicus*	72	385	0.2	0.2
Total Species and Overall CPUE			**19**	**16**	**690.4**	**4075.5**

Figure 25. Fish captured ascending Berrys Weir fishway during monitoring

Case Study 3 - Leitchs Crossing, South Pine River

Introduction

The remediation of Leitchs Crossing with a nature-like rock-ramp fishway was undertaken in partnership between Moreton Bay Regional Council and Catchment Solutions. Leitchs Crossing is located in the lower reaches of the South Pine River and was ranked the 11th highest priority fish barrier in the Greater Brisbane region. A fish passage options assessment determined that a full width rock-ramp fishway was the best fish passage remediation option for this barrier type in assisting fish to ascend past the barrier.

Barrier Ranking	11th in Greater Brisbane region
Barrier Type(s)	Surface drop barrier, water depth barrier and flow velocity barrier
Total Surface Drop (head loss)	0.5 m
Best Remediation Method	Full width rock-ramp fishway
Length of Fishway	15
Number of Ridges	7
Drops Between Pools	75 mm
Total Construction Time	4 days
Total Rock Used	192 t
Total Overall Cost	$60 000

Figure 26. Showing Leitchs Crossing fish barrier prior to fishway construction

Fishway Construction Works

Figure 27. Showing during and post construction of Leitchs Crossing fishway

Post Remediation Works

Following the construction of the rock-ramp fishway at Leitchs Crossing, fishway monitoring was carried out in October 2017 to assess the capabilities of the fishway at passing the full suite of fish species and size classes expected to occur in South Pine River. The fishway trap was set at the exit of the fishway on the upstream side of the crossing, to show the numbers and species of fish that were able to ascend the rock-ramp fishway. Across five days of monitoring, a total of 19 species were surveyed ascending the fishway, at an overall rate of 1,195.9 fish per day. Notable captures include juvenile freshwater mullet and speckled goby, both diadromous fish species that had not previously been recorded during annual EHMP fish surveys in the South Pine River (survey site located upstream of the barrier/fishway site). It's anticipated that improved connectivity as result of the fishway will assist in the recovery of freshwater mullet and speckled goby populations in the South Pine River. Also significant was the high numbers of juvenile sea mullet; SEQ most important inshore net commercial species, recorded at a catch rate of 209 fish per day. Similar to all fishway monitoring sites, no wild Australian bass were recorded, potentially suggesting poor and/or failed recruitment of this species. Australian bass populations in SEQ waterways appear to be masked by escaped stocked fish from impoundments during overtopping events.

Migration Classification	Common Name	Species Name	Size Range (mm)	CPUE (Fish/day)
Diadromous	Empire gudgeon	*Hypseleotris compressa*	19- 72	19.87
	Long-finned eel	*Anguilla reinhardtii*	70- 800	1.42
	Sea mullet	*Mugil cephalus*	23- 308	209.36
	Striped gudgeon	*Gobiomorphus australis*	19- 41	17.74
	Bullrout	*Notesthes robusta*	45- 150	2.60
	Freshwater mullet	*Trachystoma petardi*	50- 65	6.86
Potamodromous	Firetail gudgeon	*Hypseleotris galii*	19- 38	812.62
	Flathead gudgeon	*Philypnodon grandiceps*	19- 56	62.69
	Western carp gudgeon	*Hypseleotris klunzingeri*	19- 34	0.95
	Agassiz's glassfish	*Ambassis agassizii*	25- 54	15.38
	Unspecked hardyhead	*Craterocephalus fulvus*	25- 63	15.61
	Crimson-spotted rainbowfish	*Melanotaenia duboulayi*	54	0.24
	Dwarf flathead gudgeon	*Philypnodon maculatus*	16- 28	15.38
	Philypnodon sp.	*Philypnodon species*	21- 45	1.42
	Speckled goby	Redigobius bikolanus	21- 26	0.95
	Australian smelt	Retropinna semoni	21- 42	8.75
Pest Fish	Mosquito fish	*Gambusia holbrooki*	19- 29	1.18
	Platy	*Xiphophorus maculatus*	28- 32	0.95
	Tilapia	*Oreochromis mossambicus*	15- 330	1.89
		Total Species and Overall CPUE	**19**	**1195.86**

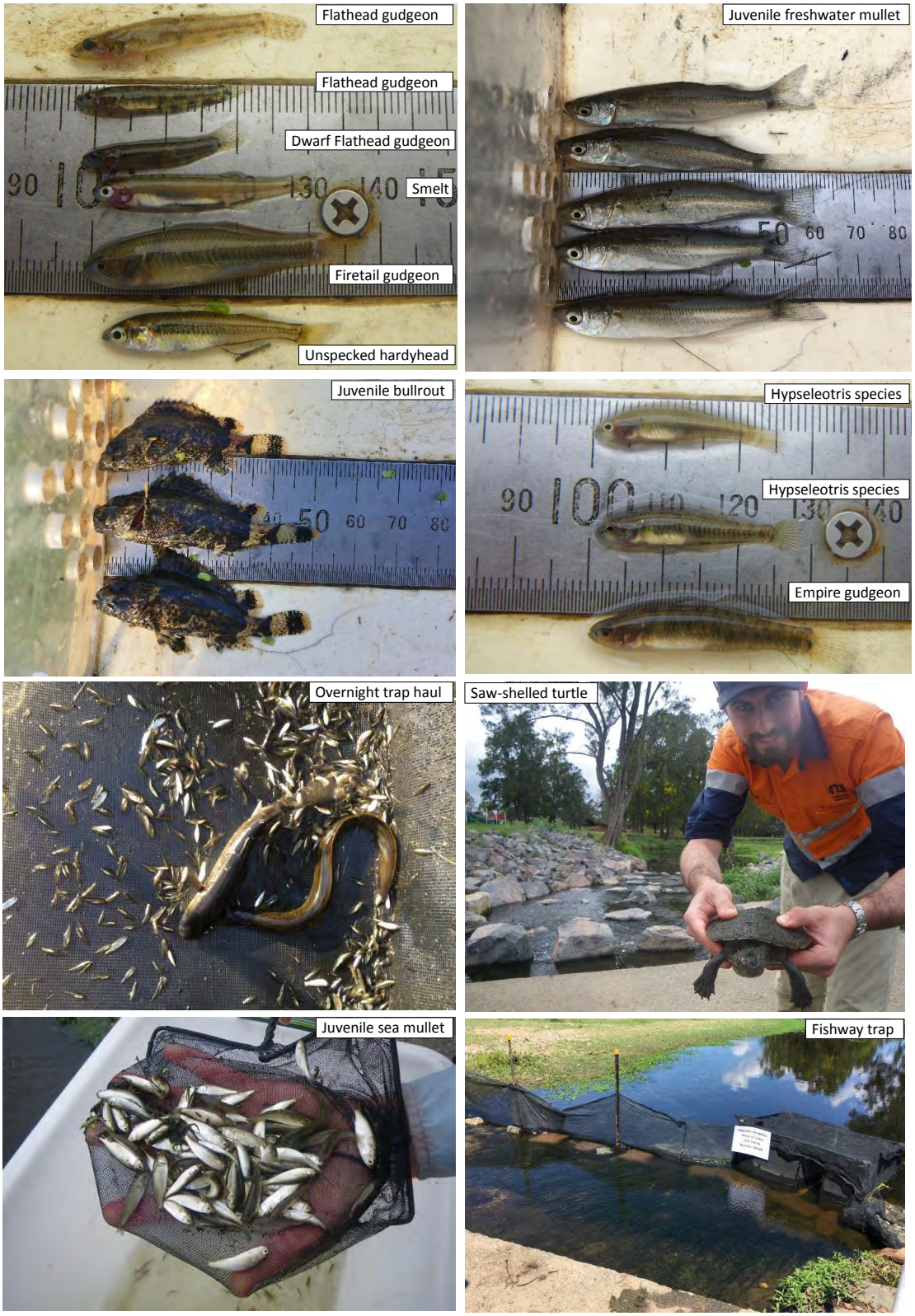


Figure 28. Fish captured successfully ascending Leitchs Crossing fishway during monitoring

Case Study 4 - Hilliards Weir, Hilliards Creek

The remediation of Hilliards Creek Weir with a rock-ramp fishway was undertaken in partnership between Redland City Council and Catchment Solutions. The relic weir on Hilliards Creek was ranked the 36th highest priority fish barrier in Greater Brisbane region. A fish passage options assessment determined that a full width rock-ramp fishway was the best fish passage remediation option for this barrier type in assisting fish to ascend past the barrier.

Barrier Ranking	36th in Greater Brisbane region
Barrier Type(s)	Surface drop barrier
Total Surface Drop	0.75 m
Best Remediation Method	Full width rock-ramp fishway
Length of Fishway	18 m
Number of Ridges	9
Drops Between Pools	80 mm
Total Construction Time	4 days
Total Rock Used	205 t
Total Overall Cost	$ 42 000

Figure 29. Showing the Hilliards Creek weir prior to fishway construction.

Fishway Construction Works

Figure 30. Showing construction images of Hilliards Creek fishway

Post Remediation Works

Following the construction of the rock-ramp fishway, monitoring was carried out in December 2016 to assess the capabilities of the fishway at passing the full suite of fish species and size classes expected to occur in Hilliards Creek. The fishway trap was set at the exit of the fishway on the upstream side of the crossing, to show the numbers and species of fish that were able to ascend the rock-ramp fishway. Across five days of monitoring, a total of 9 species were surveyed ascending the fishway, at an overall catch rate of 177.66 fish per day. The small size of fish (≥15 mm) that were successful at ascending the fishway indicates the fishway is operating as intended (small size fish are generally weaker swimmers than adults, as they don't possess the same muscle to propel them through the water). However, due to a low passability fish barrier located downstream in Fellmonger Park (Figure 31), the numbers of fish migrating through the fishway were reduced when compared to other fishways constructed as part of this project.

The Fellmonger Park barrier consists of a raised pedestrian causeway with two small partially blocked pipe culverts buried underneath. This causeway is a major barrier to fish passage during all base, low and medium flow events. Only during very in-frequent 'drown out' events is fish passage potentially available past this barrier, but only if migrating fish are located below the weir at the time of 'drown out' and possess swimming abilities in-excess of the velocities experienced at the barrier site.

Boat electrofishing surveys were undertaken upstream and downstream of this barrier to detect any differences in fish community condition. The survey results demonstrated the barrier was significantly impacting upstream fish communities, with the catch rate (56.97 fish/min) of diadromous fish species downstream of the barrier more than four times higher than upstream of the barrier (12.37 fish/min) (Moore, 2017).

Table 1. Showing fish species, size range and catch per unit effort of fish (fish/day) successful at ascending the fishway

Migration Classification	**Common Name**	**Species Name**	**Size Range** (mm)	**CPUE** (Fish/day)
Diadromous	Empire gudgeon	*Hypseleotris compressa*	19- 81	18.22
	Long-finned eel	*Anguilla reinhardtii*	60- 800	1.08
	Sea mullet	*Mugil cephalus*	38- 51	15.62
	Striped gudgeon	*Gobiomorphus australis*	38- 51	1.3
Potamodromous	Hypseleotris species	*Hypseleotris sp.*	20- 43	77.44
	Unspecked hardyhead	*Craterocephalus fulvus*	20- 71	54.66
Pest Fish	Mosquito fish	*Gambusia holbrooki*	15- 35	8.68
	Platy	*Xiphophorus maculatus*	64	0.22
	Tilapia	*Oreochromis mossambicus*	329	0.22
		Total Species and Overall CPUE	**9**	**177.66**

Figure 30. Showing Hilliards Creek fishway monitoring catch results.

Figure 31. Left; showing an adult tarpon captured immediately upstream of the barrier site post fishway construction. tarpon are a highly prized recreational fishing species, which breed in estuarine waters before migrating upstream into freshwater as juveniles. Barriers significantly impact the distribution and population of this species. Right; Fellmonger Park pedestrian causeway fish barrier. A Hilliards Creek fish community study found this barrier to be significantly impacting fish populations within Hilliards Creek , particular diadromous species.

Appendix 3 - Barriers of Each LGA

Brisbane City Council LGA

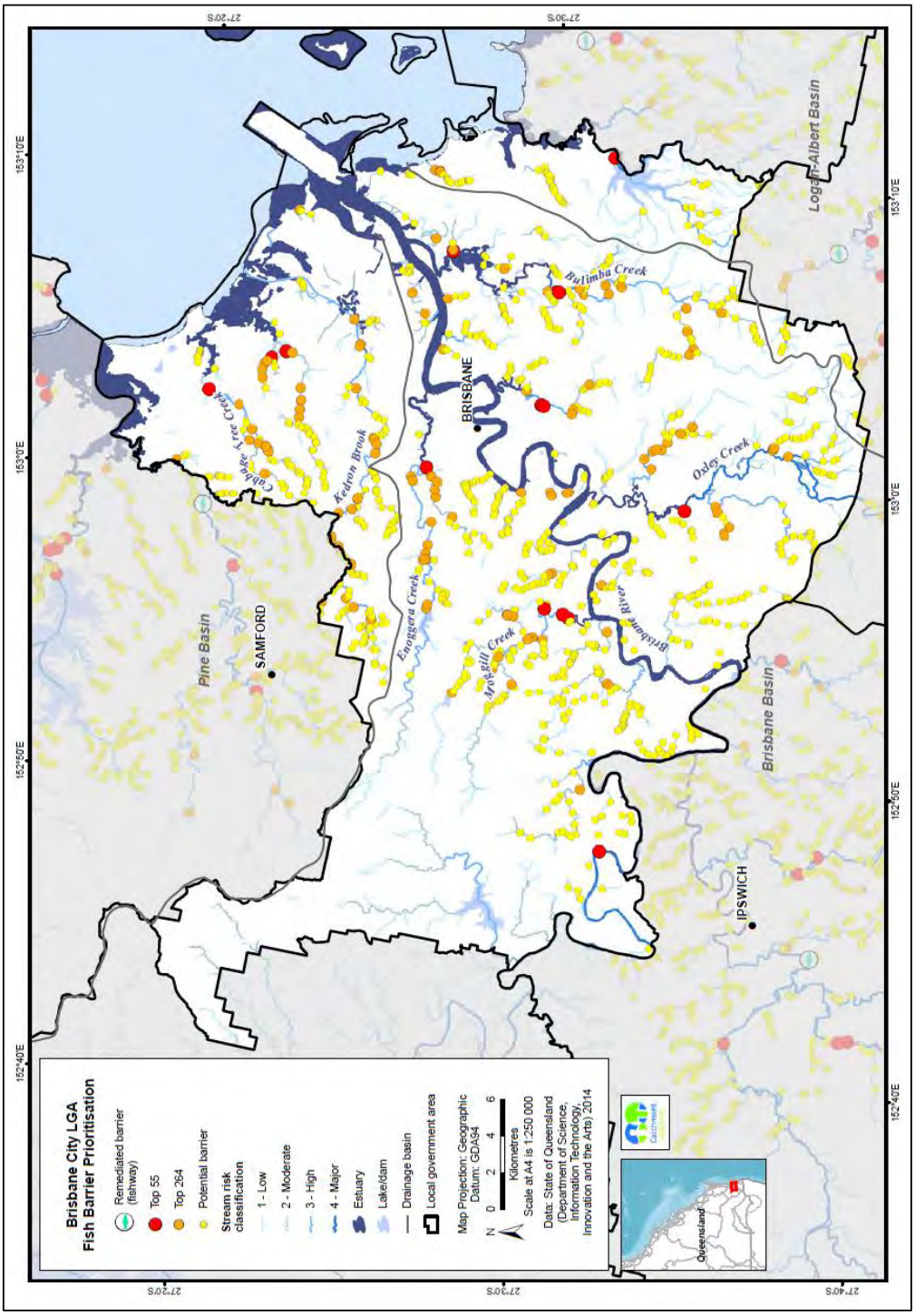


Figure 32. Brisbane City Council LGA barriers, broken down into top 55 (red), top 264 (orange), potential barriers (yellow) and remediated barriers (green)

Gold Coast City Council LGA

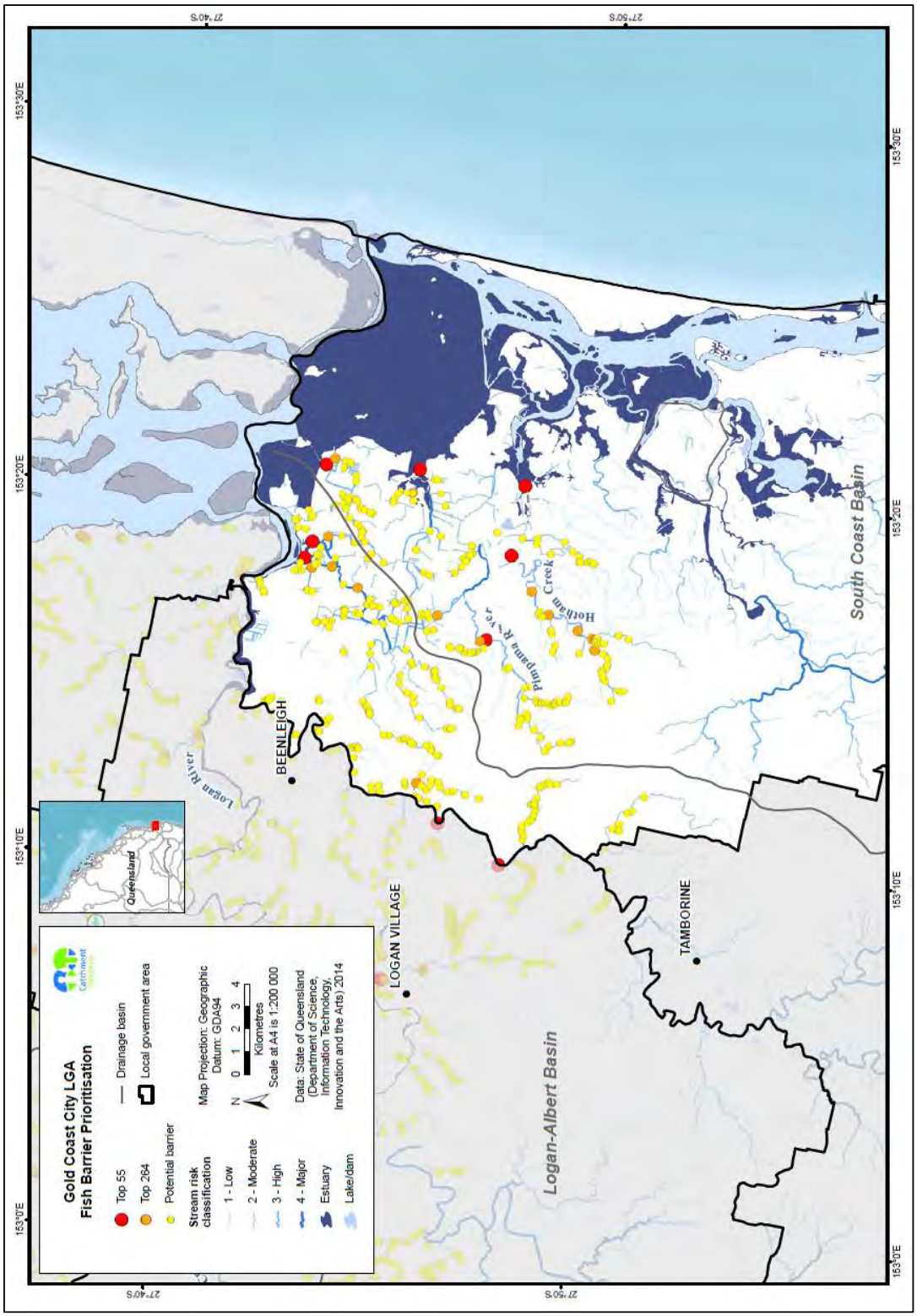


Figure 33. Gold Coast City Council LGA barriers, broken down into top 55 (red), top 264 (orange), potential barriers (yellow) and remediated barriers (green)

Ipswich City Council LGA

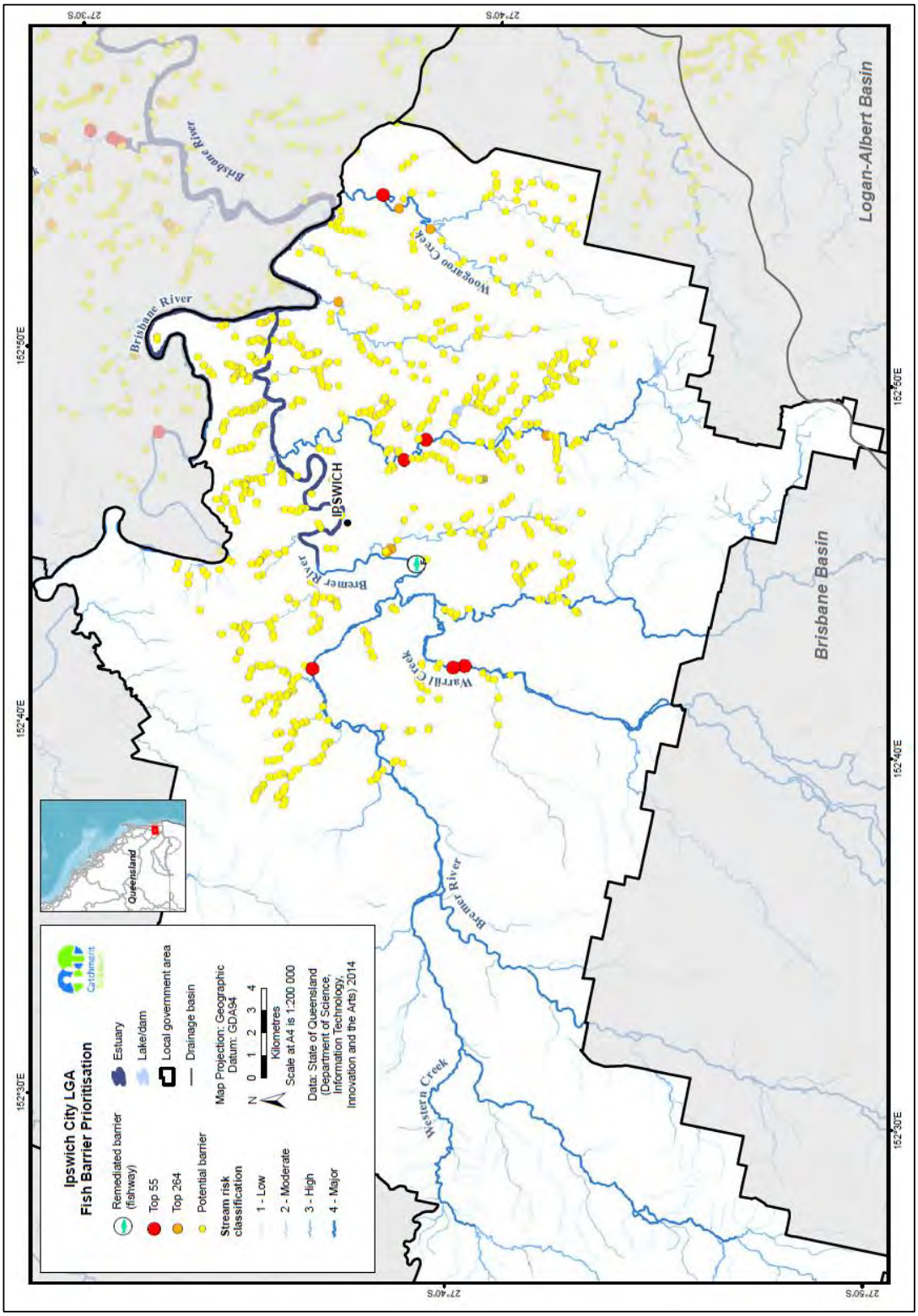


Figure 34. Ipswich City Council LGA barriers, broken down into top 55 (red), top 264 (orange), potential barriers (yellow) and remediated barriers (green)

Logan City Council LGA

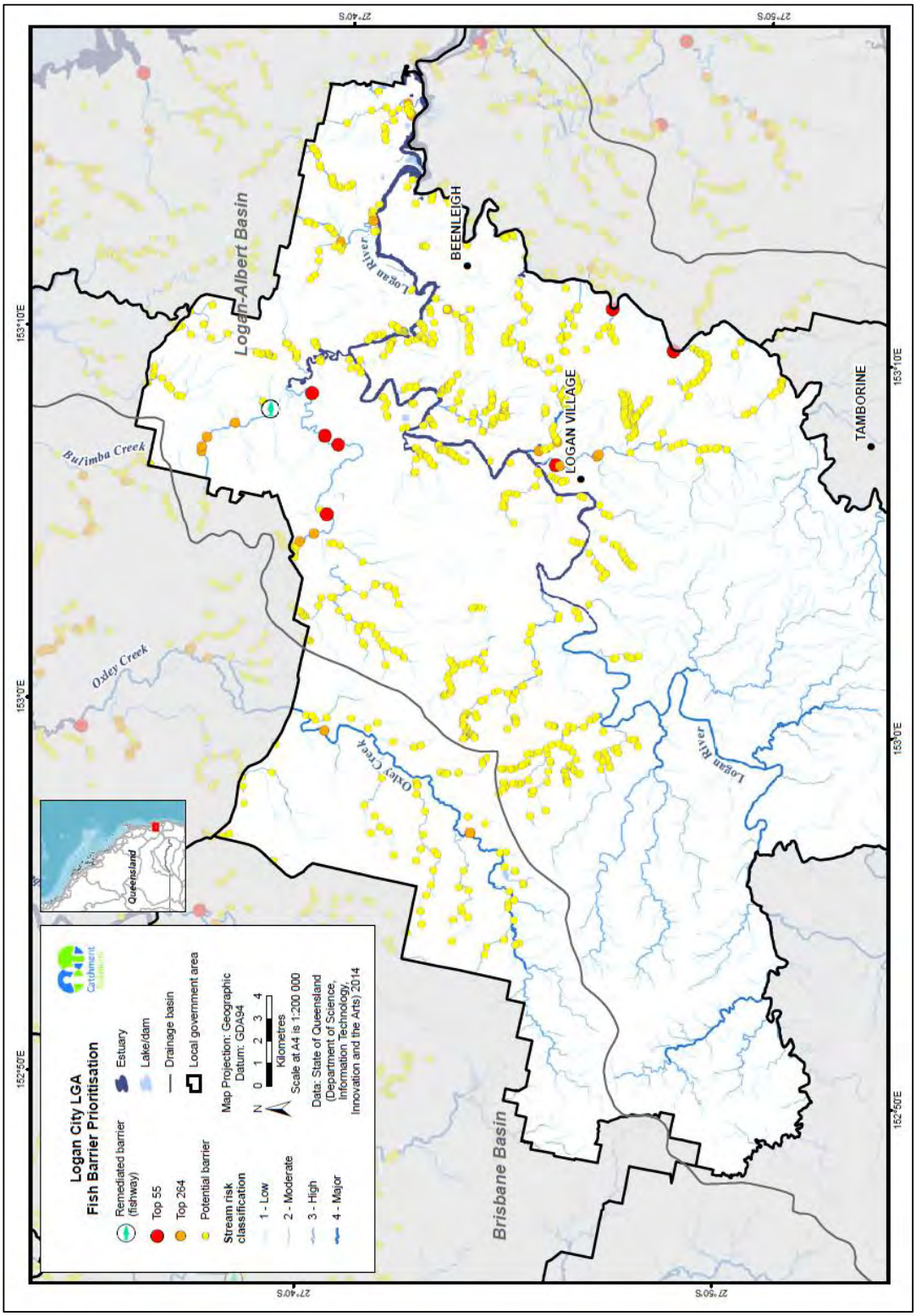


Figure 35. Logan City Council LGA barriers, broken down into top 55 (red), top 264 (orange), potential barriers (yellow) and remediated barriers (green)

Moreton Bay Regional Council LGA

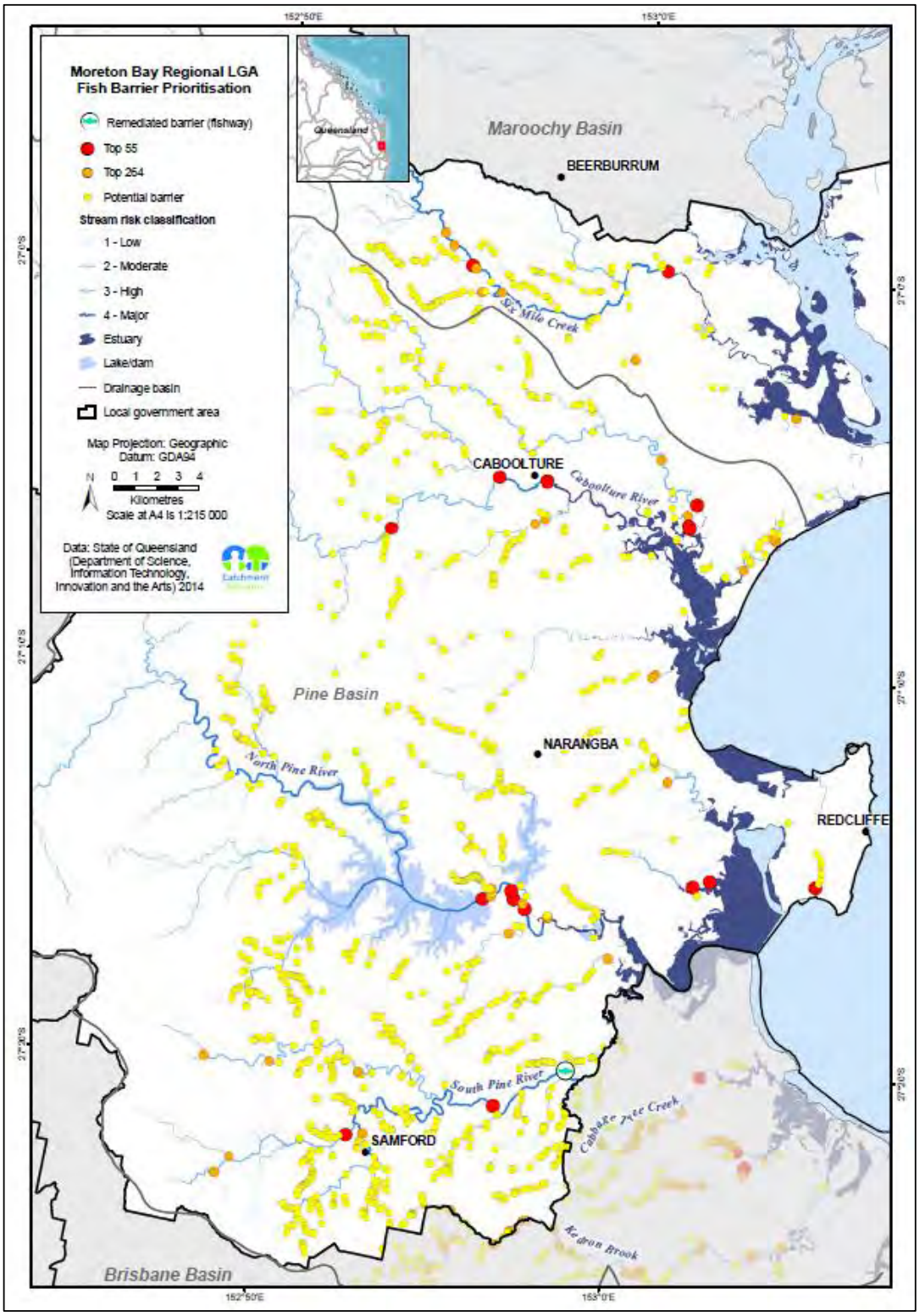


Figure 36. Moreton Bay Regional Council LGA barriers, broken down into top 55 (red), top 264 (orange), potential barriers (yellow) and remediated barriers (green)

Redland City Council LGA

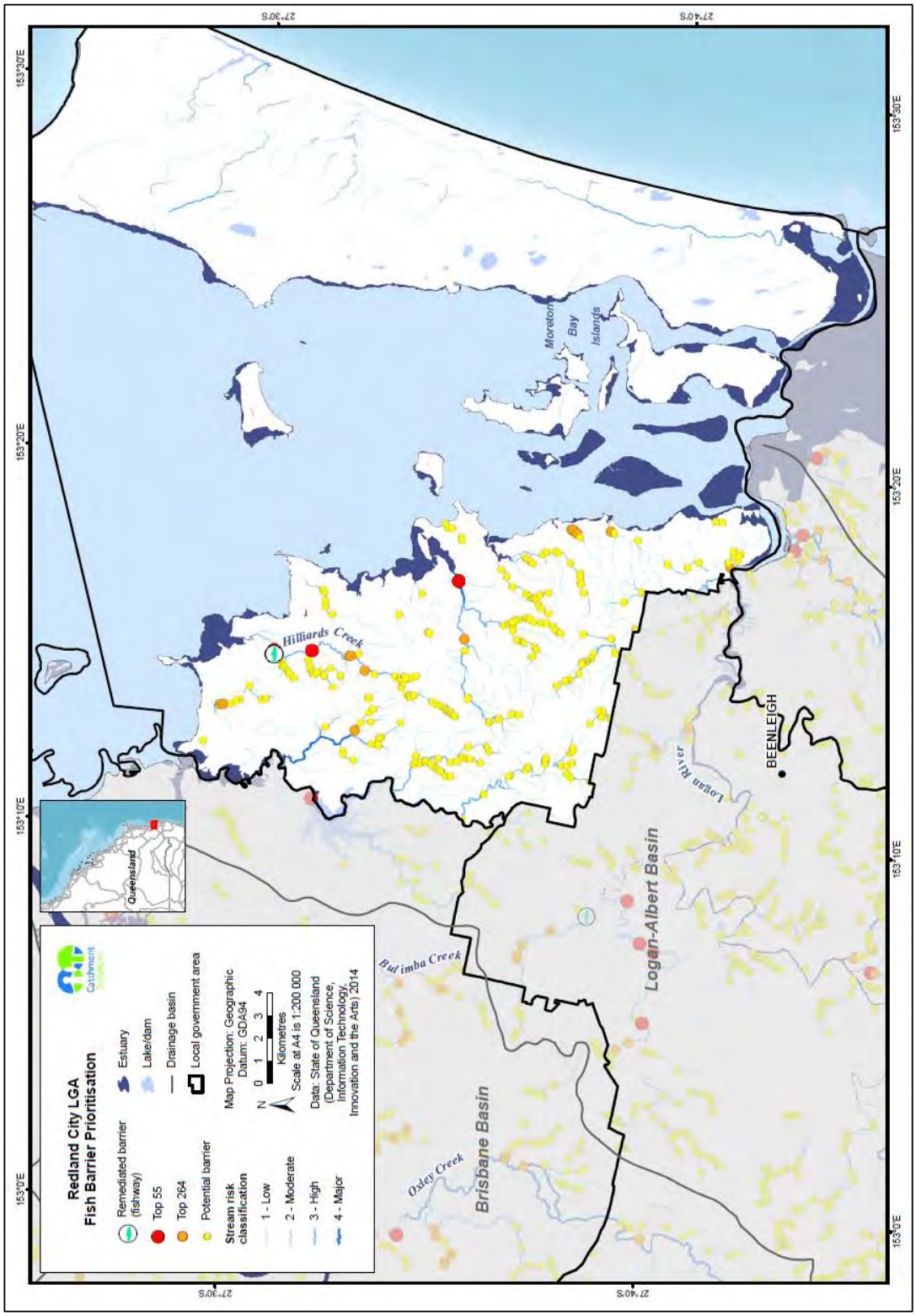


Figure 37. Redland City Council LGA barriers, broken down into top 55 (red), top 264 (orange), potential barriers (yellow) and remediated barriers (green)

Appendix 4. Example Informative Fishway Sign

Hilliards Creek Fishway, Redland City Council

Figure 38. Example informative fishway sign which could be installed at a fish passage remediation site to inform the local community regarding the many benefits of improved aquatic connectivity and describe how fishways operate.
Fishway Sign designed and installed by Redland City Council.

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Bremer River and Warrill Creek Fish Barrier Assessment Report

April 2018

Matt Moore and Jack McCann

Information contained in this document is provided as general advice only. For application to specific circumstances, professional advice should be sought.

Catchment Solutions has taken all reasonable steps to ensure the information contained in this document is accurate at the time of publication. Readers should ensure that they make appropriate enquiries to determine whether new information is available on the particular subject matter.

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Cover Image: Top, left to right: Bremer River DNRM v-notch gauging weir and Warrill Creek sheet pile weir. Bottom, left to right: Warrill Creek DNRM v-notch gauging weir, fish captured during Bremer River fish community monitoring, clockwise from top; sea mullet (top) freshwater mullet (bottom), Queensland lungfish, Yellow-fin bream and Australian bass.

Contents

Background

Construction of Berry's Weir partial width rock-ramp fishway on the Bremer River in Ipswich was completed in October 2016. The fishway was constructed on a 2.4 m weir (Berrys Weir) that was built in the 1960's to impound water for power generation (Swanbank Power Station). Berrys Weir was identified as the 7th highest priority fish barrier in the Greater Brisbane region, and the highest located wholly within the Ipswich City Council (ICC) region (Moore *et al.,* 2018). The weir is located in the lower reaches of the Bremer River catchment approximately 5 km's upstream from the estuarine interface. Prior to the construction of the fishway, Berrys Weir blocked upstream fish passage to approximately 97.5% of the catchment. This led to significant reductions in upstream fish diversity, fish species distribution and the proliferation of pest fish species such as tilapia and carp. Overall, Bremer River aquatic ecosystem health was significantly impacted by the weir.

To evaluate the effectiveness of the fishway, monitoring was undertaken in December 2016 and again in December 2017. Monitoring demonstrated the fishway was successful at passing the full suite of fish species and size classes expected to occur within the Bremer River catchment. Over 4000 fish per day were recorded successfully ascending the fishway. Notably, fishway monitoring recorded four new fish species (speckled goby, fork-tailed catfish, Yellow-fin bream and freshwater mullet) that have not been recorded within the Bremer River in over 14 years of Environmental Health Monitoring Programme (EHMP) fish surveys. With fish passage past Berrys Weir now restored, assessment of the next fish barriers upstream is required.

As further commitment to improving fish passage within the Bremer River catchment, ICC engaged Catchment Solutions to undertake assessments of the next barriers upstream of Berrys Weir. The assessment aimed to determine the level of impact these barriers have on fish communities of the Bremer River. This report details the barriers which were assessed, findings of the assessments and provides recommendations on the best ways to further improve fish passage in the Bremer River catchment.

Introduction

In coastal Queensland catchments migratory (diadromous) fish species which move between saltwater and freshwater environments in order to complete their life-cycle are most affected by barriers, particularly the first barrier located upstream from the estuary (e.g. Berrys Weir). Within the Bremer River catchment this includes key commercial, recreational and indigenous fishery species such as: Australian bass, sea mullet, freshwater mullet, Yellow-fin bream, long-fin eel, short-fin eel and potentially jungle perch. All these species were impacted by Berrys Weir. Many other non-economic migratory fish were also impacted by Berrys Weir, these include empire gudgeon, striped gudgeon, Redigobius sp., fork-tailed catfish and bullrout. These species play important roles in aquatic food webs (predator-prey relationships) and the transfer of carbon between estuarine and freshwater habitats.

Although low passability barriers located in the lower reaches of coastal catchments have the greatest impact on migratory fish species, potamodromous (wholly freshwater species) are also affected. This is particularly important for the Bremer River catchment which comprises a small population of endangered Mary River Cod (MRC). MRC (Figure 1) have been restocked into the Brisbane-Stanley catchment, including the Bremer River catchment for conservation purposes. The MRC Recovery Plan undertaken by Simpson and Jackson (1996) list the remediation of fish barriers as a key management action required to ensure the long-term maintenance of cod populations. MRC have been known to migrate up to 30 km in both upstream and downstream directions in response to elevated stream flow events, with a tendency to move upstream in spring and summer and downstream in winter (Simpson

and Jackson, 1996). This movement may be undertaken to find breeding partners or food resources, before moving back to their home river reach area (100 m – 1000 m), where they reside for the majority of time. Simpson and Jackson (1996) suggest that individual fish may return to a previous home range after an absence of at least 8 months and a return journey up to 70 km. Prior to the construction of Berrys Weir rock ramp fishway, MRC that moved downstream past the weir were most likely blocked from undertaking a return migration. However, now that fish passage has been restored, it's possible for MRC to move freely within the lower reaches of the Bremer catchment.

To test whether MRC are able to negotiate Berrys Weir fishway, a small number (n=20) of juvenile MRC were released at the bottom of the fishway during the first round of fishway monitoring in December 2016. During the subsequent 4 days of fishway monitoring, one 62 mm long MRC was recorded successfully ascending the fishway (Figure 1). While this capture only represents 5% of the fish that were released, the result did provide an indication that juveniles of this species can pass the fishway.

Figure 1. Left; Juvenile MRC released downstream of Berrys Weir fishway as part of a research trial and captured during monitoring having successfully ascended the fishway. Right; Showing an adult MRC captured in the Mary River catchment during research monitoring.

Monitoring of the Berrys Weir fishway occurred across 5 days in December 2016 and again for 5 days in December 2017. Monitoring was undertaken to evaluate the success of the fishway. Monitoring demonstrated the fishway was successful at passing the full suite of fish species and size classes expected to occur within the Bremer River catchment. Fishway monitoring results in December 2016 recorded a total of 3514 individual fish representing 21 species at a catch rate of 690 fish per day, while monitoring in December 2017 recorded 16,401 individuals representing 16 species at a catch rate of 4075 fish per day. With fish passage past Berrys Weir now restored, assessment of the next fish barriers upstream was required. This assessment forms the current report, and was undertaken to determine the impact of the next three barriers upstream within the Bremer River catchment.

Bremer River Catchment Barriers

The Bremer River catchment comprises two major tributaries; the larger Warrill Creek with its headwaters originating in the south of the catchment and the Bremer River with its headwaters originating to the west (Figure 2). These tributaries meet at a junction approximately 2 km upstream from Berrys Weir.

- The first fish barrier along the Bremer River arm is located at Walloon approximately 9 km upstream from Berrys Weir (Figure 2). This barrier structure comprises a v-notch gauging weir operated by the Queensland Department of Natural Resources Mines & Energy. The weir was ranked the 12th highest priority barrier out of 13, 629 potential barriers in a recent fish barrier priorisation project (Moore *et al.*, 2018) and the equal 1st in ICC LGA.

- The first fish barrier upstream along Warrill Creek is located approximately 10 km upstream from Berrys Weir adjacent 'Runnymede' trotting stable (Figure 2). The barrier was ranked 15th highest priority in the Greater Brisbane region and consists of a sheet pile weir with gabion basket scour protection.

- Approximately 600 m further upstream along Warrill Creek is the location of the 3rd barrier assessed as part of this project. This barrier comprises a v-notch gauging weir owned and operated by the Queensland Department of Natural Resources and Mines & Energy. This barrier was ranked the equal 12th highest priority fish barrier in the Greater Brisbane region (Moore *et al.,* 2018) and equal 1st in the ICC LGA.

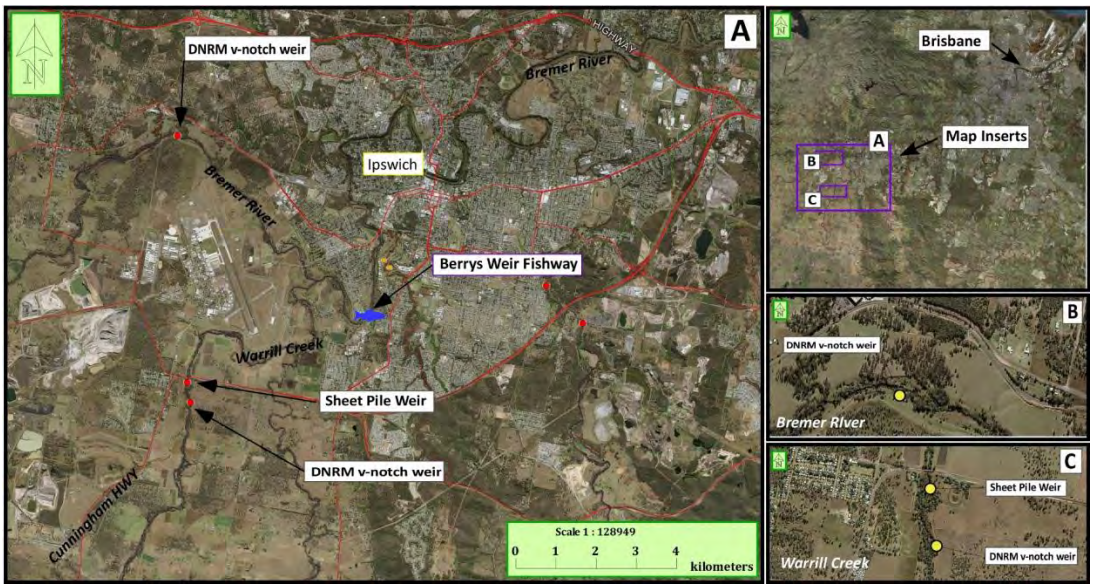

Figure 2. Maps showing the location of the Bremer River, Warrill Creek, Berrys Weir fishway and the three fish barriers assessed as part of this project. Images courtesy of Google Earth.

Assessment of the Bremer River v-notch weir and the Warrill Creek sheet pile weir was undertaken using purpose built fishway traps. The traps were deployed immediately upstream of each barrier and included wing walls to guide fish into the entrance and prevent fish from swimming around or under the traps. Water depth immediately upstream from the v-notch gauging weir on Warrill Creek was too deep (~1.5 m) to successfully set a trap. Instead, a video camera was positioned on the downstream side of the barrier to record any potential fish that were able to ascend. Furthermore, fish community monitoring was undertaken using backpack and boat electrofishing techniques to better understand fish species present in the catchment. Boat electrofishing was undertaken to effectively monitor all habitat types upstream and downstream of Berrys Weir fishway. Due to site constraints, a backpack electrofisher was used to effectively monitor immediately downstream from the sheet pile weir. This was undertaken to compare fish species immediately under the weir (within 10 m) to those potentially captured in the fish trap deployed upstream of the weir.

Fish Barrier Assessments

Walloon V-Notch Gauging Weir, Bremer River

Location

A concrete V-notch gauging station weir had been previously identified in the upper reaches of the Bremer River. The barrier is situated approximately 9km upstream of the Berry's Weir fishway, approximately 7 km upstream of the junction of the Bremer River and Warrill Creek (Figure 3).

Figure 3. Location of upper Bremer River V-notch gauging barrier (Imagery: Google Earth).

The barrier consists of a vertical concrete wall intersecting the full width of the stream, with a deep V-notch groove formed within the concrete to create a channel of flow for stream height gauging (Figure 4). In total, the estimated head loss from upstream to downstream of the barrier was 300 mm, whilst the estimated drop from the lowest point of the notch to the water surface downstream was 80 mm.

Figure 4. Measuring the velocity through the concrete v-notch gauging station barrier at Walloon in the lower reaches of the Bremer River.

Methods

Fish trapping surveys were undertaken upstream and downstream of the Walloon v-notch gauging weir (Figure 5). Sampling was undertaken to identify differences in fish communities successful at ascending the barrier compared to those that were accumulated below the weir (attempting to ascend past).

The trap configuration included a single cone entrance. The frame was covered with shade cloth (4.0 mm mesh size. The trap dimensions were 1400 mm x 1000 mm x 1100 mm. Shade cloth wing walls were used to prevent fish from swimming around and underneath the trap, whilst sand bags were used to secure the trap and wing walls in place. The fish trap positioned immediately above the barrier was set for 24.25 hours (Figure 5). Following trapping above the barrier, the trap was set up below the v-notch to sample fish attempting to migrate past the barrier. The entrance to the fish trap was positioned directly in-line with the prevailing stream flow exiting through the v-notch. Fish possess an inherent behavioural response to swim upstream during stream flow events (rheoreation), attracting fish attempting to migrate upstream into the trap (Wang, 2008). The fish trap was left in place below the barrier for a total of 21.75 hours (Figure 5)

All individual fish captured in the trap were identified to species level, counted and measured to the nearest millimetre (fork length for forked-tailed species, total length for all other species). When more than 25 individuals of a single species were captured in any single trapping event, a randomised subset of 25 fish were measured and the remainder only counted to contribute to abundance data. All native fish were then released back to the site of capture, whilst pest fish species were euthanised as per Biosecurity Queensland legislation and ANZCCART procedures and disposed of in an appropriate manner. In order to evaluate the flow velocities through the v-notch (weir crest) flow velocity measurements were taken using a Global Water flow meter (GWFP111). Flow velocity measurements were taken at the downstream extent of the v-notch (weir crest), at the centre of the v-notch and at the upstream extent of the v-notch at 15:00 on 22/12/2017.

Figure 5. Fish trap set above the V-notch gauging barrier (left), and below the barrier (right)

Results

Upstream Barrier

After 24.25 hours of trapping above the Bremer River v-notch gauging weir, a total of eight native species were captured, comprising three diadromous and five potamodromous fish (Table 1). In total, 105 individual fish were caught ascending the barrier at a rate of 4.33 fish per hour, with the most abundant being firetail gudgeon (*H. galii*) at a catch rate of 1.57 fish per hour, followed by crimson-spotted rainbowfish (*M. duboulayi*), empire gudgeon (*H. compressa*) and unspecked hardyhead (*C. fulvus*) at catch rates of 0.95, 0.78 and 0.33 fish per hour respectively (Figure 6).

Figure 6. Showing fish that were successful at ascending the barrier. Left: fish captured in trap, Right: Close up of some of the captured species: (top to bottom) juvenile sea mullet crimson- spotted rainbowfish, unspecked hardyhead, firetail gudgeon, smelt and empire gudgeon.

Downstream Barrier

After 21.75 hours of trapping below the Bremer River v-notch gauging weir, a total of 12 species were captured, comprising 11 native species and 1 pest fish (mosquitofish) (Table 1). Native fish included four diadromous species and seven potamodromous species. In total, 770 individual fish were caught at a rate of 35.4 fish per hour, with the most abundant species being firetail gudgeon (*H. galii*) at a rate of 27.77 per hour, followed by Australian smelt (*R. semoni*), Bullrout (*N. robusta*) and mosquitofish at catch rates of 3.72, 0.74 and 0.64 fish per hour respectively. Photos of some fish captured below the weir are provided in Figures 6 & 7.

Figure 7. Fish captured whilst trapping below barrier (left), and showing fish captured on measuring board, including bullrout (*N. robusta*), long-finned eel (*A. reinhardtii*) and firetail gudgeon (*H. galii*) (right).

Figure 8. Showing juvenile bullrout, eel sp. smelt, unspecked hardyhead, dwarf flathead gudgeon and firetail gudgeon captured downstream of the Walloon v-notch gauging weir. Note: bullrout, eel sp. and dwarf flathead gudgeon were not captured upstream of the weir, indicating that the weir is potentially blocking upstream passage for these species.

Table 1. Fish catch results of trapping above and below Bremer River v-notch gauging weir barrier

Migration Class	Common Name	Species Name	Total Individuals		CPUE (Fish/hour)	
			Downstream	Upstream	Downstream	Upstream
Diadromous	Empire gudgeon	*Hypseleotris compressa*	6	19	0.28	0.78
	Striped gudgeon	*Gobiomorphus australis*	8	7	0.37	0.29
	Sea Mullet	*Mugil cephalus*		2		0.08
	Bullrout	*Notesthes robusta*	16		0.74	
	Long-finned eel	*Anguilla reinhardtii*	8		0.37	
Potamodromous	Crimson- spotted rainbowfish	*Melanotaenia duboulayi*	11	23	0.51	0.95
	Unspecked hardyhead	*Craterocephalus fulvus*	11	8	0.51	0.33
	Firetail gudgeon	*Hypseleotris galii*	604	38	27.77	1.57
	Flathead gudgeon	*Philypnodon grandiceps*	8	1	0.37	0.04
	Australian smelt	*Retropinna semoni*	81	7	3.72	0.29
	Dwarf flathead gudgeon	*Philypnodon maculatus*	1		0.05	
	Agassiz's glassfish	*Ambassis agassizii*	2		0.09	
Pest Fish	Mosquito fish	*Gambusia holbrooki*	14		0.64	
Total Species, Individuals & Overall CPUE		**13**	**770**	**105**	**35.4**	**4.33**
Total species by fish trapping location			**12**	**8**		

V-notch Flow Velocity

Table 2. Stream flow velocity results taken at the Walloon v-notch (weir crest) gauging weir

V-notch flow measurement location	Distance from the downstream edge of the v-notch (mm)	Flow Velocity (m/sec)
Downstream extent	0	2.2
Center	150	1.7
Upstream extent	300	0.8

Discussion

The results obtained show a substantial difference between upstream and downstream trapping, eluding to the fact that the barrier is severely impacting fish passage to upstream reaches of Bremer River. Although 105 individuals representing eight species were able to ascend the barrier during low flows at a rate of 4.33 fish per hour, downstream results showed 12 species at rate of 35.4 fish per hour were captured attempting to ascend the barrier (Figures 7 and 8). Significantly, five species were captured downstream of the barrier and not upstream, including Agassiz's glassfish (*A. agassizii*), bullrout (*N. robusta*), long- finned eel (*A. reinhardtii*), dwarf flathead gudgeon (*P.maculatus*) and mosquitofish (*G. holbrooki*). It's possible that these species do not possess the swimming ability to ascend the Warrill Creek v-notch gauging weir under the stream flow conditions experienced during monitoring (low flow).

The capture of eight juvenile eel sp. downstream and none upstream potentially indicates that they are unable to 'climb' past this weir. Eels require wet surfaces away from the main flow to climb obstacles such as man-made barriers and natural waterfalls. The downstream concrete face of the weir comprised wet surfaces, which appear to be suitable for eels to climb. However, to ascend up and over v-notch gauging weirs (Walloon and Warrill Creek DNRM weirs) eels have to first climb the vertical downstream face of the weir, then negotiate fast velocities encountered at the downstream lip of the weir crest (v-notch), and finally swim past or climb over the longitudinal distance of the crest (v-notch). The longitudinal distance of the Walloon v-notch crest is 310 mm. Stream velocity measurements were recorded across the crest to determine velocities fish have to negotiate to ascend past. Stream flow velocity measurements recorded at downstream extent of the crest (lip) were very high, measuring 2.2 m/sec, velocities in the middle of the crest (150 mm in from the downstream edge) were still high (1.7 m/sec), while velocity at the upstream edge of the crest were lower at 0.8 m/sec (Table 2). It's not known if 'climbing' species such as eels are unable to negotiate the 2.2 m/sec experienced at the lip of the v-notch crest or they are unable to negotiate the fast velocities experienced across the longitudinal distance (310 mm) of the v-notch crest or a combination of both. However, it is clear that the Walloon gauging weir is a significant barrier to upstream passage of eels. Interestingly, some eel sp. were able to negotiate the significantly shorter longitudinal crest (~10 mm) of the Warrill Creek sheet pile weir, indicating that the distance of the weir crest (Bremer River and Warrill Creek v-notch weirs) may be the limiting factor in the successful passage of eel sp. past v-notch weirs.

A total of 16 juvenile bullrout (Figure 8) were captured downstream of the weir and none upstream. Bullrout are a sedentary bottom dwelling diadromous fish species, which undertake upstream migrations as juveniles from estuarine environments (Pusey *et al*., 2004). Barriers that block upstream passage, such as the Walloon v-notch gauging weir have the potential to significantly reduce upstream populations of bullrout. The configuration of the v-notch weir crest combined with tailwater pool water level being approximately 80 mm lower than the control of the crest, results in the creation of an air pocket or void as stream flow passes over the crest prior to entering the tailwater pool. It's likely that for fish to successfully ascend they would either need to climb the vertical surface (e.g. eels) or leap over the void (e.g. rainbow fish). Sedentary species such as bullrout may not be able to leap over

the air pocket. The impact and extent of the Walloon v-notch barrier on the upstream passage of bullrout is further highlighted by EHMP fish surveys, which have not recorded bullrout upstream of this barrier in over 14 years (25 occasions) of fish monitoring.

Warrill Creek Sheet Pile Weir ('Runnymede')

Location

A sheet pile and rock gabion weir had been previously identified in the lower reaches of Warrill Creek (Figure 9). The barrier is situated approximately 10 km upstream of the Berry's Weir fishway, approximately 8 km upstream of the junction of the Bremer River and Warrill Creek.

Figure 9. Location of Warrill Creek rock gabion and sheet pile weir fish barrier (Imagery: Google Earth)

The barrier consists of a shallow rock gabion basket with a step-up of approximately 400 mm where the rock gabion basket continued for approximately 2 m before reaching the base of the sheet pile. The sheet pile, which extended across the full width of the stream, then rises approximately 350 mm to the head of the upstream water body (Figure 10). In total, the combined sheet pile and rock gabion basket barrier poses a 750 mm (approx.) surface drop barrier.

Figure 10. Close up image of the Warrill Creek sheet pile fish barrier (left), and close up of sheet pile surface showing roughness and algae used by striped gudgeon and eel sp. to climb this barrier (right).

Methods

In order to investigate and determine the extent of impact the barrier has on fish movement, surveys were conducted both above and below the structure to determine any differences in fish communities.

Above the barrier, a fishway trap (Figure 11) was used for sampling. The trap configuration included a single cone entrance. The frame was covered with shade cloth (4.0 mm mesh size. The trap dimensions were 1400 mm x 1000 mm x 1100 mm. Shade cloth wing walls were used to prevent fish from swimming around and underneath the trap, whilst sand bags were used to secure the trap and wing walls in place. The fishway trap was positioned immediately above the barrier was set for a total of 45.25 hours.

Figure 11. Image of fishway trap and wing wall assembly set above the Warrill Creek sheet pile weir

Below the barrier, sampling was performed using a backpack electrofisher unit. The backpack unit utilised was a Smith-Root Model-LR24 backpack electrofisher operating a 300-500 volt pulsed-DC current and a standard pulse setting (1ms). An operator and single dip-netter were employed during all backpacking operations. Sampling protocol involved a series of 'shots' that consisted of altering power-on and power-off periods encompassing all instream habitat types present within the site. Power-on time was recorded to standardize results by Catch Per Unit Effort (CPUE). An operator used a sweeping motion as they moved through the pool and riffle below the barrier while a netter followed behind collecting stunned fish (Figure 12). During electrofishing operations, the observation of uncaptured, positively identified fish were also recorded and included in abundance records.

All fish captured by trapping or electrofishing were identified to species level, counted and measured to the nearest millimetre (fork length for forked-tailed species, total length for all other species). When more than 25 individuals of a single species were captured in any single trapping event, a randomised subset of 25 fish were measured and the remainder only counted to contribute to abundance data. All native fish were then released back to the site of capture, whilst pest fish species were euthanised as per Biosecurity Queensland legislation and ANZCCART procedures and disposed of in an appropriate manner.

Figure 12. Image of backpack electrofisher operator conducting fish community surveys below barrier

Results

After 45.25 hours of trapping above the Warrill Creek sheet pile barrier, only two species were captured including striped gudgeon (*G. australis*) and eel sp. (*Anguilla species*) at an overall catch rate of 2.8 fish per hour (Figure 13). In total, 116 Striped gudgeon and 3 eel sp. were captured at catch rates of 2.7 and 0.07 fish per hour respectively (Table 3).

Table 3. Fish catch results of trapping above Warrill Creek rock gabion basket and sheet pile barrier

Migration Classification	Common Name	Species Name	Total Individuals	CPUE (Fish/hr)
Diadromous	Eel sp.	*Anguilla species*	3	0.07
	Striped gudgeon	*Gobiomorphus australis*	116	2.7
Total Species, Individuals and Overall CPUE		**2**	**119**	**2.8**

Figure 13. Showing juvenile striped gudgeon and eel sp. successful at 'climbing' the sheet pile weir.

Fish monitoring below the sheet pile barrier consisted of 245 seconds of 'power on' backpack electrofishing. A total of nine species were captured (Table 4). The nine species were comprised of four native diadromous (migratory) species, four native potamodromous species and one introduced pest species.

Table 4. Fish catch results of electrofishing below Warrill Creek rock gabion basket and sheet pile barrier.

Migration Classification	Common Name	Species Name	Total Individuals	CPUE (Fish/min)
Diadromous	Sea mullet	*Mugil cephalus*	3	0.52
	Empire gudgeon	*Hypseleotris compressa*	138	24
	Striped gudgeon	*Gobiomorphus australis*	328	57
	Eel sp.	*Anguilla species*	9	1.57
Potamodromous	Unspecked hardyhead	*Craterocephalus fulvus*	1	0.17
	Firetail gudgeon	*Hypseleotris galii*	14	2.43
	Gudgeon sp.	*Hypseleotris species*	1	0.17
	Crimson- spotted rainbowfish	*Melanotaenia duboulayi*	2	0.35
Pest Fish	Mosquito fish	*Gambusia holbrooki*	5	0.87
Total Species, individuals and Overall CPUE		**9**	**501**	**87.13**

Striped gudgeon (*G. australis*) were caught in the highest abundance comprising 328 individuals at a catch rate of 57 fish per minute, followed by 138 empire gudgeon (*H. compressa*), 14 firetail gudgeon (*H. galii*) and 9 eel sp. at catch rates of 24, 2.43 and 1.57 fish per minute respectively. Overall, the combined total catch per unit of all species was 87.13 fish per minute. Diadromous migratory species dominated the catch comprising 95% of the total catch below the barrier (Figure 8).

Figure 14. Showing fish captured below the sheet pile weir, Left: juvenile sea mullet (*M. cephalus*), striped gudgeon (*G. australis*) and empire gudgeon (*H. compressa*). Right:, firetail gudgeon (*H. galii*).

Discussion

Only two (22%) of the nine species monitored directly under the sheet pile weir were captured upstream (striped gudgeon and eel sp.), clearly demonstrating that the headloss (750 mm) of the sheet pile weir is significantly impacting fish passage. Two diadromous species were successful at ascending the sheet pile weir, with striped gudgeon dominating the catch representing 97%. All fish captured were juveniles and sub-adults. Both striped gudgeon and eel sp. undertake migrations as juveniles from downstream estuarine environments to upstream freshwater habitats, with eel sp. in-particular known to penetrate to the very upper headwater reaches of waterways. Furthermore, both of these species are noted 'climbers', and have the ability to crawl up rough, wet surfaces to ascend small barriers such as waterfalls. It is postulated that all individual eels and striped gudgeon captured upstream of the barrier had climbed the wet, algae-coated surface of the sheet pile weir to ascend the barrier and move upstream (Figure 10).

Although striped gudgeon were able to 'climb' the sheet pile weir, it's hypothesised that many more striped gudgeon would be attempting to ascend this barrier and are unsuccessful. This is highlighted when the catch rate of striped gudgeon successfully 'climbing' the sheet pile weir is compared to the catch rate of striped gudgeon successfully ascending Berrys Weir fishway, located approximately 10

km downstream (monitoring of both structures occurred concurrently). Striped gudgeon were captured successfully migrating through the fishway at a rate of 1284 fish per day, compared to just 65 per day at the sheet pile weir, equivalent to 22 fold decrease in numbers at the sheet pile barrier. It must be noted that potentially not all striped gudgeon that migrated through the fishway would endeavour to migrate upstream to the sheet pile weir.

Although striped gudgeon and eel sp. are noted 'climbers', the remaining seven fish species monitored downstream of the sheet pile weir and not upstream, are not known to 'climb'. This potentially explains why these species were not captured upstream. Although only a snapshot, these numbers elude to this barrier posing substantial impacts to the fish communities of Warrill Creek and warrant further investigation and remediation works.

Warrill Creek DNRM Gauging Weir

Location

A DNRM v-notch gauging weir had been previously identified in the lower reaches of Warrill Creek (Figure 15). The barrier is situated approximately 10 km upstream of Berry's Weir fishway, approximately 8 km upstream of the junction of the Bremer River and Warrill Creek and 600 m upstream from the 'Runnymede' sheet pile weir.

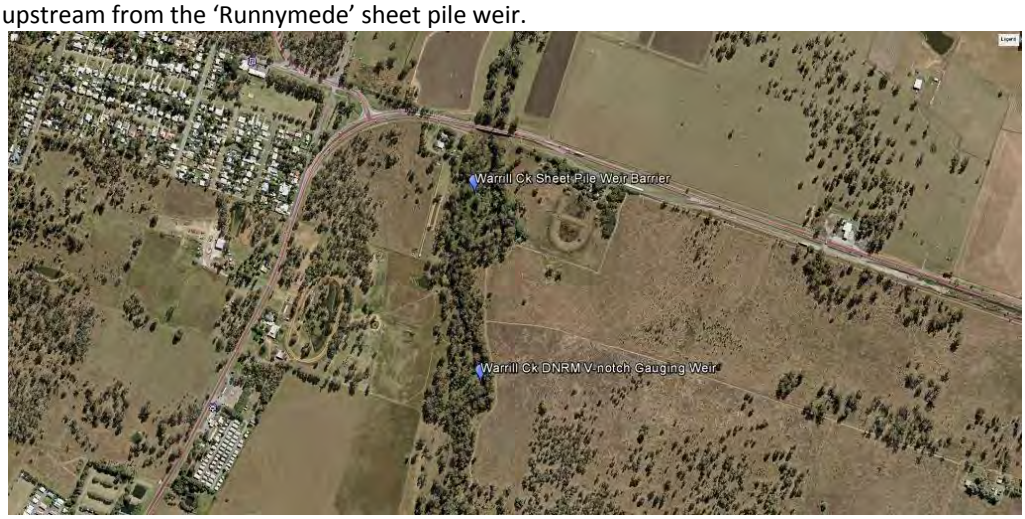

Figure 15. Showing the location of the DNRM v-notch gauging weir (Imagery: Google earth)

Methods

Site constraints (water depth) prevented the fish trap from effectively being deployed at this site. In lieu of this, waterproof cameras (Go Pro) were set up at the weir across two consecutive days for a total of three hours. Waterproof cameras were set up parallel with the weir wall facing towards the stream flow exiting through the v-notch, so that any fish successful at either 'leaping' over the weir crest or 'climbing' up the weir wall would be captured on footage.

Results

No fish were captured successfully leaping over the weir crest or climbing the weir wall during camera monitoring. At least two (potentially more) Duboulay's rainbowfish were sighted in the footage unsuccessfully attempting to leap past the weir (Figure 17).

Discussion

A second barrier was identified in Warrill Creek only 600 m upstream of the sheet pile barrier (Figure 16). This concrete v-notch gauging station weir poses similar threats to the sheet pile barrier

downstream, restricting upstream passage of juvenile and adult native fish. Surveying was intended to take place on this barrier, however site constraints made surveys difficult. The substantial water depth (≥1.5m) on the upstream side of the weir meant that a fish trap could not be set up successfully i.e. a trap could not be set up to prevent fish from going under or around the trap. In lieu of this, waterproof cameras were set up at the barrier across two consecutive days for a total of three hours.

Figure 16. V-notch gauging station weir identified approximately 600 m upstream of sheet pile barrier

Although the monitoring duration was short, no fish were captured in the footage ascending the barrier. Duboulay's rainbowfish were captured attempting to ascend by 'leaping' towards the water flowing through the v-notch (Figure 16). It is possible that some striped gudgeon and eel sp. are able to ascend this weir. However, unlike the sheet pile weir, where potential 'climbing' fish only have to negotiate a short distance of ~10 mm (sheet pile width) with extremely high velocity (as water shoots past the barrier) the width of the gauging weir is approximately 20 times greater. This distance fish has to travel while negotiating high velocities potentially reduces the likelihood of 'climbing' fish ascending this barrier. Along with the sheet pile barrier, the impacts of this gauging station weir warrant further investigation and remediation works to restore connectivity along Warrill Creek

Figure 17. Showing video footage of Duboulay's rainbowfish attempting to 'leap' past the Warrill Creek gauging weir

While the sampling only provided a brief snapshot of current fish passage at these weirs, the results give valuable insight into the impacts these types of smaller head loss barriers (when compared to dams and large weirs) can have on fish passage and aquatic ecosystem health.

Electrofishing Surveys

Location

Boat-based electrofishing surveys were conducted in order to gain a better understanding of the fish species living within the lower reaches of the Bremer catchment, within accessible reaches upstream and downstream of the Berry's weir fishway surveyed.

Upstream of the fishway, the electrofishing boat was launched into a small off-stream pool where good access was available to launch the boat into the river. Electrofishing surveys were then conducted from the reaches immediately upstream of the fishway, to the survey completion point, where log jams prevented further access upstream. In total, approximately 750 m of river was surveyed The habitat at the upstream site was characteristic of weir pool environments, dominated by deep reaches of stream with relatively low flow. In-stream habitat comprised of fallen trees and log jams, with large sections of open water (weir pool) devoid of habitat complexity (Figure 18)

Figure 18.Stretch of river upstream of the Berry's weir fishway that electrofishing surveys were conducted (Imagery: Google Earth)

Downstream of the fishway, a suitable stretch of river was identified in the lower reaches of the Bremer River close to the city of Ipswich, approximately five kilometres downstream of the fishway. This reach was accessed through a small boat ramp at Shapcott Park in Ipswich, where an approximate 650 m stretch of river was electrofished (Figure 19). The upper extent of the site was characterised by deeper water with a large number of trees on the streambanks providing cover, and also a large number of log jams within the stream. The lower reaches of the site were dominated by in-stream rock bars and shallower, faster moving water. Overall, habitat condition at this site was excellent.

Figure 19. Stretch of river approximately five kilometres downstream of the Berry's weir fishway that electrofishing surveys were conducted, accessed through Shapcott Park (Imagery: Google Earth)

Methods

Electrofishing surveys were conducted using a small boat electrofishing unit (Electrolyte). Electrolyte is a 3.7 m vessel which operates a Smith-Root 2.5 GPP electrofisher unit, equipped with a single boom arm, six dropper anode array and hull cathode. An operator and single dip-netter was utilised during electrofishing operations (Figure 20).

Throughout electrofishing operations settings were adjusted based on electrical conductivity of the water on site to maximise the efficacy of electrofishing operations. Sampling was conducted at various depths and encompassed a variety of in-steam habitats as well as cross-sections of the open water. The electrofishing methodology used was a combination of power on, power off for the duration of the sampling effort. Power-on time was recorded to standardise results by Catch Per Unit Effort (CPUE) if necessary. During the sampling, the boat was manoeuvred in and out from the shoreline as well as parallel to the shore in deeper water. The effective electric field of the unit was approximately between a three and five metre radius (centred on the anode) to a depth of between three and five metres below the water surface.

As the surveying was primarily to assess community assemblages, if fish could be positively identified to species level without being removed from the water, their presence was recorded and they were not brought on board. Any fish brought on board for identification were identified to species level and fork length measurements recorded. All native fish were released immediately after processing back to the site of capture, whilst pest fish species were euthanised as per Biosecurity Queensland legislation and ANZCCART procedures and disposed of in an appropriate manner.

Figure 20. Electrofishing dip- netter extracting stunned fish from the water (left) and an aerated tub of fish on board the vessel after being electrofished (right)

Results & Discussion

Upstream of Fishway

Upstream of the fishway, a total of eight species were surveyed at a catch rate of 5.65 fish per minute, with the catch being comprised of seven native species and one pest fish species (Table 4). Of the eight species, five were diadromous migratory species including Australian bass (*M. novemaculeata*), freshwater mullet (*T. petardi*), long finned eel (*A. reinhardtii*), sea mullet (*M. cephalus*) and striped gudgeon (*G. australis*) (Figure 21).

Of the species surveyed, sea mullet were encountered in the highest abundance at a rate of 4.35 fish per minute. Interestingly, only one individual pest fish, carp (*C. carpio*) was surveyed upstream during electrofishing efforts.

Table 5. Electrofishing catch results upstream of Berry's Weir

Migration Classification	Common Name	Species Name	Total Individuals	CPUE (Fish/min)
Diadromous	Australian bass	*Macquaria novemaculaeata*	1	0.48
	Freshwater mullet	*Trachystoma petardi*	14	0.67
	Long-finned eel	*Anguilla reinhardtii*	3	0.14
	Sea mullet	*Mugil cephalus*	91	4.35
	Striped gudgeon	*Gobiomorphus australis*	1	0.48
Potamodromous	Bony bream	*Nematalosa erebi*	1	0.48
	Crimson-spotted rainbowfish	*Melanotaenia duboulayi*	6	0.29
Pest Fish	Carp	*Cyprinus carpio*	1	0.48
Total Species and Overall CPUE			**8**	**5.65**

Figure 20. Images from upstream Berry's weir electrofishing (top to bottom, left to right) site images of upstream habitat type, bony bream (*N. erebi*), Australian bass (*M. novemaculeata*), sea mullet (*M. cephalus*), carp (*C. carpio*) and freshwater mullet (*T. petardi*) adult and juvenile.

Downstream of Fishway

Downstream of the fishway, a total of 16 species were surveyed at a rate of 12.34 fish per minute, with the catch comprised of 15 native species and one pest fish species (Table 5). Of the 16 species, six were diadromous migratory species including Australian bass (*M. novemaculeata*), empire gudgeon (*H. compressa*), freshwater mullet (*T. petardi*), long finned eel (*A. reinhardtii*), sea mullet (*M. cephalus*) and striped gudgeon (*G. australis*) (Figure 21). Of the species surveyed, sea mullet were encountered in the highest abundance at a catch rate of 3.08 fish per minute. Only one individual pest fish, tilapia (*O. mossambicus*) was surveyed upstream during electrofishing efforts. Notably, 5 Queensland lungfish (*N. forsteri*) were captured as part of the survey (Figure 22).

Table 5. Electrofishing catch results downstream of Berry's Weir

Migration Classification	Common Name	Species Name	Total Individuals	CPUE (Fish/min)
Potamodromous	Bony bream	*Nematalosa erebi*	39	1.51
	Pacific blue-eye	*Pseudomugil signifer*	2	0.08
	Flathead gudgeon	*Philypnodon grandiceps*	7	0.27
	Queensland lungfish	*Neoceratodus forsteri*	5	0.19
Diadromous	Australian bass	*Macquaria novemaculaeata*	22	0.86
	Empire gudgeon	*Hypseleotris compressa*	44	1.71
	Freshwater mullet	*Trachystoma petardi*	39	1.51
	Long-finned eel	*Anguilla reinhardtii*	17	0.66
	Sea mullet	*Mugil cephalus*	79	3.08
	Striped gudgeon	*Gobiomorphus australis*	11	0.42
Marine Vagrant	Bull shark	*Carcharhinus leucas*	1	0.04
	Dusky flathead	*Platycephalus fuscus*	1	0.04
	Estuary glassfish	*Ambassis marianus*	2	0.08
	Fork-tailed catfish	*Arius graeffei*	4	0.16
	Yellowfin bream	*Acanthopagrus australis*	41	1.60
Pest Fish	Tilapia	*Oreochromis mossambicus*	3	0.12
		Total Species and Overall CPUE	**16**	**12.34**

Figure 21. Showing fish species electrofished during fish surveys downstream of Berrys Weir, Bremer River. Left to right, top to bottom: estuary perchlett, dusky flathead, Yellow-fin bream and Australian bass

Discussion

Results of electrofishing surveys show that twice as many species were surveyed downstream of Berry's weir than upstream of Berry's weir. It is postulated that this is due to the good quality in-stream and riparian habitat features located at the lower site, including; pool, run and riffle sections, snags, rock bars and shade. Whereas habitat at the upstream site above Berrys Weir is dominated by deep open water lentic habitat. Australian native fish communities, including coastal Queensland fish communities contain few species that specialise in living in lentic habitats such as weir pools (Koehn and Kennard, 2013). These habitats tend to favour pest fish such as tilapia and carp and a few native demersal species such as bony bream and fork-tailed catfish and can potentially lead to declines in local riverine fish abundance (Koehn and Kennard, 2013).

Following the river continuum theory, lower reach sites such as Shapcott Park usually contain a greater diversity of habitat types and larger stream size and therefore a greater diversity of fish species. This is evident in the sampling, whereby a high number fish species were recorded at Shapcott Park, including bull shark (*C. leucas*), dusky flathead (*P. fuscus*), estuary glassfish (*A. marinus*), fork tailed catfish (*A. graeffei*) and yellowfin bream (*A. australis*). Although at least two of these species have been recorded successfully ascending Berrys Weir fishway and entering the weir pool site; yellowfin bream and fork tailed catfish, they were not captured at the weir pool site during the current electrofishing surveys. The monitoring results here are consistent with Koehn and Kennard (2013), suggesting a preference of Queensland coastal native fish species for river reaches with pool, run and riffle reaches over open weir pool waterbodies, characterised by a lack of structural habitat complexity and stream flow.

Of particular interest, was the capture of five Queensland lungfish (*N. forsteri*) (Figure 22) which are listed under the EPBC Act (1999) as a vulnerable species, with population declines observed throughout south- east Queensland. Their presence in the Bremer River highlights the diversity of this system and ecological importance of this increasingly urbanised catchment. Other significant captures include the high diversity and abundance of key commercial, recreational and indigenous fishery species including sea mullet, freshwater mullet, Australian bass, Yellow-fin bream , dusky flathead and bull shark. The presence and high numbers of some of these species recorded at Shapcott Park highlights the importance of maintaining free connectivity between saltwater and freshwater habitats.

Figure 22. Showing Queensland lungfish (left) and good quality in-stream habitat located Shapcott Park.

Conclusion

The findings of the current study demonstrate that the 'Runnymede' sheet pile weir on Warrill Creek is significantly impacting fish passage. Approximately 80% of the fish species sampled directly under the weir were not recorded in the fish trap upstream. Additionally, the two species that were recorded in the upstream trap, striped gudgeon and eel sp., possess a unique ability to climb wet vertical surfaces, allowing them to ascend some barriers. The number of these species captured upstream of the weir was relatively low compared to the number observed downstream. If the fish observed below the weir were attempting to move upstream, this may be an indication that the weir is still impeding passage of striped gudgeon and eel sp. This is supported by concurrent fish trap monitoring at Berrys weir fishway, where striped gudgeon was recorded successfully ascending the fishway at a catch rate 1284 fish per day, compared to just 64 striped gudgeon per day successful at ascending the sheet pile weir, which is located only 10 km further upstream.

Site constraints (≥1.5 m water depth) at the DNRM v-notch gauging weir located approximately 600 m upstream from the sheet pile weir prevented fish trap barrier monitoring. Instead a waterproof video camera was set up to record any potential fish that were successful at ascending this barrier. Although the camera was deployed only for a short duration (across 2 days for a total of 3 hours), no fish were recorded successfully ascending the Warrill Creek v-notch gauging weir. Duboulay's rainbowfish were recorded attempting to leap past the barrier, however, the ~750 mm headloss at this site prevented their attempts. Coastal Queensland native fish do not possess the leaping ability of their famous Northern Hemisphere cousins; Atlantic salmon, and it's highly unlikely that fish communities of the Bremer River catchment are able to leap over this barrier.

Although a small number of striped gudgeon and eel sp. were able to 'climb' the downstream sheet pile weir, the different configuration of the upstream v-notch gauging weir potentially prevents these species from successfully ascending (climbing). The longitudinal crest distance (thickness) of the sheet pile weir was approximately 10 mm, whereby fish that are able to climb the vertical face only have to negotiate a small distance (10 mm) of extremely high velocity to reach the upstream pool. The longitudinal crest distance (thickness) of the upstream v-notch gauging weir is approximately 15-20 times greater, potentially reducing the chance of fish that are successful in climbing the vertical face of negotiating this distance and associated high velocities. Although striped gudgeon and eel sp. are proficient 'climbers' they are extremely susceptible to high velocities, particularly juveniles, which comprised 100% of those fish captured upstream of sheet pile weir. Furthermore, site conditions at the Bremer River v-notch gauging weir allowed for the fish trap to be set upstream and downstream of this barrier, providing valuable information that can be used to evaluate certain aspects of the Warrill Creek v-notch weir, particularly fish climbing ability.

Upstream and downstream fish trap monitoring results at the Bremer River v-notch gauging weir showed that eight eel sp. were captured below the weir, and no eel sp. were captured in the fish trap above the weir. This provides an indication that the configuration of this v-notch weir, and potentially other v-notch weirs with a similar configuration (e.g. Warrill Creek v-notch weir), contain adverse conditions which may prevent or restrict 'climbing' species, such as eels, from successfully ascending. It is likely, that the longitudinal weir crest distance and associated high velocity encountered over this distance (2.2 m/sec on the downstream lip, 1.7 m/sec in the centre and 0.8 m/sec on the upstream edge) is the limiting factor for successful fish passage of 'climbing' species.

The findings of the current study demonstrate that the Bremer River v-notch gauging weir at Walloon is severely impacting fish passage within the Bremer River catchment. Although eight species were able to ascend the barrier in low abundance (during low flow conditions), five species were not, including economically important eel sp., and bullrout, agassiz's perchlett, dwarf flathead gudgeon and mosquitofish. Furthermore, the catch rate of fish downstream of the weir (35.4 fish/hour) was more than eight times higher than upstream (4.33 fish/hour), further highlighting the impact of this weir on fish passage.

The high number of fish species recorded during fish community boat electrofishing at Shapcott Park in the lower reaches of the Bremer River highlight the importance of well-connected river reaches with good in-stream and riparian habitat. A number of notable captures occurred at this site. Of particular interest, was the capture of 5 Queensland lungfish (*N. forsteri*) (Figure 22) which are listed under the EPBC Act (1999) as a vulnerable species, with population declines observed throughout south- east Queensland. Their presence in the Bremer River highlights the diversity of this system and necessity to continue improving connectivity, in-stream habitat and water quality. Other significant findings include the capture of 39 freshwater mullet, which are currently under consideration to be included as a listed fish species under the EPBC Act (1999). Freshwater mullet populations have undergone significant declines in abundance and distribution along the entire east coast Australian seaboard. The presence and number of freshwater mullet encountered in the Bremer River indicates that this population may be extremely important to the sustainability of this species in south-east Queensland (SEQ).

The presence and relatively high numbers of key recreational species; Australian bass, Yellow-fin bream, sea mullet, freshwater mullet, dusky flathead and bull shark recorded at Shapcott Park potentially indicates that habitat and water quality at this location is in good condition. The presence of these species is a great result for local recreational anglers. Notably, many of the Yellow-fin bream captured at this site were juveniles, indicating that they are potentially using this habitat as a nursery area. Although high numbers of Australian bass were captured (22) at Shapcott Park, they were all mature fish. The absence of juvenile Australian bass at this site, at Berrys Weir fishway and upstream of Berrys Weir indicates that recruitment of wild Australian bass is poor or not occurring at all. These findings align with fishway and boat electrofishing monitoring that has occurred at several other south-east Queensland waterways over the last few years (Catchment Solutions unpublished. Data), which have all failed to record a single juvenile wild Australian bass. It potentially appears the occurrence of Australian bass in SEQ waterways is a direct result of stocked fish that have escaped over dams such as Moogerah, Wivenhoe, Somerset, North Pine and Hinze. The instinct to breed and the necessity to reach estuarine waters for this to occur means that thousands of Australian bass escape over dams during overtopping events, and due to barriers, are unable to access these dams after spawning, and therefore remain in lower river reaches such as the Bremer River at Shapcott Park.