Appendix B

SUMMARY OF DPI FISHERIES MONITORING 2014-2020

Orange City Council Pipeline

Summary of DPI Fisheries Monitoring 2014-2020

NSW GOVERNMENT | Regional NSW

This summarises the work undertaken by DPI Fisheries between 2014-2020 to support Orange City Council (OCC) to "determine the efficiency of the offtake design and screens to limit impingement, entrainment and minimise impacts to eggs, larvae or changes to recruitment of threatened aquatic species".

DPI Fisheries Research cannot make a determination whether Orange City Council (OCC) have satisfied condition B.2 of OCC Aquatic Environmental Management Program. OCC will need to use the information provided for their own documentation.

- The initial project contracted to NSW DPI Fisheries in 2014 -2017 intended to use field trials to determine efficiency of the offtake design and screens to limit impingement, entrainment and minimise impacts to eggs and larvae of native fish.
- Due to operational restrictions of the OCC pump by August of 2016 water extraction through the Orange Pipeline had yet to commence and so the scheduled field experiments for offtake efficiency could not be conducted. It was agreed between OCC and DPI Fisheries to conduct controlled tank trials in 2016 and 2017 to examine the efficiency of the offtake design and screen to limit impingement and entrainment of larval and juvenile fish.
- The OCC operational pump approach velocity is ~0.15 $m.s^{-1}$, with ability to reach 0.176 $m.s^{-1}$ according to design specifications.
- Trials were conducted on larval and juvenile Murray cod and juvenile golden perch obtained from the Narrandera Fisheries Centre Hatchery. These two species are known to occur in the upper Macquarie river. These species were also selected as they have similar life histories (spawning seasons, egg and early life history characteristics) to threatened species recorded in the area, golden perch are representative of silver perch and Murray cod for Trout cod.
- Early life stages of these fish were used as their smaller body size and weaker swimming ability makes them more susceptible to entrainment at river diversions and impingement on diversion screens. Experiments were run on 17.5mm SL golden perch & 26.6mm SL Murray cod that were of a size large enough to be impinged on the screen rather than entrained through the screen and 10.6mm SL Murray cod that were of a size susceptible to entrainment through the screen.
- Results from the golden perch trials have been published in peer reviewed literature (Stocks et al. 2018). The Murray cod trials are currently in preparation for publication (Walsh et al. in prep.).
- The tank trials involved the use of an artificial off-take flume that simulated an diversion screen of the same material (2mm wedge-wire) as is fitted to the OCC pump, and similar, and higher, approach velocities of the OCC pump (between 0.05 and 0.3 $m.s^{-1}$). The reason for examining higher velocities was to investigate what may happen if the screen became partially blocked by debris, or otherwise has 'hotspots' of higher velocity on the screen due to uneven distribution of flow across the entire screen face.
- The laboratory trials showed that having the screen in place reduced entrainment and therefore fish mortality.
- Higher velocities up to 0.3 $m.s^{-1}$ led to increases in impingement rates therefore any blocking of the screen (through debris) will increase approach velocities and increase impacts to fish.
- For golden perch when screen impingement did occur at an approach velocity of 0.15$m.s^{-1}$ for a duration of 1 minute, it did not result in mortality. Impingement duration trials were conducted at 0.15$m.s^{-1}$ for a duration of only 1 minute. Prolonged impingement at higher approach velocities did result in mortality.
    - Impingement rates of juvenile golden perch were approximately 65% at an approach velocity of 0.15 $m.s^{-1}$ (Table 1).
    - Impingement rates of juvenile Murray Cod were approximately 10 and 30% at approach velocities of 0.10 and 0.20 $m.s^{-1}$ respectively (Table 1).
    - Mortality rates for golden perch increased with increased impingement duration at the 0.3 $m.s^{-1}$ approach velocity trials (1 minute impingement = 1% mortality; 10 minute impingement = 10% mortality; 20 minute impingement = 24% mortality; 40 minute impingement = 42% mortality).

Table 1: impingement and entrainment percentages for larval Murray cod and juvenile Murray cod and golden perch under experimental approach velocities.

Approach velocity ($m.s^{-1}$)	**0.05**	**0.075**	**0.1**	**0.125**	**0.15**	**0.2**	**0.25**	**0.3**	**0.35**	**0.4**
Juvenile Golden Perch (17.5mm SL) Impingement (%)	6	-	41	-	62	78	96	100	-	-
Larval Murray Cod (10.6mm SL) entrainment (%)	9	28	58	71	90	95	-	100	-	-
Juvenile Murray Cod (26.6.mm SL) Impingement (%)	-	-	10	-	-	30		68	83	95

- Theoretically, if the screens have been designed to create a 0.15 $m.s^{-1}$ approach velocity with a 2mm wedge-wire screen, the screen should meet current fisheries recommended guidelines.
- However, caution should be applied transferring results from experimental trials to field operations of the OCC pump due to the multitude of variables that operate in the natural environment that cannot be replicated.
- Although the screen has an airburst cleaning system, it is important that it is operated frequently enough to ensure the screen face is kept clean. A seasonal maintenance program of checking the screen for fouling would be beneficial.
- Higher approach velocities may also be experienced on sections of the screen if internal baffling does not adequately spread the velocity across the entire screen face, or if the screen has 'hotspots' of higher velocity on the screen due to uneven distribution of flow across the entire screen face.
- As the pump was not operational at the time of the experimental trials, the operational approach velocities was provided to Fisheries by OCC James Locke, email 21st Feb 2020.
- If there is concern that the field operational velocities being experienced at the screen may exceed the guidelines, then further field measurements should be taken. A number of options are available to do this involving either computational fluid dynamics modelling or by taking direct measurements of velocities at the screen face with a velocity meter.

Fish community studies conducted within the vicinity of the OCC pump between 2014 and 2020 recorded 15 fish and 3 crustacean species.

- This includes the presence of **two threatened species**: trout cod (endangered, IUCN classification) and silver perch (vulnerable, IUCN classification); and **one endangered population**, the western population of freshwater catfish.
- The threatened species/populations sampled in the upper Macquarie River demonstrate obligate or facultative downstream drifting phases; trout cod and freshwater catfish larvae and juveniles drift downstream after leaving the nest (similar to Murray cod) and silver perch have pelagic drifting eggs and larvae (similar to golden perch). Species with these life history characteristics are particularly vulnerable to entrainment and impingement in pumps.
- The known spawning seasons for these species are between October-March (King et al 2005; Koehn & Harrington 2006; Tonkin et al 2007, Davis 1977, Lake 1967, Merrick & Midgley 1981).

Examples of further published literature applicable to the OCC pump include:

- Baumgartner L. J. and Boys C. (2012) Reducing the perversion of diversion: Applying world standard fish screening practices to the Murray- Darling Basin. Ecological Management & Restoration 13, 135–143.
- Baumgartner L. J., Reynoldson N. K., Cameron L. and Stanger J. G. (2009) Effects of irrigation pumps on riverine fish. Fisheries Management and Ecology 16, 429–437.
- Boys C., Lee B., Ben R. et al. (2012) Development of fish screening criteria for water diversions in the Murray Darling Basin. Fisheries Final Report Series Fisheries NSW, Port Stephens.
- Boys C. A., Baumgartner L. J. and Lowry M. (2013a) Entrainment and impingement of juvenile silver perch, Bidyanus bidyanus, and golden perch, Macquaria ambigua, at a fish screen: Effect of velocity and light. Fisheries Management and Ecology 20, 362– 373.

- Boys C. A., Robinson W., Baumgartner L. J., Rampano B. and Lowry M. (2013b) Influence of approach velocity and mesh size on the entrainment and contact of a lowland river fish assemblage at a screened irrigation pump. PLoS ONE 8, e67026.
- Stocks, J.R., Walsh, C.T., Rodgers, M.P. and Boys, C.A., 2019. Approach velocity and impingement duration influences the mortality of juvenile Golden Perch (Macquaria ambigua) at a fish exclusion screen. *Ecological Management & Restoration*, *20*(2), pp.136-141.
- Laboratory Evaluation of Wedgewire Screens for Protecting Early Life Stages of Fish at Cooling Water Intakes, EPRI, Palo Alto, CA: 2003. 1005339.

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