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Efficacy and performance of Hydrolox™ Fine-Screening and Fish Recovery and Return (FRR) system at Blackwell Raw Water Pumping Station, River Tees.
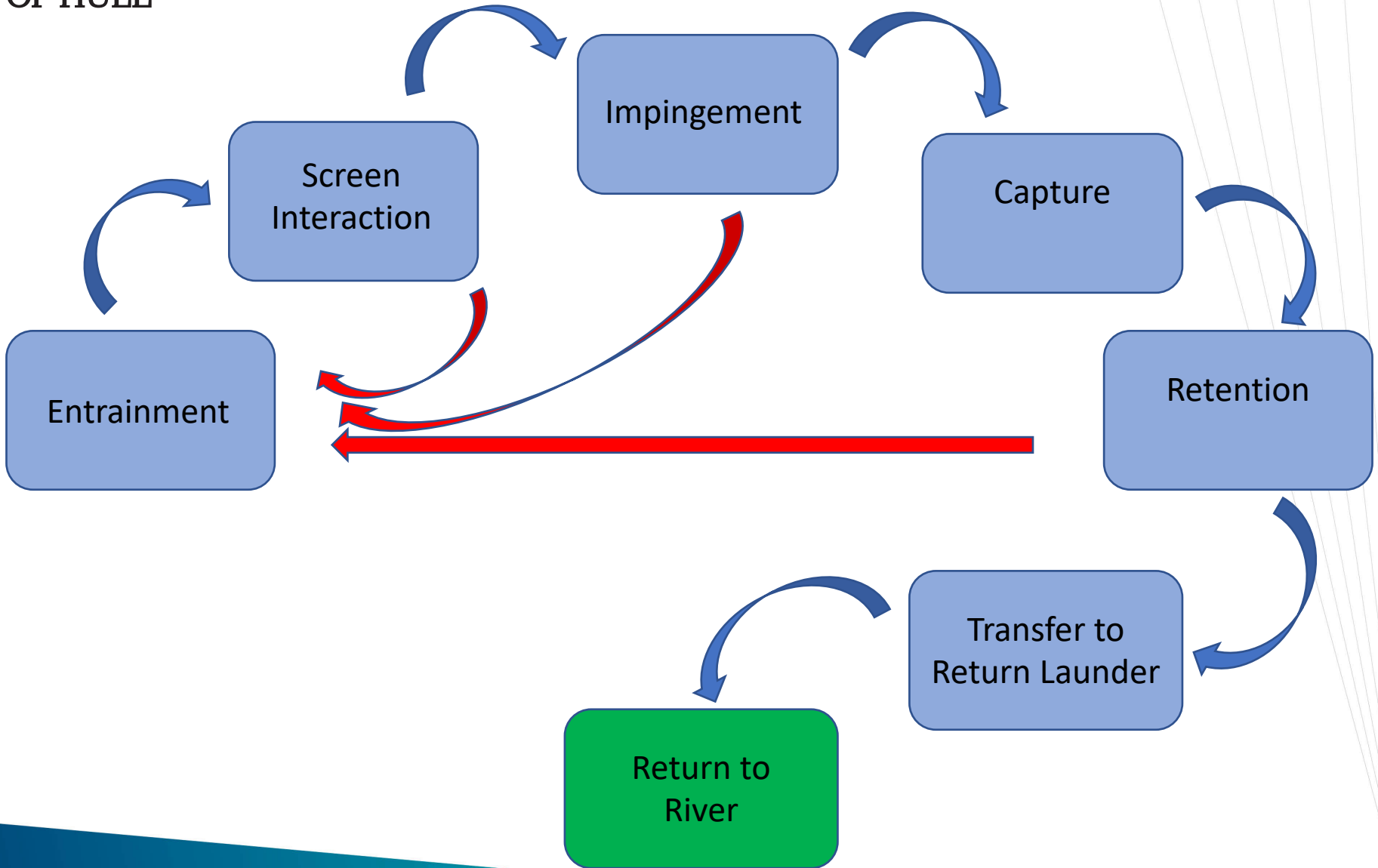
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Contents

- Fish Recovery and Return (FRR) systems

- Blackwell RWPS & Hydrolox Screens/FRR

- Study design

- Results

  - Transfer to return launders

  - Behaviour in fish launder

  - Return to river

  - Fish health & Condition

- Conclusions & Outcomes

Fish Recovery and Return Systems (FRR)
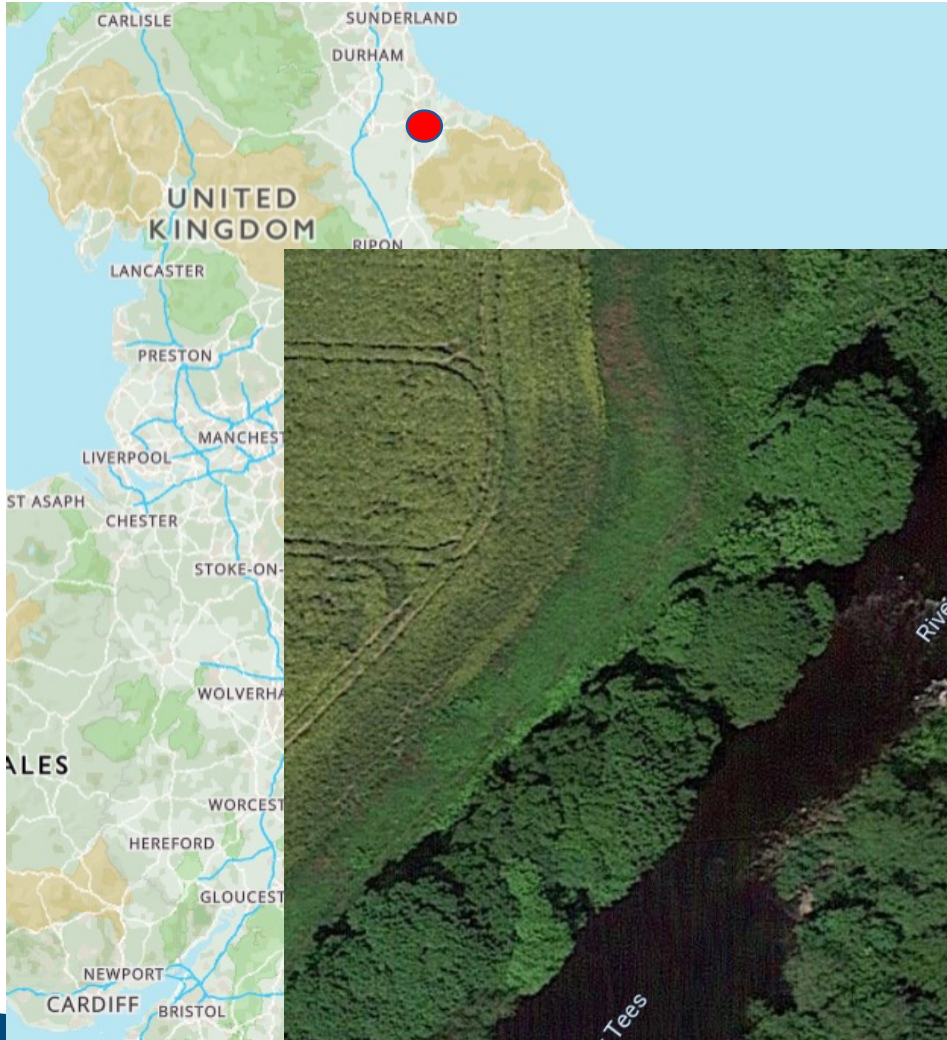
Entrainment to Return

Screen Interaction

Impingement
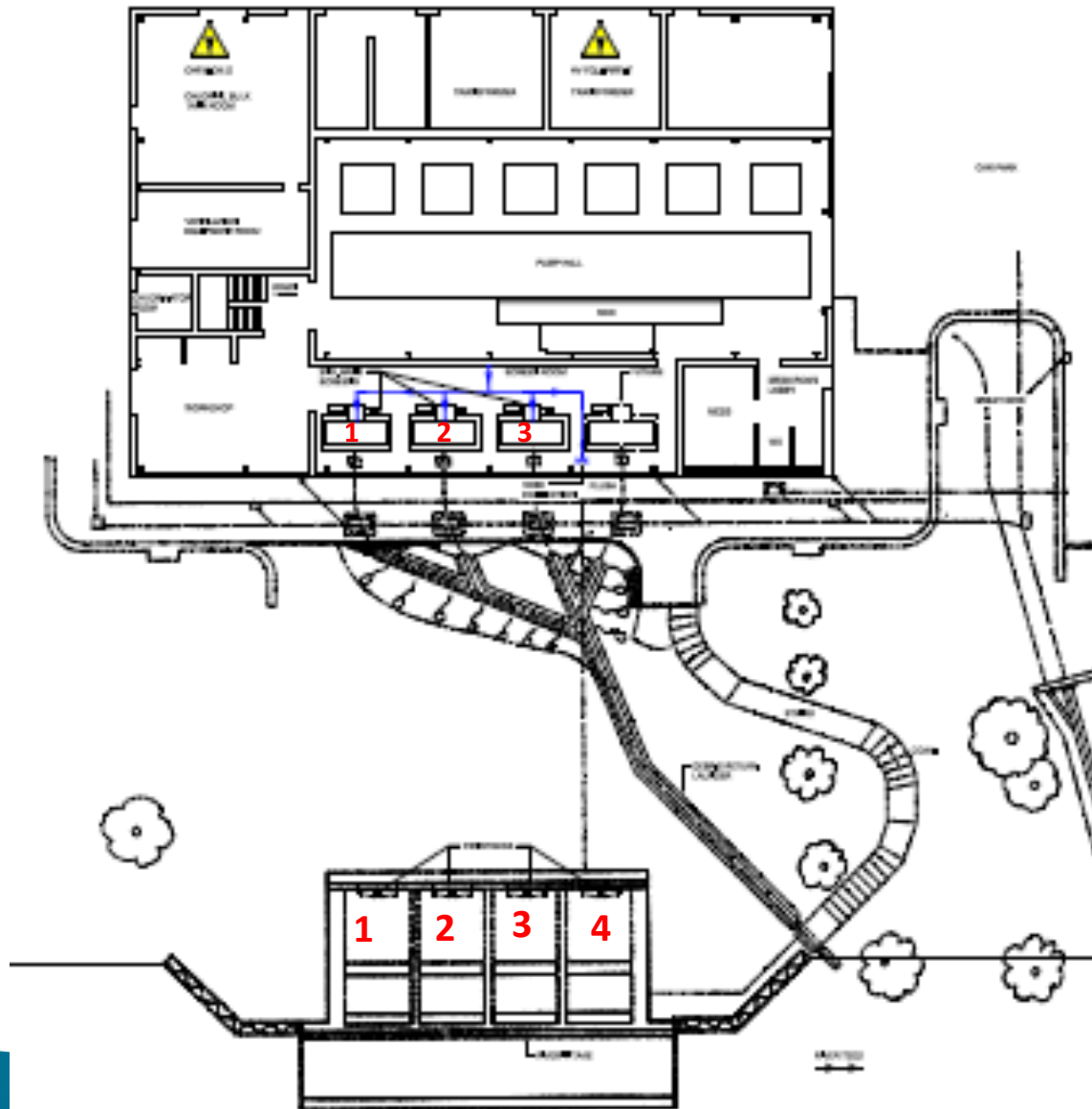
Capture

Entrainment

Retention

Transfer to Return Launder

Return to River

Blackwell RWPS

River Tees
Darlington (NE England)

Site Layout

Intake Apron

Site Layout

SECTIONAL ELEVATION
BETWEEN GRID LINES 5 & 6
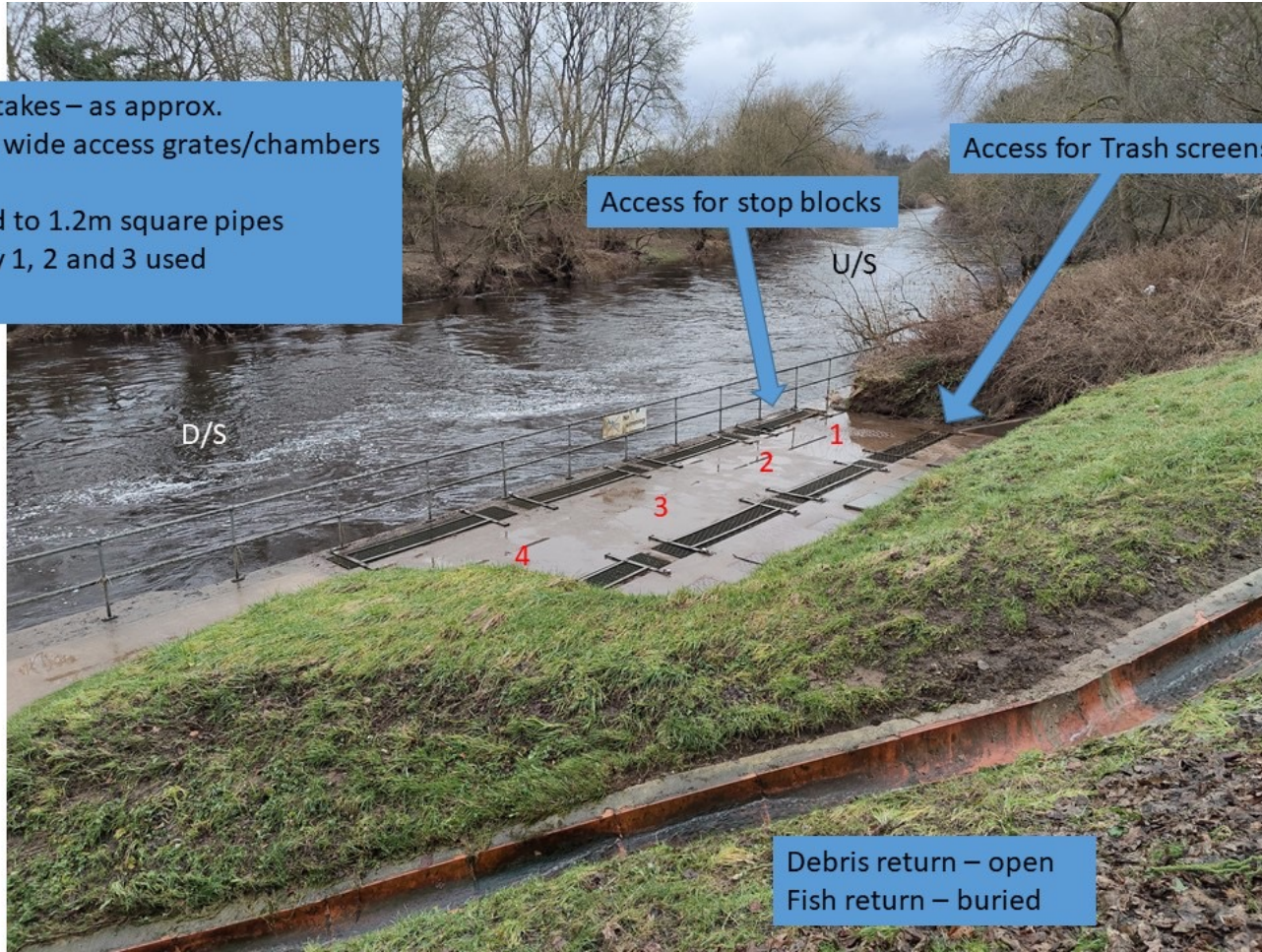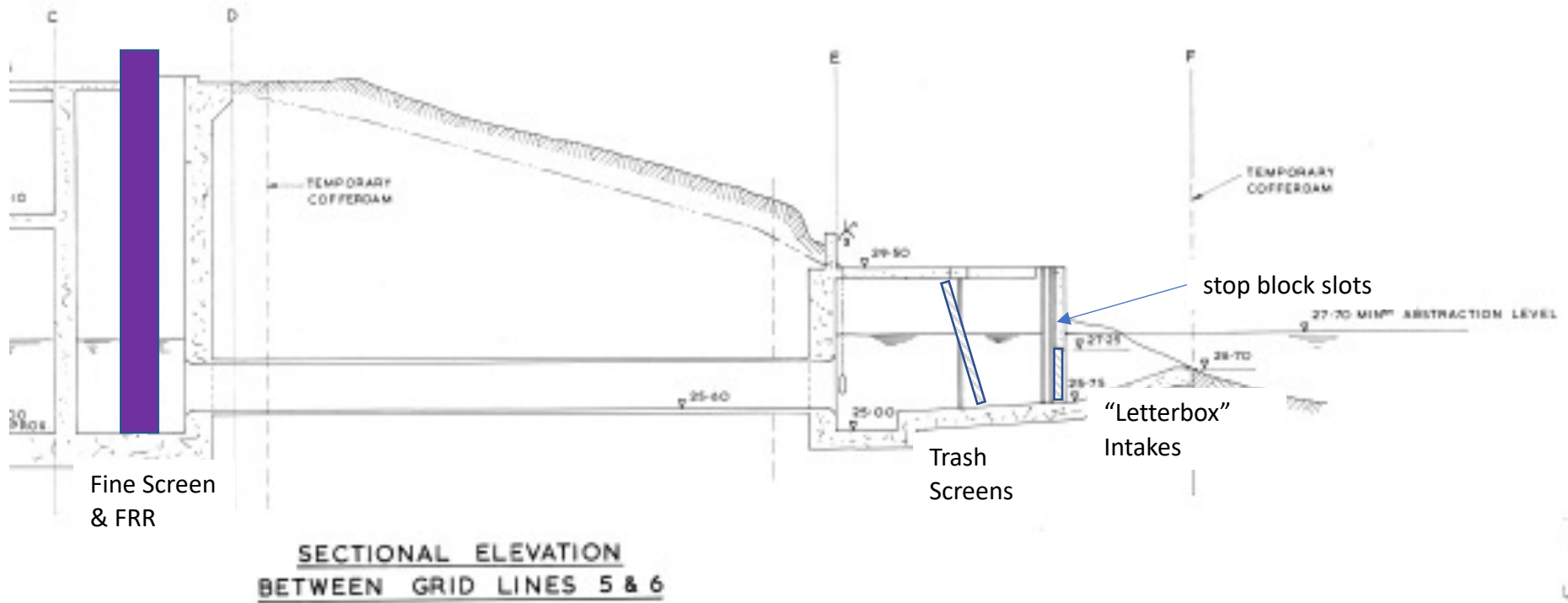
Screen/FRR Design

Fish Bucket Spray Bar

Fish Trough spray bar (98 l/min at 3 bar)

Trash Trough spray bar (358 l/min at 7 bar)

Return Launders

Return launder outfalls

Debris Return Pipe

Fish return pipe
Crests at very low summer flows

Design Parameters

- Hydrolox™ Series 6000 Mesh Top Engineered Polymer panels
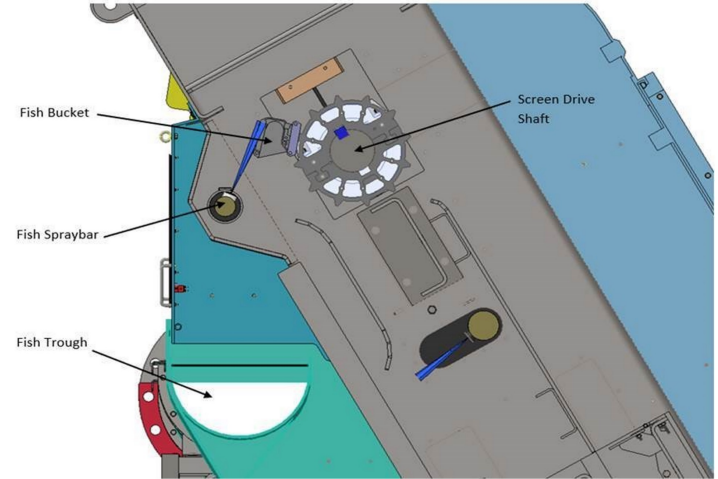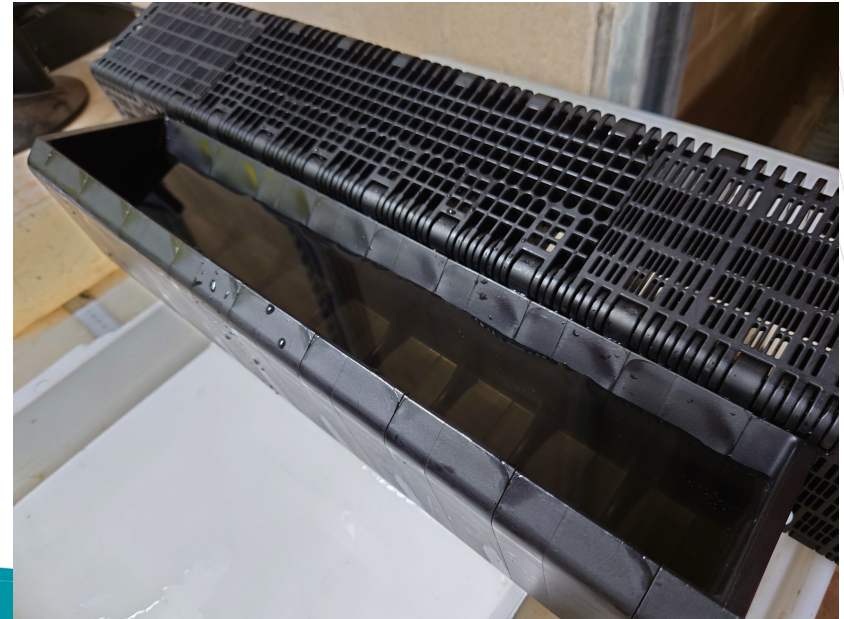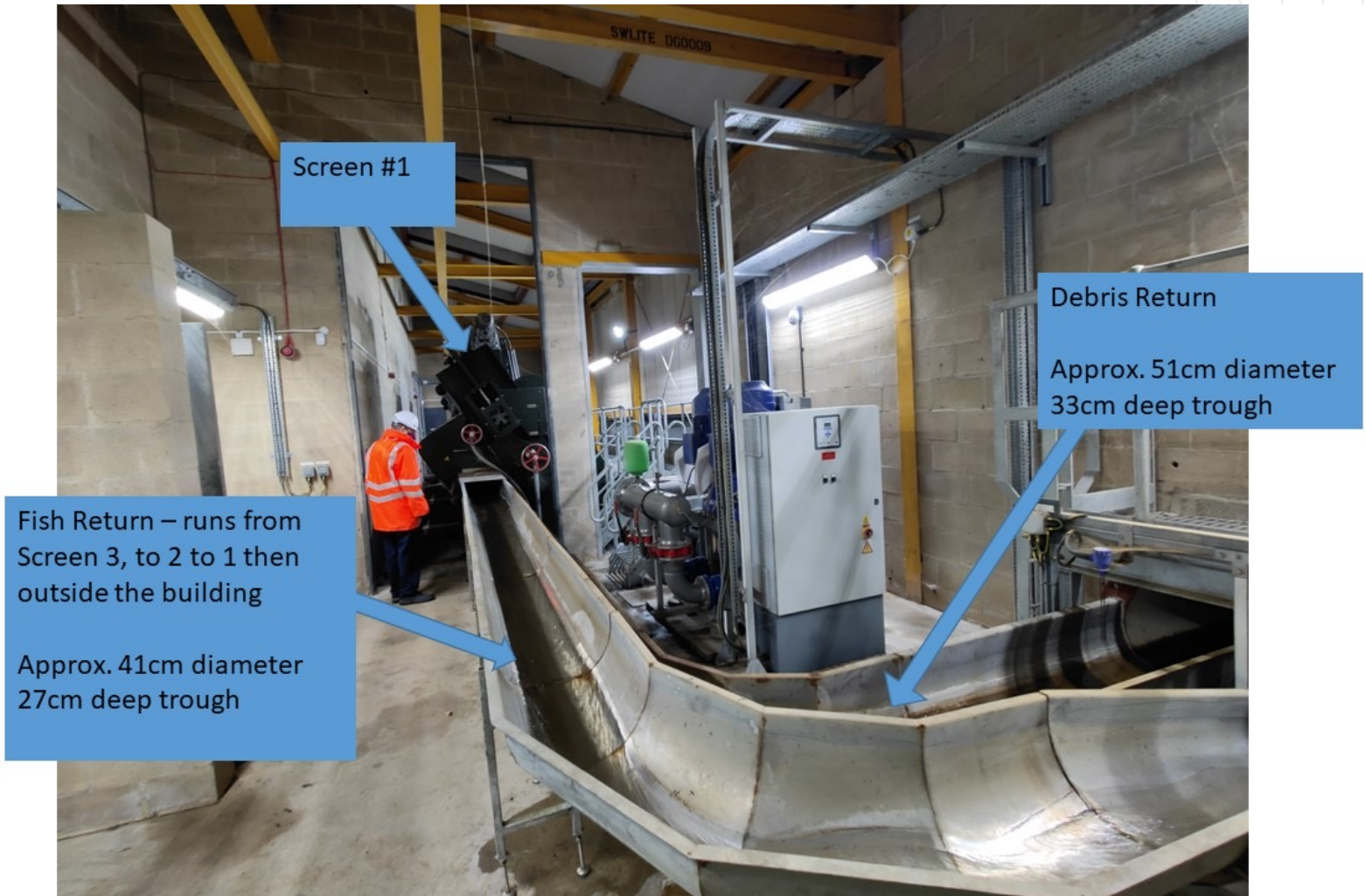   - 1.75 mm and slot lengths between 7.62 mm and 22.35 mm.
    - 1.45 m wide, 10.75 m C-C length in a 12.1 m tall screen - belt width of 1.37 m.
    - maximum abstraction flow rate of 0.613 m^3s^{-1}
    - low flow entrainment velocity = 0.23 ms^{-1} (0.25 ms^{-1} with 10% blockage) / high flow = 0.06 ms^{-1} (0.07 ms^{-1} with 10% blockage)
    - Paired fish recovery buckets set at 535-mm intervals along the screens - 457-mm wide, 96.5 mm in height and 96.5-mm deep (off the screen)
    - 67% of the screen width has fish recovery buckets
    - 2.4 m per min rotation speed - buckets take approximately 5 minutes to rise from the bottom of the sump to the screen head

- Water levels in the sumps - between 2.7m (minimum operating depth) and 8 m deep (maximum operating depth)

Study Design

Entrainment to Return
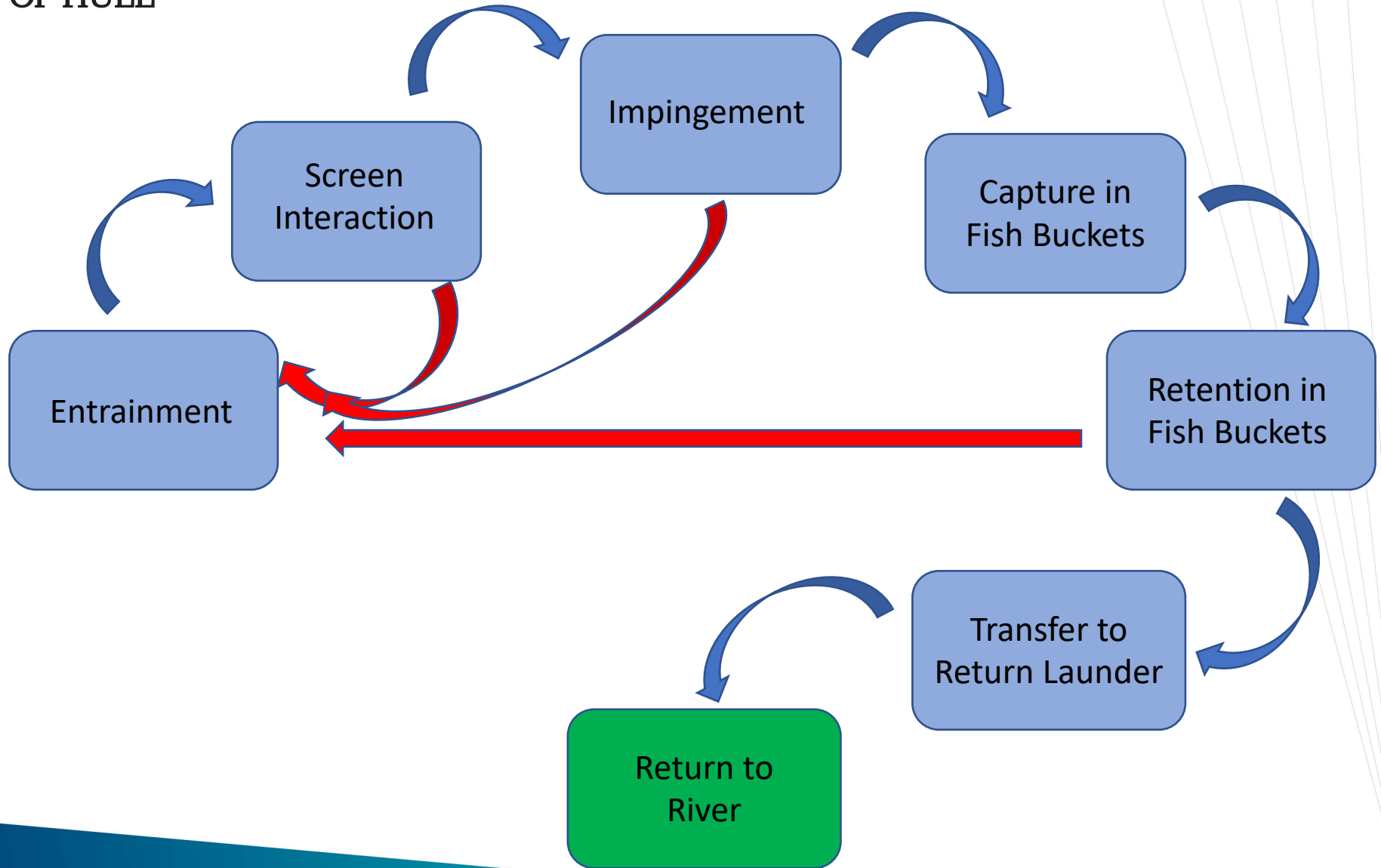
Objectives

1. Assess the potential entrainment risk of fish encountering the Blackwell intake on the River Tees (and potentially being entrained to encounter the fine screens).

2. Assess the background rates of entrainment and transfer of fish into the fish return launders.

3. Assess if fish in the buckets on the band screen are transferred effectively to the fish return launder (and not the trash launder).

4. Assess the condition of fish leaving the fish return launder after recovery and transfer from the screen.

Methods

IR Cameras deployed over fish/trash return troughs

UPS, adaptor, laptop, HDD, WIFI Dongle, DVR

Low voltage power/data cables to Pump room

ARIS line of sight across the intake chamber towards trash screening

Power & data cable – 48v DC

ARIS deployed through stop block access slot on intake #3
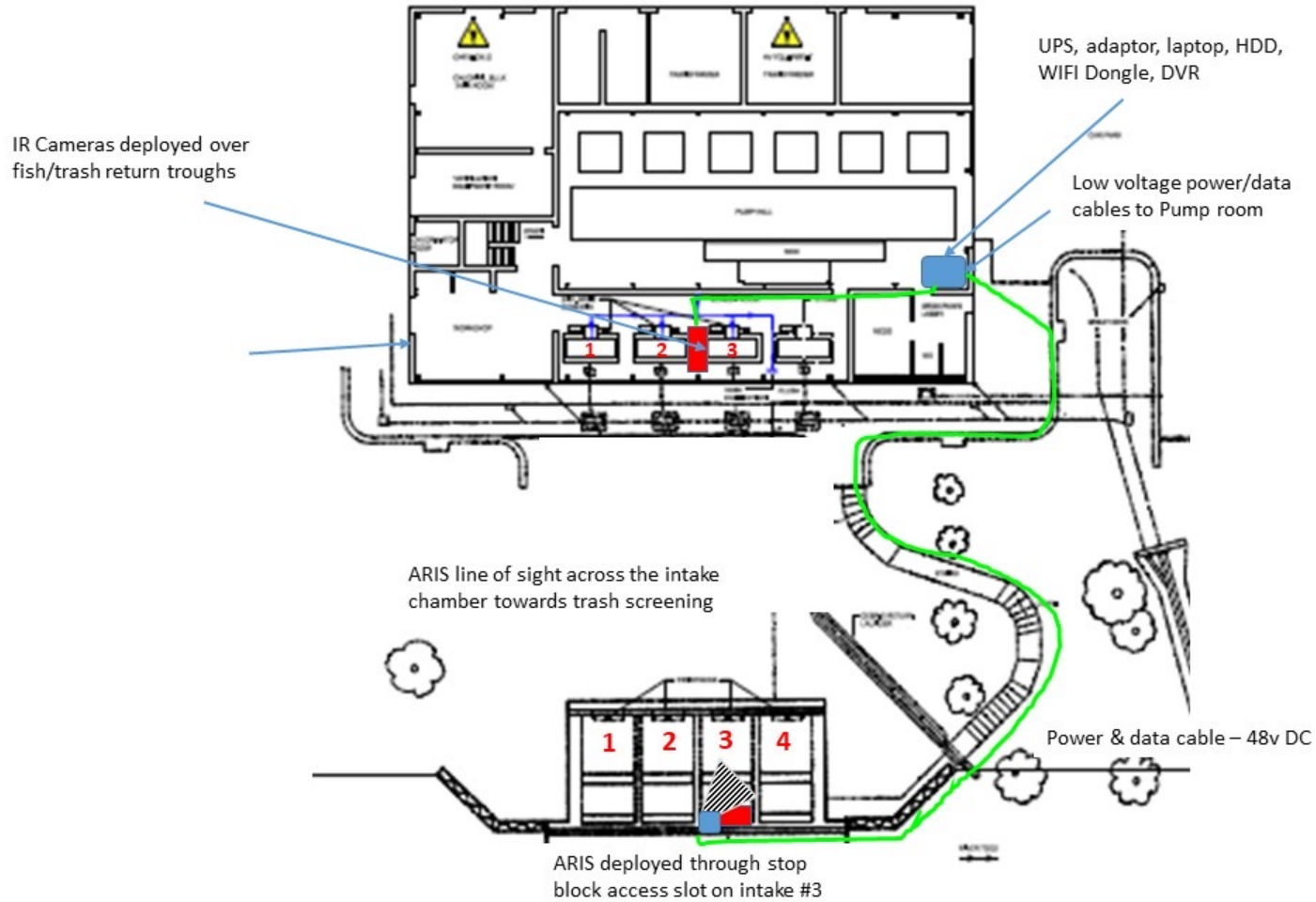
Intake Monitoring
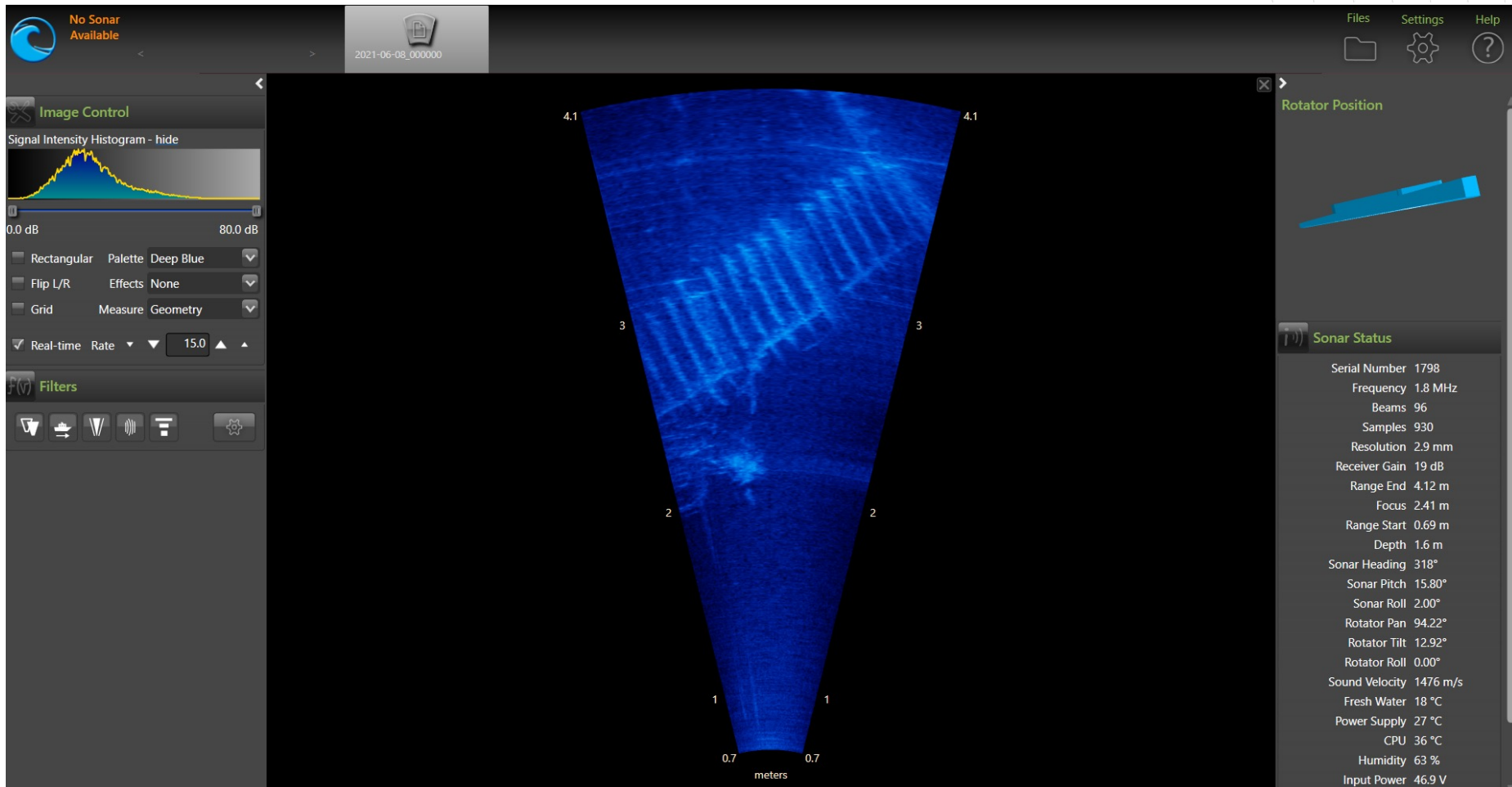
Sub-sampled – dawn/dusk & Pumping events

Return Launder Monitoring

IR Camera Deployment Between Screen 3 and 2

Key Clamp frame supporting 2x IR cameras

FISH TROUGH BAFFLE PLATE

ADJUSTABLE DEBRIS FISH TROUGH TROUGH SLIDE PLATE

DEBRIS TROUGH

DEBRIS TROUGH BAFFLE PLATE

SUPPORTS ARE ADJUSTABLE TO DICTATE TROUGH HEIGHT

TROUGH SUPPORTS SOLUS VG-511-03-SM20-L7. 10MM ANCHOR BOLTS TO BE SUPPLIED BY OTHERS.
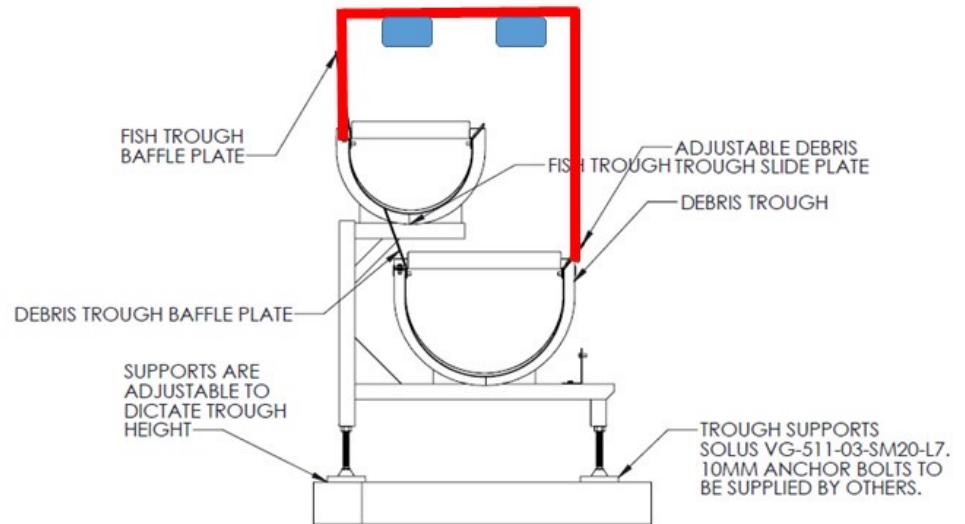
- 10% of footage (3 mins in every 30 mins) for 96 hours
- First 15 minutes of every new pumping event
- Last 5 minutes of every pumping event.

Transfer & Return Trials

2021-11-09 14.25.06
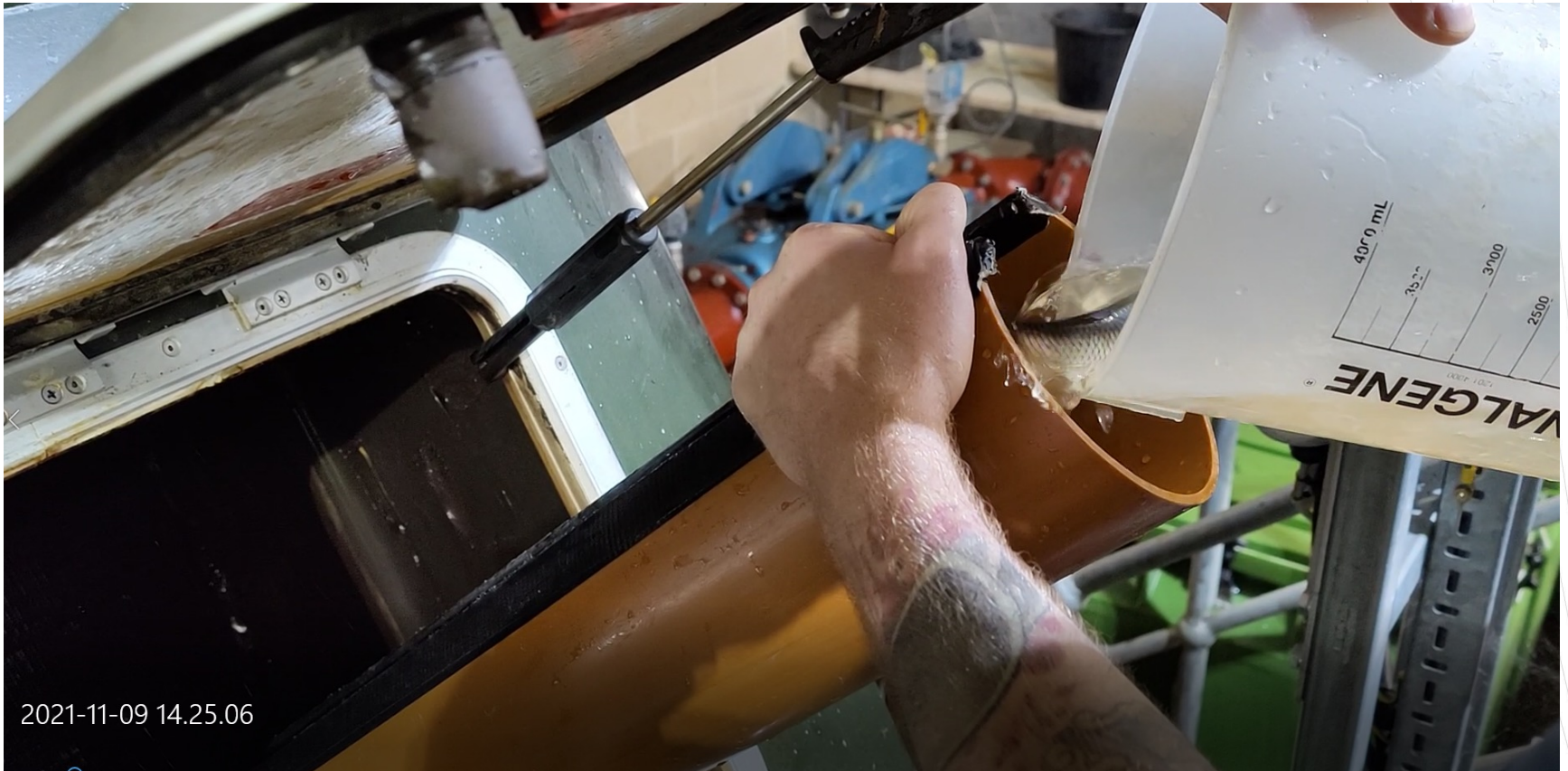
Treatments

Species
- Chub 0+ (87 ± 11 mm)
- Chub 1+ (143 ± 18 mm)
- Dace 0+ (63 ± 5 mm)
- Dace 1+ (120 ± 9 mm)
- Elvers   (72 ± 4 mm)

Treatments
- 10 treatments (5 x cyprinid 5 x elver)
- Typically 10 individuals per species/size per treatment
- Control, 0-hr and 48-hr condition (cyprinids)
- Variation in augmented launder flow
- Recovery from river (cyprinids) or launder (elvers)

Metrics

Launder transfer
- Fish/Trash/Missing
- Visual observation/Camera validation

Fish Behaviour
- Orientation / Swimming behaviour
- Resisting transit?

Fish Health and Condition
- Control, 0-hr and 48-hr post recovery
- Visual assessment & Scoring

Return to river
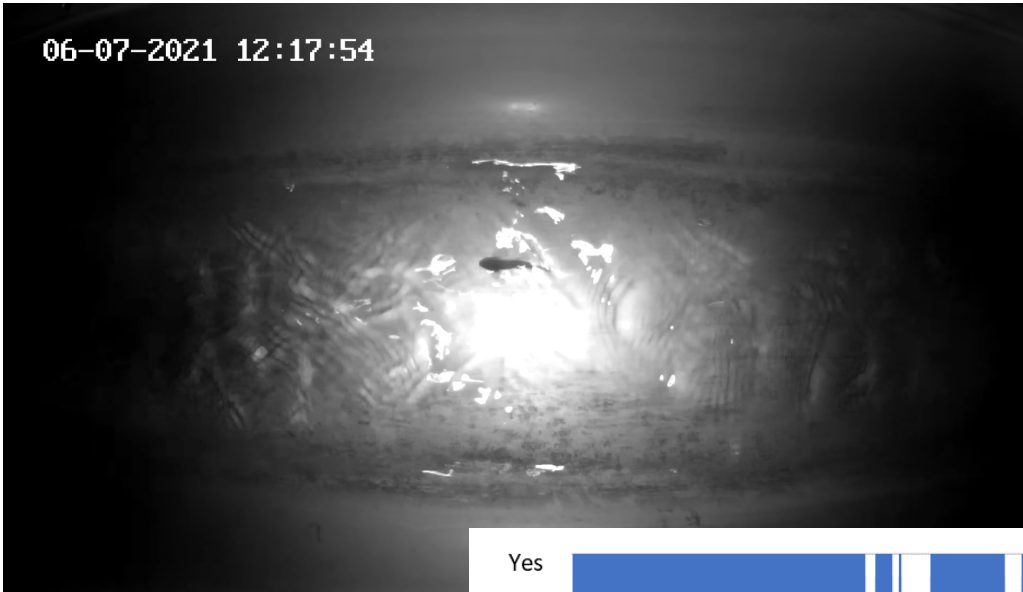- Visual observation of building exit/retention in launders
- Time to transit
- Recovery from fyke net on outfall

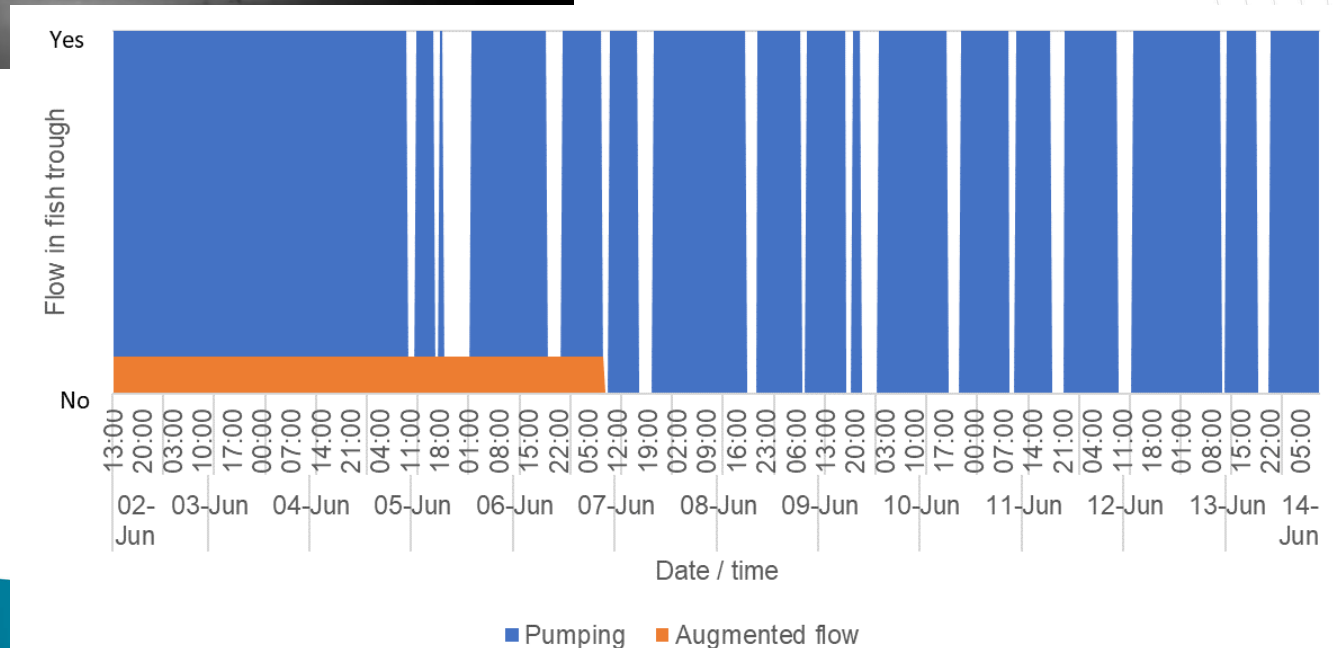# Background Entrainment

06-07-2021 12:17:54

Three instances of fish in the fish return launder between screen #3 and screen #2

Bullhead (*Cottus gobio*)

Observed for up to 4 hours

24 start-up / 23 switch-off events

Transfer to Fish Launder

Effectiveness of the fish recovery buckets and rotating screens at retaining fish and transferring them into the fish return launder

Species	Size group	Number inserted	% (n) in Fish Launder	% (n) in Trash Launder	% (n) no observation
Dace*	0+	39	97.4 (38)	0.0 (0)	2.6 (1)
	1+	40	97.5 (39)	0.0 (0)	2.5 (1)
Chub	0+	40	100.0 (40)	0.0 (0)	0.0 (0)
	1+	45	100.0 (45)	0.0 (0)	0.0 (0)
Eel (T6 & T7)[a]	Elver	41	29.3 (12)	2.4 (1)	68.3 (28)
Eel (T8 & 10)	Elver	52	32.7 (17)	63.5 (33)	3.8 (2)
Eel (T9)	Yellow	2	100.0 (2)	0.0 (0)	0.0 (0)

* one dace was observed visually during the trials in the fish launder but could not be clearly seen on the camera footage for validation – hence observation efficiency was not 100%.

[a] during these treatments the observation of the trash launder was incomplete – therefore many elvers with no observation may have been in the trash launder for these trials.

Behaviour in Fish Launder (1)

99.4% of dace and chub swimming normally immediately after transfer into the fish return launder

64.8% tail first drifting backwards with the flow, 25.5% head first facing downstream and 9.6% side on to the flow

One 0+ chub observed listing and drifting down the trough with the flow.

167 transit events of fish being observed between screens #3 and #2

8 instances were of fish re-entering the field of vision for more than one time.

Elvers exhibited propensity to swim against the flow and congregate at upstream end of the fish launder

Behaviour in Fish Launder (2)

Time (average - min, max seconds) between insertion into the fish buckets and exit of the screen room

Species	Size group	Treatment 3	Treatment 4	Treatment 5
Chub	0+	227 (75 – 510)	n/a	105 (69 – 279)
	1+	178 (81 – 495)	144 (68 – 414)	156 (63 – 315)
Dace	0+	102 (76 – 125)	118 (64 – 360)	n/a
	1+	134 (93 – 231)	114 (95 – 153)	70 (66 – 75)

Percentage of fish taking longer than 8 minutes to be observed leaving the screen building via the fish return launder.

Species	Size group	Treatment 3	Treatment 4	Treatment 5
Chub	0+	50%	n/a	10%
	1+	0%	20%	20%
Dace	0+	0%	*0%	n/a
	1+	50%	40%	0%

Return to River
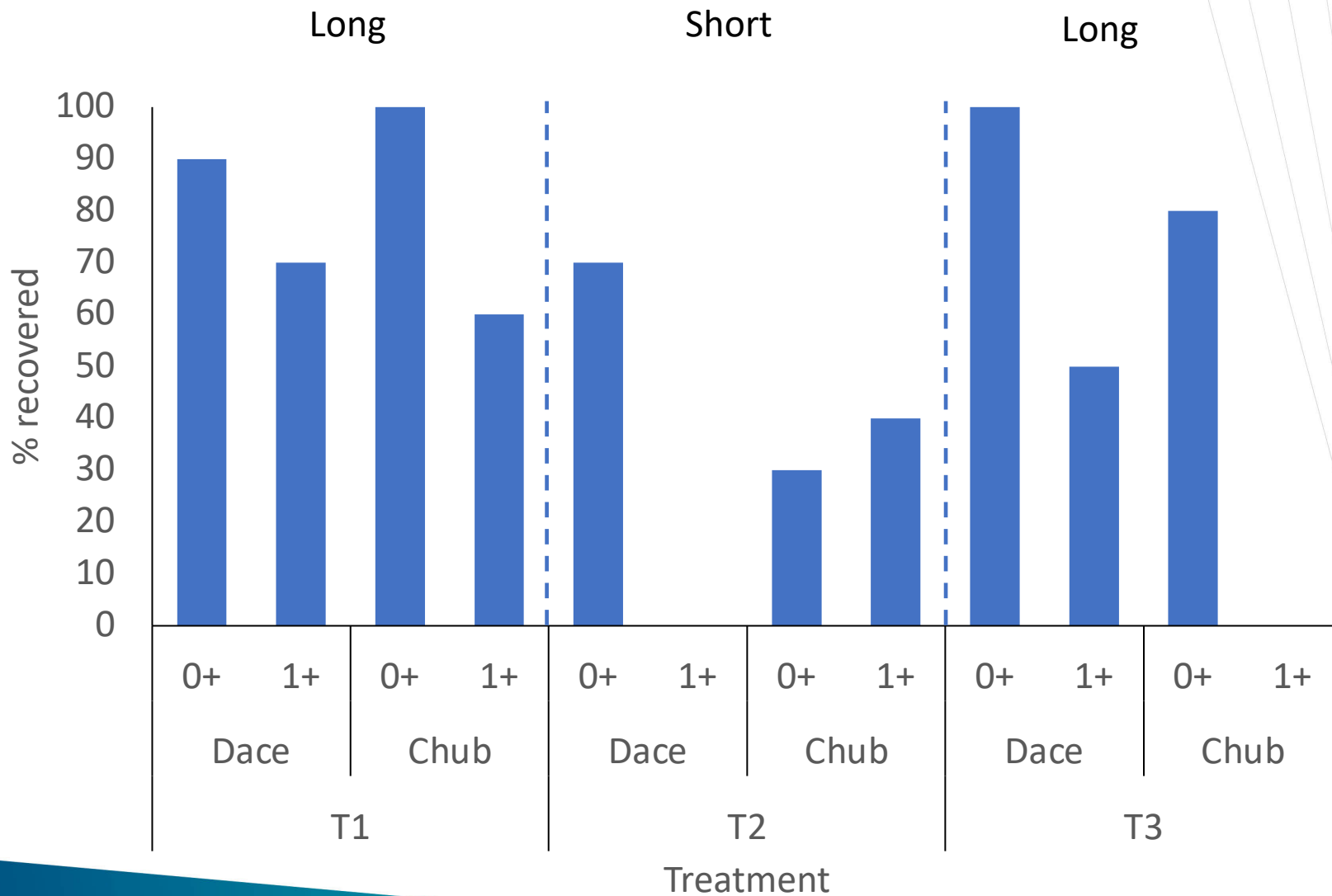
Fish Health & Condition

- On recapture 100% of 1+ dace and 1+ chub exhibited normal, lively, behaviour and indicated no sign of stress

- Only for 0+ dace were there mortalities of fish; 1 immediately after recapture (6% of recoveries), 1 control fish after 48 hours (20%) and 4 0+ dace (44%) from T1 after 48 hours

- Very minor amounts of scale loss (<5% coverage) was observed in all species, age groups and treatments (17 to 100%) and was more prevalent for 0+ fish

- Minor fin damage (0 to 47%) – most frequent for 0+ individuals and those held in the tank for 48 hours after recovery

- All eels and elvers recaptured after had pristine external physical condition score and the majority exhibited normal swimming behaviour

- 6 elvers appeared lethargic and had reduced swimming activity – treatment with augmented launder flows

Conclusions

Conclusions

- Transfer efficiency of dace/chub into fish launder was very high (>97%)

- Transfer efficiency for elvers was low (31%)

    - Majority placed into trash launder

- No ill effects for elvers exposed to the recovery and return system or missing the transfer to the fish recovery launder

- Mortality and physical damage rates were generally low: minor scale loss and minor fin damage – cannot be isolated from handling effects

- Return rates were not observed to be 100% - lowest for the largest bodied individuals (e.g. 1+ chub)

- Delay in the fish leaving the building and then transiting the return pipe to the river

Outcomes & Future Work

- **Improve transfer efficiency of glass eels and elvers into the fish launder**
  - **Fish Trough spray bar pressure modified from 3 bar to 1-1.5 bar - implemented at installations in the USA and proven successful**
- **Improve depth of water in the fish launder**
  - **new baffle plate at upstream inflow**
- **Reduce delay in fish launder transit**
  - **increased design fall of fish return launder**

- **Research required to assess the interaction of fish with screen and fish buckets under in-situ pumping conditions to assess the effectiveness of recovery of impinged fish on the screens**

Acknowledgements

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