Queensland **the Smart State**

Targeted collection of inventory data for wetlands fish barriers in the Great Barrier Reef catchment

Mary Lawrence, Dave Sully, John Beumer and Dawn Couchman

Final Report

Australian Government
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Executive Summary

Fish depend on access to a wide range of habitats for their survival. Coastal wetlands are dynamic ecosystems that are vital habitats for fish. Wetland habitats provide fish with food, shelter that helps protect fish from predation and are also important as breeding and nursery areas (Blaber, 1997). A number of fish species move into wetland habitats at various times of their lives in order to breed and complete their life cycles. Maintaining connectivity between wetland habitats and access to a diverse mosaic of healthy fish habitats is critical to sustaining fish populations that are important to Queensland's commercial, recreational and traditional fisheries (Meynecke et al., 2008).

To meet the demands of expanding residential, industrial and agricultural development, a range of instream structures have been developed throughout freshwater, estuarine and marine wetland fish habitats. Instream structures include floodgates, levee banks, jetties, pontoons, boat ramps, revetments, moorings and road crossings. These structures can impact fish habitats by modifying flow regimes and causing permanent physical disturbances that result in direct habitat loss or fragmentation (Burns, 2001; Adams, 2002). Other structures may form complete or partial barriers that prevent or severely limit important migrations and movements of fish and other aquatic species within these areas (Fairfull & Witheridge, 2003). Negative impacts of instream structures lead to population declines, reduced distributions of species and degraded fish habitats, which can have detrimental effects on Queensland's commercial, recreational and traditional fisheries.

These pressures and impacts also exist within the declared Fish Habitat Area (FHA) Network and are of greater concern. In response to development pressures in the coastal zone, DPI&F established the declared Fish Habitat Area (FHA) network in the late 1960s (McKinnon et al., 2003). The purpose of the declared FHA network is to protect key estuarine and inshore areas of fish habitats that sustain the fish on which commercial, recreational and traditional fisheries rely, from development. The *Fisheries Act 1994* regulates the types of developments that are permitted within FHAs, assisted and supported by a number of DPI&F policies and guidelines. All new developments, including the building, placing and maintenance of structures, in declared FHAs are required to be subject to assessment to ensure development impacts are minimised.

Despite this legislative and policy framework, development impacts that conflict with current FHA policies and management arrangements do exist in these Areas. Of most concern are the impacts of those structures constructed before FHA declaration, or structures that are illegal either without an approval or contrary to an approval. There is a high risk that the associated impacts of such structures on fish habitats are unacceptable, particularly those that have not been subject to the development assessment process.

In order to address the impacts of instream structures within the declared FHA network, an integrated and consistent approach is needed. DPI&F has previously developed inventory and prioritisation processes for addressing the impacts of priority fish barriers in several Queensland catchments, primarily in freshwater habitats. However inventory work to date has not addressed the impacts of the range of other instream structures that exist in coastal fish habitats, such as pontoons, boat ramps, revetments and moorings. These structures often exceed the number of fish barrier structures in coastal areas and their cumulative impacts on fish habitat can be large.

In response, the instream structure inventory (ISI) project was initiated in June 2007 and started in February 2008 following funding approval under the second phase of the Natural Heritage Trust. The project complemented the Queensland Wetlands Programme. The aim of the project was to develop a framework and guidelines for conducting a physical inventory and data storage for identifying and plotting all man-made structures that impact on estuarine and marine fish habitats and movement of fish in declared FHAs in coastal Queensland.

Trial inventories were undertaken within two declared FHAs in north Queensland: Trinity Inlet (7 212 ha) and Hinchinbrook (12 268 ha). Data was collected using a personal digital assistant (PDA) uploaded with Arcpad and the fish barrier menu system. A Decision Support System (DSS) was

developed and used to prioritise structures for consideration of management responses. The DSS involved a number of criteria used to score individual structures as well as a prioritisation matrix to identify priority structures. Potential management considerations were then applied to different structure categories identified during the inventory process. The purpose of this process was to assist NRM and key stakeholder groups to identify those that continue to have a negative impact on fish habitat or fish passage. This would lead to informed management decisions for strategic modification or removal of problem structures in cooperation with investment strategies of NRM agencies.

The results from the trial inventories, including a priority listing of structures for each project area and consideration of management responses, are discussed herein.

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Introduction

The following report outlines the findings from the pilot inventories conducted in the Trinity Inlet and Hinchinbrook declared FHAs for the project "*Targeted collection of inventory data for wetlands fish barriers of the Great Barrier Reef Catchment*". The project was managed by Queensland Department of Primary Industries and Fisheries (DPI&F) and funded by the Department of Water, Heritage, Environment and the Arts (DEWHA) under the second phase of the Natural Heritage Trust. The project complemented the Queensland Wetlands Programme, a joint initiative between the Queensland and Australian governments to minimise the degradation of wetlands and reduce impacts on water quality and biodiversity in Queensland.

Project objectives

The purpose of the project was to develop a framework and guidelines to conduct a physical inventory and data storage for identifying and plotting structures that impact on fish habitats and movement of fish and other aquatic species. The project was developed and managed to meet the following main objectives:

1. Modify the available New South Wales Department of Primary Industries (DPI) fish barrier menu system to suit Queensland conditions and encompass an expanded range of structures.

2. Trial the menu system and methodology in one or more catchments with the long-term aim to conduct inventories over all Queensland catchments.

3. Link the data to the Wetland mapping and the Inventory data collection system and other data bases within the Queensland Wetlands Programme (QWP)

4. Develop a technical guideline detailing the framework, inventory and response protocols for dissemination to regional Natural Resource Management (NRM) groups.

In complementing the QWP, the project met the Programme's objective *'To support projects and programs that will result in long-term benefits to the sustainable use, management, conservation and protection of Queensland wetlands'* through developing a methodology and documenting the impacts of instream and crossing structures on wetland habitats leading to adoption of management responses to address these impacts. The key theme or QWP Focus Area the project linked to is Focus Area 1 'Improving the Wetland Information Base', requirements identified for effective wetland assessments/management (comprehensive inventory data).

The project also met the objective of conducting an inventory of impacts within catchments, considered an additional phase to the existing inventories of wetland mapping and other GIS data layers within the mapping and inventory projects of the QWP. In leading to informed management decisions for strategic modification or removal of structures/ barriers in cooperation with investment strategies of regional NRM agencies, the project linked to theme 3 of the QWP: on-ground works to remove or modify impacts from instream barriers.

Existing QWP activities have mapped the wetlands in Queensland in terms of distribution and other information has been provided relating to classification and the degree of disturbance of the wetlands. This is seen as the key initial stage in effective wetlands management. Integral to this mapping base has been the identification of a number of larger structures through interpretation of aerial photography. However any exercise of this broad nature is limited in identifying smaller but often more numerous structures which collectively have equal or greater impact on wetland condition than those structures already identified.

The project, in comprehensively documenting the threats to mapped wetlands from the impacts of all in-stream structures and establishing a DSS to assist in remediation of problem structures, will

lead to the higher resolution of management advice for wetlands and the subsequent development of a threat abatement/response program for the structures. The key outcome is regarded as the restoration of connectivity between adjacent wetland types.

Background

First developed in June 2007, the Instream Structure Inventory (ISI) project started in February 2008 following funding approval under the second phase of the Natural Heritage Trust. The project aimed to build on the outcomes of existing efforts targeting fish passage in freshwater fish habitats in order to establish a systematic approach to identifying and prioritising (man-made) instream structures in Queensland's coastal areas.

The threat that fish barrier structures pose to the viability of fish populations is now widely recognised and a significant amount of work has been undertaken in freshwater fish habitats, where the majority of fish barriers exist. DPI&F has undertaken projects throughout coastal Queensland to remediate fish passage at priority 'problem' barriers primarily in freshwater and riverine waterways (Stewart & Marsden, 2006; Marsden & Moore, 2008 *pers comm*.; Stockwell et al., 2008). Through research in the Mackay Whitsunday region, DPI&F developed a process for identifying high priority sites for fish passage rehabilitation (Marsden *et al*., 2006) and DPI&F is currently undertaking this process to prioritise problem fish barriers throughout the Fitzroy River basin (Marsden & Moore 2008 *pers comm*.). Based on these and other fish habitat rehabilitation projects, guidelines were developed to assist NRM groups in dealing with problem structures (cf. *"Reef Coast Freshwater Fish Habitat Rehabilitation Strategy, June 2006" – Stewart, R. & Marsden, T., 148 pp*.). In conjunction with the Burnett Mary Regional Group, DPI&F developed a similar strategy in the Burnett/Mary region to prioritise problem barriers within the region's subcatchments (Stockwell *et al*., 2008). New South Wales DPI&F have also undertaken extensive work associated with freshwater fish barrier remediation (NSW DPI 2006a; 2006b).

However in addition to structures that impact fish passage, there are a number of other instream structures that are being increasingly developed in the coastal zone that impact on estuarine and marine fish habitats. Such structures include jetties, pontoons, moorings, revetments and boat ramps. The diversity of instream and crossing structures and their locations within catchments impact on fish habitat values and functions locally, upstream and downstream of each structure. Note that the term 'fish' is used in its broadest sense and includes finfish, crustaceans and molluscs.

This project has extended previous inventory work to develop a framework that can be applied to include a range of other 'non-barrier' structures in estuarine areas of coastal Queensland. The framework allows for the collection of data necessary for decisions to be made on prioritising management responses to remove or reduce the impacts of all man-made instream structures in coastal areas and which integrates and adds to inventory data collected from other sources. Development of the framework was based on its application within 2 pilot declared Fish Habitat Areas (FHAs) in north Queensland adjacent to the Great Barrier Reef, the results of which are presented in this report.

A key outcome of the trials (that fulfilled a main project objective) was development of FHG 007 *Fisheries guidelines for conducting an inventory of instream structures in coastal Queensland*. The guidelines provide both government (e.g. State agencies, Councils) and non-government (e.g. Natural Resource Management bodies) organisations with the capacity to undertake inventory projects throughout Queensland. The Guidelines consist of two user-friendly parts: an inventory protocol that describes the inventory process; and a response protocol, including a Decision Support System, to facilitate prioritisation of problem structures for management responses. The guidelines will be accessible via the DPI&F website www.dpi.qld.gov.au.

Steering Committee

A Steering Committee was established to review progress of the project and to provide technical input. The Steering Committee met twice during the term of the project and had representatives from the following agencies and organisations: Department of Environment, Water, Heritage and the Arts (DEWHA), Environmental Protection Agency (EPA), Department of Natural Resources and Water (NR&W), Department of Primary Industries and Fisheries (DPI&F), Terrain Natural Resource Management, Lower Herbert Catchment Group and the Great Barrier Reef Marine Park Authority (GBRMPA). Members are listed in Appendix A.

Project areas

Development of the framework and guidelines was based on trial inventories within the Trinity Inlet (7 212 ha) and Hinchinbrook (12 268 ha) declared FHAs, located within the Great Barrier Reef lagoon. The Trinity Inlet and Hinchinbrook FHA are downstream of extensive catchments. Each was selected to reflect the urban and rural levels of development respectively, and to provide data on the different impacts of development that instream structures pose as a consequence of land use and on downstream and inshore wetland values. The location of each declared FHA is shown in Figure 1.

The declared FHA network was established by DPI&F in the late 1960's in response to development pressures in the coastal zone (McKinnon *et al.*, 2002). These areas protect key fish habitats and fish stocks that sustain the commercial, recreational and traditional fisheries, from development. While protecting natural fish habitats (e.g. vegetation, sand bars, rocky headlands) from alteration and degradation from development impacts, declared FHAs allow for natural processes and community use, including community access; boating; commercial, recreational and traditional fishing.

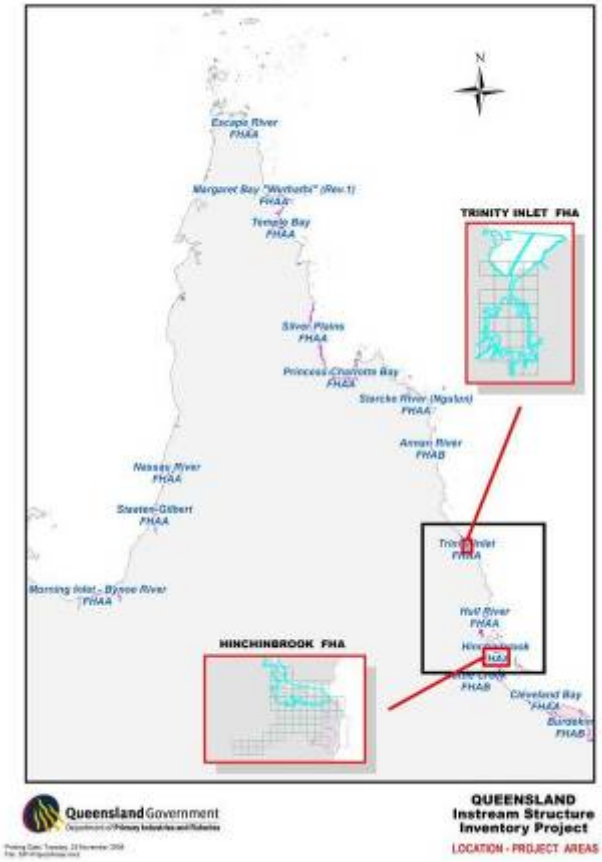

Figure 1. Location of project areas encompassing Trinity and Hinchinbrook declared FHAs.

Trinity Inlet

The Trinity Inlet declared FHA (Fig. 2) is part of the Mulgrave/Russell catchment and is located adjacent to the city of Cairns. Cairns has an estimated population of 140 900 and most development in the area is urban (Derbyshire *et al.*, 2003). The 7212 hectares of the Trinity Inlet FHA encompass extensive mangrove zones and communities of seagrass and saltmarsh.

Figure 2. Trinity Inlet declared Fish Habitat Area.

These habitats provide nursery areas for several species of commercially important fish, including mackerel, queenfish and barramundi (CHRIS). Seagrass meadows in Cairns Harbour support a multispecies commercial penaeid prawn fishery offshore (Watson *et al*., 1993) and the Inlet also sustains multi-species prawn aquaculture. Trinity Inlet declared FHA is home to a recreational mud crab fishery and provides habitats for a range of recreational fish species (including barramundi, blue salmon, bream, estuary cod and flathead).

Hinchinbrook

The Hinchinbrook declared FHA (Fig. 3), draining the Herbert River catchment, is part of one of the largest and most complex estuarine systems in eastern Queensland and is the largest tropical estuary of the north-eastern coastal zone.

Figure 3. Hinchinbrook declared Fish Habitat Area.

Covering 12 268 ha. The Hinchinbrook declared FHA includes extensive mangrove stands and seagrass meadows and is an important nursery ground for banana and offshore tiger prawn fisheries. Hinchinbrook fish habitats support a range of commercially caught species including mud crab, barramundi, threadfin and mackerel (CHRIS). The Hinchinbrook declared FHA supports a sea cage barramundi aquaculture farm and there are a number of aquaculture operations in the wider Hinchinbrook region.

Important recreational species include barramundi, blue salmon, bream, estuary cod and mangrove jack. With an estimated population of 12 500, most development within the Hinchinbrook Shire is rural and dominated by sugarcane cultivation and milling. In addition to aquaculture, other main land uses include tourism and cattle farming.

Project methods

The project methods outlined below formed the basis for the inventory protocol that is described in detail in Fish Habitat Guideline 007 (FHG007). The guidelines can be consulted for further information on how to prepare for fieldwork, including preparation of maps and project area grids.

Inventory data was collected in April and May 2008, using a TDS Nomad personal digital assistant (PDA). The PDA was uploaded with Arcpad (V.7.0.1), project area maps and a modified version of the fish barrier menu system v.4, a GIS based digital assessment system. The fish barrier menu system was originally developed by New South Wales Department of Primary Industries (NSW DPI, 2006). On-ground surveys involved using a combination of boat and car to access structures. Prior to on-ground surveys, an aerial survey was undertaken in both project areas. The purpose of the aerial surveys was to obtain an overall perspective of the project area, identify the location of structures and access points and to assist with on-ground navigation. These surveys were conducted at low tide to allow the greatest visibility of structures.

Preparation of project area maps and project area grid

All project area maps incorporated the latest GIS data layers (watercourses, vegetation, infrastructure, waterholes and bores, land tenure) and existing approval information (fisheries development approvals, QT boat ramps, prescribed tidal works, Section 86 approvals) for each project area with base layers (Digital Cadastral Data Base (DCDB), topographic, Fish Habitat Area mapping, wetlands mapping and imagery). Maps were created using ArcGIS and Arcpad.

Firstly an overview map of the project area was developed using Arcmap. The overview map, including the above mentioned layers, consisted of the project area and associated buffer area, allowing some flexibility in project area boundaries. Once the project area was finalised, a one-minute grid was placed over the project area map, to allow fieldwork progress to be monitored. Each grid square was numbered consecutively for ease of reference. The overview map with a one-minute grid was used as a map key for all the individual maps. An example of the map key is shown in Figure 4. Map keys for the Trinity Inlet and Hinchinbrook project areas are included in Appendices B and C respectively.

Figure 4. Trinity Inlet project area map key.

Individual maps were subsequently created for each numbered grid square and used for field navigation. An example of an individual map used in the field in Trinity Inlet is shown in Figure 5.

Figure 5. Individual map number 7 of the Trinity Inlet project area.

Field data collection

Data was collected via a combination of field and desktop assessment methods. Field data collection was conducted between April – May 2008. The inventory trial in Trinity Inlet declared FHA was undertaken over two weeks (April 28 – May 9 2008), while inventory trials in the Hinchinbrook declared FHA was completed during the week of 19-23 May 2008.

Data collection involved using the PDA to record the GPS location of each structure and information on a range of data attributes, viewable on each page of the menu system that acted as digital data entry forms. Prior to field work the fish barrier menu system was modified to incorporate the required data attributes. Data attributes in the menu system were grouped into

different pages based on the following broad categories: general, spatial location, site details, non-barrier, barrier type, barrier details, fish passage details, habitat, vegetation, threats (or impacts), location and ownership. A full list of data attributes is provided in Appendix B. Details regarding specific data attributes and application of the fish barrier menu system are outlined in FHG 007 *Fisheries guidelines for conducting an inventory of instream structures in coastal Queensland*.

Decision Support System and prioritisation of structures

A Decision Support System (DSS) was developed and used to score and prioritise structures for management responses, based on a number of criteria. Due to the different nature of impacts of barriers and non-barriers, these groups of structures were considered separately during this process. Prioritisation criteria were based on those developed by DPI&F (Marsden *et al*., 2006) to prioritise fish barriers in the Mackay Whitsunday region. The original criteria have been modified to extend to non-barrier structures and allow prioritisation of structures within declared FHAs.

The criteria were separated into two categories: habitat value criteria and fish-friendly criteria. Habitat value criteria indicate the value of habitat that surrounds a particular structure as classified by habitat class, extra fisheries value, habitat condition, and location in relation to the FHA. Fish-friendly criteria include structure type and disturbance area (non-barriers) or barrier type and impact (barriers). Fish-friendly criteria measure the severity of a structure's impacts on either fish habitats or fish passage.

Values were assigned under each criterion, to derive a habitat value score and a fish-friendly score for each structure. A high habitat value score indicates a structure located in an area of high habitat value, while a low score refers to a structure located in relatively poor quality habitat. Similarly, a high fish-friendly score refers to a structure that is fish-friendly and has a low impact on fish habitat/fish passage, while a structure that is not fish-friendly with a relatively high level of impact on habitats/fish passage would result in a low fish-friendly score.

Habitat value criteria

There are four criteria within the habitat value category that provide an assessment of the value of the habitats surrounding the structure and these are listed in Table 1. These criteria include habitat class, presence of special fisheries feature/s, habitat condition and the structure location in relation to declared FHAs.

Table 1. Habitat value criteria and scoring system.

Habitat value		
1. Habitat class	Inshore coastal waters/tidal inlet/main stream/lowland lagoon	**10**
	Major tributary of main stream direct to sea/small lowland lagoon	**8**
	Minor tributary of main stream/large low-order tributary direct to sea	**4**
	Minor, low order tributary	**0**
2. Extra fisheries value	Known special fisheries features	**4**
	No special fisheries features known to date	**0**
3. Habitat condition	Pristine, 100% natural forest	**10**
	Low disturbance, <25% of stream degraded	**8**
	Moderate disturbance, 25-50% of stream degraded	**6**
	High disturbance, 51-75% of stream degraded	**4**
	Very high disturbance, >75% of stream degraded	**0**
4. Relation to FHA	If in declared FHA A	**10**
	If in declared FHA B	**7**
	Adjacent to or within tributary of an FHA	**4**
	None of the above	**0**

Fish-friendly criteria for non-barriers

There are two criteria in the fish-friendly category for non-barriers: structure type and disturbance area. Structures that cause relatively minimal disturbance to the existing environment are considered to be relatively fish-friendly and receive a higher score. Those structures that have a high level of impact on fish habitats receive a lower score, as their impact is considered to be relatively large. The scoring system is illustrated in Table 2.

Table 2. Fish-friendly criteria and scoring system to prioritise non-barriers.

Fish-friendly score		
1. Structure type	Moorings - environmentally friendly	**18**
	Discharge/pipe - with scour protection / drain with no scouring of substrate	**18**
	Discharge/pipe - no/inadequate scour protection / drain with some scouring/erosion	**16**
	Bridge crossing (with instream pylons)	**14**
	Pile supported - adequate light penetration	**14**
	Pile supported - inadequate light; shading; inhibiting marine plant growth	**12**
	Moorings - traditional block system	**10**
	Stabilisation structures - rubble/rock; providing some fish habitat	**8**
	Rubbish/wreckage - fish/epibiota observed/likely habitat	**6**
	Rubbish/wreckage - no fish/epibiota observed/unlikely habitat	**4**
	Stabilisation structures - vertical/concrete face; unlikely habitat	**3**
	Fill, slab - no changes to sand and wave patterns observed	**2**
	Fill, slab - clear & observable changes to wave and sand patterns	**0**
2. Disturbance area	0-10m²	**10**
	11-50m²	**8**
	50-100m²	**4**
	>100m²	**0**

Fish-friendly criteria for barriers

There are two criteria that are used to prioritise barriers: barrier type and barrier impacts. Both criteria provide an indication of the severity of a particular fish barrier in restricting fish passage.

Table 3. Fish-friendly criteria and scoring system for barriers.

Fish-friendly score		
1. Barrier type	Not a barrier (e.g. bridge spanning waterway/few pylons/access road maintains flow)	20
	Bridge that may cause a barrier (e.g. by trapping debris; excessive # pylons)	18
	Culverts >60% waterway width or causeway/ford/levee <1.5m high	10
	Culverts <60% waterway width or causeway/ford/levee 1.5m-3m high	5
	Tidal floodgate actively managed	5
	Causeway/ford/levee >3m	2
	Tidal floodgate passively managed	2
	Tidal barrage	0
2. Barrier impact (a, b, c or d)	**a. Culvert crossings (score each criterion to get total of 0-6)**	
	Culvert length <6m	2
	Culverts length >6m	0
	Individual culvert width >600mm	2
	Individual culvert width <600mm	0
	Culverts at bed level	2
	Culverts raised from bed	0
	b. Causeways/fords	
	Headloss/invert <100mm	6
	Headloss/invert >100mm	0
	c. Levee banks/bunds	
	Some tidal flow through	6
	No/minimal tidal flow through	0
	d. Floodgates	
	Leaky; some fish passage likely	6
	Not leaky; fish passage unlikely	0

Structures with a higher score are structures that are more fish-friendly with lower impacts on fish passage, while structures with a lower score are not very fish-friendly and have relatively high impacts on fish passage. These criteria and scores are shown in Table 3.

Table 4 indicates the range of habitat value and fish-friendly scores for barriers and non-barriers. Habitat value and fish-friendly scores can be combined to obtain a total score for each structure, which is useful in identifying priority structures within structure categories in the prioritisation matrix (see below).

Table 4. The range of habitat value and fish-friendly scores for non-barriers and barriers

	Non-barriers	Barriers
Habitat value score	0 - 30	0 - 30
Fish-friendly score	0 - 28	0 - 20
Total	0 – 58	0 - 50

Prioritisation matrix

Each structure was assigned a position in a prioritisation matrix based on each of the habitat value and fish-friendly scores (matrix concept presented in Figure 6). The matrix separated structures into four main quarters: less fish-friendly structures in high value habitat (quarter 1); less fish-friendly structures in low value habitat (quarter 2); more fish-friendly structures in low value habitat (quarter 3); and more fish-friendly structures in high value habitat (quarter 4).

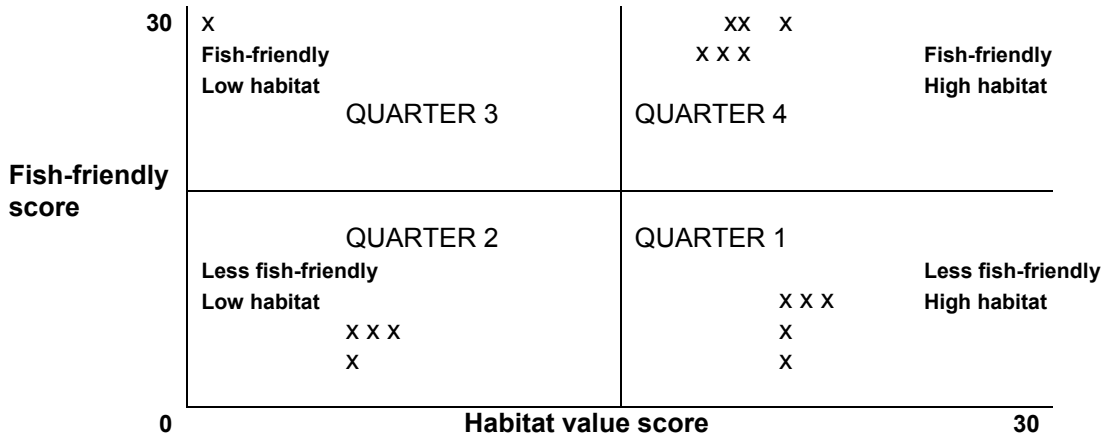

Figure 6. Prioritisation matrix concept diagram.

Identification of structures that occur within each matrix quarter allowed priorities to be developed for each project area. Structures identified in quarter 1 were considered as being of highest priority for management response; these structures had relatively high impacts on fish habitats and were located in relatively high value habitat. Fish-friendly structures in areas of high value habitat (quarter 4) were considered a low priority for management responses. Separate matrices were developed for barriers and non-barriers.

While structures in quarter 1 were identified as the highest priority for consideration of management responses to remediate problem structures, the other 3 quarters of the matrix may also be useful to various groups undertaking inventory projects with different objectives. For

example, groups that are interested in rehabilitating habitats, e.g. planting marine plants or undertaking some shoreline protection work etc., may be more interested in quarters 2 and 3 of the matrix that include structures in poorer quality habitats. Given that structures in quarter 3 are relatively fish-friendly, it would be beneficial to focus rehabilitative efforts here rather than on those habitats in quarter 2, where structures are less fish-friendly and more resources would be required to increase the value of these habitats for fish.

Following identification of priority structures, they were evaluated in terms of the impacts and related management considerations that applied within structure categories. While it is acknowledged that a range of management considerations (e.g. current/ancillary uses, presence of acid sulfate soils, availability of funding, etc.) should be applied in the assessment of individual priority structures before initiating a response, it was not within the scope of the project to investigate these. The project aimed however to provide NRM and key stakeholder groups with an overview of some of the management considerations that apply within structure categories and starting point in the decision making process to address problem structures.

Project results and discussion

While each of the Trinity Inlet and Hinchinbrook project areas included a declared Fish Habitat Area (FHA), the project areas also extended to areas outside declared FHA boundaries. Due to the different management implications that exist for structures within and outside of declared FHAs, the project results for structures under each of these circumstances are presented separately.

A summary of the number of barrier and non-barrier structures located in each of the project areas is listed in Table 5. A total of 198 instream structures, consisting of 43 fish barriers and 155 non-barriers, were assessed in the Trinity Inlet project area. Of the total 198 structures, 56 of these occurred within the Trinity Inlet declared FHA, of which 7 were barriers and 49 were non-barriers.

116 instream structures were assessed in the Hinchinbrook project area, of which 22 were barriers and 94 were non-barriers. 15 structures occurred within the Hinchinbrook declared FHA which consisted of non-barrier structures only. The relative number of structures in each of the Trinity Inlet declared FHA (56) and Hinchinbrook declared FHA (15) reflects the respective urban and rural nature of development in each region. Appendices E-H consist of maps showing the locations of structures within the Trinity Inlet and Hinchinbrook project areas and declared FHAs.

Table 5. Summary of structures in each project area.

		In project area	In FHA only
Trinity Inlet	Barriers	43	7
	Non-barriers	155	49
	Total	198	56
Hinchinbrook	Barriers	22	0
	Non-barriers	94	15
	Total	116	15

Identified structures and impacts

A list of all structures identified during inventory trials and whether they were considered as a barrier or non-barrier structure is displayed in Table 6. The name of each different structure type was abbreviated to a two-letter code, also included in Table 6.

Table 6. Structure types (and abbreviated codes) identified during inventory trials

Non-barriers	Barriers
Moorings MO Pipe and drain intakes/outlets PI Pile supported structures: • Boardwalks BW • Jetties JE • Pontoons (PX fixed; PF floating) • Walkways WW • Viewing decks VD Rubbish/wreckage: • Dumped material DM • Derelict vessels DV Stabilisation structures: • Revetments RE Fill and slab: • Boat ramps BR • Slipways SW • Wharves WH • Other non-barriers (e.g. illegal huts) ON	Stream crossings SX: • Bridges • Culverts • Causeways Floodgates FL Levee banks/bunds LB

Table 7 provides a summary of the different structure types identified in the Trinity Inlet project area and declared FHA. The largest group of structures were moorings, making up 41% of the total number of structures within FHA boundaries. Approximately 18% of structures in the FHA consisted of either dumped material or derelict vessels.

Table 7. Summary of different structure types in Trinity Inlet project area and declared FHA.

			Trinity Inlet project area	In FHA only
BARRIERS	Floodgates		12	2
	Levee banks/bunds		4	2
	Stream crossings	Bridges	12	1
		Causeways	4	1
		Culvert	9	1
	Other barriers		2	0
NON-BARRIERS	Fill, slab	Boat ramps	12	4
		Wharves	1	0
		Other non-barrier	1	1
	Stabilisation	Revetments	17	4
	Pile supported	Pontoons	3	1
		Walkways	3	1
		Jetties	3	3
		Viewing decks	2	0
		Boardwalk	1	0
	Pipe/drain outlets	Pipe outlets	23	2
		Drain outlets	7	0
	Rubbish/wreckage	Dumped material	15	3
		Derelict vessels	11	7
	Moorings		56	23
	TOTAL		198	56

The Hinchinbrook declared FHA, although nearly double the Trinity Inlet FHA in area, had relatively few instream structures. A summary of these structures and those in the Hinchinbrook project area are listed in Table 8. Similar to the Trinity Inlet project area, the largest group of structures in the Hinchinbrook project area were moorings, making up about 31% of the total number of structures. Within the Hinchinbrook FHA, pile supported structures (including pontoons, walkways and jetties) were the most common, attributing to 40% of the total number of structures.

Table 8. Summary of structure types in Hinchinbrook project area and declared FHA.

			Hinchinbrook project area	In FHA only
BARRIERS	Floodgates		8	0
	Levee banks/bunds		1	0
	Stream crossings	Bridges	10	0
		Causeways	1	0
		Culvert	2	0
NON-BARRIERS	Fill, slab	Boat ramps	12	2
		Wharves	0	0
		Other non-barrier	6	3
	Stabilisation	Revetments	6	0
	Pile supported	Pontoons	6	2
		Walkways	7	3
		Jetties	11	1
		Viewing decks	1	0
		Boardwalk	0	0
	Pipe/drain outlets	Pipes	1	0
		Drains	0	0
	Rubbish/wreckage	Dumped material	6	4
		Derelict vessels	2	0
	Moorings		36	0
	TOTAL		116	15

Prioritisation of structures and management responses

Scoring of structures against habitat value and fish-friendly criteria and application of the prioritisation matrix resulted in identification of priority structures for each project area. A number of structures were identified as having impacts on fish habitats and fish passage. Within each of the project areas, the structures in quarter 1 consisted of 6 categories in Trinity Inlet and 7 different categories in Hinchinbrook. Thirty-four structures were identified as high priority (in quarter 1) in the Trinity Inlet project area and 26 structures were identified as high priority structures in the Hinchinbrook project area. The different structure categories consisting of high priority structures in quarter 1 for each project area is displayed in Table 9.

Table 9. Number of high priority structures in each project area

	Trinity Inlet	Hinchinbrook
Floodgates	1	2
Stream crossings	1	1
Fill, slab	10	11
Pile supported	1	2
Stabilisation	1	4
Rubbish, wreckage	20	5
Moorings	0	1
TOTAL	34	26

The category with the largest number of high priority structures in Trinity Inlet is the rubbish and wreckage category. Including dumped material or rubbish and abandoned derelict vessels, the rubbish/wreckage category consists of unauthorised structures that conflict with declared FHA management and are of large concern.

In Hinchinbrook, the fill and slab structure category contains the highest number of high priority structures. The fill/slab structure category included boat ramps, slipways, wharves, housing/huts and other structures that are directly installed on the substrate. In having typically large footprints and causing permanent loss of fish habitats these structures are generally considered as high impact. Incorrect placement of boat ramps on erosive river bends can also lead to bank erosion upstream or downstream of the structure.

The occurrence of a higher number of structures from these two relatively high impact categories in quarter 1 of the matrix demonstrates the value of the prioritisation matrix as an effective tool in identifying high impact / problem structures in FHAs.

Full listings of structures within each quarter of the prioritisation matrix are presented for each project area in Tables 10-17. Within each structure grouping structures are listed in order of their total score for the habitat value and fish-friendly criteria, with low scoring structures at the top of the list being higher priorities than those structures with high scores. Structures that occur within declared FHA boundaries are highlighted, with light brown highlight referring to structures in management level A areas and blue highlight referring to those structures in FHA management level B areas. All evaluations of structures in terms of impacts and related management considerations are presented in Table 18.

Priority listing of structures in Trinity Inlet

Table 10. Quarter 1 of the Trinity Inlet matrix: less fish-friendly structures in higher value habitat. For management responses see Table 18.

Structure grouping	Structure ID	Habitat value score	Fish-friendly score	Total score
Floodgates	MULG058FL	22	8	30
Stream crossings	MULG090SX	16	5	21
	MULG091BR	17	0	17
	MULG164BR	22	2	24
	MULG165BR	22	2	24
	MULG163WH	22	2	24
Fill, slab	MULG136BR	19	6	25
	MULG076BR	25	2	27
	MULG184BR	20	8	28
	MULG061BR	19	10	29
	MULG100BR	20	10	30
	MULG101BR	20	10	30
Pile supported	MULG153BW	18	12	30
	MULG192RE	16	8	24
	MULG044RE	17	11	28
Stabilisation	MULG190RE	17	11	28
	MULG188RE	22	8	30
	MULG186RE	20	11	31
	MULG124RE	26	8	34
	MULG138DM	16	8	24
	MULG139DM	16	8	24
	MULG047DV	20	6	26
	MULG071DV	20	6	26
	MULG111DM	16	12	28
	MULG073DV	20	8	28
	MULG108DM	16	14	30
	MULG007DM	16	14	30
Rubbish, wreckage	MULG010DM	16	14	30
	MULG011DM	16	14	30
	MULG012DV	24	6	30
	MULG072DV	20	10	30
	MULG064DM	19	12	31
	MULG049DV	26	6	32
	MULG057DV	26	6	32
	MULG095DV	26	6	32
	MULG135DM	19	14	33
	MULG001DV	25	10	35
	MULG002DV	25	10	35
	MULG096DV	26	10	36

Table 11. Quarter 2 of the Trinity Inlet matrix: more fish-friendly structures in lower value habitat. For management responses see Table 18.

Structure grouping	Structure ID	Habitat value score	Fish-friendly score	Total score
Floodgates	MULG142FL	4	2	6
	MULG143FL	4	2	6
	MULG144FL	4	2	6
	MULG149FL	4	2	6
	MULG151FL	4	2	6
	MULG150FL	7	2	9
	MULG146FL	8	2	10
Stream crossings	MULG114SX	4	9	13
	MULG123SX	8	7	15
	MULG148SX	4	14	18
	MULG079SX	11	10	21
	MULG127SX	12	9	21
	MULG122SX	12	10	22
Fill, slab	MULG080BR	8	0	8
	MULG081BR	8	6	14
	MULG183ON	15	2	17
	MULG089BR	8	12	20
Stabilisation	MULG199RE	0	8	8
	MULG195RE	8	12	20
	MULG178RE	15	12	27
Rubbish, wreckage	MULG116DM	0	14	14
	MULG132DM	12	10	22
	MULG131DM	12	14	26

Table 12. Quarter 3 of the Trinity Inlet matrix: more fish-friendly structures in lower value habitat. For management responses see Table 18.

Structure grouping	Structure ID	Habitat value score	Fish-friendly score	Total score
Floodgates	MULG084FL	8	11	19
	MULG085FL	8	11	19
	MULG086FL	8	11	19
	MULG087FL	8	11	19
Levee banks/bunds	MULG145LB	8	11	19
	MULG121LB	4	16	20
Stream crossings	MULG125SX	0	18	18
	MULG120SX	4	16	20
	MULG126SX	12	14	26
	MULG082SX	8	20	28
	MULG128SX	12	20	32
	MULG130SX	12	20	32
	MULG133SX	14	20	34
	MULG129SX	15	20	35
Pile supported	MULG179WW	15	20	35
Stabilisation	MULG198RE	4	16	20
	MULG189RE	8	16	24
	MULG193RE	8	16	24
	MULG194RE	8	16	24
	MULG196RE	8	16	24
	MULG197RE	8	16	24
Pipe outlets, drains	MULG118DR	0	24	24
	MULG115DR	0	26	26
	MULG117DR	0	26	26

Table 13. Quarter 4 of the Trinity Inlet matrix: more fish-friendly structures in higher value habitat. For management responses see Table 18.

Structure grouping	Structure ID	Habitat value score	Fish-friendly score	Total score
Levee banks/bunds	MULG083LB	24	11	35
	MULG187LB	19	16	35
Stream crossings	MULG152SX	16	11	27
	MULG137SX	18	16	34
	MULG004SX	16	20	36
	MULG005SX	16	20	36
	MULG006SX	16	20	36
	MULG008SX	16	20	36
	MULG107SX	18	20	38
	MULG109SX	18	20	38
	MULG110SX	18	20	38
	MULG078SX	25	20	45
Pile supported	MULG171VD	18	16	34
	MULG174VD	18	16	34
	MULG043PF	17	20	37
	MULG059JE	19	20	39
	MULG181JE	19	20	39
	MULG048PF	20	20	40
	MULG099PX	20	20	40
	MULG185WW	20	20	40
	MULG191WW	20	20	40
	MULG062JE	19	22	41
Stabilisation	MULG200RE	18	16	34
	MULG180RE	20	16	36
Pipe outlets, drains	MULG168PI	18	16	34
	MULG177PI	18	16	34
	MULG134DR	16	22	38
	MULG154PI	18	20	38
	MULG155PI	18	20	38
	MULG156PI	18	20	38
	MULG157PI	18	20	38
	MULG158PI	18	20	38
	MULG159PI	18	20	38
	MULG160PI	18	20	38
	MULG162PI	18	20	38
	MULG172PI	18	20	38
	MULG173PI	18	20	38
	MULG140DR	16	24	40
	MULG141DR	16	24	40
	MULG009PI	16	24	40
	MULG161PI	18	24	42
	MULG170PI	18	24	42
	MULG167PI	18	26	44
	MULG169PI	18	26	44
	MULG175PI	18	26	44
	MULG176PI	18	26	44
	MULG166PI	22	24	46
	MULG060PI	19	28	47
	MULG074PI	22	26	48
	MULG075PI	25	26	51
Rubbish, wreckage	MULG063DM	19	16	35
	MULG045MO	17	18	35

Structure grouping	Structure ID	Habitat value score	Fish-friendly score	Total score
	MULG046MO	17	18	35
	MULG003MO	19	18	37
	MULG050MO	20	18	38
	MULG051MO	20	18	38
	MULG052MO	20	18	38
	MULG053MO	20	18	38
	MULG054MO	20	18	38
	MULG097MO	20	18	38
	MULG098MO	20	18	38
	MULG102MO	20	18	38
	MULG103MO	20	18	38
	MULG104MO	20	18	38
	MULG105MO	20	18	38
	MULG021MO	22	18	40
	MULG022MO	22	18	40
	MULG023MO	22	18	40
	MULG024MO	22	18	40
	MULG025MO	22	18	40
	MULG027MO	22	18	40
	MULG028MO	22	18	40
	MULG029MO	22	18	40
	MULG030MO	22	18	40
	MULG031MO	22	18	40
Moorings	MULG032MO	22	18	40
	MULG033MO	22	18	40
	MULG034MO	22	18	40
	MULG035MO	22	18	40
	MULG036MO	22	18	40
	MULG037MO	22	18	40
	MULG038MO	22	18	40
	MULG039MO	22	18	40
	MULG040MO	22	18	40
	MULG041MO	22	18	40
	MULG042MO	22	18	40
	MULG106MO	22	18	40
	MULG026MO	24	18	42
	MULG013MO	25	18	43
	MULG014MO	25	18	43
	MULG015MO	25	18	43
	MULG016MO	25	18	43
	MULG017MO	25	18	43
	MULG018MO	25	18	43
	MULG019MO	25	18	43
	MULG020MO	25	18	43
	MULG055MO	26	18	44
	MULG056MO	26	18	44
	MULG065MO	26	18	44
	MULG066MO	26	18	44
	MULG067MO	26	18	44
	MULG068MO	26	18	44
	MULG069MO	26	18	44
	MULG070MO	26	18	44
	MULG092MO	26	18	44
	MULG093MO	26	18	44
	MULG094MO	26	18	44

Priority listing of structures in Hinchinbrook

Table 14. Quarter 1 of the Hinchinbrook matrix: less fish-friendly structures in higher value habitat. For management responses see Table 18.

Structure grouping	Structure ID	Habitat value score	Fish-friendly score	Total score
Floodgates	HERB122FL	16	8	24
	HERB106FL	16	8	24
Stream crossings	HERB107SX	16	5	21
Fill, slab	HERB036BR	16	4	20
	HERB024BR	20	2	22
	HERB029BR	20	2	22
	HERB002ON	22	2	24
	HERB005ON	22	2	24
	HERB020BR	18	6	24
	HERB014ON	16	10	26
	HERB030BR	18	10	28
	HERB035BR	18	10	28
	HERB120ON	28	2	30
	HERB013BR	22	10	32
Pile supported	HERB065WW	18	6	24
	HERB067WW	22	8	30
Stabilisation	HERB118RE	18	3	21
	HERB015RE	16	8	24
	HERB114RE	20	8	28
	HERB023RE	20	10	30
Rubbish, wreckage	HERB003DM	22	4	26
	HERB071DM	22	8	30
	HERB001DM	22	12	34
	HERB004DM	22	12	34
	HERB012DM	22	14	36
Moorings	HERB072MO	22	14	36

Table 15. Quarter 2 of the Hinchinbrook matrix: less fish-friendly structures in lower value habitat. For management responses see Table 18.

Structure grouping	Structure ID	Habitat value score	Fish-friendly score	Total score
Floodgates	HERB111FL	0	2	2
	HERB042FL	4	2	6
	HERB112FL	4	8	12
Levee banks/bunds	HERB058LB	14	5	19
Fill, slab	HERB053BR	14	2	16
	HERB051BR	14	10	24
	HERB054BR	14	10	24
Pile supported	HERB066PF	14	2	16
Stabilisation	HERB064RE	14	2	16
Rubbish, wreckage	HERB049DV	14	8	22
	HERB050DM	14	14	28
	HERB086DV	14	14	28
Moorings	HERB074MO	8	2	10
	HERB075MO	8	14	22

Table 16. Quarter 3 of the Hinchinbrook matrix: more fish-friendly structures in lower value habitat. For management responses see Table 18.

Structure grouping	Structure ID	Habitat value score	Fish-friendly score	Total score
Floodgates	HERB115FL	0	11	11
	HERB043FL	4	11	15
	HERB116FL	12	11	23
Stream crossings	HERB113SX	4	11	15
Stream crossings	HERB041SX	4	20	24
	HERB060SX	14	18	32
	HERB062SX	12	20	32
	HERB059SX	14	20	34
	HERB061SX	14	20	34
	HERB117SX	14	20	34
Fill, slab	HERB057BR	14	24	38
Pile supported	HERB046JE	14	20	34
	HERB044JE	14	22	36
	HERB048JE	14	22	36
	HERB045JE	14	22	36
	HERB047JE	14	22	36
	HERB052JE	14	24	38
Moorings	HERB090MO	14	18	32
	HERB092MO	14	18	32
	HERB097MO	14	18	32
	HERB098MO	14	18	32
	HERB077MO	14	18	32
	HERB078MO	14	18	32
	HERB082MO	14	18	32
	HERB089MO	14	18	32
	HERB091MO	14	18	32
	HERB099MO	14	18	32
	HERB100MO	14	18	32
	HERB076MO	14	18	32
	HERB081MO	14	18	32
	HERB083MO	14	18	32
	HERB084MO	14	18	32
	HERB085MO	14	18	32
	HERB087MO	14	18	32
	HERB101MO	14	18	32
	HERB102MO	14	18	32
	HERB103MO	14	18	32
	HERB104MO	14	18	32
	HERB125MO	14	18	32
	HERB079MO	14	18	32
	HERB080MO	14	18	32
	HERB088MO	14	18	32
	HERB094MO	14	18	32
	HERB095MO	14	18	32
	HERB096MO	14	18	32

Table 17. Quarter 4 of the Hinchinbrook matrix: more fish-friendly structures in higher value habitat. For management responses see Table 18.

Structure grouping	Structure ID	Habitat value score	Fish-friendly score	Total score
Stream crossings	HERB121SX	18	20	38
	HERB055SX	18	20	38
	HERB056SX	18	20	38
	HERB063SX	20	20	40
	HERB022SX	20	20	40
Fill, slab	HERB119ON	18	18	36
	HERB070BR	22	22	44
Pile supported	HERB019JE	16	20	36
	HERB018JE	16	20	36
	HERB037PI	16	22	38
	HERB026VD	20	18	38
	HERB017JE	16	22	38
	HERB069PF	22	18	40
	HERB124WW	20	20	40
	HERB016JE	16	24	40
	HERB028WW	20	20	40
	HERB027PF	20	22	42
	HERB038PX	20	22	42
	HERB007WW	22	22	44
	HERB025WW	22	22	44
	HERB006PF	22	24	46
	HERB009PF	22	24	46
	HERB011JE	22	24	46
	HERB008WW	22	24	46
Stabilisation	HERB068RE	22	22	44
Moorings	HERB031MO	20	18	38
	HERB032MO	20	18	38
	HERB033MO	20	18	38
	HERB034MO	20	18	38
	HERB040MO	20	18	38

Management considerations for priority structures

Evaluations of structures in terms of the impacts and related management considerations that applied within structure categories are presented in Table 18. These evaluations are to provide NRM and key stakeholder groups with an overview of some of the considerations that apply within structure groupings and starting point in the decision making process to address problem structures. Considering these evaluations in conjunction with the prioritisation matrix and priority listing of structures for the project area, will assist in making decisions to achieve the best outcome for fish habitats.

Before responding to individual structures, it will be necessary to undertake further assessment of priority structures, considering for example the legality of the structure, ownership, logistics of undertaking action, availability of funding, and other management considerations. However it was beyond the scope of the project to explore these additional considerations in detail.

Note that the recommendations for management responses presented below relate to structure categories identified in the Trinity Inlet and Hinchinbrook project areas.

Table 18. Management responses that should be applied to structure groupings.

Structure grouping	Management response
Floodgates	Floodgates cause problems for fish if only passively managed or poorly maintained, as these remain closed for extended periods of time and limit tidal flushing and fish passage upstream and onto floodplain areas. This can also lead to poor water quality being trapped above the floodgate, reducing or eliminating the habitats available to fish. Acid sulfate soils (ASS) can become an issue if tidal flushing is restricted and soils have the opportunity to dry out and create acidic conditions. In flood events or on the occasion when the tide is able to inundate the area, acid sulfate runoff can create harmful conditions for fish and may result in fish kills. Floodgates are recognised as infrastructure for agricultural activities to protect farming lands and/or developments from flood and saltwater intrusion. While it is unlikely that floodgates will be able to be removed completely, they should be actively and properly managed. If obsolete they may be removed and area rehabilitated.
Levee banks/bunds	By obstructing tidal flows, levee banks/bunds can degrade the health of wetland fish habitats and prevent fish from accessing floodplain and upstream habitats. These structures are recognised as necessary to protect adjacent land and developments from saltwater intrusion. Any obsolete structures should be removed and the affected areas rehabilitated. If structures are still in use and are identified as a problem for fish movement the structural design features of the levee/bank should be modified or upgraded to provide for fish passage, e.g. incorporation of floodgates. Management of levee banks should ensure that fish are not trapped upstream. In the case where the trapping of fish may occur, a contingency plan should be developed for relocation of fish. One management issue that applies across structure categories and is an important consideration before responding to structures is the presence of potential acid sulfate soils (ASS) in the area.
Stream crossings	Bridges and culverts can be commissioned by government departments (e.g. Main Roads, Queensland Rail), local governments, statutory authorities (e.g. Port Authority) and property owners (farmers, developers). Causeways tend to be used on private roads or infrequently used public roads. Stream crossings are recognised as crossings for public and private use. If crossing structures are identified as a problem for fish movement the structural design features of the crossing (e.g. culvert design, structure slops, number of pipes, etc.) should be modified or upgraded to incorporate fish-friendly design principles. DPI&F's stream crossing guidelines should be consulted for further information on fish-friendly design of stream crossings. It may be feasible to install a fishway at the crossing site. Any obsolete crossing structures should be removed.
Fill, slab	This category includes structures that satisfy a basic requirement of launching and retrieving vessels and servicing and loading vessels. Many are public structures while others are operated privately. Illegal

Structure grouping	Management response
	housing is included in this category and (or permanent 'squatting') is an activity that isolates fish habitats and prevents public access to and through tidal waters. The main impacts are from permanent loss of fish habitats, e.g. with boat ramps, slipways, and shading and erosion from wharves. Management of these structures relates to regulating launching/retrieving to designated areas, provision of ancillary facilities for parking (vehicles/trailers) on non-tidal lands, maintenance of boat ramps and slipways, and using appropriate materials/preservatives used for decking on wharves. Within declared FHAs, subject to the management level, public structures can be approved and private structures may be approved. Potential management actions include determining the legality of the existing structures and their fate, ensuring public access is regulated, employing fish-friendly design and construction, and best management practices are used on wharf maintenance. Where removal of structures occurs, rehabilitation may be appropriate for impacted areas.
Pile supported structures	These structures provide access to vessels and fishing platforms or to enable the general public to view key fish habitats up close as part of gaining an awareness of the benefits of such habitats. The main impacts are those of location relative to intertidal marine plant communities, shading of the substrate and loss of the fauna and flora communities, physical disturbance of habitat through anchoring with chains/wires, and localised scouring/erosion. The management of these structures relates to the decking that promotes light penetration (40% minimum) to the substrate to ensure communities are maintained and passage is not disrupted; use of materials (e.g. timber with preservatives or metals) that do not leach and pollute the waterways, materials that promote epibiotic growth, treatment of runoff water prior to discharge to ensure higher downstream water quality, and appropriate siting. Within declared FHAs, subject to the management level, these structures are encouraged and supported for public purposes but constraints apply to private structures. Potential management actions include determining the legality of the existing structures and their fate, a maintenance program to upgrade decking to meet light penetration targets, raising the height of the structure, and minimisation of scouring/erosion, especially at lower tide levels.
Stabilisation structures	This category includes structures that armour foreshore against erosion. Many are public structures while others are operated privately. The main impacts are from permanent loss of fish habitats, alteration of the extent of tidal inundation and changing tidal regimes. Management of these structures relates to maintenance. Within declared FHAs, subject to the management level, public structures can be approved and private structures may be approved.

Structure grouping	Management response
	Potential management actions include determining the legality of the existing structures and their fate, employing fish-friendly design and construction, and ensuring best management practices are used on revetment maintenance. Where removal of structures occurs, rehabilitation may be appropriate for impacted areas.
Pipe/drain intakes/outlets	The main impacts are those of inappropriate location of pipe or drain outlet relative to substrate and river bends, and subsequent scouring and erosion, particularly during flood events and from inadequate armouring around the outlets. Deep, narrow drains also impact with higher runoff velocities and often convey acid runoff. It is acknowledged that these structures are fundamental to maintaining runoff from residential, industrial or agricultural lands. Management of these structures relates to the treatment of runoff water prior to discharge to ensure higher downstream water quality, appropriate siting and armouring, and replacement of deep drains with shallower wider drains. Within declared FHAs, subject to the management level, pipes and drains may be approved. Potential management actions include determining the legality of the structures and their fate, a replacement program to upgrade substandard pipes and drains, and armouring appropriate for all outlets.
Rubbish/wreckage	The materials and structures in this category are of concern as their presence is usually the result of unauthorised activities. The main impacts are those of materials covering and smothering intertidal habitats and communities and derelict vessels not having been properly decommissioned (e.g. hydrocarbons drained off, batteries removed, etc) or scuttled in approved sites. The management of these materials and structures relates to the physical removal of these materials from fish habitats and restoration of the impacted sites. Within declared FHAs, no approval can be supported for the dumping of materials or the deployment of derelict vessels. Potential management actions include determining the persons responsible for the dumping of the materials and the derelict vessels, a coordinated program to remove the materials and vessels from within the boundaries of the declared FHAs, and restoration of impacted sites.
Moorings	These structures are integral to the safe storage of vessels and may be for private or public purposes. While the mooring block may have relatively minor direct impacts on the substrate and its fish habitat values in terms of the area occupied generally being less than $1m^2$, impacts do occur from the chain or rope attaching the mooring block to the float and the vessel, particularly where the mooring blocks are located on seagrass habitats. Permanent losses of these habitats result from scouring by the attachment line and the vessel. Environmentally-friendly moorings are designed to avoid these impacts.

Structure grouping	Management response
	Management of these structures relates to ensuring that moorings are located away from key fish habitats such as seagrass, only environmentally-friendly moorings are deployed, designated mooring areas are provided and a program for replacing traditional moorings is implemented. Within declared FHAs, subject to the management level, moorings may be approved. Potential management actions include determining the legality of the existing structures and their fate, a replacement program to deploy environmentally-friendly moorings, and designation of specific mooring areas.
Fish-friendly stream crossings	Structures that span waterways have relatively minor direct impacts on instream fish habitat values, other than from the impacts of pylons or other footings and bank armouring and from shading of a section of the waterway. Within declared FHAs these public structures may be approved to ensure safe crossing of the waterways. Impacts for fish passage are minor although there are often localised increases in current velocities around the pylons/footings. If velocities are considered to be having a significant negative impact on fish passage, these structures may be considered as a fish barrier. Recognised as crossings for public use, the management of these structures relates to access to allow maintenance; maintenance to ensure the integrity of pylons/footings/armouring and of decking/surface; use of materials (e.g. timber with preservatives) that do not leach and pollute the waterways; and erosion and scouring at pylons/footings and armouring locations. Other than best management practices during maintenance no further management action is proposed. Where crossings are for private use, determination of legality and assessment of impacts are warranted.

Conclusions and future inventory directions

From the project we developed a framework for the identification and prioritisation of instream structures within declared FHAs for management responses and established a systematic and integrated approach to addressing the impacts of instream structures on wetland fish habitats in coastal areas.

The framework has been encapsulated in FHG 007 *Fisheries guidelines for conducting an inventory of instream structures in coastal Queensland*, a key project outcome. The purpose of the guidelines is to provide both government (e.g. State agencies, Councils) and non-government (e.g. Natural Resource Management bodies) organisations with the capacity to undertake further inventory projects throughout Queensland. The guidelines consist of two user-friendly parts: an inventory protocol that describes the inventory process, including the identification of structures and their location and assessment of structure impacts; and a response protocol, including the Decision Support System, to facilitate prioritisation of problem structures for delivery of enhanced management responses.

Conducting further inventory work would include refinement of the fish barrier menu system and data attributes and development of a Statewide database of instream structures. Enhancement of the guidelines and DSS protocol to include additional attributes identified by stakeholders, during the current project and from future training workshops, including enhanced links to AquaBAMM and to the IDAS/IPA process would add to the value of the protocol and assist in achieving objectives. Training workshops, including on-ground demonstration and application of the protocol and associated software would address the transfer of knowledge and skills to NRM, local government and key stakeholder groups, and facilitate the implementation of inventory projects Statewide.

In addition to the implementation of additional structure inventory projects within other declared FHAs, future inventory directions would involve carrying out remedial actions on priority problem structures identified by projects. This would include addressing the impacts of priority structures identified in the recently inventoried Trinity Inlet and Hinchinbrook project areas. Trials in these Areas yielded specific inventories for structures and identified a number of priority structures that are currently impacting on wetland condition. This information will contribute to the existing wetlands mapping and inventory projects of the Queensland Wetlands Programme (QWP). Establishing a framework for data transfer to the QWP as part of this project has formed the basis for future linkages between a DPI&F Statewide instream structure database and the QWP.

In terms of FHA management, establishing a Statewide database of structures has a number of implications for declared FHA management and would assist DPI&F and other agencies in future decisions relating to planning and assessment in coastal areas. Documentation of the number and location of existing instream structures in a declared FHA provides a measure of current development pressures in the Area and temporal changes in these pressures since FHA declaration. This information can be used to assess the effectiveness of current FHA management arrangements and identify issues relating to the future declaration and management of FHAs, with a view to maintaining and enhancing the habitat values currently protected by the declared FHA network in supporting and sustaining Queensland's fisheries.

Acknowledgements

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Many thanks go to Shareen Wall (DEWHA) for her assistance with project administration.

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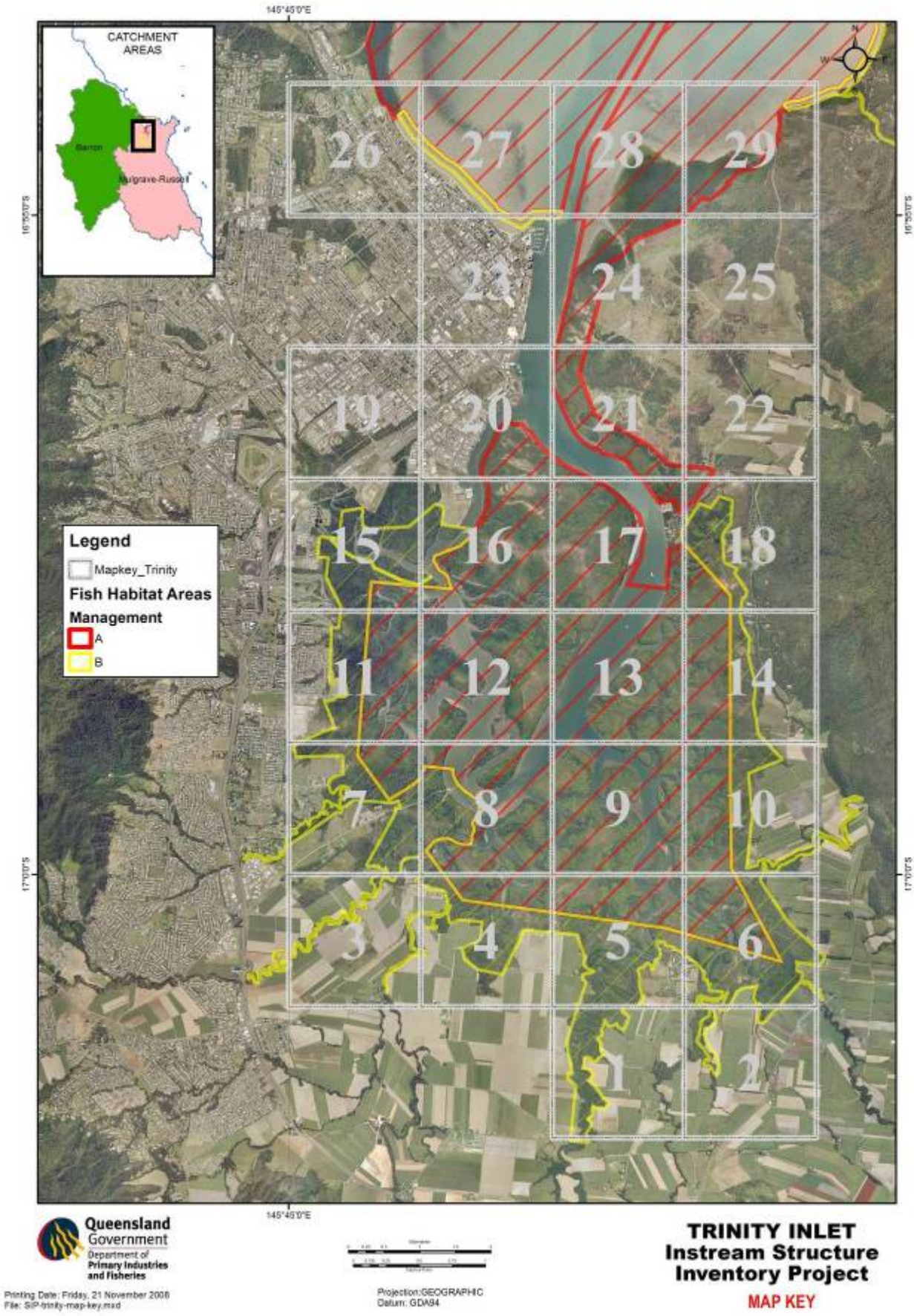
Appendices

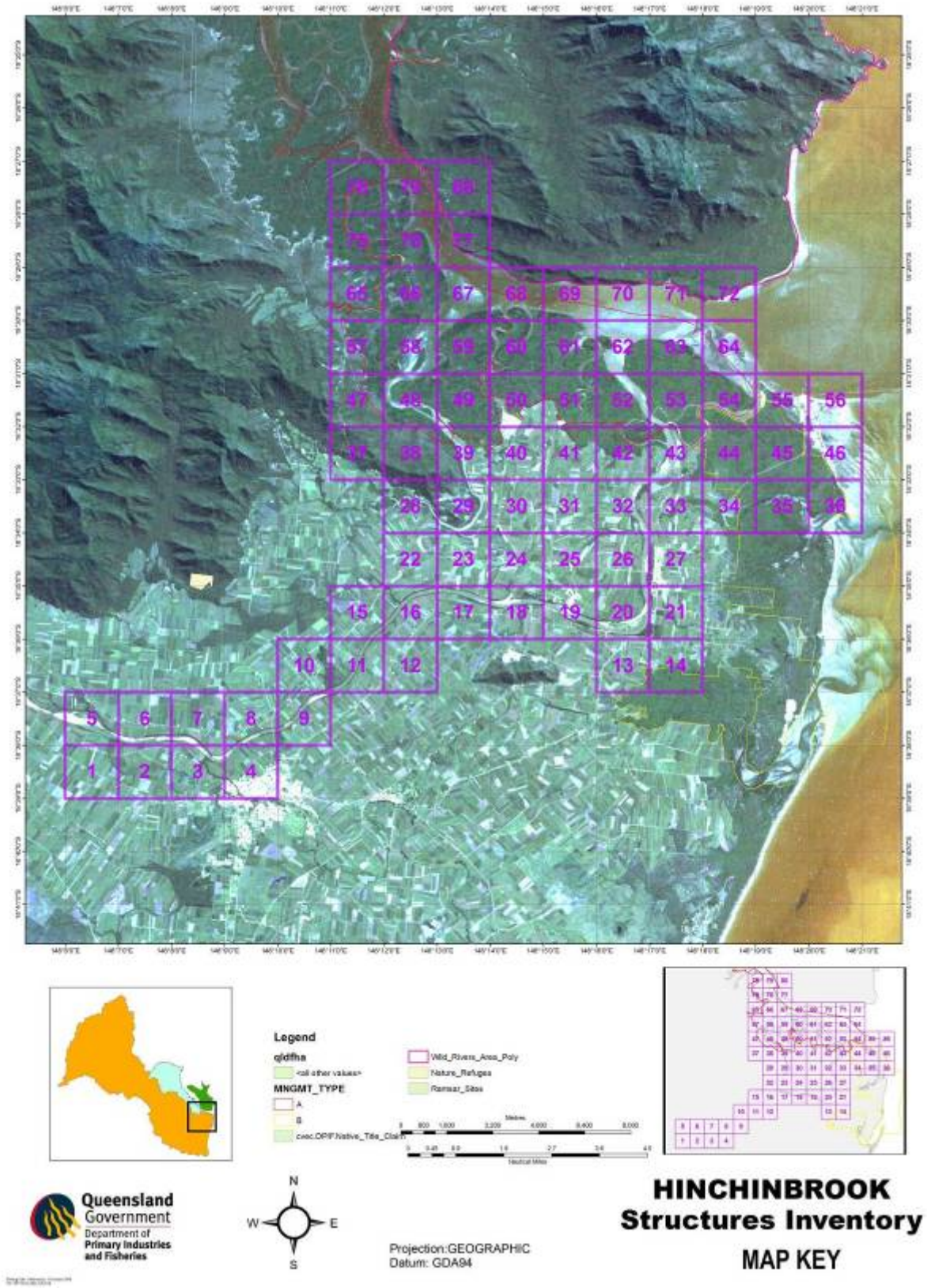
APPENDIX A: List of Steering Committee members

Name	Organisation
Fiona Barron	Catchment Planner – Cairns Urban Landscape - Terrain
Steve McDermott	Coastal Landscapes Programme Planner - Terrain
Dale Mundraby	Mandingalbay Yidinji Corporation (at North Qld Land Council)
Vince Vitale	Chairperson – Lower Herbert Catchment Group
Donna-marie Audas	Project Manager GBR Wetlands & Northern Liaison Water Quality & Coastal Development Great Barrier Reef Marine Park Authority
Gayle Partridge	Queensland Wetlands Programme Department of the Environment Water Heritage and the Arts
Shareen Wall	Wetlands Section Department of the Environment, Water, Heritage and the Arts
Gayle Stewart	Wetlands Section Department of the Environment, Water, Heritage and the Arts
Dr Jonathan Marshall	Principal Scientist Aquatic Ecosystems Unit Dept. Natural Resources & Water
Michael Ronan	Project Manager Resource Assessment Unit Environmental Protection Agency
Dr John Robertson	Project Director & General Manager Fisheries & Aquaculture Industry Development, DPI&F
Dr John Beumer	Project Manager & Principal Scientist, Marine Fish Habitat, DPI&F
Dawn Couchman	Project Mentor & Senior Fisheries Scientist, Marine Fish Habitat, DPI&F
Mary Lawrence	Project Leader and Fisheries Scientist, Marine Fish Habitat, DPI&F

APPENDIX B: Map key for Trinity Inlet project area



APPENDIX C: Map key for Hinchinbrook project area



APPENDIX D: Data attributes included in the fish barrier menu system

GENERAL PAGE

Assessor given name/surname: the given name and surname of the person recording data in the field.

Start time: The start time of data collection at a site; this should be set to automatically record when a GPS point is recorded.

Date: date of data collection; this should be set to automatically record when a GPS point is recorded.

Organisation: This is the ordinary name of the organisation with which contact should be made to obtain more detailed information about the project. If a private individual collects data they should enter their organisation as "individual".

Present weather: Indicate the current weather conditions, particularly in relation to precipitation. Select from:
1) Dry, 2) Smog/smoke, 3) Fog/mist, 4) Frost, 5) Intermittent rain/drizzle, 6) Intermittent hail, 7) Intermittent snow, 8) Continuous rain/drizzle, 9) Continuous hail, 10) Continuous snow, 11) Thunderstorm.

Flow/tide stage: A broad categorisation of hydrology at the site. For sites in tidally influenced wetlands (potentially all wetland types), this describes the current state of the tide. For sites in non-tidally influences wetlands (potentially all wetland types other than estuarine and marine) this describes the degree of flow. Select from 1) Dry, 2) Non-tidal: standing water, 3) Non-tidal: slow flow, 4) Non-tidal: rapid flow, 5) Tidal: incoming/between tide, 6) Tidal: within 1 hour of high tide, 7) Tidal: outgoing/between tide, 8) Tidal: within 1 hour of low tide.

Non-barrier type: select appropriate non-barrier type from scroll down menu: BR Boat Ramp, BW Boardwalk, CA Canal, DM Dumped Material, DR Drain intake/outlet, DV Derelict vessel, GR Groyne, JE Jetty, MO Mooring, ON Other Non-barrier, PI Pipe Intake/Outlet, PF Pontoon floating, PX Pontoon fixed, RE Revetment, SW Slipway, VD Viewing Deck, WH Wharf, WW Walkway.

Barrier type: select appropriate non-barrier type from the scroll down menu: BC Bed Control, FL Floodgate, GS Gauging Station, LB Levee bank/bund, NA Natural, OB Other Barrier, RX Road Crossing, WD Weir/Dam.

Structure ID: this is a unique identification number assigned to each individual structure, e.g. PIN001RX (Pine River catchment - PIN; structure number that increases incrementally - 001; structure type – RX).

Project ID: The ordinary name of the project in full, e.g. Targeted Collection of Inventory data for wetlands fish barriers in the Great Barrier Reef catchment. A maximum of 200 characters is allowed.

Image file numbers: Photos should be taken of the following, **using the digital camera**: 1. structure front-on (either from river or land); 2. upstream habitat; 3. downstream habitat. At least one photo should be taken of the structure **using the PDA**, so that the structure can be linked to its corresponding GPS location.

SPATIAL LOCATION PAGE

Location ID: identification code based on the GPS coordinates of the structure. Attempt should be made to record the location ID at the mid-point of the structure.

Location derived: Select from AGPS, DGPS, EST, MAP.

Datum: The datum (or geographic referencing system) in which the original data was recorded. GDA94 is the preferred datum for project data and all efforts should be made to convert to GDA. In the case where this is not possible, other datum may be used. Select from: 1) (AGD66) Australian Geodetic Datum 1996; 2) (AGD84) Australian Geodetic Datum 1984; 3) (GDA94) Geocentric Datum of Australia 1994; or 4) (WGS84) World Geodetic System 1984 (used in GoogleEarth™).

Location precision (m): The precision of location coordinates in metres.

If position is incorrect: This attribute refers to the accuracy of the GPS position that has been recorded for a structure. Should a recorded position be found to be incorrect, the GPS point can be edited to reflect the accurate position of the structure.

Feature moved: This refers to whether the GPS location has been edited in order to reflect a more accurate position.

Date position edited: this is the date on which the GPS point was edited.

SITE DETAILS PAGE

Wetlands ID: (refer to wetlands layer)

Structure name: Enter the common name(s) for the structure if known, e.g. College's Crossing.

Waterway name: Enter the name of the waterway if known.

Road name: Enter the name of the road that crosses the watercourse, or the road that is closest in proximity to the structure being assessed. Consult nearby street signs, QLD State topographic maps, the ArcPad road layer, local/state street directories, Council asset registries, or the web. Please note though that the name of the road on site may vary from the name appearing on topographic maps or within the Roads layer on ArcPad. If the road is an unnamed private driveway, enter "Private Road", else if no name or ownership (private vs public) can be discerned, enter "Unnamed Road".

Road type: sealed or unsealed.

System type:
Estuarine – wetlands with oceanic water sometimes diluted with freshwater runoff from the land.
Lacustrine – large, open, water-dominated systems (for example, lakes) larger than 8 hectares. This definition also applies to modified systems (for example, dams), which possess characteristics similar to lacustrine systems (for example, deep, standing or slow-moving waters).
Marine – the area of ocean from the coastline or estuary, extending to the jurisdictional limits of Queensland waters (3 nautical mile limit).
Palustrine – primarily vegetated non-channel environments of less than 8 hectares. They include billabongs, swamps, bogs, springs, soaks, etc, and have more than 30% emergent vegetation;
Riverine – All wetlands and deepwater habitats within a channel. The channels are naturally or artificially created; they periodically or continuously contain moving water, or form a connecting link between two bodies of standing water.

The Wetland Mapping and Classification Methodology of the Queensland Wetlands Programme definition of wetlands: *Wetlands are areas of permanent or periodic/intermittent inundation, with water that is static or flowing fresh, brackish or salt, including areas of marine water, the depth of which at low tide does not exceed 6 metres. To be classified as a wetland, the area must have one or more of the following attributes:*

i. *at least periodically, the land supports plants or animals that are adapted to and dependent on living in wet conditions for at least part of their life cycle, or*
ii. *the substratum is predominantly undrained soils that are saturated, flooded or ponded long enough to develop anaerobic conditions in the upper layers, or*
iii. *the substratum is not soil and is saturated with water, or covered by water at some time.*

(Environmental Protection Agency, 2005)

This definition differs from the definition of Ramsar wetlands, as the Ramsar definition includes waters greater than 6 metres below the lowest astronomical tide.

Catchment section:
Tidal: refers to sites in the inshore coastal zone and in the estuarine zone where at its seaward margin water is measurably diluted by freshwater from land drainage and at its landward margin water levels are measurably altered by tides (Adams, 2002)
Lower: refers to sites low in the catchment generally associated with waterways with a high stream order
Middle: pertains to sites on mainstream rivers, major tributaries, and lower sections of minor tributaries
Upper: refers to sites high in the catchment generally associated with waterways with a relatively low stream order.

Habitat class:
1) Inshore coastal waters or tidal inlet or main stream or river or large lowland lagoon
2) Major tributary of main stream or river or major creek direct to sea or small lowland lagoon
3) Minor tributary of main stream or river, or large lower-order tributary or minor creek direct to sea
4) Minor, low-order tributary.

NON-BARRIER PAGE

Non-barrier type: select appropriate non-barrier type from scroll down menu: BR Boat Ramp, BW Boardwalk, CA Canal, DM Dumped Material, DR Drain intake/outlet, DV Derelict vessel, GR Groyne, JE Jetty, MO Mooring, ON Other Non-barrier, PI Pipe Intake/Outlet, PF Pontoon floating, PX Pontoon fixed, RE Revetment, SW Slipway, VD Viewing Deck, WH Wharf, WW Walkway.

Construction material: concrete, cemented rock, debris (man-made), debris (natural), gravel, log, metal/steel, other, polystyrene, rock, rubble, timber.

Obsolete structure: Record if the structure no longer appears to serve a current purpose (e.g. a causeway superseded by a bridge). A structure may not be obsolete just because it does not appear to be in use. Consultation with the structural owner and adjacent landholders is required to ascertain the use of the structure.

Structure condition:
Good – structure functioning in good working order; no apparent maintenance required
Fair – structure function may be restored through remediation measures
Poor – purpose of structure should be reviewed; may no longer serve function

Length (m): Measure the length of the structure (metres).

Breadth (m): Measure the breadth of the structure (metres).

Height (m): Measure the structural height (metres). For those structures that are supported by pylons, the height of the structure is the measurement from the seabed to decking of the structure. The height of the pylons should also be noted in the 'pylons' attribute below.

Comments: e.g. note if there are any ancillary uses of the structure, or note details of any associated structures, e.g. if the structure is a pontoon and there is a walkway attached, although a separate GPS point and attribute details will be recorded for the walkway, it should be noted when recording information about the pontoon that there is a walkway attached (and vice versa). For example, the comments pertaining to the pontoon structure would include, e.g.: 10x2 metal/steel WW (pontoon associated with a 10 metre long by 2 metre wide metal/steel walkway). Comments included when recording information relating to the GPS point of the walkway might include: 8x5 poly PF (walkway associated with an 8 metre long by 5 metre wide polystyrene floating pontoon). Although the relative location of these structures can be deduced from the spatial layer of structures, it is important to include such comments so that it is clear that the two structures are linked. Details (number, size, construction material) should also be recorded here of any instream pylons that are supporting the structure, e.g. 2 x 0.5dia concrete.

BARRIER TYPE PAGE

Barrier type: select appropriate non-barrier type from the scroll down menu: BC Bed Control, FL Floodgate, GS Gauging Station, LB Levee bank/bund, NA Natural, OB Other Barrier, RX Road Crossing, WD Weir/Dam.

Road crossing: box culvert, bridge, causeway, ford, pipe culvert.

Floodgate: auto tidal, hinged flap, other, sluice, winch.

Structure condition:
Good – structure functioning in good working order; no apparent maintenance required
Fair – structure function may be restored through remediation measures
Poor – purpose of structure should be reviewed; may no longer serve function

Construction material: clay, concrete, gabion, gravel, other, timber, rock, sand/fines, sheet piling, steel.

Obsolete structure: Record if the structure no longer appears to serve a current purpose (e.g. a causeway superseded by a bridge). A structure may not be obsolete just because it does not appear to be in use. Consultation with the structural owner and adjacent landholders is required to ascertain the use of the structure.

BARRIER DETAILS PAGE
Length (m): Measure the length of the structure (metres) from bank to bank for full bank flows.

Breadth (m): Measure the breadth of the structure (metres) in the upstream to downstream direction.

Height (m): Measure the structural height (metres) from the downstream toe of the structure to its apex.

Invert height (m): Measure the invert height (metres) from the downstream toe of the structure to the lowest point that flows over/through the structure.

Number pipes/cells: Record the number of pipes or cells beneath the deck of the structure.

Pipe/Cell width (m): Record the cross-sectional width (metres) of a cell beneath the deck of the structure or pipe diameter. If variable cell widths or pipe diameters are evident, attempt to record the average width. The range of individual cell or pipe widths can be recorded in the 'comments' field.

Cell height (m): Record the cross-sectional height (metres) of a cell beneath the deck of the structure. If variable cell heights are evident, attempt to record the average height.

Cell shape: Identify the cell shape from the following options: arched, box, circular, or other.

Pipe diameter (m): Record the cross-sectional diameter (metres) of a pipe. If variable pipe diameters are evident, attempt to record the average pipe diameter.

Water pools upstream: Indicate whether water pools upstream of the structure.

Comments: If an average has been recorded for any of the structural dimensions such as cell width, cell height, pipe diameter, etc., the range of any average dimensions recorded should be noted here. For example, if the structure has three cells with heights of 1m, 0.5m and 2m respectively, an average cell height of approximately 1.2m would be recorded above. The comments field should then read: "cell height range 0.5m-2m". Any additional barrier details not already recorded may be included here.

FISH PASSAGE PAGE

Fishway type: Record if there is a fishway associated with the structure. Select from: bypass, denil, fishlock, full-width rock ramp (RR), other, partial width rock ramp (RR), submerged orifice, vertical slot, fishlift.

Fishway working: Indicate if the fishway is working: yes, no, unknown.

Head loss (mm): If excessive headloss occurs across the barrier measure the vertical drop in water height (millimetres) occurring from the upstream to downstream side of the barrier.

Slope: Estimate the slope of the barrier as being 1:20-1:10 or >1:10.

Debris: If woody or sediment debris has accumulated at the top of the structure identify whether the accumulated debris acts as a partial or complete barrier to migrating fish.

Flow depth: Select this box if flow depth exceeds 100mm.

Light: Select this box if light the amount of light under the structure may present a barrier to fish passage.

Comment: Record any other information about fish passage at the site.

HABITAT PAGE

Dominant Substratum: Indicate the dominant substratum at a site. Select from fines (<0.06mm), sand (0.06-2mm), gravel (2-16mm), pebble (16-64mm), cobble (64-256mm), boulder (>256mm), bedrock/reef, unknown.

Acid Sulfate Soils: disturbed, present in area, unknown. To deduce the status of acid sulfate soils at the site of the structure, the Department of Natural Resources and Water (DNR) mapping and the Australian Soil and Resource Information System (ASRIS) should be consulted, in addition to any other relevant studies.

Bank height (m): Estimate the bank full height (m) as determined from the channel bed just downstream of the structure to average bank apex.

Bank full width (m): Estimate the bank-full width (m) of the waterway just downstream of the structure.

Channel depth (m): Estimate the low-flow channel depth (m) downstream of the structure. If the structure has altered the immediate downstream channel bed (e.g. scour pool), do not incorporate this into the estimate.

Low flow wetted width (m): Estimate the average low-flow channel width (m) of the waterway downstream of the structure. If the structure has altered the immediate downstream channel bed (e.g. scour pool), do not incorporate this into the estimate.

Epibiota: note if any epibiota is observed on the structure surface, e.g. barnacles.

Habitat condition: Select from 1 (Pristine) 2 (Low disturbance), 3 (moderate disturbance), 4 (high disturbance) or 5 (Very high disturbance).

Comments: E.g. dense mangrove forest, heavy weed infestation, productive yabby bank, mangrove seedlings present, mullet observed.

VEGETATION PAGE

Dominant vegetation genus: Indicate the dominant vegetation family/group/genus visible at the site and in the vicinity of the structure. Select from: blue bush, bulrush/cumbungi, cane grass, casuarina, common reed (Phragmites), eucalypt, ferbland, ferns, grass, heath, lignum, mangrove, other, paperbarks, rainforest, saltbush, saltcouch, samphire, sedge, spikerush (Eleocharis), water lilies, wattle, wild rice.

Dominant vegetation: Indicate the dominant vegetation growth form visible at the site and in the vicinity of the structure. Select from: Emergent, floating, grasses/herbs, not vegetated, shrubs, submerged, trees.

Weeds: cabomba, hymenachne, lantana, parthenium, rubber vine, water hyacinth, water lettuce.

Wetlands present: Indicate if a wetland/swamp is located upstream of the structure being assessed.

Landuse: Identify the predominant land use upstream of the structure E.g. Agriculture/livestock, urban/residential, industrial, recreation/tourism, State Forest, National Park.

THREATS PAGE

Threats: Indicate any impacts on wetland ecosystems and processes that are associated with the structure - Erosion, dredging, dumped material, filling, footprint only, maintenance, accretion downstream, accretion upstream, siltation, slumping, scouring, dead native flora, Altered inundation extent, inhibiting marine plant growth.

Disturbance area (outside footprint): <10m, 11-50m, >50m In the case of barriers, consider the impact of the barrier on fish passage. In the case of all other structures, estimate the area outside the footprint of the structure that is observed to be directly impacted by the structure.

Noxious fish of Qld: note if any noxious fish species are observed at the site of the structure: carp, Chinese weatherloach, gambusia/mosquitofish, tilapia, other,

Comments: Any notes required to clarify or describe the observed threat mechanisms. For example, 4 dead freshwater catfish observed.

LOCATION TAB

Desktop assessor: the given name and surname of the person entering or editing data via desktop methods.

NRM: Record the name of the relevant Natural Resource Management Group in the region, e.g. Terrain, Burdekin-Dry Tropics, Mackay-Whitsunday, Murray Darling, Gulf, North East Coast.

Catchment: Record the overarching catchment that the structure is located within rather than the subcatchment.

LGA: Record the local government area that the structure is located within.

Nearest town: Record the town in closest proximity to the structure being assessed.

Topographic map: Record the name of the 1:25,000 or 1:50,000 QLD topographic map that the structure is located on.

Fish Habitat Area: select the name of the appropriate declared Fish Habitat Area.

OWNERSHIP PAGE

Structure ownership: Determine whether structure ownership is private, local government, government agency or commercial. If the ownership of the structure has been investigated extensively, yet no owner has been identified, label as 'unknown'.

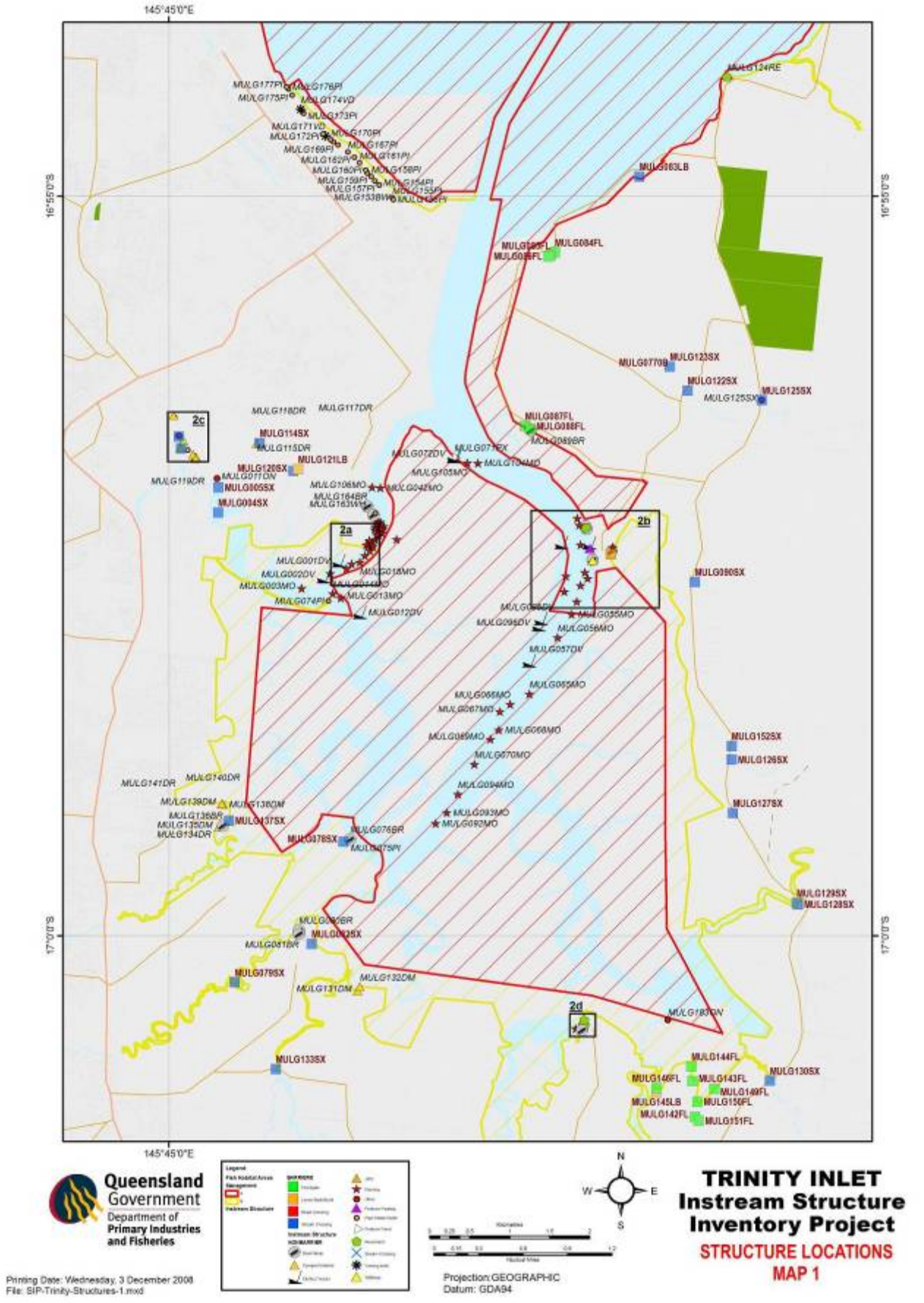
Owner name: Record the full name(s) of the structural owner(s). If the ownership of the structure has been investigated extensively, yet no owner has been identified, label as 'unknown'. Entering of personal details should be conducted only with the consent of the structural owner, with full knowledge that their details will be recorded into a database.

Contact details: Record all known contact details for the structural owner(s) including: telephone, fax, email, residential address, and mailing address.

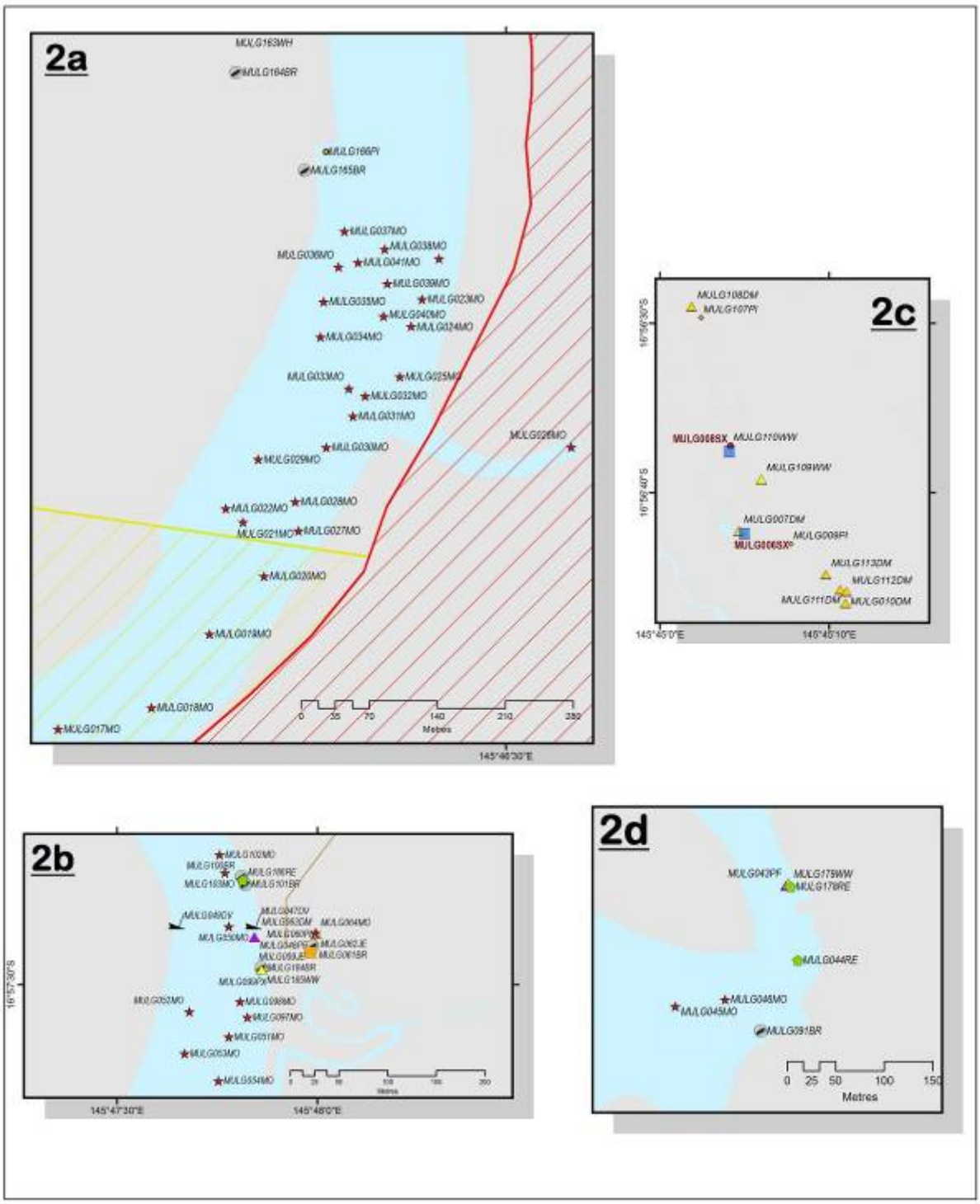
License/Code ID: If the structure is licensed of has a departmental or LGA code, record the relevant reference ID.

Authorised? If it is known, indicate if the structure is authorised (Yes) or not (No).

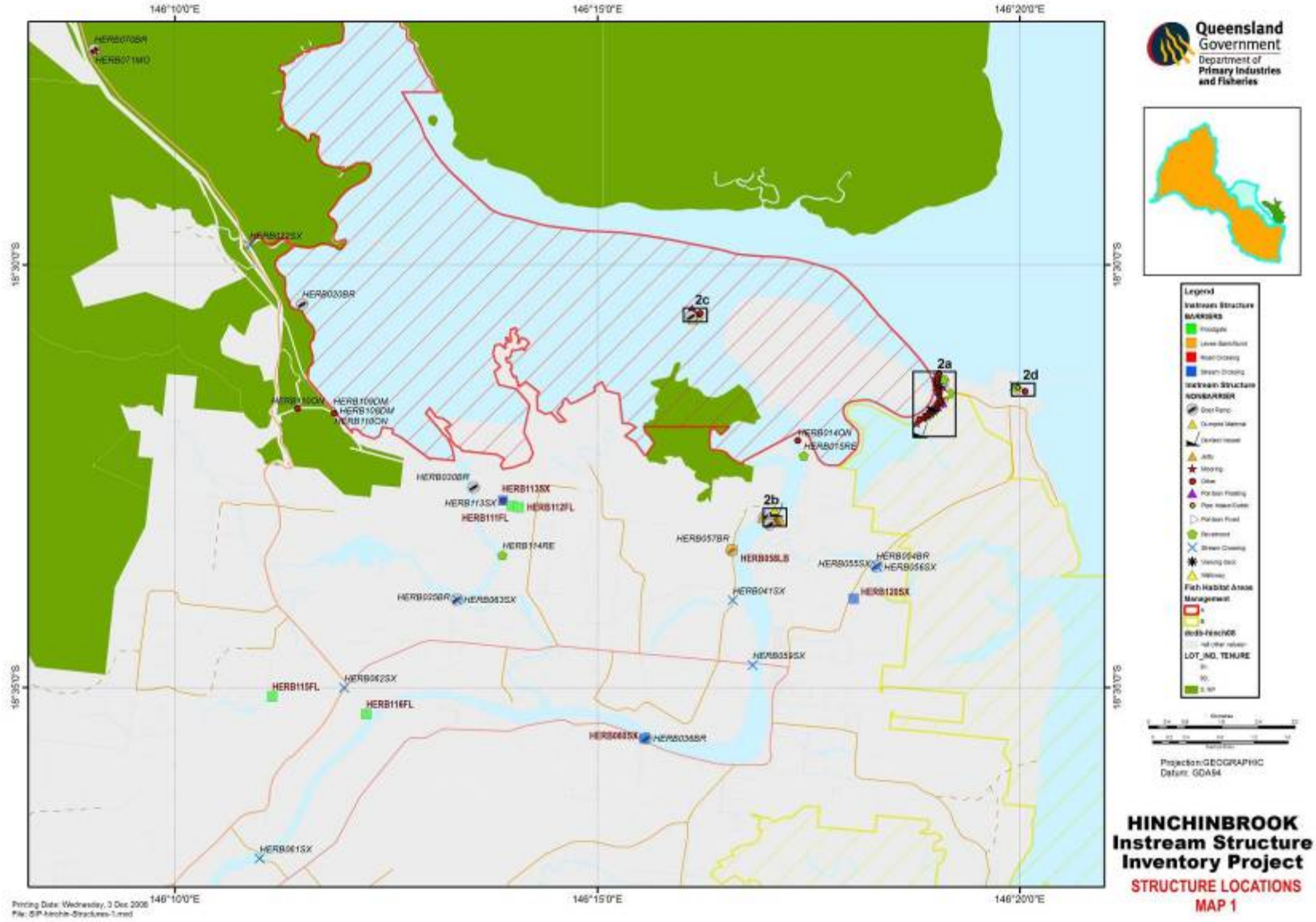
APPENDIX E. Map of structure locations in Trinity Inlet



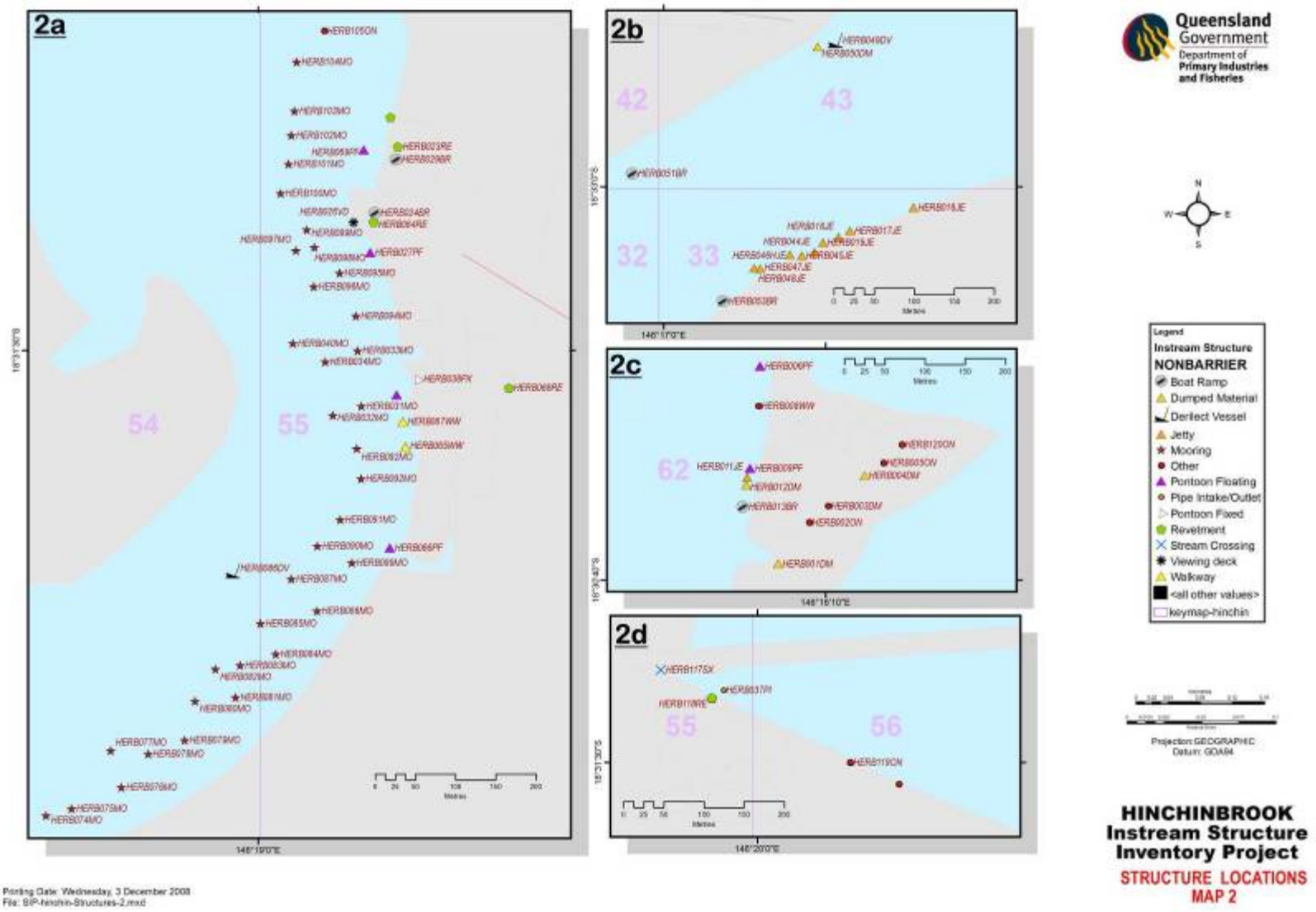
APPENDIX F. Map showing structure locations in development nodes.



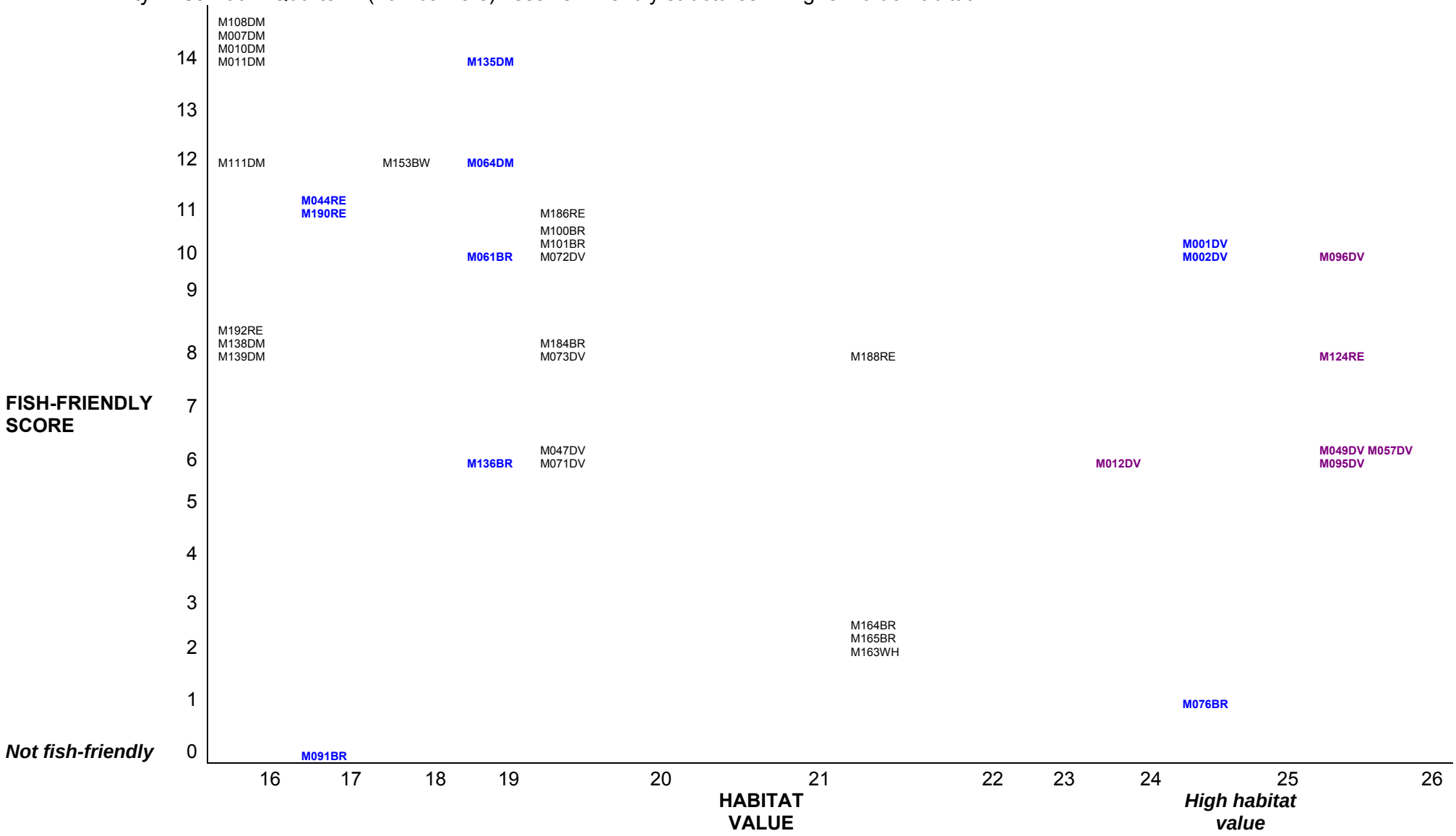
APPENDIX G. Map of structure locations in the Hinchinbrook



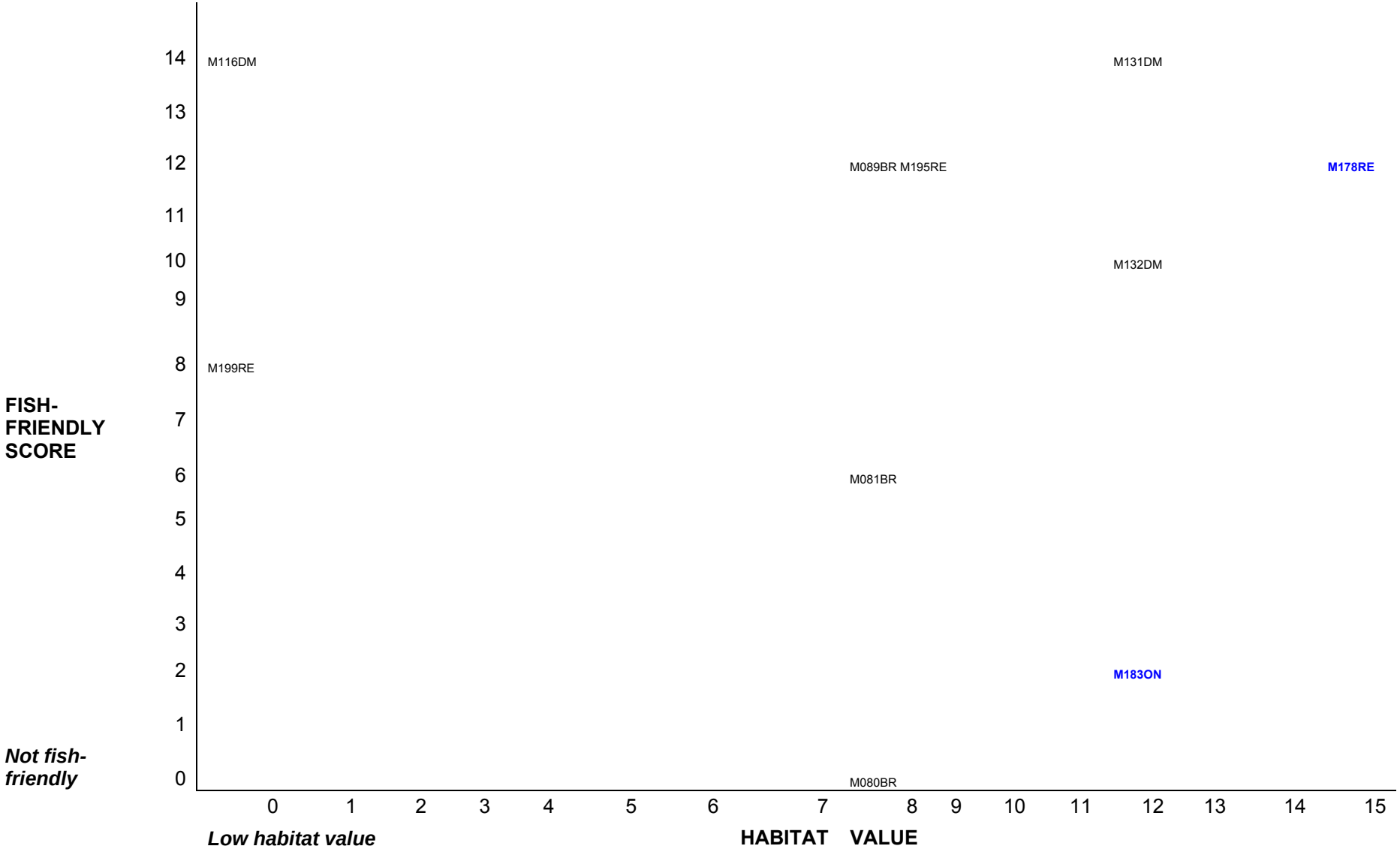
APPENDIX H. Map of structure locations in Hinchinbrook development nodes



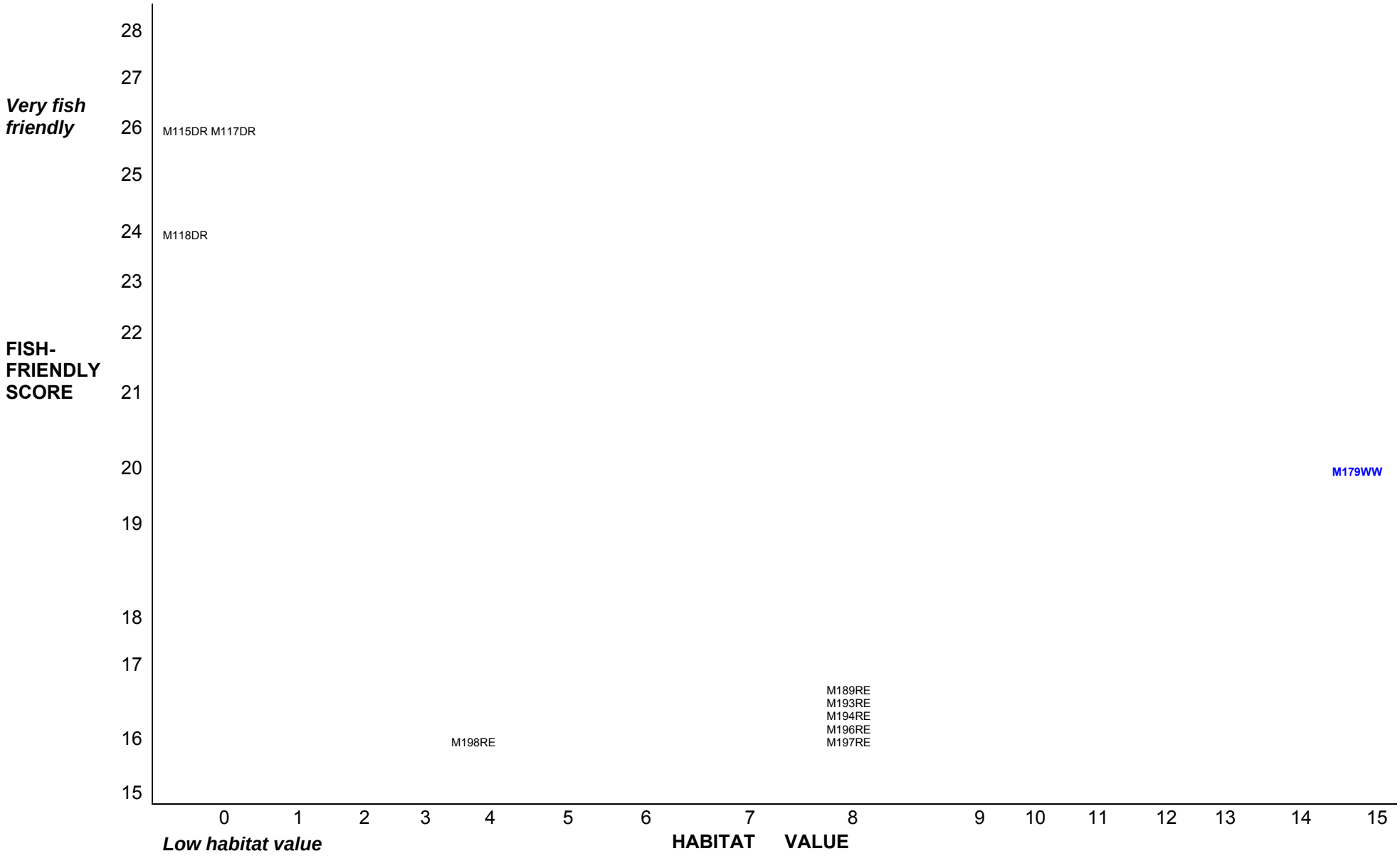
APPENDIX I: Trinity Inlet Matrix Quarter 1 (non-barriers): less fish-friendly structures in higher value habitat



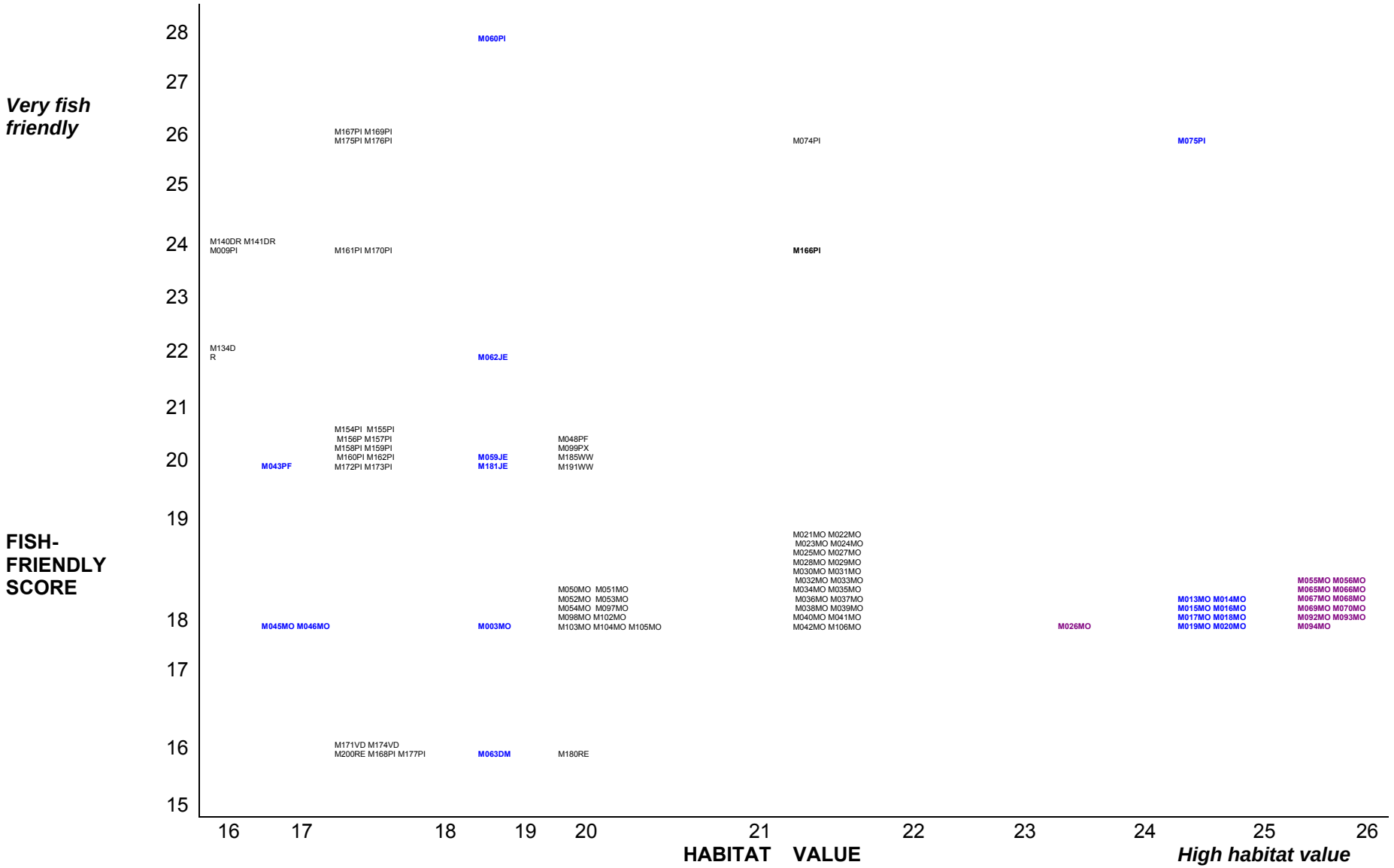
APPENDIX J: Trinity Inlet Matrix Quarter 2 (non-barriers): less fish-friendly structures in lower value habitat



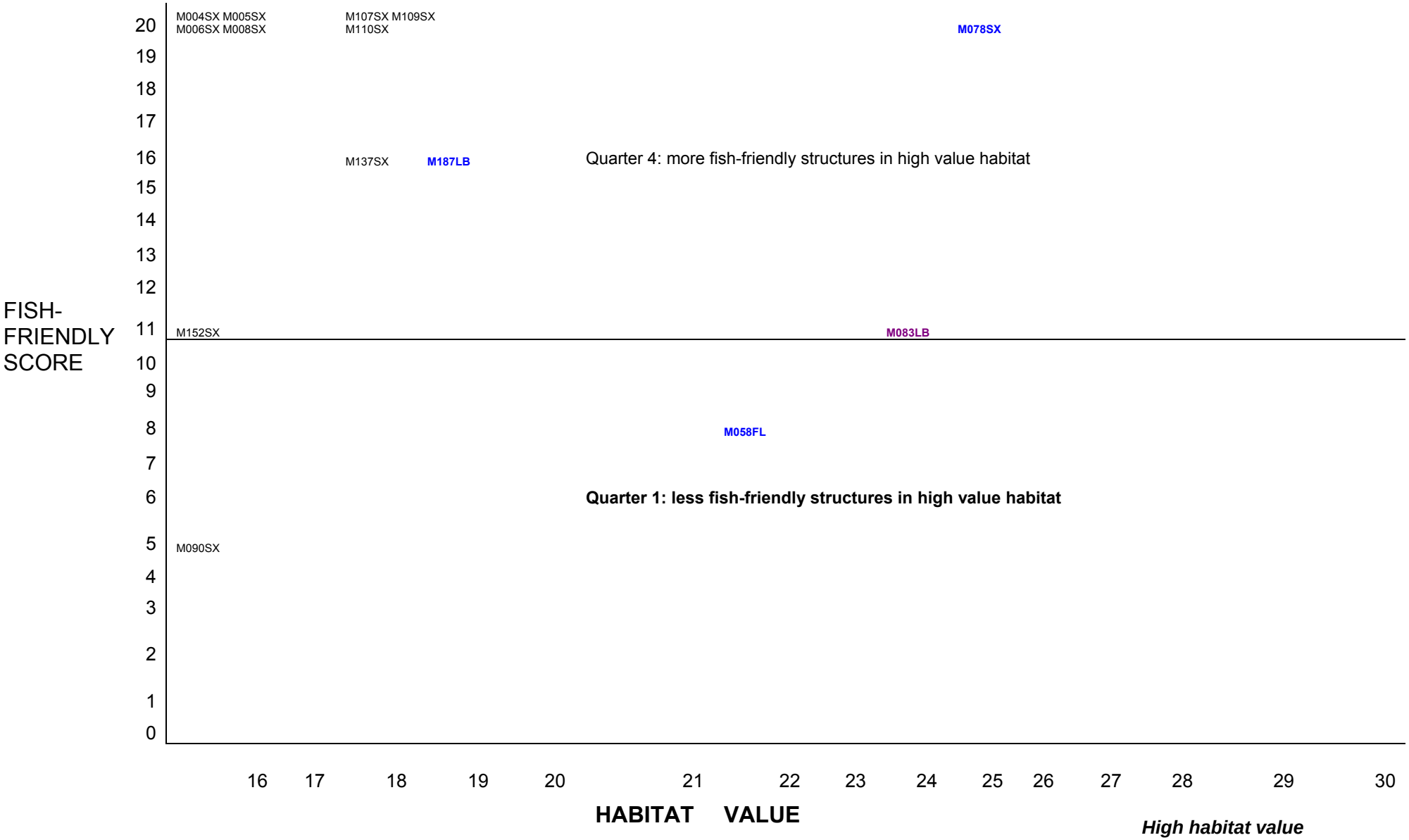
APPENDIX K: Trinity Inlet Matrix Quarter 3 (non-barriers): more fish-friendly structures in lower value habitat



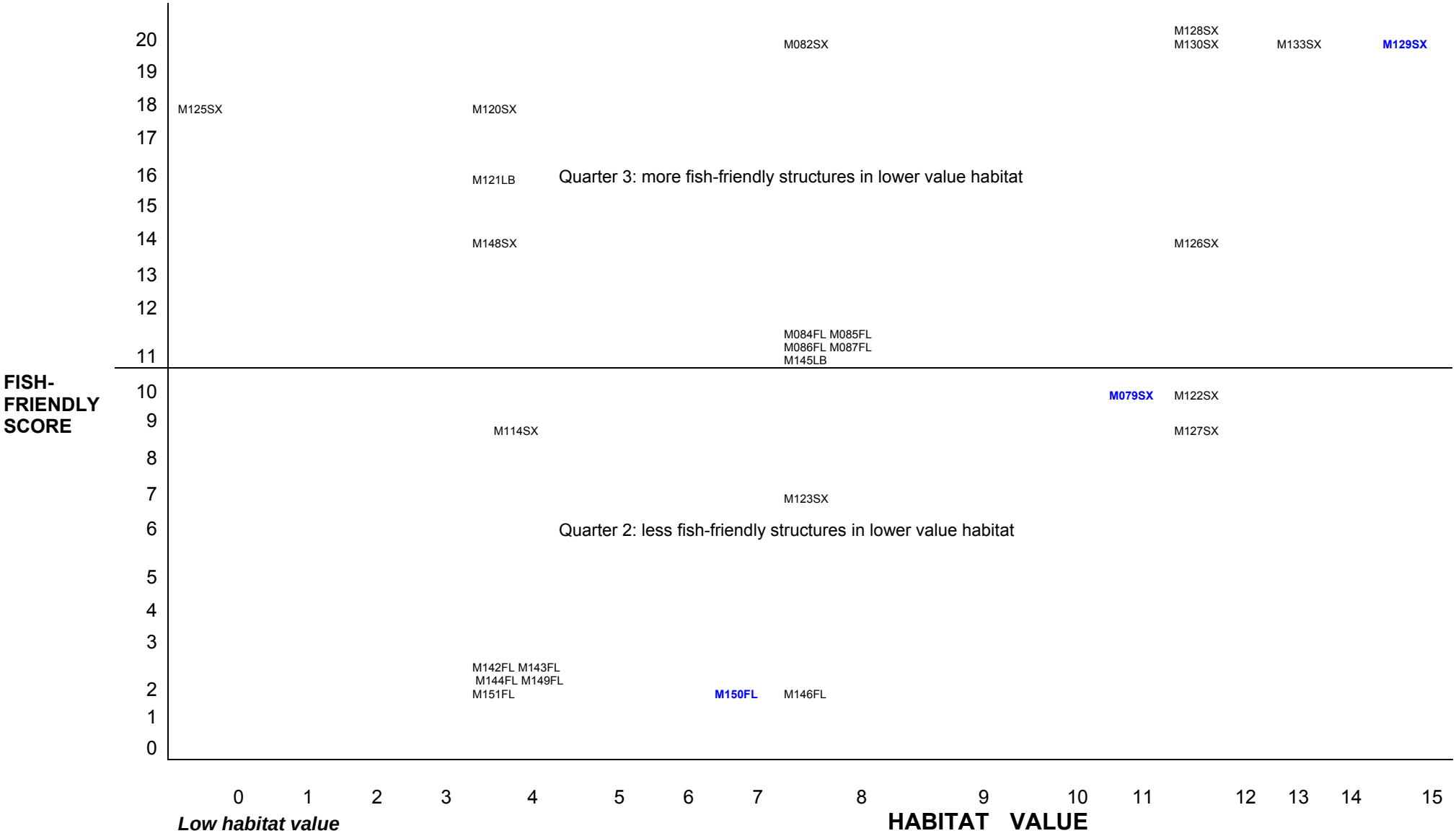
APPENDIX L: Trinity Inlet Matrix Quarter 4 (non-barriers): more fish-friendly structures in higher value habitat



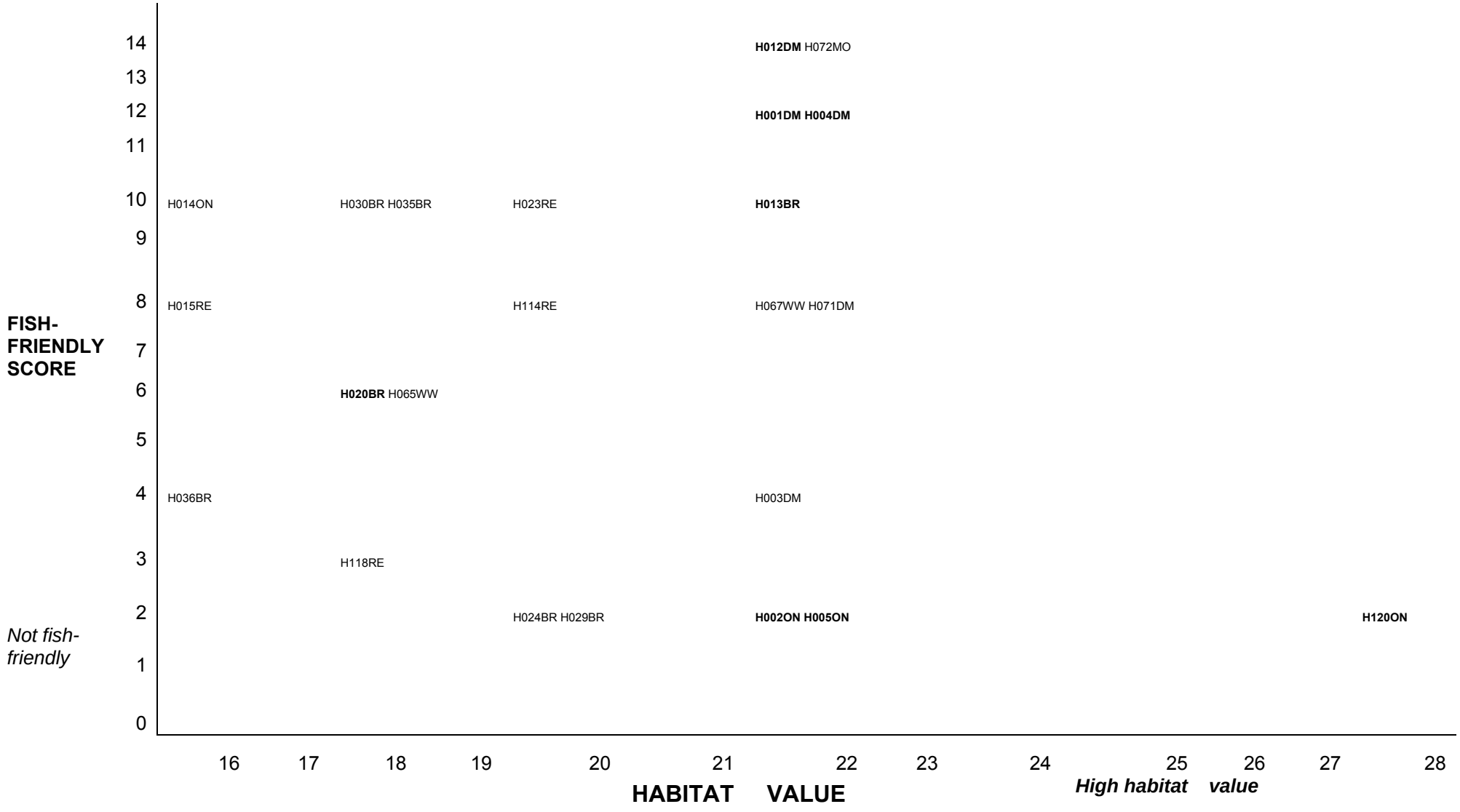
APPENDIX M: Trinity Inlet Matrix Quarter 1 and Quarter 4 (Barriers)



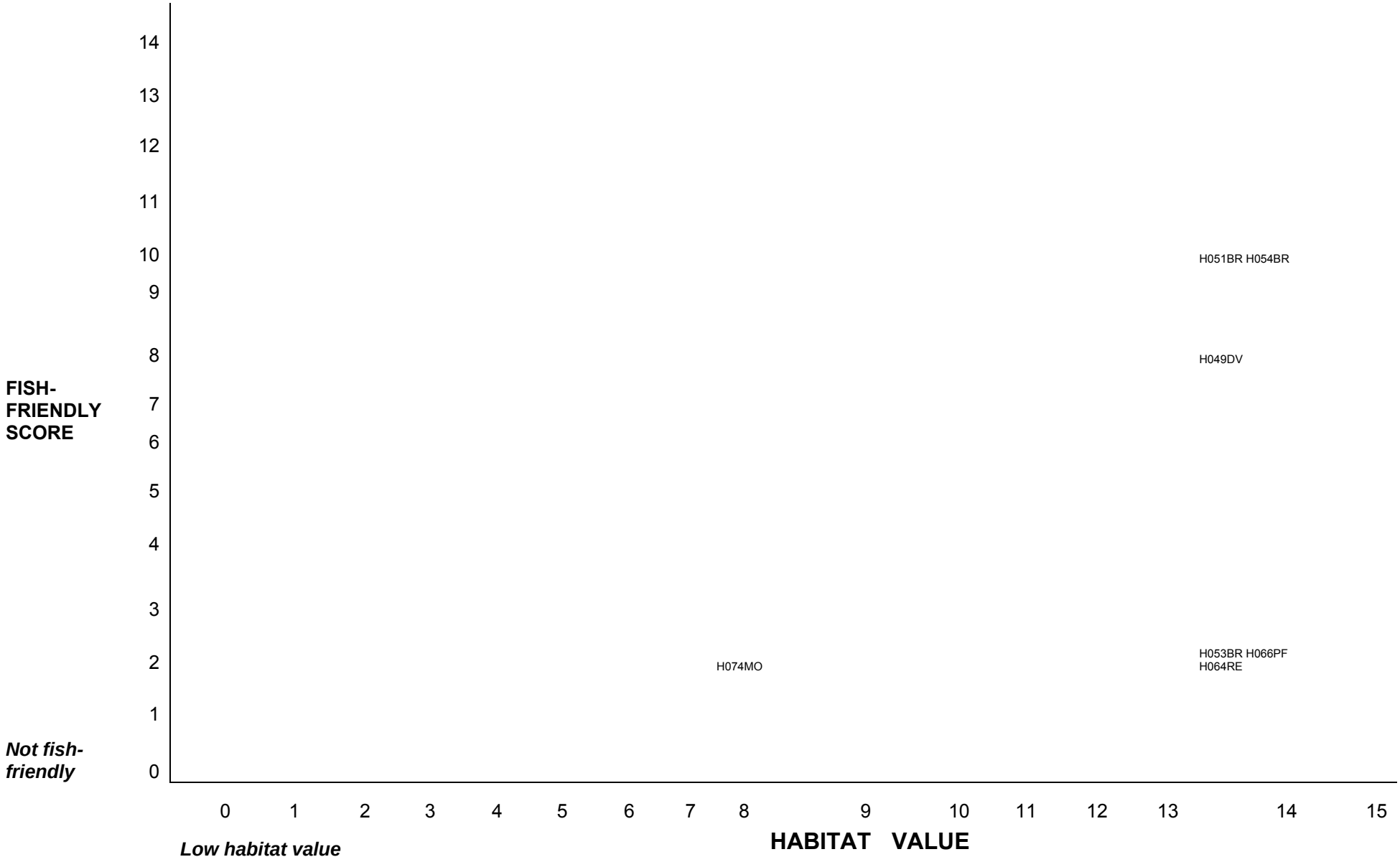
APPENDIX N: Trinity Inlet Matrix Quarter 2 and Quarter 3 (Barriers):



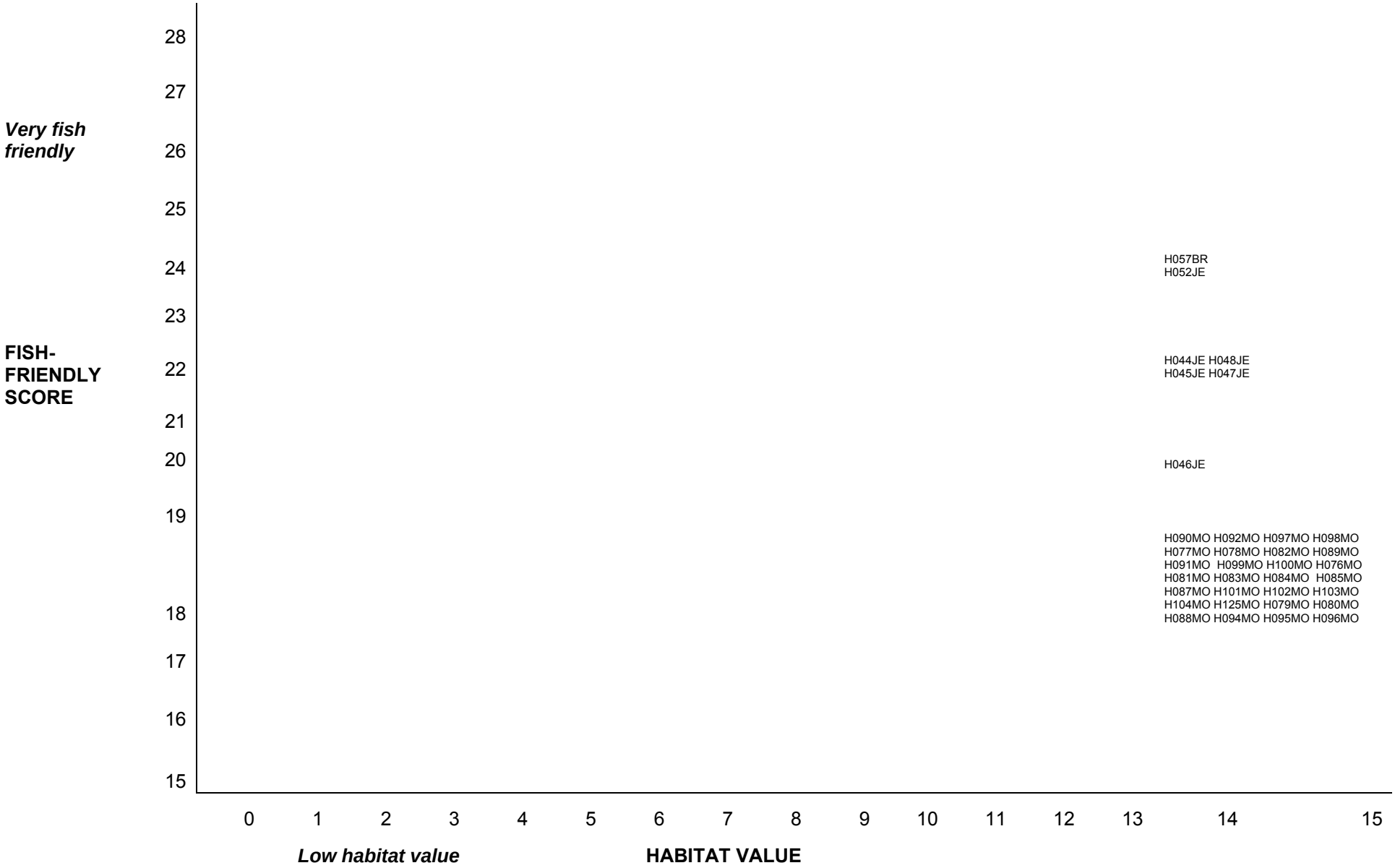
APPENDIX O: Hinchinbrook Matrix Quarter 1 (non-barriers): less fish-friendly structures in higher value habitat



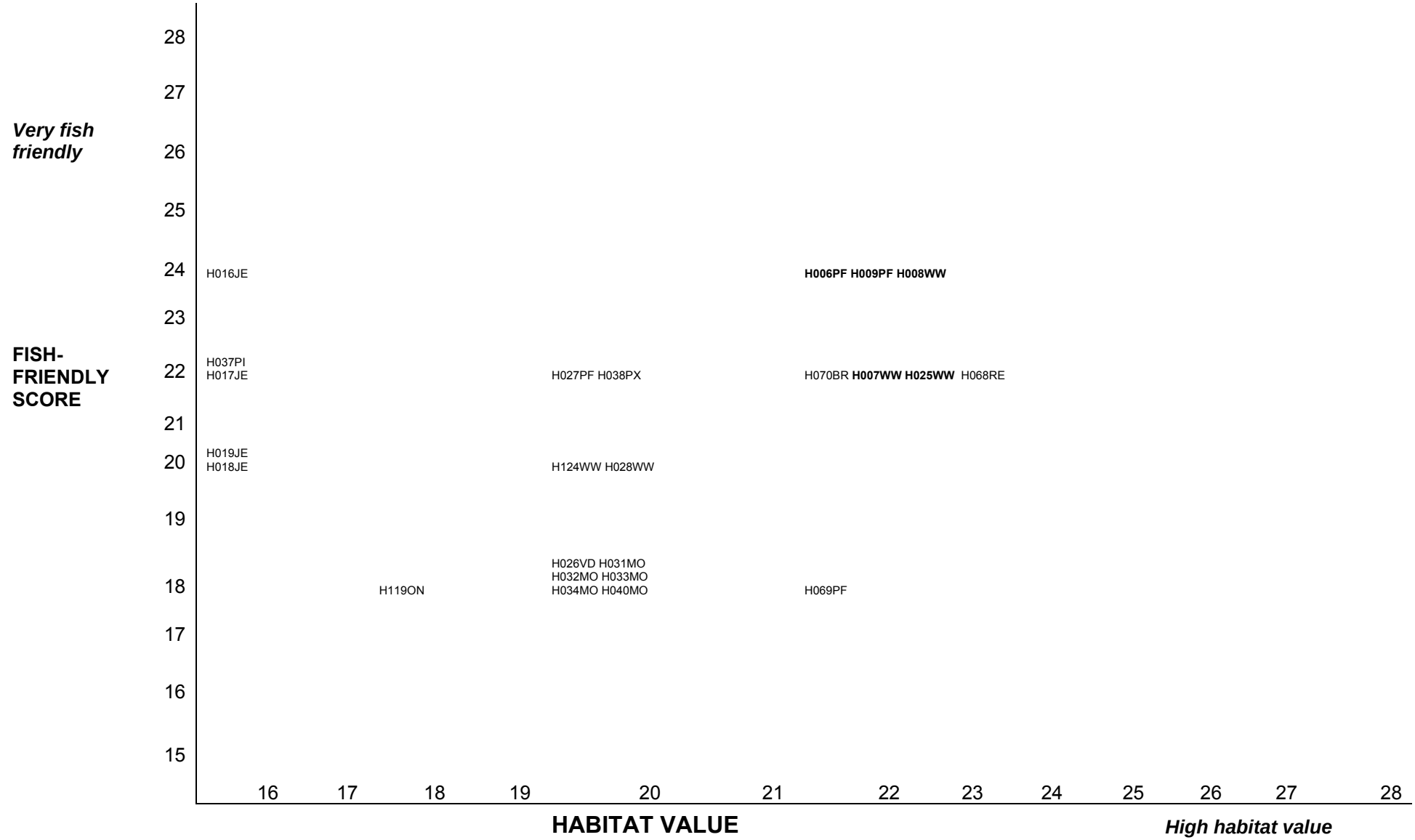
APPENDIX P: Hinchinbrook Matrix Quarter 2 (non-barriers): less fish-friendly structures in lower value habitat



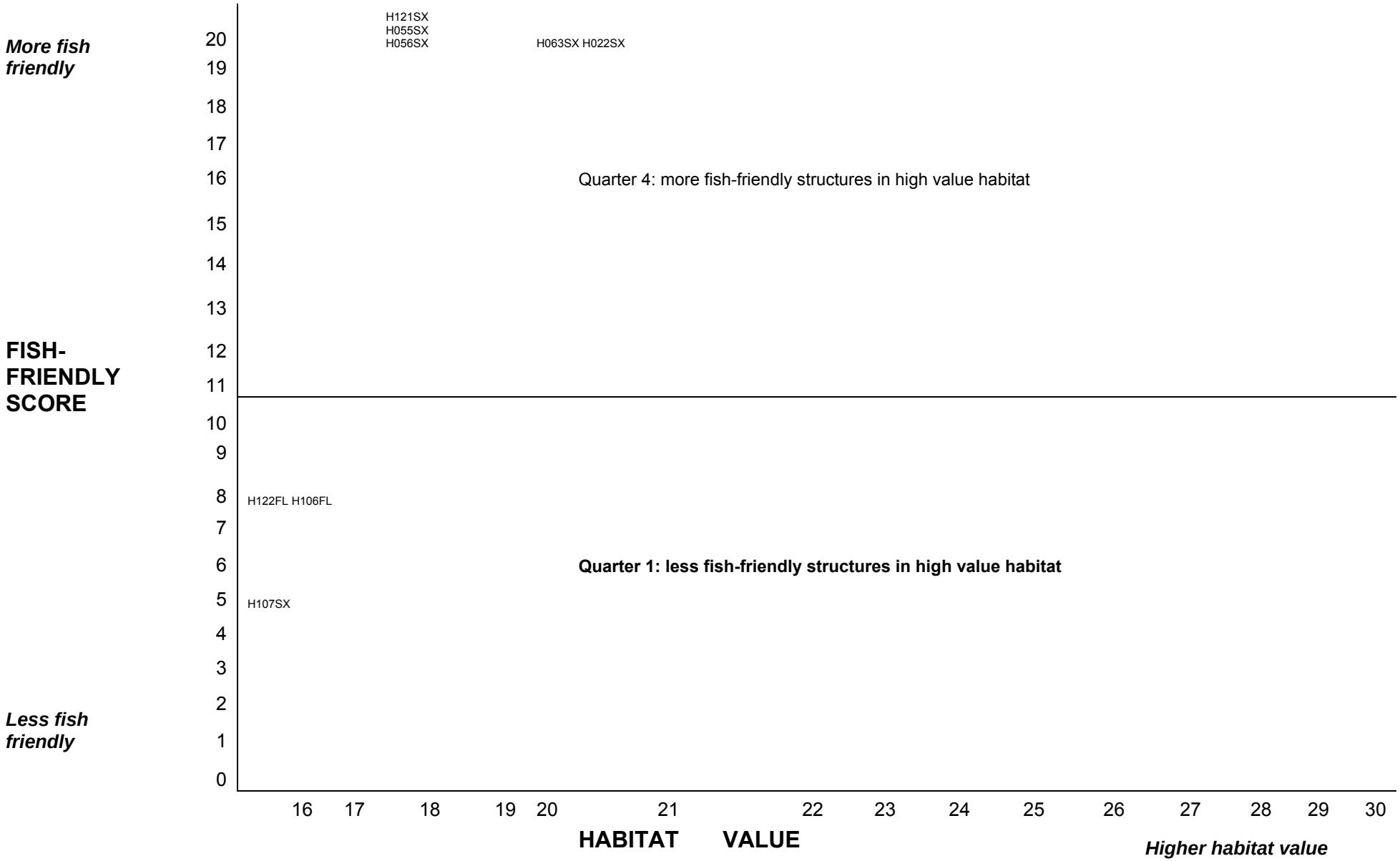
APPENDIX Q: Hinchinbrook Matrix Quarter 3 (non-barriers): more fish-friendly structures in lower value habitat



APPENDIX R: Hinchinbrook Matrix Quarter 4 (non-barriers): more fish-friendly structures in higher value habitat



APPENDIX S: Hinchinbrook Matrix Quarter 1 and Quarter 4 (barriers)



APPENDIX T: Hinchinbrook Matrix Quarter 2 and Quarter 3 (barriers)