Department of **Employment, Economic Development and Innovation**

Southern Gulf Catchments Barrier Prioritisation Report

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Cover image: Clockwise from top image: Leichardt River causeway; Flinders River, Richmond, pipe and culvert crossing; Road crossing at L Creek; and Doomadgee Weir on the Nicholson River

Contents

Glossary of Terms

Diadromous - These fish are true migratory species whose distinctive characteristics include migrating between freshwaters and the sea. Their movement is usually obligatory migration takes place at fixed seasons or life stages. There are three distinctions within the diadromous category, catadromous, amphidromous and anadromous.

- Catadromous - Diadromous fishes which spend most of their lives in fresh water, and migrate to sea to breed.
- Amphidromous - Diadromous fishes in which migration between freshwater and the sea is not for the purpose of breeding, but occurs at some other stage of the life cycle.
- Anadromous - Diadromous fishes which spend most of their lives at sea, and migrate to freshwater to breed.

Potamodromous - fish species whose migrations occur wholly within freshwater for breeding and other purposes.

Acronyms

SGC – Southern Gulf Catchments Natural Resource Management Group

Introduction

In 2005 Fisheries Queensland (formally Queensland Primary Industries and Fisheries) completed a 'Gulf Catchments Fish Passage Assessment' that examined potential fish barriers within the Southern Gulf Region. This report, funded by the Mount Isa Stocking Group, identified 15 priority barriers that required fish passage remediation. In 2008 and 2009 four of these barriers were retrofitted with fishways – Gregory River Doomadgee Road Crossing (rock ramp fishway), Gin Arm Creek (rock ramp fishway), Escott Causeway Nicholson River (concrete cone fishway) and the Flinders River Burketown-Normanton Road Crossing (concrete cone fishway).

In 2009, Southern Gulf Catchments approached Fisheries Queensland to undertake a complete prioritisation of all barriers in the Southern Gulf Region. This report details the prioritisation process and lists the current top 20 barriers within the region based on this prioritisation, outlining recommended remediation works.

The Southern Gulf Region

The Southern Gulf region covers approximately 200,000 square kilometres of Gulf Savannah country in northwest Queensland. This region is comprised of a number of major and minor river catchments including the Mornington Inlet, Flinders, Bynoe, Leichhardt, Nicholson, Gregory, Albert, Saxby, Cloncurry, Gilliat, Woolgar, O'Shannassy, Thornton, Cameron, Malbon and Williams Rivers. The major settlements within the Southern Gulf region include Burketown, Doomagee, Mount Isa, Julia Creek, Cloncurry, Richmond, Hughenden and the Wellesley Islands.

Essentially, the region is a large coastal plain comprised of over two million hectares of wetlands and extensive floodplains that surround each of the major river systems (Southern Gulf NRM 2010). The three major bioregions including the Gulf Plains, the Mitchell Grass Plains and the North West Highlands make up the Southern Gulf Region. The Gulf Plains, the largest of the bioregions, covers almost 12% of Queensland's land area and consists primarily of coastal salt flats, mangroves, and grass and woodland areas (Australian Government 2010). The Mitchell Grass Downs bioregion is dominated by Mitchell Grass tussock on its large undulating plains, while the rugged, hilly country of the North West Highlands is dominated by eucalypt and spinifex communities (Australian Government 2010). Land usage in the Southern Gulf is primarily cattle and sheep grazing (93.7%) with mining (copper, silver, lead, zinc, gold and phosphate), national parks/reserves and urban centres making up the remainder (Southern Gulf Catchments 2010).

The Southern gulf region can be described as semi-arid in the south and southwest sections to tropical monsoon in the north (Southern Gulf Catchments 2010). It is generally cool and dry in the winter and hot and wet in the summer, with 80% of the annual rainfall arriving with the monsoon between December and March (Southern Gulf Catchments 2010). Average annual rainfalls vary from 350mm in the southern areas, up to 900mm along the coast. Mornington Island has slightly higher rainfall than the mainland, having recorded 1200mm in recent years (Southern Gulf Catchments 2010).

The major rivers within the SGC are long, low gradient systems with intermittent flows that often dry up to form refuge pools in the dry season. Much of the riparian zones of these rivers are well vegetated often with areas of overhanging vegetation, instream habitat such as snags, undercut banks and submerged vegetation. The majority of the rivers and streams within the SGC are still natural in form i.e. unmodified by realignment, farming or mining practices.

Fish Communities and Passage Requirements

Several fish community surveys have been conducted within the Southern Gulf NRM region, including the most recent by Hogan and Vallance (2005) that found 50 species of freshwater fish within the Flinders, Leichardt and Nicholson Rivers (see Appendix 4). A number of these species, including barramundi, sawfish, fork-tailed catfish, long-tom, mullet, and the nurseryfish are diadromous, meaning that they migrate between freshwater and the sea at some point in their life cycle. A number of potamodromous species, those that migrate wholly within freshwater, were also found in the study, including rainbow fish, giant glassfish, sleepy cod, sooty grunter and fly-speckled hardyhead. Hogan & Vallance's list also contains species endemic to the Southern Gulf region, including the gulf grunter, elongate glassfish, strawman, saltpan sole, small mouth catfish, river gar, mariana's hardyhead, carpentaria catfish, neil's grunter, tadpole goby, golden goby, square-blotched goby, giant glassfish and the freshwater anchovy. As they are found nowhere else except the SGC passage requirements are very important.

There are a number of commercial and recreational species found within the SGC including barramundi, sooty grunter, mullet, archerfish, sleepy cod and the salmon catfish. A number of these species are also important to the aquarium industry including rainbowfish, hyrtl's tandan, mariana's hardyhead, fly-speckled hardyhead, strawman and mouth almighty being very attractive in captivity.

The fish communities within the SGC in some areas have been impacted by mining, agriculture and some river regulation. However as much of this development is limited and due to the very large size of the catchments the SGC remains in relative good condition, (Marsden and Stewart, 2005). However, barriers to migration have had an impact on the fisheries condition.

Streams of the SGC are mostly ephemeral systems where flows can be extremely high during the wet season and very low during the dry season. With peak flows many of the barriers are drowned out allowing free passage for fish migration. However when these flows decrease to medium and low flows passage becomes very limited. As many of the fish species found within the SGC move on lower flows, they require passage towards the end of the wet season when flows have started to recede and often fall below the level of the barrier. Quite often these lower flows can continue for extended periods of time, leaving many fish (adults and juveniles) stranded below barriers.

Barriers found in the SGC including pipes, culverts, road crossings and weirs constructed for water storage. These can affect fish communities as they prevent the free movement of migratory fish species (Figures 1 and 2). Barriers such as these can often cause local extinctions upstream of the obstruction and can also cause a reduction in fish populations downstream of the barrier (Thorncraft and Harris, 2000). Pipes and culverts can cause considerable modification to channel form and flow conditions with increased velocities, turbulence and also a reduction of water depth within the structure, (NSW DPI, 2006). Scouring at the culvert or pipe outlet can create a drop that is often impassable to fish, this can also indicate a velocity barrier existing inside the structure during higher flows (Bates, 2003).

Causeways, although they can drown out, cause obstructions to migration with excessive headloss height and depth of water over the structure (NSW DPI, 2006). Scouring can also occur on the downstream side of the causeway created by high velocity flow. Weirs cause a distinctive barrier in-stream with drown-outs rarely occurring and connectivity often limited due to the short duration floods, and the high velocities associated with flooding, (Gehrke, 1995). The ability to negotiate barriers at peak flows may be limited to a very select suite of fish species, (Gehrke, 1995).


Figures 1 and 2. Culvert/pipe fish barrier Flinders River, Richmond (left); Burketown-Normanton Road causeway crossing of the Little Bynoe River (right).

Of particular concern are the tidal barriers affecting fish migrating upstream from the estuary. Estuaries provide spawning and nursery grounds for many riverine species and also operate as a buffer zone between the fresh and salt water for freshwater fish washed downstream during high flows. At tidal barriers, many fish, particularly juveniles, can easily become trapped below the structure if it is too large to negotiate. Subsequent barriers upstream of tidal barrages have similar effects on fish communities and can often isolate seasonal or ephemeral habitats in wetlands and floodplains (NSW Department of Primary Industries 2006).

Barriers can have serious implications for the conservation of threatened and vulnerable species such as the freshwater sawfish, *Pristus microdon,* found in the Southern Gulf region. Listed as vulnerable under the national Environment Protection and Biodiversity Conservation (EPBC) Act 1999, the sawfish is a diadromous species where both adults and juveniles utilise freshwater (DEWHA 2010). It is believed that juvenile sawfish spend up to 5 years in freshwater steams before returning to the estuary (Thorburn et al 2007). Barriers to migration can potentially prevent the successful breeding of such important species leading to problems in their management.

GIS Prioritisation

GIS Prioritisation of potential barriers is a fast and efficient way to analyse large numbers of barriers to identify the highest priority sites for remediation investment. This process is a good way to obtain a manageable number of barriers to ground-truth in the field, by eliminating those with poor or limited habitat, time in the field can be maximised on those of highest priority.

A three stage selection criteria process was used to prioritise barriers from most important through to least important based on the biological, social and economic benefits and the cost of remediation. The selection criteria process has taken into consideration the importance of various migration patterns and the likelihood of localised extinctions caused by barriers. The process was designed to favour barriers located close to the estuarine interface in large coastal river systems as they may prevent diadromous species from migrating to upstream freshwater habitats. The impact of barriers on diadromous fish communities is considered to be more critical than the effect on potamodromous fish communities as the species that migrate wholly within freshwater can maintain populations despite the presence of barriers.

The three stage prioritisation process includes undertaking an automated GIS prioritisation of five biological criteria (see methods) to refine the list of barriers. Then field validation and further refinement of the barriers by four more biological criteria is to be completed. From this social, economic, environmental and technical criteria are evaluated and the list is refined further and finally the GIS program can analyse all the criteria for each barrier and rank them in priority order.

Methods

Stage 1 – GIS Prioritisation of Biological Criteria

The aim of Stage 1 was to identify all potential barriers within the Southern Gulf Region and to provide an initial prioritisation to allow further field investigation of high priority sites. Using OziExplorer software and NATMAP Raster 250K map (2005) from Geosciences Australia, waypoints were created at all intersecting roads/rail lines and water bodies. ArcMap 9.3 GIS software was utilised to validate these barriers using Spot 5 satellite imagery. This imagery was also used to identify any further barriers not found using the NATMAP software. All waypoints originally created in OziExplorer were replaced with shape file points (in ArcMap), so that a GIS analysis could be performed. Every potential barrier was assigned a unique identification number to maintain quality assurance.

Once all potential in-stream barriers had been cross checked using Spot 5 satellite imagery and assigned a shape file point, they were analysed using an automated GIS program. The GIS program was created specifically to prioritise the large quantity of potential in-stream barriers identified during the study. To achieve this, five biological criteria questions were incorporated into the GIS program. For each question, a score was assigned relating to how the barrier fulfilled the biological criteria. Barriers were then prioritised based on their total score, with the top scoring barrier becoming the highest priority.

All scores were based on the premise that free access to and from the sea is essential to the breeding of diadromous species and they cannot survive without this access. Therefore habitats and barriers close to the sea gain higher scores as they have the greatest impact on the movement of diadromous species. Upper habitats and barriers score lower as the potamodromous species found there can still maintain populations, even though they may become fragmented, while diadromous species become extinct without access to the sea.

The following are fundamental for a potential in-stream barrier to attain a high score in stage one:-

- High Stream order
- Located lower down in the system, closer to the estuary
- Catchment condition has minimal adverse surrounding land use practices
- A large area of the catchment will be opened up above the barrier to the next barrier (or to the top of the catchment) if the barrier is removed
- Minimal or no barriers downstream

The software utilised for this process includes ESRI ArcGIS 9.3 and ArcGIS Extension tools that include Network Analyst, Spatial Analyst, EtGeowizards and X-Tools.

The five biological questions and associated scoring system incorporated into the automated GIS program for the first round of the prioritisation process were as follows:

Question 1.

<u>Stream Type</u>
The first GIS question determined the stream order of the stream segment on which the barrier was located. Higher stream orders (large streams) gained a higher score, while minor stream orders (small streams) gained a lower score. (Appendix 6 outlines the Strahler stream order method). Stream orders 1 and 2 within the first 50km of the important coastal zone and stream orders 1, 2, 3 and 4 from beyond the coastal zone to the head waters of the catchment were removed from the barrier prioritisation process as they contained little or poor fish habitat.

Stream orders 3 to 11 within the Coastal Zone and Stream orders 5 to 11 from the coastal zone to the headwaters were scored as follows:-

Stream order in the Coastal zone	Score	Stream orders inland from the coastal zone	Score
3	2	5	4
4	4	6	6
5	6	7	8
6	8	8	10
7	10	9	12
8	12	10	14
9	14	11	16
10	16		
11	18		

Question 2.

<u>What is the stream length (km) cut off by the barrier, expressed as a proportion (%) of the total stream network within the entire catchment?</u>

The total stream network should take into account all tributaries of the catchment upstream and downstream (to the saltwater interface) of the barrier, not just the tributary in which the barrier is located. The greater the percentage of stream network cut-off by the barrier then the likelihood for a greater benefit from removing the barrier.

a. 80% or more of total stream network *(5 points)*
b. 60-79% of total catchment. *(4 points)*
c. 40-59% of total catchment. *(3 points)*
d. 21-39% of total catchment. *(2 points)*
e. ≤20% of total catchment. *(1 point)*

Question 3.

<u>What stream length (km) exists upstream of the barrier that is not impeded by further barriers?</u>

Include all tributaries if there are no further barriers. If there is another barrier upstream, then only measure to this point. If it is the uppermost barrier in the system and there are barriers below, take 3 points off of the score (lowest score possible is 0). This takes into account that uppermost barriers often have large stream networks, but of relatively low value habitat.

a. 500+ km's. *(5 points)*
b. 100 - 499 km's. *(4 points)*
c. 50 - 99km's. *(3 points)*
d. 10 - 49 km's. *(2 Points)*
e. 0.6 – 9 km's *(1 Point)*
f. 0 – 0.5 km's. *(0 Points)*

Question 4

Number of barriers downstream.

a. No barriers downstream. *(7 points)*
b. One barrier downstream. *(5 points)*
c. Two to four barriers downstream. *(3 points)*
d. Five to Nine barriers downstream. *(2 points)*
e. Ten or more barriers downstream. *(0 points)*

Question 5

Catchment Condition

Take into account the whole catchment downstream to the declared downstream limit, not just the sub-catchment the barrier is located. E.g. if a barrier is located on the Flinders River, then its catchment condition would include the entire Flinders catchment include the Saxby, Cloncurry and any other associated rivers.

a. No intensive cropping/urban. *(7 points)*
b. 1%-4% intensive cropping/urban. *(4 points)*
c. 5%-14% intensive cropping/urban *(3 points)*
d. 15-29% intensive cropping/urban. *(2 points)*
e. 30%-39% intensive cropping/urban. *(1 point)*
f. ≥40% intensive cropping/urban. *(0 points)*

Stage 2 – Full Biological Criteria Prioritisation

Stage two of the barrier prioritisation process involved field validation of the top 100 ranked barriers from stage one. To achieve this, a GPS (Garmin GPS map 76) tracking system was set up on a laptop computer using the moving map function of OziExplorer mapping software. Together with remotely indentified and prioritised waypoints, allowed field staff to systematically locate the geographical position of each barrier in relation to identifiable locations (towns, roads, streams), allowing for efficient validation of potential barriers.

Once a potential barrier was located and confirmed as a barrier to fish passage, information about the relevant physical and biological (surrounding habitat) aspects were recorded. These aspects included: the type of barrier; number of culverts/pipes; head loss (difference between upstream and downstream water levels); length, height and width of the structure, and; access information. Additionally, video footage and photos of the barrier were taken. Detailed biological information on stream condition, water supply, habitat for migratory fish upstream of the barrier, fish passage status downstream and distance to tidal interface was also recorded for use in the second stage scoring process.

The second stage scoring process involved allocating a score to all barriers for each of the biological criteria. Scores were collated and added to the stage one scores, the barrier with the highest combined score became the highest ranking barrier.

The biological questions and associated scoring system for the second stage of the prioritisation process are as follows:

Question 1.

Barrier type

a). Tidal barrage. *(5 points)*
b). Dam or weir ≥3m. *(4 Points)*
c). Dam or weir 1.5–3m high or culvert/pipes that span ≤60% of stream width. *(3 Points)*
d). Dam or weir ≤1.5m high or culvert/pipes that span ≥60% of stream width. *(2 Points)*
e). No barrier – *DO NOT SCORE REMAINING CRITERIA.*

Question 2.

Stream condition

a). Pristine; undisturbed (no apparent clearing of rip veg; no bank degradation). *(5 Points)*
b). Low disturbance (≤ 25% of upstream areas degraded as above). *(4 Points)*
c). Moderate disturbance (25-50% of upstream areas degraded as above). *(3 Points)*
d). High disturbance (51-75% of upstream degraded) *(2 Points)*
e). Very high disturbance (≥ 75% of upstream degraded). *(1 Point)*

Question 3.

Water Supply/Quantity

a). Natural, permanent or non-polluted. *(5 Points)*
b). Natural, permanent via supplemented flow or minimal pollution. *(4 Points)*
c). Stream occasionally dries up with refuge pools or some pollution. *(3 Points)*
d). Stream seasonally dries up with refuge pools or moderate pollution. *(2 Points)*
e). Stream dries seasonally with no refuge pools or heavy pollution. *(1 Point)*

Question 4.

Habitat for migratory fish species upstream of barrier site
a). Excellent (diverse and abundant fish habitat). *(5 Points)*
b). Good (reasonable amount of suitable fish habitat). *(4 Points)*
c). Moderate (moderate amount of suitable fish habitat). *(3 Points)*
d). Poor (little suitable fish habitat). *(2 Points)*
e). Very poor. (little or no suitable fish habitat). *(1 Point)*

Stage 3 – Social, Economic and Technical Feasibility Prioritisation

The third stage of the prioritisation process involved investigating the social, economic and environmental benefits of the barrier remediation works. A very important aspect of this stage of the process was considering the net benefits of fixing the barrier versus the economic cost of the remediation. As much of the remediation works are funded by Natural Resource Management groups who's funding is often quite limited, this stage of the prioritisation is important in understanding which barrier can be affordably fixed in line with the funding. Smaller structures are cheaper to construct and therefore most cost affective for the investor.

This third process is achieved through analysing the top 28 barriers with a range of social, economic and biological criteria. Like stage one and two of the prioritisation process, each criterion contained a question with multiple answers. A score of 1 to 5 was assigned to each answer and

once all the barriers had been analysed, scores were collated, and as with stage 2, the highest scoring barrier become the top ranked barrier of the SGC region. The end result of the third stage is a list of the 28 barriers to fish migration in the SGC region in order of highest priority (see Appendix 1).

The social, economic and biological questions and associated scoring system of the third stage of prioritisation included:

Question 1.

Estimated cost

a). Low cost	small/low nature-like fishway (<0.8m) or short culvert baffles (<0.8m)	*(5 Points)*
b). Low-moderate cost	small/high nature-like fishway (0.8-1.5m) or small/low height technical fishway (<0.8m) or tall culvert baffles (>0.8m)	*(4 Points)*
c). Moderate cost	high nature-like fishway (1.5-2.0m) or medium/low height technical fishway (0.8-1.5m)	*(3 Points)*
d). Moderate-high cost	large/low height technical fishway (>1.5m)	*(2 Points)*
e). High cost	large/high height technical fishway (>1.5m)	*(1 Point)*

Question 2.

What assistance by way of access, financial or in-kind support is available?

a). Easy access, good financial and in-kind support available.	*(5 Points)*
b). Reluctant access, some financial or in-kind support available.	*(3 Points)*
c). Reluctant access, no financial or in-kind support available.	*(1 Point)*
d). No access, no financial or in-kind support available.	*(0 Points)*

Question 3.

Technical viability - How difficult is the design and construct?

a). Simple installation of current design, limited engineering required.	*(5 Points)*
b). Modest installation of current design, some engineering (includes multi-design fishways)	*(3 Points)*
c). Complex installation and engineering or a new concept design.	*(1 Point)*

Question 4.

Productivity benefits

What fish species will benefit from the remediation and will this benefit commercial/recreational fisheries and/or increase local business revenue (consider added improvement to current fish passage as well)?

a). A high benefit to a large number of commercial and or recreational species.	*(5 Points)*
b). A moderate benefit to a moderate number of commercial and or recreational species	*(3 Points)*
c). A small benefit to a small number of commercial and or recreational species.	*(1 Point)*
d). No benefit to commercial and or recreational species.	*(0 Point)*

Question 5.

Conservation significance

Will the improvement have a positive impact on the conservation of species?

a). Listed (under EPBC Act 1999) species present. *(5 Points)*
b). Species present that are rare or restricted within the region (but not rare or restricted outside the region). *(3 Points)*
c). Only common or abundant species within the region present. *(1 Point)*

Question 6.

How effective will the fish passage remediation be?

a). All species at all migration flows will be able to pass. *(5 Points)*
b). All species at some migration flows or some species at all migration flows will be able to pass. *(3 Points)*
c). Some species at some migration flows will be able to pass. *(1 Point)*

Results

Stage One

Before removing the lower order systems 7992 in-stream road crossings were identified in the Southern Gulf Catchments, (see appendix 2). The removal of these lower order streams by the automated GIS programme in Stage One of the prioritisation process reduced this number to 536 potential barriers to fish migration. The ranking of the 536 barriers was achieved by using the questions in the stage one process.

Table 1. The number of potential barriers identified at each score from the highest score to the lowest score.

Score	No. Potential Barriers	Score	No. Potential Barriers
35	1	20	6
34	2	19	7
30	1	18	4
28	1	17	13
27	1	16	7
24	4	15	18
21	5	14 and lower	464

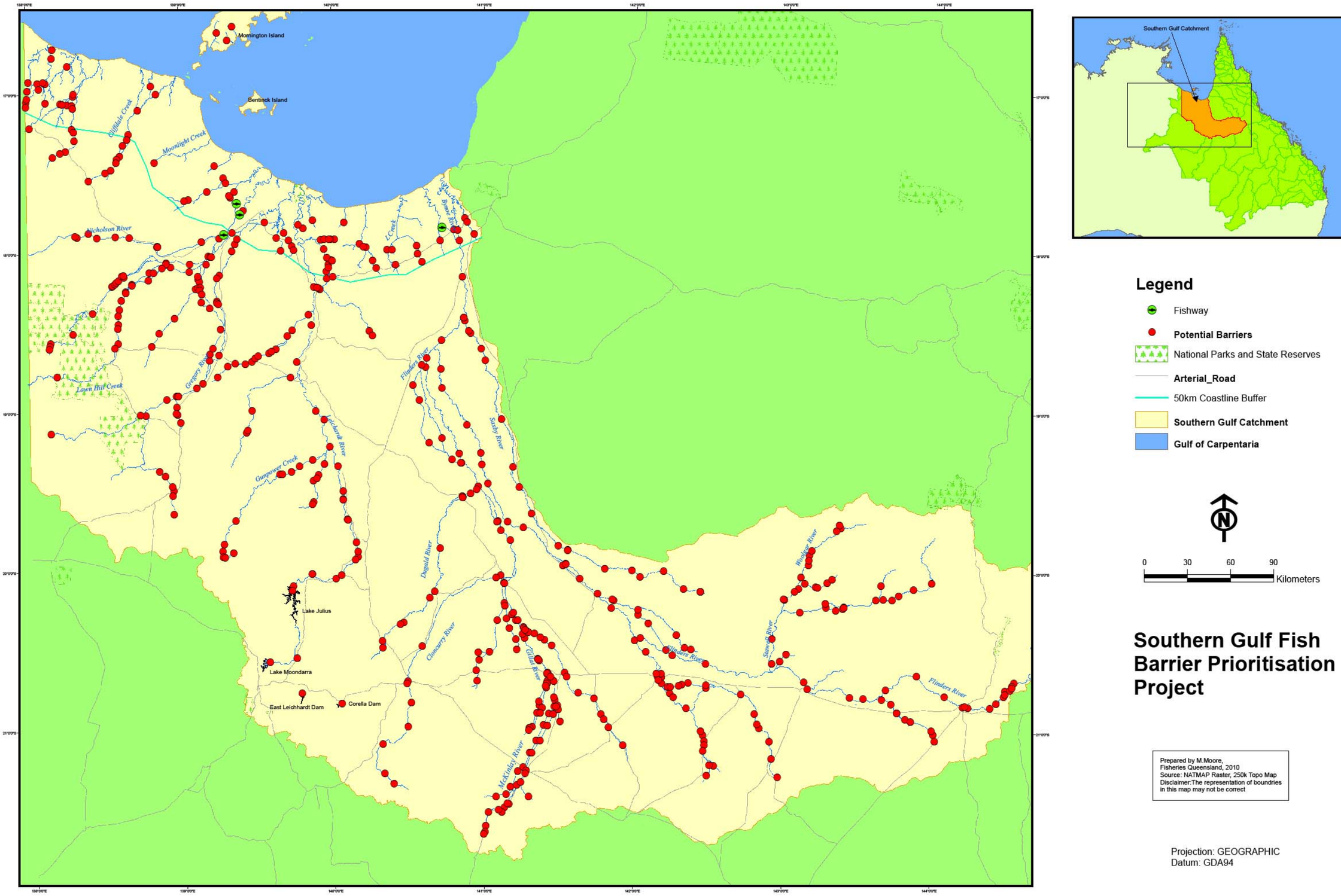

Figure 3. Map of the 536 potential barriers identified within the Southern Gulf Catchments region following the Stage 1 automated GIS program.

Stage Two

A total of 60 potential barriers were validated in the field during stage two of the prioritisation process (see figure 4). This resulted in 28 confirmed barriers to fish migration and by using the questions set out in Stage Two. These barriers were ranked in order of priority (see Table 2.).

Table 2. The 28 confirmed barriers and their rank in order of priority after Stage Two of GIS Prioritisation process.

Barrier Number	Stream Name	Barrier Type/Name	Stage 2 Rank
411	Bynoe River	Pipe causeway	1
412	Little Bynoe River	Pipe causeway	2
106	Nicholson River	1st Escott causeway	3
186	Flinders River	Walkers Bend causeway	4
514	L Creek	Inverleigh Station weir	5
152	Leichardt River	Augustus Downs causeway	6
104	Pear Tree Creek	Culvert crossing	7
253	Flinders/Saxby Rivers junction	Earth bund – single pipe	8
122	Big Oaky Creek	Low bridge crossing	9
535	Nicholson River	Doomadgee Weir	10
408	Leichardt River	Lake Julius Dam	11
534	Alexandra River	Causeway	12
177	Armstrong Creek	Culvert crossing	13
118	Nicholson River	Pipe causeway	14
250	Saxby River	Wondoola Road causeway	15
176	L Creek	Causeway – single pipe	16
147	Leichardt River	Coolullah Station causeway	17
348	Flinders River	Richmond culvert and pipe crossing	18
150	Cloncurry River	Fort Constantine causeway	19
182	Magowra Creek	culvert crossing	20
525	Flinders River	Punchbowl Waterhole causeway	21
157	Lagoon Creek	Earth causeway – single pipe	22
259	Flinders River	Pipe Causeway	23
103	Crooky Creek	Culvert crossing	24
417	Saxby River	Millungera Station culvert crossing	25
466	Lagoon Creek	Earth causeway – single pipe	26
65	Cloncurry River	Cloncurry Anabranch culvert crossing	27
225	Eastern Creek	Culvert crossing	28

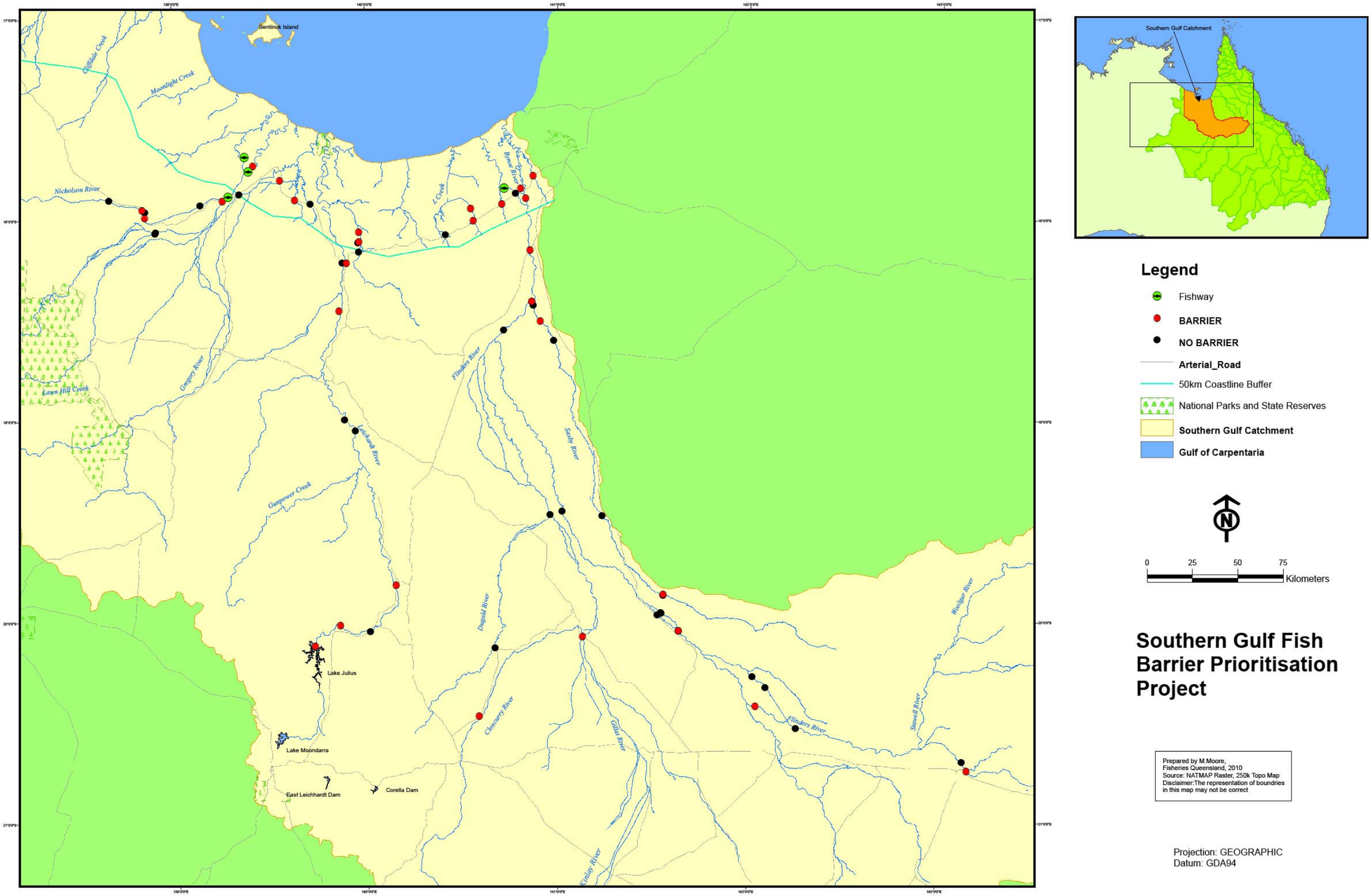

Figure 4. Map of top 60 barriers validated in the field during Stage 2.

Stage Three

The final stage of the prioritisation process involved analysing the 28 confirmed barriers using the economic, social and technical questions in Stage Three. This resulted in the prioritisation of the 28 barriers to fish migration in the SGC (see Table 3 and figure 5). Appendix 1 outlines the recommended remediation activities for each of the 28 barriers.

Table 3. Final scores for the top priority barriers in SGC.

Barrier Number	Stream Name	Barrier Type/Name	Total adjusted Rank
411	Bynoe River	Pipe causeway	**1**
412	Little Bynoe River	Pipe causeway	**2**
106	Nicholson River	1st Escott causeway	**3**
152	Leichardt River	Augustus Downs causeway	**4**
186	Flinders River	Walkers Bend causeway	**5**
514	L Creek	Inverleigh Station weir	**6**
104	Pear Tree Creek	Culvert crossing	**7**
534	Alexandra River	Causeway	**8**
122	Big Oaky Creek	Low bridge crossing	**9**
253	Flinders/Saxby Rivers junction	Earth bund – single pipe	**10**
177	Armstrong Creek	Culvert crossing	**11**
176	L Creek	Causeway - single pipe	**12**
250	Saxby River	Wondoola Road causeway	**13**
147	Leichardt River	Coolullah Station causeway	**14**
535	Nicholson River	Doomadgee weir	**15**
182	Magowra Creek	Culvert crossing	**16**
118	Nicholson River	Pipe causeway	**17**
103	Crooky Creek	Culvert crossing	**18**
408	Leichardt River	Lake Julius Dam	**19**
259	Flinders River	Causeway – four pipes	**20**
150	Cloncurry River	Fort Constantine causeway	**21**
157	Lagoon Creek	Earth causeway – single pipe	**22**
417	Saxby River	Millungera Station culvert crossing	**23**
525	Flinders River	Punchbowl Waterhole causeway	**24**
466	Lagoon Creek	Earth causeway – single pipe	**25**
348	Flinders River	Richmond culvert and pipe crossing	**26**
65	Cloncurry River	Cloncurry Anabranch culvert crossing	**27**
225	Eastern Creek	Culvert crossing	**28**

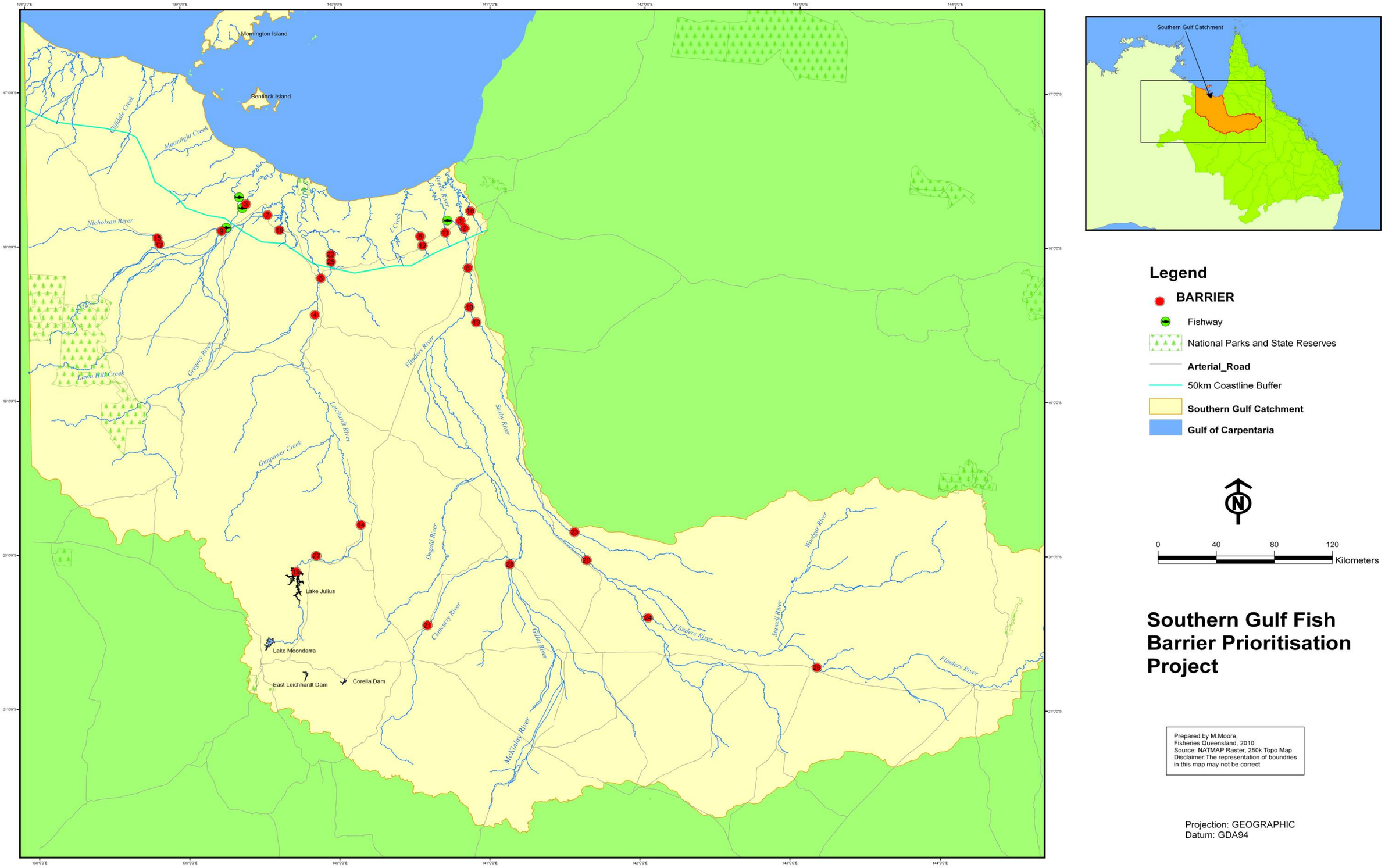

Figure 5. Map of the top 28 barriers identified in the Southern Gulf Catchment.

Discussion

Of the 7992 potential barriers identified in Stage One of the prioritisation process, 7456 were found to be in systems that our GIS program deemed to have limited or poor fish habitat and by providing passage beyond that potential barrier would not be beneficial to fish populations.
After removing these potential barriers from the prioritisation process, there remained a further 536 potential barriers that were ranked in accordance of priority that would be most beneficial to maintaining fish populations.
Of those barriers identified in the 2005 study, six out of the fifteen sites were included in the current study as they met all the criteria of the prioritisation. Four of the fifteen sites have had fishways retrofitted to them and therefore passage is no longer an issue, one is a natural barrier and one is no longer considered to be within the SGC (boundaries have changed since the council amalgamation in 2008). Three that did not rate high in the prioritisation process as they where found in the upper catchment and were eliminated in stage one. Nevertheless, as they are barriers to fish migration, appendix 3 lists these barriers with remediation activities that could be undertaken.

Although validation of only the top 50 to 100 potential barriers was required, the top 200 sites were identified for field validation to ensure that as many potential barriers could be surveyed as possible. As expected, of the top 200 potential barriers only 60 were actually validated in the field. This was due to the extended wet season leaving many roads impassable (especially those close to the coast). Future validation of these sites should be considered, however, communication with landholders suggests that the majority are bed level crossings and are not barriers to fish migration. Landholders indicated that they did not access these areas during the wet season and therefore there was no requirement for in-stream structures (large or small) for access. Other sites that could not be accessed were on remote properties and along roads that were closed to the public and communication with landholders could not be made.

From the field validation 28 of the 60 sites surveyed were found to be actual barriers to fish migration. These were mostly culvert and pipe crossings, weirs and causeways. The highest priority barriers were generally lower in the system usually on large creeks and rivers, and had been installed for either in-stream water storage or where the system was too wide or too deep for bed level and rock crossings. The 28 confirmed barriers were ranked according to impact on fish communities, cost of construction, effectiveness of the remediation, conservation issues (e.g. freshwater sawfish), access and financial support from all parties involved.

The top 6 priority sites were, The Bynoe River, The Little Bynoe River, The Nicholson River at Escott Station, The Leichardt River at Augustus Station, Walkers Bend on the Flinders River and Inverleigh Station weir on L Creek. To remedy these 6 barriers would cost $ 485,000.00 and would result in over 900 km of stream becoming available to fish migration.
Providing passage these barriers would improve the fish community and provide the most cost effective remediation for investors.

The 32 crossings that were found not to be barriers were either bed level crossings or bridges. These do not obstruct fish migration as they promote natural unimpeded stream flow, allowing the free movement of fish during a wide range of hydrological conditions (Fairfull and Witheridge, 2003; NSW DPI 2006).

Conclusion

The study clearly demonstrates what while there are thousands of barriers with the SGC NRM region, remediation of a small number of the highest priority barriers will significantly increase the habitat available fro fish. By restoring fish passage to these priority sites, free passage between tidal zones, wetlands floodplains and instream lagoons will be greatly enhanced, maximizing the productivity of these systems and ensuring that the fishermen of the Gulf have many more healthy and well fed fish to catch.

Recommendations

- Prepare an investment strategy for the highest priority sites based on the information contained within this report
- Landholder negotiations should be commenced to permit rehabilitation of the highest priority sites.
- Detailed surveys should be undertaken to produce suitable fishway designs
- Contracts should be initiated to detail ongoing maintenance and monitoring agreements to ensure the success of any fishway installed.
- Fish community sampling should be undertaken to monitor population sizes and species diversity after remediation activities have been completed.

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Appendix 1 – The 28 Barriers to Fish Migration in SGC

Rank	**1**
Barrier Id number	411
System Name	Bynoe River
Barrier Type	Causeway and Pipes
Barrier Height	1.3m
Location	40km west of Normanton
Fishway Option	Concrete cone Fishway
Approximate cost	$45 000.00

Rank	**2**
Barrier Id number	412
System Name	Little Bynoe River
Barrier Type	Causeway and pipes
Barrier Height	~2m
Location	35km west of Normanton
Fishway Option	Concrete cone fishway
Approximate cost	$75 000.00

Rank	**3**
Barrier Id number	106
System Name	Nicholson River
Barrier Type	Causeway
Barrier Height	~2m
Location	Escott Station
Fishway Option	Concrete Cone
Approximate Cost	$ 40 000.00

Rank	**4**
Barrier Id number	152
System Name	Leichhardt River
Barrier Type	Causeway
Barrier Height	700mm
Location	Augustus Downs station
Fishway Option	Rock Ramp Fishway
Approximate cost	$25 000.00

Rank	**5**
Barrier Id number	186
System Name	Flinders River
Barrier Type	Causeway
Barrier Height	2m
Location	Walkers Bend
Fishway Option	Partial Removal & / or Culvert installation
Approximate cost	$ 150 000.00

Rank	**6**
Barrier Id number	514
System Name	L Creek
Barrier Type	Weir
Barrier Height	1.8m
Location	Inverleigh Station
Fishway Option	Vertical Slot Fishway or Concrete cone Fishway
Approximate cost	$150 000.00

Rank	**7**
Barrier Id number	104
System Name	Pear Tree Creek
Barrier Type	Culvert Crossing
Barrier Height	1.2m
Location	9km south of Burketown
Fishway Option	Baffles
Approximate cost	$15 000.00

Rank	**8**
Barrier Id number	534
System Name	Alexander River
Barrier Type	Causeway
Barrier Height	400mm
Location	73km SE of Burketown
Fishway Option	Rock Ramp fishway
Approximate cost	$25 000.00

Rank	**9**
Barrier Id number	122
System Name	Big Oaky Creek
Barrier Type	Low Bridge Crossing
Barrier Height	1m
Location	38km SW of Burketown
Fishway Option	Rock Ramp & Baffles
Approximate cost	$ 40 000.00

Rank	**10**
Barrier Id number	253
System Name	Flinders/Saxby Rivers Junction
Barrier Type	Earth-bund Crossing
Barrier Height	600mm
Location	Warrenvale Station
Fishway Option	Culverts & baffles & rock ramp fishway
Approximate cost	$ 75 000.00

Rank	**11**
Barrier Id number	177
System Name	Armstrong Creek
Barrier Type	Boxed Culverts
Barrier Height	1.2m
Location	54km west of Normanton
Fishway Option	Concrete Cone Fishway
Approximate cost	$45 000.00

Rank	**12**
Barrier Id number	176
System Name	L Creek
Barrier Type	Causeway and Pipe
Barrier Height	700mm
Location	Inverleigh Station 80km west of Normanton
Fishway Option	Concrete cone Fishway
Approximate cost	$ 45 000.00

Rank	**13**
Barrier Id number	250
System Name	Saxby River
Barrier Type	Causeway
Barrier Height	1m
Location	Wondoola station
Fishway Option	Rock Ramp Fishway
Approximate cost	$ 35 000.00

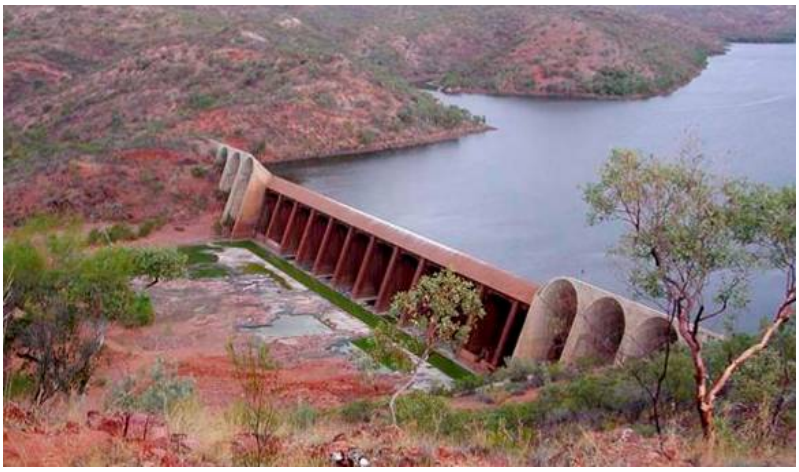
Rank	**14**
Barrier Id number	147
System Name	Leichhardt River
Barrier Type	Causeway
Barrier Height	1.1m
Location	Coolullah Station
Fishway Option	Rock Ramp Fishway
Approximate cost	$35 000.00

Rank	**15**
Barrier Id number	535
System Name	Nicholson River
Barrier Type	Weir
Barrier Height	1.5m
Location	5km south of Doomadgee
Fishway Option	Vertical Slot Fishway
Approximate cost	$750, 000.00

Rank	**16**
Barrier Id number	182
System Name	Magowra Creek
Barrier Type	Culvert crossing
Barrier Height	~1m
Location	25km west of Normanton
Fishway Option	Baffles
Approximate cost	$ 15 000.00

Rank	**17**
Barrier Id number	118
System Name	Nicholson River
Barrier Type	Pipe causeway
Barrie Height	~1m
Location	5km south of Doomadgee
Fishway Option	Concrete cone
Approximate cost	$55 000.00

Rank	**18**
Barrier Id number	103
System Name	Crooky Creek
Barrier Type	Culverts
Barrier Height	~600mm
Location	25km SE of Burketown
Fishway Option	Baffles & cleanout
Approximate cost	$ 15 000.00



Rank	**19**
Barrier Id number	408
System Name	Leichhardt river
Barrier Type	Dam
Barrier Height	30m
Location	Lake Julius
Fishway Option	Fish Lift
Approximate cost	$ 14 million

Rank	**20**
Barrier Id number	259
System Name	Flinders River
Barrier Type	Pipe Causeway
Barrier Height	1.15m
Location	75km north of Julia Creek
Fishway Option	Removal
Approximate cost	$ 30 000.00

Rank	**21**
Barrier Id number	150
System Name	Cloncurry river
Barrier Type	Causeway and Pipe
Barrier Height	1.8m
Location	Fort Constantine
Fishway Option	Concrete cone fishway
Approximate cost	$ 75 000.00

Rank	**22**
Barrier Id number	157
System Name	Lagoon Creek
Barrier Type	Earth-bund causeway
Barrier Height	~600mm
Location	Wernadinga Station
Fishway Option	Rock Ramp
Approximate cost	$ 20 000.00

Rank	**23**
Barrier Id number	417
System Name	Saxby River
Barrier Type	Culvert Crossing
Barrier Height	600mm – 2m
Location	Millungera Station
Fishway Option	Rock Ramp Fishway and Baffles
Approximate cost	$30 000.00

Rank	**24**
Barrier Id number	525
System Name	Flinders River
Barrier Type	Culvert Crossing
Barrier Height	2.4m - 4m
Location	Punchbowl Waterhole
Fishway Option	Rock Ramp & Baffles
Approximate cost	$ 65 000.00

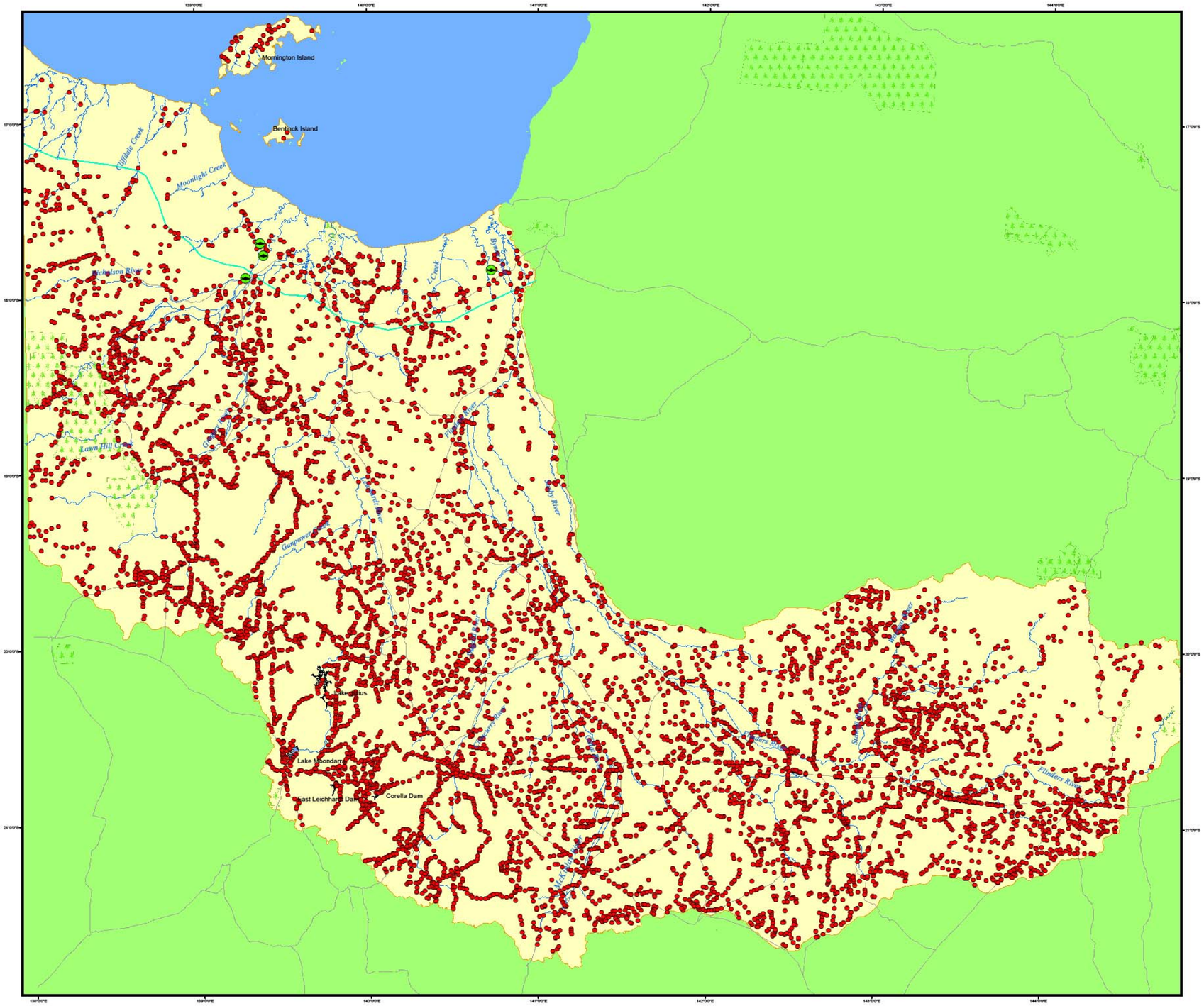
No Photo Available	Rank	**25**
	Barrier Id number	466
	System Name	Lagoon Creek
	Barrier Type	Earthbund causeway
	Barrie Height	~600mm
	Location	Wernadinga Station
	Fishway Option	Rock Ramp Fishway
	Approximate cost	$20 000.00

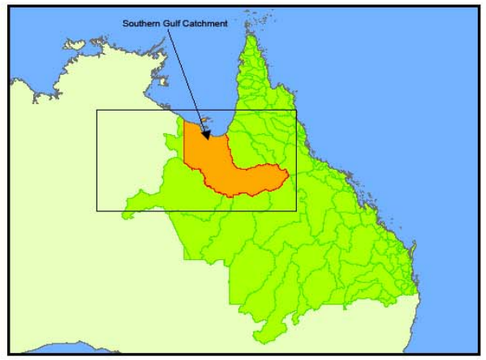
	Rank	**26**
	Barrier Id number	348
	System Name	Flinders River
	Barrier Height	3.4m
	Barrier Type	Culvert & Pipe Crossing
	Location	Richmond
	Fishway Option	Rock Ramp and Baffles
	Approximate cost	$100 000.00

	Rank	**27**
	Barrier Id number	65
	System Name	Cloncurry River Anabranch
	Barrier Type	Culvert crossing
	Barrier Height	3.7m
	Location	Cloncurry
	Fishway Option	Removal
	Approximate cost	$ 25 000.00

Rank	**28**
Barrier Id number	225
System Name	Eastern Creek
Barrier Type	Culvert Crossing
Barrier Height	3m?
Location	Gilliat river, 93km NW of Julia Creek
Fishway Option	Baffles and Rock Ramp
Approximate cost	$ 20 000.00

Appendix 2. Total barriers (7992) identified in Southern Gulf Catchments before a Stage 1 criterion was applied.





Legend

- Fishway
- Total Potential Barriers
- National Parks and State Reserves
- Arterial_Road
- 50km Coastline Buffer
- Southern Gulf Catchment
- Gulf of Carpentaria

0 30 60 90 Kilometers

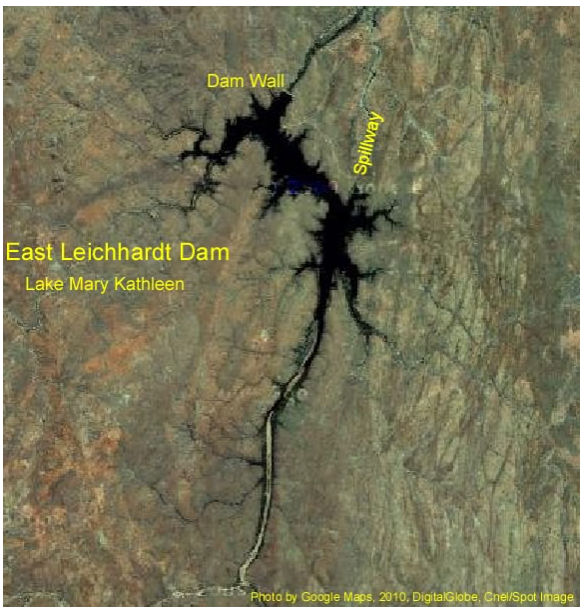
Southern Gulf Fish Barrier Prioritisation Project

Prepared by M.Moore,
Fisheries Queensland, 2010
Source: NATMAP Raster, 250k Topo Map
Disclaimer:The representation of boundries in this map may not be correct

Projection: GEOGRAPHIC
Datum: GDA94

Appendix 3 – Barriers Previously Assessed in 2005

These Barriers did not score high enough to be included in the 2010 prioritisation



System Name	East Leichhardt River
Barrier Type	Dam
Barrier Height	~30m
Location	East Leichhardt Dam
Fishway Option	Rock ramp and By-pass channel
Approximate cost	$ 200 000.00

System Name	Leichardt River
Barrier Type	Large Dam spillway
Barrier Height	~40m
Location	Lake Moondarra Spillway
Fishway Option	Downstream fish protection and smoothing of spillway
Approximate cost	$ 1 million

System Name	Leichhardt River
Barrier Type	Culvert Causeway
Barrier Height	1m
Location	Lake Moondarra Road
Fishway Option	Concrete cone fishway
Approximate cost	$ 45 000.00

Appendix 4 - Fish Species of the Southern Gulf Region

Species	Flinders River	Leichhardt River	Nicholson River	Seasonal Movements				Flows			Reason for movement
				Summer	Autumn	Winter	Spring	Low	Mod	High	
Potamodromous Species											
Archerfish (*Toxotes chatareus*) ® ∞	29	36	22	✓	?	?	✓	?	✓	?	R, D
Banded Grunter (Amniataba percoides) ∞	26	46	28	✓		✓	✓	✓	✓	?	D
Gulf Grunter (*Scortum ogilbyi)*	31	14	10	?	?	?	?	?	?	?	?
Boney Bream (*Nematolosa erebi*)	124	70	67	✓	✓	✓	✓	✓	✓	✓	D, S
Spangled perch *(Leiopotherapon unicolour*) ∞	51	34	45	✓	✓	✓	✓	✓	✓	✓	D, S
Rainbow Fish (*Melanotaenia splendida)* ∞	53	40	64	✓	✓	✓	✓	✓	✓	✓	R, D
Sleep Cod (*Oxyeleotris lineolatus*) ®	64	48	39	✓	?	?	?	?	✓	?	D
Striped sleepy cod (oxyeleotris selheimi)	13	6	33	?	?	?	?	?	?	?	?
Mouth Almighty (*Glossamia aprion)* ∞	23	45	37	✓	✓	✓	✓	✓	✓	✓	D, S
Giant Glassfish (*Parambassi gulliveri)*	52	17	2	?	?	?	?	?	?	?	?
Reticulated Glass Fish (Ambassis macleayi)	6	29	40	✓	✓	✓	✓	✓	✓	✓	?
Square-blotched goby (*Glossogobius sp. 2)* ∞	18	12	2	?	?	?	?	✓	✓	?	?
Unidentified goby (*Glossogobius sp)*	1	4	4	?	?	?	?	?	?	?	?
Berney's catfish (*Arius berneyi)*	13	3	5	?	?	?	?	✓	✓	?	?
Black Catfish (*neosilurus ater)* ®	4	4	3	✓	?	?	✓	?	?	✓	S
Carpentaria Catfish (*Arius paucus)*	31	12	4	?	?	?	?	?	?	?	?
Hyrtl's Tandan (Neosilurus hyrtlii) ® ∞	7	3	11	✓	?	?	✓	?	?	✓	S
Toothless Catfish *(Anodontiglanis dahli)*	20	3	1	✓	?	?	?	✓		✓	?
Rendal's catfish (porochilus rendahli) ® ∞	18	--	2	✓	?	?	?	?	?	✓	S
Northwest glassfish (ambassis sp)	10	--	8	?	?	?	?	✓	✓	✓	?
Elongate glassfish (Ambassis elongatus)	--	3	8	?	?	?	?	✓	✓	✓	?
Sooty grunter (Hephaestus fuliginosus ®	--	15	12	✓	✓	✓	✓	✓	✓	✓	S
Strawman (craterocephalus stramineus) ∞	--	7	16	?	?	?	?	✓	✓	✓	?
Northern Trout Gudgeon (Mogurnda mogumba) ∞	1	--	--	✓	?	?	✓	✓	✓	?	D
New Catfish (Porochilus sp)	1	--	--	?	?	?	?	?	?	?	?
Fly-specked hardyhead (craterocephalus stercusmuscarum) ∞	--	--	26	✓		✓	✓	✓	✓		R, D

Mariana's hardyhead (craterocephalus marianae) ∞	--	--	3	✓	?	?	?	?	?	✓	?
Neil's grunter (scortum neili)	--	--	1	?	?	?	?	✓	?	?	?
Diadromous Species											
Barramundi (L*ates calcarifer)* © ® ∞	42	18	12	✓	✓	✓	✓	✓	✓		C, S
Freshwater anchovy (*Thryssa scratchleyi)*	25	19	4	?	?	?	?	?	?	?	?
Long tom (*Strongyluar krefftii)*	5	25	16	✓	✓		?	✓	✓	?	R, D
Golden Goby *(Glossogobius aureus*) ∞	18	18	11	✓	✓	✓	✓	✓	?	?	D
Forktailed Catfish (*Arius graeffei)* ®	27	32	--	✓	✓	✓	✓	✓	✓	✓	R, D, S
Diamond Mullet (*Liza alata)* © ®	5	3	--	?	?	?	?	✓	✓	?	?
Small-eyed Sleeper *(Prionobutis microps)* ∞	5	--	--	?	?	?	?	✓	✓	?	?
Speckled Goby (*Redigobius bikolanus)* ∞	2	--	--	?	?	?	?	?	?	?	?
Tadpole goby (chlamydogobius ranunculus) ∞	7	--	--	?	?	?	?	✓	?	?	?
Freshwater Sole *(Brachirus selheimi)* ∞	8	--	--	?	?	?	?	?	?	?	?
Saltpan sole (brachirus salinarum)	1	--	--	?	?	?	?	?	?	?	?
Freshwater Stingray (*Himantura chaophrya)*	2	--	--	✓	✓	✓	✓	✓	✓	✓	?
Crimson-tipped Flathead Gudgeon (*Butis butis*) ∞	4	--	--	?	?	?	?	?	?	?	?
Spotted Scat (*Scatophagus argus)* ∞	1	--	--	✓	?	?	✓	✓	✓	?	D
Small-mouthed Catfish *(Cinetodus froggatti)*	3	--	--	?	?	?	?	✓	✓	?	?
Salmon catfish (arius leptaspis) ®	3	--	--	✓	✓	✓	✓	✓	✓	✓	R, D, S
Nurseryfish (kurtus galliveri)	1	--	--	?	?	?	?	?	?	?	D
River Gar (*Zenarchopterus spp)*	2	--	--	?	?	?	?	?	?	?	?
Pony fish (leiognathus equulus)	--	3	--	✓	✓	✓	✓	✓	✓	✓	?
Silverbiddy (gerres filamentosus)	--	5	--	?	?	?	?	?	?	?	?
Snub-nosed gar (arrhampus sclerolepis) ®	--	4	--	?	?	?	?	?	?	?	?
Papuan River sprat *(Clupeoides cf. papuensis)*	15	--	--	?	?	?	?	?	?	?	?
Total	720	578	535								

© - Commercial Species ® - Recreational Species ∞ **-** Aquarium species ✓ - Large numbers of fish ✓ - Small numbers of fish
? - Limited Information S – Spawning D – Dispersal R – Re-colonisation C - Colonisation

Hogan and Vallance (2005), Renfree and Marsden (2006), Pusey, Kennard and Arthington (2004), Allen, Midgley and Allan (2002), www.fishbase.org (2010)

Appendix 5 – Fishways completed 2008 & 2009 within the SGC

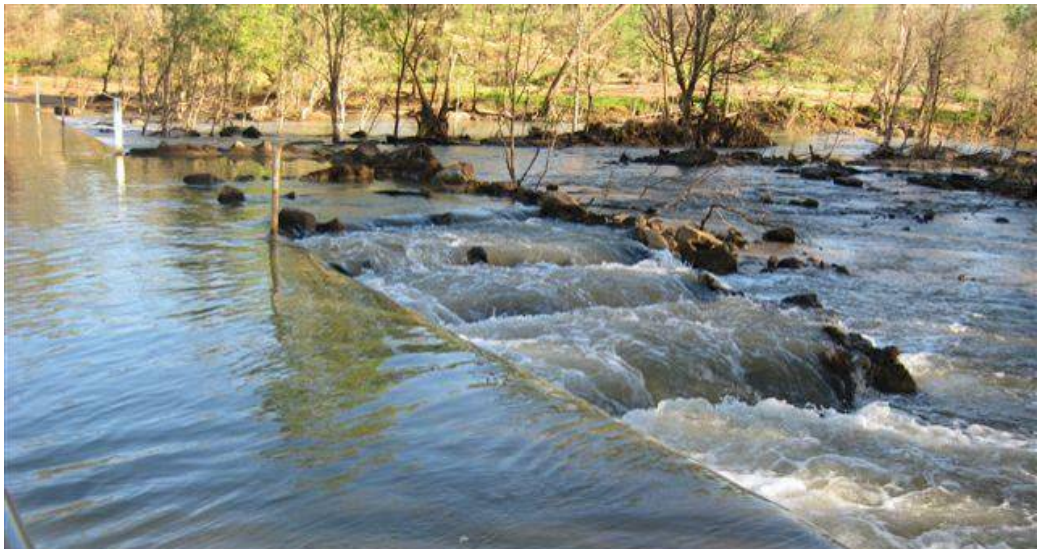
Fishway	Flinders River, October 2009
Type	Pre Cast Concrete Cone Fishway
Height	1.3m
Length	11 meter slab, + 3 culverts
Cells	7 cells
Drops	67mm drops
Materials	Precast concrete cones, concrete walls, rock armouring
How long to construct	7 days

The third photo shows the cut-out section of the upstream box surrounding the culverts, this section was cut-out (0.5m) to allow the fish that have migrated though the fish to exit into the permanent pool upstream.

Fishway	Escott Causeway Fishway, 2008
Type	Pre Cast Concrete Cone Fishway
Height	1.95m
Length	25m
Cells	17 cells
Drops	87.5 mm drops
Materials	Precast concrete cones, concrete walls
How long to construct	11 days

During construction of the fishway at Escott Causeway, the side wall was raised to ensure maximum flow through the first cell.

Fishway	Gregory River Fishway, 2008
Type	Rock Ramp Fishway
Height	600mm
Length	7 m
Cells	5 cells
Drops	100 mm drops
Materials	Rock and Concrete
How long to construct	4 days



The Gregory river fishway during and after construction in 2008

Fishway	Gin Arm Creek Fishway, 2008
Type	Rock Ramp Fishway
Height	1.2m
Length	20m
Cells	13 cells
Drops	100mm drops
Materials	Rock and concrete
How long to construct	4 full days

Gin Arm creek fishway during construction, the rocks were concreted in place to ensure they stayed in position during the high flows of the wet season.

Appendix 6 – Stream Order

The Strahler stream order is the preferred method when defining stream orders. This is used to define stream size based on the hierarchy of the streams tributaries. A first order stream is found at the headwaters of a system; when two first-order streams come together, they form a second-order stream. When two second-order streams come together, they form a third-order stream and so on. An increase in stream order can only be achieved when two creeks of the same order join, if a first order stream joins a second order stream it does not become a third order system; only when two second order streams join do they become a third order stream. (http://www.babylon.com/definition/Strahler_Stream_Order/English)

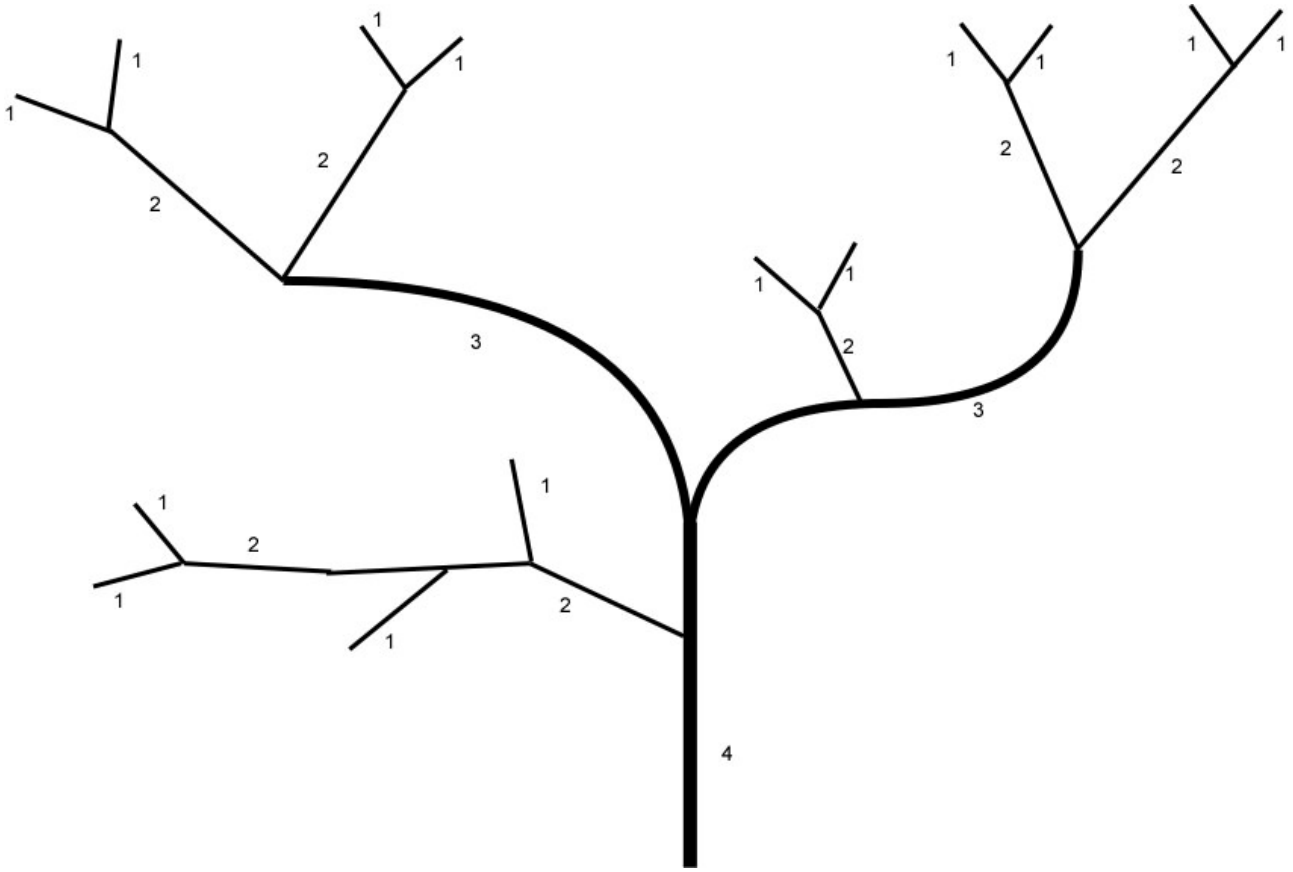


Figure 6. The Strahler Stream Order system