

Wonder Reef

Diver Safety Plan

CITY OF
GOLDCOAST.

 **WONDER REEF**

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Wonder Reef Annual Report

Transport and Infrastructure – City Assets – Beaches



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1. Introduction

The Wonder Reef Precinct includes a purpose-built reef, four moorings and four navigational markers. Wonder Reef comprises of a series nine buoyant sculptural Reef Flutes gravity anchored to the sea floor by Reef Foundations. The buoyant reef design is a first of its kind anywhere in the world.

Wonder Reef is designed to attract and sustain a rich diversity of fish and other marine life while offering an exciting and unique diving experience for certified divers of all levels.

The design of Wonder Reef has been developed in consultation with a local dive industry reference group.

This Diver Safety Plan provides an overview of Wonder Reef. The objective of the Diver Safety Plan is to assist in dive planning and operations and enhance diver safety and wellbeing.

It should be noted that the Diver Safety Plan is limited to providing background information around the design of Wonder Reef. As with all recreational diving, there are a large range of hazards to which divers may be exposed to such as environmental, equipment, marine life and human factors which are not addressed in this Diver Safety Plan.

Ultimately recreational divers are responsible for their own safety. Commercial dive operators should undertake their own due diligence to assess the site's conditions, safety and suitability for their dive group.

2. Site location and accessibility

Wonder Reef is located approximately 3.5 kilometres south-east of the Gold Coast Seaway and 2.5 kilometres offshore from Main Beach, at a depth of approximately 31 metres at the highest astronomical tide (HAT).

The Wonder Reef Precinct is comprised of a 500m x 500m management area. Four navigational markers positioned at the four corners of the precinct delineate the boundary and serve as a notice to marine traffic.

Wonder Reef is positioned approximately in the centre of the Dive Precinct.

Overwater access to Wonder Reef is available through the existing entrance of the Gold Coast Seaway. Overwater access can also be made from the Tweed River entrance approximately 25 kilometres south of the site and the Port of Brisbane approximately 70 kilometres to the north.

Four moorings provide access for dive vessels and maintenance operations.

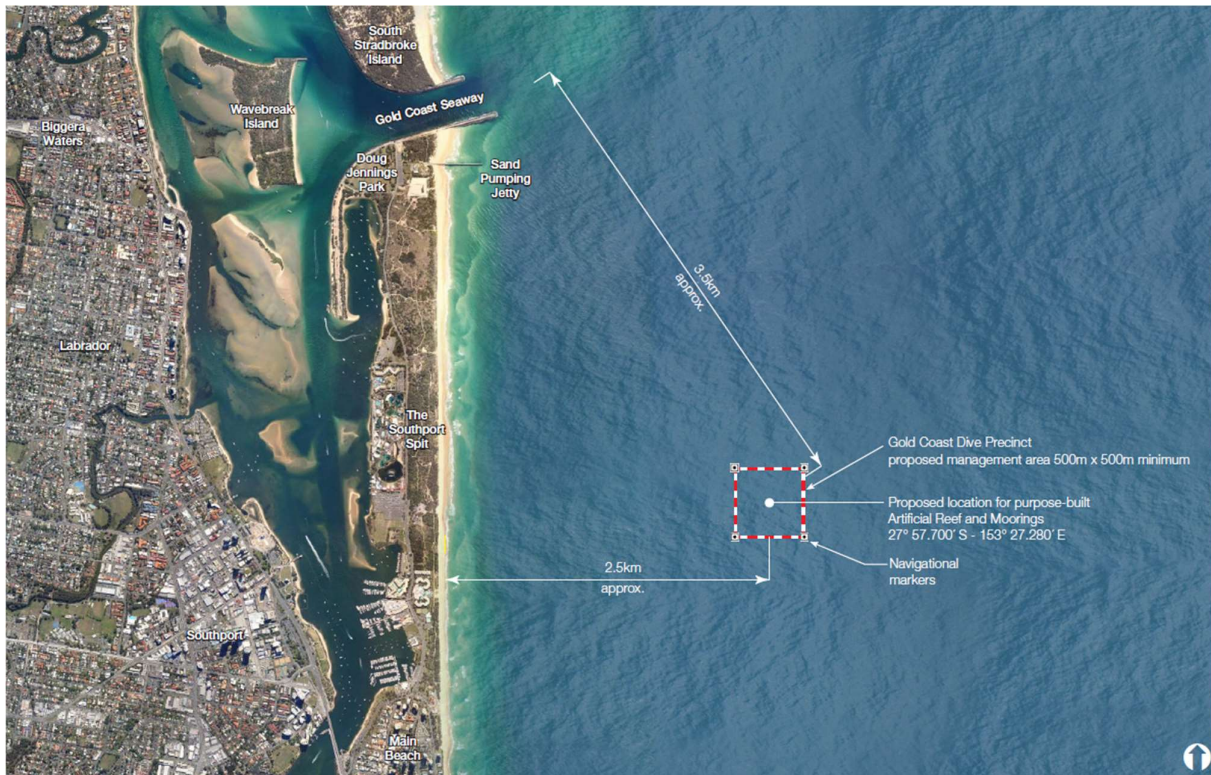


Figure 1 - Purpose-Built Dive Attraction Location

3. Reef design

Wonder Reef consists of nine Reef Structures. Each Reef Structure comprises of a floating Reef Flute, Reef Tether and Reef Foundation. Refer Figure 2.

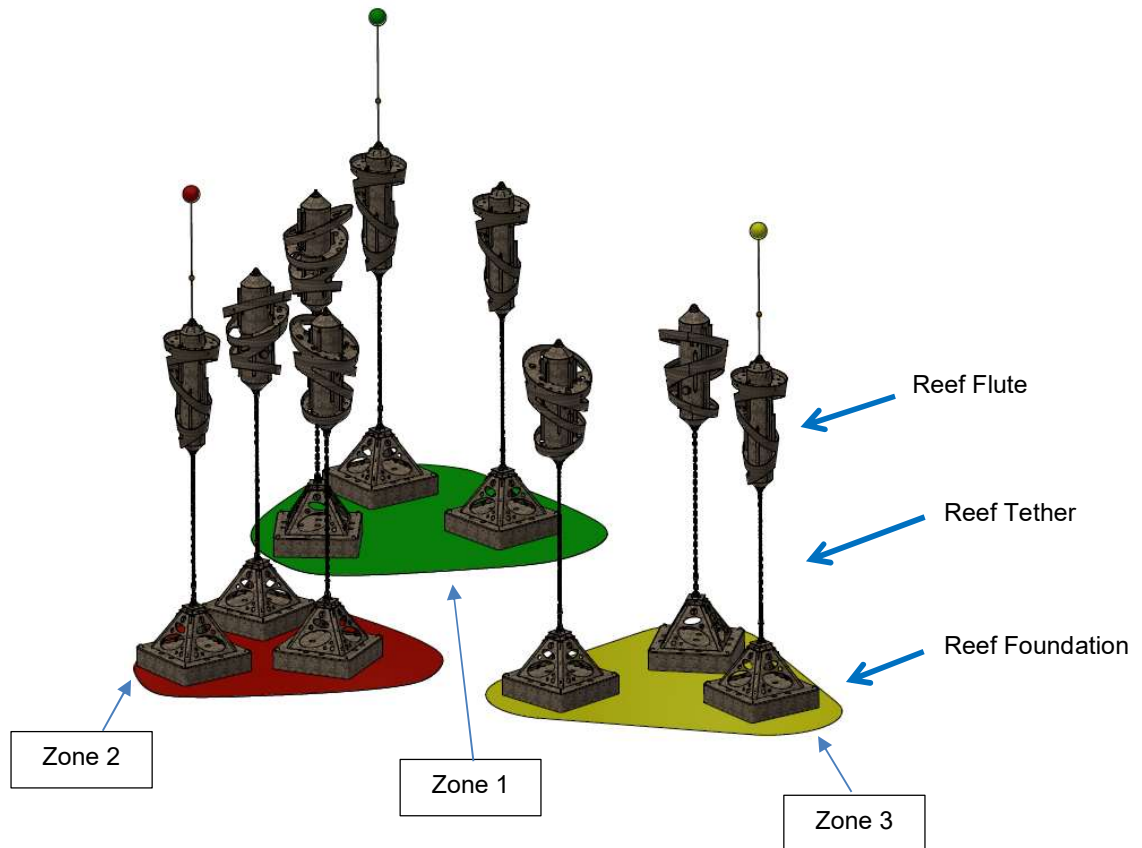


Figure 2 - Gold Coast Dive Attraction Nine Reef Structures

3.1 Reef Flutes

The Reef Flute is the uppermost component of each Reef Structure. The Reef Flutes are positioned as high as permissible in the water column to take advantage of improved visibility conditions closer to the surface.

Each Reef Flute is made of steel and features:

- A large cylinder buoyant tank that allows the Reef Flute to float. Anode rods are attached to the buoyant tank to minimise corrosion overtime.
- A series of ring plates wrapping around the buoyant tank. The ring plates feature holes and standpipes to promote marine growth, prevent silt build-up and allow light to penetrate.

There are two different Reef Flute designs:

- 4 Ring Reef Flute (five total); and
- 5 Ring Reef Flute (four total).

Three of the 5 Ring Reef Flutes have a mooring line attached, allowing divers to descend directly onto the reef flutes.

3.1.1 4 Ring Reef Flute

The 4 Ring Reef Flute features four ring plates wrapping around the central buoyant tank. The 4 Ring Reef Flute is approximately 4 metres wide and 7 metres in length. The 4 Ring Reef Flute is the wider of the two Reef Flute designs.

Large voids (at least 750mm wide) provide vertical swim-through opportunities for certified divers.



Figure 3 - Example swim through on 4 Ring Reef Flute

3.1.2 5 Ring Reef Flute

The 5 Ring Reef Flute features five ring plates wrapping around the central buoyant tank. Handrails attached to the top of the buoyant tank are provided for divers to hold onto while stopping.

Each 5 Ring Reef Flute is approximately 3.3 metres wide and 8 metres in length. The 5 Ring Reef Flute is the slenderer of the two Reef Flute designs.

Three of the four 5 Ring Reef Flutes include a swing mooring attached to the top of the buoyant tank. This allows divers to descend from the mooring onto the reef flutes, following the mooring line. Further details on the moorings are provided in Section 4.

3.1.3 Reef Flute movement

Detailed hydrodynamic analysis has been undertaken to anticipate the movement or “sway” of a Reef Flute (attached to a Reef Tether) in the water as a result of wave forces.

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The “diveable day” wave criteria are deemed to be the most severe weather that divers will still be able to access and safely dive the Reef Structures. This condition is defined is shown in below:

Table 1 - Diveable day weather criteria

Wave Criteria	Water Depth (m)	H _s (m)	H _{max} (m)	T _P (s)	Jointly Occurring Current Speed (m/s)
Diveable day [Ref B3]	29.1	1.1	2	9.5	0.5

On a standard operating “diveable day”, Reef Flutes without moorings (2, 3, 4, 6, 7 and 8) could theoretically move a maximum distance of 0.27 metres over a period of 9.5 seconds. This movement is considered negligible, and it has been assessed that it will not pose a risk to diver safety.

The Reef Flutes with moorings attached (1, 5 and 9) could theoretically move up to 1.6m over the same period, although the analysis was performed assuming a 25m long vessel. Wonder Reef limits the maximum vessel size for these moorings to 14m, therefore movement is expected to be much lower. Regardless, divers should always have awareness of their positioning and maintain appropriate distance from the Reef Flute and Tether including avoiding touching the Reef Tether and connectors. It is recommended that only experienced divers access Wonder Reef in weather conditions approaching the maximum diveable day.

3.2 Reef Tethers

The Reef Tether connects the Reef Flute to the Reef Foundation. The length of Reef Tethers is approximately:

- 9.3 metres for the 5 Ring Reef Flute structures
- 10.3 metres for the 4 Ring Reef Flute structures.

As the Reef Tethers are below 18 metres from the water’s surface, only Advanced Open Water divers can descend to the depth of the Reef Tethers. Advanced divers may use the Reef Tether as a visual guide to descend or ascend along the Reef Structure.

While movement of the Reef Tether is expected to be minimal in diveable conditions, divers should avoid touching the Reef Tether to mitigate potential pinch point injury or risk of finger / hand entrapment.

3.3 Reef Foundations

The pyramid shaped Reef Foundations gravity anchor each Reef Structure to the sea floor, providing stability of the floating Reef Flute above. The Reef Foundations are only accessible to divers with Advanced Open Water certification.

Each Reef Foundation is approximately 5 metres wide by 4 metres high. They are predominately made of steel with a concrete base and steel skirt.

Each Reef Foundation features:

- Large oval cut-outs approximately 1.0m high x 2.0m wide on each side, providing swim-through opportunities for Advanced Open Water divers
- Smaller holes to promote marine growth

- Four D-ring connection points for connecting the wayfinding lines between Reef Foundations

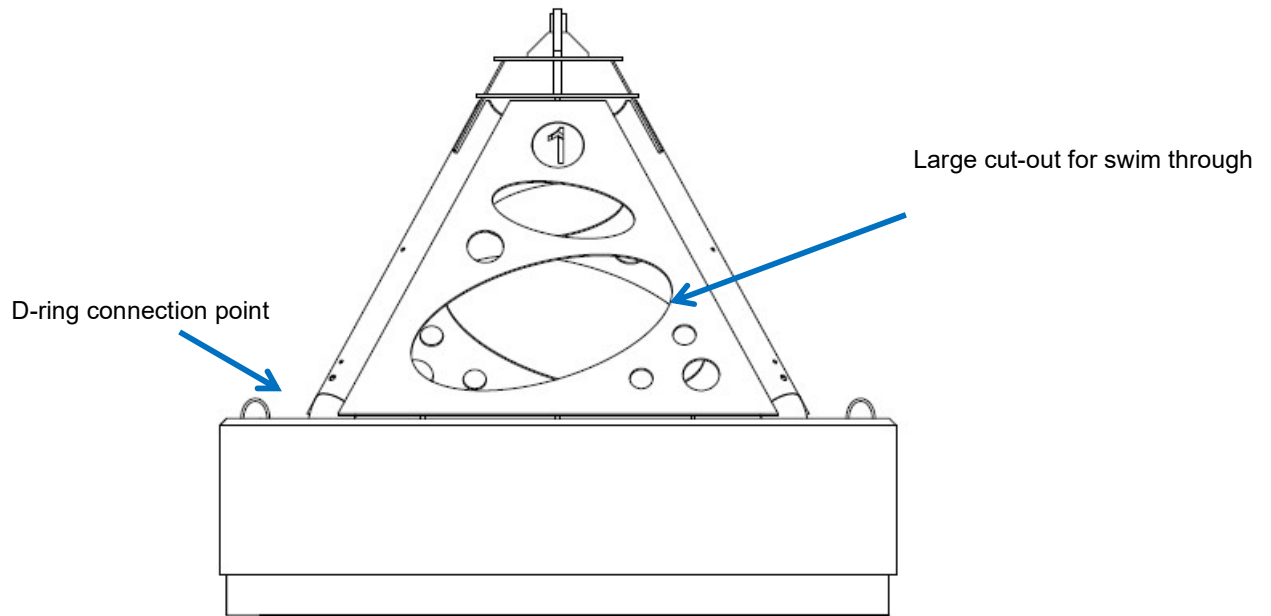


Figure 4 - Reef Foundation Side View

4 Moorings

Four moorings provide access for dive vessels and maintenance operations. The moorings include:

- Three 'Reef Flute moorings', each attached to a 5 Ring Reef Flute (one in each dive zone). These are connected to Reef Flutes 1, 5 and 9
- One 'Outer mooring' gravity anchored to the sea floor.

Bookings for the public mooring can be made at <https://www.wonderreef.com.au/book-now/>. Refer to APPENDIX C: for the Dive Mooring General Arrangement. The mooring design is included in the As Constructed drawing package provided.

4.1 Reef Flute moorings

The three moorings attached to the 5 Ring Reef Flutes provide the most direct access to the Reef, with a maximum swim distance of 30 metres.

The design criteria / features of the Reef Flute moorings include:

- 24 knots maximum wind criteria
- Maximum wave height of $H_s=1.1$ metres
- Maximum swing radius of 10 metres
- Maximum vessel length capacity of 14 metres
- 4 metre rope line with attached to the upper section of the mooring for securing the vessel bow or stern quarter cleats
- Subsurface marker situated at 5 metres from the surface at LAT. Divers will be able to use this subsurface marker as a guide for decompression on ascent. However due to tide variations, divers should rely on their own depth gauge to confirm appropriate decompression depth.

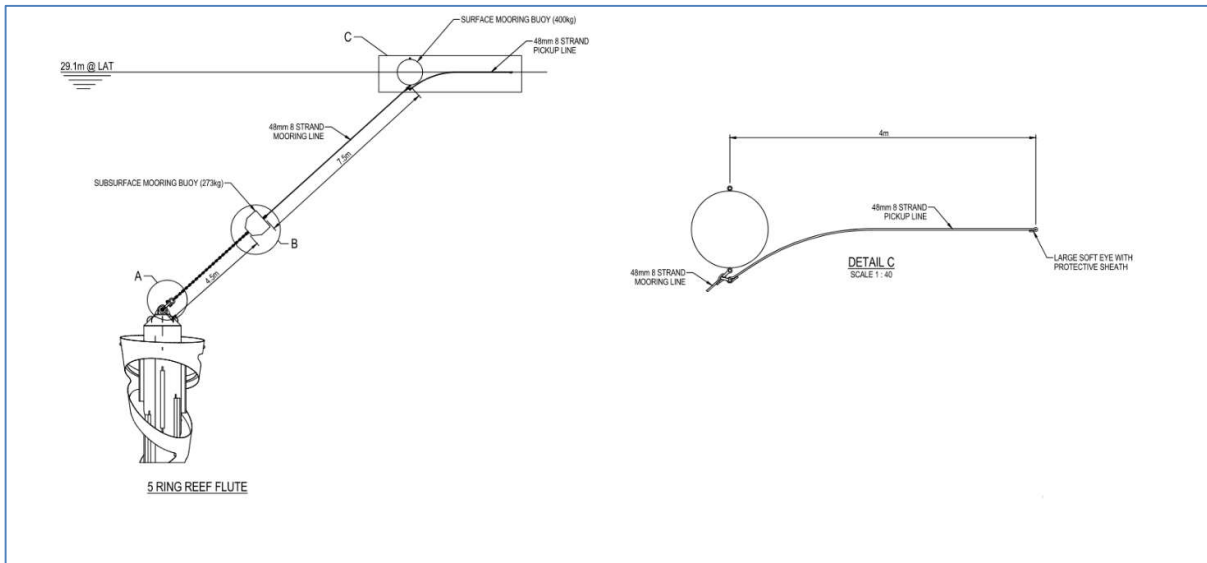


Figure 5 - Reef Flute Dive Mooring (3 on Reef Flutes 1, 5 and 9)

4.2 Outer mooring

The outer mooring is a standard swing mooring gravity anchored to the sea floor with a large concrete block. It has been positioned to the north of the Reef to provide access in a variety of wind conditions, and push vessels closer to the Reef during northerly conditions predominate in the summertime.

The design criteria / features of the outer mooring are:

- Gravity anchor mooring with 1:5:1 scope
- 24 knots maximum wind criteria
- Maximum wave height of $H_s=1.1$ metres
- Maximum swing radius of 43 metres
- Maximum vessel length capacity of 25 metres, providing a maximum swim distance of 111 metres (43m + 43m + 25m) to the nearest Reef Flute
- Installed 45 metres away from the nearest Reef Structure to avoid the potential of the mooring chain tangling with a Reef Structure.

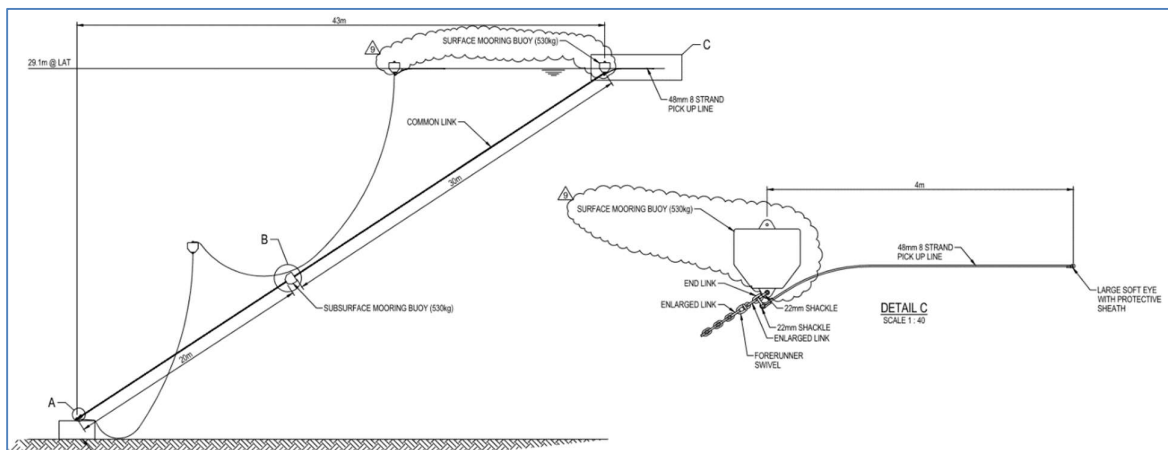


Figure 6 - Outer Dive Mooring

5. Navigational markers

Four yellow navigational markers positioned at the four corners of the Dive Precinct delineate the management area, serve as a notice to marine traffic and advise of any specific restrictions for the precinct. Poseidon 1750 navigation markers made by Sealite are used on this project. They sit approximately 2.6m free of the waterline and are topped with solar powered lanterns for visibility at night.

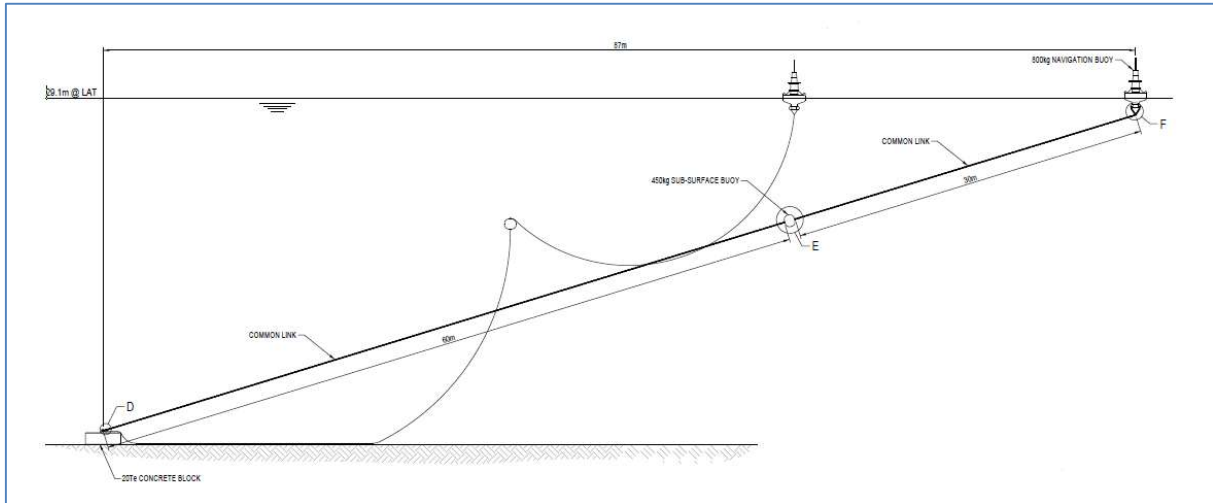


Figure 7 - Navigation Marker - Typical layout

6. Reef elevation and diver depths

Wonder Reef has a maximum depth of approximately 31 metres at the highest astronomical tide (HAT). All the Reef Structures stand approximately 20 metres tall.

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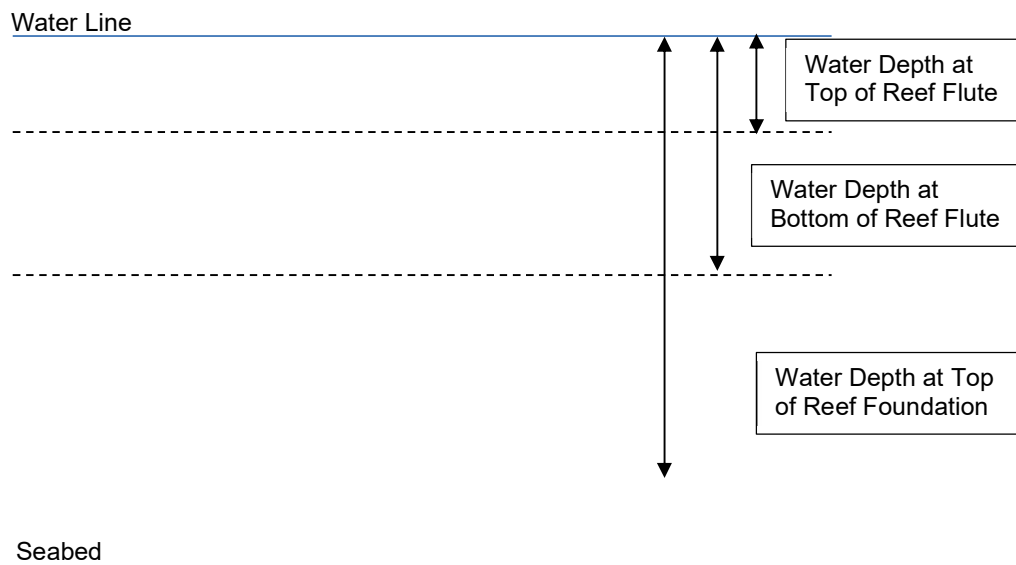


Figure 8 - Water Depths Representation

Error! Reference source not found. below provides a summary of the water depths of the Reef Structures relative to lowest astronomical tide (LAT) and highest astronomical tide (HAT).

Table 2 - Reef Structure Depths

Reef Flute Type	Datum	Water Depth at Top of Reef Flute (m)	Water Depth at Bottom of Reef Flute (m)	Water Depth at Top of Reef Foundation (m)
5 Ring Reef Flute	LAT (29.1)	7.8	15.6	25.1
	HAT (31.01)	9.7	17.5	27.0
4 Ring Reef Flute	LAT (29.1)	7.5	14.6	25.1
	HAT (31.01)	9.4	16.5	27.0

7. Dive Zones

Wonder Reef has three dive zones, each zone having three Reef Structures with one Reef Mooring in each zone. The dive zones are spaced apart to mitigate the risk of moored vessels in each zone colliding. Refer to APPENDIX B: for the Field Layout of Wonder Reef

Dive zone 1 is the western-most zone and features:

- One 4 Ring Reef Flute
- Two 5 Ring Reef Flutes one with a mooring attached.

Dive zone 2 is the southern-most zone and features:

- Two 4 Ring Reef Flutes.
- One 5 Ring Reef Flute with a mooring attached.

Dive zone 3 is the northern-most zone and features:

- Two 4 Ring Reef Flutes
- One 5 Ring Reef Flute with a mooring attached.

The Reef Structures in each dive zone are spaced approximately 10 metres apart (centre to centre).

Each zone caters for a range of certified divers. Divers should be aware that the distances between zones shown in Figure 9 - Dive Zones below are indicative only and represent the minimum distances (i.e., distance from Reef 3 in Zone 1 to Reef 4 in Zone 2 is only 15m). Distances between other inter Zone Reef Assemblies or between Zone 1 and Zone 3 will be greater and this is represented best in Isometric view (**Error! Reference source not found.** below). The maximum horizontal swim distance between Reef Assemblies on Wonder Reef would be between Reef 2 (Zone 1) and Reef 8 (Zone 3) as shown in **Error! Reference source not found.**. Finally, divers of all experience levels should be mindful of the three-dimensional nature of this Dive Attraction and so plan their total dive time and distance accounting for both depth and excursion from the vessel.

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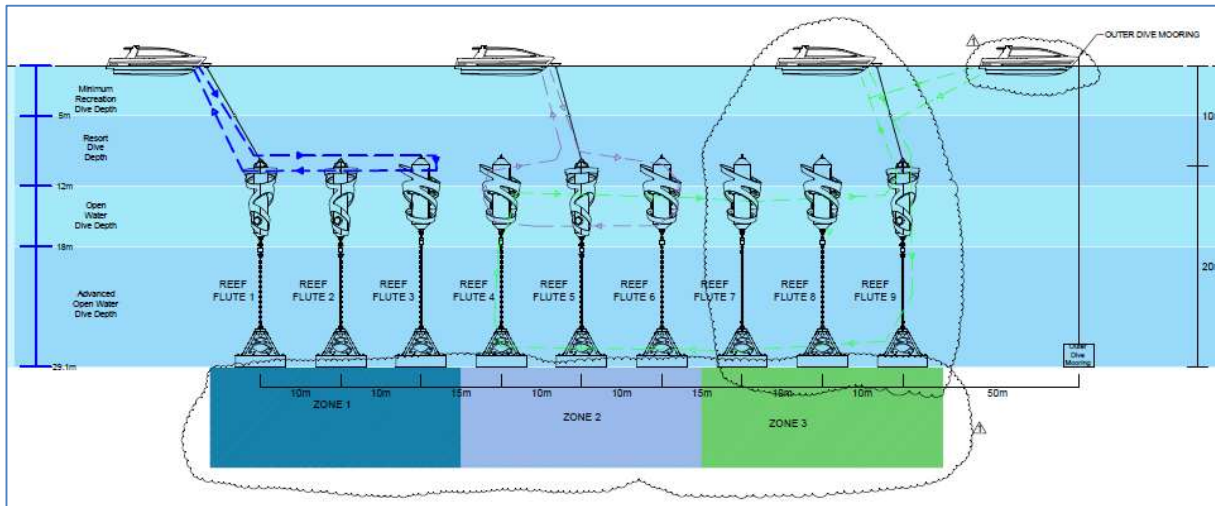


Figure 9 - Dive Zones

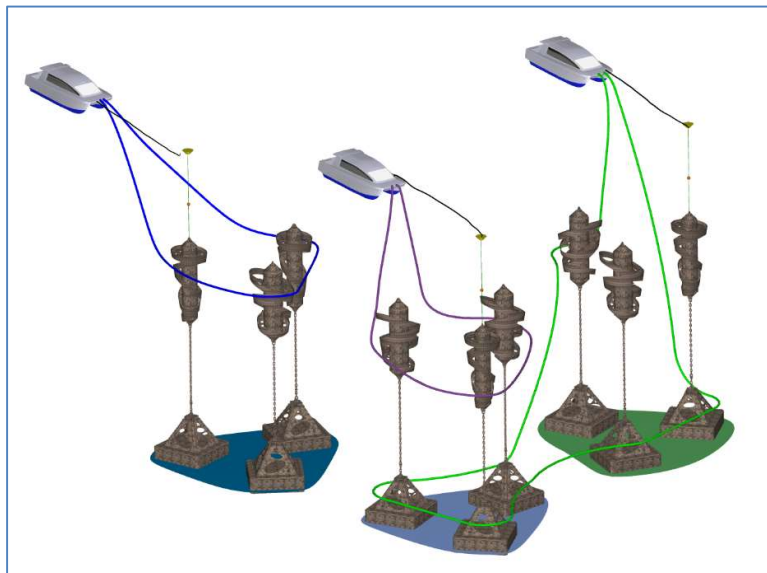


Figure 10 - Example Dive Paths in Isometric View

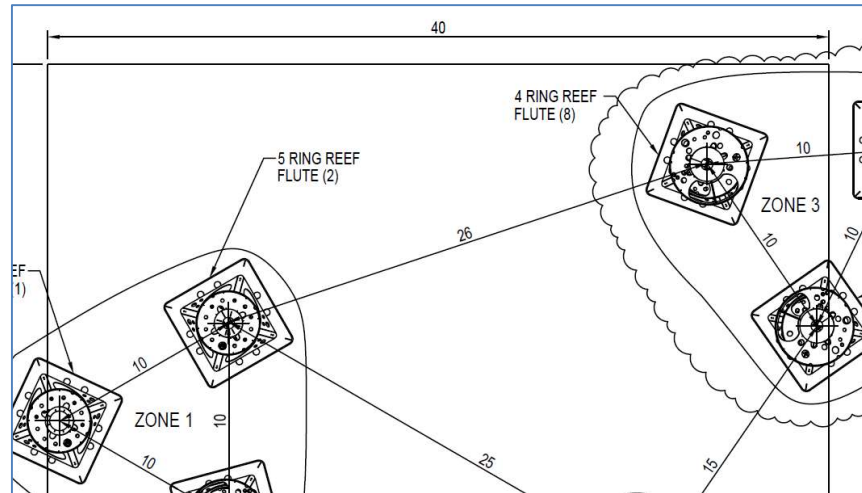


Figure 11 - Maximum horizontal swim distance between Reef Assemblies

8. Example dive paths

8.1 Open Water divers

Certified Open Water divers can plan and execute dives with a certified buddy or dive professional to a maximum depth of 18 metres.

It is anticipated that an Open Water diver would enter the water from a vessel moored directly to a 5 Ring Reef Flute Mooring or the Outer Mooring. There is the option to run a dive line from the vessel to one of the Reef Flutes, as well as between Reef Flutes, noting each Reef Flute has four D Rings for dive lines to be attached.

The bottom of the Reef Flutes is approximately at the 18-metre depth limit (dependent on the tide). As such Open Water divers can experience the entirety of all Reef Flutes and use the bottom of the Reef Flutes as a guide to their maximum depth limit. Divers should, however, use their depth gauge to monitor the distance to the water's surface.

Depending on the experience level of the Open Water diver, it is expected that they could comfortably experience up to six Reef Flutes across two dive zones in a single dive. This includes the option for vertical swim-throughs with the 4 Ring Reef Flutes. Very experienced divers could experience all nine Reef Assemblies in Wonder Reef in a single dive although this would involve a swim distance of approximately 120m or more if multiple depths were explored.

During ascent, divers may use the -5m marker buoy on the mooring line as a guide for their safety stop.

An example dive path is shown in **Error! Reference source not found.** below, however the actual dive path is at the discretion of the diver(s).

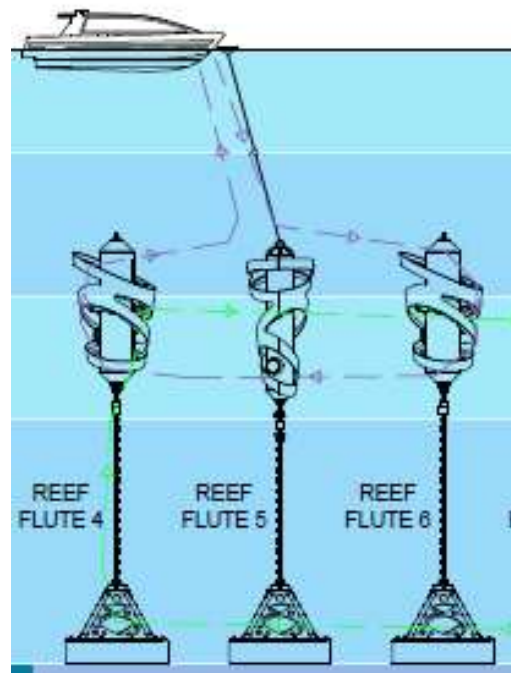


Figure 12 - Example Open Water Diver Path

8.2 Advanced Open Water divers

Certified Advanced Open Water divers can plan and execute dives with a certified buddy or dive professional to a maximum depth of 30 metres. As the Dive Precinct has a maximum depth of approximately 31 metres HAT, Advanced Open Water divers can explore the entire Reef (Reef Flutes, Reef Tethers and Reef Foundations). This includes the option for vertical swim-throughs with the 4 Ring Reef Flutes and horizontal swim-throughs with the Reef Foundations.

The maximum water depth at the top of the Reef Flutes is 27 metres. As such, Advanced Open Water Divers can swim down to the Reef Foundations and use the seafloor as a guide to ensure they do not swim past their 30-metre limit. Divers should, however, use their depth gauge to monitor the distance to the water's surface.

There are four D-Ring attachments on each Reef Foundation (one per side) which provide wayfinding lines connecting each structure within the same zone as well as wayfinding line connecting to each of the other zones.

Divers can use the Reef Tethers as a visual aid during descent and ascent. During ascent the divers may use the 5m marker buoy on the mooring line as a guide for their safety stop. It should be noted that there is no marker buoy on the Outer Dive Mooring.

Advanced Open Water divers should be aware that visibility at the lower depths of the site where the Reef Foundations are is often limited due to particulates in the water such as sand, sediment and weed. Divers should take extra caution and establish points of reference (such as the Reef Tether) during descent and ascent.

An example dive path is shown in **Error! Reference source not found.** below, however the actual dive path is at the discretion of the diver(s).

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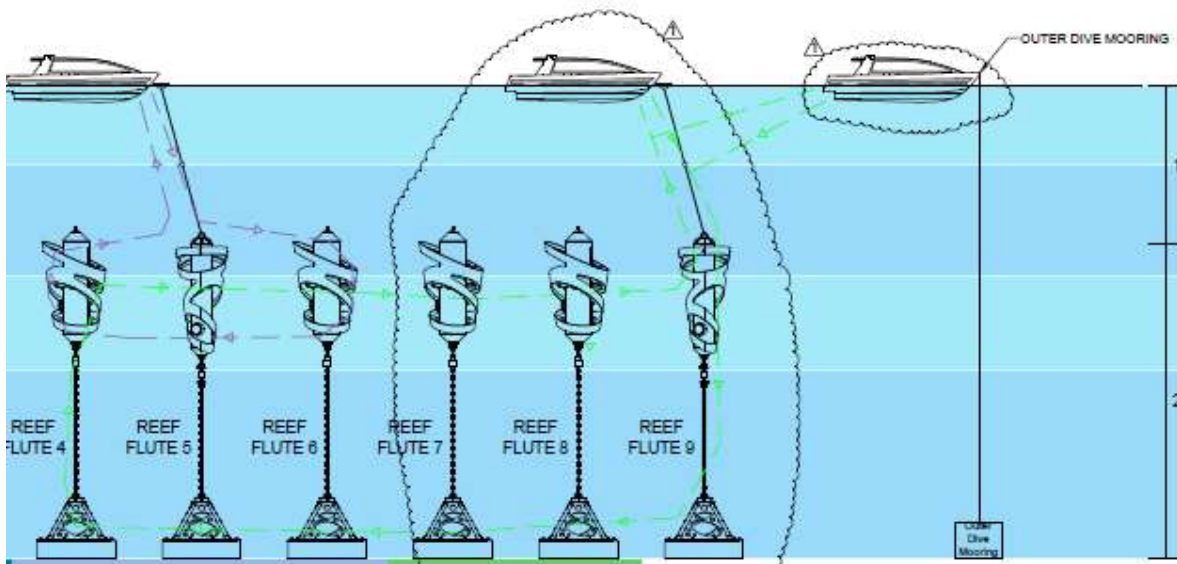


Figure 13 - Example Advanced Diver Path

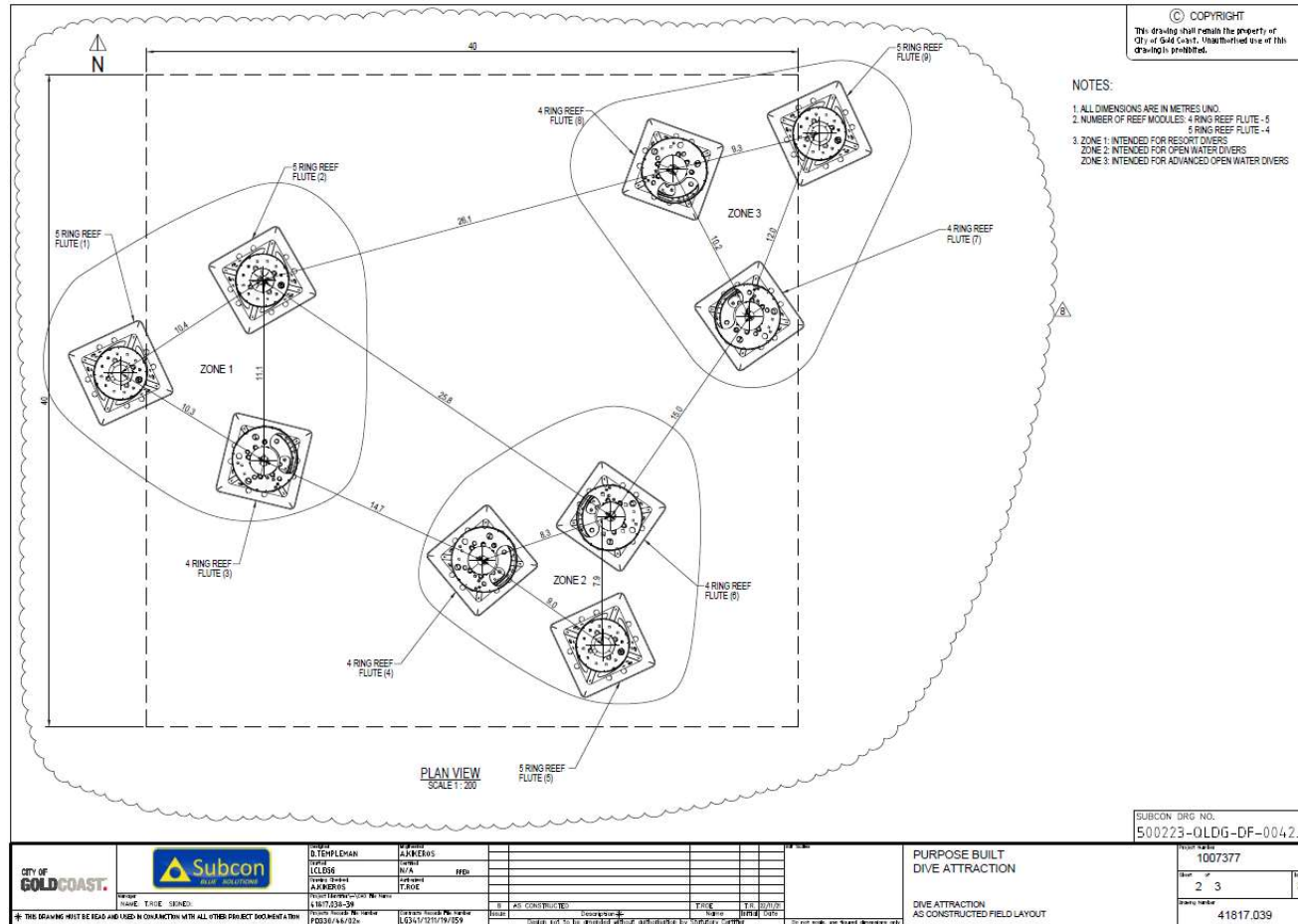
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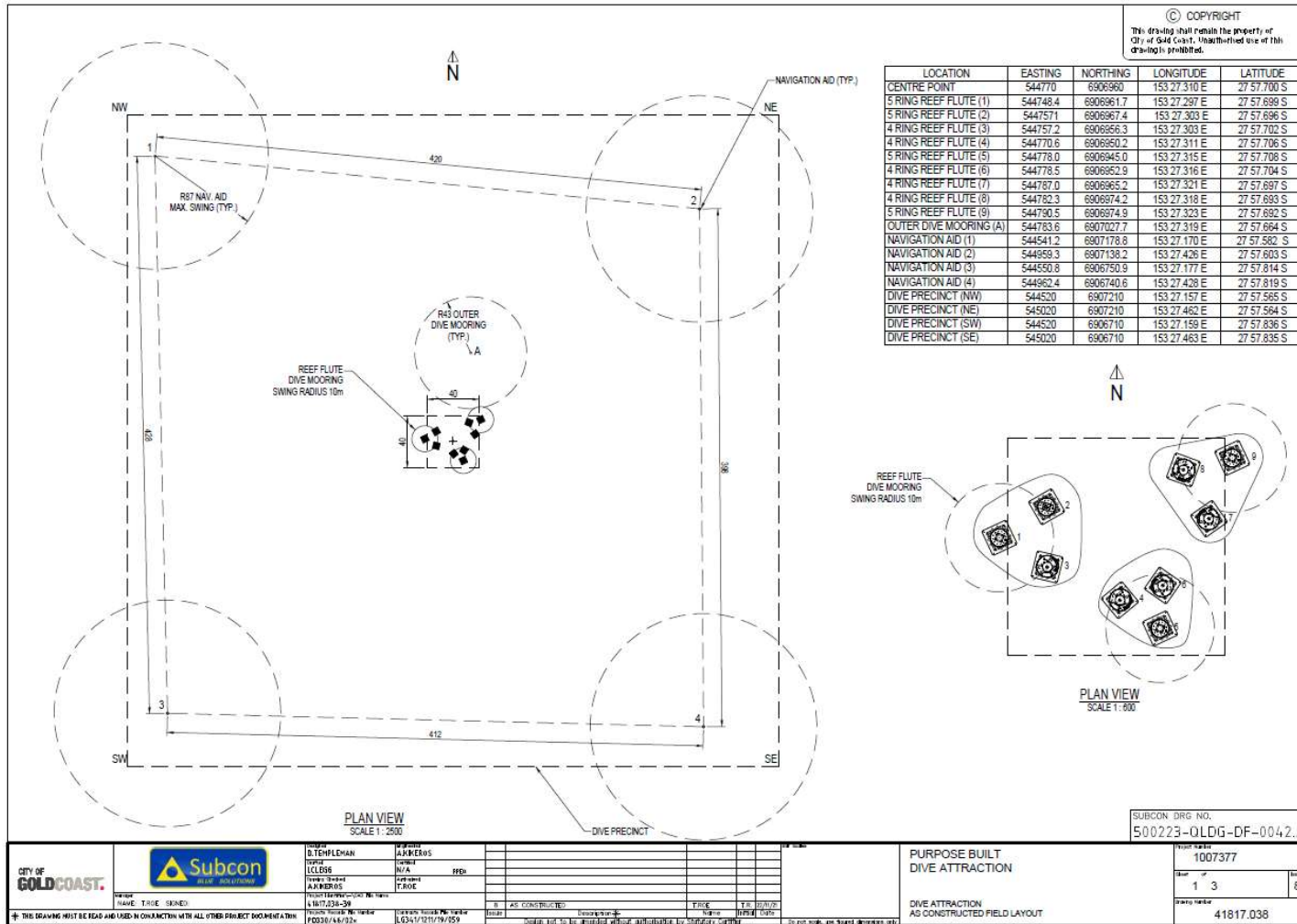
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APPENDIX B: PURPOSE-BUILT DIVE ATTRACTION FIELD LAYOUT



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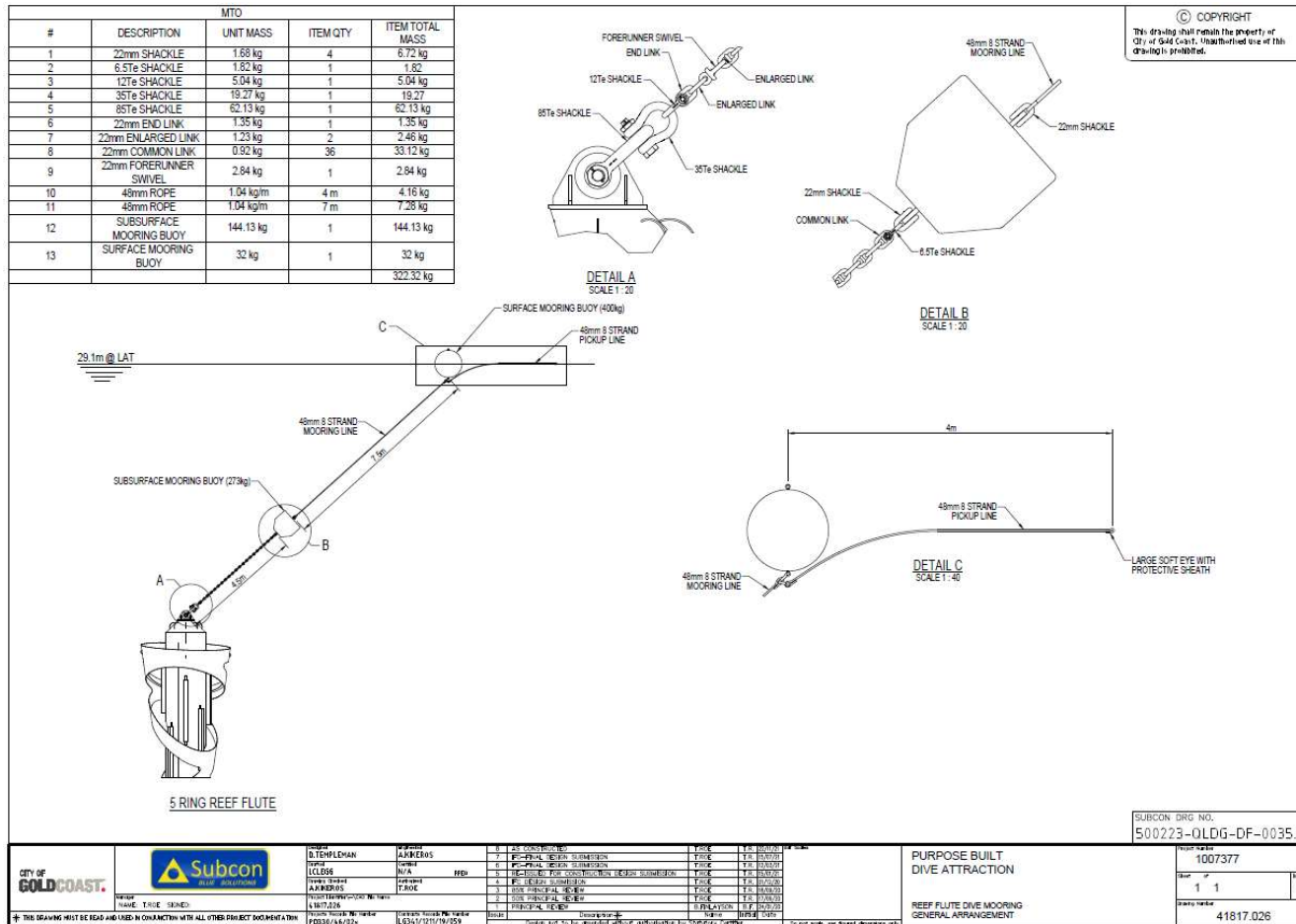
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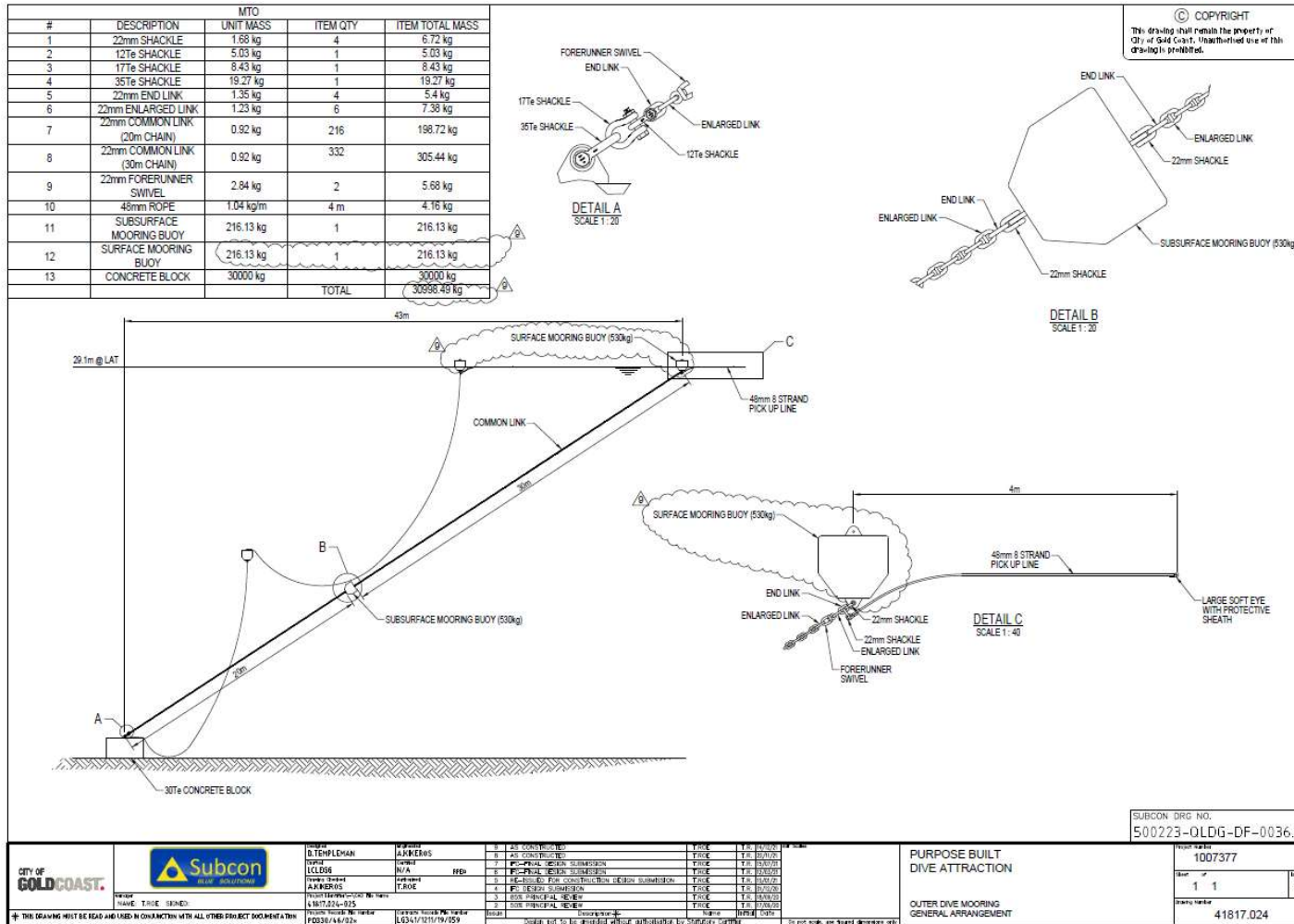
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APPENDIX C: DIVE AND OUTER MOORING GENERAL ARRANGEMENTS



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FOR MORE INFORMATION

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