

PEMBROKE DOCK MARINE INFRASTRUCTURE

Gate 4 – Timber Pickling Pond / Graving Dock Infill

FEBRUARY 2019



CONTACTS



NIGEL HORWELL
Associate Technical Director

dd +44 (0)17 5268 9000

df +44 (0)17 5276 4546

m +44 (0)78 0959 5100

e nigel.horwell@arcadis.com

Arcadis.

Unit 7, Chamberlain

House

Davy Road

Derriford

Plymouth

PL6 8BX

United Kingdom

VERSION CONTROL

Version	Date	Author	Checker	Approver	Changes
01	23.01.19	N.Horwell	A.Branch	G Flower	Original
02	13.02.19	N.Horwell	A.Branch	G Flower	Client Review
03	15.02.19	N.Horwell	A.Branch	G Flower	Client Review
04	06.03.19	N.Horwell	A.Branch	G Flower	RPS Review
05	20.05.19	A Branch	N Horwell	N Horwell	CADW comments

This report dated 06 March 2019 has been prepared for Milford Haven Port Authority(the "Client") in accordance with the terms and conditions of appointment dated 12 December 2018(the "Appointment") between the Client and **Arcadis Consulting (UK) Limited** ("Arcadis") for the purposes specified in the Appointment. For avoidance of doubt, no other person(s) may use or rely upon this report or its contents, and Arcadis accepts no responsibility for any such use or reliance thereon by any other third party.

CONTENTS

1	SCOPE.....	1
2	BACKGROUND.....	2
2.1	Historical Summary	2
2.2	Reference Documents	2
2.3	Liaison	3
3	CURRENT SITUATION.....	4
3.1	Timber Pickling Pond	4
3.2	Graving Dock.....	5
4	CONSIDERATIONS	6
4.1	Masterplan	6
4.1.1	Development Phase 1	6
4.1.2	Development Phase 2	6
4.2	Heritage.....	7
4.2.1	Timber Pickling Pond	7
4.2.2	Graving Dock	9
4.3	Site Drainage	11
4.3.1	Timber Pickling Pond	11
4.3.2	Graving Dock	11
5	SOLUTIONS.....	13
5.1	Timber Pickling Pond	13
5.1.1	Infilling the Pond.....	13
5.1.2	Risks and Opportunities	15
5.2	Graving Dock.....	16
5.2.1	Infilling the Dock.....	16
5.2.2	Option 1 – New caisson gate façade.....	16
5.2.3	Option 2 – Mass wall.....	17
5.2.4	Option 3 – Re-use existing caisson	17
5.2.5	Preferred Option.....	18
5.2.6	Risks and Opportunities	19

6	NEXT STEPS.....	20
6.1	This Study.....	20
6.1.1	Phase 1: Concept Design.....	20
6.1.2	Phase 2: Outline Design.....	20
6.2	Additional Work.....	20

APPENDICES

APPENDIX A

Historic Drawings of Pembroke Yard

APPENDIX B

Existing Site & Reconnaissance Plans (extracted from RPS EIA Scoping Report – June 2018)

APPENDIX C

Masterplan Rev.L (RPS dated April 2018)

APPENDIX D

Culvert Location / Routes (Atkins Pickling Pond Culvert System - Preliminary Inspection Report dated June 2013)

1 Scope

Pembroke Dock Marine is a proposal to develop a world-class centre for heavy fabrications, principally related to wave and tidal stream energy development, fabrication, testing and deployment at the former Royal Naval dockyard of Pembroke Dock, which is now under the ownership and control of Milford Haven Port Authority (MHPA). The development is part of the Swansea Bay City Deal programme supported by the UK Government and the Welsh Government and administered through a joint committee of four regional Local Authorities.

The scope of Arcadis's commission is to provide concept technical solutions / design proposals for sealing and infilling the Timber Pickling Pond and the Graving Dock within an area known as Gate 4 to the west of Pembroke Docks (see **Appendix B**). Budget costs will be prepared for each of the infill areas (+/- 25%) and presented in a later version of this technical note. This is known as **Phase 1**. The commission for Phase 1 is based on the following assumptions:

- a. The swept path analysis and concept and outline design of the mega-slip will be undertaken by others.
- b. Surfacing and any buildings (and their foundations) built within or straddling the infill areas will be designed by others, although account will be taken of the general intent.
- c. The surface load bearing and related aspiration for settlement (short and longer term) requirements for the infill areas are to be confirmed. However, it is assumed for the purpose of this technical note that standard highway loadings will apply.
- d. The Planning Consultant (RPS) is undertaking additional ground investigation, sampling and testing in the Timber Pickling Pond. It is assumed that this includes sediment thickness, geotechnical characteristics and contamination testing and that interpretative reports will be provided at a later date. The disposal, treatment or remediation of contaminated soils/sediments (if any) will be resolved by others. As stated in Arcadis' offer, at this stage it is MHPA's intent that all sediments found within the Timber Pickling Pond and Graving Dock will be removed and disposed of at an appropriate disposal site. In addition, the Timber Pickling Pond and Graving Dock are listed and, consequently, Listed Building Consent (LBC) is required for any works to the structures, with emphasis that any works preserve the structures as far as reasonably practical.

The Pembroke Dock Marine development will create a flexible, port-related industrial area capable of meeting the needs of the modern blue economy and will be the subject of an outline planning application for the erection of buildings, extension to the slipway and associated development at the port, as well as a Marine Licence application to the Natural Resources Wales Marine Licensing Team (NRW-MLT). Design for the erection of buildings and the extension of the slipways is being undertaken by others, however technical solutions for the infill work may impact on the nature of this work. Hence the impact of proposed technical solutions on the work being undertaken by others will be highlighted within this technical note.

MHPA has appointed consultants RPS to prepare the Outline Planning Application including an Environmental Impact Assessment (EIA). This document will be used to inform the EIA.

Phase 2 will involve outline design following the approval of the Phase 1 Concept Design proposals from the MHPA. Additional data will be identified to inform the design process. For this phase MHPA will need to define their planned use of the land to determine the structural load carrying capacity of the backfill, and expectations concerning future buildings' foundation arrangements, floor slabs and related loading. Arcadis will prepare outline design drawings and outline specifications for the proposed infill works. These will be supplemented by calculations and records to support the design process and decisions. The budget cost estimate will be updated based on the outline design drawings and specifications. The cost estimate will include an elemental breakdown of all items reflective of the level of detail shown on the drawings.

2 Background

2.1 Historical Summary

Pembroke Dockyard (formally Pater Yard) was established in 1813. The site has been extended and developed over the years to cater for a variety of uses including a Graving Dock in the mid-19th century. A heritage assessment of the site has been undertaken (Heritage Assessment – Port of Pembroke, August 2016, Turley Heritage), parts of which are summarised in this document, and should be referenced for a wider heritage perspective.

The focus of this report is to propose options for the continued protection of the grade II* listed Graving Dock and Grade II listed Timber Pickling Pond during the proposed development of the dockyard site, the historical background to each is given below:

The **Timber Pond** (or Pickling Pond) was constructed in 1844 to allow new timber to equalise in saline water for ships masts (a process known as “pickling”). It is formed of limestone retaining walls with granite copings on the north, south and west side with a sloping paved revetment on the east side. The invert is formed of puddle clay. There is an ‘egg’ shaped culvert outlet on the north wall and there is a controlled inlet/outlet culvert with tidal flap and sluice gate on the west wall at invert level.

The **Graving Dock** was constructed in circa 1858, replacing a smaller dry dock at the same location. At the time of construction, it was the largest dry dock facility in Britain and helped elevate the importance of Pembroke Docks as a marine construction facility. The dock walls are formed of five steps (or altars) in Limestone Ashlar which are integrated into a stone invert. The dock entrance is narrowed with battered walls and a slot to secure a caisson gate. The south end of the dock has been extended more recently and is formed of concrete and currently houses the dock caisson gate. The caisson is a ‘ship’ style caisson, curved in section similar to a ship’s hull, and is largely intact although its specific internal condition is relatively unknown and requires a further detailed survey. The dock has granite copings and 12 iron bollards are located along each side. Remnants of damaged capstans are also evident.

2.2 Reference Documents

The following documents have been supplied by MHPA:

1. Roy (Nov 1843): “Sketch of proposed Pond for the preservation of elm timber”
2. Unknown Source (1862): “Plan of Pembroke Yard – showing water mains and pipes”
3. Unknown Source (Oct 1863): “Dock at Pembroke Yard – Transverse and Longitudinal Sections”
4. Contract Surveys (Aug 2008): “Services Layout” Ref: W6727.007/SW-TE/001
5. Contract Surveys (Aug 2008): “Topographic Level Survey” Ref: 5728/500A0/2.2
6. Jacobs (Dec 2010): “Graving Dock Refurbishment/Upgrade – Preliminary Feasibility Study” Ref: B1185504/R-1 (Rev A1)
7. Atkins (Jun 2013): “Gate 4, Pickling Pond Culvert System – Preliminary Inspection Report” Ref: 5116155-008 DG01_Inspection Report (v2)
8. RSK (Mar 2015): “Site within Gate 1 – Pembroke Dock – Preliminary Risk Assessment – Ground Conditions and Contaminated Land” Ref: 312994-R1 (00)
9. Aspect (Nov 2015): “Pembroke Dock 4 - Hydrographic – Sub-Bottom Geophysical Survey (incl. Section sheets 1 & 2” Ref: A5715
10. Turley Heritage (Aug 2016): “Port of Pembroke – Heritage Assessment”
11. Royal Haskoning DHV (Aug 2016): “Pembroke Dock Redevelopments – Ground Investigation Report” Ref: PB4337-R007-D01 (Rev 01/Draft)
12. RPS (Apr 2018): “Pembroke Dock Marine – Draft Proposed Masterplan” Ref: JPW1115-04 (Rev.L)
13. MHPA: “Demolition / Intervention Plan” (Rev.B)

pembroke dock marine infrastructure

14. RPS (May 2018): "Proposed Investigation Locations" Ref: JER1262-SR-001 ((Rev.B)
15. RPS (Jun 2018): "Pembroke Dock Marine – Environmental Impact Assessment – Scoping Report" Ref: 180615 R JPW1115 DW EIA SR (v3)
16. CADW (Jul 2018): "Pembroke Dock – Scoping Opinion" App.Ref: 18/0332/SO
17. NRW (Jul 2018): "Pembroke Dock – Scoping Opinion" App.Ref: 18/0332/SO
18. Pembrokeshire Council (Aug 2018): "Pembroke Dock – EIA Scoping Opinion" App.Ref: 18/0332/SO
19. MHPA (Oct 2018): "Pembroke Dock Marine – Supplementary Information to the Full Business Case" (Rev. Working Draft)
20. MHPA (Jan 2019): "Sketch – Storm Drains – Units 29 & 29A"
21. MHPA (Jan 2019): "The Triangle – Land Ownership"

2.3 Liaison

Arcadis visited site on 8th – 9th January 2019 and held a workshop with the following:

- Tim Bownes (MHPA – Engineering Director)
- Tim James (MHPA – Director of Energy Development)
- Steve Phillips (MHPA – Port Engineer)
- Adrian Rowlands (MHPA – Engineering Project Manager)
- Dafydd Williams (RPS – Associate)

The workshop focussed on methods of sealing and infilling the timber pickling pond and graving dock and the outcome is the subject of this technical note.

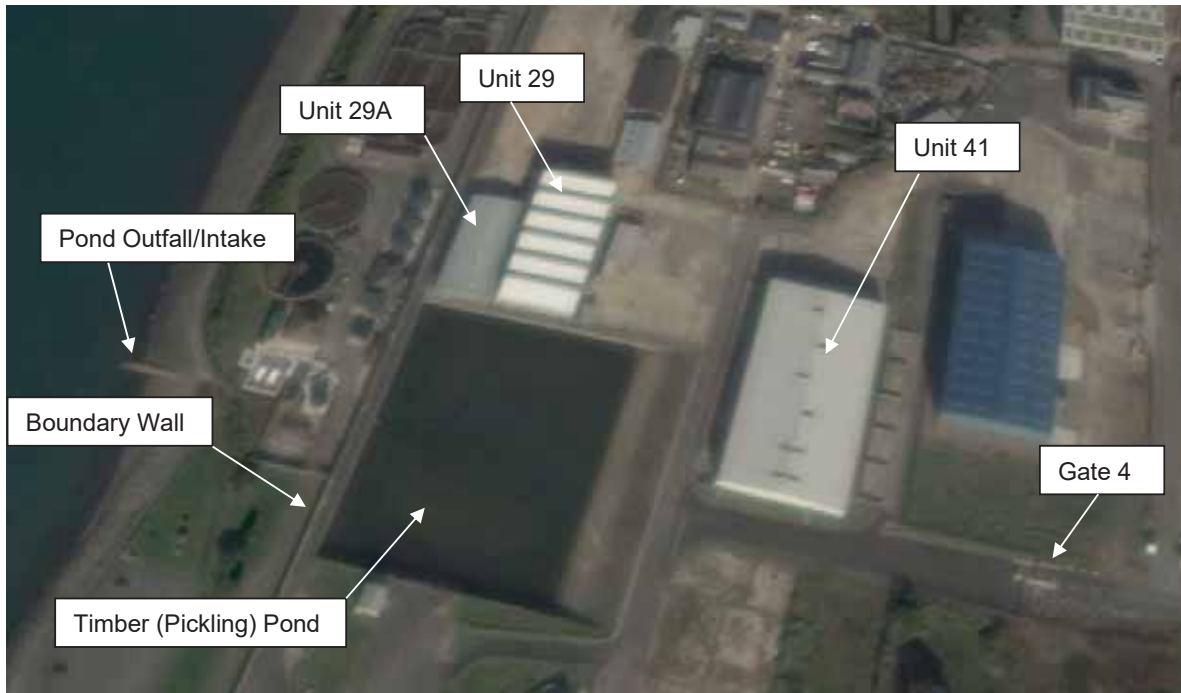
In addition, we have spoken to the following:

- Stuart Berry (Pembroke Dock Sunderland Trust - Heritage Centre Manager)

3 Current Situation

3.1 Timber Pickling Pond

The timber pickling pond is located on the western side of the dockyard and is surrounded by late 19th and 20th Century buildings. The buildings immediately to the north are disused (**Units 29 & 29A**). The building to the north east (**Unit 41**) is currently used by Pembrokeshire Council as a waste transfer station.



Aerial View of Timber Pickling Pond (courtesy of Google Earth © 2019 DigitalGlobe)

There are areas of extensive hardstanding to the south and east of the structure and Gate 4 lies some 50m to the east of the pond.

Access roads divide the pond from the building and access gate to the east. To the west, an access road divides the pond from the boundary wall. To the south there is a small building of historic nature and a storage pile of granite cope stones. Further to the south is a car park and an access road which links the western and eastern roads. Two gates penetrate the historic boundary wall which, in the past, allowed vehicle access to the car park and access roads. The gates are now disused.

The pond is protected by a pedestrian guard rail, reinforced, where necessary, by un-tensioned corrugated vehicle protection barriers (UCB). Precast concrete blocks have been placed behind the UCB to the east to guard against large vehicles from penetrating the barrier and entering the timber pickling pond after passing through Gate 4.

3.2 Graving Dock

The graving dock forms part of the northern edge of the dockyard along with the remaining slipways and the Carr Jetty. There is an access road immediately to the south of the graving dock level with cope stones which rise to form the northern edge of the road. There are disused railway tracks built into the road arising from the previous operation of the dockyard.



Aerial View of Pembroke Docks – Gate 4 Area (courtesy of MHPA)

The area immediately to the west and east of the graving dock is raised and grassed and protected from intrusion by a security fence with gates accessing either side.

On the southern side of the access road is an area known as “The Triangle”. The buildings and perimeter walls around this area are owned by third party landowners and are currently used for light engineering purposes (i.e. car repairs).

4 Considerations

4.1 Masterplan

4.1.1 Development Phase 1

4.1.1.1 Construction of new Mega-Slip

The operation seeks to create a new super-structure access slipway geared mainly for use by marine energy technology developers and marine operations (**Areas 3 & 4** – see **Area J** in **Appendix C**). The new slipway will combine two existing slipways creating combined structure that aims to extend into at least 5 - 8m of water at all states of the tide, meaning 12m depth at most high tides (see **Appendix B – Site Reconnaissance Plan**). Slipway No's 1 and 2 are Grade II Listed structures.

The first stage will be the careful dismantling and recording of those elements which form the listed structure. The dismantling will expose the 'wedge' of infill land behind the masonry walls so this will be reduced in level. The material arising could be used to assist with the infill to either the graving dock or the timber pickling pond depending on legislative controls, regulatory approvals and its suitability as a structural fill. Depending on the nature of the material and the masonry it may be necessary to remove the fill in advance of the masonry; this will be confirmed during detailed design.

4.1.1.2 Infilling of the Timber Pickling Pond

The infilling of the Timber Pond (also known as the pickling pond) is required to allow a large Fabrication Building for sub-assemblies and marine engineering related activities to be constructed (whilst the exact size is to be confirmed the maximum dimensions of the building will be 170m x 70m x 40m to ridge) (**Area 9**). The Timber Pickling Pond is a Grade II listed structure.

The timber pickling pond is technically the marine environment, so will need to be considered in the Marine Licence application. Once the Timber Pickling Pond is isolated from the Marine Environment it may be possible to agree that a Marine Licence is no longer necessary for the area.

In discussion with CADW, MHPA has agreed to consider the following restrictions:

- a. Foundations for the building should not damage the walls of the Timber Pickling Pond;
- b. The western wall, road and barrier should remain;
- c. Provide a lower level walkway between the building and the adjacent perimeter road with the pond west wall facade visible; and
- d. If practical, the sloping stone access to the Timber Pickling Pond should remain in-situ.

4.1.2 Development Phase 2

4.1.2.1 Infilling of the Former Graving Dock

The Graving Dock is currently derelict, and it is proposed to infill the Graving Dock to enable a high bay ship repair and fabrication facility to be erected in the future (whilst the exact size is to be confirmed the maximum dimensions of the building will be 75 x 65 x 40m to ridge) (**Area 10**). This work will be part of a later development phase. The former Graving Dock is a Grade II* Listed structure.

In consultation with CADW, MHPA has agreed to consider the following being incorporated in order to mitigate heritage impact:

- a. Retain the dressed stone entrance walls
- b. Re-locate or replicate the Caisson Gate in the original position
- c. Permanently identify the footprint of the Graving Dock on the new hard-standing.
- d. Other features such as the bollards to be re-located (where possible in locations which give them appropriate context) and preserved
- e. Graving Dock to be sensitively infilled to enable extraction to be undertaken in the future (if required).

4.2 Heritage

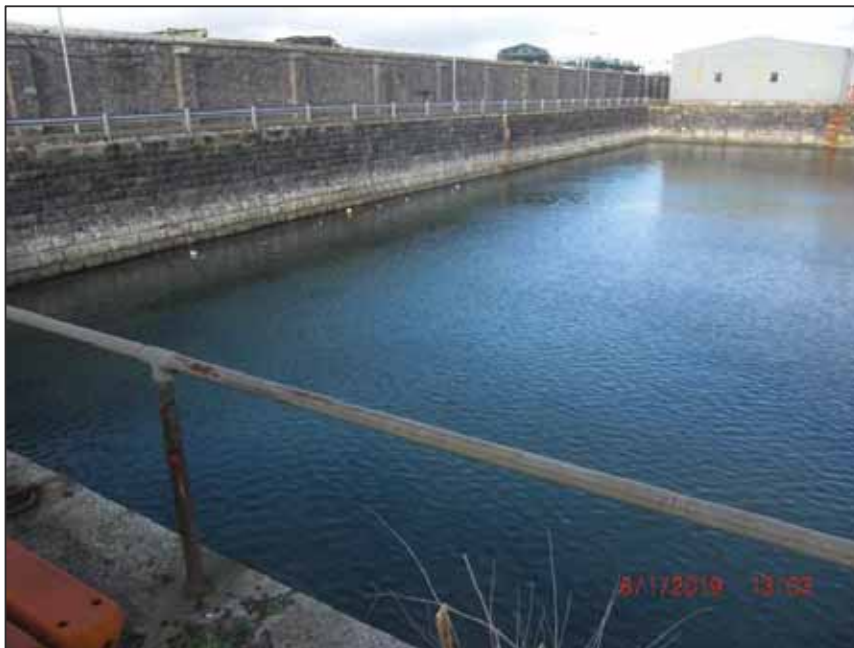
Section 2 above outlines the importance of the heritage of the site, and the individual importance of the structures at the Timber Pickling Pond and Graving Dock.

Heritage assessments have been carried out and CADW has been engaged and consulted from an early stage to ensure that proposed works are developed to ensure that heritage fabric is preserved, and the wider context of the historical port remains legible.

The constraints from a heritage perspective to which the infilling works should be carried out are described for each site below.

4.2.1 Timber Pickling Pond

Historical context It is considered important that the timber pickling pond remains legible following the proposed development. Therefore, the structure will be carefully recorded, including the culverts to both the north and west walls, to ensure the form is understood. It is proposed that the top section of the western wall could remain visible, including copings and a portion of the stone fascia, to give a visual signpost to the location of the Timber Pickling Pond and the form and materials used in its construction.



View of the west wall of the Timber Pickling Pond

pembroke dock marine infrastructure

Limestone retaining walls - These are located on the north, south and west sides of the pond. These ideally should remain intact, including the granite copings



View of the north wall including the culvert outlet

Sloping Stone Revetment - This is located on the east side of the pond. Corroded pipes are located at the northern end which are noted on the 1862 drawing as saltwater supplies for an adjacent smithery tank and Saw Mills (now demolished). There is evidence of damage caused by past work across the revetment. Any further damage to the revetment should be minimised and remain localised where possible (i.e. minimal breakout to allow piling etc.).



Sloping stone revetment to the east side of the pond

Puddle Clay Invert – It is envisaged that building foundations (piles etc.) may pass through this layer but this should be limited as much as possible. The clay could be retained as it forms the historical invert to the pond but its removal would facilitate quicker settlement of this area of the pond.

4.2.2 Graving Dock

Historical context – The Graving Dock is visible within the wider site context. It is adjacent to the slipways and other buildings, it has a frontage to Milford Haven and original quayside furniture remains largely intact. The ship style caisson gate also remains largely intact although further detailed internal and external surveys are recommended. The structure will be carefully recorded, including locations of bollards and capstans and any other furniture or associated equipment. Following infilling, the aim should be that the entrance to the dock remains visible to such an extent as to give a clear legibility as to the form, function and location of the Dock.

Limestone Ashlar Altars and granite copings - These are located on the east and west sides of the dock and should be preserved intact where possible. Any foundations to the proposed buildings should be designed not to damage the fabric of these walls, so the buried footprint of the structure needs to be fully understood. The infilling should allow for a protective layer of sand or other suitable material to all faces including the granite copings. As described above, the entrance to the docks should remain visible.



West side of the graving dock showing the limestone ashlar altars

Limestone Invert – As with the altars, this should be protected, and the foundations of any proposed structures designed not to damage the fabric

Original Bollards and Capstans – Location and details should be recorded. Where possible these should remain in-situ, which is likely to be at the dock entrance area. Where it is not possible for them to remain in-situ they should be carefully removed intact and either stored or reused on site, ideally where their original function can be readily understood.

pembroke dock marine infrastructure



Existing iron bollard on the east dock wall

Existing Caisson Gate – The caisson gate is currently located at the south end of the dock. It appears largely intact, but a specialist survey would be required to determine its exact condition. It is a very good example of a ‘ship’ type caisson, i.e. with a cross section resembling a ship’s hull. It is a clear, legible link with the Graving Dock structure, with the grooves to secure the caisson in place still visible in the walls at the dock entrance. If possible, and subject to structural condition, the caisson should be retained in a location such that its connection to the Graving Dock can be appreciated.



The existing caisson gate

4.3 Site Drainage

4.3.1 Timber Pickling Pond

There is a considerable amount of existing surface water and foul water drainage around the site of the Timber Pickling Pond. To the north of the pond, the pavement area has a network of drainage gullies. Anecdotal evidence suggests that these drain into a combined foul/surface water sewer that runs along the access road to the east of the pond though the combined topographic and service survey of the area notes two separate discharge points into the pond along the pond's northern edge (both 100 & 150mm dia.). The existing vacant buildings (**Units 29 & 29A**) to the north of the Pond discharge roof rainwater runoff directly onto the pavement which then drains into the pond. Gullies on the access road to the east of the pond also drain directly into the pond through 100mm dia. pipes which pass through a small concrete retaining wall. In addition, the concrete paved area to the southeast is shown on the service drawing to discharge through a 150mm dia. pipe into the pond.

There is an existing large brick culvert that exits through the north wall of the pond. It appears that this is no longer in use and does not carry any drainage, but this would need to be confirmed. It is believed that the original use was to drain water from the Graving Dock which was pumped through a network of culverts into the Timber Pickling Pond (see **Appendix A** - 1862 drawing + **Appendix D**). This is still a potential informal drainage route and consideration will need to be given to blocking the exit into the pond prior to infilling.



Existing culvert outlet on the north wall and a road gully and outlet on the east wall

A new surface water drainage system will need to be devised for the development that eliminates runoff into the pond area and that properly intercepts and routes surface water to a separate discharge point from the site.

Consideration also needs to be given to drainage of the Timber Pickling Pond once infilled. Currently the pond is filled with seawater via the western culvert with a flap valve located on the inside of the pond's west wall. The function of the flap valve is to allow seawater in rather than letting it out. The structure was designed to be water retaining and therefore there is the risk of it becoming waterlogged, once infilled, if some form of permanent drainage is not incorporated into the design.

4.3.2 Graving Dock

There is no visible evidence of a formal surface water drainage system that empties into the Graving Dock but this will need to be confirmed by survey, particularly to the south of the Dock which is of more recent construction, close to an access road and currently mostly obscured by the caisson gate. Historic drawings show a culvert opening in the invert on the centreline at the original southern end of the dock (see **Appendix A** – 1863 drawing). Anecdotal evidence suggests that this was a conduit used to pump water out of the

pembroke dock marine infrastructure

Dock into the Timber Pickling Pond. The dock was extended to accommodate the ships caisson but only excavation of the sediment on the original end of the dock invert will reveal existence of the culvert's opening. The drainage design for the proposed development will need to ensure that surface water runoff is properly intercepted and does not discharge in the Graving Dock area. In a reverse manner to the Timber Pickling Pond, the Graving Dock was constructed to be water-excluding, but once infilled, proper consideration will need to be given to the drainage of the area to avoid it becoming water logged.

5 Solutions

5.1 Timber Pickling Pond

The following section outlines the proposed solution for the infilling of the Timber Pickling Pond.

5.1.1 Infilling the Pond

A key requirement of the infilling of the pond is to minimise damage to the historic fabric of the structure and keep it as intact as possible. The topography of the site is such that the coping level of the majority of the dock is up to 850mm lower than the adjacent ground and road level. This offers the opportunity to set the finished floor/road level of the proposed development such that the majority of the pond can be buried intact. The exception to this would be the western side where the cope is close to access road level. In order to align with the CADW restrictions that MHPA has agreed to consider (see 4.1.1.2), this area provides an opportunity to leave the top section of the wall exposed, in order to show at least a part of the structure which will otherwise be buried. The masterplan notes the provision of a walkway between the current western access road and the proposed new building to be built over the pond. The Supplementary Information for the Full Business Case (Section 2.5.3) suggests that the walkway level could be around 2m lower than the western cope in order to showcase the heritage. However, if this is to be provided, then the walkway would need to be provided with adequate drainage to prevent it from retaining water and this presents a problem for the design of the new surface water drainage system that the west road would need.

To facilitate the infilling and reduce long term settlement (as the soft sediments consolidated), the pond would need to be cleared of all existing sediment. Any drainage pipes, culverts etc. would also need to be suitably blocked up and the drainage re-routed. A protective layer of sand can then be placed on the invert and this would include both the limestone pitching which can be seen on the eastern side and across the top of the puddle clay which forms the bottom of the pond. Care in sediment removal, informed by advance survey of thicknesses, will be needed to prevent puddle clay being mistaken for sediment. This protective layer can be built-up against all faces as the backfill progresses.

The backfill would be a suitably specified granular, structural fill material. It may be possible to use excavated material from the site (i.e. mega-slip construction) as infill subject to contamination testing and an assessment of whether this material would be useful. Reuse of existing material would offer a sustainable solution which would reduce cost, programme duration and waste. It would be well compacted in layers to minimise internal self-weight settlement and ensure a suitable bearing capacity. However, due to the layer of puddle clay, and dependent on its thickness, settlement within this material may exceed MHPA performance limits at the fill surface. Post-completion settlement could be reduced, for example, by surcharging the infill, to accelerate settlement, such that when the surcharge is removed, a stable fill level will have been established. This can be achieved by overfilling the pond and then removing the surcharge layer when the formation level is desired for construction. In addition, if, for example, project economics favours an available clay infill, vertical drainage “wicks” and/or horizontal drainage bands linking to the perimeter protective sand layer could be used to accelerate settlement by increasing the rate at which pore water is removed from the low permeability infill. This will be the subject of detailed design when the characteristics of the infill are known.

In order to help accelerate settlement, the puddle clay lining (away from the limestone pitching) could be excavated and replaced with compacted structural backfill. This would need to be agreed with the appropriate authorities.

The Atkins “Preliminary Inspection Report” for the pickling pond culvert system helpfully includes a section on how the pond was drained for the purposes of the inspection. The system will need to be permanently replicated in order to prevent the infill to the pond from becoming waterlogged. Hence, the western tidal flap valve will need to be either removed or lifted and then permanently secured in the open position. In addition, the penstock gate will need to either be removed or secured in the open position. The west culvert will then need to be plugged with concrete or a geopolymer resin-based material. The plug will need to incorporate through-drainage in order to ensure that any water that does enter the pond can be drained into the estuary. This through-drainage outlet will be “flapped” in order to allow water out but exclude tidal water from

penetrating in. Hence, effectively, the existing western outlet will continue to serve a function, but this will become a function to drain excess groundwater from the infilled pond rather than to fill it up.

The western culvert could be used to discharge surface water from the southern end of the Gate 4 site as it already provides direct access to the estuary and there is already a significant volume of water discharging from it at low tide. However, the culvert is at depth and the area will be covered by a large building. Access manholes will need to be located within the building and an agreement made that these should not be covered over preventing access.

The fill will naturally become fully saturated (over time) up to the surrounding Ground Water table level. Water Table equalisation cannot be prevented, but the tidal rise and fall of large volumes of water needs to be prevented to avoid the wash-out of the fine fraction in the fill. If wash-out was allowed to occur, then collapse settlement would develop over time which needs to be avoided.

The penstock chamber may provide a suitable location for the flap noted above but the Atkins report does not provide a chamber size. From photographs it is estimated at 1.4m square with an invert level of +0.6mOD (+4.3mCD) and a depth of 5.5m. Using this location will facilitate inspection and maintenance of the flap valve.

The Atkins report notes that the northern culvert used to drain the graving dock has a fall into the pond with an invert level of +2.3mOD (+6.0mCD). This outlet will also need to be plugged in a similar fashion to the western culvert and through-drainage will need to be incorporated to prevent water from accumulating within the culvert. For culvert locations and routes see **Appendices A & D**.

The building proposed for this site will need to be designed such that the foundations do not damage the walls of the timber pickling pond. Due to the need for movement routes along the western and eastern sides, the building line will be located inside the pond east and west walls. The building structural grid will need to be large enough to ensure that the northern and southern pond walls are “spanned” and that foundations are located away from the walls. This can be achieved by careful consideration of the foundation locations. Piled foundations for the building structure are thought to be most appropriate but this will involve local “holes” being taken out of the limestone pitching forming the eastern side of the pond and penetrations through the puddle clay on the western side. The ground water in this area is high and likely to also be linked to the tide, therefore there are no expected implications to the puddle clay due to penetrating with support piles. As mentioned above, the puddle clay may however need to be removed to control settlement. There is also the possibility of hard spots developing over the copings. The specification and placement of the fill should limit these hard-spots but it would be prudent to make allowances in the design of the floor slab should this be ground bearing.

Since there will be a varying depth of fill from east to west under the floor slab of the building, then there will be an increasing expectation of settlement from east to west. Although greater settlement is expected on the western side, this is expected to be more uniform (due to the similar depth of infill) and hence easier to accommodate. If the floor slab is expected to be ground bearing and subject to loading soon after placement of the infill then a high degree of compaction for the infill will be required and a clay infill can be ruled out. The most logical way of eliminating this settlement will be to adopt the surcharge solution described earlier in this section.



The northern wall of the timber pickling pond with Unit 29 behind.

5.1.2 Risks and Opportunities

The following risks have been identified:

- A drainage strategy will need to be developed for the site in order to avoid the infill within the timber pickling pond from becoming waterlogged.
- Following infill, there will be varying differential settlement from east to west across the site. This risk can be minimised by surcharging the area to induce more rapid settlement.
- If the floor slab is to be ground bearing, then more time will be required between placement of fill and load imposition than if the slab was to be located on piles. However, a piled slab will damage the limestone pitching.
- The building's structural grid will need to be arranged to enable the pond's north and south walls to be spanned.

The following opportunities have been identified:

- The tidal flap valve and penstock gate could be removed, renovated and displayed locally to provide historical information to help inform the heritage context of the pond.
- The timber pickling pond walls could be allowed to remain intact by designing a road/floor slab level that enables the cope stones to remain insitu.
- Settlement could be accelerated by removal of the pond's puddle clay lining (away from the limestone pitching) and replacement with compacted structural backfill. The puddle clay lining under the historic limestone pitching will need to remain in order not to damage the pitching.

5.2 Graving Dock

The following section outlines the proposed solution for the infilling of the Graving Dock. The proposal for the infilling of the dock is given along with a number of options that focus on the dock entrance in particular.

5.2.1 Infilling the Dock

A key constraint to the infilling of the dock is to minimise damage to the structure and keep it as intact as possible. The topography of the site is such that the coping level of the majority of the dock is lower than the adjacent ground and road level. This offers the opportunity to set the finished floor/road level of the proposed development such that the majority of the dock can be buried intact with the copings remaining in situ. The exception would be the part of the dock to the extreme south. This is the newer construction, formed of concrete, which has a higher coping level, close to existing road level. This section is likely to need to be lowered to accommodate the development.

Bollards and capstans would also need to be relocated except at the dock entrance where it may be possible to retain them in their original position. By relocating within the development, they can retain a visual link and some context to their original use in the docks.

The Graving Dock is likely to be founded on good strata, existing information suggesting that mudstone is present close to the level of the invert of the dock. Given that the dock walls and inverts are formed of substantial mass limestone, it is likely that the structure will be capable of accommodating the loading from infilling without any risk of substantial settlement or damage to the existing structure.

To facilitate the infilling, the dock would need to be cleared of all existing material. Therefore, silts would need to be removed from the dock as well as the current rubble ramp located at the south east corner and the caisson gate located to the south of the dock. Any drainage pipes, culverts etc. would also need to be suitably blocked up, or if still 'live' run through the infilled dock to a new outfall. A protective layer of sand can then be placed on the invert and built up against all faces as the backfill progresses. The backfill would be a suitably specified granular, structural fill material. It would be well compacted in layers to minimise settlement and ensure a suitable bearing capacity.

As the Graving Dock is designed as a water-excluding structure, once the caisson is located and sealed, the infill will need to be provided with a drainage outlet. This is best located at the dock entrance with "flapped" outlet to the estuary so as to allow water out but exclude tidal water from penetrating in. As noted in the Timber Pickling Pond (Section 5.1), potentially the fill will become saturated (over time) up to the surrounding Ground Water table level. That cannot be prevented, but the tidal rise and fall of large volumes of water needs to be prevented to avoid the wash-out of the fine fraction in the fill. If wash-out was allowed to occur, then collapse settlement would develop over time which needs to be avoided. The flap valve arrangement will provide an outlet for groundwater.

The building proposed on this area of the site will need to be designed such that no deep piles are required within the footprint of the Graving Dock that could impact the structure, including any buried elements. There is also the possibility of hard spots developing over the copings. The specification and placement of the fill should limit settlement, but it would be prudent to make allowances in the design of the floor slab and consider surcharging the infill as described in section 5.1.1 above. The ground to either side of the Graving Dock is likely to be poorly compacted and variable so careful consideration needs to be given to the form of structural footings.

The dock entrance will need to be blocked off using a retaining structure. There are several options for achieving this as described below:

5.2.2 Option 1 – New caisson gate façade

From the liaison that has currently been undertaken with Cadw and Pembrokeshire County Council, there is a desire to maintain a heritage link to the existing caisson gate. It is very unlikely that the existing caisson can be refurbished such that it could safely retain the infill to the dock. Therefore, this option proposes fabricating a new retaining wall with a façade resembling the seaward face of the caisson gate, designed to retain the infill material in the dock. The new facade would be fabricated to replicate the existing and would

be placed at the dock entrance in the location the existing caisson would have been used. The existing caisson could be recovered, restored and displayed in a suitable location elsewhere on or near the site.

This option has the advantage that the new façade could also block off the dock entrance and retain water during construction so the infilling can be undertaken in the dry, making the operation quicker and easier. It also maximises available land. However, given the intricate shape of the existing caisson, it may be difficult to fabricate, and would need maintenance over its life, including repainting. The existing dock entrance wall would also need to be assessed for the additional imposed loading and may need to be strengthened.

5.2.3 Option 2 – Mass wall

This option proposes to use a mass concrete wall to retain the fill. The location of the wall would be set back to give a good visual appreciation of the entrance to the Graving Dock and the location the old caisson would have occupied when operational. A mass wall can be founded on the invert of the dock and designed such that it will not damage the existing structure. It will also be fairly simple to build which is an advantage given the tidal nature of the docks. As with Option 1 above, the early indications from superficial inspections suggest the existing caisson could be recovered from the dock, restored and possibly displayed in a suitable location.

An advantage of this option is that the simplicity of a mass wall structure would reduce the risk of the works causing damage to the listed structure. Once the mass wall is installed the infilling operation could also be carried out in the dry. It also protects the existing caisson, which will have a much longer residual life when outside of the tidal environment. There is, of course a risk that existing caisson cannot be recovered intact, in which case it would have to be carefully removed in sections. This which would make restoration more difficult but might provide the opportunity to make the internal structure of the caisson more visible. It is planned to make a more detailed assessment of this at a later stage.

5.2.4 Option 3 – Re-use existing caisson

This option relocates the existing caisson to the dock entrance but uses either a gravity or reinforced earth structure to retain the infill material. The existing caisson would be relocated to the dock entrance and fixed in place. Limited restoration works to the caisson may be possible to accessible elements. As the caisson will not be able to retain the infill (it is designed to resist force from the water outside, not inside), a new retaining structure would be constructed. This could be either a mass wall or a reinforced earth structure. Both could be designed not to load the caisson and to retain fill to the back face of the caisson. The level of fill at the caisson could be lowered by a few metres to partially expose the back face and the top of the stone altars; however suitable drainage would need to be provided to this area. It will be difficult to find a drainage route that does not damage either the caisson or the Graving Dock.

This option showcases the caisson in its intended position and gives visibility to some of the heritage features of the dock. There is a risk however that the caisson cannot be moved intact. Also, once in place, the caisson will be exposed to a harsh environment and will be difficult to maintain, which will limit its remaining life.

5.2.5 Preferred Option

The table below shows each of the options scored against key criteria. Each criteria is scored from 1-5 with 1 being a negative impact and 5 being a positive impact.

Option	Preservation of heritage fabric	Heritage link between caisson and dock structure	Risk to the caisson and surrounding infrastructure	Ongoing maintenance required and longevity of the caisson	Overall cost of works	Total Score
1	5	3	4	3	2	17
2	5	4	4	4	3	20
3	2	5	1	2	2	12

After due consideration, the preferred option is to use a mass wall and recover the existing caisson for restoration as described in **option 2**. This option requires the least amount of in-service maintenance in the marine environment which has significant health and safety benefits. It also allows a significant proportion of the dock entrance to remain visible, which will aid the interpretation of the dock once the remainder is infilled. Restoring the existing caisson, possibly for display in an appropriate nearby location, gives a good visual link and will maximise its remaining life. The building design for this area should ensure that any piling required is outside of the footprint of the Graving Dock (including any buried elements) to avoid damage to the structure.



The entrance to the graving dock which will be maintained under the preferred option

5.2.6 Risks and Opportunities

The following risks have been identified in the delivery of the preferred option:

- The condition of the dock wall under the rubble ramp is not known and it may need to be repaired;
- The condition of the existing caisson cannot be determined without a further staged approach, and it may not be possible to extract it from the dock intact;
- Ground conditions under the dock will need to be assessed to confirm the underlying strata

The following opportunities have been identified in the delivery of the preferred option:

- The refurbished caisson can be a focal point of the development. A similar style caisson is being displayed in the Hamilton Dock in Belfast (<https://titanic-foundation.org/our-heritage/the-hamilton-dock-pumphouse-and-the-caisson-gate/>);



Similar style caisson being displayed in the Hamilton Dock, Belfast (photograph credit www.titanic-foundation.org)

- Features of the dock will be retained and visible (e.g. the dock entrance, caisson slot and quayside walls.
- The dock will be preserved intact and in-situ; and
- Items such as bollards and capstans can be reused both close to and elsewhere on site.

6 Next Steps

6.1 This Study

6.1.1 Phase 1: Concept Design

The next step for this study is to prepare drawings for the Concept Design for infilling of the Timber Pickling Pond and Graving Dock, to be submitted by RPS with the Outline Planning Application (OPA). The drawings will be based on site data provided by MHPA and the concept designs developed in this technical note. They will set-out the proposal for the asset to address the geotechnical, structural and heritage aspects, and will show the proposed materials and proposed surface loading.

Separate drawings will be produced for the Timber Pickling Pond and Graving Dock showing:

- A drawing to showing the existing site plans, a section and elevation
- A drawing of the proposed site plans, a section and elevation

6.1.2 Phase 2: Outline Design

Having received approval of the Phase 1 Concept Design proposals from the MHPA and when development funding has been secured, Phase 2 will be progressed to produce an Outline Design. It is estimated that Phase 2 will take 6 weeks to complete.

A second site visit and workshop will be arranged with the project team, the RPS project team, a Civil Engineering Contractor, the Pembrokeshire County Council Conservation Officer and the Arcadis project team. This visit will provide the opportunity for a more detailed examination of the site and existing assets. All bollards, coping stones and other unique features will be identified and recorded. A detailed visual inspection of the Graving Dock caisson is required to enable an assessment of its integrity and possibility of reuse.

Outline designs of the Timber Pickling Pond and Graving Dock infill will be developed following the outcomes of the visit and second workshop. Any additional data that is required to inform the design process will be identified. Outline design drawings and outline specifications for the proposed infill works will be prepared. The outline designs will be used to support the OPA and LBC applications.

6.2 Additional Work

1. RPS should make enquiries with Natural Resources Wales (NRW) - Marine Licensing Team (MLT) to determine if the infill works will require a Marine Licence once the timber pickling pond and graving dock have been technically isolated from the marine environment.
2. As noted, a drainage strategy and surface water outline design for the site will be required in order to support the above work and enable the appropriate permissions to be granted for the development.
3. It is understood that RPS is undertaking additional ground investigation, sampling and testing in the Timber Pickling Pond. This will need to include sediment thickness, geotechnical characteristics and contamination testing, to support the future Outline Design phase and future Planning and Marine Licence applications. This will also be required for the Graving Dock.
4. At the appropriate time it will be important to identify, in more detail, the uses and loadings to be applied to the various areas and to ensure the resulting designs take account of the need to consider the buried structures as described in this report.

pembroke dock marine infrastructure

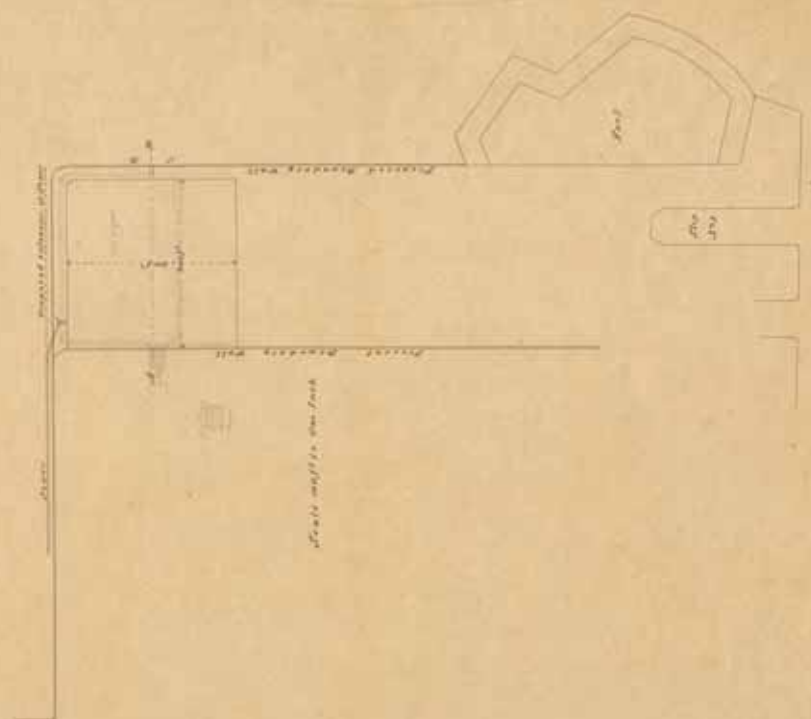
APPENDIX A

Historic Drawings of Pembroke Yard

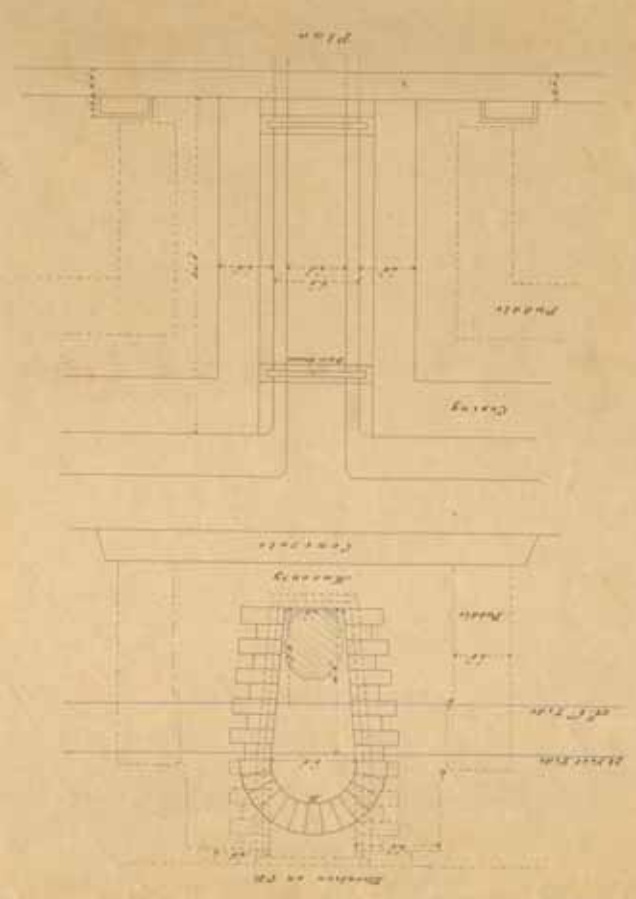
Sketch of proposed Canal for the possession of Olden Harbor



Scale is Quarter Inch to One Foot



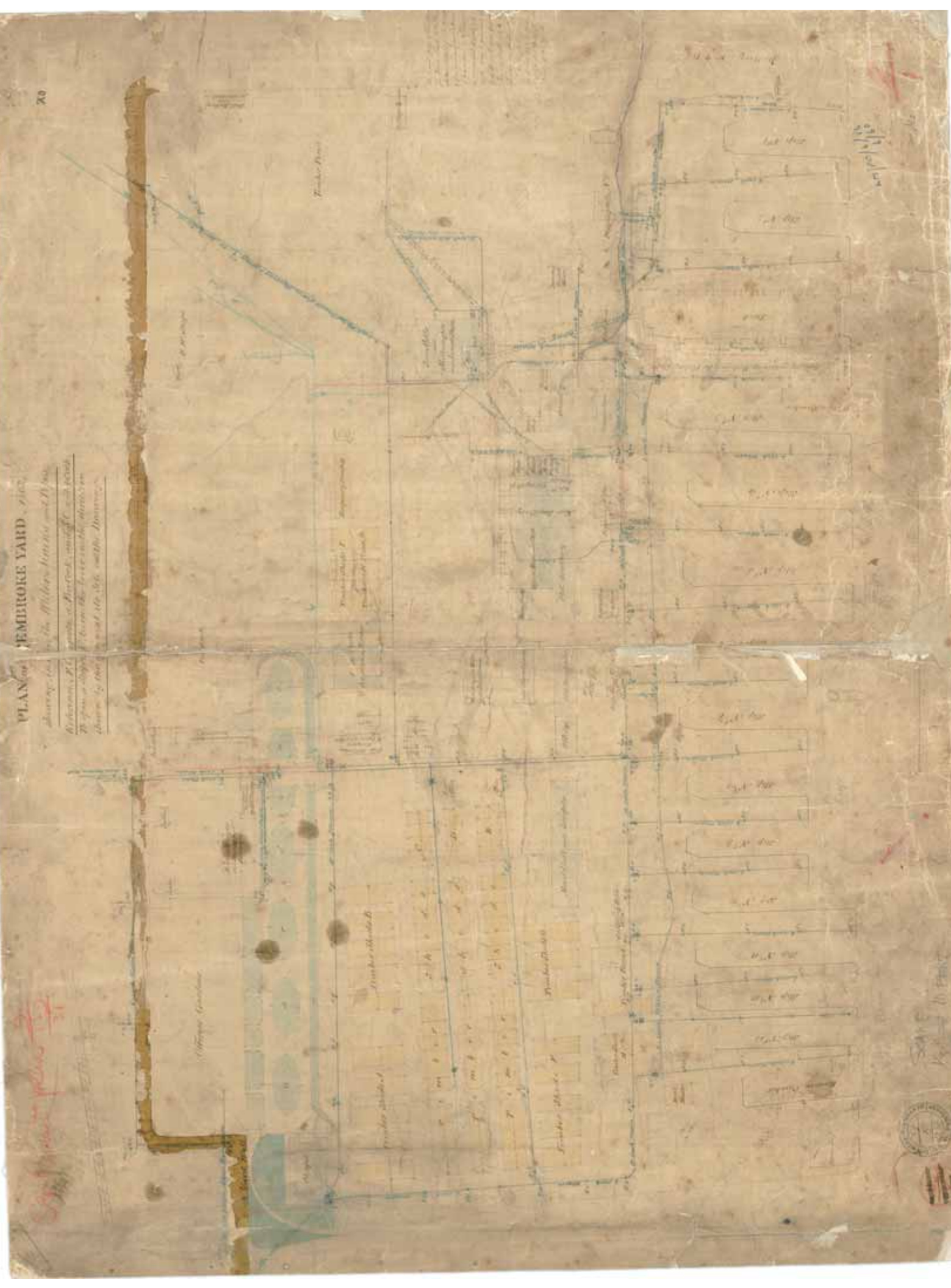
Scale is Quarter Inch to One Foot



*John C. Howard
Surveyor General
New York 1845*

PLAN of PEMBEROKE YARD

asurveyed for the Military Lines and Ditch
between the points of Direction marked C and D with
the plan of the Ditch and the other things as
shown by the scale of 1000 feet.



Scale of 1000 feet



DOCK AT PEMBROKE YARD,

with the particulars proposed by the Architect of the Navy's Circular dated 13th and D.N. 2000 dated 17th Oct 1860.

Transverse Section at Midships



Vertical Longitudinal Section through Central Line



The drawing of the floor of the Dock from the level of the sea to the top of the Dock.



APPENDIX B

Existing Site & Reconnaissance Plans (extracted from RPS EIA Scoping Report – June 2018)

This drawing was prepared in accordance with the rules of RPS, Inc. and is subject to the terms and conditions of the contract. It is not to be used for any other purpose without the written consent of RPS, Inc. and is not to be used for any other project without the written consent of RPS, Inc. All other drawings are the property of RPS, Inc. and are not to be used for any other project without the written consent of RPS, Inc.

- Application Red Line
- Other Ownership Areas



Project Name	Site	Project Number

RPS

Client: Millred Haven Port Authority
 Project: Pembroke Dock Marine
 Title: Site Location Plan

Scale: 1:1000
 Date: 1/2007
 Drawn: JPM
 Checked: JPM
 Approved: JPM

Project Number: JPM/115-001

Project Name: Millred Haven Port Authority

This drawing has been prepared in accordance with the scope of RPS's appointment with its client and is subject to the terms and conditions of that appointment. RPS accepts no liability for any use of this document other than by its client and only for the purposes for which it was prepared and provided.
 It is the responsibility of the recipient to ensure that the drawing is used for the correct purpose and that any necessary amendments are made to the drawing to correct errors. Only written dimensions should be used.

Legend

- Milford Haven Port Authority Other Land Ownership
- Application Site Boundary
- Overgrown with Vegetation

Note: Observations from site reconnaissance visit by RPS in January 2018.



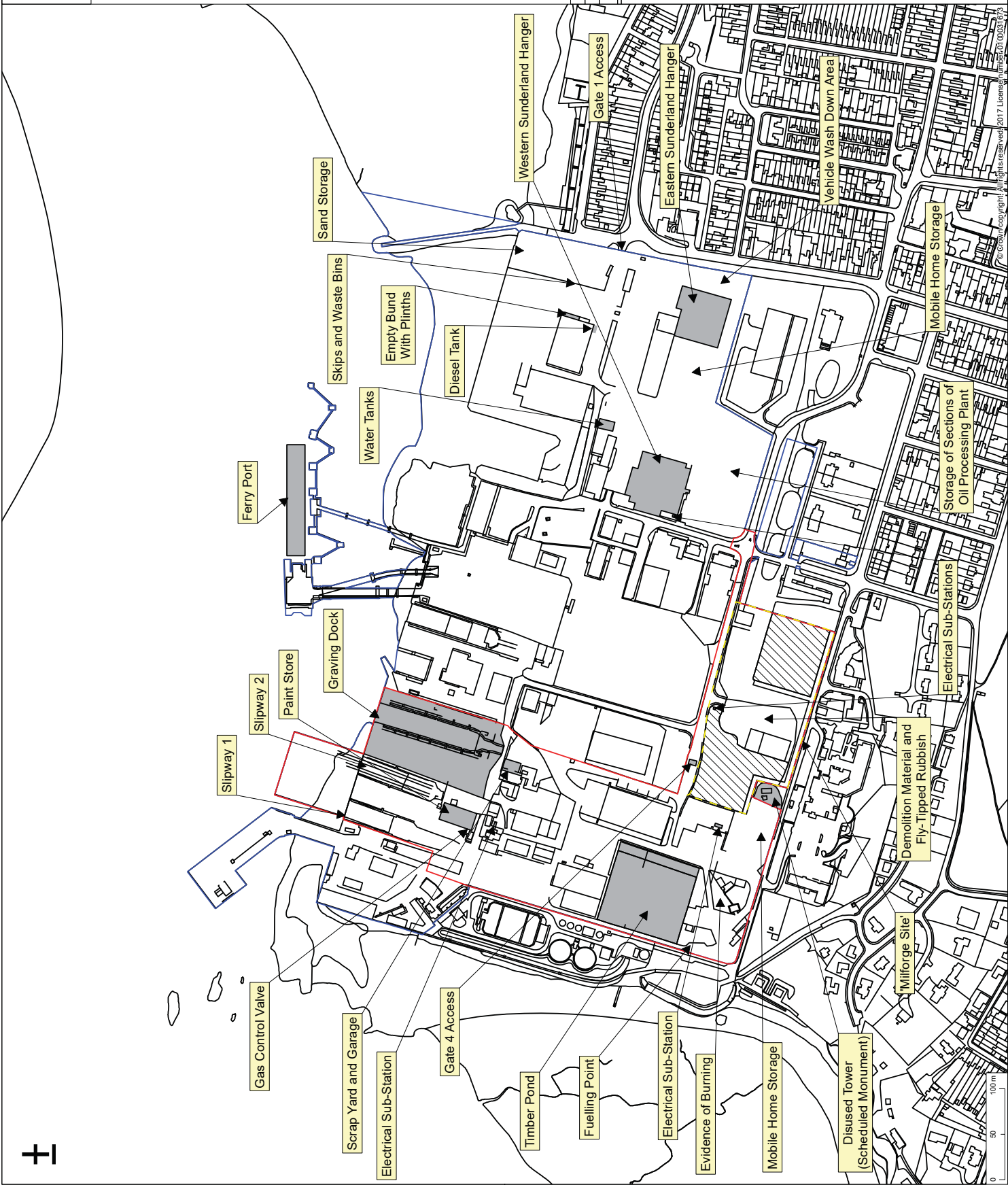
260 Park Avenue, Aztec West, Almondsbury, Bristol, BS32 4SY
 T: +44(0)1454 853 000 E: rps@rpsgroup.com F: +44(0)1454 205 820

Client MILFORD HAVEN PORT AUTHORITY
 Project PEMBROKE DOCK MARINE DEVELOPMENT
 Title SITE RECONNAISSANCE PLAN

Status PRELIMINARY
 Job Ref JER1262
 Drawn By AM
 Scale @ A3 1:4,000
 Date Created FEB 18

PM/Checked By AT
 Rev -

Drawing Number **JER1262-DTS-001**



pembroke dock marine infrastructure

APPENDIX C

Masterplan Rev.L (RPS dated April 2018)

Notes
 1. This drawing has been prepared in accordance with the scope of RPS's appointment. It is not to be used for any other purpose without the written agreement of RPS. RPS accepts no liability for any use of this document other than that for which it was prepared.
 2. Only the dimensions shown on this drawing are to be used. All other dimensions should be used.

- Application boundary
11.20 ha (27.67 acres)
- Land Leased to Ministry
- Existing buildings to be retained
- Proposed buildings to be retained
- Proposed transport corridor
- Ship Access
- Mean Low Water
- Mud/Meen High Water
- Proposed Multi-use laydown/assembly yard Areas
- Security gate/check point
- Temporarily Manned Security Point
- Key movement routes
- Landscaping
- 6m ecology corridor (including 1m maintenance footpath)
- Key Access Points
- Proposed Revetment
- Heritage Mitigation areas and enhancement (subject to separate LDC application)

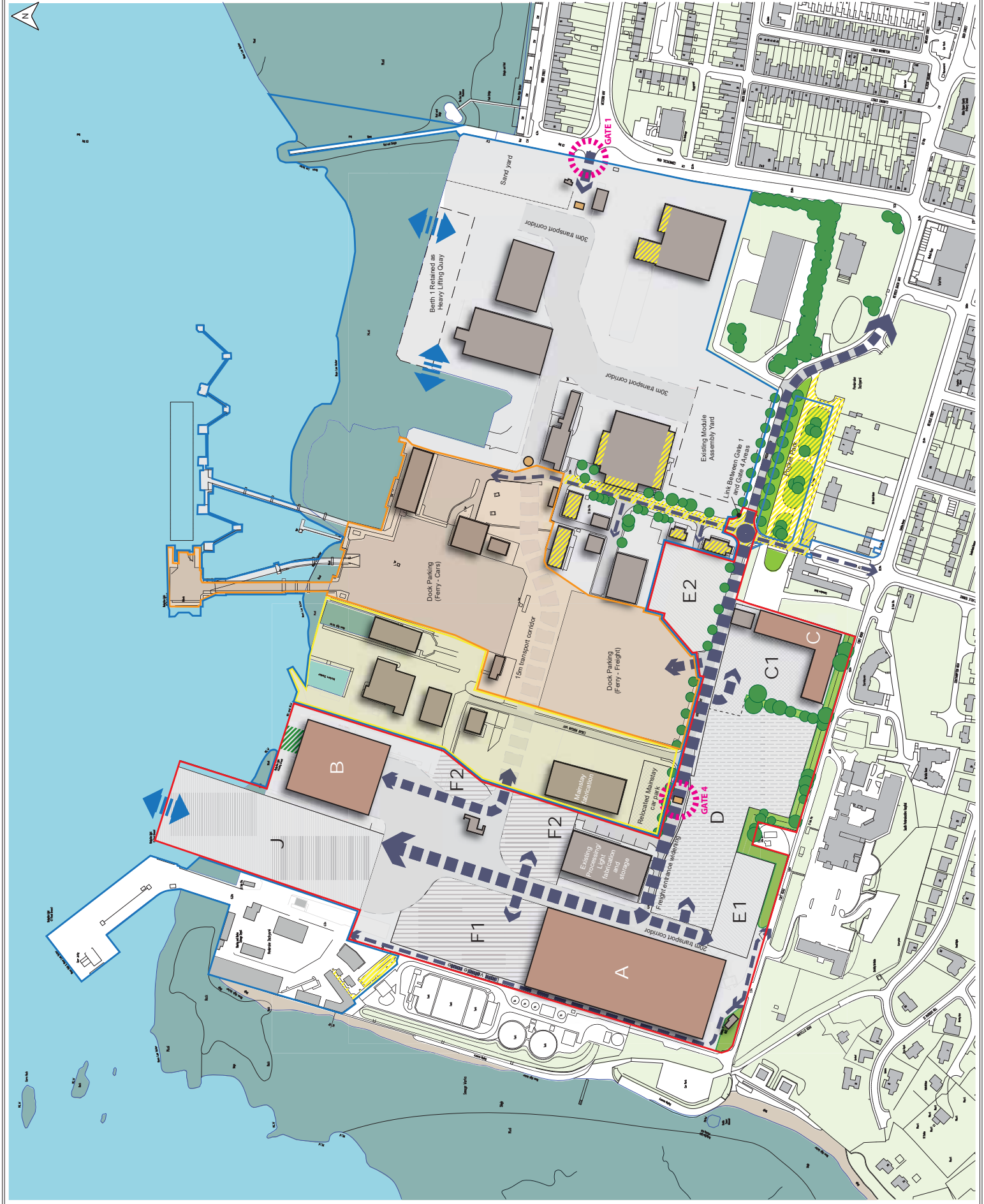
Proposed High Quality Fabrication Facility
A – Fabrication building for sub-assemblies and main engineering related activities (11,900sqm) – (170m X 70m and 6,005sqm) – (170m X 70m and 6,005sqm) – (170m X 70m and 6,005sqm)
F1 – External open multi-use laydown and final assembly area (6,005sqm) – (170m X 70m and 6,005sqm) – (170m X 70m and 6,005sqm)
F2 – Internal open multi-use laydown and final assembly area (6,005sqm) – (170m X 70m and 6,005sqm) – (170m X 70m and 6,005sqm)
Proposed High Bay Ship Repair and Fabrication Facility
J – Ship repair and fabrication building (6,500sqm) – (75m X 85m and 40m to ridge)
Proposed Slipway and Tug Barge Area
J – Slipway and large open transition area (13,05 sqm) – (130m X 20m and 10m to ridge)
Proposed Light Assembly and Maintenance Facility
C1 – Light assembly and maintenance external storage and parking area (5,000sqm)
Proposed Batching Plant
D – Open batching plant and storage area (12,937sqm)
Proposed Employee Car Park
E1 – Employee car park (3,040sqm)
E2 – Employee car park (4,933sqm)
 The building sizes are indicative parameters only and will be adjusted to suit exact requirements. The building sizes are indicative parameters only and will be adjusted to suit exact requirements. The building sizes are indicative parameters only and will be adjusted to suit exact requirements. The building sizes are indicative parameters only and will be adjusted to suit exact requirements.

RPS
 200 Park Avenue, Adelaide (Water Management)
 Burswood, South Australia 5000
 T: +61(0)8 833 8000 E: rps@rpsgroup.com F: +61(0)8 833 8020

Client Milford Haven Port Authority
Project Pembroke Dock Maine
Title Draft Proposed Masterplan

Status	Drawn By	PM/Checked By
Draft	AWPO	DW
Job Ref	Scale @ A1	Date Created
JPW1115	1:1000	April 2018
Drawing Number	Rev	
JPW1115-04	L	

rpsgroup.com/uk



APPENDIX D

Culvert Location / Routes (Atkins Pickling Pond Culvert System - Preliminary Inspection Report dated June 2013)

DO NOT SCALE

SAFETY, HEALTH AND ENVIRONMENTAL INFORMATION

In addition to the hazards identified on this drawing, note the following:

CONSTRUCTION

MAINTENANCE/CLEANING

DECOMMISSIONING/DEMOLITION

It is assumed that all works will be carried out by a competent contractor working, where appropriate, to an approved method statement.

Rev.	Date	Description	By	Checked	App'd
P2	21/06/13	FOR INFORMATION - CHANGED FOLLOWING RECEIPT OF REPORT - 03/06/13	EB	RM	RM
P1	20/03/13	FOR REPORT	JW	EB	RM

FOR INFORMATION

ATKINS
West Glamorgan House
52 Orchard Street
SA1 5AD

Copyright © Atkins Limited (2013)
www.atkinsglobal.com



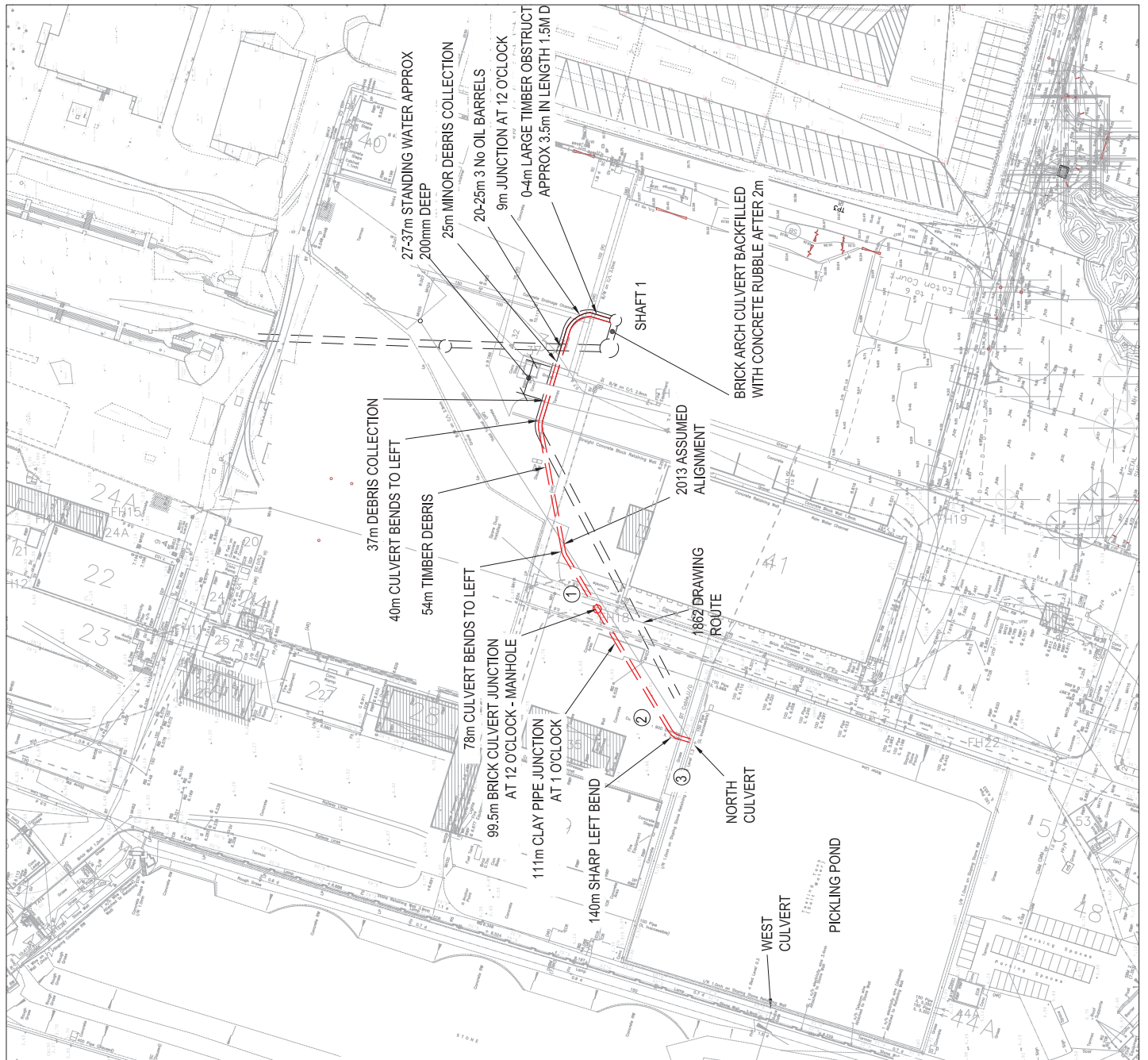
CCTV PEMBROKE PORT

2013 OBSERVED CULVERT ROUTE

Drawn	Checked	Author
DJW	E.B.	R.A.M.

Scale	Original	Date	Scale	Date
1:1250	AS	03/06/13	03/06/13	03/06/13

5116155-008-ATK-XX-ZZ-DR-C-0001 P 2



1 SLOW BEND WITHIN CULVERT



2 BEND NEAR ENTRANCE



3 ENTRANCE TO PICKLING POND



Arcadis Consulting (UK) Limited

Unit 7, Chamberlain House
Davy Road
Derriford
Plymouth
PL6 8BX
United Kingdom
T: +44 (0)1752 689 000

arcadis.com

