Site Assessment for Land-based, Temperate Marine Aquaculture, from Shark Bay to South Australian Border, Western Australia

Department of Fisheries

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Department of
Fisheries

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Introduction

Western Australia possesses the natural resources to support a significant land-based aquaculture industry; however, the development of the industry has been impeded by the difficulty of identifying and gaining rights of access to suitable coastal sites. Historically, there has been considerable duplication of effort by prospective aquaculturists in respect of the site identification, selection and application processes. To remove the need for this repetitive, basic, survey work, the Department of Fisheries undertook this site assessment study to identify, evaluate sites suitable for land-based temperate marine aquaculture in Western Australia.

Selection of Sites for Land-Based Temperate Marine Aquaculture

Sites were identified from two main regions: the Mid-West Coastal Region, which extends from the Zuytdorp Cliffs of Shark Bay southwards to Perth; and the Southern Coastal Region, extending southwards and eastwards from Perth to the Western Australia border.

The main selection criteria used to identify the preliminary sites were: elevation above mean sea level; area; proximity to power and roads; distance from the low water line, a river mouth and the nearest town; and site tenure and relevant offshore features.

As a result of the GIS work a total of 75 preliminary sites were selected, 30 in the Mid-West Coastal Region and 45 in the Southern Coastal Region. Forty of these preliminary sites were inspected and evaluated during the ensuing on-site work. This detailed site work involved the evaluation of each site against an expanded, more detailed set of selection criteria developed specifically for that purpose. The final list of sites considered suitable for land-based aquaculture in the short to medium term, and for which detailed descriptions are provided in this report, was finally reduced to number fourteen. The sites not included as one of the final 14 suitable sites are not necessarily unsuitable for aquaculture aquaculture; many share common features with the suitable sites and are considered to have equal promise.

Most Promising Temperate Marine Aquaculture Sites in the Mid-West Coastal Region

The selected sites in the Mid-West Coastal Region, their locations and main features are briefly described in the following table, modified from table 6 of this report.

SITE NO.	SITE NAME	LOCATION AND MAIN FEATURES
3	Lynton	Near Port Gregory, southern end of Hutt Lagoon. Good physical and biological features. Good infrastructure and services. Possibly the best site north of Geraldton. High potential.
11	Bowes River	Between Bowes River mouth and Horrocks. Small area but otherwise suitable physical and biological features. Relatively remote. High-to-medium potential.
16	Illawong	North of Jurien, 75 km. Reasonable physical and biological features. Reasonable infrastructure, no services. Medium potential.
24	Jurien Boat Harbour	Just north of Jurien. Very good physical and biological features. Very good infrastructure and services. One of the best sites in the Mid-West Coastal Region. High potential.
25	Island Point	Just south of Jurien. Good physical and biological features. Very good infrastructure and services. One of the best sites in the Mid-West Coastal Region. High potential.

Most Promising Temperate Marine Sites in the Southern Coastal Region

The selected sites in the Southern Coastal Region, their locations and main features are briefly described in the following table, modified from table 7 of this report.

SITE NO.	SITE NAME	LOCATION AND MAIN FEATURES
31	Preston Beach	Alongside Lake Preston, 140 km south of Perth. Large area with very good physical and biological features. Good infrastructure and services. High potential.
31	Cable Sands	South of Bunbury, 15 km. Very good physical and biological features. Good infrastructure and services. One of the best sites in the Southern Region. High potential.
49	Boat Harbour	West of Albany, 85 km. Very good physical and biological features. Good infrastructure and services. One of the best sites in the Southern Region. High potential.
50	Parry Beach	West of Albany, 85 km. Good physical and biological features. Good infrastructure and services. High-to-medium potential.
52	William Bay West	West of Albany, 65 km. Good physical and biological features. Good infrastructure and services. High potential.
57	Nanarup Beach	East of Albany, 25 km. Good physical and biological features. Good infrastructure and services. High potential.
58	Two Peoples Bay	East of Albany, 50 km. Very good physical and biological features. Good infrastructure and services. One of the best sites in the Southern Region. High potential.
59	Cheyne Beach	East of Albany, 65 km. Good physical and biological features. Reasonable infrastructure and services. High potential.
75	Esperance Bay	East of Esperance, 15 km. Very good physical and biological features. Very good infrastructure and services. One of the best sites in the Southern Region. High potential.

Conclusions

The sites considered to have high and high-to-medium potential for land-based temperate marine aquaculture were generally characterised by favourable physical and biological features, particularly in respect of site elevation and water quality, and their proximity to main regional centres and infrastructure. Sites along the south-western and southern coasts were particularly characterised by high-quality sea water.

Of all the sites described as suitable for land-based temperate marine aquaculture in this study, the five considered the most promising for that purpose and on which further development work could be contemplated are:

- Jurien Boat Harbour (Site 24);
- Cable Sands (Site 36);
- Boat Harbour (Site 49);
- Two Peoples Bay (Site 58); and
- Wylie Head North (Site 75).

Part One: Introduction

1 Introduction

1.1 Background

Western Australian coast has significant potential for aquaculture of marine species, using land-based production systems. Coastal sites in Western Australia have been difficult or expensive to access and the identification and availability of suitable sites constitutes a constraint to aquaculture development. Previously, to acquire suitable sites, different proponents have undertaken similar site identification, selection and application processes. This has resulted in substantial replications of effort and resources. In order to remove the need for future proponents and applicants to repeat the basic survey work, the Department of Fisheries undertook this site assessment study to identify, evaluate sites for land-based temperate marine aquaculture in Western Australia from Shark Bay to the South Australian border.

It is important to note that whilst this study included a field evaluation of the sites identified, this evaluation should only be considered preliminary, as such, it is recommended that more detailed evaluation are conducted as part of a site specific production and financial feasibility studies.

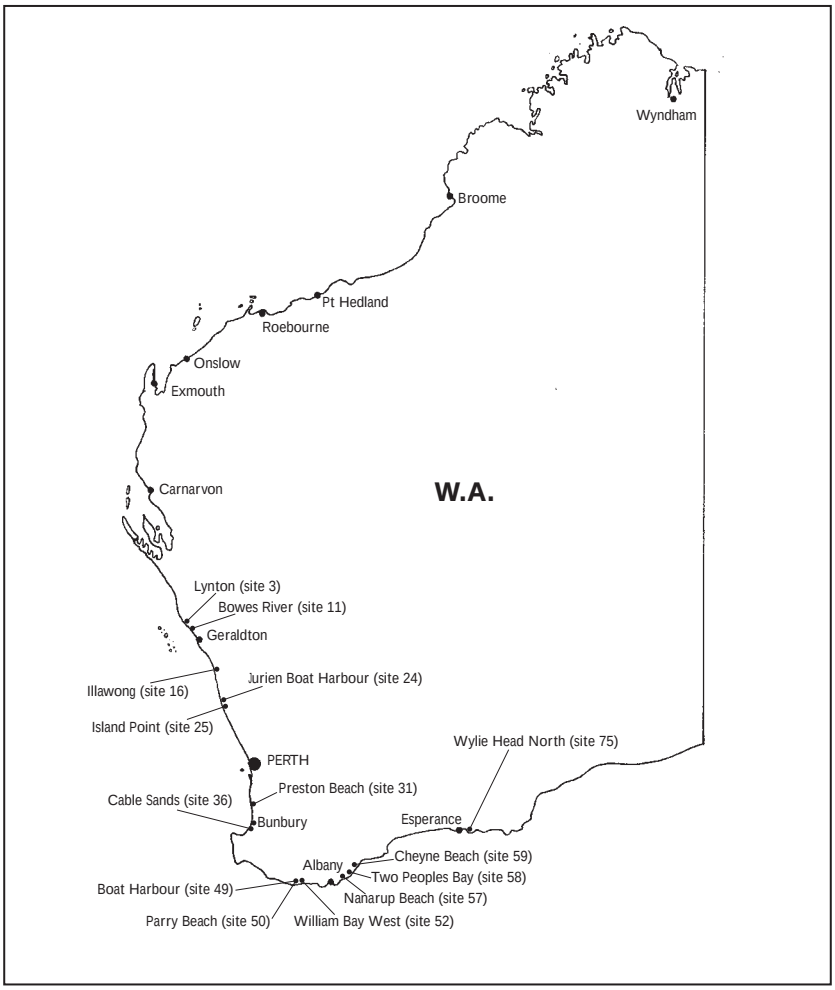

Figure 1: Map indicating the location of all potential sites along the WA temperate coast.

2. Identification and Selection of Sites for Temperate Marine Aquaculture

2.1 Geographic Information Systems (GIS) Study

Selection criterion	Suitable site
Distance from low water mark (m)	0-300
Distance from river mouth (km)	1.0
Distance from town (km)	50
Proximity to road (km)	<10
Proximity to power grid (km)	<5
Elevation above MSL (m)	0-20
Area (ha)	5-20
Site tenure	Freehold>UCL>vested land
Offshore features	Protection for marine intakes

Table 1. Site selection criteria used for the GIS Study.

Table 1 shows the site selection criteria used in the GIS Study to carry out a preliminary estimation of the suitability of coastal sites in the Mid-West and Southern coastal regions for temperate marine aquaculture.[1]

The GIS Study uses three main terms to identify land areas, namely *parcels*, *sites* and *areas*. Parcels are the land areas used by the Department of Land Administration to identify all land areas in Western Australia. The areas of different parcels can vary widely. Sites comprise land parcels of common ownership. Areas are regions that can comprise several adjacent sites and were identified on the draft maps as shaded zones.

All sites located within Nature Reserves, National Parks and Conservation Parks were eliminated, since it would be unrealistic to expect commercial, land-based temperate marine aquaculture would be permitted in these areas.[2] A set of preliminary sites was thus identified for the Mid-West and Southern coastal regions.[3] These preliminary sites, or areas within them, are generally considered suitable for land-based temperate marine aquaculture, according to the site selection criteria and the GIS Study.

Section 2.3 provides a brief description about each of the preliminary sites, including the rationale behind their selection or rejection as sites considered suitable for more detailed evaluation. The selected sites are described separately in parts two and three of this report. Appendix One provides details of Department of Land Administration site identification numbers and ownership and Appendix Two location and site maps for each of the preliminary sites.

[2] The main purpose of Nature Reserves, which represent the highest order of reserve conservation in Australia, is the conservation of wildlife; they can be used by people only where that use is entirely passive. National Parks, which represent the next (lower) order of conservation, are used for conservation and compatible recreational activities. Conservation Parks constitute the State equivalent of National Parks; they have a similar conservation importance and permit compatible recreational use but have no national significance.

[3] For the avoidance of doubt, within the context of this document, the terms preliminary sites and suitable sites are used to describe, respectively, sites generated from the GIS Study (which are identified in table 2) and the 14 sites selected from the preliminary sites considered the most suitable for further assessment and evaluation.

2.2 Site Selection Criteria for Land-Based Temperate Marine Farms

Commercial, land-based aquaculture requires sites characterised by certain features; generally, the optimum sites are those that best satisfy the biological requirements of the target species and the financial and management requirements of the aquaculturist.

The selection of a suitable site is critical if an aquaculture operation is expected to make a sustainable profit (Shang, 1990). Different site parameters or features can affect the viability of commercial aquaculture at any given site. These need to be considered carefully, in respect of the effect of each feature as well as the relative effects of different parameters and hence site selection priorities. In the selection and assessment of sites with potential for land-based temperate marine aquaculture, the following relative effects were considered:

- factors affecting yield or production capability, such as site area, can have significant effects on capital and operating costs;
- under favourable biological conditions, some physical site deficiencies may be acceptable. However, good physical site conditions may not compensate for poor biological conditions;
- intensive production systems carried out under good biological conditions can reduce the importance of physical site features and conditions;
- water supply and discharge costs can have significant impact on capital and operating costs, with scale having an important influence; site elevation is a major determinant of pumping costs; and
- access costs can be moderate, but can become significant for extremely remote sites.

The major site selection criteria for commercial aquaculture encompass certain physical, biological, ecological, economic, social and legal factors (Shang, 1990; Pillay, 1993; Huguenin and Colt, 1989). Sections 2.2.1 to 2.2.5 identify and summarise the selection criteria considered the most critical for successful, land-based temperate marine aquaculture in the Mid-West and Southern coastal regions of Western Australia. These criteria are used in this study to first identify (Section 2.3) and then assess and evaluate each of the selected sites.[4] The criteria in the following sections expand on the selection criteria (Table 1) used in the GIS Study to identify preliminary sites and are summarised in table three.

2.2.1 Physical Features

The physical features considered important for land-based temperate marine aquaculture are: site location and size; topography and hydrography; hydrology; options for sea water intake and discharge; soil and vegetation; and climate.

Location and Size

For the purpose of this study, all potential temperate marine sites are land-based. Other location factors include the distance from low water and the total land area of the site. Suitable sites are those located within about 300 m of the low water mark and larger than 5 ha in area.[5]

Some of the sites identified by the GIS Study are quite large, in the order of several hundred hectares. In some cases, only a relatively small portion of a large site may be considered appropriate for land-based marine aquaculture; in others, the entire site may be suitable. If developed for land-based marine aquaculture, the latter,

[4] Some site features are common to all the sites within the region. To avoid repetition, these common features are considered separately in section 3.2 of this report.
[5] The minimum size of 5 ha is based on information provided by industry members and The Department of Fisheries scientists. It is generally thought that a 5ha site would require more intensive systems.

larger sites could accommodate a number of independent farms, each of which may have a maximum size restriction imposed. For the purpose of this study, each site identified is evaluated as a single area, irrespective of its potential for subdivision.

Topography and Hydrography

The topography of suitable sites is such that their elevations above mean sea level ("MSL") range between 0 and 20 m. Ideally, the elevation of the levelled site should be such that the maximum pumping head is 10 m or less, to allow economic pumping costs and adequate fall for gravity discharge (L. Cilia, Pump Works Pty Ltd, pers. comm.) and avoid flooding. Fairly level land is preferred, to reduce earthmoving and construction costs.

The sites should have relatively deep water close to shore. A water depth of 5-10 m within about 200 m of the low water mark is acceptable.

Hydrology

Tidal flows and currents should facilitate the removal and dilution of used sea water discharged from the farm and be conducive to the efficient separation of intake and discharge flows.

Sea Water Supply and Discharge

Land-based marine farms require large volumes (in excess of 500 litres per second) of high-quality sea water, so sites with physical features conducive to the construction of secure, cost-effective seawater intake and discharge systems have distinct advantages.

Marine intakes supply sea water directly from the ocean and require areas with high-quality sea water and deep water close to shore. Land-based beach wells may be viable in areas where salt water intrusions occur in porous, underlying strata. Physical features that favour marine intakes include headlands and other structures that provide shelter from storms and to which pipelines may be attached.[6]

Soil and Vegetation

Soil type is not considered an important factor, since it is unlikely that earthen ponds would be used in temperate marine farms; however, features such as rocky outcrops are important cost factors where large areas may need to be levelled to accommodate growout tanks or raceways. Local vegetation is important in respect of clearing and construction costs.[7] Sites vegetated by grasses and low shrubs would clearly be preferred to those with dense vegetation and forests.

The regulations that exist in respect of clearing native vegetation should be noted. Approval is required to clear areas greater than one hectare of native vegetation on rural-zoned land. Regulations under the *Soil and Land Conservation Act* apply over the whole of the State and require that anyone wishing to clear more than one hectare of native vegetation for a change in land use should notify the Commissioner of Soil and Land Conservation at least 90 days before the anticipated beginning of clearing. Proposals are evaluated according to a Memorandum of Understanding signed by six Government agencies and depends on advice from Department of Agriculture, the Department of Environmental Protection, the Department of Conservation and Land Management and the Waters and Rivers Commission. The evaluation processes operate under the *Soil and Land Conservation Act* and

[6] It is thought that marine intakes are better suited to sites in the Southern Coastal Region, although the use of beach wells in these areas has not been fully explored. Beach wells are likely to be more suited to the Mid-West Coastal Region at sites characterised by poor quality water, subject to confirmation of suitable water quality being delivered by this system. All other factors being equal, marine intakes are generally preferred.

[7] It should be noted that, in this study, vegetation is not considered in an environmental context and a botanical survey of species was not undertaken. Vegetation is considered purely in terms of site development for land-based aquaculture.

the *Environmental Protection Act*. Clearing is usually only allowed if it can be shown that it will not cause significant land or water degradation, including adverse impacts on neighbouring and downstream properties, particularly from salinity. The onus is on the land owner to provide the requisite evidence.

Climate

Climatic factors relevant to site selection consider significant meteorological events such as flooding. Air temperature and rainfall are less important for intensive systems.

2.2.2 Biological Features

The biological features considered important for land-based temperate marine aquaculture are: water quality; parasites and predators; and pollution and history of usage.

Water Quality

Physical and chemical water-quality parameters mainly include temperature, salinity, turbidity, pH, nitrogenous compounds, heavy metals and dissolved gases.[8] The coastal regions under consideration are within the natural ranges of the temperate marine species with aquaculture potential.

The proximity of significant rivers or water flows to potential sites is considered as part of this selection criterion since large fresh-water flows can dramatically influence the quality of sea water. Preferred sites would be more remote from major rivers.

Parasites and Predators

The presence of parasites and predators can affect aquaculture according to the species under culture and the production system. Within the context of this study, given the anticipated intensity of operations and the ability of the land-based production systems to control pest organisms, this criterion is not considered critical.

Pollution and History

Ideally, sites for aquaculture should be remote from all sources of pollution such as natural or introduced heavy metals and other toxic substances. Any previous use of the site should not be incompatible with land-based temperate marine aquaculture.

2.2.3 Economic Factors

The economic factors considered important for land-based marine aquaculture are: infrastructure and services (regional and site); labour, trades and security; feed sources; equipment and raw materials; diagnostic services; processing and packaging; and transportation and markets.

Infrastructure and Services

The regional infrastructure and services relevant to site selection for land-based marine aquaculture refer to the region generally. Local or site infrastructure and services refer to roads, buildings and equipment that may already exist within the boundaries of a site. Land-based marine aquaculture farms use large quantities of electrical power, to which they need cost-effective access. For the purposes of this study ideal sites would have access to three-

[8] The pH and concentration of dissolved gases, such as oxygen and carbon dioxide, in sea water extracted from beach wells may vary from natural levels, according to factors such as the depth of the wells and their distance from the coast. For the purpose of this study, it is generally assumed that beach wells located close to the shore are more likely to yield high-quality sea water with physical and chemical properties that approximate those of the adjacent ocean; however, it is emphasised that this factor needs further consideration and, if beach wells are to be used, the quality of the sea water they deliver needs to be ascertained by testing water pumped from test wells.

phase electricity supplied from the metropolitan power grid. Suitable sites are within 10 km of a sealed or primary unsealed road and 5 km of a power grid.

Labour, Trades and Security

The availability of skilled and semi-skilled labour to build, manage and operate it is an important selection criterion for a land-based marine aquaculture farm. It is assumed that security services would be provided internally.

Feed Sources

The proximity of feed sources is more a regional or state issue, since few farms are likely to be vertically integrated to the extent they manufacture their own feed. Accordingly, this criterion is considered of relatively minor importance.

Equipment and Raw Materials

The proximity of suppliers of equipment and raw materials that may only be required infrequently is considered of relatively minor importance; however, the proximity of suppliers of large quantities of raw material such as concrete is considered an advantage during the construction stage.

Diagnostic Services

Given that high-quality pathology laboratories and other diagnostic services are present in the State and would be available to any temperate marine farms, their proximity is not considered a critical criterion.

Processing and Packaging

It is considered likely that land-based marine aquaculture farms would invest in their own post-harvest facilities and that all processing and packaging would ultimately occur on site. Access to commercial processing and packaging facilities will therefore not be required and the proximity of these resources is therefore considered unimportant.

Transportation and Markets

The proximity, availability and cost of specialised road and airfreight services are an important determinant of site suitability. Given the value of the likely target species and its products, market proximity is considered of relatively minor importance.

2.2.4 Social and Legal Factors

The social and legal factors considered important for land-based aquaculture are: urban proximity, competitive resource use and land tenure.

Urban Proximity

Urban proximity is considered important if high-quality staff are to be attracted and retained. Suitable sites should be within 30 km of a town.

Competitive Resource Use

The competitive use of limited resources is seen as one of the major factors affecting aquaculture development in Western Australia. Preferred sites would not compete with any existing use, for example by limiting access to recreational fishing areas.

Land Ownership and Tenure

Freehold land invariably presents fewer problems and would be preferred over unallocated Crown land. Preferred sites are also those comprising one or more parcels of land with common ownership.

Each of the preliminary and selected sites comprise one or more land parcels. These parcels are identified by a Department of Land Administration parcel number. The Department of Land Administration parcel numbers for all sites, as well as their vesting and purposes, are provided in Appendix One. Parcel numbers for selected sites are also provided in the relevant sections in Parts Two and Three of this report.

2.2.5 Summary of Selection Criteria

Table 2 provides a summary of the selection criteria used in this study to select and assess sites for land-based temperate marine aquaculture.

Selection criteria	Preferred parameters for land-based temperate marine aquaculture
Physical features	
Location and size	Within 300 m of the low water mark and 5-20 ha in area.
Topography and hydrography	Maximum elevation 20 m above MSL and ideally <10 m; low-gradient land; deep water close to shore.
Hydrology	Suitable tidal flows and currents; good circulation.
Sea water supply and discharge	Suitable, cost-effective options for marine intakes or beach wells.
Soil and vegetation	Few or no rocky outcrops, sparse vegetation.
Climate	No history of flooding.
Biological features	
Water quality	Physical and chemical parameters to suit species; low turbidity, remote from fresh water discharge and other obvious threats to water quality.
Parasites and predators	Low importance.
Pollution and history	Remote from past, present or future sources of pollution, particularly pesticides.
Economic factors	
Regional infrastructure and services	Within 10 km of a sealed or primary unsealed road; within 10 km of a power source. Ideally three-phase power.
Site infrastructure and services	Low importance, but suitable existing infrastructure is an advantage.
Labour, trades and security	Access to labour, trades and security.
Feed sources	Proximity is of low importance.
Equipment and raw materials	Proximity is generally of low importance.
Diagnostic services	Proximity is of low importance.
Processing and packaging	Access to suitable facilities is of low importance.
Transportation and markets	Freight services are important. Proximity to markets is not critical.
Social and legal factors	
Urban proximity	Within 30 km of a town.
Competitive resource use	No competing resource use is preferred.
Land ownership and tenure	Freehold land is preferred, unallocated Crown land is acceptable.

Table 2. Summary of selection criteria and preferred requirements for land-based temperate marine aquaculture sites.

2.3 Identification and Selection of Sites in the Mid-West and Southern Coastal Regions

2.3.1 The Site Identification and Selection Process

The steps used in the identification and selection process to identify and evaluate sites for land-based temperate marine aquaculture may be summarised as follows.

Step 1. Preliminary selection of 75 sites ("preliminary sites"), principally by the GIS Study, according to specific selection criteria and extant knowledge.[9] All the preliminary sites generally satisfy the selection criteria established for the study. Site boundaries were based principally on land tenure. Sites initially selected by the GIS Study but located within Nature Reserves, National Parks or Conservation Parks were eliminated as candidates.

Step 2. Interim selection of 40 of the preliminary sites for on-site inspections, according to existing knowledge of the areas in question and more specific selection criteria.

Step 3. Final selection of the sites considered best suited for land-based temperate marine aquaculture ("most promising sites"), according to information generated from the on-site assessment process.

Sections 2.3.2 and 2.3.3 provide brief overviews of the preliminary sites in the Mid-West Coastal and Southern Coastal regions respectively. A summary list of preliminary sites in the regions is provided in Appendix One; location and site maps are provided in Appendix Two.

2.3.2 Overview of the Preliminary Sites in the Mid-West Coastal Region

Sandalwood Bay (Site 1)

Sandalwood Bay is located at the northern end of Hutt Lagoon, about 110 km north of Geraldton, via Northampton.

The site is comparatively remote and characterised mainly by extensive sand dunes and poor access. The average elevation of the area is estimated at 10-15 m. During the inspection, the road was impassable and closed to all traffic. Access is unlikely to improve in the foreseeable future since, further inland, there is a better, all-weather road northwards to Kalbarri. Local residents, who periodically use four-wheel-drive vehicles to gain access to the beach for recreational fishing, confirm access is very difficult and that there is little low-lying land between the coast and Hutt Lagoon. Due mainly to its remote location, poor access and elevation, Sandalwood Bay is considered to have low prospects for land-based temperate marine aquaculture.

Leander Passage (Site 2)

Leander Passage is located between the coast and Hutt Lagoon, extending southwards from Sandalwood Bay to Port Gregory, which is about 100 km north of Geraldton.

The site features generally high, extensive coastal dunes and relatively few level areas. There is some access from Port Gregory at the southern end of the site. Leander Passage is probably a little better than Sandalwood Bay for land-based temperate marine aquaculture but is still remote, so is considered to have medium-to-low prospects.

[9] The iterative process used to select the sites considered best suited for land-based aquaculture was based principally on the knowledge of the areas in question collectively possessed by the consultant, Department of Agriculture WA and Dept. of Fisheries WA, the staff of the latter including the Aquaculture Development Officers, research staff and members of the Aquaculture Program. During the on-site inspections, local fishermen and surfers provided useful information about the accessibility, seasonal and otherwise, of various sites.

Lynton (Site 3)

Lynton, which extends southwards from Port Gregory to the mouth of the Hutt River, is a suitable site considered to have high potential for land-based temperate marine aquaculture. A detailed description of the site is provided in Chapter Four.

Broken Anchor Bay (Site 4)

Broken Anchor Bay is located to the south of Lynton, about 85 km north of Geraldton by road.

Access is poor by the road and from the beach, but may be better through cleared farm lands. Coastal dunes are high, rising from about 20 m frontal dunes to over 40 m about 1 km inland. There are no apparent low-lying areas behind the frontal dunes. Due mainly to its remote location, poor access and elevation, Broken Anchor Bay is considered to have low prospects for land-based temperate marine aquaculture.

Menai Hills (Site 5)

Menai Hills is situated between Broken Anchor Bay to the north and White Cliffs to the south.

The site features high frontal dunes and cliffs that rise to elevations of about 80-100 m within a few hundred metres of the coast. There are a few low-lying areas adjacent to the coast, but these are limited in size and difficult to access. Due mainly to its remote location, poor access and elevation, Menai Hills is considered to have low prospects for land-based temperate marine aquaculture.

White Cliffs (Site 6)

White Cliffs is situated to the south of and adjoins Menai Hills. As for Menai Hills, the site features high frontal dunes and cliffs that rise to elevations of about 80-100 m within a few hundred metres of the coast. Due mainly to its remote location, poor access and elevation, White Cliffs is considered to have low prospects for land-based temperate marine aquaculture.

Deep Gorge, Deep Gorge South and Whaleboat Cove (Sites 7, 8 and 9)

Deep Gorge, Deep Gorge South and Whaleboat Cove are three adjoining sites situated between White Cliffs to the north and Three Mile Beach to the south. They are about 80 km north of Geraldton by road.

The sites are remote and access from roads and the beach is very difficult. They have high frontal dunes and cliffs that rise to elevations higher than 80 m within a few hundred metres of the coast. There are small, comparatively low-lying areas at Deep Gorge and at the southern sector of Whaleboat Cove; however, these sectors have very poor access. Due mainly to their remote locations, poor access and elevation, these sites are considered to have low prospects for land-based temperate marine aquaculture.

Three Mile Beach (Site 10)

Three Mile Beach is located to the north of and adjoins the town of Horrocks, which is about 75 km by road to the north of Geraldton.

There are no coastal cliffs at the site, but it features high frontal dunes and other topographical features typical of this general area. There is reasonably good access to the southern part of the site through the town of Horrocks. Mainly due to its elevation, the site is considered to have low prospects for land-based temperate marine aquaculture.

Bowes River (Site 11)

Bowes River, situated between Horrocks and the mouth of the Bowes River, is a suitable site considered to have high-to-medium potential for land-based temperate marine aquaculture. A detailed description of the site is provided in Chapter Five.

Bowes River South, Teakle Hill North and Teakle Hill (Sites 12, 13 and 14)

Bowes River South, Teakle Hill North and Teakle Hill are three adjoining sites situated between Bowes River to the north and Woolawar Gully to the south. They are located about 40 km to the north of Geraldton.

These sites are remote and access by road and from the beach is very difficult. Physically, they are all characterised by high coastal dunes. They are considered to have low prospects for land-based temperate marine aquaculture.

Bookara (Site 15)

Bookara is located about 45 km south of Geraldton. The area is characterised by high coastal dunes and access is very difficult. Typically, privately-owned land in this area is sold in lots of about 200-250 ha, for about $400-500/ha. Some areas that have been sub-divided for residential development purposes are unlikely to be available for aquaculture. Some small areas of suitable, low-lying land may occur adjacent to the coast. Due mainly to its poor access and elevation, Bookara is considered to have low prospects for land-based temperate marine aquaculture.

Illawong (Site 16)

Illawong, located about 75 km north of Jurien, is a suitable site considered to have medium potential for land-based temperate marine aquaculture. A detailed description of the site is provided in Chapter Six.

Illawong South (Site 17)

Illawong South comprises a narrow coastal strip, south of the settlement at Illawong, located about 75 km north of Jurien.

The ground rises from a narrow beach to low coastal limestone cliffs. A sealed coastal road runs parallel to the site, providing good access. The water quality along the coast is often poor as a result of the large quantities of detached seaweed that accumulate on the beaches. While the site may have some prospects for land-based temperate marine aquaculture, it is considered marginal and ranked low.

Coolimba (Site 18)

Coolimba, located about 55 km north of Jurien, comprises a narrow coastal strip backed by moderately high sand dunes. A sealed coastal road runs parallel to the site, providing good access. The water quality along the coast is often poor, as a result of the large quantities of detached seaweed that accumulate on the beaches. The site is ranked as having low potential for land-based temperate marine aquaculture.

Leeman (Site 19)

Leeman is located about 45 km north of Jurien. The site comprises a narrow coastal strip adjacent to the town site. While there is good access, the site is limited in size and unlikely to be approved for land-based temperate marine aquaculture due to its proximity to the town. It is ranked as having low potential for land-based temperate marine aquaculture.

Billygoat Bay and Anchorage Bay (Sites 20 and 21)

Billygoat Bay and Anchorage Bay are located immediately to the north of the town of Green Head, about 35 km north of Jurien.

These are potentially good sites for temperate marine aquaculture. The topography is suitable, water quality high and infrastructure good. However, since they occur in a developing area used extensively for recreation and tourism, aquaculture is unlikely to be permitted. The sites are therefore ranked as having low potential for land-based temperate marine aquaculture.

Green Head and South Bay (Sites 22 and 23)

Green Head and South Bay are located at and to the east of the town of Green Head, about 35 km north of Jurien.

As for Billygoat Bay and Anchorage Bay to their north, the sites generally satisfy the criteria for land-based temperate marine aquaculture but are unrealistic prospects due to the residential development occurring in the area. They are ranked as having low potential for land-based temperate marine aquaculture.

Jurien Boat Harbour (Site 24)

Jurien Boat Harbour is located to the north of the boat harbour at Jurien, about 270 km north of Perth. This is a suitable site considered to have high potential for land-based temperate marine aquaculture. A detailed description of the site is provided in chapter seven.

Island Point (Site 25)

Island Point is located to the south of Jurien, about 270 km north of Perth. This is a suitable site considered to have high potential for land-based temperate marine aquaculture. A detailed description of the site is provided in Chapter Eight.

Cervantes (Site 26)

Cervantes is located about 20 km south of Jurien along the coast. The site comprises a narrow coastal strip to the south of the town. Due mainly to the poor access and limited size, the site is ranked as having low potential for land-based temperate marine aquaculture.

Lancelin (Site 27)

The Lancelin site is located to the south of the town of Lancelin, about 140 km north of Perth. The site comprises a narrow coastal strip and is marginal in area. Due mainly to the proximity to the town, the limited size of the site and the potential for conflict with other users of the resource, such as windsurfers and recreational fishers, the site is ranked as having low potential for land-based temperate marine aquaculture.

Ledge Point (Site 28)

The Ledge Point site is located to the south of the Ledge Point settlement, about 125 km north of Perth. The site comprises a narrow coastal strip and is marginal in area. Due mainly to the limited size of the site and the potential for conflict with other users of the resource, such as windsurfers and recreational fishers, the site is ranked as having low potential for land-based temperate marine aquaculture.

Guilderton (Site 29)

The Guilderton site is located to the north of the town of that name, about 85 km north of Perth. The site comprises a narrow coastal strip and is marginal in area. Due mainly to the limited size of the site and the potential for conflict with other users of the resource, such as windsurfers and recreational fishers, the site is ranked as having low potential for land-based temperate marine aquaculture.

Yanchep (Site 30)

Yanchep is located about 60 km north of Perth. Based on the selection criteria, the Yanchep site is ranked high. The physical and biological features are favourable. There are large areas of land with suitable topography and the water quality is high. The site is about 60 km north of Perth and has significant infrastructure such as sealed roads and electrical power. Significant, future residential and industrial development is anticipated in this area, so it is considered unlikely that any significant land-based temperate marine aquaculture development would be permitted. The site is included as a preliminary one in this study in the event that a parcel of land in it may be allocated for aquaculture. Under this circumstance, the site would be considered to have high potential for land-based temperate marine aquaculture.

2.3.3 Overview of the Preliminary Sites in the Southern Coastal Region

Preston Beach (Site 31)

Preston Beach, located between Lake Preston and the coast, is a suitable site considered to have high potential for land-based temperate marine aquaculture. A detailed description of the site is provided in chapter nine.

Preston Beach South and Myalup Beach (Sites 32 and 33)

Preston Beach South and Myalup Beach are located about 125 km south of Perth between Lake Preston and the coast and extend southwards from the southern boundary of Preston Beach towards the settlement of Myalup Beach. In many respects, these sites may be considered similar to Preston Beach (Site 31). Access from Old Coast Road is good, through the settlements at Preston Beach to the north and Myalup Beach to the south.

The sites feature sandy beaches rising to low frontal dunes mainly between 5 and 20 m high and rising in areas to 30-40 m. Generally, the larger areas of low-lying land occur to the north. The water quality is high and the coast exposed and high-energy. Infrastructure and services are reasonably close and accessible. A new residential development, "Pamelup", is located to the south of the Myalup Beach site, 7 km north of the Myalup Beach settlement, and an unsealed road extends northwards to the site from the settlement. Preston Beach South and Myalup Beach are considered to have, respectively, high-to-medium and medium potential for land-based temperate marine aquaculture.

Dalyellup Beach and Dalyellup Beach South (Sites 34 and 35)

Located between about 15 and 20 km south of Bunbury, Dalyellup Beach and Dalyellup Beach South extend northwards from the northern boundary of Cable Sands, to which, in many respects, these sites may be considered similar. Access to the sites off Bussell Highway is reasonably good, via Harewood Road to the north of Dalyellup Beach and Lakes Road to Dalyellup Beach South.

These sites feature sandy beaches backed by frontal dunes with average elevations between about 10 and 20 m. The coastal dunes vary in width by 0.5-1.0 km, before giving way to reasonably large areas of low-lying land, which is subject to periodic inundation and includes some swamps, watercourses and small lakes. Dalyellup Beach South is intersected by a waterway. The water quality is high and the coast exposed, with no shelter for marine

intakes. A sewage treatment works located 3.0 km north of the northern end of Dalyellup Beach is unlikely to affect sea water quality at the sites since the prevailing current flows northwards. The sites are close to infrastructure and services and, although the beaches are popular destinations for recreational activities, are unlikely to impose any major constraints on development. Dalyellup Beach and Dalyellup Beach South are considered to have high-to-medium potential for land-based temperate marine aquaculture.

Cable Sands (Site 36)

Cable Sands, located between Dalyellup Beach and Stirling Beach about 25 km south of Bunbury, is a suitable site considered to have high potential for land-based temperate marine aquaculture. A detailed description of the site is provided in Chapter Ten.

Minninup, Stirling Beach and Stirling Beach South (Sites 37, 38 and 39)

Located between about 25 and 28 km south of Bunbury, Minninup, Stirling Beach and Stirling Beach South extend southwards from the settlement of Minninup. These sites are similar in many respects to Cable Sands (Site 36). Access to the sites off the Bussell Highway is reasonably good, via Roberts Road to the north of Minninup.

The main features of these sites are similar to those described for the adjoining sites to the north, although the elevation of the coastal dunes tends to be higher. Large areas of land cleared for agricultural purposes run parallel to the coast, inland from the coastal dunes. The potential of Minninup for land-based temperate marine aquaculture is considered high and that of Stirling Beach and Stirling Beach South high-to-medium.

Eagle Bay, Bunker Bay East, Bunker Bay West and Canal Rocks (Sites 40, 41, 42 and 43)

Eagle Bay, Bunker Bay East and Bunker Bay West are located approximately 10 km north-west from Busselton, facing Geographe Bay near Cape Naturaliste. Canal Rocks is situated about 15 km south-west from Dunsborough. Access to the sites is good, by sealed road from Dunsborough via Naturaliste Road to the first three sites and via Caves Road to Canal Rocks.

The sites reputedly feature rocky headlands and elevations only marginally suited for pumped-ashore aquaculture production systems. They are located in areas considered to have high value for conservation, recreation and tourism. Accordingly, their potential for land-based temperate marine aquaculture is considered medium-to-low.

Turner Brook (Site 44)

Turner Brook is located just south of Cape Hamelin, about 15 km north-west of Augusta and Cape Leeuwin. Caves Road passes within about one kilometre of the site; however, access to the site itself is difficult as a result of a reasonably dense forest. Access is seasonal, via a four-wheel-drive track and along the beach.

This section of the coast features rocky headlands, cliffs and high coastal dunes with a few small beaches. Local information supports the view that there are high coastal dunes at the site, but indicates there may be some low-lying land close to shore. The site is therefore considered to have medium potential for land-based temperate marine aquaculture.

Ledge Point West and Ledge Point East (Sites 45 and 46)

Ledge Point West and Ledge Point East are located to the east of Augusta and Hardy Inlet. Only 6 km directly to the east of Augusta, they are about 55 km away by road, the final 15 km of which is unsealed. The sites can be reached from Brockman Highway via Scott River Road. They may be considered comparatively remote and difficult to access over the last several kilometres due to an extensive swamp area.

The general topography of the sites may be suitable, since there are low-lying areas inland from the coastal dunes, which can reach an estimated height of about 20 m. The water quality at these sites is likely to be variable. The Blackwood River, the largest in the South-West, flows into Hardy Inlet and thence eastwards along the coast in the prevailing current towards the sites. Extensive mud flats in the area indicate high turbidity and large fresh water flows. These sites are considered to have medium-to-low potential for land-based temperate marine aquaculture.

Scott River West and Scott River East (Sites 47 and 48)

Scott River West and Scott River East are located to the east of Ledge Point West and Ledge Point East. The comments made for the latter sites apply to the former, which are therefore also considered to have medium-to-low potential for land-based temperate marine aquaculture.

Boat Harbour (Site 49)

Boat Harbour, located 32 km west of Denmark, is a suitable site considered to have high potential for land-based temperate marine aquaculture. A detailed description of the site is provided in Chapter Eleven.

Parry Beach (Site 50)

Parry Beach, located 30 km west of Denmark near Point Hillier, is a suitable site considered to have high-to-medium potential for land-based temperate marine aquaculture. A detailed description of the site is provided in Chapter Twelve.

Parry Inlet (Site 51)

The Parry Inlet site is located about 22 km west of Denmark and to the east of the inlet after which it is named. Access to the site is reasonably simple from the beach and from land by unsealed, but often private, roads off South Coast Highway.

A corridor of William Bay National Park about 200-250 m wide separates the site from the ocean.[10] Within this corridor occur frontal dunes that vary in height up to about 20-25 m. Lower-lying areas of land within the site may be suitable for temperate marine aquaculture. The water quality is high and generally not affected by the comparatively small discharges from Parry Inlet, which is a shallow basin with small water flows. Infrastructure and services to the general area are good. The site is considered to have high-to-medium potential for land-based temperate marine aquaculture.

William Bay West (Site 52)

William Bay West, located about 22 km west of Denmark, is a suitable site considered to have high potential for land-based temperate marine aquaculture. A detailed description of the site is provided in Chapter Thirteen.

Mazzoletti Beach West, Mazzoletti Beach East and William Bay East (Sites 53, 54 and 55)

Mazzoletti Beach West, Mazzoletti Beach East and William Bay East are situated behind Mazzoletti Beach between 18 and 22 km west of Denmark. Access to the sites is possible from the beach and from land by unsealed, but often private, roads off South Coast Highway.

As for the Parry Inlet site, a narrow corridor of William Bay National Park that varies in width between about 100 and 250 m separates the sites from the ocean. Within this corridor occur frontal dunes that vary in height up

[10] The corridor connects larger sections of William Bay National Park at Parry Inlet to the west and Edward Point to the east.

to about 20-25 m. Lower-lying areas of land within the sites may be suitable for temperate marine aquaculture. The water quality is high and probably remains unaffected by discharges from Parry Inlet. Infrastructure and services to the general area are good. The sites are considered to have high-to-medium potential for land-based temperate marine aquaculture.

Taylor Inlet (Site 56)

About 30 km east of Albany by road, the Taylor Inlet site adjoins the small inlet of that name. The site is easily accessible from the sealed road to Nanarup Beach. Taylor inlet is adjacent to the site at Nanarup Beach (Site 57), to which it is similar in many respects.

The site occupies an area of low ground behind high frontal dunes to the east of the inlet. At the time of inspection, when the inlet was flowing, the quality of the sea water along the coast appeared high. The site currently accommodates several beach cottages that are clearly uninhabitable and it is close to good infrastructure and services. Taylor Inlet is considered to have high potential for land-based temperate marine aquaculture.

Nanarup Beach (Site 57)

Nanarup Beach, located 30 km east of Albany, is a suitable site considered to have high potential for land-based temperate marine aquaculture. A detailed description of the site is provided in Chapter Fourteen.

Two Peoples Bay (Site 58)

Two Peoples Bay, located 50 km by road east of Albany, is a suitable site considered to have high potential for land-based temperate marine aquaculture. A detailed description of the site is provided in Chapter Fifteen.

Cheyne Beach (Site 59)

Cheyne Beach, located 58 km by road east of Albany, is a suitable site considered to have high potential for land-based temperate marine aquaculture. A detailed description of the site is provided in Chapter Sixteen.

Hassell Beach South, Hassell Beach, Hassell Beach North and Warriup (Sites 60, 61, 62 and 63)

Hassell Beach South, Hassell Beach, Hassell Beach North and Warriup are between Cheyne Beach in the south to Warriup in the north, between about 60 and 100 km by road to the east of Albany. Access to the sites is from South Coast Highway via unsealed roads and four-wheel-drive tracks. Generally, the sites are difficult to reach.

Northwards from Cheyne Beach, the frontal dunes appear to progressively increase in height to over 20 m. Inland from the coastal dunes there is an extensive system of lakes and wetlands that may exacerbate difficulties with access and development. Water quality is generally high, although there are several creeks that drain into the sea from the coastal lakes and wetlands. There is no significant infrastructure or services in the vicinity. The sites are considered to have medium-to-low potential for land-based temperate marine aquaculture.

Pallinup Beach (Site 64)

Pallinup Beach is located 55 km by road to the east of Bremer Bay and adjoins the southern side of Beaufort Inlet. There is access to the north of Beaufort Inlet off Bremer Bay Road by four-wheel-drive track; however, the track only provides access to the north of the inlet and can become difficult to traverse when wet. Access to the south of Beaufort Inlet and the Pallinup Beach site is possible off South Coast Highway via Boat Harbour road, but access by this route is difficult since the four-wheel-drive access track terminates several kilometres from the site.

Site elevation is likely to be suitable, but the water quality may be poor seasonally, when the Pallinup River is flowing and the bar across the inlet open. The prevailing easterly current often sets up anticlockwise currents in bays on the south coast; this would have the effect of carrying poor-quality water towards the site. The cost of providing infrastructure and services to the site is likely to be high. The site is considered to have medium-to-low potential for land-based temperate marine aquaculture.

Foster Beach (Site 65)

Foster Beach is situated 20 km to the south-west of Bremer Bay. Access is difficult and there are no roads or tracks leading to the area. At its closest point, Bremer Bay Road passes within 10 km of the site.

The site occupies a narrow band along the length of the beach; given the usual topography of the area, it is anticipated that the frontal sand dunes would be high and close to the beach. The water quality is likely to be high, since no rivers or streams discharge into the area. Given the remote location and access difficulties, it is certain that the provision of infrastructure and services will be high and possibly prohibitive. The site is considered to have low potential for land-based temperate marine aquaculture.

Dillon Beach and Blossoms Beach (Sites 66 and 67)

Dillon Beach is located 16 km by road to the south-west of Bremer Bay. Access to the site is reasonably good, from Bremer Bay Road via Dillon Bay Road, the last kilometre of which comprises a four-wheel-drive track. Blossoms Beach is located about 8 km to the south of Bremer Bay and can be reached easily by a good, unsealed road. Both sites face Dillon Bay.

The aquaculture potential of the two sites is described by Ecologia et al., (1996). Their physical and biological features are considered suitable. The main disadvantages are, for Dillon Beach, relatively poor access and anticipated high cost of providing infrastructure and services and, for Blossoms Beach, possible conflict with other users of the resource.[11] Dillon Beach and Blossoms Beach are considered to have, respectively, medium and high-to-medium prospects for land-based temperate marine aquaculture.

Short Beach and Back Beach (Sites 68 and 69)

Short Beach and Back Beach are both within about 5 km of Bremer Bay and there is good access to both by an unsealed road.

The aquaculture potential of the sites is described by Ecologia et al., (1996). Their physical and biological features are considered suitable. The proximity of and access to infrastructure and services is favourable. It should be noted that areas of Back Beach are the subject of current applications for temperate marine aquaculture. Short Beach and Back Beach are considered to have high prospects for land-based temperate marine aquaculture.

James Cove, Peppermint Beach and Toorgellup Beach (Sites 70, 71 and 72)

James Cove, Peppermint Beach and Toorgellup Beach are located between about 10 and 12 km from the town of Bremer Bay. James Cove and Peppermint Beach face Bremer Bay; Toorgellup Beach extends southwards from Gordon Inlet, the area to the north of which lies within Fitzgerald River National Park, and faces Doubtful Island Bay. Seasonal access is possible to these sites from the town of Bremer Bay across the beach, when the bar across Wellstead Estuary is closed. Bremer River, which flows into the estuary, usually has significant discharges during the winter rains and, at this time, access is only possible from Bremer Bay Road via Swamp and Gordon Inlet

[11] A previous study considered access to Blossoms Beach to constitute a disadvantage; however, for the purpose of abalone aquaculture, given the relevant cost structures, access is not considered a significant problem. This study therefore provides a higher ranking for the site.

roads through Fitzgerald River National Park. The state of the final 10-15 km of these roads is such that access is difficult, even by four-wheel-drive.

It is likely that the physical and biological features of these sites would be well suited for temperate marine aquaculture. The water quality in the area is invariably high. The cost of providing the requisite infrastructure and services is likely to be high. These sites are considered to have medium prospects for land-based temperate marine aquaculture.

Wylie Head West and Wylie Head South (Sites 73 and 74)

Wylie Head West and Wylie Head South are located about 10 km east of Esperance and 5 km east of Bandy Creek Boat Harbour. These sites are adjacent to and similar in many respects to Wylie Head North (Site 75). Good access is provided to the sites by a sealed road.

The sites are separated from the coast by a narrow ridge of frontal dunes, inland of which the land is level and elevated an estimated 5-10 m above MSL. The water quality is high and several options exist for sea water intake and discharge systems. Infrastructure and services are available adjacent to the sites. The area is used for recreational and tourism purposes. The sites are considered to have high prospects for land-based temperate marine aquaculture.

Wylie Head North (Site 75)

Wylie Head North, located 15 km by road east of Esperance, is a suitable site considered to have high potential for land-based temperate marine aquaculture. A detailed description of the site is provided in Chapter Seventeen.

2.3.4 Synopsis of Preliminary and Suitable Sites

Tables 3 and 4 provide synopses of the preliminary sites for land-based temperate marine aquaculture in the Mid-West and Southern coastal regions respectively. In the tables, tenure ("Tnr") is shown as either unallocated Crown land ("UCL") or privately-owned ("P"). In addition, a rank is provided for each site. Ranks are shown as high ("H"), high-to-medium ("H-M"), medium ("M"), medium-to-low ("M-L") or low ("L"). The ranks are based mainly on the identified selection criteria but should be considered somewhat subjective. Their purpose is to provide an indication of the respective merits and suitability of all the sites.

Site no. and name	Tnr	Area (ha)	Rank	Site no. and name	Tnr	Area (ha)	Rank
1 Sandalwood Bay	UCL	394	L	16 Illawong	UCL	20	M
2 Leander Passage	UCL	1185	M-L	17 Illawong South	UCL	21	L
3 Lynton	UCL	228	H	18 Coolimba	UCL	16	L
4 Broken Anchor Bay	P	415	L	19 Leeman	UCL	8	L
5 Menai Hills	P	81	L	20 Billygoat Bay	P	195	L
6 White Cliffs	UCL	333	L	21 Anchorage Bay	UCL	62	L
7 Deep Gorge	P	15	L	22 Green Head	UCL	35	L
8 Deep Gorge South	P	39	L	23 South Bay	P	40	L
9 Whaleboat Cove	P	57	L	24 Jurien Boat Harbour	UCL	14	H
10 Three Mile Beach	UCL	179	L	25 Island Point	UCL	12	H
11 Bowes River	UCL	140	H-M	26 Cervantes	UCL	9	L
12 Bowes River South	P	240	L	27 Lancelin	UCL	6	L
13 Teakle Hill North	UCL	47	L	28 Ledge Point	UCL	15	L
14 Teakle Hill	P	137	L	29 Guilderton	UCL	15	L
15 Bookara	P	17	L	30 Yanchep	P	178	H

Table 3. Preliminary sites (1-30) for land-based temperate marine aquaculture in the Mid-West Coastal Region.

Site no. and name	Tnr	Area (ha)	Rank	Site no. and name	Tnr	Area (ha)	Rank
31 Preston Beach	P	22	H	54 Mazzoletti Beach East	P	12	H-M
32 Preston Beach South	P	20	H-M	55 William Bay East	P	8	H-M
33 Myalup Beach	P	18	M	56 Taylor Inlet	P	24??	H
34 Dalyellup Beach	UCL	67	H-M	57 Nanarup Beach	UCL	66	H
35 Dalyellup Beach South	P	41	H-M	58 Two Peoples Bay	P	78	H
36 Cable Sands	P	80	H	59 Cheyne Beach	UCL	136	H
37 Minninup	P	18	H	60 Hassell Beach South	UCL	181	M-L
38 Stirling Beach	P	10	H-M	61 Hassell Beach	P	24	M-L
39 Stirling Beach South	P	28	H-M	62 Hassell Beach North	P	36	M-L
40 Eagle Bay	UCL	11	M-L	63 Warriup	UCL	10	M-L
41 Bunker Bay East	P	13	M-L	64 Pallinup Beach	UCL	80	M-L
42 Bunker Bay West	P	12	M-L	65 Foster Beach	UCL	53	L
43 Canal Rocks	P	10	M-L	66 Dillon Beach	UCL	123	M
44 Turner Brook	P	30	M	67 Blossoms Beach	UCL	19	H-M
45 Ledge Point West	P	52	M-L	68 Short Beach	UCL	20	H
46 Ledge Point East	P	74	M-L	69 Back Beach	UCL	22	H
47 Scott River West	P	106	M-L	70 James Cove	UCL	75	M
48 Scott River East	P	39	M-L	71 Peppermint Beach	UCL	46	M
49 Boat Harbour	UCL	50	H	72 Toorgellup Beach	UCL	645	M
50 Parry Beach	UCL	27	H-M	73 Wylie Head West	P	14	H
51 Parry Inlet	P	28	H-M	74 Wylie Head South	P	28	H
52 William Bay West	P	10	H	75 Wylie Head North	P	58	H
53 Mazzoletti Beach West	UCL	19	H-M				

Table 4. Preliminary sites (31-75) for land-based temperate marine aquaculture in the Mid-West Coastal Region.

The following notes are provided in respect of the preliminary and suitable sites listed.

- High frontal dunes may not invariably represent a major constraint to land-based temperate marine aquaculture, provided that there is an adequate area of land behind the dunes with an average elevation lower than about 20 m.
- Some of the preliminary sites, particularly those ranked as having low potential, may always be unsuitable for land-based temperate marine aquaculture due to their high elevation or remote location.
- Many of the preliminary sites not selected as suitable sites for land-based, land-based temperate marine aquaculture may have prospects as good, or nearly as good, as those of the latter. All sites in tables 3 and 4 ranked higher than “low” may be considered to have some potential.
- Frequently, good options may exist for using beach wells for supplying sea water, particularly for sites featuring high frontal dunes. If beach wells are being contemplated, it would be essential to drill test wells to allow water quality and sustainable pumping rates to be determined. Provided that the water quality is

suitable, beach wells may provide the most attractive means of providing water at exposed sites. Generally, beach wells should be located as close to the high water line as practicable.

Tables 5 and 6, respectively, list the sites in the Mid-West and Southern coastal regions selected for more detailed assessment and include summaries of the main reasons for their selection. As previously stated, this does not imply that the preliminary sites not selected for detailed assessment are considered unsuitable for land-based temperate marine aquaculture; for various reasons they are simply considered less suitable than the selected sites. Indeed, in several cases, the preliminary sites adjacent to or in the vicinity of suitable sites are considered to have similar potential for land-based temperate marine aquaculture.

SITE NO.	SITE NAME	MAIN RATIONALE FOR SELECTION
3	Lynton	Reasonably large area of low-lying land and good options for intake and discharge. Good water quality. Excellent services, with a sealed road and power adjacent to the site. Possibly the best site north of Geraldton.
11	Bowes River	Contains possibly the only relatively small land area of suitable elevation and reasonable access in the coastal region near Horrocks. Biological features are favourable and roads and power reasonably close.
16	Illawong	One of the few coastal areas between Dongara and Jurien with an adequate land area of suitable elevation. Subject to securing good-quality water, possibly through beach wells.
24	Jurien Boat Harbour	A good location comprising a reasonably large land area and suitable elevation. Water quality is generally good. Infrastructure and services are very good, with sealed roads and power adjacent to the site. This is considered one of the best sites in the Mid-West Coastal Region.
25	Island Point	A good location comprising a large area of land and suitable elevation. This site would probably have access to high-quality sea water and affords some protection for a marine intake by an offshore reef. Infrastructure and services are good, with sealed roads and power near the site. This is considered one of the best sites in the Mid-West Coastal Region.

Table 5. Selected land-based temperate marine aquaculture sites in the Mid-West Coastal Region.

SITE NO.	SITE NAME	MAIN RATIONALE FOR SELECTION
31	Preston Beach	Close to Perth and comprises a large land area. Elevation is good and access simple. Water quality is very good on an exposed, high-energy coastline. Access to infrastructure and services is good, with a sealed road near the site. The site is reasonably representative of two adjacent sites to the south.
36	Cable Sands	Good potential for temperate marine aquaculture, with low-lying land behind low frontal dunes and good options for sea water intake and discharge systems. Water quality is good and site access simple. A sealed road and power are in the vicinity. The site is representative of adjacent sites to the north and south, which are equally good.
49	Boat Harbour	The site has physical and biological features that more than compensate for the relatively poor access by unsealed road and track. Water quality is very good and options for sea water intake and discharge excellent.
50	Parry Beach	The elevation is higher than for other similarly-ranked sites, but other physical and biological features more than compensate. There are good options for intake and discharge. Access is by sealed road and power is available.
52	William Bay West	One of several sites in the area with freehold tenure. Physical features are generally good, but possibly more marginal than for other sites in respect of elevation. Water quality is generally good but prone to occasional fresh water discharges. Other features are good. Access is good through privately-owned land. The site is representative of adjacent sites to its east and west.
57	Nanarup Beach	Close to Albany, the site features medium-height dunes the elevation of which is acceptable. Water quality is high, although the beach is exposed and high-energy, offering few options for sheltered marine intakes. Water quality is good. Sealed roads and power are adjacent to the site. The site is reasonably representative of a relatively small adjacent site to the west.
58	Two Peoples Bay	An excellent site that adjoins a Nature Reserve. Access is good by unsealed road. A large area of privately-owned land of suitable elevation occurs behind low frontal dunes. Good options exist for sea water intake and discharge.
59	Cheyne Beach	The site has good physical and biological features. A large land area, the elevation of which is acceptable, occurs behind medium-height frontal dunes. Water quality is good. The coast is exposed and offers no protection for marine intakes, but discharge could be via existing drainage channels. The site is reasonably representative of adjacent sites to the north, but has better elevation and access.
75	Wylie Head North	This is a site with very good physical and biological features for land-based temperate marine aquaculture. A large area of privately-owned, low-lying, level land occurs behind low frontal dunes. There are good options for sea water intake and discharge. Water quality is high, as is typical for most southern coastal areas. Access to the site is by sealed road and power is available within a few kilometres. The site is representative of two adjacent sites to its south and west, which are considered equally good.

Table 6. Selected land-based temperate marine aquaculture sites in the Southern Coastal Region.

3. Coastal Geomorphology and Common Site Features

3.1 Geomorphological Features

This section briefly describes the main geomorphological features of the areas of the Mid-West and Southern coastal regions within which the preliminary sites for land-based temperate marine aquaculture occur; that is, respectively, the area between Hutt Lagoon and Perth and that between Perth and Esperance.[12]

3.1.1 The Mid-West Coastal Region

A single geomorphological region, the Central West Coast, comprises the Mid-West Coastal Region as it is defined for this study.[13]

Figure 2. An example of the high frontal dunes characteristic of much of the coastline of the Mid-West Coastal Region north of Dongara.

The coast in this region is surge-dominated; that is, it is dominated by storm surges or changes in sea level caused by changing barometric pressures, winds and waves. The region has small tidal ranges of less than one metre and a high-to-moderate wave energy. The coastline usually features long, sandy beaches with occasional limestone cliffs and headlands. Much of the coastline comprises extensive dunes, which often rise to an elevation of over 80 m within several hundred metres of the coast (Fig. 2).

The area features an extensive system of limestone reefs that run parallel to the coast. This is one of the largest temperate limestone reef systems in Australia. The reefs protect the sandy coastline and permit the growth of extensive beds of seaweeds and seagrasses.

Between Hutt Lagoon and Dongara, the shoreline is relatively straight and has a moderate energy and sandy beaches. Offshore, the sea water is usually very clear as a result of limited fresh-water drainage from the adjacent land areas. Seaweeds dominate the limestone reefs. Southwards of Dongara to Perth, coastal landforms are similar and offshore limestone reefs more extensive. Land-based features generally include extensive, coastal dune fields, the oldest of which have consolidated into limestone ridges. Most of the ridges above sea level feature a mantle of Holocene sand dunes. Small offshore islands are common in the area. In many localities, sheltered, semi-

[12] Information about the geomorphological features of the various coastal regions is taken, among other sources, from Department of Conservation and Land Management (1994); Makaira and Ecologia (1997a); and IMCRA Technical Working Group (1997).
[13] The Central West Coast geomorphological region extends between Kalbarri and Perth and includes the Abrolhos Islands.

lagoonal habitats are formed behind the offshore limestone reefs. Decomposing, detached seaweeds, which often form large aggregations in these areas behind sheltering reefs, have a major effect on the quality of sea water in these areas.

The region has several small to medium-size rivers, the discharges from which have minor effects on the relatively-clear coastal waters. There is a cool, nearshore current that flows northwards in summer.

3.1.2 The Southern Coastal Region

Two geomorphological regions make up the Southern Coastal Region as it is defined for this study; viz. the Leeuwin-Naturaliste Coast, which extends between Perth and Walpole Inlet, and the South Coast, extending from Walpole to Esperance.

Within the Southern Coastal Region, between Perth and Cape Naturaliste the coast is surge-dominated, as for the Mid-West Coastal Region, and between Cape Naturaliste and Esperance it is wave-dominated. In the wave-dominated sector, the wave heights typically exceed the small tides and moderate surge activity.

The Leeuwin-Naturaliste Coast is exposed to high-energy wave action and its shores are affected by heavy swells. During early summer, a cold inshore current runs northwards, counter to the further-offshore, warm Leeuwin Current. During late summer and some years in winter, the southerly Leeuwin Current can reach the shore. Waters off this coast are high in quality. The shoreline features granite headlands and sandy beaches. Southwards of Perth to Bunbury, the shores comprise long, reasonably exposed sandy beaches and limestone headlands. Southwards from Bunbury, the coast is exposed to moderate wave energy. Between Cape Naturaliste and Cape Leeuwin, the wave energy is high and the coast comprises sandy beaches between rocky headlands. South of Cape Leeuwin to Walpole, the coast is exposed and subject to high wave energy and large swells.

The South Coast is swept by the West Wind Drift and the nearshore current is in an easterly direction. The coast features high wave energy, strong winds and high-quality sea water. The coastline features limestone shores and comprises sandy bays, inlets, rocky headlands and cliffs, with limited numbers of sheltered areas. The sand bars across estuaries are usually only breached during high river flows after heavy rainfall. The western part of this region features small bays and beaches between high headlands, the shores near which usually drop off rapidly into deep water, so are well suited for seawater intake systems.

3.2 Common Regional Features

Several of the selection criteria used to assess them are common to all suitable sites in the Mid-West and Southern coastal regions. To avoid repetition, these common criteria, which mainly include economic factors, are dealt with separately in this section. For the avoidance of doubt, it is emphasised that these common criteria refer only to the suitable sites listed in Tables 5 and 6.

Hydrology

While a great deal is known about the offshore Leeuwin Current, comparatively few studies have been undertaken on nearshore currents along the coast of Western Australia. However, in broad terms and from anecdotal evidence, it is generally assumed that the nearshore current along the western coast is northerly, particularly during summer under the influence of strong southerly winds, and along the southern coast, it is easterly. [14]

[14] On the south coast, the easterly current has the effect in many of the bays of setting up an anticlockwise current. An example of this effect was provided during an inspection of sites in the vicinity of Bremer Bay: water from the Bremer River, which was flowing and had breached the sand bar at the mouth of Wellstead Estuary, could be clearly seen flowing in a southerly, anticlockwise direction.

Climate

Most of the Mid-West area has a temperate to semi-arid climate dominated by rain-bearing, cold fronts in winter and easterly winds in summer. Climate extremes are less pronounced in coastal regions. The area around Perth and down to Bunbury is dominated by rain-bearing cold fronts during winter and hot, easterly winds in summer.

The South-West experiences high winter rainfall from rain-bearing depressions and cold fronts during winter and dry, easterly winds in summer. The temperate south coast features cold fronts in winter and mild, dry summers.

Parasites and Predators

The impacts of parasites and predators will be species specific and is beyond the scope of this study, however, it is recommended that this form part of each individual farm's risk management.

Regional Infrastructure and Services

Regional infrastructure and services are usually good throughout the region, even to the more remote sites north of Geraldton. Sealed or unsealed roads commonly lead to within a few kilometres of the sites. The regions are well serviced by a network of highways that enable all-weather traffic movement. Most of the sites are reasonably close to three-phase electrical power supplied from the Perth grid. Electrical power is generally reliable and competitively priced. Most sites are close to telecommunication land lines and within mobile phone cells. Services such as potable water supplies and sewerage vary according to location, but may generally be considered lacking at most sites.

With few exceptions, the suitable sites are within a reasonable distance of and have good access to a wide range of light and heavy industries required for the construction and support of land-based aquaculture facilities. In Perth and some regional centres, fully serviced industrial estates accommodate light and heavy industries and industry parks have been developed to support research, development and production.

Labour

Most of the suitable sites are within a short distance of reasonably large towns or cities that can provide skilled, semi-skilled and unskilled work forces, sophisticated technical support and a commercial environment conducive to project development.

The major centres have well-developed services sectors with expertise in engineering, construction and environmental management. Both large and small centres generally have a full range of trades persons such as electricians and plumbers. It is anticipated that land-based temperate marine aquaculture farms would provide internal security, so the availability of professional security firms has not been considered as a selection criterion.

Sources of Feed, Equipment and Raw Materials

It is expected that feed for land-based temperate marine farms would be purchased from mills in the eastern states. In the longer term, as the industry grows and creates the requisite demand, it is likely that Perth-based mills would be contracted to supply feeds. In either event, proximity of the sites to the mills is not considered a major determinant of site suitability. Similarly, all the suitable sites are well located in respect of sources of equipment, which may be purchased variously from local or domestic suppliers or imported from abroad.

The proximity of suppliers of raw materials such as concrete will be a reasonably important criterion, particularly during the construction stages. Again, all the suitable sites are reasonably close to such suppliers, with the possible exception of the more remote sites north of Geraldton.

Diagnostic Services

The Fish Health Laboratory, established in Perth by The Department of Fisheries, is well placed to provide services in respect of fish health and treatment in the event of mortalities or problems that may ensue from disease or other causes. Perth and the major regional centres are also well placed to provide analytical services in respect of water quality parameters and environmental monitoring.

Transportation

Freight companies are located in Perth and most of the major regional centres. Given the well-established and sophisticated road and air transportation systems in the State and the relatively high value of the product, transportation is not considered a critical factor. All the suitable sites may be considered to have good access to the requisite transportation services for the delivery of feeds and other materials and to ensure efficient access to domestic and export markets.

Urban Proximity

The suitable sites in the Mid-West Coastal Region, in particular Lynton and Bowes River, tend to be comparatively remote from major centres. These two sites are close to the small towns of Port Gregory and Horrocks and reasonably close to Northampton, the nearest town of a reasonable size. The remaining sites in the Mid-West Coastal Region are near or at Jurien, which is the largest town on the Central West Coast.

With the exception of a few of the more remote sites, such as Cheyne Beach, most of the sites in the Southern Coastal Region are within a comfortable distance by road from cities and large and small towns such as Perth, Bunbury, Denmark, Albany and Esperance. These cities and towns offer all modern conveniences such as hospitals, schools and shopping facilities.

Competitive Resource Use

Land-based temperate marine aquaculture should be promoted as being highly compatible with other resource uses such as tourism and recreational fishing. There are many examples of synergies between aquaculture and tourism activities, which can be mutually beneficial. Similarly, provided that they do not restrict access to favoured fishing spots, aquaculture developments can benefit recreational fishers and other resource users by providing access to previously-inaccessible areas.

Part Two: Temperate Marine Sites in the Mid-West Coastal Region

4. Lynton (Site 3)

4.1 Site Description

4.1.1 Physical and Biological Features

Location and Size

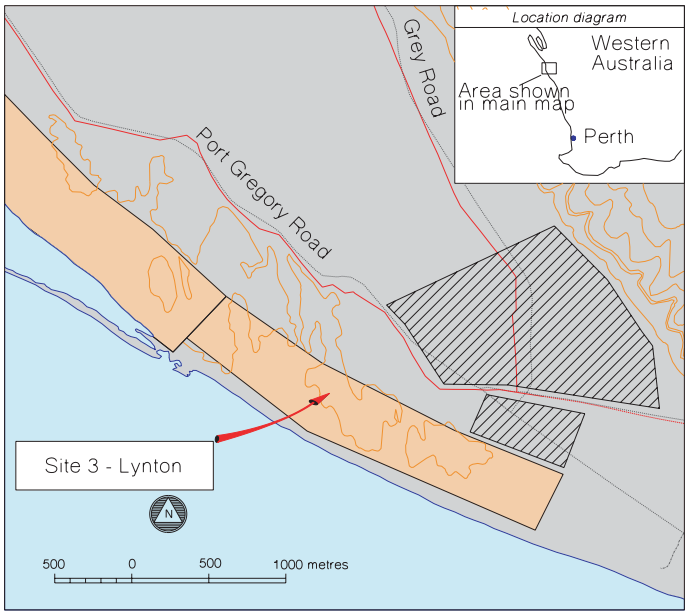

Figure 3. Map illustrating the location and major physical features of Lynton (Site 3).

Lynton (Site 3) is located near the southern end of Hutt Lagoon, about 95 km north of Geraldton via Northampton, off Port Gregory Road.[15] A sealed road provides good, all-weather access to the site. The preliminary site selected from the GIS Study comprised an extensive coastal area larger than 200 ha (Fig. 3). Because this area was composed mainly of the elevated frontal dunes generally characteristic of the region, its potential for land-based temperate marine aquaculture was considered low. However, the region does contain an area considered suitable, and hence was selected as a site for, land-based temperate marine aquaculture. The area is situated at the southern end of Hutt Lagoon within a large, low-lying area as indicated by the hatched areas in Figure 3. Two areas are shown, separated by Port Gregory Road, within the area indicated. One area of about 8 ha is located to the south of the road, near its intersection with Grey Road. A much larger area of over 100 ha is situated to the north of Port Gregory Road, between the southern end of Hutt Lagoon and Hutt River. It is this latter area, particularly its southern sector, that constitutes the suitable site described in the remainder of this chapter.

[15] It is noted that Lynton was identified in a previous study (Makaira and Ecologia, 1997) as being suitable for land based aquaculture; it is reiterated here as a suitable site for abalone aquaculture mainly because it is considered the best site for that purpose in the Mid-West Coastal Region north of Jurien.

Topography and Hydrography

Figure 4. Looking south-eastwards over Lynton, showing the low-lying areas considered suitable for land-based land-based temperate marine aquaculture in the background.

In areas, the frontal dunes at Lynton are lower than is usual for the area. The width of the dunes between the coast and the low-lying areas at the southern end of the lagoon is about 500 m and their height generally lower than 20m. Figure 4 shows the large area of low lying land to the south of the lagoon. The area in the background at the foot of the hills is lower than 20 m above MSL and would be suitable for land-based temperate marine aquaculture.

The water close to shore is reasonably deep and, towards the northern end of the site, there is an offshore reef that runs mainly parallel to the coast. The prevailing northwards-flowing current can be more pronounced during summer.

Soil and Vegetation

The soil is mainly clay and sand, according to the specific location within the site. The vegetation would present no problems for clearing and comprises salt bushes and low, medium-density coastal heath and shrubs. Part of the site has been cleared for agricultural purposes.

Sea Water Supply and Discharge

A marine intake located inside the offshore reef may provide the best option for a sea water supply system, given the shelter that would be afforded. The alternate option of beach wells may be feasible, depending on the quality of water delivered and the flow rate that can be sustained. At this site, subject to sea-water quality and quantity conditions being satisfied, beach wells may have significant economic advantages.

There are two main options for discharging used water: northwards to Hutt Lagoon and southwards to Hutt River.

The first option involves draining used water into the lagoon. Some synergies may be possible with Cognis Pty Ltd, a company currently culturing algae within Hutt Lagoon, if the increased level of nutrients in the used water is perceived by the company as a resource that it could integrate into its algal growing operations. The surface of the lagoon is higher than some parts of the site, so the farm's design and engineering would need to ensure the water supply and discharge system was constructed to permit gravity discharge. Irrespective of whether or not the used water could be utilised by Cognis Pty Ltd, Hutt Lagoon may provide a suitable means for disposing of used water by evaporation.

The second option for discharging water is to direct the flow into Hutt River and thence into the sea. This would have the effect of maintaining open the bar across the river mouth but is unlikely to have any detrimental environmental, recreational or social effects.

Water Quality

The water quality at the site is very good. There is no evident accumulation of large quantities of seaweed between the reef and the coast and, with the obvious exception of significant rainfall events, fresh water discharge from the Hutt River is minimal. Even at times of river flooding, due to the high-wave-energy coast and currents, we consider it unlikely that any detrimental effects would be realised by a land-based temperate marine aquaculture farm.

Pollution and History

There is no obvious pollution from industrial or agricultural sources in the vicinity of the site. Part of the site would have a history of use for agricultural purposes and the presence of any pesticides in the soil would have to be ascertained. Even if present, given that the production system would not include earthen ponds, small pesticide or herbicide concentrations in the soil are unlikely to be of any concern.

4.1.2 Economic, Social and Legal Factors

Site Infrastructure and Services

The presence of a sealed road and three-phase power lines, which transect the site at its southern portion, is an important feature of this site, giving it an economic advantage that in part compensates for its relatively remote location. A telecommunications line similarly transects the site. There is no potable water supply or sewerage at Lynton and provision would need to be made for these services in any farm design.

Competitive Resource Use

There is no apparent conflicting resource use at this site. Ruins of stone buildings near the southern part of the site are a tourist attraction; however, rather than being competitive, an temperate marine farm in the area would be more likely to augment tourism by providing an additional point of interest. Land-based temperate marine aquaculture in the area would not restrict access to the coast for fishing and other recreational activities.

Tenure

The boundaries of the two sites identified in this area are shown in Fgure 3 and Appendix Two (Site 3, Lynton). The preliminary site identified from the GIS study, indicated as a roughly-rectangular area adjacent to the coast, is unallocated Crown land vested in the Crown. The hatched area identified as having high potential for aquaculture at the southern limit of Hutt Lagoon, about 200 m inland (Fig. 3 and Appendix Two) is private land owned by Simkin.

The Department of Land Administration parcel number for the latter site is: VICTOL7454, CT 1119/599.

Contact Details: Mr Ron Simkin
Lynton Station
Northampton WA 6535
Tel: (08) 9935 1040

4.2 Site Evaluation

4.2.1 Potential for Development

Lynton has high potential for land-based temperate marine aquaculture and is considered one of the best sites for that purpose north of Jurien. The site comprises several areas that may be suitable for development. Within the site boundary, in addition to the larger area to the south of and adjoining Hutt Lagoon, there are a few areas of 5 ha or more on the western side of the road behind the coastal dunes that would also be suitable.

Some opportunities may exist with Cognis Pty Ltd for synergies in respect of operations such as sea-water supply and discharge.

4.2.2 Constraints to Development

There are no known, major constraints to development. Potential minor constraints to development include:

- the high elevation of the frontal dunes;
- limited discharge options;
- the proximity to a river; and
- conflict with existing users of the resource.

If marine intakes are used, the cost of pumping large volumes of sea water may be high unless an intake channel or pipeline can be constructed or laid through the frontal dunes to limit the pumping head.

Discharge may be a problem unless the used water can be discharged through the river. In this event, the intake would be likely to be to the north and hence downstream from the discharge point, so steps would need to be taken to ensure used water is recycled through the intake. If Hutt River or Hutt Lagoon is to be used for discharge, the environmental effects of discharging water into either would have to be ascertained.

Conflict with other resource users would probably be limited to the proposed discharge method involving Hutt River. This is not considered an important issue, since the aquatic environment in the river is already modified and not in its natural state. In fact, the water discharged from a land-based temperate marine farm may assist in rehabilitating the riverine environment.

5. Bowes river (Site 11)

5.1 Site Description

5.1.1 Physical and Biological Features

Location and Size

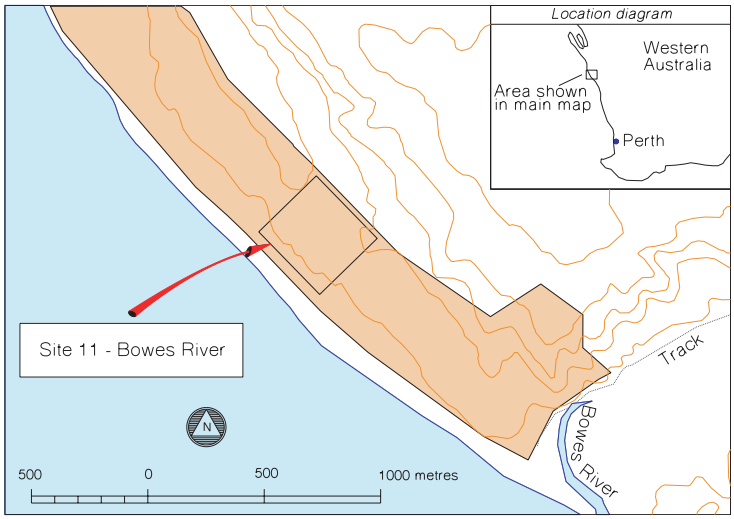

Figure 5. Map illustrating the location and major physical features of Bowes River (Site 11).

Bowes River (Site 11) is located between the town of Horrocks and the mouth of Bowes River, about 72 km from Geraldton via Northampton, off Horrocks Road. The best access to the site is from its southern end by way of Bowes River Road, an unsealed road leading to the river mouth; access from Horrocks is poor. The roads are generally good, with all but the last 3 km sealed.

The preliminary site selected from the GIS Study comprised an extensive coastal area of 140 ha; however, the elevation of much of this area is higher than 20 m, increasing to 80 m about 1 km inland (Fig. 5). A smaller, lower-relief site within this larger region, shown in Figure 5 as a roughly-rectangular area, was selected as suitable for land-based temperate marine aquaculture. Figure 6 provides a photographic image of this area. This suitable site is situated approximately one-third of the way from the south of the site, precisely 1.4 km north of the river mouth and covers an area of about 5-8 ha. Access to the site is by four-wheel-drive track leading from the unsealed road, which terminates at the river mouth.

Topography and Hydrography

The elevation of the area behind the frontal dunes averages about 10-15 m above MSL.

The water close to shore is reasonably deep and the prevailing current to the north. A limestone reef flat runs along the shoreline.

Figure 6. Bowes River, showing the eroded, low-lying area considered suitable for temperate marine aquaculture.

Soil and Vegetation

The soil is mainly beach sand that overlies a clay-like material and there are no exposed, rocky outcrops. The vegetation mainly comprises low, medium-density coastal heath and shrubs and the site has been subject to erosion. Few difficulties in clearing and levelling the site would be anticipated.

Sea Water Supply and Discharge

A marine intake fixed to the longshore reef may be suitable; however, the coast is exposed and subject to large swells, so any pipelines or intake structures would have to be well secured.

Subject to confirmation of water quality from test wells, it is possible that this site may be suited for beach wells. There are no aggregations of decomposing seaweed along the coast, possibly due to the presence of the reef and the coastal form, and beach wells could be located close to the coast, immediately behind the low frontal dunes. Given the proximity to water, it is possible the quality of water extracted from the wells would be the same as that of the sea. Given the presence of the underlying limestone, a high extraction rate could probably be sustained. At this site, subject to quality and quantity conditions being satisfied, beach wells may have significant economic advantages.

The only option for discharging used water after it has been treated is directly to the sea, by way of a channel or pipeline. The most practicable system would be via an open channel that allows the water to flow directly over the surface of the reef.

Water Quality

The Bowes River site is characterised by high-quality sea water. Given the distance of the site from the river mouth and the exposed, high-wave-energy coastline, any effects of large fresh water discharges are unlikely to be experienced at the site. For similar reasons, the accumulation and ensuing decomposition of large quantities of seaweed is considered unlikely.

Pollution and History

There is no obvious pollution from industrial or agricultural sources in the vicinity of the site. The area between the site and the river mouth is apparently used for recreational activities such as fishing and surfing, but the site itself has had no obvious previous use.

5.1.2 Economic, Social and Legal Factors

Site Infrastructure and Services

The roads leading to the site are reasonably good, except for the final 1.4 km, which comprises a four-wheel-drive track along the coast. Power lines, which follow Horrocks Road to the town, pass within about 2 km of the site in a direct line, or 5.4 km by road. A telecommunications line is a similar distance from the site.

There is no potable water supply or sewerage at Bowes River and provision would need to be made for these services in any farm design.

Competitive Resource Use

There is no apparent conflicting resource use at this site. The general area is used by recreational fishers and surfers. A land-based temperate marine aquaculture farm in the area would not restrict access to the coast. Horrocks Beach to the north of the site is a popular holiday and fishing destination, but a temperate marine aquaculture farm at the Bowes River site would be remote and is unlikely to affect any tourism or recreational activities. If anything, the presence of a land-based temperate marine aquaculture farm may complement the current use of the resource and enhance the attraction of the area.

Tenure

Bowes River is private land owned by Dymocks Holdings Pty Ltd.

The Department of Land Administration parcel number for the site is: Lot 20 PO16031-20, CT 1859/161.

Contact details:

Ms Ann Verschuer
Director
Dymocks Holdings Pty Ltd
GPO Box 1521
Sydney NSW 2001

Tel: (02) 9244 0411
Fax: (02) 9224 0469

5.2 Site Evaluation

5.2.1 Potential for Development

Bowes River is considered a good site with high-to-medium potential for land-based temperate marine aquaculture.

While not large, the area is adequate for more intensive land-based production systems. An advantage of this site may be its apparent suitability for beach wells. Should preliminary trials confirm the suitability of the site for a sea water supply system based on wells situated near the shore, the potential of the site for commercial land-based temperate marine aquaculture would increase significantly.

5.2.2 Constraints to Development

Potential constraints to development include:

- the small size and remote location of the site;
- its proximity to a river; and
- conflict with existing users of the resource.

The main constraints to development of the site are its comparatively remote location and small size. Neither of these factors is considered a serious impediment. Positive, more critical site features such as high-quality sea water would probably more than compensate for these constraints, for which economic solutions exist.

The site is distant enough from the mouth of Bowes River for the effects of fresh-water discharge to be considered minimal. The high-energy coastline would disrupt any coastal, northwards-flowing current from the river and assimilate any fresh water or turbidity in the sea water.

It appears unlikely that development of this site would be constrained by issues in respect of the environment or conflicting use of the resource. In relation to the environment, the coastal dunes in the area are quite eroded. Development of an intensive land-based temperate marine aquaculture farm would help rehabilitate and stabilise the dunes, in and around, the proposed farm site.

6. Illawong (Site 16)

6.1 Site Description

6.1.1 Physical and Biological Features

Location and Size

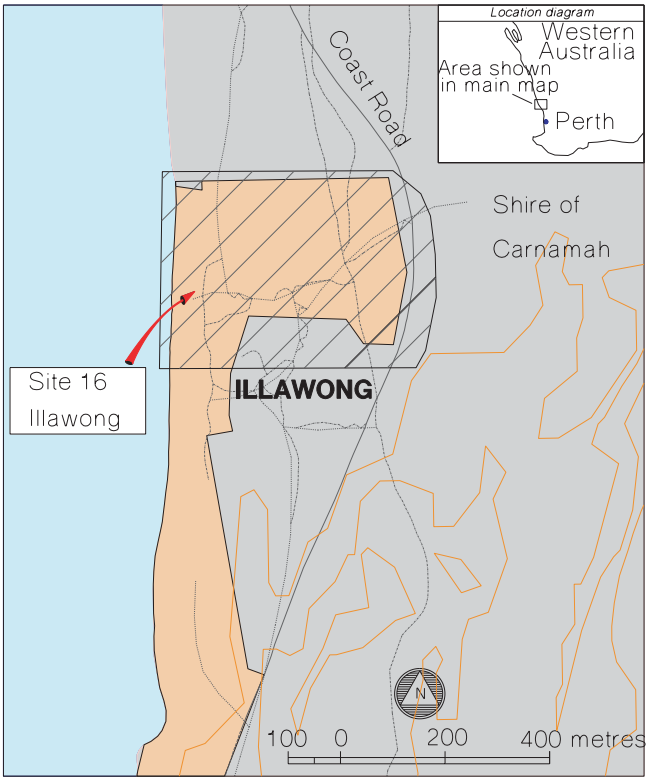

Figure 7. Map illustrating the location and major physical features of Illawong (Site 16).

Illawong (Site 16) is located at the settlement of the same name, about 129 km south of Geraldton and 75 km north of Jurien on the old coastal road. There is good access to the site from the north and south, by an all-weather, sealed road.

Much of the preliminary site, selected from the GIS Study and comprising a narrow coastal area of about 20 ha extending northwards from the settlement, was considered to have limited potential (Fig. 7). However, its northern portion, immediately to the north of the settlement, includes an area of low-lying land that is considered suitable. The area is indicated by the hatched area in Figure 7. The area of the site is about 5 ha, but it could be increased by several hectares if required by undertaking cut-and-fill earthworks.

Topography and Hydrography

The suitable area averages about 10 m above MSL and lies behind frontal dunes of varying height.

The water close to shore is reasonably deep, but this is not necessarily an important factor if the sea water supply system is based on beach wells. The prevailing current is northwards-flowing.

Soil and Vegetation

The soil is sandy and no limestone or other rocky outcrops were evident. That limestone underlies the sandy soil is evident from the rocky outcrops that form low cliffs along this section of coastline.

The vegetation mainly comprises the low shrubs typical of coastal dunes in the region. It would present no problems for clearing and levelling the site.

Sea Water Supply and Discharge

Although there is some limited shelter afforded by a small, rocky promontory and a headland at the northern end of the site, a marine intake may not be a viable option at this site due to the large quantities of detached, drifting seaweed that frequently occur offshore. The most viable solution to achieving large volumes of adequate-quality sea water would probably be through beach wells placed near the high-water mark. The feasibility of beach wells would be governed by the quality of water delivered and the flow rate that can be sustained. At this site, subject to quality and quantity conditions being satisfied, beach wells may represent the only option for a sea water supply system. There may be engineering solutions to extracting sea water through a self-cleaning filter; however, given the fine screens that would be needed and the quantity of material in the water, this solution may represent an unacceptable risk.

Options for disposing of used water, after treatment, are limited to gravity discharge along a channel or pipeline through a low section of the frontal dunes directly into the ocean.

Water Quality

The quality of the sea water in the vicinity of the site is better than other more sheltered areas to the north and south, where seaweed accumulates and decomposes, thereby affecting water quality. However, the water quality at the site may be considered poor, as a result of the presence of large amounts of drifting seaweed it contains.

There are no large rivers that discharge in the area so the quality of the sea water is unlikely to be affected during or after heavy rainfall.

Pollution and History

There is no obvious pollution from industrial or agricultural sources in the vicinity of the site and it does not appear to have been used for any other purpose.

6.1.2 Economic, Social and Legal Factors

Site Infrastructure and Services

An all-weather, sealed road passes near the eastern boundary of the proposed site, which has no other infrastructure. The nearest power is some distance to the south. For electrical power, the most viable solution might be for the farm to establish its own generators.

There is no potable water supply or sewerage at the site and provision would need to be made for these services in any farm design.

Competitive Resource Use

There is no apparent conflicting resource use at this site. It is unknown whether the few fishermen inhabiting the shacks at the southern end of the site would object to any proposal to establish an temperate marine aquaculture

farm there. Any objections may be appeased by offers by developers to, for example, provide residents with incentives such as electrical power for domestic use.

Tenure

Illawong is unallocated Crown land vested in the Crown. There is no Department of Land Administration parcel number allocated to the site, adjoining Reserve 42477.

Contact: Aquaculture Officer
Department of Land Administration
Midland Square Midland
Morrison Rd (cnr Great Northern Hwy)
Midland WA 6056

Tel: (08) 9273 7373
Fax: (08) 9273 7334

6.2 Site Evaluation

6.2.1 Potential for Development

Illawong is considered to have medium potential for development. Although less remote than Bowes River, a site in the same coastal region to which it is similar in size, the quality of the sea water at Illawong is not as good, hence its lower ranking.

6.2.2 Constraints to Development

Constraints to development at this site include:

- poor water quality;
- the absence of electrical power; and
- possible conflict with other users of the resource.

Much of the section of coastline south of Geraldton is characterised by the accumulation of large quantities of detached seaweed on beaches in sheltered areas behind the many limestone reefs that run parallel to the coast. The decomposing seaweed has a significant effect on the quality of the sea water. In addition, the nearshore sea water frequently contains large amounts of detached, drifting seaweed that would almost certainly cause severe problems with open marine intakes. Even if intakes were screened by a self-cleaning filter, the quantities of seaweed often present might preclude efficient operations. This criterion represents the most significant constraint to this site, of which the potential for any temperate marine aquaculture farm would be determined by the ability to provide large volumes of adequate-quality sea water. The only practicable means of overcoming the problem may be by using beach wells drilled into the subterranean limestone, which presumably underlies the surface dunes. Trial wells would need to be drilled and the water pumped from them tested to ensure adequate quality and sustainable flow rates.

The absence of electrical power is not considered a serious constraint. Any proposed farm would probably include its own diesel-powered generators.

Conflict may arise with professional fishers who live in the shacks near the beach. As mentioned previously, this constraint may best be overcome by offering incentives such as electricity to the inhabitants.

7. Jurien Boat Harbour (Site 24)

7.1 Site Description

7.1.1 Physical and Biological Features

Location and Size

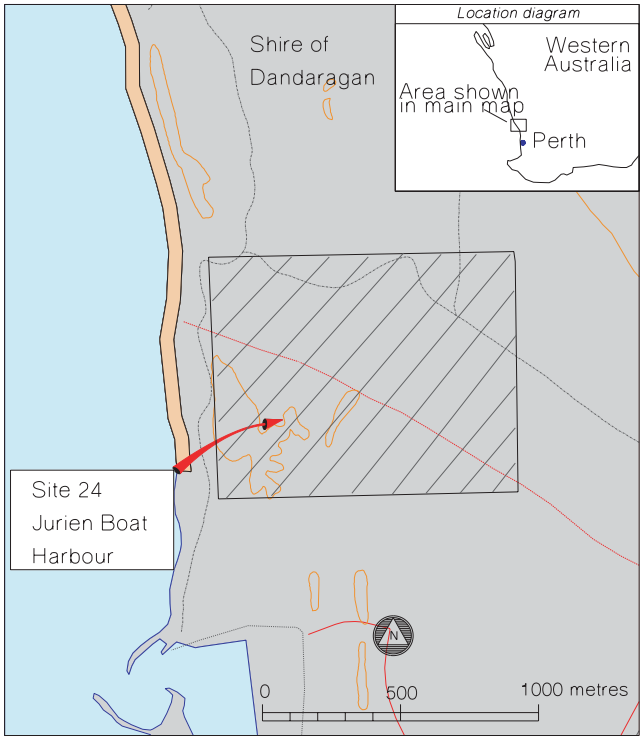

Figure 8. Map illustrating the location and major physical features of Jurien Boat Harbour (Site 24).

Jurien Boat Harbour (Site 24) is located to the north of the boat harbour, near the town of Jurien, about 250 km north of Perth. There is good access to the site by an all-weather, sealed road.

The preliminary site selected from the GIS Study, comprising the narrow coastal area of about 14 ha was considered to have limited potential. However, an area of low-lying land at the southern end of the preliminary site and to the north of the boat harbour, shown as a rectangular, hatched area in Figure 8, is considered highly suitable for development for land-based temperate marine aquaculture. The total area of this suitable site is approximately 50 ha. Figure 9 provides a photographic image of the site, taken from the northern breakwater of the boat harbour seen in Figure 8 to the south of the site.

Topography and Hydrography

As is evident from the contour lines shown on the map in Figure 8, the elevation of the suitable area averages less than about 5 m above MSL and the land is reasonably level. In many respects the area and represents an ideal site for a land-based temperate marine aquaculture farm. Figure 9 provides a view of the proposed site from the northern breakwater of the boat harbour.

The water close to shore is comparatively shallow but deep enough for a marine intake. The nearshore current is northwards-flowing, but probably at a comparatively slow rate within the bay.

Figure 9. The Jurien Boat Harbour site, looking north-east from the northern breakwater of the boat harbour.

Soil and Vegetation

The soil is sandy and there are no rocky outcrops. Some of the area has been partially cleared and it is not in a natural state. The vegetation comprises typical low bushes and shrubs and would present few problems for clearing and levelling.

Sea Water Supply and Discharge

Although there is usually some seaweed in the water in the bay, the amounts generally appear comparatively low and a marine intake may be a feasible option for a sea water supply system. Other than that provided by the northern armour wall protecting the boat harbour, there are no structures that would shelter a marine intake. The most obvious solution is to anchor the intake pipelines using heavy concrete blocks. An alternate solution, the viability of which would be governed by the size of a proposed farm, would be to construct a breakwater from large limestone blocks similar to those used for the boat harbour. The cost of such a wall is estimated at $1,000 per metre, or $100,000 for a breakwater 100 m long. A breakwater such as this could be used to support intake as well as discharge pipelines. Beach wells may be feasible; however, test wells previously drilled in the area yielded sea water varying in salinity and of poor quality. It is anticipated that a marine intake would present the most economic solution for sea water supply and discharge at this site.

The only option for discharging used water after treatment is directly into the ocean, downstream from the intake, possibly using the same structures put in place to support the intake.

Water Quality

The site has high-quality sea water that contains only small quantities of drifting seaweed. There are no major rivers in the area, so the sea-water quality is unlikely to be influenced by fresh water discharge during major rainfall events.

Pollution and History

At present, there is no obvious pollution from industrial or agricultural sources in the vicinity of the site. There is a potential threat of oil, fuel or other toxic substances being spilled within the boat harbour. If this occurs, the

nearshore current may carry the spill northwards with the current to a marine intake. This threat would have to be evaluated and dealt with by any proponent.

The site has no previous history of use.

7.1.2 Economic, Social and Legal Factors

Site Infrastructure and Services

There is no infrastructure on the site itself; however, the presence of the boat harbour and its associated industries have contributed to the development of significant infrastructure in the immediate vicinity of the proposed site. Infrastructure and services include sealed, all-weather roads, three-phase electrical power supplied by the Perth grid, potable water supplies and telecommunications facilities. The site is close to a range of light industries associated with the commercial fishing industry. In respect of this selection criterion, the Jurien Boat Harbour site may be considered one of the best on the western and southern coasts.

Competitive Resource Use

There is no apparent conflicting resource use at this site; on the contrary, it would be expected that a land-based temperate marine farm is consistent with and would complement activities in the area. The boat harbour services the rock lobster fishing fleet that operates out of Jurien and an existing, licensed aquaculture project.

The development of the site for land-based temperate marine aquaculture farm would be unlikely to restrict access to the coast for fishing and other recreational activities.

Tenure

Jurien Boat Harbour is vested in the Crown and managed by the Shire of Dandaragan. The purpose is Crown Reserve: Recreation - Foreshore. For land-based aquaculture to occur the purpose of the Crown Reserve will need to be changed with the Department of Land Administration. This will require Council approval.

The Department of Land Administration parcel number for the site is: Reserve 19206.

Contact:

CEO
Dandaragan Shire
Dandaragan Rd
Dandaragan WA 6507

Tel: (08) 9651 4010
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7.2 Site Evaluation

7.2.1 Potential for Development

The Jurien Boat Harbour site is considered to have high potential for development.

The physical features of the site are well suited for land-based marine aquaculture, the water quality is good and the quantities of drifting seaweed in the coastal water small. The establishment of a breakwater or similar structure to provide protection for marine intake and discharge systems is considered an economically-viable solution, given the cost structures of an temperate marine farm with a reasonably high annual production capability.

Economic factors are equally good: the site is located in an area reasonably close to Perth and has adjacent to it a level of infrastructure and services highly conducive to comparatively-low-cost development.

Aquaculture is an industry consistent with current activities in the area and development at the site unlikely to restrict access to the beach for recreational purposes.

7.2.2 Constraints to Development

The main constraint to the development of the site for land-based temperate marine aquaculture is likely to be environmental; specifically, in relation to the physical impact of the construction of a marine intake and discharge system and the discharge of used sea water back into the bay. This potential constraint needs consideration within the context of the current planning process being undertaken for the Jurien Marine Reserve.

Given that any sea water discharged from a land-based aquaculture operation will be required to be treated to a defined standard, aquaculture constitutes a resource use that is in tune with basic ecological prerequisites for sustainable production. This is particularly true for land-based aquaculture, in which all used water can be treated before being discharged into the ocean.

The Jurien Boat Harbour site is one of the few in the Mid-West Coastal Region ranked as having high prospects for land-based temperate marine aquaculture.[16]

[16] The Island Point site, described in Chapter 8, has similar attributes to and is ranked the same as the Jurien Boat Harbour site. These are two of only three sites in the entire Mid-West Coastal Region considered to have high prospects for land-based abalone aquaculture. Island Point lies immediately to the south of Jurien Bay and would be similarly affected by the proposed Jurien Marine Reserve.

8. ISLAND POINT (Site 25)

8.1 Site Description

8.1.1 Physical and Biological Features

Location and Size

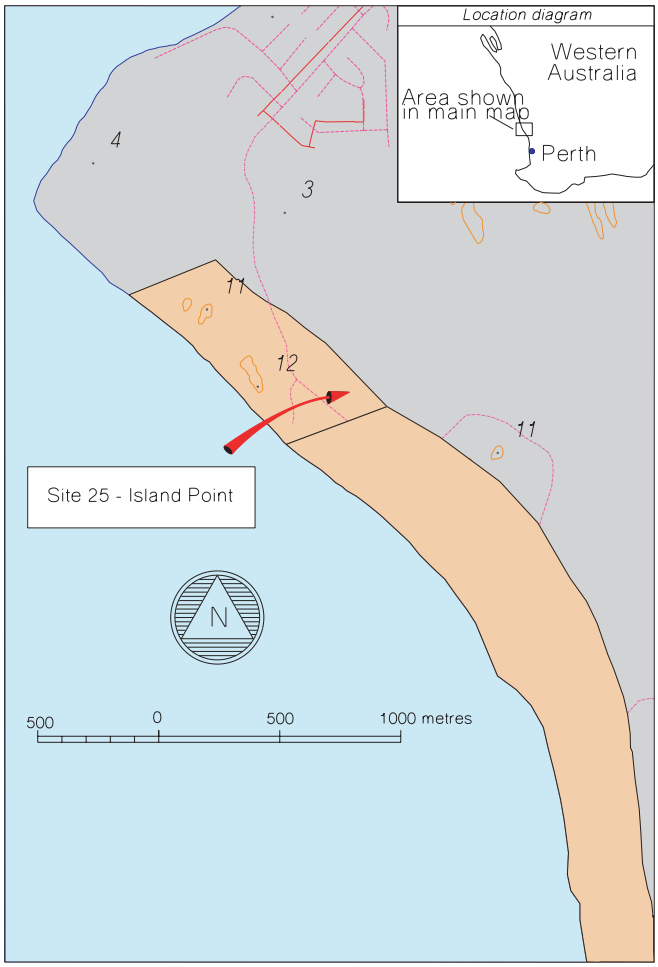

Figure 10. Map illustrating the location and major physical features of Island Point (Site 25).

Island Point (Site 25) is located to the south of Jurien, about 250 km north of Perth. There is good access to the northern end of the site by an all-weather, sealed road.

The preliminary site selected from the GIS Study comprised a narrow coastal area of about 12 ha and was considered to have limited potential. However, the on-site inspection confirmed that the area of suitable land is in fact much wider than initially indicated (Fig. 10). The proposed site area is over 250 m wide and extends along the coast for several kilometres. An area of 25 ha (250 m wide and 1 km in length) at the northern end of the area indicated would be considered the most suitable for an temperate marine aquaculture farm.

Topography and Hydrography

The elevation of the suitable area averages less than 10 m above MSL. The site is reasonably level and considered well suited for a land-based temperate marine farm.

The water close to shore is comparatively shallow but deep enough for a marine intake. The nearshore current is northwards-flowing.

Soil and Vegetation

The soil is sandy and there are no rocky outcrops. The vegetation comprises typical medium-density coastal heath and shrubs that would present few problems for clearing and levelling. The vegetation is in its natural state and not degraded.

Sea Water Supply and Discharge

The options for sea water intake and discharge systems are generally similar to those described for Jurien Boat Harbour. Possibly as a consequence of slightly different coastal processes operating off Island Point, which is protected to some extent by a reef about 1 n mile offshore that runs parallel to the shoreline, there is apparently little drifting seaweed in the water. Given the shelter afforded by the reef and the lower quantities of drifting seaweed, a marine intake would probably be a good option for a sea water supply system. The intake and discharge pipelines or structures could either be anchored by heavy concrete blocks or alongside a limestone breakwater constructed for that purpose. Beach wells could be feasible at the site and this option may be worth exploring. We expect that a marine intake would present the optimum solution for sea water supply and discharge at this site.

The only option for discharging used water after treatment is directly into the ocean, either downstream or further offshore from the intake, using the same structures put in place to support the intake.

Water Quality

The site has high-quality sea water that contains small quantities of drifting seaweed. The only river near the site is the Hill River, the mouth of which is about 8 km south of the site. Any fresh water discharge from the river would be unlikely to influence the water quality at the site, due to its distance from the discharge point and the high-energy coastline.

Pollution and History

There is no obvious pollution from industrial or agricultural sources in the vicinity of Island Point. Previous visits to the site identified the presence of several squatters' shacks, but these are no longer evident. The site has no other history of use.

8.1.2 Economic, Social and Legal Factors

Site Infrastructure and Services

The site has no existing infrastructure, but is within a few kilometres of Jurien and 250 m of a good, all-weather, unsealed road that leads from the town to Island Point. The services and industries associated with the boat harbour, which is about 5 km from the site, are significant and would be of benefit to any temperate marine farm developed at this site. Infrastructure and services in the general area and within a few kilometres of the site include sealed, all-weather roads, three-phase electrical power supplied by the Perth grid, potable water supplies and

telecommunications facilities. As for the Jurien Boat Harbour site, Island Point is considered one of the best on the western and southern coasts in respect the proximity of good infrastructure and services.

Competitive Resource Use

There is no apparent conflicting resource use at the site, at which a land-based temperate marine aquaculture farm would be expected to be consistent with, and complementary to, associated activities in the area.

It is considered that the development of the site for land-based temperate marine aquaculture farm is unlikely to restrict access to the coast for fishing and other recreational activities.

Tenure

Island Point is vested in the Crown and managed by the Shire of Dandaragan. The purpose is Crown Reserve: Recreation - Foreshore. For land-based aquaculture to occur the purpose of the Crown Reserve will need to be changed with the Department of Land Administration. This will require Council approval.

The Department of Land Administration parcel number for the site is: Reserve 28541.

Contact: CEO
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Tel: (08) 9651 4010
Fax: (08) 9651 4057
Email: council@dandaragan.wa.gov.au

8.2 Site Evaluation

8.2.1 Potential for Development

Island Point is considered to have high potential for the development of land-based temperate marine aquaculture.

As for Jurien Boat Harbour, the physical features of the site are well suited for aquaculture, the water quality is good and drifting seaweed is largely absent from coastal water. The establishment of a breakwater or similar structure to provide protection for marine intake and discharge systems is considered an economically-viable solution, given the cost structures of an temperate marine aquaculture farm with a reasonably high annual production capability. Economic factors are equally good: the site is located in an area reasonably close to Perth and is within a few kilometres of infrastructure and services highly conducive to comparatively-low-cost development.

Aquaculture is an industry consistent with current activities in the area and development at the site unlikely to restrict access to the beach for recreational purposes.

8.2.2 Constraints to Development

The main constraints to the development of the site are:

- the proximity of a new residential development;
- the current use of some of the water for sea cages; and
- environmental issues.

The on-site inspection found that a major road in the construction process leading southwards from Jurien. A residential subdivision, which appears to be under development on the western side of the road, may limit the size of the proposed site. If the boundaries of the development will ultimately extend to the frontal dunes, the use of the site for aquaculture may be constrained.

The use of the water resource may be perceived as competitive with an existing aquaculture project presently using offshore sites to culture fish in sea cages. However, it is unlikely that the water discharged from a land-based temperate marine aquaculture farm would reach the cages or reduce the quality of sea water in the area.

A potential environmental constraint is that described for Jurien Boat Harbour and relates to the construction of a marine intake and discharge system and the discharge of used sea water back into the bay.

Given that any sea water discharged from a land-based aquaculture operation will be required to be treated to a defined standard, aquaculture constitutes a resource use that is in tune with basic ecological prerequisites for sustainable production. This is particularly true for land-based aquaculture, in which all used water can be treated before being discharged into the ocean.

Part Three: Temperate Marine Sites in the Southern Coastal Region

9. Preston Beach (Site 31)

9.1 Site Description

The following description for Preston Beach may also be considered to generally apply to Preston Beach South (Site 32) and Myalup Beach (Site 33), which are located immediately to the south of the Preston Beach site (Appendix 2). One of the differences between these sites is their topography: the elevation of the frontal dunes becomes progressively higher towards the south.

9.1.1 Physical and Biological Features

Location and Size

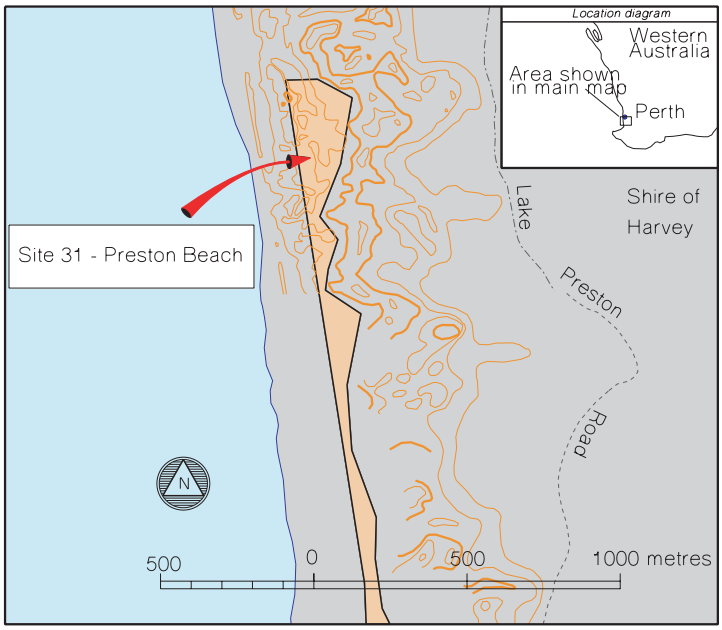

Figure 11. Map illustrating the location and major physical features of Preston Beach (Site 31).

Preston Beach (Site 31) is located on the southern, west coast between Lake Preston and the sea, about 140 km by road south of Perth and 70 km by road north of Bunbury. The site has good access from Preston Beach Road, an all-weather, sealed road, which leads from Old Coast Road to the beach and the Preston Beach Holiday Village and Caravan Park. The sealed road terminates at the coast about 4 km north of the northern end of the site.

As shown in Figure 11, the site occupies an elongate area of 22 ha, but it could easily be approximately doubled in size by extending its eastern boundary further inland than shown in the figure.

Topography and Hydrography

Figure 12. Coastal features of Preston Beach, showing wide beaches and low frontal dunes.

The site features wide, sandy beaches backed by frontal dunes that rise in some places to a height of 30 m, but with extensive areas between 5 and 10 m elevation. Some cut-and-fill earthworks would be needed to achieve an adequate area at a suitable elevation, but these are unlikely to be extensive or prohibitive in cost. At the northern end of the site there is an extensive system of low dunes; towards its southern half the dunes recede, giving way to a wider beach (Fig. 12). The general topography of this site is very well suited to land-based aquaculture.

The coast is exposed and subject to high wave energy. The water close to shore appears deep enough for a marine intake and the inshore current flows to the north.

Soil and Vegetation

The soil is sandy and there are no rocky outcrops. The vegetation comprises low to medium-density coastal heath and shrubs and there are no trees or forested areas. Some dune rehabilitation work is in progress to the north of the site. Few physical problems are likely to be encountered for clearing and levelling the site. The dunes are partially degraded and the establishment of a temperate marine aquaculture farm at the site would assist with the general rehabilitation of the area.

Sea Water Supply and Discharge

The coast is exposed with no offshore reefs to provide protection. The options for sea water intake systems include an offshore, marine intake or beach wells. The water appears very clean and free of drifting seaweed, possibly eliminating the need for self-cleaning intake screens. Notwithstanding the exposure, a marine intake probably represents the best option for a sea water supply system, given that some supporting structure would be needed in any case for a discharge pipeline. The intake and discharge pipelines or structures could either be anchored by heavy concrete blocks or alongside a breakwater constructed for that purpose. Beach wells may be feasible at the site and this option may be worth exploring. However, a marine intake would present the optimum solution for sea water supply and discharge.

The only option for discharging used water after treatment is directly into the ocean, either downstream or further offshore from the intake, using the same structures put in place to support the intake.

Water Quality

The sea water at the site is very high in quality. While several small streams discharge seasonally into Lake Preston, the nearest fresh water discharge of any size is out of the diversion drain from the Harvey River, which discharges at the south of Lake Preston about 20 km from the site. It is unlikely that the effects of fresh water discharge at this point would influence the quality of the sea water at the site.

Pollution and History

There is no obvious pollution from industrial or agricultural sources in the vicinity of the site. Other than for recreational activities, the site has no other history of use.

9.1.2 Economic, Social and Legal Factors

Site Infrastructure and Services

The site has no existing infrastructure, but is within a few kilometres of Preston Beach Road and power lines. It is well located in that it is close to the significant range of services and light industries provided at Bunbury. Infrastructure and services in the general area and within a few kilometres of the site include sealed, all-weather roads, three-phase electrical power supplied from the Perth grid, potable water supplies and telecommunications facilities. Preston Beach is considered a good site in respect of its proximity to infrastructure and services.

Competitive Resource Use

There is no apparent conflicting resource use at the site. Its development for land-based temperate marine aquaculture is unlikely to restrict access to the coast for fishing and other recreational activities.

Tenure

Preston Beach is privately owned land. The owner is Mark Stephen Chew.

The Department of Land Administration parcel number for the site is: WELLIL712, CT 1314/16.

Contact: Mark Stephen Chew
Level 12
68 St. Georges Tce
Perth WA 6000

Tel: (08) 9226 1800
Fax: (08) 9226 2688

9.2 Site Evaluation

9.2.1 Potential for Development

Preston Beach is considered an excellent site for land-based temperate marine aquaculture and has high development potential. Its main positive features include good access, good site elevation, reasonable options for a sea water supply and discharge system, very high-quality sea water, proximity to major urban centres and favourable land tenure.

9.2.2 Constraints to Development

There are no obvious constraints to development.

The site comprises privately-owned land on the opposite side of Lake Preston to the Yalgorup National Park, which would be unaffected by any of the activities of a land-based temperate marine aquaculture farm. The camping areas associated with the National Park are well separated from the site. It is unlikely that there would be any rational social or environmental objections to the development of the site for aquaculture. On the contrary, the presence of a temperate marine aquaculture farm in the area may constitute an additional tourist attraction for the area.

10. Cable Sands (Site 36)

The following site description for Cable Sands may be considered generally applicable to Dalyellup Beach and Dalyellup Beach South (respectively, Sites 34 and 35), which are located immediately to the north of Cable Sands; and Minninup, Stirling Beach and Stirling Beach South (respectively, Sites 37, 38 and 39), which are located immediately to its south (Appendix 2). There are few major differences between these sites, which are therefore all considered to have high potential for the development of land-based temperate marine aquaculture farms.

10.1 Site Description

10.1.1 Physical and Biological Features

Location and Size

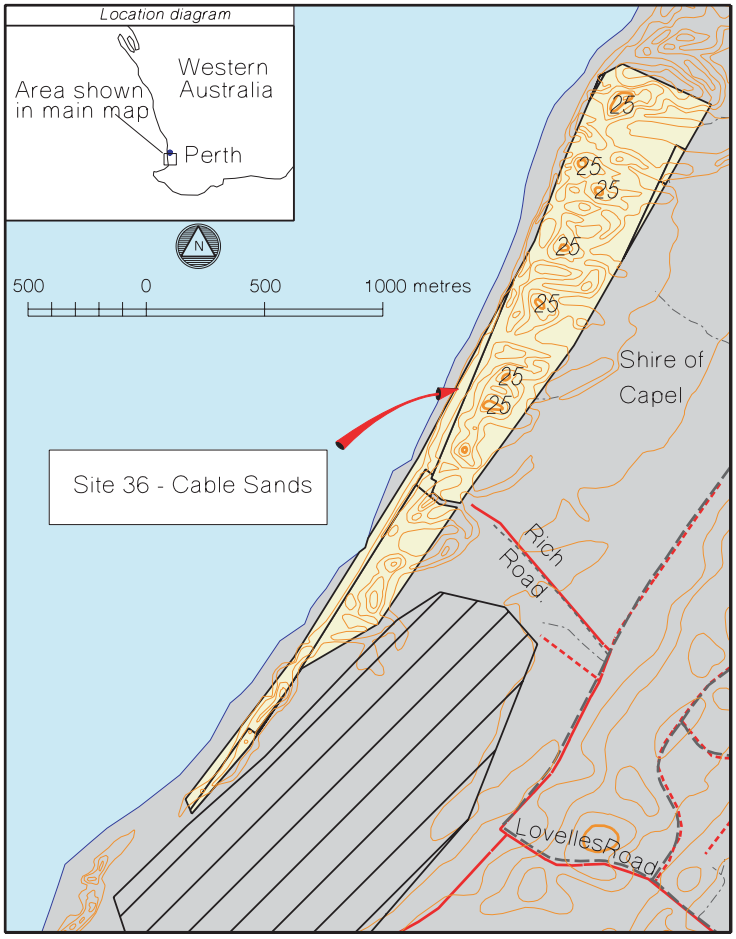

Figure 13. Map illustrating the location and major physical features of Cable Sands (Site 36).

Cable Sands (Site 36) is located on the southern, west coast about 15 km by road south of Bunbury (Fig. 13). There is good access to the beach roughly at the centre of the site from Rich Road, via Fishermans Road and Bussell Highway, all of which are all-weather, sealed roads. A minimum area of 20 ha would be available in the section of the site south of Rich Road. A larger area exists to the north of the road. The total area of the site is 80 ha. The hatched area shown in Figure 13 at the southern portion of the site indicates an area considered highly suitable for temperate marine aquaculture, since it occupies a low-lying area of privately-owned land, currently

under pasture, which is adjacent to a waterway that could be used for sea water discharge purposes. The opening in the frontal dunes is evident in Figures 11 and 14.

Topography and Hydrography

The site features sandy beaches, which are usually reasonably wide but narrow in places, backed by low frontal dunes. The height of the dunes can reach 20 m, but there are extensive areas in which their maximum height is less than 10 m.

A feature of the topography of the site is the area of low-lying ground that occurs immediately behind the frontal dunes. Parts of this area are flooded, but not seriously, during the winter months after periods of heavy or protracted rainfall. The area is well drained, much of it is not flooded and large areas would be available for the construction of land-based facilities at an ideal elevation above MSL.

The coast is exposed and subject to high-to-moderate wave energy. The water close to shore appears deep enough for a marine intake and the inshore current flows to the north.

Soil and Vegetation

The soil is sandy and there are no rocky outcrops. The vegetation on the frontal dunes comprises medium-density coastal heath and shrubs that are partially degraded and there are no trees or forested areas. Some dune rehabilitation work being carried out in the area has been partially successful. The section of the site that would be used to establish an temperate marine aquaculture farm comprises more loamy soil and has been cleared for agricultural use. At the time of inspection, it was being used as pasture for livestock. Few physical problems are likely to be encountered in levelling the site.

Sea Water Supply and Discharge

Figure 14. A drainage channel near the southern sector of Cable Sands, which could provide a good option for discharging used water.

The coast is exposed and the nearshore waters contain no offshore reefs that could be used to anchor or shelter a water supply system. The main option for a sea water intake system at the site is possibly an offshore, marine intake. The water appears reasonably clean but does contain some drifting seaweed, so a marine intake would probably need to include self-cleaning screens. The marine intake and water supply pipelines could either be anchored by heavy concrete blocks or placed alongside a purpose-built breakwater. Beach wells may constitute a

viable, alternate option for water supply at the site, if test wells provide positive results in terms of water quality and sustainable flow.

Options for disposing of used water after treatment include is direct discharge into the ocean through pipelines placed alongside the intake lines, but placed downstream from the intake point, or indirect discharge by taking advantage of the existing water course located near the southern part of the site (Fig. 14) The latter option is considered optimum for this site. From an environmental perspective, the water currently discharged from the water course cannot be considered pristine or in its natural state, since it presently drains a large area used for agricultural purposes.

Water Quality

Although it does contain some drifting seaweed, the sea water at the site is high-quality.

The large rivers in the area are the Ferguson, Preston and Capel rivers, but the locations and distances of their points of discharge from the site are such that they are unlikely to influence the water quality at the site. Preston and Ferguson rivers flow northwards into Leschenault Inlet, so their flows would be carried away from the site with the prevailing current. Capel River discharges into the ocean about 6 km south of the southern boundary of the Cable Sands, so any effects of its fresh-water flows at the site would be minimal or non-existent.[17]

Pollution and History

There is no obvious pollution from industrial or agricultural sources in the vicinity of the site.

The portion of the site inside the frontal dunes is presently being used for agricultural purposes. The presence of any pesticides or herbicides that may have been used or are residual in the soil would need to be ascertained, so the necessary precautions can be taken. Earthen ponds would not be used for intensive, land-based temperate marine aquaculture farms, so the presence of biocides in the soil would not present significant problems. The beach in front of the frontal dunes is used, but not heavily, for recreational activities such as fishing.

10.1.2 Economic, Social and Legal Factors

Site Infrastructure and Services

Cable Sands has no existing infrastructure, but is traversed by Rich Road, alongside which runs a three-phase power supply. The site is well located in that it is close to the significant range of services and light industries provided at Bunbury. Infrastructure and services in the general area and within a few kilometres of the site include sealed, all-weather roads, three-phase electrical power supplied from the Perth grid, potable water supplies and telecommunications facilities.

Competitive Resource Use

There is no apparent competitive resource use at the site. Its development for land-based temperate marine aquaculture is unlikely to restrict access to the coast for fishing and other recreational activities.

Tenure

The site is privately owned, by Cable Sands Pty Ltd.

[17] The southern portion of one of the sites adjoining Cable Sands, Stirling Beach South (Site 39), is a short distance from the mouth of Capel River. Any proposed development of that site would need to consider the effects of fresh water discharged from the river on the quality of the sea water supplied to a farm.

The Department of Land Administration parcel number for the site is: PO18477-1, CT 1946/794.

Contact: Managing Director
Cable Sands Pty Ltd
Level 15
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250 St. Georges Tce
Perth WA 6000

Tel: (08) 9212 6000
Fax: (08) 9486 4711

10.2 Site Evaluation

10.2.1 Potential for Development

Cable Sands is considered an excellent site for land-based temperate marine aquaculture and has high development potential. Its main positive features include very good access, excellent elevation, reasonable options for a sea water supply system and a good option for a discharge system, high-quality sea water, close proximity to a major urban centre and favourable land tenure.

10.2.2 Constraints to Development

There are no obvious, major constraints to development.

The site comprises privately-owned land adjacent to a coastline, the sand dunes of which have already been subject to some degradation. Access to the beach for recreational purposes is unlikely to be restricted by a temperate marine aquaculture farm, the development of which at this site would be unlikely to raise any rational social or environmental objections.

11. Boat Harbour (Site 49)

11.1 Site Description

11.1.1 Physical and Biological Features

Location and Size

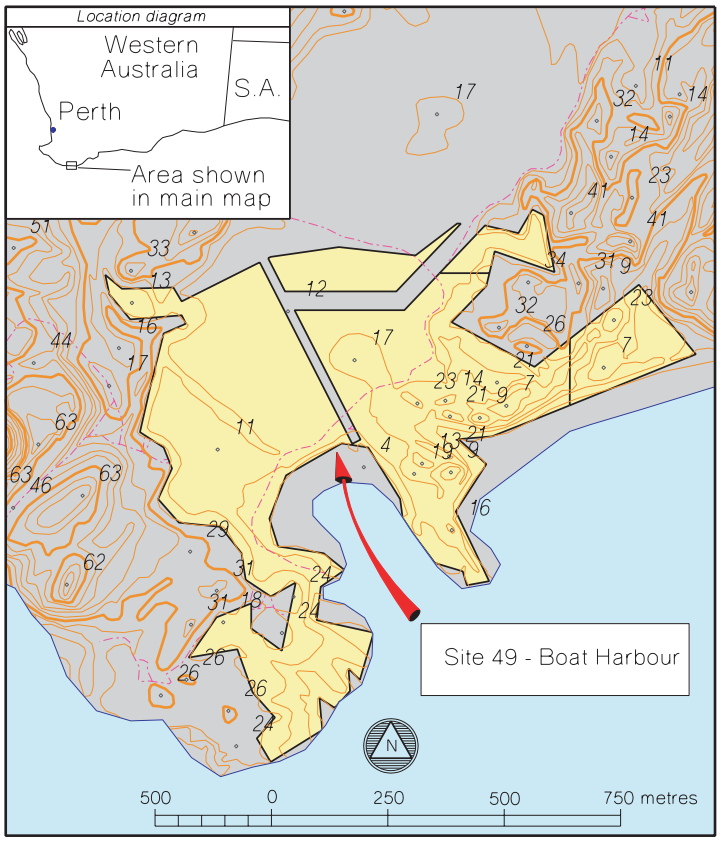

Figure 15. Map illustrating the location and major physical features of Boat Harbour (Site 49).

Boat Harbour (Site 49) is located on the south coast about half-way between the towns of Walpole and Denmark. By road, the site is about 30 km from Denmark and 85 km from Albany, both of which are to the east. The site is 7 km from South Coast Highway. Boat Harbour Road, which intersects the highway, is an unsealed road for the first 1.5 km, at which point camping grounds and chalets are situated, followed by a 5.5 km four-wheel-drive track that leads to the site. The track would be passable during the summer, but at the time of inspection was flooded at its lower points.

The total site area as it is shown in Figure 15 is 50 ha; however, the sector more suited for land-based temperate marine aquaculture is that to the north-west of the small bay, including a narrow strip of land along its western side. This area comprises about 25 ha. The sector to the east, including the headland that forms the eastern side of the bay, is largely unsuitable because it has moderately-high frontal dunes with only small, eroded pockets of lower-lying areas.

Topography and Hydrography

The site features a small bay contained by high, rocky headlands and a small, sandy beach. The large area of relatively low-lying land to the north-west of the bay and a smaller strip of land along its western shore collectively constitute the Boat Harbour site as it is described in this chapter. The area to the east of the bay generally comprises high frontal dunes, within which there is only a small, low-lying area. The average height of the dunes at the suitable site to the north-west and west of the bay is about 10-15 m. A large portion of the site comprises reasonably level land.

The coast is exposed and subject to high wave energy and high swells. The small bay and headlands provide a well-protected environment considered ideal for the establishment of a marine sea-water intake system. The water within the bay and off the steep headlands is deep close to shore. The inshore current flows to the east, presumably under the influence of the West Wind Drift.

Soil and Vegetation

The soil is sandy and there are a few rocky outcrops. The vegetation on the frontal dunes to the east of the bay comprises medium-density coastal heath and shrubs that are severely degraded in some areas. The section of the site to the west of the bay features a grassy area and that to the north-west a lightly forested area of low to medium-height shrubs and small trees generally lower than about 1 m height but up to 2 m in small patches. Few physical problems are likely to be encountered for levelling the site.

Sea Water Supply and Discharge

Boat Harbour presents excellent options for sea water intake and discharge systems.

A marine intake could be located at any of several locations within the inner bay, close to the shore. The ideal location for an intake is in the north-eastern corner of the bay, an area that affords the maximum protection from southerly and south-easterly winds. A marine intake and water supply pipelines could be attached to or anchored alongside the rocks that form the shore of the bay. Beach wells are considered a less practicable water supply option at this site.

The preferred option for discharging used water is via an existing water course that travels behind the high frontal dunes and enters the sea to the east of the promontory that forms the eastern side of the bay. The very-high-energy coastline in this area would ensure the water is well mixed and the currents are such that the proposed discharge point is downstream from the small bay in which the marine intake would be located. An alternate option for discharging used, treated sea water is by way of a pipeline extended along the western side of the bay and entering the water in a protected area inside the headland. The discharge pipeline could then be extended to allow the water to be discharged at a point further out to sea, so the used water is not carried back to the intake.

Water Quality

The sea water at Boat Harbour is very high in quality and typical of the very clear, unpolluted water along much of the south coast of Western Australia.

The high quality of the sea water would not be influenced by the limited quantities of fresh water that drain into the area during the winter rainy season. The main fresh water discharge point is to the east of and hence downstream from the site. The large rivers and inlets common along this section of the south coast are remote from, and do not affect, the water quality at Boat Harbour.

Pollution and History

There is no obvious pollution from industrial or agricultural sources in the vicinity of the site.

The site does not appear to have been subject to any previous use. The beach to the east of the site is used, but not heavily, by recreational fishers. It is unlikely that the area would be used for other recreational purposes: except on very calm days, the high swell, high wave energy and rapidly-shelving beach combine to make conditions dangerous for activities such as swimming.

11.1.2 Economic, Social and Legal Factors

Site Infrastructure and Services

Boat Harbour has no existing infrastructure and, compared to other sites selected as suitable for land-based temperate marine aquaculture, has poor access. The last 5.5 km of the four-wheel-drive track leading to the site would have to be upgraded to allow efficient access.

The site is reasonably well located in that it is close to the range of services and light industries provided at Denmark and Albany. Three-phase electrical power supplied from the Perth grid is available at a point 7 km from the site, at South Coast Highway. Telecommunications lines are a similar distance. There is no potable water supply or sewerage at Boat Harbour and provision would need to be made for these services in any farm design. Adequate fresh water supplies would probably be collected in rain water tanks.

Competitive Resource Use

There is no apparent competitive resource use at the site. Rather than restricting it, the development of the site for land-based temperate marine aquaculture may increase access to the coast for fishing and other recreational activities.

Tenure

The site is vested in the Crown and managed by the Shire of Denmark. The purpose is Crown Reserve: Recreation - Conservation - Foreshore. For land-based aquaculture to occur, the purpose of the Crown Reserve will need to be changed with the Department of Land Administration. This will require Council approval.

The Department of Land Administration parcel number for the site is: Reserve 7723.

Contact:

CEO
Denmark Shire
PO Box 183
Denmark WA 6333

Tel: (08) 9848 1106
Fax: (08) 9848 1985
E-mail: denmarkshire@wn.com.au

11.2 Site Evaluation

11.2.1 Potential for Development

Boat Harbour is considered an excellent site for land-based temperate marine aquaculture with high potential for development.

The physical and biological features of the site are well suited for aquaculture. Its main positive features include good elevation, excellent options for a sea water supply and discharge system, very-high-quality sea water, pristine environment and a reasonable distance from towns. The establishment of a breakwater or similar structure to provide protection for marine intake and discharge systems would be unnecessary, resulting in significantly-reduced construction costs.

The main disadvantages of the site are its comparatively poor access and distance from infrastructure and services. However, these disadvantages are not considered significant and they have simple, economic solutions. The positive attributes of the site by far outweigh its few disadvantages.

Aquaculture is an industry consistent with current activities in the area and development at the site is unlikely to restrict access to the beach for recreational fishing purposes. Given the high profile of tourism in the south coastal areas, it is likely that an operating land-based temperate marine aquaculture farm would provide an additional attraction to the area.

11.2.2 Constraints to Development

There are no obvious, major constraints to development. Potential, minor constraints to development include:

- access difficulties, the remote location and lack of infrastructure and services;
- environmental issues;
- conflict with existing users of the resource; and
- proximity to a Nature Reserve.

Access difficulties could be overcome relatively simply and cost-effectively, by constructing an unsealed road over the existing four-wheel-drive track. Power lines and other services would also need to be provided. The cost of providing these services to the site from the existing supply may be mitigated by applying for government grants established specifically for that purpose.

The frontal dunes to the east of the site have been subject to fairly severe degradation, so the area cannot be considered in pristine condition. If anything, aquaculture development at the site would assist with the rehabilitation of the coastal area and improving the coastal environment.

Any potential conflict with existing resource users would almost certainly be offset by allowing public use of the access road, thereby improving access to the beach.

A proposal to aquaculture fish species at Boat Harbour would be looked at carefully, due to the proximity of the site to Quarrum Nature reserve. A land-based temperate marine aquaculture development at the proposed site would need to be sensitive to the conservation value of the area and deal with the relevant issues in an aquaculture licence application. The Department of Conservation and Land Management would be interested in issues such as access and threats to any endangered species, so any proposal would have to deal with these matters. Notwithstanding the proximity of Quarrum Nature Reserve, few insurmountable difficulties are expected with the development of Boat Harbour for temperate marine aquaculture, mainly because the site is downhill, and hence downstream, from the nature reserve, which would be largely unaffected by any discharged water.

12. Parry Beach (Site 50)

12.1 Site Description

12.1.1 Physical and Biological Features

Location and Size

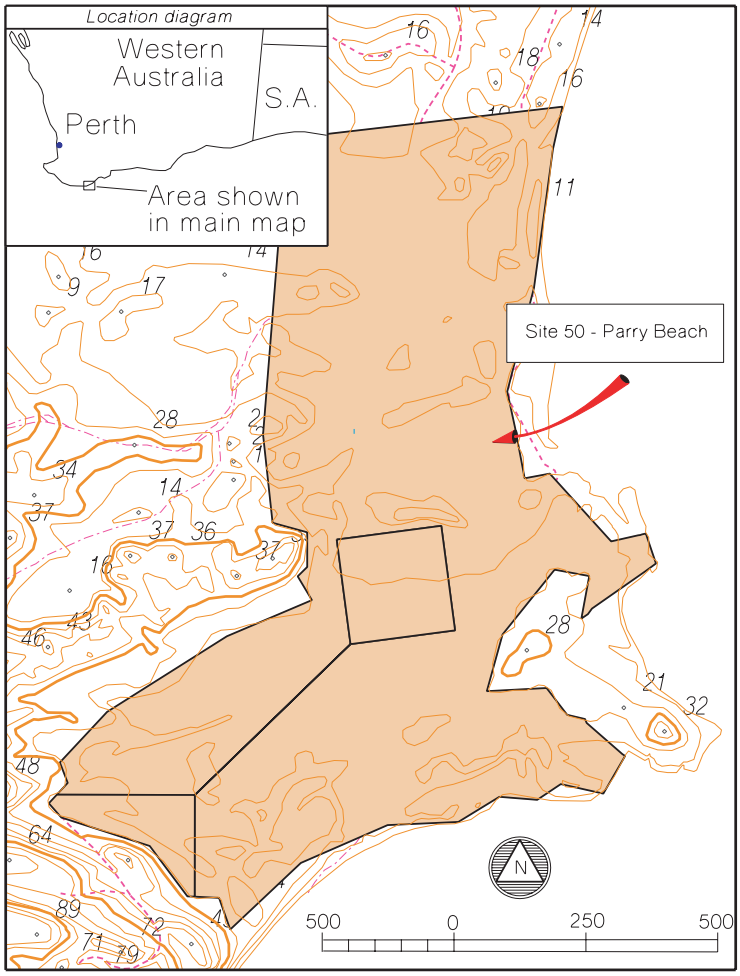

Figure 16. Map illustrating the location and major physical features of Parry Beach (Site 50).

Parry Beach (Site 50) is located on the south coast to the west of Denmark and Albany, the distances of which are, respectively, about 30 km and 85 km by road. The site is 6 km from South Coast Highway via Parry Beach Road. There is good access by the sealed, all-weather roads. The site as it is illustrated in Figure 16 occupies a total area of 27 ha and encompasses the beach to the south of Parry Inlet, the headlands surrounding the small bay and the area to the south-west. It is the latter sector to the south-west that constitutes the Parry Beach site. Its area is about 10 ha. It would be unrealistic to propose the use of the remainder since it is subject to heavy recreational use and includes a caravan park and camping ground. The caravan park is shown in Figure 16 as the square area located approximately in the centre of the site. The Parry Beach site includes an old quarry, which is near its south-western portion.

Topography and Hydrography

The coast in this area is characterised by protruding, elevated, rocky headlands that shelter small, sandy beaches. The frontal dunes are generally high, although the area proposed for the Parry Beach site has an average elevation of about 15 m or less.

Parry Beach is about 8 km to the east of Boat Harbour and has similar hydrography and hydrology to that site. The exposed parts of the coast are subject to high wave energy and swells. The small bays and headlands of this coast are exposed to easterly and south-easterly winds, however, so are less protected than Boat Harbour. The water within the bay and off the steep headlands is deep close to shore and the inshore current flows to the east.

Soil and Vegetation

The soil is sandy and there are numerous rocky outcrops. The vegetation on the frontal dunes mainly comprises low to medium-density coastal heath and shrubs. Some problems may be encountered in levelling the site as a result of the rocky outcrops.

Sea Water Supply and Discharge

There are reasonable options for sea water intake and discharge systems at Parry Beach.

A marine intake could be located at one of several locations around the headlands, close to the shore in an area that affords the best protection from easterly and south-easterly winds. As for Boat Harbour, a marine intake and sea-water supply pipelines could be attached to or anchored alongside the rocks that form the headlands. Beach wells are considered a less practicable water supply option at this site due to the rocky ground and its probable impermeability.

The options for discharging used water may be limited to pipelines that discharge directly into the ocean, downstream from the intake point. There is an existing water course that drains onto Parry Beach to the south of the mouth of Parry Inlet; however, for environmental and aesthetic reasons, it may be difficult to gain permission to discharge water into this area. The very high energy coastline in this area would ensure the water is well mixed and the currents are such that water discharged downstream from the intake point would not be recycled.

Water Quality

The sea water at Parry Beach is very high in quality and unlikely to be influenced by any fresh-water discharge. Parry Inlet, which opens about one kilometre to the north of the site, is a very shallow basin with low water flows.

Pollution and History

There is no obvious pollution from industrial or agricultural sources in the vicinity of the site.

The only previous use of the site appears to be limited to quarrying in a small area. The area adjoining the northern and eastern parts of the site is heavily used for recreational activities including camping and fishing.

12.1.2 Economic, Social and Legal Factors

Site Infrastructure and Services

The Parry Beach site has no existing infrastructure, but is within 100 m of a sealed road and power supply. The possibility that services such as potable water and telecommunications might be available near the site was not

confirmed during the on-site inspection. The site is well located in that it is close to the range of services and light industries provided at Denmark and Albany.

Competitive Resource Use

In the vicinity of the site, there are a caravan park and camping grounds. Both are heavily used by tourists. The proposed land-based temperate marine aquaculture site does not encroach on these grounds.

Tenure

The site is vested in the Crown and managed by the Shire of Denmark. The purpose is Crown Reserve: Recreation - Foreshore. For land-based aquaculture to occur the purpose of the Crown Reserve will need to be changed with the Department of Land Administration. This will require Council approval.

The Department of Land Administration parcel number for the site is: Reserve 20928.

Contact: CEO
Denmark Shire
PO Box 183
Denmark WA 6333

Tel: (08) 9848 1106
Fax: (08) 9848 1985
E-mail: denmarkshire@wn.com.au

12.2 Site Evaluation

12.2.1 Potential for Development

Parry Beach is considered a reasonably good site for land-based temperate marine aquaculture development, its potential for which is ranked at high-to-medium.

The physical and biological features of the site are well suited for aquaculture. Its main positive features include good access, moderately good elevation, good options for a sea water supply and discharge system, very-high-quality sea water, proximity to infrastructure and services and a reasonable distance from towns. As for Boat Harbour, the establishment of a breakwater or similar structure to provide protection for marine intake and discharge systems would be unnecessary, resulting in significantly-reduced construction costs.

12.2.2 Constraints to Development

Potential constraints to development include:

- site elevation;
- proximity to a fresh-water discharge point;
- conflict with existing users of the resource; and
- proximity to a National Park.

Although the topographic data indicate the elevation of the site above MSL is favourable, the on-site inspection suggested the ground elevation may in fact be marginal. It is recommend that any proposal to develop this site for land-based aquaculture be preceded by a more detailed topographic survey to confirm the suitability of this criterion.

The proximity of the site to the mouth of Parry Inlet is not considered a development constraint for several reasons that include: the limited flow from the inlet; the distance and upstream location of the site in relation to the inlet; and the high-energy feature of the coast, which would rapidly and efficiently disperse any effects of fresh-water discharge.

Aquaculture is an industry considered consistent with current recreational activities in the area. The proposed site has been located to ensure its development for land-based temperate marine aquaculture is unlikely to restrict access to the caravan park, camping grounds or beach for recreational fishing purposes. Indeed, given the high profile of tourism in the south coastal areas, it is likely that an operating temperate marine farm would provide an additional attraction to the area. In any case, any land-based temperate marine aquaculture development would need to be sensitive to the conservation value of the area.

The site is within 1-2 km of the sector of William Bay National Park that adjoins the eastern side of Parry Inlet. This is not considered an important constraint, but is noted because it would be important for any licence application to deal with issues such as access and impact on native or endangered species.

13. William Bay West (Site 52)

13.1 Site Description

The following site description for William Bay West may be considered generally applicable to Parry Inlet (Site 51), located immediately to the west of William Bay West; and Mazzoletti Beach West, Mazzoletti Beach East and William Bay East (respectively, Sites 53, 54 and 55), located immediately to the east of the site (Appendix 2). There are several differences between William Bay West, which is considered to have high potential for the development of land-based temperate marine aquaculture farms, and the adjoining sites, which are all ranked high-to-medium for that purpose.[18] A feature of these sites is they are encompassed on their eastern, western and southern boundaries by William Bay National Park. The separate, large eastern and western sectors of the National Park are connected by the narrow southern corridor, which varies between about 100 and 250 m in width, along Mazzoletti Beach.

13.1.1 Physical and Biological Features

Location and Size

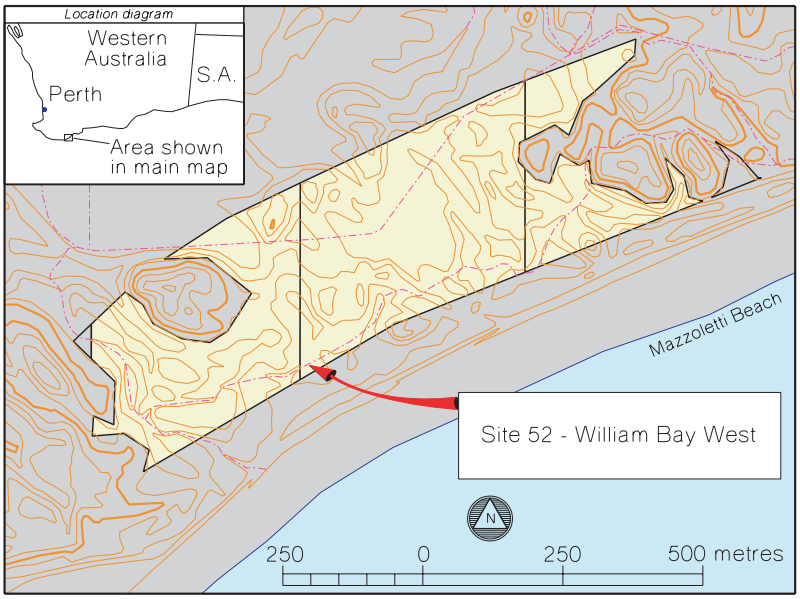

Figure 17. Map illustrating the location and major physical features of William Bay West (Site 52).

William Bay West is one of several sites behind Mazzoletti Beach, within William Bay, on the south coast about 20 km by road to the west of Denmark and 65 km from Albany. The site is 3.8 km from South Coast Highway, along an unnamed, unsealed road in reasonably good condition and may be considered all-weather.

Generally, this area comprises elevated frontal dunes but does include several areas large enough for the establishment of intensive temperate marine aquaculture farms. The site proposed for land-based temperate marine aquaculture is located at the centre of the area shown in Figure 17, approximately 300 m from the beach and occupies an area of about 5 ha (Fig. 17).

[18] The differences referred to that warrant the higher ranking for William Bay West include better access, options for sea water supply and discharge and elevation.

Topography and Hydrography

The site lies behind Mazzoletti Beach, which is a wide, reasonably steeply-shelving beach bounded by headlands at Point Hillier and Edward Point at its western and eastern ends respectively. The site is roughly in the middle of the beach, so is remote from the headlands and exposed to waves and swells from the south-western to south-eastern directions. The frontal dunes along the beach vary in height up to about 20 m, but are generally lower near the site. The area proposed for William Bay West has an average elevation of about 15 m. The site is reasonably level, although the surrounding areas comprise extensive dunes.

William Bay West is exposed and subject to high wave energy and swells. The beach is shelved steeply and the water within the bay is deep close to shore. The nearshore current is easterly.

Soil and Vegetation

The soil is sandy and there are few rocky outcrops. The vegetation on the frontal dunes comprises medium-height and density coastal heath and shrubs. Behind the dunes, at the site, there is a small, cleared area, with the remainder of the site lightly forested by shrubs and small trees, most of which are 2 m in height but some of which reach approximately 6 m.

Sea Water Supply and Discharge

The coast is exposed and there are no offshore reefs that could be used to anchor or shelter a water supply system. The best option for a sea water intake system at the site would probably be an offshore, marine intake. The water appears very clean with little drifting seaweed, so a marine intake would probably not need self-cleaning screens. The marine intake and water supply pipelines could either be anchored by heavy concrete blocks or placed alongside a purpose-built breakwater. Beach wells may constitute a viable, alternate option for water supply at the site, if test wells provide positive results in terms of water quality and sustainable flow; however, the underlying strata at this site may be impermeable rock unsuitable for beach wells.

Options for disposing of used water after treatment include indirect discharge, by taking advantage of an existing water course that flows into the ocean between the site and the beach, or direct discharge into the ocean through pipelines placed alongside the intake lines downstream from the intake point. The former option is preferred for this site. From an environmental perspective, the water currently discharged from the water course appears to drain a large area used for agricultural purposes, so would not be considered in its natural state.

Water Quality

The sea water at William Bay West is very high in quality. There is very little drifting seaweed in the water and the beaches are clean and free of large quantities of washed-ashore seaweed.

At the time of the on-site inspection there was a small area of turbid water near the site, probably as a result of drainage from the small wetlands behind the dunes. The extent of the turbidity was such that it is unlikely to be of concern in respect of its effect on the quality of the sea water. The site is located about 4 km to the east, and therefore upstream, of Parry Inlet; however, it is unlikely the sea water adjacent to the site would be adversely influenced by any fresh-water discharge from the inlet.

Pollution and History

There is no obvious pollution from industrial or agricultural sources near the site.

The area in the vicinity of the site inside the frontal dunes is presently being used for agricultural purposes. The presence of any pesticides or herbicides that may have been used or are residual in the soil would need to be ascertained, so the necessary precautions can be taken. The presence of biocides in the soil would not present significant problems. The beach in front of the frontal dunes is used, but not heavily, by recreational fishers.

13.1.2 Economic, Social and Legal Factors

Site Infrastructure and Services

William Bay West has no existing infrastructure, but can be reached by an unsealed road and track that does not require a four-wheel-drive vehicle. There is no power supply to the site and it should be assumed that power lines and other services will need to be brought in from South Coast Highway, a distance of less than 4 km. The site is well located in that it is close to the range of services and light industries provided at Denmark and Albany. It would be simple to ensure a high level of security at the site, given that it occupies privately-owned land.

Competitive Resource Use

There is no competitive resource use at the site. The development of an temperate marine aquaculture farm would not affect recreational users of the beach.

Tenure

The land is privately owned, by Powley.

The Department of Land Administration parcel number for the site is: DO65936-2.

Contact Details:

Mr B & B Powley
PO Box 317
Denmark WA 6333

Tel: (08) 940 93 64
Fax: (08) 9840 9364

13.2 Site Evaluation

13.2.1 Potential for Development

William Bay West is considered a good site with high development potential for land-based temperate marine aquaculture, for which purpose its physical and biological features are well suited. Its main positive features include reasonably good access, good elevation, reasonable options for a sea water supply system and a good option for a discharge system, high-quality sea water, a reasonable distance from towns and favourable land tenure.

The main disadvantages of the site are its comparatively small size and distance from infrastructure and services. However, these disadvantages are not considered significant and they have simple, economic solutions. The positive attributes of the site are believed to outweigh its few disadvantages.

Aquaculture is an industry consistent with current activities in the area and development at the site would not restrict access to the beach for recreational fishing purposes.

13.2.2 Constraints to Development

There are no obvious, major constraints to development. Potential, minor constraints to development include:

- some access difficulties, the remote location and lack of infrastructure and services;
- proximity to fresh-water discharges;
- conflict with existing users of the resource; and
- proximity to a National Park;

Access difficulties could be overcome relatively simply and cost-effectively, by improving the existing access road and track. Power lines and other services would also need to be provided. The cost of providing these services to the site from the existing, main supply on South Coast Highway would be mitigated by applying for government grants established specifically for that purpose.

Fresh water discharges near the site are noted, but considered unlikely to adversely affect the quality of the sea water. Parry Inlet, which is upstream from the site, is a very shallow basin with low water flows. The fresh-water discharge seen at the site at the time of inspection was minimal and occurred during and after a period of moderate rainfall.

The Department of Conservation and Land Management and existing resource users may raise objections if a breakwater is to be constructed for a sea water supply system. Objections may also be raised if used water is to be discharged across the beach using an existing channel. In this event, it may be necessary to use buried pipelines anchored offshore by large, concrete blocks for the sea water supply and discharge system.

Any aquaculture proposal at William Bay West would be looked at carefully, due to the proximity of the site to William Bay National Park. An easement would be required across the portion of the National Park that lies between the site and the beach. Preliminary discussions with Department of Conservation and Land Management indicate such a proposal would be considered within the context of access, threats to any endangered species and related issues. The beach and frontal dunes would have to be restored to their original condition following the disruption that would be caused by laying intake and discharge pipelines. Any proposal would have to thoroughly deal with these matters. Notwithstanding the proximity of the National Park, few insurmountable difficulties are expected with the development of William Bay West for temperate marine aquaculture.

14. Nanarup Beach (Site 57)

14.1 Site Description

The following description for Nanarup Beach may be considered generally applicable to Taylor Inlet (Site 56), which is located immediately to the west of the site (Appendix Two).

14.1.1 Physical and Biological Features

Location and Size

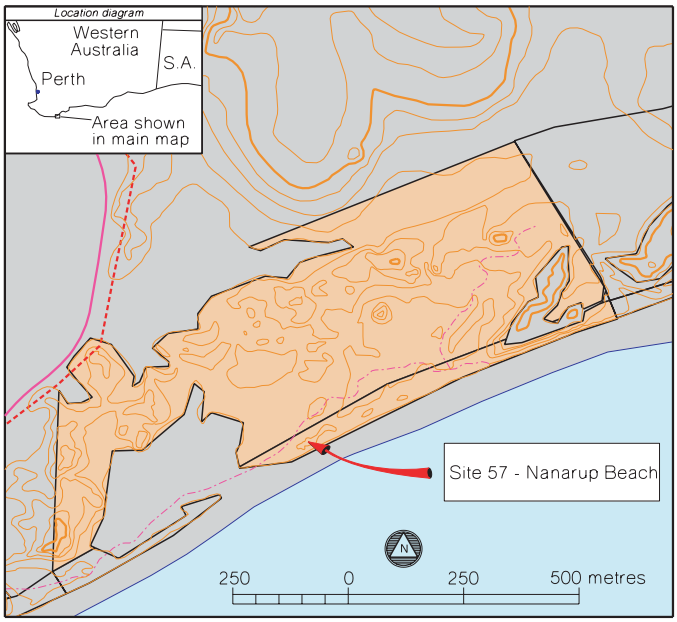

Figure 18. Map illustrating the location and major physical features of Nanarup Beach (Site 57).

The Nanarup Beach site (Site 57) occupies the beach of the same name and is located about 25 km by road from the east of Albany. There is good access to the site via Nanarup Road, off Lower King Road. The roads are all sealed and in good condition.

The site is bordered on its eastern side by the western boundary of Two Peoples Bay Nature Reserve. The total area of 66 ha indicated for the site in Appendix One may in fact be reduced by the Nature Reserve, but there still remains an area more than adequate in size for land-based temperate marine aquaculture (Fig. 18).

Topography and Hydrography

The site features a sandy beach backed by an extensive dune system severely eroded in places. The height of the dunes can rise to 20 m in a few places, but there are extensive areas in which their maximum height is less than 10 m. The coast is exposed and subject to high-to-moderate wave energy. The water close to shore appears deep enough for a marine intake and the inshore current flows to the east.

Soil and Vegetation

The soil is sandy. The coastal vegetation comprises typical dune growth that is severely degraded as a result of the erosion of frontal dunes.

Sea Water Supply and Discharge

The coast is exposed mainly to the south and east, with no offshore reefs to provide protection. Despite the exposure, a marine intake probably represents the best option for a sea-water intake system, given that some supporting structure would be needed for a discharge pipeline. The intake and discharge pipelines or structures could either be anchored by heavy concrete blocks or fixed alongside a breakwater constructed for that purpose from large, limestone blocks. Beach wells may be feasible at the site and this option may be worth exploring.

The only option for discharging used water after treatment is directly into the ocean, either downstream or further offshore from the intake, using the same structures put in place to support the intake.

Water Quality

The sea water at Nanarup Beach is very high in quality. There is very little drifting seaweed in the water and the beach is clean and free of any washed-ashore seaweed.

The mouth of Taylor Inlet, which is situated about 100 m from the site, was flowing at the time of inspection. The small quantity of fresh water being discharged did not flow towards the beach, but generally to the south and west. Based on information provided by local surfers, this is usually the case and the quality of water off the beach is invariably high. It is considered unlikely the sea water adjacent to the site would be adversely influenced by any fresh-water discharge from the inlet.

Pollution and History

There is no obvious pollution from industrial or agricultural sources in the vicinity of Nanarup Beach.

14.1.2 Economic, Social and Legal Factors

Site Infrastructure and Services

Nanarup Beach is considered a good site in respect of its proximity to infrastructure and services. The site itself has no existing infrastructure, but it is well located in that it is close to the range of services and light industries provided at Albany. Infrastructure and services in the general area and within 500 m of the site include sealed, all-weather roads, three-phase electrical power supplied from the Perth grid, potable water supplies and telecommunications facilities.

Competitive Resource Use

There is no competitive use of the site itself, but the beach, inlet and surrounding area are subject to heavy recreational use by fishers, surfers and swimmers. The proposed site does not encroach on these activities.

Tenure

Twenty hectares of Nanarup Beach are vested with the City of Albany. For land-based aquaculture to occur, the purpose of the Crown Reserve will need to be changed with the Department of Land Administration. This will require Council approval.

The Department of Land Administration parcel number is: Reserve 45631.

Contact Details: CEO
City of Albany
PO Box 484
Albany WA 6331

Tel: (08) 9841 9302
Fax: (08) 9841 9222
E-mail: staff@albany.wa.gov.au

14.2 Site Evaluation

14.2.1 Potential for Development

Nanarup Beach is considered a good site with high development potential for land-based temperate marine aquaculture.

The physical and biological features of the site are well suited for aquaculture. Its main positive features include very good access, good elevation, reasonable options for a sea water supply and discharge system, high-quality sea water, close proximity of infrastructure and services and short distance to a major regional centre.

Aquaculture is an industry consistent with current activities in the area and development at the site would not restrict access to the beach or inlet for recreational purposes.

14.2.2 Constraints to Development

There are no obvious, major constraints to development. Potential, minor constraints to development include:

- proximity to fresh-water discharges;
- conflict with existing users of the resource; and
- proximity to a Nature Reserve;

Fresh water discharges near the site appear minimal and are considered unlikely to adversely affect the quality of the sea water. The fresh-water discharge seen from the inlet near the site at the time of inspection was minimal and occurred after a period of moderate rainfall.

The Department of Conservation and Land Management and existing resource users may raise objections if a breakwater is to be constructed for a sea water supply system. In this event, it may be necessary to use buried pipelines anchored offshore by large, concrete blocks for the sea water supply and discharge system.

A proposal to farm temperate fish species at Nanarup Beach would be looked at carefully by the Department of Conservation and Land Management, due to the proximity of the site to Two Peoples Bay Nature Reserve, which adjoins its eastern boundary. A land-based temperate marine aquaculture development at the proposed site would need to be sensitive to the conservation value of the area and deal with the relevant issues in an aquaculture licence application.

From an environmental perspective, the coastal area would benefit from aquaculture development, which would of necessity involve some rehabilitation of the eroded frontal dunes.

15. Two Peoples Bay (Site 58)

15.1 Site Description

15.1.1 Physical and Biological Features

Location and Size

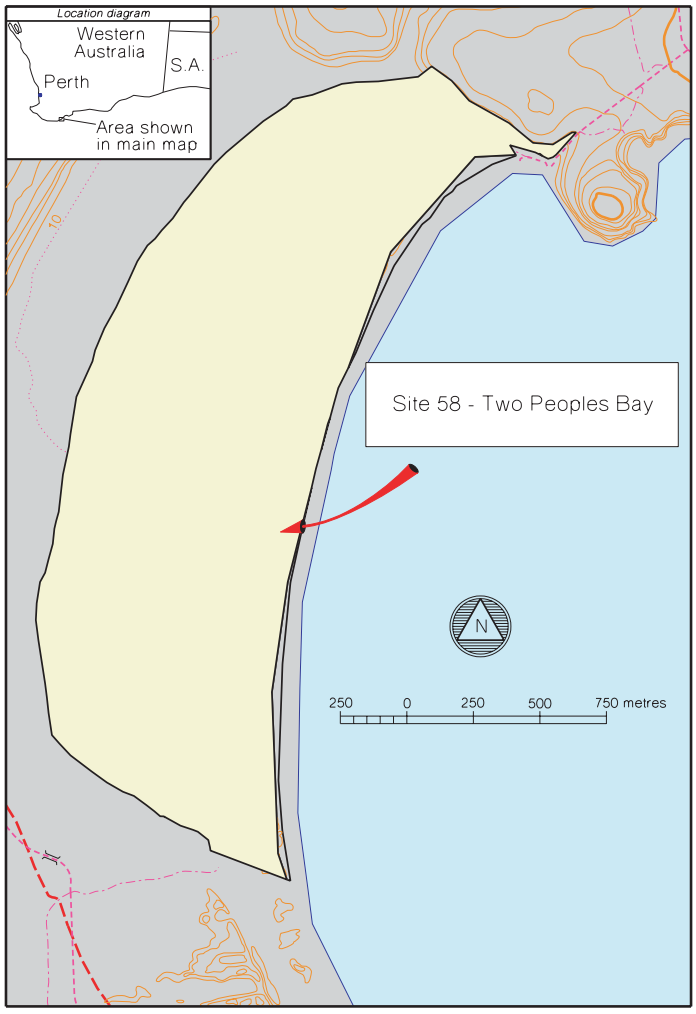

Figure 19. Map illustrating the location and major physical features of Two Peoples Bay (Site 58).

The Two Peoples Bay site (Site 58) is located along the northern portion of the bay of the same name. The site is about 50 km to the east of Albany by road and can be reached via Homestead Road off South Coast Highway. There is good access to the northern part of the site: the roads leading to it are sealed, with the exception of the last 10 km of unsealed road in good condition.

The preliminary site initially determined according to the GIS study constituted a narrow strip of land along the beach less than 100 m wide and 78 ha in area. As a result of the on-site inspection, there was no apparent reason why the site should not be extended further inland. This larger site is shown in Figure 19.

Topography and Hydrography

A clean, sand beach runs along the length of the site, which is bounded at its northern limit by a steep, rocky headland. The beach is backed by frontal dunes that rise to 10 m in a few places but are generally between 5 and 10 m height. The large land area behind the frontal dunes is generally low-lying with an average elevation below 10 m and falls gently to Angove Lake, which is located off the north-western sector of the site. The headland at the northern limit of the site provides a well-protected area considered ideal for the establishment of a marine sea-water intake system.

The coast in this region is subject to high wave energy and high swells, but the sector in front of the site is reasonably well sheltered. Most of the site is exposed mainly to easterly winds, waves and swells, while its northern portion is exposed to the south-east. The water within the bay and off the steep headlands is deep close to shore. The current outside the bay presumably flows to the east, but the direction of any current and extent of water circulation within the bay is poorly known. From the direction of flow of fresh water entering the bay near its southern end, it appears likely that there is a slow, anti-clockwise current within the bay.

Soil and Vegetation

The soil within the site is sandy to loamy and few rocky outcrops were evident. The vegetation on the frontal dunes comprises typical, low to medium density medium-density coastal heath and shrubs that are partially degraded and there are no trees or forested areas. The section of the site that would be used to establish an temperate marine farm comprises more loamy soil and a large area has been cleared for agricultural use. At the time of inspection, it was being used as pasture for livestock. Few physical problems are likely to be encountered in levelling the site.

Sea Water Supply and Discharge

Two Peoples Bay presents some excellent options for sea water intake and discharge systems.

Figure 20. The northern end of Two Peoples Bay, showing a possible location for a marine intake.

A marine intake would ideally be located at the northern limit of the site, which is well protected by a steep, rocky headland, next to which the water is deep. Figure 20 shows the headland at the left; the high headland in the background forms the southern boundary of the bay. A marine intake and water-supply pipelines could be

attached to or anchored alongside the base of the headland. Beach wells are considered a less practicable water supply option at this site.

One option for discharging used water after it is treated would be directly into the ocean via a pipeline anchored alongside the intake lines. The discharge pipeline would be extended to allow the water to be discharged at a point further out to sea, to ensure the discharged water is not drawn in through the intake and recirculated.

An alternate option that should be explored would be to discharge the treated water into an existing drain running from the swampy area that extends southwards from the southern part of Angove Lake. The drain enters a water course that travels southwards parallel to the beach, within the Nature Reserve, and enters the sea near the southern limit of the Bay. Water entering the Bay at this point was seen at the time of inspection to be carried in an easterly current out into the open ocean. This may present an excellent and environmentally-sound means of discharging used water from a temperate marine farm.

Water Quality

The high quality of the sea water adjacent to the site, particularly that at the proposed sea-water intake point, would not be influenced by the limited quantities of fresh water that drain into the southern part of the bay during the winter, rainy season.

Pollution and History

There is no obvious pollution from industrial or agricultural sources in the vicinity of Two Peoples Bay.

Some areas of the site demonstrate no obvious signs of previous use; other areas are presently under pasture and have been used for agricultural purposes. The presence of any biocides used or residual in the soil would need to be ascertained, so the necessary precautions can be taken. The beach in front of the frontal dunes is used, but not heavily, for recreational activities.

15.1.2 Economic, Social and Legal Factors

Site Infrastructure and Services

Two Peoples Bay has no existing, on-site infrastructure but features good access by sealed and unsealed roads in good condition. The site is well located in that it is reasonably close to the range of services and light industries provided at Albany. Three-phase electrical power supplied from the Perth grid is available at a point about 15 km from the site, at South Coast Highway. Telecommunications lines are a similar distance. There is no potable water supply or sewerage at Two Peoples Bay and provision would need to be made for these services in any farm design. Adequate fresh water supplies could be collected in rain-water tanks.

Competitive Resource Use

There is no competitive use of the site itself, but the headlands and beach are subject to recreational. The proposed land-based temperate marine aquaculture site would not encroach on these activities.

Tenure

The area of the proposed site is privately owned, by Milgraum.

The Department of Land Administration parcel number for the site is: PLANTL 3777.

Contact Details: Mr L Milgraum
C/- Arthur Johnston Samuel
PO Box 5019
Albany WA 6331

Tel: (08) 9841 1777
Fax: (08) 9841 3997

15.2 Site Evaluation

15.2.1 Potential for Development

Two Peoples Bay is considered an excellent site for land-based temperate marine aquaculture with high potential for development.

The physical and biological features of the site are well suited for aquaculture. Its main positive features include good access, very good elevation, excellent options for sea water supply and discharge systems, high-quality sea water, pristine environment and a reasonable distance from towns. The establishment of a breakwater or similar structure to provide protection for marine intake and discharge systems would be unnecessary, resulting in significantly-reduced construction costs. The close proximity to Albany would allow personnel employed on a farm to commute daily from Albany to the site.

The main disadvantage of the site is its distance from infrastructure and services. However, given the outstanding positive attributes of the site, this disadvantage is not considered significant and has a simple, economic solution. The positive attributes of the site by far outweigh its few disadvantages.

Aquaculture is an industry consistent with current activities in the area and development at the site unlikely to restrict access to the beach for recreational fishing purposes. Given the high profile of tourism in the south coastal areas, it is likely that an operating temperate marine aquaculture farm would provide an additional attraction to the area.

15.2.2 Constraints to Development

Potential constraints to development include:

- the distance from the requisite infrastructure and services;
- conflict with existing users of the resource;
- the discharge of used sea water into the bay; and
- the proximity to a Nature Reserve.

The cost of providing power lines and other requisite services to the site from the existing supply would be mitigated by applying for government grants available specifically for that purpose. Alternatively, electrical power could be generated on site.

Conflict with existing resource users would be limited to the seawater intake and discharge systems, if these are evident and considered to detract from the visual aspects of the area. Any potential conflict with existing resource users could be circumvented by ensuring that these structures are inconspicuous.

The option to direct used sea water into the existing drain and water course that subsequently empty into the southern part of the bay is considered a practicable and pragmatic means of discharge. Opposition to this proposal

is likely, since the drain and water course travel through the Nature Reserve. To demonstrate an environmentally and ecologically sound approach to dealing with this issue, it would be necessary to for any land-based temperate marine aquacultre farm proposal adopting this discharge option to:

- include in the farm design a reliable and effective means of treating the used water before it is discharged from the farm; and
- undertake a detailed environmental study to demonstrate there would be no detrimental environmental effects in the Nature Reserve.

A proposal to farm temperate marine at Two Peoples Bay would be considered carefully, due to the presence of Two Peoples Bay Nature Reserve, which adjoins the southern boundary of the site. The Department of Conservation and Land Management would be interested in issues such as access and threats to any endangered species, so any proposal would have to deal with these matters. Any aquaculture development at the proposed site would need to be highly sensitive to the conservation value of the area. Difficulties with access would be circumvented by using the roads indicated earlier and avoiding Two Peoples Bay Road, which provides a shorter route to Albany by about 20 km, but travels through the Nature Reserve. Two Peoples Bay is in a pristine environment and the Nature reserve has a very high profile area for nature conservation and threatened species.

16. Cheyne Beach (Site 59)

16.1 Site Description

The following site description for Cheyne Beach may be considered generally applicable to Hassell Beach South, Hassell beach, Hassell Beach North and Warriup (respectively, Sites 60, 61, 62 and 63), which are located to the north of Cheyne Beach (Appendix 2). The differences between Cheyne Beach and the sites to its north are remoteness, difficulty of access and topography. These factors are significantly less favourable for the latter sites. They usually have coastal wetlands inside the frontal dunes, which are usually quite high, and access is limited to four-wheel-drive tracks that are in poor condition and seasonally impassable.

16.1.1 Physical and Biological Features

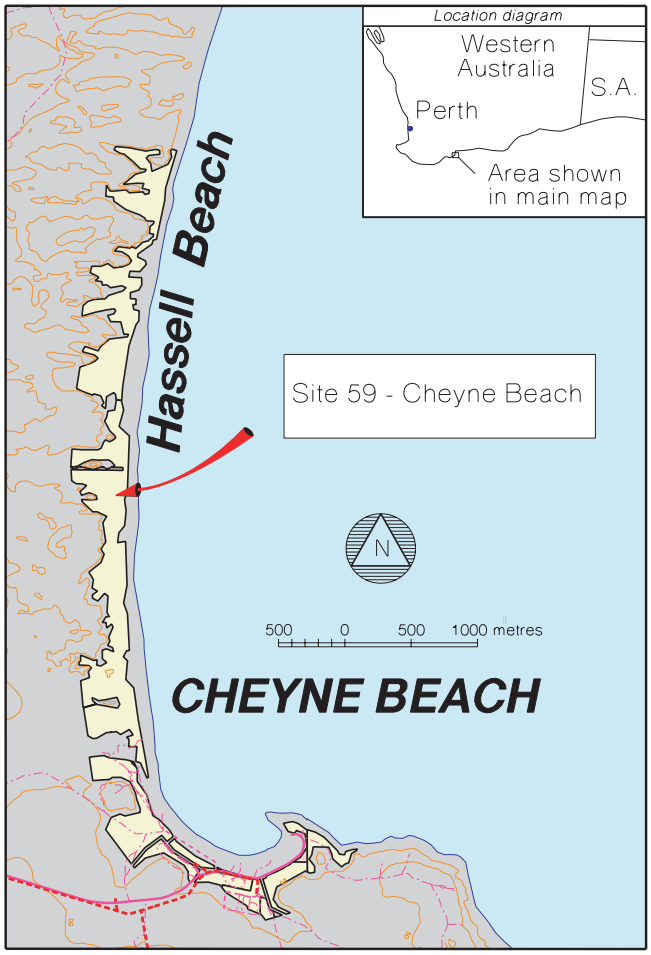

Figure 21. Map illustrating the location and major physical features of Cheyne Beach (Site 59).

Location and Size

The Cheyne Beach site (Site 59) is located along the southern portion of Hassell Beach, immediately to the north of the small settlement of Cheyne Beach. The site is about 65 km to the east of Albany by road and can be reached via Cheyne Beach Road off South Coast Highway. There is good access to the southern part of the site: the roads leading to it are sealed, all-weather and in good condition.

The proposed site extends northwards along the coast, roughly from 500 m north of the settlement to 500 m south of the mouth of Bluff River (Fig. 21).[19] Waychinicup National Park extends along its western, inland boundary. The site occupies a total area of 130 ha; it is approximately 4 km in length and averages about 300 m in width. Within this larger area, the site considered optimum for initial development is located near the southern boundary.

Topography and Hydrography

A clean, sand beach runs along the length of the site. The beach is backed by moderately-high frontal dunes that average between 10 and 15 m high. The height of the frontal dunes increases progressively from a point about 3 km north of the settlement. The land area behind the frontal dunes is generally low-lying and contains numerous wetland areas. A water course that drains the area enters the ocean at a point 450 m north of the settlement.

The coast in this region is subject to high wave energy and high swells. The site faces eastwards and is exposed to north-easterly to south-easterly winds. The water within the bay is reasonably deep close to shore. The existence and direction of nearshore currents are poorly known, but there is probably a slow, northwards-flowing current.

Soil and Vegetation

The soil is sandy and there are some rocky outcrops. The vegetation on the frontal dunes comprises medium-density coastal heath and shrubs. Few problems are likely to be encountered in levelling the site, but consideration would have to be given to ensure the drainage of the wetlands remains unaffected by any development, to avoid flooding.

Sea Water Supply and Discharge

The coast is exposed and there are no offshore reefs that could be used to anchor or shelter a water-supply system. An offshore marine intake probably offers the best option for a sea water supply system at the site. The water appears clean with little evidence of drifting seaweed, so a marine intake would probably only need simple, not self-cleaning, screens. The marine intake and water supply pipelines could either be anchored by heavy concrete blocks or placed alongside a purpose-built breakwater. Beach wells may constitute a viable, alternate option for water supply at the Cheyne Beach site, if test wells provide positive results in terms of water quality and sustainable flow.

Used water could be disposed of directly or indirectly, after treatment. The direct disposal option would involve discharge into the ocean through pipelines placed alongside and downstream from, or further out to sea than, the intake lines. Indirect discharge, the preferred method of eliminating used sea water from this site, would take advantage of the existing water course located near the southern part of the site by directing into it the treated water being discharged from the farm.

Water Quality

The sea water quality off the coast at Cheyne Beach is very high. There is very little drifting seaweed in the water and the beaches are equally clean and relatively free of washed-ashore seaweed.

[19] Despite its obvious attributes, the southern portion of the preliminary site, south of the settlement, was not included within the boundaries of the suitable site because of local sensitivity to aquaculture development in this area. The establishment of a land based aquaculture farm in this area would be unrealistic and unlikely to receive approval.

There are no major rivers entering the sea in the vicinity of the coast. The minor fresh water being discharged from the wetlands behind the frontal dunes is unlikely to have any significant impact on the quality of the sea water.

Pollution and History

There is no obvious pollution from industrial or agricultural sources in the vicinity of Cheyne Beach. The site has no history of previous usage.

16.1.2 Economic, Social and Legal Factors

Site Infrastructure and Services

Cheyne Beach has no existing, on-site infrastructure but has reasonably good access to its southern part by sealed road, which terminates at the settlement, and tracks. The site is reasonably close to the range of services and light industries provided at Albany. Power supplied from the Perth grid leads to the settlement, but it is unlikely the line could carry the power needed for an land-based temperate marine aquaculture farm. Three-phase power is available at South Coast Highway, 18 km from the site. Provision would need to be made for services such as sewerage in any farm design. Adequate fresh water supplies could be collected in rain-water tanks.

Competitive Resource Use

There is no competitive use of the site itself, but the beach is subject to recreational use by fishers and swimmers. The proposed site is unlikely to encroach on these activities. Offshore, there are commercial fishing activities. A Proclaimed Fishing Zone applies in the coastal area between Cheyne Beach to Bluff River from 15 February to 30 April each year.

Tenure

Cheyne Beach is vested in the Crown. The purpose of the vesting is Crown Reserve - Mining. For land-based aquaculture to occur the purpose of the Crown Reserve will need to be changed with the Department of Land Administration. This will require Department of Mineral and Petroleum Resources approval.

The Department of Land Administration parcel number for the site is: Reserve 30033.

Contact Details: Senior Land Use Planning Geologist
Land Access Branch
Department of Mineral and Petroleum Resources
Perth WA 6000

Tel: (08) 9222 3502
Fax: (08) 9222 3808

16.2 Site Evaluation

16.2.1 Potential for Development

Cheyne Beach is considered an excellent site for land-based temperate marine aquaculture with high potential for development.

The physical and biological features of the site are well suited for aquaculture. Its main positive features include reasonably good access and elevation, reasonable options for sea water supply and discharge systems, high-quality sea water, pristine environment and being within commuting distance of Albany.

The main disadvantage of the site is its distance from infrastructure and services. However, given the outstanding positive attributes of the site, this disadvantage is not considered significant and has a simple, economic solution. The positive attributes of the site are considered to outweigh its few disadvantages.

Aquaculture is an industry consistent with current activities in the area and development at the site unlikely to restrict access to the beach for recreational fishing purposes.

16.2.2 Constraints to Development

Constraints to development include:

- the lack or ease of access to of infrastructure and services;
- conflict with existing users of the resource; and
- proximity to a National Park.

Three-phase power and other services would need to be provided to the site. The cost of providing these services to the site from the existing supply may be mitigated by applying for government grants established specifically for that purpose. Alternatively, according to cost, a temperate marine aquaculture farm could provide its own power generator.

In this context, existing resource users principally include local residents and professional fishers. Conflict with these groups may be circumvented by avoiding the more sensitive area to the south of the settlement, locating the land-based farm so it is relatively inconspicuous and undertaking environmental work to demonstrate any aquaculture development would not adversely affect the local commercial fishery. An added bonus that could be emphasised is the employment opportunities that may be provided to local residents by such a development.

Due to its proximity to Waychinicup National Park, a proposal to aquaculture fish at Cheyne Beach would be considered carefully by the Department of Conservation and Land Management, particularly in respect of issues such as access and threats to any endangered species. Any aquaculture development at the proposed site would need to deal with these issues and be sensitive to the conservation value of the area. Notwithstanding the proximity of the National Park, few insurmountable difficulties would be anticipated with the development of Cheyne Beach for temperate marine aquaculture, mainly because the site is downhill, and hence downstream, from the park, which would be largely unaffected by any discharged water.

17. Wylie Head North (Site 75)

17.1 Site Description

The following site description for Wylie Head North may be considered generally applicable to Wylie Head West and Wylie Head South (respectively, Sites 73 and 74), which are located adjacent to the suitable site in the directions suggested by their names (Appendix 2). These sites are all ranked as having high potential for land-based temperate marine aquaculture.[20]

17.1.1 Physical and Biological Features

Location and Size

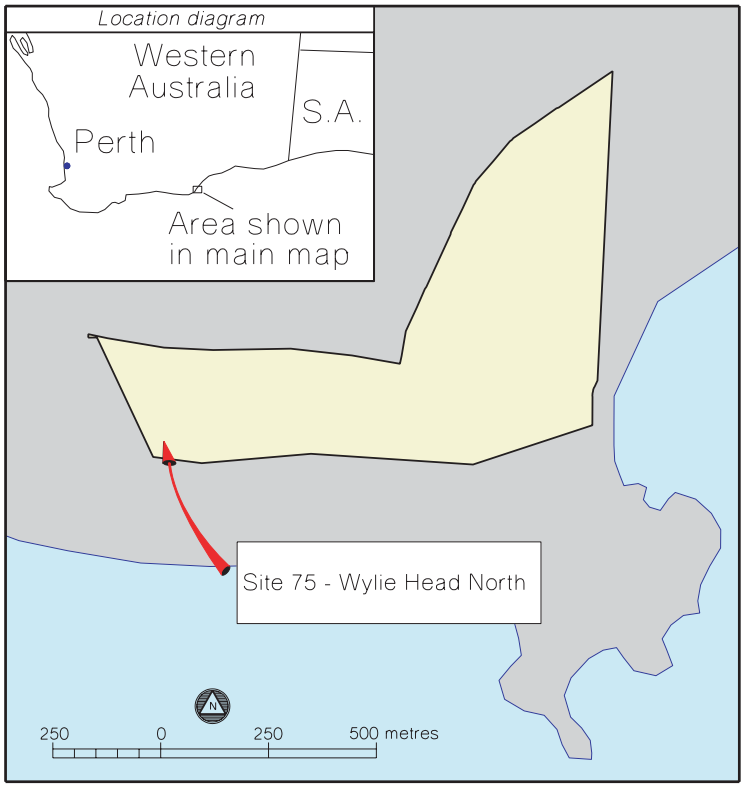

Figure 22. Map illustrating the location and major physical features of Wylie Head North (Site 75).

Wylie Head North (Site 59) is located about 15 km to the east of Esperance by road, via Wylie Bay Road and Fisheries Road. There is very good access to the site: the roads leading to it are sealed, all-weather and in good condition. Bandy Creek Boat Harbour is situated approximately half-way between Esperance and Wylie Head North.

The site is situated on the northern side of the road, to the north-west of the large, granite headland that forms Wylie Head and to the west of Wylie Bay (Fig. 22). The site occupies a total area of 58 ha. A reserve for the

[19] The three sites at Wylie Head are not considered as a single site in order to remain consistent with the remainder of this document, which differentiates sites principally on the basis of common ownership. Further, Wylie Head West and Wylie Head North, which do have a common owner, are considered separate sites because of their spatial separation.

conservation of flora and fauna extends to the north of Wylie Bay and continues as a narrow corridor along the eastern and southern boundaries of the site, between it and the coast.

Topography and Hydrography

Figure 23. An overview of Wylie Head North looking north from the rock headland. Wylie Bay is at the right.

Esperance Bay and Wylie Bay lie near, respectively, the southern and eastern boundaries of Wylie Head North. Wylie Head is a large, granite outcrop that separates the two bays. The coast of Esperance Bay in the vicinity of the site comprises rocky outcrops at the eastern end and a clean, sandy beach. The coast at the much-smaller Wylie Bay to the north of the headland comprises a sand beach with large quantities of accumulated seaweed along its length. The beach is backed by frontal dunes that rise to 10 m in a few places but are generally between 5 and 10 m in height. The width of the frontal dunes varies between about 50 and 100 m. The land area behind the frontal dunes is generally level and low-lying with an average elevation lower than 10 m (Fig. 23). Wylie Head provides a well-protected area considered ideal for the establishment of a marine intake for the sea-water supply system.

The coast at the top of Esperance bay is exposed and subject to high wave energy and high swells, but the sector in front of the site within the complex of rocky outcrops that extend from Wylie Head is reasonably well sheltered. The site is exposed mainly to southerly to south-westerly winds. Wylie Bay is reasonably well sheltered from all directions, which possibly explains the large accumulation of seaweed that occurs there. The water in the vicinity of Wylie Head within Esperance Bay is deep close to shore, but relatively shallow in Wylie Bay. The current in Esperance Bay is an easterly and, due to its exposure, the degree of water circulation within the bay is probably high.

Soil and Vegetation

The beaches and frontal dunes comprise fine-grained, white sand supporting low coastal shrubs. Further inshore at the site, the soil is also sandy but reasonably-heavily vegetated with mallee shrubs between 1.5 and 2.0 m in height. Few problems are likely to be encountered in clearing and levelling the site.

Sea Water Supply and Discharge

Wylie Head North presents excellent options for sea water intake and discharge systems.

A marine intake would ideally be located in Esperance Bay, adjacent to the complex of granite outcrops at Wylie Head, close to the shore. The ideal location for an intake is at the southern part of the headland. A marine intake

and water supply pipelines could be attached to or anchored alongside the rocks that form the headland. Given the prominence of the area for recreational use and as a tourist destination, it would be unrealistic to assume that the construction of a breakwater to support pipelines and an intake would be permitted. Beach wells are considered a less practicable water supply option at this site, but the option may be worth exploring as an alternative should it be required.

The preferred option for discharging used water would be directly into the ocean via submerged pipelines into Wylie Bay. This strategy would achieve good separation between the intake and discharge water flows. The alternate option for discharging used sea water is by way of a pipeline extended alongside the intake lines to a point downstream from the intake or further out to sea, so the used water is not recirculated back into the intake.

Water Quality

The sea water at Wylie Head North is high in quality. No major rivers discharge into the area.

Pollution and History

There is no obvious pollution from industrial or agricultural sources in the vicinity of Wylie Head. The site has no history of previous usage. Bandy Creek Boat Harbour is situated 5 km to the west of the site, so any spill of oil or fuel in the harbour would be unlikely to affect the quality of the sea water near the site.

17.1.2 Economic, Social and Legal Factors

Site Infrastructure and Services

Other than a sealed road that adjoins its southern boundary, the site itself has no existing infrastructure or services; however, it is well located in that it is close to the range of services and light industries provided at Esperance. It is also within 5 km of the boat harbour, the construction of which has contributed to the development of significant infrastructure near the proposed site, including a three-phase power source. The site is close to a range of light industries associated with the commercial fishing industry.

Competitive Resource Use

There is no competitive use of the site itself, but the beach is subject to recreational use by fishers and swimmers and Wylie head is a popular tourist destination.

Tenure

The site is on land privately owned, by Lalor Holdings Pty Ltd.

The Department of Land Administration parcel number for the site is: ESPERL821.

Contact Details: Lalor Holdings Pty Ltd
19 Peppermint Grove
Esperance WA 6450

Tel: (08) 9071 1707
Fax: (08) 9071 1707
E-mail: mclalor@wn.com.au

17.2 Site Evaluation

17.2.1 Potential for Development

Wylie Head North is considered an excellent site for land-based temperate marine aquaculture with very high potential for development.

The physical and biological features of the site are well suited for temperate marine aquaculture. Its main positive features include very good access, close proximity to significant infrastructure and services, level land ideally elevated above MSL, excellent options for sea water supply and discharge systems, high-quality sea water, a pristine environment and a short distance from the major regional town centre. The establishment of a breakwater or similar structure to provide protection for marine intake and discharge systems would be unnecessary, resulting in significantly-reduced construction costs. The close proximity to Esperance would allow personnel employed on a farm to commute daily to the site.

The site is characterised by having no significant technical disadvantages.

Aquaculture is an industry consistent with current activities in the area and development at the site unlikely to restrict access to the beach for recreational purposes or access to Wylie Head and the surrounding area for tourism. Indeed, it is highly likely that an operating temperate marine aquaculture farm would provide an additional attraction to the area.

17.2.2 Constraints to Development

Potential constraints to development include:

- opposition to the establishment of marine intake and discharge systems; and
- conflict with existing users of the resource.

The cost of providing power lines and other requisite services to the site from existing supplies is not considered a major constraint at this site.

Opposition to the construction of seawater intake and discharge systems may be anticipated if these are evident and considered to detract from the visual aspects of the area, or if they in any way restrict recreational activities at the beaches in the area. Any potential conflict would need to be circumvented by ensuring that these issues are identified and thoroughly dealt with in any proposal to undertake aquaculture at Wylie Head North. It would also be necessary to demonstrate that the option of discharging used water directly into Wylie Bay constitutes an environmentally and ecologically-sound approach. It would be necessary to for any temperate marine aquaculture farm proposal adopting this discharge option to ensure used water is treated to an acceptable standard before it is discharged.

Conflict with existing users of the resources close to the site may be prevented ensuring the farm and its facilities are as inconspicuous as possible and undertaking environmental work to demonstrate any aquaculture development would not adversely affect the local environment. An added bonus that could be emphasised is the significant employment opportunities, both direct and indirect, that such a development would create for local people.

Part Four: Conclusion

18. Conclusions

18.1 Priority Sites for Land-Based Temperate marine aquaculture

Of 75 preliminary sites selected, a total of 30 were considered to have either high or high-to-medium potential for land-based temperate marine aquaculture. Of these, 25 were in the Southern Coastal Region and five in the Mid-West (Table 8).

Coastal Region	High	High to medium	Medium	Medium to low	Low	Total
Mid-West	4	1	1	1	23	30
Southern	14	11	6	13	1	45
Total	18	12	7	14	24	75

Table 7. Summary of ranks allocated to sites in the Mid-West and Southern coastal regions.

The principal reasons for the lower ranking of the sites in the Mid-West Coastal Region were the higher elevations of coastal dunes and, in some areas, comparatively poor water quality. Economic solutions for these problems are possible but, in many cases, unlikely to be commercially feasible using current technology.

The sites considered to have high and high-to-medium potential for land-based temperate marine aquaculture were generally characterised by favourable physical and biological features, particularly in respect of site elevation and water quality, and their proximity to main regional centres and infrastructure. Land tenure was not considered a major determinant of site suitability at this stage of the project.

Of all the sites described as suitable for land-based temperate marine aquaculture in this study, the following five are considered the most promising for that purpose and for which further development work could be contemplated.

- Jurien Boat Harbour (Site 24), located adjacent to the northern side of Jurien Boat Harbour, about 3 km from the town of Jurien and 250 km north of Perth.
- Cable Sands (Site 36), located on the southern, west coast about 15 km south of the city of Bunbury.
- Boat Harbour (Site 49), located on the south coast, about half-way between Walpole and Denmark. The site is about 35 km to the west of Denmark and 85 km west of Albany.
- Two Peoples Bay (Site 58), located on the south coast about 50 km to the east of Albany.
- Wylie Head North (Site 75), located on the south coast, about one kilometre to the east of Bandy Creek Boat Harbour and 15 km east of Esperance.

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Appendix One

List of Preliminary Sites for Land-Based Temperate marine aquaculture

Appendix One provides the list of the 75 preliminary sites evaluated for their suitability for land-based temperate marine aquaculture.

For each site, the following information is provided.

- The name and number allocated for this study.
- The area in hectares, as indicated by the shaded areas in appendix two.
- The current owner or vesting.
- The parcel number used by the Department of Land Administration. Parcels are the land areas used by the Department of Land Administration to identify all areas of land in Western Australia. Detailed file or folio information about each site can be obtained from the Department by citing the relevant parcel number.
- For sites comprising Crown land, the purpose of the land.

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Site no.	Site Name	Area (ha)	Owner/Vesting	Parcels	Purpose
1	Sandalwood Bay	394	Crown / DOLA	VICTOL11263,VICTOL11221, VICTOL7462	Unallocated Crown Land - 186 ha, Remainder vested with DOLA
2	Leander Passage	1185	Crown / DOLA	VICTOL7462	Unallocated Crown Land - 591 ha, Remainder vested with DOLA
3	Lynton	228 (additional 147 ha for Potential Area)	Crown / Simkin	VICTOL7454	Unallocated Crown Land - 118 ha
4	Broken Anchor Bay	415	Simkin	VICTOL11833	
5	Menai Hills	81	Bonara Pty Ltd	VICTOL4484	
6	White Cliffs	333	DOLA	P017468-1	
7	Deep Gorge	15	Bonython	P017562-1	
8	Deep Gorge South	39	Page	P017561-4	
9	Whaleboat Cove	57	Jupp	P021880-111	
10	Three Mile Beach	179	Jupp	P021880-111	
11	Bowes River	140	Dymocks Holdings Pty Ltd	P016031-20	
12	Bowes River South	240	Ash	VICTOL3512	
13	Teakle Hill North	47	DOLA	P009033-3	
14	Teakle Hill	137	Teakle	OAKABE00046	
15	Bookara	17	Edwards	VICTOL2857,VICTOL2477	
16	Illawong	28	Crown		Unallocated Crown Land
17	Illawong South	21	CALM	Reserve 24496	
18	Coolimba	16	CALM	Reserve 24496	
19	Leeman	8	Crown	LEEMAT00678	Crown Reserve
20	Billygoat Bay	195	Ardross Estates Pty Ltd	VICTOL11761	
21	Anchorage Bay	62	Crown		Unallocated Crown Land
22	Green Head	35	Crown	GREEHT00210	Crown Reserve
23	South Bay	40	Crown		Unallocated Crown Land
24	Jurien Boat Harbour	14	Crown	Reserve 19206	Crown Reserve: Recreation - Parklands
25	Island Point	120	Crown	Reserve 28541, Reserve 19206	Crown Reserve: Recreation - Foreshore
26	Cervantes	9	CALM	MELBOL4126	
27	Lancelin	6	Crown	LANCET694	Crown Reserve

Sites of High Priority Sites of High -Medium Priority Sites of Medium Priority Site of Medium- low Priority Site of low Priority

Site no.	Site Name	Area (ha)	Owner/Vesting	Parcels	Purpose
28	Ledge Point	15	CALM	R42946, R36447	
29	Guilderton	15	Dewar	SWANL11293	
30	Yanchep	178	Tokyu Corporation	P021931-312	
31	Preston Beach	22	Cardwick Pty Ltd	WELLIL712	
32	Preston Beach South	20	Zurick Bay Holdings	D003815-0	
33	Myalup Beach	18	Ederny Pty Ltd	WELLIL1059	
34	Dalyellup Beach	67	State Housing Commission	WELLIL497	
35	Dalyellup Beach South	41	Roberts	D087171-2	
36	Cable Sands	80	Cable Sands Pty Ltd	PO18477-1	
37	Minninup	18	Brockman	D009842-2	
38	Stirling Beach	10	Price	WELLIL343	
39	Stirling Beach South	28	Hayes	WELLIL180	
40	Eagle Bay	11	Crown	DUNSBT264	Crown Reserve
41	Bunker Bay East	13	Chemco Pty ltd	SUSSEL302	
42	Bunker Bay West	12	British Patent Perforated Paper Co. Pty Ltd	SUSSEL422	
43	Canal Rocks	10	Canal Rocks Pty Ltd	SUSSEL413	
44	Turner Brook	30	Thompson	SUSSEL1393	
45	Ledge Point West	52	Hart	SUSSEL448	
46	Ledge Point East	74	Brockman	SUSSEL645	
47	Scott River West	106	Ensmann	SUSSEL449	
48	Scott River East	39	Grugeon	SUSSEL 00367	
49	Boat Harbour	50	Crown	Reserve 7723	Crown Reserve: Recreation-Conservation-Foreshore
50	Parry Beach	27	Crown	Reserve 20298	Crown Reserve: Recreation-Conservation-Foreshore
51	Parry Inlet	28	Brenton	PLANTL4612, PLANTL4611, PLANTL4610	
52	William Bay West	10	Powley	D065936-2	
53	Mazzoletti Beach West	19	CALM	Reserve 24482	
54	Mazzoletti Beach East	12	Armstrong	D069896-5	

Sites of High Priority Sites of High -Medium Priority Sites of Medium Priority Site of Medium- low Priority Site of low Priority

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Site no.	Site Name	Area (ha)	Owner/Vesting	Parcels	Purpose
55	William Bay East	8	Longley	D069896-4	
56	Taylor Inlet	24	Beatson	D000171-A88	
57	Nanarup Beach	66	DOLA / CALM	PIN 594240	CALM - 20 ha, Remainder vested with DOLA (Unspecified)
58	Two Peoples Bay	340	Milgraum	PLANTL3777	
59	Cheyne Beach	136	Crown	Reserve 30033	Crown Reserve - Mining
60	Hassell Beach South	181	Crown	Reserve 30033	Crown Reserve - Mining
61	Hassell Beach	24	Ashley	D019495-2	
62	Hassell Beach North	36	Hassell	P008205-4	
63	Warriup	10	DOLA	P016725-5	
64	Pallinup Beach	80	Crown	Reserve 14987	Crown Reserve
65	Foster Beach	53	Argyle	L3114-478	
66	Dillon Beach	123	Argyle / Crown	L3114-479, Reserve 31737	Crown Reserve
67	Blossoms Beach	19	Wellstead / Crown	P019130-503	Crown Reserve - 6 Ha
68	Short Beach	20	Crown		Crown Land
69	Back Beach	22	Crown	Reserve 511	Crown Reserve
70	James Cove	75	Crown	Reserve 32666	Crown Reserve
71	Peppermint Beach	46	Beard	KENTL1325	
72	Toorgellup Beach	233	Crown	Reserve 32666	Crown Reserve
73	Wylie Head West	14	Brunner	ESPERL819	
74	Wylie Head South	28	Craig	ESPERL2041	
75	Wyie Head North	58	Brunner	ESPERL821	

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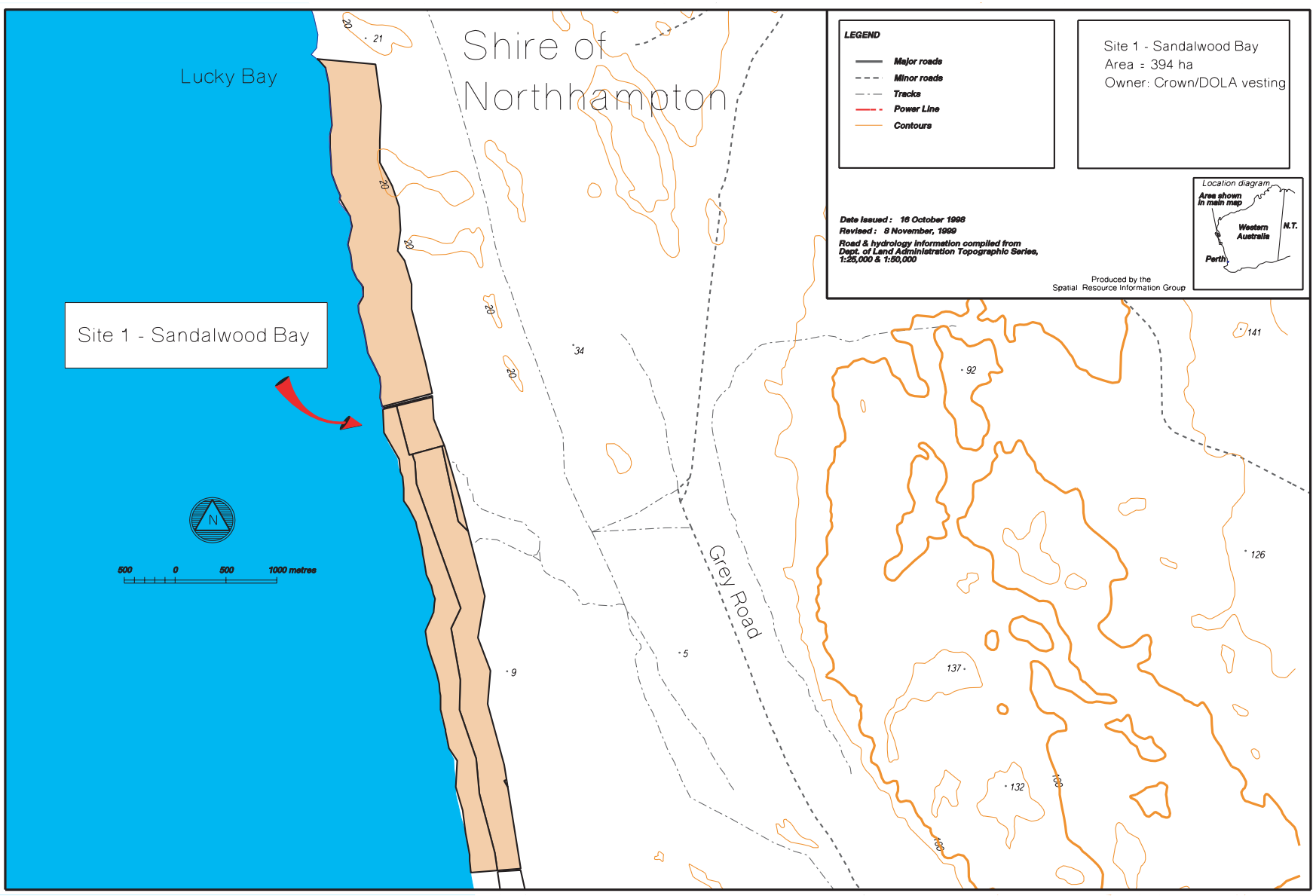
Appendix Two

Site and Location Maps for the Preliminary Sites

Appendix Two provides site and location maps for each of the preliminary sites.


Lucky Bay
Shire of Northhampton
Site 1 - Sandalwood Bay
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500 0 500 1000 metres
LEGEND
Major roads
Minor roads
Tracks
Power Line
Contours
Site 1 - Sandalwood Bay
Area = 394 ha
Owner: Crown/DOLA vesting
Location diagram
Area shown in main map
Western Australia
N.T.
Perth
Date issued : 16 October 1998
Revised : 8 November, 1999
Road & hydrology information compiled from Dept. of Land Administration Topographic Series, 1:25,000 & 1:50,000
Produced by the Spatial Resource Information Group
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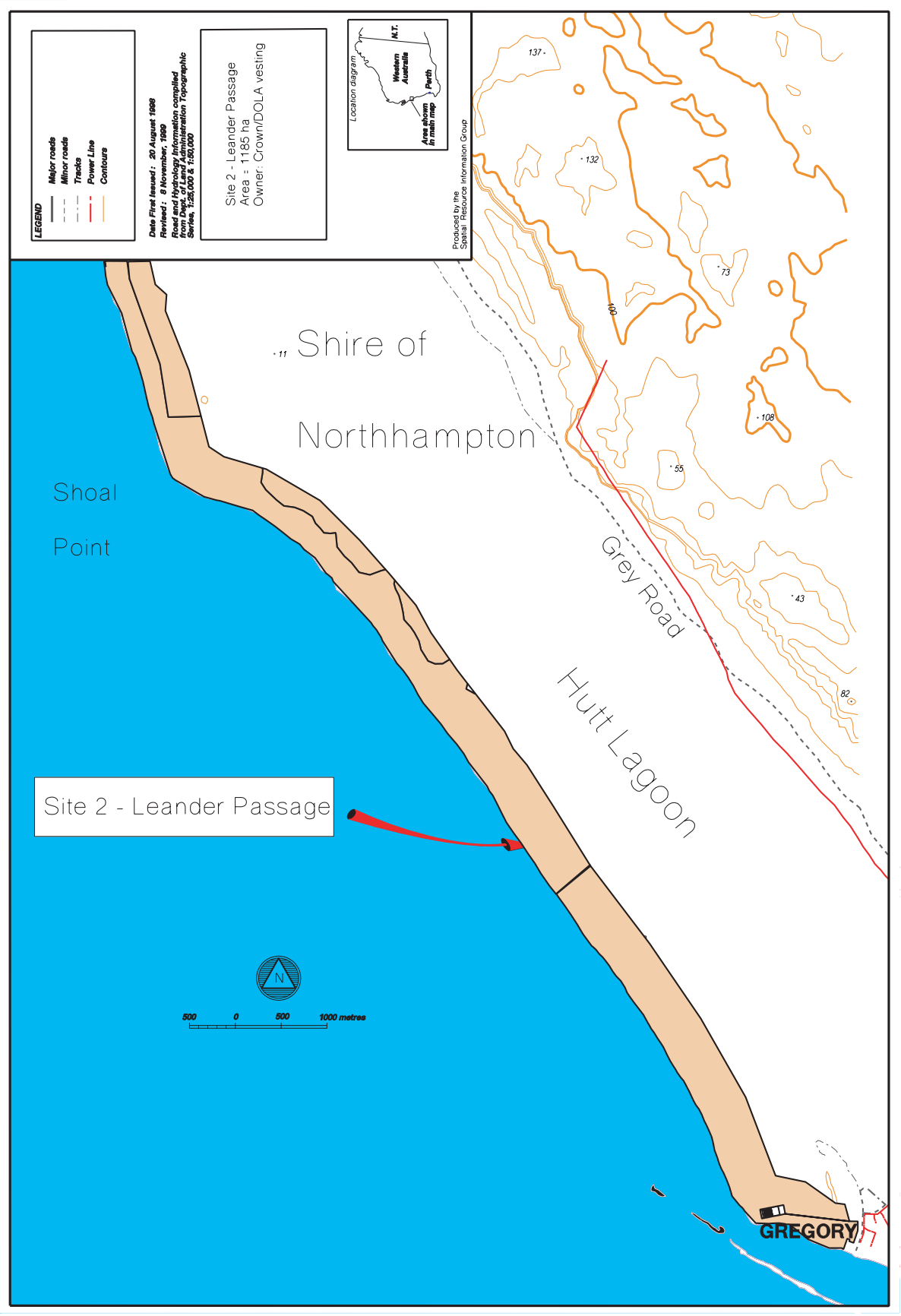
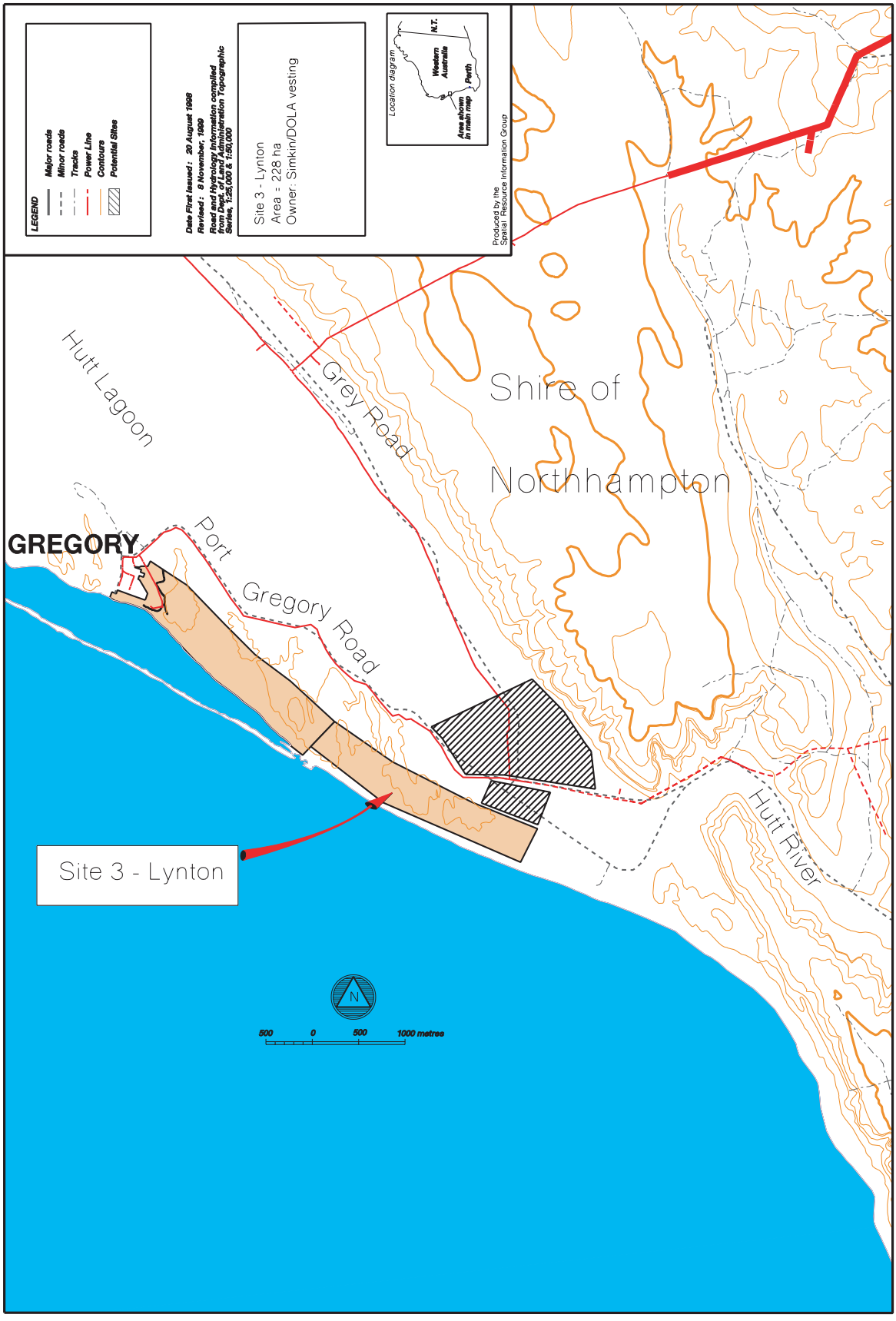
5
100


LEGEND
Major roads
Minor roads
Tracks
Power Line
Contours
Date First Issued : 20 August 1999
Revised : 8 November, 1999
Road and hydrology information compiled from Dept. of Land Administration Topographic Series, 1:25,000 & 1:50,000
Site 2 - Leander Passage
Area = 1185 ha
Owner: Crown/DOLA vesting
Location diagram
N.T.
Western Australia
Perth
Area shown in main map
Produced by the Spatial Resource Information Group
Shire of
Northhampton
Shoal
Point
Grey Road
Hutt Lagoon
Site 2 - Leander Passage
N
500 0 500 1000 metres
GREGORY
137
132
73
108
55
43
82
11



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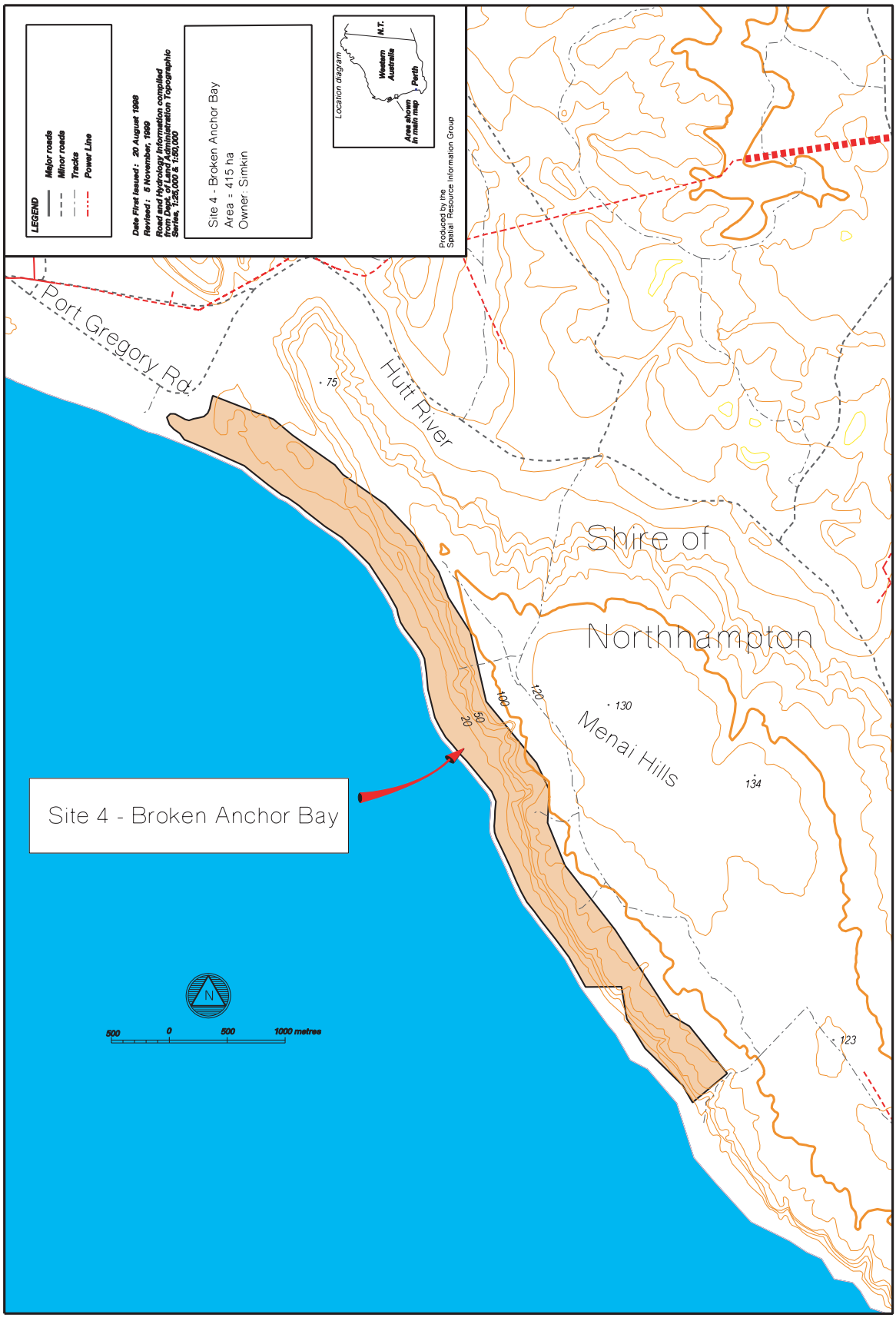

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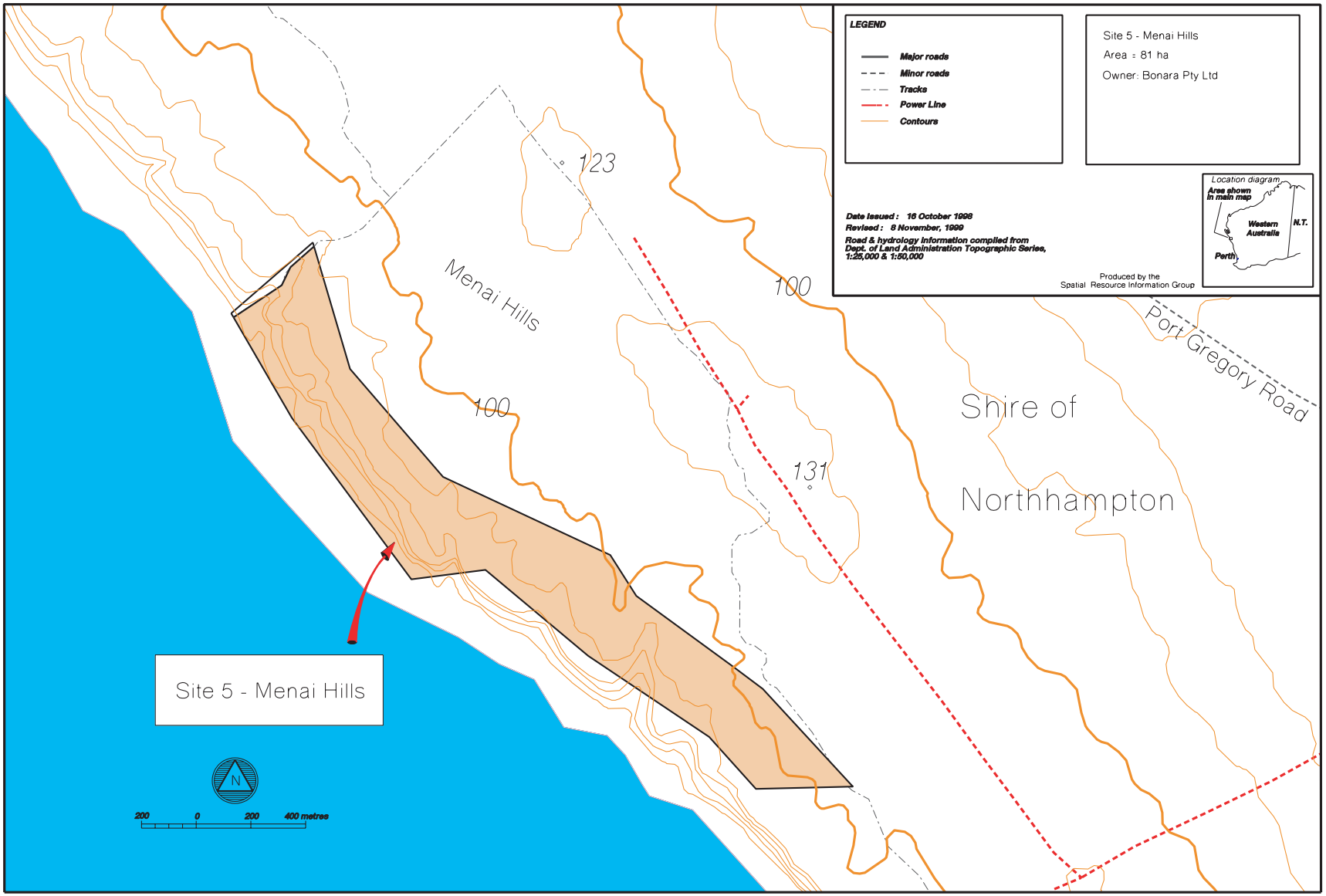

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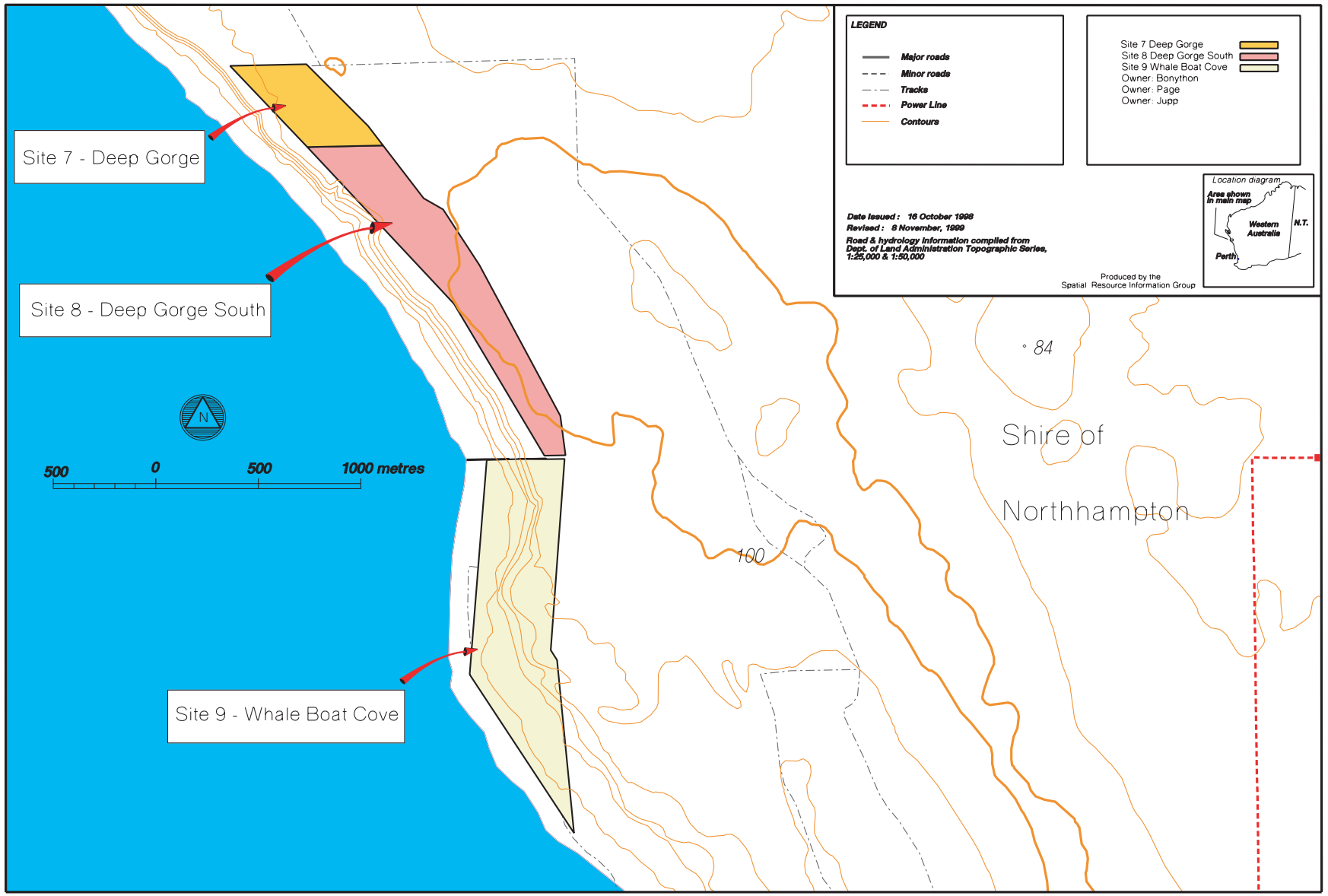

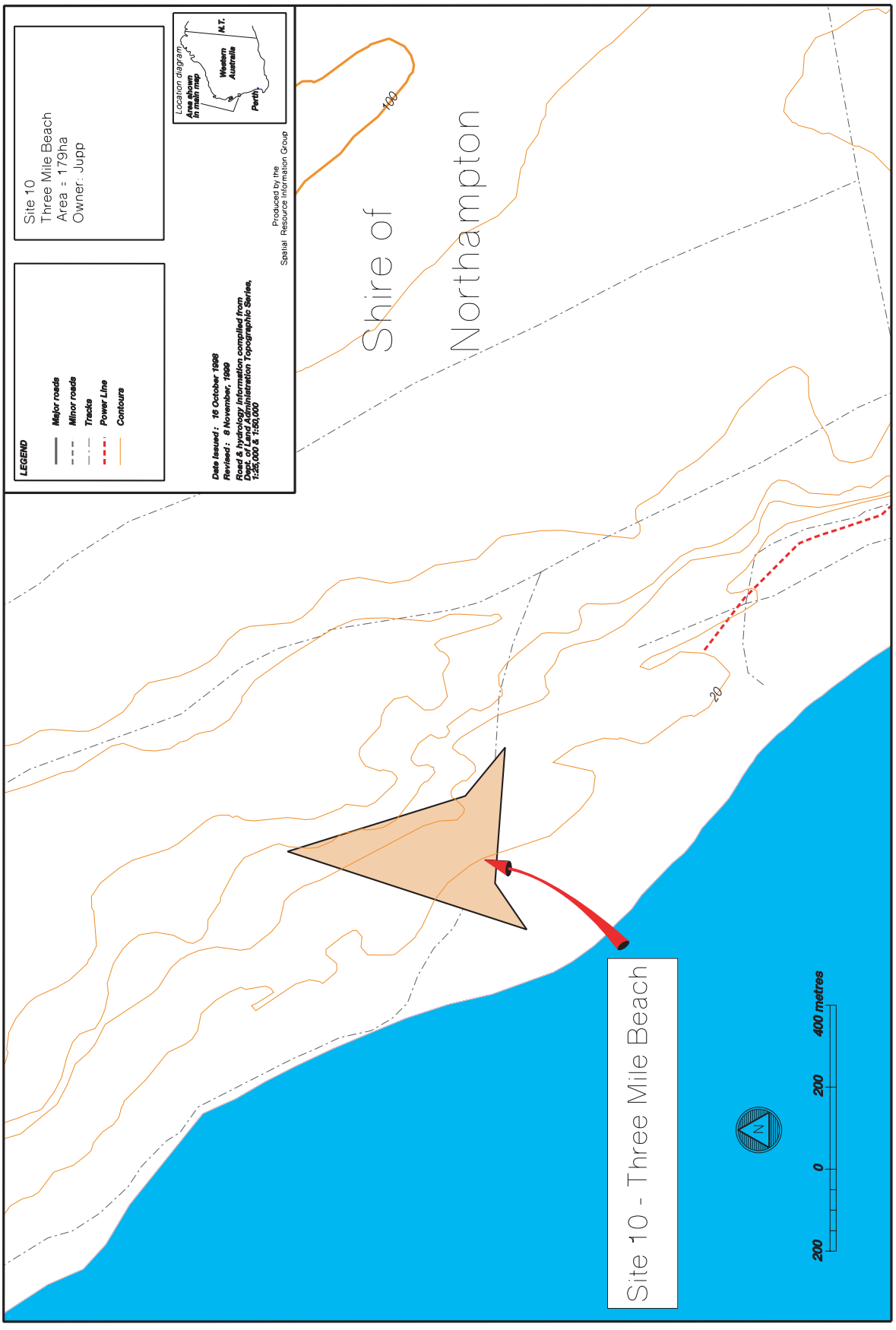

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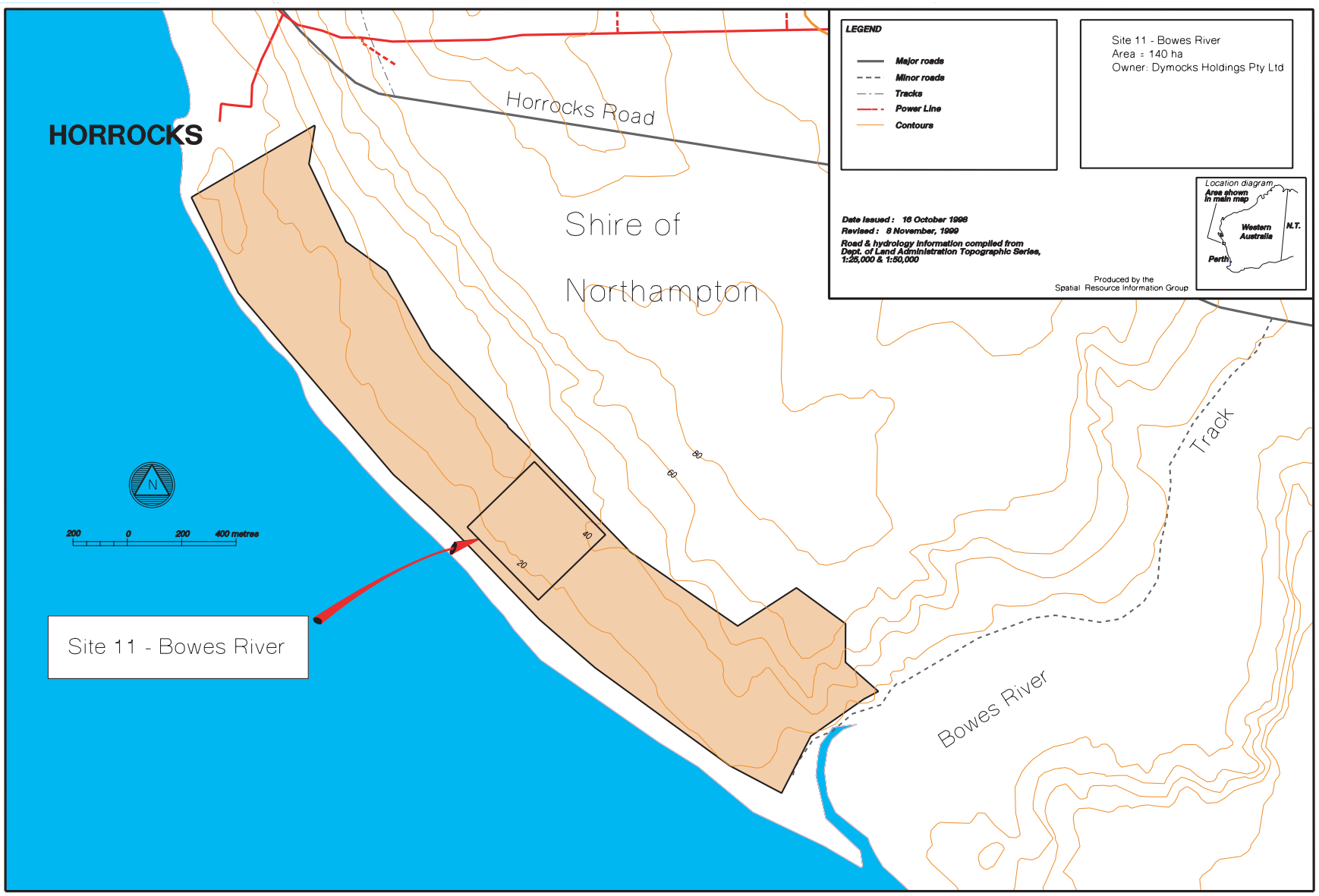

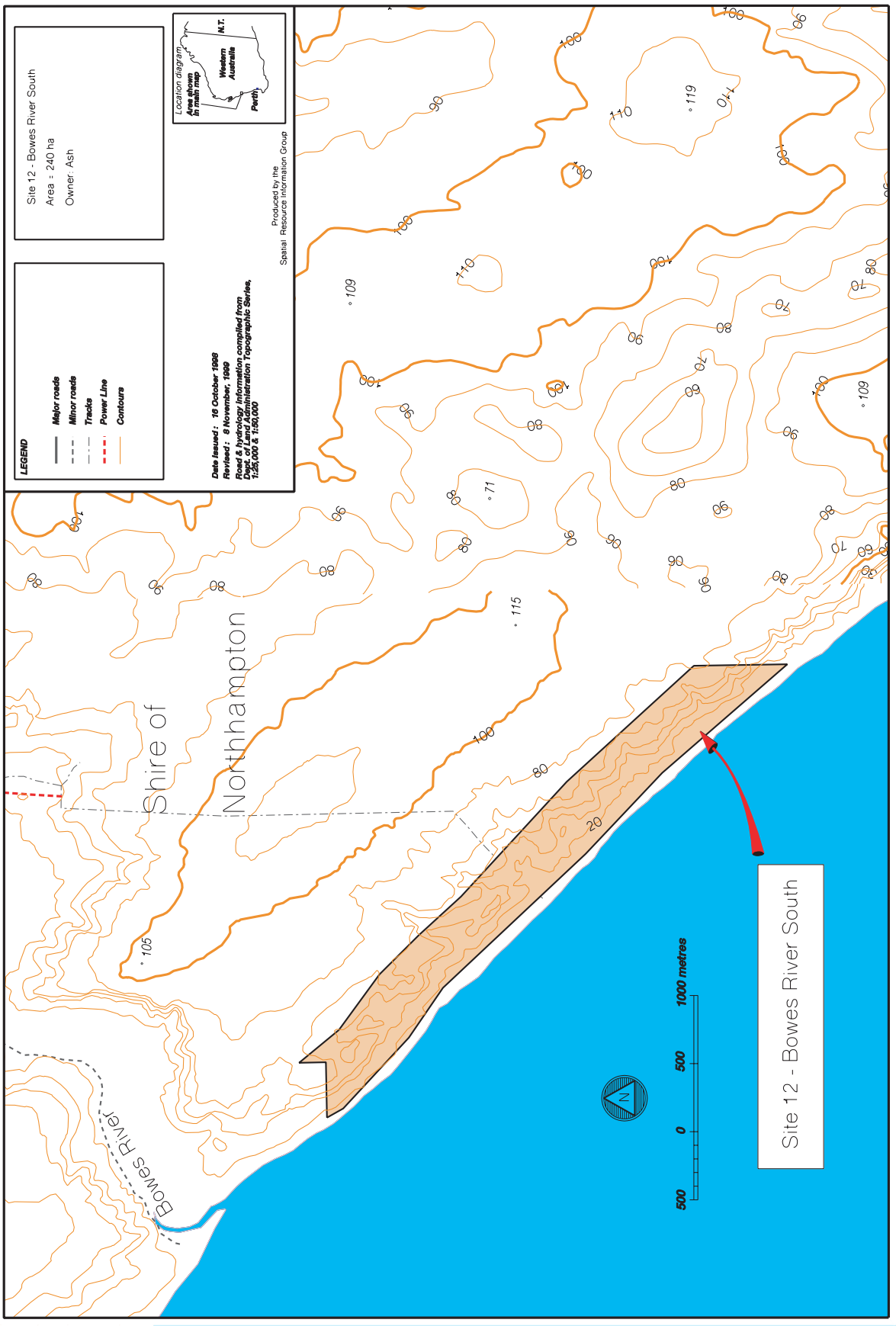

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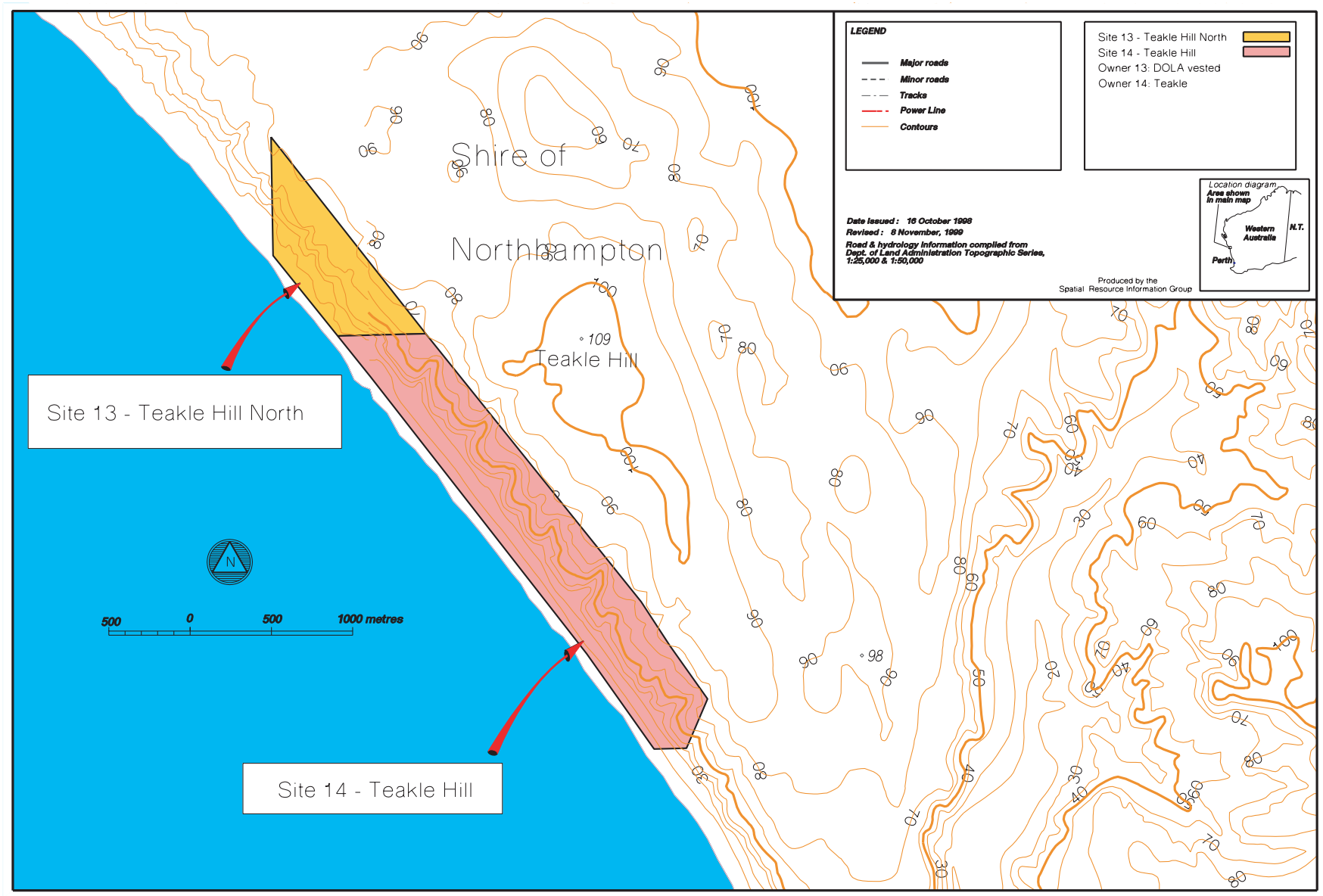

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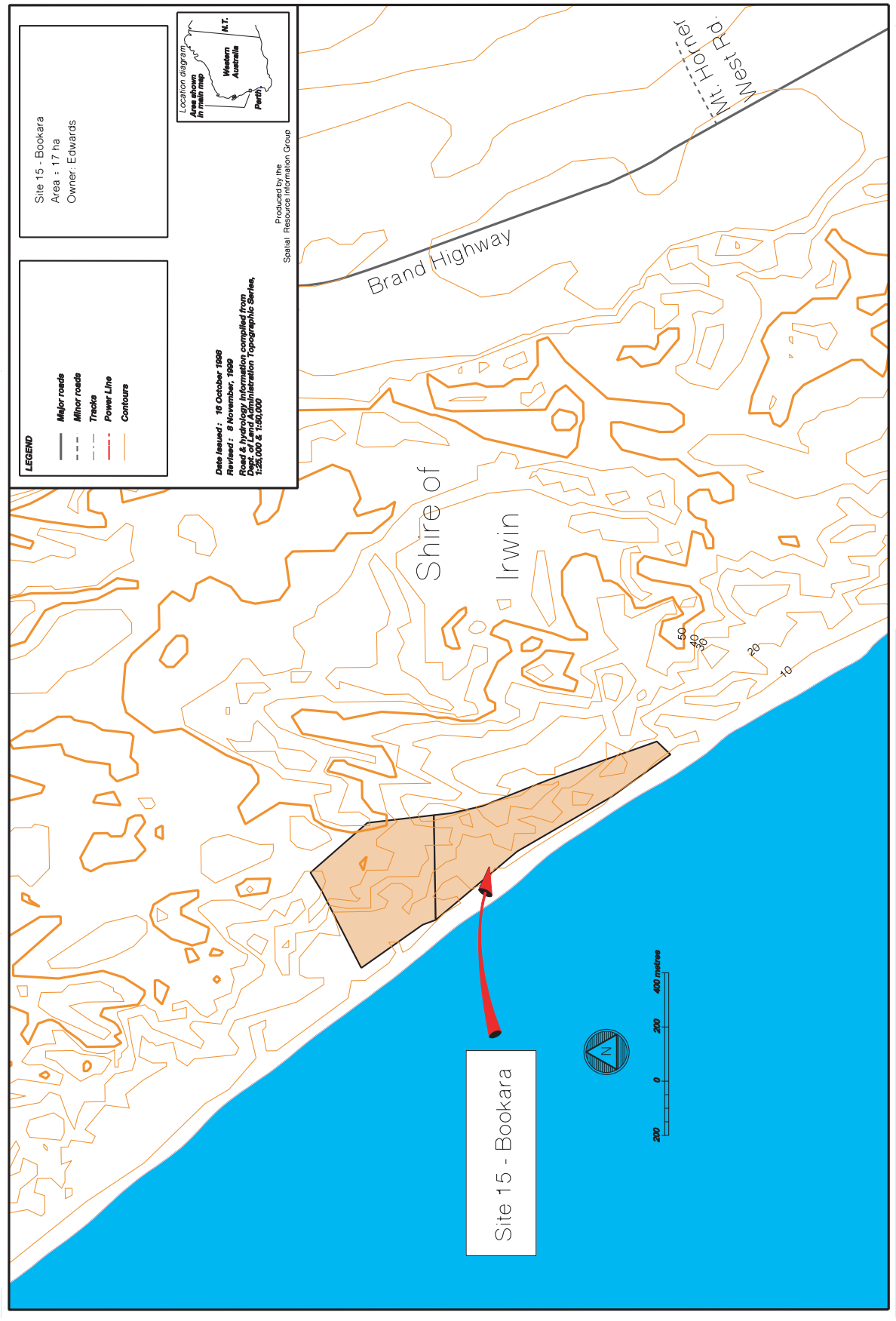

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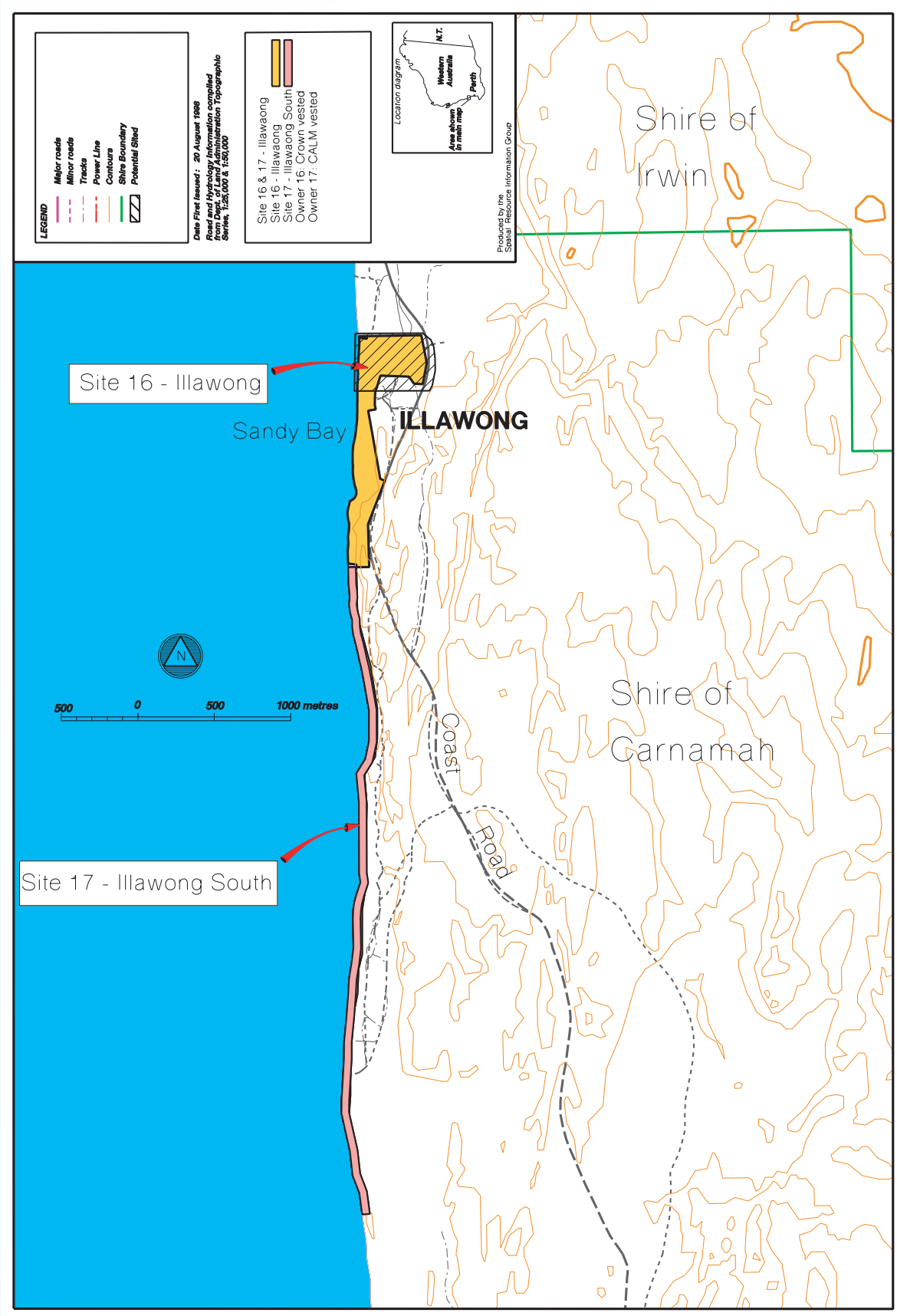

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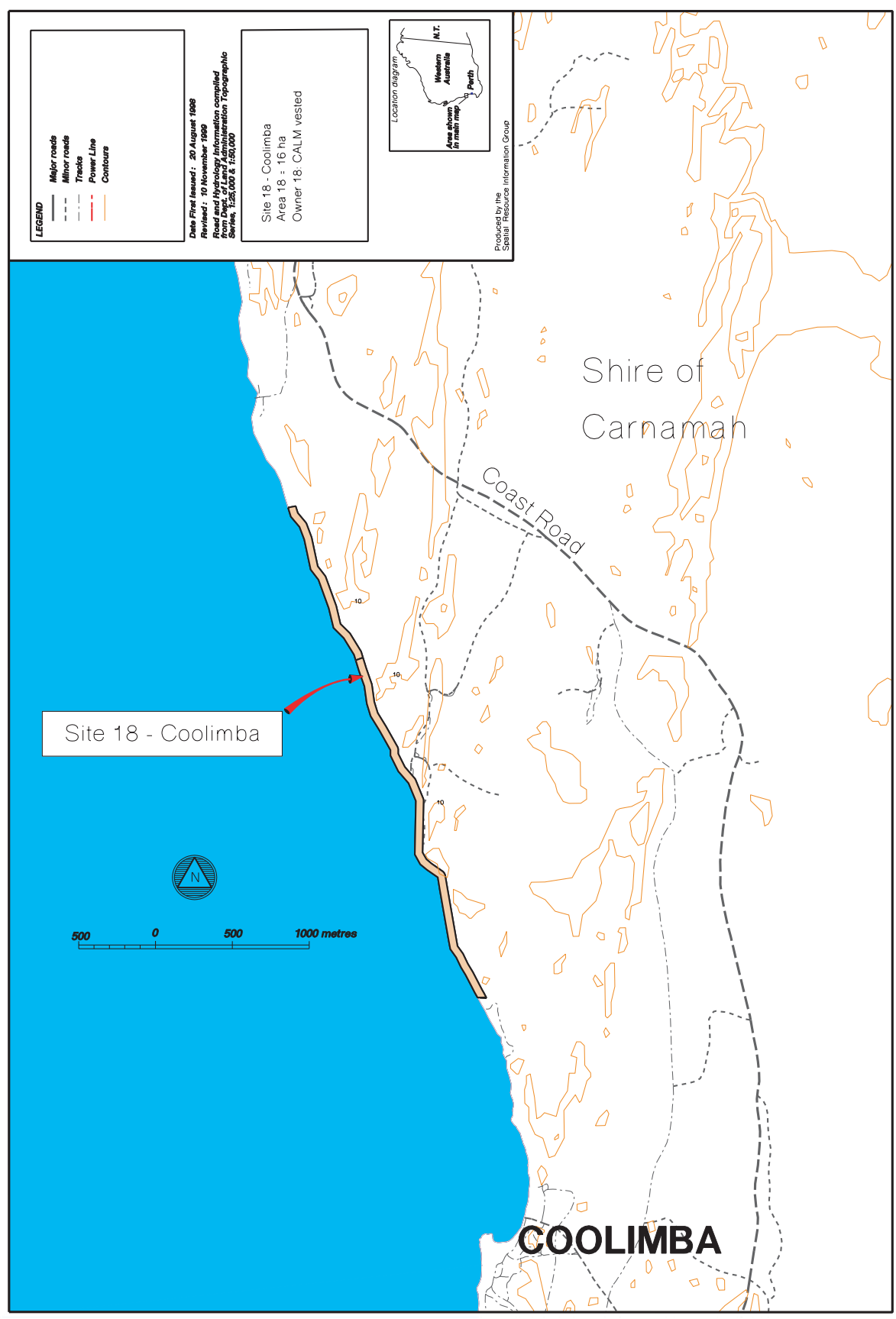

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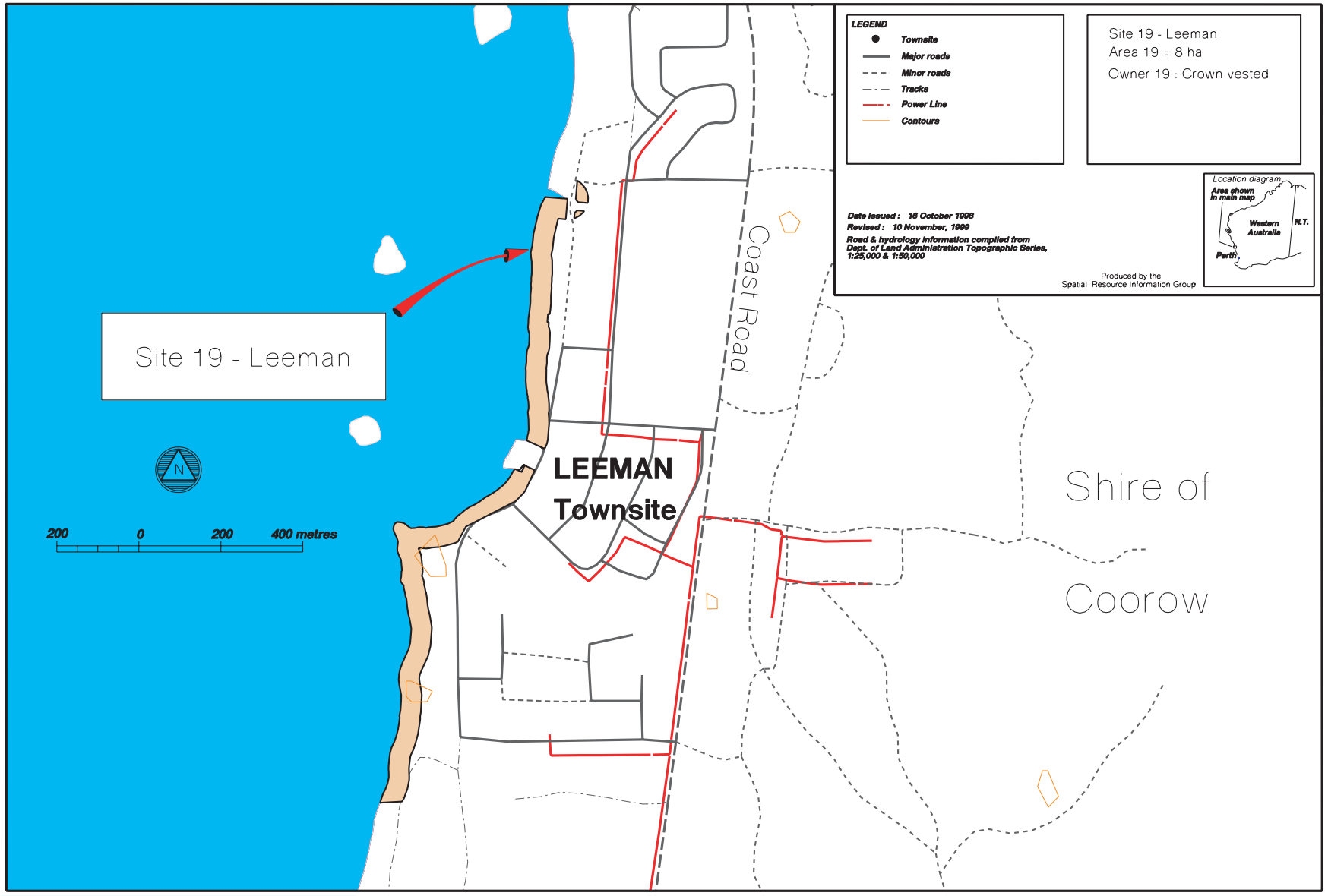
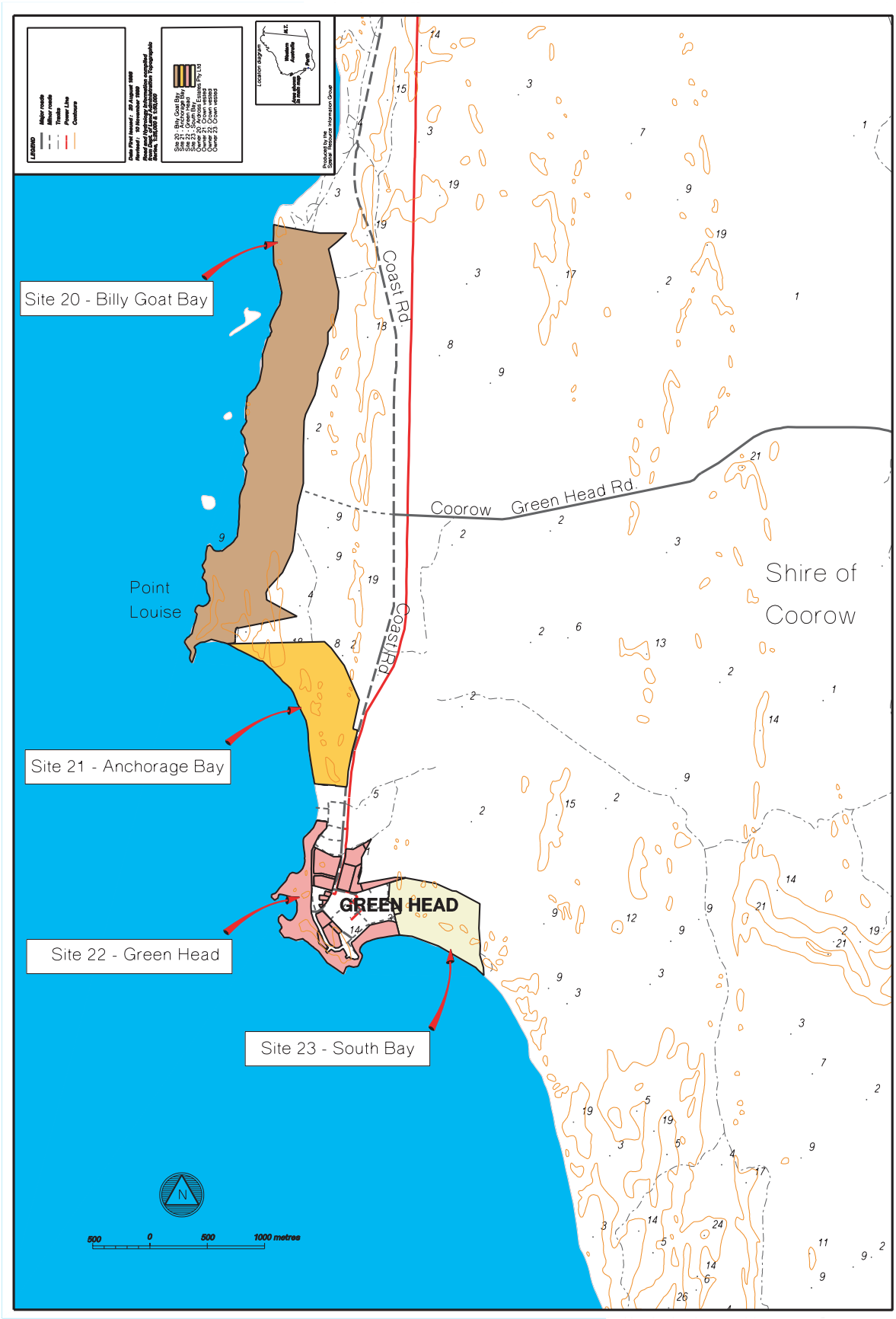

LEGEND
Townsite
Major roads
Minor roads
Tracks
Power Line
Contours
Site 19 - Leeman
Area 19 = 8 ha
Owner 19 : Crown vested
Location diagram
Area shown in main map
Western Australia
N.T.
Perth
Date issued : 16 October 1998
Revised : 10 November, 1999
Road & hydrology information compiled from Dept. of Land Administration Topographic Series, 1:25,000 & 1:50,000
Produced by the Spatial Resource Information Group
Site 19 - Leeman
N
200 0 200 400 metres
LEEMAN Townsite
Coast Road
Shire of Coorow



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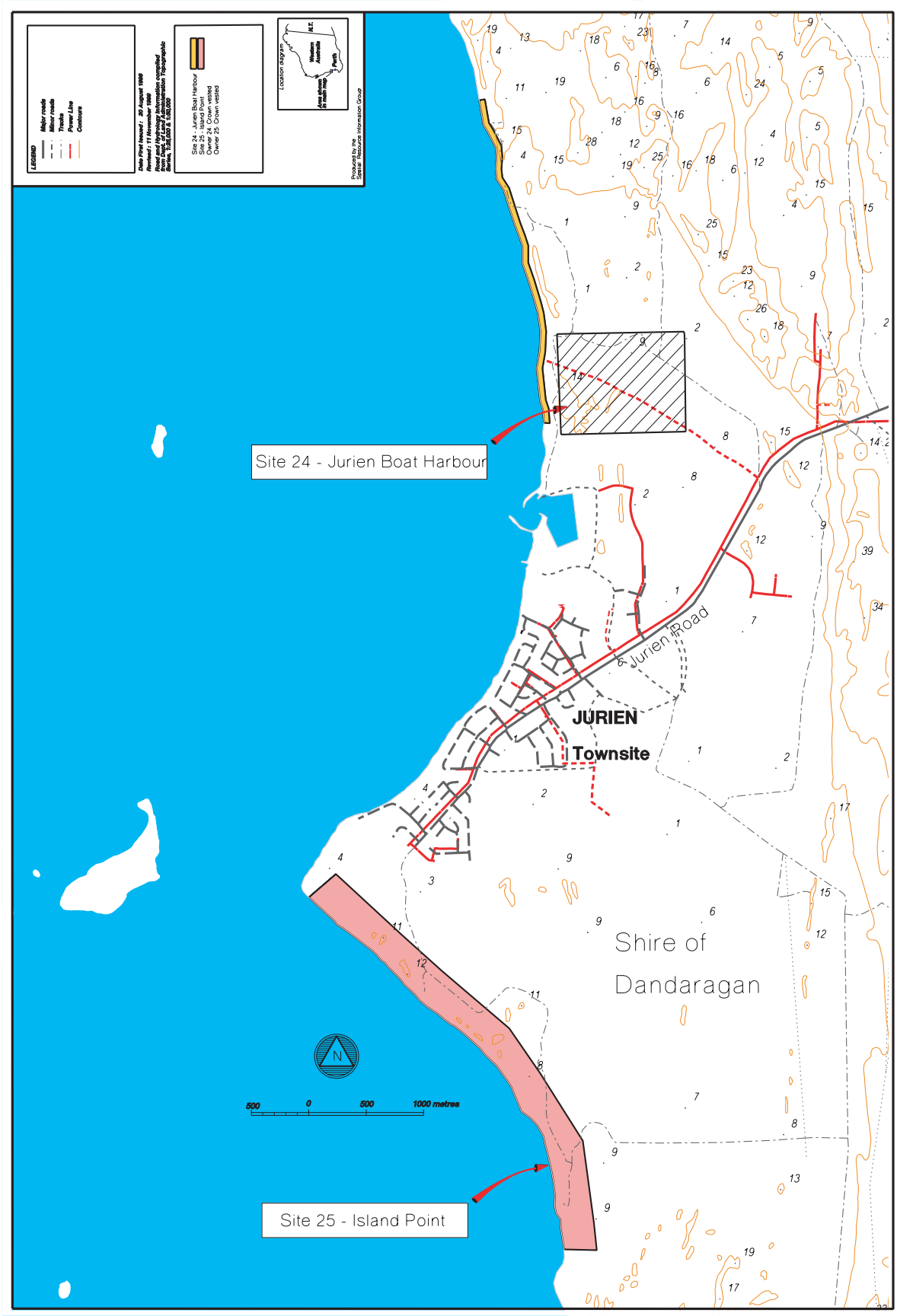

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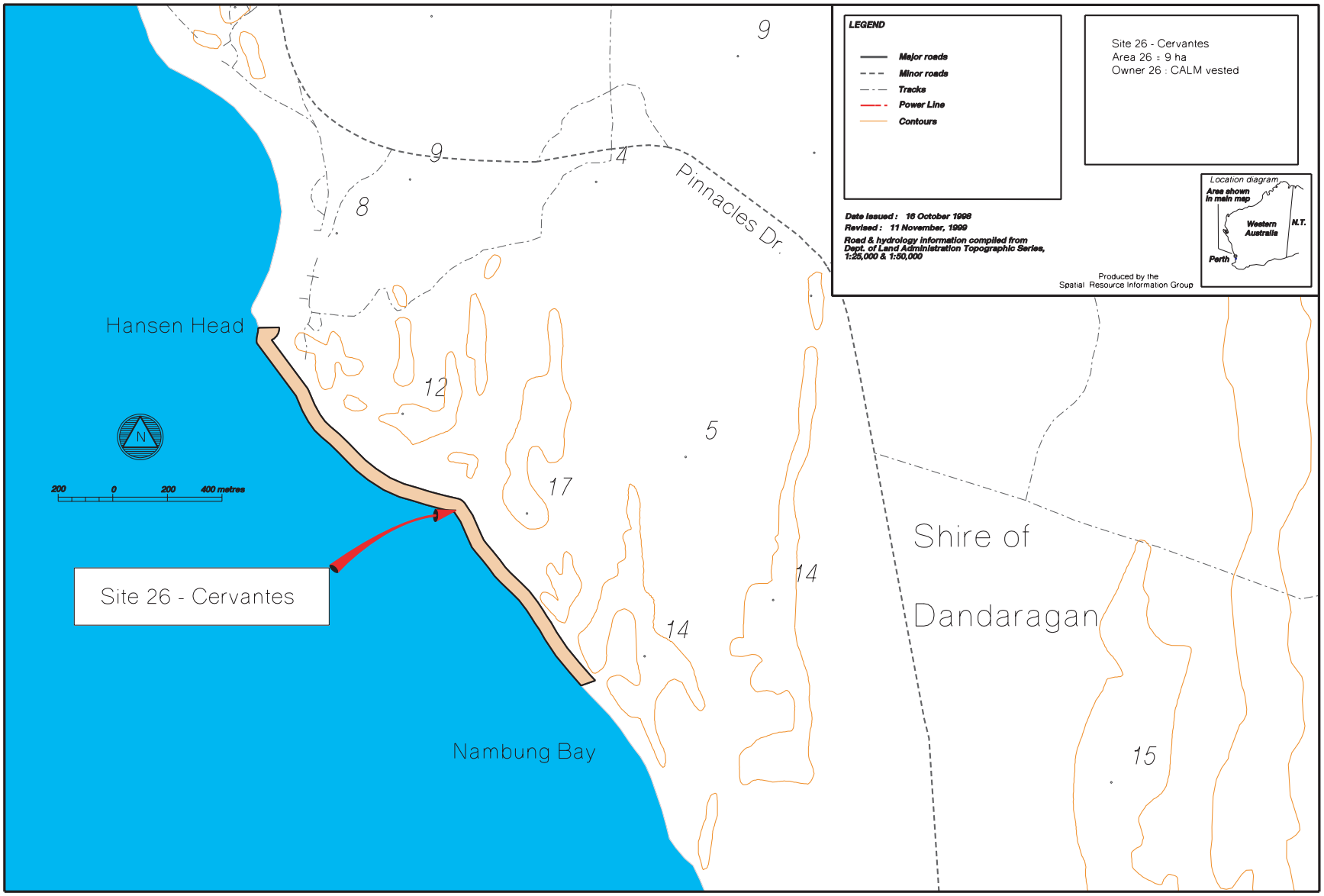
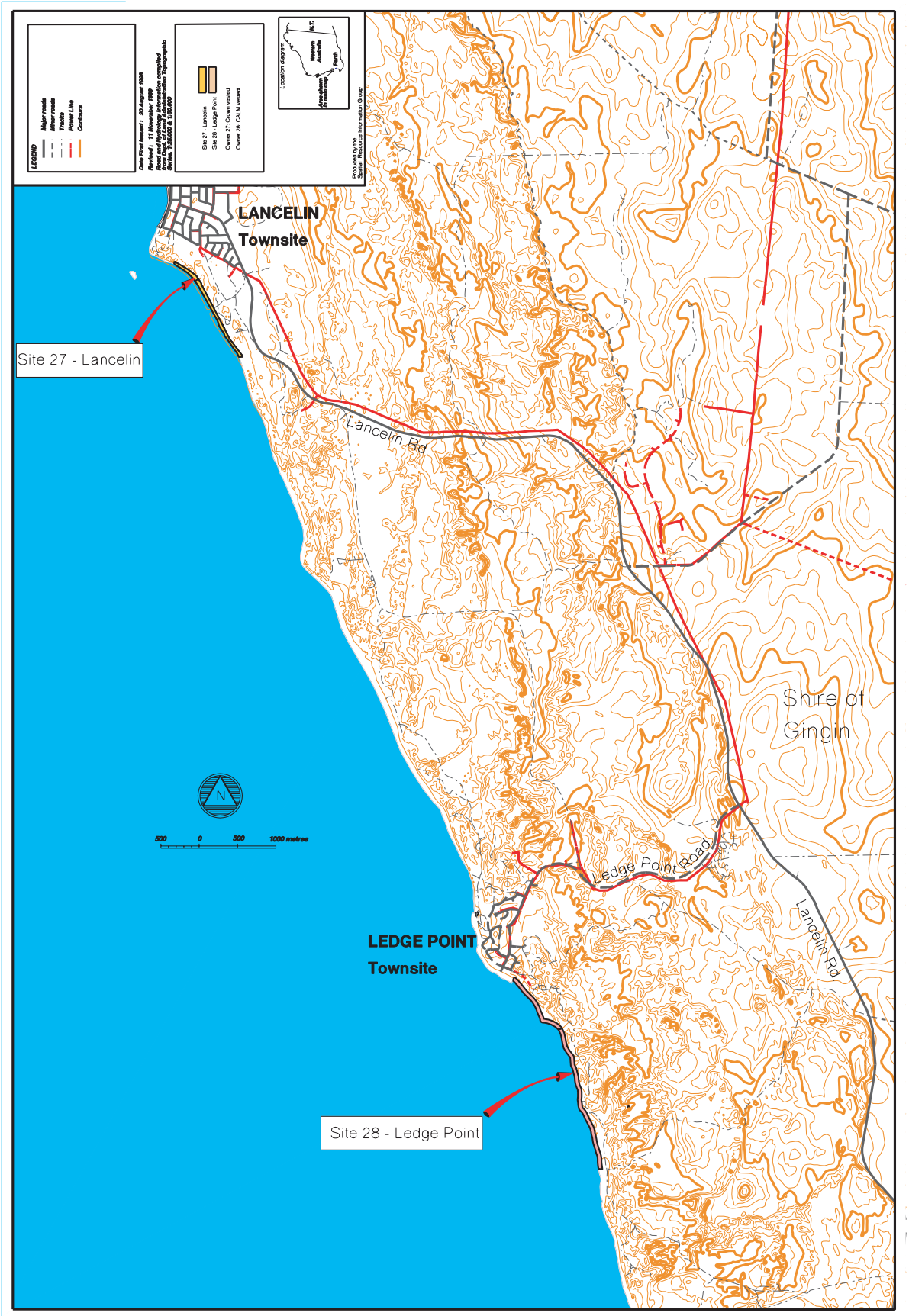

LEGEND
Major roads
Minor roads
Tracks
Power Line
Contours
Site 26 - Cervantes
Area 26 = 9 ha
Owner 26 : CALM vested
Location diagram
Area shown in main map
Western Australia
N.T.
Perth
Date issued : 16 October 1998
Revised : 11 November, 1999
Road & hydrology information compiled from Dept. of Land Administration Topographic Series, 1:25,000 & 1:50,000
Produced by the Spatial Resource Information Group
Hansen Head
Pinnacles Dr
Site 26 - Cervantes
Nambung Bay
Shire of Dandaragan
N
200 0 200 400 metres
9
8
12
5
17
14
15



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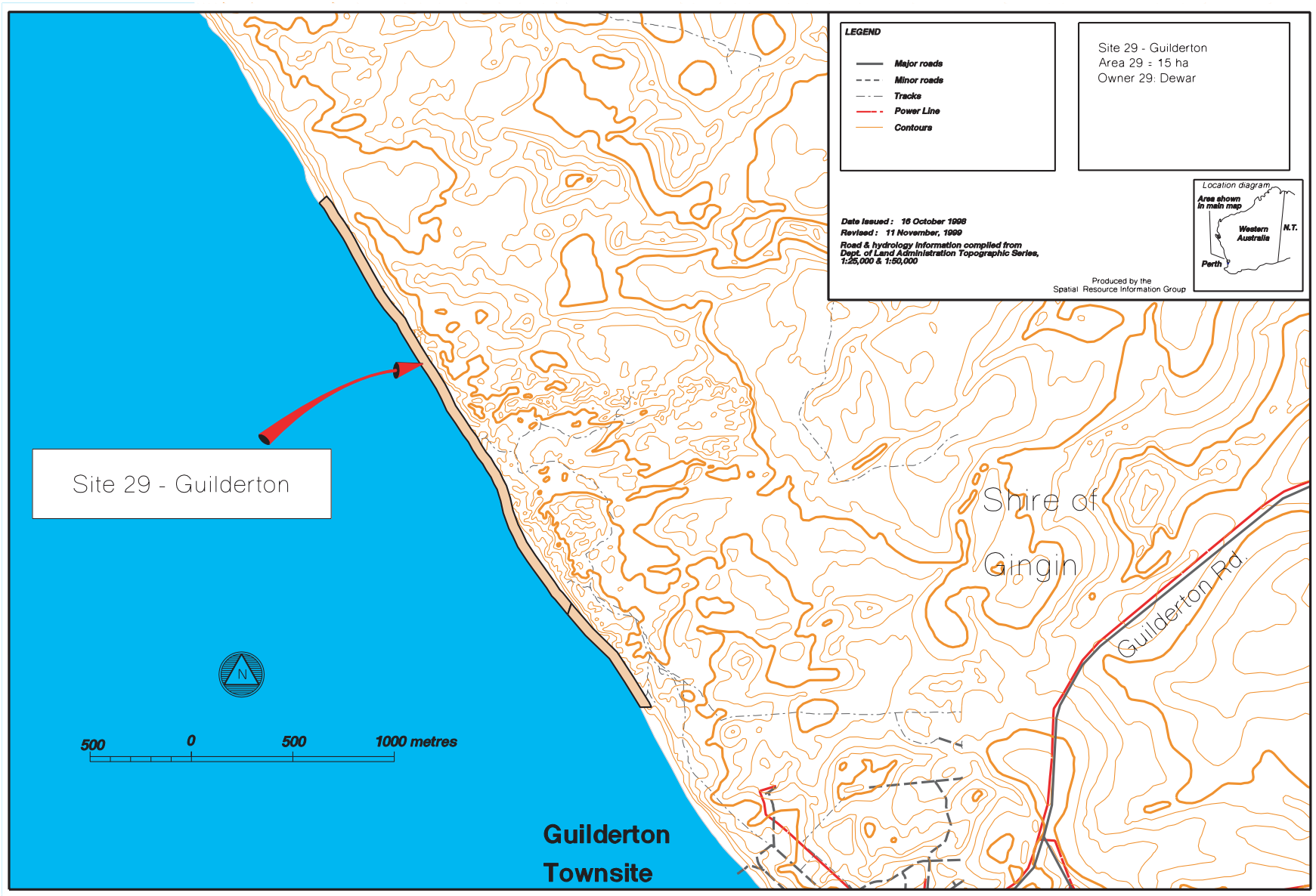
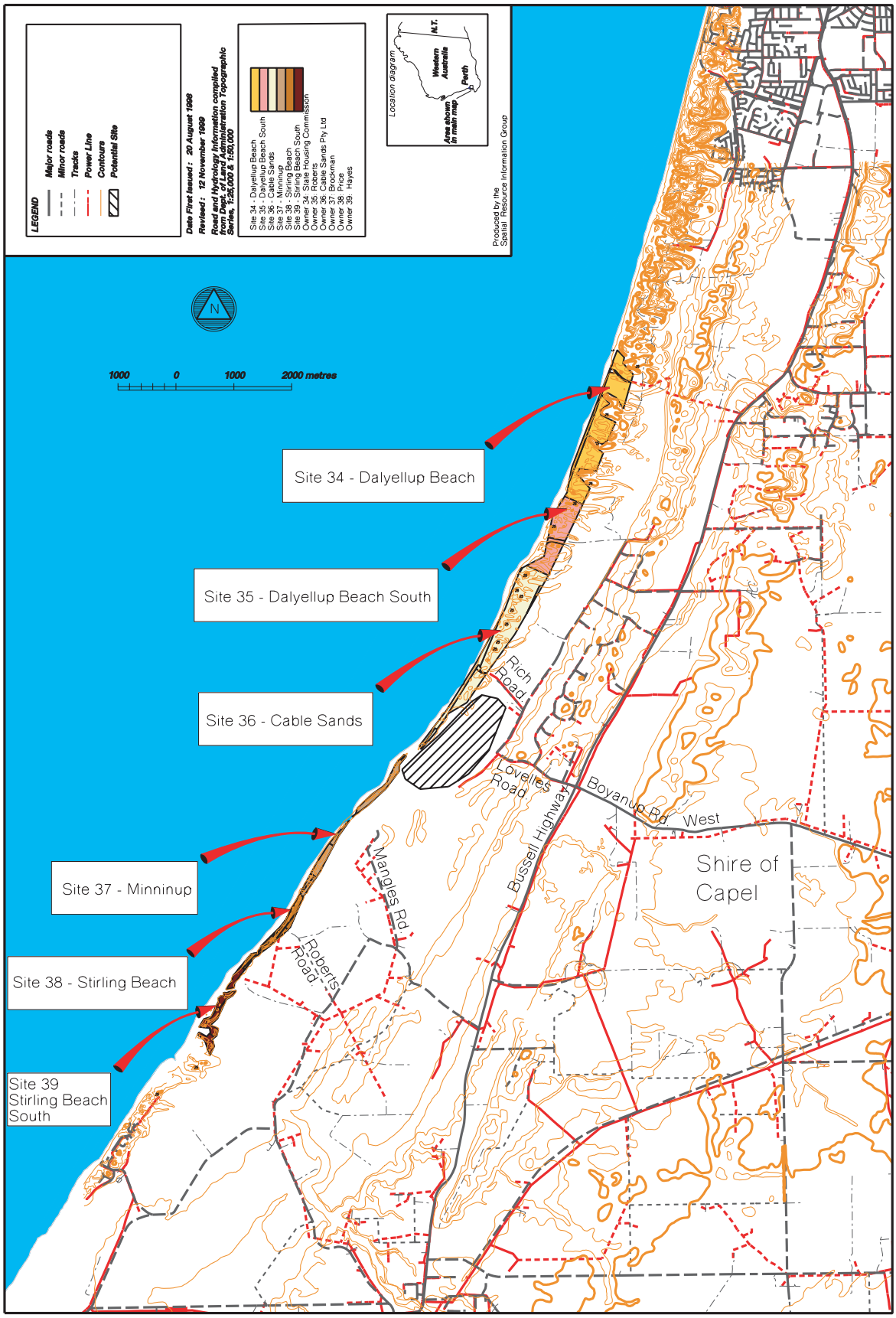

LEGEND
Major roads
Minor roads
Tracks
Power Line
Contours
Site 29 - Guilderton
Area 29 = 15 ha
Owner 29: Dewar
Location diagram
Area shown in main map
Western Australia
N.T.
Perth
Date Issued : 16 October 1998
Revised : 11 November, 1999
Road & hydrology information compiled from Dept. of Land Administration Topographic Series, 1:25,000 & 1:50,000
Produced by the Spatial Resource Information Group
Site 29 - Guilderton
Shire of Gingin
Guilderton Rd.
N
500 0 500 1000 metres
Guilderton Townsite

BACK TO CONTENTS


LEGEND
Major roads
Minor roads
Tracks
Power Line
Contours
Site 31 - Preston Beach
Site 32 - Preston Beach South
Site 33 - Myalup Beach
Owner 31: Cardwick Pty. Ltd
Owner 32: Zurick Bay Hold
Owner 33: Ederny Pty Ltd
Location diagram
Western Australia
Perth
Produced by the Spatial Resource Information Group
Lake
Preston
Road
Site 31 - Preston Beach
Site 32 - Preston Beach South
Site 33 - Myalup Beach
Shire of Harvey
N
500
0
500
1000 metres



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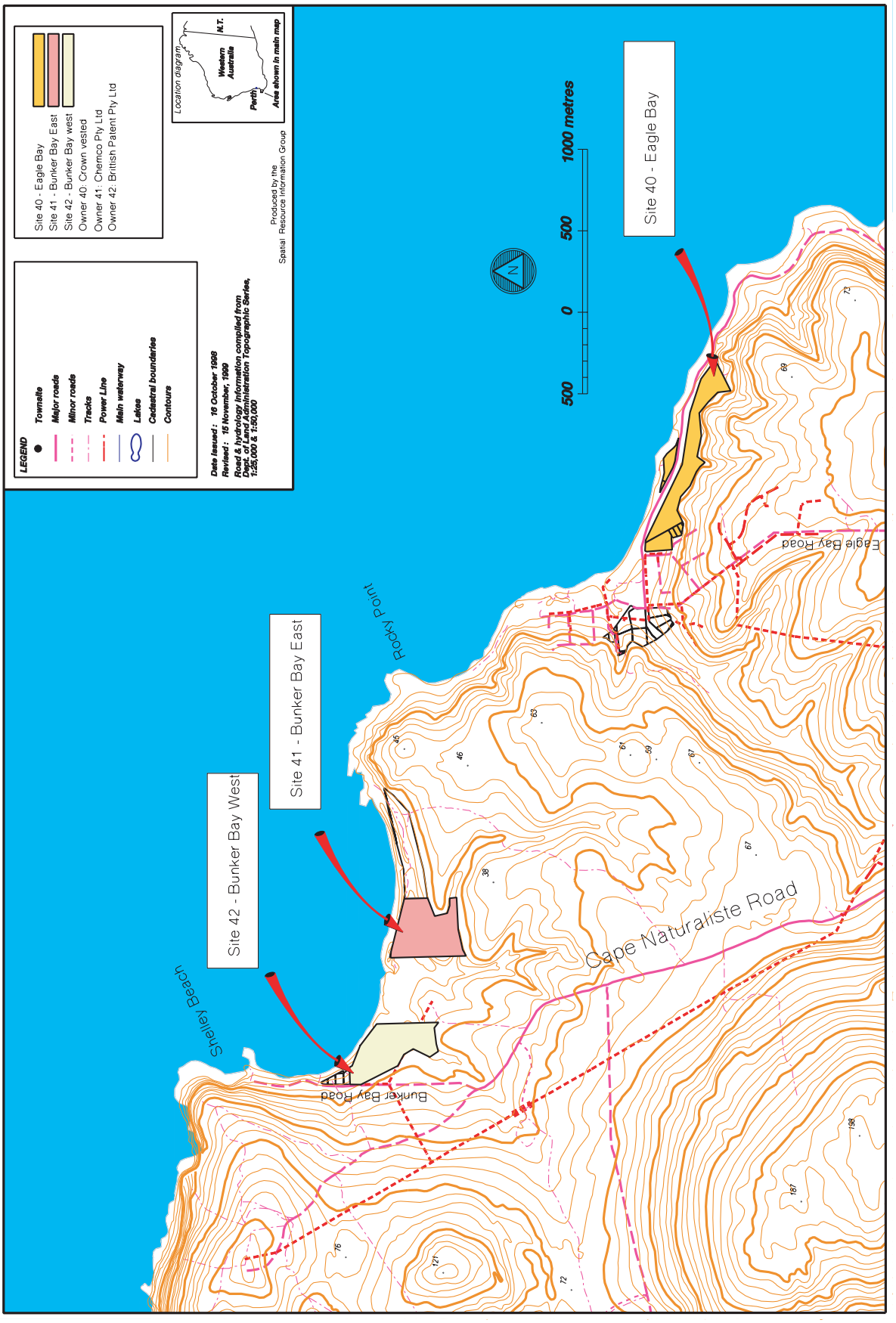

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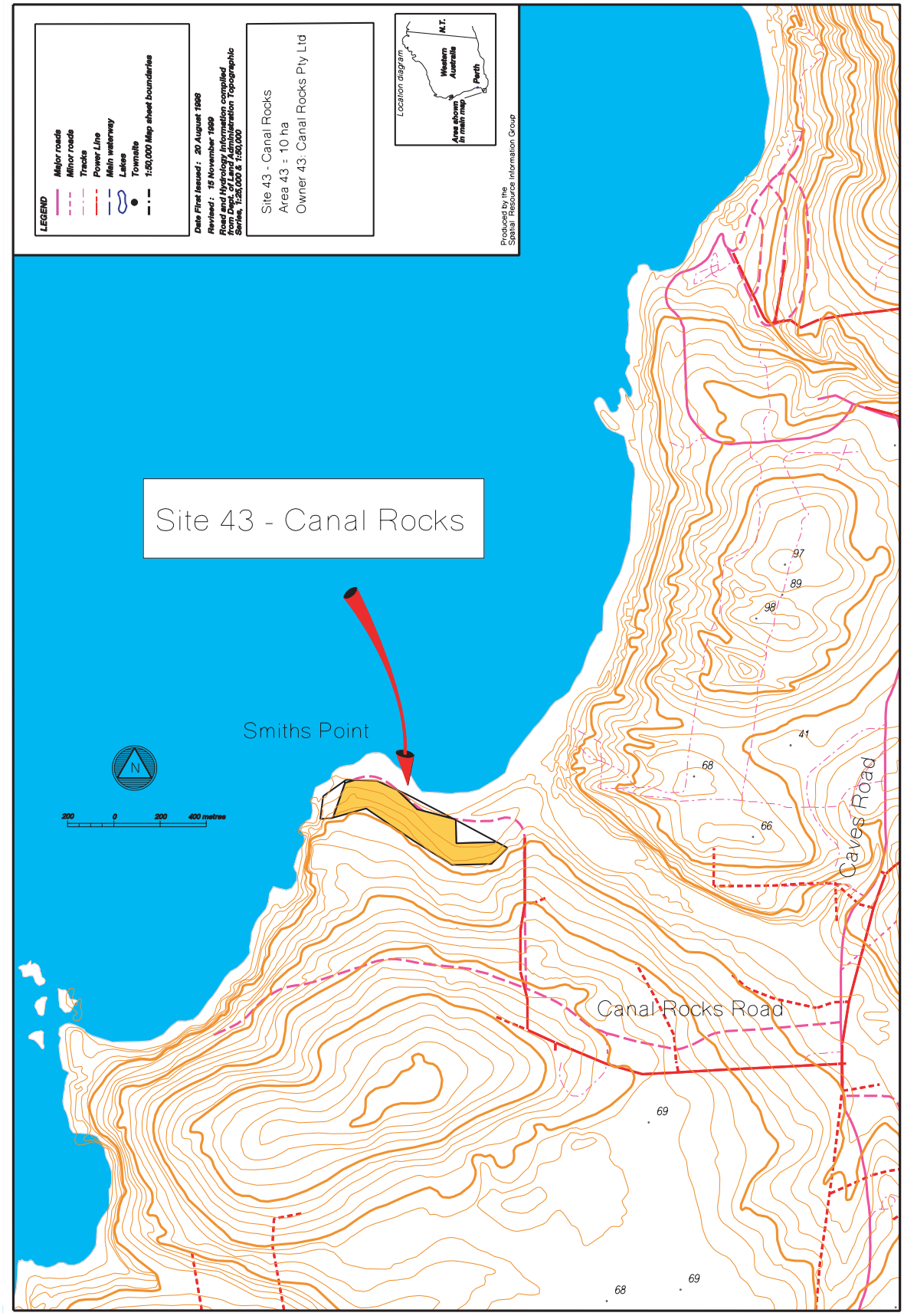

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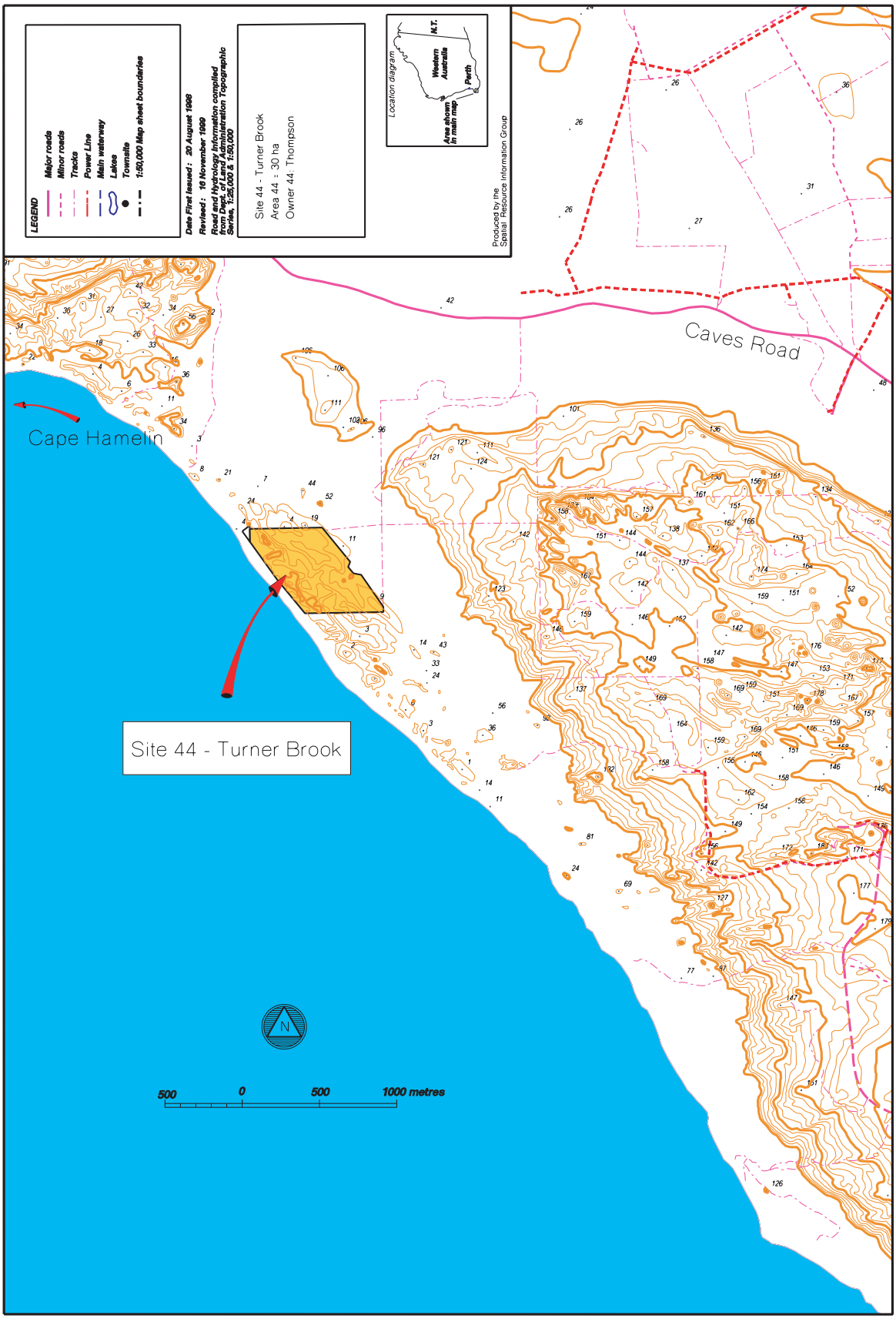
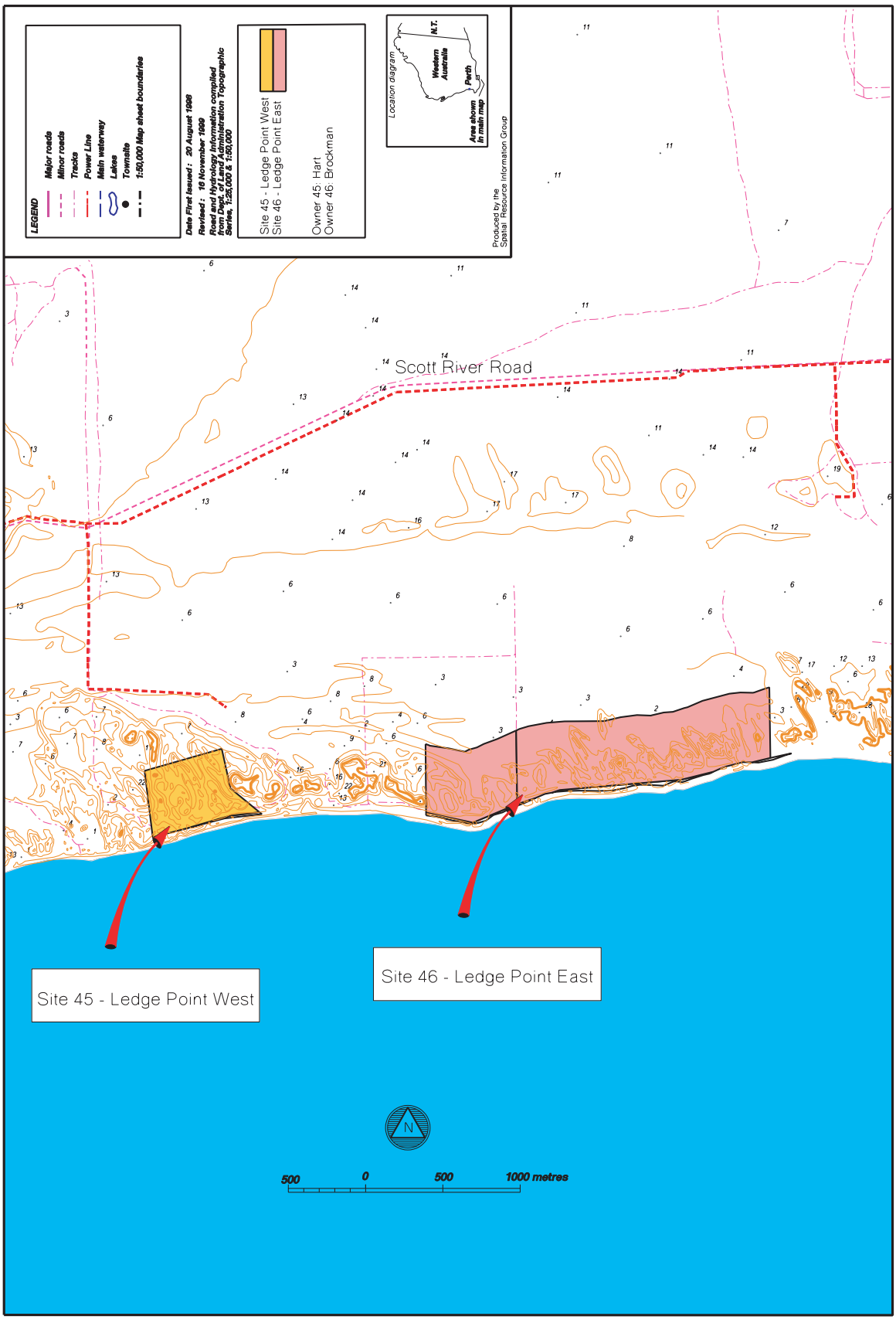

LEGEND
Major roads
Minor roads
Tracks
Power Line
Main waterway
Lakes
Townsite
1:50,000 Map sheet boundaries
Date First Issued : 20 August 1998
Revised : 16 November 1999
Road and Hydrology Information compiled from Dept. of Land Administration Topographic Series, 1:25,000 & 1:50,000
Site 44 - Turner Brook
Area 44 = 30 ha
Owner 44 Thompson
Location diagram
W.A.
Western Australia
Perth
Area shown in main map
Produced by the Spatial Resource Information Group
Caves Road
Cape Hamelin
Site 44 - Turner Brook
N
500
0
500
1000 metres



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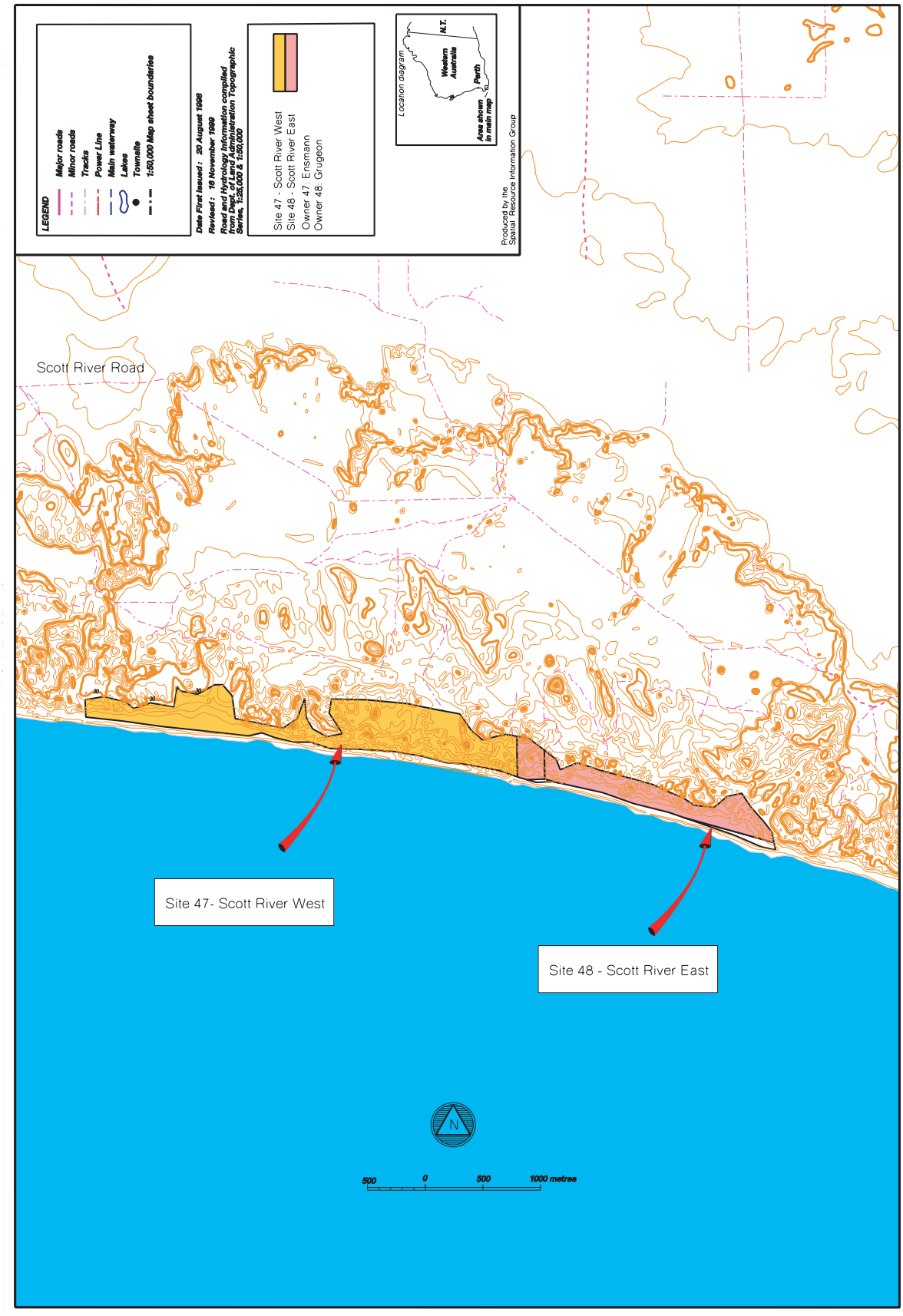

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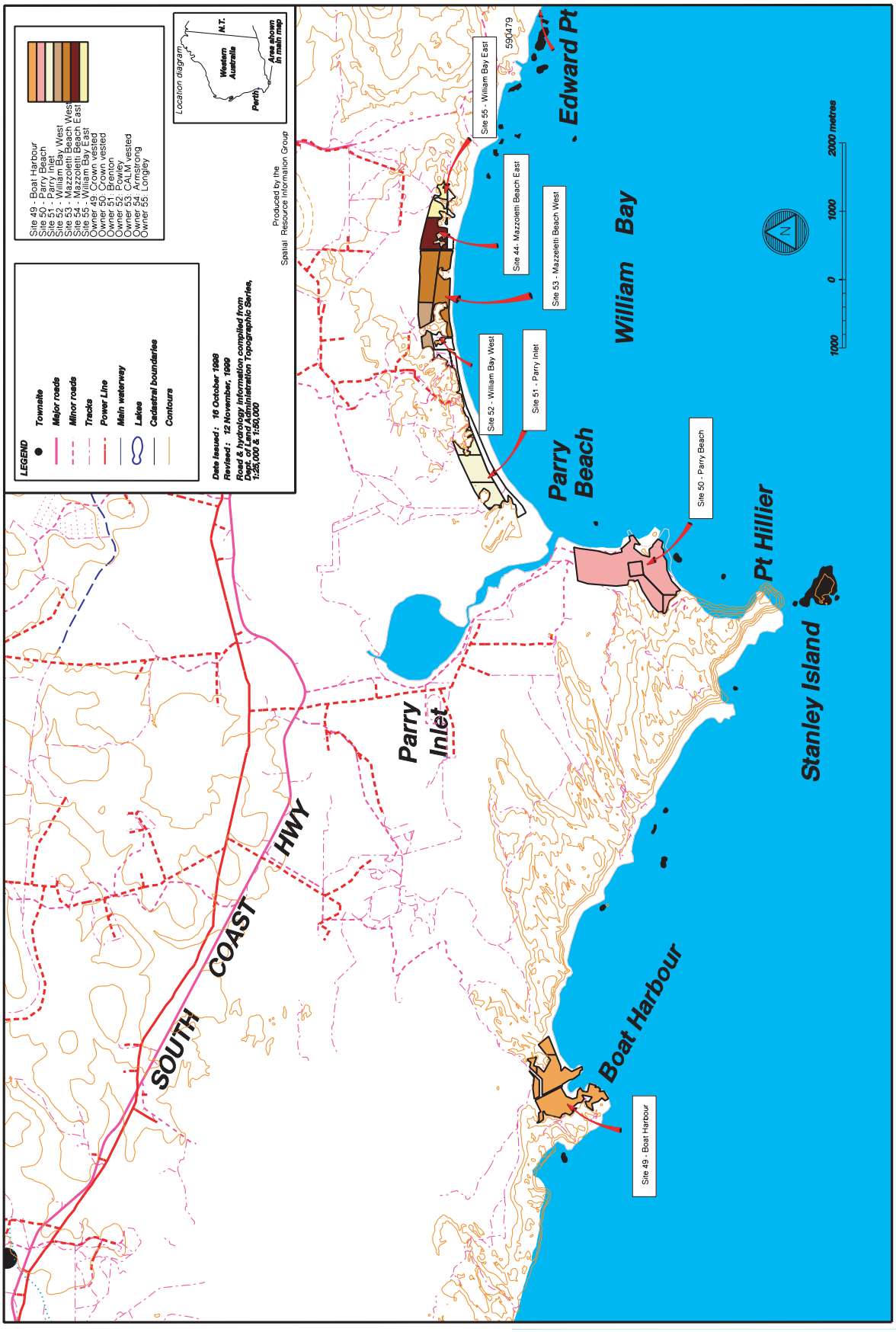

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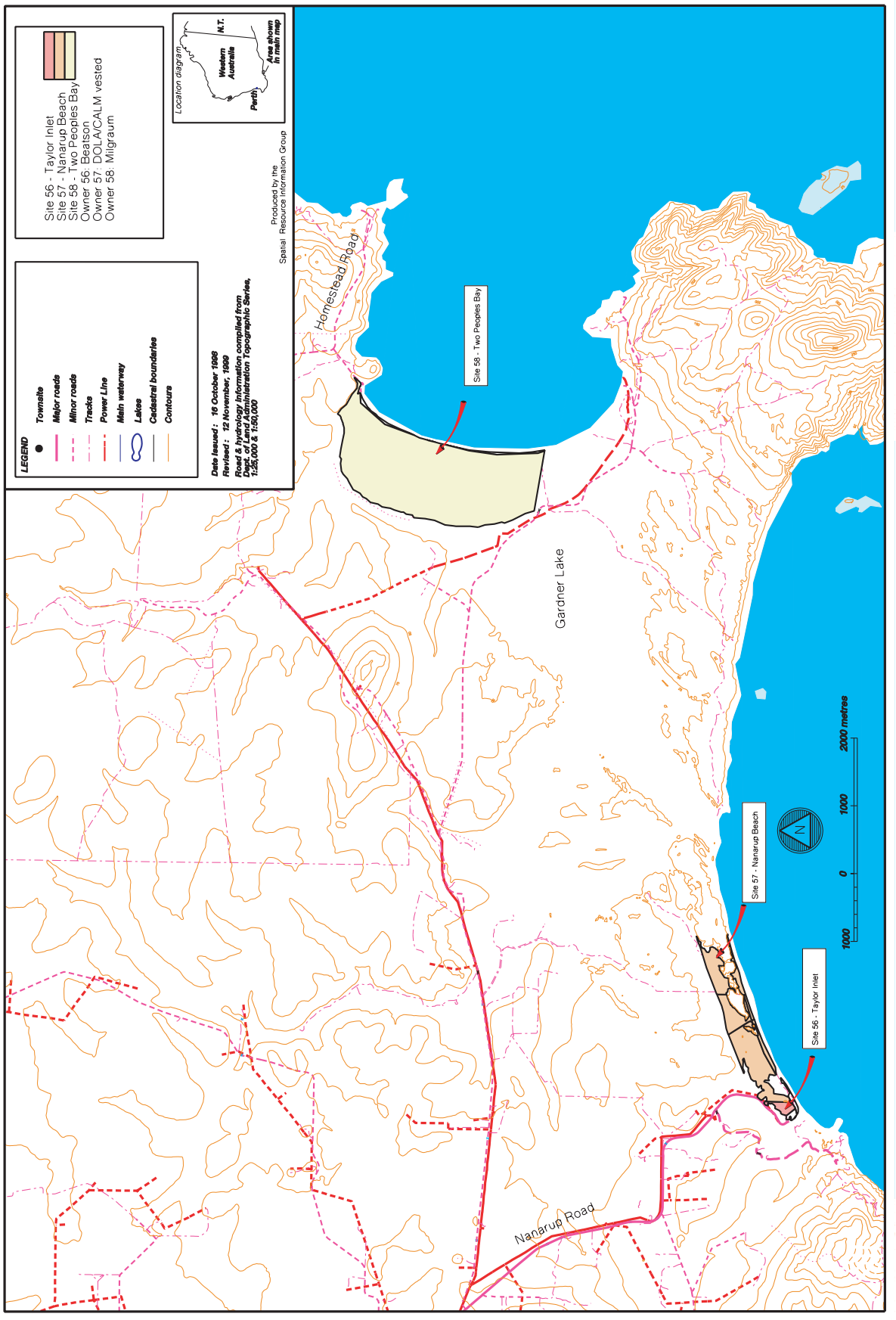

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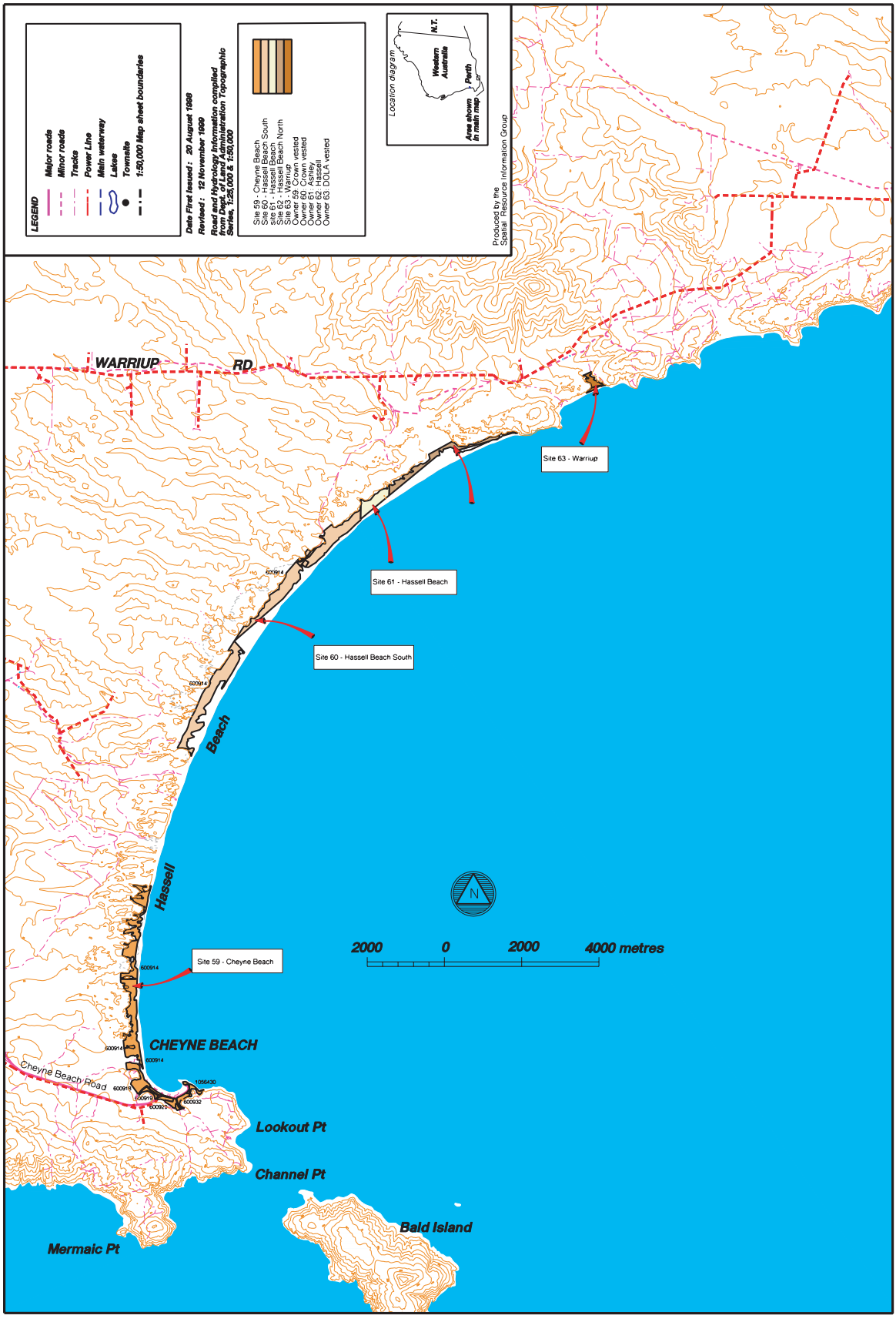

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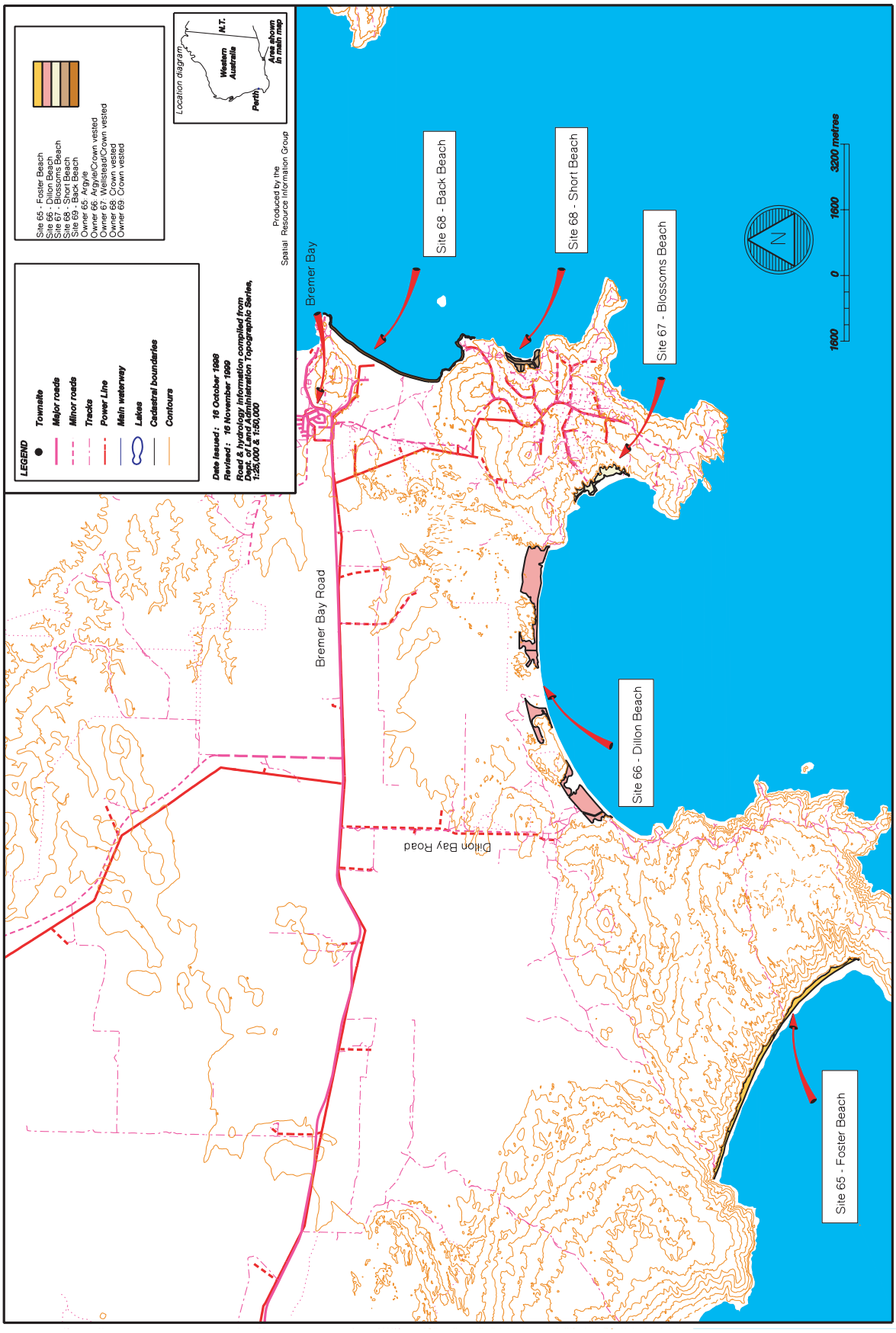
BACK TO CONTENTS



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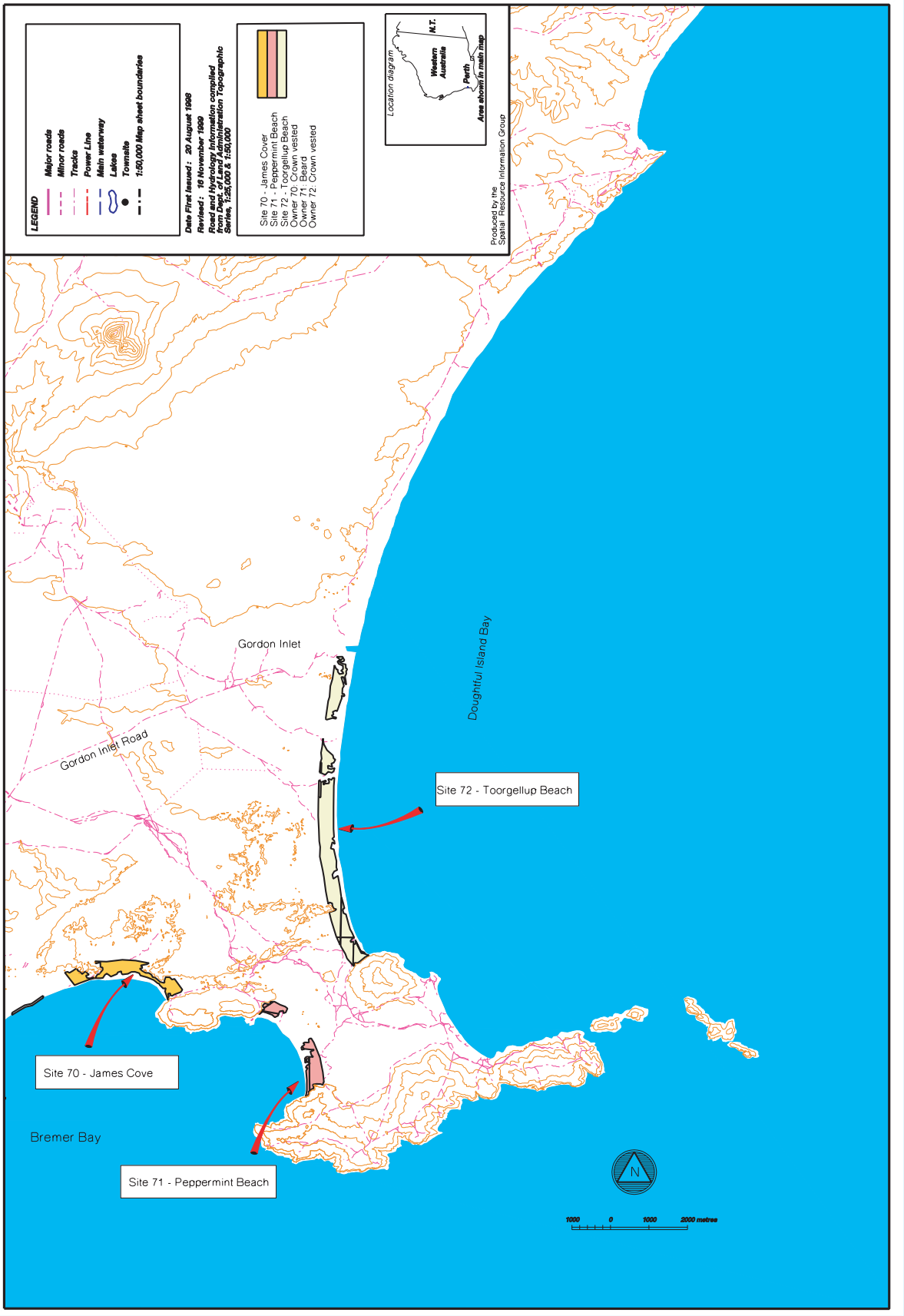

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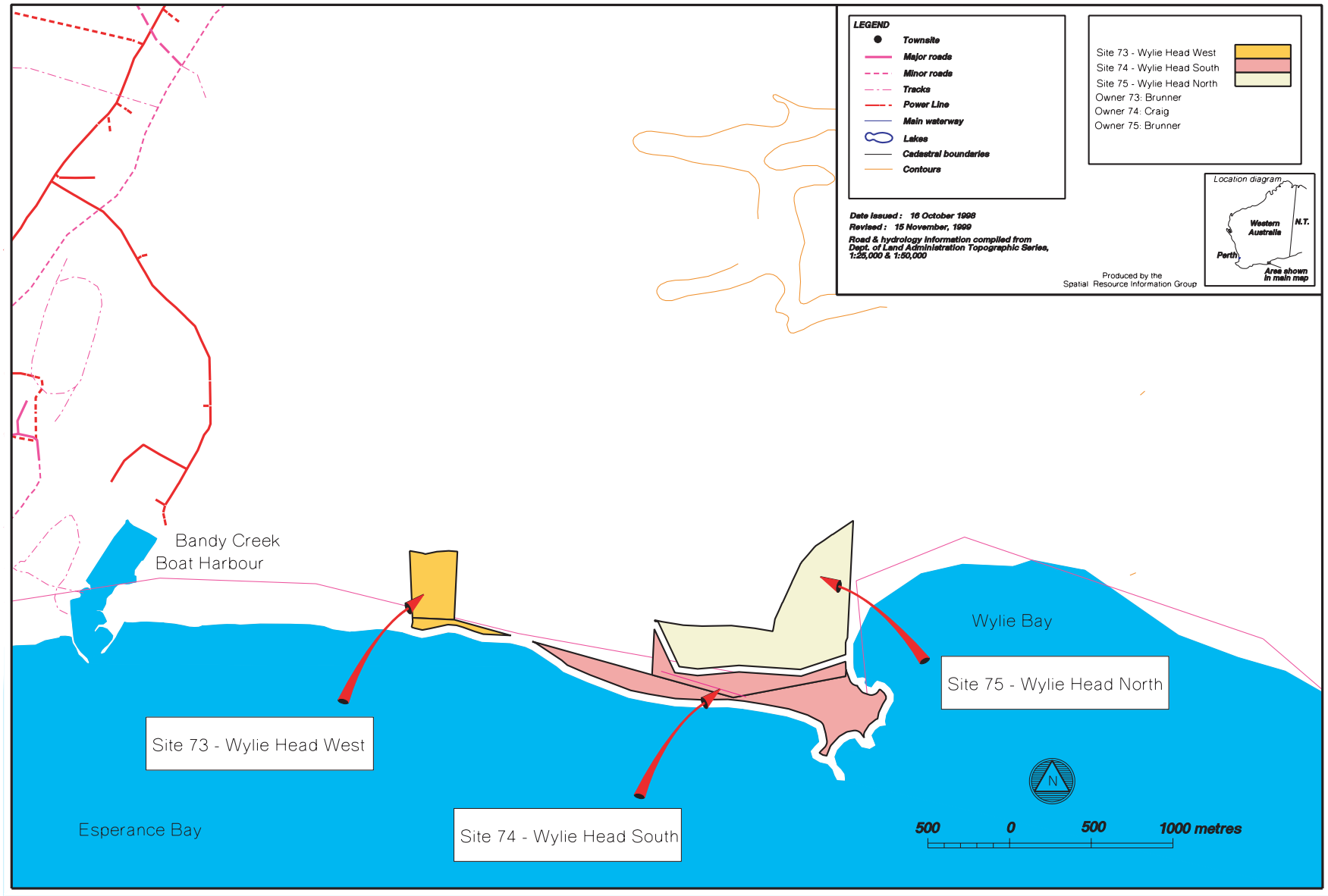
LEGEND
Townsite
Major roads
Minor roads
Tracks
Power Line
Main waterway
Lakes
Cadastral boundaries
Contours
Site 73 - Wylie Head West
Site 74 - Wylie Head South
Site 75 - Wylie Head North
Owner 73: Brunner
Owner 74: Craig
Owner 75: Brunner
Location diagram
Western Australia
N.T.
Perth
Area shown in main map
Date issued : 16 October 1998
Revised : 15 November, 1999
Road & hydrology information compiled from Dept. of Land Administration Topographic Series, 1:25,000 & 1:50,000
Produced by the Spatial Resource Information Group
Bandy Creek Boat Harbour
Wylie Bay
Site 75 - Wylie Head North
Site 73 - Wylie Head West
Esperance Bay
Site 74 - Wylie Head South
N
500 0 500 1000 metres