

Technical Specification for Khawr Kabir

1. SITE DESCRIPTION

1.1 Location

Governorate/ Region	Dhofar
Wilayat	Salalah
Distance from the Centre of Waylay	It is located approximately 10 km west of the city centre of Salalah.
Nearest Locality	Salalah
Fame of the Site/ Distinctive Features	None
Facilities in the Site	Plant Nursery is in operation and taking a roll of seedling supply station for Regions near to Salalah.
Features of Surrounding Areas	This Khawr is located 0.5 km east side of Hilton Salalah Hotel.

1.2 Natural Conditions

Climate Zone	Dhofar Zone
General Terrain	Flat plain
Geological Features	No data
History of Geological Change	In May 2002, a large cyclone produced floods around Salalah and Khawr Kabir received floodwater, which broke through the sandbar. This lowered the water level and allowed seawater to enter at high tide. The sandbar is now rebuilt and the salinity of the water is about 2.4% (before it was about the same as seawater 3.4-3.7%) and is expected to gradually increase again as seawater enters during the khareef. During the flood the sand banks along the channel nearer the sea collapsed in places, killing some smaller mangroves. This also has the effect of widening the channel and small mangroves that had germinated along the previous waterline were now surrounded by water about 1 meter from the shore.
Soil	Khawr Kabir lies on the flat plain located at east of Hilton Hotel in western part of Salalah. The khawr is cut off by short sandbar from sea. The soils of both sides at the mouth of khawr are deep sand. Also the narrow and sandy shore on the south of khawr is stretching to the place near mangrove nursery. On the other hand, the north shares of khawr are steep and sandy soils. The upper shores at both side of khawr are covered by mangrove. The soils under this vegetation are basically deep and silty with organic matter and humic substances. However, sandy soils are observed at surrounding areas adjacent to the mangrove vegetation. Many gravels and stones, which were carried by flooding, are recognized in the area of upper khawr. Details are shown in attached table “ Attachment 4: Soil Profile in Khawr Kabir ” and “ Attachment 9: Soil Profile Samples in Khawr Kabir ”
Water	Salinities of water in khawr were 2.6% at the mouth and 2.9% at upstream in Jan 2003, and 2.0%. The values of COD were 5-10mg/l. DO on surface water on upper khawr showed relatively lower value (2.8mg/l) than khawr mouth (more than 7.2mg/l) in January 2003. But these values were decreased to 1.5mg/l at khawr mouth and 3.1mg/l on upper khawr. in May 2003. Green alga was found in surface water in khawr. Water quality was getting worse compare to the data on January 2003.

	Details are shown in attached table “ Attachment 5: Surface Water Quality in Khawr Kabir ”
Fauna	<p>Several large active holes of the land crab (<i>Cardisoma carnifex</i>) were found on the landward edge of the mangroves. Burrowing shrimp holes (<i>Callichirus</i> sp) were common (up to 400/m²) in open sandy areas covered by shallow water. A few holes of ghost crabs (<i>Ocypode</i>) were present.</p> <p>Sieved samples of sand near the mouth of the khawr behind the sandbar contained elements of marine (small mussels cf <i>Musculista senhousia</i>), estuarine (burrowing amphipods cf <i>Corophium</i> and small horn shells, <i>Potamides conicus</i>) and freshwater (chironomid larvae, <i>Hydrobia</i> snails) fauna. Mosquito larvae (<i>Anopheles coustani</i>) occurred in isolated pools. Small fish were abundant. Birds recorded in the winter were 1 moorhen, 1 little egret, 1 great white heron, waders (4 redshank, 1 wood sandpiper, 1 common sandpiper). In the summer, 10 night herons were counted roosting in the trees. These birds roost mainly in mangrove trees and are not normally found elsewhere.</p> <p>Compared with studies in 1993, the khawr had a greater freshwater component but diversity was high.</p>
Flora	<p>Algae were recorded in the water (<i>Chaetomorpha crassa</i>, <i>Enteromorpha flexuosa</i>). The main plant zone along the edges of the khawr was the grass, <i>Sporobolus virginicus</i>, which was joined by the reed, <i>Phragmites australis</i>, along the drainage channels at the landward side of the mangroves. Some patches of reed near the road gate showed signs of previous heavy grazing with the main stem eaten and numerous side branches bearing small spiky leaves. The vegetation of the drier sandy banks comprised the normal plant association for this zone (<i>Suaeda vermiculata</i>, <i>Cyperus conglomeratus</i>, <i>Urochondra setulosa</i>, <i>Aeluropus lagopoides</i>, <i>Sporobolus spicatus</i>, <i>Cressa cretica</i>, <i>Heliotropium fartakense</i>, <i>Senra incana</i>).</p>
Impacts from the Surrounding Areas	None

1.3 Socio-economic Situation

Population of the Wilayat (2001)	162 thousand
Population of the Nearest Locality (1993)	162 thousand
Main Economic Activities	Tourism, industry
Infrastructure	All utility and infrastructure available. Highway passing through beside the site. The mangroves of Khawr Kabir were fenced in 2002 to allow the trees to recover from overgrazing by camels.
Main Usage	No distinctive activities and utilization except for plant nursery established by MRMEWR in cooperation with JICA expert.
Community Interference with the Area	Residential and commercial development will encroach the area.
Cultural Significance	None

1.4 Legal Setup and Development Plans

Land Ownership and Land Use Designation	The Khawr was designated as a Nature Reserve by Royal Decree Royal Decree 49/97 dated 28/6/97 with the Ministry of Regional Municipalities and Environment as the managing authority. The management plan aims to protect the mangrove trees while allowing controlled access for fodder collection. Sustainable fishing and the use of the area as a picnic site would also be allowed.
Development Plans in the Site and the Surrounding Area	N/A
Existing Conservation Proposal	Declared as nature reserve in 1997

2. PROGRAMME AND PROJECT

2.1 Prerequisite

Legal Setup for Land Use Control	Set a distinct boundary of NR (see 4.2 Required Action for Conservation and Management) and building regulation of surrounding area.
Facility Development Control	No permanent structure in NR, except hide for bird watching, sign and information boards, and board walking or pedestrian bridge. Footpath should be designated but not paved. No permanent commercial buildings such as restaurants hotels shops and mechanized amusement facilities in the park development area. Basic activities in this park are relaxation and picnicking. Partial lighting for safety only. Utilities lines (water and electricity should be minimum) and setback 150 m from the edge of Mangrove.

2.2 Description of Programmes

Facility Development Programme	N/A
Restoration and Afforestation Programme	N/A
Monitoring Programme	(1) Mangrove monitoring project (2) Soil and water monitoring project (3) Fauna and flora monitoring project (4) Pollution monitoring project (5) Monitoring project on legal setup and development plans
Public Awareness Programme	It will include an educational programme for school children and conservation campaign for residents of the Wilayat. Required materials and facilities are (6) Pamphlets and posters distributed to the residents, (7) Information boards describing significance of the natural environment.

2.3 Implementation Mechanism

Projects	Responsible Agencies	Implementing Body/ Agencies	Related Agencies
(1) Mangrove Monitoring Project	MRMEWR	Wylayat Salalah	
(2) Soil and Water Monitoring Project	MRMEWR	Wylayat Salalah	
(3) Fauna and Flora Monitoring Project	MRMEWR	MRMEWR/ Omani Institute for Birds	
(4) Pollution Monitoring Project	MRMEWR	Waylay Salalah/ MRMEWR	
(5) Monitoring Project on Legal Setup and Development Plans	MRMEWR	Wylayat Salalah	
(6) Pamphlets and posters distributed to the residents	MRMEWR	MRMEWR	MOE
(7) Information boards	MRMEWR	MRMEWR	MOE

2.4 Implementation Schedule

Project No.	1 st	2 nd	3 rd	4 th	5 th	6th	7th	8th	9 th	10 th
(1)										
(2)										
(3)										
(4)										
(5)										
(6)										
(7)										

3. IMPLEMENTATION PLAN

3.1 Restoration and Afforestation

3.1.1 Existing Mangrove Area

Location and Area	Both shores surrounding Khawr Kabir covered by mangrove area is 4.2 ha approximately. (Figure 2 Location Map)
Conditions of Existing Mangrove	Healthy and tall mangrove trees are lushly surviving on both banks at the upper khawr. Tall trees reached more than 10m heights. Many falling trees due to last flooding are observed. Before fencing, grazing by camels was severe. Many new branches from grazing branches are developing. Many seeds are observed after flowering season. New seedlings have planted by MRMEWR at the northern shore of khawr mouth (1500m ²), southern narrow shore and shore of inmost khawr in January 2003. Most of planted trees are growing well. Much garbage at inmost khawr. No more grazing by camels due to fencing.

3.1.2 Plantation Area

Tidal Condition	Normal: mouth is closed
Wave and Wind	Calm in Winter, Drifted sand damages seaward fringe.
Flood	Every 5 to 10 years
Water Salinity and PH	Salinity; <u>2.6 ~ 2.9 %</u> , PH; <u>- 7.5 ~ 7.9</u> (“ Attachment 5: Surface Water Quality in Khawr Kabir ”)
Soil Conditions	Sandy soil with aerobic condition. Surveyed data is in the “ Attachment 4: Soil Profile in Khawr Kabir ” of this technical specification.
Potential Area	N/A

Table 3.1 Location and Areas of Potential Planting Area(s)

	Designated Area	Area (ha)
Area-1	No plantation	

3.1.3 Conservation Area

Area of Land Use	Nature Reserve (NR) Area
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3.1.4 Required Action for Conservation and Management

Inspection	Daily observation by the management body, 2 to 3 times of inspection by MRMEWR (Mangrove Information Centre)
Cleaning	Management Body
Replantation of Seedlings Growing Bad, Dead or Washed Away	MRMEWR (Mangrove Information Centre) for 5 years after plantation.
Service for Associated Facilities	Regularly by Management Body
Patrol and Enforcement	Daily ordinary patrol by a police office of Wilayah is required, and the management body regularly inspects facilities conditions and littering and waste disposal to the ground and water in NR areas.
Restoration and Rehabilitation Work	The mangrove plantation work in the planting area described in the previous section is necessary.
Facilities Required for the Conservation and Management Activities	Direction signs along the highway and entrance to the access road(s), guide signs in the reserve, and information boards in the NR area can be seen in the area to explain the significance of the reserve and major flora and fauna. Footpath and boardwalk for observation of wild life as well as mangrove are also necessary.

3.2 Monitoring

3.2.1 Mangrove

Monitoring Method	Existing mangrove: Label trees for monitoring. Monitor mangrove by using the attached “ Attachment 1: Field Monitoring Sheet for Mangrove ”. Mangrove planted: First 4 years: tree height, canopy X:Y After 4 years: follow monitoring sheet
Frequency	Existing mangrove: Every 2 years

	Mangrove planted: First 4 year: annual monitoring After 4 year: every 2 year
Monitoring Target	Existing mangrove: 1) Kb-OT2: Coordinate Easting 182547 /Northing 1880283 2) Kb-OT3: Coordinate Easting 182580 /Northing 1880358 3) Kb -OT4: Coordinate Easting 182716 /Northing 1880457 Mangrove planted: Select 20 trees at random and monitor them.
Baseline Data	Baseline data and monitoring trees are listed in “ Attachment 2: List of the Observed Points in Khawr Kabir ”.

3.2.2 Soil and Water

Monitoring Method	Monitoring soil and water in and around mangrove vegetation by using attached table “ Attachment 3: Field Monitoring Sheet for Soil and Water (Khawr Kabir) ”
Frequency	Soil: (Mangrove planted area) Every 2 year (Existing mangrove area) Every 2 Year Water; Before (Apr) and after (Nov) monsoon season (Every year) (Outflow water at low tide should be measured.)
Monitoring Target	Attachment 3
Baseline Data	See attached table “ Attachment 4: Soil Profile in Khawr Kabir ” and “ Attachment 5: Surface Water Quality in Khawr Kabir ”

3.2.3 Fauna and Flora

Monitoring Method	Monitor fauna and flora by using the attached “ Attachment 6: Field Monitoring Sheet for Fauna and Flora and Pollution. ” For the observation of birds, an institute that is studying birds in Oman can be the best institute to take a part of the monitoring work by sub-contract base.
Frequency	At least twice a year
Monitoring Target	Attachment 6
Baseline Data	The result of field reconnaissance of flora and fauna is shown in “ Attachment 7: Result of Field Reconnaissance of Flora and Fauna in Khawr Kabir ”

3.2.4 Pollution (garbage and waste)

Monitoring Method	Monitor pollution by using the attached “ Attachment 6: Field Monitoring Sheet for Fauna and Flora and Pollution. ” Water Quality and Soil Sample Tests should be carried out by MRMEWR.
Frequency	At least twice a year
Monitoring Target	Attachment 6
Baseline Data	See “ Attachment 7: Result of Field Reconnaissance of Flora and Fauna in Khawr Kabir ”

3.2.5 Change on Legal Setup and Development Plans

Frequency	At least once a year
Monitoring Target	Any changes on legal situation of the site should be recorded. Land Ownership, Land Use Designation, Development Plans in the Site and Surrounding Area

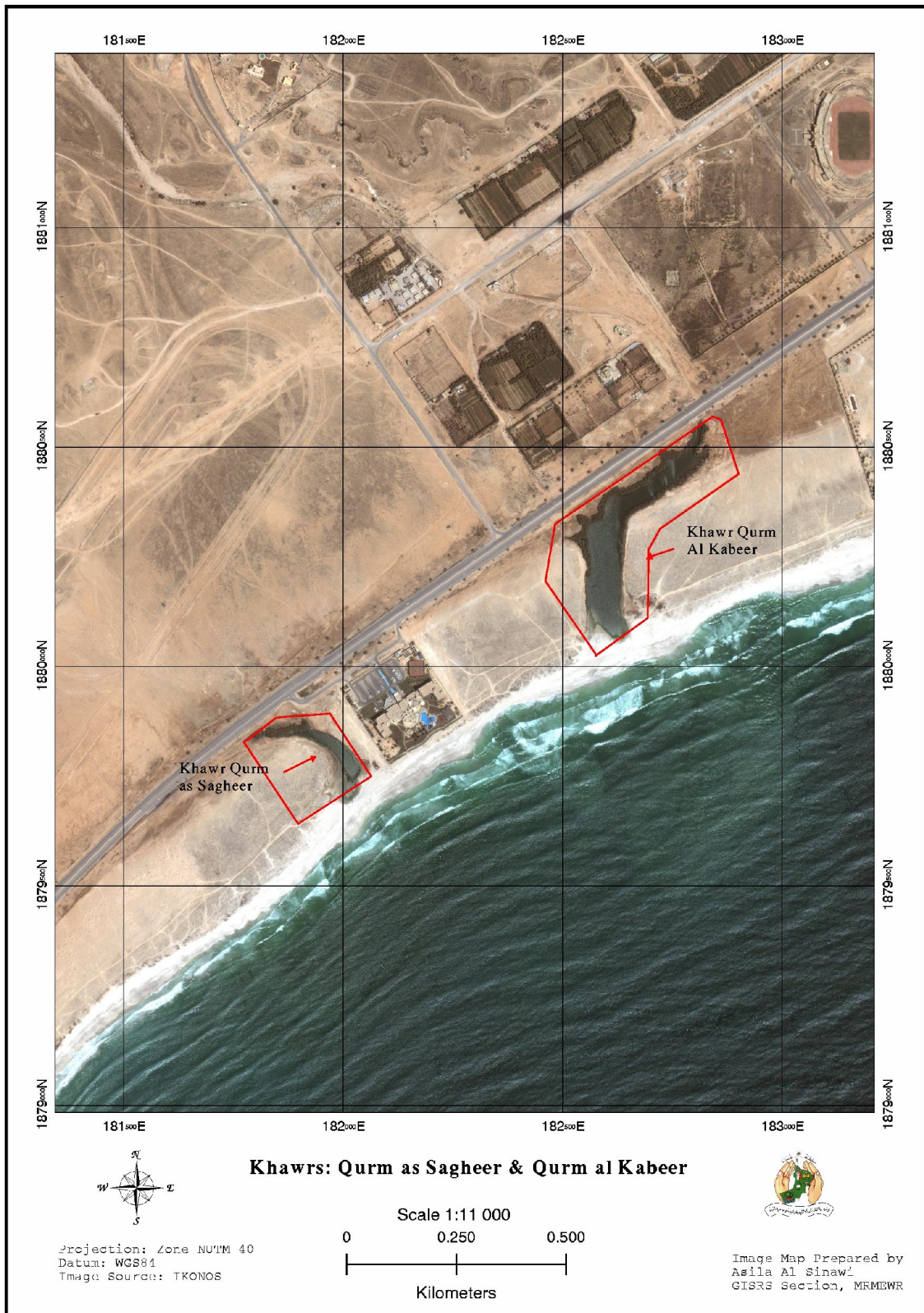


Figure 1 Key Map



Figure 2 Location Map

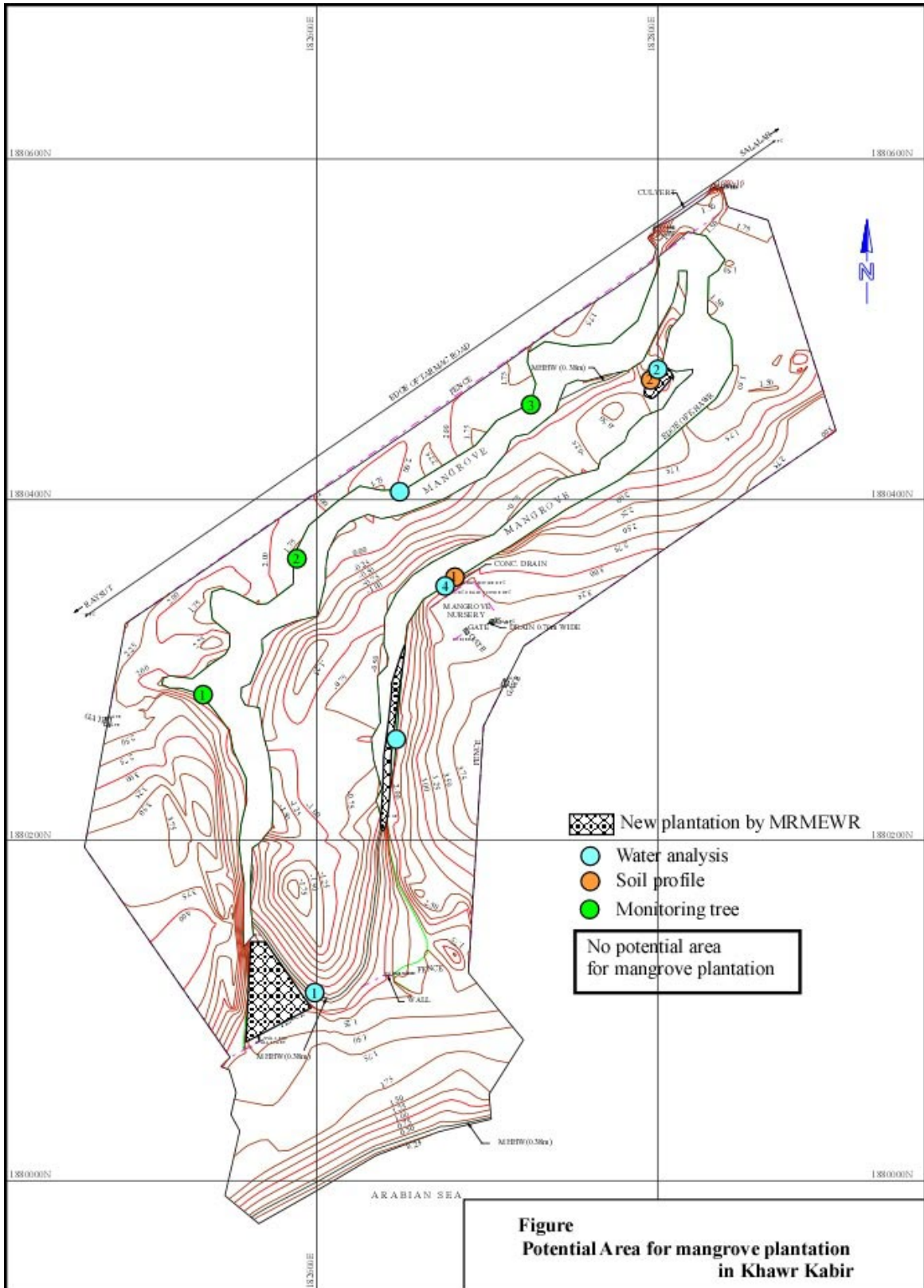


Figure 3 Planting Map

“Attachment 1: Field Monitoring Sheet for Mangrove”

Mangrove Observation Records																									
<p>1) Identification No. _____</p> <p>2) Location by GPS (WGS 84, UTM) Easting: _____ Northing: _____</p> <p>3) Photograph No. _____</p> <p>4) Observation of tree size and shape a) Tree Height (cm) _____ b) Trunk diameter near bottom (cm) _____ c) Live branches at the position about 1.3m off the centre of tree bottom (painted) Branch/ limb diameter measured in cm</p> <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="text-align: center; width: 25%;">1</td> <td style="border: 1px solid black; width: 100px; height: 20px;"></td> <td style="text-align: center; width: 25%;">2</td> <td style="border: 1px solid black; width: 100px; height: 20px;"></td> <td style="text-align: center; width: 25%;">3</td> <td style="border: 1px solid black; width: 100px; height: 20px;"></td> <td style="text-align: center; width: 25%;">4</td> <td style="border: 1px solid black; width: 100px; height: 20px;"></td> </tr> <tr> <td style="text-align: center;">5</td> <td style="border: 1px solid black; width: 100px; height: 20px;"></td> <td style="text-align: center;">6</td> <td style="border: 1px solid black; width: 100px; height: 20px;"></td> <td style="text-align: center;">7</td> <td style="border: 1px solid black; width: 100px; height: 20px;"></td> <td style="text-align: center;">8</td> <td style="border: 1px solid black; width: 100px; height: 20px;"></td> </tr> <tr> <td style="text-align: center;">9</td> <td style="border: 1px solid black; width: 100px; height: 20px;"></td> <td style="text-align: center;">10</td> <td style="border: 1px solid black; width: 100px; height: 20px;"></td> <td></td> <td></td> <td></td> <td></td> </tr> </table> <p>5) Observation of tree history, health and environment a) History Tree shape: _____ Sign of cut in the past: _____</p> <p> b) Health Nodes with leaves: _____ Inter-node length: _____ Leaf length: _____ Leaf colour: _____ Looks / die back: _____</p> <p> c) Environment Soil depth / texture: _____ Surface water Salinity: _____ Ground level: _____ Position: _____</p>	1		2		3		4		5		6		7		8		9		10						<div style="border: 1px solid black; padding: 5px; min-height: 150px;"> <p>Memo: (specific information or data significant for the tree will be written here)</p> </div>
1		2		3		4																			
5		6		7		8																			
9		10																							
<div style="border: 1px solid black; padding: 5px; min-height: 80px;"> <p>Note:</p> </div>																									

“Attachment 2: List of the Observed Points in Khawr Kabir”

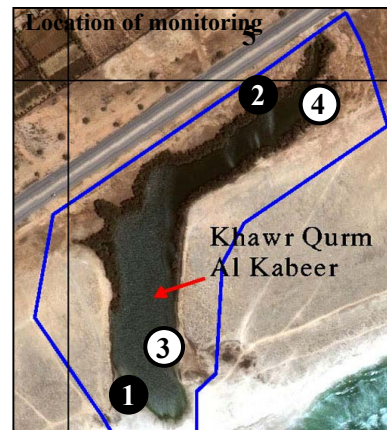
Khawr	Tree Number	Monitoring Trees	Date of Observation	Coordinate (UTM)		Photo Number	Height (cm)	Trunk near bottom	Diameter (cm)										Remarks
				Easting	Northing				Live branches at the position about 1.3m off the centre of tree bottom (DBH: Diameter Breast Height)										
									1	2	3	4	5	6	7	8	9	10	
Kabir	Kb-OT1	1	22 Dec '02	182547	1880283	kabirtree1a & 1b	994		23	22	23	10	19	7.2	13				
Kabir	Kb-OT2	2	22 Dec '02	182580	1880358	kabirtree2a & 2b	1084		30	31	12	9.4	7.5	6.5					5 more dead branches
Kabir	Kb-OT3	3	22 Dec '02	182716	1880457	kabirtree3a & 3b	854		20	35	27	21							2 more dead branches

“Attachment 3: Field Monitoring Sheet for Soil & Water (Khawr Kabir)”

Location	
Date / time:	____ / ____ .200____ : ____
Recorder	

General Condition in plantation area:

(garbage, rubbish, leaf, alga, crab, shell, etc)



● Soil ○ Water

(1) Soil Condition

		Transplanted Mangrove① at west shore	Existing Mangrove ② dense forest at upper khawr
Coordinate	Easting	182570	182750
	Northing	1880010	1880480
Surface condition			
Soil Texture	0-10cm		
	30-40cm		
	50-60cm		
Soil Colour	0-10cm		
	30-40cm		
	50-60cm		
Root development			
Depth of surface humus			
Free water	GWL* (cm)		
	pH		
	Salinity (%)		

Soil colour by Munsell notation, GPS*:by UTM of WGS84 GWL: Ground water level

(2) Surface Water Quality

(Observation time: _____ : _____)

		Khawr mouth ③	Upper khawr ④	Sea Water ⑤
Coordinate	Easting	182630	181830	-
	Northing	1880200	1880480	-
Surface waste				
pH				
Salinity (%)				
Temperature (C)				
DO (mg/l)				
Turbidity / Colour				

“Attachment 4: Soil Profile in Khawr Kabir”

Profile No.	Location	Coordinate (UTM)		Ground Water		Texture			Soil Colour		Hardness		
		Easting	Northing	Depth (cm)	pH	Salinity (%)	Surface (0-30cm)	Sub-surface (30-60cm)	Deep layer (>90cm)	Surface (0-30cm)	Sub-surface (30-60cm)	Surface	Sub-surface
Ka-1	Front of nursery under vegetation	182689	1880357	Core sample, under surface water			Sandy - sand	Sand - loam	Sand	Greyish olive	Grey	Soft	-
Ka-2	Upstream of khawr under vegetation	182825	1880503	Core sample			Silty loam - clay loam	Silt	- organic m.	Dull yellowish brown - greyish olive	-	Hard	-

Data of hardness in parenthesis by hand observation

“Attachment 5: Surface Water Quality in Khawr Kabir”

No.	Location	Coordinate (UTM)		Colour/ Visibility	pH	Salinity (%)	Temperature (C)	DO (mg/l)	COD (mg/l)	NO3 (mgNO3/l)
		Easting	Northing							
1	Mouth of khawr	182634	1880154	±	7.9	2.6	21.6	7.20	5-10	-
2	Inmost upstream of khawr	182804	1880488	+	7.5	2.9	21.4	2.80	5-10	-
3	Mouth of khawr	182598	1880101	+	7.9	2.0	30.7	3.10	-	-
4	Front of nursery	182710	1880368	±	7.9	2.0	31.7	2.30	-	-
5	Inmost upstream of khawr	182821	1880505	±	7.9	2.0	32.6	1.50	5-10	1<

Observation Date: 12-14 January 2003 for sample No.1-2, 31 May 2003 for sample No.3-5

“Attachment 6: Field Monitoring Sheet for Flora and Fauna and Pollution”

Location Khawr Kabir	Date
Time	Tide
Recorder	

Bird counts:	species:	number:
Winter Birds expected: moorhen, reef heron, waders (redshank, wood sandpiper, common sandpiper).		
Summer birds expected: night heron, little green heron		

Pollution:	
Evidence of:	solid waste (garbage), liquid waste, oil.
Water quality:	clear/muddy/green/salinity
Fishing:	nets

Domestic/feral animals:

Vegetation:
Mangroves
Plants in the water
plants at the edges of the khawr
sandy banks

Invertebrates:

Other comments:

“Attachment 7: Result of Field Reconnaissance of Fauna and Flora and Pollution in Khawr Kabir”

Field Monitoring Sheet for Fauna and Flora and Pollution Sample (1)

Location	Khawr Kabir	Date	06/01/2003
Time	12.00	Tide	non-tidal
Recorder	N.V. Clarke		

Bird counts: species: 6 number: 9
 Birds recorded were 1 moorhen, 1 little egret, 1 great white heron, waders (4 redshank, 1 wood sandpiper, 1 common sandpiper).

Pollution:

Evidence of:	solid waste (garbage), liquid waste, oil.	none
Water quality:	clear/muddy/green/salinity	clear
Fishing: nets		none

Domestic/feral animals: recently fenced

Vegetation:

Plants in the water included a filamentous alga. The main plant zone along the edges of the khawr was the grass, *Sporobolus virginicus*, which was joined by the reed, *Phragmites australis*, along the drainage channels at the landward side of the mangroves. Some patches of reed near the road gate showed signs of previous heavy grazing with numerous side branches bearing small spiky leaves. The vegetation of the drier sandy banks comprised the coastal plant association (*Suaeda*, *Cyperus conglomeratus*, *Urochondra setulosa*, *Aeluropus lagopoides*, *Sporobolus spicatus*, *Cressa cretica*, *Heliotropium firtakense*, *Senra incana*).

Invertebrates:

Several large active holes of the land crab (*Cardisoma carnifex*) were found on the landward edge of the mangroves. Burrowing shrimp holes (*Callichirus* sp) were common (up to 400/m²) in open sandy areas covered by shallow water. A few holes of ghost crabs (Ocypode) were present. Sieved samples of sand near the mouth of the khawr behind the sandbar contained elements of marine (small mussels cf *Musculista senhousia*), estuarine (burrowing amphipods cf *Corophium* and small horn shells, *Potamides conicus*) and freshwater (chironomid larvae, *Hydrobia* snails) fauna. Mosquito larvae (*Anopheles coustani*) occurred in isolated pools. Small fish were abundant.

Other comments:

The mangroves of Khawr Kabir are in the process of being fenced to allow the trees to recover from overgrazing by camels. In May 2002, a large cyclone produced floods around Salalah and Khawr Kabir received floodwater, which broke through the sandbar. This lowered the water level and allowed seawater to enter at high tide. The sandbar is now rebuilt and the salinity of the water is about 2.4% (previously it was about the same as seawater 3.4-3.7%). The sand banks along the channel nearer the sea had collapsed in places, killing some smaller mangroves. This also has the effect of widening the channel and small mangroves that had germinated along the previous waterline were now surrounded by water. Compared with studies in 1993, the khawr had a greater freshwater component but diversity was high.

Field Monitoring Sheet for Fauna and Flora and Pollution Sample (2)

Location	Khawr Kabir	Date	15/07/03
Time	12.00	Tide	non-tidal
Recorder	N.V. Clarke		

Bird counts: species: 1 number: 10
 Birds recorded were 10 night herons (roosting in mangroves)

Pollution:

Evidence of:	solid waste (garbage), liquid waste, oil.	none
Water quality:	clear/muddy/green/salinity	clear
Fishing: nets		none

Domestic/feral animals: recently fenced

Vegetation:

This is the site for a mangrove nursery and seedlings have been planted out on the seaward side of the khawr channel where the bank has been shaped to provide a shallow shelf.

The main terrestrial plant zone along the edges of the khawr was the grass, *Sporobolus virginicus*, which was joined by the reed, *Phragmites australis*, along the drainage channels at the landward side of the mangroves.

The vegetation of the drier sandy banks comprised the normal coastal plant association, (*Suaeda vermiculata*, *Cyperus conglomeratus*, *Urochondra setulosa*, *Aeluropus lagopoides*, *Sporobolus spicatus*, *Cressa cretica*, *Heliotropium fartakense*, *Senra incana*).

Animals:

A few burrowing shrimp holes (*Callichirus* sp) were seen.
 Small fish were abundant.

Other comments:

The mangroves of Khawr Kabir are recovering rapidly from overgrazing by camels since being fenced. Many young seedlings are appearing naturally among the larger trees.

The mangroves form an important roosting area for night herons.

“Attachment 8: Site Photos”

General Condition



View of midstream of water channel



North shore near mouth of khawr

Mangrove Vegetation



Transplanted seedlings near beach side



Standing dead trees at upstream of water channel

Soil Condition



Front of nursery under vegetation (Profile No. Ka-1)



Upstream of khawr under vegetation (Profile No. Ka-2)

Attachment 9: Soil Profiles in Khawr Kabir

(Profile No.Ka-1)

Location		(K. Kabir) front of nursery under vegetation	
Coordinate (UTM)	Easting: 182689	Northing: 1880357	
Physiologic position	Lower terrace	Topography	Gentle slope
Soil Classification	Humaqueptic (Mollic) Fluvaquents		
Parent material	Alluvial deposit	Depth of free water	Surface water
Vegetation/ mangrove	Avicennia marina vegetation Observation of core sample *1		
Description of soil profile *2)			
O	0-8cm	Olive black (5Y 3.5/2) loamy sand with single grain structure and non-sticky consistency; common greyish olive (5Y 4.5/2) mottle; gradual boundary	
A	8-23cm	Greyish olive (5Y 4/2) soft sand with single grain structure and non-sticky consistency; common grey (5Y 4.5/1) sand mottle; many small roots; gradual boundary	
C	23-32cm	Grey (5Y 5/1) sand with single grain structure and non-sticky consistency; common grey (5Y 4/1) mottle; common small roots; wavy boundary	
C	32-45cm	Olive black (5Y 3/2) silty loam with sticky consistency; common small and many very small roots	

*1: Descriptions of structure and boundary are estimated from limited observation of core sample.

*2: Texture was classified at field by visual and touching observation

(Profile No.Ka-2)

Location		(K. Kabir) end of khawr under vegetation	
Coordinate (UTM)	Easting: 182825	Northing: 1880503	
Physiologic position	Medium terrace	Topography	Gentle slope
Soil Classification	Humaqueptic (Mollic) Fluvaquents		
Parent material	Alluvial deposits	Depth of free water	22cm
Vegetation/ mangrove	Avicennia marina vegetation Observation of core sample *1		
Description of soil profile *2)			
A	0-19cm	Dull yellowish brown (10YR 4/3.5) silty loam with non-sticky consistency; many thin layers; many black and yellowish grey (7.5Y 2/1 and 2.5Y 4/1) mottles	
C	19-27cm	Greyish olive (5Y 5/2) sandy loam clay with slightly sticky consistency; many Grey and dull reddish brown (5Y 6/1 and 5YR 4/4) mottles with stones	
C	27-65cm	Silt, maybe apart of 2nd layer (difficult to take core sample)	
C	65-92cm	Brownish black (5YR 3/1 ~2/1) accumulation of organic matter	

*1: Descriptions of structure and boundary are estimated from limited observation of core sample.

*2: Texture was classified at field by visual and touching observation

Technical Specification for Khawr Saghir

1. SITE DESCRIPTION

1.1 Location

Governorate/ Region	Dhofar
Wilayat	Salalah
Distance from the Centre of Wylayat	This Khawr is located just west side of Hilton Salalah Hotel and is located approximately 10 km west of the city centre of Salalah.
Nearest Locality	Salalah
Fame of the Site/ Distinctive Features	None
Facilities in the Site	The mangroves of Qurm Saghir were first fenced in 1996 to allow the trees to recover from overgrazing by camels. Floods damaged the fence, which was later repaired by 2002.
Features of Surrounding Areas	The Hilton Hotel is considered as one of the best international hotels in Salalah.

1.2 Natural Conditions

Climate Zone	Dhofar Zone
General Terrain	Flat plain
Geological Features	No data
History of Geological Change	In May 2002, a large cyclone produced floods and Qurm Saghir received considerable floodwater. However, the sandbar did not open to the sea and floating woody debris clogged the water, lowering the salinity and depleting the oxygen. This has now been cleared by bulldozer with some reshaping of the lower end to accommodate the planting of seedlings.
Soil	Small-scale Khawr Saghir lies on the flat plain located west of Hilton Hotel in western part of Salalah. The khawr is cut off by short sandbar from sea. Mangroves cover the upper khawr. Some young vegetation occurred on both shores midstream of khawr but most of these plants were unhealthy (Jan 2003). Soil of this khawr is basically sand. Shallow (less than 10cm), silty and humic soil layers on sandy soils are found at the upper khawr where covered by vegetation. Shores are eroded and micro- topographically steep. Details are shown in attached table “ Attachment 4: Soil Profile in Khawr Saghir ” and “ Attachment 9: Soil Profile Samples in Khawr Saghir ”
Water	In January 2003, surface water in the khawr showed low pH, low DO and high COD. COD was very high (50to100mg/l). DO at mouth was less than 1mg/l and 1.75mg/l at upper khawr. There was a bad smell from the water. The surface of khawr was almost covered by floating substances including wood, leaves and rubbish, which were carried during flood in the spring season in 2002. Clean up operation to remove all floating materials was done on February 2003. The water quality has improved after clean up operation. DO changed from 0.9 to 5.9mg/l at khawr mouth and 1.75 to 3.4mg/l at khawr mouth but values of COD showed still high value (about 20mg/l) as shown in following table. Table Analysis of water quality in Khawr Saghir

	<table border="1"> <thead> <tr> <th rowspan="2"></th> <th colspan="2">At Upper khawr</th> <th colspan="2">At Khawr mouth</th> </tr> <tr> <th>Jan 2003</th> <th>Jun 2003</th> <th>Jan 03</th> <th>Jun 2003</th> </tr> </thead> <tbody> <tr> <td>Salinity (%)</td> <td>1.3</td> <td>0.9</td> <td>1.5</td> <td>1.3</td> </tr> <tr> <td>pH</td> <td>7.1</td> <td>7.9</td> <td>7.2</td> <td>8.1</td> </tr> <tr> <td>DO (mg/l)</td> <td>1.75</td> <td>3.40</td> <td>0.90</td> <td>5.90</td> </tr> <tr> <td>COD (mg/l)*</td> <td>50±</td> <td>10-20</td> <td>100±</td> <td>20±</td> </tr> </tbody> </table> <p>Details are shown in attached table “Attachment 5: Surface Water Quality in Khawr Saghir”</p>		At Upper khawr		At Khawr mouth		Jan 2003	Jun 2003	Jan 03	Jun 2003	Salinity (%)	1.3	0.9	1.5	1.3	pH	7.1	7.9	7.2	8.1	DO (mg/l)	1.75	3.40	0.90	5.90	COD (mg/l)*	50±	10-20	100±	20±
	At Upper khawr		At Khawr mouth																											
	Jan 2003	Jun 2003	Jan 03	Jun 2003																										
Salinity (%)	1.3	0.9	1.5	1.3																										
pH	7.1	7.9	7.2	8.1																										
DO (mg/l)	1.75	3.40	0.90	5.90																										
COD (mg/l)*	50±	10-20	100±	20±																										
Fauna	<p>A few large holes of the land crab (<i>Cardisoma carnifex</i>) were found on the landward edge of the mangroves. Burrowing shrimp holes (<i>Callichirus</i> sp) were not seen but a few holes of ghost crabs (Ocypode) were present. Numerous amphipods were found among the debris near the sandbar in January. Damsel and dragonflies represented a freshwater element. No fish were seen. Birds recorded were 1 moorhen, 1 common sandpiper, 3 sand plover and 1 grey wagtail.</p>																													
Flora	<p>Some of the young mangrove trees were killed by the sudden change in salinity and oxygen levels and suffered from collapse of the sandy banks. The larger mangroves however looked very healthy with lush new growth and many of the smaller mangroves had recovered by July. Generally the plants on the edges of the khawr have benefited from the floodwater and reduced grazing. Submerged aquatic plants were absent in January 2003 but after clearing of the flood debris, clumps of <i>Potamogeton pectinatus</i> had appeared by July 2003. The grass and reeds (<i>Sporobolus virginicus</i> and <i>Phragmites australis</i>) showed excellent growth particularly along the drainage channels at the landward side of the mangroves. The vegetation of the drier sandy banks comprised the normal plant association for this zone (<i>Suaeda vermiculata</i>, <i>Cyperus conglomeratus</i>, <i>Urochondra setulosa</i>, <i>Aeluropus lagopoides</i>, <i>Sporobolus spicatus</i>, <i>Cressa cretica</i>, <i>Heliotropium firtakense</i>).</p> <p>There is some scope for planting mangrove seedlings at this khawr filling the gaps between existing trees. Ideally seeds from the same khawr should be used.</p>																													
Impacts from the Surrounding Areas	The khawr is located next to Hilton Hotel.																													

1.3 Socio-economic Situation

Population of the Wilayat (2001)	162 thousand
Population of the Nearest Locality (1993)	162 thousand
Main Economic Activities	Residential area
Infrastructure	Just beside the national highway and close to Salalah city centre.
Main Usage	The site is designated as protected area and fenced to avoid graze by camels.
Community Interference with the Area	Road and utility lines are located closely.
Cultural Significance	None

1.4 Legal Setup and Development Plans

Land Ownership and Land Use Designation	The Khawr was designated as a Nature Reserve by Royal Decree Royal Decree 49/97 dated 28/6/97 with the Ministry of Regional Municipalities and Environment as the managing authority. The management plan aims to protect the mangrove trees while allowing controlled access for fodder collection. Sustainable fishing and the use of the area as a picnic site would also be allowed.
Development Plans in the Site and the Surrounding Area	Housing Development
Existing Conservation Proposal	Declared as nature reserve in 1997

2. PROGRAMME AND PROJECT

2.1 Prerequisite

Legal Setup for Land Use Control	Set a distinct boundary of NR and RDA (see 4.2 Required Action for Conservation and Management)
Facility Development Control	No permanent structure in NR, except hide for bird watching, sign and information boards, and board walking or pedestrian bridge. Footpath should be designated but not paved. No permanent commercial buildings such as restaurants hotels shops and mechanized amusement facilities in the park development area. Basic activities in this park are relaxation and picnicking. Partial lighting for safety only. Utilities lines (water and electricity should be minimum) and setback 150 m from the edge of Mangrove.

2.2 Description of Programmes

Facility Development Programme	N/A
Restoration and Afforestation Programme	N/A
Monitoring Programme	(1) Mangrove monitoring project (2) Soil and water monitoring project (3) Fauna and flora monitoring project (4) Pollution monitoring project (5) Monitoring project on legal setup and development plans
Public Awareness Programme	It will include an educational programme for school children and conservation campaign for residents of the Wilayat. Required materials and facilities are (6) Pamphlets and posters distributed to the residents, (7) Information boards describing significance of the natural environment.

2.3 Implementation Mechanism

Projects	Responsible Agencies	Implementing Body/ Agencies	Related Agencies
(1) Mangrove Monitoring Project	MRMEWR	Wilayat Salalah/ MRMEWR	
(2) Soil and Water Monitoring Project	MRMEWR	Wilayat Salalah/ MRMEWR	
(3) Fauna and Flora Monitoring Project	MRMEWR	MRMEWR/ Omani Institute for Birds	
(4) Pollution Monitoring Project	MRMEWR	Wilayat Salalah/ MRMEWR	
(5) Monitoring Project on Legal Setup and Development Plans	MRMEWR	Wilayat Salalah/ MRMEWR	
(6) Pamphlets and posters distributed to the residents	MRMEWR	MRMEWR	MOE
(7) Information boards	MRMEWR	MRMEWR	MOE

2.4 Implementation Schedule

Project No.	1 st	2 nd	3 rd	4 th	5 th	6th	7th	8th	9 th	10 th
(1)										
(2)										
(3)										
(4)										
(5)										
(6)										
(7)										

3. IMPLEMENTATION PLAN

3.1 Restoration and Afforestation

3.1.1 Existing Mangrove Area

Location and Area	Upper shore at Khawr Saghir covered by mangrove area is 1.7 ha approximately. (Figure 2 Location Map)
Conditions of Existing Mangrove	Small mangrove vegetation. Healthy and tall mangrove trees are lushly surviving on north bank at the upper khawr. Many long aerial roots are showing up from water. Tall trees reached more than 10m heights. Small and withered trees are scattering along narrow shore. Many seeds are producing after flowering season. New seedlings have planted by MRMEWR at the corner of western mouth (1500m ²) in March 2003. Growing of these seedlings is not glowing well. No more grazing by camels due to fencing.

3.1.2 Plantation Area

Tidal Condition	Normal: Mouth is closed
Wave and Wind	Calm in Winter, Drifted sand damages seaward fringe.
Flood	Every 5 to 10 years
Water Salinity and PH	Salinity; <u>1.3 ~ 1.5 %</u> , PH; <u>- 7.1 ~ 7.2</u> (“ Attachment 5: Surface Water Quality in Khawr Saghir ”)
Soil Conditions	Sandy soil with aerobic condition. Surveyed data is in the “ Attachment 4: Soil Profile in Khawr Saghir ” of this technical specification.
Potential Area	N/A

Table 3.1 Location and Areas of Potential Planting Area(s)

	Designated Area	Area (ha)
Area-1	No plantation	

3.1.3 Conservation Area

Area of Land Use	Nature Reserve (NR) Area
------------------	--------------------------

3.1.4 Required Action for Conservation and Management

Inspection	N/A
Cleaning	N/A
Replantation of Seedlings Growing Bad, Dead or Washed Away	N/A
Service for Associated Facilities	N/A
Patrol and Enforcement	Daily ordinary patrol by a police office of Wilayat is required, and the management body regularly inspects facilities conditions and littering and waste disposal to the ground and water in NR areas.
Restoration and Rehabilitation Work	The mangrove plantation work in the planting area described in the previous section is necessary. The culvert will be necessary to improve the water environment in the existing mangrove area (“ Figure 4: Proposed Culvert at Khawr Saghir ”).
Facilities Required for the Conservation and Management Activities	Direction signs along the highway and entrance to the access road(s), guide signs in the reserve, and information boards in the NR area can be seen in the area to explain the significance of the reserve and major flora and fauna. Footpath and boardwalk for observation of wild life as well as mangrove are also necessary.

3.2 Monitoring

3.2.1 Mangrove

Monitoring Method	Existing mangrove: Label trees for monitoring. Monitor mangrove by using the attached “ Attachment 1: Field Monitoring Sheet for Mangrove ”. Mangrove planted: First 4 years: tree height, canopy X:Y After 4 years: follow monitoring sheet
Frequency	Existing mangrove: Every 2 years Mangrove planted: First 4 year: annual monitoring After 4 year: every 2 year
Monitoring Target	Existing mangrove: 1) Sg-OT1: Coordinate Easting 181841 /Northing 1879841 2) Sg-OT3: Coordinate Easting 181908 /Northing 1879833 Mangrove planted: Select 20 trees at random and monitor them.
Baseline Data	Baseline data and monitoring trees are listed in “ Attachment 2: List of the Observed Points in Khawr Saghir ”.

3.2.2 Soil and Water

Monitoring Method	Monitoring soil and water in and around mangrove vegetation by using attached table “ Attachment 3: Field Monitoring Sheet for Soil and Water (Khawr Saghir) ”
Frequency	Soil: (Mangrove planted area) Every 2 year (Existing mangrove area) Every 2 Year Water; Before (Apr) and after (Nov) monsoon season (Every year) (Outflow water at low tide should be measured.)
Monitoring Target	Attachment 3
Baseline Data	See attached table “ Attachment 4: Soil Profile in Khawr Saghir ” and “ Attachment 5: Surface Water Quality in Khawr Saghir ”

3.2.3 Fauna and Flora

Monitoring Method	Monitor fauna and flora by using the attached “ Attachment 6: Field Monitoring Sheet for Fauna and Flora and Pollution ” For the observation of birds, an institute that is studying birds in Oman can be the best institute to take a part of the monitoring work by sub-contract base.
Frequency	At least twice a year
Monitoring Target	Attachment 6
Baseline Data	The result of field reconnaissance of flora and fauna is shown in “ Attachment 7: Result of Field Reconnaissance of Flora and Fauna and Pollution in Khawr Saghir ”

3.2.4 Pollution (garbage and waste)

Monitoring Method	Monitor pollution by using the attached “ Attachment 6: Field Monitoring Sheet for Fauna and Flora and Pollution. ” Water Quality and Soil Sample Tests should be carried out by MRMEWR.
Frequency	At least twice a year
Monitoring Target	Attachment 6
Baseline Data	See “ Attachment 7: Result of Field Reconnaissance of Flora and Fauna and Pollution in Khawr Saghir ”

3.2.5 Change on Legal Setup and Development Plans

Frequency	At least once a year
Monitoring Target	Any changes on legal situation of the site should be recorded. Land Ownership, Land Use Designation, Development Plans in the Site and Surrounding Area

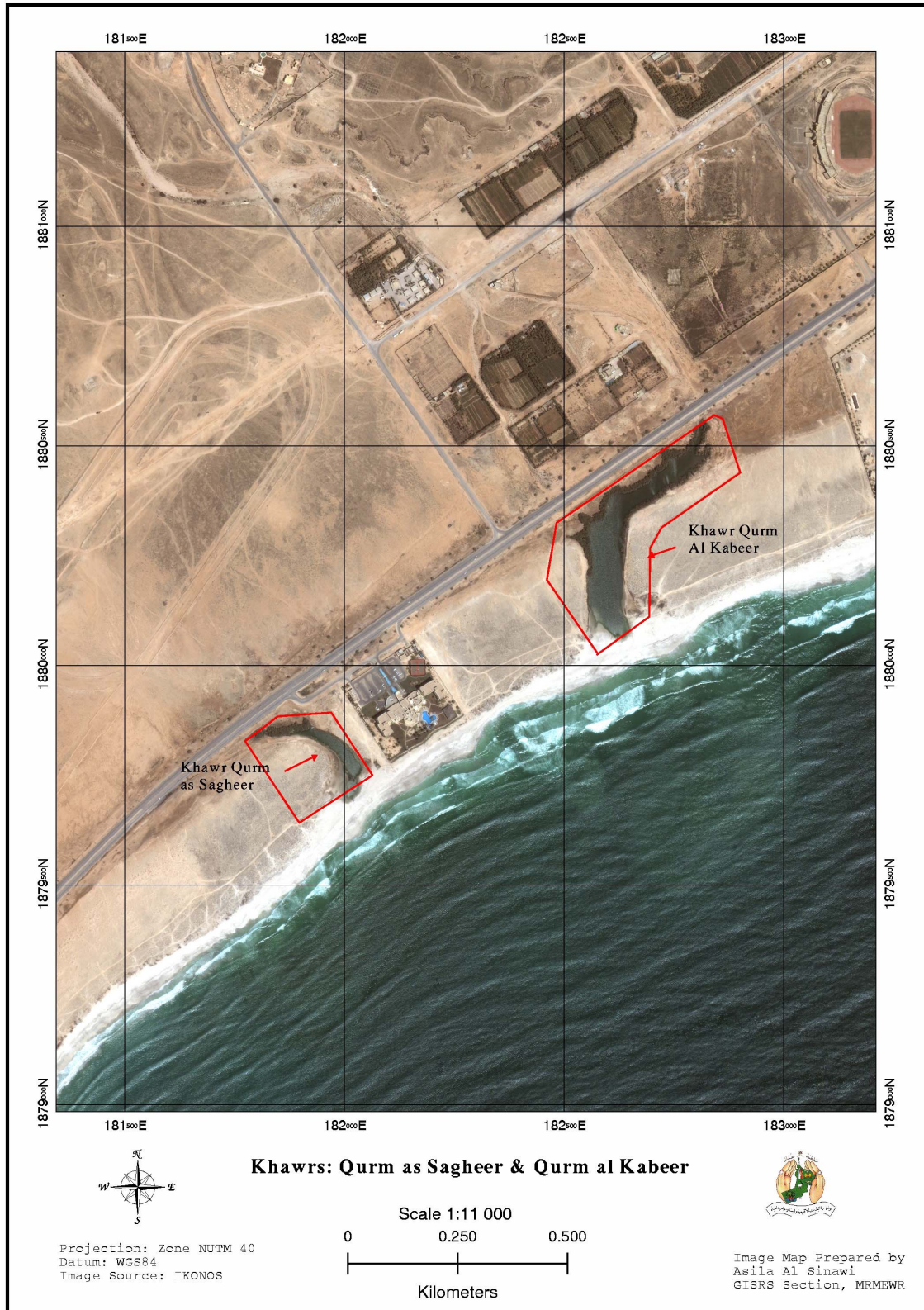


Figure 1 Key Map



Figure 2 Location Map

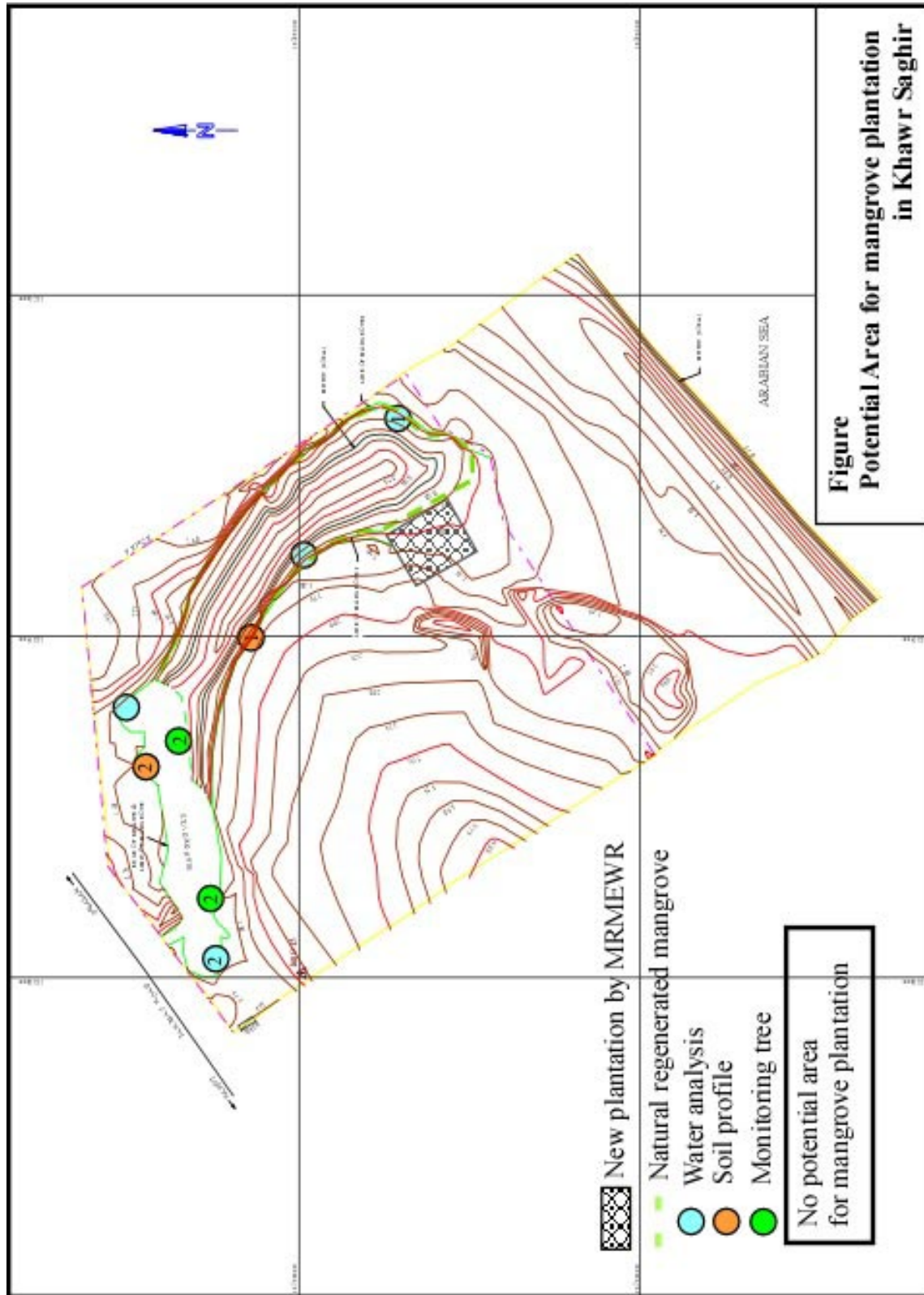


Figure 3 Planting Map

“Attachment 1: Field Monitoring Sheet for Mangrove”

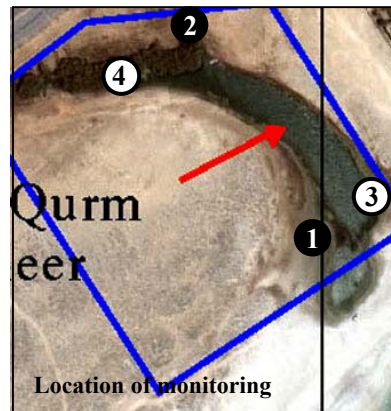
Mangrove Observation Records													
<p>1) Identification No. _____</p> <p>2) Location by GPS (WGS 84, UTM) Easting: _____ Northing: _____</p> <p>3) Photograph No. _____</p> <p>4) Observation of tree size and shape a) Tree Height (cm) _____ b) Trunk diameter near bottom (cm) _____ c) Live branches at the position about 1.3m off the centre of tree bottom (painted) Branch/ limb diameter measured in cm</p> <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 25%; text-align: center;">1</td> <td style="width: 25%; text-align: center;">2</td> <td style="width: 25%; text-align: center;">3</td> <td style="width: 25%; text-align: center;">4</td> </tr> <tr> <td style="text-align: center;">5</td> <td style="text-align: center;">6</td> <td style="text-align: center;">7</td> <td style="text-align: center;">8</td> </tr> <tr> <td style="text-align: center;">9</td> <td style="text-align: center;">10</td> <td></td> <td></td> </tr> </table>	1	2	3	4	5	6	7	8	9	10			<div style="border: 1px solid black; padding: 5px; min-height: 150px;"> <p>Memo: (specific information or data significant for the tree will be written here)</p> </div>
1	2	3	4										
5	6	7	8										
9	10												
<p>5) Observation of tree history, health and environment</p> <p>a) History Tree shape: _____ Sign of cut in the past: _____</p> <p>b) Health Nodes with leaves: _____ Inter-node length: _____ Leaf length: _____ Leaf colour: _____ Looks / die back: _____</p> <p>c) Environment Soil depth / texture: _____ Surface water Salinity: _____ Ground level: _____ Position: _____</p>													
<div style="border: 1px solid black; padding: 5px; min-height: 80px;"> <p>Note:</p> </div>													

“Attachment 2: List of the Observed Points in Khawr Sather”

Khawr	Tree Number	Monitoring Trees	Date of Observation	Coordinate (UTM)		Photo Number	Height (cm)	Trunk near bottom	Diameter (cm)										Remarks
				Easting	Northing				Live branches at the position about 1.3m off the centre of tree bottom (DBH: Diameter Breast Height)										
									1	2	3	4	5	6	7	8	9	10	
Saghir	Sg-OT1	1	22 Dec '02	181841	1879841	saghirtree1b	878		18	6.5	9.3	9.7	17	11	5.2				
Saghir	Sg-OT2		22 Dec '02	181829	1879860		902		50										
Saghir	Sg-OT3	2	22 Dec '02	181908	1879833	saghirtree2a & 2b	1023		12	28	17	7.3	12	14	12	14	36		

“Attachment 3: Field Monitoring Sheet for Soil & Water (Khawr Saghir)”

Location	
Date / time:	/ ,200 :
Recorder	



General Condition in plantation area:

(garbage, rubbish, leaf, alga, crab, shell, etc)

(1) Soil Condition

● Soil ○ Water

		Transplanted Mangrove ①	Existing Mangrove ②
Coordinate	Easting	182000	181900
	Northing	1879750	1879840
Surface condition			
Soil Texture	0-10cm		
	30-40cm		
	50-60cm		
Soil Colour	0-10cm		
	30-40cm		
	50-60cm		
Root development			
Depth of surface humus			
Free water	GWL* (cm)		
	pH		
	Salinity (%)		

Soil colour by Munsell notation, GPS*:by UTM of WGS84 GWL: Ground water level

(2) Surface Water Quality

(Observation time: :)

		Khawr mouth ③	Upper khawr ④
Coordinate	Easting	182040	181850
	Northing	1879750	1879840
Surface waste			
pH			
Salinity (%)			
Temperature (C)			
DO (mg/l)			
Turbidity / Colour			

“Attachment 4: Soil Profile in Khawr Saghir”

Profile No.	Location	Coordinate (UTM)		Ground Water			Texture			Soil Colour		Hardness	
		Easting	Northing	Depth (cm)	pH	Salinity (%)	Surface (0-30cm)	Sub-surface (30-60cm)	Deep layer (>90cm)	Surface (0-30cm)	Sub-surface (30-60cm)	Surface	Sub-surface
Sa-1	North share, up-stream under vegetation	181902	1879868	Core sample, under surface water			Clay loam - silt	Silty - Sand	Sand	Black - dark greyish yellow	Dark greyish yellow	Soft	Soft
Sa-2	South share, 1.5m from water channel	181957	1879819	No water			Sandy - sand	Sand	Sand	Yellowish brown	Greyish - dull yellow	Hard	-

Data of hardness in parenthesis by hand observation

“Attachment 5: Surface Water Quality in Khawr Saghir”

No.	Location	Coordinate (UTM)		Colour/ Visibility	pH	Salinity (%)	Temperature (C)	DO (mg/l)	COD (mg/l)	NO3 (mgNO3/l)
		Easting	Northing							
1	Mouth of khawr	182036	1879734	++	7.2	1.5	20.1	0.90	100±	-
2	Inmost upstream of khawr	181877	1879839	++	7.1	1.3	-	1.75	50±	-
3	Mouth of khawr	182036	1879731	±	8.1	1.3	31.2	5.90	20±	1>
4	Mid khawr north shore	181944	1879858	+	8.0	1.1	31.2	2.30	20±	2
5	Inmost upstream of khawr	181822	1879834	++	7.9	0.9	31.9	3.40	10-20	-

Observation Date: 12-14 January 2003 for sample No.1-2, 31 May 2003 for sample No.3-5

“Attachment 6: Field Monitoring Sheet for Flora and Fauna and Pollution”

Location	Qurm Saghir	Date
Time		Tide
Recorder		

Bird counts:	species:	number:
Winter birds expected: moorhen, waders, plovers, herons Summer birds expected: night heron		

Pollution:	
Evidence of:	solid waste (garbage), liquid waste, oil.
Water quality:	clear/muddy/green/salinity
Fishing:	nets

Domestic/feral animals:

Vegetation:
Submerged:
Water edge:
Sandy bank:

Animals:

Other comments:

“Attachment 7: Result of Field Reconnaissance of Fauna and Flora and Pollution in Khawr Saghir”

Field Monitoring Sheet for Fauna and Flora and Pollution Sample (1)

Location	Qurm Saghir	Date	06/01/2003
Time	08.00	Tide	non-tidal
Recorder	N.V. Clarke		

Bird counts: species: 3 number: 5
 Birds recorded were 1 moorhen, 1 common sandpiper, 3 sand plover and 1 grey wagtail.

Pollution:

Evidence of:	solid waste (garbage), liquid waste, oil.	Full of flood debris
Water quality:	clear/muddy/green/salinity	stagnant
Fishing: nets		none

Domestic/feral animals:

fenced

Vegetation:

Some of the young mangrove trees were killed by the sudden change in salinity and oxygen levels and suffered from collapse of the sandy banks. Submerged aquatic plants were also absent. The larger mangroves however looked very healthy with lush new growth. Generally the plants on the edges of the khawr have benefited from the floodwater and reduced grazing. The grass and reeds (*Sporobolus virginicus* and *Phragmites australis*) showed excellent growth particularly along the drainage channels at the landward side of the mangroves. The vegetation of the drier sandy banks comprised the normal plant association for this zone (*Suaeda*, *Cyperus conglomeratus*, *Urochondra setulosa*, *Aeluropus lagopoides*, *Sporobolus spicatus*, *Cressa cretica*, *Heliotropium fartakense*). A small shrubby mallow (*Senra incana*) was also present. A composite (*Eclipta alba*) was found on wet sand near the sandbar.

Animals:

A few large holes of the land crab (*Cardisoma carnifex*) were found on the landward edge of the mangroves. Burrowing shrimp holes (*Callichirus* sp) were not seen but a few holes of ghost crabs (Ocypode) were present. Numerous amphipods were found among the debris near the sandbar. Damsel and dragonflies represented a freshwater element. No fish were seen.

Other comments:

The mangroves of Qurm Saghir were fenced in 2002 to allow the trees to recover from overgrazing by camels. In May 2002, a large cyclone produced floods around Salalah and Qurm Saghir received considerable floodwater. However, the sandbar did not open to the sea and floating woody debris is clogging the water. Where the debris covers the surface oxygen levels are depleted. The flood also lowered the salinity of the water, which is now 0.9% at the drainage entrance and 1.5% nearer the mouth (previously it varied from about 2.0 –3.5 %). Compared with 1993, the khawr had less marine species (*Callichirus* not seen). It is also unlikely that the white shrimp (*Penaeus indicus*) previously recorded survived the flood conditions.

Field Monitoring Sheet for Fauna and Flora and Pollution Sample (2)

Location	Qurm Saghir	Date	15/07/03
Time	16.00	Tide	non-tidal
Recorder	N.V. Clarke		

Bird counts: species: 1 number: 1
 Birds recorded were 1 moorhen,

Pollution:

Evidence of:	solid waste (garbage), liquid waste, oil.	none
Water quality:	clear/muddy/green/salinity	clear
Fishing: nets		none

Domestic/feral animals: fenced

Vegetation:

Landscaping of the seaward end of the khawr has produced a shallow bay, which is now planted with mangrove seedlings.

Submerged vegetation has developed since the winter with large clumps of *Potamogeton pectinatus*.

Some of the young mangrove trees affected by previous floods are recovering. The larger mangroves looked healthy with lush new growth. Generally the plants on the edges of the khawr have benefited from the floodwater and reduced grazing.

Animals:

Other comments:

The khawr looked much healthier than the previous visit (06/01/2003). The water is now clear after the removal of debris from the flood in May 2002, and some of the young mangroves have new leaves.

“Attachment 8: Site Photos”

General Condition



East shore



West shore with natural regeneration

Mangrove Vegetation



Mangroves at upstream of water channel



Transplanted trees on reclamation area

Soil Condition



North shore, up-stream under vegetation (Profile No. Sa-1)



South shore, 1.5m away from water channel (Profile No. Sa-2)

Attachment 9: Soil Profiles in Khawr Saghir

(Profile No.Sa-1)

Location		(K. Saghir) north shore, up-stream under vegetation	
Coordinate (UTM)		Easting: 181902 Northing: 1879868	
Physiologic position		Lower terrace	Slope
Soil Classification		Humaqueptic (Mollic) Fluvaquents	
Parent material		Alluvial deposits	Depth of free water
Vegetation/ mangrove		Near Avicennia marina vegetation	
		Observation of core sample *1	
Description of soil profile *2)			
A	0-5cm	Black (2.5Y 2/1) clay loam with sticky consistency; many very small roots; gradual boundary	
C	5-23cm	Dark greyish yellow (2.5Y 4/2) silty clay loam with sticky consistency; few very small roots; gradual boundary	
C	23-31cm	Greyish yellow (2.5Y 6/2) silt with sticky consistency; gradual boundary	
C	31-41cm	Dark greyish yellow (2.5Y 5/2) silt with slightly sticky consistency; with gravels; clear boundary	
C	41-48cm	Brownish black (2.5Y 3/2) sand with massive structure and non-sticky consistency; with gravels; many dark reddish brown (5YR 3/2) mottles;	

*1: Descriptions of structure and boundary are estimated from limited observation of core sample.

*2: Texture was classified at field by visual and touching observation

(Profile No.Sa-2)

Location		(K. Sather) south shore, 1.5m away from water channel	
Coordinate (UTM)		Easting: 181957 Northing: 1879819	
Physiologic position		Upper terrace	Topography
Soil Classification		Typic Torrifluvents	
Parent material		Alluvial deposits	Depth of free water
Vegetation/ mangrove		No vegetation, 1m away from khawr shore	
Description of soil profile *2)			
A	0-6cm	Olive brown (2.5Y 4/3.5) compact loamy sand with plate structure and non-sticky consistency; common dull yellow (2.5Y 6/3) mottle; gradual smooth boundary	
C	6-19cm	Yellowish brown (2.5Y 5/4) compact sand with massive structure and non-sticky consistency; diffuse smooth boundary	
C	19-49cm	Greyish yellow (2.5Y 6/2) sand with single massive and non-sticky consistency; few yellowish brown (10YR 5/6) mottle; gradual wavy boundary	
C	49-55cm	Dull yellow (2.5Y 6/3) sand with massive structure and non-slightly sticky consistency, gravels under this layer	

*1: Descriptions of structure and boundary are estimated from limited observation of core sample.

*2: Texture was classified at field by visual and touching observation

Chapter 2: Technical Guideline for Afforestation

2. Technical Guideline for Afforestation

2.1 General

2.1.1 Objective of Guideline Preparation

This Guideline is prepared for mangrove plantation work to be carried out by those who intend to implement the mangrove plantation on site. Therefore, descriptions in the guideline should be as practical as possible. A guideline user who is interested in more scientific background should consult with MRMEWR personnel in charge.

Descriptions in this guideline are all for *Avicennia marina* that is the only native mangrove and commonly found in Oman.

2.1.2 Contents of Guideline

Mangrove afforestation consists of certain tasks for successful planting. Figure 2.1.1 shows the general tasks to be taken. The guideline shows the procedure of each task in the following sections.

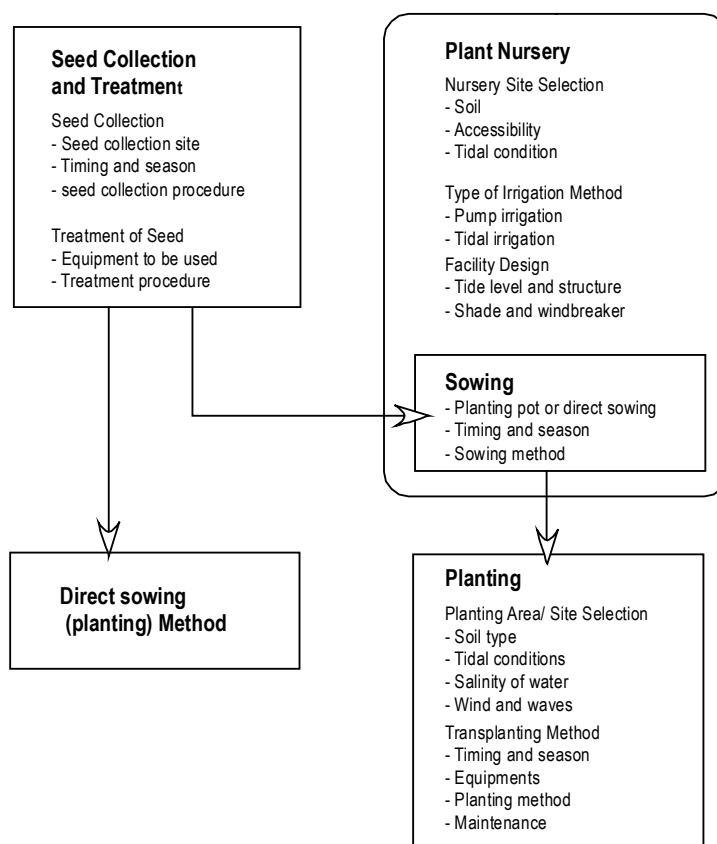


Figure 2.1.1 General Tasks for Mangrove Afforestation

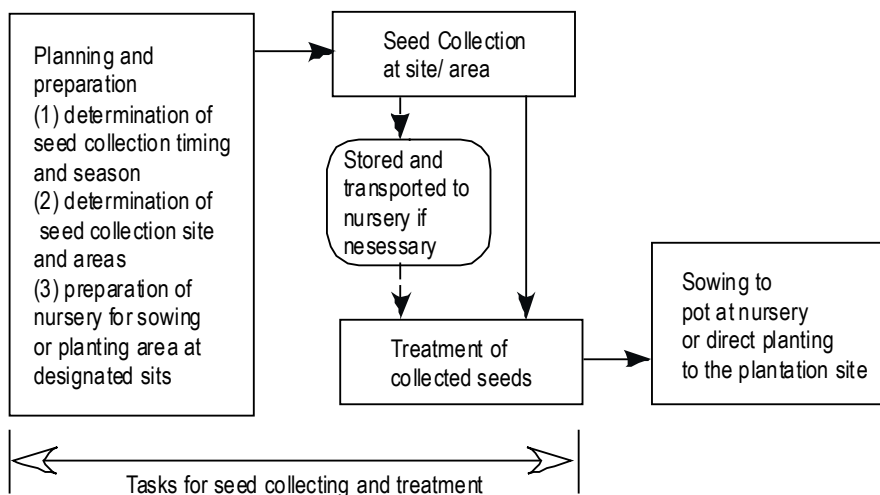
2.2 Guideline for Seed Collection

2.2.1 General Characteristics of Mangrove (*Avicennia marina*) Seed

Mangrove seeds cannot be stored for a long period because they are viviparous, in other words they are germinated already. Therefore, the seeds are quite delicate and deteriorate easily in hot and dry condition. Special care and attention is required for seed collection, storage and treatment.

Mangrove (*Avicennia marina*) seeds have pericarp for floatation in seawater, and seed coat (pericarp) also protects from dry conditions. When the seed matures, it drops in to the seawater, and seed coat is removed after 6 hours to 2days. These characteristics of mangrove seed should be taken in to consideration for treatment and storage.

The following shows the general flow of seed collection and treatment.



2.2.2 Seed Collection

a. Timing and Season

Seeds can be collected at certain periods in a year. It is early July and August in the northern region. There are two seasons of May ~ June and December ~ January in Dhofar region. Prior to the seed collection work, places for sowing such as nursery and planting area should be prepared because seeds cannot survive more than 2 to 3 weeks. Ideally, sowing should be implemented immediately right after seeds treatment. This is the best timing.

b. Seeds collection site

- A site should be easily accessible for the workers to carry out the task with necessary equipment.

- Basically, near the nursery site. In case of direct planting, the site should be located as close as possible.
- Workers for implementation should be available in the vicinity of the site.
- Seawater for treatment of the collected seeds should be abundant near the nursery or planting site where seed treatment is carried out.
- Healthy and matured mangrove forest should be selected for the seed collection site.

c. Procedure

- Size of seed to be collected should be large, preferably weighing more than 3 grams with pericarp, and the seeds should be mature.
- The collected seeds should be treated within 1~2 hours.
- In case the seeds are stored after collection, they should not be wet during the collection work.

2.2.3 Treatment of Seed

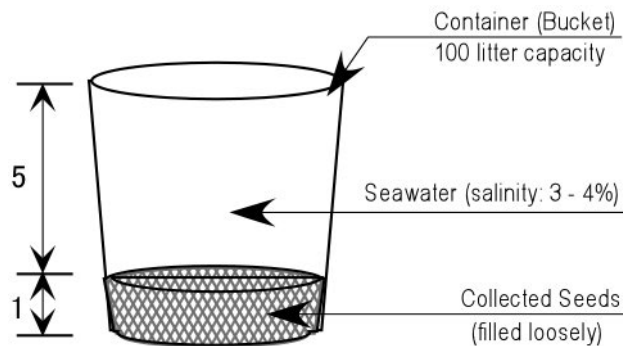
a. Equipment

- Large water containers (or buckets) with a capacity of 70~100 liters each. The number of containers will be determined by the number of workers and sowing schedule. If sowing is implemented immediately after treatment of the seeds, the required number of containers is 2 or 3.
- Meshed nets (the same number as the large buckets or containers).
- Small buckets or water pump to draw water (if the same number of small buckets as containers mentioned above can be prepared, small buckets are preferable to water pump.)

b. Procedure

The collected seeds need pretreatment before sowing.

- At first, the collected seeds should be soaked and washed for 6 hours or more by seawater. Put the collected seeds into the large container and fill with fresh clean seawater. The amount of seeds put in to the container should be less than one sixth (1/6) of volume of the container to avoid damage to the seeds by their weight.



- After a little while, the wastewater in the container (bucket) will change color to brown. Change the water every 2 hours or more frequently.
- When changing the soaking water, cover the container by mesh net, and empty the wastewater out of the container. This water will damage the seeds and the nursery. Therefore, the wastewater used for soaking and washing the seeds should not be dumped inside the nursery but outside.



- Seed coats (pericarp) of the seeds will be peeled off by themselves, otherwise, they should be removed manually. Removed seed coats will also damage the seeds, so after the seed coats are removed, the seeds should be put into another plastic container (bucket) filled with new seawater for washing for 6 hours or more and the removed seed coats should be taken out of the bucket.



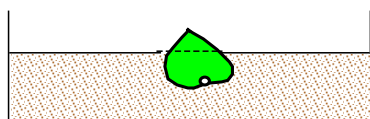
2.2.4 Storage of Seeds

Storage of seeds will be required when sowing cannot be implemented immediately after the seed coat is removed. For example, the nursery is located at remote area or needs long distance transportation. In some cases, sowing cannot catch up with progress of seed collection and treatment work.

- Store seeds with seed coat in a cool and dry shaded area. Temperature should be less than 26 degree, and seeds should not be wet. Water and temperature lead to germination. Seeds can be stored for 10 to 15 days.
- Keep cool and away from water is the key.

2.3 Sowing

After the pre-treatment, seeds can be sown. The following pictures show an example of sowing into a seedling pot (agricultural vinyl pot) to be used in the nursery.



Depth for sowing

2~3 seeds/pot



- Seedling pot to be used is the agricultural vinyl pot. The size is 10cm diameter and 25cm height with punched holes for water to drain.

- Normal beach sand at the site or near the nursery should be used. No silt or muddy soil should be used.
- 2 to 3 seeds per pot.
- One third (1/3) to half (1/2) of the seed should be out of sand.
- Seedling pots should be under shade for 2 to 3 weeks after sowing seeds.

2.4 Guideline for Plant Nursery Operation

There are two types of nurseries. One is a permanent type, which continuously supplies seedlings to various planting sites. A permanent type of plant nursery can cover time distance of two hours drive as a designated supply area. It is usually 100 to 150 km of distance to the planting sites from a nursery. The supply capacity of a nursery is also a factor to be planned in a nursery site. If one nursery cannot meet the demand of seedlings in the designated supply area, additional nurseries or a temporary nursery described below should be considered.

The other type of plant nursery is a temporary type. When a designated mangrove plantation site is in the remote area, and the supply of equipment, materials and access for maintenance staff is difficult, provision of a temporary nursery should be considered.

In this section the permanent type of a nursery is discussed first. The temporary type nursery will be discussed in the separate sub-section.

Figure 2.4.1 shows a general flow of plant nursery development and operation.

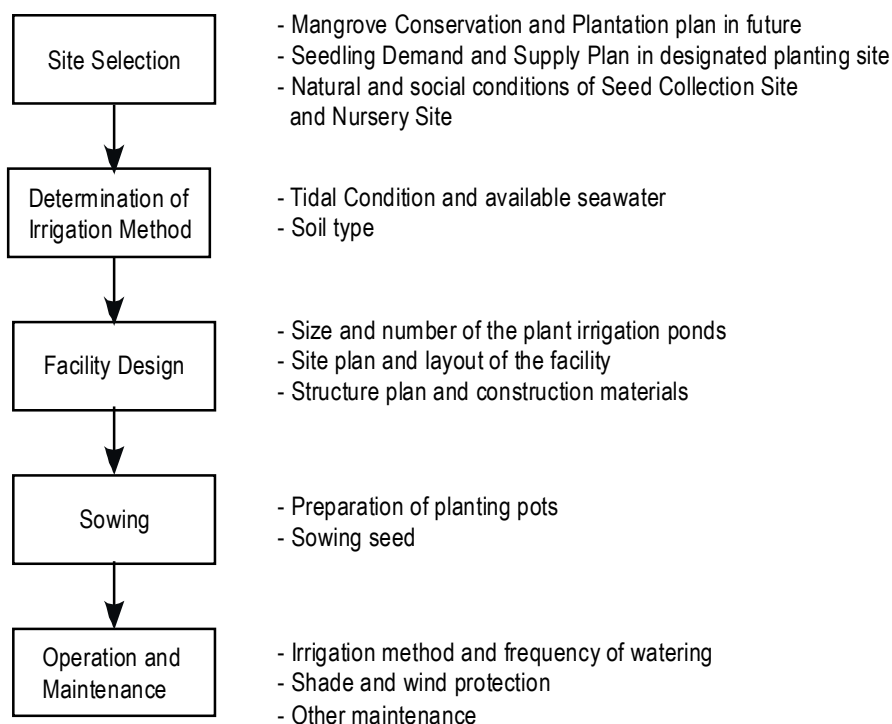


Figure 2.4.1 General Flows of Plant Nursery Development and Operation

2.4.1 Site Selection

Nursery sites should fulfil the following conditions.

- A strategic location should be selected to meet the future mangrove conservation and management plan (distance to the planting area, accessibility for operation and management).
- The scale of nursery should be determined by the future seedling demand.
- The site should be in the vicinity of a lagoon or of an arm of the sea (irrigation water supply condition).
- Soil at the site should be suitable for the plant pots, which will be used in a nursery.
- Accessibility for operation and maintenance should be convenient.
- The site should be free from floodwater.

2.4.2 Irrigation Method and Site Preparation

There are two types of irrigation method. One is a pump irrigation method, and another is a tidal irrigation method. The following table shows the selection criteria of an irrigation method.

At first, examine the tidal condition of the site, and then check the water infiltration of soil. It is impossible to apply a tidal irrigation method without distinct tidal effect.

Item	Condition	Pump Irrigation	Tidal Irrigation
(1) Tidal condition	Distinct tidal level changes every day and all year		Applicable
	Indistinct tidal level changes due to the sand bar accumulation at the mouth of lagoon	Applicable	
(2) Soil	High infiltration of water (coarse to medium sand)		Applicable
	Low infiltration of water (fine sand or silt)	Applicable	

The site should be graded flat with special care with its elevation in conjunction with a tide level as described in the next section. Necessary access roads and utilities will be prepared.

2.4.3 Facility Design

a. Tide and elevation of structure

Most essential element of design is a tide level. Elevation of plant pool floor, intake (tidal irrigation) and overflow drain channel (pump irrigation) shall be determined by the tide level. The following shows how to determine the intake level for a tidal irrigation nursery.

- From the tide table, choose the highest tide every day----- H
- Select the lowest among the H----- (Lowest H)
- Chose the lowest tide every day ----- L
- Select the highest among the L----- (Highest L)
- Set Intake Level = (Lowest H + Highest L) /2

For the pump irrigation, discharge of overflow irrigation water and drainage is necessary, therefore the elevation of the planting pool floor is usually set higher than the highest High Tide.

Select highest among H from the tide table (Highest H), and then set the outlet level at least 50 cm higher than Highest H.

The following figures show the concept of tidal irrigation and an example of a nursery by tidal irrigation.

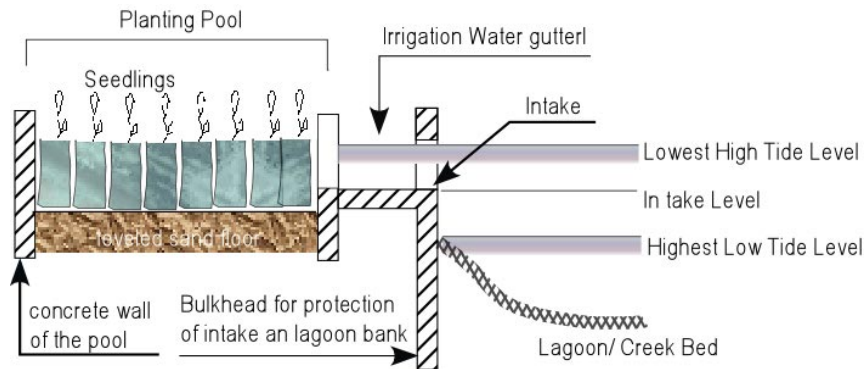
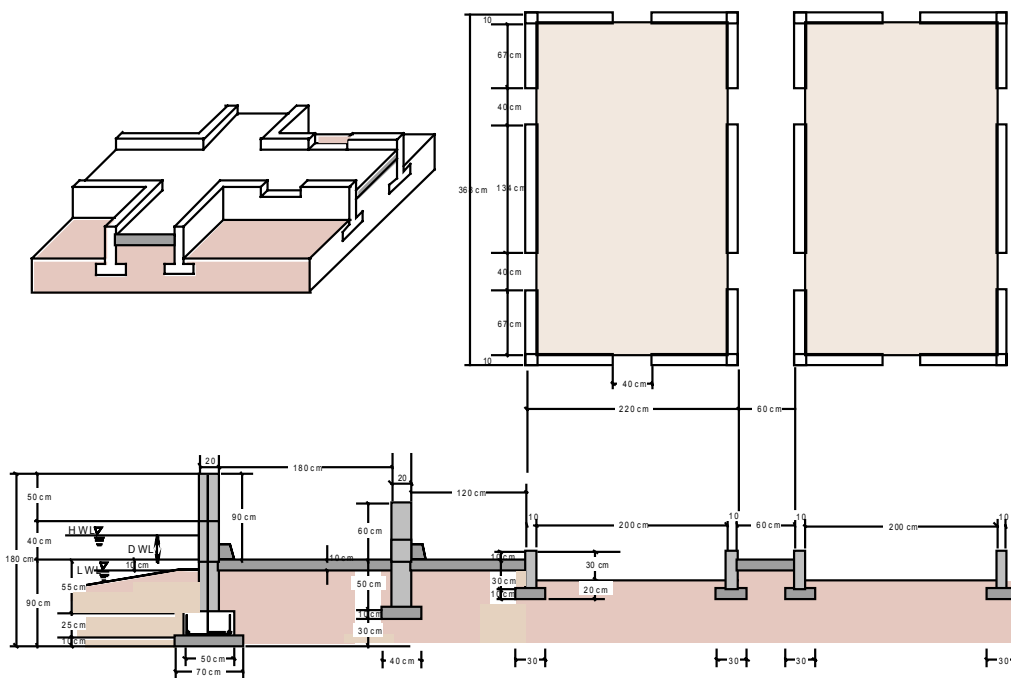


Figure 2.4.2 Concept of Tidal Irrigation



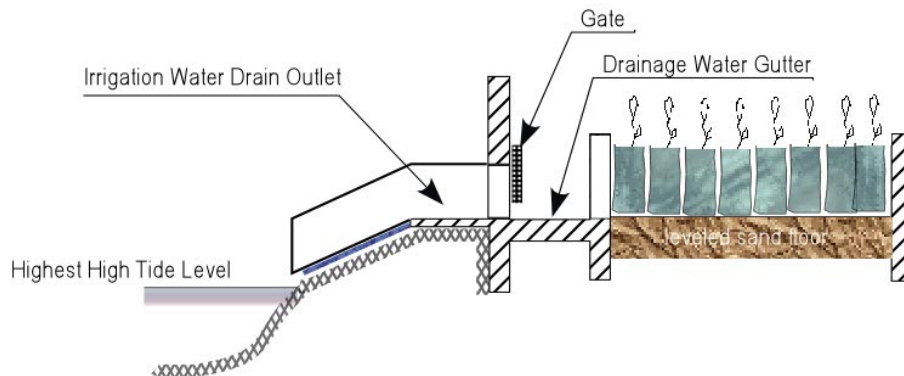
Source: Nursery development work in Oman, JICA Expert Tomoo Shoji, MRMEWR

Figure 2.4.3 An Example of Nursery by Tidal Irrigation (at Qurm and Sur)

Irrigation water in the planting pool is drained from the bottom of the pool during the low tide period. High infiltration of the site (bottom of pool) is required.

In case of the pump irrigation method, irrigation water from the planting pool is drained and discharged into the sea, lagoon or creek. Therefore, provision of the drainage

gutter and drain outlet is required, and they should be higher than the Highest High Tide level.



Source: Nursery development work in Oman, JICA Expert Tomoo Shoji, MRMEWR

Figure 2.4.4 Drain Outlet for the Pump Irrigation Nursery

b. Shade and windbreaker

Direct sunlight and hot dry wind damage sowed seeds and young seedlings. Provision of shade and windbreaker is required.

The following pictures show an example of shade and windbreaker covering the nursery.

Frame constructed by steel pipes.



2.4.4 Temporary Nursery Construction

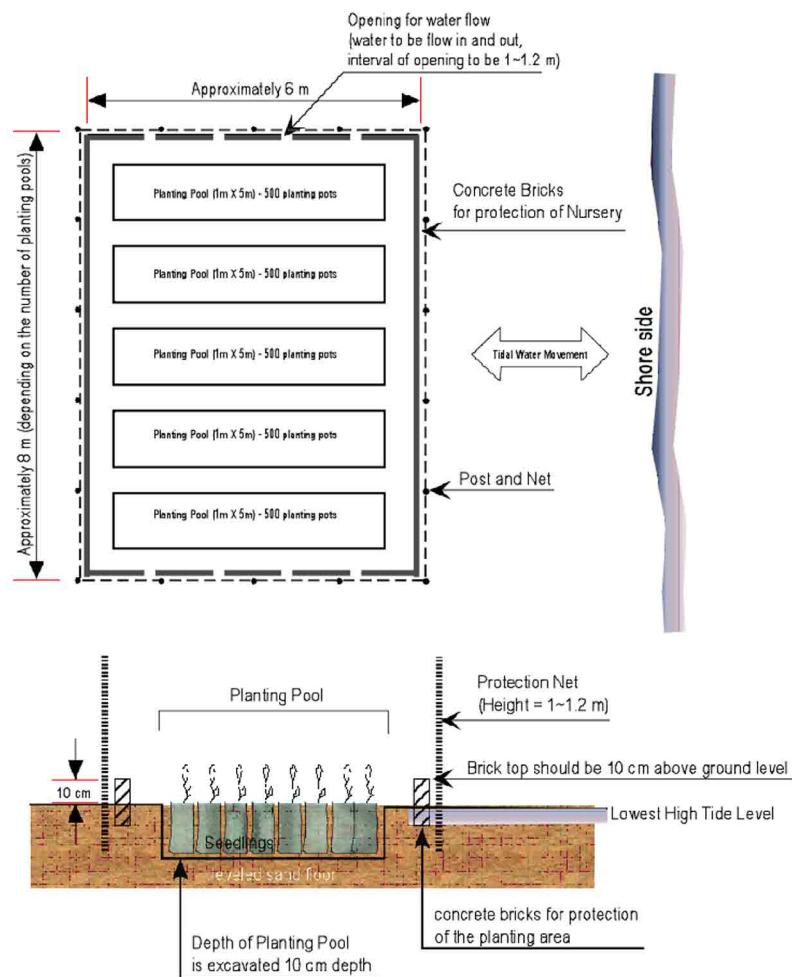
In case the designated planting area is far from the nursery, which supplies seedlings for planting, a temporary nursery construction can be considered. Criteria for site selection is the same as tidal irrigation type nursery described in previous section.

Facility design procedure and conditions to be fulfilled is also the same as the tidal irrigation type nursery. However the structure of the temporary nursery is much simpler than permanent type. The construction materials to be used are mainly available at site and minimal requirement of concrete structures.

Number of planting pool to be constructed should be determined by calculating the number of seedling to be required for the designated planting area and planting schedule. One planting pool can contain 500 pots.

Following figure shows the conceptual design of the temporary nursery layout and structure.

Schematic Design of Temporarily Nursery Construction



2.4.5 Operation and Maintenance (shading and irrigation)

Main activities after sowing seeds are irrigation management and shade control.

- Pots in the planting pool should be irrigated by seawater. Fill the pool once in a day and drain naturally.
- The pool should be covered by shade for 2 to 3 weeks after sowing.
- Open shade and give sun light to the seedling for better growth.



- Germination will be observed around 1 week ~ 10 days after the sowing as seen in this photograph.



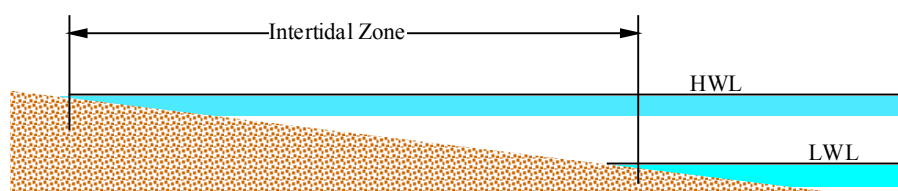
- This is a general view of the nursery almost 4 months after the sowing.

2.5 Guideline for Planting

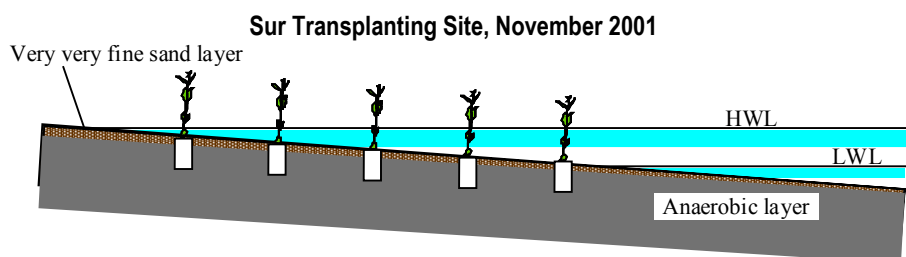
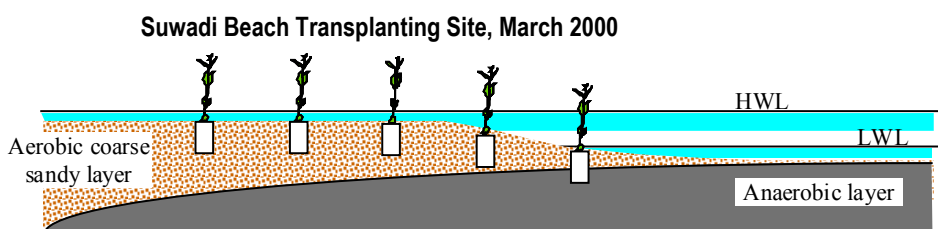
2.5.1 Planting Site/ Area

- Vast tidal flat adjacent to arms of the sea
- Inter tidal area of an elevation between LWL and HWL (MWL)
- With very slow current and no strong wave
- Well protected conditions, no domestic animals, etc.
- Soil with good drainage (sand)
- High hydraulic conductivity (Good drainage)
- Low content of very fine sand (Good aeration)Salinity less than 50 ppt (5%)

The following figure shows the inter tidal zone. At high tide, the ground will be covered with seawater, and at low tide, the ground will appear.



The following figures show examples of the designated planting area implemented in Oman.



2.5.2 Transplanting

a. Timing and season

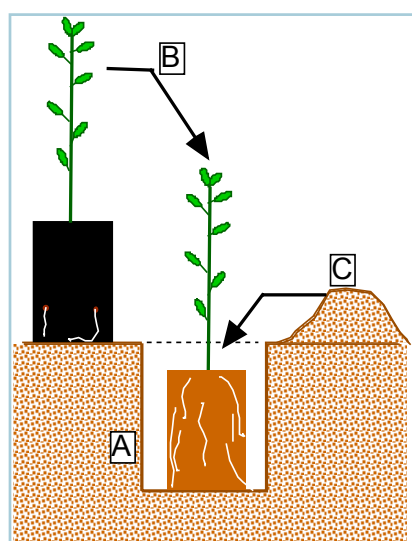
- Seedlings should be transplanted after 6 months of care at the nursery, in other words, 6 months after seed collection and sowing to planting pot at the nursery.
- Transplant timing is therefore in December ~ January in Northern Regions, and two times in November ~ December and June ~ July in Dhofar region.

b. Equipment

- Pickup truck(s) and wheel barrow(s) for transportation of seedling, pots and equipments.
- Trowels or shovels for digging and backfilling.
- 50 meters long measuring rope(s) with one-meter interval mark to indicate and lead the planting point indication for planting workers.
- Compass bearing to determine direction of the measuring rope.

c. Procedure

- Start transplanting work at the time of the lowest tide.
- Stretch a measuring rope at the designated planting area.
- Transplant seedlings at the mark on the rope, as shown in the figure below.



A: Dig a hole a little bit deeper than the pot

B: Remove the plastic pot and put the seedling with soil without damaging roots

C: Backfill the hole with soil and compact moderately

- Move one meter forward when a row of plantation along the rope finishes, and continue to transplant by moving the measuring rope.

- To protect plants from waves and being covered and bent down by the seaweeds and grasses, the frontline of plantation area is planted densely. Width shall be one (1) meter, and density shall be 9-10 seedlings per square meter. Fencing will be required if there is potential browsing by animals.

d. Maintenance

- Periodic inspection should be carried out.
- Removing seaweeds, sea grasses and rubbish will be necessary if they obviously damage the seedlings. The pictures below are examples of rubbish and seaweeds covering the seedlings.



- When some areas show bad growth or dead seedlings compared to other areas, investigate the area such as soil conditions, tidal conditions, living things, etc. And replant again if the considered area has a chance to grow mangrove.
- Check the fence and other facilities associated with the plantation area, and maintain them as required.

2.5.3 Direct Sowing

Direct sowing for mangrove plantation has been considered to be not appropriate in Oman. Because most of the mangrove areas and designated potential mangrove areas are close to the ocean with big waves, strong current and flashing water by storms. However there might be suitable locations for direct sowing of mangrove seeds at the areas difficult for transplanting.

Basic conditions required for the planting site is the same as the transplanting case. However, more strict conditions of calm water and distinct tidal movement are required.

a. Timing and season

- Depend upon the seed collection time. It should be June ~ July in northern Regions, May ~ June and December ~ January in Dhofar Region.

b. Procedure

- Conditions required for sowing areas are the same as transplanting areas with calm water conditions.
- Depth of sowing should be changed, according to the soil conditions. In sand areas seed should be placed 3 cm under surface and covered with sand. In muddy or silty areas half of the seed should be out of mud.
- Seeding interval should be 20 to 25 cm or seeding density of 16 to 25 seeds per square meter.
- Maintenance is preferably the same as transplanting areas, if possible.