A-1. Member List of the Study Team

Member List for Phase-1 Field Survey

Name	Position	Organization
Mr. Noriaki NISHIMIYA	Leader	Executive Advisor to the Director General, Economic Infrastructure Department, JICA
Mr. Shinichi MATSUURA	Procurement Management Planning	JICS[1)]
Mr. Ryuji OGATA	Planning Management	Water Resources Management Division 1, Global Environment Department, JICA
Mr. Hirofumi SANO	Chief Consultant/Water Supply Planning	NJS Consultants Co., Ltd
Mr. Tetsuo IZAWA	Facility Plan and Design (Plant) 1	
Mr. Yoshihiro AKIYAMA	Facility Plan and Design (Plant) 2	
Mr. Takeo YAMAGUCHI	Facility Plan and Design (Construction)	
Mr. Ronald J. PETERSON	Operation and Maintenance Plan/Financial Analysis	
Mr. Ravi PEREIRA	Environment and Social Considerations	
Mr. Yoshihiro KIRISHIMA	Construction Schedule/Cost Estimation/Tender Document	

1) JICS: JAPAN INTERNATIONAL COOPERATION SYSTEM

A-2. Study Schedule

No.	Date	Day	Action Plan	Member									
				Nishimiya	Matsuura	Ogata	Sano	Izawa	Akiyama	Yamaguchi	Peterson	Pereira	Kirishima
1	27-Sep-09	Sun	Transportation (Tokyo～Manila, Colombo～Cebu)	○	○	○	○	○	○	○	○	○	○
2	28-Sep-09	Mon	Meeting with JICA Philippines Office, NEDA, DOF and Japan Embassy	○	○	○	○	○	○	○	○	○	○
3	29-Sep-09	Tue	Transportation (Manila～Cebu), Courtesy visit to NEDA and MCWD	○	○	○	○	○	○	○	○	○	○
4	30-Sep-09	Wed	Site visit for Candidate site, Mactan Rock and Existing Facility	○	○	○	○	○	○	○	○	○	○
5	1-Oct-09	Thu	Meeting with MCWD and Cebu Regional Office	○	○	○	○	○	○	○	○	○	○
6	2-Oct-09	Fri	Meeting with MCWD	○	○	○	○	○	○	○	○	○	○
7	3-Oct-09	Sat	Materials and Documents Collection	○	○	○	○	○	○	○	○	○	○
8	4-Oct-09	Sun	JICA, JICS(Move to Manila), Day Off	○	○	○	○	○	○	○	○	○	○
9	5-Oct-09	Mon	JICA, JICS(Meeting with NEDA, JICA Phi., Embassy), Meeting with MCWD(Site Selection)	○	○	○	○	○	○	○	○	○	○
10	6-Oct-09	Tue	JICA, JICS (Arrive Japan), Candidate Site visit with MCWD	○	○	○	○	○	○	○	○	○	○
11	7-Oct-09	Wed	Comparison Study for the Site Selection				○	○	○	○	○	○	○
12	8-Oct-09	Thu	Comparison Study for the Site Selection				○	○	○	○	○	○	○
13	9-Oct-09	Fri	Meeting with MCWD(Candidate Site)				○	○	○	○	○	○	○
14	10-Oct-09	Sat	Study Team Meeting, Analysis and Study				○	○	○	○	○	○	○
15	11-Oct-09	Sun	Day Off				○	○	○	○	○	○	○
16	12-Oct-09	Mon	Documents Collection & Analysis, Study for Candidate Site				○	○	○	○	○	○	○
17	13-Oct-09	Tue	Documents Collection & Analysis, Study for Candidate Site				○	○	○	○	○	○	○
18	14-Oct-09	Wed	Site Visit and Discussion at Imperial Pales Hotel				○	○	○	○	○	○	○
19	15-Oct-09	Thu	Documents Collection & Analysis, Study for Candidate Site				○	○	○	○	○	○	○
20	16-Oct-09	Fri	Study on Contents of the Project, Transportation (Cebu～Tokyo)				○	○	○	○	○	○	○
21	17-Oct-09	Sat	Study Team Meeting				○	○	○		○	○	○
22	18-Oct-09	Sun	Day Off, Sea Coast Inspection in Mactan				○	○	○		○	○	○
23	19-Oct-09	Mon	Study on Contents of the Project				○	○	○		○	○	○
24	20-Oct-09	Tue	Study on Contents of the Project				○	○	○		○	○	○
25	21-Oct-09	Wed	Study on Contents of the Project				○	○	○		○	○	○
26	22-Oct-09	Thu	Study on Contents of the Project				○	○	○		○	○	○
27	23-Oct-09	Fri	Study on Contents of the Project				○	○	○		○	○	○
28	24-Oct-09	Sat	Study Team Meeting				○	○	○		○	○	○
29	25-Oct-09	Sun	Day Off				○	○	○		○	○	○
30	26-Oct-09	Mon	Transportation (Cebu～Tokyo, Cebu～Colombo), Candidate Site Inspection				○	○	○		○	○	○
31	27-Oct-09	Tue	Discussion on MCWD Boad Meeting Results				○						
32	28-Oct-09	Wed	Information Collection for the Candidate Site				○						
33	29-Oct-09	Thu	Transportation (Cebu～Manila), Meeting in JICA Phi. Office				○						
34	30-Oct-09	Fri	Transportation (Manila～Tokyo)				○						

A-3. Member List of the Counter Part

Organization	Name (nickname)	Status
MCWD Metro Cebu Water District	Mr. Armando Paredes (Mandy)	General Manager
	Mr. Lasaro P. Salvacion (Boboy)	Manager, Water Resources Department
	Mr. Michael M. Balazo (Mike)	Assistant General Manager, Technical Services
	Ms. Rowan E. Tenedo (Wawa)	Manager, Corporate Planning Department
	Mr. Edgar H. Donoso (Edgar)	Assistant General Manager, Finance
	Mr. Noel R. Dalena (Noel)	Assistant General Manager, Pipeline Maintenance
	Mr. Angelo H. Cabije (Gelo)	Manager, Service Connection & Installation Dep.
	Mr. Jose Eugenio B. Singson (Eugene)	Officer in Charge, Project Management Office
	Mr. Roel A. Panebio (Roel)	Division Manager, Environment Division, WRKC
DOF Department of Finance	Mr. Rommel Herrera	International Finance Group
NEDA Manila (National Economic & Development Authority)	Ms. Pia Reyes	Infrastructure Staff
	Mr. Reno Cantre	Infrastructure Staff
	Ms. Joyse Ann	Infrastructure Staff
NEDA Reagion7 (Cebu Office)	Ms. Mariene	Resional Director
	Mr. Rafael Tagalog	Division Chief
	Mr. Engr. Margarito Cabadsan	Senior Economic Specialist
Province of Cebu (Cebu State Government)	Mr.Adolfo V. Quiroga	Provincial Planning & Development Coordinator
JICA Philippines Office	Mr. Norio Matsuda	Chief Representative
	Mr. Masafumi Nagaishi	Senior Representative
	Mr. Naoto Kuwae	Representative, Poverty Reduction Section
	Mr. Makoto Iwase	Representative

A-4.　Minutes of Discussions（M/D）

Following Minutes of Discussions (M/D) was signed on 13th of October 2009 between JICA study team and Philippine Side (MCWD) under mutual agreement.

MINUTES OF DISCUSSIONS
ON
THE PREPARATORY SURVEY
ON
THE PROGRAMME GRANT AID
FOR
ENVIRONMENT AND CLIMATE CHANGE (WATER TECHNOLOGY)
IN
THE REPUBLIC OF THE PHILIPPINES

OCT 13 2009

In response to the request from the Government of the Republic of the Philippines (hereinafter referred to as "the Philippines"), the Government of Japan decided to conduct the Preparatory Survey on the Programme Grant Aid for Environment and Climate Change (Water Technology) (hereinafter referred to as "the Programme") and entrusted the implementation of the survey to Japan International Cooperation Agency (hereinafter referred to as "JICA").

JICA sent to the Philippines the Preparatory Survey Team (hereinafter referred to as "the Team"), headed by Mr. Noriaki Nishimiya, Executive Advisor to the Director General for Economic Infrastructure Department, JICA, scheduled to stay in the country from 27th September to 26th October, 2009.

The Team held a series of discussions with the officials concerned from the Government of the Philippines and conducted a field survey in the requested area.

In the course of discussions and field survey, both parties confirmed the main items described on the attached sheets. The Team will proceed with further works and prepare the Preparatory Survey Report.

Cebu, October, 2009

Mr. Noriaki Nishimiya Leader, the Preparatory Survey Team Japan International Cooperation Agency (JICA)	Mr. Armando H. Paredes General Manager, Metropolitan Cebu Water District

ATTACHMENT

1. Objectives of the Programme

The objective of the Programme is to improve the water supply for residents in the project area based on the perspective of climate change countermeasures.

2. Scheme of the Project

Both sides confirmed that the Programme would be implemented within Japan's Programme Grant Aid for Environment and Climate Change described in **Annex IV.**

3. Survey Area and Project Site

The area of the Survey is within Mactan Island, and the area of the Programme is shown in **Annex I**.

4. Coordination Agency and Implementing Agency

4-1) The Coordination Agency is the National Economic and Development Authority (hereinafter referred to as "NEDA").

4-2) The Implementing Agency is Metropolitan Cebu Water District (hereinafter referred to as "MCWD"). The Organization chart of MCWD is shown in **Annex II.**

5. Items requested by the Government of the Philippines

After discussions, the items described in **Annex III** were requested by the Philippine side. The both sides confirmed that the Philippine side in coordination with the Team would prepare the revised list of items with its number, specification, installation location and priority during the further studies by the consultants. JICA will examine the appropriateness of the request and will recommend to the Government of Japan for approval.

6. Scheme of Japan's Programme Grant Aid for Environment and Climate Change

6-1) The Philippine side understands the scheme of Japan's Programme Grant Aid for Environment and Climate Change explained by the Team as described in **Annex IV** and **Annex V**. The Team explained that the scheme of Japan's Grant Aid for Environment and Climate Change is under discussion and might be slightly modified.

6-2) The Philippine side may take necessary measures, as described in **Annex VI**, to expedite the smooth implementation of the Programme.

7. Administration of the Programme

7-1) Both sides confirmed the administration of the Programme as shown in **Annex VII.**

7-2) For promoting proper and smooth execution of the Programme, both sides confirmed that the Consultative Committee of the Programme (hereinafter referred to as "the Committee") would be established and the composition of the Committee would be discussed and determined during the second phase of Preparatory Survey in November and December 2009. Its functions and provisional composition are described in **Annex VIII**

8. Schedule of the Survey

8-1) The consultants will proceed to further studies in the Philippines until October 26, 2009.

8-2) Based on the result of the First Phase of Preparatory Survey, JICA will determine whether to dispatch the Second Phase of Preparatory Survey Team in November 2009 or not, which aims at collecting data and information required for outline design and preliminary cost estimation of the Programme, and at the same time, baseline data required for the measurement of the effect of the Programme.

8-3) JICA will prepare the draft Outline Design Report and dispatch a mission in order to explain its contents to the Philippine side around April, 2010.

8-4) In case that the contents of the report is accepted in principle by the Government of the Philippines, JICA will complete the final report and send it to the Government of the Philippines by June 2010.

9. Other Relevant Issues

9-1) Procurement Procedure

The Procurement Guidelines for the Program Grant Aid for Environment and Climate Change described in **Annex IV** will be applied for the procurement procedure of the Programme.

9-2) Land for the Facilities and equipments

The Team requested to the Philippine side to ensure the land for the facilities installed by the Programme by Explanation Mission of Draft Outline Report in mid-April, 2009 and the Philippine side will take every possible measure to meet the request from Japanese side. The site for the land shall be determined by mid-October, 2009 and informed to JICA.

9-3) Relevant Permissions for the Programme

The Philippine side will expedite necessary procedure before the Explanation Mission of Draft Outline Design Report, if the official approval or permission is required for the component of the Programme.

9-4) Soft Assistance (Soft Component Programme and Technical Assistance)

The Team explained to the Philippine side that the Japan's Programme Grant Aid for Environment and Climate Change could be utilized also for Soft Assistance which could contribute to mitigation and adaptation to the Climate Change as well as to improve the operation and maintenance related to the procured equipments.

9-5) Arrangement for the Survey

As a response to the request by the Team, the Philippine side agreed to arrange counterpart personnel for the Survey and to provide promptly all the data and information relevant to the Programme for the smooth implementation of the Survey.

9-6) Safety and Security

The Team explained that security measures are indispensable for effective study. The Philippine side agreed to take the necessary measures to secure the safety of the members of the Team.

9-7) Operation and maintenance of the facilities and the equipments

The Philippine side agreed to take any necessary measures and allocate necessary budget and staff in order to operate and maintain the facilities and equipment provided by the Programme.

9-8) Confirmation of Payment of Value Added Tax (VAT) and Customs Duties

The Team explained to the Philippine side that confirmation of assumption of VAT and Customs Duties on the Programme by GOP is essential for the implementation. The commitment of MCWD to comply with the tax and/or duties will be subject to the final amount of that computed after the Second Phase.

9-9) Environmental Impact Assessment (EIA)

Both sides confirmed that the Philippine side is responsible for taking any measures to complete EIA. The Team will provide necessary data for proceeding EIA by Philippine side.

9-10) Procurement of Main Component of Desalination Plant

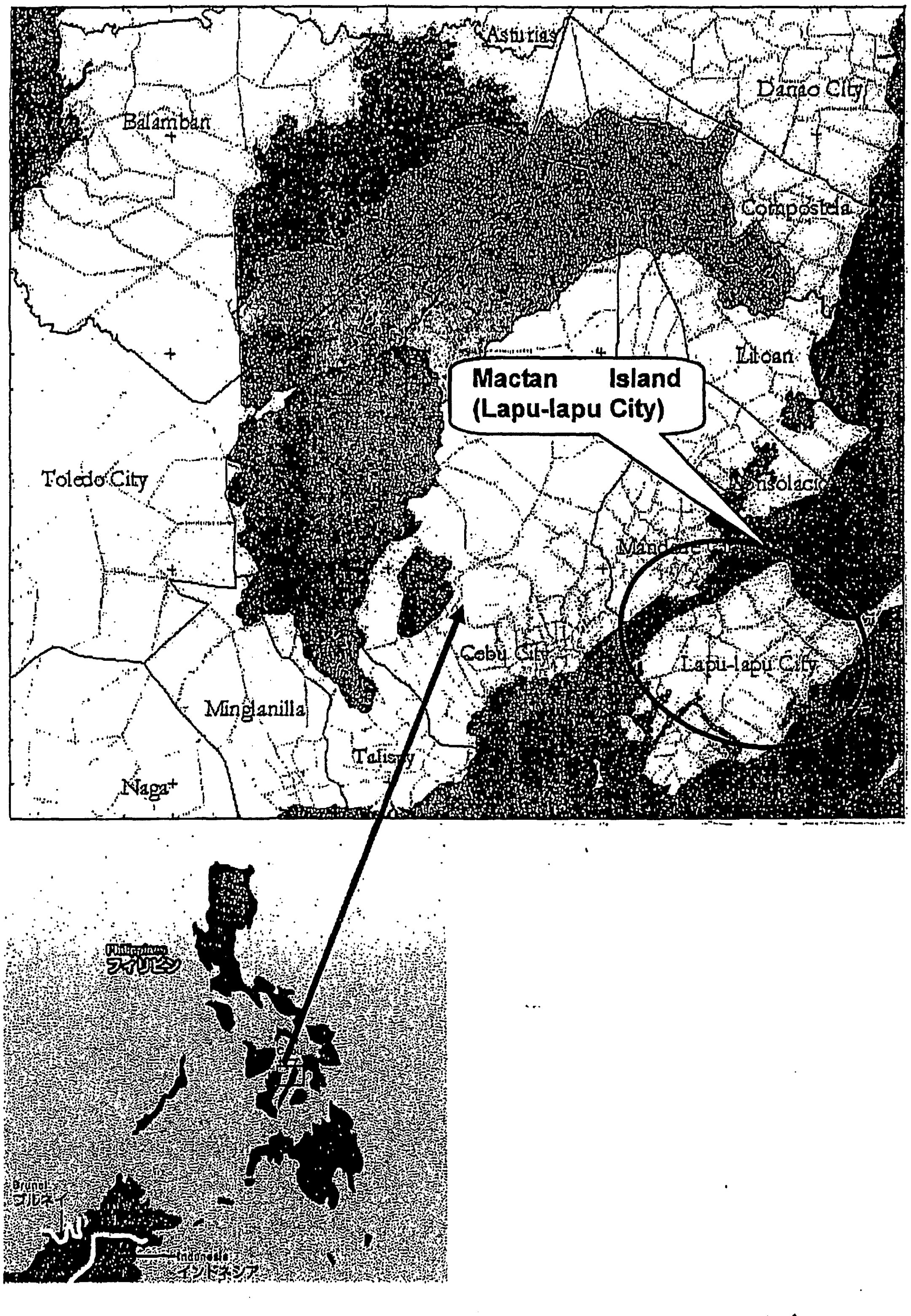
Under the Programme Grant Aid for Environment and Climate Change (Water Technology), in principle, Japanese products are to be purchased for the main component of desalination plant at least high-pressure pumps, reverse osmosis membranes.

9-11) Request on GAEC

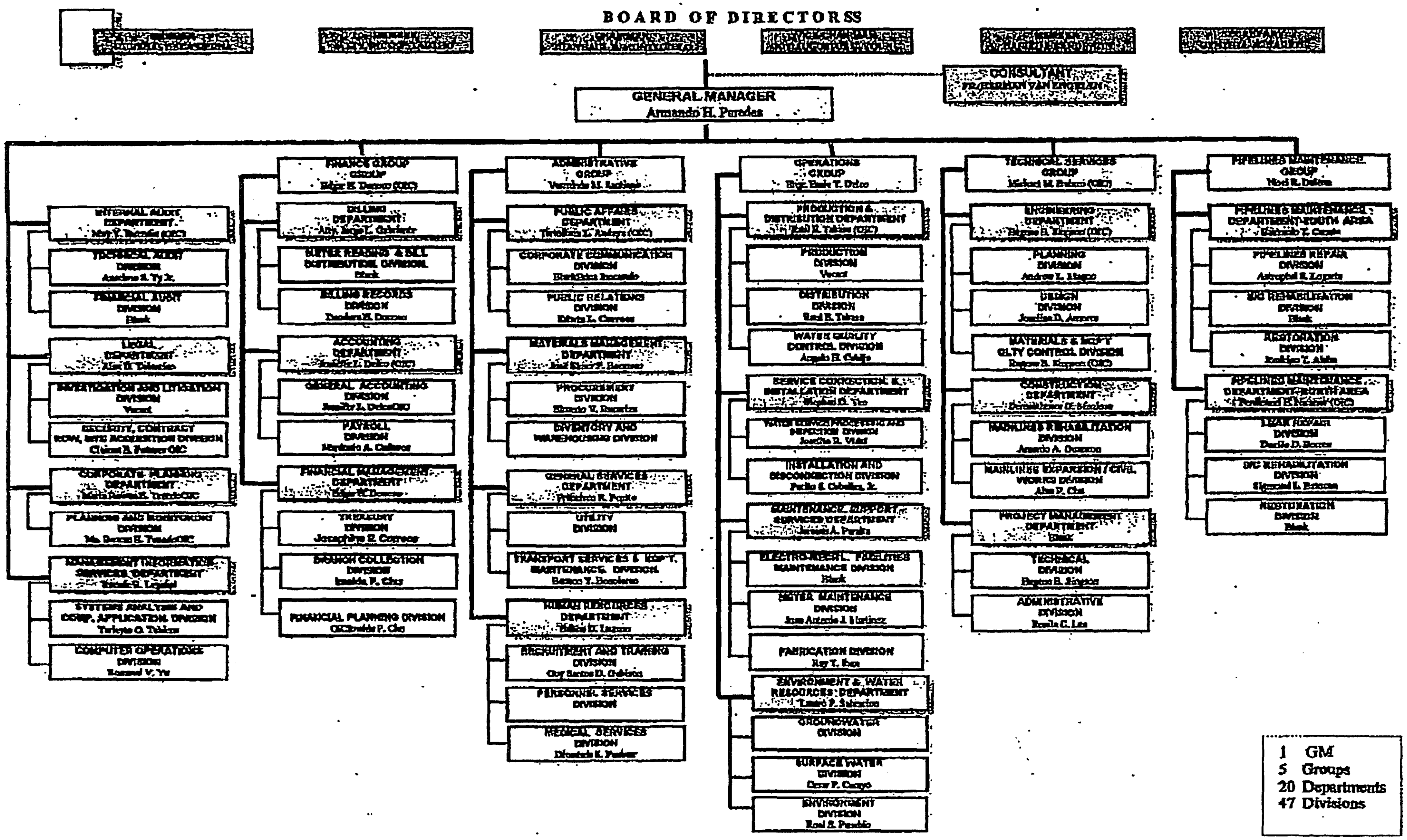
The Philippine side agreed to submit the official request on GAEC to GOJ promptly.

Annex I	Survey and Project Site Map
Annex II	Organization Chart of MCWD
Annex III	Tentative List of Items Requested by the Government of the Philippines
Annex IV	Japan's Programme Grant Aid for Environment and Climate Change Scheme
Annex V	Flow of Funds and Implementation of the Project
Annex VI	Major Undertakings to be Taken by Each Government
Annex VII	Organization Chart for the Implementation of the Programme
Annex VIII	Consultative Committee

Annex I Survey and Project Area Map



Annex II Organization Chart of MCWD



Annex III Tentative List of Items Requested by the Government of the Philippines

1. Desalination Plant

1-1 Main Component

The Capacity of the desalination plant is between 3,000m3/day and 10,000m3/day.

1-2 Intake

1-3 Drainage

1-4 Connection to the main supply line

2. Supplemental Items for Desalination Plant

Details will be determined by further discussions between The Team and MCWD.

Programme Grant Aid for Environment and Climate Change of the Government of Japan (Provisional)

Grant Aid is non-reimbursable fund to a recipient country to procure the facilities, equipment, and services (engineering services and transportation of the products, etc.) for economic and social development of the country under principles in accordance with relevant laws and regulations of Japan. The Grant Aid is not supplied through the donation of materials as such.

Based on the "Cool Earth Partnership" initiative of the The Government of Japan (hereinafter referred to as "the GOJ"), the Programme Grant Aid for Environment and Climate Change (hereinafter referred to as "GAEC") aims to mitigate negative effects of global warming by reducing Green House Gas emission (mitigation measure such as improvement of energy efficiency) and to adapt the supposed effects (adaptation measures such as stabilization of water supply in a region suffering less precipitation due to the climate change).

GAEC may contain multiple components that can be combined to effectively achieve its objectives. The contractors and suppliers may not be confined to Japanese firms and construction, in principle, can be conducted by utilizing local standards.

1. GAEC Procedures

GAEC is executed through the following procedures.

- Application
    - Request made by the recipient country
- Preparatory Survey (hereinafter referred to as "the Survey")
    - The Survey for Outline Design conducted by Japan International Cooperation Agency (hereinafter referred to as "JICA")
- Appraisal & Approval
    - Appraisal by the GOJ and Approval by the Cabinet
- Determination of Implementation
    - The Notes exchanged between the GOJ and a recipient country
- Grant Agreement (hereinafter referred to as "the G/A")
    - Agreement concluded between JICA and a recipient country
- Implementation
    - Implementation of the Project on the basis of the G/A

Firstly, the application or request for a GAEC project submitted by the recipient country is examined by the Government of Japan (the Ministry of Foreign Affairs) to determine whether it is eligible for GAEC. If the request is deemed appropriate, the GOJ assigns JICA to conduct a survey on the request.

Secondly, JICA conducts the Survey for Outline Design with Japanese consulting firms.

Thirdly, the GOJ appraises the project to see whether it is suitable for Japan's GAEC, based on the Survey report prepared by JICA, then the result is submitted to the Cabinet for approval.

Fourthly, the project, once approved by the Cabinet, becomes official with the Exchange of Notes (hereinafter referred to as E/N) signed by the GOJ and the recipient country. Simultaneously, the Grant will be made available by concluding the G/A between the recipient country and JICA.

JICA is designated by the GOJ as the organization responsible for necessary works for proper execution of the Grant.

Procurement Agent (hereinafter referred to as "the Agent") is designated to conduct the procurement services of products and services (including fund management, preparing tenders, contracts) for GAEC on behalf of the recipient country. The Agent is an impartial and specialized organization that shall render services according to the Agent Agreement with the recipient country. The Agent is recommended to the recipient country by the GOJ and agreed between the two Governments in the Agreed Minutes (hereinafter referred to as "A/M").

2. Preparatory Survey for Outline Design

1) Contents of the Survey

The purpose of the Survey, conducted by JICA on a requested project ("the Project"), is to provide the basic documents necessary for the appraisal of the Project by the GOJ. The contents of the Survey are as follows:

(1) Confirmation of background, objectives, and benefits of the Project and institutional capacity of agencies and communities concerned of the recipient country necessary for the implementation of the Project.

(2) Evaluation of relevance of the Project to be implemented under the Grant Aid Scheme from a

technical, social, and economic point of view.

(3) Confirmation of items agreed upon by both parties concerning the basic concept of the Project.

(4) Preparation of the outline design of the Project.

(5) Preliminary Estimation of cost for the Project.

The contents of the original request by the recipient country are not necessarily approved in their initial form as the contents of the Project. The Outline Design of the Project is confirmed considering the guidelines of the Japan's Grant Aid scheme.

JICA requests the Government of the recipient country to take whatever measures are necessary to ensure its self-reliance in the implementation of the Project. Such measures must be guaranteed even though they may fall outside of the jurisdiction of the organization in the recipient country actually implementing the Project. Therefore, the implementation of the Project is confirmed by all relevant organizations of the recipient country through the Minutes of Discussions.

2) Selection of Consultants

For the smooth implementation of the Survey, JICA will conduct the Survey with JICA-registered consulting firms. JICA selects the firms based on proposals submitted by firms with interest in implementing the Survey. The firms selected will carry out the Outline Design Survey and prepare a report, based on the terms of reference set by JICA.

The consulting firms that will implement the Project after the G/A can be, in principle, Japanese firms recommended by JICA for maintaining technical consistency with the Survey.

3. Implementation of GAEC after the E/N

1) The E/N and the G/A

The content of GAEC will be determined in accordance with the E/N exchanged by the two Governments, in which the objectives of the Project, length of the Project, conditions and amount of the Grant Aid are confirmed. The conclusion of the G/A between the recipient country and JICA follows the exchange of E/N to determine the paying conditions responsibilities of the recipient country and procurement conditions.

2) Details of Procedures

Details of procedures on implementing the Project under GAEC will be agreed between the authorities of the two governments concerned at the time of the signing of the E/N and the G/A. Essential points to be agreed are outlined as follows:

a) JICA will supervise the implementation of the Project.

b) Products and services shall be procured and provided in accordance with JICA's "Procurement Guidelines for the Programme Grant Aid (Type I – E) for Environment and Climate Change."

c) The recipient country shall conclude a contract with the Agent.

d) The Agent is the representative acting in the name of the recipient country concerning all transfers of funds to the Agent.

3) Focal points of the "Procurement Guidelines for the Programme Grant Aid (Type I – E) for Environment and Climate Change"

a) The Agent

The Agent is the organization, which provides procurement of products and services on behalf of the recipient country according to the Agent Agreement with the recipient country. The Agent is recommended to the recipient country by the GOJ and agreed between the two Governments in the A/M.

b) Agent Agreement

The recipient country shall conclude the Agent Agreement, in principle, within two months after the signing of the G/A, in accordance with the A/M. The scope of the Agent's services shall be clearly specified in the Agent Agreement.

c) Approval of the Agent Agreement

The Agent Agreement is prepared as two identical documents and the copy of the Agent Agreement shall be submitted to JICA by the recipient country through the Agent. JICA will confirm whether the Agent Agreement is concluded in conformity with the E/N, A/M, and G/A and the Procurement Guidelines for the Programme Grant Aid for Environment and Climate Change then approves the Agent Agreement.

The Agent Agreement concluded between the recipient country and the Agent shall become effective after the approval by JICA in a written form.

d) Payment Methods

The Agent Agreement shall stipulate that "Regarding all transfers of the fund to the Agent, the recipient country shall designate the Agent to act on behalf of the Government and issue a Blanket Disbursement Authorization ("the BDA") to conduct the transfer of the fund (hereinafter referred to as "the Advances") to the Procurement Account from Account of the Government.

The Agent Agreement shall clearly state that the payment to the Agent shall be made in Japanese yen from the Advances and that the final payment to the Agent shall be made when the total remaining amount become less than three percent (3%) of the Grant and its accrued interests.

e) Products and Services Eligible for Procurement

Products and services to be procured shall be selected from those defined in the G/A.

f) Selection of firms

In principle, firms of any nationality could be contracted as long as the firms satisfies the conditions specified in the tender documents.

g) Method of Procurement

When conducting the procurement, sufficient attention shall be paid to transparency in selecting the firms and for this purpose, in principle, competitive tendering shall be employed.

h) Tender Documents

The tender documents should contain all information necessary to enable tenderers to prepare valid offers for the products and services to be procured by GAEC.

The rights and obligations of the recipient country, the Agent and the firms supplying products and services should be stipulated in the tender documents to be prepared by the Agent.

i) Pre-qualification Examination of Tenderers

The Agent may conduct a pre-qualification examination of tenderers in advance of the tender so that the invitation to the tender can be extended only to eligible firms. The pre-qualification examination should be performed only with respect to whether the prospective tenderers have the capability of concluding the contracts.

For this, the following points should be taken into consideration:

(1) Experience and past performance in contracts of similar kind
(2) Financial credibility (including assets such as real estate)
(3) Existence of offices and other items to be specified in the tender documents.
(4) Their potentialities to use necessary personnel and facilities.

j) Tender Evaluation

The tender evaluation should be implemented on the basis of the conditions specified in the tender documents.

Those tenderers which substantially conform to the technical specifications and other stipulations of the tender documents, shall be judged in principle on the basis of the submitted price, and the tenderer who offers the lowest price shall be designated as the successful tenderer.

The Agent shall submit a detailed evaluation report of tenders to JICA for its information, while the notification of the results to the tenderers will not be premised on the confirmation by JICA.

k) Additional procurement

If there is any remaining balance after the competitive and/or selective tendering and/or direct negotiation for a contract, and if the recipient country would like to procure additional items, the Agent is allowed to conduct this additional procurement, following the points mentioned below:

(1) Procurement of same products and services

When the products and services to be additionally procured are identical with the initial tender and a competitive tendering is judged not efficient, additional procurement can be conducted by a negotiated contract with the successful tenderer of the initial tender.

(2) Other procurements

When products and services other than those mentioned above in (1) are to be procured, the procurement should be conducted through competitive tendering. In this case, the products and services for additional procurement shall be selected from among those in accordance with the G/A.

l) Conclusion of the Contracts

In order to procure products and services in accordance with the guideline, the Agent shall conclude contracts with firms selected by tendering or other methods.

m) Terms of Payment

The contract shall clearly state the terms of payment. The Agent shall make payment from the "advances," against the submission of the necessary documents from the firm on the basis of the conditions specified in the contract. When the services are the object of procurement, the Agent may pay certain portion of the contract amount in advance to the firms on the conditions that such firms submit the advance payment guarantee worth the amount of the advance payment to the Agent.

4) Undertakings required by the recipient country

In the implementation of the Grant Aid Project, the recipient country is required to undertake necessary measures as the following:

a) To secure land necessary for the sites of the Project.

b) To provide facilities for distributing electricity, water supply and drainage and other incidental facilities in and around the sites if necessary.

c) To assist prompt execution for domestic transportation of products purchased under the Grant Aid as necessary,

d) To ensure that customs duty, internal tax and other fiscal levies that may be imposed in the recipient country with respect to the purchase of the Components and the Agent's services shall be exempted by the recipient country.

e) To accord all the concerned parties, whose services may be required in connection with supply of the products and services under the contracts, such facilities as may be necessary for their entry into the recipient country and stay therein for the performance of their work.

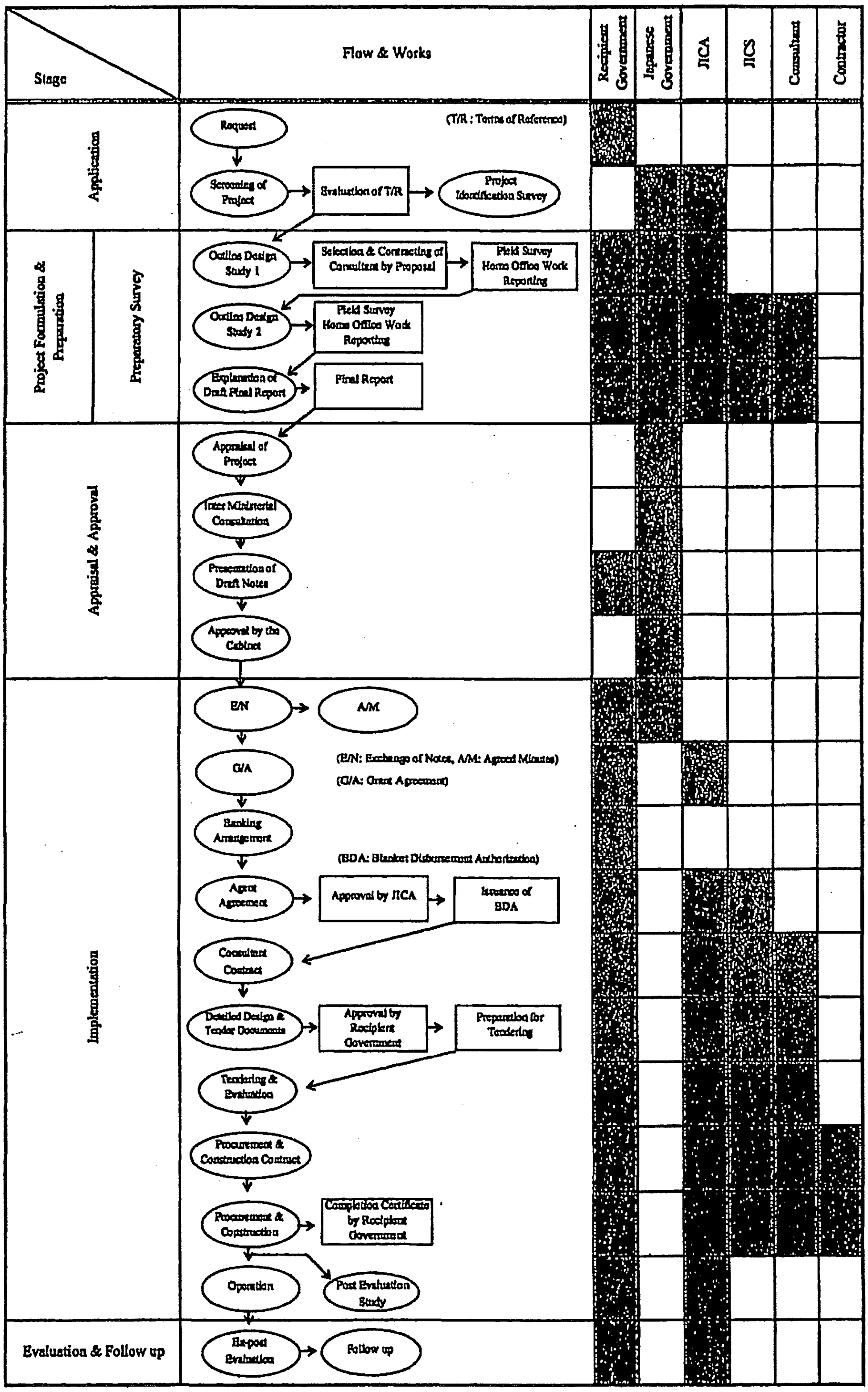
5) "Proper use of funds"

The recipient country is required to take necessary actions so that the facilities constructed under the Grant Aid are properly and effectively used and to ensure sustainable operation and maintenance as well as to bear all the expenses other than those covered by the Grant Aid.

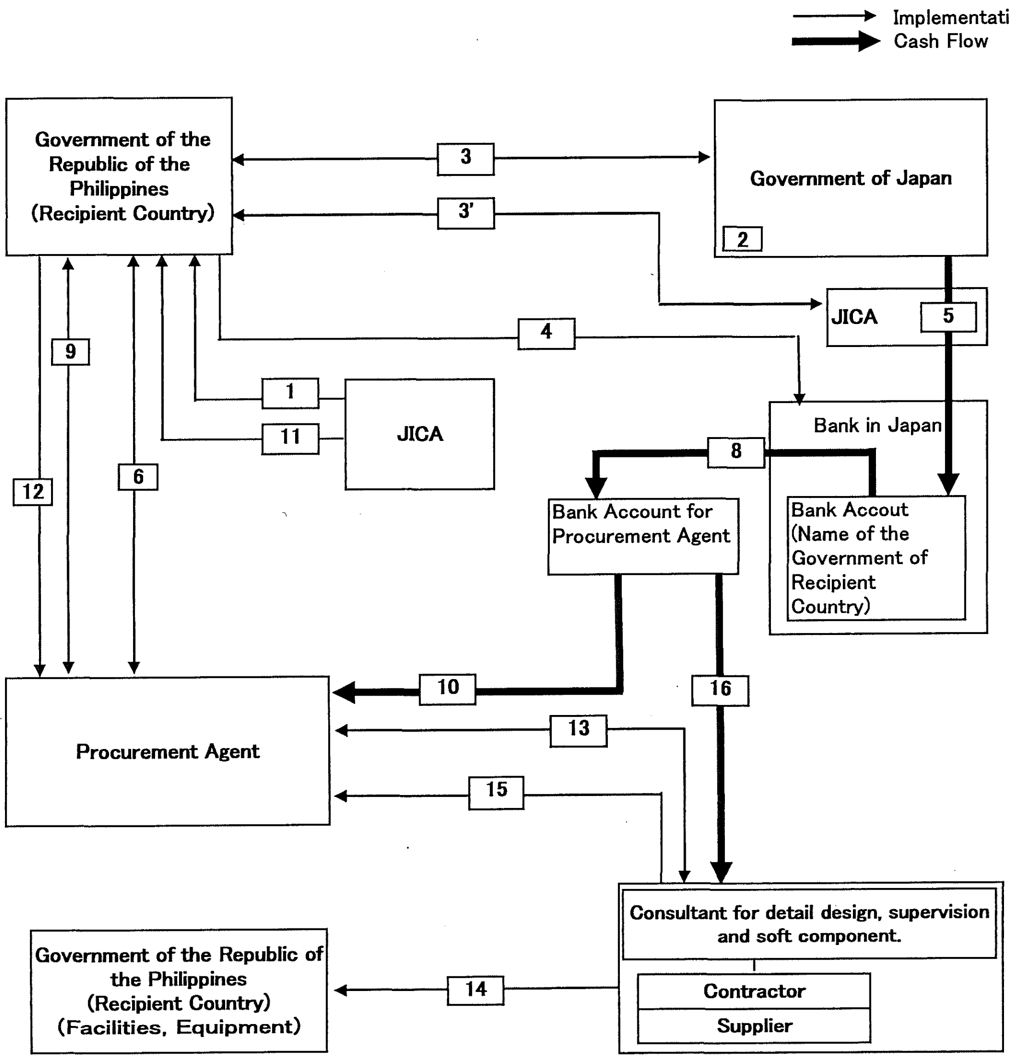
6) "Exported or Re-export"

The products purchased under the Grant shall not be exported or re-exported from the recipient country.

FLOW CHART OF JAPAN's PROGRAMME GRANT AID FOR ENVIRONMENT AND CLIMATE CHANGE PROCEDURES



Annex V Flow of Funds and Implementation of the Programme



1	Preparatory Survey / Reference Document for Tender
2	Approval of Cabinet
3	Signing of Exchange of Notes (E/N)
3'	Signing of Grant Agreement (G/A)
4	Banking Arrangement (B/A)
5	Disbursement of Funds from the Government of Japan
6	Signing of Agent Agreement (A/A) +BDA
7	N/A
8	Transfer of Funds
9	Decision of Project Components
10	Payment of Remuneration for Agent
11	Recommendation of Consultant for Detail Design/Supervision (JICA→Government of the Philippines)
12	Recommendation of Consultant for Detail Design / Supervision (Government of Philippines → Procurement Agent)
13	Conclusion of Contract
14	Construction and Procurement
15	Application for Payment
16	Payment

Annex VI Major Undertakings to be Taken by each Government

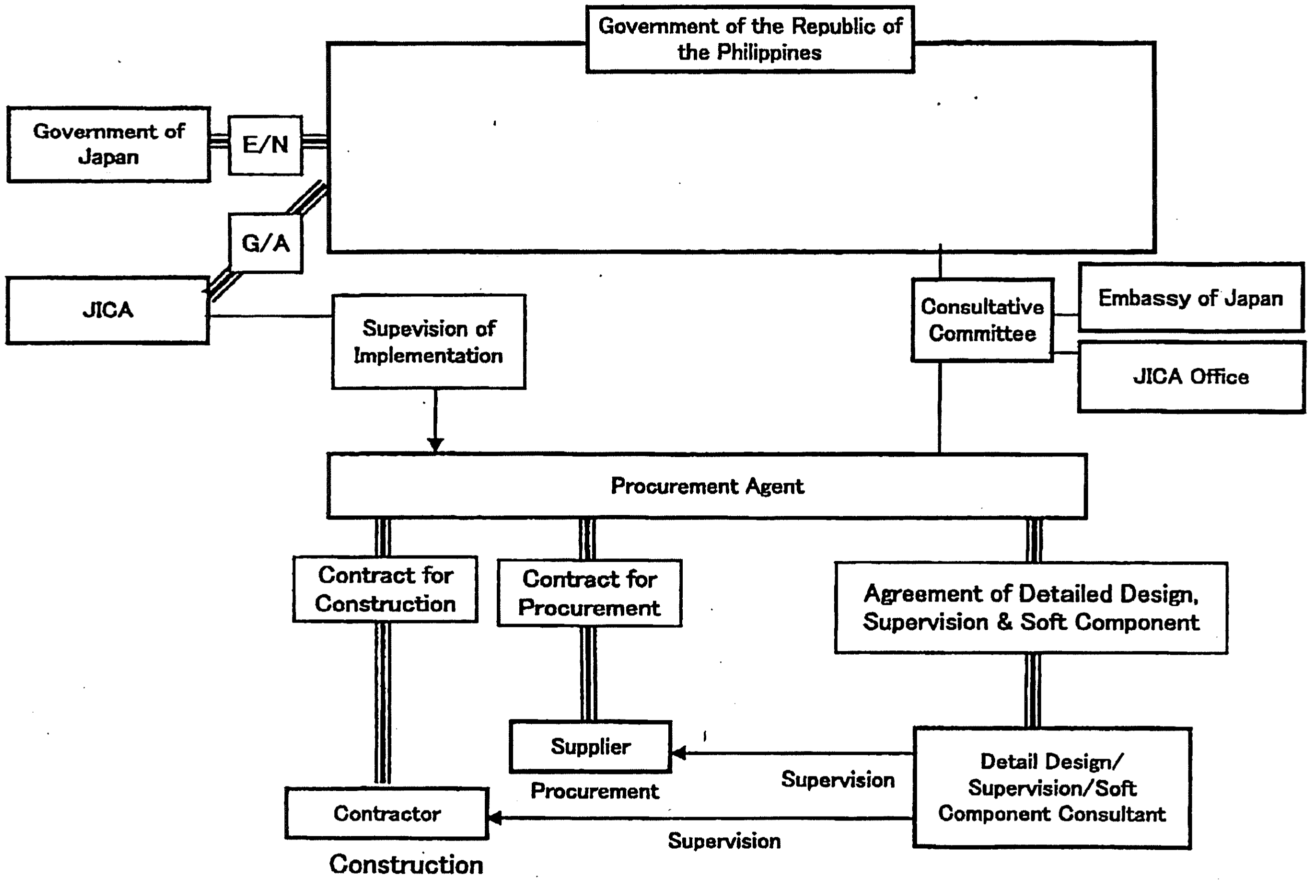
	Items	To be covered by the Grant	To be covered by Recipient side
1	To secure land		•
2	To clear, level and reclaim the site when needed		•
3	To construct gates and fences in and around the site		•
4	To construct the parking lot	•	
5	To construct roads		
	1) Within the site	•	
	2) Outside the site		•
6	To install desalination plant including the building	•	
7	To provide facilities for the distribution of electricity, water supply, drainage and other incidental facilities		
	1)Electricity		
	a.The distributing line to the site		•
	b.The drop wiring and internal wiring within the site	•	
	c.The main circuit breaker and transformer	•	
	2)Water Supply		
	a.The city water distribution main to the site		•
	b.The supply system within the site (receiving and/or elevated tanks)	•	
	3)Drainage		
	a.The city drainage main (for storm, sewer and others) to the site		•
	b.The drainage system (for toilet sewer, ordinary waste, storm drainage and others) within the site	•	
	4)Gas Supply		
	a.The city gas main to the site		•
	b.The gas supply system within the site	•	
	5)Telephone System		
	a.The telephone trunk line to the main distribution frame / panel (MDF) of the building		•
	b.The MDF and the extension after the frame / panel	•	
	6)Furniture and Equipment		
	a.General furniture		•
	b.Project equipment	•	

8	To bear the following commissions to a bank of Japan for the banking services based upon the B/A		
	Payment commission		●
9	To ensure prompt unloading and customs clearance at the port of disembarkation in recipient country		
	1) Marine(Air) transportation of the products from Japan to the recipient country	●	
	2) Tax exemption and customs clearance of the products at the port of disembarkation		●
	3) Internal transportation from the port of disembarkation to the project site	(●)	(●)
10	To accord all concerned parties, whose services may be required in connection with the supply of the products and the services under the approved contract such facilities as may be necessary for their entry into the		●
11	To exempt or bear of all concerned parties from customs duties, internal taxes and other fiscal levies which may be imposed in the recipient country with respect to the supply of the products and services under the approved		●
12	To maintain and use properly and effectively the facilities constructed and equipment provided under the Grant		●
13	To bear all the expenses, other than those to be borne by the Grant, necessary for construction of the facilities as well as for the transportation and installation of the equipment		●

(B/A: Banking Arrangement, N/A: Not Applicable)

Annex VII Organization Chart for the Implementation of the Programme

Programme Implementation System



Annex VIII Consultative Committee

1. Functions

The Consultative Committee (hereinafter referred to as "the Committee") will be established in order to fulfill the following functions:

1) to confirm an implementation schedule of the Programme for the speedy and effective utilization of the Grant and its accrued interest;
2) to discuss determination and/or modification of the Components, taking into account of the products enumerated in the list attached to the Procurement Guidelines and/or the result of the preparatory survey for the Programme by JICA;
3) to discuss modifications of the Programme;
4) to exchange views on allocations of the Grant and its accrued interest as well as on potential end-users;
5) to identify problems which may delay the utilization of the Grant and its accrued interest, and to explore solutions to such problems;
6) to exchange views on publicity related to the utilization of the Grant and its accrued interest; and
7) to discuss any other matters that may arise from or in connection with the G/A.

The first meeting of the Committee shall be held immediately after the approval of the Agent Agreement by the JICA, which shall be concluded between MCWD and the Procurement Agent (hereinafter referred to as "the Agent").

The selection of the Agent will be agreed between the two governments in the Agreed Minutes attached in the Exchange of Notes.

Further meetings will be held by the request of either the Philippine side or the Japanese side. The Agent also may advise both sides on the necessity to call a meeting of the Committee.

2. Composition (Provisional)

1) Representative of National Economic Development Authority
2) Representative of MCWD
3) Representative of the Procurement Agent
4) Representative of Embassy of Japan in the Republic of the Philippines
5) Representative of JICA Philippine Office

A-5. References and Collected Documents List

Name of Materials	Month/ Year	Publication
Feasibility Study of Seawater Desalination Facility for Water Supply in Metro Cebu Final Report	Sep. 2005	JBIC: Japan Bank for International Cooperation TEPSCO: Tokyo Electric Power Service Co., Ltd.
Provincial Water Supply, Sewerage and Sanitation Sector Plan (PW4SP) CEBU Main Report	Dec. 2003	GTZ: German Technical Cooperation Provincial Government of Cebu
Provincial Water Supply, Sewerage and Sanitation Sector Plan (PW4SP) CEBU Appendix		
Imperial Palace Hotel RO System Design Materials & System Flow Diagram	2009	Imperial Palace Hotel Internal Document
The Study for Improvement of Water Supply and Sanitation in Metro Cebu in the Republic of the Philippines Progress Report	Apr. 2009	NJS: NJS CONSULTANTS CO., LTD. NK: NIPPON KOEI CO., LTD.
Revised Procedural Manual (RPM) for DENR Administrative Order No. 30 of 2003 (DAO 03-30) Implementing Rules and Regulations of PD. No. 1586 establishing PEISS	August 2007	DENR: Department of Environment and Natural Resources EMB: Environmental Management Bureau
Environmental Laws in the Philippines	1999 – 2nd Ed	Central Book Supply Inc. Editorial Staff
A Legal Arsenal for the Philippine Environment The Philippine Islands: Batas Kalikasan	2002	Antonio A. Oposa Jr.
Geological Map of Cebu Quadrangle (Sheet 3750 I)	First Ed. 1985	Philippine Bureau of Mines and Geosciences

A-6. Other Information and Specifications

A6-1 Specifications of Desalination Plant

- ✓ Materials of Seawater Desalination
- ✓ Public Health and the Environment World Health Organization Geneva 2007, Desalination for Safe Water Supply Guidance for the Health and Environmental Aspects Applicable to Desalination
- ✓ RO Desalination Plant for Imperial Palace Hotel by Asian Industry Inc.
- ✓ Technical Evaluation Committee, Study on Development of Seawater Desalination Technology, Interim Report, October 1998

A6-2 Breakdown of Project Components

A6-3 Photographs of Site Investigation

Materials of Seawater Desalination

【1】 Seawater Desalination Q & A Editorial Committee of Okinawa Prefectural Enterprise Bureau, November 1994

- O/M cost of seawater desalination plant in Okinawa is approximately 170 Yen/m3; among which the costs of power consumption, depression of invest cost, chemicals and membrane replacement are 33, 28, 12, 11 %, respectively.
- pH of water produced by seawater desalination plant is low. Scaling does not occur because its langelier index shows a big negative figure; which shows it corrosive and has the tendency of generation of red water supply and distribution system including pipes and equipment. For this reason, caustic soda is added to the production for pH adjustment. Furthermore, calcium is also added because calcium hardness level in the production water is low.
- However, special post treatment is not necessary because the water treated in the next water purification plant is hard water. Blending the production water with it makes the water with good taste with appropriate hardness and alkalinity.

Outline of Seawater Desalination Plant

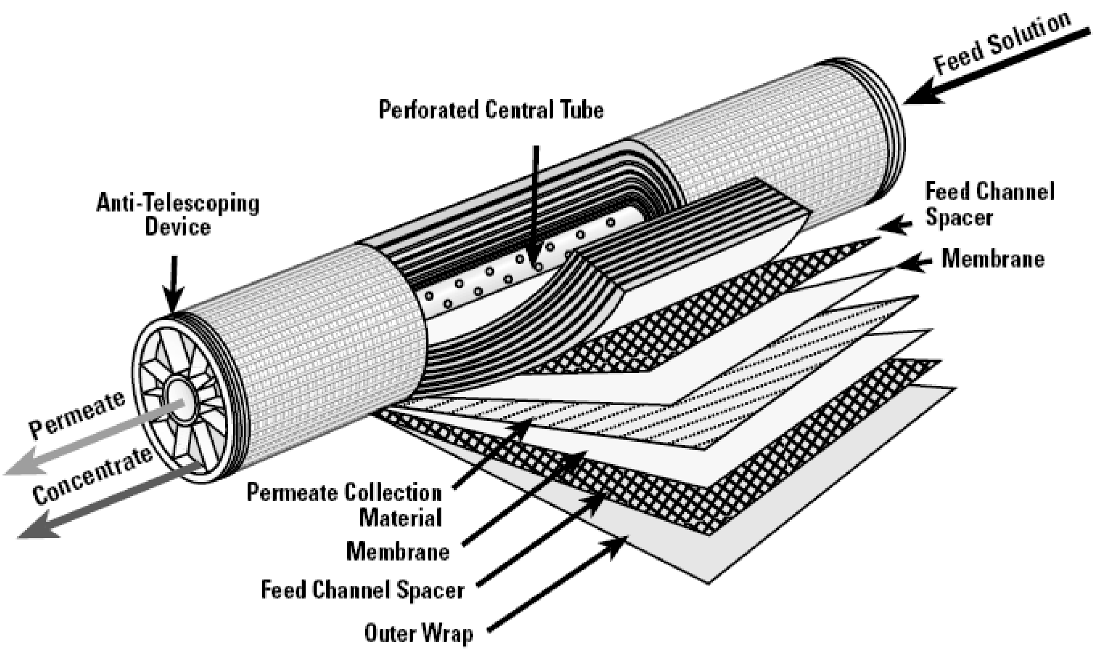
• Location	Miyagi, Kutancho, Okinawa Prefecture
• Space	Approx. 12,000 m^2 (0.3m^2/m^3-capacity)
• Building space	Approx. 9,900 m^2 (Total floor space approx. 17,600 m^2)
• Building	RC and PC (Basement with four ground floors)
• Capacity of production water	40,000 m^3/day
• Desalination process	RO process
• Recover	Approx. 40 %
• Membranes	Spiral type aromatic polyamide composite (RO membrane)
• Receiving electricity	Approx. 8,000 kW, special high voltage electricity receiving (66 kV) according to supply regulations by Okinawa Electric Power Company
• Seawater intake method	Intake from sea bottom method
• Brine discharge method	Diffusion to seawater method
• Total invest cost	Approx. 34.7 billion Yen (Japanese Government subsidiary rate 85 %) 86,750 Yen/m^3/day

2005 Water quality

	Raw Seawater (RO Supply)	Product water	Removal Rate (%)
TDS (mg/L)	34,800	278	99.20
Cl^- (mg/L)	19,800	119	99.40
SO_4^{2-} (mg/L)	2,490	5.9	99.76
Na (mg/L)	11,400	96.1	99.16
T-hardness (mg/L)	6,360	10	99.84
Conductivity (μS/cm)	50,800	456	99.10

RO membrane unit

- Approximately 5,000m^3-product/day/unit
- 1 unit 63 RO module
- 1 module 6 elements below

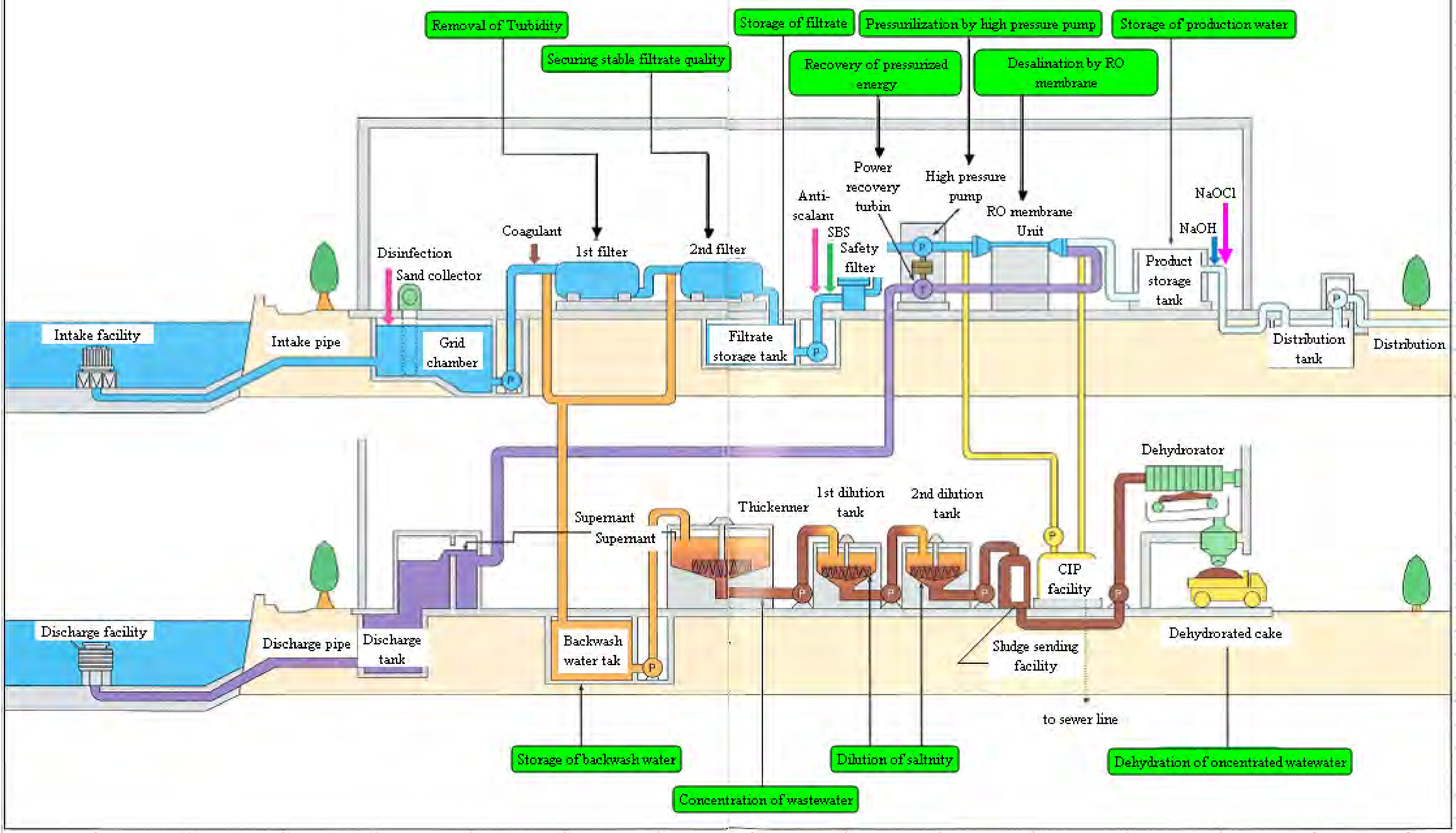


Outline of Seawater Desalination Facilities

Facility		Design Parameter (40,000 m^3/day), Intake 100,000 m^3/day)	Remarks
1) Raw water Intake Facility	Intake Pipe	Φ1,200 x 220 m x 1 (Sea bottom intake method)	V = 1.0 m/sec
	Intake Pit	$4.5m^W$ x $10.5m^W$ x $5.3m^H$ (Effective) x 2	V =500 m^3
	(Grid Chamber)	(Auto-sand collector)	RT: 7.2 min
	Intake Pump	19.4 m^3/min x 48mH x (4+1)	Total Q = 112,000 m^3/day
2) Pre-treatment	Filter	Direct coagulation filtration (Direct two-stage filtration)	
		First filter: 32m^2/tank x (12+1)	A= 384 m^2, LV= 10 m/H
		Second filter : 33.6m^2* (8+1)	A= 270 m^2, LV= 15 m/H
	Buffer tank	V= 1,000 m^3 x 2	V =2,000 m^3 , RT = 30 min
3) RO facility	Feed pump	8.9m^3/min x 45mH x (8+1)	Total Q = 102,500 m^3/day
	Safety filter	537m^3/h x (8+1)	
	High pressure pump	8.91m^3/min x 650mH x 8	Total Q = 102,500 m^3/day
	RO membrane	5,131 m^3/day x 8 unit	Total production = 41,000 m^3/day
		63 vessel/unit (7 rows x 9 stages), 6 elements/vessel	13.6 m^3/element
	Booster pump	4m^3/min x 40mH x (2+1)	Total Q = 11,500 m^3/day
	Desalination tank	V = 200 m^3 x 2 (used for suck-back water tank as well)	RT: 14 min
4) Discharge facility	Discharge pipe	Φ700 x 230 m x 1 (Sea bottom discharge method)	V = 1.8 m/sec
	Discharge tank	V = 2,100 m^3 x 1	RT: 50 mins
(Wastewater treatment facility)	Backwash water tank	V = 330 m^2 x 2	
	Thickener feed pump	1.63 m^3/min x 20mH x (3+1)	
Dehydration facility	Thickener	V = 380 m^3 x 3, A=94 m^2, H=4.0 mH (Effective)	Water surface load: 25 m^3/m^2/day
	Dilution tank	V = 260 m^3 x 3, A=64 m^2, H=4.0 mH (Effective)	Water surface load: 36 m^3/m^2/day
	Dehydrator	Operation hours: 4 -5 hours/day	
		Area: 100 m^2 x 2	
		Dehydrated sludge: approximately 2.5 m^3/day (Moisture less than 65 %)	
5) Chemical feeding facility		$FeCl_3$ feeding facility	
		NaOCl feeding facility	
		$NaHSO_3$ feeding facility	
		NaoH feeding facility	
6) Electricity receiving and sub-station facilities		Electricity introduction, receiving, transmission and distribution facilities	
7) Electrical control system		Power supply, emergency generator, Control panel, Observation panel, control system	

Note: Remarks are estimated by the specifications

Flowsheet of Seawater Desalination Plant



Vol.39 No.5（2002_9）

Application of Reverse Osmosis Sea Water Desalination Technology on Ser vice Water Treatment

1. Treatment Flow

- Turbidity in the raw seawater by pre-treatment, sand-filter as a typical, after disinfection.
- Growth of microorganism in RO module and/or supply of seawater with high turbidity will affect the RO performance due to accumulation of microorganism and/or turbidity on the surface of the RO membrane.
- Cleared seawater by pre-treatment is pumped up by high pressure pump with the pressure of 5 – 8 MPa. With the operation, 30 to 60 % of seawater is permeated as fresh water.
- The rest of the seawater is discharged as brine with high pressure. The pressure is converted to energy with recover turbine, etc.

2. Characteristics of RO System

RO system has the following characteristics compared to those of evaporation system in seawater desalination technology,

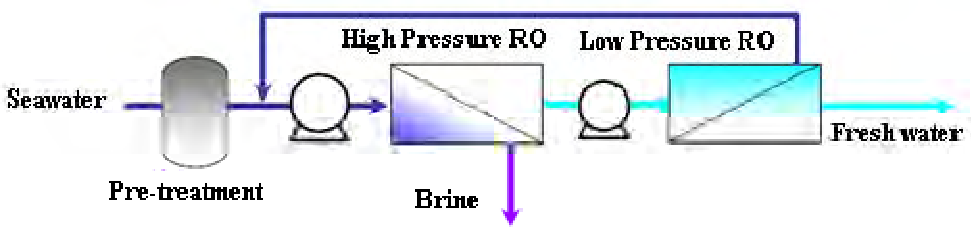
- Less energy consumption
- Containing some extents of minerals in production water
- Easiness of operation and maintenance
- Compact plant

Up to now, production cost by seawater desalination RO system is said to be high in Japan.
It is because that energy consumption unit per production is approximately 7 to 8 kWh/m^3 which occupies a big portion in case of recover rate of 40 % and without energy recovery devices. However, unit energy consumption unit is around 3 kWh/m^3 with the increase of recover rate up to 50 – 60 % and with application of energy recover devices. The latest production cost in Japan is less than 170 Yen/m^3. In foreign countries the cost is reported to reach 65 -130 Yen/m^3 depending on the conditions of plant location, plant specifications, etc.

3. Current issues to be solved and Countermeasures in Seawater Desalination Plant

Issues of RO system	Countermeasures
More production cost reduction	♦ To reduce cost by reduction of construction and O/M - Increase of filtration velocity of pre-treatment filter - Increase of RO system recover rate - Application of energy recovery device - Reduction of unit energy consumption by appropriate plant operation
Measures for polluted seawater	Pre-treatment for seawater with high turbidity (over SS 10mg/l) and high organic pollution ♦ Improvement of sand-filtration system - Improvement of filtrate quality by inorganic coagulant + organic polymer - Load reduction on direct filtration with the combination of sedimentation without chemical addition and conventional filtration ♦ Introduction of membrane system - Application of MF (microfiltration) or UF (Ultra-filtration) to extend chemical cleaning of RO membrane and to get better quality. The cost of it needs two or three times cost than that of sand-filtration at present; however, cost reduction is possible with bigger scale and high flux, appropriate operation, etc.

Issues of RO system	Countermeasures
High quality of product water, concretely, removal of parameters regulated in water quality such as halogen organic compounds like tri-halomethane, boron, etc.	♦ Appropriation of two stage RO system for advanced water quality High removal rates of tri-halomethane and boron are achieved by two stage system where first production water is treated by special RO membrane. For an example, boron level in seawater is 4.5 mg/l as molecular nature and is not removed to meet water quality standard of 1 mg/l boron under the single stage RO system with 6.5 -7.5 pH.[1] In this case, the first production water is treated by low pressure RO system to meet water quality standard. There are some low pressure RO membranes can't remove tri-halomethane sufficiently; however, effluent from polyamide RO membrane can meet water quality standard.



Two Stage RO System

4. O/M Cost

Estimation Conditions		Estimation Result			
Item	**Used Figure**	**Item**		**Cost (Yen/m^3)**	**Rate (%)**
Production water	50,000 m^3/day	Operation Cost	Electricity	60.0	41.5
Recover rate	50 %		Membrane	4.6	3.2
Operation rate	95 %		Chemicals	8.8	6.1
Unit power consumption	5 kWh/m^3		Maintenance	5.8	4.0
Electricity cost	12 Yen/kWh		Labor	9.8	6.8
Membrane replacement	10 % per year		Sub-total	89.0	61.6
Unit construction cost	200,000 Yen/m^3/day	Depression cost		55.6	38.4
Depression	15 years	Total		144.6	100
Interest rate	5 %				

[1]Boron level by the standard of drinking water in Philippines is 0.5 mg/L. The current WHO guideline value for boron (borate) in drinking water is 0.5 mg/litre, however, this is due to be reconsidered under the rolling revision of the Guidelines (WHO, 2004). Although a health based guideline might possibly be 1 mg/litre or higher, there are plants that are sensitive at 0.5 mg/litre.
The latter might become the principal issue for residual boron i.e. its effect as an herbicide if present in sufficient amount in irrigation water, particularly in areas where rainfall is so low as to not cause leaching of salts from soils.

Fukuoka Area Water Supply Business Group, Outline of Project of Seawater Desalination Plant (50,000 m^3/day)

1. Project Schedule

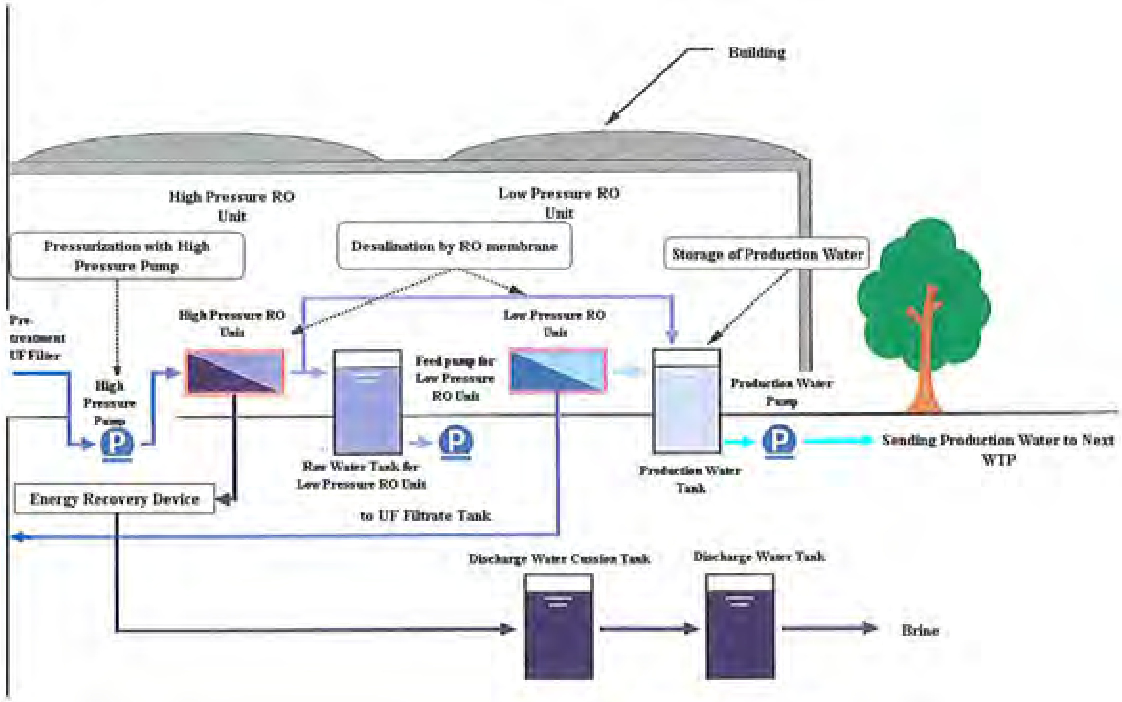
- Construction Period：Water Piping 5.5 years, Seawater Desalination Plant 4.5 years

2. Outline of the Project

• Space：	Approximately 46,000 m^2 (0.92 m^2/m^3/day), Building space approximately 16,000 m^2 (Total floor space 21,000 m^2), Seawater desalination unit: 0.42 m^2/m^3/day
• Production water：	Max. 50,000 m^3/day
• Water intake method：	Permeate intake method
• Desalination process：	RO system (Production recover rate 60 %)
• Discharge method：	Mixture with effluent from wastewater treatment plant and discharge into Hakata Bay
• Water Piping：	Conduct pipe ϕ 800 x approximately 20 km Plant to water treatment plant, length approximately 12 km Water purification plant to distribution tank length approximately 8 km
• Project cost：	Approximately 440 billion Yen （88,000 Yen/m^3/day）

3. Objectives of the Project

- Permeate intake method：to intake clear seawater with stability
- Pre-treatment : To remove microorganism and supper fine particles by UF membrane (Polysulfone, spiral type)
- RO system : Two stage RO system (High pressure RO Unit (Tri-acetyl cellulose Hollow Fiber Type) + Low Pressure RO Unit (Polyamide, spiral type) for better production water quality
- Low cost：Approx. recover rate 60 %



4. Special Remarks

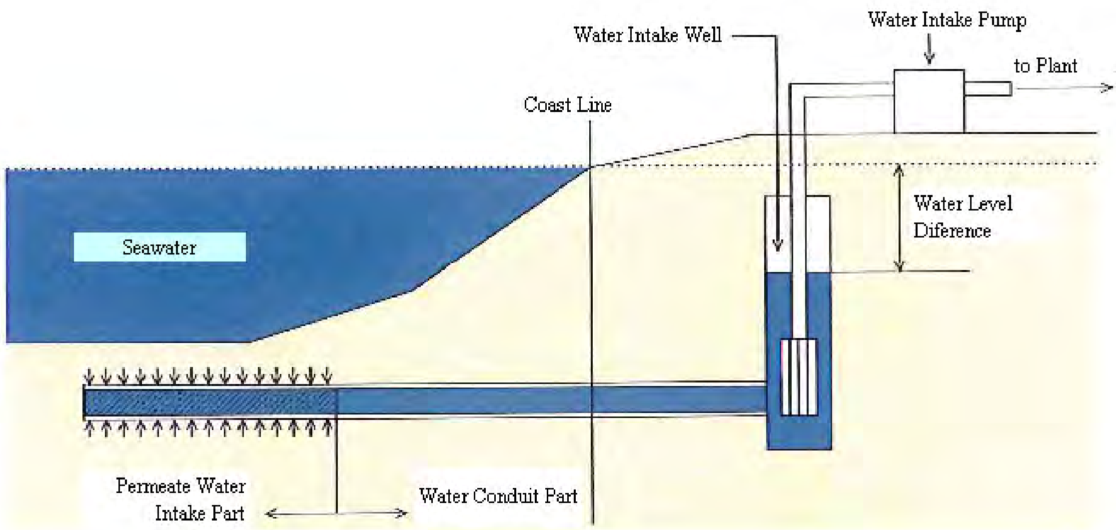
(1) Seawater Intake Method : Permeate Intake method

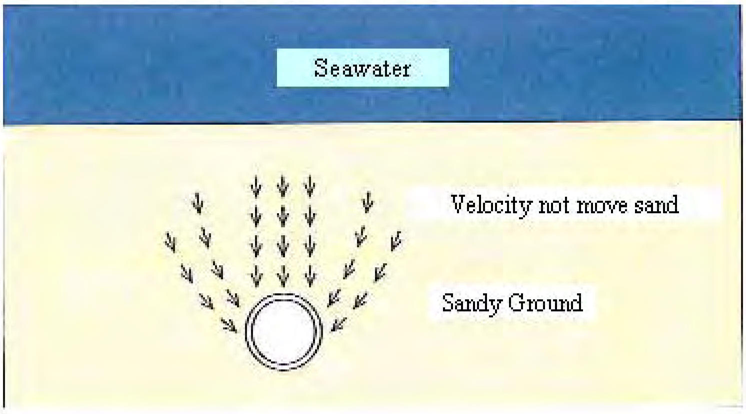
(2) Basic concept of permeate intake method

- To lessen the negative impact on the area of sea around by installation of structures and to intake raw seawater clean seawater by filtration with sand
- To fall the water level of the intake well by intake pump and to intake water with such a slow velocity as not to move sand (less than limit velocity) with the level difference

(3) Life of RO membrane : More than 5 years

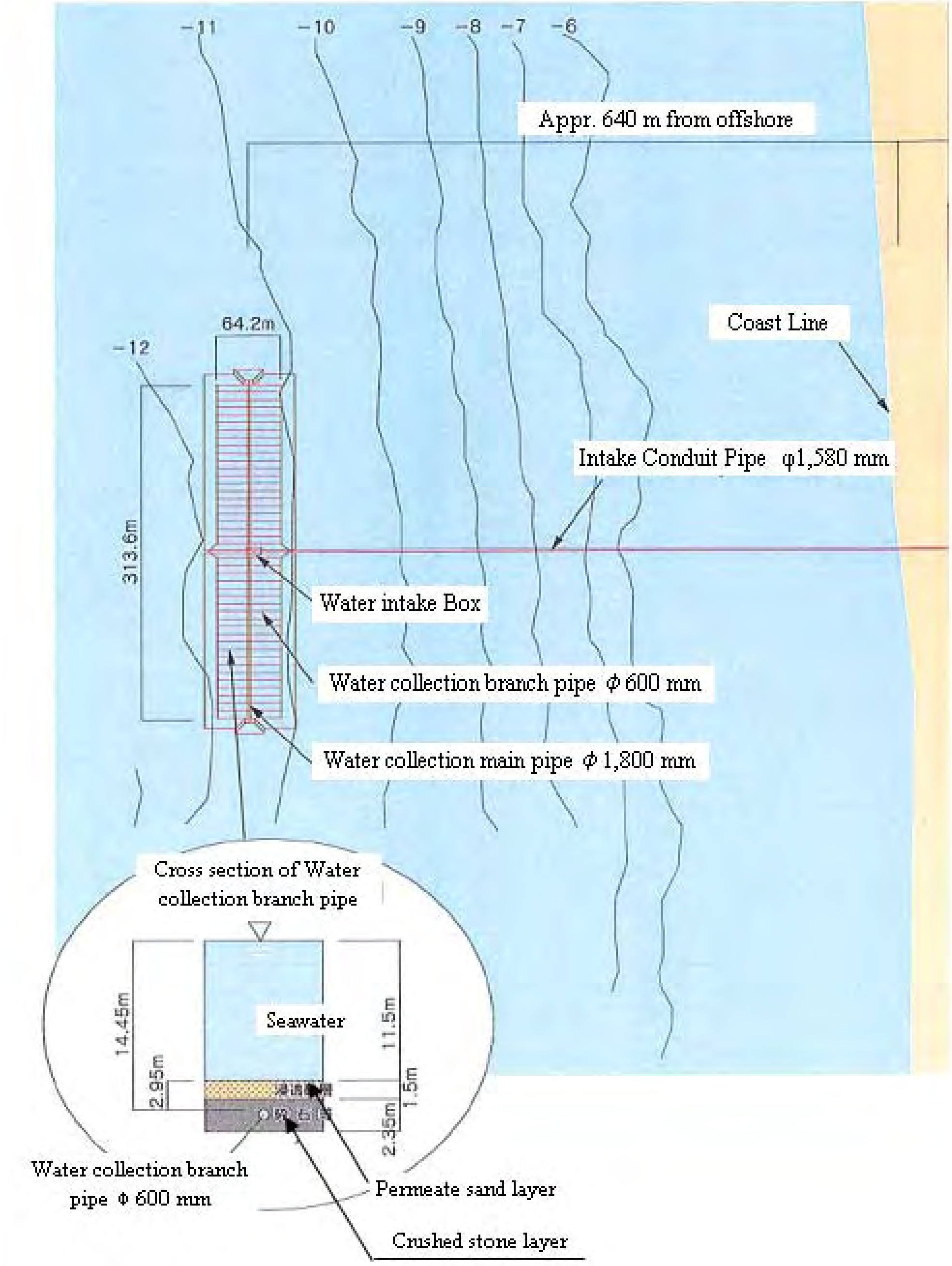
Permeate intake method supplies raw water with extremely low turbidity. Membrane can achieve stable performance for a long time under the ideal operation without mechanical or chemical deterioration.





Structure		
Permeate collection Facility	Permeate Velocity	6 m/day
	Water collction main pipe	ϕ 1,800 mm, L = appr. 314 m
	Water collction brance pipe	ϕ 600 mm, L = appr. 30 m
		5 m pitch (Total length 3,500 m)
Water conduit facility	ϕ 1,580 mm, L = 1,178 m	
Water conduit box	5.0 m^W x 8.0 m^L x 4.9 m^H (Inner size)	
Water Intake Well	5.0 m^W x 13.0 m^L x 10.2 m^H (Inner size) x 2	

Outline of Raw Seawater Intake Facility



(4) Energy Recovery Device

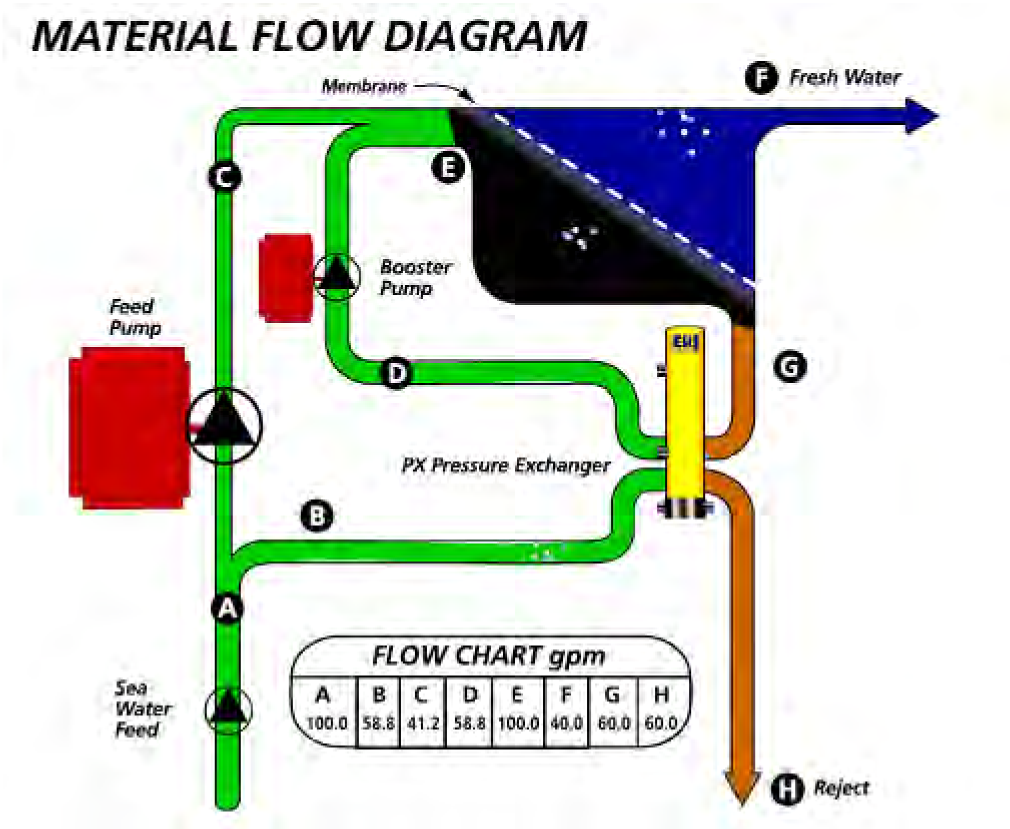
Energy recovery device is the device which concerts pressure energy which discharge brine has to revolving energy by recovery turbine and uses it as a supplementary energy for a drive for high pressure pump. It can recover approximately 20 % of energy.

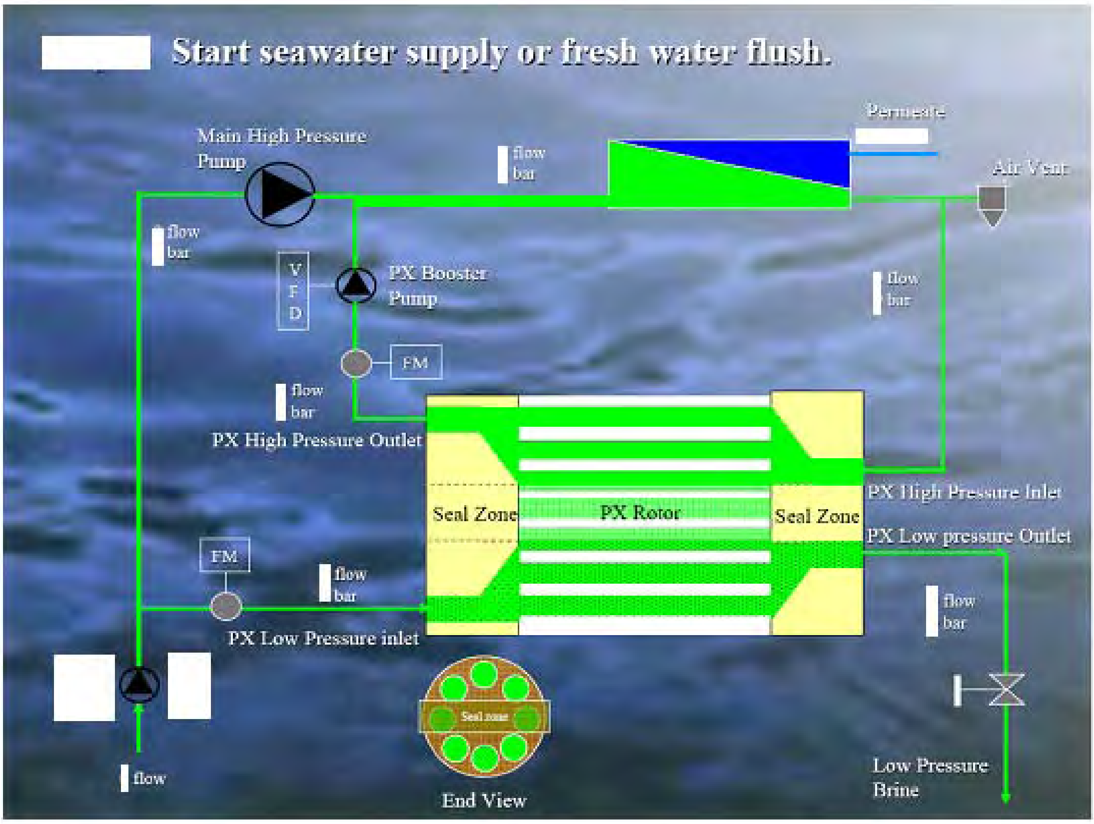
<u>(Reference)</u>

The PX Pressure Exchanger® (PX®) is a rotary-type energy recovery device (ERD) with only one moving part that recovers energy from the waste stream of seawater reverse osmosis (SWRO) systems at up to 98% efficiency.（At the core of the device is a ceramic rotor which resists corrosion and has low vibration, providing maintenance-free and fail-safe operation. PX technology dramatically reduces costs associated with the energy intensive SWRO desalination process by up to 60% as compared to desalination plants without any energy recovery devices. It is also the most widely used ERD today with installations in over 30 countries world-wide.

Energy Recovery, Inc. invented, patented, and commercialized the most efficient, energy saving, energy recovery solution available today:

The PX energy recovery device uses the principle of positive displacement and isobaric chambers to achieve extremely efficient transfer of energy from a high-pressure waste stream, such as the brine stream from a reverse osmosis desalination unit, to a low-pressure incoming feed stream. Because the PX is highly efficient — up to 98% virtually no energy is lost in the transfer.



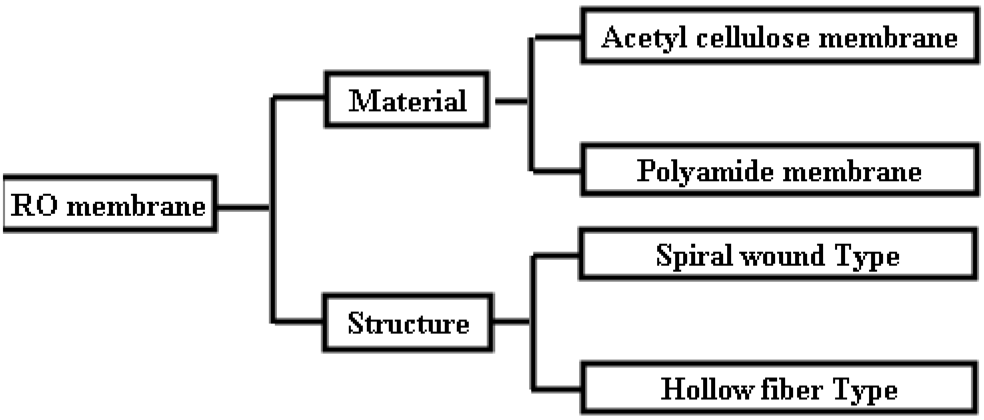

Start seawater supply or fresh water flush.
Main High Pressure
Pump
flow
bar
Permeate
Air Vent
flow
bar
V
F
D
PX Booster
Pump
flow
bar
FM
flow
bar
PX High Pressure Outlet
Seal Zone
PX Rotor
Seal Zone
PX High Pressure Inlet
PX Low pressure Outlet
FM
flow
bar
flow
bar
PX Low Pressure inlet
flow
End View
Low Pressure
Brine

Seawater Desalination Q & A Editorial Committee of Okinawa Prefectural Enterprise Bureau, November 1994

1. Reference: Principal and Features of Seawater Desalination by Pervaroration

Process	Principal	Features
PERVAPORATION	Method for the separation of mixtures of liquids by partial vaporization through a non-porous or porous membrane. The name of this membrane-based process is derived from the two basic steps of the process, firstly the permeation through the membrane by the permeate, then its evaporation into the vapor phase. The membrane acts as a selective barrier between the two phases, the liquid phase feed and the vapor phase permeate. Typically, the upstream side of the membrane is at ambient pressure and the downstream side is under vacuum to allow the evaporation of the selective component after permeation through the membrane. Driving force for the separation is the difference in the partial pressures of the components on the two sides and not the volatility difference of the components in the feed.	Most appropriate in energy saving where sufficient exhausted heat to be used such as solar energy exists.

2. Kinds of RO membranes and characteristics



RO membrane being used is roughly categorized acetyl cellulose membrane and polyamide membrane from material aspect and spiral wound and hollow fiber type from structural aspect.
Acetyl cellulose and polyamide membrane are used for hollow fiber type membrane and polyamide composite membrane is used for spiral wound type membrane.
There are two types of spiral wound polyamide composite membranes; cross-link and filament aromatic polyamide membranes.
The factors to give negative effects on RO performance are scale generation on the surface of RO

membrane and biological fouling due to growth of bacteria.
Accordingly, disinfectant like chlorine to prevent from bacteria growth and H_2SO_4 to low pH or anti-scalant to prevent from scaling are added before RO module inlet.
Acetyl cellulose membrane is relatively tolerant to chlorine; therefore, chlorine dosing is effective for prevention of bacteria growth.
The features of spiral wound type polyamide composite membrane are widely being used due to the features;

- Possible to remove tri-halomethanes which can not be removed by acetyl cellulose membrane.
- In general, spiral type wound RO membrane is superior to hollow fiber type membrane in clogging. Mesh spacer with acceptable openings of approximately 30 μm is used in spiral wounded type RO element in order to increase inlet flow velocity and to improve turbulence effect at inlet.
- Spiral wound type membranes are produced by many companies and have the common dimensions, although their appearances are different. It means those membranes can be accommodated in the same pressure vessels.
- Others

However, de-chlorination by SBS before RO module for polyamide membranes.

(Notes)

- Asymmetric membrane : Material of desalination function layer and supporting layer is the same as asymmetric acetyl cellulose membrane.
- Composite membrane : Materials of desalination function layer (cross-link aromatic polyamide membrane, etc) and supporting layer (Polysulfone, etc.) are different. Most functionally suitable materials of them can be selected. Polyamide composite membrane is a typical one.

Classification of RO membranes on the market.

Membrane material/Manufactures			Product Name	Module Type
Cross-link aromatic polyamide				
	Film Tec		TW/BW/SW/HR-30*	Spiral
		(DOS)	HR-95*, HR-99*	Plate & frame
		(PCII)	ZF-99*	Tubular
	Toray		SU-700*, SU-800*, SU-900*	Spiral
	Nitto Denko		NTR-759*	Spiral
Filament aromatic polyamide				
	Du Pont		Permasep B-9, B-10	Hollow fine fiber
	Du Pont		Permasep B-15	Spiral
Allyl-alkyl polyamide/Polyurea				
	UOP		RC-100 (and PA-300)*	Spriral
	Hydranautics		CPA*	Spriral
	Nitto Denko		NTR-7197*, NTR-739HF*	Spriral
	Du Pont		Permasep A-15*	Spriral
Polypiperazineamide				
	Film Tec		NF-40*, NF-40HF*	Spiral
	Nitto Denko		NTR-7250*, NTR-729*	Spiral
	Toray		SU-200*, SU-600*, SU-500*	Spiral
Acetylcellulose				
	Toray		SC-1000, 3000	Spiral
	UOP		ROGA-4160	Spiral
	Hydranautics		4007-1620CA	Spiral
	DSI		8054-98	Spiral
	Du Pont		C-1	Spiral
Cellulose triacetate				
	Toyobo		Hollosep	Hollow Fiber
Cross-link polyesther				
	Toray		PEC-1000*	Spiral
Polyacrylonitrile				
	Sumitomo Chemical Industry		Solrox	Tubular, Spriral
Polybenzamidazolone				
	Teijin		PBIL	Tubular, Sriral
Polysulfone				
	DSI		DesalPlus*	Spiral
	Millipore		PSRO*	Spiral
	Nitto Denko		NTR-6410,7450*	Spiral

*: Composite membrane

（Source) Kurihara, Aoki, Surface, 29(10)、 837(1991)

3. Seawater Intake Facility：

(1) Seawater intake point

The location of intake point is determined at approximately 200 m away from seashore with approximately 9 m depth from view points not to allow foreign bodies such as sea weed, sand, etc to enter during stormy weather like typhoon with enough seawater current.

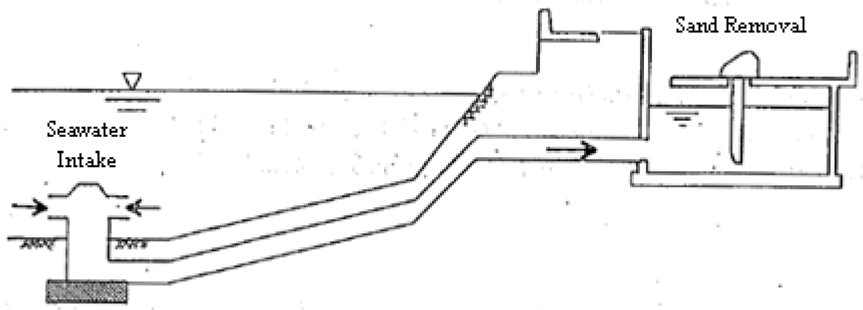
(2) Intake pipe

Assuming inner velocity in intake pipe is 1.32 m/sec, the pipe size is φ1,100 mm. With some allowance like shell adherence on the entrance of the pipe, the size was determinedφ1,200 mm. Chlorine injection was not used with the considerations of chlorine leakage into the sea by damage and/or corrosion of chlorine injection pipe.

The material of intake pipe is STPY 400, general material as sea bottom piping, with two type painting; epoxy resin for inner side and coal tar enamel for outer side of the pipe plus electroplating good for twenty years' resistance. .

(3) Intake pit

Intake pit level was estimation from the seawater level observation data at Naha Port Observatory with the considerations of the head losses in the pipe and at automatic sand collector. Maximum passing velocity of the screen is 0.13 m/sec.



4. Pre-treatment facility (Filter)

- Raw seawater turbidity : NTU 1～2 (SS 2 mg/L)
- To select the horizontal pressurized filters with the same type between first and second filter with economical construction cost
- Filtrate quality sometimes becomes worse just after back washing because some turbid particles leak from filter media. The second filter is for polishing to catch the leaked particles and get stable filtrate quality.
- The dimension of the filter was planned from the limits in manufacturing and transportation.

(1) Specifications of first filter

Type：	Horizontal pressurized filter (Dual Media Filter)
Dimension：	φ3,200 x 11,000L
Material：	SS/rubber lining inside
Filter media and depth ：	Anthracite 400 mm、sand 400 mm、stone 200 mm
Liner velocity ：	300 m/ day
Nos. of unit：	（12 +1）

(2) Second filter

Type：	Horizontal pressurized filter (Singe media)
Dimension：	φ3,200 x 11,500L
Material：	SS/ rubber lining inside
Filter media and depth：	Sand 700 mm、Stone 200 mm
Liner velocity：	400 m/day
Nos. of unit：	（9 +1）

5. <u>Chemicals for Pre-treatment</u>

Chemicals	Purpose
NaOCl	Disinfection, Prevention of pipe clogging by microorganism growth
$FeCl_3$	Removal of turbidity by coagulation-filtration
H_2SO_4	Prevention of scaling by lowing pH
$NaHSO_3$ (SBS)	Removal of chlorine, prevention of membrane deterioration

Chemical Dosing Rate

Chemicals	Dosing Rate (mg/L)
NaOCl	０.5 to 2.5
$FeCl_3$	2 to 8
H_2SO_4	40 to 50
$NAHSO_3$	5 x 2 台

(1) RO supply water quality indicators ：SDI or FI value 、ｐH、ORP, etc

(2) SDI value：less than 4

- Sea water with chlorine dosing →direct coagulation and filtration (Dual media filtration, polishing sand filtration)

(3) pH

- pH of seawater is about 8.3, to low pH up to less than 7 to prevent $CaCO_3$ deposition in seawater

(4) ORP：Confirmation of chlorine removal by $NaHSO_3$

6. Safety Filter

Production water : 537 m^3/h x (8+1)

Element allowable filtration size： More than 95 % removal of particles with over 20 μm

7. High Pressure Pump： Horizontally split type multistage centrifugal pump

8. Energy Recovery Device

- Seawater desalination RO system produces fresh water of around 40 % of feed water and the rest of around 60 % is discharged as brine with almost the same pressure as operation pressure.
- The power consumption by high pressure pump occupies more than 75 % of the total power consumption to operate whole RO system, which greatly gives impact on production cost.
- Accordingly energy saving is required by using pressure energy brine has as energy recovery turbine.
- Energy recovery rate by energy recovery turbine changes with the turbine efficiency. In general, the bigger the turbine capacity, the higher the energy recovery rate.
- The capacity of the one unit is 5,000 $m^{3/}$day. Accordingly, turbine suction capacity is 320 m^3/hour (Brine 3,000 m^3/day + 5,000 m^3/day = 8,000 m^3/day = 333 m^3/hour)
- Reverse rotation type (Francis Type) was determined as the type of the energy recovery turbine from the reasons below.

1) Efficiency and economy
   Although efficiency is inferior to the one of Pelton turbine, but economical.
2) Easiness in repair and maintenance
3) Installation space and civil base

Suitable for ground installation because civil base for installation is relatively easy in case of limitations of land space and weak supporting ground.

4) Achievements

9. Specifications of membrane element and vessel

(1) Membrane element

Type：	Spiral type
Material：	Aromatic polyamide composite membrane
Size：	ϕ 201 x 1,016^L
Performance ：	Permeate average more than 15 m^3/day
Salt rejection rate:	Average more than 99.75%（35,000 mg/L seawater）
	More than 99.60%（35,000 mg/L NaCl 溶液）
Nos. of element：	Approx. 5,000 m3/day/unit, 378 elements, 13 m^3/element
Total Nos. of element:	3,024/8 units (Approx. 40,000 m^3/day)

(2) Membrane Vessel

Type：	Cylindrical, horizontal. (for six membrane elements)
Nos. of vessels：	63 per unit, 7 rows x 9 beds
Design pressure ：	7.5 MPa
Material：	FRP

10. Operation Pressure

- Seawater permeate pressure: Approx. 2.5 MPa
- RO operation pressure : 5.6 ~ 6.5 MPa, More than two times pressure to seawater permeate is necessary for RO operation

Energy for RO membrane operation (theory)

Separation process (recovery rate or voltage charge to unit cell)	Theoretical unit power (kWh/m^3)
RO process (Recovery rate 40 %)	3.5
With 80 % energy recovery	1.8
RO process (Recovery rate 30 %)	4.7
With 80 % energy recovery	2.0
Electrolysis dialysis process (Voltage charge: 0.15 V)	2.4
Electrolysis dialysis process (Voltage charge: 5 V)	8.0
Multi-stage flush process	10.9*
Pervaporation (5 %)	14.9

*：100℃、35℃、Production ratio 10 exergy value

(Source) Haruhiko OTANI, Membrane separation, JIS

11. RO membrane cleaning agent

- Microorganism fouling： $NaHSO_3$ (SBS) or chloramine
- Inorganic fouling such as Fe, $CACO_3$：クエン酸 Citric acid (pH2~4)
- Organic fouling： Anion surfactant like DSS 0.1~1%

12. Slime generation prevention

- Seawater intake, Pre-treatment ： Chlorine
- RO membrane ： Chlorine gives a negative impact on for polyamide membrane Intermittent injection of SBS or chloramine (500 mg/L of SBS: 60 minutes' injection or 1mg/L chloromine: about 60 minutes)
- Contact chlorine with polyamide membrane brings improvement of water quality with

decrease of production water in a short time at the first stage. Chlorine leakage for a while results in
deterioration of water quality with increase of production water due to membrane damage by oxidation and decomposition of the membrane.

13. Attentions in Operation

With the operation time, decrease of production water and deterioration of water quality occur. The countermeasures are;

- Operation in compliance with membrane performance
  - Avoid excess operation pressure in constant quantity operation
  - Appropriation of feed water supply
- Asymmetric membrane like acetyl cellulose hollow fiber membrane has the tendency of compaction. Constant pressure operation will bring about decrease of production water. Aromatic polyamide membrane has less chance of the tendency.

14. Preservation of RO membrane：in SBS 0.05～0.1%

15. Parameters to give impacts on membrane performance

Main operation parameters;

- Pressure
- Temperature
- TDS concentration
- Feed flow
- Recovery rate

Conditions	Acetyl cellulose membrane	Composite membrane
High temperature		• Production water ：Big • TDS in production water： Big Increase of salt permeate rate is bigger than that of water production
High pressure	• Production water：Small • Compaction	• Production water： Big • TDS in production water：Small Increase of water production rate is bigger than that of salt permeate
Low pressure		• Production water：Small • TDS in production water：Big
Chemical reaction (Chlorine)	• Decrease of chlorine resistance in high temperature	• Deterioration

Condition	Impact
Constant recovery rate, high temperature	• Feed seawater ：Big • Both water production and TDS in it increase
Constant feed supply, high temperature	• Recovery rate： Increase Water production increases

Increase of recover rate means increase of TDS in brine and TDS in average feeding seawater, i.e permeate pressure in other words.

16. Wastewater Treatment

(1) Brine

- Adjust low pH brine because H_2SO_4 is injected to feed water due to anti-scaling. Reduce COD which comes from SBS to remove residual chorine by aeration in case of using polyamide membrane module.

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(2) Waste water from membrane preservation

- Membrane modules are reserved in SBS solution. The volume of wastewater generated is estimated approximately 180 m^3/cycle (60 L/element x 3,204 elements) for spiral type module.
- The wastewater is stored in a storage tank. It will be treated by aeration to reduce COD and discharged after pH adjustment with NaOH.

(3) Membrane cleaning wastewater

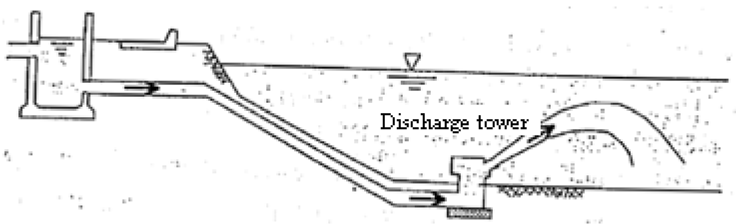
- 1 % citric acid is used for cleaning membrane module. COD in the wastewater will be equivalent to approximately 5,200 mg/L, SS 100 -500 mg/L with pH 4.
- Cleaning membranes are conducted several times per year. About 40 m^3/unit (about 5,000 m^3/cycle)
- pH adjustment by NaOH for membrane cleaning wastewater is necessary.

(4) Filter backwashing wastewater

- *About one time/day/unit (in case of SSinlet= 2mg/L, too much)*
- Total backwashing wastewater : *About 5,900 m^3/day (3.8 times/total V-media)*
- Wastewater is of high color and turbidity.
- Coagulation-sedimentation treatment is necessary.

17. Discharge Facility

- Adoption of discharge method in water; installation of discharge pipe to off-shore discharge point (multi nozzle type)



(1) Discharge point

Discharge point is about 200 m from off-shore, at 13 m water depth (Discharge nozzles about at 10 m water depth with the same conditions of intake point.

(2) Discharge pipe

- The material of discharge pipe is STPY 400, general material as sea bottom piping, with two type painting; epoxy resin for inner side and coal tar enamel for outer side of the pipe plus electroplating good for twenty years' resistance. .

(3) Discharge tank : V=210 m^3 x 1

(4) Discharge nozzle

16 nozzles (ϕ 100 mm) at the opposite side of the land, maximum flow velocity 6.4 m/sec

<u>Considerations of seawater intake and discharge point</u>

- To avoid corals which are exposed in ebb tide

- The location to avoid not to allow foreign bodies such as sea weed, sand, etc to enter during stormy weather like typhoon.
- The location with enough seawater current to change clean seawater .
- Location of discharge point: not to give impact on water intake point by discharge brine with heavy specific gravity

18. Materials of Main Equipment

Materials of Main Equipment

Equipment		Material
Filter	Body	SS 400/Rubber lining
	Accessories inside	SS 400/Ruber lining、 SUS-316L
Safety filter	Body	SUS-316L
	Accessories inside	Polypropylene、 SUS-316L
High pressure pump	Body and impeller	Duplex stainless
	Main shaft	Duplex stainless
Energy recovery turbine	Body and impeller	Duplex stainless
	Main shaft	Duplex stainless
Sea water pump	Body	Duplex stainless
	Impeller	SCS14
	Main shaft	SUS-316L
Pipe、 Valve	High pressure pipe	SUS-316L
	High pressure valves	SCS14
	Low pressure pipe	SGP/polyethylene lining、 SUS-316L
	Low pressure valves	FCD/rubber lining、 SCS-14
H2SO4 tank	Tank	SS400/PTFE
	Feed pump	SCS14/PTFE
FeCl3 tank	Tank	FRP
	Feed pump	PVC/PTFE
Cushion tank		RC with epoxy resin paint inside
Production water tank		SUS444

（Note）PTFE：Teflon

19. Building, Installation Conditions

(1) RO plant should be in a building

- RO elements in RO vessels will be deteriorated by direct sunlight, increase of temperature, unexpected weather conditions, etc.

(2) The plant should be installed on a firm ground.

(3) Generator is necessary.

(4) To keep RO plant within 35 ℃.

(5) To prevent vapor from being condensed

Public Health and the Environment World Health Organization Geneva 2007, Desalination for Safe Water Supply Guidance for the Health and Environmental Aspects Applicable to Desalination

1. Intake facilities

- Intake facility occupies 10 -30 % of the capital cost of entire facility.
- Seawater intake wells are either vertical or horizontal source water collectors, which are typically located in close vicinity to the sea. In the case of aquifers of high porosity and transmissivity, which easily facilitate underground seawater transport such as the limestone formations, seawater of high quality and large quantity may be collected using intake wells located in-land rather than at the shore. (well: less than 20,000 m^3/day)
- Raw sea water collected using wells is usually of better quality in terms of solids, silt, oil & grease, natural organic contamination and aquatic microorganisms, as compared to open seawater intakes. Well intakes may also yield source water of lower salinity than open intakes.

2. Pretreatment

- Generally most membranes require feed water with an SDI of less than 5 (favorably 4) in order to maintain steady and predictable performance.
- Chemicals used for pretreatment prior to membrane desalination

3. Product Water Disinfection

- Usually chlorine dosage used for disinfection is 1.5 to 2.5 mg/litre.
- Usually, sodium hypochlorite solutions decay rapidly over time and loose 10 to 20 % of their strength over a period of 10 to 15 days, especially in warm climates.

4. Concentrates management

- The TDS level of concentrate from seawater desalination plants usually is in a range of 65,000 to 85,000 mg/litre;
- The amount of particles, total suspended solids (TSS) and biological oxidation demand (BOD) in the concentrate is usually below 5 mg/litre because these constituents are removed by the plant's pretreatment system.
- Often scale inhibitors contain phosphates or organic polymers. The concentration of scale inhibitors in the concentrate may reach 20 to 30 mg/litre.
- The elevated salt content of the concentrate samples could interfere with the standard analytical procedures and could often produce erroneous results. Therefore, concentrate

analysis has to be completed by an analytical laboratory experienced with and properly equipped for seawater analysis.

- Many crops and plants cannot tolerate irrigation water that contains over 1000 mg/litre of TDS. However, TDS is not the only parameter of concern in terms of irrigation water quality.
- Boron/borate levels in the effluent could also limit agricultural reuse because borates are herbicides. Chlorides and sodium may also have measurable effects on the irrigated plants. Most plants cannot tolerate chloride levels above 250 mg/litre.

Pretreatment chemicals used in membrane desalination systems

Chemical Type	Purpose of Use	Dose	Application
Scale inhibitors (polyelectrolyte polymer blends).	Increase of solubility of sparingly soluble salts such as calcium and magnesium carbonates and sulfates. Additional chemicals may be used to target specific species, such as silica.	<2-5 mg/litre	Primarily in brackish water desalination and water reclamation using RO and ED/EDR operating at high recoveries.
Acid (usually sulfuric acid).	Reduction of pH for inhibition of scaling and for improved coagulation.	40-50mg/litre as required to reduce pH to ≈6-7	Primarily in seawater RO applications. Not used in all applications.
Coagulant (usually ferric chloride or ferric sulphate).	Improvement of suspended solids removal.	5 -15 mg/litre	Primarily in open intake seawater RO and surface water RO systems.
Flocculant Aid (usually cationic polymer).	Improvement of suspended solids removal.	1-5 mg/litre	Primarily in open intake seawater RO and surface water RO. May only be used intermittently when feed SDI is unusually high.
Oxidizing Agent; most often a form of chlorine. However biocides have found some use, particularly in smaller systems.	To control bio-fouling and aquatic organism growth in the intake and pre-treatment facilities. Chloramines may be used for pre-treatment in reclamation systems and their use should be avoided in seawater desalination systems.	Site specific but may be 3.7mg/litre for 30-120 minutes every 1-5 days	Used for large surface and sea water intakes. Small systems and those using wells, especially those in which source water is anaerobic may not require oxidation.
Reducing agent (usually a form of bisulfite); function of chlorine dosage	To eliminate oxidizing impacts on the RO membrane.	Generally 2 to 3 times higher than oxidizing agent dose	In all membrane processes using polyamide RO membranes (Less common cellulose acetate membranes have greater tolerance of oxidants).
Membrane preservation and sterilization	Off line membranes must be sterilized and preserved. Sterilization may utilize hydrogen peroxide. In some cases acetic acid is also used to create peracetic acid. Preservation most commonly utilizes sodium bisulfite.		

- Chemicals used for pretreatment should be of high-quality ("food-grade")

Residuals from membrane desalination processes

Residual	Source or cause	Application
Backwash Solids/Sludge	Suspended solids in the feed water	Open intake seawater, brackish surface water
Backwash water	From removal of suspended	Open intake seawater, brackish solids in the feed water surface water
Cleaning Solutions	Cleaning of filtration membranes (MF/UF) and process membranes (RO, NF)	Open intake seawater, brackish surface water
Concentrate or blow down (if cross flow)	Filtration membranes operating in a cross flow mode	Open intake seawater, brackish surface water
Spent media (sand, anthracite and/or garnet)	From the removal of suspended solids in the feed water	Open intake seawater, brackish surface water
Cartridge Filters – polypropylene	Final fine filtration prior to RO, periodic replacement	Most membrane desalination processes, except those using MF/UF filtration membranes
MF/UF membranes – polymeric material (polypropylene, polysulphone, polyvinylidene-fluroide (PVDF), cellulose acetate	Membrane replacement for MF/UF systems	Open intake seawater, brackish surface water
RO membranes (polyamide thin film composite, cellulose acetate)	Membrane replacements.	Open intake seawater, brackish surface water

- In general, the membrane pretreatment systems produce 1.5 to 2 times larger volume of spent filter backwash water than the granular media filters. However, contrary to the MF or UF membrane pretreatment filters, the granular media filters require their feed water to be preconditioned with coagulant (usually iron salt) prior to filtration. This typically adds 60 to 80 percent of additional solids load to the spent filter discharge, and therefore its disposal typically results in higher solids handling costs.
- Filter backwash sedimentation tanks are often designed for a retention time of 3 to 4 hours and allow removing more than 90 percent of the backwash solids.

5. Small desalination systems

- Less than 4.000 m^3/day
- Sea based mobile applications that are configured in one skid and often referred to as package plants.
- For small skid mounted systems, it is common to have the pretreatment chemical injection points, cartridge filter, feed pump, and membranes and pressure vessels on the skid.
- Small membrane desalination units may be deigned to operate with smaller size (2-inch ~5 cm or 4-inch ~10 cm) membranes.

6. Chemical Aspects of Desalinated Water

(1) Boron and bromide

In terms of key contaminants of direct interest for health and environment, the most important is probably boron, which can be of significance in reverse osmosis plants since the rejection ratio of boron (probably mostly as borate) is less than that for most other inorganics.

The current WHO guideline value for boron (borate) in drinking water is 0.5 mg/litre, however, this is due to be reconsidered under the rolling revision of the Guidelines (WHO, 2004). Although a health based guideline might possibly be 1 mg/litre or higher, there are plants that are sensitive at 0.5 mg/litre.

The latter might become the principal issue for residual boron i.e. its effect as an herbicide if present in sufficient amount in irrigation water, particularly in areas where rainfall is so low as to not cause leaching of salts from soils.

7. Quality control

Quality control of chemicals, maintenance of monitoring equipment, review of laboratory performance and selection of test methods are important components of monitoring programs.

(1) Additives and chemicals

- to use only chemicals certified for use in the production of drinking water.
- Documented procedures for the control of chemicals, including purchasing, certification, delivery, handling, storage and maintenance should be established and adherence to these procedures should be monitored.

(2) Monitoring equipment, sampling, laboratories and methods of analysis

Monitoring can be undertaken using on-line instruments, field kits and laboratory-based analyses depending upon the application of the data and the precision and accuracy requirements.

- Maintenance and regular calibration of on-line instruments and field kits. Chemicals used in these instruments and kits should be stored under appropriate conditions and results obtained should be periodically checked by comparison with laboratory based analyses.
- Assurance of the accuracy and representative nature of water samples. Guidance on sample collection is provided in International Organization for Standardization (ISO) Standard 5667.
- Regular assessment of the competence and accuracy of testing laboratories. General guidance on quality assurance for analytical laboratories is provided in Water Quality Monitoring (Bartram, 1996).
- An important issue for desalination facilities is the selection of appropriate testing
- Equipment and testing methods. Equipment and methods used to monitor freshwater

sources of drinking water may not be suitable or provide accurate results when used with high salinity water

- Suggested monitoring parameters and frequencies for desalination plants (Small plant)

Component Control measures	**Control measures**	**Operational Parameters**	**Monitoring frequency**
Source	Detect and prevent contamination by sewage (Pathogenic protozoa, viruses, bacteria) (Likelihood of presence based on sanitary inspection)	Enterococci and/or E.coli	Weekly
	Detect and prevent impacts of storm events	Turbidity (used as on-line measurement for process control)	Preferably on-line
	Detect and prevent impacts of microalgae/cyanobacteria	Algal species, including cyanobacteria, dinoflagellates, or chlorophyll as a surrogate	Monthly
	Detect and prevent impacts by industrial discharges (based on an assessment of local conditions)	TOC (if concentrations change investigate sources)	Monthly
		Petroleum oil hydrocarbons/grease including volatile compounds	Yearly
		Industrial chemicals	Monthly
		Radioactivity	Yearly
	Monitoring associated with downstream control measures (pre-treatment and treatment)	Salinity	Daily
		Chloride	Daily
		Sodium	Weekly
		Boron	Yearly
		Bromide	Yearly
		Silica	Daily
		Iron	Weekly
		Manganese	Yearly
		Turbidity	On-line
		Alkalinity	Daily
		pH	On-line
		Temperature	On-line
		Heavy metals	Monthly
		Low solubility chemicals e.g. Ca, , F, Ba, Sr, Mg, ,fluoride, sulfate	Monthly
		Hydrogen sulphide and metal sulphides	Monthly
		Ammonia	Monthly
		Total dissolved solids (TDS)	Daily
Pre-treatment	Detection and prevention of biofouling/scaling/precipitation	SDI	On-line
		Flow rates	On-line
		Conductivity	On-line
		Conductivity/TDS ratios	Daily
		Turbidity after pre-treatment, particle counts	Daily
		pH (if acidification or alkalinisation)	On-line
	Use of additives e.g. antiscalant	Flow and dose rate monitoring	On-line
	Quality control on additives and materials	Test additives and materials; check records	Daily
	Prevention of microbial fouling	Disinfectant residual or ORP	On-line
Process Management	Membranes	Recovery ratio (calculated from flow rates)	Daily

Component Control measures	Control measures	Operational Parameters	Monitoring frequency
Process Management	Membranes	Chemical balance from conductivities and flow rates (calculated)	Monthly
		Trans-membrane pressure	On-line
		Flow meters on permeate and brine	On-line
		Conductivity in permeate and brine	On-line
		TOC (particularly where source water contains elevated microbial contamination)	On-line
Disinfection	Removal of microbial contaminants	Disinfectant dose monitoring	On-line
		Calculate Ct (Values for Inactivation of Viruses (mg-minutes/L) (Concentration x time)	Weekly
		HPC (heterotrophic plate counts)	Yearly
		Disinfection byproducts (including brominated compounds) relevant to the method of disinfection	Monthly
Corrosion inhibition	Reduction of corrosion in distribution systems using inhibitors such as phosphates and silicates	Flow and dose rate monitoring	On-line
	Quality control on additives and materials	Test additives and materials; check records	Daily
Storage Distribution	Preventing microbial and chemical contamination by controlling intrusion through cross connections/backflow or faults in mains or other infrastructure	E.coli	Weekly
		HPC	Monthly
		Turbidity	Daily
		Inspect for system integrity, monitor burst main frequency and repairs	Monthly
		Monitor system leakage	Yearly
	Control of free living microorganisms	HPC	Weekly
		Disinfectant residual (consider persistent disinfectant where Legionella/Naegleria potential considered unacceptable)	Daily
	Prevention of corrosion in storage tanks, long pipes, domestic plumbing	pH	Daily
		Iron	Monthly
		Zinc	Yearly
		Nickel	Yearly
		Copper	Yearly
		Lead (if problem)	Monthly
		Zinc and phosphate (if corrosion inhibitors are used)	Weelky
	Maintain chemical stability after mixing different sources (desalinated/non-desalinated water) or after disinfection	Post mixing or post disinfection monitoring for LSI (Langlier Saturation Index) /CCPP (Calcium Carbonate Precipitation Potential) where mortar linings used or Larson Index where steel or carbon/steel used	Daily
	Disinfection	Disinfection by-products (including brominated compounds)	Monthly

Component Control measures	Control measures	Operational Parameters	Monitoring frequency
Concentrate discharges	In marine or brackish lake environments select discharge points to minimise impacts. Discharge into areas with high levels of mixing or use diffusers to promote mixing	Temperature and DO (thermal processes)	On-line
		pH	On-line
		Salinity	On-line
		Heavy metals/salts	Quarterly
		Additives	Quarterly
		Phosphates and nitrates	Quarterly
Wastewater effluents from pre-treatment facilities or from membrane cleaning	Collect discharges and treat or discharge in accord with requirements set by environment protection agencies	pH	On-line
		Turbidity	On-line
		Suspended solids(SS)	Daily
		Residual disinfectants	Daily
		Iron or aluminum – based on the type of coagulant used	Monthly
		Membrane cleaning agents	On discharge

8. EIA (Standard Approach)

- "Mandatory' or 'positive' lists which include projects always requiring EIA (e.g. major projects, possibly large co-generation plants for electricity and water);
- Project lists which define thresholds and criteria above which EIA is required (e.g. a desalination plant with more than 20,000 m3/day of production capacity);
- 'Exclusion' or 'negative' lists which specify thresholds and criteria below which EIA is never required or below which a simplified EIA procedure applies (e.g. a desalination unit with less than **4,000 m^3/day** of production capacity).

Jørgen Wagner, B. Sc. Chem. Eng, Membrane Filtration Handbook Practical Tips and Hints, Second Edition, Revision 2, November 2001

1. Replacement spiral wound element price.

- Thin-film RO sells for US$ 15 - 25 per m^2 membrane area

(Note) the price varies from country to country. It also depends on the number of elements and element construction.

2. DESIGNING A SYSTEM

1	Select, guess or measure flux in lmh.
2	Calculate the number of m2 membrane area by dividing permeate volume by flux. (15 to 25 lmh)
3	Select a membrane element and find the m2 membrane area per element.
4	Calculate the number of membrane elements: (membrane area) / (membrane area per module)
5	Is the number of modules reasonable? If NO : go back to # 4 If YES : continue to # 6
6	Is there more than one membrane element per housing, e.g. spiral wound elements? If YES : select the number of modules per housing and calculate number of housings. If NO : continue to #7
7	Calculating the number of recirculation loops is a bit tricky, because several parameters are involved in making a decision. If the flux curve is steep, select relatively many loops. If the flux curve flat, select relatively few loops. Select a number of loops and distribute the membrane elements evenly. Are the number of housings/modules big enough to justify the number of loops chosen? (The more expensive a system is, the more loops can be justified in order to increase efficiency and decrease membrane costs.)
8	Find the specified feed flow and typical pressure drop per module. Since all modules/housings in a loop are in parallel, the type of recirculation pump can be chosen. Knowing the volume to be treated and (hopefully) the operating pressure, a feed pump can be chosen.
9	Having selected flow, pressure and pumps, the kW consumed can be calculated.
10	With respect to the cost of a membrane system, only a broad guideline can be provided. For industrial applications: Most spiral wound element systems will cost between US$ 400 and US$ 600 per m^2 installed. These numbers can be doubled for more expensive tubular or fiber systems. For water desalination: Somewhat less expensive than industrial systems.
11	The internal volume is typically 1.5 liters per m^2 membrane area. This figure is important in order to calculate the amount of water used for flushing.
12	Water for flushing is three times the internal volume per flush.
13	Variable costs are mostly US$ 0.4 - 1.0 per m3 permeate. Interest and amortization is the same number as the variable costs. US$ 1 per m3 permeate in total is a good figure.
14	There are no good rules of thumb for floor space. A lab system will usually take 2 -3 m^2. A production system with 1,000 m^2 membrane as spiral wound elements needs 30 square meters of floor space. Compared to most other processes, membrane filtration equipment does not take up much floor space.
15	Membranes are a consumable item. All users want to know how long membranes last, but it varies widely

	from application to application. The following is typical for polymer membranes, but even small variations in product composition can have a big impact on the life time, and so can the plant operator. Water RO, NF 3 to 6 years Water UF 2 to 4 years
16	Typical investment in a complete system, Prices based on incl. pumps, tubes, membranes and controls exchange rates January 2000. US$ per m^2 Spiral wound element water 150 Spiral wound element industrial 350 Tubular 1400 Plate and frame >1700 Fiber system >1700 Ceramic >3000

3. Comparison Between Spiral and Hollow Fiber Membrane Modules

	Spiral wound element	**Hollow Fiber (wider)**	**Hollow Fiber (fine)***
Membrane density (m^2/m^3)	High	Average	Very high
Plant investment	Low	Very high	Medium
Tendency to fouling	Average	Low	Very high
Cleanability	Good	Low	None
Variable costs	Low	Average	Low
Change of membrane (see note 1)	No	No	No
Flow demand	Medium	High	Low
Pre-filter, Other demands	≦50 µm, no fibers	≦100 µm, few fibers	≦5 µm, extreme pre-treatment

Note 1) Membrane systems can be designed in such a way that a change of membrane means a complete change of a major part of the hardware. Most tubular and flat sheet designs are made in such a way that only the membrane is changed, leaving the bulk of the system unchanged.

4. Glass Fiber and Stainless Steel Vessel

	(FRP)	**Stainless Steel**
Pressure	20 mPa	rarely above 8.0 mPa
Temperature	<70°C	<100°C
Side port entry	difficult / rare	easy / standard
End cap entry	standard	non-standard
Sanitary	no	yes (possible)
Price	100%	150 - 200%
2.5", 4.0", 8.0"	water standard	difficult
3.8", 5.8", 6.3"	not available	dairy standard
6.0"	military standard	not used
4.3", 8.3"	not available	Koch dairy standard

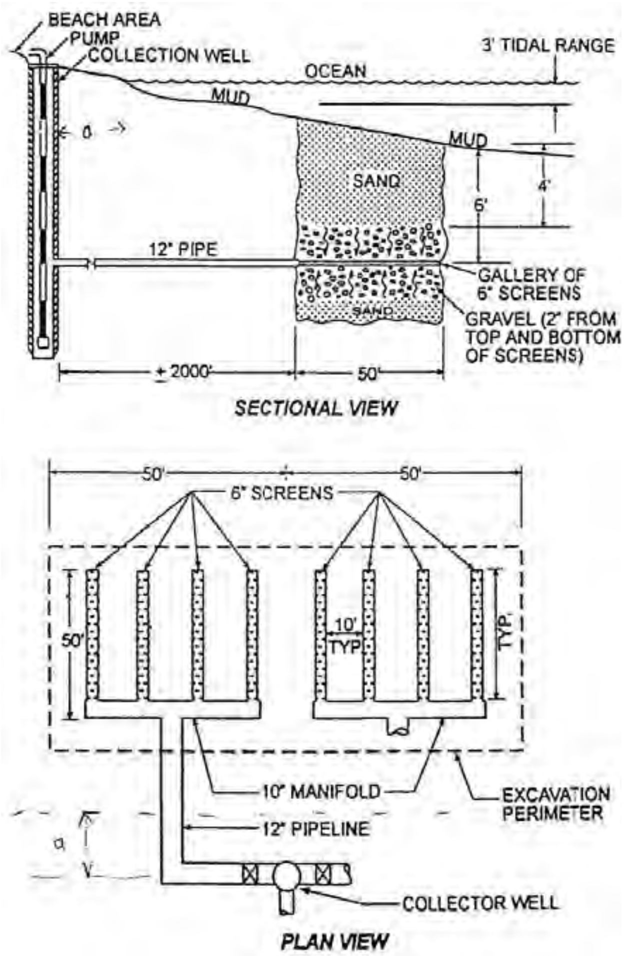
Desalination: A National Perspective Committee on Advancing Desalination Technology, National Research Council ISBN: 0-309-11924-3, 316 pages, 6 x 9, (2008)

1. Average Seawater Quality (mg/L)

TDS	35,000
Chloride	19,000
Sodium	10,500
Sulfate	2,700
Magnesium	1,350
Calcium	410
Potassium	390
Bicarbonate	142
Bromide	67
Strontium	8
Silica	6.4
Boron	4.5
Fluoride	1.3
Nitrate	3.0
Arsenic	0.003
Uranium	0.003
Selenium	0.00009

2. Intake facility

- Design engineering, equipment procurement, and construction spending on intakes and outfalls are estimated to total 5 to 7 percent of capital costs for RO
- Coastal subsurface intakes include beach wells, radial wells, horizontal directionally drilled (also called slant-drilled) wells, and infiltration galleries. By taking advantage of the natural filtration provided by sediments, subsurface seawater intakes can reduce the amount of total organic carbon and total suspended solids, thereby reducing the pretreatment required for membrane-based desalination systems and lowering the associated operations and maintenance costs. Pumping from subsurface intakes may also under some conditions dilute the seawater with less saline groundwater, thereby reducing the total dissolved solids (TDS) in the intake water.
- Vertically drilled beach wells are typically used for small (<19,000 m^3/day; 5 MGD) systems where the local hydrogeology (e.g., aquifer transmissivity) will permit it.
- One of the potential disadvantages of beach wells is that deep wells may result in lower water temperature and thus higher viscosity; hence, higher pressure (and increased energy) will be required to pump the water through the RO



Seabed filtration system.

3. Pre-treatment

- Proper pretreatment of feed water is the most important factor in the successful operation of an RO plant, and pilot testing of the pretreatment process is a critical part of plant design.
- Subsurface seawater intakes, aquatic filter barriers, and deep ocean water intakes can greatly reduce the need for pretreatment.

4. RO membrane

- For seawater RO, the specific energy usage is typically about 3-7 kwh/m^3 with energy recovery devices
- For brackish water RO, energy usage is comparatively lower, about 0.5-3 kwh/m^3
- Predominant Seawater RO Processes

Operating temperature (°C)	<45
Pretreatment requirement [d)]	High
Electrical energy use (kWh/m^3)	2.5-7
Current, typical single train capacity (m^3/d) [a)]	< 20,000
Product water quality (TDS mg/L)	200-500 [b)]

Typical water recovery	35-50%
Reliability [c)]	Moderate

a) For the purpose of this table, a train is considered a process subsystem which includes the high pressure pump, the membrane array(s), energy recovery devices, and associated instrumentation/control.

However, larger facilities may group pumps, membranes, and energy recovery into process or pressure centers to lower capital costs and improve operating costs.

b) Product water quality for RO is a design variable. Each pass through an RO plant typically removes 99 to 99.5 percent of dissolves salts in the feed water. Successive passes using additional membranes can be added along with other design optimizations to achieve permeate with the TDS required for a target water use. Potable water requirements can readily be met with 200-500 mg/L TDS water, which can be achieved from seawater with a single RO pass.

c) and d) : Compared to electro-dialysis or vapor process

5. Energy Recovery Devices.

- Typically 40 to 60 percent of the applied energy in the process can be lost if the concentrate is discharged to atmosphere without any attempt to recover that energy.
- In general, energy recovery devices can recover from 75 to 96 percent of the input energy in the concentrate stream of a seawater RO plant
- Existing energy recovery systems can be divided into two categories.
- The first are devices that transfer the concentrate pressure directly to the feed-stream (e.g., pressure exchanger, work exchanger), which have energy recovery efficiencies of about 95 percent.
- The second category includes devices that transfer concentrate pressure to mechanical power, which is then converted back to feed pressure (e.g., Pelton turbine, Francis turbine, reverse-running pumps). The overall efficiency of energy recovery here is about 74 percent (assuming a Pelton turbine efficiency of around 87 percent coupled with a pump efficiency of 85 percent).

6. Typical NF and RO cleaning formulations.

Foulant	Type Cleaning Solutions
Inorganic saltsa	0.2% HCl
	0.5% H_3PO_4
	2% citric acid
Metal oxides	2% citric acid
	1% $Na_2S_2O_4$
Inorganic colloids (silt)	0.1% NaOH, 0.05% Na dodecyl benzene sulfonate, pH 12
Silica (and metal silicates)	Ammonium bifluoride

	0.1% NaOH, 0.05% Na dodecyl bezene sulfonate, pH 12
Biofilms and organics	Hypochlorite, hydrogen peroxide, 0.1% NaOH, 0.05% Na dodecyl bezene sulfonate, pH 12
	1% sodium tripolyphosphate, 1% trisodium phosphate, 1% sodium EDTA

Source: Dow Chemical

7. Climate Change and Desalination

There seems to be no question that climate change will significantly impact the water resources sector and, as such, will indirectly impact desalinization. A rise in sea level over tens of years may have adverse impacts on coastal aquifers from increased seawater intrusion. Direct impacts of rising ocean levels may over the lifetime of the project have some minor effect on desalination structures built adjacent to coastlines because current sea-level rise is approximately 2 mm/year (United Nations Intergovernmental Panel on Climate Change, 2007). Furthermore, storms associated with climate warming may be of either higher frequency or higher intensity.

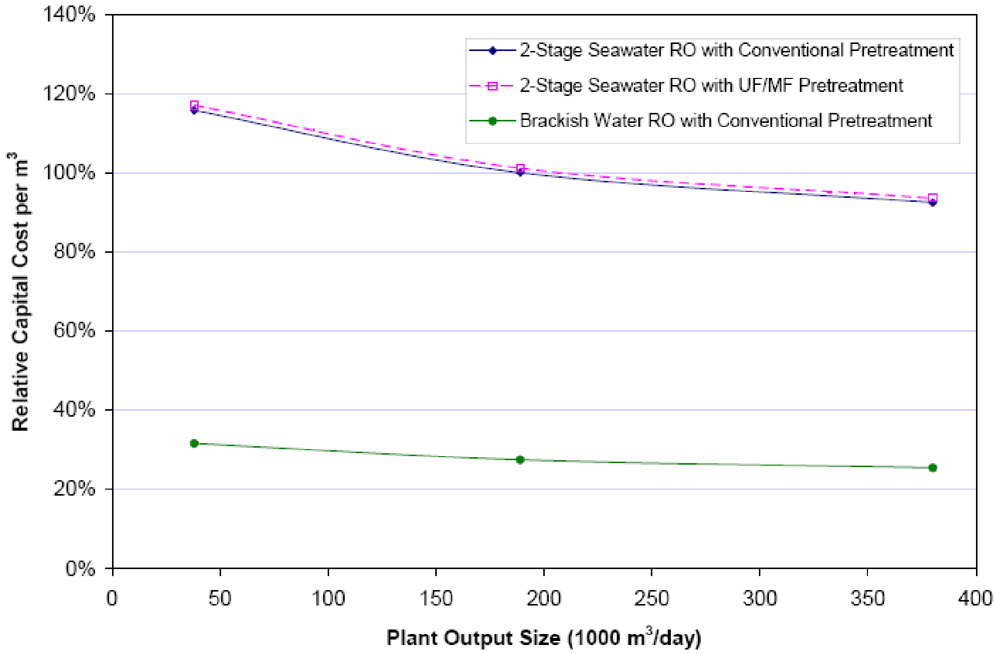
Depending on the location of the intake, the temperature of the water may increase slightly, requiring small changes to the desalination process. Although these direct impacts to desalination structures and processes appear to be small, they should be clearly understood prior to the design of a major desalination facility.

8. The Costs and Benefits of Desalination

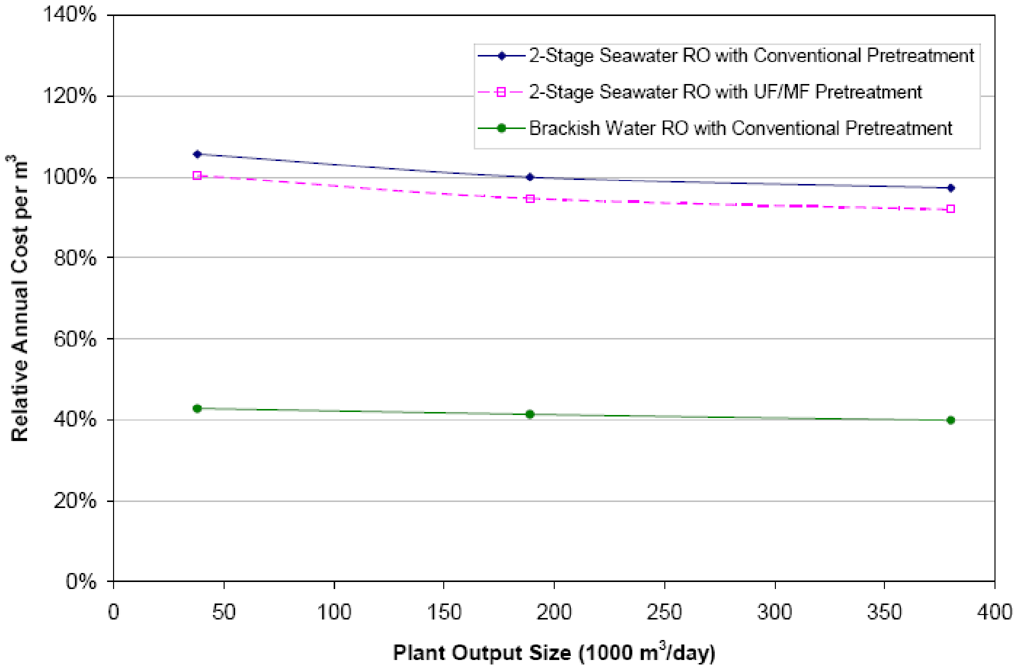
- The costs for the seawater desalination process by RO to be \$0.61/m^3. The cost is based on a system of 100,000 m3/day; a normal interest rate of 6 percent; \$450 element cost; \$0.05/kWh energy cost; assumed electricity use of 4.5 kWh/m^3; and 20-year capital invest period.

Annualized capital costs	0.15
Parts/maintenance	0.03
Chemicals	0.07
Labor	0.10
Membranes (life not specified)	0.03
Electrical energy (\$0.05 k/Wh)	0.23
Total (\$/m3)	**0.61**

- Bid construction cost for a 3,000 m^3/day (0.8 million gallons per day [MGD]) RO facility was about \$26 million, of which approximately \$7 million was accounted for by the costs of a brine concentrator
- Impact of Water Source, Scale, and Process Design on Capital Costs (38,000 to 380,000 m^3/day)
- Membrane Life. Membrane costs are now quite modest, ranging from only 3 to 5 percent of annual costs. Extending membrane life is likely to have a very small impact on desalination costs.



Relative capital costs per cubic meter for seawater and brackish water RO desalination according to facility size. Brackish water is 1,000 mg/L TDS(38,000 to 380,000 m^3/day). below 38,000 m^3/day where the costs rise even more dramatically (USBR, 2003)



Effect of facility size, water source, and pretreatment process on relative annual costs per cubic meter for RO plants. The baseline assumptions for this scenario are as follows: energy costs are constant at $0.07/kWh; membrane life is assumed to be 5 years; nominal interest rate is 5 percent; depreciation period is 25 years.

9. Research to Lower the Costs of Desalination

(1) Improve pretreatment for membrane desalination

Pretreatment is necessary to remove potential foulants from the source water, thereby ensuring sustainable operation of the RO membranes at high product water flux and salt rejection. Research to improve the pretreatment process is needed that would develop alternative, cost-effective approaches.

- **Develop more robust, cost-effective pretreatment processes.**

  Membrane fouling is one of the most problematic issues facing seawater desalination. Forms of fouling common with RO membranes are organic fouling, scaling, colloidal fouling, and bio-fouling. All forms of fouling are caused by interactions between the foulant and the membrane surface. Improved pretreatment that minimizes these interactions will reduce irreversible membrane fouling.

  Alteration of solution characteristics can improve the solubility of the foulants, preventing their precipitation or interaction with the membrane surface. Such alteration could be chemical, electrochemical, or physical in nature.

Membranes such as microfiltration (MF) and ultrafiltration (UF) have several advantages over traditional pretreatment (e.g., conventional sand filtration) because they have a smaller footprint, are more efficient in removing smaller foulants, and provide a more stable influent to the RO membranes. Additional potential benefits of MF or UF pretreatment are increased flux, increased recovery, longer membrane life, and decreased cleaning frequency. More research is necessary in order to optimize the pretreatment membranes for more effective removal of foulants to the RO system, to reduce the fouling of the pretreatment membranes, and to improve configuration of the pretreatment membranes to maximize cost reduction.

- **Reduce chemical requirements for pretreatment**.

  Antiscalants, coagulants, and oxidants (such as chlorine) are common chemicals applied in the pretreatment steps for RO membranes. Although these chemicals are added to reduce fouling, they add to the operational costs, can reduce the operating life of membranes, and have to be disposed of properly or they can adversely impact aquatic life. Antiscalants may also enhance bio-fouling, so alternative formulations or approaches should be examined. Research is needed on alternative formulations or approaches (including membrane pretreatment) to reduce the chemical requirements of the pretreatment process, both to reduce overall cost and to decrease the environmental impacts of desalination.

(2) Improve membrane system performance

Sustainable operation of the RO membranes at the designed product water flux and salt rejection is a key to the reduction of desalination process costs. In addition to effective pretreatment, research to optimize the sustained performance of the RO membrane system is needed.

- Develop high-permeability, fouling-resistant, high-rejection, oxidant-resistant membranes. New membrane designs could reduce the treatment costs of desalination by improving membrane permeability and salt rejection while increasing resistance to fouling and membrane oxidation. Current membrane research to reduce fouling includes altering the surface charge, increasing hydrophilicity, adding polymers as a barrier to fouling, and decreasing surface roughness.

  Oxidant-resistant membranes enable feedwater to maintain an oxidant residual that will reduce membrane fouling due to biological growth. Current state-of-the-art thin-film composite desalination membranes are polyamide based and therefore are vulnerable to damage by chlorine or other oxidants. Thus, when an oxiant such as chlorine is added to reduce bio-fouling, dechlorination is necessary to prevent structural damage. Additionally, trace concentrations of chlorine may be present in some feed waters. Cellulose-derivative RO membranes have much higher chlorine tolerance; however, these membranes have a much lower permeability than thinfilm composite membranes and operate under a narrower pH range. Therefore, there is a need to increase the oxidant tolerance of the higher-permeability membranes. Lower risk of premature membrane replacement equates to overall lower operating costs.

  Past efforts to synthesize RO membranes with high permeability often resulted in reduced rejection and selectivity. There is a need to develop RO membranes with high permeability without sacrificing selectivity or rejection efficiency. Recent research on utilizing nanomaterials, such as carbon nanotubes, as a separation barrier suggest the possibility of obtaining water fluxes much higher than that of traditional polymeric membranes.

  The development of membranes that are more resistant to degradation from exposure to cleaning chemicals will extend the useful life of a membrane module. The ability to clean membranes more frequently can also decrease energy usage because membrane fouling results in higher differential pressure loss through the modules. By extending the life of membrane modules, the operating and maintenance cost will be reduced by the associated reduction in membrane replacements required.

- **Optimize membrane system design.**

  With the development of high-flux membranes and larger-diameter membrane modules, new approaches for optimal RO system design are needed to avoid operation under thermodynamic restriction and to ensure equal distribution of flux between the leading and tail elements of the RO system. The key variables for the system design will involve the choice of optimal pressure, the number of stages, and number and size of membrane elements at each stage. An optimal system configuration may also involve hybrid designs where one type of membrane (e.g., intermediate flux, highly foulingresistant) is used in the leading elements followed by high-flux membranes in the subsequent elements. Fouling can be mitigated by maintaining high crossflow velocity; thus, foulingresistant membranes may be better served in the downstream positions where lower crossflow velocity is incurred. Thus, additional engineering research on membrane system design is needed to optimize performance with the objective of reducing costs.

- **Develop lower-cost, corrosion-resistant materials of construction**.
  The duration of equipment life in a desalination plant directly relates to the total costs of the project. Saline and brackish water plants are considered to be a corrosive environment due to the high levels of salts in the raw water. The development and utilization of corrosion-resistant materials will minimize the frequency of equipment or appurtenance replacement, which can significantly reduce the total project costs.

- **Develop ion-selective processes for brackish water**.
  Some slightly brackish waters could be made potable simply though specific removal of certain contaminants, such as nitrate or arsenite, while removing other ions such as sodium, chloride, and bicarbonate at a lower rate.
  High removal rates of all salts are not necessary for such waters. Ion-specific separation processes, such as an ion-selective membrane or a selective ion-exchange resin, should be able to produce potable water at much lower energy costs than those processes that fully desalinate the source water. Ion-selective removal would also create fewer waste materials requiring disposal.
  Ion-selective processes would be useful for mildly brackish groundwater sources with high levels of nitrate, uranium, radium, or arsenic. Such an ion-selective process could also be used to optimize boron removal following RO desalination of seawater.

- **Develop hybrid desalination processes to increase recovery**.
  Overall product water recovery in a desalination plant can be increased through the serial application of more than one desalination process. For example, an RO process could be preceded by a “tight” nanofiltration process, allowing the RO to operate at a higher recovery than it could with less aggressive pretreatment. Other options could be devised, including

hybrid thermal and membrane processes to increase the overall recovery of the process.

The possible hybrid combinations of desalination processes are limited only by ingenuity and identification of economically viable applications. Hybridization also offers opportunities for reducing desalination production costs and expanding the flexibility of operations, especially when collocated with power plants, but hybridization also increases plant complexity and raises challenges in operation and automation.

(3) Improve existing desalination approaches to reduce primary energy use

Energy is one of the largest annual costs in the desalination process. Thus, research to improve the energy efficiency of desalination technologies could make a significant contribution to reducing costs.

- **Develop improved energy recovery technologies and techniques for desalination**.
  Membrane desalination is an energy-intensive process compared to treatment of freshwater sources. Modern energy recovery devices operate at up to 96 percent energy recovery, although these efficiencies are lower at average operating conditions. The energy recovery method in most common use today is the energy recovery (or Pelton) turbine, which achieves about 87 percent efficiency. Many modern plants still use Pelton wheels because of the higher capital cost of isobaric devices. Thus, opportunities exist to improve recovery of energy from the desalination concentrate over a wide operating range and reduce overall energy costs.

- **Research configurations and applications for desalination to utilize low-grade or waste heat**.
  Industrial processes that produce waste or low-grade heat may offer opportunities to lower the operating cost of the desalination process if these heat sources are co-located with desalination facilities. Low-grade heat can be used as an energy source for desalination via commercially available thermal desalination processes. Hybrid membrane-thermal desalination approaches offer additional operational flexibility and opportunities for water production cost savings. Research is needed to examine configurations and applications of current technologies to utilize low-grade or waste heat for desalination.

- **Understand the impact of energy pricing on existing desalination technology over time**.
  Energy is one of the largest components of cost for desalination, and future changes in energy pricing could significantly affect the affordability of desalination. Research is needed to examine to what extent the economic and financial feasibility of desalination may be threatened by the uncertain prospect of energy price increases in the future for typical

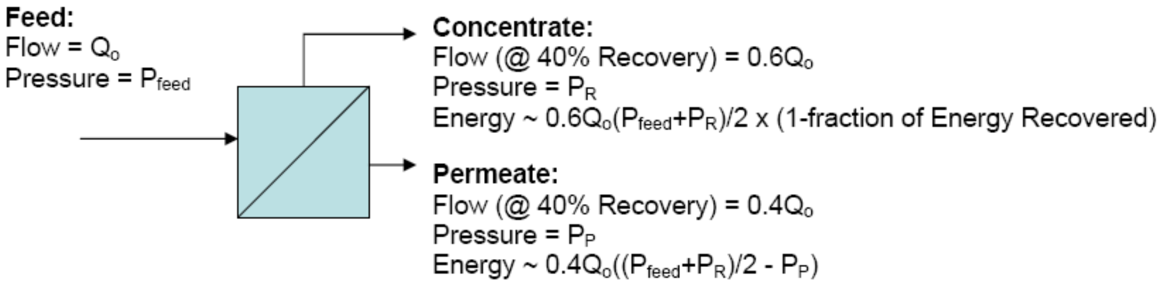
desalination plants in the United States. This research should also examine the costs and benefits of capital investments in renewable energy sources.

- **Investigate approaches for integrating renewable energy with desalination.**
  Renewable energy sources could help mitigate future increases in energy costs by providing a means to stabilize energy costs for desalination facilities while also reducing the environmental impacts of water production. Research is needed to optimize the potential for coupling various renewable energy applications with desalination.

(4) Develop novel approaches or processes to desalinate water in a way that reduces primary energy use

Because the energy of RO is only twice the minimum energy of desalination, even novel technologies are unlikely to create step change (>25 percent) reductions in absolute energy consumption compared to the best current technology. Instead, substantial reductions in the energy costs of desalination are more likely to come through the development of novel approaches or processes that optimize the use of low-grade heat. Several innovative desalination technologies that are the focus of ongoing research, such as forward osmosis, dewvaporation, and membrane distillation, have the capacity to use low-grade heat as an energy source. Research into the specific incorporation of waste or low-grade heat into these or other innovative processes could greatly reduce the amount of primary energy required for desalination and, thus, overall desalination costs.

Mass and Energy Balance on Reverse Osmosis System:



Following is an approximation of the energy used in a typical RO process operating at 40% recovery and an energy recovery device operating at an efficiency of η_{eff}.

$$\text{Energy Used} \cong 0.6Q_O \frac{(P_O + P_R)}{2}(1-\eta_{eff}) + 0.4Q_O(\frac{P_O + P_R}{2} - P_P).$$

Making the assumption that P_P is significantly less than the applied average operating pressure,

(i.e., that $P_P = 14.7$ at atmospheric pressure and

because this term is << $\frac{P_0 + P_R}{2}$ this term is presumed to be negligible and $\cong 0$)

and taking a ratio of a future, new energy balance based on a new membrane with new properties relative to a baseline energy balance we get the following equation:

$$\frac{\text{Energy}_{\text{New}}}{\text{Energy}_{\text{Baseline}}} = \frac{0.6Q_O \frac{(P_{ON} + P_{RN})}{2}(1-\eta_{eff}) + 0.4Q_O \frac{(P_{ON} + P_{RN})}{2}}{0.6Q_O \frac{(P_O + P_R)}{2}(1-\eta_{eff}) + 0.4Q_O \frac{(P_O + P_R)}{2}}$$

This equation can be factored as follows,

$$\frac{\text{Energy}_{\text{New}}}{\text{Energy}_{\text{Baseline}}} = \frac{\frac{(P_{ON} + P_{RN})}{2}(0.6Q_O (1-\eta_{eff}) + 0.4Q_O)}{\frac{(P_O + P_R)}{2}(0.6Q_O(1-\eta_{eff}) + 0.4Q_O)}$$

and further simplified to the following equation:

$$\frac{\text{Energy}_{\text{New}}}{\text{Energy}_{\text{Baseline}}} = \frac{\dfrac{(P_{ON} + P_{RN})}{2}}{\dfrac{(P_O + P_R)}{2}} = \frac{P_{\text{Avg. Applied New}}}{P_{\text{Avg. Applied Baseline}}} = \frac{P_{\text{Avg Driving New}} + P_{\text{Osmotic}}}{P_{\text{Avg. Applied Baseline}} + P_{\text{Osmotic}}}$$

As shown above, the average applied pressure can be broken down into two components: (1) the osmotic pressure required to overcome the osmotic energy barrier and (2) the net driving pressure required to overcome the native resistance of the membrane permeability.

For the purposes of illustrating the sensitivity of membrane permeability on potential future energy reductions, the following system operating data is taken from "The Guidebook to Membrane Desalination Technology," p. 472, Balaban Desalination Publications, 2007:

Average Total Dissolved Solids (TDS): 59,921 ppm

Temperature: 26 °C

$P_{\text{Avg Osmotic}}$ = 656 psi (at the average TDS of 59,053 ppm and Temperature of 28 °C; calculated by using the Van't Hoff equation)

$P_{\text{Avg Applied Baseline}}$ = 936 psi (P_{feed} = 947 psi; $P_{\text{concentrate}}$ = 924 psi)

$P_{\text{Avg Driving Baseline}}$ = (936 – 656) = 280 psi

$P_{\text{Avg Driving New}}$ = 0.5 x 280 = 140 psi (Reflecting a doubling of membrane permeability)

Assuming that the membrane permeability can be doubled without sacrificing salt rejection, the average driving pressure for the new membrane can be reduced by 50 percent (shown above).

Substituting these values into the equation above,

$$\frac{\text{Energy}_{\text{New}}}{\text{Energy}_{\text{Baseline}}} = \frac{P_{\text{Avg. Driving New}} + P_{\text{Osmotic}}}{P_{\text{Avg Applied Baseline}} + P_{\text{Osmotic}}} = \frac{140 + 656}{280 + 656} = 0.85$$

results in an energy ratio of new to baseline of 0.85. This translates into a net reduction of energy equal to 15 percent from today's baseline

RO Desalination Plant for Imperial Palace Hotel by Asian Industry Inc.

2 x 500 m^3/day sea water desalination, consisting of ;

1. Specifications

(1) Wells pumps (2+1)

- For transferring the sea water into the feed water tank
- Type: Grundfos SP-R, submergible centrifugal pumps
- Material: Stainless steel
- Specification: 5 -60 m^3/hr x 150 – 400 kPa x 9 kW x 3 phase x 380 V x 60 Hz
- Quantity: (2+1)
- Connection Outlet: Rp 4 inch

(2) Feed water tank 1

- For storage of well water
- Volume: 200 m^3
- All measurement devices are included in scope of supply
- Civil works to be supplied locally

(3) Feed pumps

- For providing flow and pressure from the feed water tank to the downstream equipment
- Type: KSB Etanorm, centrifugal pumps, bronze alloy
- Specification: 5 -60 m^3/hr x 350-550 kPa x 11 kW x 3 phase x 380 V x 60 Hz
- Quantity: (2+1)
- Connection inlet/outlet: DN65/DN40

(4) Prominent Media Filters

- For the removal of turbidity from the feed water
- Type: KF-4882 SIA
- Specification

Dimension	Dia 1,300 x 2,500H
Filter media	Support: gravel 3 -5 mm x 130 mmH
	Filter: sand 1 -2 mm x 820 mmH
Flow rate	13.9 m^3/hr (LV 10 m/hr).
Operating pressure	300 kPa (Min.), 800 kPa (Max.)
Operating temperature	35 ℃ max.

Air temperature 40 ℃ max.
Backwash $19 m^3/hr$ (LV 14 m/hr)
Backwash pressure loss 80 kPa
Backwash period 5- 20 minuets
Backwash volume 1.6 – 6.4 m^3

- Materials

Pressure vessel x 1 Fiber glass
Control valves x 1 ABS + fiber glass type SIATA
Pressure gauges x 2 Stainless steel (316 or similar)

- Quantity 2 (parallel)
- Notes
  - Including distributer for raw water, ascending pipe and sieve for filtered water, support gravel and filter sand (both to be filled into pressure vessel at site
  - Electronic controller for programming of backwash cycles as well as backwash periods
  - Limit switch for switching off the RO-unit during backwashing
  - Unit pre assembled and ready for connection
  - Space for installation for one filter is 2,500H x 1,600x 1,600
  - Gross weight on filter 1,700 kg

(5) Prominent dosing system

- For injection of AntiScalant to prevent membrane scaling
- Type Bt4a
- Specifications

Capacity 0.74 l/hr
Back pressure max.1 MPa
Volume of dosing tank 60 l
Suction lance 6 x 4 mm
Dosing hose 6 x 4 mm
Motor 0.02 kW x 230 V x 60 Hz

- Materials

Dosing tank x 1 PE
Suction launce x 1 PP with 2 stages float switch fault indicator
Injection valve x 1 PVC
Meter dosing hose x 5 PE

- Quantity 1

(6) Prominent Inline mixer

- For optimizing of chemical reactions in the feed water
- Type PE-DN 100
- Specifications

Total capacity mixture	50 m^3/hr
Pressure loss	10 kPa
Connection	DN 100
Dimension	ϕ 110 x 500 mm
Material construction	PVC

- Quantity 1

(7) Prominent ORP-controlling “OPR”-measurement of raw water”

- For control and monitoring of the final ORP value of the raw water
- Type D1Ca OPR

Redox controller Type D1CA	x 1
DGM in –line probe housing	x 1
Redox recorder	x 1

- Specifications

Power supply	230 v x 60Hz
Measure range	1,000 to + 1,000 (mV)
Relay control	alarm relay
Ambient temperature	0.5 -50 ℃
Dimensions	125^W x 75^D x 135^H

- Quantity 1

(8) Prominent pH-controlling “pH”-measurement of raw water”

- For control and monitoring of the pH value of the raw water
- Type D1Ca pH

pH controller Type D1CA	x 1
DGM in line probe hosing	x 1
pH sensor	x 1

- Specifications

Power supply	230 v x 60Hz
Measure range	1 to 12
Relay control	alarm relay
Ambient temperature	0.5 -50 ℃
Dimensions	125^W x 75^D x 135^H

- Quantity 1

- Quantity 1

(9) Prominent conductivity-controller ”Cond-measurement of raw water”

- For control and monitoring of the conductivity of the raw water
- Type D1Ca Cond

  Conductivity controller Type D1CA

  DGM in –line probe housing x 1

  Inductive conductivity sensor x 1
- Specifications

  Power supply 230 v x 60Hz

  Measure range 0.2 to 1,000 mS/cm

  Relay control alarm relay

  Ambient temperature 0.5 -50 ℃

  Dimensions 125^{W} x 75^{D} x 135^{H}
- Quantity 1

(10) Prominent RO unit (20 m^3/hr/unit) incl. AC for control cabinet

- For desalination of sea water
- Type Pro 1700SW ERI
- Quantity 1

(11) Prominent Dosing Station

- For injection of NaOCl
- Type Bt4a
- Specifications

  Capacity approx. 0.74 l/hr

  Back pressure max. 1 MPa

  Volume of dosing tank 60 l

  Suction lance 6 x 4 mm

  Dosing hose 6 x 4 mm

  Motor 0.02 kW x 230 V x 60 Hz
- Materials

  Dosing tank x 1 PE

  Suction launce x 1 PP with 2 stages float switch fault indicator

  Injection valve x 1 PVC

  Meter dosing hose x 5 PE
- Quantity 1

(12) Prominent Dosing Station

- For injection of Na_2CO_3

- Type		Bt4a
- Specifications

Capacity	approx. 12.3 l/hr
Back pressure	max. 0.4 MPa
Volume of dosing tank	1,000 l
Suction lance	8 x 5 mm
Dosing hose	8 x 5 mm
Motor	0.02 kW x 230 V x 60 Hz

- Materials

Dosing tank x 1	PE
Suction launce x 1	PP with 2 stages float switch fault indicator
Injection valve x 1	PVC
Meter dosing hose x 5	PE

- Quantity		1

(13) Prominent Dosing Station

- For injection of $CaCl_2$
- Type		Bt4a
- Specifications

Capacity	approx. 12.3 l/hr
Back pressure	max. 0.4 MPa
Volume of dosing tank	1,000 l
Suction lance	8 x 5 mm
Dosing hose	8 x 5 mm
Motor	0.02 kW x 230 V x 60 Hz

- Materials

Dosing tank x 1	PE
Suction launce x 1	PP with 2 stages float switch fault indicator
Injection valve x 1	PVC
Meter dosing hose x 5	PE

- Quantity		1

(14) Prominent Inline mixer

- For optimizing of chemical reactions in the permeate line
- Type		PE-DN 65
- Specifications

Total capacity mixture	20 m^3/hr
Pressure loss	11 kPa

Connection	DN 65
Dimension	ϕ 75 x 500 mm

- Material construction PVC
- Quantity 1

(15) Prominent pH- controller

- For control and monitoring of the pH values of the permeate
- Type D1Ca pH incl. Accessories

pH controller Type D1CA	x 1
DGM in line probe hosing	x 1
pH sensor	x 1

- Specifications

Power supply	230 v x 60Hz
Measure range	1 to 12
Relay control	alarm relay
Ambient temperature	0.5 -50 ℃

- Dimensions 125^{W} x 75^{D} x 135^{H}
- Quantity 1

(16) Prominent conductivity -controller

- For control and monitoring of the conductivity value of the permeate
- Type D1Ca cond. incl. Accessories

Conductivity controller Type D1CA	x 1
DGM in line probe hosing	x 1
Conductive conductivity sensor	x 1

- Specifications

Power supply	230 v x 60Hz
Measure range	0.01 to 20 (mS/cm)
Relay control	alarm relay
Ambient temperature	0.5 -50 ℃

- Dimensions 125^{W} x 75^{D} x 135^{H}
- Quantity 1

(17) Permeate storage tank

- For storage of product water
- Volume (min.) 800 m^3
- Quantity 1
- Civil works construction to be supplied locally
- All necessary level measurements, scope of supply

(18) Prominent central control panel (each line independent)

- For control and monitoring of the positions 1-18
- Type: PM CCP17
- Quantity: 1

(19) Product pumps

- For transferring the product water into the hotel distribution
- Type: Grundfos CR
- Specifications

Flow	5-15 m^3/hr
Pressure	320-570 kPa
Power supply	5.5 kW x 380 V x 3 phases x 60 Hz
Connection (Inlet/Outlet)	DN 65/DN65

- Material: Stainless steel DIN 1.4401
- Quantity: (3+1)

2. Price **780,000 US $**

- Deliver on site, CIF Cebu
- Including transport, installation and start up service
- Exclusions;
  - Raw water tank
  - Product water storage tank
  - Building permits, DENR license
  - Main power supply to the plant room
  - Construction of civil works and drainage

3. Delivery time Approx. 12- 14 weeks after clarification of all technical and commercial issues

Notes:

1. The sea water RO design is based on a theoretically feed water analysis with a TDS of 35,000 mg/l and a temperature of 25 ℃. The feed water entering the RO-unit s beach well sea water or sea water coming from an open intake which is suitably pre-treated.

In general the feed water entering the Ro-unit should be filtered, chemically conditioned, have a COD<5 mg/l, fouling index≦3.0, max turbidity 0.5 NTU, and it is to be free of oil, chlorine, H_2S and colloidal SiO_2. Further parameters such as Ba, Sr, Fe, Mn Al are to be in acceptance non-scaling concentrations.

2. If the sea water comes from a good maintained well, the following pre- and post treatment are recommended;

- Homogenous distribution of the injected chemicals via inline mixer
- Filtration over 25 μ m or a sand filter for removal of SS (in addition to 5 μ m filter on RO)
- Injection of anti-scalant (e.g. Permatreat) to prevent precipitation of sparingly soluble salt in the sea water
- Monitoring of the redox potential, pH and conductivity of the sea water via suitable controllers
- Injection of NaOCl or $Ca(OCl)_2$ to disinfect the permeate of RO
- Injection of (Na_2CO_3 + $CaCl_2$) to adjust the pH and hardness of the permeate according to WHO
- Monitoring of the pH and conductivity of the final drinking water via suitable controllers

3. The daily consumption of anto-scalant (e.g. Permatreat 100 for sea water) can be calculated after provision of a detailed feed water analysis.

4. The salt rejection of the proposed RO is approximately 99 % for the sea water desalination unit, perfect drinking water quality will be produced having salinities well under 500 mg/l. However, due to the low permeate pH and low hardness it is necessary and recommended to adjust the pH and the hardness of the final drinking water, eg. by injection of Na_2CO_3 and $CaCl_2$, or by filtration over dolomite. Finally, a disinfection e.g. by NaOCl or chlorine dioxide should be done before it is distributed into the hotel.

5. Proposed RO units are supposed to run at a recovery of 40 % (sea water desalination unit). This might be able to be optimized after provision of a detailed feed water nalysis.

6. The estimated energy consumption of the above sea water desalination RO-Unit is to be expected around 2.6 to 3 kWh/m3 of permeate only, because the state of the energy recovery by pressure exchanger is applied.

7. Control cabinet for the power distribution and control of the complete for each version as offered above.

8. At least 300 kPa is required directly before the RO plants.

9. Prominent Sea Water Desalination RO-Unit Type PRO SW ERI

For desalination of filtered and chemically conditioned sea water according to theoretically created sea water analysis with a max. feed water salinity (TDS) of 35,000 mg/l at a temperature of 25 ℃ (to be free of residual Chlorine, colloidal SiO_2, and H_2S, COD < 5 mg/l, fouling index ≦3.0 and max. turbidity 0.5 NTU. Further parameters such as Ba, Sr, Fe, Mn, Al are to be in accordance to WHO guidelines), consiting of;

- Compact frame made of stainless steel x 1
- Front table for control instruments mad of PP x 1
- Pre-filter made of PP incl. filter bag 5 μm x 1
- Set of glycerol filled pressure gauges made of stainless steel x 1
- Motor valve for raw water made of PES x 1
- Set of check valves made of PVC + stainless steel x 1
- Pressure switch for raw water x 1
- Thermometer made of stainless steel x 1
- High pressure axial piston pumps in parallel operation brand new Danfoss made of duplex and super duplex stainless steel x1
- **Set (5 pieces) of pressure vessels mad of glass fiber**
- **Set (30 pieces) of membrane elements made of composite membrane (PE, PS, PA*) x 1**
- **Pressure exchanger incl. booster pump and incl. variable frequency drive for energy recovery from brine stream x 1**
- Magnetic inductive flow meters made of neoprene coated mild steel for flow on pressure exchanger low and high pressure side x 2

- Variable area type flow meter for permeate and concentrate flow made of polyamide x 2
- Set of sampling valves made of PVC and stainless steel x 1
- **CIP system** for chemical cleaning, disinfecting or stand still conservation of modules and piping incl. pump made of stainless steel, cartridge filters made of PP, tank made of PE, 2 –way valves and drain valve x 1
- **System for automatic filling of cleaning tank and rinsing of membranes by permeate at every unit shut off** x 1
- Interconnecting piping made of PVC, stainless steel DIN 1.4539 or equal at high-pressure side x 1
- **Air conditioned micro-processor control panel** according to EN 60204, DIN VDE 0113 standard-protection class IP 54 incl.
  - backlit graphical display with real text messages, digital conductivity meter, adjustable limit values,
  - operation and malfunction real text messages and LEDs,
    - main switch,
    - menue for activation of automatic operation and cleaning or disinfecting,
    - 1 potential-free contact for remote alarm,
    - terminals for pre-treatment units as softner, dosing pumps, hardness control as well as level control for permeate tank

Note:

* PE = Polyester, PS=Polysulfon, PA=Polyamide; PP=Polypropylene

10. Technical Data of Prominent Sea Water Desalination RO-Unit Pro SW ERI per unit

• Permeate flow rate at 25 ℃	Approx. 20.8 m^3/hr (16.7 m^3/day/element)
• Operating pressure	Approx. 6.3 MPa
• Recovery*	Max. 40 (%)
• Raw water consumption	Approx. 50 (m^3/hr)
• Required raw water pressure (min./max.)	0.3/0.6 MPa
• Rejection rate	99 %
• Main supply	380 v x 60 Hz
• Power installed	55 + 7.5 kW
• R.O power/m^3	2.2 kWh
• Connections: Raw water, permeate, concentrate	DN 100, 65, 80

- Dimensions of RO frame $7{,}000^W$ x $1{,}400^D$ x $2{,}200^H$
- Dimensions filter frame $2{,}500^W$ x $2{,}500_D$ x $1{,}800^H$
- Dimensions cleaning tank ϕ 1,100 x $1{,}720^H$

Note:

- Prominent RO units are produced according to EC (European Community) standards and will be delivered incl. EC conformity declaration as well as CE (Certificate European) plate.
- The max. recovery can only be adjusted in case of best water quality, fouling index ≦ 3.0 problem free operation, and according to the needed permeate quality.

Technical Evaluation Committee, Study on Development of Seawater Desalination Technology, Interim Report, October 1998

1. Countermeasures of Seawater Pollution

- To use membrane system as pre-treatment for polluted sweater with maximum turbidity of 12 NTU, SDI of around 6.5, maximum oil of 10 mg/L in order to achieve SDI less than 4 without coagulation injection.
- Rapid deterioration of RO membrane and performance by oil could not found by the seawater with less than 1 mg/L oil.
- Fluorescence photometer method is effective for less than 0.1 mg/L of oil.

2. High Recovery RO System

- To aim total cost reduction of 25 % with the combination of scale prevention by NF and high recovery rate by high pressure RO membrane.

NF（Low pressure RO） membrane

- The removal rate of monovarent ion by NF is low but that of multivarent is high (Ca, Mg, SO_4^{2-}, etc, : scaling elements) and NF has the posibility of removing organic matters as well as fine particles and baxteria.
- Flux of NF is big at low pressure, less than 1.5 MPa, and NF is effective to remove boron.

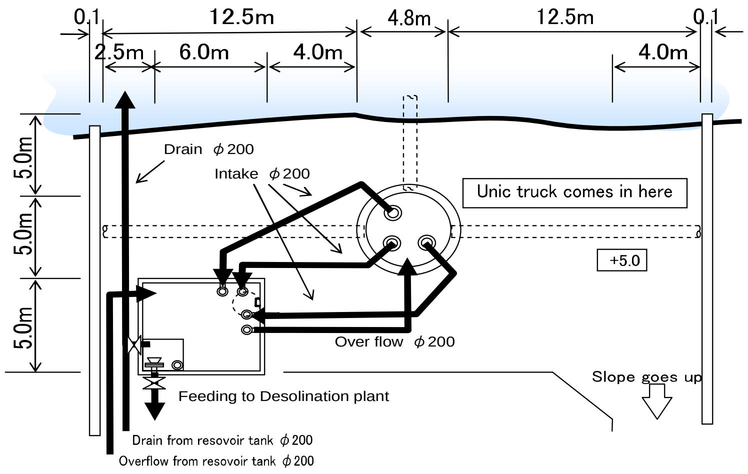
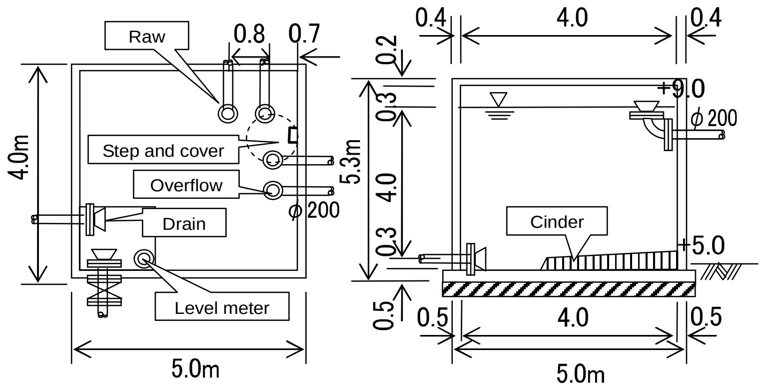
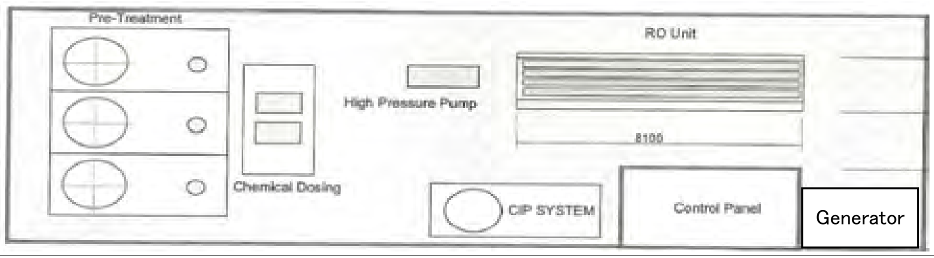
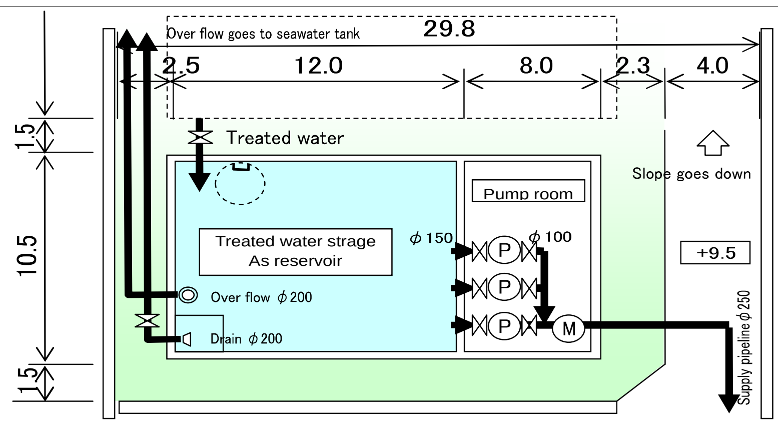
3. Removal of Boron

- Two stage desalination process with polyamide synthetic composite low pressure membrane can remove boron in seawater up to less than 1mg/L which is drinking water quality guideline of Japan. Effluent boron levels less than 0.2 and 0.6 mg/L at pH 7 -8 and more than 10, respectively.

4. Attentions in using membrane system in pre-treatment

- Practical filtration rate with approx. 1,000 to 2,000 hours' continuous operation
  MF membrane (0.1～0.2μ,)： 0.5～1.0m/day（SDI Value：less than 4）
  UF membrane： 0.6～0.6m/day（SDI Value：less than 2）
- Chemical cleaning should be conducted when TMP reaches 100 kPa at least

A6-2. Breakdown of Project Components

No.	Facilities	Specifications	Image
1	Well	ϕ 3,000 to 4,000 diameter well Seawater Pump ϕ 200 x 3 Porus concrete pipe	
2	Intake Pipe	Intake: PVC ϕ 200 x 3, L=30m x3 Overflow: PVC φ200 x 1, L=30m Flexible connecter, Air valve, Butterfly valve	
3	Raw Seawater Tank	L4.0m x B5.0m x H5.3m Waterproofing painting Butterfly valve, Flexible Connecter, Drain pipe ϕ 200,L=20m	
4	RO Desalination Facility	**3,000m^3/day RO unit** Pre-treatment unit Chemical dosing unit High pressure pump CIP system	See plan for details 
5	Electricity and Generator Facility	Electricity panels (No.1 LV, No.2 LV, Static capacitor, Intake pump, Distribution pump, Chemical dosing) Backup generator	
6	Building	RO desalination plant building Electricity and generator room Control room or adminstration room	See plan for details
7	Treated Water Tank and Pump Room	L12.0m x B10.5m x H5.3m Waterproofing painting Pump room L8.0m x B10.5m x H5.3m Flexible connecter, Drain pipe ϕ 200,L=100m Overflow pipeφ200,L=80m	
8	Distribution Pipe and Pump	PVC pipe ϕ 250, L=200m Distribution pump, 1.83～0.85m3/min, h=27～48m Flow meter for ϕ 250	
9	Waste water tank	L4.0m x B5.0m x H5.3m Waterproofing painting Butterfly valve, Flexible connecter, Drain pipe ϕ 200,L=20m	Almost same as 3. Influent tank
10	Discharge Pipe	PVC pipe ϕ 300, L=700m Distribution outlet, Butterfly valve, Flexible connecter	See plan for details
11	Pavement etc.	Administration road Gravel and asphalt pavement	See plan for details
Others	Chemicals and Analysis Machinery	FI (SDI), pH, Turbidity, Residual chlorine, Electric conductivity, ORP meter, Anthracite, Sand, NaClO, etc.	-
	Design and management	Construction management, Operation test and training, Soft componet	-
Total			
Contingency 8%			
VAT 12%			**MCWD responsibility**
Grand Total			
O&M Cost (per year)		Including RO exchange, Chemicals, Electricity, Manning, Sand and Anthracite exchange, Cartridge filter exchange and Repair cost 5% Initial	**MCWD responsiblity,** Unit cost 50Php/m^3 Note: RO excnage will be every 5 years (20% per year)

Items			Remarks
Civil and Building Construction Cost			
Contents	1	Well	
	2	Transmission pipe	
	3	Raw Seawater Storage Tank	
	6	Building	
	7	Water Distribution Reservoir	
	8	Distribution Pipe	
	9	Wastewater Strage Tank	
	10	Seawater Discharge Pipe	
	11	In-plant work	
①	Direct Construction Cost		
②	General and Temporary Construction Cost		①×0.20
③	Site Management Cost		①×0.20
④	General Management Costs		①×0.10
Total (①+②+③+④)			
Mechanical and Electrical Cosntruction Works			
Contents	4	RO Facility	
	5	Power Receiving Station and Generator	
⑤	Direct Construction Cost		
⑥	General and Temporary Construction Cost		⑤×0.10
⑦	Site Management Cost		⑤×0.10
⑧	General Management Costs		⑤×0.10
Total (⑤+⑥+⑦+⑧)			
Construction Cost Total			
Procurement			
⑨	Consumables and Chemicals		
⑩	Equipments (Water Quality Meter etc.)		
Total (⑨+⑩)			
Design and Management			
⑪	Construction Management		
⑫	Trial Operation and Operational Trainning		
⑬	Soft Component		
Total (⑪+⑫+⑬)			
Total Cost			
Reserve (8% of Total Cost)			
Grand Total Cost (except VAT)			
VAT (12% of above)			
Grand Total Cost (include VAT)			

Well

No.	Item	Q-ty
1	Drilling Works	
	ϕ 3,000-4,000	
	15m x 1	15 m
2	Well Logging & Casing Installation	
		1 set
3	Gravel Packing & Seal	1 set
4	Surface Sealing with cement	1 set
	Sub-total	
5	Sea water Pump (submarged type)	
		3 set
6	Pump Installation	
	Footstool, etc.	
		3 set
7	Well Development & Pumping Test	
		1 set
8	Transportation (to and return)	
		1 set
9	Porous concrete pipe	
	ϕ 300mm x 10m x 2 pipes	20 m
Subtotal		1 set
10	Others (Water Level Meter, Cover, Step, etc., 10% of above)	
	Total	

Intake pipe, ϕ 200 x 3

E

No.	Item		Q-ty
1	PVC Pipe		
		L=30m	
		ϕ 200 x 3	90 m
2	Overflow Pipe	L=30m	
		ϕ 200 x 1	30 m
3	Flexible Connecter	ϕ 200	
		Twin sphere	8 set
4	Air Valve complete set		
		Assembly	
		1set stand-by	4 set
5	Butterfly valve		
		ϕ 200, Assembly	
		1set stand-by	4 set
Subtotal			
6	Others	10% of above	
	(PVC pipe coating for sun protect, etc.)		1 set
		Total	

Raw Seawater Tank

No.	Item		Q-ty
1	Earthwork		
		Back-hoe	50 m^3
		Backfilling Manpower	20 m^3
2	Gravel Base		9 m^3
	Mortar		5 m^3
			1 set
3	Rainforced Concrete		
		4.0m x 5.0m x 5.3m	
			50 m^3
4	Form work		
		Assembly	200 m^2
5	Waterproofing painting		
			100 m^2
6	Pipe work		
	Enveded pipe	ϕ 200 x 5set	
		ϕ 300 x 1 set	6 set
7	Butterfly valve		
		Assembly	
		ϕ 300 x 1 set	1 set
8	Flexible Connecter	ϕ 200	
		Twin sphere	3 set
9	Pipe work	Drain pipe	
		L=20m	
		ϕ 300 x 2 set	40 m
Subtotal			
10	Others (Manhole, Water level meter, etc.)		
		10% of Above	1 set
		Total	

RO desalination plant

No.	Item	Q-ty
1		
	1000m3/day x 3 unit	3 unit
	Total	

Electricity, Generation facility

No.	Item	Q-ty
1	Backup Generator	
	1,000kVA, Mafler	1 set
2	Electricity Panels	
	No.1 LV, No.2 LV, Static Capacitor, Intake Pump,	
	Distribution Pump, Chemical dosing	1 set
Subtotal		
3	The establishment costs	
	35% of above subtotal	
	Total	

RO, Electricity and Generator Building

No.	Item	Q-ty
1	Earthwork	
	Back-hoe	3,000 m^3
	Backfilling Manpower	500 m^3
2	RO desalination plant	
		750 m^2
3	Electricity and Generator Room	
		50 m^2
4	Control room or Adminstration room	
		50 m^2
5	Administration room etc.	
		100 m^2
	Total	

Treated Water Tank

No.	Item		Q-ty
1	Earthwork		
		Back-hoe	170 m^3
		Backfilling Manpower	60 m^3
2	Rainforced Concrete		
	Tank	12 x 10.5 x 5.3m	
	Pump room	8 x 10.5 x 5.3m	290 m^3
3	Form work		
		Assembly	550 m^2
4	Flexible Connecter	ϕ 250	1
		ϕ 200	2
		Assembly	
5	Pipe work		
	Enveded pipe	ϕ 150	
		ϕ 200	
		Assembly	6 set
6	Waterproofing painting		
			400 m^2
7	Drain from Resovoir tank		
		ϕ 200	
			100 m
8	Overflow from Resovoir tank		
		ϕ 200	
			80 m
Subtotal			
9	Others (Manhole, Water level meter, etc.)		
		10% of Above	1 set
		Total	

Distribution pipe ϕ 250 x 1, Distribution Pump

No.	Item		Q-ty
1	PVC Pipe		
		L=200m	
		ϕ 250 x 1	200 m
2	Flexible Pipe	ϕ 250	
		Assembly	1 set
3	Air valve	for ϕ 250	
		Assembly	2 set
4	Butterfly valve	φ100 x 3	3 set
		φ150 x 3	3 set
		φ250 x 1	1 set
		Assembly	
5	Distribution pump	1.83～0.85m3/min	
		h=27～48m	
			3 set
6	Flow Meter		
		for φ250	
		Assembly	1 set
Subtotal			
7	Others		
		10% of Above	1 set
		Total	

Waste Water Tank

No.	Item	Q-ty
1	Earthwork	
	Back-hoe	50 m^3
	Backfilling Manpower	20 m^3
2	Gravel Base	8 m^3
	Mortar	4 m^3
		1 set
3	Rainforced Concrete	
	4.0m x 5.0m x 5.3m	
		50 m^3
4	Form work	
	Assembly	200 m^2
5	Pipe work	
	L=10m	
	φ200 x 3 set	30 m
6	Waterproofing painting	
		600 m^2
	Gravity flow	
Subtotal		
7	Others (Manhole, Water level meter, etc.)	
	10% of Above	1 set
	Total	

Discharge pipe, ϕ 300 x 1

No.	Item		Q-ty
1	PVC Pipe	Submarine	
		L=700m	
		ϕ 300 x 1	300 m
2	Flexible Pipe		
		Assembly	2 set
3	Distribution outlet		
		Assembly	1 set
Subtotal			
4	Others		
		10% of Above	1 set
		Total	

Pavement etc.

No.	Item	Q-ty
1	Gravel Pavement	550 m^2
	Asphalt Pavement	550 m^2
	Subtotal	
2	Excavation	
		180 m^3
3	Back filling with compaction	
		180 m^3
	Total	

Consumablles, Chemicals

No.	Item		Q-ty
1	Anthracite		
			13 ton
2	Sand	for water purification	
			20 ton
3	NaClO	10% liquid	
		Dose: 0.5 to 2.5 mg/L	
			1 ton
5	Anti-scalant	63% or 75% liquid	
		Dose: 40 to 50 mg/L	
			1.35 m3
6	SBS ($NaHSO_3$)		
			3.8 m3
7	NaOH	20% liquid	
	Post treatment for pH control		
			0.54 m3
8	**RO unit stock for one(1) year**		
		Total	

Instruments

No.	Item	Q-ty
1	FI (SDI) measurement tools	
		1 set
2	pH meter with temperature meter	
		1 set
3	Turbidity meter	
		1 set
4	Residual chlorine analyzer	
		1 set
5	Electric conductivity meter	
		1 set
6	ORP meter	
		1 set
	Total	

Fence & Gate

No.	Item		Q-ty
1	Net Fence		
		30m x 2	
			60 m
2	Gate	Road access	4 m
		Seashore access	2 m
		Total	

Land Price

No.	Item	Q-ty
1	Land Acquisition	
	90m x 30m	
		2,700 m²
	Total	

Breakdown for Electrical Equipment

Name	Parts	Q'ty	Remarks
N0.1 LV Feeder Panel	panel	1	1000W
	MCCB3P 1000A	2	motor operated
	MCCB3P 150A	1	with ZCT
	tie transformer 50kVA	1	440V/220-110V
	MCCB3P 100A	2	
	MCCB3P 50A	1	
	PT	6	
	CT	6	
	V meter	2	
	A meter	2	
	F meter	1	
	Power Factor meter	1	
	WHM	1	
	AS, VS	4	
	Total		
N0.2 LV Feeder Panel	panel	1	1000W
	MCCB3P 300A	3	with ZCT
	MCCB3P 100A	3	with ZCT
	MCCB3P 100A	2	
	Total		
Static Capacitor Panel	panel	1	
	MCCB3P 50A	5	
	Static Capacitor	3	20kVA with SR
	Total		
Intake Pump Panel	panel	1	
	PT	1	
	CT	1	
	V meter	1	
	A meter	1	
	MCCB 100A	1	
	MCCB 50A	7	
	MCCB 30A	1	with ZCT
	Direct on-line stater	3	15kW
	Reverse starter	3	0.4kW
	tie transformer 5kVA	1	
	MCCB 10A	3	
	COS 2p	3	
	CS 2p	3	
	CS 3p	3	
	Lamp	15	
	Total		
Distribution Pump Panel	panel	1	
	PT	1	
	CT	1	
	V meter	1	
	A meter	1	
	MCCB 100A	1	
	MCCB 50A	7	
	MCCB 30A	1	with ZCT
	Direct on-line stater	3	30kW
	Reverse starter	3	0.4kW
	tie transformer 5kVA	1	
	MCCB 10A	3	
	COS 2p	3	
	CS 2p	3	
	CS 3p	3	
	Lamp	15	
	Indicating Controller	1	pH controll

Name	Parts	Q'ty	Remarks
	Indicator	1	Flow
	Totarizer	1	Flow
	pH meter	1	
	Flow meter	1	150mmDIA
	Total		
Chemical Dosing Panel	panel	1	
	PT	1	
	CT	1	
	V meter	1	
	A meter	1	
	MCCB 100A	1	
	MCCB 50A	7	
	MCCB 30A	1	with ZCT
	Direct on-line stater	6	0.2kW
	tie transformer 5kVA	1	
	MCCB 10A	3	
	COS 2p	6	
	CS 2p	6	
	Lamp	12	
	Total		
Diezel Engine Generator	750kVA	1	Pacage type
	Mafler	1	65dB
	Total		
Equipment Total			
Marerial and Installation			35%
Grand total			

A6-3. Photographs of Site Investigation

Meeting with MCWD

Candidate Site Overview

Desalination Plant of Mactan Rock Company (1)

Desalination Plant of Mactan Rock Company (2)

Desalination Plant of Mactan Rock Company (3)

Desalination Plant of Mactan Rock Company (4)

Tisa Water Treatment Plant (1)

Tisa Water Treatment Plant (2)

Tisa Water Treatment Plant (3)

Tisa Water Treatment Plant (4)

Dam Site for Tisa Water Treatment Plant

Dam Site for Tisa Water Treatment Plant


Candidate Site (1) Opposite site


Candidate Site (2)


Candidate Site (3)


Candidate Site (4)

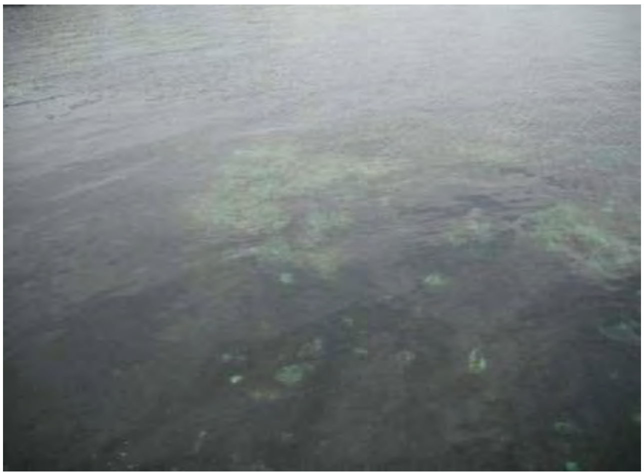

Candidate Site (5)


Candidate Site (6) Seashore Side

Candidate Site (7) Seashore Side

Candidate Site (8) Seashore Side

Candidate Site (9) Seashore Side



Candidate Site (10) Seawater Condition

Electricity Receiving Facility Image

Meeting with NEDA Reagion7 (Cebu)

A-7. Official Letters

Republic of the Philippines
Metropolitan Cebu Water District
Lapu-Lapu - Magallanes Sts., Cebu City
Tel. Nos. (032) 254-8434, 412-1836, 256-0413 to 15, 256-0424
Fax Nos. 254-5391, 412-2774
MCWD is ISO 9001 Certified

October 27, 2009

MR. MASAFUMI NAGAISHI
Senior Representative
Japan International Cooperation Agency (JICA)
Philippine Office

SUBJECT: PROGRAM GRANT AID FOR ENVIRONMENT AND CLIMATE CHANGE

Dear Mr. Nagaishi:

With reference to your letter of October 22, 2009 requesting MCWD Management to present and discuss with our Board of Directors the conditions established by JICA in order to proceed with the next phase of above-subject, we wish to inform you that the MCWD Board of Directors had decided to respectfully decline the JICA grant because of the following reasons:

1. The cost of Taxes and Customs duties that shall be borne by MCWD is substantial that it can be considered as of less priority at present.

2. The schedule to ink a Purchase Agreement with the prospective land owner of plant site is apparently tight (end of January 2010) based on our experience in acquiring real estate especially with such magnitude.

We highly appreciate the time and financial undertaking of the Japanese Government in its effort to extend assistance to water utilities like Metro Cebu Water District and it is our hope to continually keep the linkage with your office for future developments.

Thank you.

Very truly yours,

ARMANDO H. PAREDES
General Manager

MMB/lae

(PP)-10-22013
22 October 2009

MR. ARMANDO H. PAREDES
General Manager
Metropolitan Cebu Water District

Dear Mr. Paredes,

With regards to the on-going Preparatory Survey for the Program Grant Aid for Environment and Climate Change (Water Technology), we would like to request the Board of Directors and Management to further discuss the results of the survey in the next board meeting.

Likewise, if MCWD should decide to implement the programe, kindly discuss in the board meeting about certainty to secure following measures on schedule, and please share with us the results of the board meeting, so that the Japanese side can consider proceeding with the next phase of study; (1) to secure the necessary budget for VAT and Customs for this programme; (2) to submit a purchase agreement between MCWD and the land owner of the site for installation of facilities to JICA Philippine Office by the end of January 2010; and (3) to submit an official request to National Economic and Development Authority (NEDA) by the end of November 2009. In addition, the contract of land purchase needs to be completed by mid-April 2010 since we have limited time on the procedures in the Government of Japan.

In addition to the decision of Board of Directors and Management, Japanese side will also consider the probability of implementing this Program Grand Aid based on the results of the study.

For any clarification/s regarding this matter, kindly contact our staff, **Mr. Naoto Kuwae** at 889-7119 Ext. 213 or E-mail at Kuwae.Naoto@jica.go.jp or **Mr. Kessy Reyes** at 889-7119 Ext. 215 or E-mail at ReyesKessy.PP@jica.go.jp.

We highly appreciate your time and support in this undertaking. Thank you.

Very Truly Yours,

MASAFUMI NAGAISHI
Senior Representative