CHAPTER 4 THE ISWM MASTER PLAN

4.1 Forecast of Future ISW Generation

a. Forecast of Future Socio-Economic Conditions

For the forecast of industrial/medical SW generation in MR, the following socio-economic indicators are selected to set up future socio-economic scenario in 2010.

i. **Population growth**

ii. **GNP growth**

iii. **Growth in the number of employees for each of 28 sub-sectors of manufacturing industry and selected 3 additional industries that potentially generate hazardous ISW**

The table overleaf shows the methods to be applied for the forecast of each indicator above.

Table 4.1a Forecast Methods

Items	Methods
1. Population Growth in MR	The Study followed the population projection conducted by INE (Institute for National Statistics). The average growth rate of population during 1992-2010 is set up at 1.5% per annum.
2. GNP Growth	The Study basically follow the government statement on the future outlook of macro-economy in Chile up until the year 2000. Regarding the period of 2001-2010, growth rate is set up on the basis of the assumption made in the long-term plan of Central Macro Zone (MZC). Consequently, average annual growth rate of GNP is set up as follows: Period — Growth rate 1994-2000 — 6% 2000-2005 — 5% 2005-2010 — 4%
3. Growth in number of employees in 28 sub-sectors of manufacturing industry	The number of employees are forecasted by the following equation. $FE = (PIR*LPF)NE$ FE : Future number of employees in 2010 PIR : Production increase rate during 1994-2010 LPF : Labor productivity factor NE : Number of employees in 1994 PIR is forecasted by applying linear regression with the least square method on the basis of collected data of 28 sub-sectors' production indexes during 1982-1994 from INE. As for LPF, because it can not be extrapolated from past labor-intensive production trends in Chile, the Study made an assumption by estimating the elasticity between the increase rate of production and number of employees by each 28 sub-sector for the period of high economic growth in Japan during 1970-1985.
4. Growth in number of employees in gasoline filling stations and laundries/dry cleaners	Because sales data could not be obtained for these two sectors, the Study forecasted the number of employees by extrapolating the growth trend of number of employees during 1985-1992 obtained from INE.
5. Growth of number of employees in electricity supply industry	There is only one coal-fired plant which is mainly used for peak demand in MR. In addition, electricity demand in MR is mainly covered by hydroelectric plants located outside MR. Considering such present conditions, the Study assumed that there will be no additional development of power plants in MR up to 2010. Based on this assumption the number of employees in electricity supply industry is assumed not to change up to 2010.

b. Forecast of ISW Generation

b.1 Method Applied

Based on the estimated amount of present ISW generation, a forecast of future ISW generation in 2010 was conducted by applying the Standard Unit Method (SUM) which required the estimation of the following indicators.

b.1.1 Population Figure for the Forecast: Number of Employees

Concerning the population figure for forecasting ISW generation, there are three major indicators, i.e. annual production, annual sales of products, and the number of employees. Since the data available to be required for the forecast is very limited regarding yearly production and annual sales, the number of employees was used as the population for the forecast. However, industrial production will increase by the modernization of production system etc. even though there is no increase in number of employees. Therefore, annual production or annual sales of products should be used as the population figure for forecasting ISW generation when such data is available in the future.

b.1.2 Generation Ratio

i. Variation of ISW generation ratio with the introduction of Cleaner Production Technology (CPT)

To estimate the fluctuation of ISW generation ratio by introducing CPT, a more detailed factory survey is needed to identify the representative production system for each of the 36 or more specific sub-sector of the manufacturing industry. Based on such survey, it may be possible to assume variation rate by CPT introduction. However, due to the time limit and availability of statistics and information, it was impossible to estimate the variation rate. Instead, the Study incorporated the labor productivity factor in the forecast of the future number of employees. Since many of the CPT were developed at a time of increasing productivity, during the period of high economic growth in Japan, the factor of minimizing ISW generation ratio by CPT introduction is somehow automatically incorporated in the process of forecasting the number of employees.

ii. Variation rate by installation of PCF

The installation rates of pollution control facilities (PCF) for air and water

pollution were determined as the target of the Master Plan respectively as shown in the table below.

Table 4.1b Installation Rate of Pollution Control Facilities

Year / Types of PCF	Installation Rate (%)		
	Unit	1995	2010
Air PCF	Installation Rate (%)	48.9*1	100
On-site Water PCF	Installation Rate (%)	2.1*2	100
Public Sewage Treatment	Installation Rate (%)	2.0	100

Note: *1: Percentage of gas effluent quantity through the "filter" over total gas effluent quantity in the MR (source: SESMA-PROCEFF data)
*2: source : information of SISS, MOP

b.1.3 Forecast

The forecast of ISW generation in 2010 was based principally upon data obtained from the Team's factory survey and EWI's RISNOR study except for sludge and dust. Hence, the ISW generation in the year 2010 was the product of "generation rate in 1995" and "forecasted employee number in 2010" for 36 respective industries' classification. The forecast of sludge and dust generation, on the other hand, was conducted by the respective methods described below.

b.2 Forecast of Sludge Generation

Sludge attributable to waste water treatment are:

- sludge generated from on-site waste water treatment facilities (to comply with the maximum limits of Nch2280), and
- sludge generated from public waste water (contaminated with discharged industrial waste water with permissible limits) treatment facilities.

Hence the sludge generation amount is forecasted based on the above two factors.

b.2.1 Sludge Generated from On-site Waste Water Treatment Facilities

The forecast of the sludge generated from on-site waste water treatment facilities was carried out by applying the methods below:

i. Firstly, "waste water rate (per employee) defined here as α", which is proportional to "water-consumption rates (per employee)", of individual industries in the MR are calculated based on the Team's investigation.

ii. Secondly, waste water (biochemical oxygen demand and suspended solid; hereafter BOD and SS respectively) concentration of respective group-wise industries in the MR are set out with reference to the data in Japan obtained through a survey done by the Ministry of Construction in Japan. (refer to Table I.2.2c in Annex I)

iii. Thirdly, "waste water BOD/SS concentration obtained from ii. above" minus "maximum limits of BOD/SS concentration defined in Nch2280" give respective BOD/SS concentration to be removed on-site (hereinafter defined Br and Sr).

iv. In calculation of sludge amount to be generated in factories through on-site BOD/SS removal processes;

- sludge generated from "oxidative decomposition process of BOD" (hereinafter Bg) ; and
- sludge generated from SS removal process (hereinafter Sg)

should be considered. Generation ratio per employee (hereinafter Tg) is calculated as:

$$Tg = Bg + Sg$$

Bg and Sg are calculated based on following assumptions.

v. Bg is calculated by the following formula with an assumption that : BOD to be removed will be (oxidatively) decomposed 50% into carbon dioxide (CO_2) and 50% into sludge.

$$Bg = \alpha \times Br \times 0.5$$

vi. Sg is calculated by the following formula with an assumption that all SS removed is transformed into sludge.

$$Sg = \alpha \times Sr$$

vii. The sludge generated from the removal of dissolved inorganic substances through physical-chemical treatment is not projected in the estimation due to the lack of available data for whole industries (available for some industries).

Accordingly, the sludge generation rates per employee are the values of on-site sludge (dry content) generation, assuming that all factories comply with the Nch2280 regulations in their on-site waste water treatment. Accordingly, future sludge generation amount (dry content) is estimated from:

"Tg" above multiplied by estimated future employee numbers

Where sludge generation amount obtained from the above comprises:

i. amount of inorganic sludge (dry content), and
ii. amount of organic sludge (dry content).

The factory survey gives the estimated proportion of 'inorganic sludge" and "organic sludge" to being 32% and 68% respectively. Meanwhile, water contents of inorganic sludge and organic sludge are assumed below.

Category	Inorganic Sludge	Organic Sludge	Ground of Assumption
Before Dehydration	90 %	99 %	Visual observation at the factory survey and Japanese empirical data.
After Dehydration	85 %	85 %	Reception standards of disposal sites in Japan and requirement for transportation by vehicles other than tank lorries.

The water content in the sludges should be reduced for the purpose of the transportation. With mechanical treatment, it can be reached a percentage of moisture content of 85% (minimum requirement for transportation). It can be reduced to lower than 85% with drying systems.

b.2.2 Sludge generated from public sewage treatment plants

According to the long term program of sewage treatment diffusion, the estimation of sludge generation amount from public sewage treatment plant was conducted based on the assumptions expressed below.

- All suspended solid removed by the sewage treatment plants converted to sludge.
- Empirical data obtained at the Santiago Poniente Plant of EMOS (Planta de Tratamiento de Agua Servidas Santiago Poniente) suggest the proportion of "inorganic matter" and "organic matter", in treated sludge, to be 50% each.

- According to the empirical data in Japan, 50% of organic matter in sludge is decomposed to water and methane gas by sludge digestion.
- The water content of dehydrated sludge cake is 75% as mentioned in the EMOS's plan.

b.2.3 Conclusions

Table below shows "Forecast for Total Sludge Generation Amount" as a summary of the above estimation.

Table 4.1c Forecast for Total Sludge Generation Amount

Sludge Generation Source		Type	Water content	1995 (ton/year)	2010 (ton/year)
Factories	(1)*1	In-organic	90%	47,035	309,879
		Organic	99%	43,518	6,585,469
	(2)*1	In-organic	85%	-	206,586
		Organic	85%	-	439,031
Sewage Treatment Plants		Organic	75% *2	6,388	631,998
Total	(1)*1	In-organic	-	47,035	309,879
		Organic	-	49,906	7,217,467
		Total	-	96,941	7,527,346
Total	(2)*1	In-organic	-	-	206,586
		Organic	-	-	1,071,029
		Total	-	-	1,277,615

(Note) *1 The figures of (1) are of before dehydration and those of (2) are of after dehydration on-site.
*2 the figure of 75% is based on the EMOS information.

b.3 Forecast of dust generation

Dust generation ratios obtained by the factory survey amount to less than half of categories of industries. Forecasted amount of dust generation in 2010 shall be a conservative estimate if the forecast is conducted without generation ratios for industries which are unaccounted for at present. In order to get the generation ratios of several industries for which ratios were not obtained by the Team's survey, generation ratios surveyed in Japan by the Ministry of International Trade and Industry (MITI) were examined (see Table I.2.2k in Annex I). However, there are large

differences between the ratios obtained by the Team's survey and MITI. In addition, it is hard to get correlation of them. This is due to differences of production processes, raw materials, fuels, flue gas treatment facilities, emission standards, etc.. Thus generation ratios of similar categories of industries, which were obtained by the Team's survey, were applied to dust generation in 2010.

On the other hand, the installation rate of facilities emitting exhaust fumes is 82% according to the Team's Factory Survey (although the SESMA-PROCEFF data base has the installation rate in the MR, it does not provide the rate in accordance with the CIIU code). Consequently, dust generation amount in 2010 is presented in Table 4.1d.

b.4 Forecast of ISW generation in 2010

Generation of ISW highly depends on the assumed water content of sludge. ISW generation in 2010 is forecasted both in the cases of without dehydration at generation sources and with dehydration on-site as shown in Table 4.1d.

As in the case of without dehydration at the generation (on-site), i.e. the water contents of C-3: Inorganic Sludge and C-4: Organic Sludge are 90 % and 99 % respectively, an estimated amount of total ISW generation in year 2010 is 8.5 times more than that in 1995 and 8.00 million ton/year. "Organic sludge (C-4)" generation amount in 2010 is forecasted to be 6.59 million ton/year, which counts for 82 % of the value estimated above.

As in the case of with dehydration on-site in order to be received at a final disposal site, an estimated amount of total ISW in 2010 is only 22 % of the above estimation, which is 1.9 times than that in 1995 and 1.76 million ton/year. In this case, organic sludge counts for 25% of the total generation.

As explained in the above discussion, assumption of water content of sludge influences the forecast of total ISW generation. Special attention should be given to this context.

Table 4.1d Summary of ISW Generation in 2010

Unit: ton/year

ISW Category		1995	1997	2000	2005	2010	Increase rate (2010/1995)
C-1	Ash including from incinerator	10,973	11,295	11,795	12,611	13,437	1.22
C-2	Dust and APC products	5,078	9,917	17,176	29,273	41,371	8.15
C-3*1	Inorganic sludge	47,035	82,081	134,650	222,264	309,879	6.59
C-4*2	Organic sludge	43,518	915,788	2,224,169	4,404,819	6,585,469	151.33
C-3*3	Inorganic sludge	-	54,721	89,767	148,176	206,586	4.39
C-4*4	Organic sludge	-	61,052	148,278	293,655	439,031	10.09
C-5	Asbestos	299	312	331	363	395	1.33
C-6	Acids	16,911	17,479	18,332	19,762	21,178	1.25
C-7	Alkalis	2,435	2,518	2,641	2,849	3,055	1.25
C-8	Solvents	485	511	550	615	679	1.40
C-9	Oily waste	3,824	3,863	3,924	4,020	4,118	1.08
C-10	Inorganic chemical residues	24,479	25,273	26,464	28,430	30,392	1.24
C-11	Organic chemical residues	7,927	8,175	8,549	9,171	9,786	1.23
C-12	Other liquid waste	4,044	4,209	4,449	4,859	5,268	1.30
C-13	Waste from food production	219,911	227,530	239,327	258,741	277,927	1.26
C-14	Glass and ceramics	129,240	133,153	139,128	149,087	159,047	1.23
C-15	Metal and scrap	55,028	56,871	59,644	64,235	68,817	1.25
C-16	Paper and cardboard	90,602	96,492	105,269	119,921	134,543	1.49
C-17	Plastics	24,858	25,758	27,117	29,374	31,626	1.27
C-18	Rubber	14,306	14,949	15,886	17,466	19,049	1.33
C-19	Textile and leather	10,158	10,321	10,573	10,993	11,418	1.12
C-20	Waste similar to domestic waste	47,984	49,664	52,221	56,455	60,675	1.26
C-21	Wood	117,359	119,799	123,274	129,204	135,182	1.15
C-22	Slag form melting	10,898	11,221	11,704	12,504	13,310	1.22
C-23	Construction Waste	6,577	6,845	7,249	7,922	8,600	1.31
C-24	Other solid waste	45,209	47,265	50,350	55,484	60,668	1.34
Grand Total *5		939,139	1,881,278	3,294,771	5,650,420	8,005,888	8.52
Grand Total *6		-	999,192	1,173,997	1,465,168	1,756,157	1.87

Note 1: The Table does not include the sludge generated from sewage treatment plants since EMOS has plans for appropriate treatment and final disposal of said sludge.

Note 2:
- *1 Before dehydration and water content is 90%.
- *2 Before dehydration and water content is 99%.
- *3 After dehydration and water content is 85%.
- *4 After dehydration and water content is 85%.
- *5 In the case of without dehydration at the generation (on-site), i.e. water contents of C-3= 90% and C-4=99%.
- *6 In the case of with dehydration on-site, i.e. water contents of C-3=85% and C-4=85%.

4.2 Planning Framework

a. Goals

The principal goal of the ISWM Master Plan is to establish a proper management system of ISW till the target year 2010 in the Metropolitan Region where the Republic centers industries and economic activities and where approximately 40% of the national population concentrates.

Through the establishment of the proper ISWM system, ***the Plan aims at:***

- ***preservation of the environment and public health, and sound development of the city;***
- ***promotion of growth of Chilean industries in gaining the international competitiveness required for compliances with issues of joining the international market and ISO's stricter standards for environment.***

The goals in practice of the Master Plan are as follows:

i. Management of all ISW under CDSI; analytical identification of HW and management of it under MS regulation appropriately be implemented.
ii. Waste water/effluent gas, which include hazardous substances, be treated at all factories. Pre-treatment before discharge into sewage line substantially be completed. Most sludge, LW and dust be managed and controlled as ISW.
iii. Factories with 100 or more employees, which facilitate higher level on-site ISWM, shall incorporate minimization of HW generation by production process alteration and by in-factory recycling (resource recovery) and shall substantiate integrated ISWM. Meanwhile small and medium sized industries shall also be in process of adopting this sort of on-site ISWM.
iv. Private sectors activities (e.g. intermediate treatment, final disposal, resource recovery, transfer, storage and transportation facilities) shall consolidate their facilities to carry out appropriate ISWM.
v. Regarding final disposal of HW, especially, long term control and management of the facilities be complied and a system to guarantee responsibilities be established (e.g. in case when environmental pollution has occurred, necessary measures such as restoration and compensation

fully be guaranteed).

vi. Appropriate market mechanism of ISWM business for adequate ISWM system be established (i.e. after substantiation of adequate ISWM system, waste generators shall bear the cost of ISW treatment/disposal works entrusted.).

b. Targets

In order to achieve the principle goal (the establishment of a proper ISWM system), it is necessary to comply with the following two requirements:

i. Establishment of Appropriate On-site ISWM

Waste generators shall take such actions that production process may be improved and altered, and appropriate on-site ISW treatment/disposal be realized.

ii. Formulation of ISWM market mechanism

Appropriate market mechanism shall be formulated in ISWM business; i.e., private sectors start to operate proper ISWM business, where waste generators entrust ISW treatment/disposal to the sectors.

In order to comply with these 2 requirements, it is necessary to accomplish 5 targets for the "establishment of appropriate on-site ISWM" and 4 targets for "formulation of ISWM market mechanism" as shown in tables below. The tables show that to what extent respective goals should be achieved in a step-wise manner towards the target year 2010.

Table 4.2a Targets for Establishment of Appropriate On-site ISWM

TARGET	Waste Generator		Phase-1 (~1997) (%)	Phase-2 (~2000) (%)	Phase-3 (~2005) (%)	Phase-4 (~2010) (%)
	Classification	Scale (No. of Employees)				
Estimated ISW Generation in phase end year (thousand ton/year)			1,881	3,295	5,650	8,006
TARGET-1 ISWM should be based on the 333 classification of CDSI. Actual state of ISWM at generation should be truly reported by factories as requested by the authorities (including the declaration system).	HPI	100~	80	100		
		50~99	50	80	100	
		10~49	10	50	100	
	PI	100~	70	100		
		50~99	30	50	100	
		10~49	-	30	70	100
	LPI	100~	50	100		
		50~99	-	30	50	100
		10~49	-	20	50	100
TARGET-2 Waste water and gas emission should be treated on-site. Sludge, LW, dust, etc. should be managed as ISW.	HPI	100~	10	80	100	
		50~99	5	50	80	100
		10~49	-	30	50	100
	PI	100~	10	50	100	
		50~99	5	20	60	100
		10~49	-	20	50	80
	LPI	100~	10	50	100	
		50~99	-	30	60	100
		10~49	-	20	50	80
TARGET-3 Processes and materials which may generate HW according to the regulation of MS should be recognized. HW should be identified and declared to authorities.	HPI	100~	50	100		
		50~99	10	100		
		10~49	-	80	100	
	PI	100~	30	80	100	
		50~99	-	50	80	100
		10~49	-	30	60	100
	LPI	100~	30	60	100	
		50~99	-	30	60	100
		10~49	-	20	50	100
TARGET-4 Analytical identification of HW should be carried out. Appropriate on-site ISWM and proper treatment/disposal should be maintained.	HPI	100~	50	80	100	
		50~99	-	30	100	
		10~49	-	20	80	100
	PI	100~	30	60	100	
		50~99	-	20	50	100
		10~49	-	10	30	100
	LPI	100~	-	30	50	100
		50~99	-	10	30	100
		10~49	-	10	30	100
Target-5 Higher (than legislative requirement) level of HW management (e.g. through process/material alteration for waste minimization) should be aimed.	HPI	100~	10	30	50	100
		50~99	-	20	30	80
		10~49	-	10	20	50
	PI	100~	10	30	50	100
		50~99	-	10	30	80
		10~49	-	-	20	50
	LPI	100~	10	30	50	100
		50~99	-	10	30	80
		10~49	-	-	20	50

Table 4.2b Targets for Formulation of ISWM Market Mechanism

Targets	Policy Objectives	Phase-1	Phase-2	Phase-3	Phase-4
Target-1 Construction of appropriate HW treatment and disposal facilities by private sectors					
	Preparation of standards for structure and operation/maintenance	●			
	Establishment of control system for ISWM facilities siting in relation to urban planning and environment	●			
	Strengthening administrative capabilities of assessing facilities siting	●			
	Improvement of EIA system regarding siting of facilities	●			
	Establishment of public participation system regarding the siting of facilities	●			
	Establishment of permission procedure for an ISWM facility siting	●			
Target-2 Elimination of illegal treatment and disposal activities (e.g. illegal dumping, unauthorized treatment and disposal activities, etc.)		0%		100%	
	Provision of laws/regulations for suspending operation and removal of illegal treatment and disposal facilities	○	●		
	Establishment of supervision and guidance system for proper waste treatment, acceptance of wastes, and facilities operation	○	●		
	Authorization to the responsible administration for report collection, on-site inspection and empowered administrative measures, etc.		●		
Target-3 Disposal of HW (stored by generators, etc.) at licenced treatment/disposal facilities					
	Supervision and guidance of appropriate on-site ISWM	○	●		
	Control of entrusted treatment/disposal activities by the declaration system		●		
	Use of administrative measures (order of suspension, etc.) against illegal actions (e.g. entrusting ISW disposal to illegal routes, etc.)		○	●	
Target-4 Formulation of sound ISWM market for proper operation and management of ISWM facilities.					
	Strict control of illegal treatment and disposal of ISW		○	●	
	Applying the duty of compensation for environmental pollution and damages upon the polluters including ISW handling agents.		○	●	
	System obligating the insurance and/or fund for compensation as a collateral condition of permission of the treatment and final disposal facilities siting.		○	●	
	Increasing the awareness of generators regarding the necessity of paying the cost for HW treatment and disposal, as well as of reducing the cost by waste minimization and appropriate management.	○	○	●	

Remarks: ● : Completed
○ : Being completed

c. Strategy

Strategies in principle to reach "targets" (mentioned in the preceding section) comprise:

i realization of thorough on-site ISWM and

ii. formulation of ISWM market which is based upon market mechanism and enables appropriate treatment, disposal, and resource recovery.

Namely, based on PPP (polluter pays principle), an outline of ISWM that treatment and disposal of ISW be carried out by private sectors should be formulated. Hence, the authorities should prepare systems of legislation, guidelines, monitoring and guidance that promote said formulation.

In practice herewith, the Master Plan period should be divided into two: i.e., the first period as until year 2000 and the second period as until year 2010. Strategies in respective stages are summarized below.

c.1 Strategies up to Year 2000 (Phase-1 ~1997, and Phase-2 ~2000)

- The current conditions of ISW generation and treatment are to be clarified in accordance with 333 ISW categories of CDSI in large factories. Identification of HW is also to be made by large factories based on the regulations of the MS. Voluntary reporting from generators to authorities are to be realized.
- More or less half of industries in the region should equip facilities of waste water and exhaust gas treatment. Sludge, LW, and dust are to be managed and controlled as ISW.
- Through the compilation of the information submitted by waste generators and on-site investigation, the authorities shall gain the capability to examine reports from factories and plans proposed by private sectors.
- HW treatment/disposal facilities shall be in practice operated. Authorities' monitoring and guidance over private ISWM sectors' activities are to be strengthened. Illegal treatment/disposal and dumping should be eliminated.

In order to realize the above-mentioned strategies, the following measures should be developed.

i. Legislative aspects

- Laws and regulations that provide the principal duties and responsibilities of factories (e.g. duties of on-site ISWM and reporting, responsibilities in contract work of ISW handling, etc.) should be enforced.
- Laws and regulations that make provisions regarding the establishment of local agencies (responsible for supervision and guidance on appropriate handling of ISW) and specification for supervision and guidance (including suspension order and facility closure order) should be enforced.
- Laws and regulations that obligate the duties of pre-treating waste water to be discharged into sewerage system should be enforced.
- Laws and regulations that enable local authorities to issue permission on the siting of facilities (for ISW storage, transfer, treatment, and final disposal) should be enforced.
- An EIA system regarding the siting of ISWM facilities should be improved.

ii. Organizational and institutional aspects

- Local agencies responsible for supervision and guidance on handling of ISW, as well as for siting of ISWM facilities should be strengthened.
- Institutions (both private and public) for identifying and analyzing HW and waste water quality should be established.
- A system to guarantee responsibilities (among waste generators and ISWM sectors) in controlling ISW should be established.
- A system to promote application of appropriate technology should be established.

iii. Other aspects

- Manuals for identification and analyses of HW based on regulations of the MS, and technical guideline regarding storage, transport, treatment and disposal of ISW should be published.
- Standards of siting permission and operation permission for ISWM (treatment/disposal/resource recovery) should be made.
- The storage, treatment and final disposal facilities for handling the presently generated hazardous wastes should be constructed and operated in this period.

c.2 Strategies up to Year 2010 (Phase-3 ~2005, and Phase-4 ~2010)

- The actual conditions of ISW and HW generation are to be clarified in almost all factories and be truly reported to authorities. Pre-treatment of industrial waste water and proper handling of treated residues (sludge) are to be carried out by almost all factories.
- Authorities' supervision and guidance are to be improved and enhanced by legal empowerment. The proper management and treatment of HW is to be realized at most factories and HW handling agents. (i.e., supervision and guidance are to be concentrated to faulty factories and handling agents.)
- As the result of the enhanced capability of waste management in factories and by waste handling agents, authorities and industries jointly aim to realize higher level of ISWM.

In order to realize the above-mentioned strategies, the following measures should be developed.

i. Legislative aspects

- Laws that provide local authorities the power of conducting administrative measures or applying penalties against illegal acts should be enacted.
- Technical standards and guidelines should be improved and tightened.
- Fund/insurance system for compensating pollution should be obligated in relation to siting of treatment/disposal facilities.

ii. Organizational and institutional aspects

- Establishment of overall local supervision and guidance system should be led by the improved and enhanced local authority.
- A system to guarantee responsibilities of factories and handling agents regarding ISW, and a system of technology management should be ameliorated.
- Private industries related to ISW and HW treatment (waste and waste water analysis, treatment plant and equipment manufacturers, environmental risk insurance services, etc.) should be developed.

iii. Other aspects

- Supporting systems that promote treatment of ISW and waste water by small and medium sized factories (such as, technical assistance, financial assistance e.g. low interest loan, for installation of treatment facilities and equipment), as well as the modernization of production processes and relocation of factories, should be established.
- A database system for authorities' monitoring and guidance (e.g. the declaration system) should be completed.
- Manuals or guidelines for higher level ISWM (e.g. waste minimization and HWM by production process alteration) should be published.

4.3 Examination of Technical System

a. Examination of Appropriate Treatment/Disposal Flow

a.1 Basic Concept

There is a wide variety of features and characteristics of ISW generated. Consequently technical systems to be applied for the management of ISW have a wide variety in their applications and background technologies. At present, a technical system for ISW in the MR is not established yet.

In view of the principal policy of the Government of Chile, a technical system of ISW in future will be established by private sectors. The Study does not employ the methodologies which propose an appropriate and/or optimum technical system through examination of each individual technical system. Instead, the Study examines appropriate treatment/disposal flows for 24 ISW categories for the authorities' proper management system of ISW. Examination of appropriate treatment/disposal flows will contribute to establish authorities' proper management of ISW in seeking effective and efficient monitoring and guidance to be placed to private sectors activities related with ISWM. Authorities, with referring to appropriate treatment/disposal flows for 24 ISW categories proposed by the Team, should control and guide waste generators and ISW handling agents for their proper ISWM to be realized, by using ISW list identified in the CDSI system and results of laboratory analysis.

Meanwhile, waste generators could compare costs of collection, intermediate treatment

and final disposal referring to the proper ISW flow, and could select their ISW treatment/disposal flow (technical system) being the most cost-effective and legally appropriate. And ISW handling agents will provide an appropriate technical system, in view of respective treatment demands, legislatively required compliances, facilities site availability, technologies available and manageable and profitability. Namely, the technical system for ISWM in future is to be formulated based upon "economic activities and market mechanisms" of waste generators and handling agents.

a.2 Appropriate Treatment/Disposal Flow

a.2.1 Choice of Final Disposal Facilities and Intermediate Treatment Technologies

Final disposal facilities are classified into:

i. Strictly Controlled Landfill (SCL) for disposal of HW;
ii. Controlled Landfill (CL) for disposal of Non-HW but non-inert; and
iii. Inert Landfill (IL) for disposal of inert Non-HW.

and appropriate disposal measures be applied for respective ISW. LW (Liquid Waste) irrespective of whether it is HW (Hazardous Waste) or non-HW shall not be disposed directly to final disposal sites.

Purposes of intermediate treatment are: "transformation of HW into Non-HW" and "volume reduction". In view of the present situation of ISW in the MR, intermediate treatment should be mainly oriented for "transformation of HW into Non-HW". However, there are some types of ISW such as sludge that treatment for "volume reduction" (e.g. dehydration) is indispensable for reducing costs of collection and transportation.

The choice of intermediate treatment technologies to be applied could not be decided by authorities but shall be determined as a consequence of private sectors' judgement in consideration of comparison of related in-house costs and/or subcontract costs (i.e. waste generators), and market demands and profitability (i.e. handling agents) of a treatment operation.

a.2.2 ISW Classification Corresponding to Appropriate Treatment Flows

333 ISW classification employed in the CDSI system of SESMA-PROCEFF has 3 sub-classifications of HW, Non-HW and LW. In order to implement a workable management of ISW, examination (of appropriate treatment flows) should be carried

out based on the existing ISWM system (i.e. CDSI system).

In this context, based on the 3 sub-classifications of ISW in the CDSI system, the following classification with the purpose of controlling ISW is proposed to realize authorities' appropriate management system of ISW corresponding to technical systems to be extended by private sectors (see Table 4.3a):

Table 4.3a ISW Classification corresponding to appropriate treatment/disposal flows

ISW Classification	Intermediate treatment and final disposal	Judgement criteria
1. LW	Intermediate treatment is indispensable due to LW in principle is not allowed to be received in any kind of landfills.	-
2. HW		
2.1 Ignitable	Not received in final disposal sites (landfill). Therefore intermediate treatment (e.g. incineration) before landfilling is indispensable.	*1 MS-article No.6
2.2 Corrosive	Not received in final disposal sites. Therefore intermediate treatment (e.g. chemical treatment) before landfilling is indispensable.	*1 MS-article No.7
2.3 Reactive	Not received in final disposal sites. Therefore intermediate treatment (e.g. chemical treatment) before landfilling is indispensable.	*1 MS-article No.8
2.4 Toxic		Leaching Test (LT) or fundamental study
a. Acute	Not received in final disposal sites. Therefore intermediate treatment (e.g. solidification, chemical treatment, etc.) before landfilling is indispensable.	*1 MS-article No.3
b. Not acute	Could be received in SCL.	*1 MS-article No.5
3. Non-HW		
3.1 Non-Inert	Intermediate treatment is to be carried out only to recycle or volume reduction, if necessary. To be disposed in CL. To be recycled or disposed in IL	-
3.2 Inert		Solubilization test (ST)

Note: *1 Regulations for HW management by MS (first working draft)

a.2.3 ISW Control Methodologies

Control over whether ISW are appropriately treated and/or disposed should basically be carried out based upon the "respective appropriate treatment flows for 24 ISW categories" and the "ISW classification corresponding to appropriate treatment/disposal flows shown in the Table 4.3a. The judgement of in which ISW classification (of Table 4.3a) an ISW generated corresponds and in what treatment/disposal is to be placed, should be given based on the PROCEFF ISW list (i.e. 333 classification) and judgement criteria described in the table above.

i. Control prior to prevalence of laboratorial analytical technologies and establishment of related institutions

It is essential to establish ISW laboratorial analysis standards, disseminate technologies and establish institutions capable to carry out said analysis. Therefore, prior to establishment of the technologies (i.e. standards/practices), controls over ISW should be carried out for HW and LW defined in the prevalent 333 waste classification in the CDSI system. It shall be prohibited for wastes defined as HW and LW in the SESMA-PROCEFF classification to be disposed in municipal landfills. It is necessary for the time being that authorities place such instructions that HW and LW shall be stored at waste generators compound or other reliable agents' compounds until ISW treatment/disposal facilities are constructed and operated. At the same time, authorities' monitoring and guidance over HPI (industries with high potentiality of generating HW and LW) should be strictly implemented. Meanwhile, preparation and enforcement of respective regulations should be promoted in order that it leads to the steady and fast establishment of appropriate technical systems (treatment and disposal systems for HW and LW).

ii. Control after prevalence of laboratorial analytical technologies and establishment of related institutions

After diffusion of laboratorial analysis technologies and after establishment of appropriate technical systems of treatment/disposal by private sectors', necessary judgement tests (along with the appropriate ISW treatment/disposal flow)should be obligated to waste generators and handling agents. In accordance with the outcome of the judgement tests, control over treatment/disposal of HW and LW should be placed. On this occasion, authorities, who are empowered to take administrative measures over management of HW treatment, should obligate waste generators to prove whether such ISW labeled as "possible" in the Table 4.3b are Non-HW or not.

a.2.4 Appropriate Treatment/Disposal Flow

An appropriate treatment/disposal flow is summarized as shown in Figure 4.3a. The respective appropriate treatment flows for 24 ISW categories are presented in the section 7.1.1 of the main report.

Table 4.3b Relations of 24 ISW Classification and HW

Type of Waste		Liquid or Not	Hazardous Waste					Non-hazardous Waste	
			Ignitable	Corrosive	Reactive	Toxic		Non-inert	Inert
						Acute	Non-acute		
C-1	Ash including from incinerator	No	No	Possible	No	Possible	Possible	Possible	Possible
C-2	Dust and APC products	No	No	Possible	Possible	Possible	Possible	Possible	Possible
C-3	Inorganic sludge	Possible	No	Possible	Possible	Possible	Possible	Possible	Possible
C-4	Organic sludge	Possible	Possible	Possible	Possible	Possible	Possible	Possible	Possible
C-5	Asbestos	No	No	No	No	No	Possible	No	No *1
C-6	Acids	Possible	Possible	Possible	Possible	Possible	Possible	Possible	No
C-7	Alkalis	Possible	Possible	Possible	Possible	Possible	Possible	Possible	No
C-8	Solvents	Possible	Possible	No	No	Possible	Possible	No	No
C-9	Oily waste	Possible	Possible	No	No	Possible	Possible	No	No
C-10	Inorganic chemical residues	Possible	Possible	Possible	Possible	Possible	Possible	Possible	No
C-11	Organic chemical residues	Possible	Possible	Possible	Possible	Possible	Possible	Possible	No
C-12	Other liquid waste	Possible	Possible	Possible	Possible	Possible	Possible	Possible	Possible
C-13	Waste from food production	Possible	No	No	No	No	No	Possible	No
C-14	Glass and ceramics	No	No	No	No	No	No	Possible *2	Possible
C-15	Metal and scrap	No	No	No	No	No	No	Possible *2	Possible
C-16	Paper and cardboard	No	No	No	No	No	No	Possible	No
C-17	Plastics	No	No	No	No	No	No	Possible	Possible
C-18	Rubber	No	No	No	No	No	No	Possible	Possible
C-19	Textile and leather	No	No	No	No	No	No	Possible	Possible
C-20	Waste similar to domestic waste	No	No	No	No	No	No	Possible	Possible
C-21	Wood	No	No	No	No	No	No	Possible	No
C-22	Slag from melting	No	No	No	No	Possible	Possible	Possible	Possible
C-23	Construction waste	No	No	No	No	No	No	Possible	Possible
C-24	Other solid waste	Possible	Possible	Possible	Possible	Possible	Possible	Possible	Possible

*1 : Asbestos without treatment is considered as hazardous waste
*2 : Considering a possibility used as containers contaminated with non-inert
*3 : Material used as container for hazardous substances (for example pesticides) can become HW.

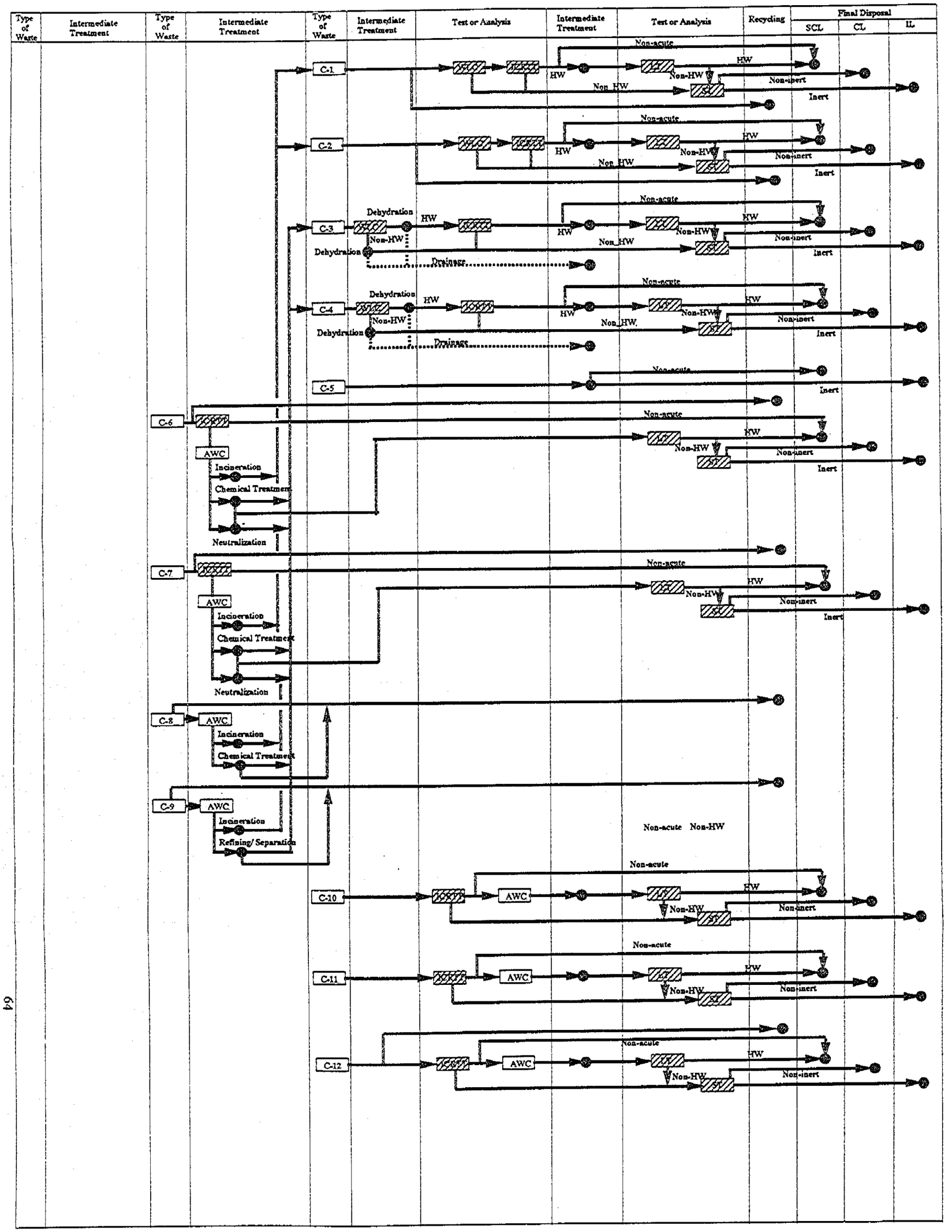


Figure 4.3a Appropriate Treatment/Disposal Flow (1)

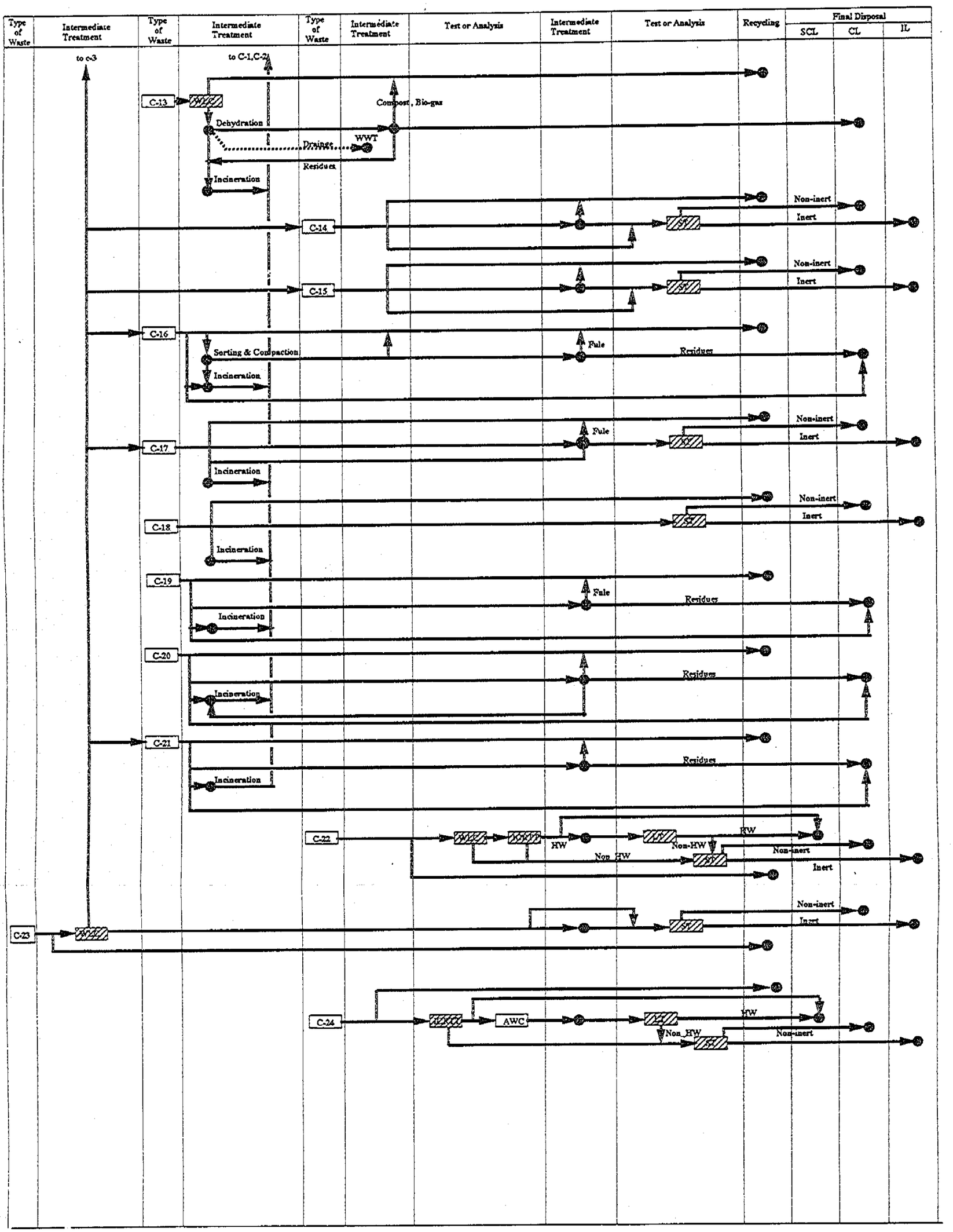


Figure 4.3a Appropriate Treatment/Disposal Flow (2)

b. ISWM by Generators (In-Factory)

b.1 Basic Framework of ISWM and Waste Minimization by Waste Generators

Based on the above-mentioned major issues of ISWM for waste generators, ISWM and waste minimization at generators should be basically implemented by the following steps.

Step 1: Proper identification of generation characteristics of ISW by waste generators

This step is to be taken by disseminating and enhancing the existing manifest system (declaration system), by which proper knowledge and awareness on ISW is to be cultivated.

Step 2: Proper management of ISW and selection of the optimum waste minimization measures to be applied inside factories and its implementation

Based on the accurate identification of waste emission characteristics by generators, the optimum management and minimization methods are to be selected for implementation. Particularly, regarding the anticipated increase of dust and sludge generation by the implementation of end-of-pipe flue gas and waster water treatment methods, it is important to consider the introduction of cleaner production technology in terms of its cost efficiency as well as efficient reduction of waste generation.

b.2 Waste Auditing as Means of Identifying the Waste Emission Characteristics of the Factories

A manifest system is very useful for public administration to supervise the waste generation and handling practices. However, in terms of examining the potential of waste minimization, the information obtained from the manifest system is very limited. In order to prevent and reduce waste generation, overall industrial production process need to be examined for the identification of waste generation sources, operational problems associated with the production process, and finally the areas where improvement can be made.

A waste audit is a typical means of problems identification by clarifying the overall material flows from input to output through observation, measuring, recording data, collecting and analyzing waste samples. The waste audit can identify the problems at

various level. A waste audit of a region can indicate the specific problem industries. Hence, at plant level, waste generation sources can be identified during particular processes. This system may be useful for factories to clearly identify the waste emission characteristics and the possible areas of waste minimization.

b.3 Possible Areas of Waste Minimization

b.3.1 Possible Areas of Waste Minimization in Raw Material Procurement Phase

Possible areas of waste minimization in this phase are:

- increase the use of recycled or wasted materials and to promote their use; and
- substitute energy resources that has low waste generation or pollutant emission.

b.3.2 Possible Areas of Waste Minimization in Production Phase

Major possible areas of waste minimization is found in production processes for most manufacturing industries. Improving the production process not only reduce the waste generation but also brings about positive effects, i.e. reduction or even elimination of environmental pollution, energy and raw materials saving, increasing productivity, and so forth. The areas of waste minimization in this phase consist of:

- energy saving
- improving production process for raw (input) materials saving
- effective reutilization of materials generated in production process
- improving production process for reduction of wastes and pollutant emission.
- reducing the use of hazardous materials
- research and development of innovative environmentally friendly production process

b.4 Implementation Plan of On-site ISWM and Waste Minimization

On-site ISWM is, in principle, self-efforts of proper ISWM and waste minimization by generators in coordination with ISW handling agents. As the measures for proper ISWM and waste minimization vary with type of industries, scale of factories, applied production system, and so forth, it is not practical to refer to the implementation plan for each type of industry. Even within one type of manufacturing industry, ISWM and waste minimization measures may be completely different between factories.

Therefore, the Study proposed the implementation plan by setting up common goals and targets to be achieved by ISW generator up to 2010.

b.4.1 Goals

The proposed goals of on-site ISWM and waste minimization in 2010 are:

- To realize proper on-site control of ISW based on the overall identification of waste generation and pollutant emission characteristics of own factories.
- To minimize the pollutant emission to the environment by utilizing the best available pollution abatement technologies.
- To minimize waste generation by incorporating the best available material recycling and reutilization technologies or introducing advanced CPT into the production system.
- To reduce the use of hazardous materials that may generate HW by the generator's continuous efforts of technology development.

b.4.2 Targets

The targets of the master plan are proposed for three periods, i.e. the short-term (1996-2000), the medium-term (2001-2005), and the long-term (2006-2010), as given in Table 4.3c below.

Table 4.3c Generator's Targets of On-site ISWM and Waste Minimization (1996-2010)

Short-term (1996-2000)

1. Manifest system
   - Generation of ISW is accurately identified and reported to the authorities as required under the improved manifest system (declaration system).

2. Environmental audit
   - Identification of waste generation and pollutant emission characteristics is to be commenced by the generators (environmental audit).

3. Flue gas and waste water treatment
   - Installation of end-of-pipe facilities is to be carried out in the existing factories.

4. Use of recycled or abandoned materials in factories (primary stage)
   - Sorting of the recyclable / non-recyclable ISW is to be initiated inside factories.

5. Primary energy saving efforts are carried out by factories
   - The worker's awareness on energy saving is to be increased.
   - Factory operation is improved to be more energy conscious.
   - Energy consumption inside factory is controlled and supervised.
   - Old or less energy efficient facilities are renewed.

6. Primary raw materials saving efforts are carried out by factories
   - The worker's awareness on raw materials saving is to be increased.

Medium-term (2001-2005)

1. Environmental audit
   - Waste generation and pollutant emission characteristics of own factories are identified by generators.

2. Use of recycled and abandoned materials
   - Use of the recycled and/or abandoned materials for industrial production is sufficiently conducted by factories.

3. Fuel substitution
   - The possibility of fuel substitution is to be examined by factories.

4. Energy saving
   - Introduction of conventional high efficiency production facilities / equipment is carried out.
   - Introduction of unused energy and/or waste heat utilization system is to be examined for application.

5. Raw materials saving
   - Conventional raw materials saving methods are examined for application.

6. In-factory recycling through the change of process
   - Conventional in-factory recycling methods are examined for application.

7. Reducing the use of hazardous materials
   - The use of non-hazardous materials are examined for application.

Long-term (2006-2010)

1. The conventional waste minimization technologies and methods (inc. CPT) are to be widely applied by factories.

2. Research and development of advanced (newly developed) CPT is to be carried out.

b.4.3 Necessary Policy Measures for Target Compliance

Policy measures requiring compliance with the above targets are specified in the prerequisite for establishment of on-site ISWM (see Table 6.2.3a in the main text). Some of the additional policy tools may be needed such as :

- guidelines/manuals for environmental audit of industrial production process;
- regional (or maybe national) inventory of CPT and material recycling/reutilization technologies;
- government sponsored demonstration program of technologies relating to waste minimization (trade fairs, exhibitions, etc.); and
- providing incentives to the factories of applying environmentally friendly technologies (awards, labeling of environmentally friendly products, etc.).

c. Investigation and IEE of Candidate Sites for Hazardous Waste Disposal

c.1 Selection of Candidate Sites for an HW Disposal

ISW is largely disposed of on municipal landfill sites if it is suitable for disposal on these landfills, but for HW there is no alternative to on-site storage in the waste generating factories, etc..

At the onset of the Study, the Team developed a set of guidelines for the selection of candidate sites for major ISWM facilities and suggested Guidelines for Selection of Potential Areas for Major Facilities for Industrial Solid Waste Management.

Work has been conducted by the Chilean side for some time with the aim of identifying suitable landfill sites in the Metropolitan Region. The Chilean counterpart requested to the Team the analysis of applicability of these sites for HW landfill in view of the need for an urgent solution.

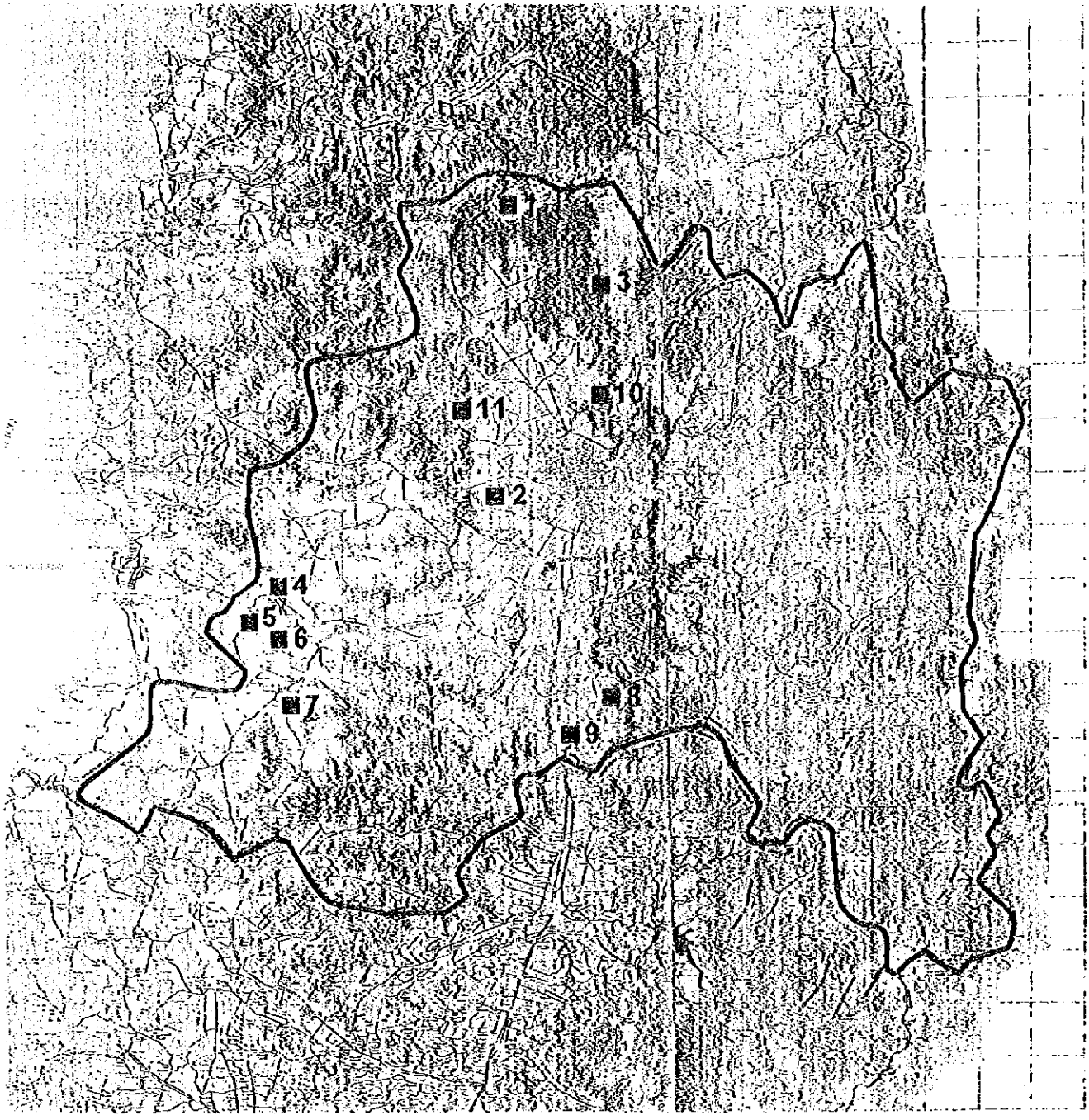


Figure 4.3b Location Map of Candidate Sites

c.2 Investigation and Comparative Environmental Evaluation of Candidate Sites

Information regarding the candidate landfill sites was compiled through field visits to all sites and from a wide range of sources. The information mainly come from open sources such as yearbooks and contemporary literature, etc.. The main sources of information have been the National Service for Geology and Mining (SERNAGEOMIN), the Metropolitan Sanitary Works Company (EMOS), Department of Farming and Grazing Service of Ministry of Agriculture, the Natural Resources Information Center (CIREN).

On top of the work, the Study Team has outlined a suitable landfill configuration at each of the sites and on the basis of this, made an estimate of landfill area and volume. The technical/environmental data for each of the sites were compiled to make a conclusive evaluation of the site's suitability as a hazardous waste landfill.

For a comparative evaluation the main issues from each of the 11 sites are summarized and the total evaluation for each of the sites is made. It is worth mentioning that the evaluation undertaken is relative and not absolute. That is, the evaluation is intended to select those sites which are most suitable for a landfill localization from a technical/environmental point of view and exclude those which are less fit or unfit. **The evaluation made in this report is thus only for a preliminary site selection and cannot substitute an in-depth assessment as this is done in an Environmental Impact Assessment.**

The order of priority thus suggests that the sites numbers 1, 2 and 3 are the ones most suitable for the establishment of an industrial hazardous waste landfill in the Metropolitan Region, with site no. 2, Cerro Carneros, receiving the first priority.

It should be emphasized that the ranking is to some extent conditional. Although there is no doubt that site no 2, Cerro Carneros, should on the basis of the information presently available receive the top priority, there might be some doubt whether site no. 1, *Montenegro, or no. 3, Quilapilún, should be second priority. The fact that the* municipal landfill at Montenegro will be constructed is for example much in favor of an industrial waste landfill on the same locality, as these two landfills could thereby benefit from the same facilities and one more landfill would not contribute to general inconveniences.

It should also be emphasized that information provided during an EIA may change the priority suggested for these three sites.

c.3 IEE of Recommended Sites for Hazardous Waste Disposal

On the basis of the conclusions it is deemed reasonable to consider the potential landfill localities Cerro Carneros, Montenegro and Quilapilún the top priority sites for the establishment of a hazardous waste landfill site. For these three sites an Initial Environmental Evaluation along the lines suggested by JICA in the "Environmental Guidelines for Infrastructure Projects VI, Solid Waste Management, September 1992" should therefore be conducted.

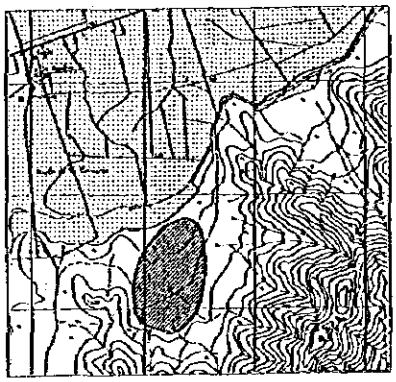
There is, however, no doubt that for a landfill intended for infinite or long-time storage of HW for the whole Metropolitan Region, a full Environmental Impact Assessment (EIA) must be conducted. The IEE is therefore not intended as a discussion of whether EIAs should be conducted, but merely as the introduction to the main topics in these EIAs.

Following aspects were considered in the IEE: location, potential landfill (downscale map segment), potential area (m^2), potential volume (m^3), resettlement, land acquisition, traffic, public facilities, cultural property, water rights, rights of common, public health, waste, ground water, hydrological conditions, coastal zone, flora and fauna, landscape, air pollution/odor, water pollution, soil contamination, noise and vibrations, general issues. All these aspects were evaluated. It was indicated in the case where information was absent.

Furthermore, an EIA has been made for the potential site of Montenegro, as this is also the site for a potential domestic waste landfill, and this landfill is finally approved and is expected to be in full operation in March 1996. As this is the case, it is deemed inappropriate to conduct an IEE for this site. The IEEs therefore only cover the sites of Cerro Carneros and Quilapilún.

The IEEs for the two sites are summarized in the table below.

Table 4.3d Summarized IEE for the candidate landfill sites Cerro Carneros and Quilapilún

Site / Topic	Cerro Carneros	Quilapilún
Localization	At the slope and foot of Cerro Carneros, 22 km west of Santiago.	At the foot (and slope) of Loma del Poquén Quillay, 50 km north of Santiago.
Potential landfill (downscaled map segment)		
Potential area (m^2)	500,000	750,000 - 1,100,000
Potential volume (m^3)	20 million	30 - 100 million
Resettlement	Not needed - no housing nearby.	Probably necessary to resettle inhabitants (and owners of farmland) close to site. Options and legal background must be carefully assessed.
Land acquisition	Will be needed as area is privately owned. Legal basis must be assessed.	Will be needed as area is privately owned. Probably also irrigated farmland between site and highway due to pollution risks. Legal basis must be assessed.
Traffic	Present access road insufficient. Alternatives must be assessed, including access from highway.	Present access road highly insufficient and past housing. Alternatives must be identified and assessed.
Public facilities	Not identified. Must be identified and assessed.	Water supply possible, but will probably compete with present use. Other facilities not identified. Must be assessed.
Cultural property	None known - assess on the basis of historical/archaeological archives.	None known - assess on the basis of historical/archaeological archives.
Water rights	None identified. Should be identified and decided upon.	Water rights may be related to farm water supply and irrigation. Must be made up and decided upon.
Rights of common	None identified at present. Planning has identified the area for future recreational purposes. Compliance with these plans should be assessed.	None identified and none likely.
Public health	No risks likely to arise. Should be assessed for Public Relation reasons.	No risks likely to arise. Should be assessed for Public Relation reasons, unless resettlement of nearby dwellers take place.
Waste	On-site disposal needs for specific waste types (e.g. special lot for infectious waste, etc.) should be assessed and incorporated in environmental permit.	On-site disposal needs for specific waste types (e.g. special lot for infectious waste, etc.) should be assessed and incorporated in environmental permit.

Site / Topic	Cerro Carneros	Quilapilún
Ground water	Ground water/geological/water pollution situation must be carefully investigated and assessed.	Ground water/geological/water pollution situation must be carefully investigated and assessed.
Hydrological conditions	Gullies (quebradas) from the slopes and suitable measures to prevent flooding should be identified.	Gullies (quebradas) from the slopes and suitable measures to prevent flooding should be identified.
Coastal zone	Not relevant.	Not relevant.
Flora and fauna	Flora and fauna vulnerable to landfill construction and operation should be identified and relevant measures suggested.	Flora and fauna vulnerable to landfill construction and operation should be identified and relevant measures suggested.
Landscape	Closed landfill's compatibility with planned activities crucial. Should be carefully assessed and acceptable solutions prescribed. Proper requirements for coverage should be incorporated in permit.	Landscape problems unlikely in this desolated area. Proper requirements for coverage should be incorporated in permit.
Air pollution/ odors	Due to distance to inhabited areas not critical. Should be evaluated with regard to planned waste types.	Air pollution probably not critical. Odor problems may arise and be critical if houses nearby still inhabited, depending on waste types received. Should be assessed on these backgrounds.
Water pollution	Crucial point, cf. "ground water" above. Water balance must be established and solutions as to leachate detainment and handling suggested and assessed.	Crucial point, cf. "ground water" above. Water balance must be established and solutions as to leachate detainment and handling suggested and assessed.
Soil contamination	Soil not assumed vulnerable. On-site waste handling in relation to waste types should be specified.	Irrigated farmland west of site may be vulnerable. On-site waste handling in relation to waste types should be specified and assessed in relation to vulnerability.
Noise and vibrations	Noise levels at nearest houses due to traffic on access road should be assessed. Noise emissions from the landfill proper deemed unimportant.	Will be critical if nearby houses still inhabited. Must be assessed if this is the case.
General issues	The EIA and the environmental permit should specify control and supervision both during construction and operation and after closing.	The EIA and the environmental permit should specify control and supervision both during construction and operation and after closing. **It is obvious from the above, that the future existence of housing and farming in the vicinity of the site is crucial. The political and legal options for acquisition of the houses and the land by expropriation should therefore be carefully assessed before a full EIA is launched.**

4.4 Examination of Technical Standard

a. Outline of Contents for Technical Standards

a.1 Principle of Establishing Technical Standard

In order to establish standards for technical systems (e.g. storage, collection, transport, intermediate treatment, recycling and final disposal), the following issues need to be solved:

- coordination of various related authorities be taken;
- in-depth examination by many experts and personnel from related authorities be placed and coordinated;
- quite a long time be spent for the work of standard establishment.

Therefore, technical standards can not easily be established in such a short time as given for the Study. Fortunately an ISWM manual was drafted in May 1995 by a local consultant as a joint study of Ministry of Economy (Department of Commercial and Industrial Policy) and CONAMA. Although the manual seems insufficient to be employed as technical standards of individual technical systems (e.g. technical standards for incineration facilities, final disposal facilities, etc.), it could serve as a basis for the standards compilation work. Other standards (such as those in USA, Brazil) should be referred to and intrinsic Chilean conditions (natural, social, economic, etc.) should be taken into consideration, where all related authorities discuss at length in examining and establishing standards for individual technical systems.

Individual technical systems to be established are listed and the outline of contents to be presented in respective standards of individual technical systems are indicated below.

a.2 Outline of Contents of Each Technical Standard

i. Standards applicable to generators of HW

- General
- The manifest
- Pre-transport requirements (packaging, labeling, etc.)
- Recordkeeping and reporting
- Exports of HW (applicability, definitions, general requirements, etc.)

ii. **Standards applicable to transporters of HW**

- Scope
- Transfer facility requirements
- Compliance with the manifest system and recordkeeping
- HW discharges

iii. **Standards for owners and operators of HW treatment, storage and disposal facilities**

- General
- General facility standards (applicability, general waste analysis, security, etc.)
- Preparedness and prevention (design and operation of facility, required equipment, testing and maintenance of equipment, etc.)
- Contingency plan and emergency procedures
- Manifest system, recordkeeping and reporting
- Releases from solid waste management units (compliance period, monitoring program, etc.)
- Closure and post-closure
- Financial requirements (cost estimate for closure, financial assurance for closure, liability requirements, etc.)
- Use and management of containers
- Tank-systems
- Landfills (design and operating requirements, leakage rate, monitoring and inspection, response actions, closure and post-closure care, etc.)
- Incinerators (waste analysis, principal organic hazardous constituents, performance standards, etc.)
- Air emission standards

iv. **Landfill disposal restrictions**

- General
- Prohibitions on land disposal
- Treatment standards
- Prohibitions on storage

v. **Guidelines for the thermal processing of solid wastes**

- General provisions

- Requirements and recommended procedures (solid wastes accepted, site selection, general design, air quality, safety, etc.)

vi. Guidelines for the land disposal of solid wastes

- General provisions
- Requirements and recommended procedures (solid wastes accepted, site selection, design, gas control, cover material, etc.)

b. Examination of Structure for Final Disposal Facilities

As mentioned above, the Study in principle does not handle individual technical standards. However, since final disposal facilities, especially HW final disposal facilities draw attentions to the most crucial and urgent issue to be solved, structure for them are examined below in order to facilitate the establishment of a final disposal facility.

b.1 Leachate

Since precipitation and evapotranspiration in the MR are 300-600 mm/year and 1,350-1,800 mm/year respectively, evapotranspiration exceeds precipitation. Therefore, in the MR it is not necessary for leachate generated at disposal sites to be taken outside of the system and treated and discharged if water inflow from outside the disposal site is shut out. Excessive leachate generated in the rainy season (if any) may be kept in a retarding pond and later circulated in the landfill.

However, in the southern regions in Chile where precipitation exceeds evapotranspiration, leachate generated at disposal sites should be led outside of the system and discharged after treatment (e.g. Puerto Montt has an annual precipitation of about 2,000 mm).

b.2 Waterproof Structure

A Comparison was made regarding the types of required waterproof structures and standards in permeability depending on the kind of final disposal facilities employed in Japan, Brazil, EU, Denmark and the USA. Consequently, the Study proposes standards for bottom and side waterproofing structures and required impermeability in Table 4.4a based on US-EPA standard.

Table 4.4a Proposed Bottom and Sides' Waterproof Structure

Items	Strictly Controlled Landfill (SCL)	Controlled Landfill (CL)	Inert Landfill (IL)
Synthetic Liner	Double with thickness more than 30 mil (0.762 mm)*1	Single with thickness more than 30 mil (0.762 mm)*1	No requirements
Clay Liner	A three(3)-foot (91.44 cm) layer of compacted soil with a hydraulic conductivity of no more than 1×10^{-7} cm/sec.	A two(2)-foot (60.96 cm) layer of compacted soil with a hydraulic conductivity of no more than 1×10^{-7} cm/sec.	No requirements

Note: *1: Synthetic liner components consisting of high density polyethylene (HDPE) shall be at least 60 mil (1.524 mm) thick.

The Study proposes criteria for the final coverage waterproof structure and required impermeability in Table 4.4b.

Table 4.4b Proposed Standards for Waterproof Structure for Final Coverage Layer

Items	Strictly Controlled Landfill (SCL)	Controlled Landfill (CL)	Inert Landfill (IL)
Synthetic Liner	Single with thickness more than 30 mil (0.762 mm)*1	No requirements	No requirements
Clay Liner	A two(2)-foot (60.96 cm) layer of compacted soil with a hydraulic conductivity of no more than 1×10^{-7} cm/sec.	A two(2)-foot (60.96 cm) layer of compacted soil with a hydraulic conductivity of no more than 1×10^{-5} cm/sec.	No requirements

Note: *1: Synthetic liner components consisting of high density polyethylene (HDPE) shall be at least 60 mil (1.524 mm) thick.

4.5 Examination of Institutional System

a. Basic Principle of Legal System

The legal system that will support the institutional organization and its actions is based on two directives and one premise. The directives are the following:

- to minimize the generation of waste; and
- to dispose waste incurring in the least environmental impact.

Meanwhile, the premise states that "the generator is responsible for all waste produced

by him", with the corollary being that "the owner of a site is responsible for the contamination inflicted upon the surroundings".

Based on this, the legal system will comprise legal acts of Presidential/Multi-Ministerial (joint acts or acts by CONAMA) and Ministerial level, represented by Supreme Decrees and Resolutions. The legal system will be detailed through Technical Norms and Technical Instructions of Ministerial Level or by the Executive Regional Authority (SESMA).

The legal acts that establish concepts, obligations and liabilities of generators and site owners are proposed, as well as the hypothesis of transferred, shared or joint liability. As a new feature, the creation of a provisional (private) fund for the remediation of contaminated grounds resulting from the transportation or disposal of ISW is proposed.

As for other legal acts, it is proposed to establish waste minimization as part of a Government program for "cleaner industrial production", including obligations, environmental auditing, incentives and funds, as well as the bodies involved and their competence.

The above-mentioned aspects are detailed through legal and technical acts which set the conditions for siting, planning and operation of ISWM activities, as well as the integrated administration of waste (solid, liquid and emissions) generated at industrial establishments.

Considering that waste management will be carried out as private undertakings under the guidance of a Competent Authority with regard to environmental aspects, certain acts are proposed for improving the EIA/DIA procedure, the participation of Municipalities in site selection for waste disposal, and the monitoring and inspection of activities.

Furthermore, the prioritized schedule for the proposed legal and technical norms is to be established in accordance with the present situation and with the necessities perceived by the Team.

b. Institutional and Organizational Development

The Competent Authority (CA) for issues related to the administration of industrial waste must be a sole and permanent one. In the MR, at the executive level, SESMA should be the Competent Authority for drafting technical instructions and regulations

of regional scope.

At a higher level, the MS will dictate the technical norms and resolutions of national scope and will exercise the highest level actions along with the Presidency of the Republic and other Ministries.

CONAMA-RM will continue to carry out the evaluation of EIA/DIA, as well as the coordination of government bodies and international cooperation.

The regional executive authority (i.e. SESMA) will evolve its present Program for Control of Fixed Sources' Emissions (PROCEFF) into the Industrial Waste Management Program (PROGRESI), where the following needs to be pointed out:

- the control will evolve into management;
- the objective of the program will comprise all wastes (solid, liquid, air emissions) generated by the industry, allowing for an integrated management, including waste minimization;

PROGRESI will consist of four sub-programs: air emissions, solid waste, liquid effluents and waste minimization, all of which will be sustained by Logistic Support and Legal Advice under the Program's directorship. The implementation will be carried out in a step wise manner (see Figure 4.5a).

The logistic support will maintain and improve a database to collect or access information of technical and juridical matters, that should be of great value to prepare and develop regulations and norms, not only to satisfy the authorities' management needs.

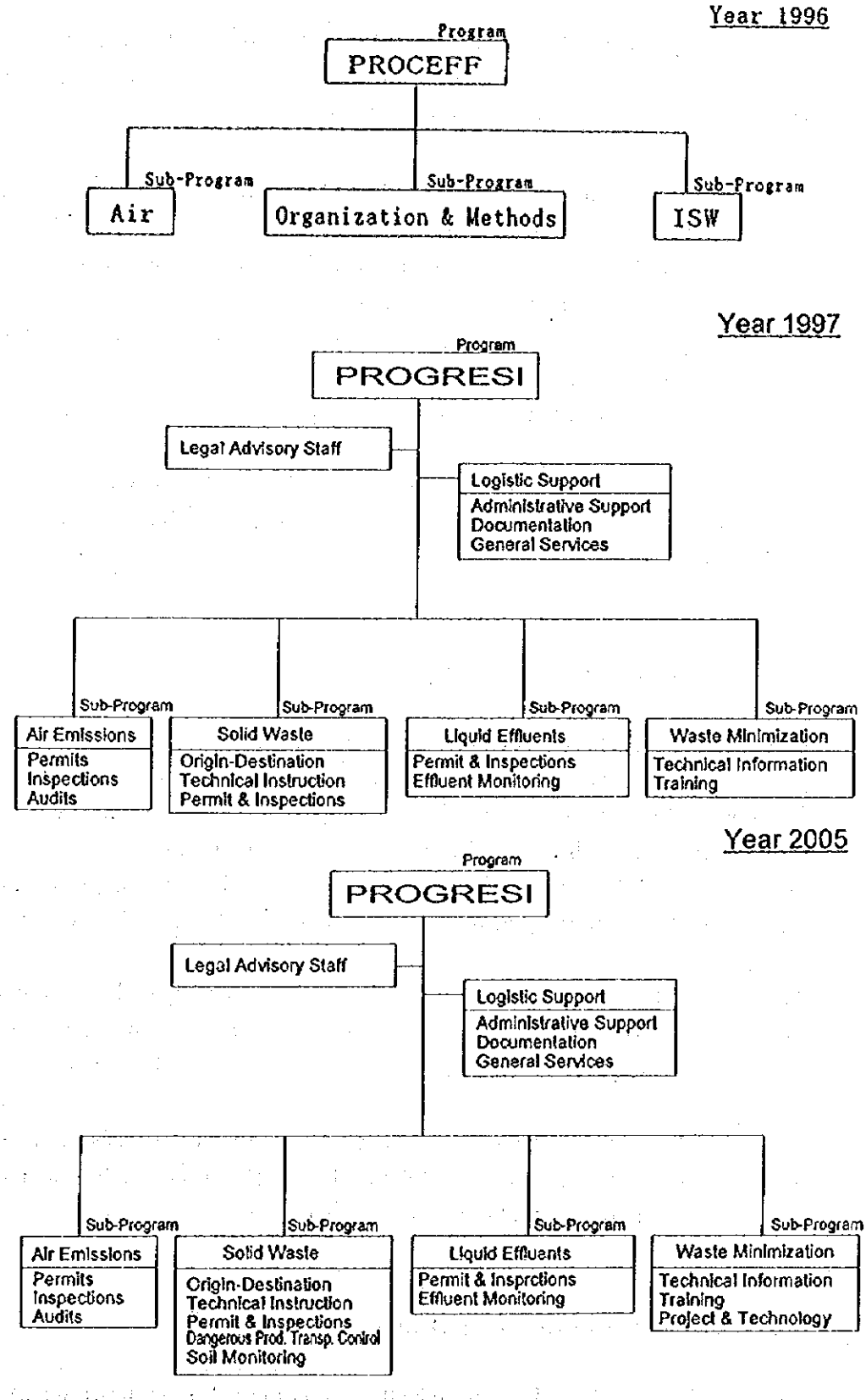


Figure 4.5a Organizational Development Plan

c. Strategy for the Short-term Administration of ISW

As long as disposal of ISW is private undertakings, the supply and demand for services related to ISWM is completely dependent on the government regulations and actions. The following are presented as the priority issues:

- the structural modification of SESMA and the training of its personnel.
- establishment of the classification of ISW;
- the treatment of liquid effluents, which generate important amounts of (almost always) hazardous sludge;
- preparation of norms and criteria that respond to the proposals regarding ISWM; and
- the treatment of dust generating emissions

The strategy is visualized by means of scenarios proposed for the years 1996, 1997, 2000 and 2005, where the legal/regulatory/normative acts and the most relevant facts for each stage are anticipated and laid out.

d. Human Resources Development

By the year 2005, at the time of its full implementation, PROGRESI should employ 73 professionals of medium and higher levels at an annual estimated cost of US$ 1,324,800. Both the initial qualification and the specialization of this personnel through programs to be established in a continuous and progressive manner are of great importance. The Master Plan proposes the basic and additional qualification, as well as the subject matter for the training programs of PROGRESI's human resources.

The National Environmental Center (CENMA) should participate in the training by means of their own laboratory facilities, which can also cover the immediate necessities which are no provided by PROGRESI and the market for the time being.

PROGRESI should also extend its training activities to professionals in the private sector and should provide the market with a Technical Information System that will become the main training tool towards waste minimization.

e. Examination of Executing Bodies

The large degree of dependency faced by the market towards the actions of authorities was previously mentioned. As the proposed competent authority for the MR, SESMA

acts in the sanitary and environmental fields by means of programs rather than by rigid administrative structures. This results in gained flexibility and adaptability, but also in a seemingly (and undesired) transitory nature.

SESMA constitutes the only authority involved in ISW, which have been under control since 1993 through a sub-program within PROCEFF. The activity of mere control will evolve into integrated management for all waste generated by any industry, therefrom resulting in the creation of PROGRESI and its four sub-programs.

Both transporters and receivers of waste for landfill disposal require sufficient financial capacity for competing and for assuming the generator's responsibility in case of an eventual soil contamination. In order to secure this capacity, a provisional fund for soil remediation will be set up by means of a compulsory surcharge over the price of services. These resources should be administered by a private institution which, in turn, should de established and supervised by the CA.

f. Procedure to obtain Neighborhood Consensus

There is an established system of "public participation" in the Republic (although the Environment Basic Law was enacted recently). In principle, a procedure for "neighborhood consensus" should be formulated along with the said established system.

However, recent municipal SW landfill projects in the MR faced quite a lot of difficulties including neighbors' objections in the appraisal stages. Namely the system of "public participation" does not function in reality for the moment.

In view of the present situation, the POS and followingly "Follow-up Research" were carried out to find any keys for solution and/or suggestion that the existing procedure for "neighborhood consensus" to be transformed operationally and substantially or be revised.

Based on the outcome of the survey, the Team judges and that if the existing EIA is transformed operationally and functionally, a sound procedure for "neighborhood consensus" could and should be realized. The following are proposed to function the existing EIA system regarding ISWM projects.

i. Agreement to be exchanged by the promoting sector and neighbor

Although sufficient environmental protection measures are presented in the

planning stage by a promoting sector, neighbors are doubtful and worried whether actual ISWM facilities to be constructed fully comply with what is proposed at the planning stage and whether proposed protection measures will actually be taken place or not. Neighborhood consensus can not be realized without removing neighbors' doubts and worries. For that purpose, as preconditions of ISWM facilities' siting and/or operation, the promoting sector should be obligated to make an agreement with neighbors regarding environmental protection measures promised by them.

ii. Fulfillment of the agreement to be secured by authorities

With regard to the above, the authority should establish a system to ensure that the promoting sector complies with environmental protection measures proposed. Namely, the following examples are recommended to authorities to establish such framework of administrative measures:

- The authority should guide the sectors so that the project is presented to the public in an honest manner and the sector explains the operation, maintenance and monitoring plans, as well as the potential environmental impacts, the prevention measures and the measures prepared for contingencies of accidents.
- The technical suitability of the project as well as the financial soundness of the promoters must be presented by the sector and be verified by the authorities.
- In order to secure the agreement, the authority needs to strengthen its day-to-day monitoring and administrative guidance capability including on-site inspections;
- The precautions required by the regulations and the authorities for such type of project must be disclosed. The maintenance to be implemented after the closure of the landfill, an environmental risk insurance, a Contingency Fund for Pollution must be obligated to the promoting sector by authorities administrative measures.

The private sector should honestly establish agreements with neighbors and related bodies that they shall fulfill the sufficient environmental protection measures. In substantiating the agreement, the authority should, in the framework of its administrative measures, secure the **fulfillment of the agreement exchanged between the promoting sector and the neighbors**.

g. Appropriate System to Promote Private Sectors Related to ISWM

g.1 Measures for Waste Generators' Improvement

The introduction of the following measures shall be examined in view of intrinsic conditions of Chile in order to improve waste generators' ISWM on-site:

i. Engineer qualification system regarding ISWM on-site to be established by the authority. Allocation of a qualified engineer to be obligated to generators and ISW handling agents. In addition, training, seminar and workshop to be held to educate engineers.

ii. The technical information required by waste generators for appropriate ISWM on-site to be compiled for the guidelines and the reference texts to be delivered to waste generators or to be used for training and seminars mentioned above.

iii. Initially, the public laboratory institutions accept laboratorial analysis of ISW at cheap prices to help waste generators to understand the characteristics of their wastes.

iv. The authorities provide waste generators with the technical consultation service to answer their inquiries and questions.

v. The license system for ISW handling agents be established and the list of licensed ISW handling agents be made public to waste generators.

vi. The data collection system and the report formats to be improved to facilitate collecting data and reporting.

g.2 Measures for ISW Handling Sectors' Improvement

The following measures are to be taken to develop ISW handling sectors.

i. Measures to enhance technical capability of the sectors; and
ii. Measures to promote creation of the market mechanism for appropriate treatment, disposal and recycling of ISW.

As for enhancement of technical capability, the measures similar to those proposed for waste generators may be applied (e.g., **ISWM engineer qualification, technical information provision, public laboratory institutions' cooperation, technical**

consultation, announcement of qualified handling agents).

As for creation of market mechanism, it may be the most crucial and effective step to develop ISW handling agents. These measures (i.e. creation of market mechanism), to begin with, require eradication of illegal treatment/disposal routes (e.g. illegal dumping). The following actions should be taken for that purpose:

- closure and/or control of all illegal dumping sites;
- procedure of localization/operation permits to be established; and
- proper and qualified ISW handling agents to be announced publicly, etc..

g.3 Laboratorial Analyses Sectors

The measures which were recommended for ISW handling agents can be applied for development of laboratorial analyses sectors, i.e.:

i. Measures to enhance technical capability of the sectors; and
ii. Measures to promote creation of the market mechanism of the sector.

As for "enhancement of technical capability", since laboratorial analysis requires specialized skills as well as many advanced facilities and equipment, the opportunity of training in this regard has to be provided. Guidelines of laboratorial analyses and textbooks for training of analyses should be prepared so as to meet needs of laboratorial analysis and environmental pollution prevention in Chile. CENMA project should be fully utilized for providing technical training course to educate analysis technicians.

As for "creation of market mechanism", it is suggested as follows. First is to enforce the regulation for waste water, gas emission and ISW (e.g. including obligation of laboratorial analysis), which consequently promote creation of the market mechanism of the sector. Second is to establish a "qualification system for environmental analysis including ISW analysis engineers" and also a "license system for laboratorial analysis institutions", in order for them to be socially recognized as technically qualified personnel and bodies, which consequently raise their social status. In Japan, the license is officially granted to the institutions which own substantial capacities to conduct analysis, and the data analyzed only by the licensed institutions are officially authorized (The license is also given to the individual engineer in Japan).

g.4 Manufacturers of Environmental Protection Facilities and Equipment

As for the measures to develop an industry of manufacturing environmental protection

facilities including SWM, since various alternative technologies are available these days, the Team understand that it might be practical for the Chilean authorities take the following measures:

i. The government provides with information concerning overseas' latest technologies and manufacturers of environmental protection facilities and equipment to help local private enterprises to enter the industries;
ii. While the regulation and the standard are being strengthened, measures to urge industries to install related facilities and equipment should be simultaneously taken by authorities; and
iii. The government should formulate a system to examine and approve the appropriate technologies for Chilean industries and introduce the information of these appropriate technologies and facilities widely to Chilean industries.

h. Monitoring and Information System

In order to establish a proper ISWM system, another set of important issues are the formation of an appropriate monitoring system and information system. The monitoring system can work only in a pair with information system, and they, therefore, contribute to establish a proper ISWM system only when both of them have functioned simultaneously.

h.1 Building a Monitoring System

The following measures should be taken to cope with the three issues pointed out described below.

i. Monitoring on ISWM on-site

This is the first step of monitoring among other, and the following measures are required:

- Identification of generated ISW (especially HW). It is possible to screen major suspected HW generators via information of the raw materials and the production process and facilities they are using.
- On-site inspection: It is necessary to check the ISW storage condition, the operation condition of on-site treatment plants and the quality of waste water, gas emission and ISW generated periodically in order to identify performance of operation.

ii. Monitoring on ISWM outside by the manifest system

This requires establishment of the manifest system by which three parties; "waste generators", "destinations (i.e. recyclers or ISW handling agents)" and "the authority" could and should mutually confirm what ISW are collected, transported, handed to the "destination" and recycled, or treated/disposed. Strict and persistent guidance by the authority is essential to make the manifest system functional because it requires that waste generators and destinations to comply with the proper transaction of data.

In addition, prosecution of illegal routes of ISW, a licensing system for treatment/disposal and recycling enterprises, the report collection from waste generators and ISW handling agents are required.

iii. Monitoring on operation of treatment/disposal facilities

In order to detect and prevent environmental pollution caused by the intermediate treatment plants, final disposal sites, etc. (in case), they have to be monitored. It requires self-monitoring by waste generators/ISW handling agents to check the quality of waste water and gas emissions from their intermediate treatment and disposal facilities. Periodical and sporadic on-site inspection (including checking of waste water and gas emissions quality) by authority is also required.

In addition, it requires to check whether the plant operate within its capacity. Inter-relation of "on-site inspection system by the authorities", "the manifest system" and "report collection" are required in this regard.

Such comprehensive monitoring system can not be attained with ease. To aim at establishment of a very precise system might bring a mess and confusion. For Santiago MR, eradication of the improper disposal routes of ISW (e.g. recycling at illegal dumps), establishment of license system for ISWM and strengthening of manifest system of PROCEFF should be challenged at first.

h.2 Building an Information System

The information control system has to include the following information and data.

1. Data regarding the conditions of generation, storage, treatment, entrustment, etc. of ISW at waste generators (on-site);
2. Data regarding the conditions of production facilities which generate HW,

and facilities of ISW storage/treatment at waste generators (on-site);

3. Data regarding the plans and programs of control and treatment of ISW at waste generators (on-site);
4. Data regarding transportation, storage, treatment, disposal and recycling of ISW outside generations (flow);
5. Data regarding reception, treatment, disposal and recycling by ISW handling agents and recyclers (destination);
6. Data regarding specification, capacity and operation record of treatment, disposal and recycling facilities owned by ISW handling agents and recyclers (destination);
7. Data regarding illegal dumping, violations and improper routes; and
8. Data regarding general information, e.g. global and local trends in ISWM business, new and conventional technologies related.

The private sectors require data and information in order to maintain their business sound and lucrative. On the other hand, authorities require data and information in order to monitor, instruct and provide guidance and consultation and consequently promote appropriate ISWM. Therefore, the final objective for the information system is to provide immediately with the data which satisfy these objectives. However, such system can be established by constant and steady accumulation of data. In practice, the following procedure have to be taken for collecting, inputting and renewing data.

- questionnaire surveys to understand the actual conditions for 1. to 6. above;
- report collection from waste generators for 1. to 3.;
- report collection from ISW handling agents and recyclers for 4. to 6.;
- on-site inspection by the authorities for 1. to 7.;
- application and permission procedures of treatment/disposal facilities and their operation for 2. and 6.;
- notices from residents, local authorities and polices for 7.; and
- exchange of information among academics and national/international institutions and organizations for 8..

How and to what extent the data is accumulated in the information system depends on the magnitude of necessity of the data and the costs incurred for collection, accumulation and renewal of data. In view of the present situation of ISWM in the MR, it is recommended that:

- the data of "major waste generators", "the actual conditions of ISW handling agents and recyclers" and "the improper/illegal routes" be accumulated mainly from individual questionnaire surveys;

- the overall flow of ISW and related problems be filed and utilized for planning macro policies; and
- the information on the "ISW flow" from manifest data be kept for a certain period as reference materials for inspection, supervision and guidance.

i. Permission Procedures for Localization of ISWM Facilities and License for ISWM Business

i.1 Permission Procedures for Localization of Facilities

In order to realize appropriate localization of ISWM facilities and formulation of ISWM business, permission procedures (especially including procedures for neighborhood consensus) should be established.

In practice, the following measures should be taken by the responsible authorities to realize a localization of ISWM facilities subject to neighborhood understanding and consensus.

i. Necessary planning particulars (such as structural requirement, O&M standards for SWM facilities, preservation measures for surrounding environment, etc.) should be established and serve as prerequisites for the permission.
ii. Submission of EIA (at the same time of proposal submission) should be obligated to the promoting sector.
iii. Once a proposal is received and certain examinations by administrative authorities are completed, when a proposal is deemed feasible the promoting sector should have a public hearing to the facility's neighbors and presumably affected people. Opinions from related people should be received within a certain time period.
iv. In response to the opinions expressed by the related people, recommendations of revision and/or modifications of the project (or recommendation that the project be withdrawn) should be issued by the authorities. The authority is responsible for the final judgement of a project receiving permits.
v. On the assumption that the above procedures are secured, where the responsible authority faces the situation of having to issue a justifiable final judgement for a project (of permission or denial of permission), if a committee composed of academics, other related authorities, industrial societies' entities, environmental groups, etc. could be formed and requested for comments, it may provide a significant reference for the

judgement that the authority issues.

i.2 License for ISWM Business

In order to practice an ISWM business, it should be necessary to own facilities and to obtain a license for ISWM business. Permission for operation of ISWM facilities and license for the business should be separately issued with following reasons:

i. Even though localization is permitted, it is necessary to verify whether the facilities are constructed as proposed and required functions are equipped. After said confirmation, permission for operation of the facilities should be issued.

ii. In addition to fulfillment of structural and functional compliances, it is a precondition in general for licensing ISWM business that "assignment of qualified technical staff", "responsible organizational structure" etc. to be fulfilled in their business practices. Judgement in this regard should be placed apart from facilities evaluation.

iii. ISWM facilities are subject to trading. If owning a facility after purchase allows the business operations, a company without technical competence may carry out the treatment/disposal practices. It consequently will undermine the reliability of the whole ISWM sectors.

4.6 Outline of the Master Plan

The outline of the ISWM Master Plan to be established by year 2010 is presented in Table 4.6a Technical System and Table 4.6b Institutional System respectively. It should be noted that various assumptions were made in order to present the technical system, especially be minded that all sludges to be generated in factories are assumed to be dehydrated on-site, i.e. at each generation source.

Table 4.6a Outline of Technical System in the Master Plan

Items	Description (assumed in the target year 2010)
1. ISW Generation Amount	8,006,000 ton/year (without dehydration of sludges)
2. Storage system	On-site
3. Collection and Transportation (C&T)	
3.1 sectors	Private ISWM enterprises and generators
3.2 amount	1,180,000 ton/year
- Collection	64,000 ton/year
- Transportation	31,000 ton/year
- C&T	1,085,000 ton/year
4. Recycling system	
4.1 sectors	Private ISWM enterprises and generators
4.2 amount	735,000 ton/year (9.2% of total)
5. Treatment system	
5.1 sectors	Private ISWM enterprises (other than dehydration on-site)
5.2 amount	
- Solidification	15,000 ton/year
- Neutralization	14,000 ton/year
- Chemical treatment	24,000 ton/year
- Dehydration	6,795,000 ton/year
On-site	6,758,000 ton/year (by generators)
Outside	37,000 ton/year
- Incineration	11,000 ton/year
6. Waste water treatment	
6.1 sectors	Private ISWM enterprises (other than waste water treatment on-site)
6.2 amount	6,145,000 ton/year
On-site	6,125,000 ton/year (by generators)
Outside	20,000 ton/year
7. Final disposal	
7.1 sectors	Private ISWM enterprises
7.2 amount	
- SCL	164,000 ton/year
- CL	589,000 ton/year
- IL	364,000 ton/year

Table 4.6b Summary of Institutional System in the Master Plan

Items	Goals to be achieved by the target year 2010
1. Legislative system	
a. legislative system of ISWM	1. legislation of basic responsibilities of waste generators. 2. legal empowerment for administrative measures including penalties. 3. legislative framework for permission of facilities siting and operation permit. 4. legislative framework for funds/insurance for ISWM facilities.
b. other legislative system	5. obligation of pre-treatment before sewage discharge.
c. standard & guideline	6. standards for structure, O&M of ISWM facilities. 7. guidelines for EIA of facility localization.
2. Organization	
a. national level	1. unified/centralized national organization responsible for ISWM. (i.e, CONAMA and MS).
b. local level	2. strengthening and amplification of local (MR) authorities' organization. i.e., be capable to place appropriate monitoring and guidance (SESMA). 3. institutional framework to promote policies on ISW inter-relating with air and water pollution prevention.
c. private sectors	4. organizational system to guarantee responsibilities of waste generators, and to establish reliable technology management. 5. organizational improvement of ISW handling agents and recyclers, in order to facilitate the system to guarantee responsibilities and promote technology management thereof. 6. promotion of other private sectors' activities, i.e., analysis laboratories, facilities/equipment manufacturers, insurance companies/fund to support the sectors.
3. Financial framework	
a. authorities administration cost	1. policies and measures to secure authorities' administration cost for proper monitoring and guidance.
b. market mechanism of ISWM	2. formulation of feasible price level in the market to allow sound and appropriate treatment and disposal.

4.7 Cost Estimation

a. Assumptions of ISW Flow in 2010

One of the principal targets of the Study is to estimate the magnitude of ISWM business in 2010. It is necessary for the estimation to assume the outline of technical system (storage, collection, transportation, treatment and disposal) in 2010, and set up the amount of ISW and unit costs of treatment/disposal in the system. Therefore, the Team, judging from present industries features and economic trends, quantity and quality of ISW, and natural conditions and so on in the MR, assumed intermediate treatment and disposal flows corresponding to 24 ISW and accordingly calculated a rough estimate of projects costs for the amount forecasted of ISW to be treated and disposed in the year 2010. Key assumptions on technical system in 2010 are:

i. Amount of ISW subject to this cost estimation are defined as estimated total generation amount of ISW in 2010 minus estimated recycled amount in 2010

ii. Recycled amount of ISW in 2010 is forecasted for 24 ISW categories respectively by "estimated generation amount" times " recycle ratio assumed".

iii. Recycling ratios of ISW in the MR in 2010 are estimated, with reference to empirical data in Japan, results of the Team's factories survey and the consultants' experiences in other projects.

iv. Volume of ISW are changed through intermediate treatment. Assumptions on the following items are employed in ISW volume changes for determining ISW flows:

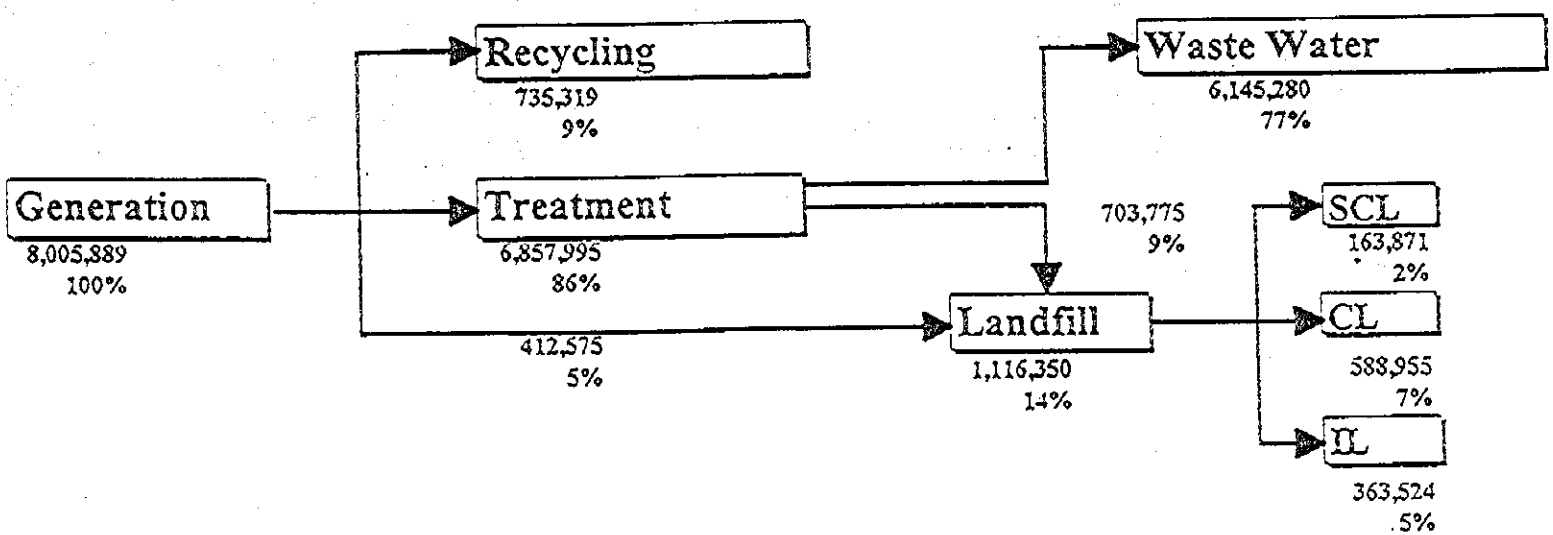
- Change of moisture content through dehydration of sludge:
- Volume reduction through incineration; and
- Volume change through solidification, neutralization and chemical treatment.

Based on the key assumptions on technical system in 2010, treatment/disposal flows assumed for the 24 ISW categories are indicated by ratios as shown in Table 4.7a. Treatment/disposal amount in total in 2010 are summarized in the flow shown below Table 4.7a by multiplying respective forecast amount of 24 ISW with ratios assumed above.

Table 4.7a Treatment/Disposal Ratios Assumed for 24 ISW Categories in 2010

	Type of Waste	Recycling	Treatment or Disposal	Intermediate Treatment						Treatment Ratio	Change to other type waste						Waste Water Treatment	Landfill			Total
				Solidification	Neutralization	Chemical	Dehydration Non-Hazard.	Dehydration Hazardous	Incineration		No.1 TW	No.1 Ratio	No.2 TW	No.2 Ratio	No.3 TW	No.3 Ratio		SCL	CL	IL	
C-1	Ash including from incinerator	40.0%	60.0%							0.0%								30.0%	15.0%	15.0%	60.0%
C-2	Dust and APC products	40.0%	60.0%	25.0%						25.0%								25.0%	25.0%	10.0%	60.0%
C-3	Inorganic sludge	2.0%	98.0%				90.0%	8.0%		98.0%							32.7%	5.3%	30.0%	30.0%	98.0%
C-4	Organic sludge	2.0%	98.0%				70.0%	28.0%		98.0%							91.4%	1.9%	4.0%	0.7%	98.0%
C-5	Asbestos	0.0%	100.0%	50.0%						50.0%								50.0%		50.0%	100.0%
C-6	Acids	45.0%	55.0%		55.0%					55.0%	C-3	27.5%	C-4	27.5%							0.0%
C-7	Alkalis	25.0%	75.0%		75.0%					75.0%	C-3	37.5%	C-4	37.5%							0.0%
C-8	Solvents	40.0%	60.0%						60.0%	60.0%	C-1	1.2%	C-2	1.2%							0.0%
C-9	Oily waste	40.0%	60.0%						60.0%	60.0%	C-1	3.0%	C-2	3.0%							0.0%
C-10	Inorganic chemical residues	0.0%	100.0%	12.5%		50.0%				62.5%	C-3	50.0%						12.5%	25.0%	12.5%	50.0%
C-11	Organic chemical residues	0.0%	100.0%			50.0%			25.0%	75.0%	C-1	2.5%	C-2	2.5%	C-4	50.0%			12.5%	12.5%	25.0%
C-12	Other liquid waste	25.0%	75.0%			75.0%				75.0%	C-3	37.5%	C-4	37.5%							0.0%
C-13	Waste from food production	80.0%	20.0%							0.0%									20.0%		20.0%
C-14	Glass and ceramics	20.0%	80.0%							0.0%										80.0%	80.0%
C-15	Metal and scrap	90.0%	10.0%							0.0%										10.0%	10.0%
C-16	Paper and cardboard	70.0%	30.0%							0.0%									30.0%		30.0%
C-17	Plastics	25.0%	75.0%							0.0%										75.0%	75.0%
C-18	Rubber	25.0%	75.0%							0.0%										75.0%	75.0%
C-19	Textile and leather	50.0%	50.0%							0.0%									50.0%		50.0%
C-20	Waste similar to domestic waste	2.0%	98.0%							0.0%									98.0%		98.0%
C-21	Wood	90.0%	10.0%							0.0%									10.0%		10.0%
C-22	Slag from melting	40.0%	60.0%							0.0%								30.0%	0.0%	30.0%	60.0%
C-23	Construction waste	35.0%	65.0%							0.0%									15.0%	50.0%	65.0%
C-24	Other solid waste	1.0%	99.0%						9.0%	9.0%	C-1	0.9%	C-2	0.9%					45.0%	45.0%	90.0%

Assumed ISW Flow in 2010



b. Assumption for Cost Estimation

These cost estimation are conducted on the following assumption and the value presented in the cost estimation are "net present value (NPV)" in October 1995.

i. The following exchange rates are employed in the cost estimation:

1 US$ = 416.2 Chilean pesos
= 102.4 Japanese yen

ii. Tipping fees including profits and insurance costs for intermediate treatment facilities are estimated.

iii Estimation of construction cost for intermediate treatment facilities are mainly referred to "The World Bank Technical Paper # 93, The World Bank".

iv. It is assumed that financial resource for land acquisition cost and construction cost of intermediate treatment facilities are to be covered by loans for all the amount. Loans conditions are assumed as follows:

- payback period: 15 years;
- interests rate: 6.0% per year

v. Net cost of intermediate treatment is estimated, assuming the life span of an intermediate treatment facility is 15 years. Consequently, unit cost for intermediate treatment is calculated as: "Total net cost (total loan payback and O&M costs for 15 years)" divided by "total ISW amount to be treated for 15 years", i.e., NPV US$ per ton.

vi. Tipping fees for treatment facilities are calculated by adding profit to the above-mentioned unit cost. Profit of the intermediate treatment handling agents are assumed to be 10%, which should cover the cost of restoration from accidents (such as insurance cost, etc.).

vii. Collection and transport (C & T) costs are divided into:

- "collection cost" from a waste generator to an intermediate treatment plant;
- "transportation cost" from a treatment plant to a final disposal site; and
- "collection and transportation cost" from a waste generator to a

final disposal site..

viii. All sludges to be generated in factories are assumed to be dehydrated on-site (i.e. at each generation source), and the scale of a dehydration facility is calculated at an average discharge amount which comes from division of total sludge generation amount by number of factories generating sludges.

ix. In the Study the cost of storage on-site is not counted because it shall be born by the generators. Whereas the cost of storage at intermediate treatment facilities is included in the tipping fees of intermediate treatment facilities.

c. Cost Estimation

Cost associated with collection, transport and final disposal are estimated referring to current prices of the activities in the MR and tipping fees of 3 categories of landfills in Brazil. As a summary of the cost estimation, unit costs (including profits, etc.) estimated for collection, transport, intermediate treatment and final disposal are listed in the table below.

Table 4.7b Unit Costs Estimated

Item	Unit. Cost (US$/ton)
Collection and Transportation (C & T)	
"Collection" for ISW	6.0 US$/ton
"Collection" for Medical Waste	40.0 US$/ton
"Transportation" for ISW and Medical Waste	6.0 US$/ton
"Collection and Transportation" for ISW	12.0 US$/ton
Intermediate Treatment	
Solidification	23.0 US$/ton
Neutralization	2.4 US$/ton
Chemical Treatment	3.4 US$/ton
Dehydration outside (Non-HW)	35.7 US$/DS-ton
Dehydration on-site (Non-HW)	32.6 US$/DS-ton
Dehydration outside (HW)	107.1 US$/DS-ton
Dehydration on-site (HW)	98.6 US$/DS-ton
Incineration	151.0 US$/ton
Waste Water Treatment outside	0.85 US$/ton
Waste Water Treatment on-site	1.02 US$/ton
Disposal	
SCL for ISW (HW)	90.0 US$/ton
CL for ISW (Non-HW/Non-Inert)	18.0 US$/ton
IL for ISW(Inert)	1.5 US$/ton

Note: DS-ton : Dry solid ton

Estimation of ISWM business scale (i.e. total costs) are forecasted by multiplying "amounts estimated of ISW to be collected, transported, treated and disposed in 2010" and "respective unit costs estimated above" in total, which are shown in Table 4.7c.

Table 4.7c ISW Handling Cost (Costs of Collection, Transportation, Intermediate Treatment and Final Disposal) in 2010

Unit: US$/year

Items		Costs
1.	Collection and Transportation	13,590,000
2.	Intermediate Treatment	
	1-1. Intermediate treatment outside	2,202,000
	1-2. Dehydration on-site	10,722,000
3.	Final Disposal	25,894,000
	Total excluding Dehydration On-site	**41,686,000**
	Total including Dehydration On-site	**52,408,000**

4.8 Evaluation of the Master Plan

a. Economic Evaluation of the Master Plan

a.1 Evaluation of the Prospect of ISW Handling Business in 2010

The total ISW handling business market in MR is estimated to be around 41.7 million US dollars (1995 price) based on handling price. It covers about 0.036% of the forecasted GNP of 114.9 billion dollars in 2010 or 0.067% of GNP in 1995 (62,500 million US dollars). Final disposal business forms the biggest market which is about 62% of the total ISW handling business market. The remaining market is covered by collection and transport (33%) and intermediate treatment (5%).

a.2 Evaluation on the Reasonability of the Cost of Public Administration and Generators for Implementing the Master Plan

a.2.1 Cost of Public Administration

The incremental cost of public administration for implementing the master plan is estimated to be about 1.3 million US dollars in 2010. Its ratio to the total ISW

handling business market (on handling price basis) is only about 3.1%. Accordingly, it indicates that approximately 41.7 million dollars of ISW handling business market is to be created by conducting the proper control and management of ISW in accordance with the master plan at a cost of 1.3 million US dollars.

a.2.2 Sensitivity Analysis on the Generators' Cost of ISW Handling

To assess viability of the cost to be covered by ISW generators, the Study made a sensitive analysis by setting up an alternative scenario of ISWM in 2010. The difference between the alternative scenario and the master plan is in the reduction ratio of sludge amount on-site (inside factories). In the alternative scenario, the water content of sludge at generation source is assumed as 90% for inorganic sludge and 99% for organic one respectively while the master plan assumes that it is 85% for both types of sludge on-site. In other words, the alternative scenario assumes that sludge dehydration is made only outside factories by ISW handling agents and there is no reduction of sludge amount on-site by generators. Table 4.8a compares the total ISW handling cost between the case of alternative scenario and master plan.

Table 4.8a Comparison of ISW Handling Cost in 2010 Between Alternative Scenario and Master Plan

Unit: US$/year

	Alternative Scenario	Master Plan
Collection & Transportation	50,562,000	13,590,000
Intermediate Treatment (dehydration on-site)	0	10,722,000
Intermediate Treatment (outside factory)	8,932,000	2,202,000
Final Disposal	25,894,000	25,894,000
Total	**85,388,000**	**52,408,000**

As obviously found in the table above, reduction of sludge amount at generation source is a crucial factor to limit incremental cost of ISW handling especially for collection and transportation in future. In addition, the necessity of in-factory reduction of sludge amount is also supported by the estimation results regarding the ratios of the total ISW handling cost to the total output value for each type of manufacturing industry in 2010.

In this estimation, the total ISW handling cost includes collection and transportation, intermediate treatment (both on-site and outside factories), and final disposal. The total output value for each type of manufacturing industry, on the other hand, is forecasted by utilizing the increase rate of production which was used for projecting

the number of employees and existing output value data available in the CORFO (Corporación de Fomento de la Producción) Study.

As a result, the average ratio of ISW handling cost to the total output value is 1.10% in alternative scenario, which is much higher than the ratio of 0.75% in the master plan. This result also implies that reduction of sludge amount at generation source is a reasonable option to be employed by generators for limiting the incremental cost of ISW handling in future. However, it should be noted that dehydration cost of sludge on-site is calculated based on the average sludge discharge amount. Therefore, the cost for small and medium scale industries shall be higher than the average.

On the other hand, even in the case of master plan, there are 6 types of manufacturing industries in which the ratio of ISW handling cost exceed 1% of the total output value. Because the affordable limit of ISW handling cost is said to be 1% of the total output value in Japan, it may be hard for these industries to pay the cost of ISW handling.

Except for potteries and ceramic industry, sludge handling cost still covers a big part of ISW handling cost in the 5 industries. Therefore, it may be necessary for these industries to make further efforts of efficiently handling sludge generated, such as the application of low cost treatment technology, recycling of treated sludge, and so forth.

Regarding potteries and ceramic industries, on the other hand, the possibility of limiting the handling cost may be found in recycling of glass and ceramic wastes as well as sludge and dust.

Moreover, reduction of sludge amount at source by generators may be a heavy burden especially for small industrial enterprises. Accordingly, it is important that the authority shall promote joint construction and operation of dehydration facilities, recycling of ISW and so on.

a.3 Benefits of the Master Plan for the Future Chilean Economy

In addition to the direct economic effect of creating a new ISW handling business market, implementation of the master plan is inferred to bring the following positive effects towards the future economy in MR:

- Benefits to the future international trade and/or the standard for environmental management of ISO (International Organization for Standardization) 14000.

- Benefits in terms of developing relevant industries such as pollution abatement equipment manufacturing industry, industries relevant to the introduction of cleaner production technology, and environmental service industries.
- Benefits in terms of introducing foreign capital investment to the MR.

b. Technical Evaluation of the Master Plan

b.1 Evaluation of the Administrative Measures to Be Applied

Administrative measures that were adopted in the master plan were settled as shown in Table 4.8b below.

Table 4.8b Administrative Measures for Supervising ISWM in the Process from Generation to Final Disposal

ISWM Stage	Administrative Measures
ISWM at source (inside factory)	@ Waste generation control by manifest system (declaration system) (Investigation items) - Identifying generation characteristics of ISW for each type of industry based on the data of material & energy input, types of products, and material input/output balance. - Identifying the potential of environmental pollution by flue gas and waste water. - Clarifying present condition of ISW generation. - Clarifying present condition of in-factory ISW management, treatment, and disposal. - Clarifying present condition of consigned ISW handling
ISWM outside factory	@ ICRT (Ignitability, Corrosivity, Reactivity, and Toxicity) test (Testing items) - Identifying hazardous/non-hazardousness - Identifying appropriate intermediate treatment methods - Identifying appropriate disposal methods @ Leaching test (Testing item) - Identifying hazardous/non-hazardousness of the wastes after intermediate treatment - Identifying appropriate type of disposal site (SCL/CL/IL) @ Solubilization test (Testing item) - Identifying appropriate type of disposal site (CL/IL)

The above administrative measures are to be taken on the basis of self-reporting by the waste generators and waste handling agents. Accordingly, re-examination of the report forms an important part of public administration so as to avoid false reporting

by the generators and/or agents. It is also important to establish legal framework that strictly regulates the self-reporting system. These necessary actions of public administration are all specified in the master plan in detail. As far as the public administration of ISWM is carried out in accordance with the master plan, the objective of the master plan will certainly be accomplished by the year 2010.

b.2 Evaluation on Technical Capability of Implementing the Master Plan

Regarding the municipal solid waste management in the MR, the technology level is high enough even comparing with developing countries', especially on landfill technology. Therefore, it is considered that the Chilean private sector has enough capability of handling advanced ISW treatment and disposal technologies. Concerning ISWM, on the other hand, a number of mishandling cases can be found mainly due to the lack of knowledge on ISW itself and its proper handling methods. In order to improve such present conditions, the Study gives extensive instructions in the master plan in the form of guidelines, manuals, etc. Consequently, since the master plan gives enough instructions and supporting technical information necessary for its implementation as described above, it is technically feasible enough to realize the master plan in the MR.

c. Environmental Evaluation of the Master Plan

Environmental evaluation here is made by identifying the environmental impact which might arise without the master plan in MR. The major negative impacts on the environment are given as follows.

c.1 Environmental Risks of Improper Flue Gas and Waste Water Treatment in Factory

As found in the result of the factory survey in the Study, considerable amount of flue gas and waste water are directly emitted and discharged into atmosphere and watercourse in the MR. Some of them may contain hazardous substances. It is also implied in the factory survey that such improper control of emission and effluent are mainly due to the lack of knowledge on ISW and its hazardousness. These improper emission and effluent treatment may cause air and water pollution which have serious impacts on human health. It is obvious from the experience in Japan that restoration and recovery cost of pollution is much higher than the cost of preventive measures.

c.2 Environmental Risks of Improper Management of ISW

Presently in the MR, there are some improper handling of ISW, such as the disposal of hazardous ISW to the municipal landfill, illegal dumping, unauthorized on-site disposal of ISW, and so forth. If these improper ISWM is neglected as it is, serious groundwater pollution and soil pollution may break out by the leak of hazardous substances from the ISW disposed. Once groundwater and/or soil pollution occur in the MR, the magnitude of damage is unpredictable because hazardous substance will spread extensively through the soil and watercourse. As found from prior cases in developed countries, preventive cost is much lower than the damage cost to be born resulting from no remedial action against pollution.

Accordingly, early implementation of the ISWM master plan will minimize or even eliminate future possible environmental hazard, and also minimize restoration and recovery costs of pollution.

CHAPTER 5 THE MEDICAL SWM MASTER PLAN

5.1 Definition and Classification of Medical Solid Waste

Based on a combination of the classification recommended by WHO and the definition of waste types applied by US-EPA, the following waste classification system for medical SW is proposed:

- Pathological waste *,
- Human blood and blood products *,
- Cultures and stocks *,
- Sharps *,
- Infectious waste *,
- Animal waste *,
- Chemical waste,
- Radioactive waste,
- General (non-hazardous) waste.

The waste types marked with * are defined as infectious waste in the following.

5.2 Forecast for the Future Medical Solid Waste Generation

For the Master Plan it is proposed to predict the future medical SW generation based on the development of the population (linear projection) combined with an assumption of an annual increase of the waste quantity of 1% for the expected impact of improved hospital hygiene and the assumed wider use of disposable equipment.

Table 5.2a presents the projection of medical SW (infections waste only) generation.

Table 5.2a Projection of Medical Solid Waste Generation 1995-2010 (Infectious Waste Only)

Year	Projection of population		Effect of improved hospital hygiene	Projected generation of infectious medical SW
	Total	Index		
1995	5,642,000	100.00	100.00	7,300 tones
1996	5,738,000	101.70	101.00	7,500 tones
2001	6,190,000	109.71	106.15	8,500 tones
2006	6,610,000	117.16	111.57	9,500 tones
2010	6,931,000	122.85	116.10	10,400 tones

5.3 Establishment of Planning Framework

a. Goals

The proposed goals of the Master Plan 1996-2010 are:

- Improved medical SWM facilities and practices at medical institutions in MR to obtain basic hygienic conditions.
- A standardized labeling and packaging system for infectious medical SW.
- A low-cost final disposal option based on safe disposal of infectious medical SW at a controlled landfill for municipal SW.
- In time, thermal treatment of infectious medical SW, possibly as co-treatment with industrial waste (ISW).

b. Targets

The targets of the Master Plan are presented in Table 5.3a for three periods, the short-term period 1996-2000, the medium-term period 2001-2005 and the long-term period 2006-2010.

c. Strategy

Supervision and enforcement of applicable standards are the authorities' only tool to accomplish the goals and targets. As no pubic involvement in technical facilities etc. is envisaged, enforcement of proper medical SWM practices will create a need of provision of waste management services by the private sector. This cannot be satisfied

immediately by the private sector today and this is considered in the implementation plan, where authorities' necessary actions in relation to involvement of the private sector are identified.

The Medical Institution Survey disclosed that the present costs of medical SWM are insignificant for many medical institutions. However, it can be expected that any increase of the costs will meet opposition. Thus, it will be necessary to build up environmental awareness and commitment at the medical institutions in order to create an understanding of the need of increased budgets for provision of improved medical SWM.

Thus, the Master Plan strategy is based on a combination of cooperative actions and enforcement. The cooperation will concern preparation of a Code of Practice, where the medical institutions should participate alongside the authorities in the standard setting, while enforcement will concern inspections on-site and, if necessary due to continuous violations of prescribed practices, legal prosecution actions.

5.4 Proposed Technical System

The Code of Practice is the key tool to obtain the proper standard for medical SWM.

The Ministry of Health (MS) is the obvious responsible body for preparation of the Code of Practice. A large number of institutions and specialists should participate in the work.

The headlines of the Code of Practice are:

- Introduction
- Legal background
- Definition of medical SW
- Background for planning of handling systems for medical SW
- Source segregation, packaging, internal collection and storage
- External collection and transport
- Treatment and final disposal
- Checklists for control of existing and new medical SWM systems

The proposed technical system is summarized in Table 5.4a.

Table 5.3a Targets of the Master Plan 1996-2010

Short-term targets (year 1996-2000)
- Preparation of a Code of Practice as a guideline for the medical institutions and as a basis for authorities' enforcement.
- Preparation of a simple labeling system for immediate implementation.
- Packaging of sharps and pointed objects in unbreakable - not reusable packaging at the source of production (also in cases where the waste subsequently is treated internally by incineration or autoclave).
- Improvement of internal collection points with respect to: . Cleanliness, . Separate storage of waste categories, . Prevention of public access, . Elimination of manual loading procedures for medical SW.
- Development of safe disposal of medical SW at a controlled landfill for municipal SW (for immediate implementation).
- Separate collection of medical SW for landfilling.
- Preparation of project for thermal treatment of medical SW, possibly at a new facility for ISW treatment (co-treatment).
- Implementation and enforcement of new environmental standard for new incinerators at hospitals.
Medium-term targets (year 2001-2005)
- Implementation and enforcement of new environmental standard for existing waste incinerators at hospitals.
- Development of thermal treatment of medical SW, possibly at a new facility for ISW (co-treatment).
- Continued improvements of standardized collection system, including improvements of collection points.
- Enforcement.
Long-term targets (year 2006-2010)
- Phasing out of landfilling for replacement by centralized thermal treatment (possibly as co-treatment with ISW).
- Enforcement.

Table 5.4a Summary of Technical System

Waste category	Packaging	Internal treatment	Collection point	External treatment
Pathological waste	Strong plastic bags, plastic buckets, or coated cardboard boxes. Pointed items such as a bone pieces should be packed in unbreakable packaging. Bags, buckets etc. should be sealable.	Incineration in hearth type incinerator to ensure complete destruction and combustion.	Separate storage, if necessary cooled (depends on the storage time).	Burial at cemetery or controlled landfilling (short-term). Incineration in hearth type incinerator (long-term).
Human blood and blood products	Scalable plastic buckets, bottles or blood bags.	Infected blood and blood products should be sterilized (autoclave). Small quantities of non-infectious blood can be discharged to the sewer. Large quantities should be landfilled or incinerated.	Separate storage of infectious wastes, if necessary cooled (depends on the storage time).	Controlled landfilling or incineration.
Cultures and stocks	Same as human blood and blood products. However, highly infectious and communicable microbiological agents must be sterilized immediately at the source of generation.			
Sharps	Unbreakable and scalable containers.	Incineration is applicable depending on the ash discharge system and the disposal method (to avoid prick accidents). Infected sharps may be sterilized by autoclave, but it should not change the subsequent safe handling of sharps to avoid accidents.	Separate storage of infectious wastes.	Controlled landfilling or incineration.
Infectious waste	Scalable strong plastic bags, plastic buckets, or coated cardboard boxes.	Incineration is applicable.	Separate storage of infectious wastes.	Controlled landfilling or incineration.
Animal waste	Scalable strong plastic bags, plastic buckets, or coated cardboard boxes.	Incineration is applicable.	Separate storage of infectious wastes.	Controlled landfilling or incineration. Note, destruction is required for highly communicable animal diseases according to veterinary regulations.
Chemical waste	Scalable strong plastic bags, plastic buckets or bottles etc. depending on the physical and chemical properties. Original packaging also applicable.	No internal treatment.	Separate storage of chemicals (well ventilated store).	Treatment and disposal facilities for (general) hazardous waste.
Radioactive waste	Scalable strong plastic bags, plastic buckets or bottles etc.	Dilution or separate storage until acceptable radiation is reached. Radioactive liquids may be discharged to the sewer after dilution.	Separate storage. Control of radiation during storage and before shipment to collection point.	Controlled landfilling or incineration.
General (non-hazardous) waste	Plastic bags, containers etc.	Incineration is applicable, but in most cases not cost effective.	Separate storage in containers.	Controlled landfilling (or medical SW incineration)

5.5 Examination of the Institutional System

a. Recommended System

The MS should establish a Regulation for the internal and external management of medical waste, in accordance with this section of the Master Plan. Meanwhile, SESMA will issue Technical Norms adapting the Regulation to the local conditions and will also enforce compliance by applying the sanctions established in the Regulation and the Sanitary Code.

At the same time, the Environmental Programs Department of the MS will carry out and coordinate the preparation of the Code of Practice, which will consolidate all necessary requirements for medical waste management. The participants will not be changed, but they shall behave in accordance to the Organizational Chart shown in Figure 5.5a, without overlapping and with respecting the generator's responsibility (i.e. medical institution's responsibility).

b. Human Resources Development

The competent authority (SESMA) will have to add a sanitary engineer and a social spokesman to their staff. It will have to concentrate efforts for, in short term, elaborating technical instructions to orient the management of the medical SW, and to promote a training program of the operative and executive personnel of the medical institutions.

The operation personnel shall be trained to sort and place the waste at the source, to operate the sterilization and incineration equipment, and to carry out maintenance, cleaning and disinfection of floors, vehicles and storage rooms. The selected head-person for this personnel shall be appropriately qualified for planning and executing these services.

Medical and paramedical staff, particularly nurses, shall be motivated for the waste management system and shall be trained to sort and place waste at the source, as well as to use the sterilization and autoclave equipment.

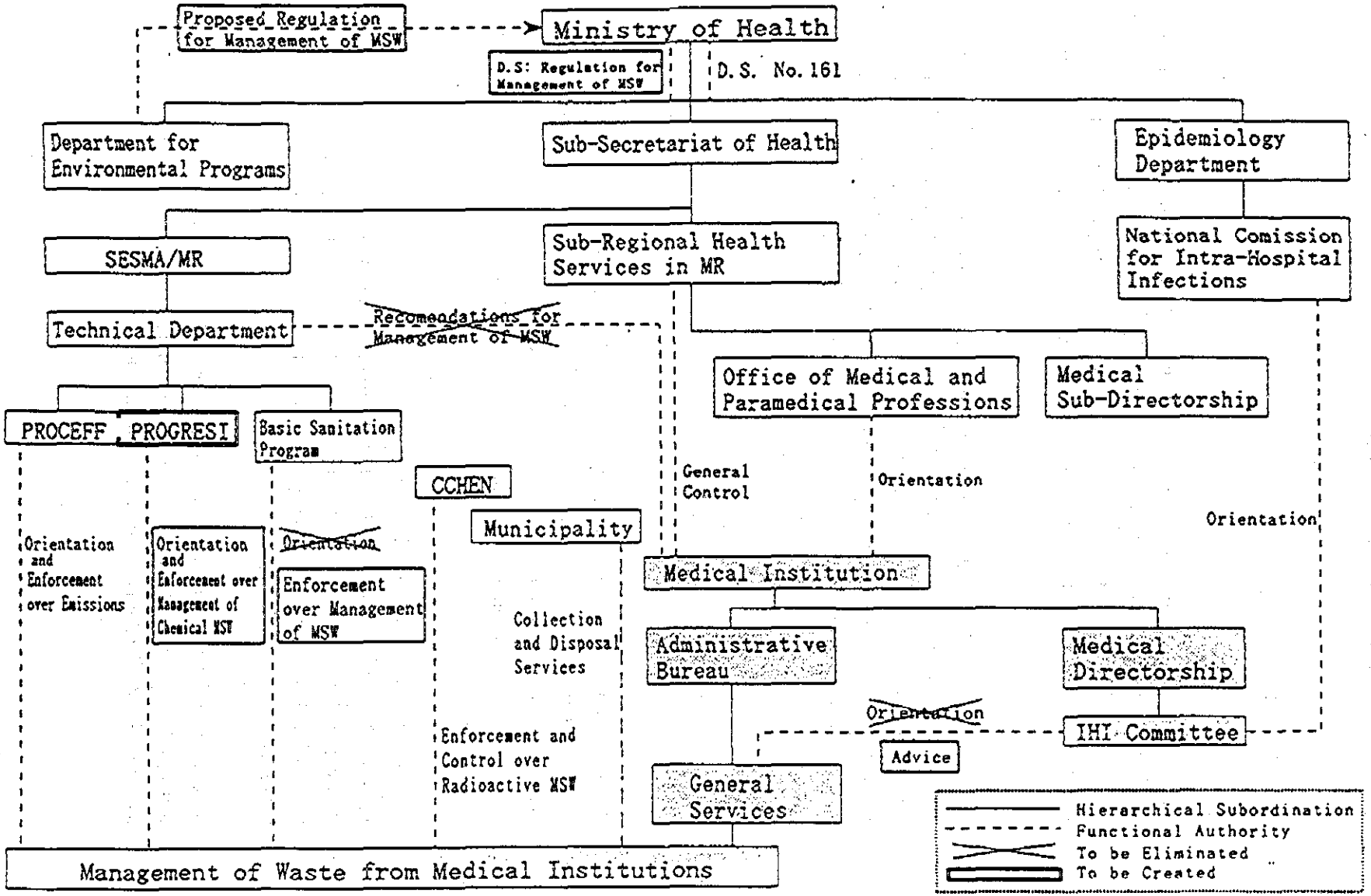


Figure 5.5a Proposed Organizational Development Related to Medical SWM

5.6 Estimation of Costs and Financial Responsible Bodies

As a rough guideline for the cost estimation, the following estimates are used.

Since medical waste other than infectious type is collected by municipal SW collection services, cost estimation on medical SW is done only for infectious type medical waste. Since packaging of infectious type wastes shall be born by each medical institutions as well as on-site medical SWM like storage, etc., it is excluded from the estimation of total costs, i.e. magnitude of medical SWM to be done by the private ISW handling agents. Estimation of medical SWM scale (i.e. total costs) are forecasted by multiplying "amounts estimated of infectious waste to be collected, transported, treated and disposed in 2010" and "respective unit costs" and totalled, which are shown in the Table 5.6a.

Table 5.6a Cost of Infectious Waste Collection, Transportation, Intermediate Treatment and Disposal in 2010

unit: US$/ year

Type of waste	Collection and Transportation	Intermediate Treatment	Disposal	Total
Infectious waste	425,000	1,570,000	0	1,995,000
C-1	0	0	19,000	19,000
C-2	0	0	9,000	9,000
Total	425,000	1,570,000	28,000	2,023,000

5.7 Evaluation of the Master Plan

a. Economic Evaluation

a.1 Evaluation on the Prospect of Medical Sw Handling Business Market in 2010

The medical SW handling market is estimated to be about 2.02 million US dollars in 2010, which is as much as 4.8% of the total ISW handling market in 2010. The distribution of medical SW market by type of waste handling is given in Table 5.7a overleaf.

Table 5.7a Distribution of Medical SW Market in 2010

Type of business	Scale of market (US$)	Ratio to total (%)
Collection & transportation	425,000	21.0
Intermediate treatment	1,570,000	77.6
Disposal	28,000	1.4
Total	2,023,000	100.0

As found in the table above, nearly 80% of the total market is covered by intermediate treatment, in this case incineration of infectious wastes in accordance with the master plan. Because the total medical SW generation amount of 10,400 ton per year is to be reduced in the process of incineration by 85%, final disposal cost is estimated to be very low in comparison with other costs.

a.2 Evaluation on the Cost of Medical SW Handling Covered by Generators

The unit cost of infectious waste handling is about 195 US dollars per ton in 2010. If converting the handling cost of infectious waste into per bed in 2010 based on the projection of the number of beds with the assumption that ratio of bed to the total population is the same as in 1995, the unit cost of infectious waste handling will be around 114 dollars per bed per year. This amount of expenses seems relatively light for the medical institutes because self-installation or upgrading of the existing incinerators by generators in accordance with the requirement of the standard need much more cost. The introduction of a modern incinerator is the most possible and cost-effective option to safely treat infectious wastes by proper collection and transportation from medical institutes. Thus, implementation of the master plan is the most cost-effective way of handling infectious medical waste in the MR.

b. Technical Evaluation

b.1 Evaluation of Administrative Measures to be Taken for Improving Medical SWM at Generators

The Code of Practice recommended in the master plan comprehensively covers the provisions necessary to properly handle medical SW from the generation source to final disposal in detail. In addition, standards for landfilling and incineration of medical SW are to be prepared in parallel, either as an integral part of the CoP or separate legal tools. Early implementation of the above policy measures in accordance with the master plan will guarantee minimization or even elimination of the possible risks of patients, workers in medical institutes who conduct internal medical SW handling.

b.2 Evaluation of Administrative Measures for External Medical SWM

b.2.1 Development of Landfill for Medical SW

Since public authorities are not financially involved in the development of medical SW facilities, they should conduct negotiations with relevant landfill operators in the MR regarding the establishment of landfill capacity for disposal of medical SW and with relevant haulage contractors for provision of an appropriate standardized collection and transportation system. This negotiation should be carried out before the enforcement of the CoP and related standards to make ways of proper medical SWM towards generators.

b.2.2 Development of Centralized Incineration for Medical SW

Implementation of centralized incineration of medical SW depends on the implementation of incineration for ISW. Taking into account the enforcement schedule of the ISWM master plan, the period 1999-2001 is proposed for development of a solution with the companies engaged in ISWM and incineration may be available from the beginning of next century. Accordingly, negotiation with the landfill operators regarding the development of landfill capacity for medical SW should be based on the careful estimation of accumulated amount of infectious medical SW to be generated up until this period. As far as taking proper care about the above issues, medical SWM can be realized through the implementation of the master plan.

c. Environmental Evaluation

The objective of environmental evaluation here is to identify what environmental risks may otherwise bring about if the master plan is not implemented. The possible problems which may occur in the absence of the medical SWM master plan are as follows.

- Uncontrolled dumping may offend (and cause a risk to public).
- Improper disposal of medical SW at the municipal SW landfills may create a bad image for landfills and reduce neighborhood acceptance. Also, it creates mistrust to the capability of the responsible authorities.
- Old type hospital incinerators are significant sources of air pollution (e.g. dioxin). Furthermore, inappropriate location and a low chimney may create nuisances such as smoke, soot and odors in the nearby neighborhood. With respect to occupational health aspects, incinerators with poor access conditions, no/poor equipment for automatic feeding of

the waste and for ash discharge may cause work related accidents.

- Improper treatment of infectious wastes may increase possible infection not only by the workers in medical institutes, but also those who handle medical SW such as:
  - staff responsible for packaging and collection at the medical institutions,
  - staff involved in public recycling activities, in case segregation is not complete,
  - scavengers at landfills where medical SW is improperly disposed.
- In the extreme situation, improper medical SWM may endanger not only the hygienic conditions at the medical institutions, but also outside them.

Thus, proper medical SWM in accordance with the master plan needs to be implemented as early as possible to avoid the future accumulated negative impacts on the environment, even on human health.

5.8 Implementation Plan

The Implementation Plan presented in Figure 5.8a includes the most important activities to implement the Medical SWM Master Plan.

Preparation of the Code of Practice is scheduled for 2 years (1996 and 1997). It could be prepared faster, but it is recommended to allocate at least 1.5 years for the work as it will be the foundation for the upgrading of the Medical SWM.

Parallel to preparation of the Code of Practice, standards for landfilling and incineration of medical SW should be prepared (also at national level) - either as an integrated part of the Code of Practice or as separate standard setting activities.

In order to ensure a reasonable speed of implementation and to eliminate the uncertainties as far as possible, CONAMA-RM should take a leading role in provision of adequate landfill capacity and provision of a standardized collection and transportation system for medical SW - the main elements of the technical Master Plan.

Implementation of centralized incineration of medical SW is made dependent on implementation of incineration for ISW. The period 1999-2001 is proposed for development of a solution with the companies engaged in ISW management and a solution may be available from the beginning of next century.

	SHORT-TERM					MEDIUM-TERM					LONG-TERM				
	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Preparation of Code of Practice															
Preparation of standard for landfilling of Medical Solid Waste															
Preparation of standard for incineration of Medical Solid Waste															
Legal implementation of standard for Medical Solid Waste incineration for new incinerators															
Legal implementation of standard for Medical Solid Waste incineration for existing incinerators															
Negotiations on landfill for Medical Solid Waste															
Landfill for Medical Solid Waste in operation															
Negotiations on collection and transportation system for Medical Solid Waste															
Collection and transportation system for Medical Solid Waste in operation															
Development of centralized incineration for Medical Solid Waste (co-treatment with ISW)															
Centralized incineration for Medical Solid Waste (co-treatment with ISW) in operation															
Phasing out of landfilling of Medical Solid Waste															

Figure 5.8a Implementation Plan for Medical SW Master Plan

CHAPTER 6 CONCLUSIONS AND RECOMMENDATIONS

a. Trends of ISW Generation

The Team's Study verified that ISW generation in the MR at present (1995) is of the order of 939,000 ton/year, which comprises 26,000 ton/year of HW, 45,000 ton/year of LW and the rest being non-HW according to the ISW classification being applied in the CDSI system. HW and LW which are subject to utmost attention and control in view of ISWM count for only 7.6% of total ISW generation. Namely great majority of ISW is non-HW at present.

Whereas ISW generation in the future (2010) is estimated about 1,756,000 ton/year, which is approximately 1.87 times of the present generation, under such circumstances where regulations for effluent gas emission and waste water discharge are being tightened and on the other hand industries are concentrated and expanding their activities in the MR. Among others, increases in dust and sludge (which should be subject to be controlled as HW) generation are remarkable. In the year 2010 organic and inorganic sludge generation is estimated 646,000 ton/year (water content is assumed 85%). It will count for 37% of the total ISW generation.

Therefore it should be reminded in planning and formulating **a proper management system of ISW** that ISW generation in the MR in the future will be quite different from that of today both in quantity and quality (i.e. component ratio).

b. Problems in Current Practice and Situation of ISW

Illegal dumping sites in the order of one hundred exist in the MR and some of the illegal dumping sites are located near present municipal landfill sites. It is strongly anticipated that the illegal dumping causes detrimental environmental pollution in the surroundings. Recycle activities presently receive 56% of ISW generated in the MR. Considerable number of recyclers deploy their activities near illegal dumping sites and after recovery of reusable materials from the ISW received the rest being dumped in those illegal dump sites.

Those which should theoretically be generated as HW and/or LW are currently dispersed into aquatic and atmospheric environment in the form of waste water discharge and exhaust gas emission. In the course of tightening of environmental regulations (waste water quality to be discharged and exhaust gas emission level), these ISW (HW and LW) are increasingly being generated. Destination of a huge amount of

ISW, namely intermediate treatment and final disposal facilities are not established yet at this moment.

Present mal-practice and poor situation (i.e., prevalent illegal dumping, defective recycling activities, absence of ISW destination) should be improved through the implementation of the ISWM Master Plan.

c. Goals, Targets and Strategies to be Confirmed

The principal goal of the ISWM Master Plan is to establish a proper management system of ISW till the target year 2010 in the Metropolitan Region.

Whereas establishment of the proper ISWM system is essential for ***"preservation of the environment and public health, and sound development of the city"*** and ***"promotion of growth of Chilean industries in gaining the international competitiveness required for compliances with issues of joining the International Market and ISO's stricter standards for environment"***.

This should be strictly reminded in promoting the Master Plan.

In order to achieve the principal goal (the establishment of the proper ISWM system), the Master Plan proposed to comply the two requirements (**i.e., Establishment of Appropriate On-site ISWM and Formulation of ISWM market mechanism**) in accomplishing "targets" and deploying "strategies".

The government of Chile, which aims to be a small government, has a general principle in his policy that public authorities should place necessary but minimal participation. This policy is also an essential fundamental in ISWM policies. It should be confirmed that "**a proper management system of ISW** should be formulated by amplifying private sectors' activities" and the administrative authorities should provide all the normative and the respective monitoring, guidance and technological information, as far as it is necessary for the promotion of the system.

d. Unified Classification of ISW to be Established Earlier

The Team understands that the 24 ISW classification proposed for the Study is effective and efficient in "identifying the actual situation of ISW generation (quantity, on-going treatment/disposal)" and "programming intermediate treatment and final disposal plans". On the other hand, ISW classification of CDSI (i.e. 333 classification) is practically being used in SESMA-PROCEFF's monitoring and control and in addition, MS regulations recently drafted requires diffusion of analytical identification of HW in employing its 44 classification.

Inter-ministries coordination should be improved with regard to ISW classification in Chile. The situation should draw utmost attention in establishing a proper management system of ISW.

It is recommended in this regard that:

- authorities' monitoring and control of ISW should be pursued with CDSI classification for the time being,
- with regard to HW, as soon as when laboratorial analytical identification become practiced and prevalent, coordination between CDSI classification and MS classification should be placed as the basis of formulating unified ISW classification earlier.

e. Treatment (Prior to Discharge and Emit) to be Obligated

In order to substantiate counter measures for pollution of HW and LW (which draw special attentions in practices of ISWM), inter-relation with "air and water pollution prevention measures" is indispensable to effect HW/LW pollution prevention.
A great majority of HW which should be subject to these preventive measures are currently released to the sewer, public water courses or to the air.

It should be reminded that treatment (prior to discharge to the sewer, superficial courses or emit to the air) and enforcement of related monitoring is the first step to realize HW pollution prevention.

f. Local Authorities to be Strengthened and Administrative Measures to be Legally Empowered

Although establishment of the proper management system of ISW should, in principle,

be promoted through private sectors activities, on the other hand strengthening of relative local authorities' organization (which is responsible for monitoring and guidance over the private sectors) is essential for the promotion. For that purpose, legal authorization of authorities' administrative measures (e.g. on-site inspection, report collection, measures against improper/illegal conducts, etc.) should be enforced.

A program for the consistent management from the waste generation to final disposal and its realization should be associated with the permit bound to the obtainment or renewal of the municipal patent.

Meanwhile, since proper on-site management of ISW is fully inter-related with "air and water pollution prevention measures" and "use of hazardous physico-chemical substances", further training and assignment of technical officers in relative authorities, who are capable to understand the inter-relation of on-site management and able to place adequate guidance, should also be promoted.

g. Waste Generators' Organizations to be Strengthened

A proper on-site management of ISW is required to be promoted inter-relating with on-site air and water pollution prevention measures and control of hazardous physico-chemical substances. In addition, alteration of production processes are necessitated for pursuing management. To formulate industries' organization (including assignment of qualified technical staff) to fulfill these requirements is a crucial issue to be solved, where it considerably requires industries' intentional efforts for reform.

The Government policies for ISWM should also, considering the importance of the issues mentioned, place higher priorities in promotion of waste generators' organizational reinforcement in this regard.

h. Human Resources to be Developed

As the former section tells the importance of qualified personnel, human resource development both in authorities and waste generators, and also in ISW handling agents is in urgent need of solution. Whereas laboratorial analysis, which is fundamentals for HW management, should be disseminated and practiced, training opportunities for acquiring laboratory analysis technologies should be provided, e.g. through the CENMA project. The CENMA project should be utilized in initial stages as a "reference laboratory" for identifying HW and followingly training courses of technical skills and practices should be included to the project. In addition, the role of the

Instituto de Salud Pública (Public Health Institute) be reinforced throughout a study with regard to its use as "reference laboratory" and with regard to the need of coordination with the CENMA project.

Human resource training plays an important role in establishing the proper management system of ISW.

i. HW Landfill for the MR to be Realized Soon

In order to formulate an appropriate management system for HW, a final disposal site for HW should be prepared as soon as possible. It is necessary that construction and operation of a HW final disposal site is promoted and realized soon.

In order for the realization of abovementioned situation, immediate actions for establishing following standards and systems are required:

- standards for structure and O&M of ISW final disposal site;
- system for neighborhood consensus (including EIA procedure and public participation); and
- system for localization and operation permission of ISW final disposal site (e.g. requirements/regulation for siting to be clarified).

In particular, the public opinion survey revealed that neighbors tend to be distrustful to authorities and promoting sectors through what they experienced in occasions of present landfill operations and localization of new landfills. The communication of the authorities and the promoting sector with the public should be direct and honest.

j. Legislative and Institutional System to be Improved Step-wise

Establishment of a proper management system of ISW in the MR requires improvement in related legislative system. It is anticipated that a whole required legislative system to be formulated and improved immediately. However, it is anticipated that several issues, that related authorities can not cope with for the time being, and/or impediments for consensus may delay the formation of required legislative system.

In this regard, step-wise manner (e.g., basic obligation to industries/handling agents and authorization of monitoring/guidance be stipulated in earlier stages, penalty against illegal conduct and/or administrative measures be put into practice in later stages)

should be employed in improving legislative and institutional system.

k. Present Situation to be Identified and Database to be Established

The most fundamental principle of SWM is precise identification of the present situation (of ISW generation and ISWM on-site and outside). Fortunately, the Manifest System is already in operation by SESMA-PROCEFF. The present situation of total 425 factories (i.e. 199 factories by Team's Survey and 265 by EWI's RISNOR study, minus duplicative visits by both study) was identified. Starting with said identification, it is necessary to elaborate for establishment of the database for a proper management system of ISW by accumulating data/information through further factory visit, on-site inspection and report collection.

In order to establish the database through information collection, the corresponding norms and regulations that require such information should be set up.

ISW generation in future is forecasted based on the data obtained by Team's Factories Survey and EWI's RISNOR study both of which were conducted only one time and almost at the same time. Therefore, especially for the forecast of dust and sludge (which are to be managed as HW) generation, various assumptions were made. It should be understood that the forecast is conditional. In order to make the forecast reliable, it is recommended that Chilean authorities conduct periodical factories' survey (in Japan it is conducted every five years.).

l. Trends of Medical SW Generation

The Team's Study verified that Medical SW generation in the MR at present (1995) is of the order of 23,600 ton/year. Infectious medical SW that are subject to special attention in medical SWM counts for 7,300 ton/year (i.e. 31% of the total). Whereas it is estimated that infectious waste in year 2010 be generated 28.5 ton/day (namely 10,400 ton/year).

A proper management system for medical SW (especially corresponding to trends of infectious waste generation) should be established.

m. Code of Practice for Medical SWM to be Prepared Soon

The Master Plan for medical SWM, apart from the Master Plan of ISWM, is produced.

Among the issues proposed in it, preparation of a Code of Practice of medical SWM should be recognized as the issue to receive high priority in taking urgent actions. Based on the outcome of the Team's investigation, immediate action for the preparation of a Code of Practice should be initiated.

n. Disposal System for Infectious Waste to be Improved Step-wise

It is necessary that technical system for infectious wastes be established (i.e., each type of medical SW be separated at generation sources, exclusive collection/transportation and treatment/disposal for infectious waste be practiced.). Thermic treatment by individual small-scale incinerators has problems in air pollution control and O&M features. Meanwhile a centralized incinerator project should overcome problems of inefficient scale and cost recovery.

In this consequence, it is proposed that an exclusive section in a municipal landfill site should be allocated for a sanitary landfill for medical SW for the time being. Separate and isolated landfill operation should be employed there. In the future, medical SW should be sent to and incinerated at an incineration plant for HW. When centralized incineration plant is in operation, strict gas emission regulation may possibly start to be imposed on existing individual small-scale medical incinerators.