ANNEX K EXAMINATION OF AN OPTIMUM TECHNICAL SYSTEM FOR ISWM MASTER PLAN

K.1 Examination of Technical System

K.1.1 Examination of Appropriate Treatment/Disposal Flow

a. 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. Current treatment/disposal system of ISW mainly comprise "recycling" and "disposal in municipal landfill sites".

In view of the principal policy of the Government of Chile, a technical system of ISW in future will be established by private sectors. Therefore, it is difficult to estimate and/or propose what technologies level be applied and extended by private sectors. While the Study has its objective in planning authorities' proper management system of ISW but does not have its objective in planning private sectors' projects.

Namely, the Study does not employ the methodologies which propose an appropriate and/or optimum technical system through examination of each individual technical system. Since the party to select a feasible and optimum technical system to be extended in the business is the private sectors, the estimation (scale of demand for ISW treatment, initial and operation cost of a facility, and consequently business profitability) is all left to private sectors.

Consequently, the Study examines appropriate treatment/disposal flows for the 24 ISW categories for the authorities to be materialized for 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 the 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 the 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. Meanwhile 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 his 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.

b. Appropriate Treatment/Disposal Flow

Appropriate treatment/disposal flows for the 24 ISW categories basically comprise:

- judgement of characteristics of ISW;
- choice of intermediate treatment technologies;
- choice of type of final disposal facilities.

ba. Choice of Final Disposal Facilities

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.

bb. Choice of Intermediate Treatment Technologies

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.

bc. ISW Classification Corresponding to Appropriate Treatment Flows

333 ISW classification employed in the CDSI system of SESMA-PROCEFF has 3 sub-classification 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 K.1.1a):

Table K.1.1a 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.	-
3.2 Inert	To be recycled or disposed in IL	Solubilization test (ST)

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

bd. 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 K.1.1a". The judgement of in which ISW classification (of Table K.1.1a) 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.

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. In 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 K.1.1b are Non-HW or not.

be. Appropriate Treatment/disposal Flow

An appropriate treatment/disposal flow is summarized as shown in Figure K.1.1a. The respective appropriate treatment flows for 24 ISW categories are presented below.

Table K.1.1b Relations of 24 ISW Classification and HW

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

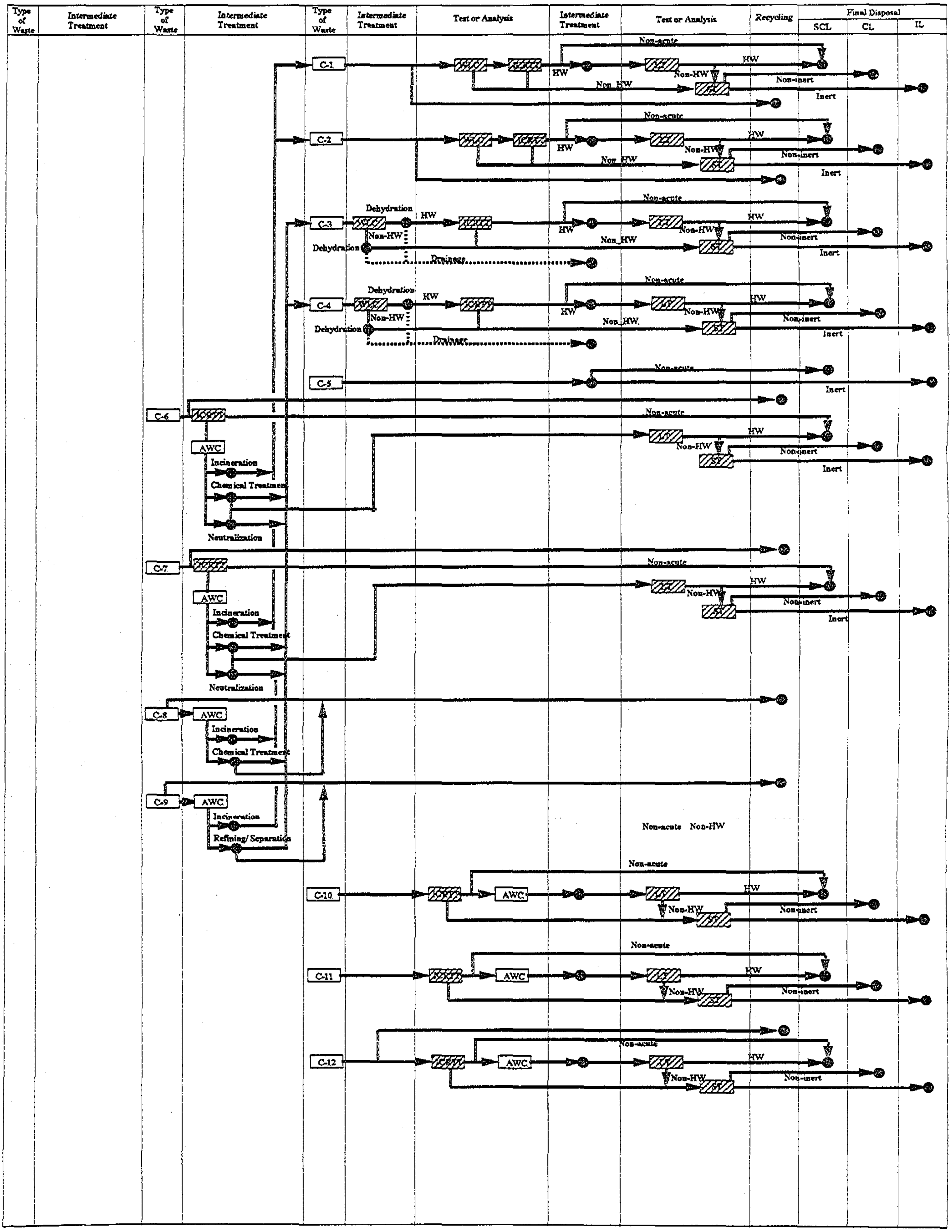


Figure K.1.1a Appropriate Treatment/Disposal Flow

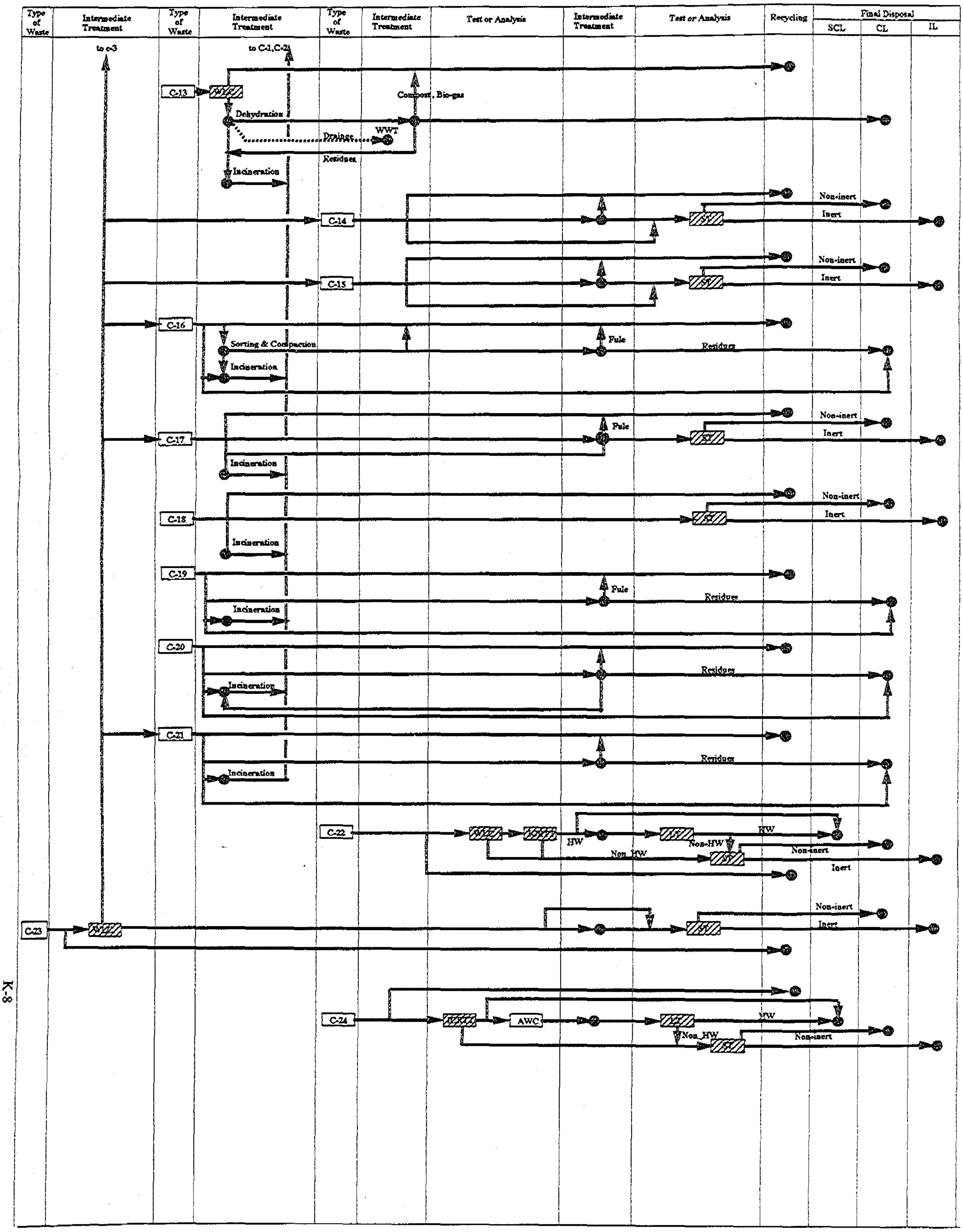


Figure K.1.1a Appropriate Treatment/Disposal Flow

c. **Explanation of 24 Individual Flows**

ca. **C-1 Ash Including from Incinerators**

At first, "recyclable C-1" should be destined for such usage (e.g., raw materials for cement and iron manufacturing industries) and "non-recyclable C-1" should be subject to treatment/disposal.

Ashes generated from combustion processes as including incinerators have wide varieties in its features and characteristics from hazardous to non-hazardous, depending on materials combusted, fuels used and combustion conditions.

Consequently, treatment/disposal of HW in this category of ISW shall be done by:

- intermediate treatment being solidification, thermic melting and chemical treatment in general with purpose of reducing hazardous characteristics; and
- HW other than acutely toxic and corrosive could be disposed of at SCL without intermediate treatment.

As for the Non-HW of this category of ISW, since said ISW is ash from combustion process, further volume reduction is difficult and not cost-effective, it should be disposed directly to final disposal sites. After a judgement of whether it is non-inert or inert, it should be disposed at CL and IL respectively.

cb. **C-2 Dust and APC Products**

"C-2 dust and APC products" consists of particulate matters and fly ashes of which generation sources are similar to those of "C-1 ash including from incinerators" and coarse particulate from stone cutting ,etc.. Most coarse particulate are inert. Particulate matters and APC products are divided in to HW and Non-HW in the same manner as C-1. At first, "recyclable C-2" should be destined for such usage (e.g., raw materials for cement and iron manufacturing industries) and "non-recyclable C-2" should be subject to treatment/disposal. Therefore, treatment/disposal systems in this category shall be same as those in C-1.

cc. **C-3 Inorganic Sludge**

At first, "recyclable C-3" should be destined for such usage (e.g., raw materials for cement and ceramic industries) and "non-recyclable C-3" should be subject to treatment/disposal.

Inorganic sludge may comprise sludge of inorganic substances such as soil and dirt, and sludge containing inorganic compounds. Inorganic compounds may contain heavy metals.

Since sludge shows features of liquid state or semi-liquid state, dehydration treatment at the initial stage is indispensable and removed liquid (waste water) after dehydration is inevitably generated, whose treatment also becomes inevitable. On the other hand, treatment/disposal systems after dehydration should, based on the fundamentals mentioned above, be:

- intermediate treatment (solidification and chemical treatment, etc.) for HW to lower hazardous characteristics;
- HW other than acute toxic, corrosive and reactive HW could be disposed of at SCL without any intermediate treatment; and
- Non-HW should be disposed of at CL or IL depending on features and characteristics of Non-HW, i.e. inert or non-inert.

cd. C-4 Organic Sludge

At first, "recyclable C-4" should be destined for such usage (e.g., raw material for cement industry, solid conditioner) and "non-recyclable C-4" should be subject to treatment/disposal.

Organic sludge comprises "organic sludge resulted from organic waste water treatment" and "sludge containing organic compounds". Organic compounds may contain organic chloride compounds.

Since sludge shows features of liquid state or semi-liquid state, dehydration treatment at the initial stage is indispensable and removed liquid (waste water) after dehydration is inevitably generated, whose treatment also becomes inevitable. On the other hand, treatment/disposal systems after dehydration should, based on the fundamentals mentioned above, be:

- intermediate treatment (solidification, incineration, bio-degradation and chemical treatment) for HW to lower hazardous characteristics;
- HW other than acutely toxic, ignitable, corrosive and reactive HW could be disposed of at SCL without any intermediate treatment; and
- Non-HW should be disposed of at CL or IL depending on features and characteristics of Non-HW.

ce. C-5 Asbestos

Although asbestos itself shows stable chemical characteristics, hazardousness of asbestos is originated in its fibrous features (i.e. ratio of its length and diameter). If long and fine fibers of asbestos are drawn to human lungs through inspiration for a long period, it may cause lung cancers, etc.. Therefore, its treatment should be oriented for protection of scattering of asbestos fibers. The treatment/disposal system should be:

- intermediate treatment with purpose of scattering protection such as (solidification, thermic melting) and then to be disposed of at IL; or
- direct disposal at SCL in case where intermediate treatment are absent.

cf. C-6 Acids

Waste acids may contain various metals and chemical substances and the majority present hazardous features and characteristics. At first, "recyclable C-6" should be destined for such usage (e.g., neutralizing agent, dissolved matter recovery). In case where it is not subject to reuse or recycling, some kind of intermediate treatment (neutralization, incineration, chemical treatment) is required. It will be transformed as other mode of ISW (e.g. C-1, C-2, C-3, C-4) after an intermediate treatment. Whereas waste acids less than pH5 shall be prohibited to direct landfill disposal. It shall at least require neutralization before landfill disposal. On the other hand, treatment/disposal systems after neutralization should, based on the fundamentals mentioned above, be:

- intermediate treatment (solidification, incineration and chemical treatment) for HW to lower hazardous characteristics;
- HW other than acutely toxic, ignitable, corrosive and reactive HW could be disposed of at SCL without any intermediate treatment; and
- Non-HW should be disposed of at CL or IL depending on features and characteristics of Non-HW.

cg. C-7 Alkalis

Waste alkalis may contain various metals and chemical substances and the majority present hazardous features and characteristics. At first, "recyclable C-7" should be destined for such usage (e.g., neutralizing agent, dissolved matter recovery). In case where it is not subject to reuse or recycling, some kinds of intermediate treatment (neutralization, incineration, chemical treatment) is required. It will be transformed as another ISW (e.g. C-1, C-2, C-3, C-4) after an intermediate treatment. Whereas waste alkalis more than pH9 shall be prohibited to direct landfill disposal. It shall at least require neutralization before landfill disposal. On the other hand, treatment/disposal systems after neutralization should, based on the fundamentals mentioned above, be:

- intermediate treatment (solidification, incineration and chemical treatment) for HW to lower hazardous characteristics;
- HW other than acutely toxic, ignitable, corrosive and reactive HW could be disposed of at SCL without any intermediate treatment; and
- Non-HW should be disposed of at CL or IL depending on features and characteristics of Non-HW.

ch. C-8 Solvents

At first, "recyclable C-8" should be destined for such usage (e.g., fuel, solvent). Waste solvents, however, due to its application features, may contain various metals and chemical substances and are flammable with a low flash point. Direct landfill disposal, therefore, shall be prohibited. In case where it is not subject to reuse or recycling, some kind of intermediate treatment (incineration, chemical treatment) shall be required. Especially in incineration treatment, it could also function as auxiliary fuels for other ISW whose calorific value is low, or as fuels for cement kilns. It finally is transformed into other ISW (C-1, C-2, C-4). Namely the treatment system should be incineration or chemical treatment with purposes of reducing hazardousness.

ci. C-9 Oily Waste

At first, "recyclable C-9" should be destined for such usage (e.g., fuel) and "non-recyclable C-9" should be subject to treatment/disposal. Oily waste is, like waste solvents, flammable with a low flash point. Direct landfill disposal, therefore, shall be prohibited. In case where it is not directly re-used or recycled, some kinds of intermediate treatment (incineration, refining) shall be required. After refining, refined oil are usable as general fuels, lubricants, etc.. However, refining processes generate residues as other sets of ISW (C-3, C-4). Especially in incineration treatment, it could also function as auxiliary fuels for incineration of other ISW whose calorific value is low, or as fuels for cement kilns. It finally is transformed into other ISW (C-1, C-2, C-3, C-4). Namely the treatment system should be incineration or refining.

cj. C-10 Inorganic Chemical Residues

Since inorganic chemical residues contain various inorganic chemical substances, irrespective of whether intermediate treatment be applied or direct disposal at landfill be applied, its composition shall be analyzed beforehand for selecting the technical system to be applied.

Other than "LW" and "ignitable, corrosive, reactive and acute toxic HW", it could be disposed of at SCL or CL or IL through characteristics verification by leaching test (LT) and solubilization test (ST). Whereas intermediate treatment is indispensable for "the above-mentioned HW".

On the other hand, intermediate treatment to be applied should be determined; first based on the analysis outcome and secondly referring with practices employed for intermediate treatment of other ISW.

ck. C-11 Organic Chemical Residues

Since organic chemical residues contain various organic chemical substances, irrespective of whether intermediate treatment be applied or direct disposal at landfill be applied, its composition shall be analyzed beforehand for selecting the technical system to be applied.

Other than "LW" and "ignitable, corrosive, reactive and acute toxic HW", it could be disposed of at SCL or CL or IL through characteristics verification by leaching test (LT) and solubilization test (ST). Whereas intermediate treatment is indispensable for "the above-mentioned HW".

On the other hand, intermediate treatment to be applied should be determined; first based on the analysis outcome and secondly referring with practices employed for intermediate treatment of other ISW.

cl. C-12 Other Liquid Waste

At first, "recyclable C-12" should be destined for such usage (usage varies depending on its composition and characteristics) and "non-recyclable C-12" should be subject to treatment/disposal.

Since "other liquid waste", alike organic/inorganic chemical residues, contain various chemical substances, its composition shall be analyzed beforehand for selecting the technical system to be applied.

Intermediate treatment to be applied should be determined based on the analysis outcome and secondly referring with practices employed for intermediate treatment of other ISW. Whereas intermediate treatment is indispensable for "ignitable, corrosive, reactive and acute toxic HW".

cm. C-13 Waste from Food Production

Waste from food production mainly comprises organic matters such as flesh of animals, debris of vegetables. Hence, in case other than direct used for feed, it could be directly disposed of at CL or intermediate treatment (such as compost, bio-gas recovery, incineration) could be applied.

cn. C-14 Glass and Ceramics

At first, "recyclable C-14" should be destined for such usage (e.g., raw material for glass and ceramic industries) and "non-recyclable C-14" should be subject to treatment/disposal.

Glass and ceramics are composed of inorganic matters. Main purposes of intermediate treatment should be 'volume reduction'" and/or "valuable resource recovery". Although glass and ceramics themselves are considered as inert, waste glass and ceramics may contain organic matters due to the use as containers. Therefore, it shall be subject to ST (Solubilization Test) whether it could be disposed of at IL or not.

co. C-15 Metal and Scrap

At first, "recyclable C-15" should be destined for such usage (e.g., raw material for metal industries) and "non-recyclable C-15" should be subject to treatment/disposal.

Great majority of metals and scraps are subject to recycling. Intermediate treatment to be applied for C-15 are also mainly intended for recycling, which in effect are such as "sorting" and "volume reduction". It is assumed that residues from intermediate treatment are extremely small.

Although metal and scrap themselves are considered inert, waste metal and scrap may contain organic matters due to the use as containers. Therefore, it shall be subject to ST (Solubilization Test) whether it could be disposed of at IL or not.

cp. C-16 Paper and Cardboard

At first, "recyclable C-16" should be destined for such usage (e.g., fuel, raw material for recycled paper manufacturing) and "non-recyclable C-16" should be subject to treatment/disposal.

Considerable proportion of paper and cardboard generated as ISW are, like "C-15 metal and scrap", subject to recycling procedure at sources. As for intermediate treatment to be applied, there are volume reduction with purpose of improving handling efficiencies, refuse derived fuel and incineration.

cq. C-17 Plastics

At first, "recyclable C-17" should be destined for such usage (e.g., fuel, raw material for recycle plastic) and "non-recyclable C-17" should be subject to treatment/disposal.

A great majority of plastics show characteristics of being inert. Although plastics themselves are considered inert, waste plastics may contain organic matters due to the use as containers. Therefore, it shall be subject to ST (Solubilization Test) whether it could be disposed of at IL or not.

cr. C-18 Rubber

At first, "recyclable C-18" should be destined for such usage (e.g., building materials, raw material for rubber) and "non-recyclable C-18" should be subject to treatment/disposal.

Most rubber show characteristics of being inert. Although rubber itself is considered inert, waste rubber may contain organic matters due to the use as containers. Therefore, it shall be subject to ST (Solubilization Test) whether it could be disposed of at IL or not.

cs. C-19 Textile and Leather

At first, "recyclable C-19" should be destined for such usage (e.g., fuel, raw material for pulping) and "non-recyclable C-19" should be subject to treatment/disposal.

Since textile and leather mainly comprise organic content, in case where direct disposal to landfill is preferred it should be disposed at CL. Since major purposes of intermediate treatment are 'volume reduction and/or "resource recovery", incineration or refuse derived fuel could be applied to.

ct. C-20 Waste Similar to Domestic Waste

At first, "recyclable C-20" should be destined for such usage (e.g., fertilizer, feed, fuel) and "non-recyclable C-20" should be subject to treatment/disposal.

Since C-20 shows characteristics similar to that of municipal solid waste, similar treatment/disposal system might be assumed for C-20 (namely, great majority might be disposed directly of at CL). As for the common intermediate treatment, there are incineration, bio-degradation (compost), or refuse derived fuel.

cu. C-21 Wood

At first, "recyclable C-21" should be destined for such usage (e.g., building material, raw material for pulping, fuel) and "non-recyclable C-21" should be subject to treatment/disposal.

It is assumed that most wood generated as ISW be re-utilized. Therefore amount subject to intermediate treatment and/or disposal are small. However, since it largely contains organic content, its direct landfill disposal should be practiced at CL. Intermediate treatment with purposes of "volume reduction" and/or "resource recovery" are to be incineration, bio-degradation (compost), or refuse derived fuel.

cv. C-22 Slag from Melting

At first, "recyclable C-22" should be destined for such usage (e.g., raw material for cement industry, road embankment, road subbase) and "non-recyclable C-22" should be subject to treatment/disposal.

Non-HW should be disposed at CL or IL based on the results of LT and ST. Acutely toxic waste among HW should, via intermediate treatment, be disposed of at appropriate landfill based on the LT outcome. Intermediate treatment for acute toxic HW should be chemical treatment or solidification.

cw. C-23 Construction Waste

At first, "recyclable C-23" should be destined for such usage (e.g., road embankment, road subbase, concrete aggregate) and "non-recyclable C-23" should be subject to treatment/disposal.

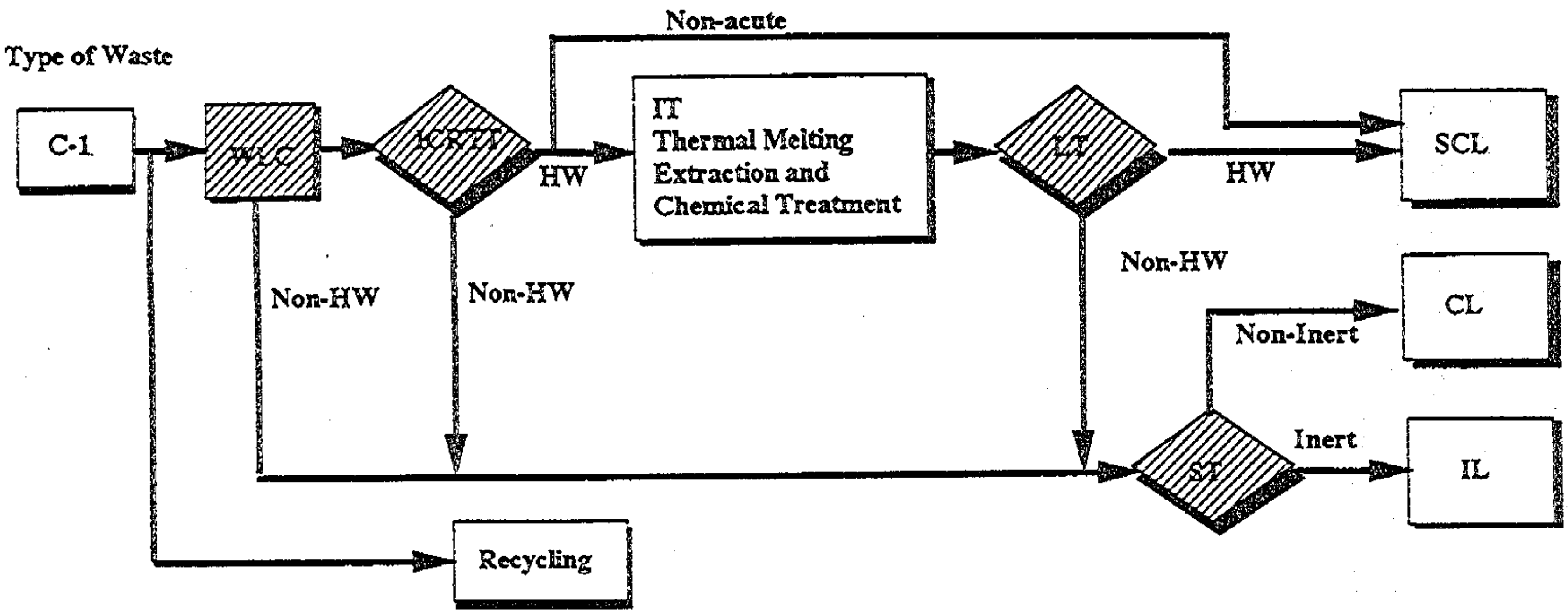
Since majority of construction waste are inert, it should be disposed of at CL or IL based on the ST outcome. Intermediate treatment to be applied should have the purpose of volume reduction.

cx. C-24 Other Solid Waste

At first, "recyclable C-24 should be destined for such usage and "non-recyclable C-24" should be subject to treatment/disposal.

Since C-24 (other solid waste) contain various substances like inorganic/organic chemical residues, it is necessary to examine its components beforehand.

On the other hand, intermediate treatment to be applied should be determined: first based on the analytical tests results and secondly referring with practices employed for intermediate treatment of other ISW. Intermediate treatment is indispensable for ignitable, corrosive, reactive and acute toxic HW in its disposal.



Legend	
WLC	: Waste List Check by Manifest
ICRTT	: Ignitability, Corrosivity, Reactivity and Toxicity Test
LT	: Leaching Test
ST	: Solubilization Test
HW	: Hazardous Waste
LW	: Liquid Waste
IT	: Intermediate Treatment
SCL	: Strictly Controlled Landfill
CL	: Controlled Landfill
IL	: Inert Landfill

Figure 7.1.1a Appropriate Treatment/Disposal Flow for C-1 (Ash including from incinerator)

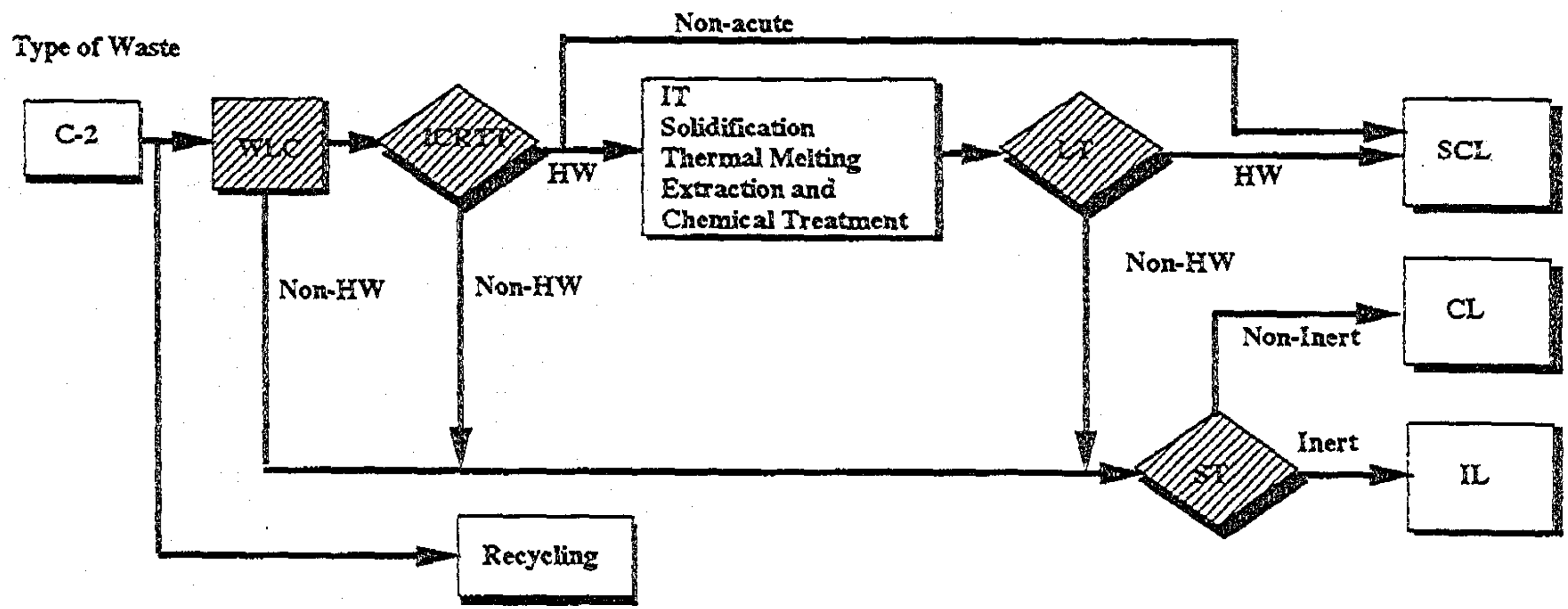


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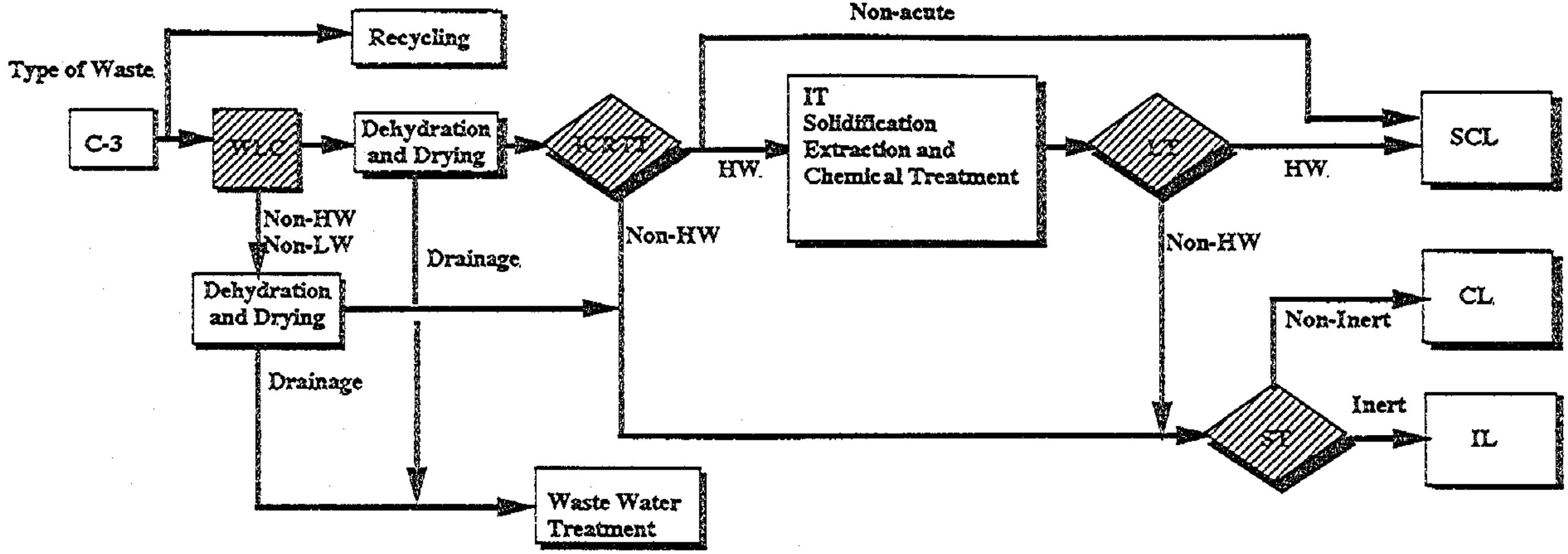
Figure 7.1.1b Appropriate Treatment/Disposal Flow for C-2 (Dust and APC products)



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LW	: Liquid Waste
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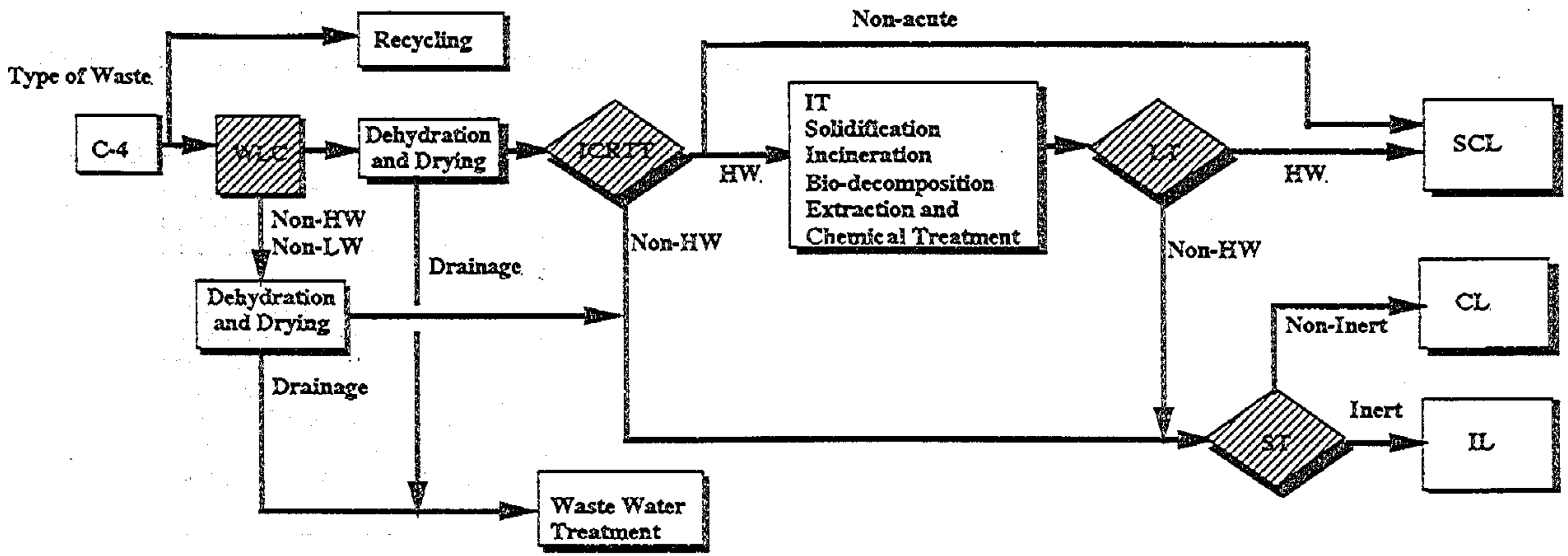
SCL	: Strictly Controlled Landfill
CL	: Controlled Landfill
IL	: Inert Landfill

Figure 7.1.1c Appropriate Treatment/Disposal Flow for C-3 (Inorganic sludge)



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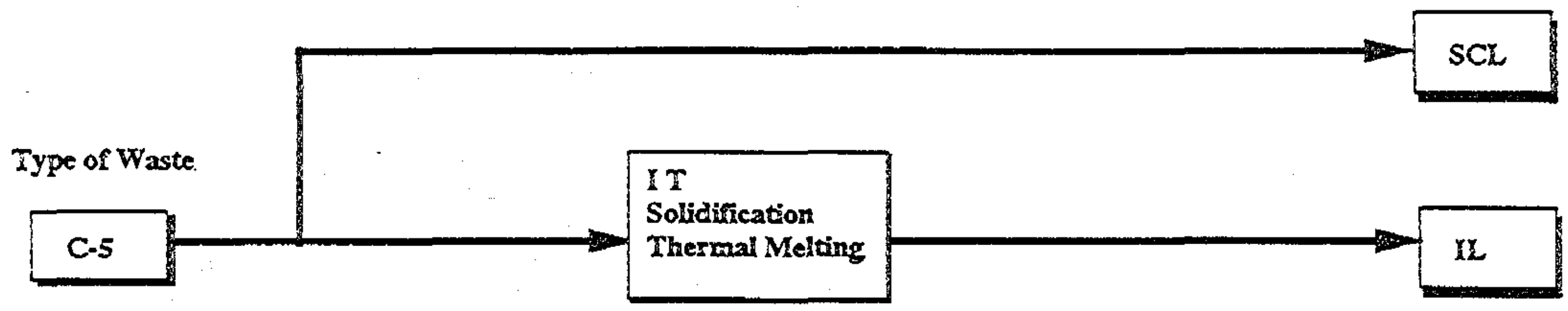
LW	: Liquid Waste
IT	: Intermediate Treatment
SCL	: Strictly Controlled Landfill
CL	: Controlled Landfill
IL	: Inert Landfill

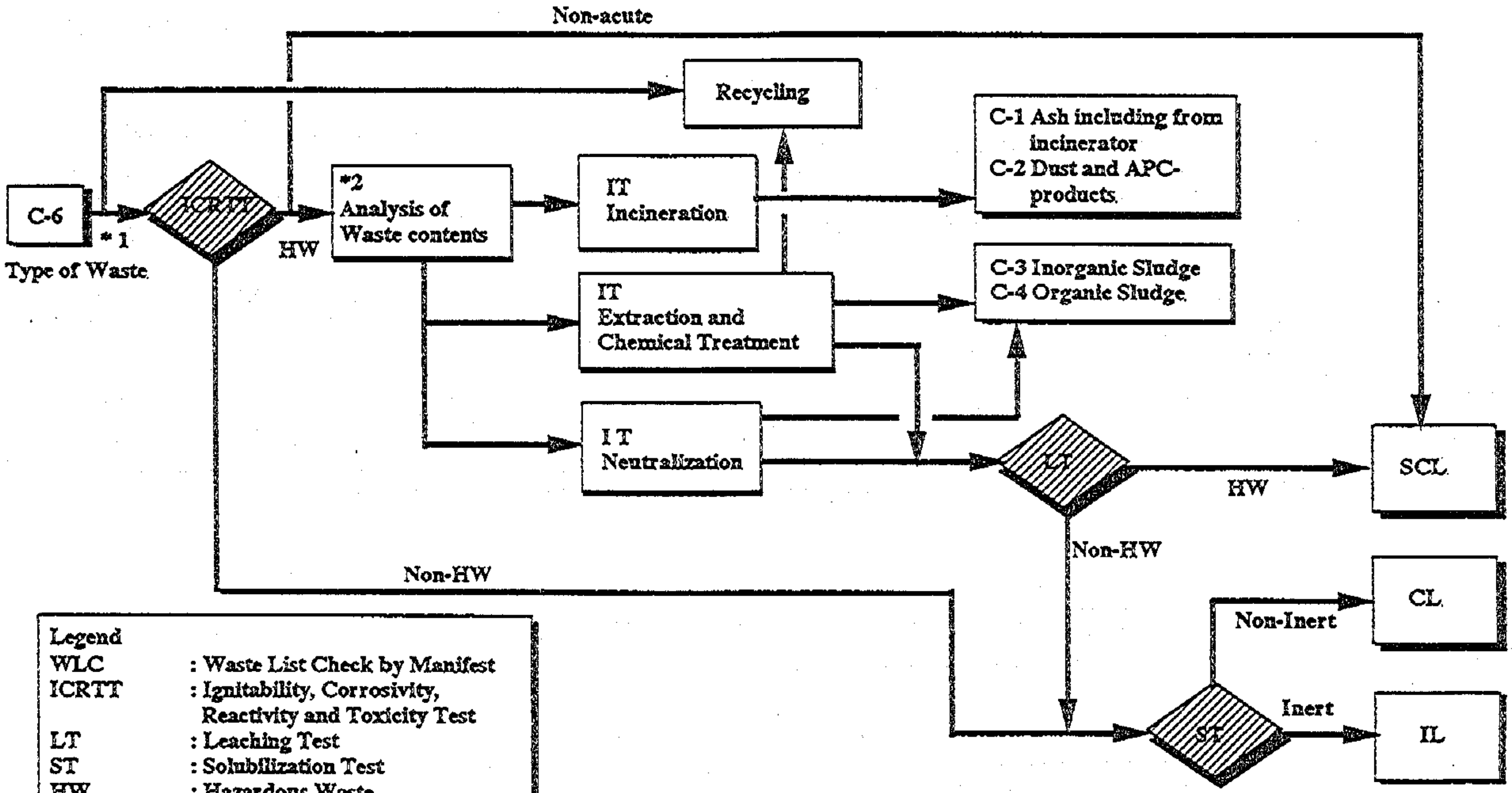
Figure 7.1.1d Appropriate Treatment/Disposal Flow for C-4 (Organic sludge)



Legend

WLC	: Waste List Check by Manifest
ICRTT	: Ignitability, Corrosivity, Reactivity and Toxicity Test
LT	: Leaching Test
ST	: Solubilization Test
HW	: Hazardous Waste
LW	: Liquid Waste
IT	: Intermediate Treatment
SCL	: Strictly Controlled Landfill
CL	: Controlled Landfill
IL	: Inert Landfill

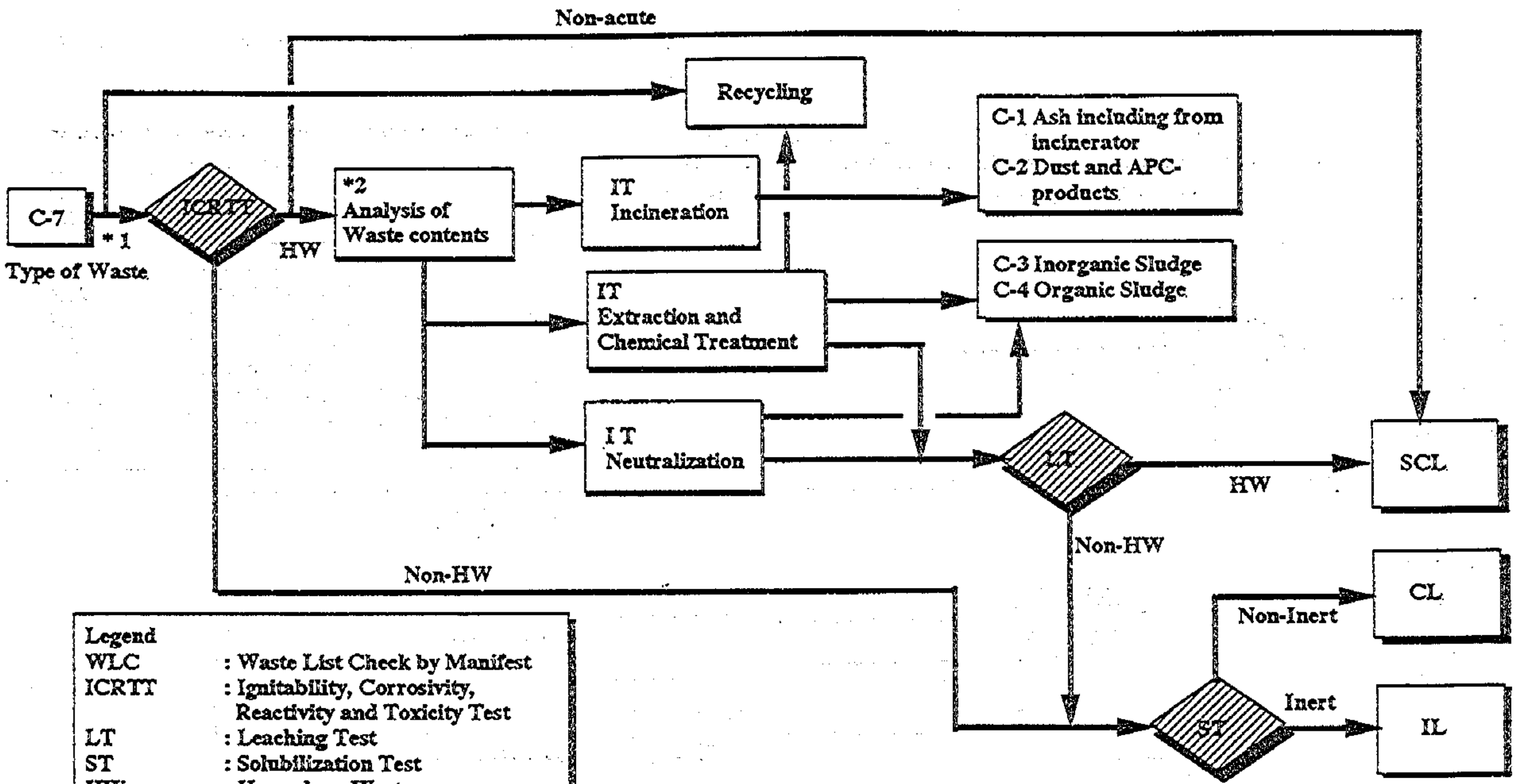
Figure 7.1.1e Appropriate Treatment/Disposal Flow for C-5 (Asbestos)



Legend
WLC : Waste List Check by Manifest
ICRTT : Ignitability, Corrosivity, Reactivity and Toxicity Test
LT : Leaching Test
ST : Solubilization Test
HW : Hazardous Waste
LW : Liquid Waste
IT : Intermediate Treatment
SCL : Strictly Controlled Landfill
CL : Controlled Landfill
IL : Inert Landfill

* 1: Direct landfill for waste acids less than pH 5 shall be prohibit ed.
* 2: The discharger and/or treatment plant need to analyze waste quality including ignitability, corrosivity, reactivity, toxicity characteristic (TCLP).

Figure 7.1.1f Appropriate Treatment/Disposal Flow for C-6 (Acids)

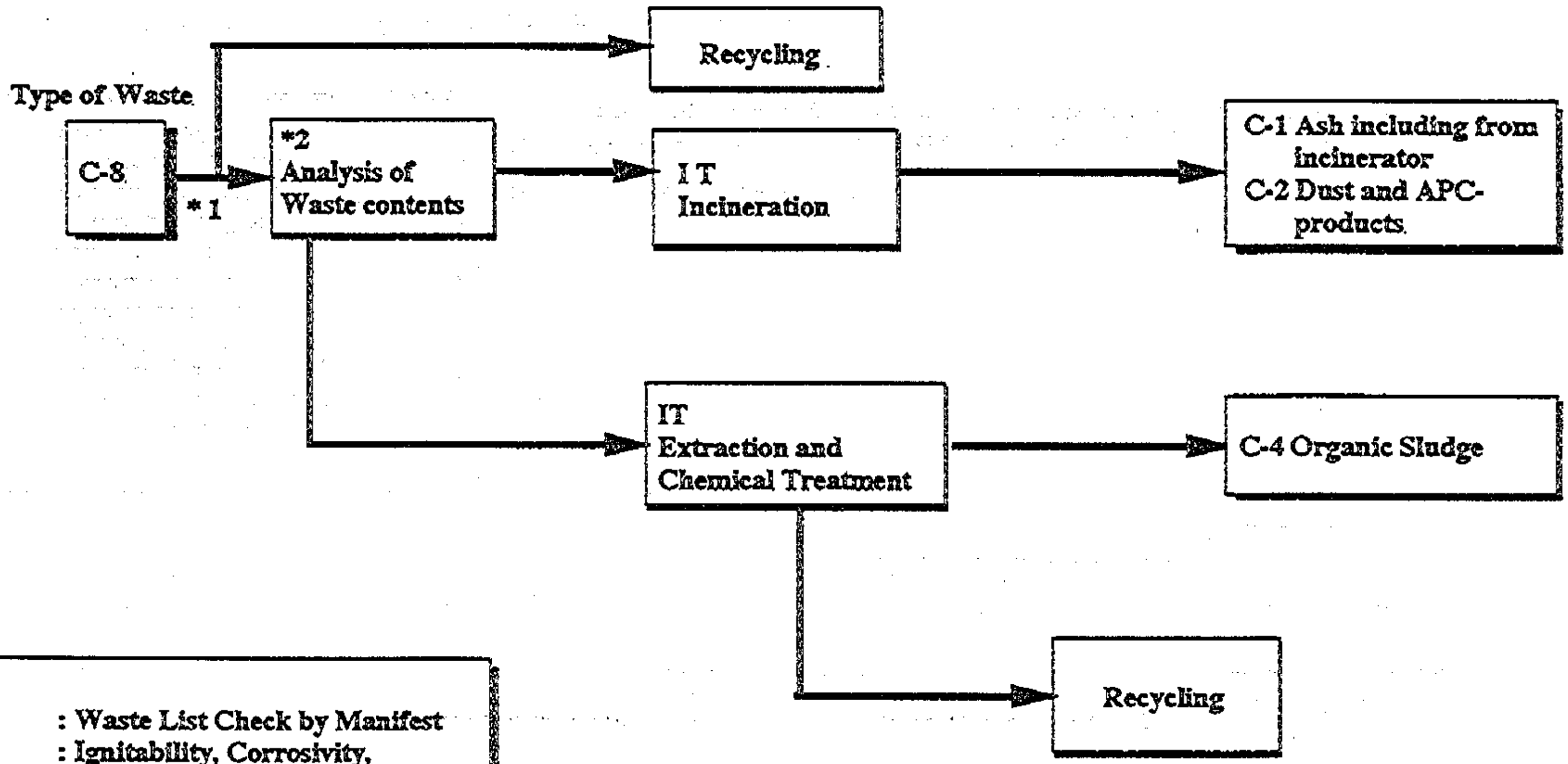


Legend	
WLC	: Waste List Check by Manifest
ICRTT	: Ignitability, Corrosivity, Reactivity and Toxicity Test
LT	: Leaching Test
ST	: Solubilization Test
HW	: Hazardous Waste
LW	: Liquid Waste
IT	: Intermediate Treatment
SCL	: Strictly Controlled Landfill
CL	: Controlled Landfill
IL	: Inert Landfill

* 1: Direct landfill for waste alkalis more than pH 9 shall be prohibited.

* 2: The discharger and/or treatment plant need to analyze waste quality including ignitability, corrosivity, reactivity, toxicity characteristic (TCLP).

Figure 7.1.1g Appropriate Treatment/Disposal Flow for C-7 (Alkalis)

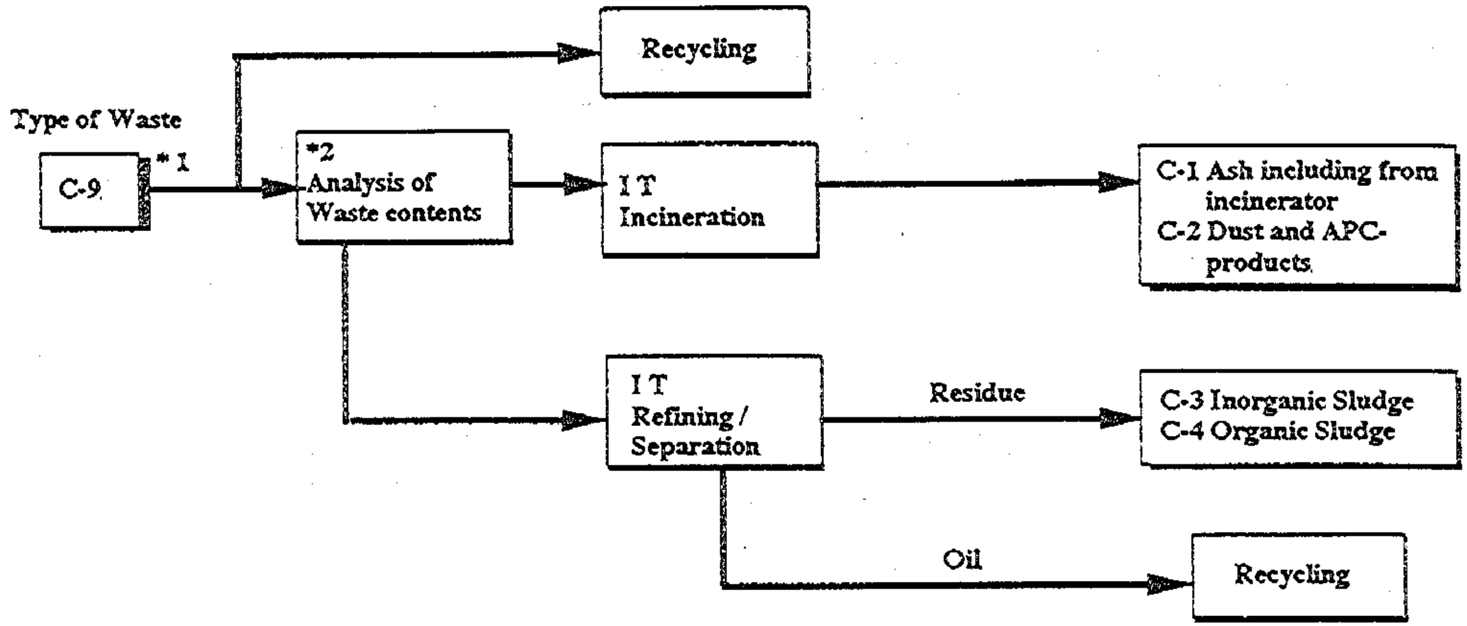


Legend	
WLC	: Waste List Check by Manifest
ICRTT	: Ignitability, Corrosivity, Reactivity and Toxicity Test
LT	: Leaching Test
ST	: Solubilization Test
HW	: Hazardous Waste
LW	: Liquid Waste
IT	: Intermediate Treatment
SCL	: Strictly Controlled Landfill
CL	: Controlled Landfill
IL	: Inert Landfill

* 1: Direct landfill shall be prohibited.

* 2: The discharge r and/or treatment plant need to analyze waste quality including ignitability, corrosivity, reactivity, toxicity characteristic (TCLP).

Figure 7.1.1h Appropriate Treatment/Disposal Flow for C-8 (Solvents)

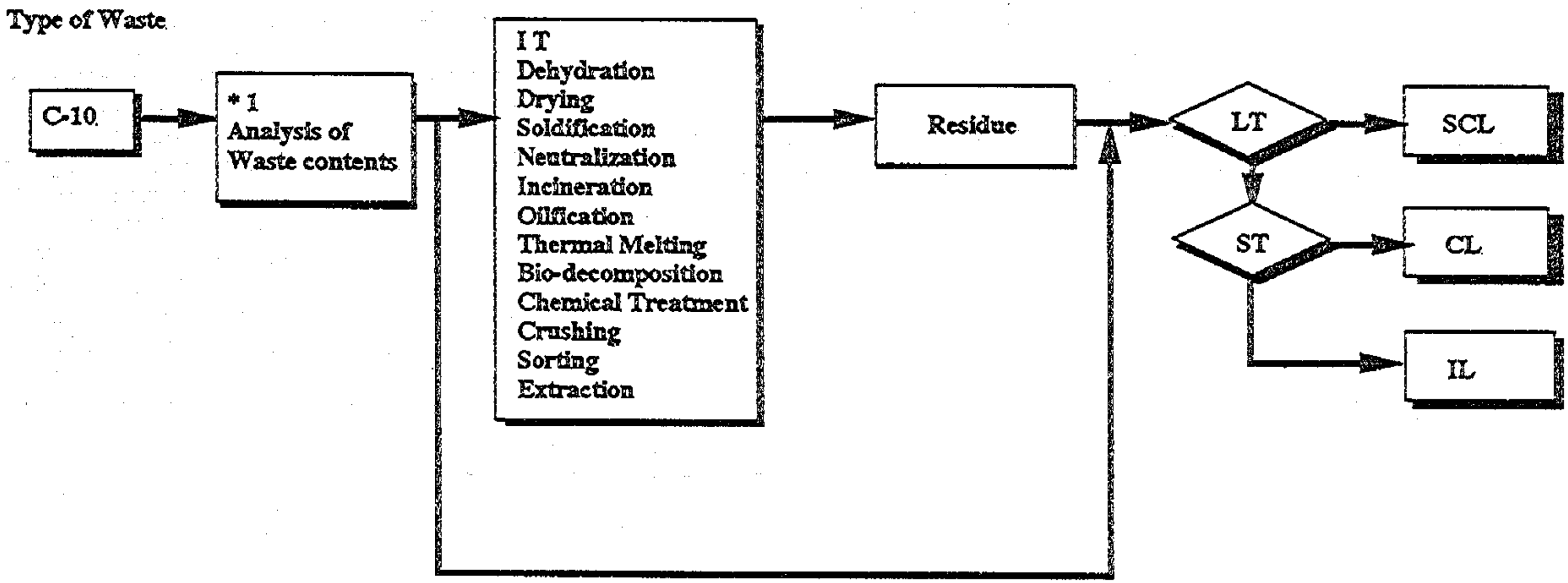


Legend	
WLC	: Waste List Check by Manifest
ICRTT	: Ignitability, Corrosivity, Reactivity and Toxicity Test
LT	: Leaching Test
ST	: Solubilization Test
HW	: Hazardous Waste
LW	: Liquid Waste
IT	: Intermediate Treatment
SCL	: Strictly Controlled Landfill
CL	: Controlled Landfill
IL	: Inert Landfill

* 1: Direct landfill prohibited.

* 2: The discharge r and/or treatment plant need to analyze waste quality including ignitability, corrosivity, reactivity, toxicity characteristic (TCLP).

Figure 7.1.1i Appropriate Treatment/Disposal Flow for C-9 (Oily waste)

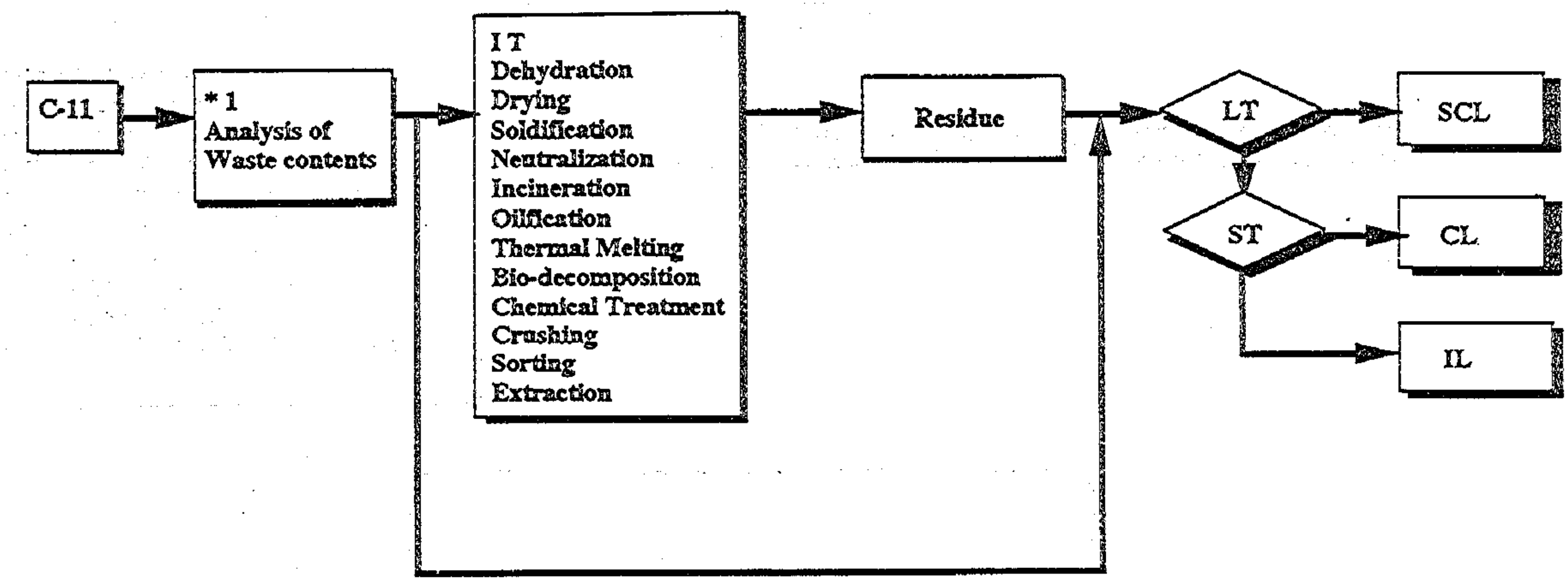


Legend
WLC : Waste List Check by Manifest
LT : Leaching Test
ST : Solubilization Test
HW : Hazardous Waste
LW : Liquid Waste
IT : Intermediate Treatment
SCL : Strictly Controlled Landfill
CL : Controlled Landfill
IL : Inert Landfill

* 1: The discharge r and/or treatment plant need to analyze waste quality including ignitability, corrosivity, reactivity, toxicity characteristic (TCLP).

Figure 7.1.1j Appropriate Treatment/Disposal Flow for C-10 (Inorganic chemical residues)

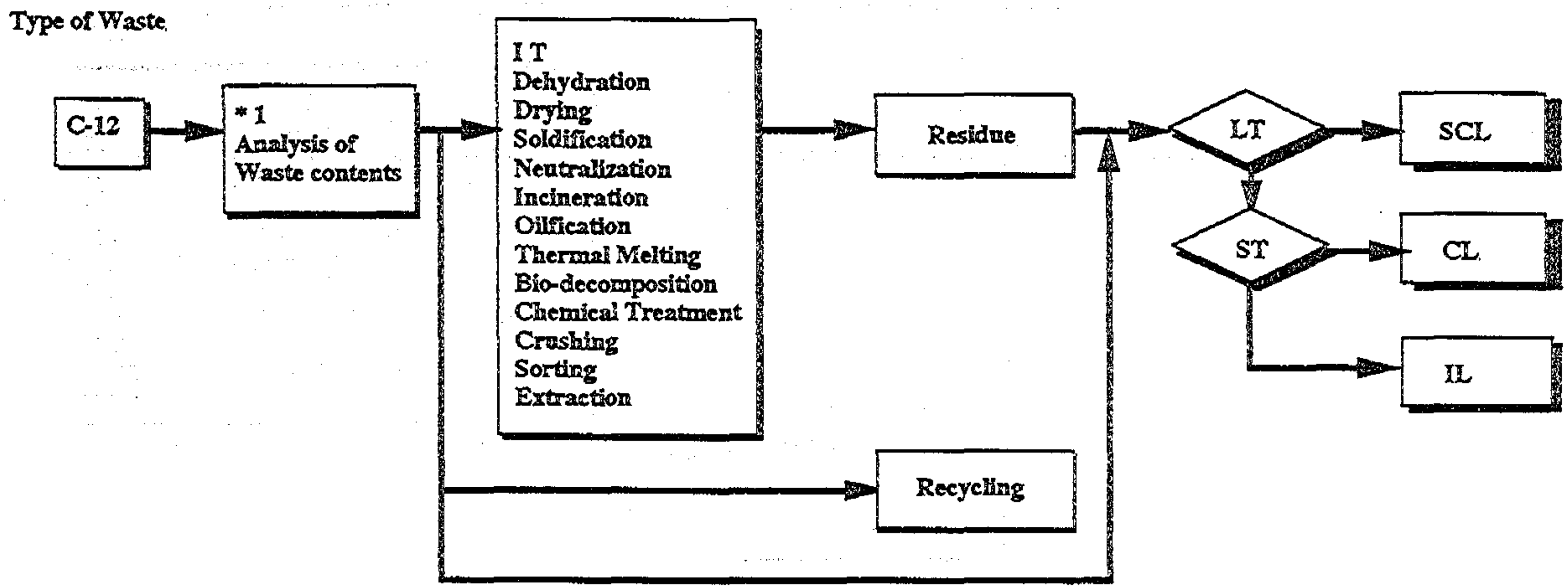
Type of Waste



Legend
WLC : Waste List Check by Manifest
LT : Leaching Test
ST : Solubilization Test
HW : Hazardous Waste
LW : Liquid Waste
IT : Intermediate Treatment
SCL : Strictly Controlled Landfill
CL : Controlled Landfill
IL : Inert Landfill

* 1: The discharge r and/or treatment plant need to analyze waste quality including ignitability, corrosivity, reactivity, toxicity characteristic (TCLP).

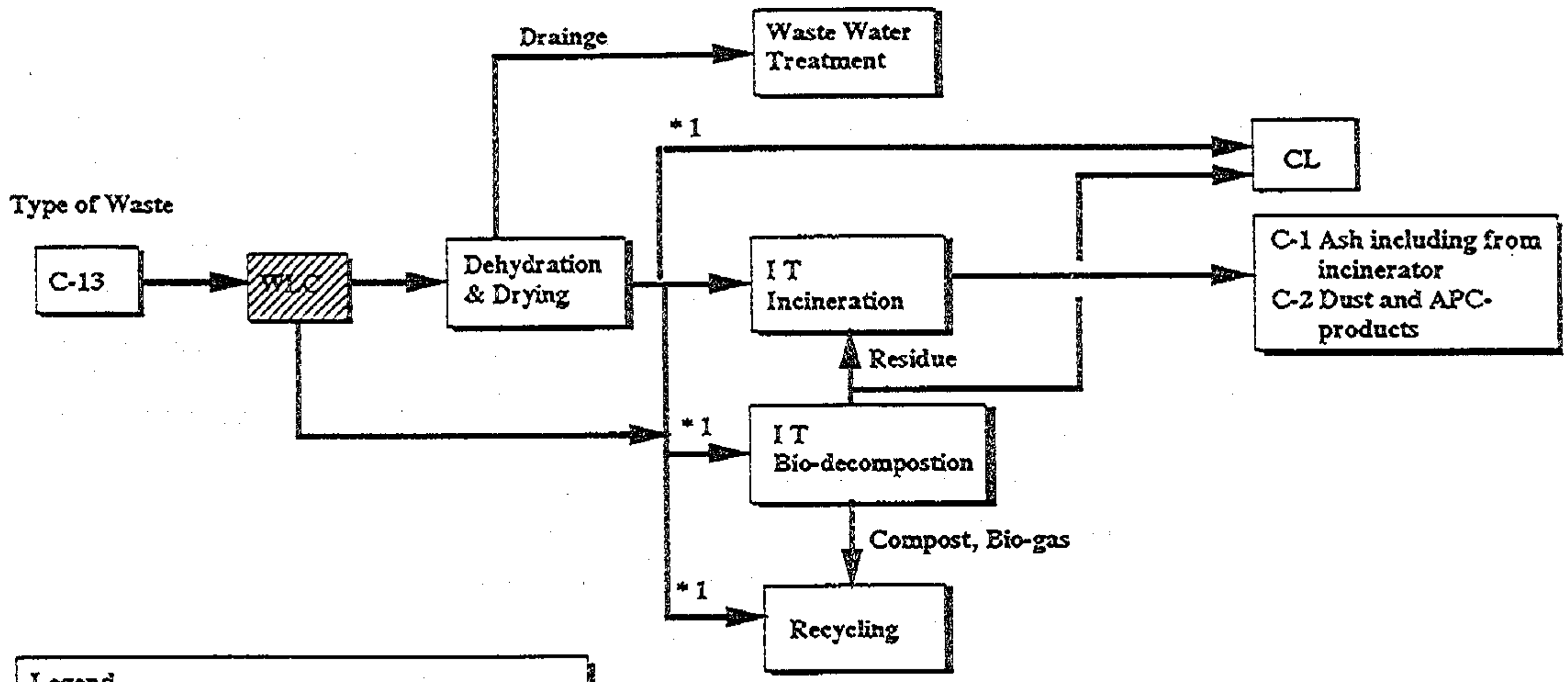
Figure 7.1.1k Appropriate Treatment/Disposal Flow for C-11 (Organic chemical residues)



Legend
WLC : Waste List Check by Manifest
LT : Leaching Test
ST : Solubilization Test
HW : Hazardous Waste
LW : Liquid Waste
IT : Intermediate Treatment
SCL : Strictly Controlled Landfill
CL : Controlled Landfill
IL : Inert Landfill

* 1: The discharge r and/or treatment plant need to analyze waste quality including ignitability, corrosivity, reactivity, toxicity characteristic (TCLP).

Figure 7.1.11 Appropriate Treatment/Disposal Flow for C-12 (Other liquid waste)

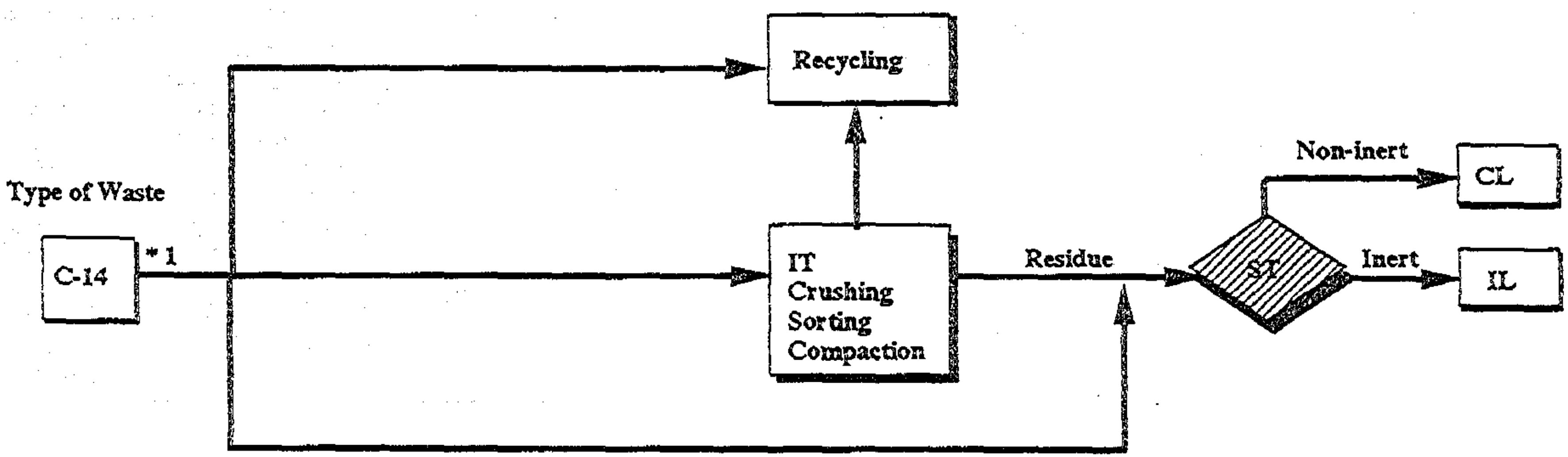


Legend

WLC	: Waste List Check by Manifest
ICRTT	: Ignitability, Corrosivity, Reactivity and Toxicity Test
LT	: Leaching Test
ST	: Solubilization Test
HW	: Hazardous Waste
LW	: Liquid Waste
IT	: Intermediate Treatment
SCL	: Strictly Controlled Landfill
CL	: Controlled Landfill
IL	: Inert Landfill

*1: Except for dead animal by infectious disease.

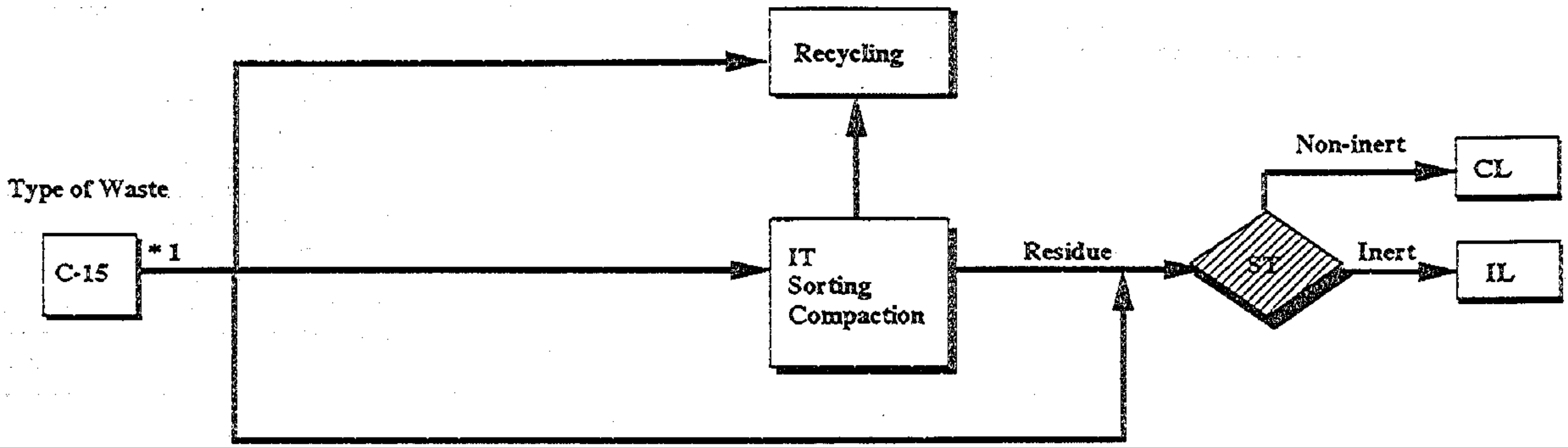
Figure 7.1.1m Appropriate Treatment/Disposal Flow for C-13 (Waste from food production)



Legend	
WLC	: Waste List Check by Manifest
ICRTT	: Ignitability, Corrosivity, Reactivity and Toxicity Test
LT	: Leaching Test
ST	: Solubilization Test
HW	: Hazardous Waste
LW	: Liquid Waste
IT	: Intermediate Treatment
SCL	: Strictly Controlled Landfill
CL	: Controlled Landfill
IL	: Inert Landfill

*** 1: Except for descarded container of hazardous wastes which shall be treated before disposal and/or recycling.**

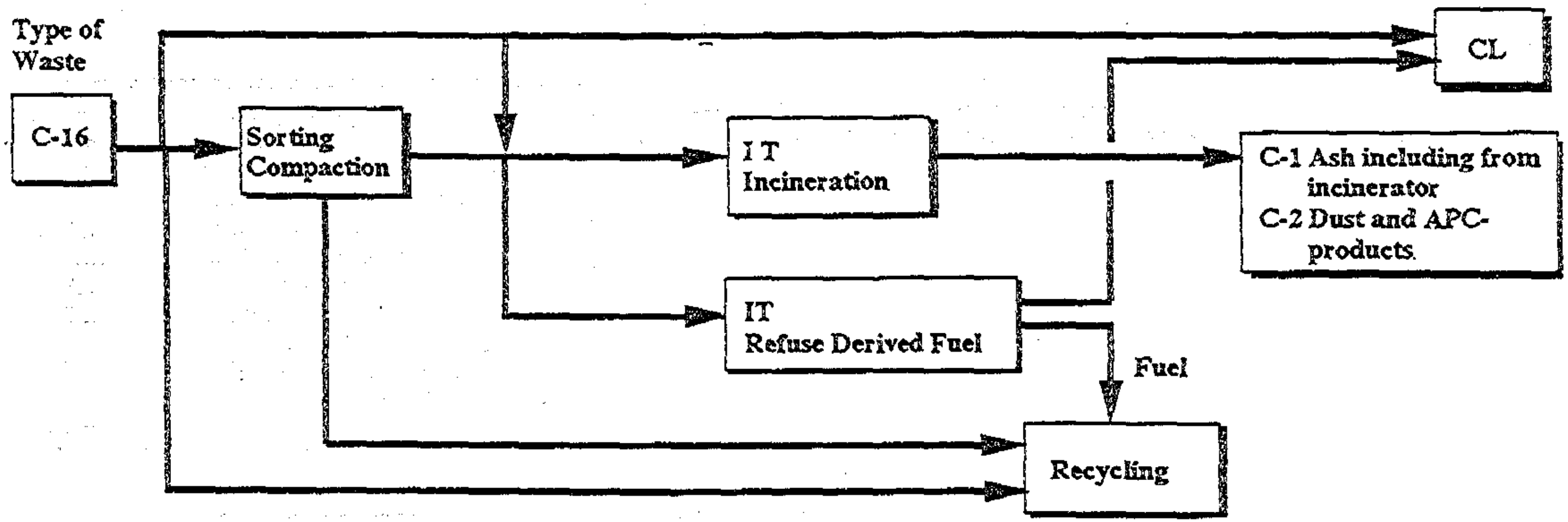
Figure 7.1.1n Appropriate Treatment/Disposal Flow for C-14 (Glass and ceramics)



Legend	
WLC	: Waste List Check by Manifest
ICRTT	: Ignitability, Corrosivity, Reactivity and Toxicity Test
LT	: Leaching Test
ST	: Solubilization Test
HW	: Hazardous Waste
LW	: Liquid Waste
IT	: Intermediate Treatment
SCL	: Strictly Controlled Landfill
CL	: Controlled Landfill
IL	: Inert Landfill

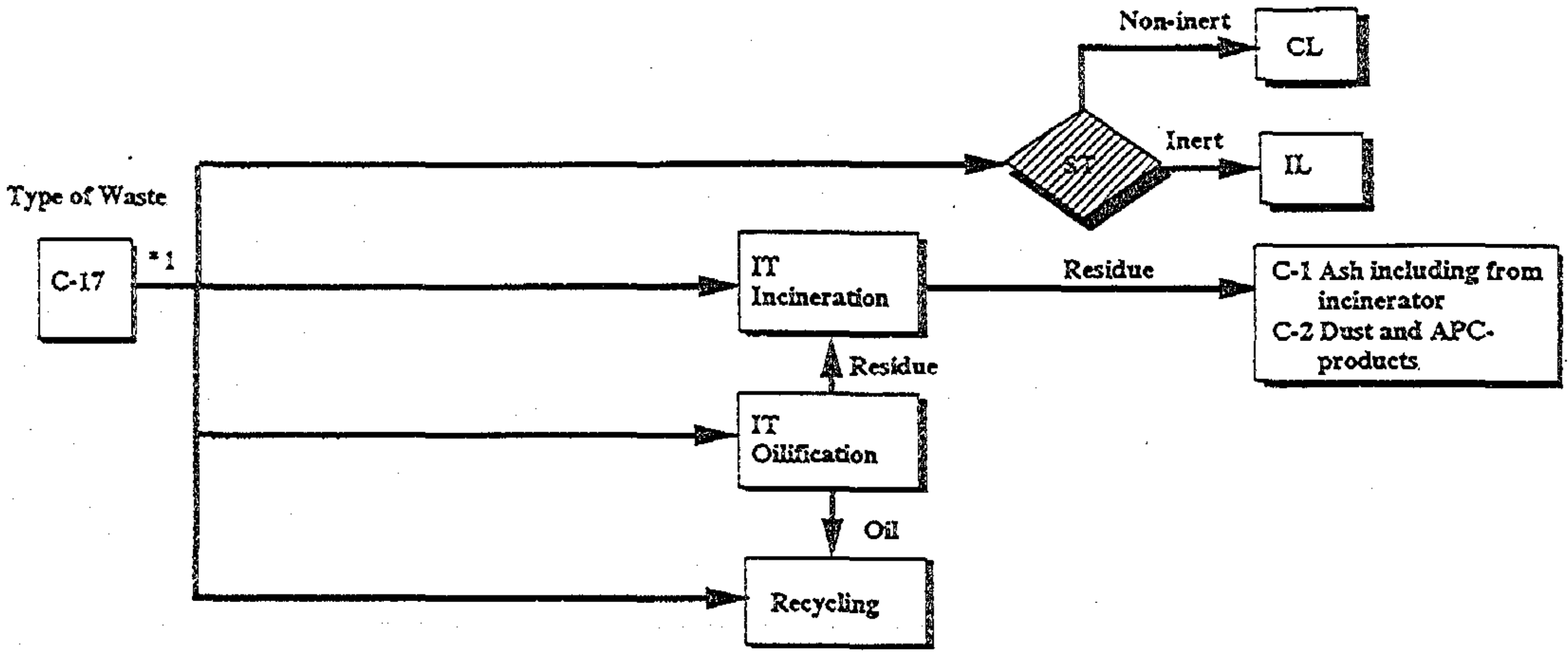
* 1: Except for descarded container of hazardous wastes which shall be treated before disposal and/or recycling.

Figure 7.1.1o Appropriate Treatment/Disposal Flow for C-15 (Metal and scrap)



Legend	
WLC	: Waste List Check by Manifest
ICRTT	: Ignitability, Corrosivity, Reactivity and Toxicity Test
LT	: Leaching Test
ST	: Solubilization Test
HW	: Hazardous Waste
LW	: Liquid Waste
IT	: Intermediate Treatment
SCL	: Strictly Controlled Landfill
CL	: Controlled Landfill
IL	: Inert Landfill

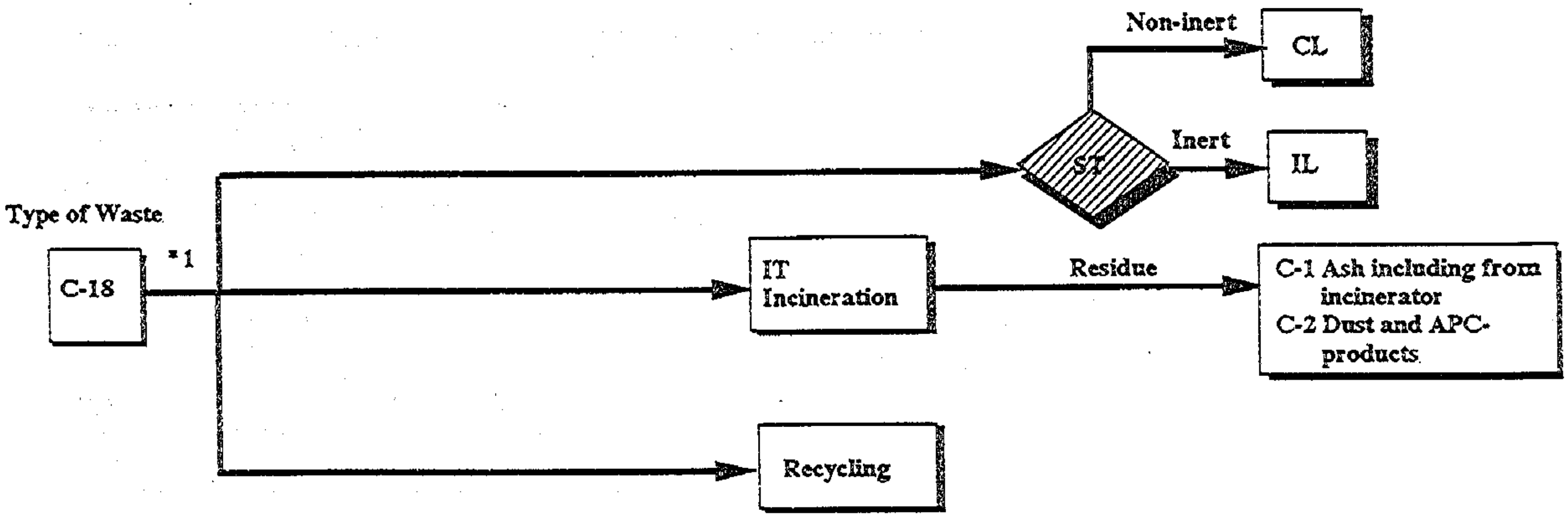
Figure 7.1.1p Appropriate Treatment/Disposal Flow for C-16 (Paper and cardboard)



Legend	
WLC	: Waste List Check by Manifest
ICRTT	: Ignitability, Corrosivity, Reactivity and Toxicity Test
LT	: Leaching Test
ST	: Solubilization Test
HW	: Hazardous Waste
LW	: Liquid Waste
IT	: Intermediate Treatment
SCL	: Strictly Controlled Landfill
CL	: Controlled Landfill
IL	: Inert Landfill

* 1: Except for descarded container of hazardous wastes which shall be treated before disposal and/or recycling.

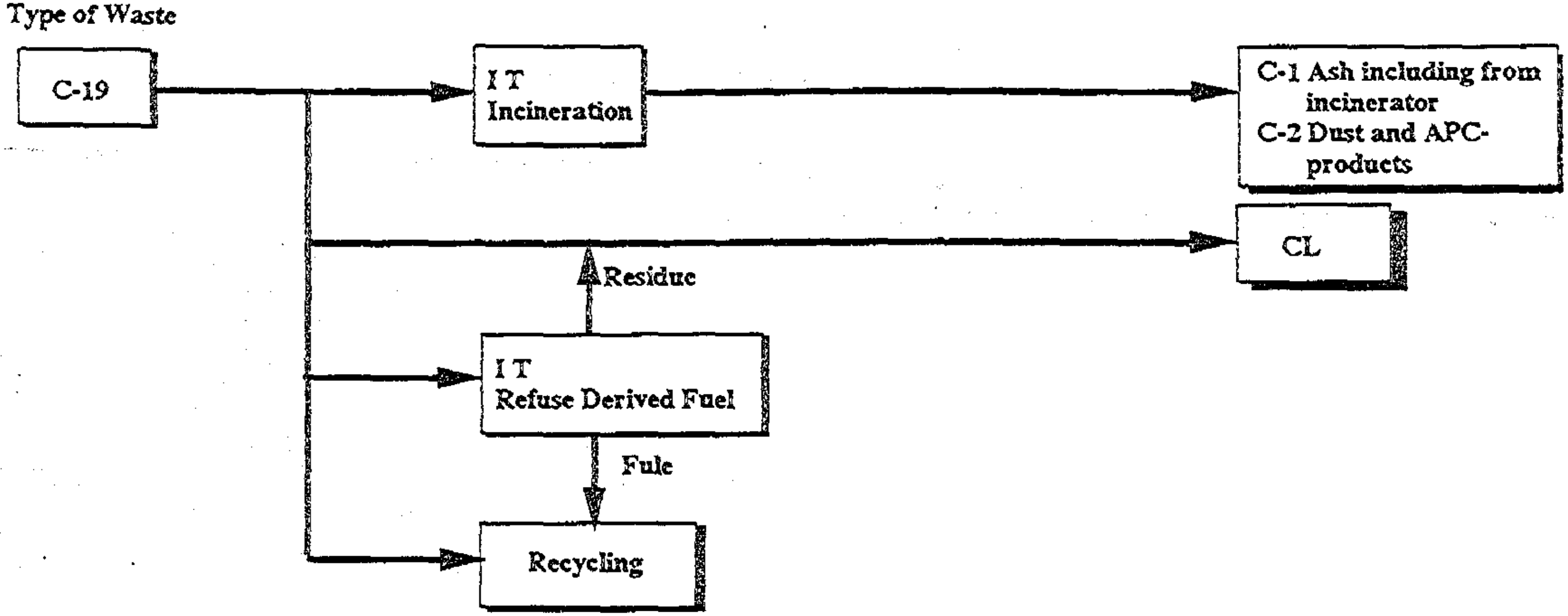
Figure 7.1.1q Appropriate Treatment/Disposal Flow for C-17 (Plastics)



Legend	
WLC	: Waste List Check by Manifest
ICRTT	: Ignitability, Corrosivity, Reactivity and Toxicity Test
LT	: Leaching Test
ST	: Solubilization Test
HW	: Hazardous Waste
LW	: Liquid Waste
IT	: Intermediate Treatment
SCL	: Strictly Controlled Landfill
CL	: Controlled Landfill
IL	: Inert Landfill

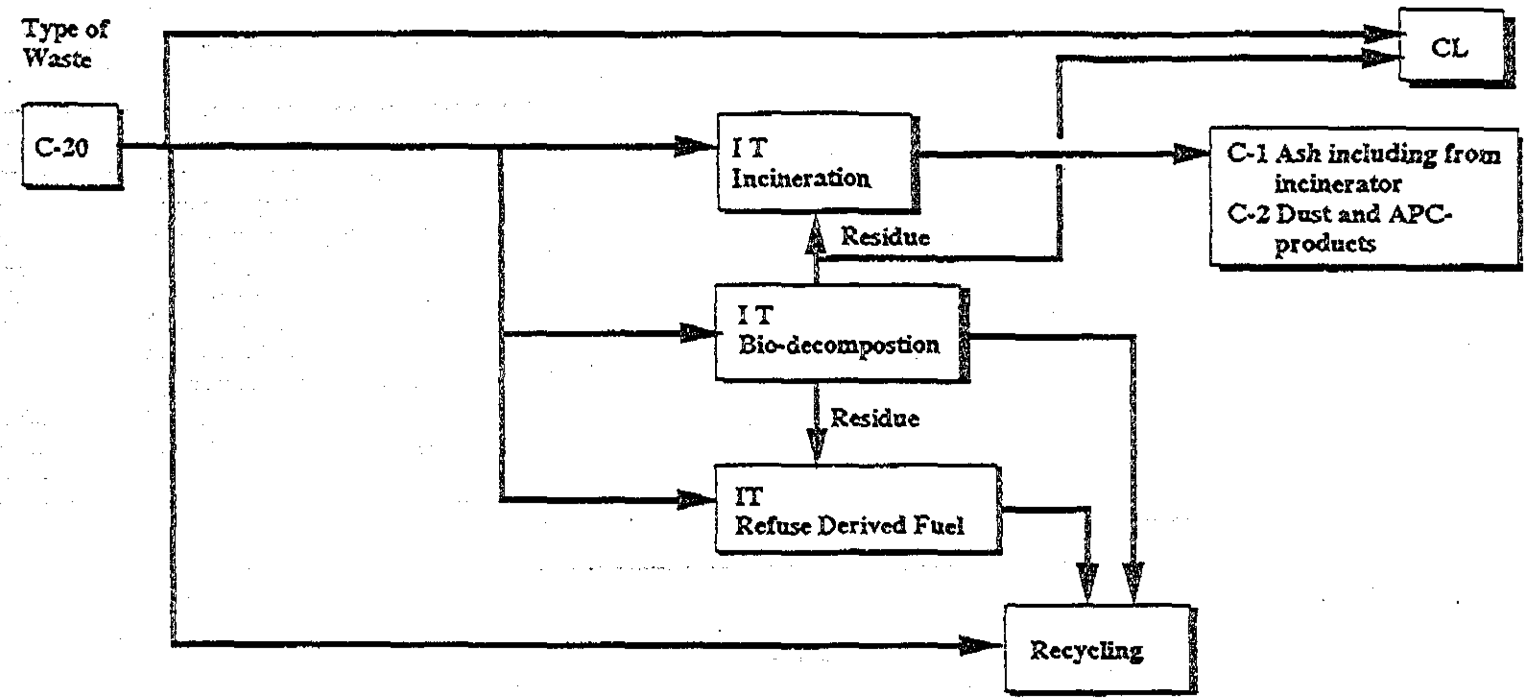
*1: Except for descarded container of hazardous wastes which shall be treated before disposal and/or recycling.

Figure 7.1.1r Appropriate Treatment/Disposal Flow for C-18 (Rubber)



Legend	
WLC	: Waste List Check by Manifest
ICRTT	: Ignitability, Corrosivity, Reactivity and Toxicity Test
LT	: Leaching Test
ST	: Solubilization Test
HW	: Hazardous Waste
LW	: Liquid Waste
IT	: Intermediate Treatment
SCL	: Strictly Controlled Landfill
CL	: Controlled Landfill
IL	: Inert Landfill

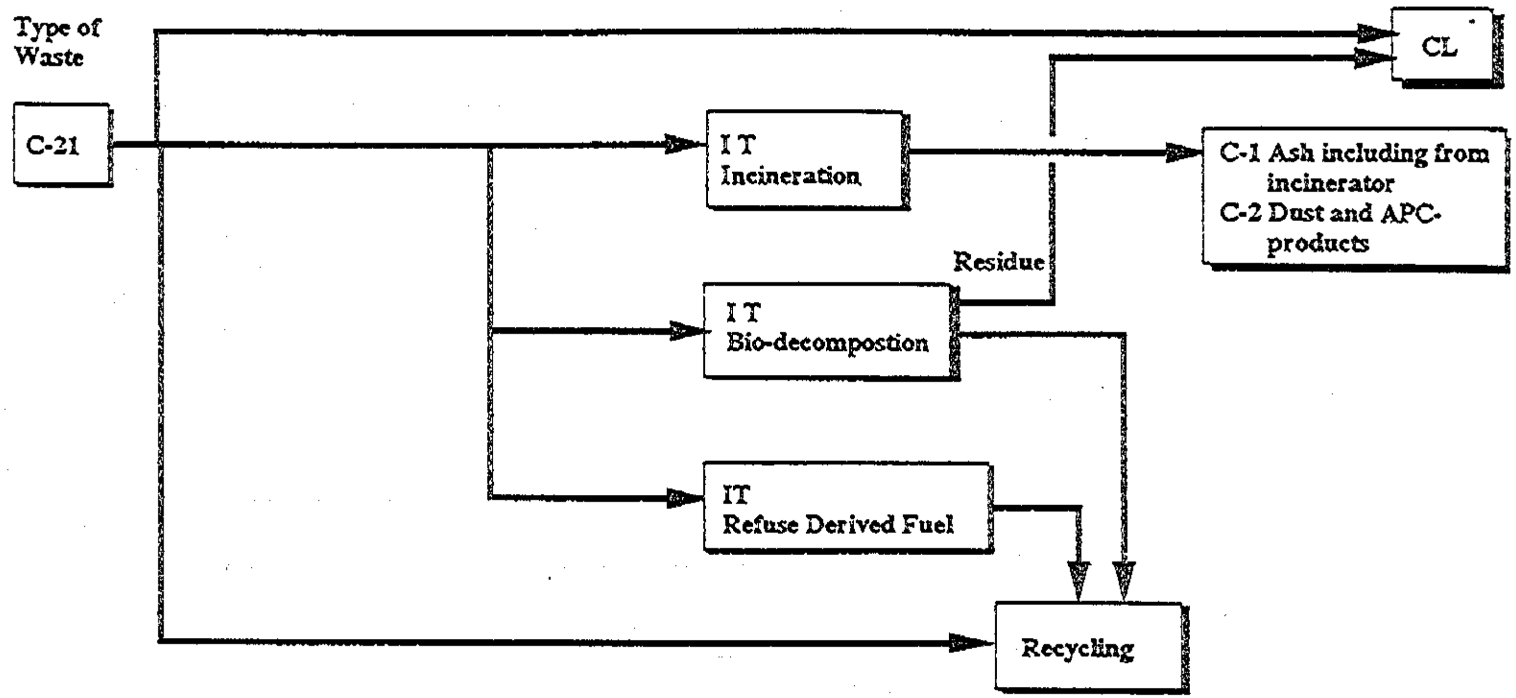
Figure 7.1.1s Appropriate Treatment/Disposal Flow for C-19 (Textile and leather)



Legend

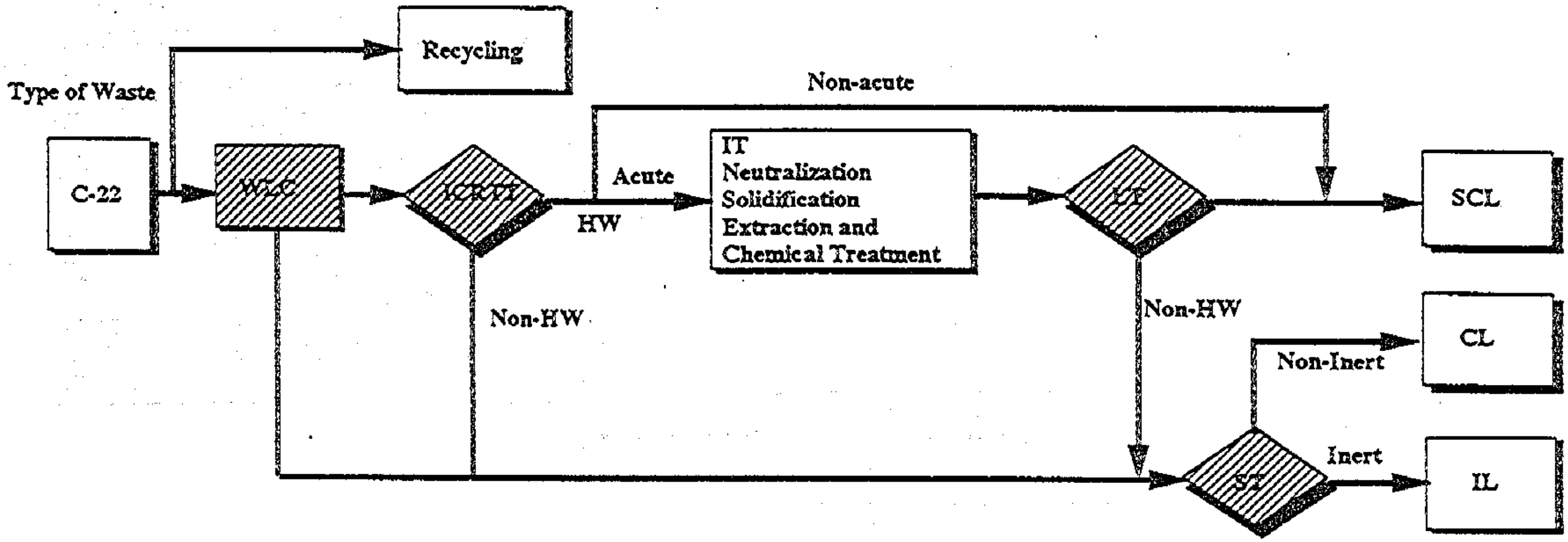
WLC	: Waste List Check by Manifest
ICRTT	: Ignitability, Corrosivity, Reactivity and Toxicity Test
LT	: Leaching Test
ST	: Solubilization Test
HW	: Hazardous Waste
LW	: Liquid Waste
IT	: Intermediate Treatment
SCL	: Strictly Controlled Landfill
CL	: Controlled Landfill
IL	: Inert Landfill

Figure 7.1.1t Appropriate Treatment/Disposal Flow for C-20 (Waste similar to domestic waste)



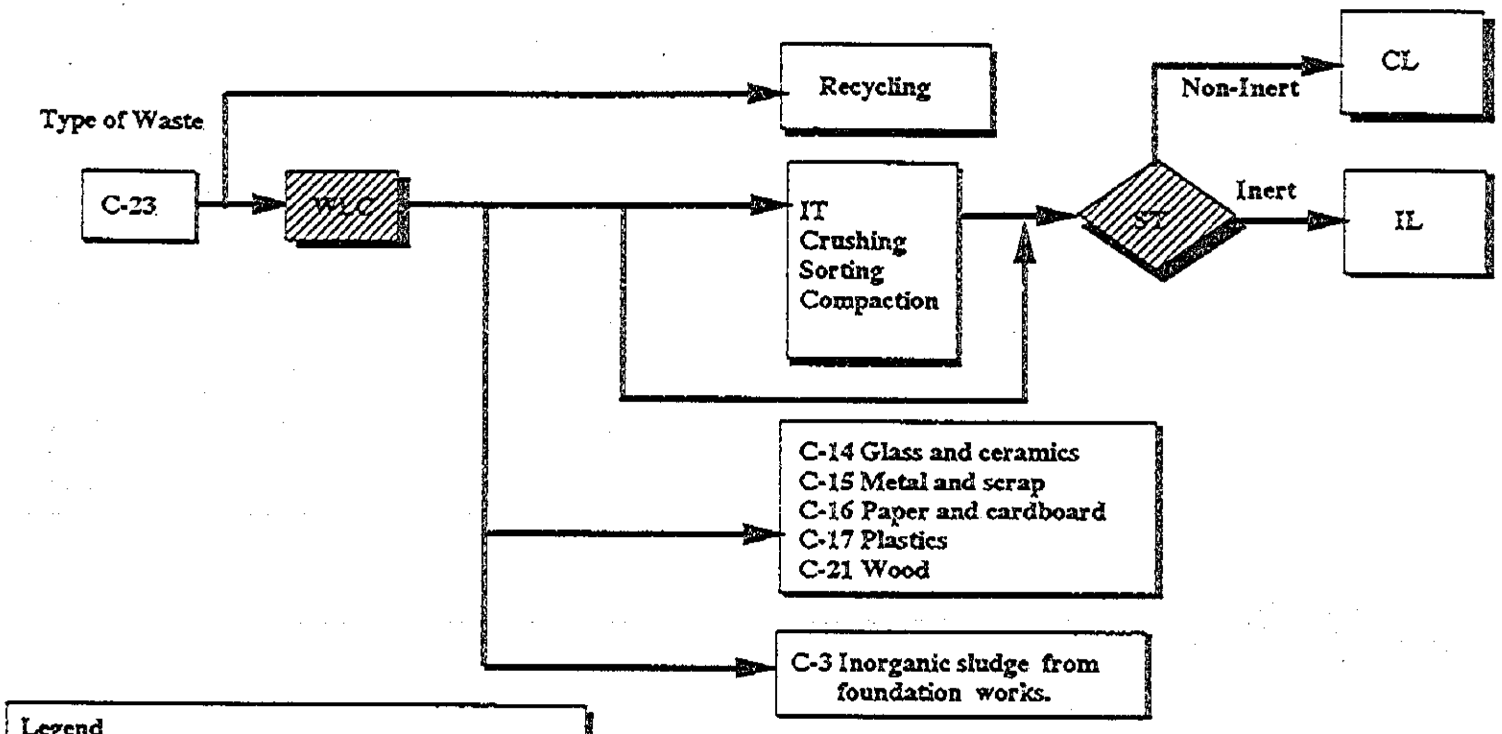
Legend	
WLC	: Waste List Check by Manifest
ICRTT	: Ignitability, Corrosivity, Reactivity and Toxicity Test
LT	: Leaching Test
ST	: Solubilization Test
HW	: Hazardous Waste
LW	: Liquid Waste
IT	: Intermediate Treatment
SCL	: Strictly Controlled Landfill
CL	: Controlled Landfill
IL	: Inert Landfill

Figure 7.1.1u Appropriate Treatment/Disposal Flow for C-21 (Wood)



Legend	
WLC	: Waste List Check by Manifest
ICRTT	: Ignitability, Corrosivity, Reactivity and Toxicity Test
LT	: Leaching Test
ST	: Solubilization Test
HW	: Hazardous Waste
LW	: Liquid Waste
IT	: Intermediate Treatment
SCL	: Strictly Controlled Landfill
CL	: Controlled Landfill
IL	: Inert Landfill

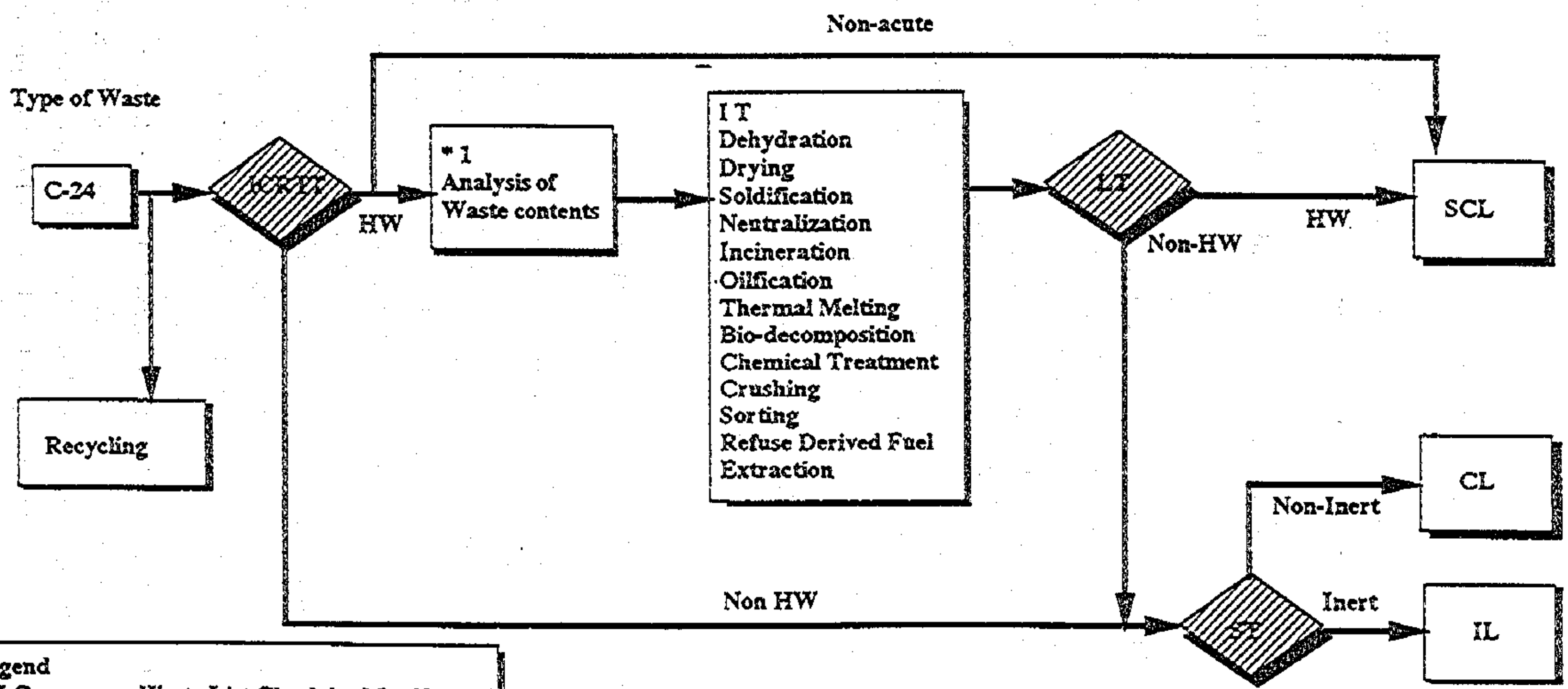
Figure 7.1.1v Appropriate Treatment/Disposal Flow for C-22 (Slag from melting)



Legend

WLC	: Waste List Check by Manifest
ICRTT	: Ignitability, Corrosivity, Reactivity and Toxicity Test
LT	: Leaching Test
ST	: Solubilization Test
HW	: Hazardous Waste
LW	: Liquid Waste
IT	: Intermediate Treatment
SCL	: Strictly Controlled Landfill
CL	: Controlled Landfill
IL	: Inert Landfill

Figure 7.1.1w Appropriate Treatment/Disposal Flow for C-23 (Construction Waste)



Legend	
WLC	: Waste List Check by Manifest
ICRTT	: Ignitability, Corrosivity, Reactivity and Toxicity Test
LT	: Leaching Test
ST	: Solubilization Test
HW	: Hazardous Waste
LW	: Liquid Waste
IT	: Intermediate Treatment
SCL	: Strictly Controlled Landfill
CL	: Controlled Landfill
IL	: Inert Landfill

* 1: The discharger and/or treatment plant need to analyze waste quality including ignitability, corrosivity, reactivity, toxicity characteristic (TCLP).

Figure 7.1.1x Appropriate Treatment/Disposal Flow for C-24 (Other solid waste)

K.1.2 ISWM by Generators (In-Factory)

a. Major Issues on Generator's ISWM in MR

Based on the results of the surveys relating to this Study, fundamental issues of ISWM at waste generators can be focused on the following points.

aa. Dissemination of Proper Knowledge on ISW and Increasing Public Awareness on ISWM

According to a result of the Team's factory survey, although about 80% of the 199 generators surveyed answered that they have designated personnel in charge of waste management, the characteristics of the factory's waste generation is not clearly identified and knowledge about proper ISW treatment and disposal is also insufficient. As a result, inappropriate management of ISW is continuously carried out by waste generators, e.g. discharge of the waste water contaminated by hazardous substances directly to the sewer and/or watercourse and disposal of hazardous ISW to municipal landfills. Most of these cases occurred because of the lack of knowledge.

Accordingly, to realize proper ISWM at waste generation source, dissemination of accurate knowledge on ISW itself and its handling technologies to the waste generators should be given a first priority.

ab. Issues on In-factory Flue Gas and Waste Water Treatment

Another important implication of the Team's survey result is that majority of the surveyed factories that have heat charging and/or watering processes are not equipped with flue gas and/or waste water treatment facilities (84% and 62% respectively), and consequently a considerable amount of dust and APC products and sludge are directly emitted to the environment (sewer, watercourse or atmosphere). Since some of those factories use the raw materials such as heavy metals, solvents, pigment, etc., hazardous materials may have already been discharged into water courses and rivers. Considering such possibility of pollution, remedial actions against flue gas and waste water are to be identified as the top priority of environmental management for most of factories.

Moreover, if flue gas and waste water treatment are carried out by using the end-of-pipe technologies, a large amount of dust and sludge will be captured and generated in factories. Proper treatment and disposal of these additional wastes is another problem for waste generators in the future, especially a burden of cost for proper treatment/disposal.

b. 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.

c. 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. Detailed waste audit manual is published by the UNEP/UNIDO Audit and Reduction Manual for Industrial Emissions and Wastes, which may be useful if a waste audit is conducted by the factory itself or by a third party.

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.

d. Possible Areas of Waste Minimization

Possible areas of waste minimization varies with type of industries, applied production processes, use of raw materials, energy input processes, operational conditions associated with industrial process, etc.. Each factory should find the areas of waste minimization by clearly identifying the production process associated with waste generation on the basis of examining the material balance. However, to provide a basic idea, the Study makes a brief explanation regarding the possible areas of waste minimization in accordance with the basic process of industrial production, which is mainly divided into raw material procurement and production phases.

da. Possible Areas of Waste Minimization in Raw Material Procurement Phase

Possible areas of waste minimization in this phase are:

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

daa. Use of Recycled or Wasted Materials

The use of recycled or wasted resources as raw material is an important option for reducing the wastes to be otherwise generated by extracting new raw materials for industrial production. Table K.1.2a showed the examples of the use of recycled or wasted resources presently carried out in Japan.

Table K.1.2a Examples of the Use of Recycled or Disposed Resources

Type of industry	Examples
Paper and pulp industry	- Development of the concrete mold to be partly made from used papers - Development of reinforcers of the used paper's fibre for promoting its use as printed materials - Use of wood wastes generated by thinning of forest as raw materials - Increasing the use of recycled papers as raw materials of pulp mold, insulating materials, etc.
Chemical industry	- Development of bio-cellulose by utilizing the living organ's function of producing fibers - Increasing the use of recycled plastics
Cement industry	- Development of eco-cement to be made from MSW incineration ashes, sludge from waste water treatment - Increasing the use of the mixed cement with fly ash, slags from shaft furnaces, etc.
Automobile, household electric appliances, electronical and office equipment industry	- Increasing the use of recycled plastics

Source: Report of sub-committee for global environment, Committee for industrial structure, MITI, 1994.

In addition to the development of recycled products and its use, it is also necessary to develop technologies of removing impurities from the wastes as well as from recycled materials for upgrading the quality of products. Sorting and pre-treatment of wastes may be necessary to increase the use of recycled products. Some of such technologies are also developed in Japan as mentioned in Table K.1.2b below.

Table K.1.2b Areas of Technology Development for Removing the Impurities from the Wastes

Type of technology	Examples
Waste sorting and pre-treatment technologies	- Discrimination technology of impurities from scrapped iron with applied infrared rays (iron & steel industry) - High efficiency sorting and discrimination technology of aluminum scrap with the applied electromagnetic wave or magnet (aluminum industry) - Sorting of plastics and its types by applied spectrum analysis technology (chemical industry) - Technology of sorting crushed waste concrete in accordance with types of appropriate use as raw materials such as for concrete aggregates, cement, mixed cement, etc. (cement industry) - High efficiency waste dehydration and handling technology (cement industry)
Impurities removing technology	- *Removing impurities from scrapped iron, aluminum, copper,* lead, zinc by utilizing difference in melting points (iron & steel, aluminum, non-ferrous metal industries) - Removing impurities such as surface paints from scrapped iron, aluminum, and plastic wastes with low temperature crushing (iron & steel, aluminum, and automobile industries) - Removing hazardous substances such as chlorine from wastes (cement industry) - Zinc dissolution and collection technology from surface coated steel plates.

Source: Report of sub-committee for global environment, Committee for industrial structure, MITI, 1994.

dab. Fuel Substitution

To minimize the generation of air pollution substances during fuel combustion, low pollutant emission energy is needed to be preferred as energy sources in factories. The reduction of air pollutant also decreases the generation amount of dust and APC products. However, energy security is another important view to be taken into account in selecting the best available energy resources. The following options of fuel substitution may be considered as waste minimization measures.

- increasing the use of LNG (Liquefied Natural Gas) and LPG (Liquefied Petroleum Gas) as an energy source
- use of waste materials as fuels (waste tires, etc.)
- use of renewable energies (photovoltaic, solar heat, wind power, hydropower, geothermal power, etc)

db. 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 the 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

dba. Energy Saving

Energy saving measures are mainly divided into two types, namely improvement of production process for energy saving and introduction of unutilized energy and waste heat utilization system.

i. Improvement of production process for energy saving

Minimization of energy consumption in production process can be principally conducted by the following type of process improvement :

- Simplification and/or efficiency improvement of production process;
- Strict energy consumption control and management; and
- Introduction of high efficiency production facilities and/or equipment.

The examples of the above measures are shown for some types of industries in Table K.1.2c below.

Table K.1.2c Examples of Improving Production Process for Energy Saving

Type of industry	Examples
Chemical industry	- Introduction of polyolefin production by gas phase polymerization methods - Introduction of high efficiency production facilities such as high efficiency compressors to ethylene plant.
Cement industry	- Introduction of high efficiency production facilities such as high efficiency kiln burners, etc.
Iron & steel industry	- Introduction of high efficiency production facilities such as high efficiency coke furnaces with low temperature, etc.
Aluminum industry	- Development of high efficiency production technologies, e.g. high efficiency dissolution, continuous casting, direct rolling, etc.
Synthetic fibre industry	- Development of one-step production process technologies which omits thread spinning process. - Development of technologies which enables low temperature dyeing of polyester thread.
Automobile industry	- Inverter control of heavy electrical machinery and equipment
Oil refinery	- Development of oil refining technologies with high quality catalyzer.

ii. Introduction of unutilized energy and waste heat utilization system

Examples of waste heat and unutilized energy using technologies to be introduced to the factories are as shown in Table K.1.2d below.

Table K.1.2d Examples of Waste Heat and Unutilized Energy Use Technologies

Type of industry	Possible technologies to be introduced
Aluminum, automobile, household electrical appliance, and oil products industries	- Introduction of co-generation system, heat pomp system, and waste heat boilers
Iron & steel, aluminum, and chemical industries	- Collection technologies of medium and low temperature energy (heat)

dbb. Improvement of Production Process for Raw Materials Saving

Examples are very limited, but the following improvement methods are considered regarding this type.

- Development of ink-jet*1 dyeing technology for saving dye (synthetic fibre industry)
- Development of no sizing yarn*2 which saves the use of starch. (synthetic fibre industry)
- Development of high efficiency coating (painting) technology to save paints

(automobile industry)

*1: ink-jet dyeing
It is an innovative dyeing technology presently being developed in Japan to increase efficiency in the use of dye. The ink-jet is a method of high speed printing technologies with which ink is sprayed on paper with static electricity. This technology is widely used for printers. Japanese dyeing industry is presently examining the application of this technology for dyeing.

*2: no sizing yarn
As the sludge generated from sizing process is the biggest source of industrial waste in dyeing industry, Japanese industries are presently developing the so-called no sizing yarn which can be wove into cloth without any size.

dbc. Reutilization of Materials Generated in Production Process

Reutilization of materials generated in production process do not have to be limited to inside factories, but should be expanded to outside factories by inter-sectoral cooperation in this field. The relevant methods and technologies here are categorized into the following types:

- in-factory (in-process) recycling,
- development of recycling and reutilization technologies inside production process, and
- expanding the use of recycled products outside factories.

i. In-factory (in-process) recycling

In-factory recycling implies the reuse of the generated materials inside its own production process or other activities inside factories. Thermal recycling of generated materials by combustion is also included in this type. Examples of in-factory recycling is given in Table K.1.2e.

Table K.1.2e Examples of In-factory Recycling

Type of industry	Examples
Aluminum industry	- Reutilization of waste acid, alkali, aluminum hydroxide sludge, etc.
Synthetic fibre industry	- Reutilization and thermal recycling of fibre wastes
Oil products industry	- Reutilization of waste catalyst - Reutilization of waste oil
Automobile industry	- Thermal recycling of waste oil
Household electrical appliance industry	- Recycling and reutilization of plastic wastes

ii. Development of recycling and reutilization technologies inside production process

To promote in-factory recycling and reuse, efficient collection and recycling technologies are needed to be developed. Such technologies include:

- high efficiency collection and recycling technologies of waste oil
- development of collecting recyclable material from aluminum *hydroxide sludge*
- recycling of waste sand from foundries
- collection of raw materials for polyester that are eluted from the production process of synthetic fibers

iii. Expanding the use of recycled products outside factories

Some of the generated materials in production process may be more useful in other industries. Wider use of generated materials increases the possibility of more waste minimization. The industrial wastes which may be utilized for other industries include, for example :

- sulfur and sulfuric acid generated from non-ferrous metal and oil products industries
- copper slag generated from non-ferrous metal industry
- steel slags generated from iron & steel industry
- sludge, incineration ashes, and dust generated from synthetic fibre industry

dbd. Improving Production Process for Reduction of Wastes and Pollutant Emission

In the case of factories in MR, the first priority is to be given to the reduction of air and water pollutant although it causes the increase of ISW generation and may cost much. Therefore, the facilities and equipment that capture these pollution substances should be installed for the existing factories as soon as possible. In the longer term, however, more efficient methods of reducing wastes and pollutant emission is to be applied, which is generally called Cleaner Production Technology (CPT). Especially, regarding the reduction of waste water discharge, application of the Closed Water Use System may be subject to the examination in the future.

dbe. Reducing the Use of Hazardous Materials

Reducing the use of hazardous materials is one of the important issues to be widely examined by all factories. Examples of such efforts are given in Table K.1.2f below.

Table K.1.2f Examples of Reducing the Use of Hazardous Materials

Type of industry	Examples
Aluminum & automobile industry	- Reducing the use of organic solvents by increasing the coating (painting) efficiency or conversion to water-paint.
Household electrical appliance industry	- Use of pre-coated metal to omit coating from production process
Paper & pulp industry	- Technology development for totally abolishing the use of chloride in paper bleaching process.

dbf. Research and Development of Innovative Environmentally Friendly Production Process

The last and the most important technologies to be developed in the future is, as mentioned above, advanced CPT (newly developed and developing CPT), which innovatively convert production processes into environmentally friendly one. Such technologies presently developed and researched for application in Japan are indicated in Table K.1.2g on next page.

Table K.1.2g CPT Presently Developed in Japan

Type of industry	CPT to be presently developed
Cement industry	- Fluidized bed kiln Different from conventional rotary kilns, by increasing the efficiency of chemical reaction with fluidized bed combustion furnace, high rate energy saving and Nox emission reduction is to be achieved.
Non-metal smelting industry	- New metal production technologies Primary smelting is to be carried out at mining point by applying photovoltaic energy, bacteria, or new solvents. High rate of energy saving and Sox reduction is to be achieved.
Chemical and oil products industry	- Bio-reactor technologies Instead of the conventional refining process for producing naphtha or other basic petrochemical raw materials with high temperature and pressured pyrolysis, refining is to be done by using bio-rection with low temperature and pressure. High rate of energy and material saving will be achieved.
All kinds of assempling industries	- Eco-factory technology By combining the the assembling technologies which enable easy dismantling when disposed and automatic dismantling system, disposed products can be recycled at its maximum by easily returning to the parts and materials.

e. Implementation Plan of In-Factory ISWM and Waste Minimization

In-factory 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 here the implementation plan by setting up the common goals and targets to be achieved by ISW generator up to 2010.

ea. Goals

The proposed goals of in-factory ISWM waste minimization in 2010 are:

- To realize proper in-factory 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 CPT into the production system.
- To reduce the use of hazardous materials that may generate hazardous ISW by the generator's continuous efforts of technology development.

eb. 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 K.1.2h below.

Table K.1.2h Generator's Targets of In-factory 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 examined 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 (in-process) recycling - Conventional in-factory recycling methods are examined for application. 7. Reducing the use of hazardous materials - The existing methods 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.

ee. Necessary policy measures for target compliance

Policy measures to be needed for complying with the above targets are specified in Table 6.2.3a of Section 6.2.3 of the main text describing prerequisite for establishment of on-site ISWM in the main text. Some of 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.)
- Providing incentives to the factories of applying environmentally friendly technologies (awards, labeling of environmentally friendly products, etc.)

K.1.3 Conventional Intermediate Treatment in Japan

a. Introduction

The basic principle of solid waste management (SWM) is: *"not discharge waste"*. Where discharge of waste is inevitable, maximum efforts to re-utilize such waste as resource is indispensable. This sort of concept for SWM is now quite common in many industrialized countries. However, "mass-production, mass-consumption and mass-disposal" was prevalent at one time in most industrialized countries. Therefore the least-cost and easiest-at-hand disposal alternative (i.e. landfill disposal) was widely employed.

In Japan as well, when rapid industrialization was promoted in 1960's and 70's, in order to dispose of huge amount of solid waste at lesser cost, landfill disposal at sand/gravel extraction pits, river bed and sea coast was widely employed. However, this kind of easy-at-hand and disorganized landfill disposal affected serious adverse impact on surrounding environment. Consequently it drew attention as social problem and siting of new disposal landfills faced difficulties. (e.g. Tokyo garbage war, disposal of Cr^{+6}.) Furthermore, rapid growth of urbanization gradually forced siting of landfill sites at farther and farther locations.

Currently in Japan, maxim effort is made at intermediate treatment (treatment and resource recovery) in order to maximize resource recovery and consequently to reduce the amount to be finally disposed of. It becomes common in Japan that unavoidable industrial solid waste (i.e. residues from intermediate treatment facilities) is disposed of at final disposal sites more than 1,000 km far away (from primary waste generators). In this connection, cost of final disposal only (except cost of collection, transport, intermediate treatment) counts for US$ 50 to 500 per tonne in today's Japan.

It seems that SWM in industrialized countries, more or less, share this sort of severe situation of bearing such high cost. Facing the situation, intermediate treatment (treatment and resource recovery) technology has been developed in order to treat solid waste for:

- recovering (re-utilizing) resource,
- minimizing waste, and
- stabilizing and making the waste non-hazardous.

b. Outline of Intermediate Treatment Technologies

Intermediate treatment (treatment and resource recovery) technologies have diversified in its sources and applications. Classification of those technologies might be proposed from various approaches. On this occasion, in relation to the above 3 objectives, intermediate treatment technologies are listed in the Table K.1.3a. Outline of respective technologies, with their objectives, methods, facilities in operation, and representative waste to be treated are shown in Table k.1.3b.

Table K.1.3a Intermediate Treatment Technologies and their Objectives

Objectives / Name of Technology		Resource Recovery	Waste Reduction	Waste Stabilization
1.	Dehydration	X	O	X
2.	Drying	X	O	X
3.	Solidification	X	X	O
4.	Neutralization	X	O	O
5.	Incineration	O	O	O
6.	Oilification	O	O	O
7.	Thermal Melting	?	O	O
8.	Bio-decomposition	O	O	O
9.	Extraction & Chemical Treatment	?	O	O
10.	Crushing	?	O	X
11.	Sorting	O	O	X
12.	Compaction	X	O	X
13.	Refuse Derived Fuel	O	O	O

Note: O; The technology is intended for and realize the objective. However, the degree of accomplishment on the objective differs from each technology.

?; The accomplishment of the objective by this technology is not sure, i.e. as for thermal melting, slag by thermal melting can be used as construction aggregates. For extraction and chemical treatment, some of technologies aim at and realize but some do not.

X; The technology is neither intended for nor realize the objective

Table K.1.3b Intermediate Treatment Technology (Objectives, Methods, Facilities and Representative Waste to be Treated)

Name of Technology	Objectives	Methods	Facilities in Operation	Representative Waste
1. Dehydration	Volume reduction of liquid wastes	- Mechanical - Gravity	Sludge dehydration facility	Liquid waste, sludge
2. Drying	Volume reduction of sludge	- Solar evaporation - Mechanical	Sludge drying facility	Sludge
3. Solidification	Prevention of elution of hazardous materials	- with cement - with glass	Cement solidification facility	Asbestos, etc.
4. Neutralization	Neutralization of acid and alkali wastes	- mixing and agitation	Waste acid and alkali neutralization facility	Waste acid, Waste alkali
5. Incineration	Wastes reduction, stabilization (to be inert) & heat recovery	Mechanical type - stoker - rotary kiln Fluidized bed type	Solid wastes incinerator Liquid wastes incinerator	Various HW
6. Oilification	Reutilization of polymer wastes and oily wastes	For polymer wastes - under normal pressure - under high pressure For oily wastes - gravity type - mechanical type	Waste plastic oilification facility Oil separator Waste oil refining facility	Oily waste, etc.
7. Thermal Melting	Wastes reduction, stabilization (to non-hazardous) & reutilization of slag	- Electric melting furnace - Plasma melting furnace - Burner melting furnace - Cokes bed furnace	Ash & APC product melting facility Asbestos melting facility Sludge melting facility	Ash, dust, etc.
8. Bio-decomposition	Recovery, reduction and stabilization of organic wastes	- Aerobic decomposition - Anaerobic decomposition - Composting	Biogas facility Compost facility	Organic waste e.g. animal excreta, night-soil, etc.
9. Extraction & Chemical Treatment	Reutilization and stabilization of hazardous waste (mainly heavy metals)	Dry method - Roasting - Deoxidization - Volatilization Wet method - Dissolution & coagulation - Ion-exchange - Solvent extraction - Electrolysis	Roasting facility for mercury containing wastes Deoxidization facility for Cr^{+6} containing wastes Organic solvents treatment facility Chemical coagulation facility Ion-exchange treatment facility	Chemical residues, etc.
10. Crushing	Pretreatment and volume reduction of wastes	Compression type Shear crushing type Shear shredding type	Bulky wastes treatment facility Pretreatment facility for the other treatment facility	Bulky waste
11. Sorting	Recovery of reusable materials	Mechanical sorting - gravity separation (vibrating, wind power) - magnetic separation - eddy current separator - electrostatic separator - water or heavy liquid separator - optical separator Manual sorting	Glass cullet sorting facility Ferrous and non-ferrous metal sorting facility Plastics sorting facility	Recyclable materials
12. Compaction	Waste volume reduction	Press compaction	Compaction facility for metals, plastics and papers	metal, plastic, paper, etc.
13. Refuse Derived Fuel (RDF)	Energy recovery from combustible wastes	Fluff-RDF Dust-RDF Densified-RDF Wet-RDF	RDF facility for papers, plastics rubbers, textiles, woods and domestic wastes	Combustible wastes

c. Conventional Intermediate Treatment in Japan

According to the ISWA's "Times" (1995, No.1), the typical treatment charges of hazardous wastes in Europe and the United States vary between US$ 100 - 2,000 per tonne, depending both on the type of waste and on national charging policy.

In Japan, charges seem to be more than these figures. Therefore each factory (who is polluter) makes best efforts to minimize waste generation by employing the concept of **Cleaner Production (CP)**, especially hazards waste generation is strictly controlled and minimized by CP. Furthermore, unavoidable SW generated shall be subject to on-site treatment in order to reduce waste disposal cost. Consequently, as shown in Table K.1.3c, 72% of ISW treatment facilities registered in Japan are owned by factories themselves.

Here on this occasion, various treatment and resource recovery technologies are explained. The most important measure of ISWM is measures employed at generation sources.

That is:

- Production process should be such that avoids generation of waste as much as possible (cleaner production), and
- Where unavoidable waste generation takes place, such waste should be recycled and stabilized.

Experiences in Japan persuadably tell that investment in environmental protection facilities in order not to produce waste (especially hazardous) is much cheaper than compensation costs and environmental restoration costs after occurrence of environmental destruction by waste, e.g. compensation for Minamata disease.

Under the current circumstances in Chile (MR), rapid and effective coverage of intermediate treatment facilities appears to be very difficult to reach. In such cases, samely as practiced in Japan 20-30 years ago, controlled landfill disposal might be popular manner in ISW disposal. It is commonly acknowledged that proper and controlled landfill is recognized solution for ISW disposal and cheaper method where appropriate site for landfill is available.

Uncontrolled and disorganized landfills once Japan experienced must be avoided. It is expected that disposal of ISW in Chile should be secured in well-controlled and organized landfill sites.

Table K.1.3c Types and Number of Industrial Waste Treatment Facilities in Japan (April 1992)

Facility Type (Capacity)	Total Number	Ownership		
		Factory	SWM Enterprise	Public Body
1. Sludge dehydration facilities (10 m^3/day or larger)	6,109	4,910	375	824
2. Sludge drying facilities (mechanical type) (10 m^3/day or larger)	221	111	57	53
3. Sludge drying facilities (solar evaporation) (100 m^3/day or larger)	86	26	12	48
4. Sludge incineration facilities (5 m^3/day or larger)	570	330	146	94
5. Oil separation facilities (10 m^3/day or larger)	280	141	137	2
6. Waste oil incineration facilities (1 m^3/day or larger)	527	298	227	2
7. Waste acid and alkali neutralization facilities (50 m^3/day or larger)	248	217	31	0
8. Waste plastic crushing facilities (5 ton/day or larger)	244	62	175	7
9. Waste plastic incineration facilities (0.1 ton/day or larger)	1,804	1,154	631	19
10. Cement solidification facilities (Any capacity)	69	19	47	3
11. Roasting facilities for mercury containing wastes (Any capacity)	2	0	2	0
12. Cyanide decomposition facilities (Any capacity)	280	226	44	10
Total	10,440 (100%)	7,494 (72%)	1,884 (18%)	1,062 (10%)

Source: Ministry of Health and Welfare in Japan

Note: A permit must be obtained for construction of facilities that have capacities specified in parentheses in Japan.

K.2 Examination of Technical Standard

K.2.1 Outline of Contents for Technical Standards

a. 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 Development and Rebuilding (Department of Commercial and Industrial Policy) and CONAMA. Although the manual seems insufficient to be employed as technical standards of individual technical systems (technical standards for e.g. incineration facilities, final disposal facilities, etc.), it could serve as basis for the standards compilation work. Other standards (such as those in USA, Brazil) should be referred 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.

b. Outline of Contents of Each Technical Standard

ba. Standards Applicable to Generators of HW

i. General
   - Purpose, scope, and applicability
   - Hazardous waste determination

ii. The manifest
- General requirements
- Acquisition of manifests
- Number of copies
- Use of the manifest

iii. Pre-transport requirements
- Packaging
- Labeling
- Marking
- Placarding
- Accumulation time

iv. Recordkeeping and reporting
- Recordkeeping
- Exception reporting
- Additional reporting

v. Exports of HW
- Applicability
- Definitions
- General requirements
- Notification of intent to export
- Special manifest requirements
- Exception reports
- Annual reports
- Recordkeeping

bb. Standards Applicable to Transporters of HW

i. General
- Scope
- Transfer facility requirements

ii. Compliance with the manifest system and recordkeeping
- The manifest system
- Compliance with the manifest
- Recordkeeping

iii. HW discharges
- Immediate action

- Discharge clean up

bc. Standards for Owners and Operators of HW Treatment, Storage and Disposal Facilities

i. General
  - Purpose, scope and applicability
  - Imminent hazard action

ii. General facility standards
  - Applicability
  - Required notices
  - General waste analysis
  - Security
  - General inspection requirements
  - Personnel training
  - General requirements for ignitable, reactive or incompatible wastes
  - Location standards
  - Construction quality assurance program

iii. Preparedness and prevention
  - Applicability
  - Design and operation of facility
  - Required equipment
  - Testing and maintenance of equipment
  - Access to communications or alarm system
  - Required aisle space
  - Arrangements with local authorities

iv. Contingency plan and emergency procedures
  - Applicability
  - Purpose and implementation of contingency plan
  - Content of contingency plan
  - Copies of contingency plan
  - Amendment of contingency plan
  - Emergency coordinator
  - Emergency procedures

v. Manifest system, recordkeeping and reporting
  - Applicability
  - Use of manifest system

- Manifest discrepancies
- Operating record
- Availability, retention and disposition of records
- Unmanifested waste report

vi. Releases from solid waste management units
- Applicability
- Required programs
- Ground-water protection standard
- Hazardous constituents
- Concentration limits
- Point of compliance
- Compliance period
- General ground-water monitoring requirements
- Monitoring program

vii. Closure and post-closure
- Applicability
- Closure performance standard
- Closure plan; amendment of plan
- Closure; time allowed for closure
- Disposal or decontamination of equipment, structures and soils
- Certification of closure
- Survey map
- Post-closure care and use of property
- Post-closure plan; amendment of plan
- Post-closure notices
- Certification of completion of post-closure care

viii. Financial requirements
- Applicability
- Cost estimate for closure
- Financial assurance for closure
- Cost estimate for post-closure care
- Financial assurance for post-closure care
- Use of a mechanism for financial assurance of both closure and post-closure care
- Liability requirements
- Incapacity of owners or operators, guarantors, or financial institutions

ix. Use and management of containers

- Applicability
- Condition of containers
- Compatibility of waste with containers
- Management of containers
- Inspections
- Containment
- Special requirements for ignitable or reactive waste
- Special requirements of incompatible wastes
- Closure

x. Tank-systems

- Applicability
- Assessment of existing tank system's integrity
- Design and installation of new tank systems or components
- Containment and detection of releases
- General operating requirements
- Inspections
- Response to leaks or spills and disposition of leaking or unfit-for-use tank systems
- Closure and post-closure care
- Special requirements for ignitable or reactive wastes
- Special requirements for incompatible wastes

xi. Landfills

- Applicability
- Design and operating requirements
- Action leakage rate
- Monitoring and inspection
- Response actions
- Surveying and recordkeeping
- Closure and post-closure care
- Special requirements for ignitable or reactive waste
- Special requirements for incompatible wastes
- Special requirements for bulk and containerized liquids
- Special requirements for containers

xii. Incinerators

- Applicability
- Waste analysis
- Principal organic hazardous constituents

- Performance standards
- Hazardous waste incinerator permits.
- Operating requirements
- Monitoring and inspections
- Closure

xiii. Air emission standards
- Applicability
- Definitions
- Standards
- Test methods and procedures
- Recordkeeping requirements
- Reporting requirements

bd. Land Disposal Restrictions

i. General
- Purpose, scope and applicability
- Definitions applicable in this part
- Dilution prohibited as a substitute for treatment
- Treatment surface impoundment exemption
- Petitions to allow land disposal of a waste prohibited
- Waste analysis and recordkeeping

ii. Prohibitions on land disposal

iii. Treatment standards
- Applicability of treatment standards

vi. Prohibitions on storage

be. Guidelines for the Thermal Processing of Solid Wastes

i. General provisions
- Scope
- Definitions

ii. Requirements and recommended procedures
- Solid wastes accepted
- Solid wastes excluded
- Site selection

- General design
- Water quality
- Air quality
- Vectors
- Aesthetics
- Residue
- Safety
- General operations
- Records

bf. Guidelines for the Land Disposal of Solid Wastes

i. General provisions
- Scope
- Definitions

ii. Requirements and recommended procedures
- Solid wastes accepted
- Solid wastes excluded
- Site selection
- Design
- Water quality
- Air quality
- Gas control
- Vectors
- Aesthetics
- Cover material
- Compaction

K.2.2 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 as the most crucial and urgent issue to be solved, structures for them are examined below in order to facilitate the establishment of a final disposal facility.

a. Types of Final Disposal Facilities

The principal function required of final disposal facilities for SW is:

- prevention of pollution in adjacent area of final disposal site by disposed SW.

Namely, it comprises:

- the waterproof function to prevent underground water contamination by leachate and disposed SW,
- the prevention of rainwater intrusion into disposal site in order to reduce excessive leachate generation,
- the prevention of outflow, scatter and leap out of disposed of SW, and
- the stability of the disposal site as a civil engineering structure in order to maintain the above functions.

Although use of persistent materials like reinforced concrete for the structure easily ensures those functions in a technical viewpoint, a huge investment incurred in from such structural facilities does not take place even in countries with higher financial capabilities.

Therefore, 3 basic types of final disposal facilities, in accordance with the degree of hazardousness of the SW to be disposed of, are proposed in this Study. These are:

- Strictly Controlled Landfills (SCL),
- Controlled Landfills (CL),and
- Inert Landfills (IL).

Table K.2.2a shows 3 types of landfills and the types of waste to be disposed there.

Table K.2.2a Types of Landfill

Types of Landfill	Types of Waste
Strictly Controlled Landfill (SCL)	Hazardous Waste
Controlled Landfill (CL)	Non-Hazardous, Non-Inert Waste
Inert Landfill (IL)	Inert Waste

b. Leachate

Leachate is the most liable source of pollution from final disposal facilities to adjacent areas and it is derived from:

- rainwater (although ground water intrusion may be a source of leachate generation, the intrusion should be avoided at a sanitary landfill), and
- water content (liquid component) of disposed SW.

The relation of these two components is expressed in the following formula (1) :

$L_0 = Ti - E - aW$ .... formula (1)

L_0	:	Free leachate retained at the site (m^3/year)
Ti	:	Total liquid input (moisture contents of waste plus precipitation plus any surface water inflow) (m^3/year)
E	:	Evapotranspiration losses (evaporation plus minimal transpiration) (m^3/year)
a	:	Absorptive capacity of the waste (m^3/ton)
W	:	Weight of waste deposited (ton/year)

Where water content of SW is very small in general, rainwater is the main source of leachate generation. Therefore, in cases where evapotranspiration exceeds precipitation (i.e. L_0 is negative or equals zero.), excessive leachate (which needs to be discharged from the disposal site) will not appear in the total annual cycle, even though intense temporal rains accelerate the generation of large amounts of leachate.

Thus, leachate generation depends highly upon the climatical conditions of where the final disposal facilities are located.

In Japan it is an obligation for leachate treatment facilities to be installed for all final disposal sites (other than inert landfills), since annual precipitation exceeds 1500 mm in most parts of Japan. Whereas precipitation and evapotranspiration in the MR are shown in the Table K.2.2b.

Table K.2.2b Precipitation and Evapotranspiration in the MR

Item	Northern area in the MR	Southern area in the MR
Annual precipitation	300 (mm)	600 (mm)
Annual evapotranspiration	1,700 to 1,800 (mm)	1,350 to 1,600 (mm)

Although the configuration of a landfill is not clear at this moment, figures in the Table K.2.2b are employed in the formula (1) above to calculate "water balance per unit (m3/year)" based on the assumptions described below. The results of calculation is tabulated in Table K.2.2c.

- Since water content of solid waste buried is not known, it is assumed that the total liquid input (Ti) equals to precipitation.
- The absorptive capacity is neglected in the calculation. Since absorptive capacity of the waste (a) is not known and to disregard this value (a) gives stringent assumption in examination of "water balance".

Table K.2.2c Estimated Amount of Free Leachate Retained in Landfills in the MR

Item	Unit	Northern area in the MR	Southern area in the MR
Ti	m^3/year	0.3	0.6
E	m^3/year	1.7 to 1.8	1.35 to 1.6
L_0	m^3/year	-1.3 to -1.5	- 0.75 to -1.0

Among values of L_0 in the table, -0.75 is shown as the maximum value. It namely means that when the water content of buried SW plus any surface water inflow reaches 0.75 m^3/year, L_0 then becomes zero.

Therefore, it is not necessary for leachate generated at disposal sites be taken outside of the system (site) and treated (except when it rains during rainy season).

In principle, the collection and circulation of leachate accelerates the evaporation of the leachate's water content and it suffices as a treatment method. Whereas excessive leachate generated in rainy season (if any) might be kept in retarding pond and later circulated in the landfill.

Therefore, in the MR it may not be necessary for leachate generated at disposal sites to be discharged outside the system after treatment, if enough storage facilities (pits) for temporary excess leachate are installed. However, in the southern regions in Chile, 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).

c. Waterproof Structure

As mentioned above, leachate is the most likely source of pollution from final disposal facilities to adjacent areas, and that is why a waterproof structure for the disposal facility itself is essential in order to prevent such pollution. Attention should be paid to:

- Water proofing of the bottom and sides of the final disposal facility, especially during the land filling operation; and
- the final covering layer's impermeability, in addition to that of the bottom and sides, after the landfill operation period has ended.

ca. Bottom and Sides' Waterproof Structure

Methods of bottom and sides' waterproof comprise in practice:

- localization of final disposal site at the least permeable natural ground (i.e., clayish ground, solid rock foundation etc.),
- lining with impermeable materials such as clay,
- lining with synthetic liners, and
- reinforced concrete (RC) structure.

Above methods (other than RC structure) can be employed in multiple combinations and/or a single application depending upon the type of final disposal facility. Table K.2.2d shows a comparison of 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. Figures K.2.2a, K.2.2b and K.2.2c show those concepts in Japan, Brazil and US-EPA.

Table K.2.2d Comparison of Bottom and Side Waterproof Structure

	Strictly Controlled Landfill	Controlled Landfill	Inert Landfill
Japan	Reinforced concrete ($Fc \geq 250$ kg/cm^2) ($t \geq 15$ cm)	Clay liner, $k \leq 10^{-6}$ ($t \geq 1$ meter) or Synthetic liner	*Clay liner, $k \leq 10^{-6}$
Brazil	Clay liner, $k \leq 10^{-7}$ ($t \geq 1$ meter) and Synthetic liner	Clay liner, $k \leq 10^{-6}$ ($t \geq 3$ meters) or Synthetic liner	No requirements
EU (draft directive 1991)	Clay liner, $k \leq 10^{-7}$ ($t > 3$ meters) or same level of safety	Clay liner, $k \leq 10^{-7}$ ($t > 3$ meters) or same level safety	No requirements
Denmark	Not applicable. Waste for SCL in Denmark is generally not landfilled, but incinerated. Slag from this process as well as other hazardous non-combustible waste is placed on one carefully located CL for the entire country.	"Clay liner, $k \leq 10^{-8}$ (laboratory value) ($t \geq 30$ cm) plus construction requirements" or "Synthetic liner ($t \geq 1.0$ mm) plus construction requirements" or "Combinations"	Not applicable
US-EPA	Double synthetic liner with Clay liner, $k \leq 10^{-7}$ ($t \geq 3$ feet)	Synthetic liner with Clay liner, $k \leq 10^{-7}$ ($t \geq 2$ feet)	No requirements

Remarks:
- k: Permeability (cm/sec.) or hydraulic conductivity
- t: Thickness
- Fc: Compression Strength
- * In Japan, waste plastic, waste rubber, scrap metals, waste glasses and construction waste are designated as "stable waste items" and are disposable in IL. If exclusively those "stable waste items" are disposed, the specification of waterproof structure is not imposed to the case. However, where contamination of other wastes with "stable waste items" are envisaged, the landfill should clear the specification mentioned in the table (*), or should equip pre-treatment facilities to separate "stable waste items" and other wastes.

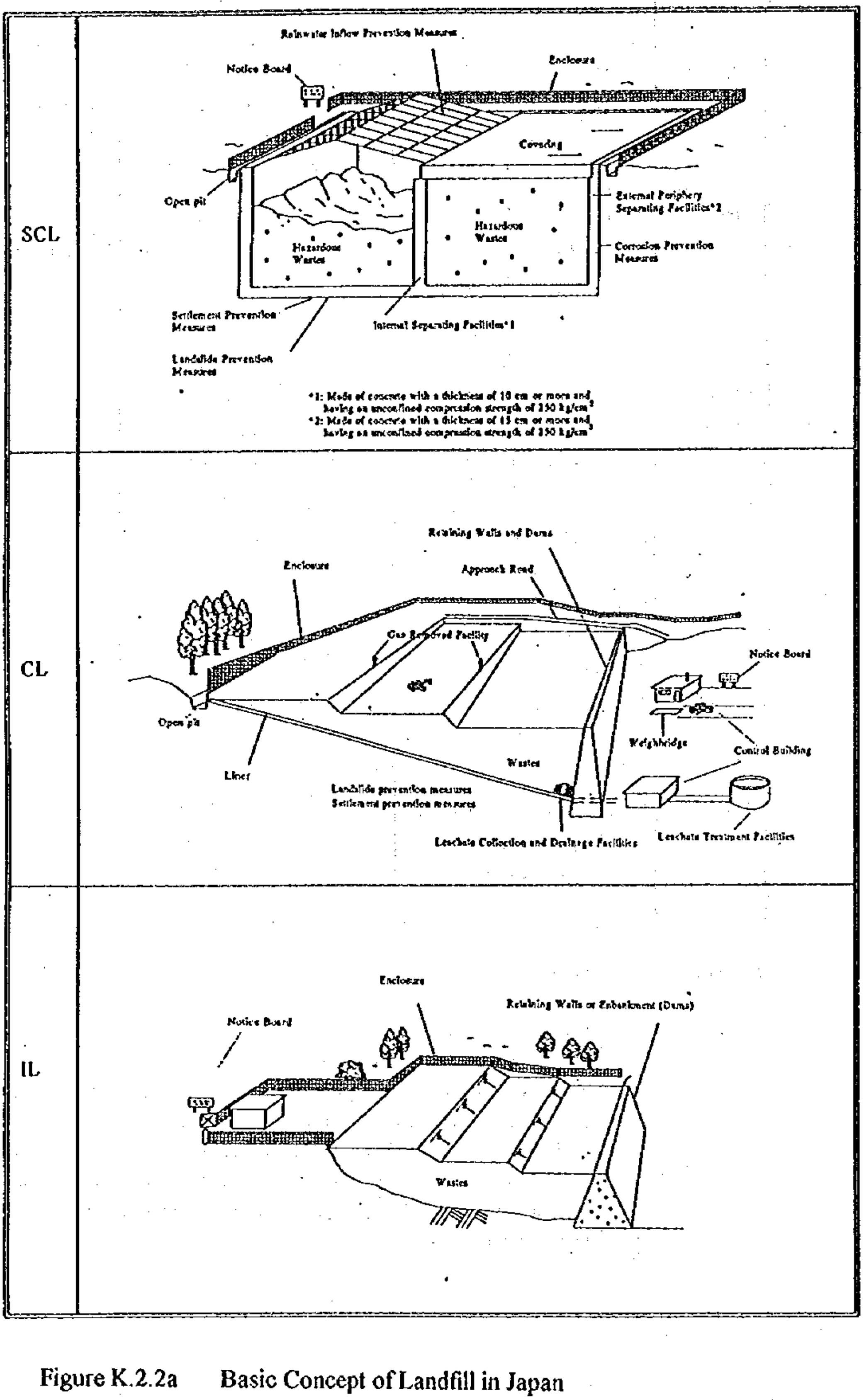


Figure K.2.2a Basic Concept of Landfill in Japan

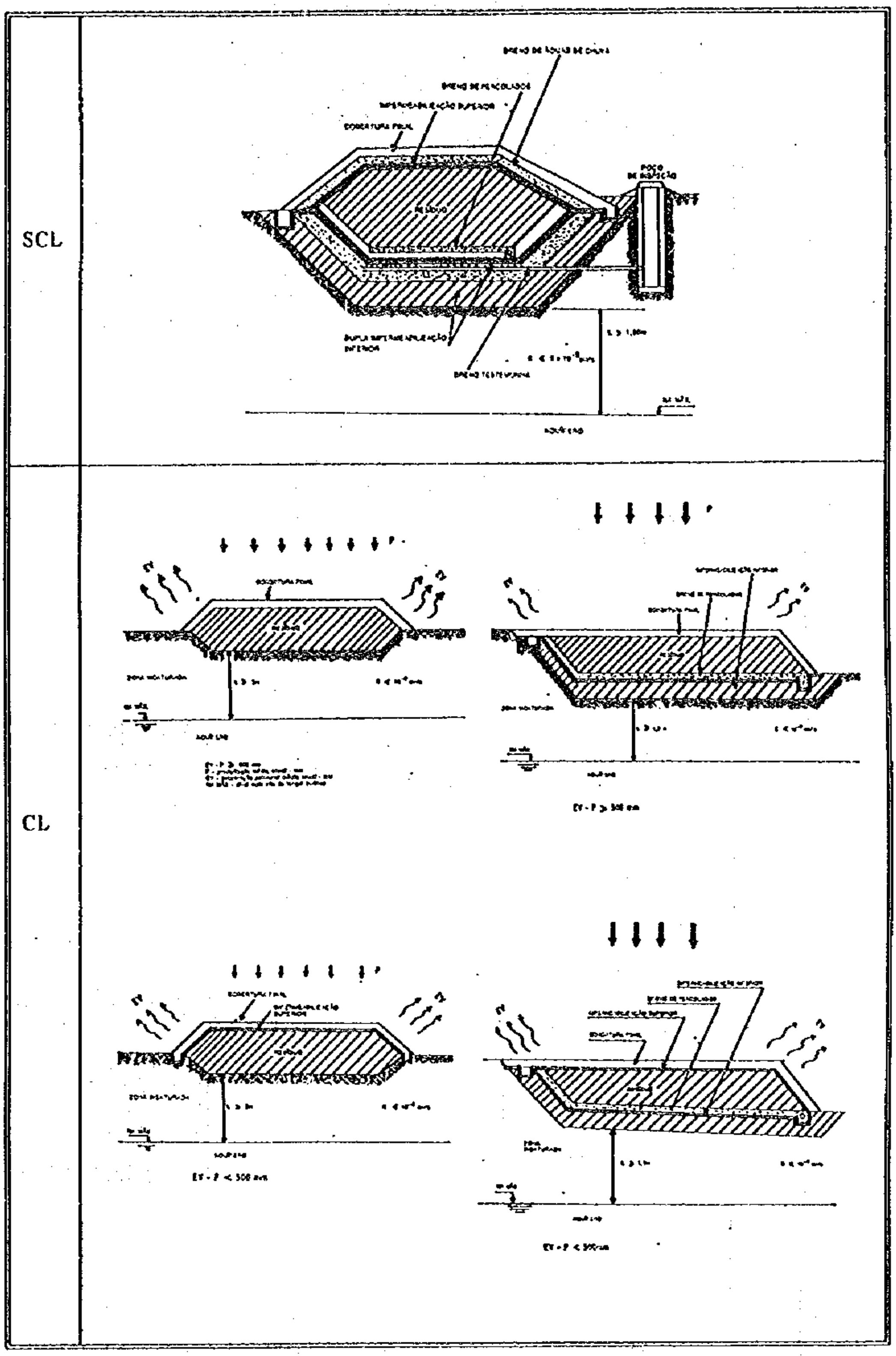


Figure K.2.2b Basic Concept of Landfill in Brazil

SCL

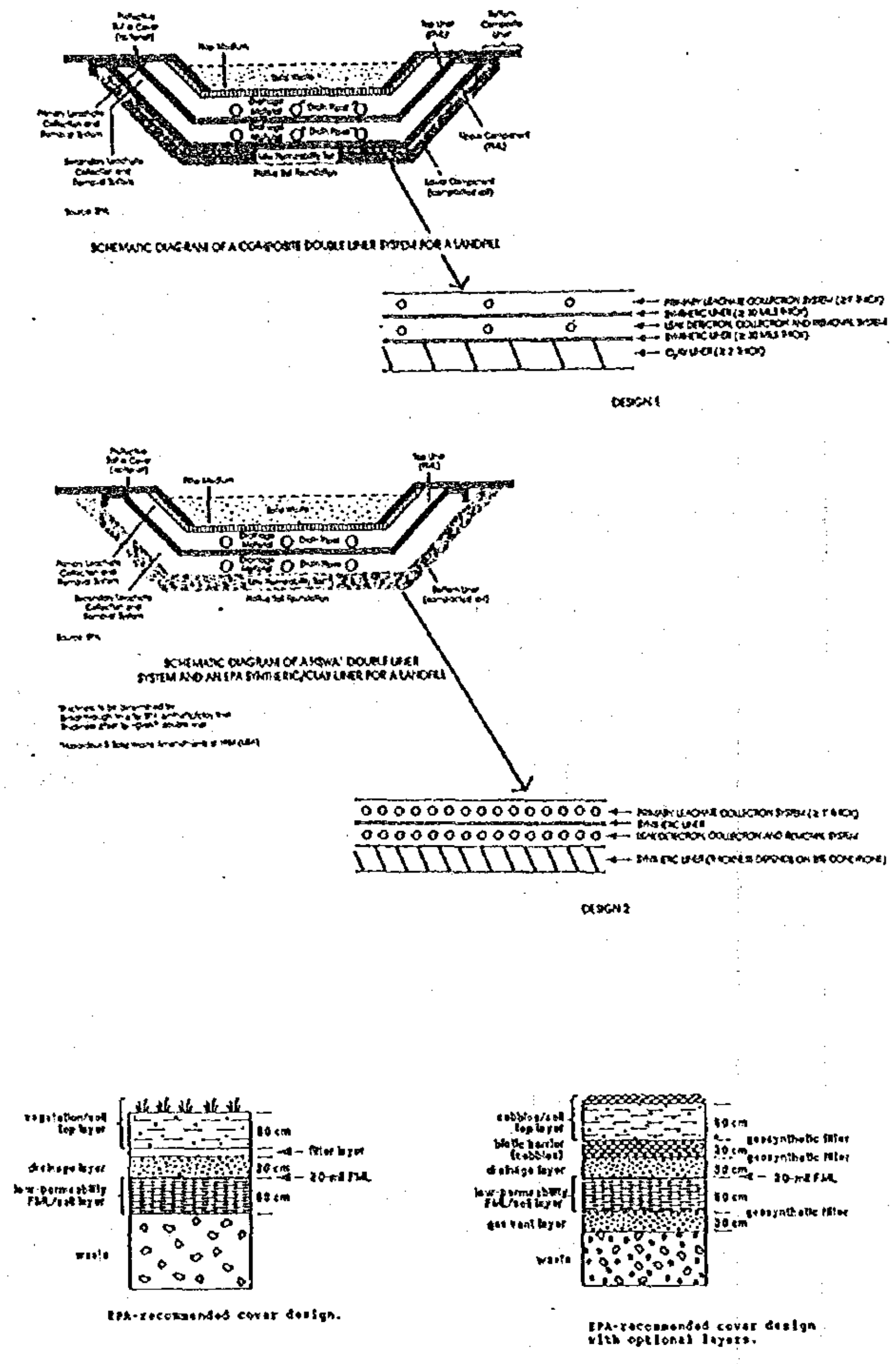


Figure K.2.2c Concept of Strictly Controlled Landfill by US-EPA

While "clay liner", "synthetic liner" and/or their combination are adopted for the waterproof structure of SCL in other countries but Japan, there are similarities in standards adopted for CL in all countries.

In Brazil and EU, although there are no specifications regarding waterproof structure for IL, waste to be disposed in IL is subject to the solubilization test which gives judgement whether it is technically inert or not. Therefore, if said solubilization test is employed and observed in judging acceptability of waste in IL, it is suggested that no specific waterproof structure is mandatory.

The standards adopted for SCL waterproof structures in Japan are attributable to:

- intrinsic Japanese natural conditions (i.e. soft ground characteristics, earthquakes, precipitation, etc.), and
- social conditions (i.e. difficulties in locating sites due to densely populated nature of the country) urge the siting of SCL irrespective of geological suitability.

Therefore, such standards are not applicable to Chile, which has its own natural and social conditions different from that of Japan.

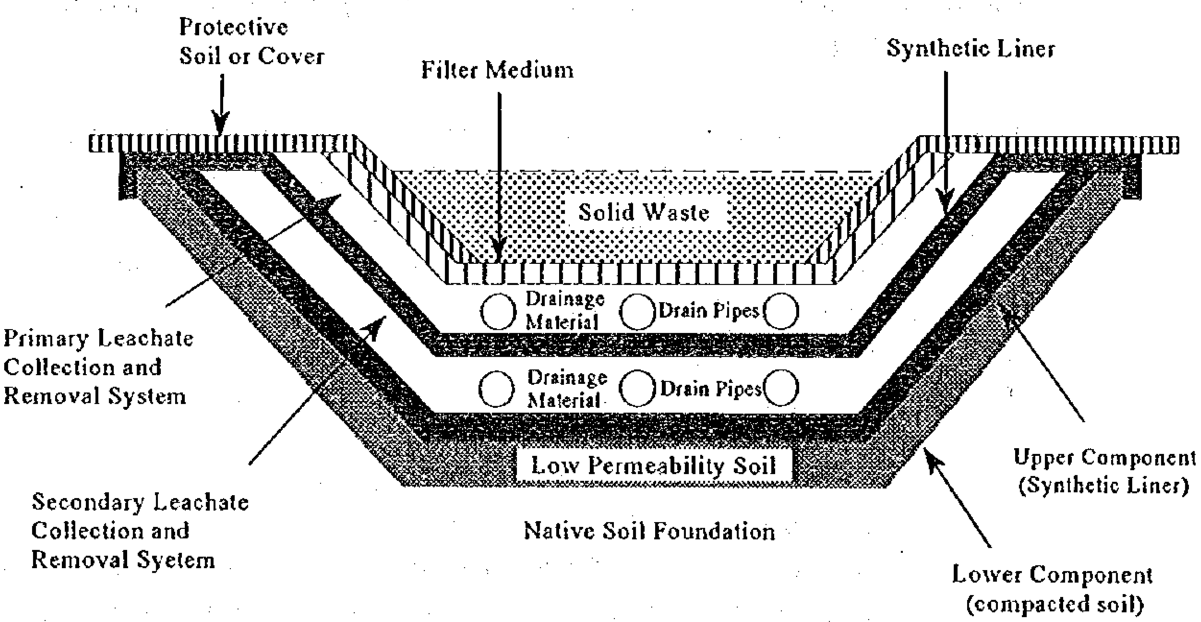
Consequently, the Study proposes standards for bottom and side waterproofing structures and required impermeability, as shown in Table K.2.2e and Figures K.2.2d and K.2.2e, with reference to:

- standards of Brazil, EU, Denmark and US-EPA for SCL,
- standards of Japan, Brazil, EU, Denmark and US-EPA for CL, and
- standards of Brazil and EU for IL.

Table K.2.2e Proposed Bottom and Sides' Waterproof Structure

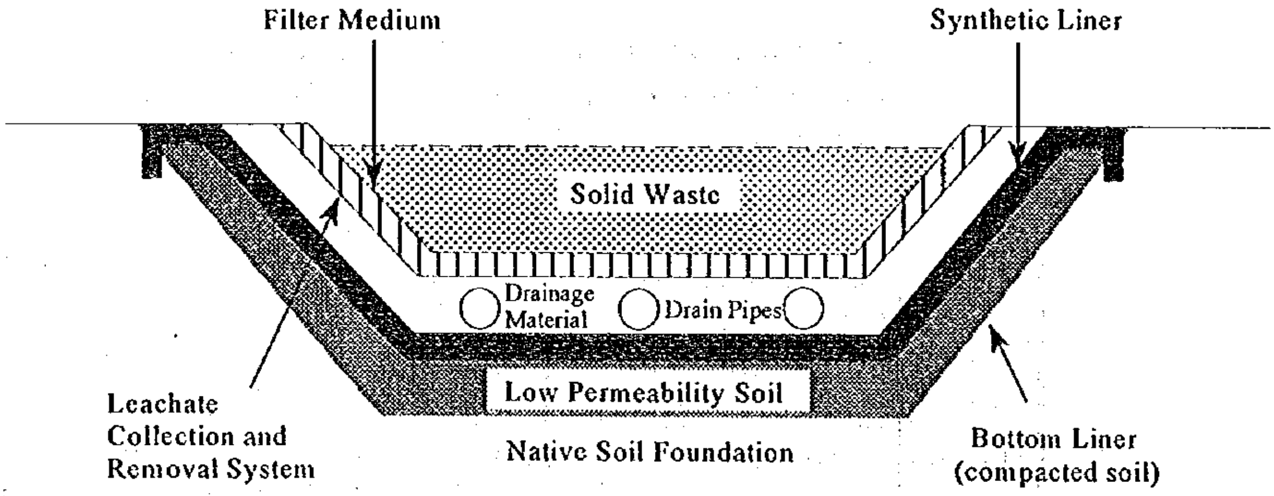
Items	Strictly Controlled Landfill (SCL)	Controlled Landfill (CL)	Inert Landfill (IL)
Synthetic Liner	Double with thickness more than 30 mil (0.762 mm)*1	Single with thickness more than 30 mil (0.762 mm)*1	No requirements
Clay Liner	A three (3)-foot (91.44 cm) layer of compacted soil with a hydraulic 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 $1 \times \leq 10^{-7}$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.



Source : US-EPA

Figure K.2.2d Proposed Bottom and Sides' Waterproof Structure for SCL



Source : US-EPA

Figure K.2.2e Propose Bottom and Sides' Waterproof Structure for CL

cb. Waterproof Structure in Final Coverage Layer

The objectives of the final coverage layer are:

- prevention of rainwater intrusion into disposed SW layers,
- prevention of scattering of disposed SW,
- maintenance of anaerobic condition in the disposed SW layers, etc..

Standard structures for the final coverage layer of disposal facilities in Japan, Brazil, Denmark and US-EPA are shown in Table K.2.2f.

Table K.2.2f Comparison of Standard Waterproof Structure for Final Coverage Layer

	Strictly Controlled Landfill (SCL)	Controlled Landfill (CL)	Inert Landfill (IL)
Japan	Reinforced concrete ($Fc \geq 250$ kg/cm^2)	Clay liner ($t \geq 100$ cm)	Clay liner
Brazil	Clay liner, $k \leq 10^{-7}$ and Synthetic liner	Clay liner or Synthetic liner	-
Denmark	Waterproof structures for final coverage are not a standard requirement in Denmark. The request will depend on type of waste disposed of. For biodegradable (municipal) waste, water is needed for the digestion, and no coverage except soil and grass/plants is required. For non-degradable waste with leakage potential, the requirement for bottom liners may apply.		
US-EPA	Synthetic Liner with Clay liner, $k \leq 10^{-7}$ ($t \geq 2$ feet)	Clay liner, $k \leq 10^{-5}$ ($t \geq 2$ feet)	-

Remarks: k: Permeability (cm/sec.) or hydraulic conductivity
Fc: Compression Strength
t: Thickness

The Study proposes, for the same reasons given for the standards for bottom and sides' waterproofing structures, criteria for the final coverage waterproof structure and required impermeability in Table K.2.2g, and Figure K.2.2f, with reference to:

- standards of Brazil and US-EPA for SCL, and
- standards of Japan, Brazil and US-EPA for CL and IL.

Table K.2.2g Proposed Standards for Waterproof Structure for Final Coverage Layer

	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 $1 \times \leq 10^{-7}$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.

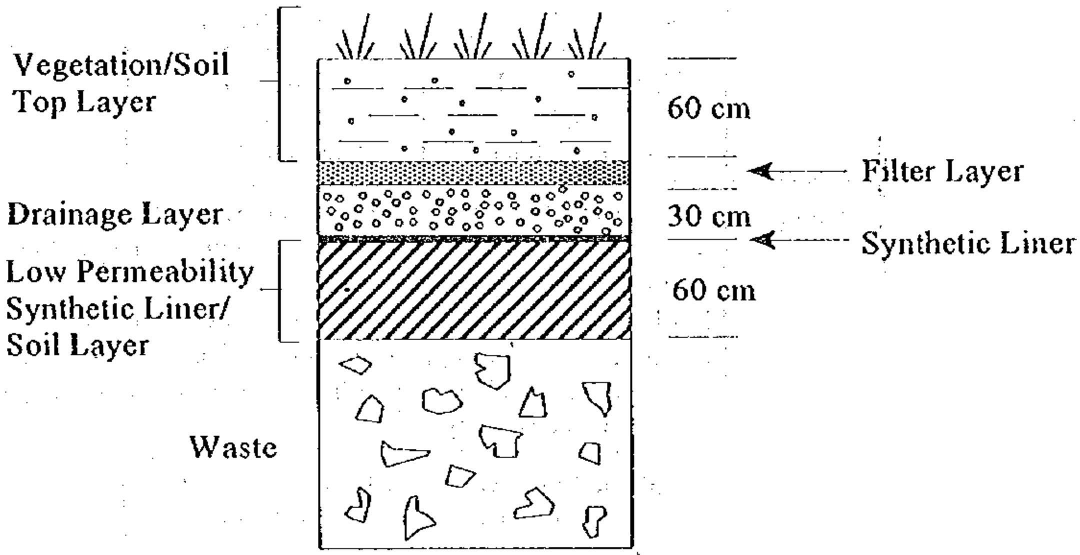


Figure K.2.2f Proposed Standards for Waterproof Structure for Final Coverage Layer of SCL

cc. Other Requirements of a Liner

Accordingly to §264.301 of "the Code of Federal Regulations of USA", a liner that is designed, constructed, and installed to prevent any migration of wastes out of the landfill to the adjacent subsurface soil or ground water or surface water at anytime during the active life (including the closure period) of the landfill. The liner must be constructed of materials that prevent wastes from passing into the liner during the active life of the facility. The liner must be:

i. Constructed of materials that have appropriate chemical properties and sufficient strength and thickness to prevent failure due to pressure gradients (including static head and external hydrogeologic forces), physical contact with the waste or leachate to which they are exposed, climatic conditions, the stress of installation, and the stress of daily operation;

ii. Placed upon a foundation or base capable of providing support to the liner and resistance to pressure gradients above and below the liner to prevent failure of the liner due to settlement, compression, or uplift; and

iii. Installed to cover all surrounding earth likely to be in contact with the waste or leachate.

d. Landfilling Operation

The landfill working area should be limited as much as possible during operation and should be covered by soil on the same day in order to:

- prevent excessive generation of leachate due to rainwater intrusion,
- mitigate the spread of foul odors from the disposed SW,
- prevent fires from the disposed SW, and
- prevent the scattering of disposed SW.

In practice, the size of the working area is determined by (for example):

- type of SW disposed,
- total landfill volume of the disposal site,
- amount of SW received daily,
- climatic conditions (e.g. precipitation), etc..

Therefore, the optimum size of the working area should be examined in view of various parameters such as the total volume disposed of each type of SW, (daily and seasonal fluctuations in SW volume received), etc..

K.2.3 Control of Final Disposal Site After Closure

a. Background

The objectives of the control of final disposal site after closure are: to identify and understand how the landfilled solid waste keeps or changes its characteristics and features in the course of time passage, and to prevent contamination (caused by landfilled solid waste) to surrounding areas.

The control in practice after closure are:

- implementation and maintenance of final coverage of the site, and
- a set of various monitoring.

b. Final Coverage

The previous section K.2.2 presents recommended standard regarding the final coverage.

c. Monitoring items and frequencies

Objectives of monitoring after closure of a landfill mainly comprise:

- identification of stabilizing degree of SW landfilled, and
- prevention of pollution related with landfilled SW to surrounding areas.

Monitoring items for identifying the stabilizing degree of landfilled SW are:

- characteristics and conditions of landfilled SW,
- leachate quality,
- quality and quantity of landfill gas generated, and
- ground subsidence.

Monitoring items with aims of pollution prevention to surrounding areas are:

- water quality of surface flow over final coverage of disposal site,
- underground water quality,
- leachate quality and quantity, and
- quality and quantity of landfill gas generated.

Table K.2.3a shows related monitoring items and frequencies in Japanese and EU standards for the control after site closure. However, it should be noted that the Japanese standard shown below is applied only for CL (Controlled Landfill) in Japan, where the EU standard states that monitoring items for leachate/underground water vary subject to composition of the waste deposited.

Table K.2.3a Comparison of Japanese and EU Standards for Monitoring Items and Frequency

		Japan	EU
Meteorological data	parameters	-	- volume and intensity of precipitation - temperature - direction and force of prevalent wind - evaporation - atmospheric humidity
	frequency	-	monthly on the day of the same day of the month
Deposited waste	parameters and substances	- physical composition - organic matter contents - water contents	-
	frequency	one time before an ultimate use of the site	-
Leachate	parameters and substances	temperature, pH, BOD, COD_{Mn}, NH_3-N, (ORP, EC, TOC, N, DO, SS, P) (*2)	- volume - composition (*1)
	frequency	every 3 months	every 6 months
Surface runoff water	parameters and substances	-	- composition (*1)
	frequency	-	every 6 months
Gas emissions	parameters and substances	CH_4, CO_2, (H_2S, NH_3, O_2, N_2, gas quantity, gas pressure) (*4)	CH_4, CO_2, O_2, (H_2S, H_2, etc.) (*3)
	frequency	every 6 months	every 6 months
Ground water	parameters and substances	-	- level of groundwater - composition (*1)
	frequency	-	every 6 months
Topography of the site	parameters	settling behavior of the landfill body	settling behavior of the landfill body
	frequency	yearly	yearly

Note: *1: The parameters to be measured and the substances to be analyzed vary according to the composition of the waste deposited.

*2: Requirement of monitoring of ORP (Oxidation-Reduction Potential), EC (Electric Conductivity), TOC (Total Organic Carbon), N (Nitrogen), DO (Dissolved Oxygen), SS, P (Phosphorous) is decided according to the composition of waste deposited.

*3: CH_4, CO_2, O_2 regularly; other gases as required, according to the composition of waste deposited.

*4: CH_4, CO_2 regularly; other gases as required, according to the composition of waste deposited.

In view of climatic features (e.g. small precipitation) and popular landfill structure (i.e. anaerobic landfill structure) etc. in the MR, it is recommended for the final disposal sites in the MR to refer mainly EU standard rather than the Japanese standard. (Rainfalls are relatively large and semi-aerobic landfill structure is dominant in Japan.)

Although the Japanese standard states that characteristics (e.g. physical composition, organic content, water content) of landfilled SW should also be monitored, it might not be recommended since it is difficult to obtain representative samples from sites where various SW are vastly landfilled. Therefore, the Study proposes the monitoring items and frequency as shown in Table K.2.3b.

As stated in the footnote of the table, the selection of parameters and substances to be analyzed must be carried out on the basis of an assessment of the waste deposited, especially for the SCL for HW. For the CL, if leachate will be treated at a public sewage treatment plant, the parameters and substances shall be selected not only in view of pollution prevention purposes but also considering the requirements (for receiving leachate) of the treatment plant.

As for the IL (Inert Landfill), if a landfill is properly operated (i.e., landfilled SW is entirely inert non-HW), monitoring after closure for the landfill should be unnecessary. In this connection, "as occasion demands" in the table refers that if it is doubted whether an IL is operated appropriately or not, monitoring of some parameters and substances mentioned in the table should be carried out.

Table K.2.3b Proposed Monitoring Items and Frequency for Final Disposal Sites after Closure in the MR

		SCL and CL	IL
Meteorological data	parameters	- volume and intensity of precipitation - air temperature - direction and force of prevalent wind - evaporation - atmospheric humidity	-
	frequency	monthly on the day of the same day of the month	-
Leachate	parameters and substances	- volume - composition (*2)	temperature, pH, BOD, COD, NH_3-N
	frequency	every 6 months	as occasion demands
Surface runoff water	parameters and substances	- composition (*2)	- composition (*2)
	frequency	every 6 months	as occasion demands
Ground water	parameters and substances	- level of ground water - composition (*2)	- level of ground water - composition (*2)
	frequency	- every 6 months	as occasion demands
Gas emissions	parameters and substances	CH_4, CO_2, O_2, (H_2S, H_2, etc.) (*3)	-
	frequency	every 6 months	-
Topography of the site	parameters	settling behavior of the landfill body	-
	frequency	yearly	-

Note: *1: Data of nearest meteorological station could be utilized instead.
*2: The parameters to be measured and the substances to be analyzed vary according to the composition of the waste deposited.
*3: CH_4, CO_2, O_2, regularly; other gases as required, according to the composition of waste deposited.

d. Period of Control After Closure of Final Disposal Site

In view of monitoring items presented above, the control period after closure of final disposal site could be defined: "period required for ensuring the stabilization of SW disposed to the extent that pollution attributable to SW do not arise later onward". The period may widely vary depending upon: the composition of waste deposited, landfill structure (e.g. aerobic or anaerobic), climatic condition and hydrogeology thereof, etc.. It should be noted that waste types deposited in a HW landfill are in most cases non-degradable or little degradable, but can nevertheless be washed out.

Japanese standard does not stipulate exact time period required for monitoring. US-EPA and EU standards specify the period be minimum 30 years after closure or until it is ensured that pollution to surrounding areas attributable to SW deposited do not arise later onward. It is not practiced and is not recommendable to determine the period of monitoring in simple numerical expression. Therefore, with reference to international standards, it is recommended that the control of final disposal site after closure should be oriented initially for the period of "minimum 30 years after closure or until it is ensured that pollution to surrounding areas do not arise later onward". With accumulating and examining the monitoring data of closed landfills, the Chilean standards to stipulate the period of the control of landfill after closure shall be determined.

Table K.2.3c Length of Monitoring after Closure of a Landfill

	Japan	US-EPA	EU
Aftercare period	not established	30 years	minimum 30 years

e. Management Period and Monitoring Frequency after Closure Required in Brazil

It is usual in Brazil to require:

- trimestrial sampling/analysis during the first year after closure,
- semestrial sampling/analysis during the next five years, and
- annual sampling/analysis until 20 or 30 (if hazardous waste landfill) years after closure.

The State Authority establishes the requirements case by case.

K.2.4 Incineration at Cement Plants

K.2.4.1 Background

At the meeting on the discussion of the Draft Final Report, in view of the possibility that incineration of some ISW be carried out at the existing plants, the Chilean side requested that the Team provide information regarding the processes used by such plants in Japan and Brazil, as well as the types and amounts of wastes that may be acceptable for this method.

K.2.4.2 Incineration at Cement Plants in Japan

a. Data Sources

In response to the request made by the Chilean side, the Team tried to collect information regarding incineration at cement plants in Japan. However, the Team could not obtain enough information regarding overall status of the incineration at cement plants in Japan due to the lack of official statistic data on it. Therefore, the Team needed to collect the information from individual plant or factory. Since time available for the preparation of the Final Report is limited and data collection from individual factory is difficult, the Team collected the information from two plants and the summary of the information is presented in Table K.2.4.2a. It should, however, be noted that the application of the information of the report should be limited.

b. Types and Amounts of Wastes Treated

The types and amount of wastes which are acceptable for the treatment and resource recovery of the cement plants differ in accordance with the types of the plants. According to the information of the two plants, when each plant is requested to treat some wastes, the following aspects are carefully examined regarding wastes to be treated:

- The treatment and resource recovery of the wastes should not make unacceptable impact on the product;
- The treatment and resource recovery of the wastes should not require much investment, i.e. less requirement of modification of the plants.
- The waste is preferable if they could be used as auxiliary fuel and/or substitute for raw materials.
- Co-incineration of the wastes should not violate emission standard of flue gas.

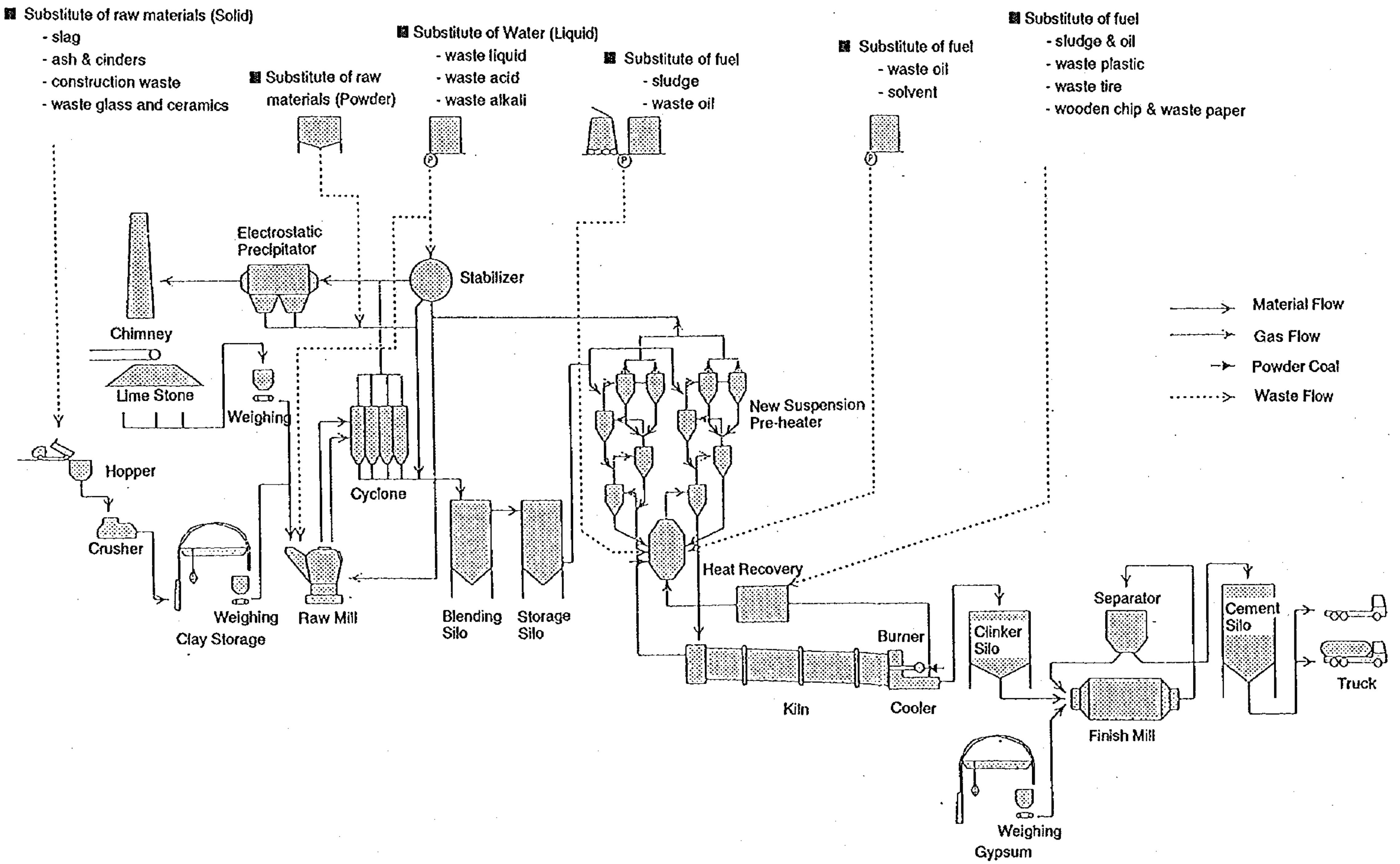
Although it is not described in details, the information given by the two cement plants in Japan is tabulated in Table K.2.4.2a.

c. Processes used in the Two Plants

The cement production processes with co-incineration of some industrial wastes in the two plants are illustrated in Figure K.2.4.2a and K.2.4.2b.

Table K.2.4.2a Types and Amounts of Wastes Treated in T Cement Factory and K Cement Factory in Japan

Items		Treatment Method	T Cement Factory	K Cement Factory
Capability of Cement Production		-	120,000 ton/month	92,000 ton/month
Types and Capacity of Waste Treatment	- Ash - Sludge - Plastics - Paper - Wood - Textile - Waste from food production - Rubber - Metals - Glass and ceramics - Slag - Construction waste - Dust and APC products	Calcination	30,000 ton/month	30,000 ton/month
	- Solvents - Only waste	Incineration	5,000 ton/month	2,000 ton/month
	- Acids - Alkalis	Calcination	5,000 ton/month	4,000 ton/month



Unloading	Raw Material Storage	Raw Material Drying/Crushing	Raw Material Blending/Storage	Preheating	Kiln	Cooler	Clinker Storage	Finish Mill	Cement Silo	Shipment

Figure K.2.4.2a Flow Sheet of Cement Production and Treatment/Resource Recovery of Industrial Waste at T Plant in Japan

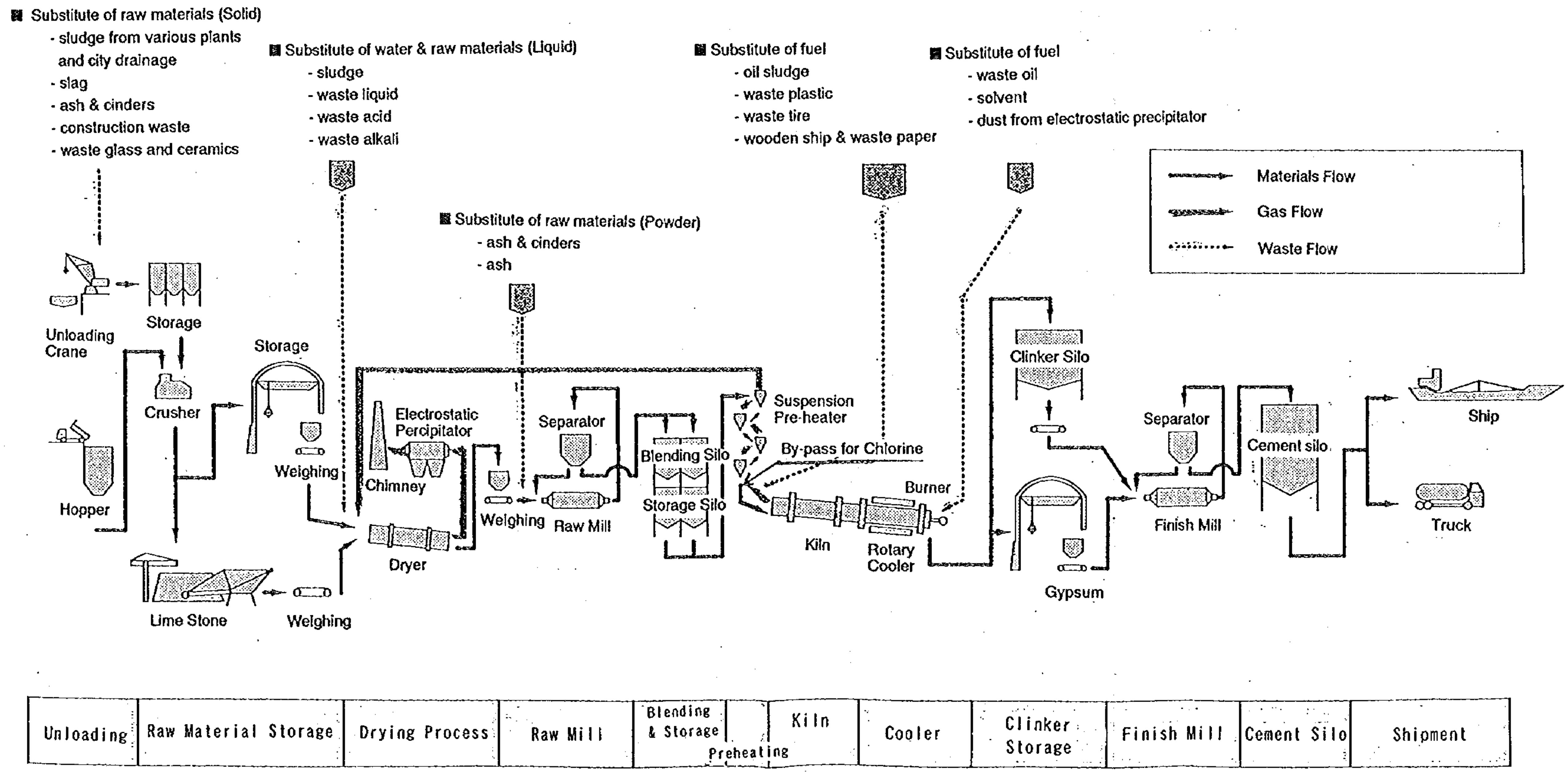


Figure K.2.4.2b Flow Sheet of Cement Production and Treatment/Resource Recovery of Industrial Waste at K Plant in Japan

K.2.4.3 Abstract of the "World Bank Technical Paper Number 93 "

As mentioned above, the information obtained is not sufficient to present a report requested by the Chilean side. In order to supplement the report an abstract of the World Bank report, "The Safe Disposal of Hazardous Wastes, The Special Needs and Problems of Developing Counties, World Bank Technical Paper Number 93" is presented below.

a. Advantages and disadvantages of Co-incineration in existing industrial facilities

i. Advantage of this approach are that:

- capital investment in new, dedicated HW incinerators is not needed; and
- existing processes can reap extra economic benefits, since the cost of accepting and destroying wastes is credited against process costs.

ii. Disadvantages are that:

- the introduction of waste streams into an existing high-temperature facility has the potential to disrupt the process or degrade the product. A thorough investigation and good scientific evidence is essential if plant management is to be persuaded to change an existing, proven process; and
- the lack of adequate gas cleaning equipment on many types of plants (e.g., boilers) necessitates careful selection and control of waste inputs.

b. Cement Kilns and Lime kilns

The kilns operate at high temperatures (1,400°C or above), and the alkalinity of the kiln material neutralizes acid gases such as hydrochloric acid, that are produced when the HW is incinerated. Kilns therefore offer both excellent destruction efficiency and effective gas cleaning.

Kilns used in the wet-process manufacture of cement are typically 155m long and 4m in diameter, the majority of this length being used to dry the clinker material. Solid charge temperatures of above 1,000°C are only achieved in the last 25% of its length, whereas gas phase temperatures rise above 1,000°C after 50% of the length. Total gas phase residence times are usually in the region of 20 seconds.

To date, waste solvents and tars, which in themselves contribute significant heat to the process and provide savings in prime fuel consumption, and halogenated waste have been successfully incinerated in cement kilns.

i. Advantages are (Trovaag 1983):

- kiln temperature is ideal for incineration;
- acidic gases are absorbed in the clinker, and therefore existing particulate arrestment equipment is usually sufficient; and
- credit due to the use of heat from wastes, and treatment charges, improves the economics of the kiln.

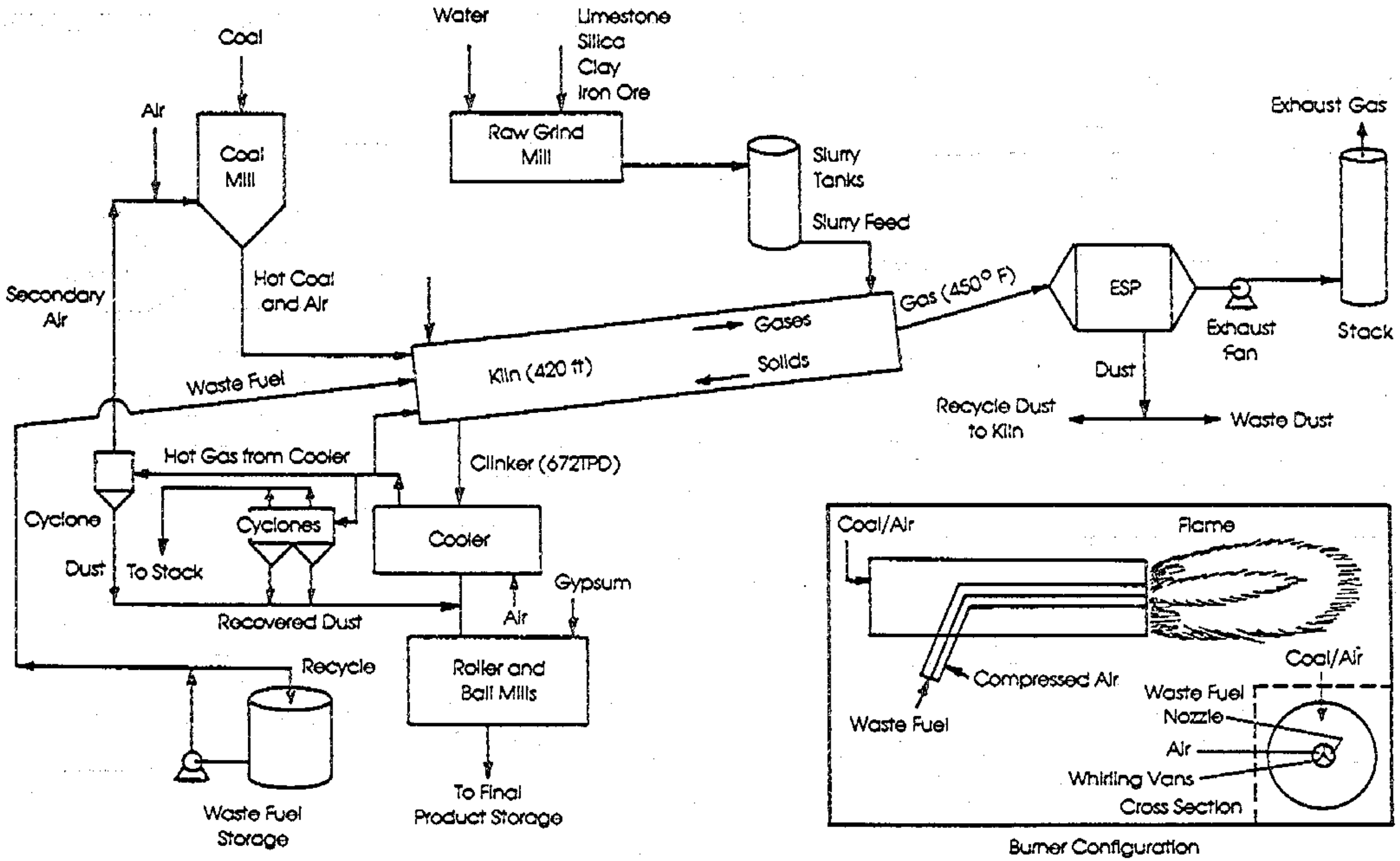
ii. Disadvantages are that:

- since the primary ain of the process is to manufacture cement or calcine lime, hazardous wastes must be controlled so as not to impact on the quality of the product. Large or bulky items are therefore excluded; and
- the production cost for the clinker (product) may be increased because of additional maintenance and the need to dispose of flue dust containing inorganic chlorides. There is also some reduction in clinker output. These are generally offset by the economic advantages of handling HW.

The use of cement kilns for incineration of HW is still limited. Commercial facilities are operating, or have operated in France, Italy, Norway, Sweden, Canada and the U.S. For example, five kilns in France burn a total of about 20,000 tons per annum, largely comprising acid tars which are otherwise difficult to dispose. In the U.S., a few facilities accept a wide range of wastes, while in Italy application is limited to waste oils.

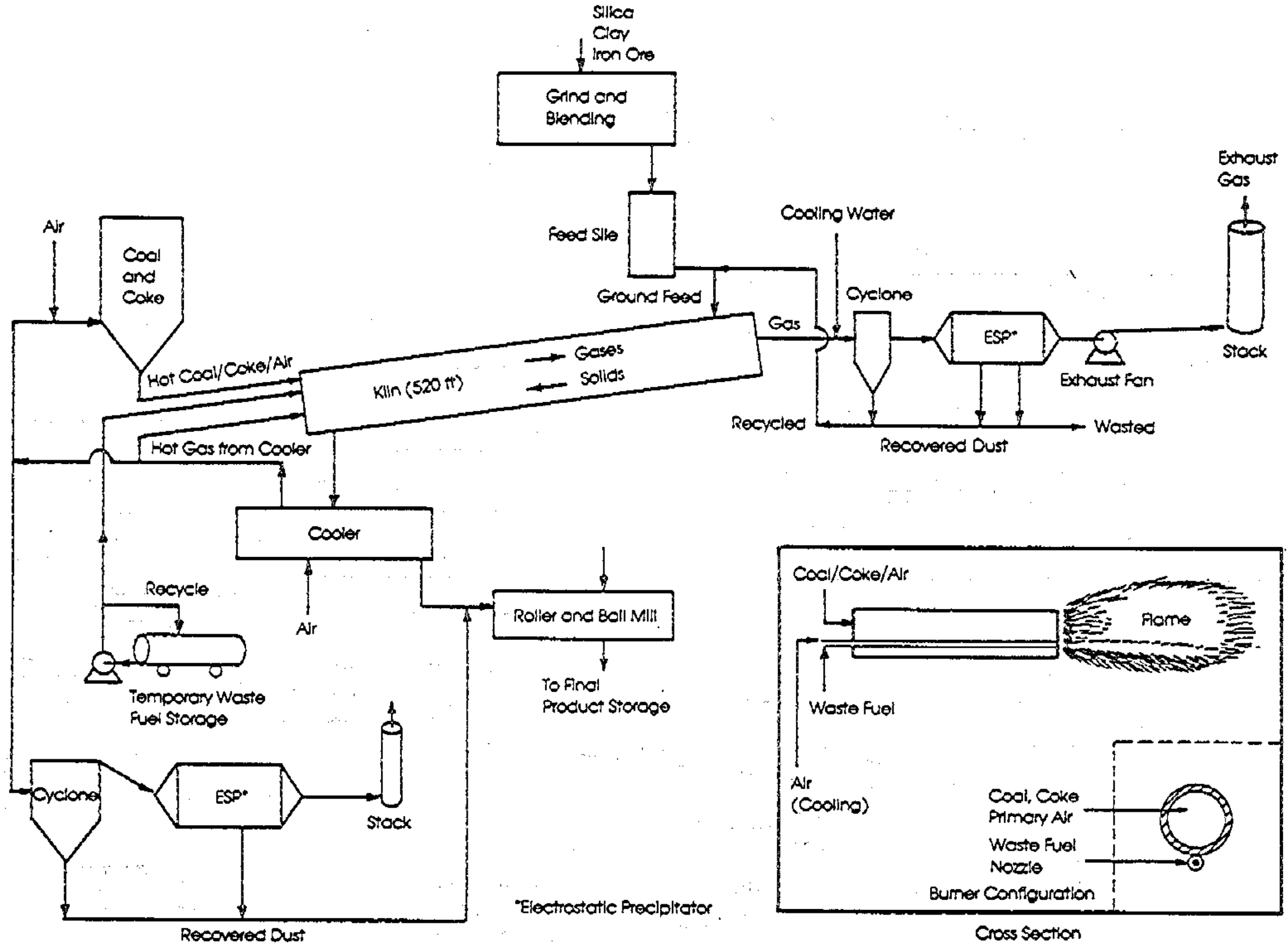
A number of kilns have been tested during waste combustion to provide more data on the effects of waste combustion. Some of these tests have been comprehensive in their attempt to determine effects on emissions, product quality, fate of metals and chlorine, and products or incomplete combustion.

Figures K.2.4.3a and K.2.4.3b illustrate the layout of typical wet and dry process cement kilns configured to accept waste fuel. Hydrocarbons are generally used to supplement prime fuel requirements, and chlorinated hydrocarbons are either introduced as contaminants on in discrete streams.



Source: USEPA. 1985 Summary Report on Hazardous Waste Combustion in Calcining Kilns. Contract no. 68-03-3149.

Figure K.2.4.3a Wet Process Cement Kiln Modified to Burn Waste Fuel



Source: USEPA. 1985. Summary Report on Hazardous Waste Combustion in Calcining Kilns. Contract no. 68-03-3149.

Figure K.2.4.3b Dry Process Cement Kiln Modified to Burn Waste Fuel

Not all incinerable waste is suitable for use as a fuel in cement kilns. The most suitable waste fuel is liquid with a high calorific value and low water and metals content. Separable water should be limited to 1% by volume and metals content must be sufficiently low to prevent blockage in burners. Generally, the waste should contain less than 20% solids, and it must be fine enough to pass through a No. 8 mess screen. These limitations, which may vary from plant to plant, are established primarily because of handling constraints. A maximum viscosity of about 1,400 SSU ensures that the supplementary fuel is readily pumpable at normal ambient temperatures.

One of the major waste selection ocnsiderations is what effect, if any, the use of waste will have on the manufacturing process and on the quality of the final product. For example, some heavy metals may be established in the clinler, or become concentrated in the wastes dust, changing the character of the emissions. Test data have shown that the ash, heavy metal or chlorine in the waste do not adversely affect cement quality.

K.2.4.4 Co-Processing in Brazil

Incineration of industrial waste in cement kilns, also called co-incineration or co-processing, is a developing practice in Brazil considered valid for some kinds of residues. It is been regulated by studies joining the environmental agencies from the states of Minas Gerais, Rio de Janeiro, Paraná, Rio Grande do Sul and São Paulo, and supported by GTZ (German government program on assistance to the environmental agencies of the third world.)

By the economical point of view, the greatest advantage of the co-incineration is that whereas an incinerator for dangerous wastes represents and investment of about US$20 million, and a feed rate of 100 to 150 kg/hour, for a cement kiln the investment is minimum and it burns from 2 to 3 tons/hour.

For the co-processing of a dangerous waste, this must have a high caloric power or substitute some raw meterials to the clincker production, furnishing merals to its composition. Some organic, as those present in solvents or paint production residues also can be co-incinerated.

Although many residues have already been studied, the authorization process for burning waste in cement kilns is slow. That is because the kilns are today licenced only for cement production, and are generally not prepared for this extra activity. Firstly the kilns must be adequated to the emission limits suggested by the environmental agencies (0.15kg of particulated material per ton of inlet dry material). Reaching this goal, a burn test efficiency of a compound called "tracer" is carried out, measuring the quantities at the inlet and outle flow. This compound is chosen among those present in the residue as the one with the higher toxicity, the higher quantity and the lower caloric power, to be sure that all the others will reach an equal or higher destruction efficiency.

A particular situation is found on cement kilns in relation of the gases and ashes treatment. The control is all done by dry route without gas washing (incompatible with cement), but using eletrostatic precipitator. The extremely alkaline atrosphere at the inside on the kiln helps to neutralize some acid pollutants such as SO_2 and HCl. In the HCl case, there is an extra care from the cement producer because high HCl levels may put the quality of the product in risk.

In São Paulo there is already an industry on blending residues for the co-incineration. The purpose is to achieve an uniform composition and sell to the cement industry which uses it as energy or raw material.

Even with all the apparent advantages, it should be always considered that the objective of the co-incinerators is the cement production and burning industrial waste is only and additional activity.

K.3 Cost Estimation

K.3.1 Assumptions of ISW Flow in 2010

a. Principle

There is a wide variety in features and descriptions of ISW, whose treatment and disposal also vary in application. Current treatment/disposal systems of ISW in the MR are mainly landfill disposal in municipal landfill sites.

In view of the principle policies of the Government of Chile, it is judged that establishment of technical systems of treatment/disposal of ISW in the MR is promoted by private sectors. Consequently, it is difficult to forecast on what technological level treatment/disposal technical systems will be realized and commercialized in 2010.

It is, however, one of principal targets of the Study to estimate the magnitude of ISWM business in 2010. It is necessary for the estimation to assume 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 followingly calculated a rough estimate of projects costs for the amount forecasted of said ISW to be treated and disposed in the year 2010.

b. Assumption on Technical System in 2010

ba. Amount of ISW Subject to the Cost Estimation

The amount of ISW subject to this cost estimation are defined:

- estimated total generation amount of ISW in 2010 minus estimated recycled amount in 2010.

Recycled amount of ISW in 2010 is forecasted for 24 ISW categories respectively by:

- "estimated generation amount" times " recycle ratio assumed (refer Table K.3.1a below").

bb. Recycling Ratios

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, as shown in the Table K.3.1a.

Table K.3.1a Recycle Ratio

unit: %

Type of Waste	Empirical data in Japan in 1991	Recycling ratio in 1995 surveyed	Recycling ratio assumed for the MR in 2010
C-1	10%	65%	40%
C-2	48%	9%	40%
C-3	2%	0%	2%
C-4	2%	0%	2%
C-5	-	0%	0%
C-6	45%	80%	45%
C-7	26%	13%	25%
C-8	-	37%	40%
C-9	40%	71%	40%
C-10	-	0%	0%
C-11	-	0%	0%
C-12	-	65%	25%
C-13	68%	96%	80%
C-14	24%	15%	20%
C-15	92%	74%	90%
C-16	63%	80%	70%
C-17	17%	36%	25%
C-18	27%	1%	25%
C-19	64%	33%	50%
C-20	-	2%	2%
C-21	47%	94%	90%
C-22	74%	4%	40%
C-23	39%	0%	35%
C-24	1%	0%	1%

Source: Empirical data in Japan in 1991 is from "Solid Waste in Japan in 1994" by Ministry of Health and Welfare of Japan. Recycling ratio in 1995 surveyed was obtained by JICA's Factories' Survey (see Table C.5.10 in Annex C).

bc. Volume Change Through Intermediate Treatment

The volume of ISW is changed through intermediate treatment. The following assumptions are employed in ISW volume changes for determining ISW flows.

i. Dehydration of sludge

Moisture content of sludge (before and after dehydration) is assumed as shown in the Table K.3.1b.

Table K.3.1b Assumed Sludge Moisture Content

	Before dehydration	After dehydration
C-3 Inorganic sludge	90%	85%
C-4 Organic sludge	99%	85%

ii. Volume reduction through incineration

Volume reduction ratios of ISW through incineration treatment vary depending on the characteristics of respective ISW incinerated. Table K.3.1c shows assumptions employed in estimation of volume reduction through incineration:

Table K.3.1c Volume reduction ratio assumed

	Before incineration	After incineration	
		C-1	C-2
C-8 Solvent	100%	2%	2%
C-9 Oily waste	100%	5%	5%
C-11 Organic chemical residues	100%	10%	10%
C-24 Other solid waste	100%	10%	10%

iii. Volume change through solidification, neutralization and chemical treatment

Although slight volume changes (increase or decrease) occur through application of chemical agents, the differences are negligible. Therefore volume changes through solidification, neutralization and chemical treatment are neglected. Whereas it is assumed that neutralization and chemical treatment transform whole amount of treated ISW into C-3 or C-4.

c. Assumption of Treatment/Disposal Flows for 24 ISW Categories

For estimating costs of treatment/disposal, flows of treatment/disposal for 24 ISW categories (in 2010) are estimated based on the consultants' experiences and present situation of the MR (e.g. sites available for ISW final disposal facilities are comparatively many and land acquisition cost is not so expensive like in Japan. And intermediate treatment facilities are to be constructed mainly aiming at "transforming ISW into harmless" rather than aiming at "volume reduction" unlike in some industrialized countries, etc.).

ca. C-1 Ash Including from Incinerators

Alternatives of intermediate treatment for C-1 are to be "thermal melting", "extraction" or "chemical treatment". Since the ISW of C-1 itself is residues of incineration, further volume reduction is impracticable. It is assumed that all amount other than those recycled should be disposed of at landfills, whose breakdown are:

- Recycle 40%
- SCL 30%
- Cl 15%
- Il 15%

cb. C-2 Dust and APC Products

Alternatives of intermediate treatment for C-2 are to be "solidification", "thermal melting", "extraction" or "chemical treatment". Since the ISW of C-1 itself is APC(air pollution control) products from combustion facilities and/or inorganic dust and particulate, further volume reduction is impracticable.

On the other hand, since dust and APC products contain hazardous substances in many cases, it is assumed that 50% are HW and 50% are Non-HW, where 80% of Non-HW (i.e. 40% to total) are to be recycled, and half of HW be subject to "solidification"and then disposed of at CL, and the other half of HW be directly disposed of at SCL, i.e. whose breakdown are:

- Recycle 40%
- Solidification 25%
- SCL 25%

- CL 25%
- IL 10%

cc. C-3 Inorganic Sludge

It is assumed that water content of C-3 at its generation be 90% and the one after dehydration be 85%, and that all amount other than those recycled be disposed of at landfills after dehydration process, whose breakdown are:

- Recycle 2%
- Dehydration 98%
- SCL 5.3%
- CL 30%
- IL 30%
- *WWT 32.7%

Note : *WWT = waste water treatment

cd. C-4 Organic Sludge

It is assumed that water content of C-4 at its generation be 99% and the one after dehydration be 85%, and that all amount other than those recycled be disposed of at landfills after dehydration process, whose breakdown are:

- Recycle 2%
- Dehydration 98%
- SCL 1.9%
- CL 4.0%
- IL 0.7%
- *WWT 91.4%

Note : *WWT = waste water treatment

ce. C-5 Asbestos

Although asbestos itself shows stable features and do not elute hazardous substances, it shows hazardous features in its fiber shapes (i.e. rate of its length and diameter) and becomes carcinogen of lung cancer. Therefore, if said features are constrained by intermediate treatment, asbestos can be disposed of at IL. If not, it is necessary to be disposed of at SCL. Whose breakdown are estimated as follows:

- Recycle 0%

- Solidification 50%
- SCL 50%
- CL 0%
- IL 50%

cf. **C-6 Acids**

Since C-6 are basically in liquid state and show features of corrosiveness, it at least requires intermediate treatment (neutralization). It will be transformed as another ISW (e.g. C-3, C-4) after an intermediate treatment. Namely breakdown of the treatment/disposal assumed are:

- Recycle 45%
- Neutralization 55%
- C-3 27.5%
- C-4 27.5%

cg. **C-7 Alkalis**

Since C-7 are basically in liquid state and show features of corrosiveness, it at least requires intermediate treatment (neutralization). It will be transformed as another ISW (e.g. C-3, C-4) after an intermediate treatment. Namely breakdown of the treatment/disposal assumed are:

- Recycle 25%
- Neutralization 75%
- C-3 37.5%
- C-4 37.5%

ch. **C-8 Solvents**

Waste solvents are flammable with low flash point. All C-8 other than those for reuse or recycling are to be subject to intermediate treatment (incineration). C-1 and C-2 are generated as residues from the process, whose generation are assumed 2% of the amount incinerated. Namely breakdown of the treatment/disposal assumed are:

- Recycle 40%
- Incineration 60%
- C-1 1.2%
- C-2 1.2%

ci. **C-9 Oily Waste**

Oily waste are, alike C-8 "waste solvents", flammable with low flash point. All C-9 other than those for reuse or recycling are to be subject to intermediate treatment (incineration). C-1 and C-2 are generated as residues from the process, whose generation are assumed 5% of the amount incinerated. Namely breakdown of the treatment/disposal assumed are:

-	Recycle	40%
-	Incineration	60%
-	C-3	3%
-	C-4	3%

cj. **C-10 Inorganic Chemical Residues**

Since inorganic chemical residues contain various inorganic chemical substances, said ISW should be subject to for example "chemical treatment" or "solidification and disposal at SCL", etc.. Ratios shown below are assumed for intermediate treatment and disposal:

-	Recycle	0%
-	Chemical treatment	50%
-	C-3	50%
-	Solidification	12.5%
-	SCL	12.5%
-	CL	25%
-	IL	12.5%

ck. **C-11 Organic Chemical Residues**

Since C-11 "organic chemical residues" contain various organic chemical substances, intermediate treatment (e.g. chemical treatment, incineration) should be applied. Namely ratios shown below are assumed for intermediate treatment and disposal, and those subject to "chemical treatment" and "incineration" are assumed to be transformed into C-4 and C-1/C-2 respectively:

-	Recycle	0%
-	Chemical treatment	50%
-	C-4	50%
-	Incineration	25%
-	C-1	2.5%

- C-2 2.5%
- CL 12.5%
- IL 12.5%

cl. C-12 Other Liquid Waste

Since "other liquid waste" are in liquid state and contaminated with various chemical substances, it is assumed that all C-12 other than those for recycling are subject to "chemical treatment" and transformed into C-3 and C-4 half-and-half:

- Recycle 25%
- Chemical treatment 75%
- C-3 37.5%
- C-4 37.5%

cm. C-13 Waste from Food Production

Waste from food production mainly comprise organic matter and are subject to recycling. All other than for recycling are assumed to be directly disposed of at CL. Therefore the ratios assumed are:

- Recycle 80%
- CL 20%

cn. C-14 Glass and Ceramics

ISW of glass and ceramics are mainly composed of inorganic matters. All other than for recycling are assumed to be directly disposed of at IL. Namely the ratios assumed are:

- Recycle 20%
- IL 80%

co. C-15 Metal and Scrap

Great majority of metals and scraps are subject to recycling. All other than for recycling are assumed to be directly disposed of at IL. Namely the ratios assumed are:

- Recycle 90%
- IL 10%

cp. C-16 Paper and Cardboard

Considerable proportion of paper and cardboard generated as ISW are subject to recycling. All other than for recycling are assumed to be directly disposed of at CL. Therefore the ratios assumed are:

-	Recycle	70%
-	CL	30%

cq. C-17 Plastics

Although C-17, in chemical category, are high molecular of organic compound, plastics show stable chemical characteristics. Therefore it is considered that hazardous substances do not elute from disposed plastics (i.e. disposable at IL). It is assumed that all other than for recycling be directly disposed of at IL. Namely the ratios assumed are:

-	Recycle	25%
-	IL	75%

cr. C-18 Rubber

Although C-18, in chemical category, are high molecular of organic compound, rubber shows stable chemical characteristics. Therefore it is considered that hazardous substances do not elute from disposed rubber (i.e. disposable at IL). It is assumed that all other than for recycling be directly disposed of at IL. Namely the ratios assumed are:

-	Recycle	25%
-	IL	75%

cs. C-19 Textile and Leather

Since textile and leather mainly comprise organic content, it is assumed that all other than for recycling be directly disposed of at CL. Namely the ratios assumed are:

-	Recycle	50%
-	CL	50%

ct. C-20 Waste Similar to Domestic Waste

Since C-20 are mainly organic matter, it is assumed that all other than for recycling be directly disposed of at CL. Namely the ratios assumed are:

- Recycle 2%
- CL 98%

cu. C-21 Wood

Since C-21 are mainly organic matter, it is assumed that great majority of wood generated as ISW be recycled and all other than for recycling be directly disposed of at CL. Namely the ratios assumed are:

- Recycle 90%
- CL 10%

cv. C-22 Slag from Melting

Where if C-22 does not include heavy metals, it is inert and stable. Meanwhile it is possible that C-22 contains hazardous substances such as heavy metals. Therefore it is assumed that all other than for recycling be directly disposed of half at SCL as HW and half at IL as inert. Namely the ratios assumed are:

- Recycle 40%
- SCL 30%
- IL 30%

cw. C-23 Construction Waste

Since C-23 is a mixture of various waste such as concrete, bricks, sand, etc., great majority are inert but may be contaminated with certain amount of organic matter. Therefore, it is assumed that all other than for recycling be directly disposed at CL and IL according to the following ratios:

- Recycle 35%
- CL 15%
- IL 50%

cx. **C-24 Other Solid Waste**

Since C-24 (other solid waste) are such ISW that are not classified into above 23 categories, it is assumed that all other than for recycling be incinerated (and be transformed in to C-1, C-2) or directly disposed of at CL or IL.

-	Recycle	1%
-	Incineration	9 %
-	C-1	0.9%
-	C-2	0.9%
-	CL	45%
-	IL	45%

cy. **Summary of Treatment/disposal Flows Assumed for 24 Categories**

Treatment/disposal flows assumed for above 24 ISW categories are indicated by ratios (shown in Table K.3.1d). Respective treatment/disposal amount in total in 2010 are summarized in Table K.3.1e and Figure K.3.1a 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							Change to other type waste						Waste Water Treatment	Landfill			Total
							Dehydration			Treatment	No.1		No.2		No.3						
				Solidification	Neutralization	Chemical	Non-Hazad.	Hazardous	Incineration	Ratio	TW	Ratio	TW	Ratio	TW	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%

Table K.3.1e Treatment and Disposal Amount Estimated for 24 ISW Categories in 2010

unit : ton/year

Type of Waste	Generation Amount	Total Input Amount	Recycling Amount	Treatment or Disposal Amount	Intermediate Treatment Amount							Disposal Amount					
					Solidification	Neutralization	Chemical	Dehydration Non-Hazad.	Dehydration Hazardous	Incineration	Total	Waste Water Treatment Non-Hazad.	Waste Water Treatment Hazardous	SCL	CL	IL	Total
C-1	13,437	14,359.3	5,743.7	8,615.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0			4,307.8	2,153.9	2,153.9	8,615.6
C-2	41,371	42,293.3	16,917.3	25,376.0	10,573.3	0.0	0.0	0.0	0.0	0.0	10,573.3			10,573.3	10,573.3	4,229.3	25,375.9
C-3	309,879	334,020.1	6,680.4	327,339.7	0.0	0.0	0.0	300,618.1	26,721.6	0.0	327,339.7	100,206.1	8,906.9	17,814.7	100,206.0	100,206.0	327,339.7
C-4	6,585,469	6,599,307.1	131,986.1	6,467,321.0	0.0	0.0	0.0	4,619,515.0	1,847,806.0	0.0	6,467,321.0	4,311,547.0	1,724,618.7	123,187.3	263,972.7	43,995.3	6,467,321.0
C-5	395	395.0	0.0	395.0	197.5	0.0	0.0	0.0	0.0	0.0	197.5			197.5	0.0	197.5	395.0
C-6	21,178	21,178.0	9,530.1	11,647.9	0.0	11,647.9	0.0	0.0	0.0	0.0	11,647.9			0.0	0.0	0.0	0.0
C-7	3,055	3,055.0	763.8	2,291.2	0.0	2,291.3	0.0	0.0	0.0	0.0	2,291.3			0.0	0.0	0.0	0.0
C-8	679	679.0	271.6	407.4	0.0	0.0	0.0	0.0	0.0	407.4	407.4			0.0	0.0	0.0	0.0
C-9	4,118	4,118.0	1,647.2	2,470.8	0.0	0.0	0.0	0.0	0.0	2,470.8	2,470.8			0.0	0.0	0.0	0.0
C-10	30,392	30,392.0	0.0	30,392.0	3,799.0	0.0	15,196.0	0.0	0.0	0.0	18,995.0			3,799.0	7,598.0	3,799.0	15,196.0
C-11	9,786	9,786.0	0.0	9,786.0	0.0	0.0	4,893.0	0.0	0.0	2,446.5	7,339.5			0.0	1,223.3	1,223.3	2,446.6
C-12	5,268	5,268.0	1,317.0	3,951.0	0.0	0.0	3,951.0	0.0	0.0	0.0	3,951.0			0.0	0.0	0.0	0.0
C-13	277,927	277,927.0	222,341.6	55,585.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0	55,585.4	0.0	55,585.4
C-14	159,047	159,047.0	31,809.4	127,237.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0	0.0	127,237.6	127,237.6
C-15	68,817	68,817.0	61,935.3	6,881.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0	0.0	6,881.7	6,881.7
C-16	134,543	134,543.0	94,180.1	40,362.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0	40,362.9	0.0	40,362.9
C-17	31,626	31,626.0	7,906.5	23,719.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0	0.0	23,719.5	23,719.5
C-18	19,049	19,049.0	4,762.3	14,286.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0	0.0	14,286.8	14,286.8
C-19	11,418	11,418.0	5,709.0	5,709.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0	5,709.0	0.0	5,709.0
C-20	60,675	60,675.0	1,213.5	59,461.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0	59,461.5	0.0	59,461.5
C-21	135,182	135,182.0	121,663.8	13,518.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0	13,518.2	0.0	13,518.2
C-22	13,310	13,310.0	5,324.0	7,986.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			3,993.0	0.0	3,993.0	7,986.0
C-23	8,600	8,600.0	3,010.0	5,590.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0	1,290.0	4,300.0	5,590.0
C-24	60,668	60,668.0	606.7	60,061.3	0.0	0.0	0.0	0.0	0.0	5,460.1	5,460.1			0.0	27,300.6	27,300.6	54,601.2
	8,005,889	8,045,712.8	735,319.4	7,310,393.4	14,569.8	13,939.2	24,040.0	4,920,133.1	1,874,527.6	10,784.8	6,857,994.5	4,411,753.1	1,733,525.6	163,872.6	588,954.8	363,523.5	7,261,629.6

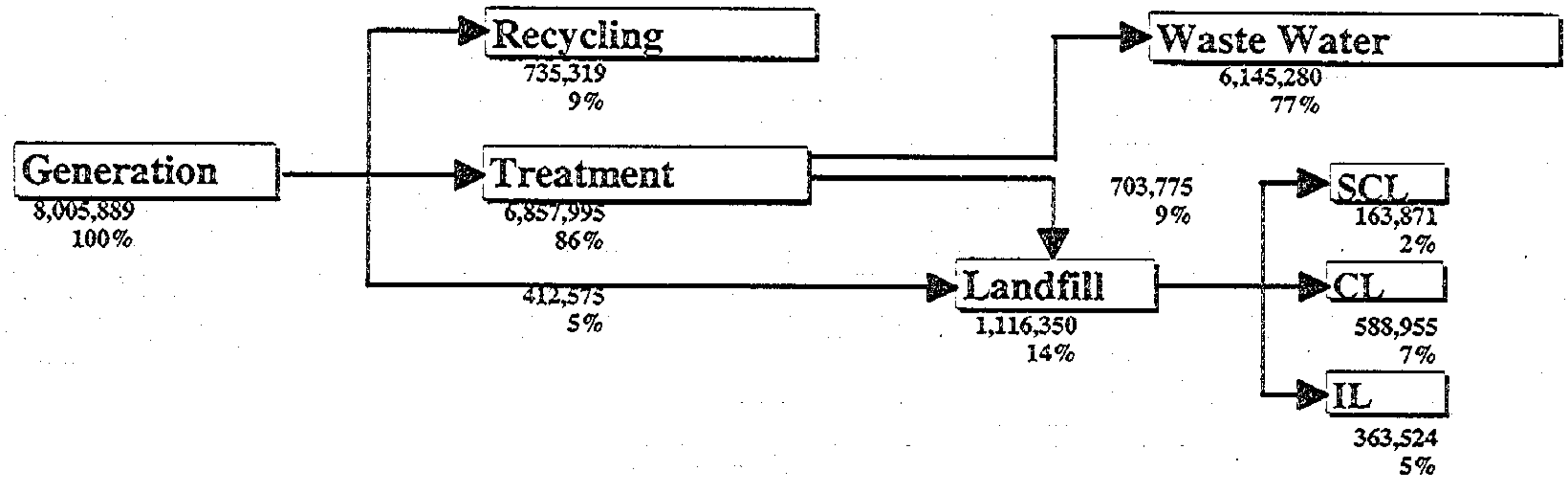


Figure K.3.1a Assumed ISW Flow in 2010