CHAPTER 2

LITERATURE REVIEW

2.1 Previous Works

Disathien (1992) identified the potential site in Saraburi Municipality for waste disposal sites. The criterion covered eight physical factors, i.e., slope, covered soil, soil permeability, soil depth, geology, groundwater level, surface runoff and landuse, and other relevant factors, i.e., road, railways, rivers, canals, distance from municipality and solid waste collection cost.

Mungkung (1992) evaluated preliminary environmental geology for regional planning in Changwat Chachoengsao e.g. future land development, agriculture area, and conservation area. The results of study, he divided future land development areas into 4 categories including housing/residential area, industrial estates, waste disposal area/site, and conservation areas.

Van der Wall and others (1992) selected domestic waste disposal sites in hilly surrounding of the Batujajar and Bandung Plains. The site selection is based on a scheme, which consists of four steps. Step I, the negative/positive –mapping included parameters of the natural environment, landuse and geology, hydrogeology are considered. The second, economic parameters are considered. Then, in Step III, a screening of the information and a description of the site are observed in field observation. The last, the remaining sites fulfilling the minimum demands for a suitable waste disposal site plus additional five sites, which were found during the field observation were rated by Modified German Standard, which was created by considering the specific Indonesia conditions, for example in climate and landuse/infrastructure.

Boonlue (1998) selected and investigated potential areas for sanitary landfill, which lifespan is at least twenty years. Solid waste is generated from seven sanitaries of Amphoe Mae Chan, Amphoe Mae Sai, and Amphoe Chiang San. The physical parameters included geology, topography, soil characteristics, water resources, hydrogeology, landuse, forest use, etc. are considered. Consequently, selected potential areas were selected from physical parameter consideration. Then, a weight-rating technique to find out select the highest score which could be a potential area to site investigation. Finally, semi-detailed site investigation was performed.

Kerdput (1999) selected potential areas for sanitary landfill in Pathum Thani province. Overlay technique and weight rating system were employed in identifying the potential areas. Solid waste defined under her study is only domestic waste, which will be generated in the next ten years. The physical parameters included the topography, soil characteristics, geology, water resources, hydrometeorology, administration, and transportation. In addition, landuse and urban planning of the Pathum Thani province are considered.

2.2 Sanitary Landfill Definition

2.2.1 Solid Waste Definition

Solid waste is any solid material in the material flow pattern that is rejected by society (Pfeffer, 1992).

2.2.2 Solid Waste Sources

2.2.2.1 Domestic/Residential Solid Waste

This category of waste includes the rejected solid material that originates from single- and multifamily household units.

Garbage. This type of residue results from food marketing, preparation, and consumption in relationship to residential units (Pfeffer, 1992).

Rubbish/trash. This category consists of paper and paper products, plastics, cans, bottles, glass, metals, ceramics, dirt, yard, and garden waste, and the like. Except for the yard and garden waste, these materials are nonputrescible (Pfeffer, 1992).

Ashes. This type of waste is the residue from any combustion process (i.e., fireplaces, wood or coal heating units, etc.) resulting from household activities (Pfeffer, 1992).

Bulky waste. This category includes furniture, appliances, mattresses and springs, and similar large items. Because of the size and weight of these items, it is usually not possible to collect them using normal collection equipment (Pfeffer, 1992).

2.2.2.2 Municipal Solid Waste

This category includes the solid residue that results from the municipal functions and services. These waste is of a nature that require special collection, and in some cases, special processing.

Street refuse. This material results from Normal Street cleaning operation, including street sweepings and catch basin cleaning. It is primarily inorganic, containing a considerable percentage of sand, grit, and dirt (Pfeffer, 1992).

Dead animals. It is the responsibility of the municipality to remove large dead animals, either wild or domesticated, from the streets (Pfeffer, 1992).

Abandoned vehicles. It is common practice in some areas of a community simply to remove the license plate from an old automobile and abandon it on the street (Pfeffer, 1992).

Water and sewage plant residues. In all urban areas, disposal of sludge resulting from treatment of water and wastewater must be properly conducted (Pfeffer, 1992).

Park and beach refuse. This is the typical refuse generated by users of these facilities: cans, bottles, paper, and plastic. Also, there may be quantities of landscape waste resulting from maintenance of the vegetation and trees (Pfeffer, 1992).

Landscape waste. In most cities, an arbor department has the responsibility for maintaining trees and areas in the parkways of streets and other public lands (Pfeffer, 1992).

2.2.3 Sanitary Landfill Methodology

Landfilling is the term used to describe the process by which solid waste and solid waste residuals are placed in a landfill. A Sanitary landfill is a solid waste disposal facility wherein refuse is placed at the greatest possible density (in the smallest possible space) for final deposition; no open burning, no water pollution, and daily cover of deposited refuse with earth are requisites of the method (Pavoni and other, 1975).

2.2.3.1 Definition of Terms

According to Kreith (1994), the general features of a sanitary landfill are illustrated in Figure 2.1. Some terms commonly used to describe the elements of a landfill are described below. The term *cell* is used to describe the volume of material placed in a landfill during one operating period, usually one day (see Figure 2.1b). A cell includes the solid waste deposit and the daily cover material surrounding it. *Daily cover* usually consists of 6 to 12 in of native soil or alternative materials such as compost, foundry sand, or auto shredder fluff that are applied to the working faces of the landfill at the end off each operating period. A *lift* is a complete layer of cells over the active area of the landfill (see Figure 2.1b). Typically, landfills comprise a series of lifts. A *bench* (or terrace) is typically used where the height of the landfill will exceed 50 to 75 ft. Benches are used to maintaining the slope stability of the landfill, for the placement of surface water drainage channels, and for the location of landfill gas recovery piping. The final lift includes the *landfill cov*er layer. *Landfill liners* are materials (both natural and man-made) that are used to line the bottom area and below-grade sides of a landfill (see Figure 2.1a). Liners usually consist of successive layers of compacted clay and/or geosynthetic material designed to prevent migration of landfill leachate and landfill gas. The final landfill cover layer is applied over the entire landfill surface after all landfilling operations are complete (see Figure 2.1c). Landfill cover consists of successive layers of compacted clay and/or geosynthetic material designed to prevent the migration of landfill gas and to limit the entry of surface water into the landfill. The liquid that forms at the bottom of a landfill is known as *leachate*. *Landfill gas* is the term applied to the mixture of gases found within a landfill. The bulk of landfill gas consists of methane

(CH_4) and carbon dioxide (CO_2), the principal products of the anaerobic biological decomposition of the biodegradable organic fraction of the MSW in the landfill. *Environmental monitoring* involves the activities associated with collection and analysis of water and air samples used to monitor the movement of landfill gases and leachate at the landfill site. *Landfill closure* is the term used to describe the steps that must be taken to close and secure a landfill site once the filling operation has been completed. *Postclosure care* refers to the activities associated with the long-term maintenance of the completed landfill (typically 30 to 50 years). *Remediation* refers to those actions necessary to stop and clean up unplanned contaminant releases to the environment.

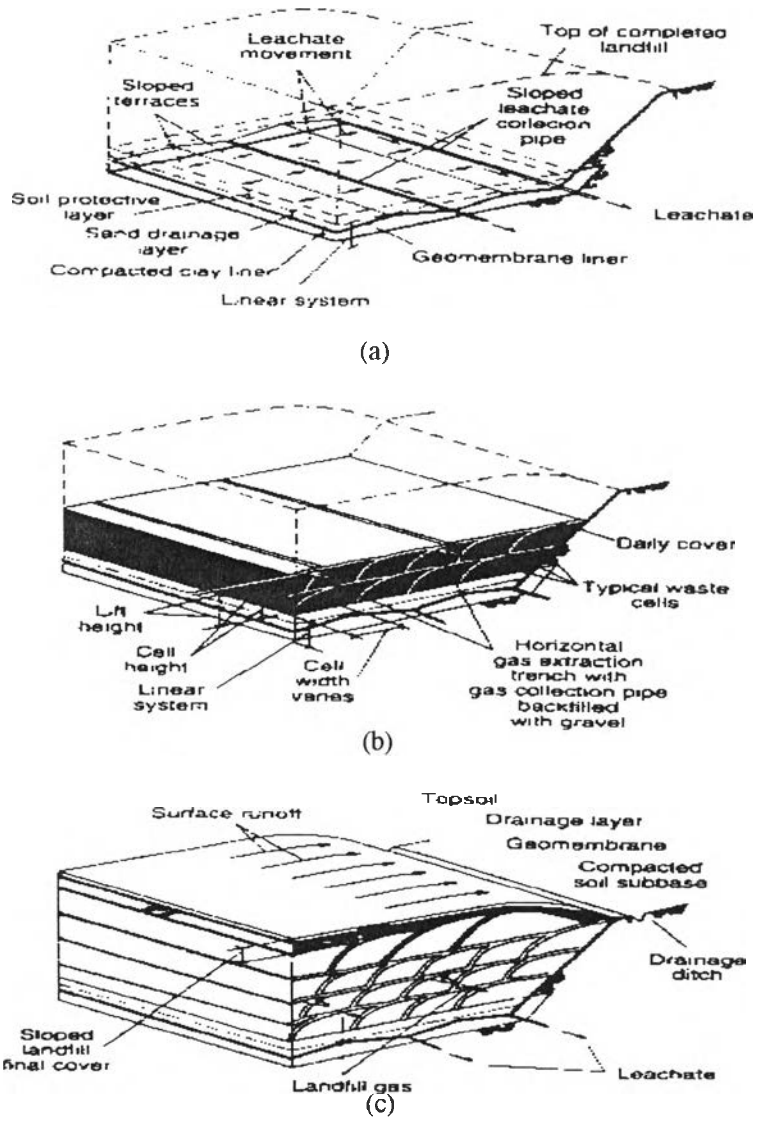


FIG. 2.1 THE GENERAL FEATURES OF A SANITARY

(After Kreith, 1994)

2.2.3.2 Landfill Method

According to Pavoni and other (1975), the technique of sanitary landfilling, which is everywhere generally the same. There are two variations in refuse placement currently used in the United States: the trench method, and the area method, which are described as below.

In *the trench method of sanitary landfilling*, a long narrow excavation is made in the earth and the soil removed from this excavation to stockpiled. Waste is then deposited at the end of the excavation on a sloped end of the trench. The refuse is spread on a rather shallow inclination (usually about 3 horizontal to 1 vertical) and is then compacted by the placement/compaction equipment used at the site. At the end of the day's operation, the compacted layers of refuse are covered with a layer of soil taken from the stockpile of material removed in the original excavation. When the entire trench has been filled with refuse, a thicker final cover layer is placed over the completed deposit of refuse. The trench method is most suitable for sites where the groundwater table is at significant depth and where there is a deep layer of suitable cover soil. Generally, the trench method of landfilling is also most suitable where the site topography is rather regular (see Figure 2.2). In *the area method of sanitary landfilling*, in contrast to the trench method, refuse is dumped on an undisturbed existing ground surface; the only prior operation in the area method landfill may be surface removal of the top soil and highly organic material (humus) suitable for final cover. After refuse is dumped from collection and transportation vehicles, it is spread over the ground surface in a uniform layer and then compacted to a higher density. The compacted layer of refuse is covered with soil at the end of an operational day or when the deposition area is filled, a final cover layer of greater thickness is placed over the completed fill. Generally, in area-method landfills, the cover soil is transported onto the site from another location. The area method is used where the groundwater table is at or near the surface and on sites where the terrain is rough and irregular (see Figure 2.3). *The ramp method* is a hybrid technique combining features of both trench and area methods of landfilling. Before refuse deposition is begun, a small excavation is made in front of the proposed face on an existing slope. The soil removed in this excavation is stockpiled nearby. Refuse is then deposited on the face of the slope, spread and compacted by standard landfilling equipment, and then covered with the soil which had been stockpiled from the preceding excavation (see Figure 2.4).

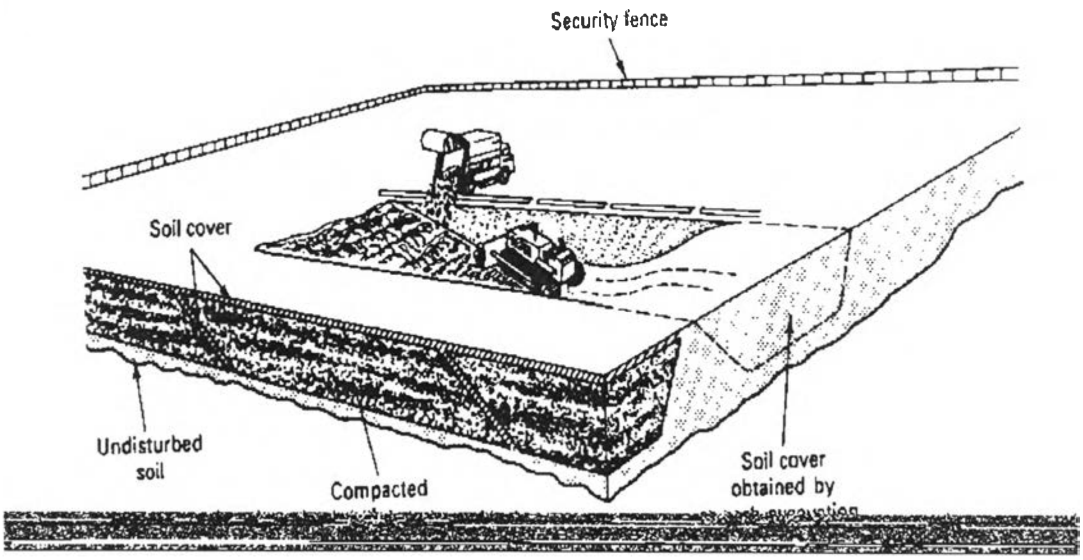


FIG. 2.2 TRENCH METHOD

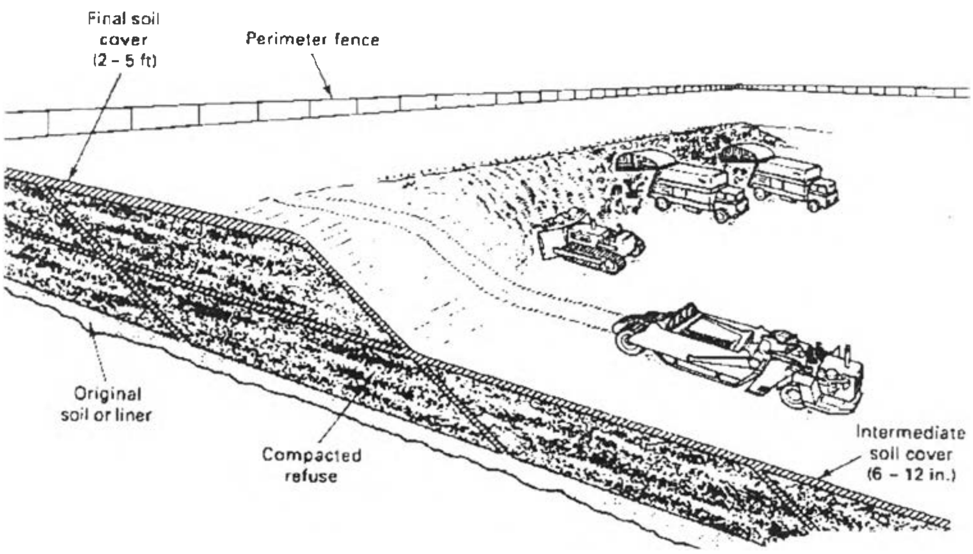


FIG. 2.3 AREA METHOD

(After Pavoni and other, 1975)

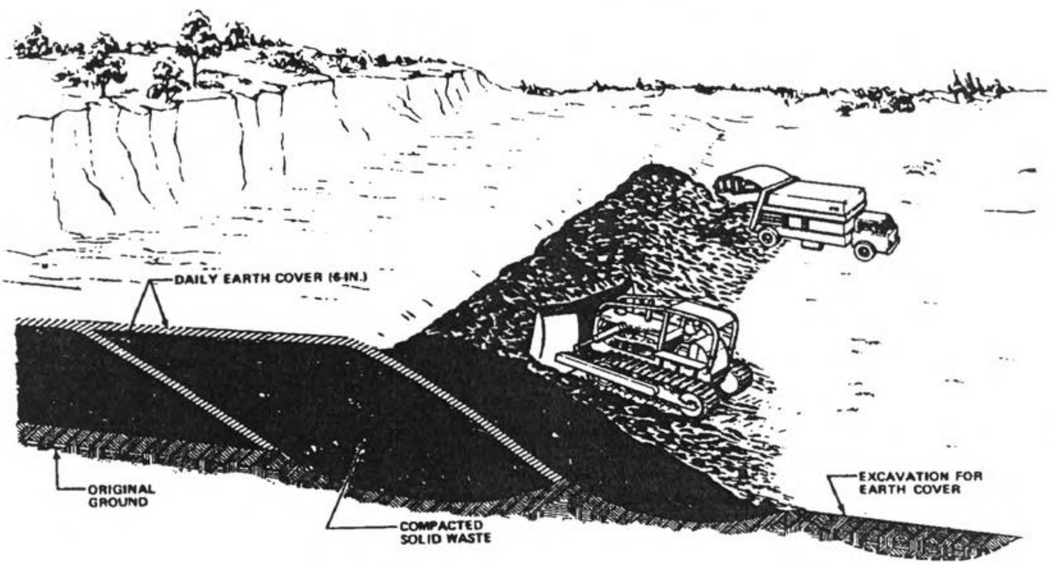


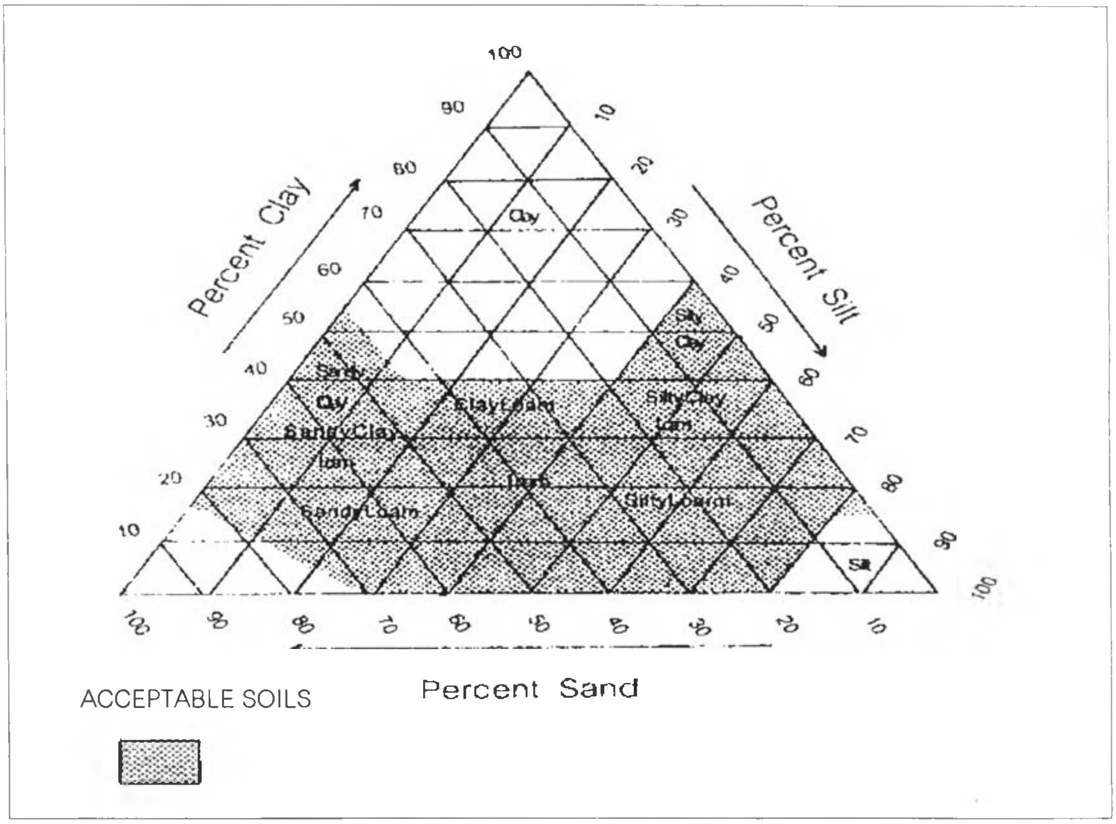
FIG. 2.4 RAMP METHOD

(After Pavoni and other, 1975)

2.2.3.3 Cover Material

The presence of suitable cover material at a particular site is much to create an efficient landfilling operation; if it is necessary to import cover soil from a source area outside the close environs of the landfill site, high transportation costs will be incurred. However, the quality of the available cover soil is just as important as is its quantity. The characteristics of a desirable cover material are easy workability, moderate cohesion, and significant strength. To fulfill these requirements, the most suitable cover soil is mixture of sand, silt, and clay. Generally, a sandy loam is a very desirable cover material. Clean sands are somewhat unsuitable for cover material since they are readily permeable and allow large quantities of water to invade the deposited refuse. Fine-grained soils such as clays and silts are not ideal cover materials because of their difficulties in working on. Noble (1976) proposed the ternary diagram to shows the soils suitable for cover material as shown in Table 2.1. Cover soil for sanitary landfill to control surface infiltration, discharge of the leachate through seepage and groundwater.

Table. 2.1 Ternary Diagram Showing Soils Suitable for Cover Material



(After Noble, 1976)

2.2.3.4 <u>Landfill Base Liners</u>

The United Nations Environment Programme (UNEP) and other organization (1993) suggested that a composite liner consists of a clay liner with an addition synthetic membrane liner (thickness $\geq$ 2.5 mm). The synthetic liner should be installed in an overlapping manner. Figure 2.6 shows basement layer system as specified in Germany.

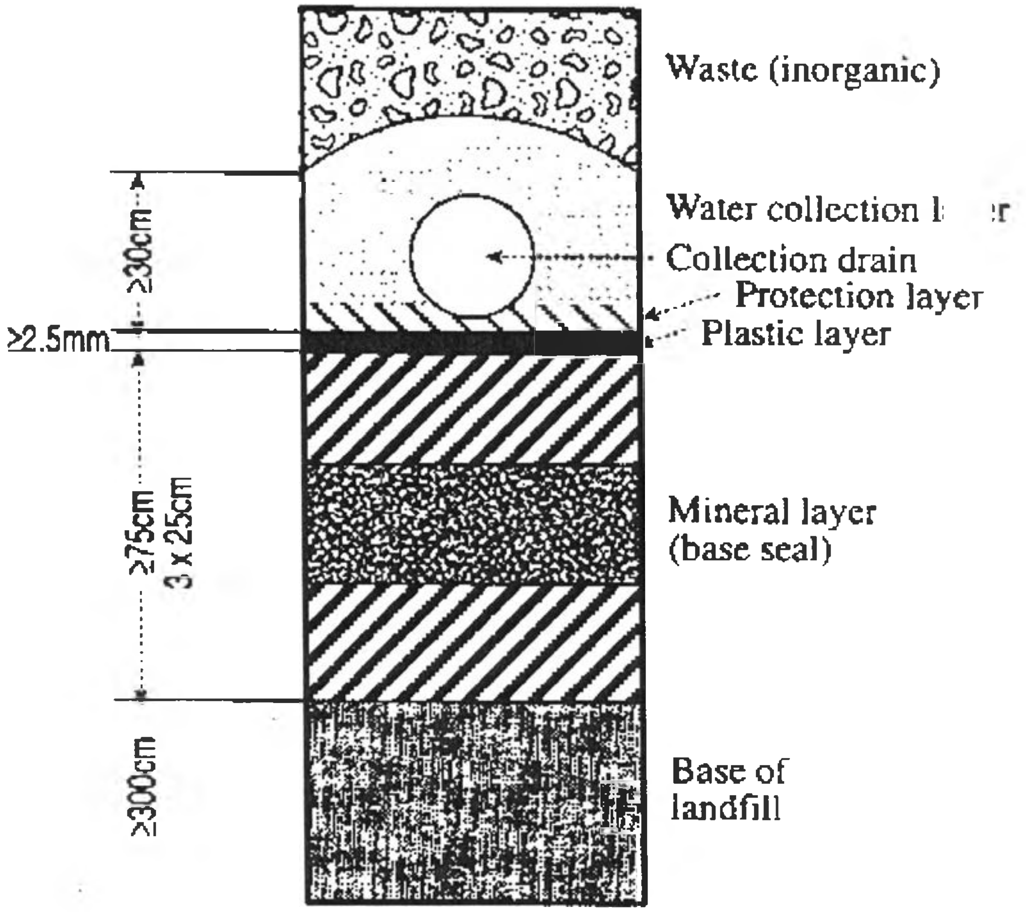


FIG.2.5 BASEMENT LAYER SYSTEM (GERMANY)

(After UNEP, 1993)

2.3 Standard and Criteria Consideration

2.3.1 Positive Criteria Consideration

Van der Wall and other (1992) explained some general demands for a proper delineation of areas suitable for waste disposal siting:

- permeability of natural underlining $\leq 10^{-7}$ m/s,
- thickness of natural underlining (sediment) ≥ 5 m,
- thickness of natural underlining (hard rock) ≥ 20 m, and
- distance from groundwater table to ground surface ≥ 2 m.

According to these sources the following sediments had been claimed as favorable for waste disposal sites since their low permeability enables them to act as a geological barrier against contamination transport:

sediments;

- fine-grained loose sediments, especially mixtures of clay and silt with less parts of sand, marl,
- claystone and unfissured sandstone

hardrocks;

- unfissured magmatic rocks,
- weathered hardrocks with a high content of clay

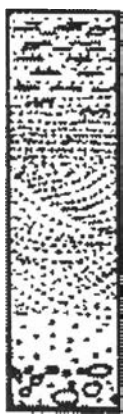
Testa (1994) summarized characteristic of sediment, which are shown in Table 2. and presented the influence of sequence of rock textures and structure in a reservoir consisting of a single point bar deposit on horizontal permeability excluding effects of diagenesis as shown in Figure 2.7. Relationship between sediment type and permeability in Table 2, and lithology of rock and horizontal permeability in Figure 2.7 were applied for physical and geological evaluation in the present study (see Appendix-B.1-B.3).

Table 2.2 Summary of Deltaic Sequences and Characteristics

Sequence	Sediment Type	Permeability
Marsh	Clay, silt, coal with a few reservoir sands of limited extent	Relative low
Inner bar	Sand with some clay/silt intercalations	Moderate to high
Outer bar	Sand with many clay/silt intercalations	Moderate
Prodelta	Clay and silt	Low
Marine	Clay	Low

(After Testa, 1994)

POINT BAR MODEL



ROCK	STRUCTURE	HORIZONTAL PERMEABILITY
- siltstone, very fine grained, muddy sandstone.	horizontal lamineae, ripple bedded.	very low
- silty, fine grained sandstone, poorly sorted.	ripple bedded. Parallel bedded.	low to moderate
- fine to medium grained sandstone, well sorted.	cross bedded	moderate to high
- medium to coarse grained sandstone and conglomerate, poor to moderate sorting.	massive or cross bedded.	low to moderate

FIG. 2.6 POINT BAR GEOLOGIC MODEL

(After Testa, 1994)

2.3.2 Negative Criteria Consideration

The sanitary landfill needs controlling and preventing environmental impacts in the long term. The following criteria are important for design, consideration, and operation of landfill.

Land requirement. It is important ensure that sufficient land area is available. It is negative criteria to operate for lifespan less than 20 years.

Slope. The suitable slope is 1-2% for drainage system and should not be over 6%. (Cited in Disathien, 1992). And According to Disathien (1992) who classified slope range into three classes, which include less than 8% of Good class, between 8-20 % of Medium class, and more than 20% of Poor class. Consequently, in the present study, slope more than 20 % is non-suitable area for sanitary landfill.

Intensive areas and urban areas. The site located less than 5 kilometers from intensive areas and urban areas (Kerdput, 1999).

Transportation. The site located less than 300 meters from main road (Disathien, 1992).

Watershed. The site located within the watershed area class 1A, class 1B, and class 2 (Pollution Control Department; PCD, in thai,1998).

Water resource. The site located far from natural water resources including wetland, man-made water body less than 300 m (PCD, 1998).

Groundwater. The site that base of landfill exists less 1.5 m above the highest anticipated groundwater table (Boonlue, 1998).

Groundwater well and water supply station. The site located far from less than 700 m (PCD, 1998).

Historical and archaeological area. The site located far from ancient remains boundary further less than 1 km (PCD, 1998).

Industrial facilities. The site located within Industrial facilities land (Boonlue, 1998).

Forest. The site located within forest-conservation type area (Boonlue, 1998).

Mineral resources. The site located within mineral resources (Boonlue, 1998).

Fault zone. The site located far from active fault less than 500 m (Boonlue, 1998).

Expected well yield of water bearing rocks. The site located within the area, which expected well yield values ≥ 5 m^3.

In the present study, these negative criteria were bounded for negative map that non-suitable area for sanitary landfill (see chapter 4.2.2.2).