Water and Waste Department • Service des eaux des déchets

STANDARDS AND GUIDELINES FOR THE MITIGATION OF METHANE GAS AT BUILDINGS AND UTILITIES

- AND -

GUIDELINES FOR CONSTRUCTION ON LANDFILL SITES

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SECTION I:

1. STANDARDS FOR MITIGATION OF METHANE GAS IN EXISTING BUILDINGS

Methane gas is a colourless, odourless, lighter than air gas. **Methane gas is explosive in a concentration range of 5% to 15% by volume in air in the presence of a source of ignition**. The lower explosive limit (L.E.L.) for methane gas is therefore 5% by volume concentration in air. A methane gas concentration described as 50% L.E.L. (50% of the lower explosive limit) is therefore a concentration of 2.5% methane gas by volume in air.

The current standard of when measures are required to mitigate methane gas infiltration into a building is when a concentration of 1% methane gas (20% L.E.L.) is encountered consistently at any point source within a building. This is generally referred to as a **"take action level"**. A point source is a measurement obtained at a floor crack, floor joint, floor drain, column base, utility access penetration, base grade crack or pile base.

"Consistently", for this purpose is determined to be a majority of monthly methane gas measurements over a period of one year being at or greater than 20% of the lower explosive limit (20% L.E.L., or 1% methane gas in air by volume).

The "take action level" set at a maximum concentration of 1% methane gas in air by volume (20% L.E.L.) (20% of the lower explosive limit for methane) allows a safety factor of 5.

A mid-air measurement of any concentration of methane gas is cause for immediate concern and assessment. A mid-air measurement is a measurement obtained in the mid-air usually at a height of 1.5 metres (4 to 5 feet) above the floor. The response to a mid-air measurement of methane gas is detailed in the "Procedures Regarding Explosive Gas Conditions in Buildings", which follows. It outlines the responsibilities of City departments and the personnel involved in the resolution and mitigation of methane gas concentrations within the building. The policy allows for individual interpretation of site specific conditions related to the building, but still establishes an action level that has a safety factor with respect to explosive concentrations. **As indicated, the detection in mid-air of a concentration of methane gas at or greater than 0.25% methane in air by volume (5% of the lower explosive limit) will be considered as an "alarm" situation.**

The "alarm" situation set at a maximum concentration of methane gas in mid-air of 0.25% methane gas in air by volume (5% L.E.L.) (5% of the lower explosive limit for methane) allows a safety factor of 20.

2. PROCEDURES REGARDING EXPLOSIVE GAS CONDITIONS IN BUILDINGS

If during monitoring of existing buildings on or adjacent to landfills an inspector designated by the Solid Waste Services Division, Water and Waste Department, of the City of Winnipeg encounters dangerous gas conditions, (as later defined herein), the following steps will be followed:

1) The inspector will advise the occupant of the building to vacate the premises until safe conditions are restored. If there are any obvious measures that can be quickly employed to lessen the hazard such as shutting off sources of ignition and providing extra ventilation by opening doors and windows, the occupant will be advised accordingly.

2) The inspector will telephone in an alarm (dial 911), identifying himself as an inspector for the Solid Waste Services Division monitoring for methane gas in buildings, and provide description and location of the subject building. Note that on receipt of a call, the alarm operator will transmit a “telephone alarm” and dispatch a full complement of Fire Apparatus.

3) The inspector will remain at the site until arrival of the Fire Department and will remain with the dispatched unit as required or until the situation has been rectified. The Fire Department will assist in the possible evacuation and ventilation of the dangerous area and remain on the scene until the emergency situation is over and conditions are stabilized.

4) If the situation warrants such action, Fire Communications personnel will attempt to contact the Manager of Development & Inspections, currently Mr. Deepak Joshi (986-5104), or other members of the Development and Inspections Division. During an emergency situation, Development and Inspections Division staff will be available to provide whatever advise or assistance that may be needed. In any event, the Fire Prevention Branch will notify the Development and Inspections Division of the incident upon receipt of the normal Fire Alarm reports. The Solid Waste Services Division will report their findings to the Development and Inspections Division as soon as possible.

5) If the condition cannot be alleviated, the building will remain vacated. If the situation is stabilized, the Solid Waste Services Division will test the premises on a daily basis or as required thereafter until long term protection is provided. Once the Development and Inspections Division is made aware of a hazardous situation they will likely issue an order to the owner to carry out whatever measures are necessary to safeguard the building. The Development and Inspections Division will also do the follow up to ensure that any remedial works were properly designed and installed.

DANGEROUS GAS CONDITIONS

Although 20% of the lower explosive limit (or 1% methane by volume in air) is the maximum acceptable standard currently employed for action to be taken, the alarm level will be at the discretion of the inspector in that there may be other pertinent considerations. In general, a maximum concentration of 5% of the lower explosive limit for methane (or 0.25% by volume in air) will be considered as an alarm situation if this concentration is encountered at mid-air level (in ambient air) within a portion of a building.

3. GUIDELINES FOR MITIGATION OF METHANE GAS IN EXISTING BUILDINGS

When methane gas mitigation measures are required as per previous standards, the approach would be to evaluate the situation on a site specific basis. The site specific approach allows for the consideration of site conditions & features, building construction & foundation, and methane generation or migration potential.

Any mitigation measures to be incorporated into the site or building will be to the satisfaction of the City of Winnipeg; Planning, Property & Development Department; Development and Inspections Division.

Mitigation measures may be in the form of the following techniques:

1) Sealing of floor cracks, breaks and joints.

   The floor cracks, breaks, and joints can be sealed with a variety of elastomeric compounds that prevent the infiltration of methane gas into the building.

2) Under slab venting

   Under slab venting may be a suitable mitigation measure and may be in the form of the following:

   a) a passive venting system, or
   b) an active venting system with or without a methane gas detection system.

3) Perimeter cut-off trench

   A number of design options are available for the installation of a perimeter cut-off trench around a building or site. The trench may include membrane technologies, collection systems, and either passive or active ventilation systems.

4) Under slab membranes

Described as modified slab-on-grade foundation design, the methane mitigation method employs the use of specially engineered membranes and collection systems under the floor slab to preclude methane gas from infiltrating the building. This technique can also be used to mitigate infiltration of methane gas into a crawl space.

All the mitigation measures above require monitoring and maintenance programs to ensure the integrity of the design and installation. The program is to be to the satisfaction of the Development and Inspections Division.

SECTION II:

A. POLICIES:

1. CITY OF WINNIPEG POLICY FOR BUILDING ON LANDFILL SITES

Buildings on landfills are allowed subject to compliance with the following conditions:

1. The elevation of the lowest part of the floor structure shall be a minimum of 750 mm above finished grade level.

2. The underside of the structural floor slab shall be free of obstructions to allow free air movement under the building. Vertical piles and shear walls shall be permitted provided they do not substantially obstruct air movement. The underside of the floor slab shall be free from pockets which may accumulate methane gas.

3. A minimum unpaved clear space of 100 percent of the building area shall be maintained equally around all sides of the building to allow for free venting and air movement around the building. Where paving is necessary for access to the building only, the clear space shall be increased by the amount of paved area. Also, the building shall be located in consideration of any existing structures, pavement or operations at the site to prevent obstruction of free venting and air movement under and around new or existing buildings.

4. Underground building services entering the building through the floor slab shall be isolated to prevent any transmission of methane gas through the slab, or within the service lines themselves.

5. Safety procedures during any excavations for the building or services shall be in accordance with the City of Winnipeg, Works and Operations, Standard Construction Specifications, Provisions CW 1100 23. In addition, water shall be added during augering for piles to prevent heating and ignition of combustibles in the fill.

6. The building and underground services shall be designed by a qualified registered engineer. The design of the building and services shall consider the chemical and physical effects of fill materials present at the site on the integrity of the building and services.

7. Twice a year, or at times satisfactory to the Manager of Development & Inspections, the owner shall submit a report to the said Manager, by a qualified registered engineer, certifying
   (a) that the structure and underground services have been tested for methane gas,
   (b) that the structure and underground services have been examined structurally, and
   (c) that venting and free air movement is being maintained under and around the

structure in accordance with conditions 1, 2, and 3. The report shall state whether the structure and services are performing as designed. In the event the results of testing and/or inspections indicate unsatisfactory conditions, the report shall set out the recommended remedial measures.

8. The owner shall execute any legal documents required by the City Solicitor.

Policy adopted by Council - December 19, 1984.

2. POLICY FOR BUILDING ON NAIRN-ELMWOOD LANDFILL SITES

Building permits on the Nairn - Elmwood landfill sites are allowed subject to compliance with the following conditions:

a) An investigation of the subject site approved by the Water and Waste Department must be undertaken to determine the nature and extent of methane generating material.

b) If methane generating material is found, it must be removed from the subject site and replaced with an inorganic fill to the satisfaction of the Water and Waste Department.

c) Methane protective measures approved by the Planning, Property & Development Department must be incorporated in the design of buildings and services.

3. POLICY REGARDING BUILDING PERMITS ADJACENT TO LANDFILLS

Zones of Concern (also known as Control Zones) from the landfill boundary in the City of Winnipeg vary from either 15 metres, 45 metres, or 90 metres. Current interim policy regarding building permits within the Zone of Concern adjacent to landfill sites states:

That building permits within the Zone of Concern adjacent to landfill sites be granted where:

(a) Test results indicate that there does not appear to be significant amounts of gas, or
(b) Acceptable safety measures are incorporated where test results indicate significant amounts of gas are reaching the permit area.

The owner must execute any forms or documents, as required by the City Solicitor. The Standard Acknowledgement Form is a minimum requirement.

If the City's monitoring program is not in place at the particular site, the owner must also install and maintain for up to three years acceptable gas test probes and must grant the City access for testing.

B. STANDARDS:

1. DEVELOPMENT AND CONSTRUCTION OF BUILDINGS ON LANDFILL SITES

Landfill sites may represent an opportunity for development, especially in areas where available land surrounding the landfill site is significantly developed and has high real estate or commercial value. The development of landfill sites require that a number of factors be addressed. The most significant factors to be addressed are:

1) Landfill Gases

The most dangerous landfill gas to be considered is methane gas, which can build up to explosive levels. Other gases that are generated are carbon dioxide and hydrogen sulphide. Trace levels of volatile hydrocarbons such as benzene, toluene, and xylene may also be generated. Mitigation measures are required in the development of the site and buildings to preclude their infiltration into buildings and structures. Adequate precautions are also required during construction and these precautions may impact on standard construction practises.

2) Leachate

The fluid in the landfill site known as leachate must be controlled to eliminate build up and "break-out" seepage, and percolation into ground water aquifers . Leachate is considered to adversely impact the environment. Leachate is also considered to have adverse impacts to health. Leachate may also be corrosive to structures and materials. Adequate precautions are to be implemented in the development and construction on landfill sites which address the adverse impacts presented by leachate.

3) Settlement

The settlement of landfills must be considered in the design of foundations and structures on landfills. The differential settlement and the unpredictability of settlement must be considered in the design and construction of access roads, utilities, light standards, parking lots, land use, land drainage, and in the long term maintenance and cost.

4) Final Cover Material and Grading

The final cover material and grading must be designed to maintain the cover integrity. Cover materials that promote infiltration are undesirable. Surfaces that are too steeply graded are subject to erosion. Steep grades are also subject to slope failures. Surface drainage that results in water accumulation and "ponding of water" must be avoided.

5) Vegetation

Careful selection of trees, shrubs, and ground covers is required to ensure that roots do not penetrate the landfill cap (clay cover) and increase its permeability. The vegetation must also tolerate the stresses of landfill gases. Some trees may require protective measures for landfill gases. Other vegetation may require enhanced nutrient soils (compost & fertilizer). Properly planned vegetative cover can assist in controlling surface erosion and infiltration. Phytoremediation can also used to treat landfill leachate

Safety is the prime objective. Ongoing surveillance and maintenance of the site is necessary in order to monitor any changes and identify any potential problems.

2. STANDARDS FOR CONSTRUCTION ON LANDFILL WASTE

POLICY - The City policy for Building on Landfill Sites requires that elevated construction must be used for enclosed buildings overlying waste, such that the lowest part of the floor is a minimum of 750 mm above finished grade level. Other conditions required include free air access under the building, venting around the building, measures to prevent methane transmission through underground services, safety measures during construction, evaluation of waste compatibility with structures, inspections, monitoring and legal arrangements.

A special policy applies to the Nairn and Elmwood Landfill sites, where random pockets of waste are spread out over a large area. At the Nairn and Elmwood sites, a property proposed for a building site must be investigated with a drilling program. If the methane generating material is found within the proposed building limits, the material must be replaced with inorganic fill. Methane protective measures must also be incorporated in the design of buildings and services.

IMPLEMENTATION - New buildings are required to use elevated construction. Other buildings previously constructed on waste are reviewed on a building specific basis with engineered gas controls, retrofit protective measures, and monitoring systems or programs.

3. STANDARDS FOR CONSTRUCTION ADJACENT TO LANDFILL WASTE

POLICY - Building permits are granted for construction in control zones adjacent to waste where test results indicate there does not appear to be “significant” amounts of gas in soil. Builders must drill or excavate to a radius equal to the control zone around their building to prove that there is no waste under the building. Where “significant” amounts of landfill gas are reaching the site, building permits may be granted, where acceptable safety measures are incorporated. If the City’s monitoring program is not in place at the particular site, the owner must also maintain acceptable gas probes and grant the City access for testing for 3 years. The City is also open to petition to reduce a control zone, subject to technical verification by the proponent.

IMPLEMENTATION - The policy does not specify a number for "significant" levels of gas. In practise, levels of methane greater than or equal to 20% LEL (1% methane in air) in the subsurface in the control zone are considered significant and would require building control measures. If levels are less than 20% LEL, an evaluation is done on a site specific basis based on the City's historical monitoring at the site and on a monitoring system set up by the proponent. A specified period of monitoring is not set, since landfill gas concentrations may vary widely with weather conditions. A three year period has been used in some cases.

4. NATIONAL BUILDING CODE OF CANADA 1995 SECTION 4.2.4.15. CONSTRUCTION ON FILL

4 . 2 . 4 . 15 . Construction on Fill

(1) *Buildings* may be placed on *fill* if it can be shown by *subsurface* investigation that:

a) the *fill* is or can be made capable of supporting the *building*,
b) detrimental movement of the *building* or services leading to the *building* will not occur, and
c) **explosive gases can be controlled or do not exist.**

Note also the previously used : MANITOBA BUILDING CODE 1992

SUBSECTION 4 . 2 . 4 DESIGN REQUIREMENTS

SECTION 4 . 2 . 4 . 15 . Construction on Fill

(1) *Buildings* may be placed on *fill* if it can be shown by *subsurface* investigation that:

a) the *fill* is or can be made capable of supporting the *design loads*,
b) detrimental movement of the *building* or services leading to the *building* will not occur, and
c) **explosive gases can be controlled or do not exist.**

There are areas in the City of Winnipeg that were investigated as landfill sites, but were not determined to be, and therefore, not designated as landfill sites. The investigations carried out at these sites showed no significant domestic refuse or commercial industrial type refuse disposal at these sites. In most cases the sites were "fill" sites - filled with a variety of fill materials described as construction demolition waste, concrete & stone rubble, "not so clean" fill, highly organic soil backfill, and clay fill. In terms of organic content, municipal landfill material contains 25 - 30%, typical Manitoba soils up to 12% in the top meter, and "fill" usually significantly lower than 10%.

The results of the Landfill Environmental Section investigation into these type of fill sites showed that when organic soils are subjected to the proper conditions for methanogen activity;

more specifically; warm, moist, anaerobic conditions; then methane gas is generated. These sites are not designated as landfill sites and the policies related to landfill sites are generally not applicable to these sites. The development of these sites and the construction of buildings on these sites is referenced in the building codes. The National Building Code of Canada 1995, Section 4.2.4.15 as presented above and the previously used Manitoba Building Code 1992 have specific reference to this situation.

The reference to explosive gases is directed at the production of methane gas in the organic fill and the requirement to include mitigation measures into the building design similar to the policies and recommended guidelines for the construction on landfills.

5. STANDARDS FOR LANDFILL GAS AT WASTE AND PROPERTY BOUNDARIES

POLICY - The lower explosive limit (LEL) of methane is 5% in air. City policy states that if gas concentrations immediately outside of the fill exceed 20% LEL (1% methane in air), gas barrier controls (with monitoring) are to be considered at the landfill. Where gas concentrations immediately outside the fill are less than 20% LEL, long term monitoring would be continued. Long term monitoring is necessary, since gas generation and migration can vary with weather conditions and soil disturbance, and because gas production is not to be reduced greatly in the foreseeable future (City of Winnipeg 1984).

IMPLEMENTATION - The City policy has been implemented as follows:

- Where the property boundary is beyond the waste boundary, the 1% methane standard applies at the property boundary instead of the waste boundary.

- Where no buildings exist beyond the property boundary, no controls are implemented. Probes have been drilled close to the waste boundaries first and then into the control zone. Barrier controls have been constructed at Kimberly Landfill and Margaret Park Landfill. Landfill gas management strategies have been developed for sites where methane is found beyond the waste boundary. These strategies include soil probe and building monitoring, reliance on natural barriers such as ditches and high water tables and engineering controls.

C. GUIDELINES:

1. DESIGN GUIDELINES FOR CONSTRUCTION ON LANDFILL SITES

The design guidelines for landfill site construction presented as follows are general in nature, and are meant to assist the owner, developer, and consultant in the interpretation of a site and how to best address the concerns related to landfill sites. The specifications are generic and are useful in developing construction drawings and construction specifications for your particular project. The methods and specifications presented here are not to be construed as policy and design approved by the City of Winnipeg. Site assessment and development plans must be accepted by the Solid Waste Division of the Water and Waste Department. Any methane protective measures incorporated into a building must be approved by the Development and Inspections Division of the Planning, Property and Development Department.

ACCEPTABLE METHODS OF CONSTRUCTION

A. ADJACENT TO LANDFILL SITES

1. Slab on grade (may require modification ie. membranes)
2. Traditional friction pile design
3. Gas migration infiltration shall be prevented by one of the following methods:
   a) elevated construction
   b) the interceptor vent trench
   c) membrane layer and collector system
   d) an intensive, approved monitoring program

B. ON LANDFILL SITES

1. Elevated construction (City of Winnipeg Policy)
2. Special conditions, alternatives to be considered
   a) Modified slab on grade construction (protective membranes) and all the refuse below the building removed. -- ie, Nairn - Elmwood Landfill site
   b) Gas infiltration prevented by one of the following methods:
      i) elevated construction
      ii) interceptor vent trench (gas barrier) may be used if refuse is completely removed behind the barrier trench.
      iii) an engineered, monitored, detection and ventilation system.
3. Note that for pile foundations, the thickness of the refuse layer must be deducted from the effective length of friction piles, and consideration given to preventing landfill fluids seeping around piles or into pile holes.

2. FOUNDATIONS FOR BUILDINGS ON LANDFILL

If the development of a landfill site includes the construction of buildings, then in addition to addressing all the other issues and policies related to development on landfills, consideration must be made in the construction and design of the buildings' foundation. Included in the Appendix are some examples of building foundations of a general nature that present the design objectives of construction on landfill sites. Each individual building foundation design must be examined on a site specific basis, and judged according to whether it addresses the landfill site hazards present, and meets the policies of the permitting authority. The permitting authority in the City of Winnipeg is the Development and Inspections Division of the Planning, Property & Development Department.

The examples presented in the Appendix include:

Figure 1 Construction of Buildings on Landfill - Elevated Construction
This figure shows a schematic of a building with a structural slab floor elevated on piles. Note that the services to the building are sealed against infiltration of landfill gases.

Figure 2 Construction of Buildings on Landfill - Slab-on-Grade Construction
This figure shows the schematic of a building with a slab-on-grade floor which has been modified to prevent the infiltration of landfill gases into the building. The modified slab-on-grade construction includes membranes, and a collection and venting system.

Figure 3 Design Guidelines for Landfill Site Construction
- Modified Slab-on-Grade Construction - Plan View
This figure shows the plan view of a collection and venting system.

Figure 4 Design Guidelines for Landfill Site Construction
- Modified Slab-on-Grade Construction - Cross-Section
This figure provides a cross-section view of this design, showing the placement of membranes, collection pipes, and granular fills.

Figure 5 Design Guidelines for Landfill Site Construction
- Modified Slab-on-Grade Construction - Cross-Section Detail
This figure shows the placement of membranes, collection pipe, and granular fills in more detail than Figure 4.

3. UTILITY TRENCHES AND SERVICES ON OR NEAR LANDFILL SITES

The development and construction of buildings or structures on or near a landfill site usually require utilities and services such as water, waste water sewers, land drainage sewers, hydro, and telephone. The installation and construction related to these services generally involve trenching and augering, and the installation of poles, transformers, switch boxes, catch basins, and manholes. All these utilities' installations must be designed to address the hazards related to landfill sites, mainly settlement and methane gas. The concern to address in design and installation with respect to methane gas is that:

1) methane gas may be present during construction,
2) the utility trench and/or conduit may create a corridor or pathway for significant gas migration to appurtenances or buildings, and
3) the utility facilities, ie. boxes, vaults, terminals, transformers, structures, posts, & conduits may accumulate concentrations of methane gas to explosive levels.

The placement of underground services and utility installations on landfill sites is not rcommended. Specific safety requirements both in design and during installation must be employed.

The area at the landfill boundary and beyond for specified distances (15, 45, & 90 meters), known as Zones of Concern, are usually where most utility and service installations are located. The design and installation of these require measures which address the possibility of methane gas migration from the landfill site.

The safety measures to be implemented during construction are referenced in the City of Winnipeg's Standard Construction Specification manual, Provision CW 1100 23. Construction Safety In and Around Landfills.

In general, mitigation measures such as barriers would be required where the potential exists for methane gas migration in concentrations at or approaching 20% of the lower explosive limit (20% L.E.L.), or 1% methane gas in air by volume, to occur at the installation site.

The Solid Waste Services Division of the Water and Waste Department should be contacted regarding:

a) Assessment of site conditions to determine the mitigation measures required.
b) Clearance for procedures involving trenching and augering for installations.
c) Approval of installation details relating to the design, and safety measures to be employed during the installation (reference CW 1100-R2, Cl. 23).
d) Monitoring following installation.

Typical utility trench barrier installations are shown in the figures included in the Appendix.

4. GAS INFILTRATION PREVENTION MEASURES

A. MEMBRANE AND COLLECTION-VENTILATION SYSTEMS

1. Primary membrane

A gas impermeable membrane installed above granular sub-base.
Typical membrane materials:

a) Polyolefin (elasticized)
b) Hypalon (chlorosulfonated polyethylene) (CSPE)
c) CPE (chlorinated polyethylene)
d) HDPE (high density polyethylene)
e) PVC membrane

Numerous types of membranes with different formulations are available from a variety of manufacturers. The membrane selected must have material performance specifications that meet the criteria for the use intended. The membrane shall be installed by an experienced membrane installer, carefully following manufacturer's instructions for installation, seaming, and joining with dissimilar materials, ie. adhering to concrete. In almost all installations, the membrane must be a minimum 20 mil thickness; continuous under the floor and extend to the grade beam; and have "slack" to allow for settlement.

2. Gas Collection System

a) Material
   i) The aggregate size for the gas collection system shall be 3" gravel down to pea size gravel. The gravel should not contain more than 10% material finer than 2 millimetres in size.

   ii) The aggregate should be durable and not subject to acid attack.

   iii) The aggregate material should be well rounded.

b) Placement of Material
   i) The aggregate should be placed in a single layer throughout the area beneath the membrane.
   ii) The layer of aggregate shall be a minimum of 8" thick.
   iii) The soil surface on which the porous material is placed should be sloped at least 1% to drain to a low point.
   iv) Provision must be made to remove condensate from the low point.
   v) The layer of porous granular material shall be discontinued at a distance of 3 metres (10 feet) from the inside perimeter of the building.

c) Gas Collector Piping

i) The gas collector piping shall be laid within the porous granular material beneath the membranes; approximately 2" beneath the primary membrane.

ii) The gas collector pipe shall be laid out in a rectangular grid pattern approximately on 20 foot centers.

iii) The pipe shall be perforated with drilled holes 3/8" to 5/8" in diameter, or slots sawed to a depth of 1/4 to 1/3 the pipe diameter, or a manufactured gas collector pipe.

iv) A minimum of four rows of drilled holes, or two rows of saw cuts, should be used on gas collector pipes.

v) Typical pipe materials include PVC, High density polyethylene, fibreglass, and ABS.

vi) Gas monitoring ports are usually provided within the system. Other monitoring probes may be installed into the granular sub-base to monitor gas accumulations below the membranes.

3. Sand Layer Above Primary Membrane

A dry 4" layer of sand shall be laid above the primary membrane. Gas probes installed into this layer of sand monitor the performance of the primary membrane. The gas probes are designed so that penetrations through membranes are properly sealed.

4. Secondary Membrane

The secondary membrane is usually identical to the primary membrane in both material and installation. It is placed above the primary membrane on top of the sand layer. This membrane provides a second level of protection for the building.

5. Protection of Secondary Membrane

A 2" layer of sand shall be placed above the secondary membrane to provide some protection from damage. Gas probes installed to monitor this layer for any accumulation of gas do not penetrate any membranes. A drilled hole through the floor slab provides access to this layer.

6. Vertical Vents

a) The vertical vents shall be located at the high points of the collection system piping. The vertical vents should be installed so that the horizontal run of the collection piping does not exceed 200 feet between vertical vents. In most designs for small buildings the spacing between vertical vents rarely exceeds 100 feet.

b) The vent piping shall be non-perforated, non-corrosive pipe. Usually the vent pipe is of the same material as the collection pipe. The vent pipe should be protected

from damage and breakage.

c) Where the vent pipe is exposed to freezing, the diameter of the vent pipe should be large enough that condensate freezing does not plug the pipe. Otherwise, alternative heat source is required for the piping, ie., heat tape.

d) The vent pipe termination, whether it is through the roof or outside wall, should be protected from precipitation and from birds.

e) Vent pipe inside the building shall be properly identified and marked distinctly.

7. Ventilation Systems

a) Passive system - The vertical vents can vent naturally into the atmosphere, or

b) Active system - a mechanical ventilation system can be connected to the collection system to extract the air and gases from the system. This system may be as simple as a "whirlybird" extractor installed at the termination of the vent stack, or a highly complex system of fans, detectors, sensors, manometers, automatic baffles, shutters, and back-up systems. The latter has detailed operating procedures and strict maintenance programs that make them expensive to install and maintain.

c) The ventilation system design and drawings shall be approved by a registered, professional engineer and stamped accordingly. Various components of the system may have to be designed for an explosive, gaseous environment. The system shall be installed by qualified professionals.

d) The system and installation must be approved by the Development and Inspections Division of the Planning, Property and Development Department.

e) Safety guidelines for construction on or adjacent to landfills must be adhered to in the installation of the collection-ventilation system.

B. INTERCEPTOR VENT TRENCH (GAS BARRIER)

For some site conditions and building development requirements, it may be desirable to install an interceptor vent trench, or gas barrier, as it is generally known, as opposed to other typical prevention measures. The interceptor vent trench can be placed immediately adjacent to the building or at any distance from the building. However, all waste material, refuse, and organic fill must be removed from under the building site, and from behind the interceptor vent trench (protected area).

a) Material

i) The granular backfill aggregate for the trench shall be well-graded, rounded, with a maximum aggregate size of 75 mm and not more than

10% finer than 2 mm. The aggregate shall be durable and not susceptible to acid attack.

ii) The membrane selected shall have the material performance specifications that meet the criteria for the use intended. The membrane shall be installed by an experienced membrane installer, carefully following manufacturer's instructions for installation, seaming, and joining with dissimilar materials, ie. adhering to concrete. The membrane must be a minimum 20 mil thickness.

iii) Typical gas collector piping materials include PVC, high density polyethylene, fibreglass, and ABS. Perforated 4" diameter pipe is the usual selection.

iv) The geotextile fabric filter selected shall have the material performance specifications that meet the criteria for the use intended. The geotextile fabric filter is used to impede the infiltration of "fines" into the trench aggregate.

b) Installation

i) The depth of the trench shall be 2 feet below the depth governed by the following:
- the depth of fill material over undisturbed clay
- the depth of silt layers or sand layers (migration corridors) in the unsaturated zone
- the depth of frost penetration and depth to continuously saturated zone.

The minimum depth of trench shall be 8 feet measured from final grade.

ii) The membrane shall be laid along the "building side" of the excavated trench wall, continue all around and down to the bottom of the trench to the opposite side. The trench shall be backfilled with granular aggregate to within 2 feet of the ground level.

iii) The geotextile fabric filter shall be placed on the top of the granular aggregate to impede the infiltration of "fines" into the trench. Under some conditions, the entire trench may have to be lined with a geotextile fabric filter. A layer of compacted clay fill shall be placed on top of the trench as a cap. Final backfill grade material shall be placed on the clay cap.

iv) The gas collection piping shall be placed in the upper section of the trench. The gas collector system shall have vertical vent stacks installed at appropriate intervals around the collection system. The vertical vent stacks shall be extended to exhaust passively or actively, and the termination protected from precipitation and birds.

v) The trench shall be capped with a layer of compacted clay approximately 2 feet thick, and a final backfill sloped away from the building foundation.

2. Interceptor Vent Trench (Gas Barrier) - Basement Foundation

a) Material

The material specifications are the same as for previous installation.

b) Installation

The installation specifications are the same as the previous interceptor trench, except as to the placement of the membrane barrier adjacent to the foundation and the installation and /or interconnection to weeping tile.

i) The membrane shall be continuous around the foundation, and shall be placed against the foundation down to the bottom and then to the outside edge of the excavation. The membrane shall be protected from punctures and tears.

ii) The weeping tile shall be installed outside the membrane and the membrane penetration shall be sealed. Designs shall have to address the possibility of gas migration through the weeping tile into the building. The weeping tile may be directly connected to the gas collection system.

iii) The gas collector piping (perforated) shall be placed to connect the lower and upper areas of the interceptor trench. More than one collection pipe around the building may be used, and installed at various levels within the trench.

iv) Monitoring programs incorporating gas probes and detection systems shall be included with this type of building protection.

c) Design

i) The design shall address the site specific conditions as determined by professional engineering investigations approved by the Solid Waste Division of the Water and Waste Department.

ii) The interceptor trench design and installation shall be approved by the Development and Inspections Division of the Planning, Property and Development Department.

iv) The safety guidelines for construction on or adjacent to landfills shall be

adhered to in the installation and maintenance of the interceptor vent trench.

C. ELEVATED CONSTRUCTION

The current accepted policy in the City of Winnipeg; adopted by Council December 19, 1984; for construction on a landfill site, to protect the building from gas infiltration, is elevated construction. The objective of this type of protection is to elevate the structure above the landfill, allowing free air movement around and under the structure, venting diffusing gases directly into the atmosphere, and creating no features within the foundation to trap gases migrating from the landfill deposits. Services provided to the building are designed so as not to create a passageway for gas infiltration. The Policy is detailed in "City Of Winnipeg Policy For Building On Landfill Sites". The policy includes the following:

1. The elevation of the lowest part of the floor structure shall be a minimum 750 mm (2 1/2 feet) above the finished grade level.

2. A minimum clear, unpaved (allowing gas diffusion) area around the building is defined by the policy, and must be maintained throughout the life of the building.

3. Provisions for ensuring that the structure does not trap gases migrating or diffusing from the landfill, and that the utility services to the building do not provide a passageway for gas to enter the building.

4. The safety regulations related to landfill construction must be adhered to in the construction and maintenance of the building, and the installation of gas protective systems.

5. A continued program of building monitoring must be carried out by the building owner and submitted to the Supervisor of Building Inspections.

6. Legal documents as required by the City Solicitor related to the landfill development policies and the building's construction and maintenance must be executed by the owner.

CAP 2001 03 19
G:\DATA\WPDOCS\BUILDING\POL01GDL.WPD

STANDARD ACKNOWLEDGEMENT FORM

Date: .....

Mr. Deepak Joshi
Manager of Development & Inspections
Planning, Property & Development Department
Mezzanine 84 - 30 Fort St.
Winnipeg, Manitoba
R3C 4X7
Phone: (204) 986-5104 Fax: (204) 986-3045

Dear Sir:

RE: _____

Property Legal Description:

I/we
being the registered owner/s of the above described property hereby acknowledge the possibility of Landfill Gas being present on, in or under the building/s and /or land affected by my application to build thereon.

I/we
understand that it might be necessary to incorporate safety measures into the design of any building located on the said lands and hereby agree to install or incorporate any such safety measures as the Manager of Building Inspections may from time to time deem necessary.

Yours truly,

....

....

AUTHORIZATION FORM
FOR
THE INVESTIGATION OF LANDFILL GAS

AUTHORIZATION

TO: THE CITY OF WINNIPEG
WATER AND WASTE DEPARTMENT

RE: Property described as:

In consideration of the City of Winnipeg carrying out, at its own cost, work it may consider appropriate to assess whether landfilled waste material exists which may produce or is producing landfill gases, mainly methane gas, in quantities which may present a hazard to buildings on or adjacent to said landfilled waste materials:

I/we

for myself/ourselves and for my/our heirs, executor, administrators and assigns hereby authorize the City of Winnipeg to enter on the above land and premises for the purpose of doing such work.

I/we further agree not to cause or commit any act which may disrupt or effect the City's work herein.

It is agreed and understood that the investigation, exploration and monitoring to be carried out by the City is intended to determine whether there is a presence of landfill gases within and beneath the building, and that such monitoring is not intended to prevent the entry or accumulation of landfill gases on lands or in buildings at the above noted premises.

SIGNED AND SEALED

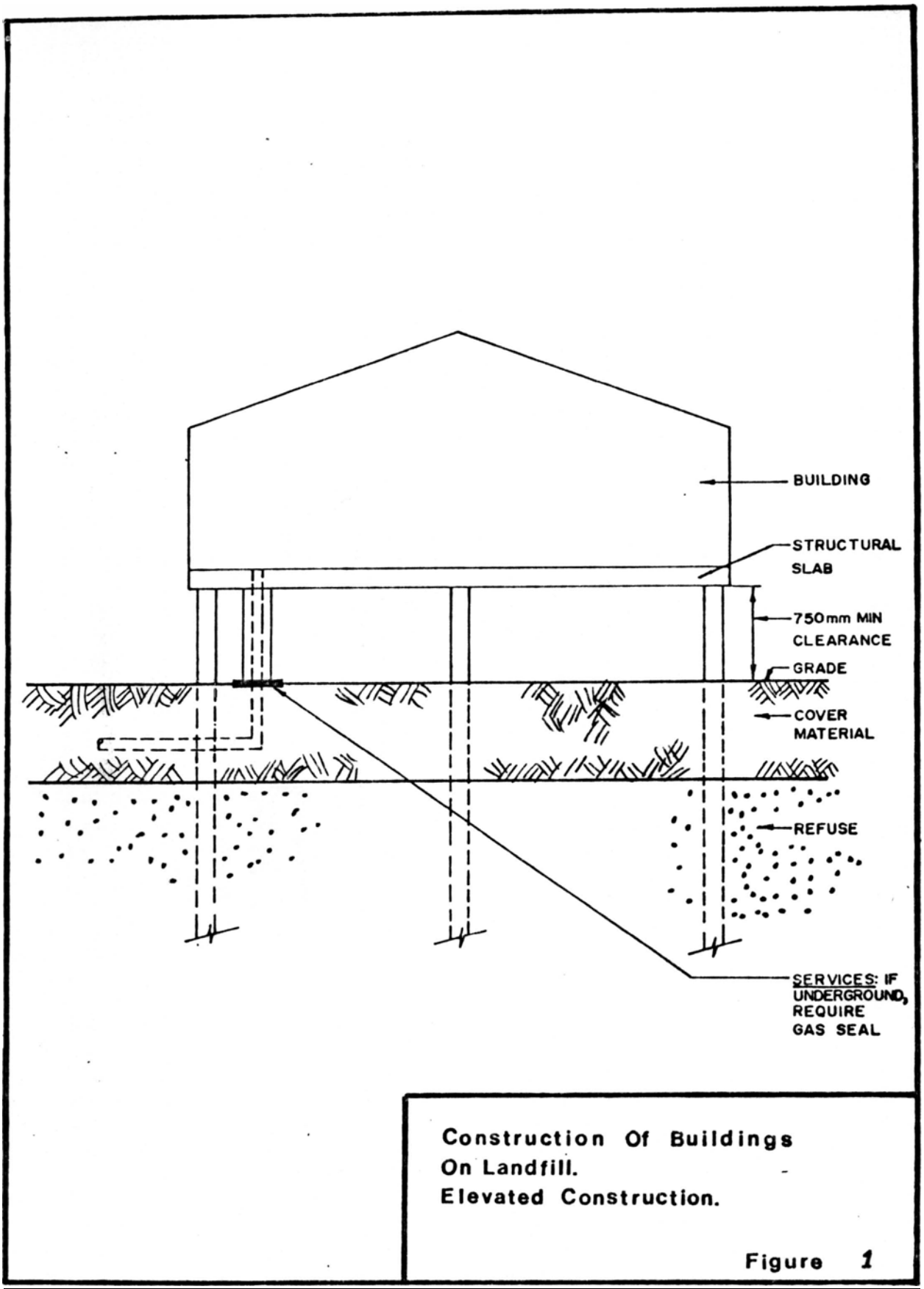
DATED the _____ day of _____ , ____ .

WITNESS:

CAP 2001 03 16

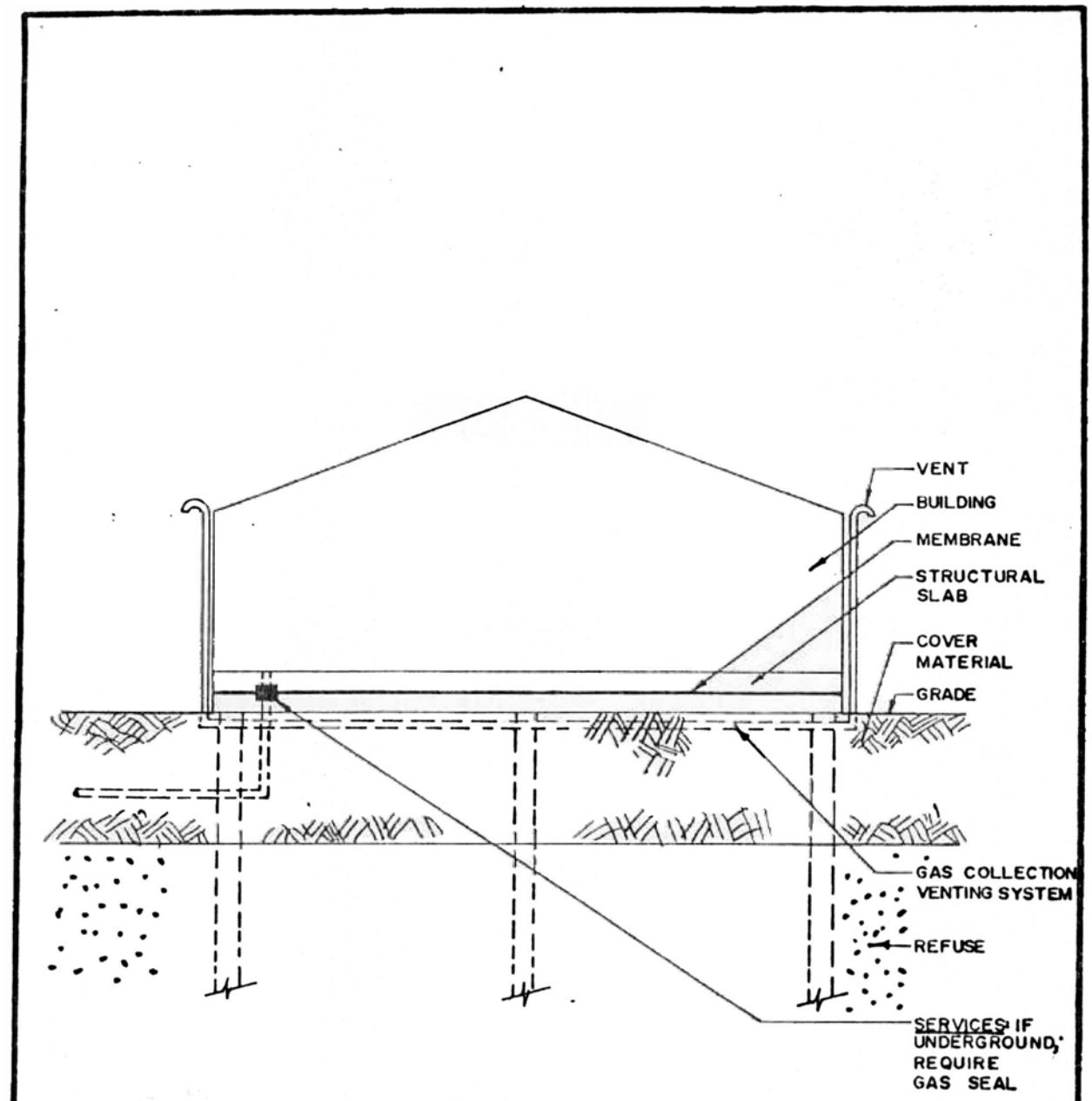
APPENDIX

LIST OF FIGURES



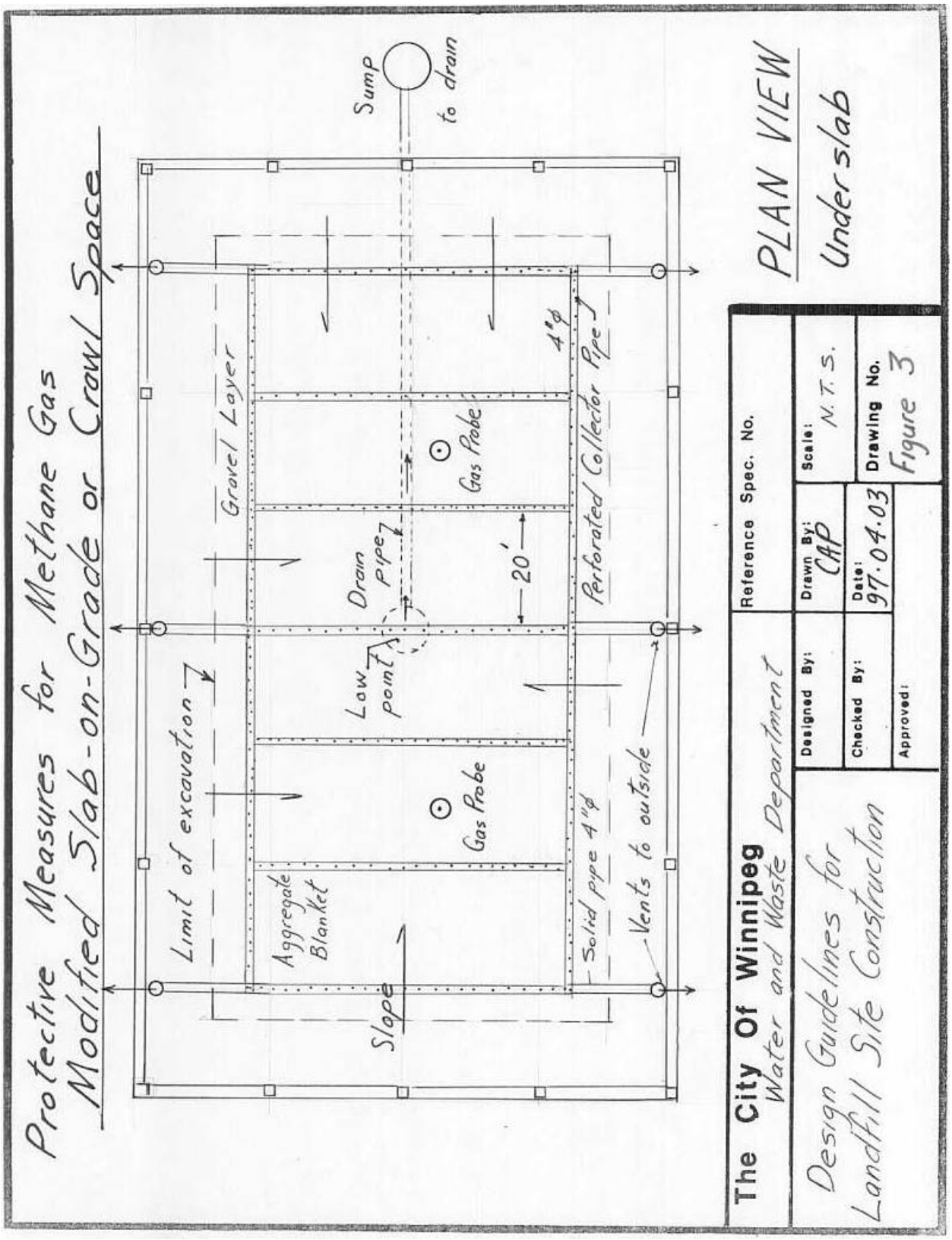
Construction Of Buildings On Landfill. Elevated Construction.

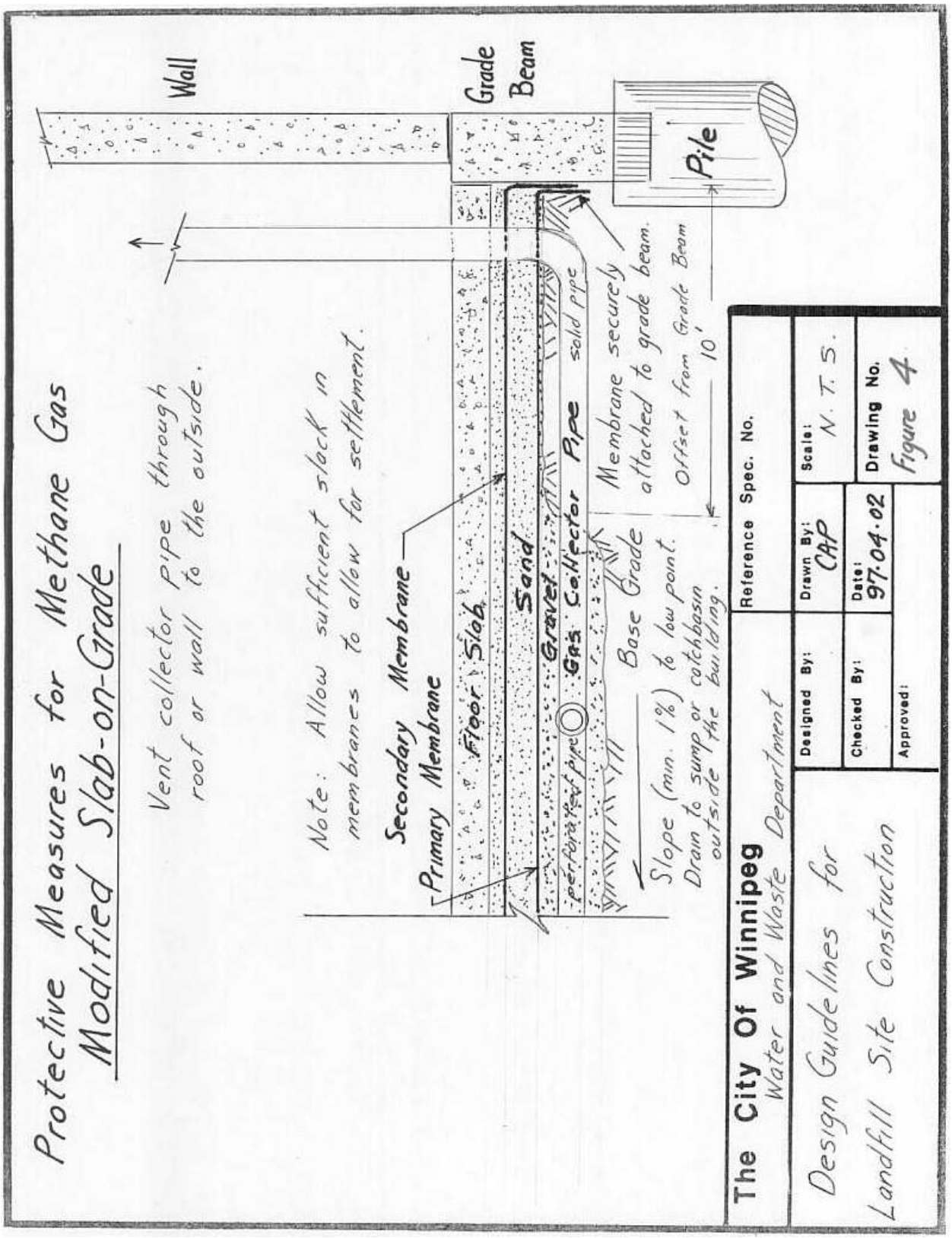
Figure 1

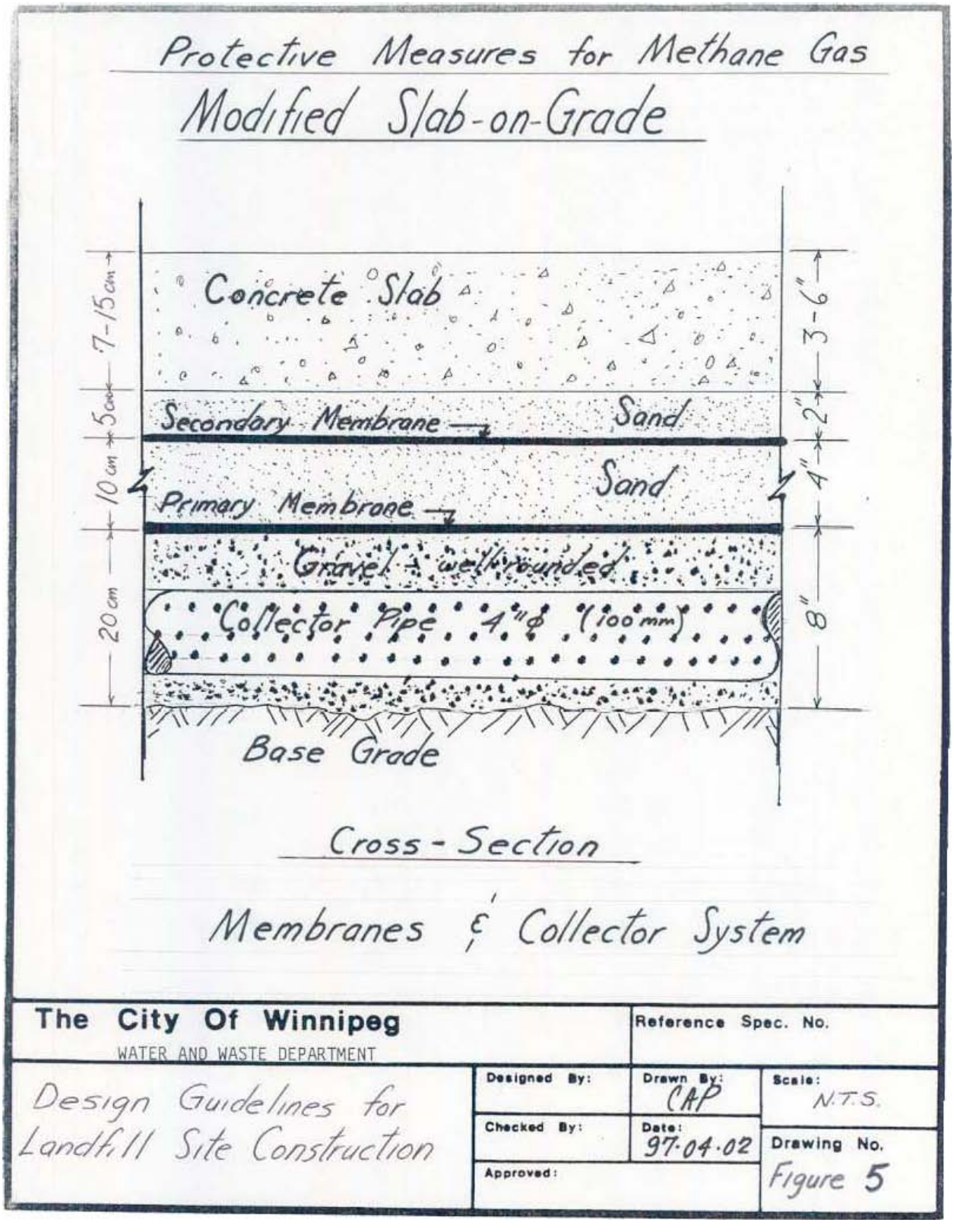


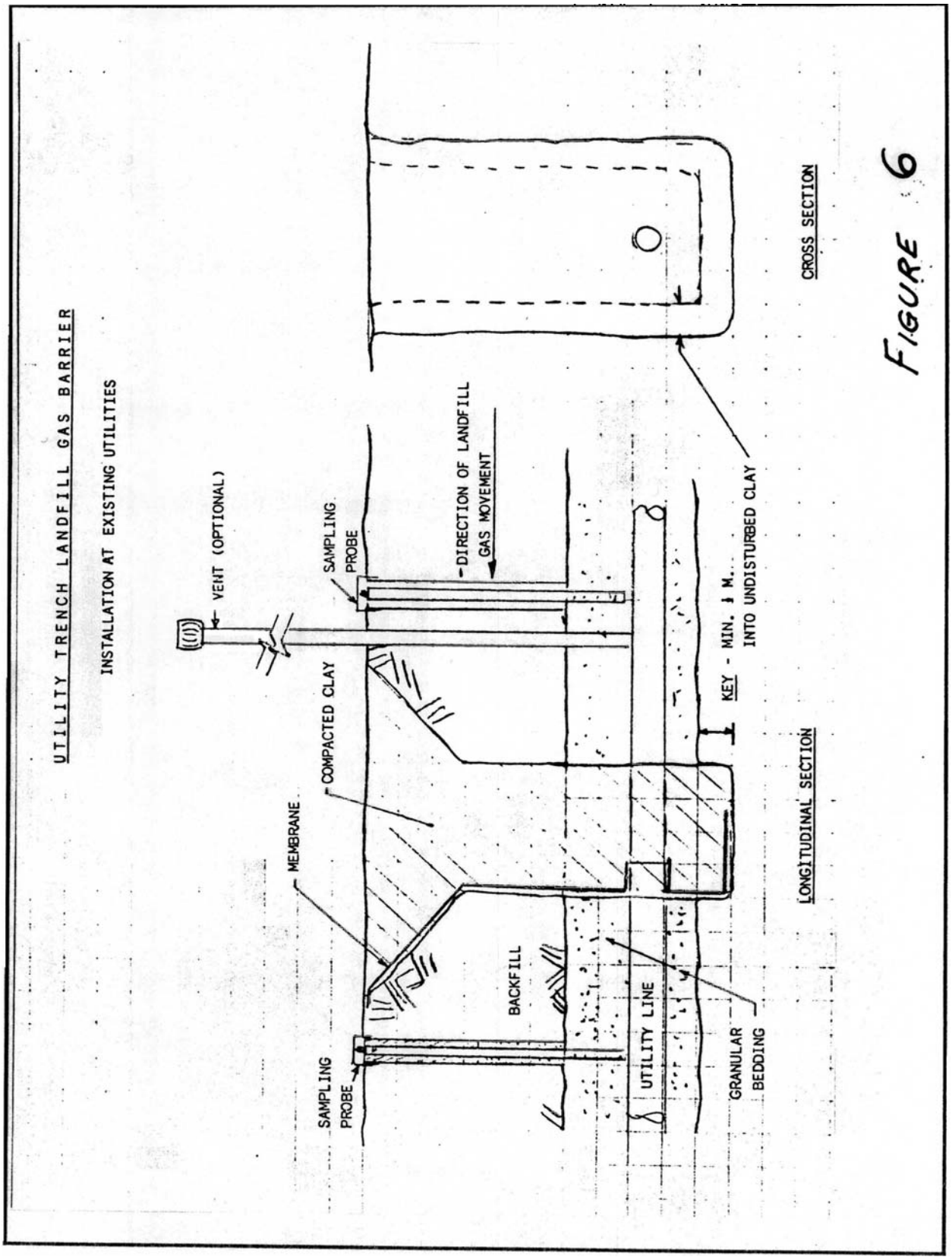
Construction Of Buildings On Landfill. Slab-on-Grade Construction

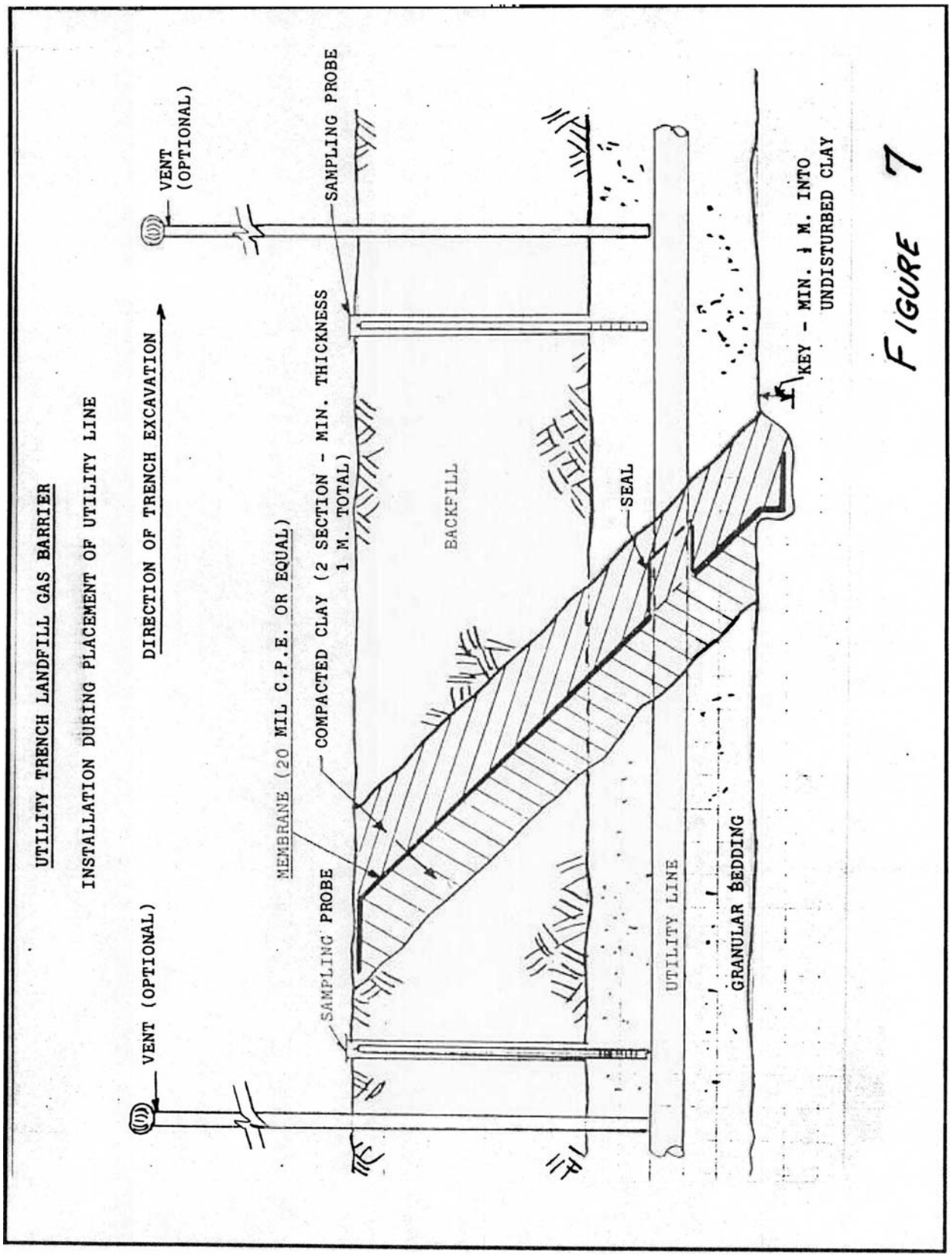
Figure 2

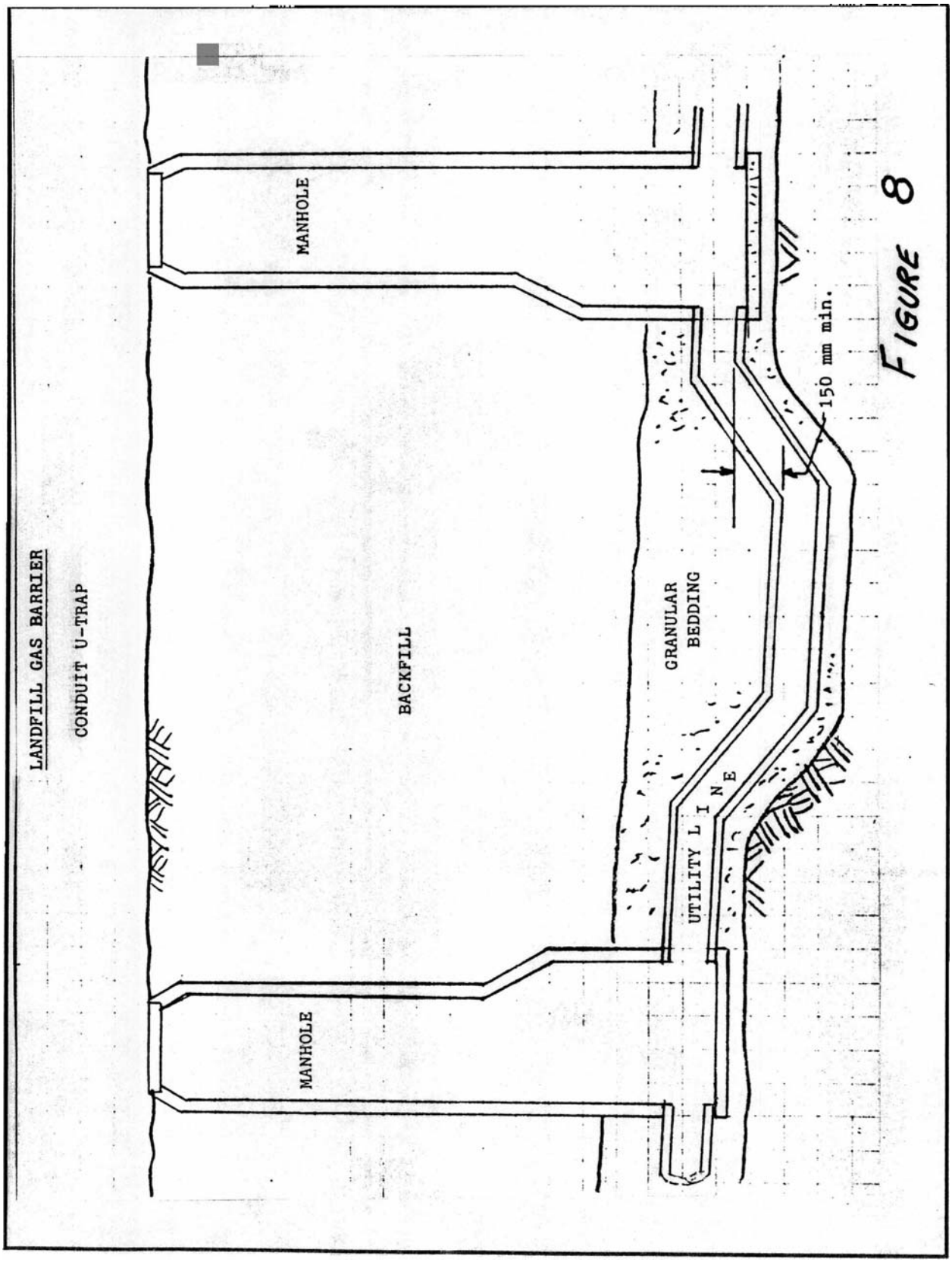

Protective Measures for Methane Gas
Modified Slab-on-Grade or Crawl Space
PLAN VIEW
Under slab
Sump
to drain
Gravel Layer
4"ϕ
Perforated Collector Pipe
Gas Probe
Drain pipe
20'
Low point
Limit of excavation
Aggregate Blanket
Gas Probe
Solid pipe 4"ϕ
Vents to outside
Slope
The City Of Winnipeg
Water and Waste Department
Reference Spec. No.
Designed By:
Drawn By: CAP
Checked By:
Date: 97.04.03
Approved:
Scale: N.T.S.
Drawing No. Figure 3
Design Guidelines for
Landfill Site Construction

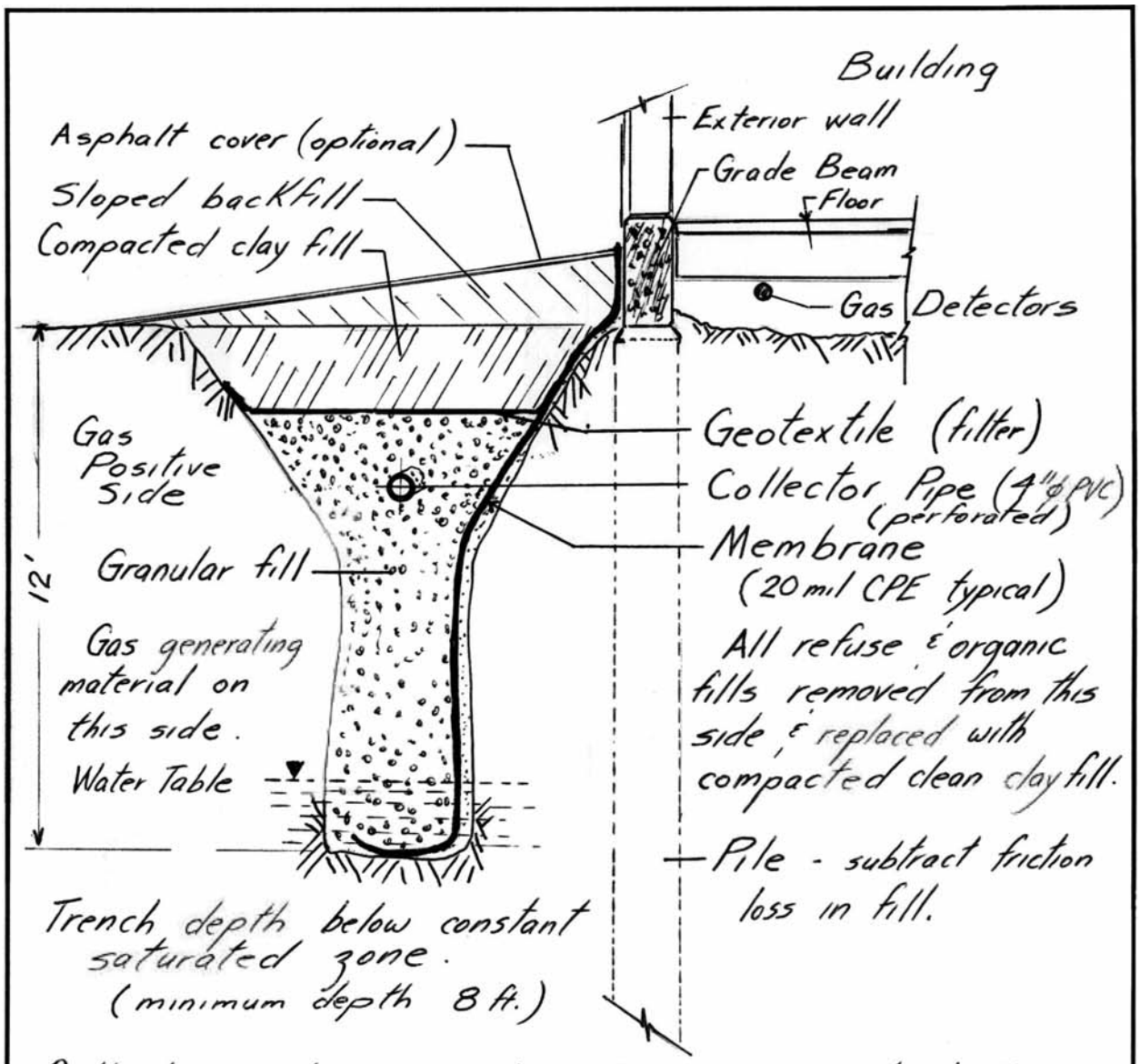

Protective Measures for Methane Gas
Modified Slab-on-Grade
Vent collector pipe through roof or wall to the outside.
Note: Allow sufficient slack in membranes to allow for settlement.
Secondary Membrane
Primary Membrane
Floor Slab
Sand
Gravel
perforated pipe
Gas Collector Pipe solid pipe
Base Grade
Slope (min. 1%) to low point. Drain to sump or catchbasin outside the building.
Membrane securely attached to grade beam.
Offset from Grade Beam 10'
Wall
Grade Beam
Pile
The City Of Winnipeg
Water and Waste Department
Reference Spec. No.
Designed By:
Drawn By: CAP
Scale: N. T. S.
Checked By:
Date: 97.04.02
Drawing No. Figure 4
Approved:
Design Guidelines for Landfill Site Construction


Protective Measures for Methane Gas
Modified Slab-on-Grade
Concrete Slab
Secondary Membrane
Sand
Primary Membrane
Sand
Gravel - well rounded
Collector Pipe 4" ϕ (100 mm)
Base Grade
7-15 cm
5 cm
10 cm
20 cm
3-6"
2"
4"
8"
Cross-Section
Membranes & Collector System
The City Of Winnipeg
WATER AND WASTE DEPARTMENT
Reference Spec. No.
Design Guidelines for Landfill Site Construction
Designed By:
Drawn By: CAP
Scale: N.T.S.
Checked By:
Date: 97-04-02
Approved:
Drawing No. Figure 5

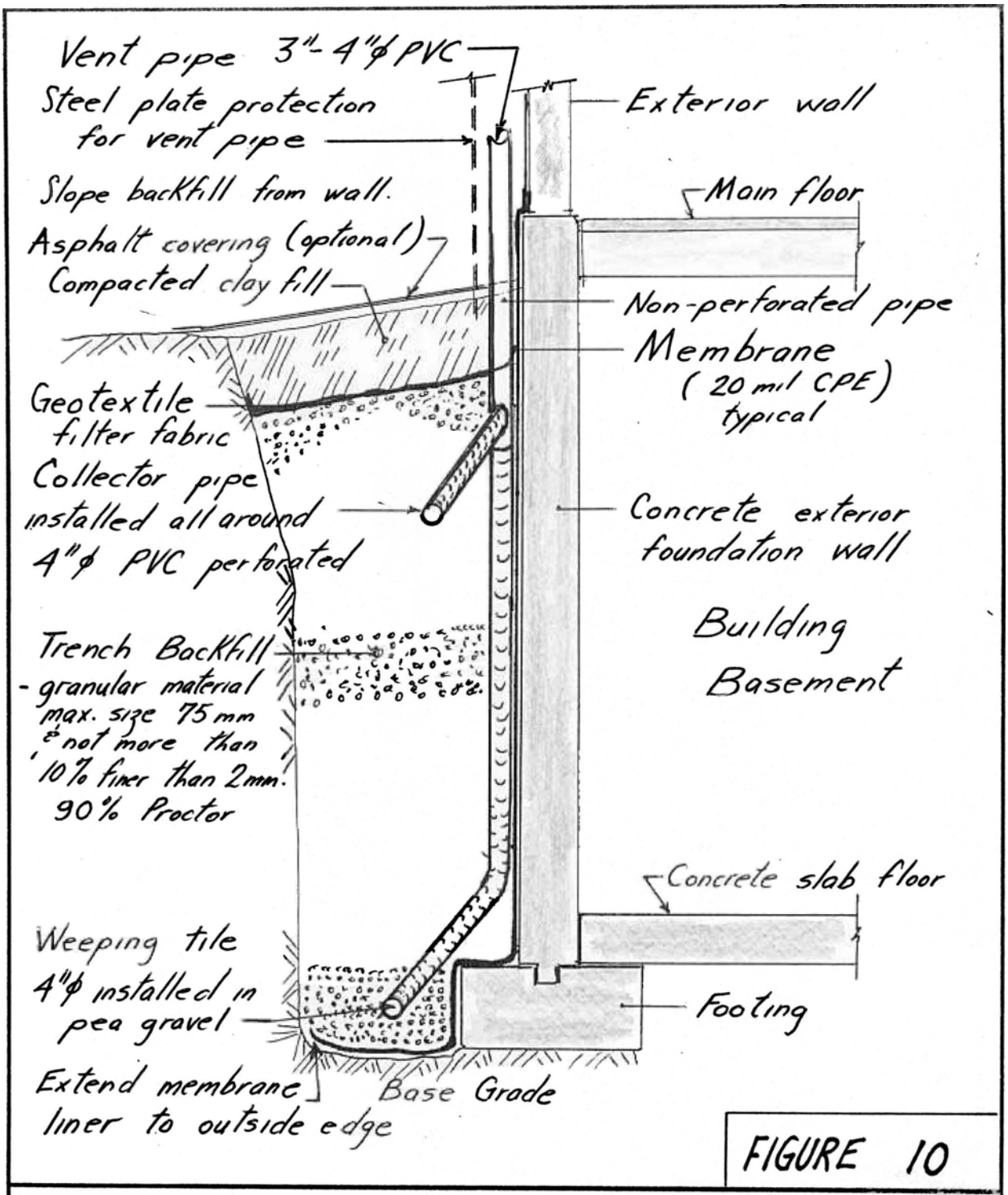

UTILITY TRENCH LANDFILL GAS BARRIER
INSTALLATION AT EXISTING UTILITIES
VENT (OPTIONAL)
SAMPLING PROBE
DIRECTION OF LANDFILL GAS MOVEMENT
COMPACTED CLAY
MEMBRANE
BACKFILL
SAMPLING PROBE
UTILITY LINE
GRANULAR BEDDING
KEY - MIN. 1 M. INTO UNDISTURBED CLAY
CROSS SECTION
LONGITUDINAL SECTION
FIGURE 6

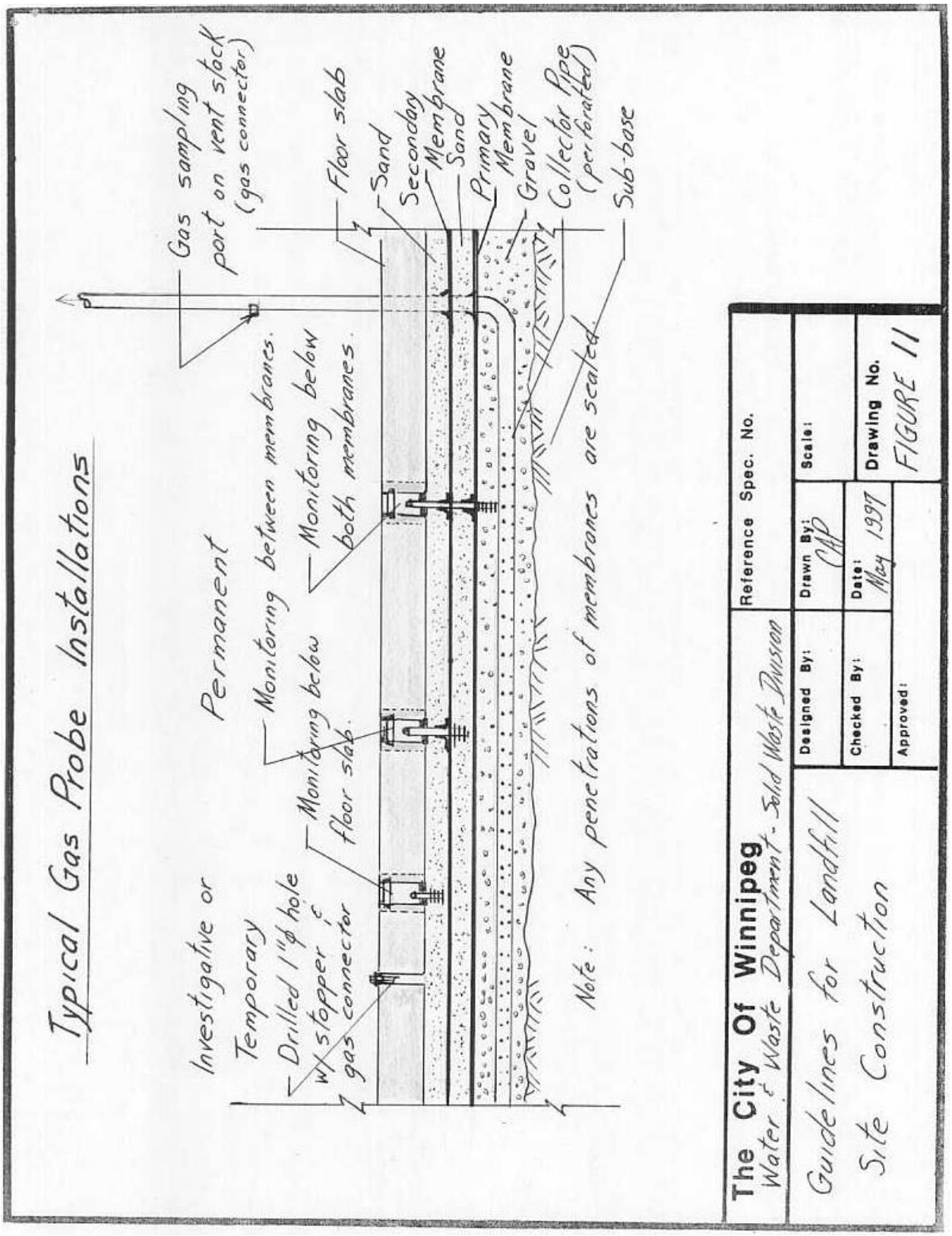

UTILITY TRENCH LANDFILL GAS BARRIER
INSTALLATION DURING PLACEMENT OF UTILITY LINE
DIRECTION OF TRENCH EXCAVATION
VENT (OPTIONAL)
SAMPLING PROBE
COMPACTED CLAY (2 SECTION - MIN. THICKNESS 1 M. TOTAL)
MEMBRANE (20 MIL C.P.E. OR EQUAL)
BACKFILL
SEAL
KEY - MIN. 1 M. INTO UNDISTURBED CLAY
VENT (OPTIONAL)
SAMPLING PROBE
UTILITY LINE
GRANULAR BEDDING
FIGURE 7

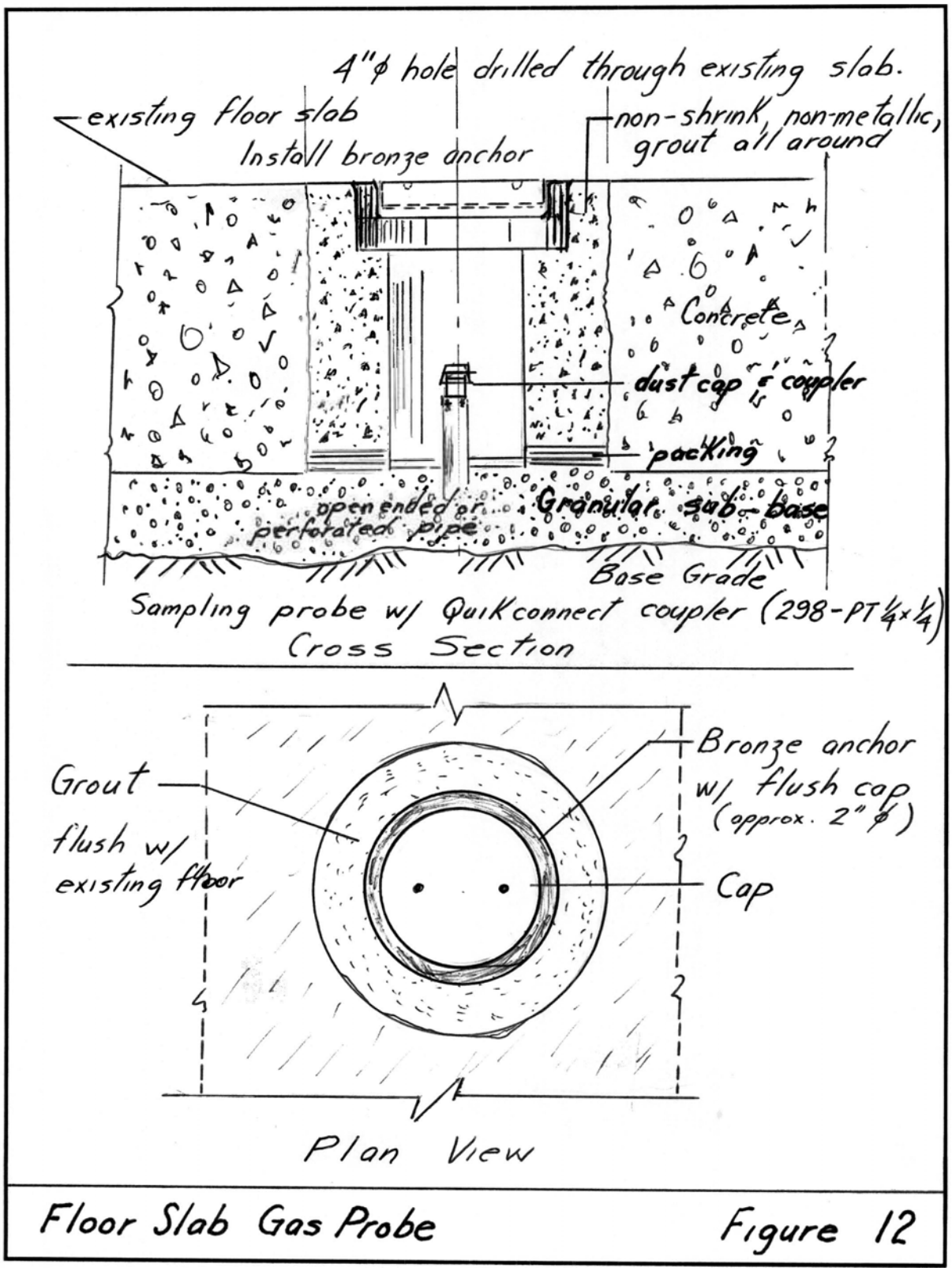

LANDFILL GAS BARRIER
CONDUIT U-TRAP
MANHOLE
BACKFILL
GRANULAR BEDDING
UTILITY LINE
150 mm min.
MANHOLE
FIGURE 8



Design Guidelines for Landfill Site Construction	FIGURE 9


Vent pipe 3"-4"ϕ PVC
Steel plate protection for vent pipe
Slope backfill from wall.
Asphalt covering (optional)
Compacted clay fill
Geotextile filter fabric
Collector pipe installed all around 4"ϕ PVC perforated
Trench Backfill - granular material max. size 75 mm & not more than 10% finer than 2mm. 90% Proctor
Weeping tile 4"ϕ installed in pea gravel
Extend membrane liner to outside edge
Base Grade
Exterior wall
Main floor
Non-perforated pipe
Membrane (20 mil CPE) typical
Concrete exterior foundation wall
Building Basement
Concrete slab floor
Footing
FIGURE 10
Design Guidelines for Landfill Site Construction
Interceptor Vent Trench - Basement Foundation


Typical Gas Probe Installations
Investigative or Temporary
Drilled 1" ϕ hole w/ stopper & gas connector
Permanent
Monitoring between membranes.
Monitoring below floor slab.
Monitoring below both membranes.
Gas sampling port on vent stack (gas connector)
Floor slab
Sand
Secondary Membrane
Sand
Primary Membrane
Gravel
Collector Pipe (perforated)
Sub-base
Note: Any penetrations of membranes are sealed.
The City Of Winnipeg
Water & Waste Department - Solid Waste Division
Reference Spec. No.
Designed By:
Drawn By: CAP
Scale:
Checked By:
Date: May 1997
Drawing No. FIGURE 11
Approved:
Guidelines for Landfill Site Construction


4"ϕ hole drilled through existing slab.
existing floor slab
Install bronze anchor
non-shrink, non-metallic, grout all around
Concrete
dust cap & coupler
packing
open ended or perforated pipe
Granular sub-base
Base Grade
Sampling probe w/ Quikconnect coupler (298-PT 1/4 x 1/4)
Cross Section
Grout flush w/ existing floor
Bronze anchor w/ flush cap (approx. 2" ϕ)
Cap
Plan View
Floor Slab Gas Probe
Figure 12