LANDFILL EVALUATION STUDY
FOR THE
CONNECTICUT DEPARTMENT OF
ENVIRONMENTAL PROTECTION
ON THE
TOWN OF WATERTOWN SANITARY LANDFILL
WATERTOWN, CONNECTICUT

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION 1
JOHN F. KENNEDY FEDERAL BUILDING · BOSTON, MA. 02203

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TECHNICAL ASSISTANCE PANELS PROGRAM
DIRECTIVE OF WORK #12
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PREPARED FOR:

REGION I
U. S. ENVIRONMENTAL PROTECTION AGENCY
WASTE MANAGEMENT BRANCH
JOHN F. KENNEDY FEDERAL BUILDING
BOSTON, MASSACHUSETTS 02203

PREPARED BY:
WEHRAN ENGINEERING CORPORATION
666 EAST MAIN STREET
MIDDLETOWN, NEW YORK 10940

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RESOURCE RECOVERY AND CONSERVATION PANELS

SEC. 2003 - The Administrator shall provide teams of personnel, including Federal, State, and local employees or contractors (hereinafter referred to as "Resource Conservation and Recovery Panels") to provide Federal, State and local governments upon request with technical assistance on solid waste management, resource recovery, and resource conservation. Such teams shall include technical, marketing, financial, and institutional specialists, and the services of such teams shall be provided without charge to States or local governments.

EPA Region I Project Managers: Conrad O. Desrosiers
Dennis G. Gagne

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FOREWORD

Wehran Engineering wishes to acknowledge the Study and Report - Part II B prepared by Roald Haestad, Inc., of Middlebury, Connecticut, which was used as a source of information for the preparation of this study. Wehran Engineering also wishes to acknowledge the assistance of Mr. William B. Owen, P.E., Watertown Municipal Engineer, and Mr. Paul W. Perlsweig, P.E., Senior Sanitary Engineer, Connecticut Department of Environmental Protection.

INTRODUCTION AND SUMMARY

Many landfills throughout the United States, like the one in Watertown, Connecticut, were started years ago without any knowledge of the potential problems that leachate and methane gas migration could produce. The objective of this study is to investigate what, if any, impacts the Watertown Landfill is having upon the environment.

This study was limited to the amount of data available concerning the landfill. One source of information regarding this site was contained in a report completed by Roald Haestad, Inc., a local engineering consulting firm. One field visit and various conversations with the local municipal engineer and Connecticut Department of Environmental Protection Landfill inspector were additional data sources. Our review of all the data did not indicate that any highly significant environmental impacts are occurring due to this landfill.

Any impact on the environment from leachate migration is minimized by its on-site dilution and attenuation by an adjacent wetland area. Our recommendation regarding the leachate migration would be to increase the contact area of the leachate flow to the wetland area located between the sediment basin and Artillery Road. To accomplish this objective, we are proposing that a level spreader be constructed right after the leachate flows out of the basin. The success of a marsh/pond system on treating sewage sludge in Upton, New York, indicates to us that the wetland appears to be adequately attenuating the present diluted leachate flow. We have also recommended that a rigorous water quality program commence. This data would be used to monitor any future impacts the leachate may have. It would also allow for adequate warning time to implement a new control strategy so as to prevent irreparable damage from occurring to the marsh from changes in the leachate quantity and quality.

No analytical data on methane gas has been collected. Our field investigation revealed that the vertical migration of the generated gas may be causing the sparse grass cover on the existing landfill. We do not feel, however, that horizontal gas migration is a problem here. We have recommended that a gas monitoring program be started.

We believe all our recommendations are reasoaable responses to the impacts which currently exist at this facility. We believe that these recommendations will lessen any existing impacts and discover any new impacts.

Background

The Watertown landfill has been in operation for approximately 40 years at its current location. The landfill has therefore undergone changes from being operated as an open burning dump to a sanitary landfill. The site consists of two distinct but contiguous parts. The older closed portion rises to elevations of approximately 757 feet, containing approximately 75 feet of solid waste. It is estimated that the bottom third of the landfill is composed primarily of partially burned solid waste due to the prior open burning history of the landfill.

As the state-of-the-art technology for sanitary landfilling has improved, so have the operations of the Watertown landfill. The Watertown landfill operation ceased open burning in the late 1960's and purchased a landfill compactor around 1972. The continual problem of leachate migrating from the landfill into an adjacent marsh was finally addressed in the mid 1970's by the Connecticut DEP and corrective actions were so ordered. The corrective actions included improvements to surface water drainage, construction of a sedimentation basin, and the channeling of leachate flow to the sedimentation basin.

These latter improvements directed the majority of leachate flows to a marsh south of the landfill and thence into Lake Winnemaug. These developments received much attention and study, the latter detailed in a report prepared by Roald Haestad, Inc. Part II B. That report (1977) included results of efforts to trace pollutants through the swamp.

Samples were taken of the discharge from the sedimentation basin approximately 200 feet downstream and at the end of the swamp. Dye tracer studies were also undertaken. Both efforts failed to show migration of pollutants through the marsh. Other limited information does not indicate any significant detrimental effects on the marsh. Any changes in vegetative species have not been investigated. Hydrogeologically, the landfill is apparently situated in a ground-water divide in a ground-water discharge zone. Previous studies by Roald Haestad, Inc. indicate that the solid waste is in direct contact with the ground water. The fact that this facility is located in a discharge zone is perhaps fortunate, in that this hydrogeologic condition prevents contamination of ground-water resources.

The purpose of this report is to evaluate the effect this landfill is having upon its surrounding environment and to recommend appropriate technical solutions. Specifically, what damage, if any, has the landfill's leachate done to the adjacent marsh. In addition, this report will discuss the landfill's influence upon ground-water quality and the possibility of methane gas migrating into neighboring lands. This report will review the available technical solutions to these problems and then recommends the solutions which are the most appropriate for this facility.

PRESENT ENVIRONMENTAL IMPACTS

The object in any assessment of managing a potential source of pollutants and its effects upon the environment is to prevent or to minimize the degradation of the environment. The focal point is the control of a pollutant's impact on the environment and not necessarily the total prevention of its discharge to the environment. The following sections evaluate what, if any, impacts the landfill's leachate and methane gas have had upon the surrounding environment based on available data and on site inspections.

Leachate Characteristics

To fully appreciate and understand the impact of the generated leachate upon the surrounding ground and surface waters, we must first review what its particular characteristics are at this site.

Leachate seeps out of the old tier and existing fill area and flows overland into the drainage ditches and eventually into the sediment basin. The constant flow of ground water through the landfill eventually emerges as leachate and it, too, flows into the basin. The discharge from this basin is measured at weir #1. Therefore, we will use weir #1 as our environmental starting point. The water quality at weir #1 was analyzed from a sample collected on May 31, 1978, by Mr. Paul Perlsweig. This data is compared to domestic sewage to enable the reader to obtain a better perspective on how potentially harmful this leachate may be. (See Table #1).

TABLE 1

Comparison of Characteristics of Watertown Landfill

Effluent and Domestic Sewage

CONSTITUENT	CONCENTRATION[1]			
	Effluent From Sediment Basin[2]	Leachate From Landfill Six months old[3]	Typical Domestic Sewage[4]	Ratio of Effluent: Sewage
Alkalinity as CaCO	500.0	3100	100.0	5.0
Biochemical Oxygen Demand	13.0	10000	200.0	0.065
Chemical Oxygen Demand	110.0	17500	500.0	0.22
Chlorides	210.0	660	50.0	4.2
pH	6.7	5.5	8.0	
Iron	83.0	55	0.1	830.0
Total Suspended Solids	150.0	360	200.0	0.75

1. Mg/l except for pH (pH Units)
2. Connecticut State Department of Health, from sample collected P. Perlsweig on May 31, 1978, from Weir #1.
3. Boone County Research Facility - Cell No. 1, Samples taken January 10 and 24, 1972.
4. Metcalf and Eddy, Inc., Wastewater Engineering: Collection, Treatment and Disposal. McGraw-Hill Book Company, New York 1972.

The landfill effluent concentrations are relatively low when compared to sewage. The dilute character of the leachate is probably due to a combination of the following factors: landfill refuse stabilization, ground-water dilution, some renovation of the leachate as it flows overland to the sediment basin, and some equalization within the sediment basin. Available water quality data does not allow for separation of the effectiveness of each of the various factors. A general discussion of the role of each of these factors is presented in the following paragraphs.

1. Landfill Stabilization

This landfill has been in operation for approximately forty years. It has passed through the stages of an area where garbage was burned to an open dump to a sanitary landfill. The amount of solid waste which is deposited here is approximately seventy-five (75) feet in depth. Rainfall must pass through new garbage and then through old garbage before it comes in contact with the ground water and then emerges as leachate. There is a general lack of knowledge of how a landfill's internal biological and chemical reactions over time. However, one possible effect of an old landfill upon leachate quality would be to dampen its strength. The older garbage would have been decomposed into its basic elemental forms devoid of leachable material. As the newly formed leachate percolates through the older garbage, it would react chemically and biologically and some contaminants from the leachate would be attenuated by the older garbage. The primary mechanism most likely active here would be adsorption by residual organic matter and incorporation by the biomass. Such attenuation should be stable in that factors which would tend to eliminate the biomass are highly limited.

2. Ground-Water Dilution

The Roald Haestad report dated June, 1977, (p.17) states that, after the landfill rehabilitation effort was completed, no changes in the ground-water table were observed. He theorizes that the ground water enters at the base of the refuse, flows through the refuse, and emerges as leachate. A site inspection on October 4, 1979 by Wehran Engineering personnel confirms this observation. This constant flow of ground water has diluted the leachate so that its strength is weakened and may have also reduced the rates of pollutant solubilization. The effectiveness of these "reactions" is evidenced by the lack of high pollutants concentrations as measured at weir #1.

3. Sediment Basin Renovation

Leachate seeps out of various locations throughout the landfill. As the leachate flows overland to the sediment basin, some biological and/or chemical pretreatment may be active. As it reaches the basin, the leachate becomes diluted with the surface water run-off and groundwater discharge. The sediment basin slowly releases the diluted leachate into the marsh. The only apparent treatment that the basin provides would be to simply settle out any of the larger silt particles and to provide retention time to prevent high concentrations of leachate from entering the marsh. A grab sample collected on April 21, 1978, by Mr. R. Smith, indicstes low strength pollutants - a pH of 6.6 and a BOD_5 of 78 ppm. The iron concentration (41 ppm), total (766 ppm) and fixed solids (708), and chlorides (190), are low strength. Mr. Perlsweig collected a sample from this basin on May 31, 1978. This analysis compares more or less with Mr. Smith's.

Surface Water

The water which enters the marsh from weir #1 is of relatively low strength when compared to other leachates. Perlsweig collected a sample on May 31, 1978, from weir #1 which is located between the basin and the swamp, and weir #2, which is located in the marsh which measures flow from weir #1 and diverted stream flow. Weir #2 is approximately 200 feet down-gradient from weir #1. A quick comparison of selected parameters shows the influence that the first section of marsh is having on the leachate.

TABLE 2

Comparison of Water Quality at Weirs #1 and #2

Parameter	Weir #1	Weir #2
pH	6.7	7.1
BOD_5	13.0 ppm	3.2 ppm
COD	110.0 "	34.0 "
Chlorides	210.0 "	70.0 "
Iron	83.0 "	22.0 "

It should be noted here that none of the analytical data of the collected water samples involved an investigation for toxic pollutants. At this time, the presence of any toxic pollutants existing in this leachate is unknown. The marsh shows an ability to render some attenuation to an already low strength leachate, in spite of the fact that its flow is primarily restricted to a small stream channel which bisects the marsh. This channel minimizes leachate contact with the marsh and therefore limits the area affecting treatment.

Perlsweig collected a sample of the stream which originates in the marsh and flows into Lake Winnemaug. The sample was collected at weir #3 just before the stream discharges into the lake. A comparison of all three (3) water samples collected by Perlsweig indicates attenuation of leachate contaminants by the marsh. Since flow data is unavailable, no quantification of pollutant removal is possible at this time.

TABLE 3

A Comparison of Water Samples Collected by
P. Perlsweig on May 31, 1978

Parameter	Weir #1	Weir #2	Weir #3
pH	6.7	7.1	7.2
BOD_5	13.0 ppm	3.2 ppm	2.5 ppm
COD	110.0 ppm	34.0 ppm	50.0 ppm
Chlorides	210.0 ppm	70.0 ppm	34.0 ppm
Iron	83.0 ppm	22.0 ppm	3.3 ppm

Between weirs #2 and #3 another source of pollution exists. Many former summer residences constructed near the lake are now being utilized year-round. These homes are serviced by septic tanks. Reports of septic tank failures were not available to assess their impact upon water quality. It can only be surmised that each year a number of these tanks and/or leach fields "fail" from over use. A portion of this effluent from these "failures" could migrate downgradient, flow into the marsh, past weir #3 and into the lake. The increase in the chemical oxygen demand (COD) between weir #2 and #3 could possibly be due to this effluent. It is not inconceivable that this effluent is increasing the COD while not increasing the 5-day biochemical oxygen demand (BOD_5). Organic or inorganic chemicals deposited into the tanks may be the source of this increased chemical activity. For example, homeowners may have deposited large amounts of copper sulfate into the tanks so as to clear their leach fields of tree roots.

Regardless of other sources of potential pollution, contaminant concentrations are reduced as you progress through the marsh to its discharge to Lake Winnemaug.

A marsh's ability to absorb the hydraulic and solids loading from a pollution source has had documented success. A marsh was created to treat a landfill's leachate at a private landfill in Barre, Massachusetts. This marsh achieved a reduction in BOD_5 of leachate from 20,000 mg/l to less than 10 mg/l. The closest example to the basin-marsh treatment configuration is a prototype experimental marsh/pond operation utilized at Brookhaven National Laboratory in Upton, New York. Brookhaven operates a 10,000 gallon per day sewage treatment system that consists only of a marsh and a pond. The following is a brief comparison between the Brookhaven and Watertown marshes.

TABLE 4

Comparison of Size and Flow of Watertown and Brookhaven Marsh Treatment Systems

	Brookhaven	Watertown
Size	.4 acre	2 to 3 (active contact) acres**
Flow	50,000 gals/acre/day	4800 gals/acre/day*

*Note p. 12 Haestad reports, leachate flows between 10-15 gpm after rehabilitation.

**Note p. 54 Haestad

The effluent from the marsh/pond in the Brookhaven system nearly complies with the discharge standards specified by the United States Environmental Protection Agency and the United States Public Health Service. The experimental data collected at Brookhaven lends credence and meaning to the Watertown results. It should be noted that the

Watertown marsh acreage does not include those portions across Artillery Road and Hamilton Lane. These additional contact acres will only further reduce the effluent's strength.

Ground Water

The Connecticut Department of Health's analytical findings of the ground-water wells in and around the landfill are fairly consistent. No indication of leachate contamination of these wells is evident. Occasionally some of the wells along Artillery Road and Hamilton Avenue had moderate sodium and chloride readings. The source of these could be home water softeners or road de-icing salts. The pH readings were consistently around 6.0. This could be attributable to the natural soils surrounding the landfill. A ground-water well was constructed through the landfill next to the dog pound. Available analysis of this water indicates that it is potable.

The flow of ground water in this area is into, through and out of the landfill. The ground water emerges as contaminated surface water. It is, therefore, unlikely that any contamination of the ground water adjacent to this site is occurring at this time. High ground-water withdrawal rates such as by a future industrial or municipal well, could however, reverse this situation resulting in possible contamination of ground-water resources.

Seven (7) ground-water monitoring wells have been installed around the landfill but, to date, no ground-water quality data has been obtained. The limited amount of ground-water data does not allow for much discussion of ground-water pollution. We recommend that a ground-water monitoring program be implemented to detect possible future changes in quality.

Methane

A methane gas monitoring program has not been undertaken at this facility or in the adjacent property. The final cover material placed on the upper tier landfill consists of a gravelly soil and probably allows most of the gas to be vented vertically, rather than encouraging horizontal migration. No venting system other than the ground-water monitoring well located in the middle of the landfill is present at this site. No destruction of plant life on adjacent lands which may occur due to gas migration was observed during site inspections. However, a poor vegetation cover was observed on the completed section of the landfill (upper tier). This sparse vegetation may be due, in part, to the vertical movement of gas through the cover soil, as well as poor soil conditions.

Summary

We believe that the impact of leachate migration from this landfill into surrounding ground waters is relatively insignificant. We have been unable to discover any specific evidence of contamination of any of the private wells in the homes located in the landfill vicinity. Also, based upon the limited data we have been unable to find specific evidence of degradation of the adjacent marsh[(1)]. The analysis of the diluted leachate at Weir #1 (See Table #1) for those selected parameters reveals a low strength effluent. The biochemical oxygen demand is very

(1) No biological or chemical analysis has been completed on virgin areas of the marsh to allow for a rigorous comparison.

low and the chemical oxygen demand is moderate. Therefore, even before the leachate leaves the sediment basin, its strength is very weak and it is not surprising to find that the marsh has not been severely impacted.

Our conclusions regarding the impact of methane gas are based upon a visual inspection of the landfill and the surrounding area. We believe that the gas is most probably vented vertically through the landfill cover soil. Therefore, we believe no immediate danger to any surrounding area due to gas migration exists. Methane gas, however, may be a major cause of the sparse and poor quality vegetative growth upon the completed landfill area.

ALTERNATIVE ENVIRONMENTAL MANAGEMENT APPROACHES

Before a leachate or a methane gas management system can be selected for this site, a review of the available technology is necessary. This section reviews what is currently being utilized in the field of solid waste management in these two areas. The ultimate selection of a system can only be completed by comparing each systems' costs and capabilities to the specific site characteristics and the severity of existing environmental problems.

Leachate

Every landfill produces leachate at various quantities and potency depending upon numerous characteristic factors of that particular landfill. The migration of leachate from a landfill to adjacent ground and surface waters has been harmful in many instances. An understanding of how leachate is produced, collected, and treated is needed before a leachate management system can be selected for this facility.

1. Production

Leachate is formed when water has been in contact with solid waste and contains dissolved or suspended materials from that solid waste - the quantity and composition of leachate varies with the characteristics of the waste, the particular site, and with time.

Leachate generation may best be understood with reference to a landfill with a refuse layer over which a final cover of clean soil has been applied. Precipitation falls onto the site where a portion, the "run-off", flows over and along the surface to drain away from the site and where the remainder infiltrates down into the soil cover. Evapotranspiration (evaporation from the soil and transpiration from plants) removed moisture from the active soil layer and returns it to the atmosphere. Once this soil layer reaches field capacity, any excess water will produce percolation downward into the underlying refuse layers.

The refuse will act as a sponge, initially absorbing the percolating water and finally reaching field capacity. Run-off and evapotranspiration essentially affect only the active soil layer, which is subject to environmental conditions. Moisture from the refuse layer is removed primarily by diffusing gases, and this amount is very small. Consequently, once the refuse layer reaches field capacity, it remains at field capacity, and any entering percolation produces and equal amount of leachate. The anaology to a sponge is still applicable - once a sponge reaches field capacity, any additional water will cause an equal release of water from the bottom or sides.

Some small quantity of leachate may be produced in advance of the refuse layer's reaching field capacity. Because solid waste is not uniform in composition, channeling may occur or, as percolation seeps through the refuse an advance wetting front may form. Both of these factors contribute to "early" leachate production.

Numerous studies indicate that most of the factors affecting leachate generation are highly site specific. Factors such as precipitation, evapotranspiration, and soil permeability at a particular site figure prominently in determining the potential for surface and ground-water infiltration and eventual leachate generation.

There are two different schools of thought regarding the management of surface and ground-water infiltration into a landfill and eventual leachate generation. One strategy to minimize the amount of generated leachate is to minimize the amount of water entering a landfill. The other stragegy is just the opposite. It encourages the flow of both surface and ground waters through a landfill. By having a constant flow of water through a landfill, a leachate of low concentration is always produced and the overall impact of this diluted flow is thereby minimized.

Another water-leachate management philosophy close in theory to the second strategy regards the rate of pollutant's solubilization within a landfill. If one believes that the rate of pollutants' solubilization is constant over a period of time, the quality (concentration) of pollutants released is inverse to the quantity of leachate produced. Less volume of leachate would produce a higher pollutant level under the first strategy. More volume of leachate would produce a lower pollutant level under the second system. In either case, the same total poundage of pollutants is assumed to be released into the environment but the effects of their release are dramatically different.

The selection of a water-leachate management system for this site depends upon what final treatment scheme is chosen. If a treatment scheme like recirculation, spray irrigation or wastewater treatment is selected, one would want to minimize the volume of leachate to be treated. This management scheme corresponds to strategy Number 1. Since groundwater flow is the largest source of water entering into this landfill, a diversion trench or cut-off wall would have to be constructed. An extensive hydrogeologic investigation would have to be completed in order to obtain the necessary soil profiles and depths and volumes of flow before an effective diversion system could be designed. The practicality of diverting the groundwater flow is very questionable since the landfill is in a discharge area and the volume of water to be managed would, most probably, be tremendous.

If the existing marsh is to be solely utilized for treatment, one would want to mix as much surface and ground water with the leachate in the sediment basin as possible. This management scheme corresponds to strategy Number 2. In essence, management of water at the landfill would be designed so as to maintain the current quantity of leachate being formed. The current day-to-day landfilling operation and soil cover type should be preserved.

2. Collection

Most newly designed sanitary landfills are required to have a leachate collection system utilizing some sort of highly impermeable liner and a piping network. The selection of a specific liner depends upon the expected groundwater pressures, economics etc. The liner is normally placed down prior to the beginning of the disposal operation. However, this landfill is existing, the placement of a liner here is not feasible. The expense of excavating the already in-place solid waste, installing a liner, and a collection system, and placing back the solid waste would be an impractical and expensive undertaking.

The installation of a conventional leachate collection piping system at this site would also require the excavation and redeposition of considerable portions of the in-place solid waste. An alternative collection system, if required, would have to be selected. This alternate system would probably consist of a toe-of-slope collection pipe to intercept leachate outcrops. This system would be constructed around the entire down-gradient slope of the landfill. The construction of this collection system would effectively be only a modification of the existing ditches. We do not recommend that this alternative system be constructed since the existing ditches can be improved easily enough to adequately collect and drain the leachate to the sediment basin. The construction of a piping system would be considerably more expensive and not that much more efficient.

3. Treatment

Once leachate has been collected it must be satisfactorily treated before it can be released into the surrounding environment. Since the requirements for designing a sanitary landfill are relatively recent, very little experience in treating leachate has been obtained. Typical leachate treatment systems include recirculation, spray irrigation, disposing of the leachate in an existing wastewater treatment facility or constructing an on-site treatment system.

Recirculation of leachate involves the pumping of collected leachate back into a landfill, usually directly into the active face.

Test results of this treatment method indicate that a rapid stabilization of the landfill and leachate occurs, because of rhe accelerated growth of anaerobic bacteria within the fill. Since biological stabilization of the organic part of the refuse would proceed at an optimal rate, biochemical oxygen demand, chemical oxygen demand and total organic carbon levels in the leachate in these landfills which used recirculation were reduced. Much research must still be completed on the effectiveness of this method. Critics claim that it does little or no real removal of pollutants and that it cannot be used in times of heavy rainfall or when the solid waste and ground are frozen. Further once the landfill is completed, the generated leachate within the landfill must still be removed and treated. We do not feel it is warranted to implement this system at Watertown because of the likelihood of the existence of a high groundwater mound within the landfill. This phenomenon is causing more leachate generation than can be handled by recirculation. Further, leachate recirculation is most effective in an ongoing landfill and since this landfill has a limited life, the expense of constructing a recirculation system here is of questionable value.

The spray irrigation of leachate relies upon the evapotranspiration characteristics of the landfill locale. Depending on the transmissibility, grass grown on the landfill cover, the moisture storage capacity of the cover, and the evaporation factor of the sun and wind in the site's area, this method can reduce leachate volumes. The volume of leachate which can be handled in general is in the vicinity of one to two inches per acre per week (precise application rates can not be determined initially). Overloading of the available spray area will contaminate the cover soil. Therefore, the loading rates must be monitored to prevent the cover from being overtaxed and rendering its attenuative properties useless. Odors are a major potential problem with this method of treatment. We do not feel this method is applicable here because of the landfill's limited life. Further, spray irrigation is of seasonal utility, whereas Watertown's landfill leachate generation is year-round. The expense of purchasing the necessary equipment would not, in our opinion, be justified.

Using an existing sewerage treatment facility or constructing a physical/chemical/biological treatment system are quite elaborate and expensive undertakings. Because of leachate's transient strength and flow characteristics, the technology of formalized treatment is still being developed. The treatment process which entails the sequence of lime precipitation/clarification/air stripping/neutralization/ phosphorous addition/activated sludge appears to provide the best treatment to date. The problem with utilizing an existing wastewater treatment plant is that a great dilution of the leachate must be accomplished to prevent disruption of the system. Preliminary work in this area indicates that a sewage treatment plant would need a present sewage flow one hundred times the anticipated leachate flow. A 1.4 mgd treatment plant would be required to accept the daily leachate flow generated at this site. The cost of transporting the leachate would probably make this alternative unacceptable.

The use of a marsh as a treatment system in attenuating wastewater and leachate has had documented success. This report has already mentioned the experimental work completed in Brookhaven on sewage and in Barre, Massachusetts on leachate. Additional work must still be completed on the long-term utilization of marshes to treat pollutants. The marsh treatment system, however, is both energy-saving and inexpensive, making it particularly attractive for small municipalities like Watertown.

Methane Gas

The gases produced by the biological degradation of deposited solid waste in a landfill can pose serious difficulties if not controlled. Methane, when ignited, can explode when it reaches a concentration of 5 to 15 percent with air. Confined spaces like basements or homes are likely candidates for gas accumulation and possible explosion hazard. Another potential problem associated with methane is that it displaces oxygen in the soil which is required by the root system of plants and can cause extensive damage to vegetation growing on lands adjacent to a landfill, as well as the landfill cover vegetation.

1. Production

The production of methane is a result of the decomposition of the organic material by microorganisms. Initial gas formation consists of carbon dioxide with some hydrogen sulfide and ammonia. It is when the biological activity depletes the oxygen supply and becomes anaerobic that methane becomes the major decomposition gas. While the production of methane is a very common process, it is somewhat delicate and easily upset. As long as sufficient moisture is available within a landfill, decomposition gas will be formed since most microorganisms are active in the presence of moisture.

Other factors which affect gas production include the organic content of the solid waste, particle size and degree of compaction of the solid waste, placement and type of cover, landfill topography, landfill hydrogeology etc. Theoretically, a pound of refuse can produce 2.7 cubic feet of carbon dioxide and 3.9 cubic feet of methane. How much of this potential production will be realized in a particular landfill over a given period of time will depend on a combination of the above factors which aid or hinder gas production.

2. Migration

At some sanitary landfills, methane gas has been reportedly found in explosive concentrations as far away as six hundred feet. Critical areas of a landfill in terms of its gas migration potential would include the following:

(1) Depth of the landfill and/or water table below the ground surface.

(2) Gas pressure within the landfill.

(3) Permeability of the landfill cover soil.

(4) Permeability of the soil surrounding the landfill.

When the cover soil is of low permeability vis-a-vis the soil surrounding the landfill, lateral gas migration would tend to occur.

One possible influence upon the gas migration could be excessive precipitation. Rainwater would saturate the soil cover and fill the soil pores. The gases vertical escape would be blocked and a pressure buildup would then occur within the landfill forcing the gas to travel laterally. Eventually, the rainwater would be evaporated or be transpirated away reopening the pore spaces for vertical gas migration.

3. Control Mechanisms

As we have already discussed, uncontrolled migration of gases from a landfill can pose a threat to the surrounding environs. Specifically, damaging vegetation or creating a hazard of gas explosion. The purpose of any control system would be to insure that all the gases are vented safely into the atmosphere. Gas control systems can be grouped into two major categories: passive or active systems.

(a) Passive Systems

There are various systems currently used today which are relatively free from maintenance after their installation. These systems are known collectively as passive gas venting systems. Some examples of these methods include the use of gravel-filled vents or gravel-filled trenches which would be located at the landfill circumference to provide a more permeable path for the escape of the gas from the landfill into the atmosphere. These methods allow for the decomposition gases to be intercepted and prevented from migrating beyond the landfill limits.

The long-term effectiveness of either of these two (2) systems is suspect. The vents only intercept the gas which flows directly into the pipe. Much of the landfill gas flow would bisect these vents and migrate off-site. The pipes are also very attractive to vandals. The gravel-filled trenches are easily covered over by vegetation and rendered useless.

Another passive system consists of utilizing a clay or some synthetic material to construct a barrier to prevent the gas from migrating beyond the landfill circumference. A venting system is usually utilized along with this system in order to prevent the buildup of positive gas pressure on the interior face of the barrier. The construction costs of this system make it practical only where a definite gas migration problem exists. We do not believe it is required at this facility.

(b) Active Systems

The active systems utilized to prevent gas migration generally consist of vertical riser pipes placed around a landfill perimeter, all connected to a header pipe which in turn is connected to an exhaust blower. This type of system has been used where the natural ventilation of the riser pipes did not provide an effective barrier to gas migration. This basic system has been modified to include an induced draft vapor fume incinerator that uses the gas as a fuel. This system may have potential at this facility. The proximity of the dog pound to the landfill makes the recovery of the methane gas a possibility. The recovered gas could be used to supplement the pound's present heating system. The feasibility of utilizing the gas in this manner would require further investigation.

At present, there appears no great potential for methane gas migration from this landfill to adjacent land. The ground-water table as depicted on Figure 8 of the Haestad Report should prevent any gas from travelling through the underlying soils. The presence of the sparse vegetation growth on the upper tier may be due to the gas displacing oxygen required by the plants' root system.

RECOMMENDED ENVIRONMENTAL MANAGEMENT APPROACHES

Presently, we find no evidence to indicate that significant environmental degradation is being caused by the operation of this facility. The leachate which migrates from this facility is not highly contaminated and, based upon the limited analytical data, appears to receive a fair degree of attenuation by the marsh. The possibility of contamination of a major ground-water resource is unlikely since this site is in a discharge area. No methane gas data is available but the possibility of lateral gas migration from landfill appears to be unlikely although some adverse effect on cover soil vegetation may be occurring.

Leachate

Based upon the experimental data from Brookhaven and the comparison chart previously presented, it appears the disposal operation and leachate migration can continue at its present level with no change in impact to the marsh. However, a monitoring program and modification of the leachate flow pattern are recommended.

1. Production

The daily landfilling procedure of having the smallest possible active face and applying daily cover should be continued. The present amount of soil cover used is sufficient. No change in the soil type appears to be warranted. When the present portion of the landfill is completed, the entire landfill area should be limed, fertilized and seeded to prevent soil erosion.

2. Collection

As much as possible, all leachate seeps, surface water run-off and groundwater discharges should be channeled into the sedminentation basin. The mixing of all these flows in the basin will dilute the pollutants concentration and lessen its impact upon the marsh. To accomplish this goal of maximum leachate dilution, we are recommending that the surface water drainage swale which exists along the landfill's westerly border be extended to service the entire southerly border and be terminated at the sedimentation basin. The extension of this swale will intercept surface run-off and leachate seeps which currently flows in this southern area. Figures 5 and 6 located in the Appendix are recommended typical drainage swales cross-sections. Where mild sloping land exists, the unlined swale can be used. Where the drainage swale descends steep slopes (>5%) erosion protection with stone has been included. The final system design should carefully consider the surface drainage peak flows to avoid possible overloading of the sedimentation basin and subsequent flushing out of contaminants during precipitation events.

3. Treatment

No change in the role of the marsh as the treatment system of this site is anticipated. The cost to the town is negligible and the choice of another treatment system would most probably not be so much superior to the marsh's attenuative ability. One possible change which should be implemented would be to spread the flow of the diluted leachate to a greater surface area of the marsh. This could be accomplished by constructing a level spreader perpendicular to the main channel flow. This spreader would be constructed right after the flow passes weir #1, utilizing the existing semi-wetland area. This wetland area would eventually be converted into a marsh. Another spreader could be constructed after Artillery Road if deemed necessary. (See Figure 2).

We also recommend that a monitoring program of the leachate flow and of the marsh itself should be continued. This monitoring data will enable one to spot any deterioration trends within the marsh and to allow modification of the leachate flow to prevent any permanent damage to the marsh. This monitoring program should include the analysis for the following parameters:

Arsenic	ABS/LAS	Sulfate
Barium	Chloride	Total Dissolved Solids
Cadium	Copper	Zinc
Chromium (CR+6)	Hardness (as $CaCO_3$)	BOD_5
Cyanide	Iron*	COD*
		Specific Conductance*
Flouride	Manganese	
Lead	Nitrate	
Selenium	Phenols*	
Silver	Sodium	

*These parameters to be monitored quarterly; all the others annually.

Methane Gas

A methane gas management system can only be selected after gas testing has been conducted upon the landfill and the surrounding area. A commercial gas testing unit can be utilized to check for the presence of gas. Specific locations to check would be the homes along Artillery Road, the area across Old Baird Road, the dog pound, garage and in the cover soil.

Gas monitoring wells (Figure 4) may be installed in various locations surrounding the landfill to allow for easier continual monitoring. The soil surrounding the landfill should be tested for its porosity, grain size distribution, etc. to enable one to gain further insight into what might be the most likely avenue for lateral gas flow. A methane gas relief vent (Figure 7) could be installed throughout the landfill to aid the vertical escape of the gas and lessen its effect upon the grass cover.

Any change in the present soil used as cover may induce a change in the gas's ability to be vented vertically. Specifically, the selection of a more impermeable cover to minimize water percolation may induce a pressure build-up within the landfill and cause the gas to migrate laterally. In this case, a formal venting system may be required. In the event that a gas venting system is deemed necessary at this site, we recommend that an active venting system rather than a passive system be selected. It has been our experience that an active system is greatly superior to a passive one in controlling gas migration.

Lastly, we would like to repeat our suggestion that the town consider utilizing the landfill's gas as a fuel supplement for the dog pound and/or the town garage particularly if gas control is found to be necessary.

SITE EXPANSION AND FINAL USE

Any expansion of this landfilling operation can only proceed by balancing the costs and liabilities incurred by the town versus the benefits received by having a convenient disposal facility.

The present landfill is properly operated and its primary environmental impacts of ground and surface water pollution have been minimized. Any expansion of this landfilling operation must be examined from the prospective of what liability the town may gain.

Currently the United States Environmental Protection Agency (USEPA) is promulgating new solid waste regulations known as the Resource Conservation and Recovery Act (RCRA). It is an all encompassing act governing the disposal of solid and liquid wastes. Although RECRA has not been officially promulgated, we believe it is just a matter of time before it does become law. There is one section of this act which has profound impact upon this landfill and more so upon any proposed landfill expansion. Section 4002 of RCRA involves the identification/closing/upgrading of open dumps. It is our interpretation of this particular section's criteria that any future expansion of the Watertown landfill would probably be classified as an open dump unless such expansion included the utilization of bottom liners, leachate collection and treatment etc. The Town may want to evaluate any landfill expansion plans in relation to the costs that may be required in order to fulfill the intent of RCRA.

The landfilling operation has already begun to fill the southern portion of the site with no apparent impact upon the marsh. We recommend that the landfill operation be limited only to that general area. Specifically, we recommend:

(1) The vertical expansion be limited to elevation 760, so as to blend in with the existing completed tier; and

(2) The horizontal expansion be limited to that area north of the grassy dirt mound which exists next to the sediment basin. It is extremely important that the horizontal landfill expansion allows for the construction of the drainage ditch extension previously recommended. Any filling beyond this mound would prevent the proper diversion of leachate and surface run-off into the basin.

We recommend that this landfill be utilized as a recreational area for at least a few years after its closure. This time period will allow for the solid waste to undergo a considerable amount of settlement and gas generation. Any construction contemplated on this site should include a methane gas warning/venting system and a rigorous foundation investigation.

Our remedial recommendations are shown on Figure 2.

Costs

We have prepared an estimate of the implementation cost of our recommendations for this facility. These costs have been tabulated and are shown in Table 5. The basis for these costs was the 1980 Dodge Construction Manual and the past experience of Wehran Engineering with similar landfill construction. The actual cost of some of these items could be much less if the Town Public Works personnel and equipment are utilized in construction.

TABLE 5

TABLE OF ESTIMATED COSTS

Watertown Sanitary Landfill

Item	Description	Unit	Unit Price	Quantity	Amount
Combustible Gas Indicator	Mine Safety Model 53 (or equivalent)	Ea.	$381.90	1	$381.90
Gas Monitoring Well	Drilling and Materials	Ea.	280.00	6	1680.00
Grass Cover	Hydraulic Spreading Lime, Fertilizer and Seed	Ac.	1200.00	12	14400.00
Refurbishing and Extending Drainage Swales	Excavation and Soil Removal	LS			4000.00
Level Spreader	Excavation and Soil Removal/Placement Rip-Rap Placement	LS			3000.00
Soil Testing	Grain Size Dist.	Ea.	32.00	6	200.00

Ea. = Each
Ac. = Acre
LF = Linear Feet
LS = Lump Sum

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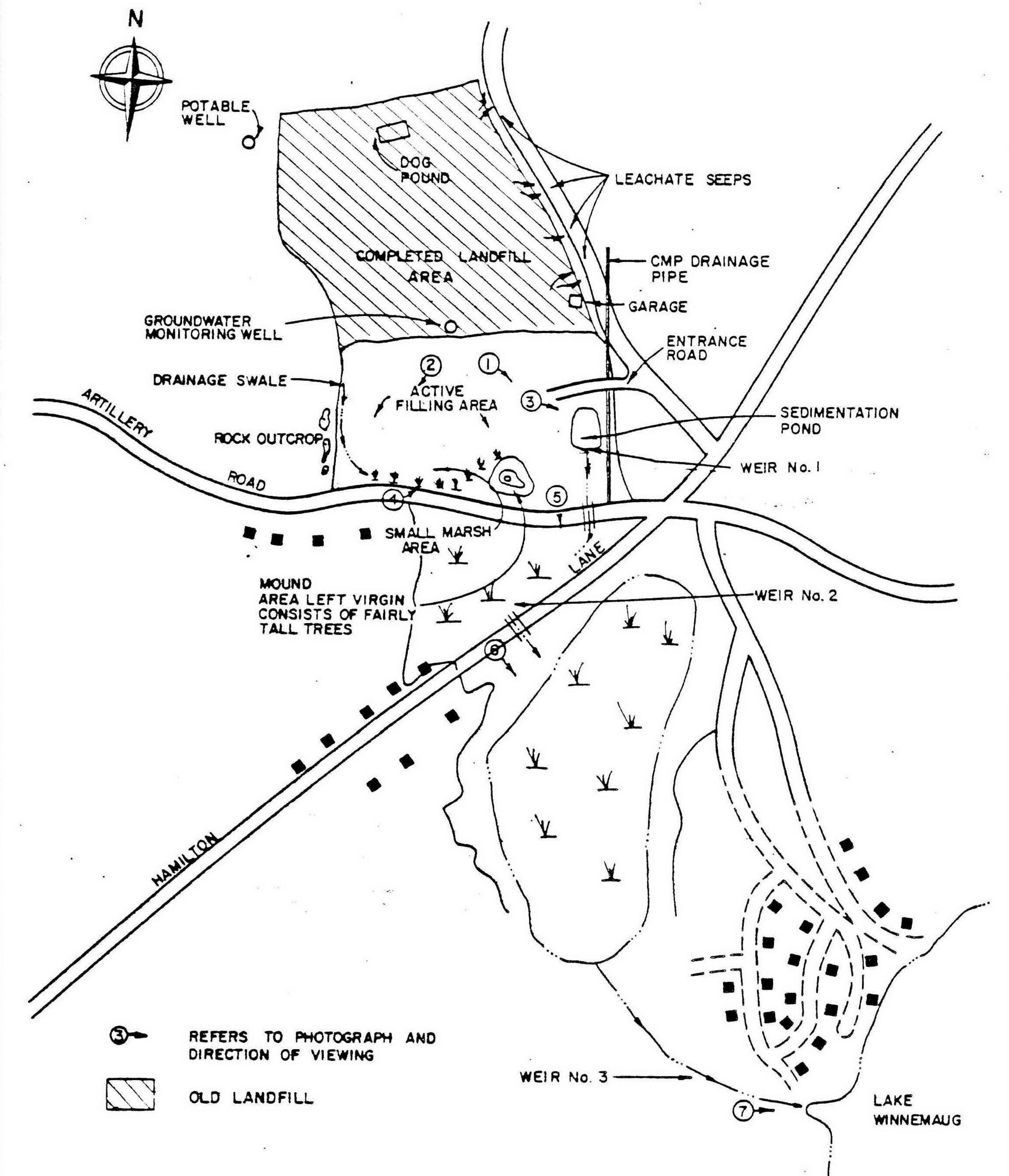
APPENDIX

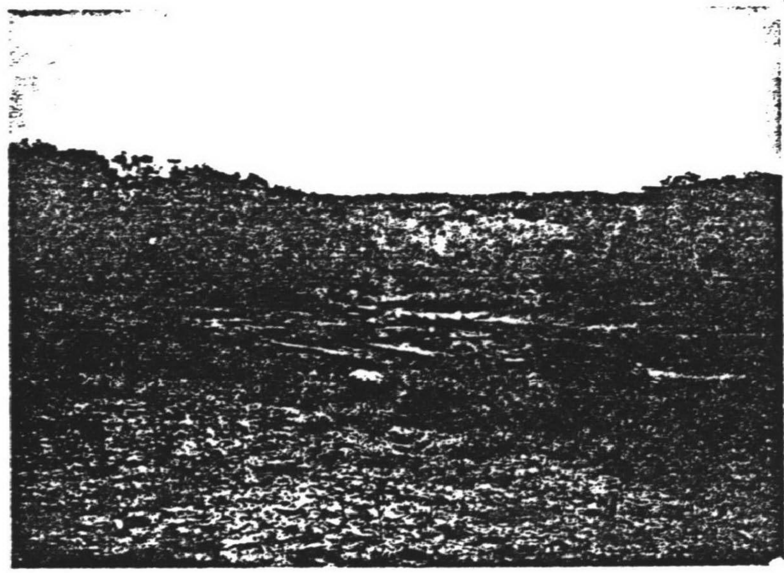


NOTE: THIS MAP IS BASED UPON INFORMATION CONTAINED IN THE R. HAESTAD, PART II B REPORT

FIGURE I

WEHRAN ENGINEERING CONSULTING ENGINEERS	SITE LOCATION MAP NOT TO SCALE OCTOBER 4, 1979	TOWN OF WATERTOWN SANITARY LANDFILL WATERTOWN CONN.

1. Looking South towards an active face. Notice in foreground gravelly soil cover and a sparse grass population. This landfill area was not being used on the date of our inspection; however, cover material was being stockpiled for future use, see piles in left background. Sedimentation pond is in middle of the photograph.



2. Looking South towards the active face which is being utilized on the date of this inspection. Note lower area in the middle of the photograph. The landfill operation is anticipated to fill this area in the future.

3. Looking Southeast into the sedimentation pond. An orange/copper color was predominant throughout the pond. No animal life was observed on this date. However, we were told by the State Inspector that he had observed frogs and a family of ducks living there.

4

4. Looking North into the active face. Notice in foreground a swamp area. This swamp appeared to be localized and not connected to the swamp(s) located across Artillery Road. Note the (two) tiers of land. The area in the background is the completed landfill area on which photographs 1 and 2 were taken from.

5. Looking South into the first swamp area. This photograph is taken of the effluent right after it travels beneath Artillery Road. Frogs were observed sunning themselves upon the sand bar. A few dead trees were observed in this swamp but much of the vegetation was lush.

5

6. Looking South into the second swamp area. No apparent impact of the effluent was observed in this area. Much of the vegetation was lush.

7. Looking into Lake Winnemaug along a stream which is fed by the swamps. The stream appeared to be healthy and contain clear running water.

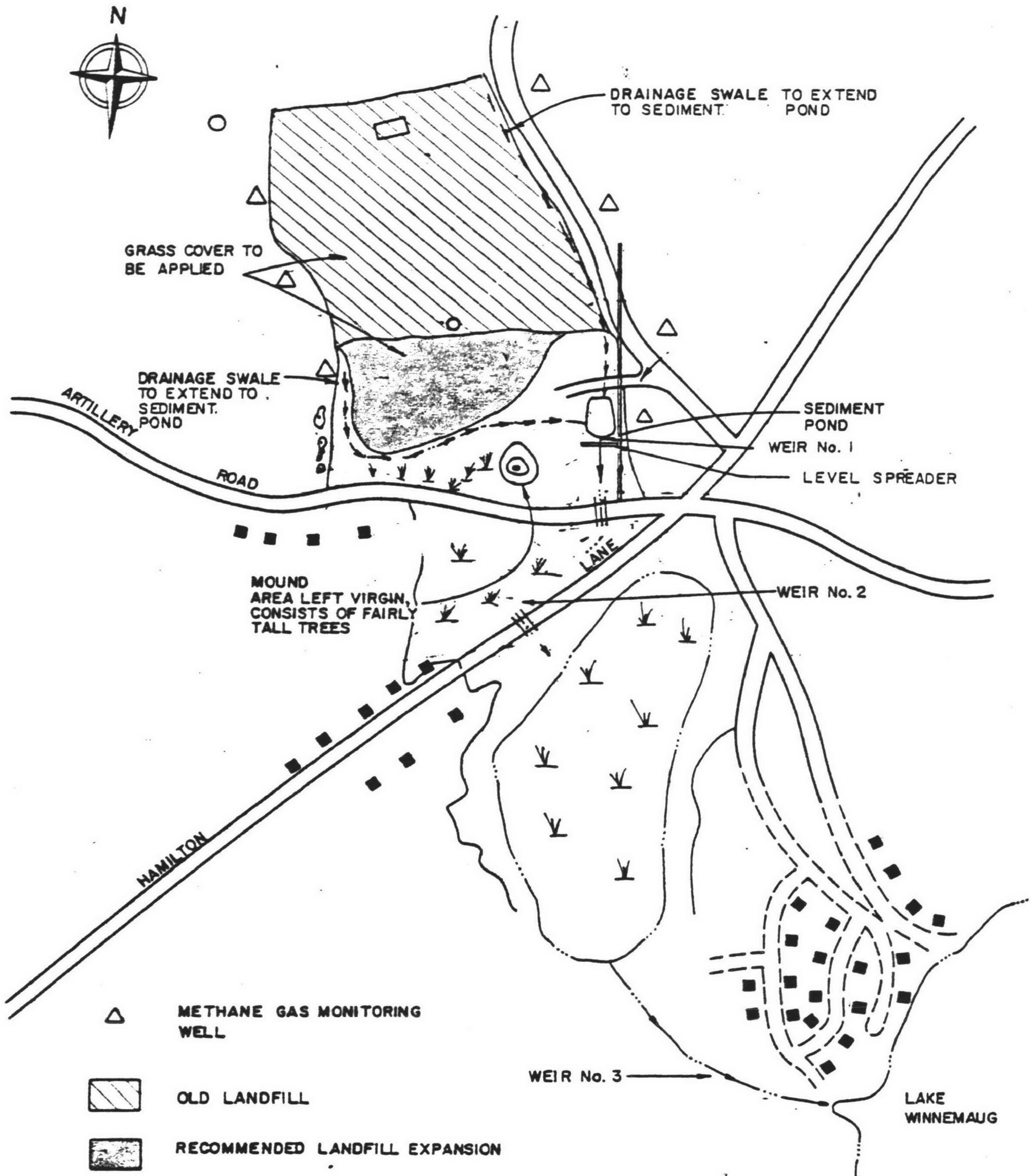
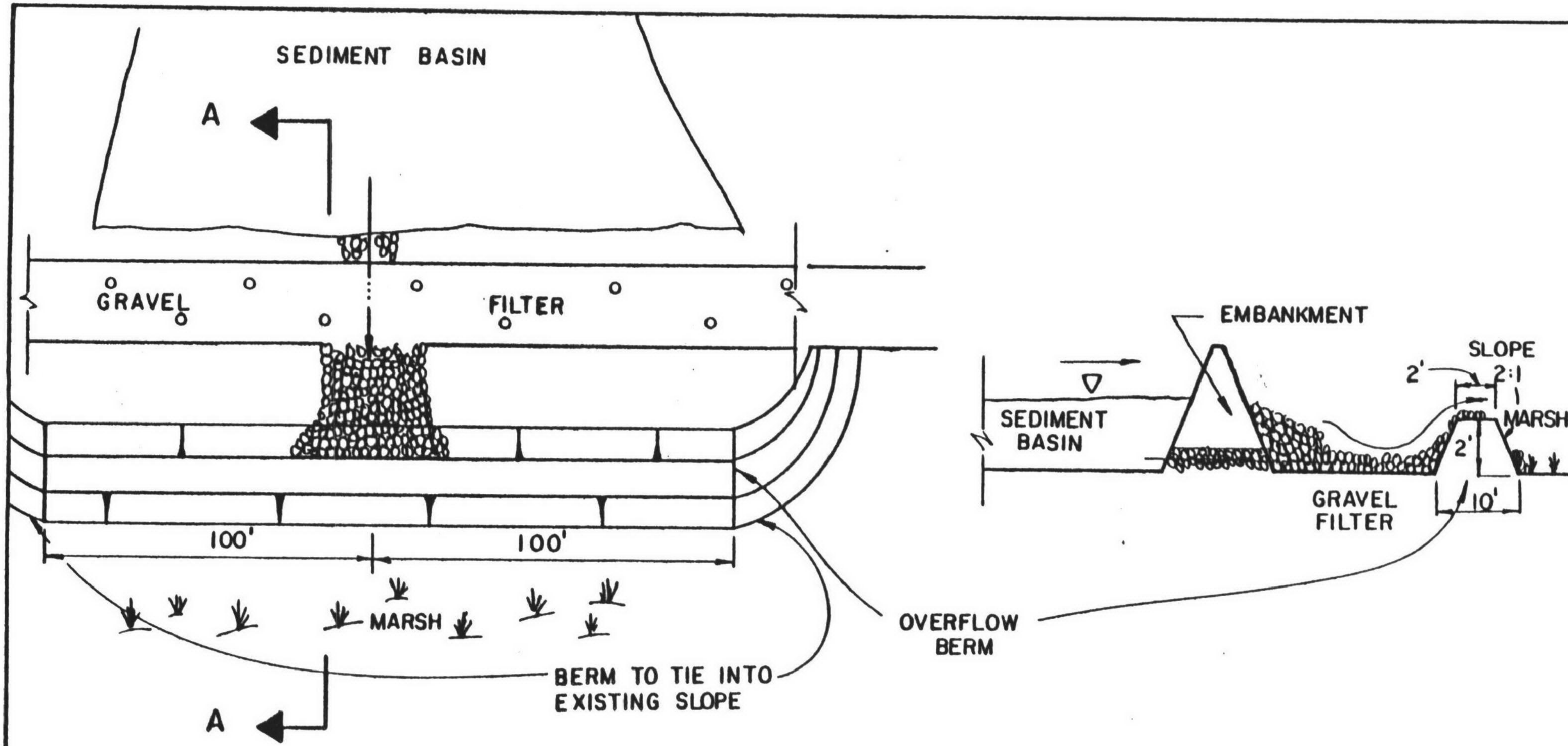


FIGURE 2

WEHRAN ENGINEERING
CONSULTING ENGINEERS

REMEDIAL ACTION
PLAN
NOT TO SCALE

TOWN OF WATERTOWN
SANITARY LANDFILL
WATERTOWN CONN



PLAN VIEW

SECTION A-A

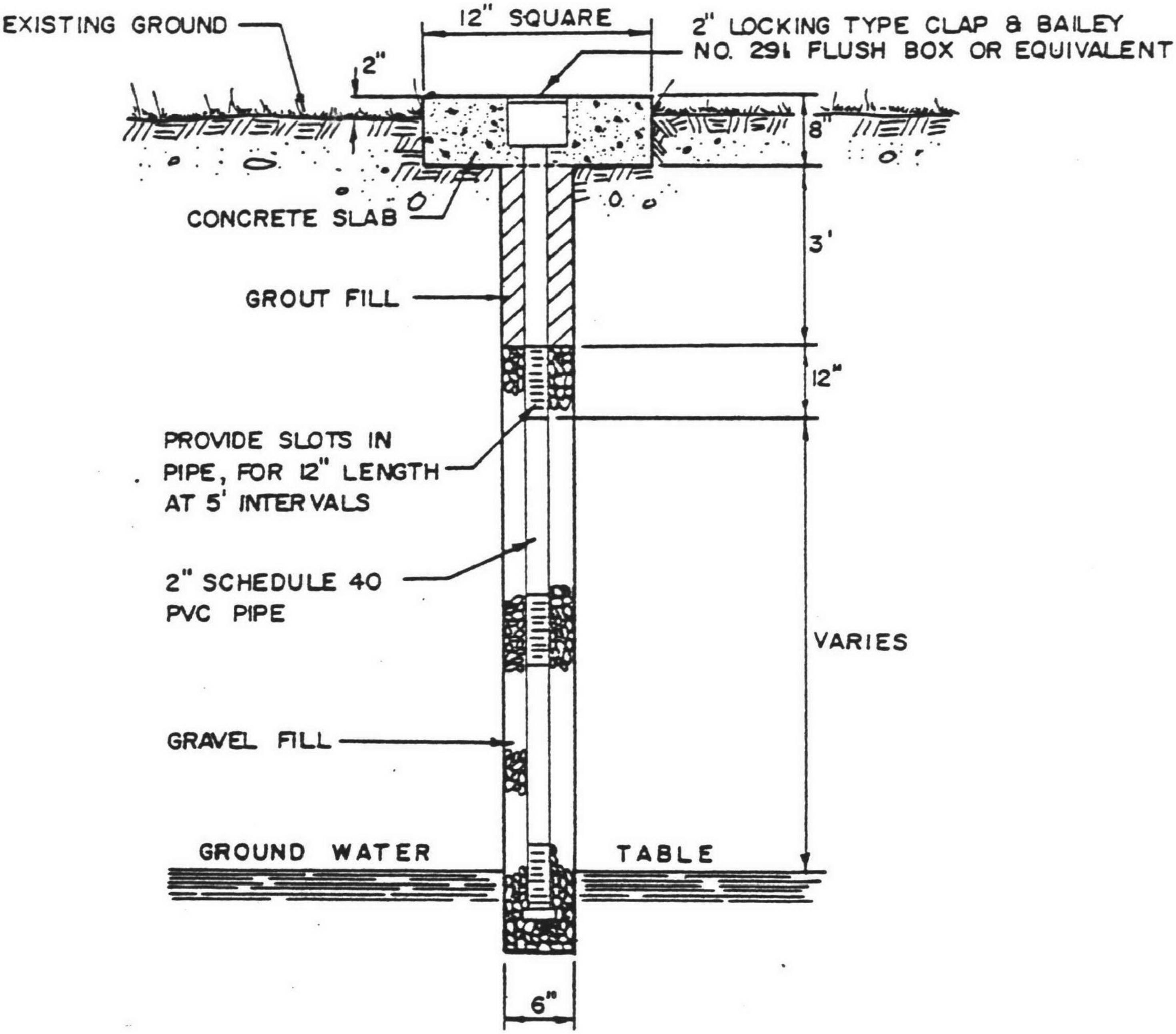
LEVEL SPREADERS

NOT TO SCALE

NOTE:

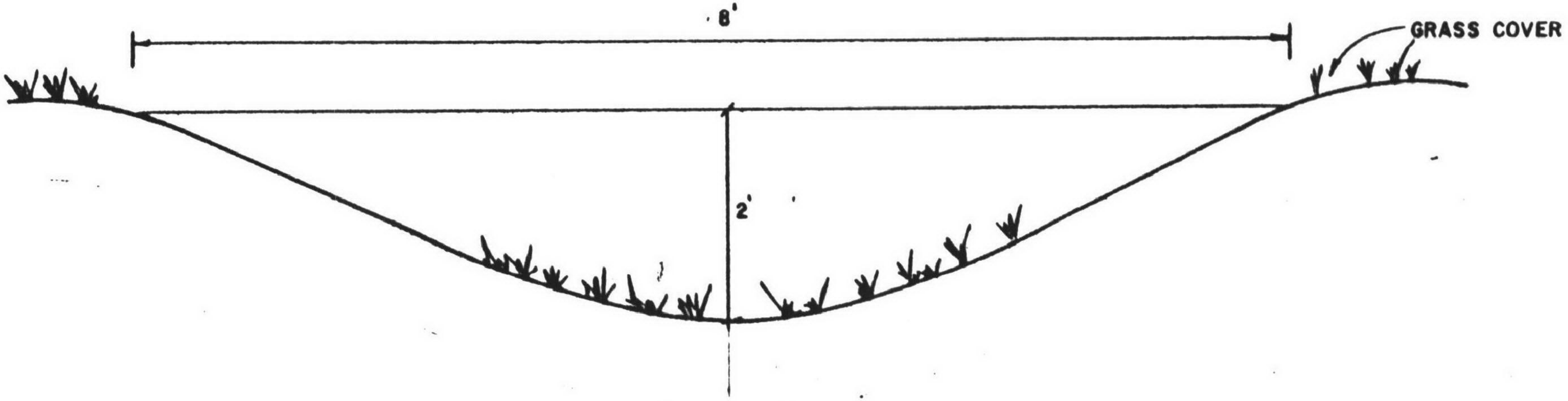
1. THE ABOVE CONSTRUCTION COULD BE REPEATED FOR THE OUTLET PIPE UNDER ARTILLERY ROAD IF DEEMED NECESSARY.
2. THE DUMPED STONE RIP-RAP SHALL CONSIST OF COBBLE AND BOULDER SIZED FRAGMENTS OR SELECTED CONSTRUCTION DEBRIS.
3. THE EARTHERN BERM SHALL BE CONSTRUCTED IN 6" LIFTS AND AND BE SUITABILY COMPACTED.

FIGURE 3



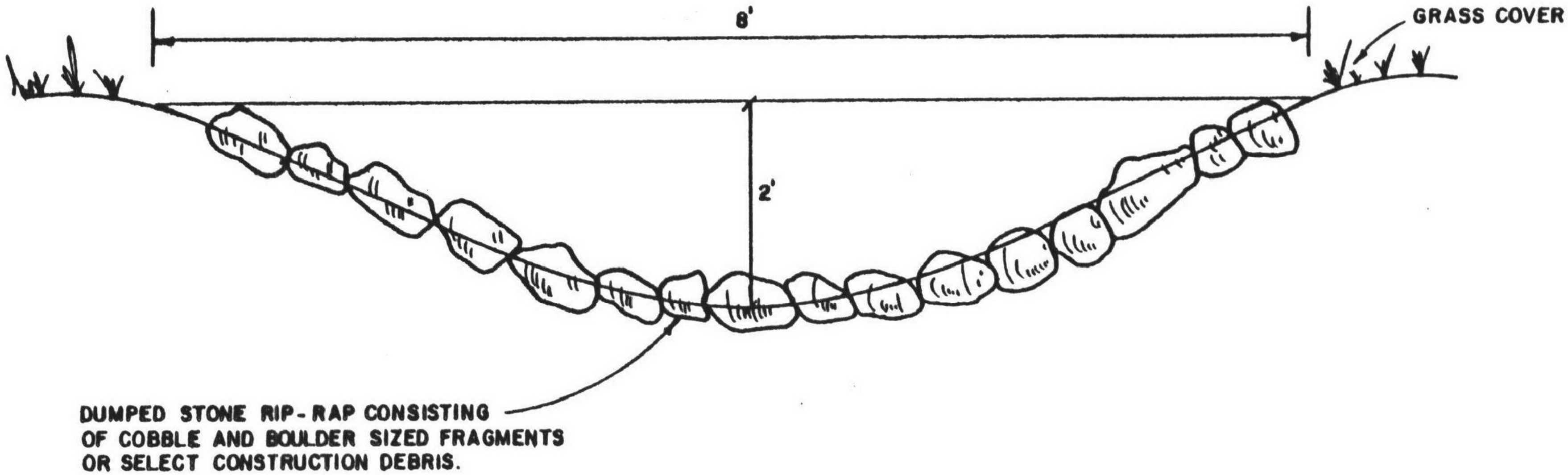
GAS MONITORING WELL

FIGURE 4



DETAIL OF DRAINAGE SWALE

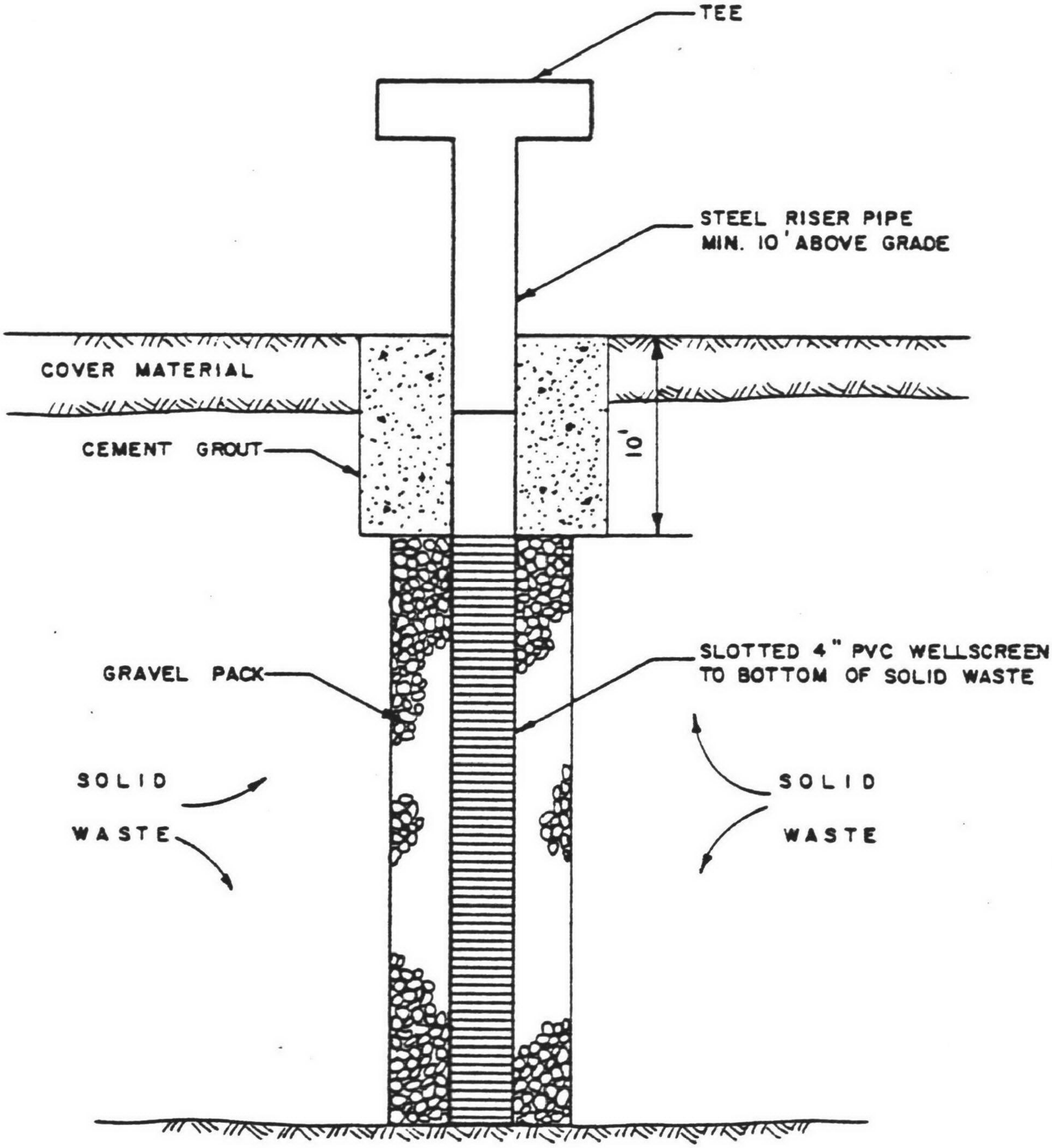
FIGURE 5



DETAIL OF DRAINAGE SWALE WITH EROSION CONTROL

NOT TO SCALE

FIGURE 6



METHANE GAS PRESSURE RELIEF VENT

NOT TO SCALE

FIGURE 7

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