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AD-HOC ADVISORY SERVICES REPORT

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INVESTIGATION

ON

PROPOSED RADIOACTIVE WASTE DISPOSAL INTO THE GROUND AT EZEIZA, BUENOS AIRES

for

Argentina Atomic Energy Commission

by

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IAEA Secretariat

Travel Report: P.J.Parsons
Division of Health, Safety and Waste Disposal

Request by Argentine Atomic Energy Commission to Joint IAEA/ILO/FAO Ad-hoc Advisory Service to report on the possibility of disposal of radioactive waste into the ground.

SUMMARY

The proposed radioactive waste disposal area at Ezeiza was investigated. Boreholes were driven and soil samples collected and tested for porosity, grading and sorptive capacity for radionuclides. The site was surveyed accurately, the water table delineated and groundwater flow pattern deduced. The infiltration capacity was measured. The environment was examined for water usage and natural drainage to evaluate possible migration paths from releases of radioactivity. The site was thus shown to be satisfactory and safe for both solid and liquid disposal with limitation on continuous low-level liquid releases.

The technical report is attached with conclusions and recommendations.

A visit to Cordoba entailed only limited boring to assess the type of soil, depth of water, and possible use for waste disposal. Nevertheless it was possible to indicate to the Commission's representatives present the preferred areas for solid radioactive waste disposal and alternate areas for liquid disposal.

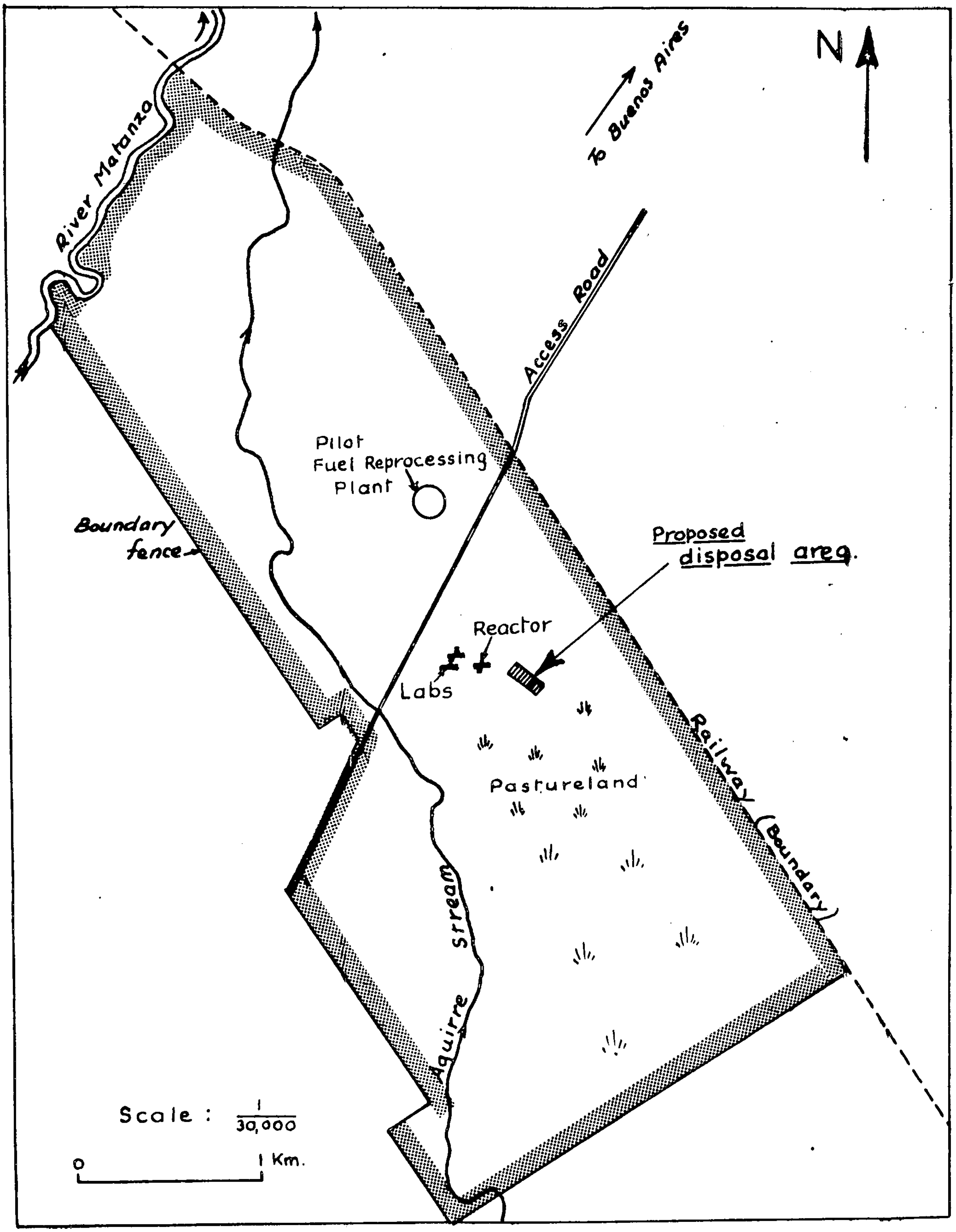

Fig. 1 General plan of Argentine Atomic Energy Commission property at Ezeiza

Radioactive Waste Disposal into the Ground at the Argentina Atomic Energy Commission's Establishment Ezeiza

by

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INTRODUCTION

This report stems from a site investigation from 5-20 March 1967 undertaken in response to a formal request to the Joint IAEA/ILO/FAO Ad-hoc Advisory Service. The objective was to examine a proposed waste disposal site and to advise on the suitability of the area to accept liquid radioactive wastes with safety.

The nuclear establishment at Ezeiza lies 35 km S.S.E. from the centre of Buenos Aires near the International Airport. It is the latest research centre of the Argentina Atomic Energy Commission (CNEA) and is still in the early stages of development. Situated in flat terrain, partly wooded and partly farmland and pasture, the project is divided into two sections 3/4 km apart along a common access road (Fig. 1). One of these is a pilot fuel-reprocessing plant (the factory) and the other is the research section which at present contains a reactor and a laboratory dealing with Health Physics and Environmental Problems. Many more laboratories and buildings are under construction and behind this complex, away from the road, lies the proposed site for radioactive waste disposal.

The possible use of local soils for waste disposal has been considered for some years and in 1961 a research contract (No.33) was awarded to CNEA. This was intended to assess the physical and chemical characteristics of the soil and its ability to absorb or retain radionuclides. The research included examination of the effect of varying pH on uptake and also the associated effeots from having large concentrations of non-radioaotive ions in the radioactive solutions. The results showed that the soil was a rather unusual admixture of sand (42%) silt (33%) and clay (25%) that was able to absorb radiooations in the neutral/alkaline range. But beoause it was sensitive to changes in pH the retention oapacity was much reduced under acid conditions.

A cursory conclusion from these results would indicate that radionuclides in solution introduced in the appropriate pH range oould be retained safely by the soil but the high percentage of clay would probably preclude contimuous liquid disposal beoause of low permeability. However, against this it was noted that all the samples examined had been colleoted from the top 80 cm of soil and were therefore probably not typioal of lower horizons. Top-soil often differs from soil underneath by containing recent organio material and by being weathered and leached by infiltrating water.

Subsequently in 1964 a field test was made to measure the direction and rate of ground water movement. Thirteen 2-in. pipes were installed down to the water table and tracer solutions containing Rhodamine B and I-131 were introduced through one of them. The results were negative and no tracer was detected in the water in any of the surrounding pipes. Nevertheless, periodic observations were continued and water level measurements in the pipes provided useful records. These show that the ground water may vary in elevation ± 1 metre from the levels measured during this investigation.

PROCEDURE

The position of the proposed disposal area is shown in Fig. 3 where a promontory of land at roughly the same elevation as the neighbouring project extends into the surrounding area lying 2-3 metres lower. The area is coarse pasture land which in early autumn (March) was covered with thistles seeded to a height of 2 m. Cattle are allowed to graze there with the permission of CNEA.

It was necessary to determine the direction of ground water movement and to find out why the tracer experiment had been a failure. Firstly, the depth to water was measured in each standpipe to an accuracy of ± 2 mm and then the pipes were surveyed for position and level to determine the relative differences in the measured water table elevations. The results were anomalous showing inexplicable differences in water levels between certain pipes. Because it was not known whether the bases of the pipes were simply open-ended or whether the bottom lengths were perforated, two pipes were withdrawn. They were indeed found to be perforated but the screened sections were filled with mud. In addition Rhodamine B was still present in the injection pipe after three years. To overcome this difficultythe remaining pipes were cleared of mud by lowering a hose down each of them to its base and flushing through with water. In this way the mud was brought to the surface.

Permeability Test

From the outset it was realized that the soil permeability would be an important criterion and that with the equipment available it would not be possible to collect representative undisturbed samples for permeability testing. So a field permeability test was initiated early in the investigations. A test-pit of roughly 2 m^2 was dug and water was introduced into it periodically over a period of 13 days to measure the rate of infiltration and its variation with time. Such data would be of prime importance for routine liquid disposal.

Boreholes

Six boreholes were made in a pattern surrounding the disposal area in the neighbouring low land; only one boring was made in the actual site where 10 pipes had already been installed. This covered a much wider area for observation and at the same time reduced to a minimum the depth of boring required to reach ground water. A hand auger was used with attachments for sampling and boring though both cohesive and granular soils. Both types were needed and normally the ground water was penetrated to a depth of $1\frac{1}{2}$ metres. Below this depth it was difficult to remove soil which became dislodged from the sampler during withdrawal through the water.

Sample Testing

The soil samples were examined for grain-size distribution, for specific gravity, for probable porosity and for their sorptive uptake of radionuclides.

The grain-size distribution was made partially by sieving, to estimate the sand fraction, and partially by sedimentation analysis to measure the silt and clay fractions. To measure soil sorption, small quantities (1g) were mixed with 100 ml batches of diluted mixed fission product solutions (2 years old) and also with batches of solution containing Sr-85 the pH was adjusted to suit. By measuring the concentration of the initial solution and its concentration after being mixed with soil and agitated for 17 hours, the distribution coefficient (K_d) was calculated.

Attempts to measure permeability on reconstituted samples were unsuccessful because of the plasticity of the clay fraction that made the sample impermeable.

Environmental Observations

To become familiar with the geological background of the area, discussions were held with a member of the Geological Division of CNEA. He was able to provide information from deep well borings in the neighbourhood and to give advice on sources of individual and general water supply.

A survey was made of wells in the neighbourhood of Ezeiza which are used largely by farmers for irrigation. The surface water drainage was also examined locally and enquiries started to determine the flow rates of rivers that may conceivably be affected by radioactive disposals in the proposed site.

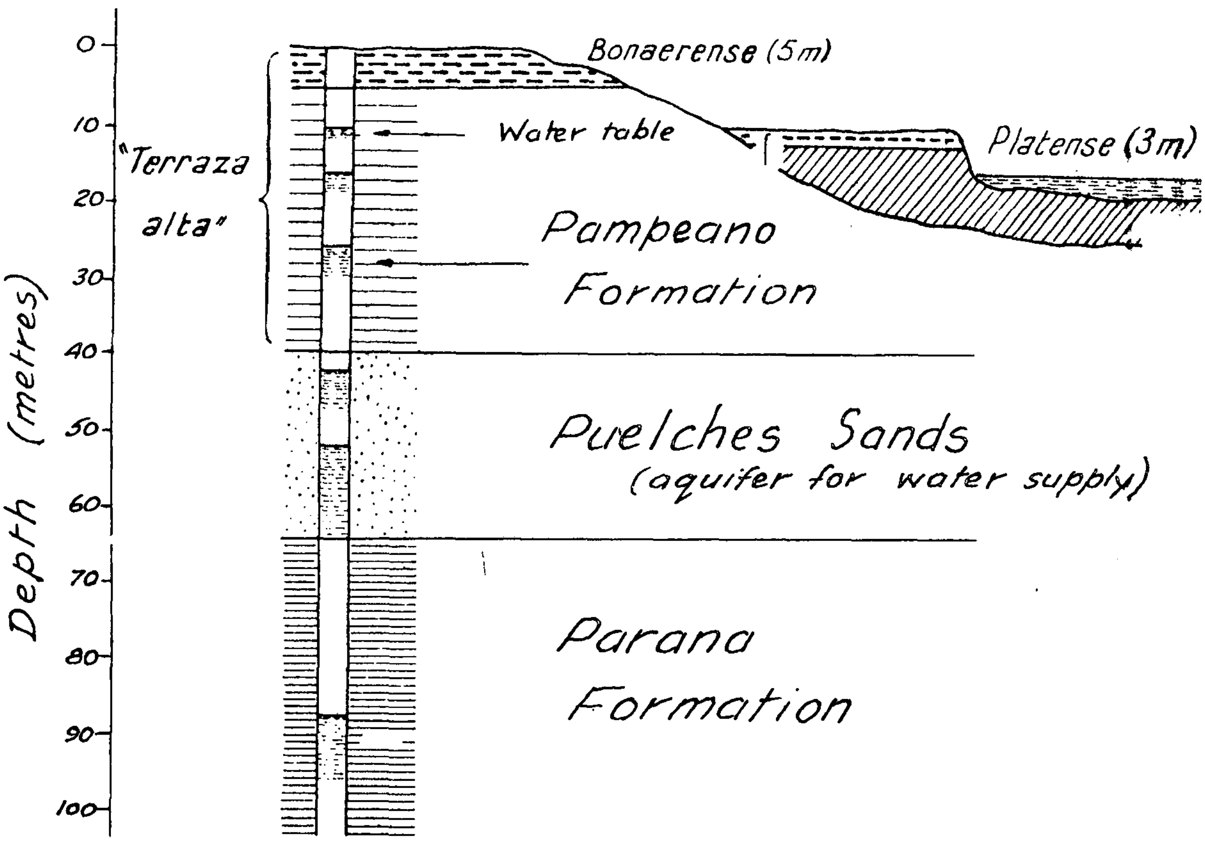

Fig. 2 Geological profile at Ezeiza

RESULTS

The top 40 metres of soil at Ezeiza is known as the Pampeano formation and is composed of loess. It contains sands, silts and clays with occasional lenses of calcium carbonate concretions known as Tosoa. It is not stratified although it is part of a high or old terrace of a former river. The profile in Fig. 2 shows that it contains three water-bearing horizons and the borings made in this study penetrated only the upper or gravity aquifer to a depth of 1-2 metres. Nevertheless from the new borings and some of those existing, it was possible to discern a pattern of water table contours indicating that the natural ground water flow is towards the W.S.W. The layout of pipes and the contours are shown in Fig. 3.

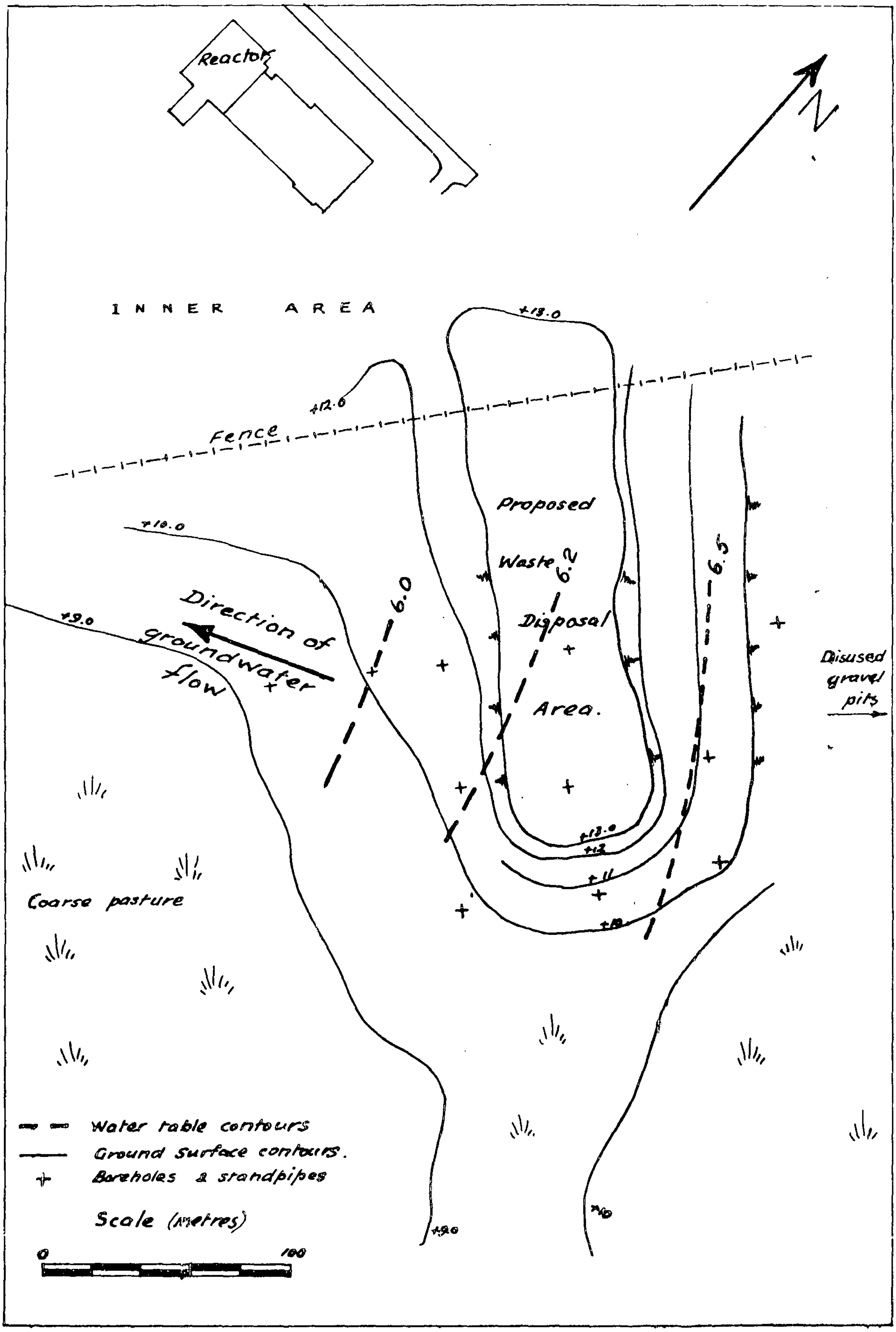

Fig. 3 Plan of disposal area showing boreholes, ground water contours and surface contours

Soil sampling showed that the top metre of soil was of dark brown stiff clayey silt with some organic material, but below this were light brown granular sandy silts with varying amounts of clay. With increasing depth, the soils tended to become more cohesive as moisture content increased but no regular pattern or horizons of deposits could be discerned. The Tosca concretions were occasionally collected generally as small granules randomly distributed in the soil matrix; but on one occasion a large lens was encountered that could not be penetrated and the hole had to be abandoned.

It was noticeable that the amount of Tosca granules increased at or near ground water and a typical particle-size analysis in Fig. 4 shows that this soil was more permeable than that in the higher horizons. Typically it was composed of 19% sand with Tosca granules, 59% silt and 12% clay and is thus classified as a silty loam.

The pH of the ground water was at pH 7 and it was observed during preliminary sedimentation tests that tap-water flocculated the clay suspension.

The soil samples retrieved from the borehole in the disposal area showed that at a depth of 2-3 metres there was a horizon of dark brown clay or silt containing organic humus. Since this was typical of the top soil in the surrounding low-land it is concluded that the elevated mound was man-made and that the soil probably originated from gravel pits lying 100 m to the east. The soil was consolidated and covered in natural vegetation and nobody could confirm that it had been dumped there artificially.

Uptake of radionuclides

Using ground water for diluting the radioactive solutions to suitable concentrations, the following results were obtained:

- For aged fission product solutions at pH 6 $K_d = 300$
- For Sr-85 solution at pH 7 $K_d = 47$ to 52.

Infiltration test

The results of the 13-day infiltration are shown in Figure 5. The spot measurements varying about the mean line were caused by variations in pressure head when fresh water was introduced into the test pit. It was not possible to arrange for a constant level head throughout the test.

The infiltration rate dropped dramatically in the first 48 hours. At the end of 13 days the infiltration rate had reduced to 76 $l/m^2/day$ and was still tending to diminish even further.

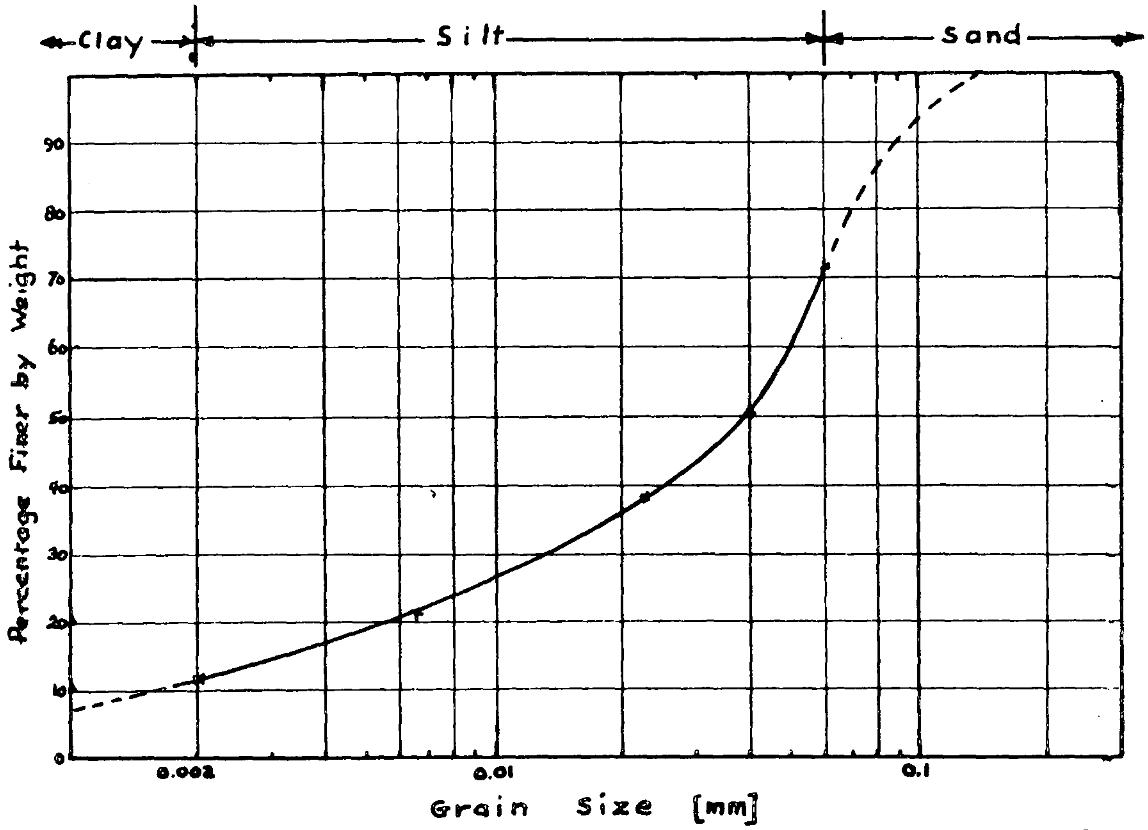

Fig. 4 Typical particle size distribution curve of silty loam in the upper aquifer

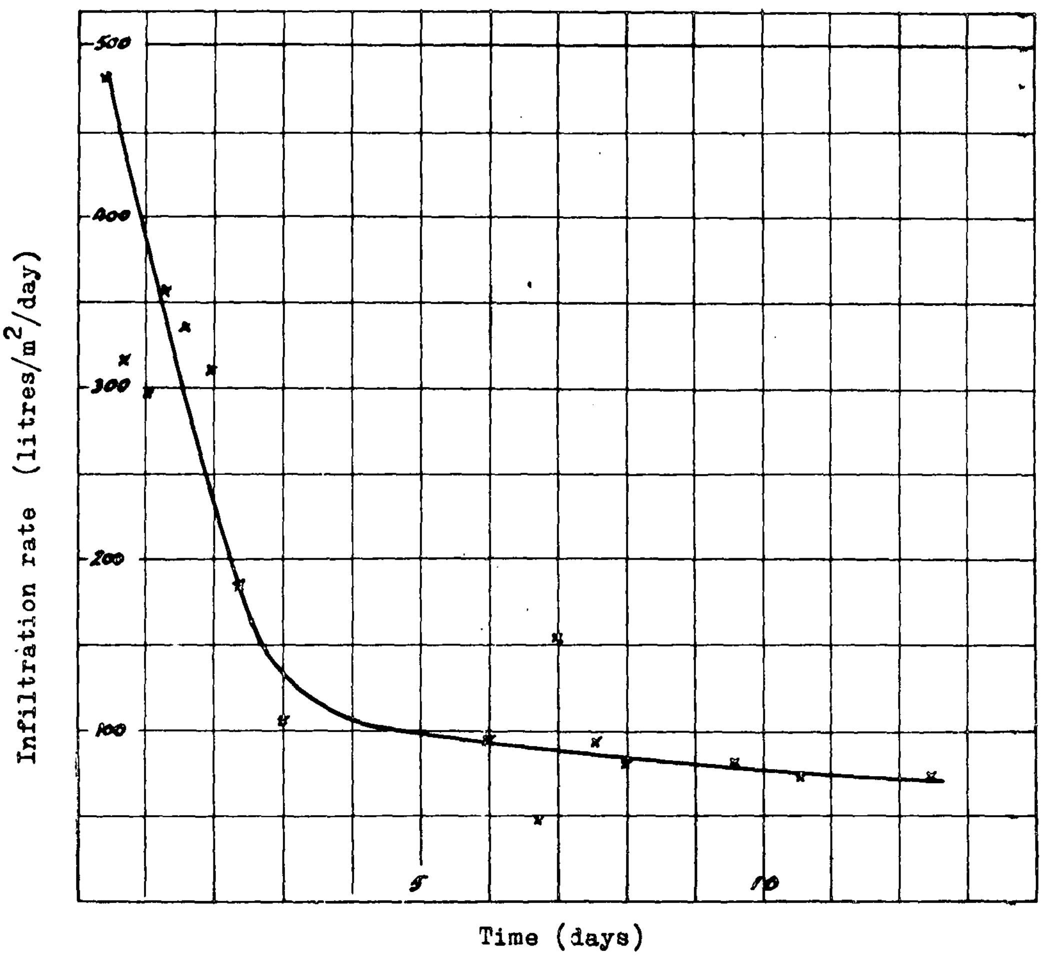

Fig. 5 Curve showing variation of infiltration with time in disposal area test pit

Environmental enquiries

Although the Federal capital of Buenos Aires has its water supply from the River Plate it was learned that in the surrounding provincial regions ground water is often used for this purpose. In fact the water supply for the nuclear establishment at Ezeiza comes from two wells. However, it was understood that the Pampeano formation (Fig. 2) cannot supply water in such quantities and the aquifer capable of sustaining adequate yield is the Puelches Sand that lies immediately beneath the Pampeano at a depth of 40-65 m. This is isolated from water-bearing horizons above.

The water supply in individual farm wells used for irrigation, all penetrate deeper than the first aquifer though not necessarily as deep as the Puelches Sands. In fact the use of water from the upper aquifer is prohibited by law because of dangers of pollution. It was ascertained that there were three wells in general use on neighbouring farms but fortunately all these lie in the opposite direction to that of the ground water flow i.e. to the east.

The main drainage for the whole surrounding area flows into the River Matanza which has a mean flow of 1000 m^3/hr and which discharges into the River Plate at Buenos Aires. The Aguirre stream that flows through CNEN property (Fig. 1) is a minor tributary which joins the main stream just beyond the property boundary. Its flow varies widely from season to season and during March was reduced to a series of discontinuous ponds along the muddy stream bed.

DISCUSSION

Technically, the proposed disposal area is probably one of the most suitable sites within the Commission's property. However, because it is only 250 m from the reactor it is conceivable that a disposal area so close might inhibit future expansion. In answer to this it was explained that future expansion is envisaged along either side of the main access road so that this problem will not develop.

Because of the high retention capacity of the soil it is anticipated that all of the cationic radionuclides in the waste solutions will be fixed or partially adsorbed on the soil provided acid waste is not released and provided that the input flow rate does not exceed the filtration capacity and so overflow the disposal pit.

In this area the groundwater was between 7-8 metres below the surface so that with a disposal pit 2 m deep and even in a season of high groundwater levels, there should remain a depth of 3-4 metres of unsaturated soil beneath the pit. Most of the radiocations would be retained in this zone and only the residual radionuclides and anions would reach the groundwater. At this stage the quantities reaching the groundwater would be controlled by the concentration of non-radioactive cations in the waste effluents. However, experience elsewhere indicates that the majority will be trapped in the aerated zone. The residual radionuclides would then migrate in the westward flow of groundwater although more slowly than the water; they would remain underground for 750 metres until they reached the Aguirre stream. Because of the low groundwater gradients and the indifferent permeability it is expected that the groundwater flow would be less than 30 cm/day. The migration of radioanions would be somewhat less and the rate for radiocations such as strontium would perhaps be only 5% of the water flow rate.

The waters would eventually emerge in the bed of the Aguirre stream but even then they flow within the Commission's property for 4 km before final dilution and dispersion in the Matanza River. As such the length of flow path and controlled migration is so long that the emerging radionuclides will be so dispersed and diluted that they should cause no hazard, but further field tests and experiments could determine accurately the rate of migration and the longitudinal dispersion to be anticipated.

In addition to this disposal area there is also another area ½ km east from this disposal area, towards the airport that might be borne in mind as a possible future site. Although it is not so convenient it is easily accessible and might be considered for possible investigation and for individual disposal experiments.

Development of disposal area

The Commission proposes to use this site for three types of radioactive waste disposal:

- Batch releases of intermediate-level liquid wastes
- Possible continuous disposal of low-level liquid wastes of minimal activity
- Solid waste disposal.

Liquid disposal

The first liquid disposal will be a batch of intermediate-level liquid waste containing either 1000 or 4000 Ci of aged mixed fission products. This solution is currently held in storage tanks, it is alkaline and has much dissolved aluminum and has formed a precipitate that contains most of the radioactivity. For the soil uptake measurements the radionuclides in the sediment were redissolved producing a pH of 6. But for the actual disposal the bulk of the radioactivity would remain in the precipitate and the alkaline medium for the remaining dissolved radionuclides would provide the best conditions to mobilize the sorptive capacity of the soil.

By introducing this waste into a specially excavated pit most of the particulate material will be deposited on the base of the pit and infiltrating solution will lose most of its radionuclides to the soil in the aerated zone probably very close to the underside of the pit. Infiltration capacity should not be a physical hindrance to this operation. However, it will be necessary to provide a gravel or pebble shielding in the pit and the solution will have to be introduced through an inlet pipe discharging the liquid close to the base. The phydical problem of keeping the sediment in suspension will also have to be solved to ensure complete transfer from the transporting tank to pit. The pit should be roofed or capped with asphalt to stop the infiltration of rain.

This initial disposal should be considered experimental even though the solution will not be typical of future intermediate-level wastes which will be entirely in solution with no precipitate. To contain the waste laterally it may be appropriate to provide concrete side walls to the pit that protrude say 15 cm above the surrounding ground to stop run-off and lateral infiltration. This could be conveniently achieved by using a section of large diameter (1.50 m - 2 m) concrete pipe that could be lowered as a caisson into the ground to a depth of roughly 2 m. This should bring the base of the pit into the layer of former surface soil containing organic detritus which might have good anionic as well as cationic retention qualities.

As much information as possible should be gained from this disposal and it should be monitored at regular intervals. To measure vertical migration of β -emitting radionuclides, a dry aluminum tube might be installed through the base of the pit and extending through the filling material so that a counter may be lowered for measurement in situ. The tube should be a tight fit in the hole to stop liquid infiltrating rapidly into the peripheral void space. Secondly, perforated pipes should be installed into the ground water close to the pit and the groundwater sampled regularly. Samples would need to be assayed both for non-radioactive anions (e.g. nitrates) as well as for radioactive ions. Thirdly, an open-ended pipe should extend into the pit to indicate the liquid level.

For subsequent batch disposals with negligible suspended material and corrected for pH of 7 or higher, it would be interesting to fill the pit partially with a mixture of some of the removed soil and coarse sand. With its improved permeability the mixture might serve as a prefilter to solutions before they enter the undisturbed soil and also act as an additional ion-exchange medium within the pit.

Continuous Liquid Disposal

The infiltration capacity of the soil is not good for continuous liquid disposal but it may well be satisfactory for discontinuous disposal. The infiltration rate diminished to a temporary equilibrium 76 $l/m^2/day$ after 10 days but it should be anticipated that this will drop even further and that a more representative figure would be attained after one month's continuous infiltration.

The rate is low compared with that attained elsewhere where routine radioactive low-level liquid disposal is practiced. At the National Reactor Testing Station the infiltration rate reduced to 350 $l/m^2/day$ after five years and at Chalk River, where there is also a shallow water table, the equilibrium infiltration after several years of slow reduction was 90 $l/m^2/day$. It should be borne in mind that the probable volume of waste effluent will be 5000 l/day and that this will normally be sufficiently inactive to permit direct release into either the sewer or to the Aguirre stream. Since delay tanks will be used, batches of liquid will be monitored before release so that the proportion diverted to the ground disposal pit may be quite small. Under such conditions it may be unnecessary to sustain maximum infiltration and the holding capacity of such a pit might serve the dual purpose of intermittent low-rate disposal pit and emergency stand-by basin for liquid wastes.

It was suggested that trenches filled with a mixture of permeable soil with good exchange capacity could be excavated between the reactor and the Aguirre stream. The objective would be to use this as a horizontal exchange column. It was pointed out that it would be difficult to attain the correct permeability and to avoid surface overflow because of the sloping profile of the ground.

Solid Disposal

The burial of solid wastes in this soil would cause no difficulties and it would only be necessary to exclude rainfall to stop leaching.

It is assumed that solid wastes would be buried in trenches oriented down the natural slope of the land and that the soil covering would be compacted to induce run-off and reduce infiltration of rainfall. The mean annual precipitation is about 100 mm so that normal precautions would be sufficient to exclude rainwater from the trenches while they are open. If necessary a water sampling tube could be inserted into a sump built into the lower end of the bed of the trench.

Environmental Investigations

At present there is much environmental information that is not known - the ground water flow being the most important. This should be studied by the introduction of tracers either by single borehole techniques or since the water is shallow by multi-injection and sampling points. The approximate direction of flow is indicated and the tracer solution might be introduced in a broad front at right angles to this direction. In this way it is easier to find the tracer solution downstream than if there is a single injection pipe. After the direction and rate flow has been determined from preliminary dye tests it may be repeated in the same installation to measure the various migration rates of radioactive tracers covering both unadsorbed nuclides and those that are retarded such as Sr-85.

Another important monitoring observation would cover the activity measurements in the Aguirre stream and the flow rate. Flow rate measurements by the installation of a weir or flume situated near the stream intersection with the access road would provide information on seasonal flow variation and indicate the component of flow that originates from groundwater sources.

It should be stressed that once radioactivity is introduced into the disposal area it should be fenced securely and all cattle excluded.

For the routine monitoring it should not be necessary to install automatic recording equipment and, except for the period immediately following disposals, weekly observations should be sufficient.

CONCLUSIONS AND RECOMMENDATIONS

1. The proposed area is suitable for radioactive waste disposal directly into the soil. Any leaching of radionuclides into the groundwater will cause them to migrate underground towards the Aguirre stream in a W.S. Westerly direction. The rate of migration is expected to be very slow for radiocations such as Sr-90 and Cs-137.

2. Liquid disposal in batches of intermediate-level waste should be treated as experimental and should be monitored regularly. The information so attained should be of great use in subsequent disposals. In particular the first disposal should show which radionuclides will be retained in the aerated zone beneath the pit against those that will gravitate to the groundwater and so migrate towards the stream.

3. The initial batch disposal pits should be positioned towards the perimeter of the proposed area so as not to interfere or inhibit the introduction of possibly larger disposal facilities at a later date.

4. Groundwater tracer experiments should be carried out, preferably in the low land between the disposal site and the Aguirre stream to measure the velocity and direction of flow. The tracer may be introduced on a broad front rather than through single injection points to aid sampling the plume in the groundwater. With the pipes remaining in place the initial dye test might be repeated with radioactive materials some of which are non-adsorbed and others that would be retarded by exchange with the soil.

5. Routine liquid disposal may be difficult to maintain because of the low infiltration rate. But if such a facility were installed it may be most useful for low-level liquid disposals when necessary. For the success of such an operation everything will depend on the rate of reduction of infiltration beyond the 13 day-long experimental period of this test. Further continuous long-term infiltration measurements should be carried out.

6. Solid disposals may be safely carried out according to well published procedures elsewhere. But since this may consume quite a large area of land it should be considered whether an alternative site ½km east could not be used for this purpose together with other experimental disposals.

7. It is recommended that the records of groundwater level measurements are continued.

8. It is recommended that the Aguirre stream should be part of the regular environmental monitoring. The flow rate should be measured by a weir or flume at the point where it flows beneath the access road. In particular flow records should indicate seasonal variations and also the component of flow that originates from groundwater as distinct from that of run-off.

9. Cattle should be excluded from all areas where disposals are made and protective fencing should be installed.

ACKNOWLEDGEMENTS

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