McMASTER UNIVERSITY
Department of Geography
1280 Main Street West, Hamilton, Ontario, L8S 4K1
Telephone: 525-9140 Ext. 4535

Ex 87

May 29, 1984.

The Joint Chairmen,
Mr. Geoffrey, Mr. Eisen,
Environmental Assessment Board,
Burlington, Ontario.

Sirs:

RE: Extension to the Burlington landfill site

Permit me to make comments on the technical report given by Dillon, especially Volume 2.

I have been a resident of Canada and Burlington since 1968, a resident of Aldershot since 1981, my home 616 Marley Road, is two kilometres distance from the site. I am Professor of Physical Geography at McMaster, specialist in soil sciences, with published papers and supervision of graduate studies in relevant fields. I have passed this site almost daily for the last three years travelling by bus or car on the North Service Road and also visiting the surroundings on many occasions.

I will first make general observations and then make specific points in brief.

Yours very truly,

Brian Bunting

Brian T. Bunting,
Professor.

BTB/dw
Encl.

1. As an objective scientist, editor and examiner I feel I can honestly say that I have never seen a more inflated piece of work, inflated by irrelevant, or second-hand, information, coupled with many gaps in what really needed to be done to assess the situation properly.

The conclusions given are not in accordance with the data supplied, or are contradicted by it. One would have expected some spatial and/or time series analysis of the data. Presumably this has not been done, because it would have shown a predictable and currently self-evident leachate loss, and a structure virtually impossible to contain given that the input of waste in the next few years (1983 and forward with 185,000 tone p.a.)+ will far exceed that from 1976 to 1982 - 654,000 tons in 7 years+, which is already responsible for the self-evident and serious impact on surrounding land and amenity.

2. Generally, since 1970, inground waste disposal has moved from dumping in abandoned rock, gravel and/or sand quarries (at least in North America) to the relatively safe procedure of digging a hole in impermeable geologic materials on level, dry ground. However, Burlington or Halton, in another of its quests for international recognition, this one unwitting, will soon gain notoriety in being one which hopes to dig a hole on top of a slope between two streams, based on calcitic till overlying weathered shale and there to bury its garbage without any deleterious effects.

Common sense, if not elementary principles of earth science, indicate the inadvisability of establishing such a site in the first place, the folly of expanding it at the anticipated rate and volume.

3. Perusal of sources, mainly Provincial studies of waste management site procedures, the recently published Federal text 'Stress on Land', especially Chapter 3 and various U.S. texts facilitates compilation of a list of 'desireable' properties of waste disposal sites:-

+ Based on data supplied by Halton Regional Office.

1) On impermeable strata, with relatively uniform widespread lithology, not subject to solution of calcite, gypsum or physical cracking, or similar phenomena.

2) Relatively flat (< 2%) land, not subject to ponding or excessive moisture from snow melt or heavy rain, similarly not generating large lateral runoff.

3) Close to a source of supply of acceptable cover materials.

4) Relatively remote, or distant, from settled areas.

5) Preferably accessible by little-used roads, or not adjacent to frequented intersections, narrow bridges or other traffic hazards.

6) Any dust or contaminants, or litter to be containable.

7) Any possible leachate or spillage to be kept or contained at a distance from aquifers, permeable soil materials, open ditches etc.

8) Landfill sites should not be placed close to:-
Incised stream valleys,
Stream or surface drainage systems having variable discharge,
Unstable or eroded soils or slopes,
Conservation, recreation or amenity lands.

9) Sites should not be placed in areas of surface water generation or accumulation (see 1 and 2).

10) Sites, should not, on closing, represent a significant alteration to the contours of the previously-existing landforms.

11) As a general rule, expansion of a site should not be permitted, if initial monitoring shows serious leakage.

12) In settled areas, frequently traversed by garbage disposal vehicles, only transport in sealed and/or covered vehicles should be permitted.

4. A perusal of this list, much abbreviated and simplified from many sources, shows that the Burlington site fails to meet the most fundamental if not all of the requirements. That is to say, it should not have been developed in the first place. Presumably it was sited on non-revenue producing, non-developable land. There are no rational criteria, given the known failure of Bayview, for its initiation or expansion.

Part B

Detailed technical comments or points of difference in Volume 2

p. 0.26 Fig. 0-6 The '*inferred groundwater table*' is quite incorrect. In the North, by Falcon Creek, there is strong seepage within the weathered shale; the contact of it and the shale (see major cross-section) slopes to the north and data already show contamination of that slope (boreholes 1, 22, 7).

To the south, borehole and water table data show that the water table is at or near the surface for many months (boreholes 11A, 12, 13, 16, 15, 17 etc.) and is highly contaminated and has been so since the winter of 1981-2.

p. 0.28 and Table 4 (p. 0.115) (*Clay*) *mineral analysis*

It is hard to understand why such an analysis should be done in Saskatchewan, more seriously what it represents. Throughout this study we have no information on how the analyses were done; for example: "How was pH determined?" "Was the cation exchange capacity done at pH7, pH8 or what?" Similarly in Table 4, -- "bulk sample"? "Was the material taken as a lump?" In borehole 21 (page 0.103) was the 6% gravel excluded before grinding and sieving? Was the X-ray analysis done on everything else, or only on that ground down to a size of 180-300 microns, the usual procedure. Or was the analysis done on the 32% clay alone -- another equally acceptable procedure!"

Personally I object to this cavalier treatment of information, especially when figures plucked out of the air, are used for estimates of permeability, percolation, cation adsorption and many other suppositions as to future impact of leachate on site behaviour.

What could be more useless a generalization; taking one set of data (Borehole 19) applying to the lowermost part of the fractured till at 3-3.5 m depth; and another set (B. 21, 12.2-12.6 m depth) in a red till, ~~and~~ then making an average value for the whole till mass, when in fact both boreholes are peripheral to the site??

The estimates of *porosity* are very dubious (last 2 lines of p.0.28).

The data in *Table* 4 give me cause for anxiety - material with from 15 to 39 per cent lime (calcite) will be highly soluble under permanently wet conditions, whether used for cover, liner or backfill. The 73% *illite* content - (mica-like minerals) in the shale presumably dominated by K ~~or~~ potassium, is very susceptible to cation exchange under wet conditions and the consultants optimism about successful long - continued cation attenuation seems unjustified. Under the impact of prolonged intense wetting the shale and till will be altered and become much more permeable. In any case this dominance of illite contradicts the consultants' assumption of calcium dominance.

p. 0.36 *Water budget*

There is gross mis-representation of this aspect.

The long-term precipitation normal for the Hamilton area is c. 860 mm. *Actual* evapotranspiration, self-evidently less than PE, is what is required. This is measured at various sites and is of the order of 520-540 mm. The Thornthwaite method is old hat, and estimates by Penman's method would estimate AE at 0.9 x open water evapotranspiration (Lake Ontario) of 565 mm = 509 mm. *

Thus any "water surplus" would be 860 - (509 to 540) c. 320-350 mm/a, varying from 280 to 450 in any year. Hence infiltration would be greater than suggested, and the final site would never be more than grass-covered, hence infiltration would approach at least 5 or 6 l/min/ha. The consultants also omit two things:-

a) the inherent water content of garbage
b) the hydrophylic nature of garbage.

Hence garbage possesses the capacity to store excess water, adding to the mass involved in calculations of head, and increasing the potential for leakage and downslope movement of more than one year's surplus.

* The study admits this on page 0.36 line 8 (below Table 1), but then ignores its own figures of 212 to 335 mm. Actually it should be 320-350 over the long period, not 212.

The Borehole data (pages 0.80-104 passim), are very poor. The self-evident vertical heterogeneity, easily seen in field exposures, is nowhere described.

Permeability

The permeability data (pages 0.146 etc.), Table 8, are incomplete. Once again no explanation of sampling or laboratory procedures is given and statistically unsound average figures are adduced. Nearly all the data comes from the north-western area; (Bunting ex. 1) a range of data from unfractured till "ranges" for only two quoted samples (plus 3 gained by other methods, techniques of packing unspecified).

Personally I cannot understand the relevance or applicability of such figures - boreholes 7 and 21 are very close to the valley-side and are much too low, the packer data for shale, of n^{-7} is more in line with such materials, similarly of n^{-5} for fractured till. (see my exhibit 2).

The data for shale, p.0.149, is equally suspect and mis-represented. It is not from 1.6×10^{-7} to 2.3×10^{-10}, but 1.33×10^{-7} to 9.45×10^{-10}, the figure 2.3×10^{-10} does not occur, it is not a median, average or any kind of representative figure.

Much of the data for shale relates to boreholes 1 and 5, on the NW and W peripheries; borehole 12, to the south is the most significant but is undervalued. The selection of 5×10^{-8} (line 9, page 149) does so too.

Similarly, there seems no sense in picking an average for shale permeability from all values when there are no pressure packer data for till. The median value for slug tests is 1.62×10^{-9}, for P.P. is 1.1×10^{-8}, however the data clearly group into relatively low values for shallow depths, higher for deeper samples, the former presumably removed in site preparation. (See ex. 2).

Thus the calculation on page 0.151 - 1.5/0.02 is extremely suspect, the figure of 0.02 applies to optimistic interpretations of non-alterable unfractured till. If that till is subject to 20% dissolution and some fracturing, the calculation could well

Presumably about 2 months

be 1.0/6 = 0.16 of a year. A realistic scenario might be 2/0.2 = 10 years, at most!!

Finally on permeability there has been no interpretation of the interaction of superposed materials of different permeabilities. (see ex 3)

In my sketch (3) I show (1) superposition of unfractured and/or compacted till on shale: the former (K1) has half the permeability (K2) of the latter. Practically they are very similar and there would be slow and wide movement into the shale, with a relatively low proportion (pecked line) of lateral seepage.

K = permeability.

However much more probable is of altered fracturing till with K about 50 times that of the shale, with enormous lateral fluxes* see ex. 4. and only shallow (c.10 m) slow flow into the shale. Hence a vast amount of lateral leachate flow, far beyond the ability of proposed contingent measures to control and/or process, is probable.

Also, in reference to permeability, the shale is so impermeable that lateral flow near the surface is most probable. Rates of lateral movement in saturated conditions far exceed those suggested in the report

Water Analyses

This data has not been mapped, used, studied by time series analysis or anything else. Presumably the consultants do not dare, for it clearly shows the seriousness of leachate accumulation, leakage and spread.

Granted we have only one data point 8A, and that incomplete, for source characteristics, very little of value from boreholes 3, 4, 5, 9, 10 and only recent but depressing data from 18, 19, 20 and from Indian Creek*, elementary spatial analysis of this data proves that the leachate leakage is much more serious than the consultants dare admit.

Ground Water elevations

In the downslope direction and in 8A, the water level has been getting higher and the surface wetter each year. In other areas, the same is evident, especially borehole 1. There is obviously a secondary movement of water from the site, northwards. However the major 'shift' of water to the toe is most serious, and the annual ground

* perusal of topographic maps leads me to wonder if this is part of Indian Creek.

water fluctuation in this area is now less than 1 m. At borehole 16, the surface was wet in the summer of 1982. Obviously, almost a million tons later, the situation will be beyond control.

Conductivity (see ex. 5)

maybe up to 1200.

Background levels c. 500-700 (?). INcreases of 30 to 110%, on levels at the end of readings, in the north, increases of 25 to 7000% in the 'toe'. Very high conductivity of leachate plume in boreholes 12, 13, 14-17, cannot be due to dissolution of gypsum alone.* Conductivity also has changed or is at very high levels compared to background in 2, 18, 19 (NE), in SW3, and in Indian Creek, especially 6, 8, 9, 10, hence leachate reaching to SE along a broad front. It would be impossible to plant trees in such areas, indeed trees have already died. (Ironically enough the access road to the site used to be called "Hickory Lane" !!).

* Gypsum crystals identified in B.12.

pH There seems to be a trend to alkalinity in similar areas to those above, as is to be expected!

$CaCO_3$ (hardness) Background levels seem to be at 200. Coincident ~~Concurrent~~ pattern to conductivity with marked increases in boreholes 1, 7 in 18, and in all the southern areas. Even "Indian Creek" shows change (increase). Strangely enough no hardness data for the main stream.

Sulphates Background 50 to 200 (given proximity to Hamilton). Northern areas are to x8 of background (of 200); similar for tree-slope. 8A borehole shows figures of lower proportion, related to high mobility of this component in 10-15 year period.

Cl Background difficult to establish, certainly 1 to 20 is more feasible than 40-50 mg/ℓ. This, and other components, witness to a contaminant plume, not mobilisable in such vast amounts from weathering of shale alone.

P data Both total and soluble. Bearing in mind the variable state of phosphorous in nature and its low solubility, and ease of reduction, one might say that 0.1 mg/ℓ (soluble) is contamination, 0.2 is an upper limit in drinking water, and very high total is of the order of 10-30 mg. (I could be corrected on this!) A ratio of

Pt/Ps of 10 is reasonable, anything < 5 is undesirable.

Several sites (1, 18, 14, 13?, 17) have shown high readings; the Falcon Creek shows a relatively narrow ratio and the 8A is a major source of P. Presumably the situation could become more fraught with double the impact and amount of garbage.

Certainly one would hope that these analyses are of fresh, non-stored samples. Delay in analysis gives low figures such as we have here. (The same applies to phenol analyses – delay of analysis gives very misleading low figures).

Total N

Obviously the dump materials are a potent source of N compounds. Their accumulation is already evident in sites 1 and 7 (north) and 18 and SW2 (periphery) and especially in the lower parts of Indian Creek area (SW 6, 10, 7-8) and in the so-called leachate plume especially 12, 13, 16.

Background of 1-3 total N, ~~relates to~~ compares with 9 in 8A (or higher) and levels of 5 to 33 in the plume area.

The *free ammonia* analyses would have a low background level (c. 0.1 mg/ℓ); levels of 4-8 are present in the north, of 4 to 18 in the plume; and high levels have occurred in SW 6 and SW 10. Ammonia is not likely to become fixed in the moist environments of the areas of leachate.

High nitrite levels occur in the plume and nitrate levels in boreholes 1, 2, 12, 13, and in the streams, especially SW 1-3; SW 7-8.

K (potassium)

As might be expected there is already considerable mobilization of potassium, with increases of about 30% in the content of K in 1983 in the plume area, when compared to the initial analyses, a few years earlier.

Background levels in mineral materials differ according to the content of mica/illite etc. but could vary from 1 to 5, perhaps 10 in the units presented.

Figures in the plume approach 50 to 150 and witness the impact of the leachate. There is some evidence that alteration is underway in the north and north-east boreholes (2 and 18).

Mg Similar tendencies are evident in the dissolution of Mg (magnesium), with background levels assumed at 50-90; leachate plume analyses at 120 to 460 and other areas at c. 100-200, i.e. up by c. 30-150% on the levels when analyses started. Unfortunately no cation data are available from stream waters.

Ca. The dissolution of calcium is very marked in the leachate plume area, or at least its accumulation in the leachate plume after being dissolved from elsewhere in the site, or derived in part from gypsum solution (vide borehole 12), also the mysterious "white coatings" which can only be calcium carbonate!!

Na As one would expect from the conductivity data, there are enormous loads of dissolved sodium in the leachate plume, in SW 10-11 and in boreholes 1 and 18.

What is most important however is to consider the total sum of cations (or Na + K(Mg) in Indian Creek). Such totals, of 1500 to 8000 in the leachate plume, the toedrain and boreholes 1, 7, 18, 14 show levels of x 10 of a background of 100-120 mg/ℓ (equals cation exchange capacity of 10-12 meq/100 gm), or of c. 30-50 mg/ℓ in the streams. Indian Creeks, has a Na + K(Mg) total of 90 to 170 in stations SW 6 to 11. (see ex. 6)

This data, $\sum$ cations, makes nonsense of the Consultants view that cation attenuation is almost infinitely possible in amount and time. Similarly of the naive view that total CEC is so available for attenuation. Given the nature and size of fresh and clay minerals, only peripheral cations are exchangeable and only a fraction of total CEC is available.

fresh

The cation attenuation powers of the downslope area have already collapsed under the impact of leachate from a small dump (c. 1/2 million tons) in ten-twelve years. If it is enlarged by a factor of 3 to 4, and lengthened and increased in height, the amount of leachate and contained substances will be much greater. Though it could be argued that all these are relatively harmless, the more a physical ~~substance~~ substrate is affected and altered with and by such substances, the less able will it be to adsorb or process more harmful substances, ca~~b~~tionic or anionic, in later times when they accumulate or move later, given their slow rate of release.

No wonder, Sirs, that the region is reluctant to permit, or is adamant in opposing, any downslope monitoring. In my opinion the leachate plume must have passed as far as, if not under, beyond the 403 -- you might care to look at the records of recent repair of the road ~~parallel~~ adjacent to the area and the reasons for such repair. If such leachate reaches the highly permeable sands south of the railway, or stagnates in ditches and areas south of 403,* it will not be to the township's advantage, far from it.

Though I could be accused of a 'not-in-my backyard' syndrome, or other Chantisms, I think I can safely say that in five years time I will have moved from Aldershot, and, on my retirement in 14 years time, I will move out of Canada.

Hence I can say such a structure should not be put in *anybody*'s backyard, without fear of personal involvement or ambivalence.

A long narrow heap of garbage, placed on a hill, on sloping non-stable materials, between active streams flowing into a developed high-density suburban area, itself based on deep sands, adjacent to an already highly-polluted land-locked body of water, within sight of Ontario's only major recreational trail, blocking or affecting the view of the scarp and intruding on a Parkway Belt, adjacent to one of Southern Ontario's major traffic intersections, and hence inflicting slow moving vehicles upon such, also within view of thousands of tourists to and through the area.

Sirs, I could go on, but if you approve the expansion of this site, on the basis of the tawdry study available, then I genuinely and sincerely fear that you would approve anything.

Yours truly

BTB/dw
May 1984

Ex. 7.

* As a matter of interest, I enclose a map of the area, dated 1909, but ~~the~~ same in … to the south of the site. The inferen…

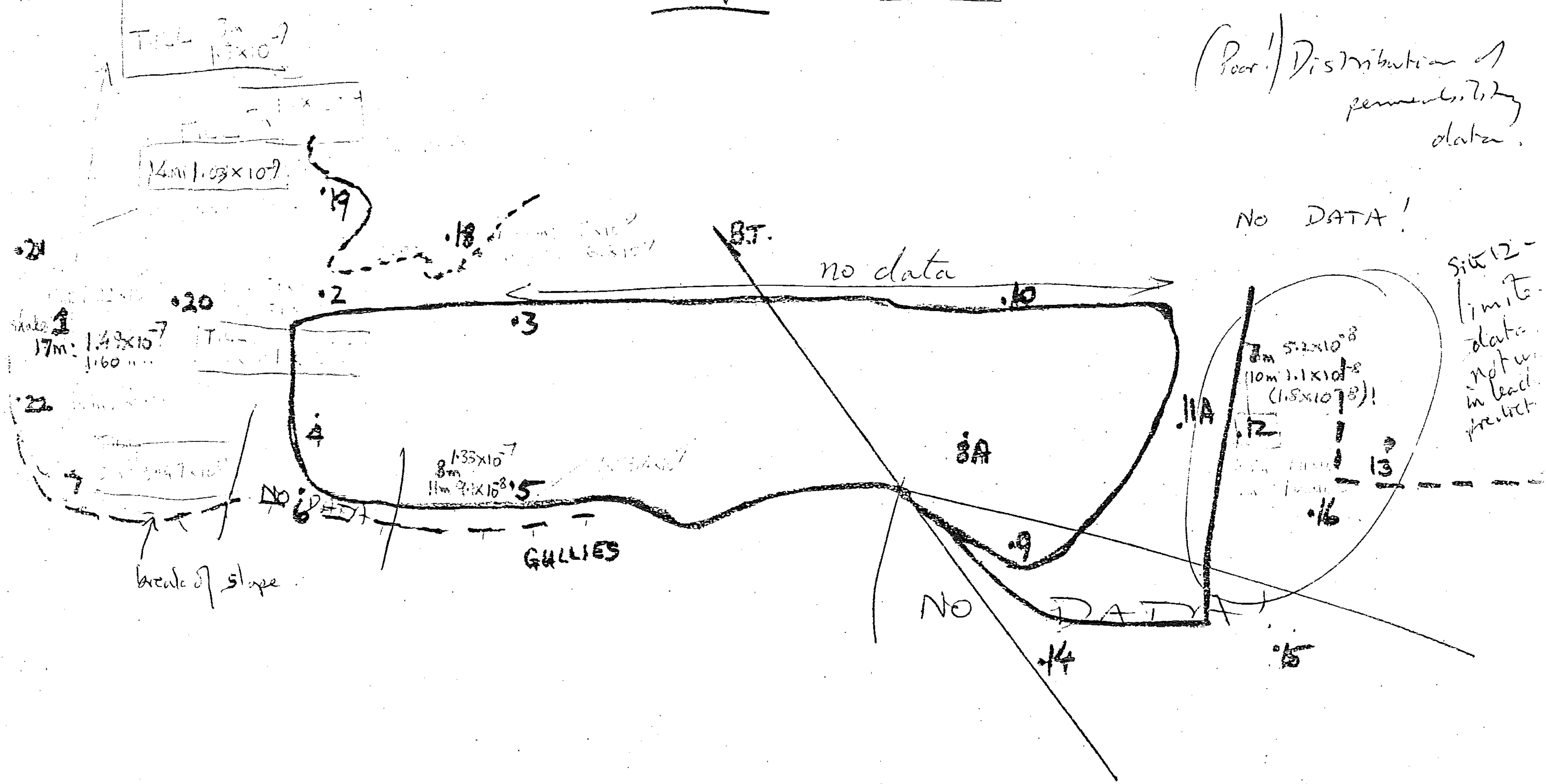
being that much of the land to the south of the 403 is or was disturbed.
It may not be solid shale and undisturbed overburden at all. Certainly its
[illegible] calculated (or guessed at)

Bunting ex. 1

Permeability 0148. !.

Pressure packer: Slug tests

1, 20 ? constant head.



enclosed line is boundary of landfill

Sites of boreholes as numbered.

c 250 metres

1: 7,500.

Scale reduced from original by x5

Permeability data.

Location, depth, type.

Dunting, ex 2.

Scatter of permeability data. m/s. (approx Depth m.)

Page 0148 also Page 0.30

SLUG TEST. Pressure packer.

Shale

Till

10^{-10} 9.45 (10.5)
5.13 (16+)
2.48 (16)

1.3 (3) CH
1.1 (5) CH

10^{-9} 9.4 (7)
7.24 (11.5)
7.00 (10.5)
1.62 (16)
1.4 (18)

3.47 (10)
1.3 (4) CH
1.03 (14)

all shale.

10^{-8}
2.45 (18)
1.22 (13)
1.11 (6.5)
1.05 (12)

10^{-8} 9.1 (11) — most 10.7 to 12.2.
8.5 (11)
5.2 (7)
1.8 (11)
1.1 (11)
1.1 (10)
1.0 (10)

borehole 12 in leachate plume

10^{-7} 5.1 (10.5) (Site 20)

10^{-7}

1.6 (17.5)+
1.49 (17.5)
1.46 (8.5)±
1.33 8.5

TILL

Constant head p.0.147

1.3×10^{-9} (4)

1.1×10^{-10} (6+)

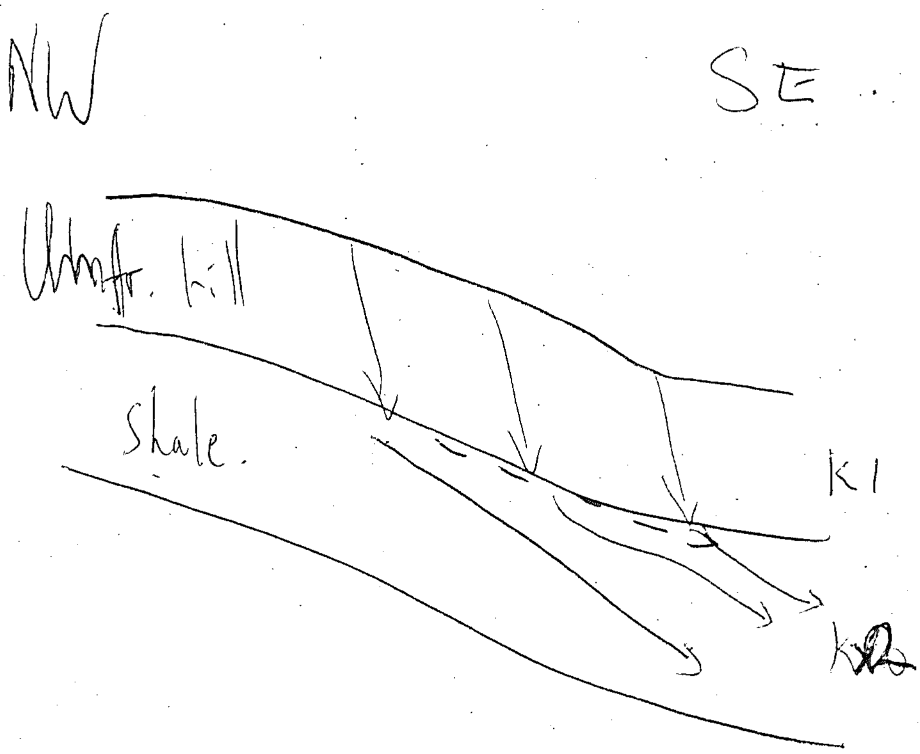
1.8×10^{-10} (8)

borehole 12 in leachate plume.

Sum of data (all) shale 24
median value $= 1.22 \times 10^{-8}$
if doubled figures ignored $= 9.1 \times 10^{-8}$

The conclusion to be made is that the 'assumed' value for shale is a middle value but does not correspond to anything in reality. There are not enough analyses for till which are comparable.
Shale at shallow depth, to 8.5 m, has permeability of 1.33×10^{-7} to 1.11×10^{-8} (one value at 9.4×10^{-9}) and it is this which will take the bulk of leach

Bunting x 3.



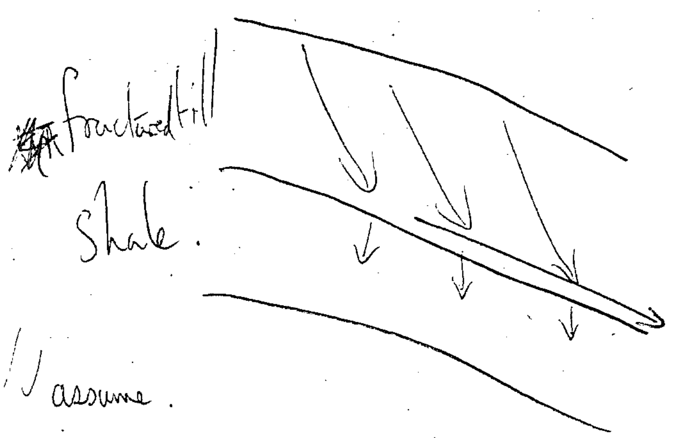
Rough sketch of assumed flow in two cases of superposed materials having different permeability.

vide Approach of Cherry J.A. et al. 1975 Contaminant Hydrogeology Pt. I. Phys. Proc. Geosci Can. vol. 2 no 2.

1×10^{-9} unfractured ~~fract~~ till.

~~1x10-7~~ Shale 5×10^{-8}

the permeabilities are either to be regarded as very similar or shale has ½ the permeability of unfractured till.



k = ~~20~~ : 1×10^{-7}

k = 1 5×10^{-8} ($1 \cdot 62^{-9}$? selected value of report)

// assume.

In either case there is much lateral or sublateral flow in the upper part of the shale or at or above the contact of till & shale.

Sketch of two scenarios

Permeability $\frac{\text{upper till}}{\text{lower shale}}$.

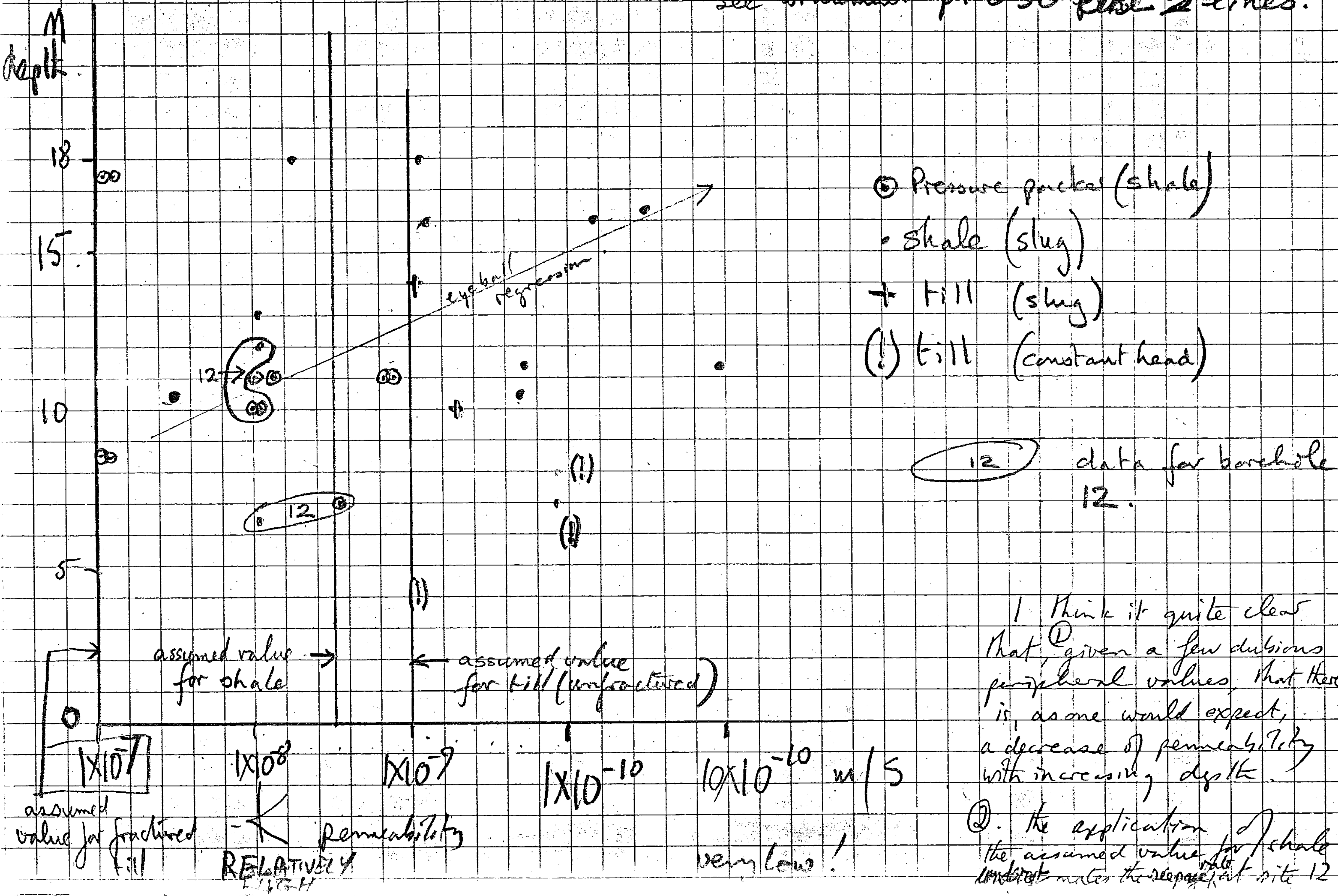
Though this is a view of the long axis, the arrangement holds for a cross-section. My main question – why no refined modelling of the seepage and/or consequences of these (or other) arrangements of materials??

Bunting. ×4

K v. depth. (shale)

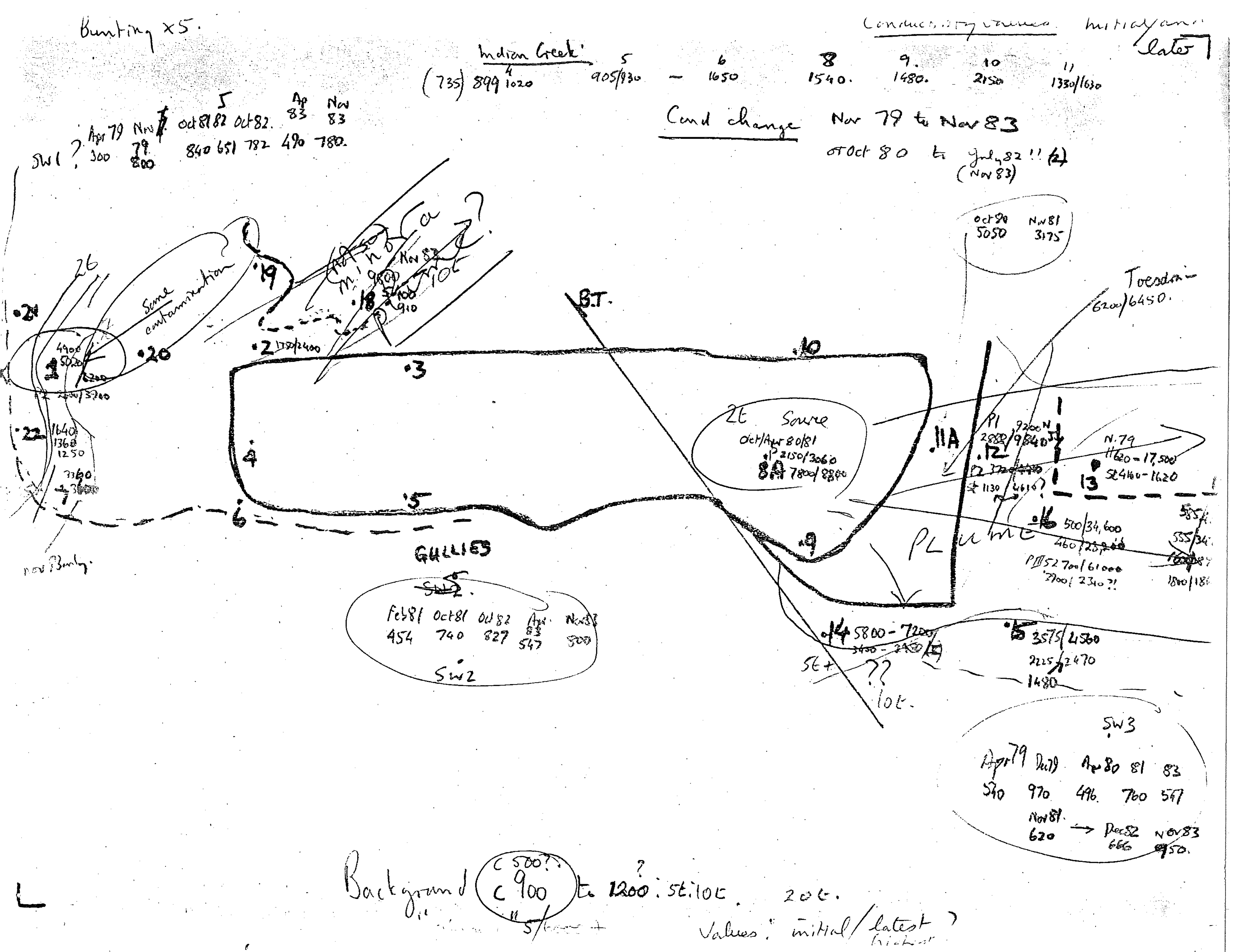
Permeability as a function of depth.

see statement p. 030 ~~last 2~~ lines.



I think it quite clear that, ① given a few dubious peripheral values, that there is, as one would expect, a decrease of permeability with increasing depth.

②. the application of the assumed value for shale the assumed value for shale ~~underest~~ ~~mates the seepage~~ rate at site 12



Bunting x5.
Conductivity values initial and later
Indian Creek
4 (735) 899 1020
5 905/930
6 1650
8 1540.
9. 1480.
10 2150
11 1330/1630
Cond change Nov 79 to Nov 83
or Oct 80 to July 82 !! (Nov 83)
SW1 ? Apr 79 300 Nov 79 800
5 Oct 81 82 Oct 82 840 651 782
Ap 83 490
Nov 83 780.
Some contamination
26
·21
4900
5020
·20
·19
·2 1750/2400
·18
Nov 83
·3
·10
B.T.
·22 1640 1360 1250
·7 3360 3600
·4
·5
6
GULLIES
SW2
Feb 81 454
Oct 81 740
Oct 82 827
Apr 83 547
Nov 83 500
Oct 80 5050
Nov 81 3175
Toesdrain 6200/6450.
2t Source
Oct/Apr 80/81
8A 7800/8800
·11A
·12
P1 2880/9840
13
N. 79
1620-17,500
·16 500/34,600
460/25,200
PLUME
·9
·14 5800-7200
·15 3575/4560
2225/2470
1480
SW3
Apr 79 540
Oct 79 970
Apr 80 496
81 760
83 547
Nov 81 620 → Dec 82 666
Nov 83 950.
Background c 500?? c 900 to 1200? 5t: 10t. 20t.
Values: initial/latest

Bunting ×6. Na+K (Mg) Indian Creek

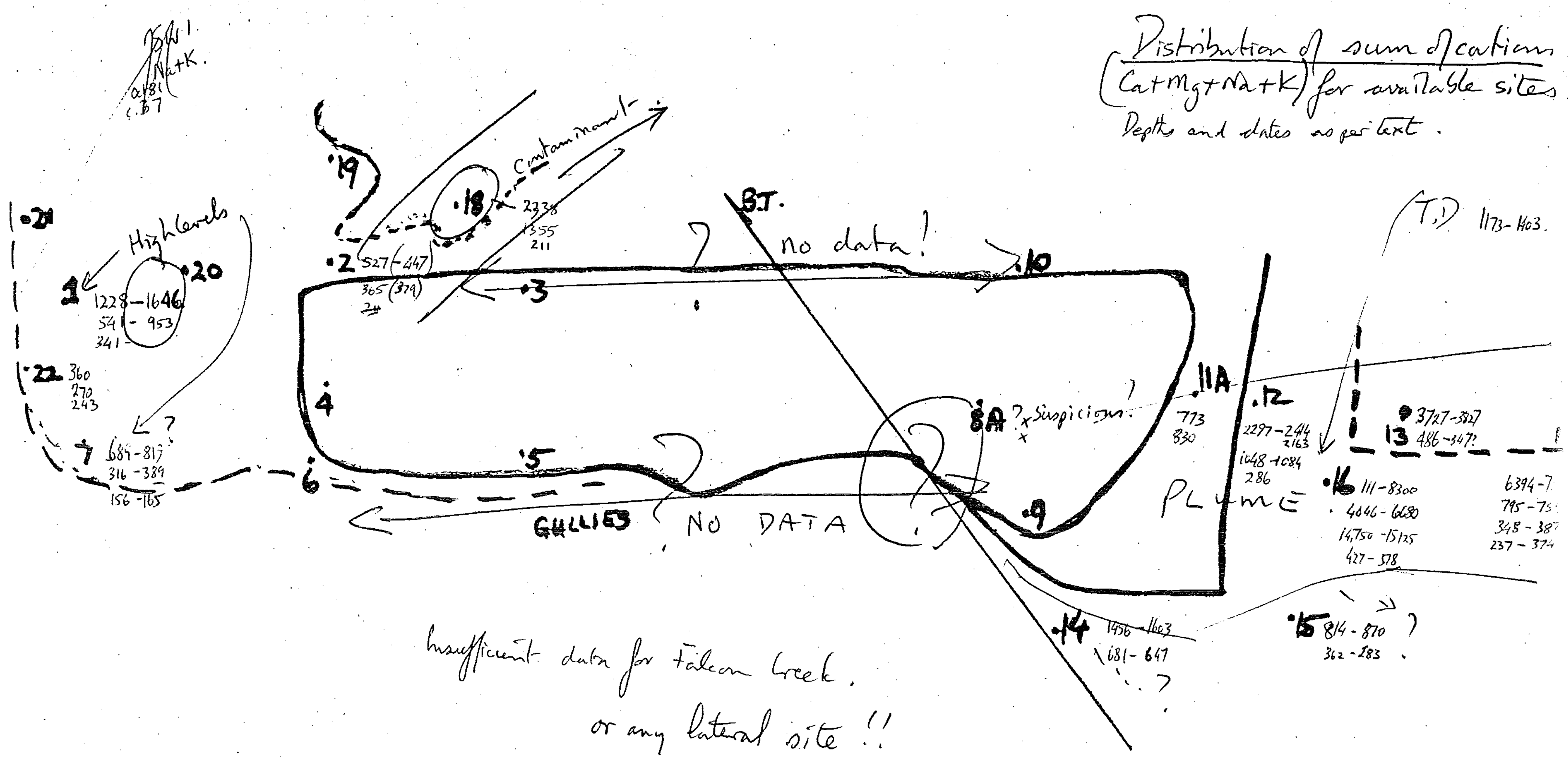
4	5	6	8	8	10	11	#
20-43.	31.37	(128)	97.5	92.6	171.5	131 -	

Σ Cations

Nov 81 - Nov 83

Distribution of sum of cations (Ca+Mg+Na+K) for available sites

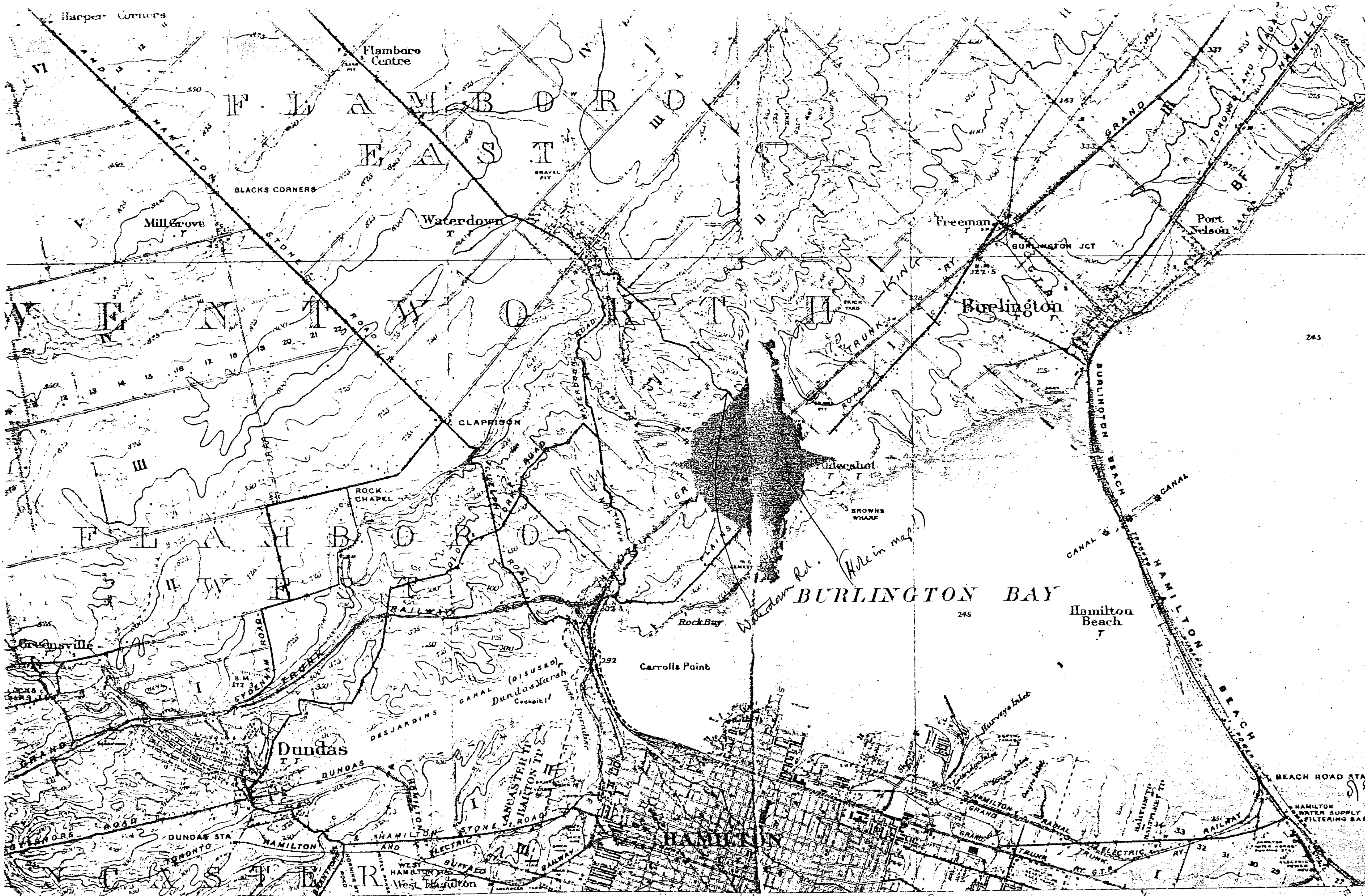
Depths and dates as per text.



120 - 300 Background (assumed).

c110 c150??

"High" figures would be of 1000 - 1500 or more.



Bunting
x 17

This copy of an old map of 1909 (– 1923) shows three railway sidings in the general area of the site & westwards. Hence min[illegible] disturbance of the land to the south-east corner before the 403 was built.

Hence continuation of shale to S of 403 ~~to railway~~ has to be researched.

Map of 1909

Current to 1923 (at least) Approximately to south of site are 3 railway sidings presumably serving clay excavation etc. now masked by 403

• Much of land between 403 & mainline is disturbed ground [illegible]