The Development of a Computer Based Modelling Environment for Upper Secondary School Geography Classes

Terence Melvin Goble

PhD

Institute of Education
University of London

VOLUME TWO

BIBL LONDON

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APPENDIX ONE

PUDDLE INTERVIEWS

PUDDLE Interview : HELEN

H1. ALRIGHT, HELEN, SO NOW WE HAVE GOT TO SORT OF RACK OUR BRAINS HAVEN'T WE, AND THINK ABOUT WHAT WE DID A COUPLE OF MONTHS AGO? WHAT DO YOU REMEMBER OF 'PUDDLE'?

'Puddle', I remember that we had a puddle and you could vary the weather conditions. Like you could snow, rain and you could vary like the evaporation rate and you let it rain for an hour and let all the weather conditions occur for an hour. And afterwards you'd see how much had gone into the ground, and gone into the puddle, overflowed or was saturated the ground, and you could read off the levels and read off the water table.

H2. RIGHT, BEFORE YOU WENT INTO THAT LESSON, YOU'D NEVER USED A COMPUTER BEFORE IN THE SCHOOL? (NO.) NEVER ANYWHERE? (NO.) DID YOU KNOW YOU WERE GOING TO USE A COMPUTER IN CLASS?

I think he told us, but we didn't really know what to expect. It sounded really complicated, I thought we were never going to get the hang of this, but once we got going again it was okay.

H3. LOOKING BACK NOW, IT WOULD SEEM FAIRLY SIMPLE I GUESS, COMPARED WITH WHAT YOU'VE BEEN DOING TODAY?

Yes, it does, yes it's practical.

H4. YOU'VE BEEN BUILDING MODELS HAVEN'T YOU TODAY?

Yes.

H5. WHAT DO THINK A MODEL IS? HOW WOULD YOU DESCRIBE IT TO THE LOWER SIXTH?

Oh, how to describe it? It's a way of putting theories that you've learnt. You put them into practice and see how they work. It is a way of proving that theories do work. Or whether if you can prove them wrong, and how you could vary them. And you can learn what various inputs can change and what are the outputs.

H6. SO YOU THINK OF MODELS IN TERMS OF INPUTS AND OUTPUTS, AND A BOX IN THE MIDDLE DOING SOMETHING TO IT? HAVE YOU HEARD OF PHRASES LIKE WHITE BOXES AND BLACK BOXES?

No.

H7. WELL SOMETIMES SCIENTISTS TALK ABOUT A BLACK BOX WHERE THERE'S AN INPUT. YOU DON'T KNOW WHAT GOES ON INSIDE IT'S ALL BLACK, AND SOMETHING COMES OUT THE OTHER END. A WHITE BOX IS ONE WHERE YOU SEE WHAT GOES ON IN THE MIDDLE. WITH A COMPUTER PROGRAM YOU DON'T NORMALLY SEE WHAT GOES ON INSIDE IT DO YOU?
No.

H8. SO, IT'S JUST LIKE A BOX?
You can type it in and then you see it works it out for you.

H9. YES, A PROGRAM LIKE 'PUDDLE' HELPS - IT GIVES YOU AN IDEA PERHAPS OF WHAT'S GOING ON INSIDE OF A MODEL OR BY SHOWING YOU THE DIFFERENT BITS IN THE PICTURE.
Yes it can, it's quite useful.... (noise)

H10. WHEN YOU SAW 'PUDDLE', YOU'D NEVER SEEN ANYTHING LIKE THAT BEFORE, DID YOU FIND IT VERY PECULIAR AS A WAY OF PRESENTING THAT ... ?
I didn't know how it was being presented, I think I was a bit slow to what would happen, but it did seem very common sense once it came up. I don't know what I would have expected really.

H11. HAVE YOU SEEN ANYTHING SIMILAR TO WHAT YOU SAW ON THE SCREEN?
I don't think I have really. I have done a lot of other population models and things like that which are quite different.

H12. HAD YOU SEEN ANY DIAGRAMS IN BOOKS, WHICH WERE LIKE THE 'PUDDLE'?
Yes I have seen, I have.

H13. HAD YOU SEEN THOSE BEFORE YOU CAME TO THE PROGRAM?
Yes.

H14. SO YOU WERE FAMILIAR WITH THAT IDEA (YES.) OF PRESENTING THINGS? SUPPOSING YOU HAD TO TAKE SOME SAY, YOUNGER STUDENTS LOWER DOWN IN THE SCHOOL AND EXPLAIN TO THEM WHAT IT'S ALL ABOUT, HOW WOULD YOU BEGIN?
Well first of all, I don't think I would start with the computer. I'd tell them the basics, what was going to happen. You know,

explain all about the weather conditions and evaporation, and various rates and how they are worked out, and then I'd say well this is how you can work it out on the computer and then give an example - and try to help them to use it.

H15. DO YOU THINK STUDENTS WOULD HAVE A PROBLEM LINKING UP WHAT THEY SEE ON THE SCREEN WITH WHAT HAPPENS OUTSIDE OF THE WINDOW. WHERE DO YOU THINK PROBLEMS COULD ARISE?
Well, obviously, when you are outside you can't exactly see evaporation. That would be hard for them to picture. It would have to be explained quite well. They could see like the runoff, surface runoff. I think most things they'd be able to see, but there is some that they wouldn't realise at all, would need quite a bit of explaining.

H16. .... USING A DIAGRAM LIKE THAT? (YES.) IT IS FAIRLY NATURAL. DO YOU THINK THEY COULD BE MISLED IN ANY WAY BY THE RECTANGULAR BOXES AND SO ON?
Yes, they might be able to picture it as it should be you know after seeing it yourself. On the program they'd probably think it is more like that.

H17. YES, SO THEY MIGHT TAKE IT A BIT TOO LITERALLY AND THINK OF BURIED TANKS UNDERNEATH THE GARDEN?
(Laughing)

H18. SUPPOSING YOU WANT TO GET AWAY FROM THAT PROBLEM, HOW DO YOU THINK WE COULD REPRESENT IT ON SCREEN WITH THE SAME INFORMATION BUT IN A WAY THAT'S CLOSER TO WHAT, TO THE WAY SOIL REALLY WORKS? OR THE WAY IN WHICH TREES REALLY WORK, OR GRASS?
Well if you try to do it like that, I think it would be a bit too complicated. There's quite a lot of detail shown on this screen. I think it would be difficult to see the results. I think it is best to simplify it (Yes.) I think it is easier to read it up like that.

H19. NOW THERE'S QUITE A LOT OF INFORMATION SHOWN ON SCREEN. FOR EXAMPLE, WE HAVE GOT ONE HERE. THIS SHOWS THE BEGINNING OF THE DEMONSTRATION RUN - WE HAVE A STORM IN THE SPRING - NOW THIS IS THE FLOW DIAGRAM AS IT STARTS OFF AT TIME ZERO (FIGURE H1). WHAT DO YOU

MAKE OF A DIAGRAM LIKE THAT? HOW WOULD YOU INTERPRET IT AND EXPLAIN IT TO STUDENTS?

Re H1. Screen image: DEMO - Storm in spring at time 0.00 hours

Explain it? Well, it starts off at the very top, where you have the rain and 5% of the rain has gone into the vegetation, but the restis going into the puddle. Out of the vegetation and the puddle it splits up into various sections and it shows you how most of its gone into the soil, and the rest of it seeps right down into the ground.

H20. THAT'S TIME ZERO, IF WE GO ON SOME 54 MINUTES INTO THE SIMULATION. WE'VE HAD AN UPDATED SCREEN EVERY 6 MINUTES. WE GET A PICTURE LIKE THIS WHICH IS RATHER .... HOW DO THOSE TWO COMPARE?

Re H2 Screen image: DEMO - Storm in the spring at time 0.54 hours

Well that shows first of all, the first box of vegetation, it shows that it's been completely covered by the rain. It's been completely full up, so it has all flowed into the puddle, that's nearly full, some is coming off the puddles that's the evaporation rate I think. It's infiltrating into the soil, it hasn't made that much of a difference into the soil though, only 4% increase. And the ground's exactly the same, 45%.

H21. DOES IT SEEM STRANGE THAT THESE HAVE CHANGED A LOT AT THE TOP OF THE DIAGRAMS BUT THE GROUNDWATER LOWER DOWN HASN'T CHANGED AT ALL?

Yes.

H22. WE'VE GOT LOTS OF FIGURES HERE, ONE FOR EACH OF THE STORES AND THEY CHANGE EVERY 6 MINUTES - DID YOU ACTUALLY SORT OF LOOK AT THE FIGURES AT ALL, CONSIDER THEM, OR DID YOU JUST GO BY THE PICTURE OF THE WATER LEVEL GOING UP AND DOWN?

Well, first of all I couldn't really take in all the figures, it was a bit too much. You just looked at it, and thought 'Oh, what's all this? So you are just looking at the actual movement and then we sort of broke it down in stages. You realised as you took the figures in, it made more sense to you then. You could see what was going on.

H23. SO IT'S QUITE A LOT OF INFORMATION TO ABSORB ISN'T THERE? DO YOU THINK THERE ARE WAYS IN WHICH THEY COULD HAVE BEEN IMPROVED - TO GIVE YOU A BETTER SUMMARY OF WHAT'S GOING ON?

I can't really see how it could have been improved. I think it's quite well displayed as it is, actually. Quite readable.

H24. RIGHT OKAY, AND THEN FINALLY, AFTER TWO HOURS THIS WAS THE END. WE'VE HAD AN HOUR OF EVAPORATION AND TRANSPIRATION. CAN YOU REMEMBER WHAT THESE OTHER LETTERS STAND FOR, THE LABELS?
Re H3- Screen image: DEMO - Storm in spring at time 2.00 hours
I think that was infiltration. (Yes.) .... was that transpiration ? (No). .... what 'T' was ...., no I can't remember.

H25. IT WAS MOVEMENT IN THE SOIL, SEE IT'S GOING THROUGH THE PORES - IN THE HOLES IN THE SOIL. SO THAT WAS CALLED THROUGHFLOW, THROUGH THE SOIL. OKAY, WHAT ABOUT THIS ONE?
Precipitation? No?

H26. IT'S FAR TOO LATE .... PERCOLATION, YES? FINALLY, WHAT IS B,?
Base flow.

H27. BASE FLOW, GOOD, RIGHT, YES. YOU'VE DONE YOUR EXAMS THIS TERM, HAVEN'T YOU? (YES.) OKAY, SO YOU DON'T HAVE TO REMEMBER THOSE THINGS FOR A WHILE. RIGHT ONE INTERESTING THING, WHEN WE WERE DEVISING THIS PROGRAM, WE ORIGINALLY WANTED TO PROVIDE A SUMMARY OF THIS ON A GRAPH; AND THERE WASN'T THE COMPUTER MEMORY TO DO IT. BUT FOR TODAY'S EXERCISE I'VE GOT SOME DIAGRAMS HERE, (IF I CAN FIND THE RIGHT ONES) SO WE CAN LOOK AT THE SAME SEQUENCE THAT WE HAVE SEEN THERE. BUT LOOK AT ITS ON A GRAPH, START OFF WITH THE RAINFALL, IF WE SUPERIMPOSE THEM LIKE THAT. SO THAT SHOWS US THE RAINFALL AT SIX MINUTE INTERVALS OVER THAT FIRST HOUR, SO THAT REPRESENTS THE STORM, THOSE ARE THE FIGURES THAT WE USED IN THE PROGRAM. ANY COMMENTS ABOUT THAT STORM FIRST OF ALL?
Re H4- DEMO - Storm in spring, graph of rainfall
Well, it's heaviest when it first starts off, and then after nearly thirty minutes; is it the same storm all the way through ?

H28. ONE STORM.
It shows that most of it's gone into the ground, and then it must have obviously saturated the ground quite a bit up to 30 because then it's ....

H29. YOU ARE RACING AHEAD A BIT THERE I THINK? (YES.) IN FACT THIS JUST REPRESENTS THE AMOUNT OF RAIN THAT'S FALLING IN DIFFERENT TIME PERIODS, ALRIGHT? SO IT'S JUST THE RAIN THAT'S MOVING AND HASN'T GOT INTO THE OTHER BITS YET. ALRIGHT, OKAY, IF WE FOLLOW THE CURVE ROUND TO THE RAIN. NOW WE CAN LOOK AT THE, WHAT HAPPENS TO THE VEGETATION STORE OVER THAT SAME PERIOD OF TIME RIGHT, SO CAN YOU SORT OF TALK US THROUGH THAT GRAPH, AND SAY WHAT IS HAPPENING AS WE WENT THROUGH THE TIME?
Re H5- DEMO - Storm in spring, graph of rainfall and vegetation store contents
Well, the first 6 minutes seems to have flooded all the vegetation, and it's all, and it can't take any, well it's taken it all, up to what about 50 minutes, 45 minutes and after that it's the same level and then it's gradually starting to seep into the ground and after that when it's stopped, it gets a chance to sink in, otherwise it just stays there, it can't do anything.

H30. YES, WHAT DID YOU NOTICE FROM THE SHAPE OF THIS CURVE?
Oh, it suddenly all goes in, it seems to all fall into the ground and then it levels off and calms down a bit. (Yes.) Not such a fast route.

H31. WHY DO YOU THINK IT LEVELS OFF?
Because the ground directly underneath it is probably quite full up by then.

H32. YES, WHAT WOULD THE NAME OF THE FLOW BE THAT COMES OFF THE VEGETATION?
I give up.

H33. WE SHOULD HAVE HERE, SHOULDN'T WE, WE ARE TALKING ABOUT THIS FLOW AREN'T WE? - IT IS A VERY TECHNICAL TERM.
Detention?

H34. DRIPS! RIGHT, SO WHAT WE ARE SEEING IS IN FACT, THE EFFECTS OF THE DRIPS ONCE THE RAIN HAS STOPPED. SO WHERE DO THE DRIPS FALL?
When the rain stops, they just go straight into the ground, it's absorbed into the earth underneath.

H35. RIGHT OKAY, SO THE NEXT STAGE THEN IS, WE'VE LOOKED AT THE VEGETATION STORE, IF WE LOOK NOW AT THE PUDDLE STORE AND SEE HOW THAT BEHAVES OVER THE SAME PERIOD OF TIME.

Re H6 : DEMO - Storm in spring, graph of rainfall and vegetation, puddle store contents

Right, when it first starts off not much has happened and then suddenly it's a great big increase, and it's really completely full-up. It doesn't stay full-up as long as the vegetation (there), it is about 12 minutes before the vegetation started to fall, the puddle falls, then it goes up a bit more and then it's suddenly all gone. It's quite a big drop down.

H36. WHY DO YOU THINK IT VARIES LIKE THIS AT THE TOP, WHY DO YOU THINK IT FLUCTUATES?

.... Maybe because it has soaked into the ground, and then I don't know, it gets pushed up somehow.

H37. CAN YOU SEE ANY CONNECTION BETWEEN THAT AND THE RAINFALL?

Well the rainfall's gone up yes, the rainfall has gone up a bit more at that stage and that's why it's filled up again.

H38. RIGHT, SO THE PUDDLE IS RESPONDING TO THE RAIN, AND IT IS FLUCTUATING RIGHT, THEN ONCE THE RAIN STOPS THE PUDDLE DRAINS?

Yes quite quickly.

H39. HOW MUCH IS LEFT IN AFTER OUR 2 HOURS, LET'S HAVE A LOOK AT THE PICTURE THERE (FIGURE H3).

Only one percent, yes.

H40. YES, ONLY ONE PERCENT, SO THAT'S COME RIGHT DOWN, HOW DOES THAT COMPARE WITH THE VEGETATION?

The vegetation is still quite high, it's what, fifty percent, so that's still obviously needs a lot more.

H41. WHY DO YOU THINK THE VEGETATION HAS STOPPED THERE, WHEREAS THE PUDDLE HAS GONE RIGHT THE WAY DOWN?

There must be something to do, maybe it's the earth or the, I don't really know.

H42. SUPPOSE, THIS IS SUPPOSED TO BE REPRESENTING A GRASSY FIELD SOMEWHERE IN THE ENGLISH MIDLANDS AFTER A STORM IN THE SPRING. SUPPOSING YOU WERE WALKING THROUGH THAT FIELD AT THE END OF THE TWO HOURS, OKAY, SAYING THAT THERE IS A SMALL AMOUNT LEFT IN THE PUDDLE, WHAT DO YOU THINK THE VEGETATION AND THE GRASS WOULD LOOK LIKE?
The grass, it still would be quite boggy, I should imagine

H43. THE GRASS - BY BOGGY, WHAT DO YOU MEAN? THE SOIL THE GRASS IS IN, OR WHAT, THE GRASS ITSELF?
Yes, the soil itself.

H44. WHAT ABOUT THE GRASS ITSELF?
That's still got a lot of moisture on it, yes that would be quite wet.

H45. HOW WOULD THE WATER ACTUALLY APPEAR ON THE PLANTS?
Sort of in droplets clinging to the leaves, and stem and things.

H46. OKAY, SO THE GRASS WOULD STILL BE QUITE WET IN FACT WOULDN'T IT? (YES.) WHY DOESN'T ALL THAT WATER FALL OFF? WHY DOESN'T IT DRAIN DOWN THE WAY THE PUDDLE DRAINS DOWN?
I don't know, something to do with the angle of the leaves, so it can't fall off at all. Because with the puddle it's just straight on the ground, so it can go straight in, but the vegetation it has to get over, it has another layer to get through.

H47. ALRIGHT, THE FINAL PART OF THE STORY. IF WE LOOK AT WHAT HAPPENS TO THE SOIL ITSELF AND THE GROUND UNDERNEATH - THE SOIL DEEPER DOWN - THE GROUND LYING THERE REPRESENTS THE AMOUNT OF WATER IN THE SOIL STORE AS A PERCENTAGE, AND THE GROUND STORE BENEATH IT - WHAT DO YOU MAKE OF THOSE?
Re H7 DEMO - Storm in spring, graph of rainfall and vegetation, puddle, soil and ground stores' contents
Well after the ground one is constant all the time the soil one has just risen slightly, then it's more or less constant, after the first hour it's a constant level.

H.48 DOES THAT MAKE SENSE? IS THAT WHAT YOU'D EXPECT FROM A STORM IN SPRING?

Yes, I think so, although I would have thought the contents, I don't know, I'd think, I thought the soil would have been after the storm, I would have thought it would have gone down more then it, I mean it seems to be quite constant, I think it ....

H49. DO YOU THINK THE SOIL WOULD DRAIN IN AN HOUR? OR DO YOU THINK IT WOULD TAKE LONGER PERHAPS TO RESPOND?
No, it would take quite a bit longer, if it's been such a heavy storm.

H50. YES RIGHT, WHAT ABOUT THE CHANGE IN THE SOIL, COMPARED WITH THE CHANGES IN THE OTHER STORES?
It's not that much in particular, it only went up by say 4 or 5% and wouldn't make that much difference. I would have thought, considering that rainfall, I thought it would have made quite a bit of difference, but it hasn't.

H51. WHY DO YOU THINK THE SOIL PERHAPS CHANGED, ASSUMING THAT THE PROGRAM IS ALRIGHT, AND IT'S NOT A MISTAKE. WHY SHOULD THE SOIL CHANGE SO LITTLE WHEREAS THE PUDDLE AND THE VEGETATION CHANGE SO MUCH IN TERMS OF PERCENTAGE CONTENTS?
I think with the puddle and vegetation, that's on the surface so it has got a chance to evaporate and dissolve into the air, but the soil it just has to stay in one place I suppose, I can't really explain it now.

H52. RIGHT, IT YOU HAD TO PUT A FIGURE ON THE CAPACITY OF THESE DIFFERENT STORES, IN TERMS OF AMOUNTS OF MILLIMETRES OF RAIN THEY COULD HOLD, HOW WOULD THEY COMPARE DO YOU THINK?
.... The ground seems to hold a steady-amount, the puddle although it can hold it, it gets full-up too quickly, and the vegetation whereas the soil you know is not too bad, it can hold it.

H53. WHEN YOU USED THE PROGRAM, DID YOU SWITCH TO THE DISPLAY THAT SHOWED YOU THE CONTENTS AND CAPACITIES OF THE STORES AT SOME STAGE - TABLE OF FIGURES?
Yes, yes.

H54. IT'S QUITE A LOT OF DETAIL TO TAKE IN?

Yes it was, I couldn't do that side of it.

H55. IT IS NOT THE DETAIL THAT YOU REMEMBER EITHER?
No.

H56. RIGHT OKAY, IF I TOLD YOU, SAY IN A TYPICAL SOIL IN THE TOP METRE (METRIC), ABOUT HALF THE SOIL IS SOIL, AND THE OTHER HALF IS HOLES, VERY SMALL HOLES MADE BY WORMS, WHERE ROOTS HAVE DECAYED, WHERE PEOPLE HAD DUG IT OVER, OR PEOPLE HAD PLOUGHED IT. SO THAT HALF THE SOIL WAS IN FACT SPACES, HOW MANY MILLIMETRES OF WATER COULD THAT SOIL IN THEORY HOLD?
It would hold a lot more than I would imagine, because there is a lot more to fill up, therefore it explains why it's , ...you know quite constant?

H56. LET'S IGNORE THAT ONE. RIGHT OKAY GOOD, NOW FOR SOMETHING COMPLETELY DIFFERENT. WE'VE BEEN PLAYING AROUND HERE WITH 'PUDDLE'. THIS WAY OF LOOKING AT THINGS, DO YOU THINK IT COULD BE USED IN OTHER PARTS OF GEOGRAPHY?
It could be used in Biology definitely I think, used as a study of plants and that. I think it would be more subjects where you could do more practical things. Maybe Biology, I don't think it would be any good, it wouldn't be any good of course for English!

H57. NO, WHICH ASPECTS OF BIOLOGY FOR EXAMPLE, WOULD YOU IMAGINE USING A SIMILAR TYPE OF PROGRAM?
Don't know how you could use it, but it would be useful because I know when I did it, you had to know quite a bit about plants and what the contents of the soil you had to analyse it and everything: So you could I suppose, you could see how much water different types of soil could hold, that would be quite relevant I think.

H58. HAVE YOU DONE ANYTHING ON NUTRIENTS, (YES.) NITROGEN CYCLES OR THINGS LIKE THAT? COULD YOU IMAGINE DOING THOSE SORTS OF CYCLES THIS SORT OF WAY?
Yes, yes.

H59. GOOD, THAT WAS SOMETHING I WANTED TO DO, BUT WE NEVER GOT ROUND TO IT. CAN YOU THINK OF OTHER EXAMPLES, MAYBE NOT TO DO WITH

H60. THE ENVIRONMENT, OTHER ASPECTS OF BIOLOGY, WHERE YOU WORK IN TERMS OF A DIAGRAM LIKE THIS?
Maybe you could do something like within ..(noise).. how much to do with the blood, how much nutrient it intakes and the waste products from the body, and things like that. I suppose you could set out, but I don't know how but, various organs what they need.

H61. WHAT ABOUT OTHER SUBJECTS, CAN YOU IMAGINE SAY IN OTHER ASPECTS OF GEOGRAPHY MAYBE?
What, using a program like this?

H62. YES, WHERE YOU TAKE MAYBE A COMPLETELY DIFFERENT TOPIC, BUT YOU PRESENT IT AS A DIAGRAM WITH BOXES AND A LINE LINKING THEM TOGETHER TO SHOW MOVEMENT OF SOMETHING AROUND THE SYSTEM?
Yes, I'm sure there are lots of examples, but I can't think of any though! (Laughs) I think anything where you can show it on a graph, on the computer on the screen, makes it much easier to understand, but I can't think of any examples.

H63. WHAT IF I GIVE YOU SOME IDEAS, WHAT ABOUT SOMETHING LIKE ECONOMICS, OR ECONOMIC GEOGRAPHY?
Yes, economic Geography, I don't know about Economics. I suppose you could plot up products, graphs and things like that. But I don't know if you could display it in

H64. HAVE YOU TALKED ABOUT SYSTEMS IN GEOGRAPHY WITH MR. GOBLE AT ALL?
I think so, yes I have to jog my memory.

H65. WHAT WE HAVE HERE IS SORT OF A SYSTEM WITH INPUTS AND OUTPUTS, AND WE CAN THINK OF THIS ALL BEING RELATED ....IN ECONOMIC GEOGRAPHY I COULD THINK OF A SITUATION WHERE MONEY MOVING ROUND AN ECONOMY COULD BE THOUGHT OF AS A SYSTEM. (YES.) THE SAME AS WE THINK OF A HUMAN BODY AS A SYSTEM. THIS IS REALLY A WAY OF THINKING ABOUT THINGS, WHICH YOU DON'T NORMALLY DO AT O-LEVEL'. (NO, IT'S QUITE DIFFERENT.) CAN YOU IMAGINE BUILDING YOUR OWN SYSTEMS?
I don't know if I would be capable, it would be good to do I think. But, I don't think I could manage it.

H66. NOW SUPPOSING YOU HAD A PROGRAM LIKE THE ONE YOU WERE USING THIS MORNING (DMS), WHICH HELPED YOU TO BUILD SYSTEMS, DO YOU THINK THAT WOULD HELP? (YES.) IT WOULD DRAW THE DIAGRAM FOR YOU. SUPPOSING YOU HAD, IF YOU COULD IMAGINE A PROGRAM LIKE THAT; HOW WOULD YOU WANT TO TELL IT, OR TYPE INSTRUCTIONS IN, TELL IT WHAT TO MAKE?
I want it to be explained, sort of to be shown as simply as possible it could be. I'm not sure, but I suppose you have to do it one bit at a time and then build up a picture at the end of it. You know the different inputs and to show the one output at the very end. But it would be quite complicated to do. (Yes.) I wouldn't want to handle it. (Laughs)

H67. WELL, IT TOOK TWO YEARS TO MAKE 'PUDDLE'. SO ..(YES, I CAN IMAGINE.).. RIGHT OKAY, COMING BACK TO THE WORD 'SYSTEMS'. PEOPLE TALK ABOUT SYSTEMS MODELS BECAUSE WE ARE NOT HERE DEALING WITH REAL SYSTEMS. IT'S ALL MAKE-BELIEVE REALLY ISN'T IT? (YES.) DOES THAT WORRY YOU, THAT IT'S ONLY A VERY SIMPLIFIED DIAGRAM?
No, I think I'd rather have it simplified than have say a real thing, which might be all crammed in and you can't understand a word of it you know.

H68. CAN YOU IMAGINE GOING OUTSIDE AND TRYING TO MEASURE AL THESE THINGS?
I think it would be very hard to do, especially the evaporation rate, it would take a lot of work.

H69. AND HAVING TO GO OUT THERE IN THE RAIN. (WOULDN'T BE MUCH FUN.) ACTUALLY, SOMETIMES THEY SHOW FILMS ON TELEVISION OF HOW THEY MEASURE ALL THESE THINGS, PEOPLE DO IT.
Do they?

H70. YES, IT TAKES THEM A LONG TIME, FOR EXAMPLE THEY CAN HAVE BUCKETS UNDERNEATH THE TREES TO CATCH THE DRIPS. AND THEY CAN PUT, LIKE A BICYCLE TYRE, AROUND A TREE AND CATCH ALL THE WATER RUNNING DOWN THE TRUNK AND RUN IT OFF INTO A LITTLE JAR AND MEASURE IT. SO THEY CALCULATE THE DRIPS AND THE STEMFLOW FROM THE TREES AND THEN THEY TAKE OUT A SAMPLE OF SOIL AND WORK OUT HOW MUCH MOISTURE IS IN IT. THEN THEY REPEAT THE MEASUREMENTS. BUT IT WOULD BE QUITE HARD, WOULDN'T IT?

Yes, it would be too complex.

H71. SO IT WAS WORTHWHILE DOING THIS FOR LEARNING?
Yes, in the course we are doing there is so much work to cover, you can't afford to spend too much time on anything but to get something like this, it's already done for you, it's up to you.

H72. SUPPOSING YOU WERE HAVING TO EXPLAIN THIS SAY TO THE LOWER SIXTH NEXT YEAR. MR GOBLE'S AWAY AND YOU HAVE BEEN ASKED TO GIVE A LESSON. HOW WOULD YOU EXPLAIN THE IDEA OF A SYSTEM AND A MODEL TO STUDENTS WHO HAD NEVER COME ACROSS THEM BEFORE?
I think I would try to introduce it through books, maybe a film of people actually going into the processes, trying to get the information together, and then, I don't know how I would explain it in words, it's very difficult.

H73. OKAY, TAKING A SIMPLER IDEA, WHAT IS A MODEL?
A way of expressing, it's an example of how a theory can work I suppose.

H74. IT'S A DIFFICULT THING TO EXPLAIN, ISN'T IT? (YES.) DIFFICULT TO PUT YOUR FINGER ON IT? (YES.) I HAD ONE STUDENT YEARS AGO, WHO DIDN'T BELIEVE THAT YOU COULD REPRESENT A RIVER OR RAINFALL ON A COMPUTER. HE DIDN'T SEE HOW IT WAS POSSIBLE. THAT WAS ONE REASON WHY WE DEVELOPED THIS PROGRAM TO SHOW HOW IT COULD BE DONE. YOU KNOW, IF YOU WENT HOME, DO YOU THINK YOU COULD EXPLAIN IT TO YOUR PARENTS?
I know, when I did go home and my mum, she kept sort of asking, well how is it done? She can't work it out at all. I found it very hard and difficult to explain. But I just said it was there.

H75. YOU DON'T HAVE A COMPUTER AT HOME?
No.

H76. DO YOU THINK YOU COULD GET A COMPUTER IN THE FUTURE PERHAPS?
I don't know if I would buy one, but my brother is interested in buying one, I would use it if he did have one. I mean she, I think my mother thinks it's playing games all the time, they don't really

you know, they never see anything like this, they don't realise that we can actually learn from it.

H77. SOME SCHOOLS SHOW THESE SORTS OF THINGS OFF ON A PARENTS EVENING, SO YOU CAN EDUCATE THE PARENTS.
That's a very good idea.

THANK YOU VERY MUCH.

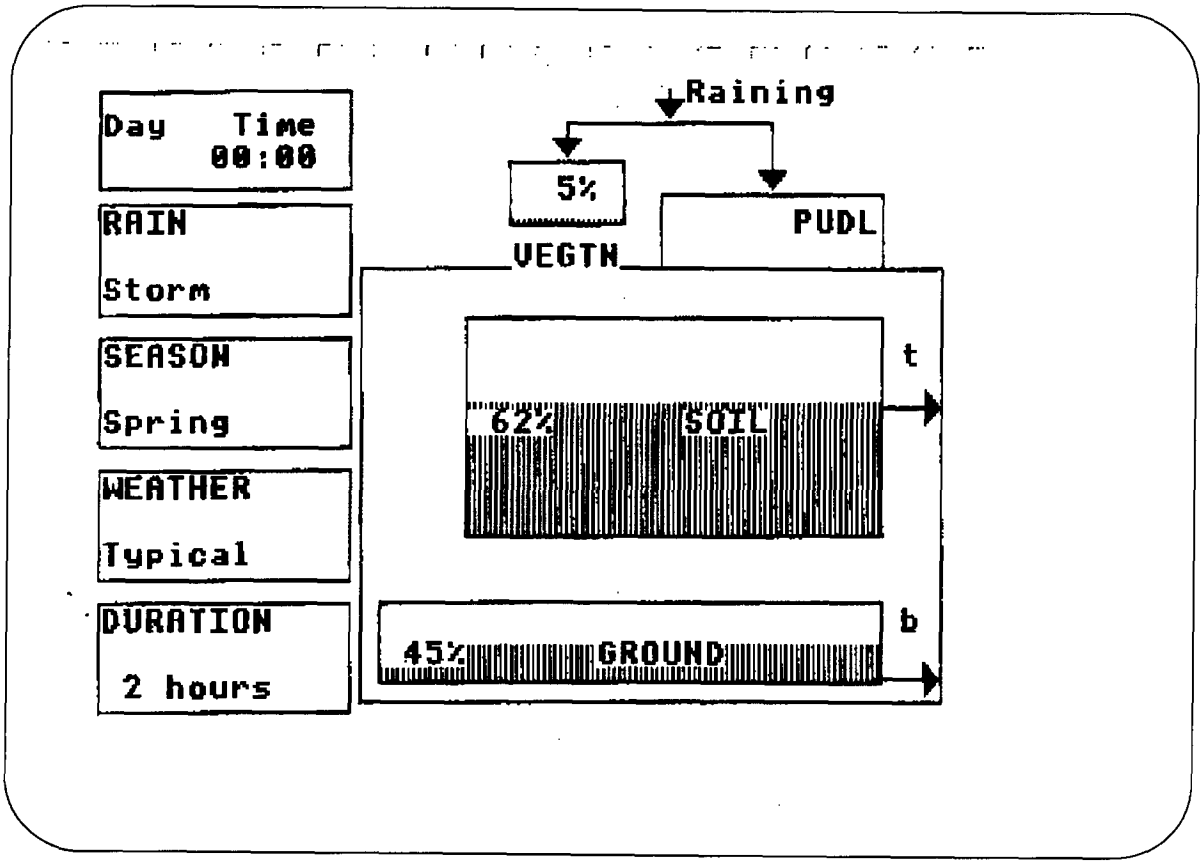
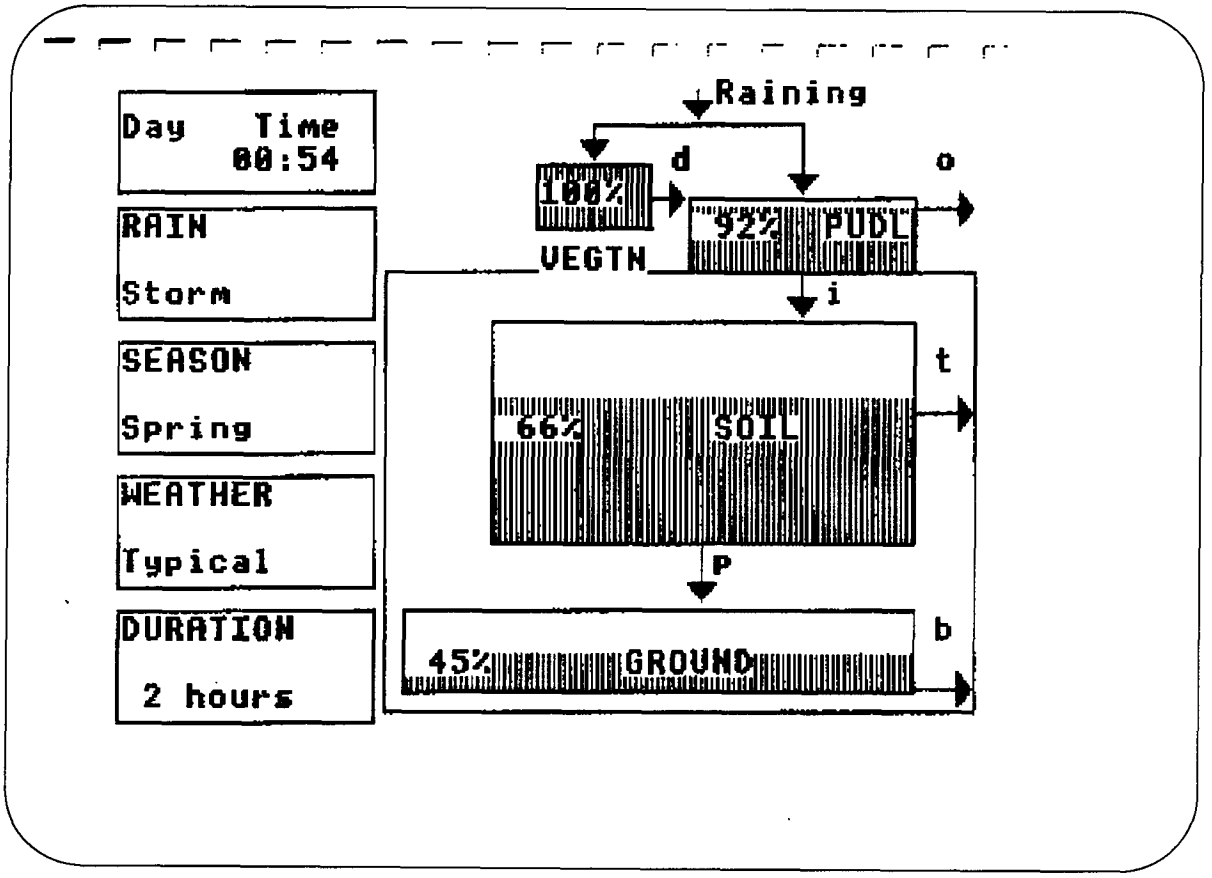

Day Time
00:00
RAIN
Storm
SEASON
Spring
WEATHER
Typical
DURATION
2 hours
Raining
5%
PUDL
VEGTN
t
62%
SOIL
b
45%
GROUND

Figure H1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00:54
RAIN
Storm
SEASON
Spring
WEATHER
Typical
DURATION
2 hours
Raining
d
o
100%
92% PUDL
VEGTN
i
t
66% SOIL
P
b
45% GROUND

Figure H2

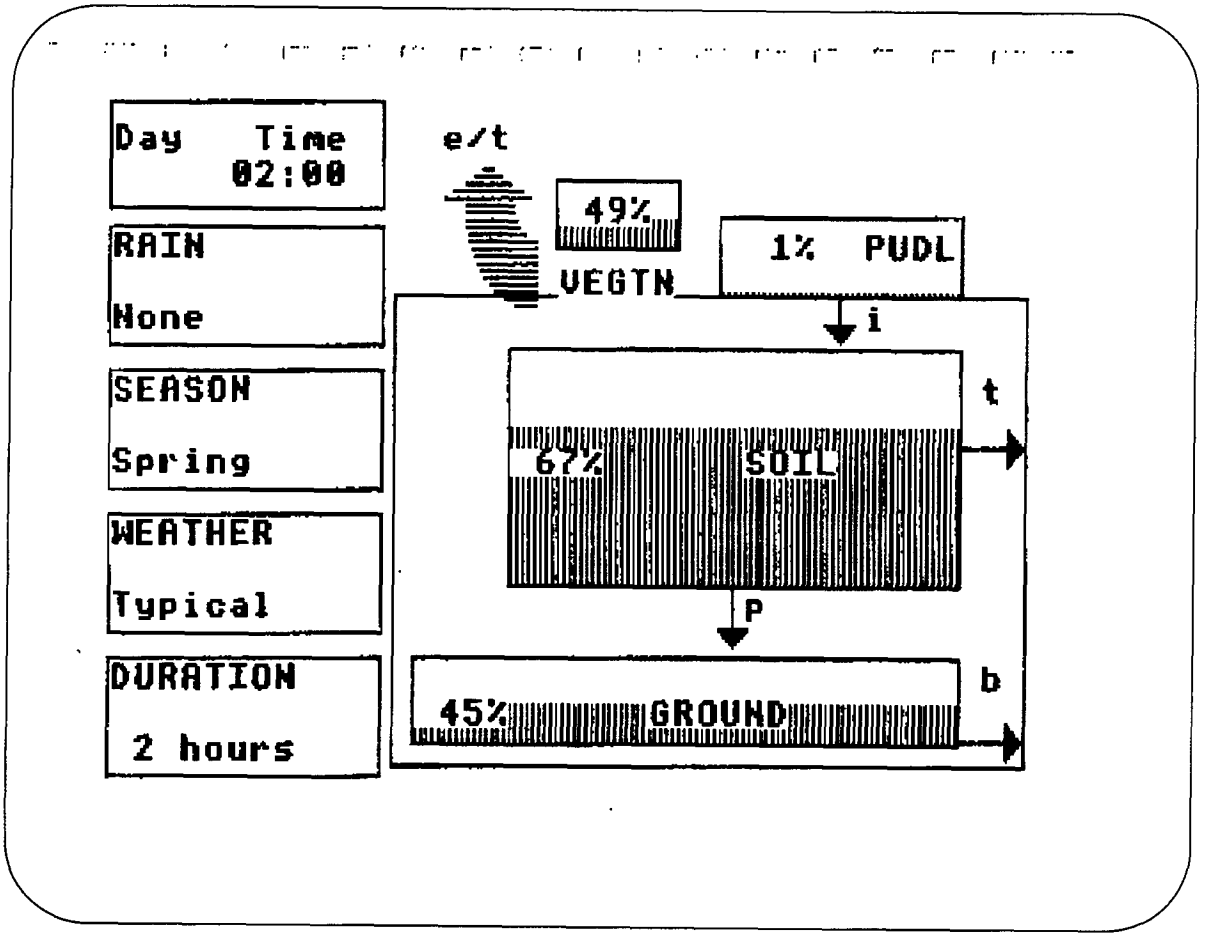

Day Time
02:00
RAIN
None
SEASON
Spring
WEATHER
Typical
DURATION
2 hours
e/t
49%
VEGTN
1% PUDL
i
t
67% SOIL
P
45% GROUND
b

Figure H3

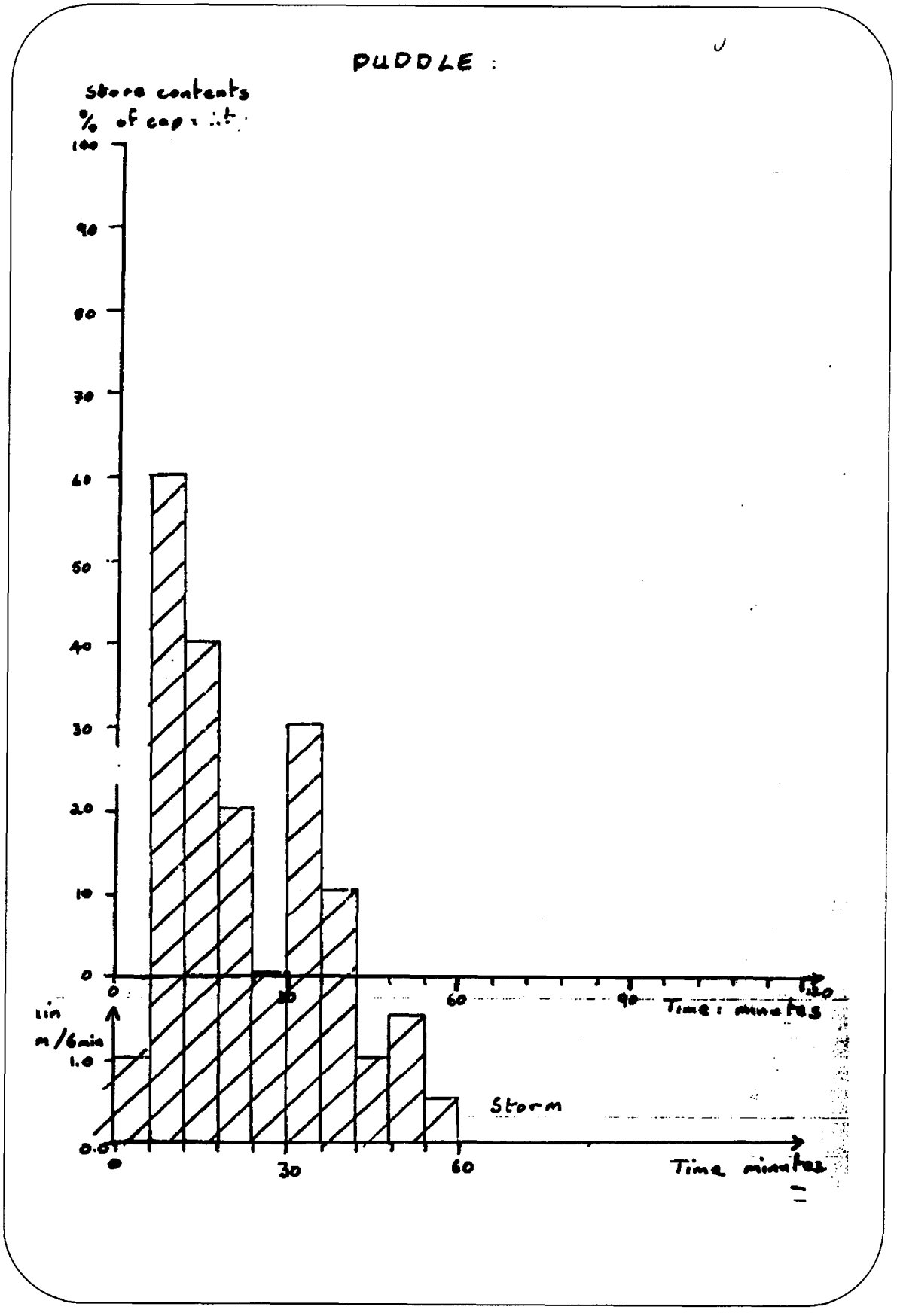

PUDDLE :
Store contents
% of capacity
100
90
80
70
60
50
40
30
20
10
0
0
30
60
90
120
Time : minutes
Storm
1.0
0.0
30
60
Time minutes

Figure H4

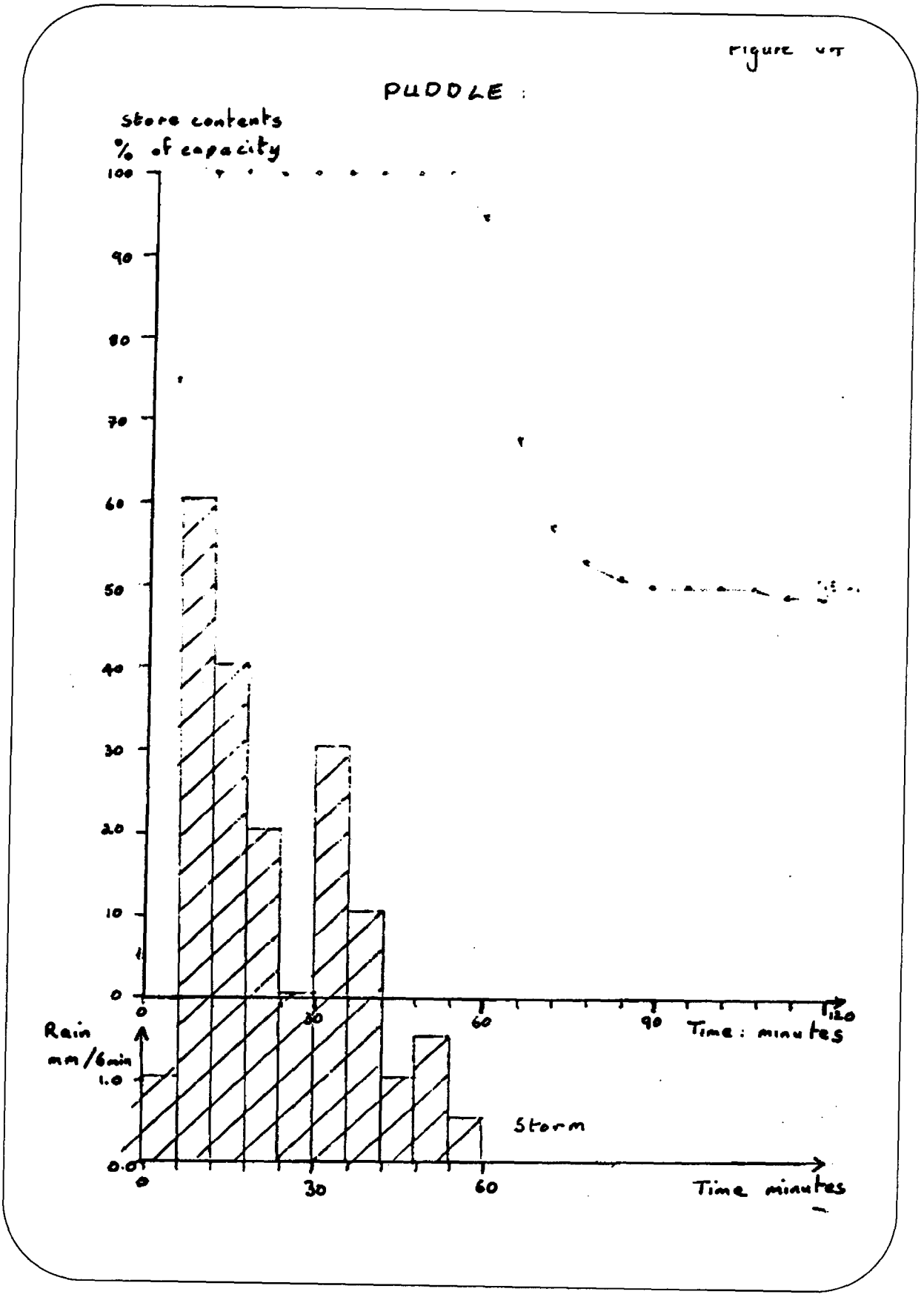


Figure H5
PUDDLE
Store contents
% of capacity
100
90
80
70
60
50
40
30
20
10
0
0
30
60
90
120
Time : minutes
Rain
mm/6min
1.0
0.0
Storm
0
30
60
Time minutes

Figure H5

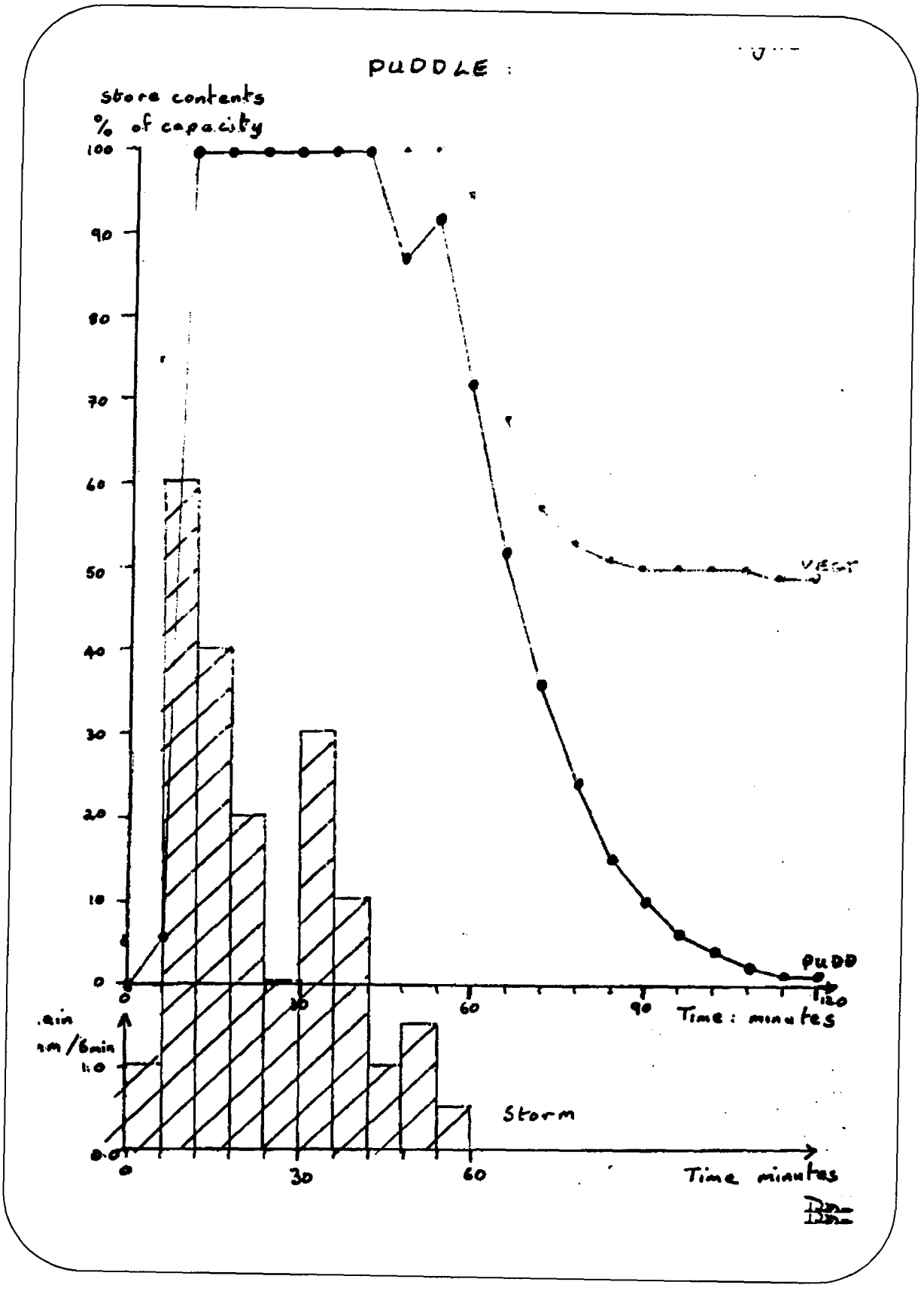

PUDDLE :
store contents
% of capacity
100
90
80
70
60
50
40
30
20
10
0
VEGT
PUDD
0
30
60
90
120
Time : minutes
rain
mm/6min
1.0
0.0
Storm
0
30
60
Time minutes

Figure H6

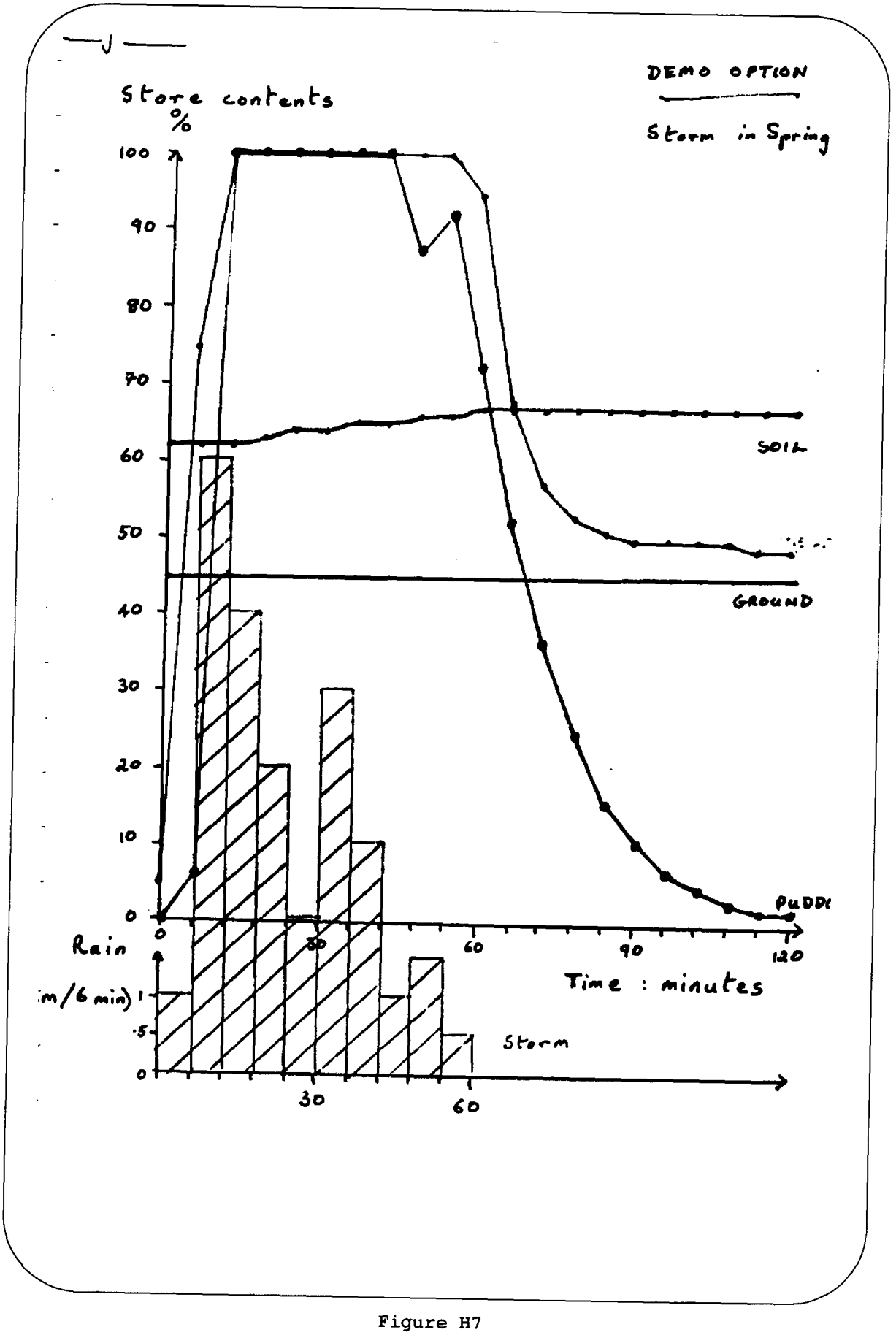

DEMO OPTION
Storm in Spring
Store contents
%
100
90
80
70
60
50
40
30
20
10
0
SOIL
GROUND
PUDDL
0
30
60
90
120
Time : minutes
Rain
(m/6 min)
1
·5
0
Storm
30
60

Figure H7

PUDDLE Interview : Manesh

MN1. SO NOW, ROUND TWO. WHAT DO YOU REMEMBER OF 'PUDDLE'?
What do I remember of 'Puddle'? I remember there's, rainfall, ev(ap)otranspiration rates, and then there's various rates, soil moisture, puddle, vegetation. Surface runoff, that's about as far as I can remember. Yes, I can remember quite a lot this time.

MN2. WHAT DID YOU ACTUALLY DO WITH IT, WHEN YOU USED THE PROGRAM?
Oh, we set the various types of area which we used like, if it was autumn and then that would determine how much rainfall like, heavy, light, drizzle so forth. And then, then you'd get the various rates of flow, water outputs such as a high percentage of surface runoff, the vegetation has got a lot of water, and, well how much the puddle can hold. And then how much will go from the puddle into the soil moisture and into the ground level, which will subsequently (go) deep down right into the ground moisture and then runoff into the earth. And then you get all the readouts, you get the readout at the end, what the contents was, and that's really it because then IT showed, then after a while it stopped raining and it showed the evapotranspiration rate over two hours if I remember, and that was it (Figure MN1)- As much as I can remember.
Figure MN1 Screen image: DEMO - the SUMMARY option at time 2.00 hours

MN3. YES, THAT'S QUITE A LOT. SO YOU HAD A LOOK AT THE AMOUNT OF WATER THAT HAD COME IN AND GONE OUT ON A SUMMARY, AND THEN YOU ACTUALLY LOOKED AT HOW MUCH WATER THERE WAS IN EACH OF THE STORES, DID YOU?
Yes, yes.

MN4. YOU CAN'T REMEMBER, WHAT SORT OF FIGURES THERE WERE, OR WHETHER .., CAN YOU REMEMBER BEING SURPRISED BY THE FIGURES OR ANYTHING LIKE THAT?
Figure MN2 Printout: DEMO - The VALUES option at time 2.00 hours
Well, I thought on the last one, right at the end there was a big table of figures and that was very complex (Figure MN2). When I saw it, it was very complex and it wasn't, didn't look right but I suppose that was right and if I figured it out, it looked a bit complex to read off, straight off. Because I think it said various

rates of infiltration and the porosity of the ground. And then there was the other thing, of taking everything into account it was, I can't remember, that's very vague. But I think it takes everything into account and does what's sort of held in, what's the percentage or something of, the percentage increase or decrease in moisture, I think so, I can't remember. Well that's as far as I can remember.

MN5. THAT'S VERY GOOD.
It's quite a long time.

MN6. WAS, THIS WAS THE FIRST PROGRAM YOU USED IN GEOGRAPHY. HOW DID YOU REGARD THIS SORT OF ... ?
It was a novelty to start off with, and it's quite a bit of fun, it was, yes it was pleasant of course and fun, but when you get into it's quite reasonable, quite a good program. I mean, not like the ones we are doing now. Again, that needed a bit of thinking, where everything wants to go, but it was predictable, most of the time it was quite predictable.

MN7 SO YOU RECKONED IT WAS REFLECTING WHAT YOU WOULD THINK WOULD BE LIKELY TO HAPPEN ... ?
Yes, quite a lot of the time it was, well I mean when you thought it was very heavy rainfall you'd think the puddle would pile up, and then quite a lot would go down to ground moisture and maybe a bit of surface runoff. And yes, you sort of got the idea of what was going on, it did happen. And if you didn't, well you just had to be a bit logically minded and the tables, and the tables would show you what had happened and how it had happened, really. And that's that, that's all I can remember again, so ....

MN8 SO YOU DIDN'T LOOK AT THE LISTING OF THE PROGRAM OR CHANGE THE MODEL?
I tried to, but that was difficult. Because, really I know I should he able to do, but I, I forgot; I couldn't see through lines, I couldn't see where they were meant to be see. So, I left it alone, I did try it once or twice and it did work. I did alter a few lines.

MN9. WHICH SORT OF LINES DID YOU CHANGE?

I think it was infiltration rate, I think I, of the soil, I think I changed that. .... noise .... a lot of the water in. Which I think was in the actual booklet which said how to change, set the infiltration rate lower, try that, it worked - quite well. I don't suppose I could have decreased it so that there would have been much more surface runoff, less going underground. But it wasn't that difficult, I could have altered it but I wasn't be too sure about people who had done that. Listing it for one thing is a problem. In that you have got to type 'LIST' and everything, and then they've got to know when to put it out when to do line number and what to put, and that could be a bit of a disadvantage.

MN10. SUPPOSING YOU COULD GET THE MODEL AND THE VALUES FOR 'PUDDLE' AND PUT THEM ONTO THE MODELLING SYSTEM YOU WERE USING THIS MORNING. DO YOU THINK YOU WOULD WANT TO PLAY AROUND WITH IT, IN THAT SORT OF SET-UP?
Oh, I see do you mean the rate of infiltration and ... ?

MN11. SUPPOSING YOU COULD TAKE THE 'PUDDLE' MODEL FROM THE PROGRAM AND PUT IT INTO THE DYNAMIC MODELLING SYSTEM, SO YOU COULD THEN CONTROL THE MODEL YOURSELF, AND CHANGE IT ...?
That'd be, that'd be much easier than it is in the existing form, it would be a lot easier but again the memory is not in there for it that much. That you can't do, but if it was in there I think it would be a lot easier. Graphs, if you could do graphs of proper, you know, proper graphs. Tables, if you could, if you had the ability that would be quite an idea. But well, I think, I think, I must admit, mixing and all that is quite good because you get the graphs on that side and tables which are very useful on that. Because .... tables is a bit dodgy and I don't like to use them straight off. And that doesn't look very nice but presentable form, the other one was very much better.

MN12 GOING BACK TO 'PUDDLE' THEN, DID YOU FIND THE PICTURE ON THE SCREEN HELPFUL, OR ... ?
Yes it was (great?), it was all laid out, so all you had to do was to really look at it. The arrows pointed whether there was any transfer or not from one source to another. Yes that was much easier to read off straight away.

MN13 AND HAVE YOU USED OTHER DIAGRAMS LIKE THE ONES IN TEXTBOOKS PERHAPS, WHICH ARE ... ?
Yes, the same kind as 'Puddle' actually. ... in textbooks looked more or less like that. They were similar, very similar to it.

MN14 HAVE YOU DONE FLOW DIAGRAMS IN COMPUTER STUDIES AS WELL?
Yes, many.

MN15 SO YOU ARE USED TO THE IDEA OF DRAWING BOXES AND ARROWS?
Yes, very. Very used to it, much of the time, because I say it makes life easier for the computer person. But, I suppose really it's more, much more commonsense really, because I mean you should be able to follow lines from one box to another, it shouldn't be too much trouble.

MN16 DID YOU EVER TRY ANYTHING LIKE DRAWING YOUR OWN 'PUDDLE' MODEL, BUT PERHAPS WITH MORE STORES IN IT OR WITH EXTRA FLOWS?
I'm afraid I didn't get round to it. I am sure it would very complex. I would have needed a lot of time for that, and because of the exam I couldn't do it. (No.) You know that would be very complex.

MN17 JUST TO SKETCH IT ON PAPER ... ?
Oh to, paper? Oh paper, yes I could have done it. Yes, it wouldn't have been too bad. But I think it would have been quite silly because I don't think there are any more stores really, except mountains maybe and that. But there were limitations for it, which could have been gone over if I'd used my own method (?). Maybe, I don't know, maybe I wouldn't be able to do it because there wasn't much memory.

MN18 CAN YOU IMAGINE BUILDING UP A PICTURE LIKE THAT'S IN A DIAGRAM FORM FOR ANOTHER ASPECT OF GEOGRAPHY? YOU KNOW, SUPPOSING YOU, COME TO ANOTHER TOPIC OF THE SUBJECT, AND YOU THINK MAYBE WE COULD HAVE ANOTHER PROGRAM HERE. COULD YOU SORT OF SKETCH OUT A DESIGN DO YOU THINK, FOR A PROGRAM YOU COULD WORK WITH?
Yes, I suppose the 'Puddle' program could have been, could be adapted to other things. So instead of bringing water levels, you could have something else. I can't tell you off-hand, but yes you could. You

could have ... I can't tell you off the top of my head, I dunno, oil maybe, I dunno. I can't tell you off the top of my head. But, you could sort of substitute parts into the boxes. And then from there you could do arrows, you know sort of like a flow diagram. Rather sort of like (ing?) oil shall we say. Except we can have programs that are say: there's was an oil crisis and so forth. Then I'd introduce, it could be done. That could be done so that arrows follow, and it shows it more in a diagrammatic form rather than reading a straight-forward text, which is much better. You can memorise things like that much easier than. It's been quite a long time since I've done 'Puddle' and I can more or less memorise it quite well. What worries, if it was in a textbook I'd have to remember it.

MN19 COMING BACK TO YOUR IDEA THEN, FOR LOOKING AT OIL. HOW COULD YOU IMAGINE THAT SORT OF FILLING IT UP, HOW CAN YOU IMAGINE IT WORKING, WHAT SORT OF THINGS WOULD IT REPRESENT?

Well, I think it would be everything the oil industry seems, since aLl was introduced to when, to now, or and maybe to the future, maybe even alter the figures and so, I dunno, say oil drops, oil prices drop and that would adapt to oil prices dropping in the present. So then they'll drop to, you know, so everything, the flow diagram following a different pattern and that will work out better. Yes, I suppose you could do that, and then I suppose you could have two flow diagrams for one for maybe past, and for present - for now, and then you could make one up yourself by feeding in the appropriate boxes by (setting them out?). You know anything any interference to do by itself to see whether you can, see if you get similar things or just change things about like change the variables slightly. Like saying that they introduced, oil prices were lower and there's enough oil in the world to (?), then obviously you are going to get different readings. It could be good, if you could stipulate it. It would be good for postulating ideas.

MN20 RIGHT, SO IN, YOU KNOW 'PUDDLE' IT WAS ALL TO DO WITH WATER. WHEN .... NOISE .... WE WONDERED WHAT TO CALL THE PROGRAM, WHEN WE HAD AN IDEA EARLY ON WE SHOULD SAY REALLY THAT DIAGRAM WAS MADE OF TWO DIFFERENT SORT OF COMPONENTS. WHAT DO YOU THINK THOSE COMPONENTS WOULD BE?

The input and outputs.

MN21 INPUT AND OUTPUTS, YOU SEE ARE THE TWO IDEAS, YES.
The rain of course which comes, and the flow of the water that is coming out. I'd would think they are the two main inputs, and main output.

MN22 AND WHAT'S ANOTHER COMPONENT, IF YOU HAD TO EXPLAIN IT TO SOMEONE WHO HAS NEVER SEEN IT?
Well, the actual program?

MN23 THE ACTUAL, THAT SCREEN DISPLAY WITH THE PICTURE.
I'd put it in three forms, input, then the store and then the output. Stores, of course, would be vegetation and the puddle. Whereas the output would be the runoffs, the various runoffs down the graph, and then of course the input would be the rain.

MN24 ARE THERE SOMETIMES WHEN THE INPUTS AND OUTPUTS ARE NOT CLEAR, DO YOU THINK?
Well not in the 'Puddle' case. I think that was quite clear.

MN25 IF WE TAKE AN EXAMPLE HERE, JUST OFF THE PILE WHICH I HAVE GOT HANDY, THAT'S NOT A GOOD ONE, LET'S TAKE ANOTHER ONE. HERE WE'VE GOT AN EXAMPLE OF THE, WHAT THE SCREEN DISPLAY WAS AFTER ONE HOUR. HOW WOULD YOU CLASSIFY THIS FLOW HERE? ONE LABELLED 'I', IN TERMS OF YOUR, YOUR CATEGORIES?
Figure MN3 Screen image: EXAMPLE - Heavy rain in the autumn at time 1.00 hours
That would be, I think that would be a, from store to output, so that I think that maybe classified as a .... That's, that's a bit more dodgy. But yes, I can see what you are trying to get to.

MN26 THAT'S WHY I ASKED YOU.
Yes, I'd say that would be a transfer, I suppose there'd be another stage really, transferring stage where it's neither really, it's inputting into there and it's also an output of there. You can't really, I suppose in a way after seeing that point you do get a bit mixed up. But I suppose you could always call it another stage like the transferring stage. From one store to the other store, yes

stores even, there's different types of stores really. I've said there's only these two stores but there are, of course, all the way down. And stores, I mean really include the ground, soil, puddle and vegetation. And really the output, the main output really is the actual flow of the water rather than out of the thing, rather than you know, from one to another. Yes, that would be it really. Because, I mean that's a bit dodgy, I mean straight from the puddle to the soil. ....noise .... but that's more twisted.

MN27 SOME PEOPLE HAVE LOOKED AT THESE DIAGRAMS AND. HAVE SAID: 'WELL THERE ARE BITS MISSING' I MEAN THIS IS A DIAGRAM SHOWING WHAT HAPPENS AFTER AN HOUR OF RAIN IN THE AUTUMN. ARE THERE ANY THINGS THERE THAT YOU THOUGHT, ANY EXTRA FLOWS PERHAPS, THAT YOU WOULD EXPECT TO BE THERE?
There are a few more flows, there's baseflow, ... surface flow.

MN28 IS THERE ANY SURFACE FLOW ON THE DIAGRAM AT THE MOMENT?
No, there isn't.

MN29 NO, WHY NOT?
Well I suppose, what, they're trying to say is, after a day, an hour ....

MN30 YOU'VE HAD AN HOUR OF RAIN.
An hour of rain, all of it's been in the puddles, most of it has gone from the vegetation into the puddle and straight into the soil. But I'd rather think there would be bit of soil (surface runoff), even though, maybe there wasn't enough rain for the (surface runoff?). Also maybe the infiltration rate is much, higher it's more porous soil rather is sort of clogged together. So there be surface runoff, surface runoff, but have thought there would have been a amount, even if they, if you know, every minute.

MN31 DO YOU OFTEN SEE WATER RUNNING OVER THE SURFACE OF THE GROUND AFTER RAIN ?
It really depends on the place you are really. I mean, if you are on the slope of a hill, maybe you do, you most probably do. When you are an level ground of course, it really (infiltrates?) and just goes straight down. So it really depends on whereabouts you are, of

course this program never did show quite a major limiting factor and that. I find that, if you know if you had different types of, if it was if it said that it was either on a slope, or at the top of it, or at the bottom of it, or wherever. You are always going to get, you are always going to get water from other sources, rather than just from puddle and vegetation. You're going to get it from other types of places. Unless you're going to think of that as a whole.

MN32 RIGHT, I'LL JUST TRY AND GET THE ORANGE PACK (WATER ON THE LAND). YES, INTERESTING POINT YOU RAISED THERE. SHALL WE GO TO THE BOOKLET, AND SEE WHAT IT SAYS (FIGURE MN3)- IT STARTS OFF EXPLAINING THE SET-UP. AND WHERE THE CONDITIONS THAT IT REPRESENTS. SO YOU GUESSED CORRECTLY THAT, IN A WAY, THAT THIS IS SUPPOSED TO BE SET AT THE TOP OF A HILL.

Figure mn4 copy of students' leaflet a from water on the land

Well, this is meant to be set on the top of the hill, maybe it could have been, it could have been altered so that it could have been a, in slightly different places. Maybe if it could have been varied, instead of putting it on top of the hill, it could have been on a slope. Then you're up the slope or maybe, maybe just flat land. (Right.) Which maybe have been or maybe even slightly undulating.

MN33 SO HOW DO YOU THINK MOVING THE PUDDLE SOMEWHERE ELSE ON THE LANDSCAPE, HOW DO YOU THINK THAT WILL CHANGE THE DIAGRAM?

Well obviously, on the top of the hill it is all going, well more or less, it's got to be a greater amount of surface flow, if there's going to be larger amount of rain. Whereas on the flat land you don't get that much, because there's no, there's no, the gravity is pulling it down below the surface. All it is, is forcing the water down into the ground. And of course it's what we were shown, because it's not exactly sloping down. I mean it it's always sloping down it's bound to get surface runoff. But maybe on flat ground you don't really get that. You don't, you may not get, it all accumulates on top and goes down straight.

MN34. RIGHT, SO YOU HAVE COMPARED FLAT GROUND THERE WITH A SITE AT THE TOP OF A HILL. WHAT DO YOU THINK THE DIAGRAM WOULD LOOK LIKE IF THIS COLUMN OF SOIL WAS PART WAY DOWN A SLOPE?

Well, I'd say it'd look quite similar to it except I think. Yes, the flow would be much greater, the rate of flow would be, well the rate of overflow would be great. The flow on land, overland flow would be quite great, it would be much greater than that because of course rain is falling on there and it would get it all in one go. Whereas on the slope you would get continuous amounts. And usually it picks up until more and more comes off and usually you get a lot of flow and that on the side. Whereas on the top it is slightly flat, slightly flat so the rate of flow isn't so much.

MN35 DO YOU THINK IT WOULD HAVE ANY EFFECT ON THE FLOW DIAGRAM, WHEN YOU REPRESENT IT IN THIS SORT OF BOX FORM'? IF IT WAS PART-WAY DOWN A SLOPE DO YOU THINK THAT DIAGRAM WOULD BE CHANGED?
Yes, it would be. To quite a great extent, well a good approach to it yes. I think, I would have thought there would be quite a lot of overland, flow. Soil moisture, I would think, let's see ....

MN36 IF YOU HAD A PENCIL, HOW WOULD YOU SHOW HOW THE DIAGRAM WOULD CHANGE. WHAT WOULD YOU SORT OF ADD TO THAT SKETCH, OR HOW WOULD YOU CHANGE IT?
That's vegetation flow , definitely get that, overland flow. You'd get, you'd get throughflow, that would be, no I think that would be the same as if it was on top of the hill. Maybe just slightly greater, but then again, ...noise .... and groundwater not so much because it's more or less flat because better infiltration .... So most of the water goes in there, soil moisture, throughflow and baseflow. If it was on a slope, that would be much greater than if it was on top.

MN37 IF WE ANALYSE THIS DIAGRAM, IN TERMS OF THE INPUTS AND OUTPUTS YOU MENTIONED EARLIER. HOW MANY OUTPUTS ARE THERE?
There's, 1,2,3,4, I'd say there are four outputs.

MN38 AND WHAT ABOUT INPUTS?
Inputs, there's only one major input really. Then if you include vegetation into the puddle, and puddle into ....

MN39 NO, JUST ONE, TO THE WHOLE SYSTEM?
To the whole system, rain, that's the only system input.

MN4O RIGHT, AND THAT'S FAIR ENOUGH ISN'T IT, AT THE TOP OF THE SLOPE? (YES.) WHAT ABOUT A COLUMN OF SOIL PART-WAY DOWN THE SLOPE? DO YOU THINK THERE WOULD BE THE SAME NUMBER OF INPUTS AND OUTPUTS, OR DO YOU THINK THEY WOULD ...?

You might, it depends really, I mean if you have got vegetation covering it they, it might sort of, sort of from the soil, there's vegetation there. Well I dunno, If the vegetation was there, I think the rain flow would be, the input wouldn't be so much. Not to such a great extent. The groundwater, I think most of the stuff would just stay the same,I think,

MN41 SUPPOSING YOU HAD A SECOND COLUMN OF SOIL HERE, PART-WAY DOWN THE SLOPE ON THE DIAGRAM, HOW MANY INPUTS DO YOU THINK THERE WOULD BE TO IT?

Well, there's bound to be rain. And then there's also going to be water from the top. (Right.) So there will be just two inputs instead of just the one input.

MN42 WELL, IN FACT THERE ARE THREE OUTPUTS FROM THIS COLUMN OF SOIL AREN'T THERE. THAT WATER IS ALL GOING TO MOVE DOWN SLOPE. SO IN FACT, YOU'LL HAVE THE RAIN PLUS YOU'LL HAVE THOSE AS WELL. SO THAT WILL MAKE THIS DIAGRAM MORE COMPLICATED WON'T IT?

Yes, they'd be inevitably pouring it out because every rain from here would be coming down. And also from there, those hills.

MN43. THAT'S WHY WE PUT IT ON TOP OF THE HILL TO MAKE IT SIMPLE.

Yes but, I would have thought really, it may have been complicated but if you gave everyone a chance to see it. I mean, in real life you don't, you don't have it always situated at the top. I know to simplify things you must do that but, once you get used to it, I suppose you could progress into a much more difficult stage. And by the level of understanding you have already got from there, you can progress altogether, and you might get a greater understanding than you might have from your geography (book?) at the end. I would have thought, you know, you would have three stages, well two main stages. Make it the top of the slope, and then the bottom of the slope. So

that's for an easier stage, and that's for a more difficult stage. So that works, maybe that would have been a bit better. (Okay.)

MN44. IF WE LOOK AT WHAT HAPPENS ON 'PUDDLE' IN TERMS OF GRAPHS, I'VE GOT A GRAPH HERE SHOWING THE STORE CONTENTS AGAINST TIME THERE. HERE WE'VE GOT A STORM IN SPRING, WHAT WE HAVE DONE IS, WE HAVE TAKEN FIGURES FROM THE COMPUTER PROGRAM, FROM THE PICTURE OF THE STORM, YOU CAN SEE THAT THE PROFILE OF THE RAIN DURING THE ONE HOUR STORM AT SUCCESSIVE INTERVALS OF A FEW MINUTES, MORE OR LESS RAIN, THEN SUPERIMPOSE THE GRAPH OF THE CONTENTS OF THE VEGETATION STORE, THAT SHOWS HOW THE STORE BEHAVES DURING THE STORM, DOES THAT SURPRISE YOU? HOW THAT WORKS?

Figure MN5 DEMO - Storm in spring, graph of rainfall, and vegetation store contents

No, I would think so, I would have thought yes, they usually do get the first amount, the first amount usually goes straight into the grass and other vegetation. It holds it, and after a while because the plants obviously need it, they need the water and they go straight into the roots, the water is usually absorbed by the roots. A lot of it is held in the plant, in all the nooks and crannies, the shape of the plant usually holds it and then after a while it does seep through, it does usually seep though down into the thing.

MN45 IT YOU LOOK AT THE SHAPE OF THIS CURVE, IT'S GOT THREE OR FOUR DISTINCTIVE PARTS, YOU WOULD REALLY EXPECT THE FIRST ONE - FILLS UP QUITE RAPIDLY WITH WATER INITIALLY, WHAT'S THE NEXT STAGE, CAN YOU TALK THROUGH THAT CURVE?

The levels are constant it can't take up any more water without losing any so it's reached it's maximum store: and then after reaching it's maximum store it just gives up because it's just too much for the plants and gives it up because of some biological event. And it's just lost by the crevices of the ground all the different types of pressure which force the water out of the plants and into the soil and there is an increase into storage in the plants and then it levels off again into the soil, and a certain amount is kept in the plants whereas half of it's gone into the plants and half of it's gone into the ....

MN46 SO YOU SEE THIS WATER HERE, AT THE END, BEING ACTUALLY INSIDE THE PLANT?
Yes, or stored somehow, maybe in the roots.

MN47 SUPPOSING, WE ARE TALKING ABOUT A STORM IN SPRING, IF YOU ARE WALKING THROUGH A FIELD OF GRASS, AN HOUR OR TWO AFTER A STORM WHAT DO YOU THINK THE GRASS WOULD BE LIKE?
I can't remember, I think it would be quite soggy, yes very soggy, I mean when you are walking everything is going to get wet, that just shows how it does hold quite a lot of the water. Besides that I can't remember much.

MN48 IS THAT WATER IN THE PLANTS, OR WATER ON THE PLANTS?
More or less there's more water on the plants because of surface tension on the plants. Rather than, it so, you can't squeeze the water out obviously, but it's usually on the plants because of the surface tension on the leaves and everything else. It's held inside by the structure, like buttercups hold water inside and flowers, that's how it's done really.

MN49 SO THAT WATER WOULD APPEAR HOW, IF YOU ACTUALLY LOOKED AT IT?
As globules, on plant stems rather than, and maybe drips obviously, dripping because it weighs too much after a while. But usually they are hanging on the underside not usually on the upperside.

MN50 WHEN COULD YOU SEE THE EFFECTS OF DRIPS THEN IN THIS DIAGRAM ON THIS GRAPH? (WELL, I WOULD START..) WHERE WOULD YOU HAVE EVIDENCE FOR SAYING THE DRIPS WERE OCCURRING?
Well obviously, the rain stops. I'd..., that is a storm in April?

MN51 THAT'S THE RAINFALL FOR THE FIRST HOUR.
I would think the rain stops around there well the rain carries on, but it's just getting too much for the store and they give up drips, and really the total amount of water in the plants is just too much for the plants to bear and they keel over under the pressure and they finally lose out to the water, and the water starts dripping from that point.

MN52 CAN YOU SEE EVIDENCE OF DRIPS STOPPING, AT ANY STAGE? CAN YOU SEE EVIDENCE FOR THE DRIPS ACTUALLY STOPPING AT SOME STAGE IN THIS CURVE?

Well in the whole graph I would say it would be when the actual rain has stopped so there is no more inputs into the plant. Whereas, therefore it can't get anything else. I mean if it's reached it's maximum and it's given away half of it already, then it is going to level off. I mean it doesn't have that much water to give away now. If it can hold water in, it will keep it in unless it is too much for it, and then it will flow. But seeing as there is no storm at this point, it should keep it in.

MN53 SO THAT MAKES SENSE THAT CURVE?

Yes, that would make sense, yes.

MN54 RIGHT, IF I CONTINUE ADDING MY OVERLAYS, IF WE'VE GOT HERE A GRAPH FOR THE PUDDLE STORE OVER THE SAME PERIOD OF THE, HOW DO YOU SEE THAT CURVE?

Figure MN6 DEMO - Graph of storm in spring with rainfall, vegetation and puddle contents

Slightly more unusual I would say. The puddle fills up with water quite rapidly, I would expect that because of the large influx of water at the beginning, gradual increase of water there. Constant, I don't know about it keeping constant. Maybe it does because the initial volume taken up, but I would have thought there wouldn't have that, I-would have thought there would have been a great gush of water, ...well it depends upon the soil before it.

MN55 THIS EXAMPLE IS SUPPOSED TO BE ON A CLAY SOIL.

Dry..?

MN56 STARTING OFF AS A CLAY SOIL WITH A LIMITED AMOUNT OF INFILTRATION CAPACITY.

Well I would have thought quite a lot, just a bit of it, there would have been a little bit, maybe indefinite. Slightly like that at the top there because the clay would take it in because of the sucking pressure in some of the actual ground, but that, I would have thought that would be a bit different. Maybe it would have kept constant. Yes everything would be full up. It would start losing it and then

there is an influx, I suppose that is because it gets water from the particles? I would think the water coming off the plants and going into the puddle. I'm saying that, I don't know why the plants .... because they coincide, the levels coincide. I wouldn't have thought the puddle had that much. If anything, the puddle would have increased rather than decreasing.

MN57 (NONE OF) THESE ARE JUST PERCENTAGES OF CONTENTS, NOT ACTUAL HEIGHTS JUST A PERCENTAGE OF WHAT THEY COULD HOLD. CAN YOU SEE ANY REASON FOR THIS SORT OF KINK IN THE CURVE FOR THE PUDDLE AFTER A PERIOD OF TIME? IT GOES DOWN AND THEN IT GOES UP AGAIN.
Well alright, there's, alright there's water, there's water losing. It's losing water, it's beginning to lose water because of infiltration, slight infiltration and maybe runoff onto other areas, and now the vegetation is giving up it's moisture and the moisture, slight amount of moisture given off into the puddle that may have been because of a slight increase. And after that it decreases because there is no more rain literally. I would have thought, again I would have thought this curve would have been slightly more, a bit more level rather than such a steep inclination but.,..

MN58 COMING BACK TO THIS, THIS POINT HERE, CAN YOU SEE ANY RELATIONSHIP BETWEEN THIS AND SAY THE RAINFALL ALL?
Yes I suppose, maybe because at 40 or 35 (Six minute intervals.) Yes 36, then because it had a third largest amount of rain it added to the puddle and at 36 and 42, well they combined I suppose, the larger amount raised the percentage of the water in the puddle slightly. Including that with the vegetation that would have made it increase by a larger amount. And that's what gave maybe the kink to the actual curve.

MN59 FINALLY, JUST VERY QUICKLY, THAT'S THE INFORMATION FOR THE GROUNDWATER STORE, AND ALSO THE SOIL. WHAT DO YOU MAKE OF THOSE?
Figure MN7 DEMO - Graph of storm in spring with rainfall, vegetation, puddle, soil and ground contents
Ground will be reasonably right. Ground doesn't usually saturate anyway, fully saturated. So it wouldn't lose or gain anything, it would just flow really. Just a constant flowing, and I would expect that I suppose, with no great argument really because I would think

that's most probably would have happened, because if it is saturated fully it can't hold any more than it usually can.

MN60 WHAT'S YOUR EVIDENCE FOR SAYING IT'S SATURATED FULLY. CAN YOU TELL FROM THE GRAPH?

Well it seems that, before the rain started falling it was at 44%, and at the end it was also 44%, if I'm reading it properly? (Yes, carry on, that's right). I think because the clay, because the soil is impermeable, it doesn't allow much water out or in, as a matter of fact. So what happens is anything that's been held in there is really just being kept there rather than, rather than sinking in, that's what I would have thought anyway. I don't think there would have been any great net changes or losses. I thought it would have been constant all the way through. Unless of course there was a drought or something like that.

MN61 RIGHT, WHAT ABOUT THE SOIL, HOW DOES THAT BEHAVE?

That's slightly more undulated, slightly more erratic. Yes it's taking it in and more or less giving it out, after a certain time it's more or less constant, except for those peaks in it which show really that it takes a certain amount and then somehow gives it away. And takes in a bit and takes it away, and then it levels off at the end. That would be because, most probably because there is suction pressure in the soil maybe. And after a while the soil of course not needing any really much, it levels off.

MN62 SO HOW DOES THE SOIL COMPARE SAY WITH THE BEHAVIOUR OF A PUDDLE WHICH WAS THE ORANGE LINE?

Yes, when the puddle is filling up, well obviously the soil isn't going to have anything, when the puddle is filling up it's giving slight. I would have thought again it would have been just a slight decline and because some of the soil would have taken the water, the initial amount and then after, the soil has been fully saturated more or less, the soil surface will be saturated, it cannot take any more water and after that the puddle gives it up to the soil, and the soil runs off, the water runs off the soil. That's what I would have thought but ....

MN63 SO THERE IS QUITE A BIG CONTRAST ISN'T THERE, BETWEEN THESE TWO CURVES - FOR THE VEGETATION THE PUDDLE AND THE BEHAVIOUR OF THESE TWO CURVES?
Yes, some of the results, I think they were a bit more different to what I was expecting maybe, because if vegetation did lose it, I can't really see where it's gone. Rather I would have thought it would have gone more on the surface, because you haven't shown that, it may have gone into the ground. But it doesn't show that, it doesn't show, it might, to a great extent into the soil.

MN64 COULD IT BE FOR EXAMPLE, THAT THE SOIL STORE IS SO LARGE EVEN IF IT'S TAKEN ALL THAT WATER, IT DOESN'T MAKE MUCH CHANGE?
Yes, it's got so much water in it already that it doesn't need any more so it just becomes self saturated, it just can't take any more.

MN65 SAY YOU.... A METRE OF SOIL IN YOUR GARDEN, IF YOU HAD TO HAZARD A GUESS HOW MANY PERCENT OF THAT SOIL WAS REALLY SOLID MATERIAL AND HOW MUCH WAS SPACES, WHAT WOULD YOU GUESS?
Well the soil always has an abundant number of air spaces, I would say soil - 50%? Usually I think, I think something like that if I can remember my Biology correct. It's not much, but there's a lot of spaces in between (Right.) in between the soil.

MN66 AND ON AVERAGE OF THOSE SPACES, HOW MUCH WOULD BE TAKEN UP BY WATER, DO YOU THINK?
A lot of it, a lot of it, most of it actually. And then it will be by oxygen, and other debris, but usually a lot of it is covered in by (?).

MN67 SO, IF WE SAY IN A METRE OF SOIL, AND YOU ARE SAYING ABOUT HALF IS SPACES, HOW MUCH STORAGE CAPACITY IS THERE FOR WATER?
Well if I was right, I would say that has got a large storage capacity. (How much?) Twice, it's got, you would have twice as much as if you didn't have any storage capacity at all! There would be enough, there would be the same amount of water held there as there is soil.

MN68 YOUR ESTIMATE IS VERY GOOD, SO WHAT YOU ARE SAYING IS IN FACT IS THAT IN THE TOP METRE OF THE SOIL, YOU COULD HAVE UPTO 500MM, HALF A METRE OF WATER. THAT'S OKAY, THAT ONE IS WITH PORES FULL, HALF OF THAT SPACE WAS AIR, IT WOULD STILL LEAVE YOU 250MM OF STORAGE. WHEREAS YOU COULDN'T HAVE A COLUMN OF WATER QUARTER OF A METRE HIGH SITTING ON TOP OF THE GRASS, SO IT'S INTERESTING TO THINK ABOUT IT IN THOSE WAYS, AND THAT WAS WHAT THE PROGRAM WAS TRYING TO GET YOU TO THINK TOWARDS. YOU DID QUITE WELL THERE, THANK YOU VERY MUCH.

THANK YOU.

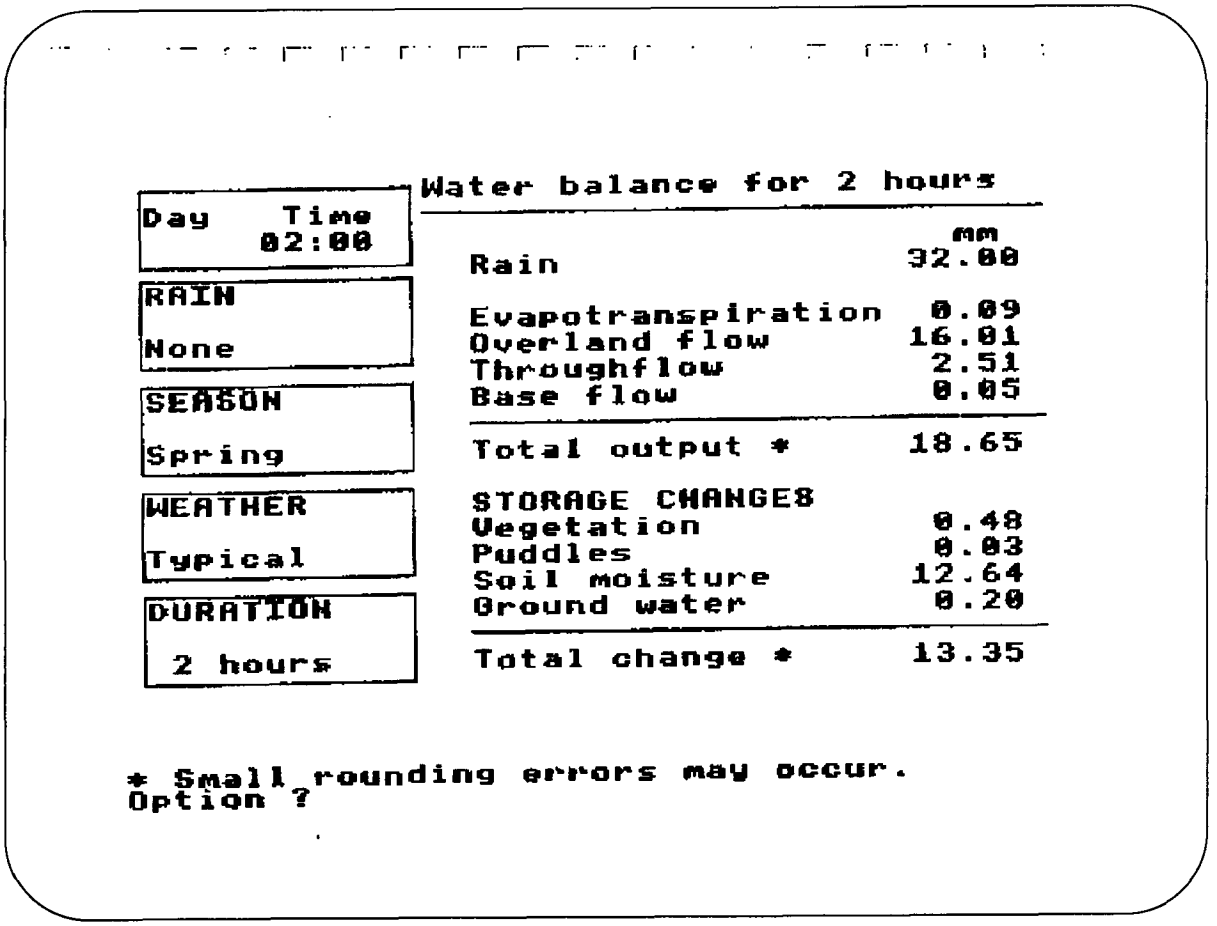


Figure MN1

Store	capacity (mm)	contents (mm)
Vegetation	1.1	0.54
Puddles	3.5	0.03
Soil moisture	250.0	167.64
Ground water	100.0	45.20

Flow	maximum rate (mm/hour)*	threshold (%)
Evapotranspiration	0.09	0 %
Drips and stem flow	4.80	50 %
Infiltration	15.00	0 %
Percolation	3.60	65 %
Overland flow	1.20	90 %
Throughflow	9.00	60 %
Base flow	0.12	0 %

Figure MN2

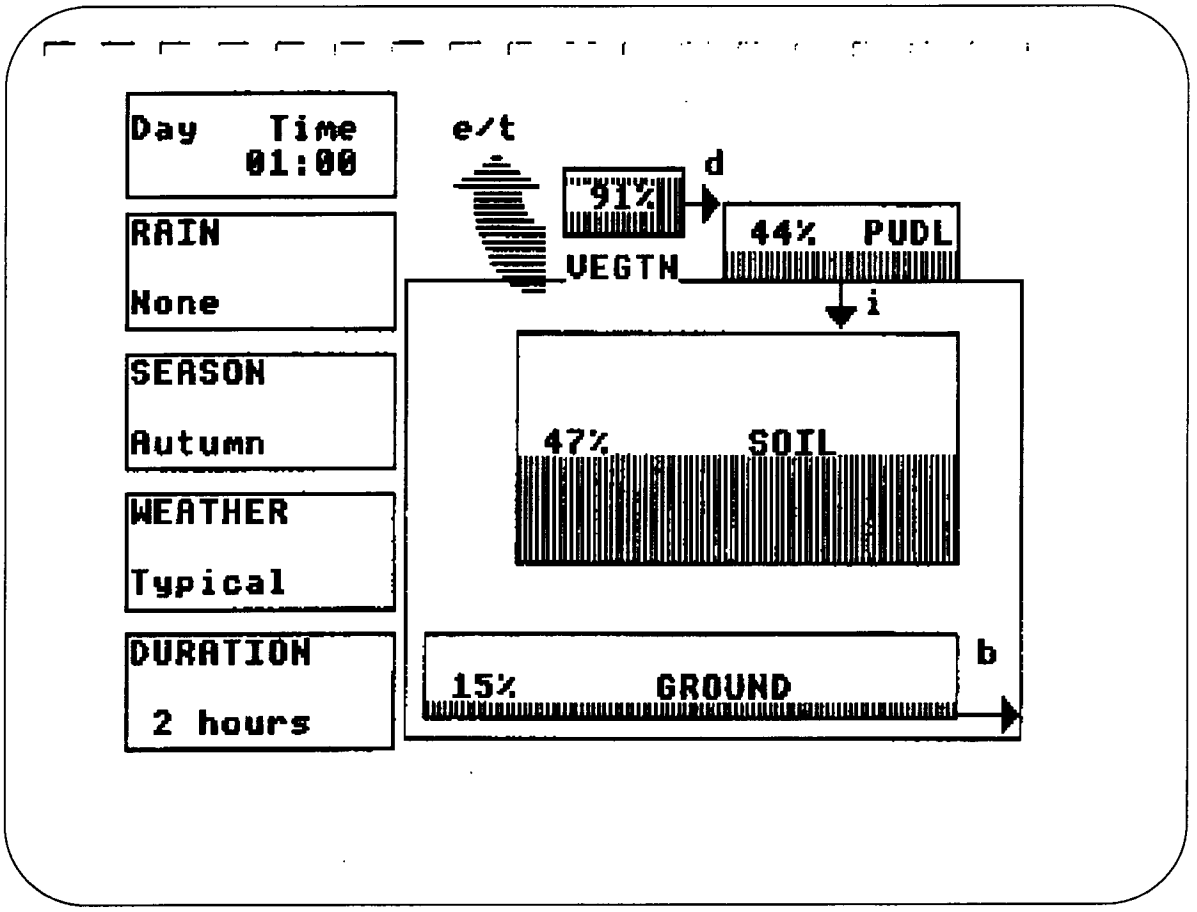

Day Time
01:00
RAIN
None
SEASON
Autumn
WEATHER
Typical
DURATION
2 hours
e/t
91%
d
44% PUDL
VEGTN
i
47% SOIL
15% GROUND
b

Figure MN3

Students' leaflet A
Water on the land

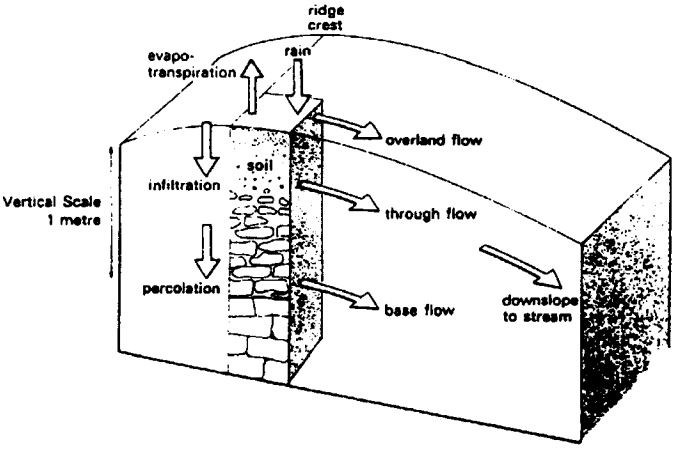
Introduction

After rain or snow falls on the ground, water follows several different paths. Some evaporates into the air, some soaks into the soil and some may run downhill over the surface.

Figure A1 shows these flows on a small area of land. As it is at the top of a slope, no water can drain into it from higher ground.

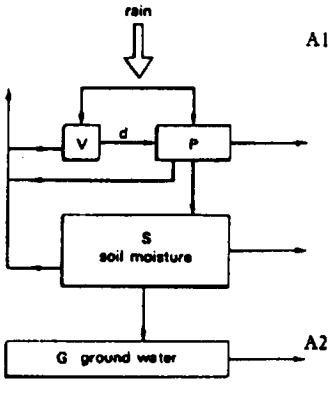
Trees, crops and plants also affect the flow of water. Rain or snow may be trapped on the surfaces of plants and some water may never reach the ground. Plants also take water out of the ground and lose it to the air by transpiration.

Figure A1
Water movement on an area of land at the top of a slope.



The flow diagram

Figure A2
The flow diagram.



The movement of water shown in Figure A1 can also be shown in a flow diagram – see Figure A2. The 'boxes' are stores where the water is held for a while between the flows.

A1 Put the missing labels on the diagram using the key below.

Key

Stores		*Flows*	
V	Vegetation – also known as store	d	Drips – throughfall – & stemflow
P	Puddles – also known as the surface depression/detention store	i	Infiltration
S	Soil moisture store	p	Percolation
G	Ground water store	o	Overland flow – surface runoff
		t	Through flow
		b	Base flow
		e/t	Evapo-transpiration

A2 Draw a new flow diagram to show the flows and stores near the bottom of a slope. (Hint – there should be several extra flows.)

Figure MN4

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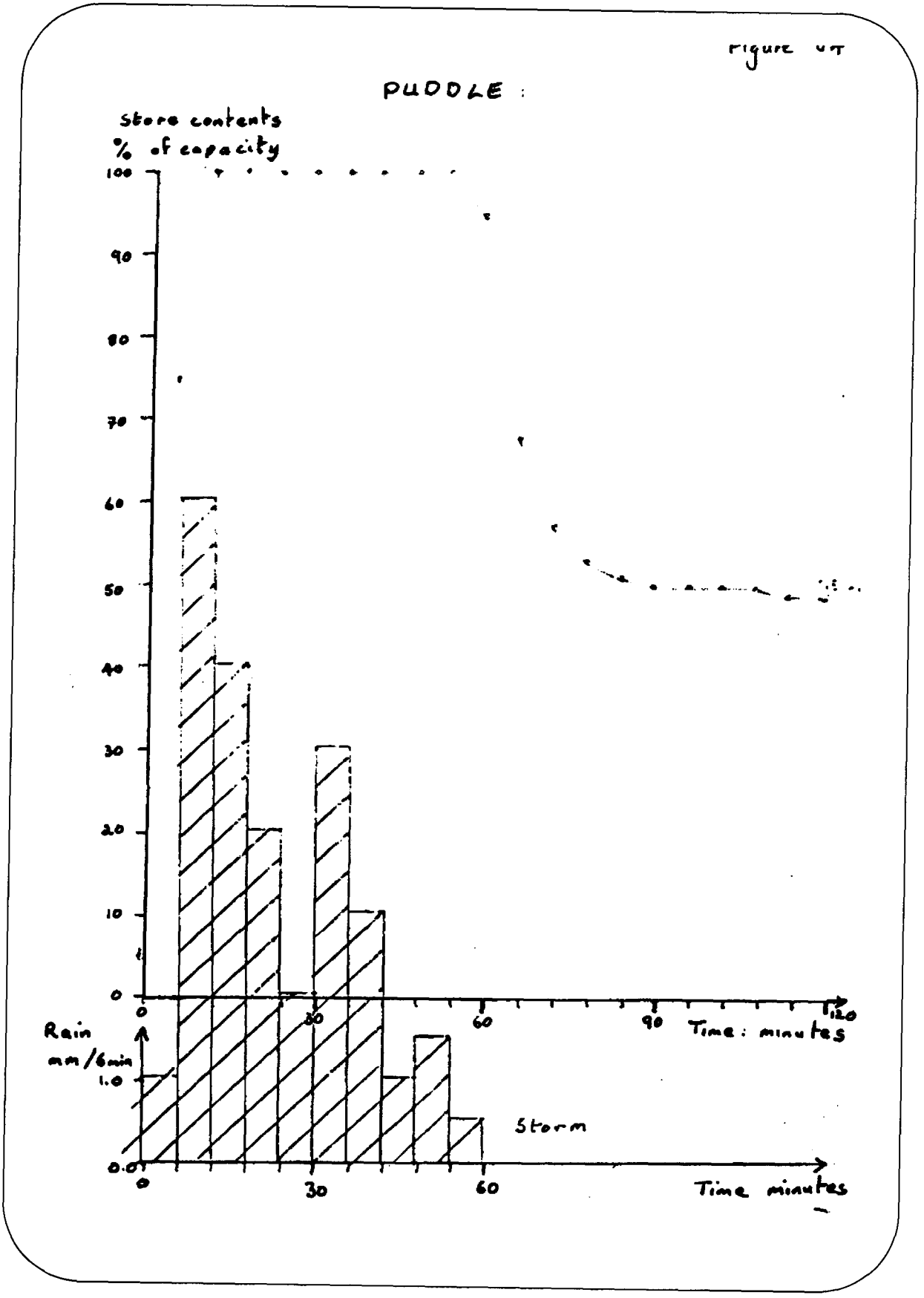


Figure MN
PUDDLE :
Store contents
% of capacity
100
90
80
70
60
50
40
30
20
10
0
0
30
60
90
120
Time : minutes
Rain
mm/6min
1.0
0.0
Storm
0
30
60
Time minutes

Figure MN5

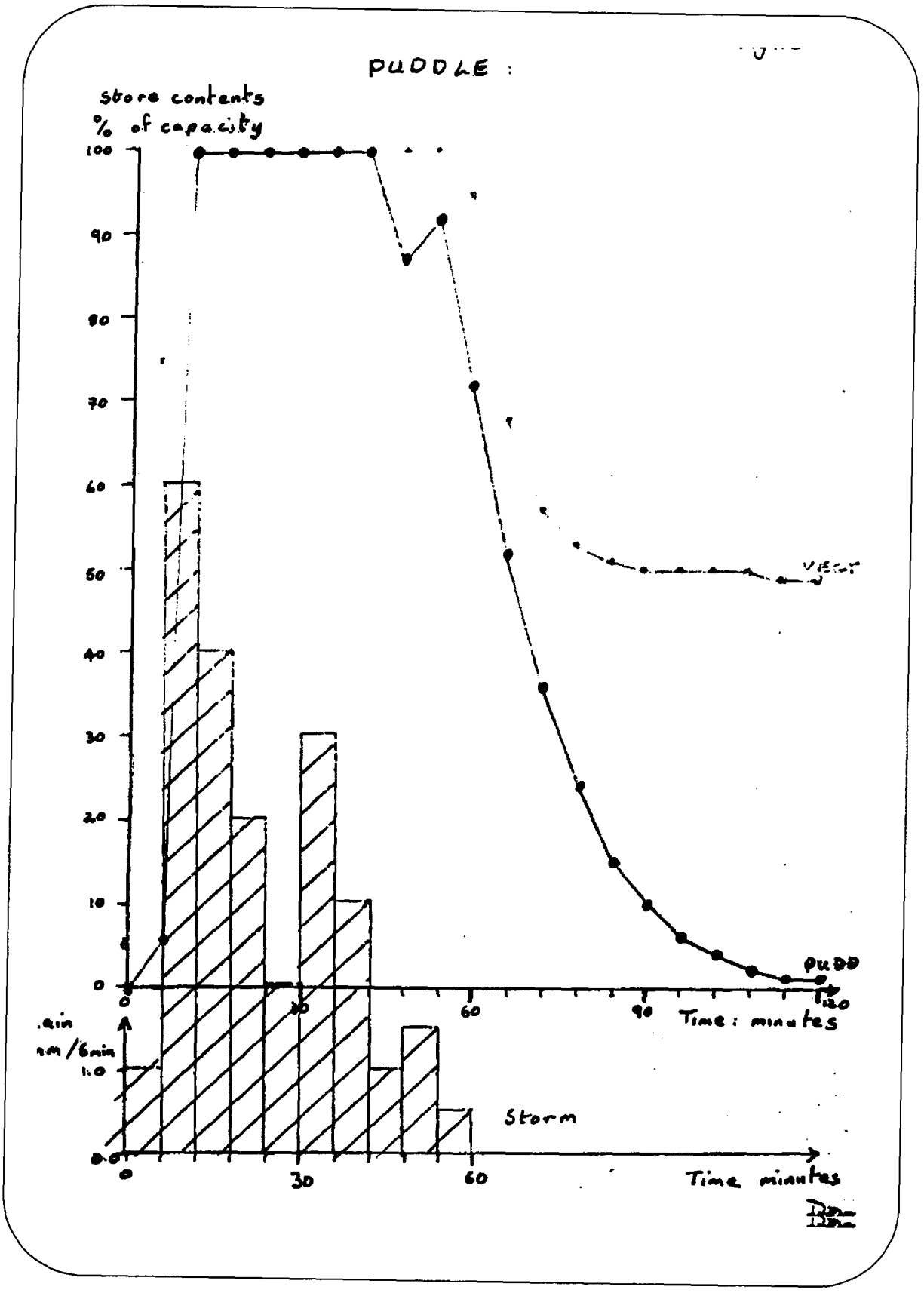

PUDDLE :
Store contents
% of capacity
100
90
80
70
60
50
40
30
20
10
0
0
30
60
90
120
Time : minutes
PUDD
Storm
0.0
30
60
Time minutes

Figure MN6

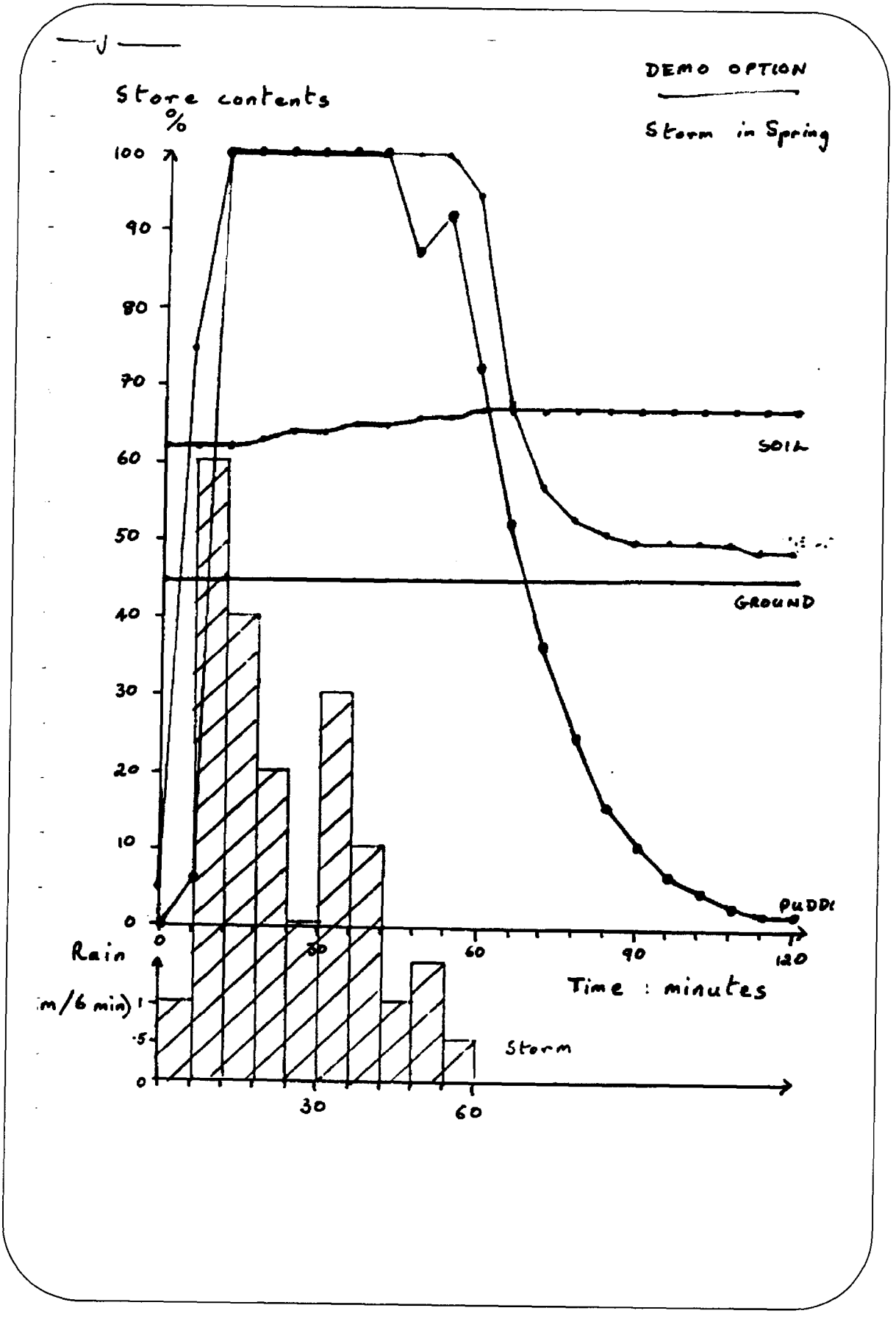

DEMO OPTION
Storm in Spring
Store contents
%
100
90
80
70
60
50
40
30
20
10
0
SOIL
GROUND
PUDDL
0
30
60
90
120
Time : minutes
Rain
m/6 min)
1
·5
0
Storm
30
60

Figure MN7

PUDDLE Interview : ANDREW

A1 OKAY ANDREW, NOW I HAVE LEARNT FROM THE OTHERS THAT YOU DID 'PUDDLE' ABOUT TWO MONTHS AGO. (YES.) REALLY THE BEST WAY TO START IS TO ASK YOU HOW MUCH YOU REMEMBER OF WHAT YOU DID AND WHAT THE PROGRAM DID?
The program was mainly about the hydrological cycle. Where water is evaporating, I think it was after an hour and certain measurements were taken, the depth of water after precipitation and, we could change certain aspects of it. Could change the amount of rainfall, the amount of sunshine, change the hours, the evapotranspiration, that was about it.

A2 RIGHT, THAT WAS THE FIRST PROGRAM YOU HAD USED AT ALL, EVER?
Yes, the first one I had worked on.

A3 WAS IT, DID YOU FIND IT A RATHER STRANGE NOVELTY, OR DID IT SEEM QUITE NATURAL TO DO?
It was quite strange at first, not knowing any of the keys, and not knowing what to do in general, just had to sit and watch everybody else.

A4 IF SOMEONE HAD SAID YOU WOULD USE THE COMPUTER IN THE GEOGRAPHY LESSON BEFORE, WOULD YOU BELIEVE THEM, OR WOULD IT HAVE SEEMED A SENSIBLE THING TO DO?
I wouldn't have thought, it's not really a normal sort of thing to do, but I think it's quite useful.

A5 IN YOUR TEXTBOOKS YOU HAVE GOT A SIMILAR DIAGRAM, IN THE BOOK THAT YOU HAVE ON THE SCREEN IN 'PUDDLE'. DO YOU THINK PLAYING AROUND WITH COMPUTER PROGRAMS IS A GOOD WAY TO START? DO YOU THINK YOU COULD HAVE LEARNT THE SAME SORT OF THINGS FROM THE BOOK, PERHAPS MORE QUICKLY?
Yes, you can learn more quickly from the book, but using computers are useful in that aspect because you can change, change the things around and find out how much quicker which processes occur according to which ones change

A6 RIGHT, SO YOU THINK THE COMPUTER TAKES TIME, TO GET FAMILIAR WITH IT TO USE THE PROGRAM, IS IT WORTHWHILE ?
In the long run, yes.

A7 IN THE LONG RUN YES, WHAT DO YOU MEAN 'IN THE LONG RUN ?
Well, once you have got it all sorted out, and know how to use it.

A8 YES, HOW DOES IT HELP YOU NOW, IT IS TWO MONTHS ON, YOUR EXAMS ARE ANOTHER YEAR FROM NOW, IN THAT SORT OF LONG RUN HOW DO YOU THINK IT COULD POSSIBLY HELP?
In general, a better understanding to, the way things, the processes that go on.

A9 WHY DO YOU THINK THAT IS, WHAT IS IT THAT MAKES FOR A BETTER UNDERSTANDING?
Well, like I said, being able to change the amount of time and the amount of rainfall, you can see actually on the graph, on the diagram, how it is interchangeable with each other.

A10 SO, BY HAVING MORE CONTROL OVER IT, MAKING IT DO WHAT YOU WANT IT TO DO, YOU GET A BETTER IDEA?
Yes.

A11 GOOD, DO YOU THINK IT HELPS YOU TO REMEMBER THAT PART OF THIS COURSE, OR THAT BIT OF GEOGRAPHY?
Yes, I think it does, you've got certain things that stick in you mind, little arrows pointing upward or whatever.

A12 ANOTHER THING, THE PICTURE IN THE BOOK IS FIXED, IT DOESN'T CHANGE, WHEREAS THE ONE ON THE SCREEN DOES CHANGE, AS YOU SAID, AND YOU ARE IN CONTROL. WERE THERE ANY THINGS THAT SURPRISED YOU, IN THE WAY IT CHANGED?
No I don't think so.

A13 IT WAS MORE OR LESS WHAT YOU EXPECTED?
But it was much quicker than plotting it on a graph, you just typed a few things in, and it was there straight in front of you.

A14 YES, CAN YOU IMAGINE USING THAT SORT OF PROGRAM IN ANOTHER PART OF YOUR GEOGRAPHY COURSE ... ?

A15 CAN YOU IMAGINE ANY, A SPECIFIC SITUATION WHERE YOU COULD REPRESENT THINGS IN A DIAGRAM IN A SIMILAR SORT OF WAY TO 'PUDDLE'?
(No answer)

A16 I WAS JUST WONDERING, MAYBE IN PHYSICAL GEOGRAPHY MAYBE YOU COULD LOOK AT SOMETHING LIKE SNOW PERHAPS AND SNOWFALL?
And how it builds up into a glacier.

A17 YES, YOU DID THE GLACIER ONE ON DMS?
No, I had a quick look at it, the graph looked quite fun, the curly graph. I am going to have a further look into that, that's my strongest point, physical Geography.

A18 HOW DO YOU FIND LOOKING AT THE GRAPH, COMPARED WITH LOOKING AT A PICTURE OF THE SORT 'PUDDLE' GIVES?
Looking at a graph is a bit easier to understand.

A19 IT'S EASIER THEN TO USE A DIAGRAM?
Yes, so long as you have got, as long as it is all labelled. I think it's a bit easier.

A20 SO YOU THINK 'PUDDLE' WOULD HAVE BEEN BETTER IF YOU COULD HAVE HAD SOME GRAPHS OF WHAT WAS GOING ON? (YES.) WELL, THAT'S INTERESTING, WE ORIGINALLY WANTED TO HAVE GRAPHS BUT THERE WASN'T ROOM IN THE COMPUTER MEMORY TO INCLUDE GRAPHS. SO THAT SOME OF THAT STUFF IS DRAWN ON PAPER HERE. SO WHAT I DID WAS TO SKETCH A GRAPH THAT WE WOULD LIKE TO HAVE PUT ON THE SCREEN. WHAT I HAVE DONE HERE, IS TO TAKE THE EXAMPLE THAT IS BUILT INTO THE PROGRAM (FIG.A1). SAY IF YOU CAN HAVE HEAVY RAIN IN THE AUTUMN, THAT WILL BE THE RAIN PROFILE - THE BARS. WE CAN SEE WHAT WOULD HAPPEN TO THE STORES BY SUPERIMPOSING THEM, SAY FOR EXAMPLE, THAT'S THE RAIN THEN THAT'S THE WAY THE VEGETATION STORE'S RESPONDED OVER THE SAME PERIOD OF TIME - TWO HOUR. SO THAT'S THE SORT OF THING WE WOULD HAVE LIKED TO HAVE INCLUDED.
Yes I think the graph is a bit easier to understand.

A21 HOW DO YOU THINK THAT COMPARES WITH SEEING SAY, THE PICTURE ON THE SCREEN? BECAUSE THIS SERIES OF PICTURES HERE, THIS SHOWS WHAT WOULD HAPPEN AFTER ONE HOUR (FIG. A3). THAT SHOWS THE STARTING POSITION (A2), AND FINALLY WE HAVE GOT ONE AFTER TWO HOURS (A4). SO THESE THREE DIAGRAMS REPRESENT THE BEGINNING, THE MIDDLE AND THE END. THIS PARTICULAR SEQUENCE..., SO THERE YOU'VE GOT THE SAME INFORMATION PRESENTED IN TWO DIFFERENT WAYS, HOW DO YOU FIND THE TWO DIFFERENT PRESENTATIONS OF THE SAME INFORMATION?

Figure A2 Screen image: EXAMPLE - Heavy rain in autumn at time 0.00 hours. Figure A3- Screen image: EXAMPLE - Heavy rain in autumn at time 01-00 hours. Figure A4- Screen image: EXAMPLE - Heavy rain in autumn at time 02-00 hours

The graph is easier to understand, although .... Yes, I can't see where it takes into account the ground.

A22 RIGHT, I HAVEN'T SHOWN YOU THE CURVES YET FOR THE OTHER STORES. THERE IS ONLY THE LINE FOR THE VEGETATION STORE. (OH, I SEE.) WHICH REPRESENTS GRASS IN THIS PARTICULAR CASE. DOES THE SHAPE OF THAT CURVE SURPRISE YOU?

Yes it does actually, at the top, where it's right up to 100% and it dips down.

A23 WHY DO YOU THINK IT DIPS DOWN?

Where the soil starts soaking it up. Soaking up the moisture.

A24 RIGHT, WHAT ABOUT RELATIONSHIPS BETWEEN SAY THE RAINFALL AND THE VEGETATION?

Some of the vegetation is going to use some of the rainfall as food.

A25 RIGHT WE WILL MOVE ON FROM THERE THEN. IT FLUCTUATED UP THERE, THEN THE CONTENTS OF THE VEGETATION STORE DROP QUITE QUICKLY. HOW WOULD YOU EXPLAIN THIS PART OF THE CURVE THEN, IMAGINE YOU ARE EXPLAINING THIS PROGRAM TO THE LOWER SIXTH NEXT YEAR. HOW WOULD YOU TEACH THEM? IF THEY ASKED YOU WHAT WAS GOING ON HERE, HOW WOULD YOU EXPLAIN IT?

As the rain, as the amount of rainfall decreases, evaporation is starting to occur, the vegetation is using some of the water that is in the soil.

A26 HOW MUCH WATER IS LEFT IN THIS STORE BY THE END OF THE TWO HOUR PERIOD? THE VEGETATION STORE?
Just over 50%.

A27 RIGHT OKAY, IF WE COMPARE THAT WITH THE CONTENTS OF THE PUDDLE STORE, OVER THE SAME TIME PERIOD, THAT'S THE CURVE FOR THE PUDDLE.
It's quite different. Up until 61% it's always increasing, the amount of water in the puddle and after that, after about 45 minutes the evaporation starts, and the water has soaked into the ground.

A28 THE VEGETATION HERE FILLS UP PRETTY QUICKLY DOESN'T IT, HOW DOES THAT COMPARE WITH THE PUDDLE?
With the puddle, the water goes straight on the ground before it actually has a chance to seep through. The rest of the vegetation soaks it up straight away.

A29 SO YOU ARE SAYING THAT THE VEGETATION RESPONDS QUITE QUICKLY?
Yes.

A30 THE PUDDLE IS SLOWER? AGAIN, CAN YOU SEE ANY RELATIONSHIP BETWEEN THIS LINE FOR THE PUDDLE AND THE RAINFALL OVER THAT PERIOD, REPRESENTED IN THE BAR GRAPHS WHICH ... ?
The puddle evaporates rapidly. Then, if the heavy rain starts again, the water, the ground would be saturated so the water will just build up on it again.

A31 RIGHT, FINALLY TO DO THE LAST BIT, WE'VE GOT THE LINES FOR THE SOIL IN BROWN THERE (FIG A5), THE GROUNDWATER IS DEEPER DOWN IN THE PURPLE COLOUR - HOW DO THOSE LOOK?
Figure A5- EXAMPLE - Heavy rain in autumn, graph of rainfall and vegetation (green), puddle (orange), soil (blue) & ground (brown) store contents
Well this shows that, most of the water falling into the puddle goes into the ground is soaked up in the soil and the ground water, but much of the water is soaked up by the vegetation, is actually on the top of the soil.

A32 RIGHT, SO THE CHANGES IN THE VEGETATION AND PUDDLE WERE QUITE DRAMATIC WEREN'T THEY, IN TERMS OF THE AMOUNT OF WATER IN THOSE STORES, HOW DOES THAT COMPARE WITH THE SOIL SAY?
(No answer)

A33 IT'S A BIT DIFFICULT BECAUSE YOU HAVEN'T GOT A GRAPH PAPER BACKGROUND. THERE ARE SUPPOSED TO BE SOME SLIGHT INCREASES THERE IN THAT LINE THAT GOES ACROSS.
The soil moisture increasing as more of the water is soaked into the soil .... Just before, just after the heavy rain, as the rain eases off, the soil takes the chance to soak up all the water in the puddle or as much of it as it can. And as that water is soaked up the soil moisture increases.

A34 WHY DO YOU THINK THE GREEN (VEGETATION) AND THE ORANGE (PUDDLE) LINES THERE SO DRAMATICALLY INCREASE, WHEREAS THE SOIL ONLY CHANGES A SMALL AMOUNT?
The store doesn't take up most of the water, moisture most of it's taken up by evaporation.

A35 RIGHT, OKAY. WELL THAT'S ENOUGH LOOKING AT THOSE GRAPHS, IF WE CAN GO ON TO SOME SLIGHTLY DIFFERENT QUESTIONS NOW. IF WE LOOK AT THESE, THIS IS ANOTHER EXAMPLE YOU MAY HAVE LOOKED AT. THAT'S A STORM IN SPRING, IT'S ONE PARTICULAR OPTION CALLED DEMO, WHICH I THINK YOU MAY HAVE LOOKED AT. THIS SHOWS THE SITUATION
Figure A6 Screen image: DEMO - Storm in spring at time 0.00 hours

A36 WOULD YOU DISCUSS THE REASONS FOR THINGS HAPPENING?
Yes.

A37 DO YOU SEE THESE ARROW KEYS HERE AS BEING PARTICULAR POSITIONS RELATIVE TO THE STORES OR (YOU) ALMOST REGARDED THEM AS RANDOM?
I just regarded them as they were coming off the boxes.

A38 IF YOU TAKE THIS EXAMPLE HERE, THE PUDDLE ITSELF, IN THIS CASE (FIG. A7) AFTER 54 MINUTES OF RAIN WE GOT THIS FLOW HERE WHEREAS AT THE END OF TWO HOURS THERE ISN'T A FLOW THERE (A8)- WHY THE

DIFFERENCE BECAUSE THERE IS STILL SOME WATER IN THE STARE HERE IN THIS CASE?

Figure A7 Screen image: DEMO - Storm in spring at time 0.54 hours. Figure A8 Screen image: DEMO - Storm in spring at time 2.00 hours

Depends what actual soil it is that the puddle is actually situated upon. Whether it's limestone that it could seep through or it is clay, there is the chance might stay there, and or seep through at all.

A39 IN FACT, WHEN WE WERE DESIGNING THIS PROGRAM WE THOUGHT WE WOULD MAKE THESE FLOWS COME OUT OF THE STORES AT A PARTICULAR HEIGHT, SO IF THE WATER LEVEL WAS ABOVE THE HEIGHT THEN THE FLOW WOULD START OUT OF THE LITTLE HOLE IN THE SIDE OF THE STORE. ANOTHER IDEA WE WANTED TO GET OVER BUT WE DIDN'T EXPLAIN IT ANYWHERE OR POINT IT OUT, AND I THINK IT'S VERY EASY TO NOT NOTICE IT. THIS IS THE SORT OF THING WE ARE TRYING TO LEARN ABOUT HOW TO IMPROVE THE PROGRAMS. SO THAT'S WHY IT IS VERY USEFUL TO GET PEOPLES' REACTIONS. SUPPOSING YOU COULD TAKE THE MODEL FOR THIS PROGRAM AND PUT IT INTO THE MODELLING SYSTEM YOU WERE USING THIS MORNING, SO YOU COULD BUILD YOUR OWN MODELS OR ADD TO THEM, DO YOU THINK THAT WOULD BE INTERESTING OR USEFUL?

It would be useful to see according to which conditions which state the weather was like, use to see what, how much evapotranspiration occurs, what precipitation, rainfall falls and how much soil actually soaks up.

A40 DID YOU FIND THIS PROGRAM INFLEXIBLE? WERE THERE THINGS THAT YOU WANTED TO DO, THAT YOU COULDN'T DO WITH THE PROGRAM?

No, I found that the things you needed to change you can alter, change.

A41 USING THIS PROGRAM NOW IT'S FAIRLY SIMPLE WOULDN'T IT, COMPARED WITH WHAT YOU HAVE DONE SINCE. SO IF YOU WANT TO TAKE A MORE COMPLICATED DIAGRAM HERE, FOR EXAMPLE THIS REPRESENTS AN AREA OF GRASSLAND OVER CLAY. SUPPOSING WE WANTED TO CONSIDER SAY THE SITUATION OF A WOODLAND, HOW WOULD YOU HAVE TO MAKE THIS DIAGRAM MORE SOPHISTICATED?

Woodland's going to be more vegetation, so, and there wouldn't necessarily be a lot of evapotranspiration, because no sunlight's getting through, even though it might be humid.

A42 DO YOU THINK TREES WOULD TRANSPIRE QUITE A LOT THROUGH ALL THOSE LEAVES?
Yes, and there's the trees and all the grasses, they are going to take up a lot of the soil moisture through the roots.

A43 YES RIGHT FINALLY, IF WE CAN COME TO THE BOOKLET HERE WITH THE STUDENTS' LEAFLETS - IT SHOWS THE SITUATION THAT 'PUDDLE' MODELS AND IT REPRESENTS A COLUMN OF SOIL AT THE CREST OF A SLOPE. SUPPOSING WE HAD ANOTHER MODEL FOR A COLUMN OF SOIL LIKE THIS, BUT FURTHER DOWN THE SLOPE, HOW DO YOU THINK THE MODEL WOULD HAVE TO BE DIFFERENT TO REFLECT THAT POSITION DOWN THE SLOPE?
Figure A9 Students' leaflet A
You would have to have different forms of rocks in it.

A44 MAYBE YOU WOULD HAVE CHALK AT THE TOP AND ANOTHER ROCK AT THE BOTTOM?
Limestone, the gradient of the slope will affect it, next, the height above sea level as well.

A46 ALRIGHT, THIS SYSTEM HERE IS DEALING WITH WATER SUPPOSING WE HAD A SITUATION WHERE WE WERE LOOKING AT WINTER TIME - CHRISTMAS TIME SAY - AND YOU HAVE GOT SNOW. HOW WOULD THAT COMPLICATE A MODEL LIKE THIS?
Snow is to be measured in a different way. With rainfall it's measured in millimetres just as it falls in like a jar or something. To measure millimetres of snow, you have to melt it down first.

A47 SO YOU WOULD HAVE TO THINK IN TERMS OF THE WATER THAT'S EQUIVALENT TO SNOW. HOW WOULD YOU THINK THE SYSTEM WOULD BEHAVE IF THE PRECIPITATION WAS SNOW?
The process would be a lot slower.

A48 SO WHAT WOULD HAPPEN IN FACT? WHICH FLOWS WOULD STOP OR SLOW DOWN? IT YOU CAN IMAGINE SNOW FALLING DOWN RATHER THAN RAIN?
Saturation of the soil would be slowed down.

A49 WHERE WOULD THE SNOW GO OR WHERE WOULD IT BE KEPT?
Any hollows.

A50 RIGHT, IF YOU CAN IMAGINE ANY SNOW COMING IN AT THE TOP OF THE DIAGRAM HERE, WOULD SNOW GO INTO THE SAME TWO PLACES AS THE RAIN?
No, more of it would go into the, well, where the puddle is rather than the vegetation.

A51 AND THEN IT WOULD JUST ACCUMULATE ON THE SURFACE? THEN WHAT WOULD HAPPEN WHEN IT MELTED, MAY BE FAIRLY QUICKLY?
Well, then it would be... (?) and it would go into the ground, where it then.... (noise).

A52 RIGHT, FINALLY WE ARE CHANGING THE CONTEXT QUITE A LOT. SUPPOSING YOU WERE LOOKING AT SOME ASPECT OF ECONOMIC GEOGRAPHY, ALRIGHT SOMETHING COMPLETELY DIFFERENT. CAN YOU IMAGINE A SITUATION THERE, WHERE THIS SORT OF DIAGRAM OF MATERIALS CIRCULATING BETWEEN VARIOUS STORES, DO YOU THINK YOU COULD APPLY THE SAME SORT OF DIAGRAM OF MATERIALS CIRCULATING BETWEEN VARIOUS STORES, DO YOU THINK COULD APPLY THE SAME SORT OF APPROACH IN ECONOMIC GEOGRAPHY ?
Probably to marketing where you've got raw materials

A53 THE 'PUDDLE' EXAMPLE IS VERY SIMPLE, JUST WATER THAT'S MOVING AROUND AT EACH STAGE. IN YOUR MANUFACTURING MODEL THAT WOULDN'T BE QUITE SO SIMPLE WOULD IT?
No, there would have to be other factors involved, such as the cost over the distance.

A54 IF YOU HAD ENOUGH TIME, OR A BIG ENOUGH MICRO, YOU COULD IMAGINE BUILDING YOUR OWN MODEL COULD YOU OF AN ECONOMICS SYSTEM.
I'd be able to do smaller, just one product being taken from, I think we took it from a book. Just staying in one place where the location would be, then sorting out whether it would be high cost or low cost.

A55 I'M JUST WONDERING HAVE YOU, IF THERE ... , ARE THERE ANY OTHER AREAS MAYBE DIFFERENT AGAIN, WHERE YOU COULD USE THIS TYPE OF APPROACH?
Hmm!

A56 LEAVE THAT. JUST ONE FINAL QUESTION, READY? WE HAVE TALKED A LOT ABOUT MODELS TODAY, ON THAT PROGRAM THIS MORNING (DMS), AND HERE AS WELL. DO YOU THINK YOU HAVE A PRETTY CLEAR IDEA NOW WHAT IS MEANT BY A MODEL?
Yes. Roughly know what I am talking about. Once I've got, actually get the idea about what's actually being seen, what we are actually looking at. (Yes.) It's quite easy to sort out. '

A57 AT EASTER YOU HADN'T ACTUALLY USED ANY COMPUTERS IN GEOGRAPHY, HAD YOU? (NO.) IF SOMEONE ASKED YOU THEN WHAT A MODEL WAS, DO YOU THINK YOU WOULD HAVE HAD ANY IDEA?
No, something like an airfix model! I wouldn't have though of it as computers.

A58 DO YOU THINK THERE ARE ANY SIMILARITIES BETWEEN AN AIRFIX MODEL AND A COMPUTER MODEL?
Only that there is lots of bits and pieces to put together. And then you've just got to finish it up at the end.

A61 YOU WOULD BE QUITE CONFIDENT, IF YOU HAVE TO DO IT FAIRLY OFTEN YOU GET USED TO IT, AND IT WOULD BE QUITE EASY?
'Practice makes perfect'

A62 THAT'S ENCOURAGING, WE WILL STOP ON THAT NOTE. THANK YOU VERY MUCH.

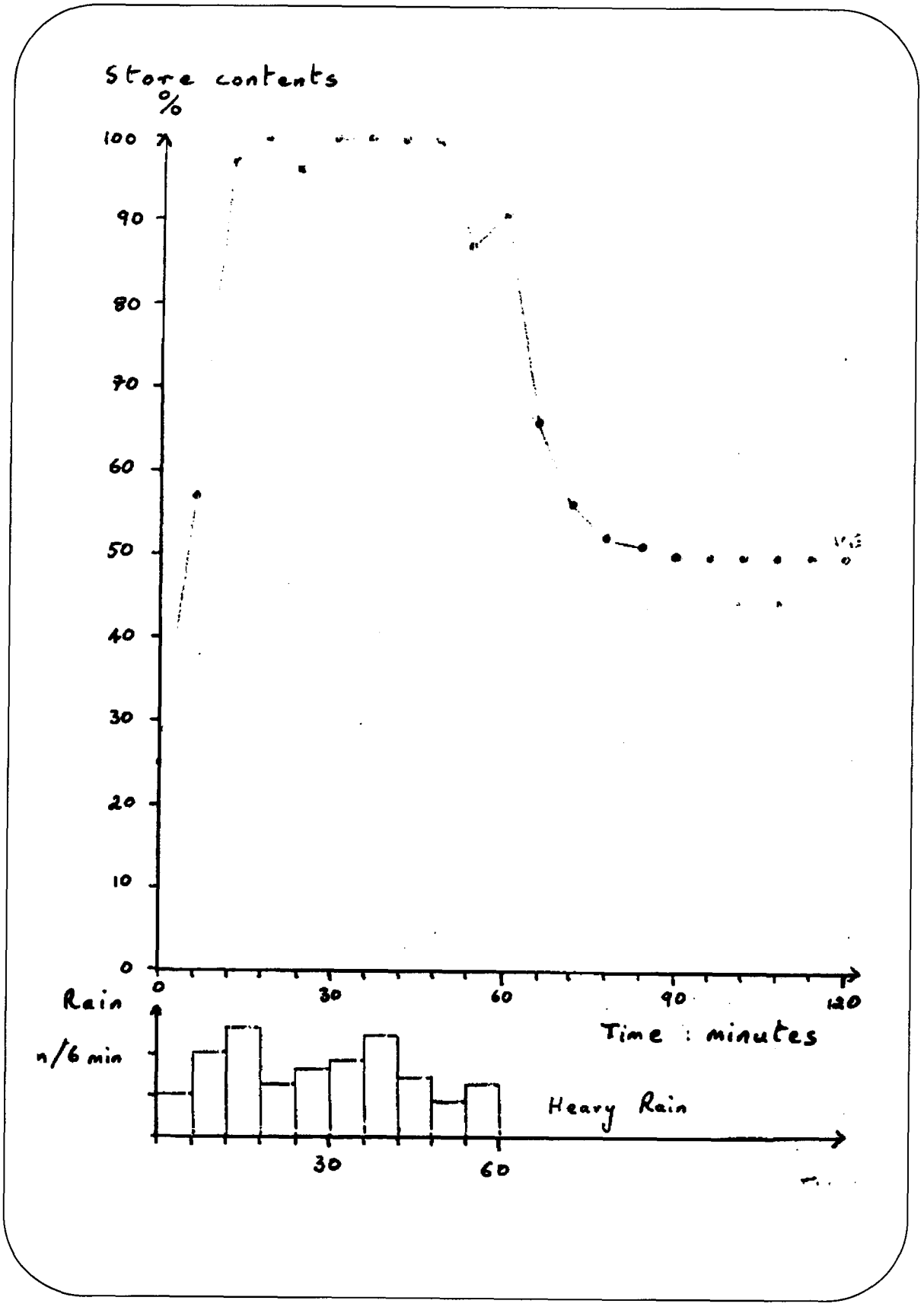

Store contents
%
100
90
80
70
60
50
40
30
20
10
0
0
30
60
90
120
Time : minutes
Rain
n/6 min
Heavy Rain
30
60

Figure A1

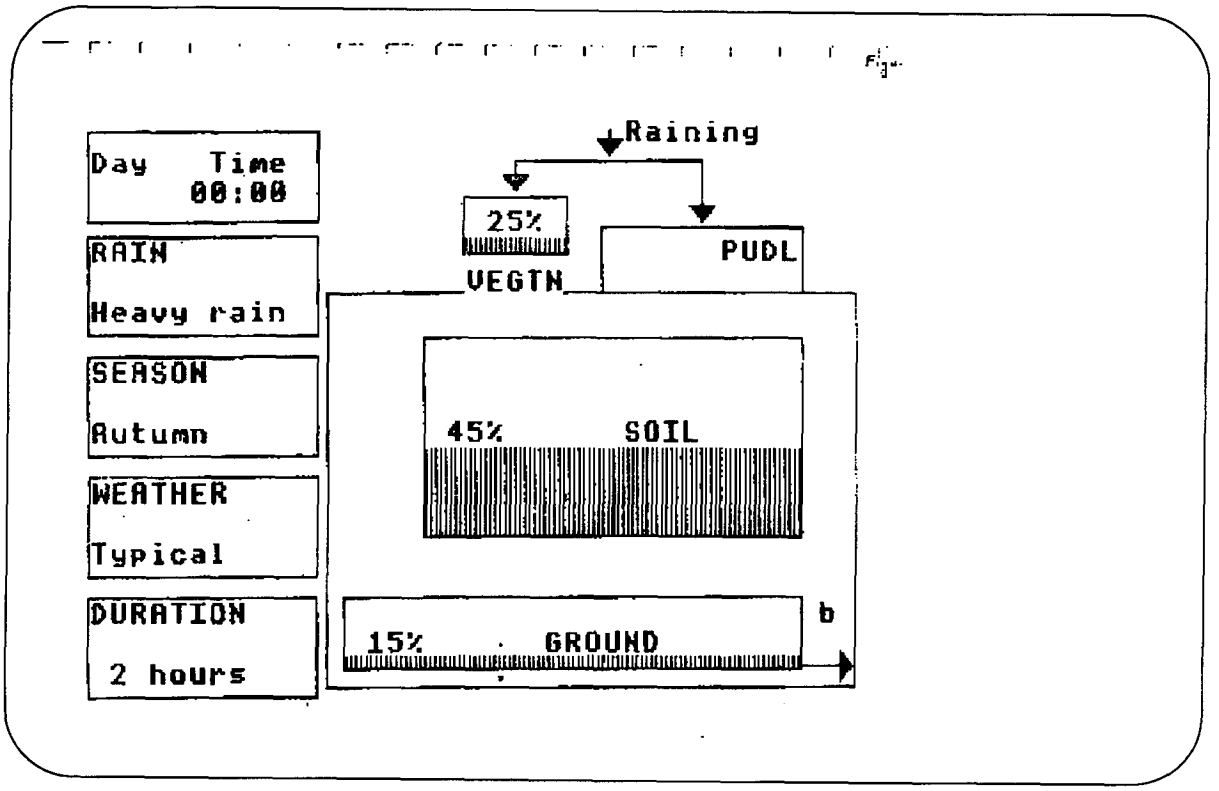


Figure A2

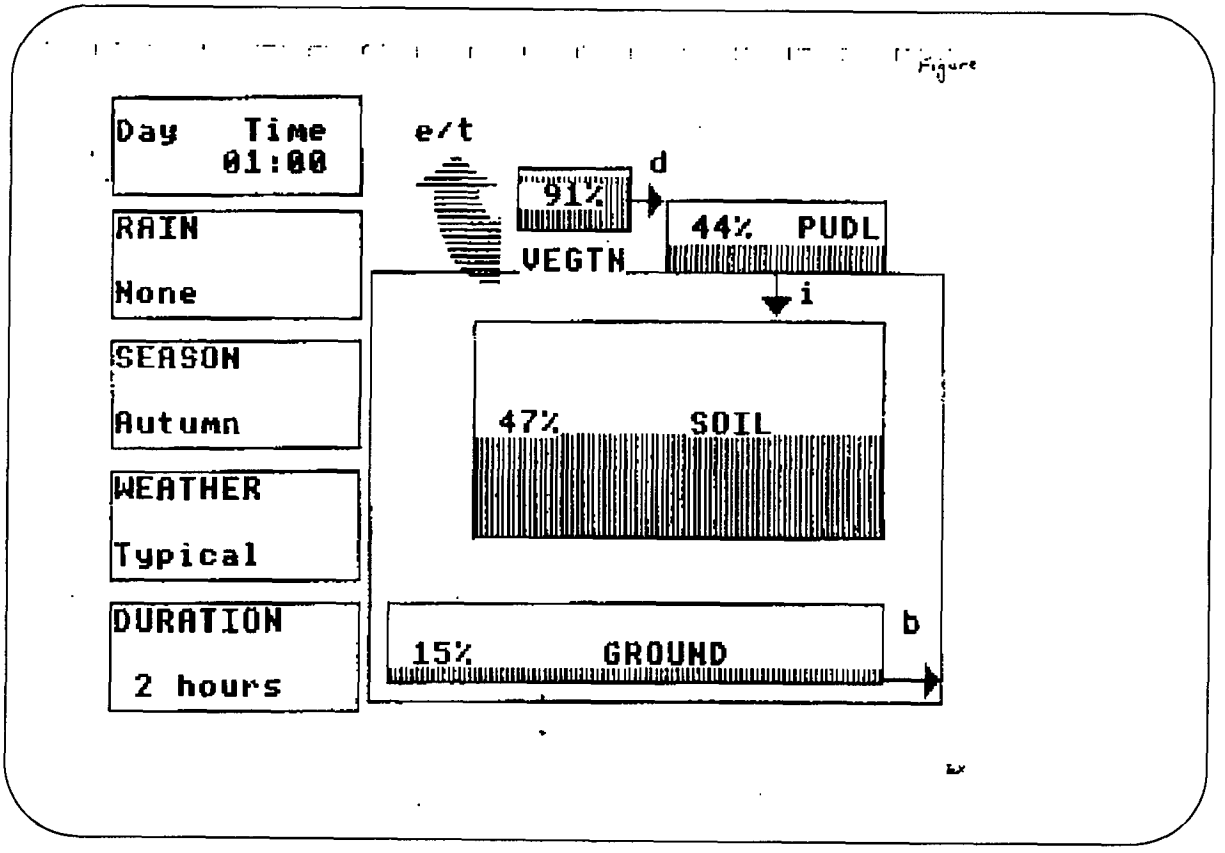


Figure A3

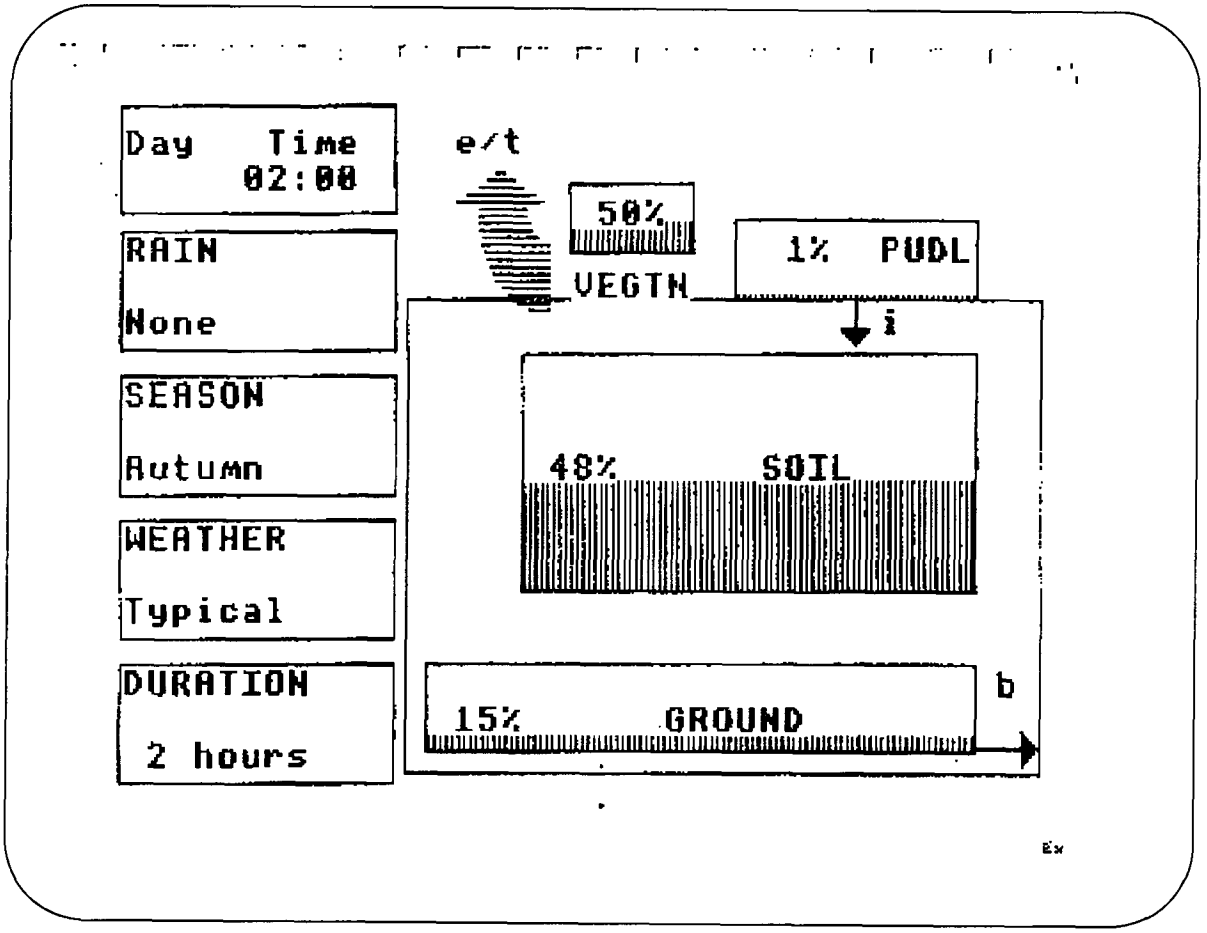

Day Time
02:00
RAIN
None
SEASON
Autumn
WEATHER
Typical
DURATION
2 hours
e/t
50%
VEGTN
1% PUDL
i
48% SOIL
15% GROUND
b

Figure A4

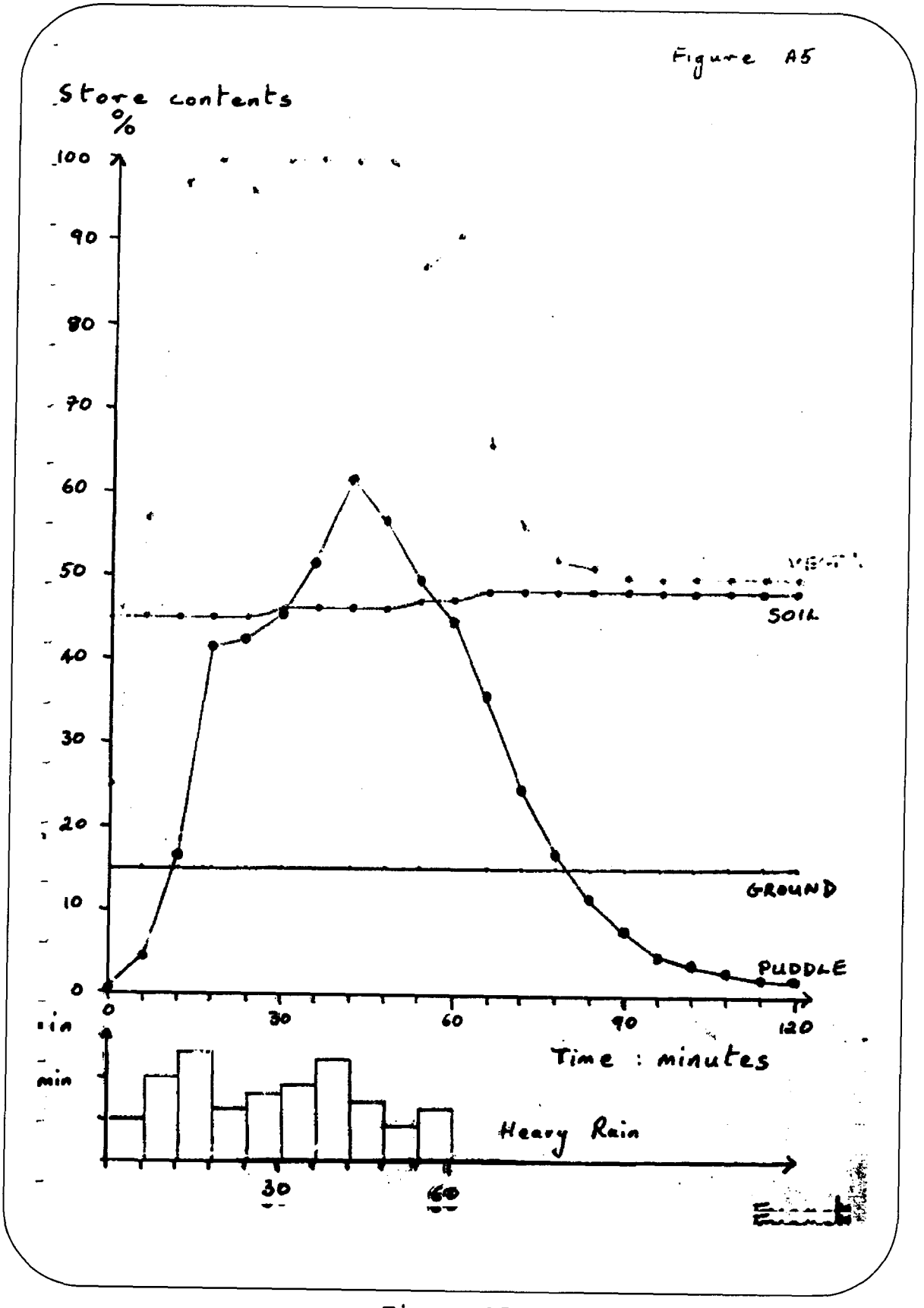


Figure A5
Store contents
%
100
90
80
70
60
50
40
30
20
10
0
SOIL
GROUND
PUDDLE
0
30
60
90
120
Time : minutes
min
Heavy Rain
30
60

Figure A5

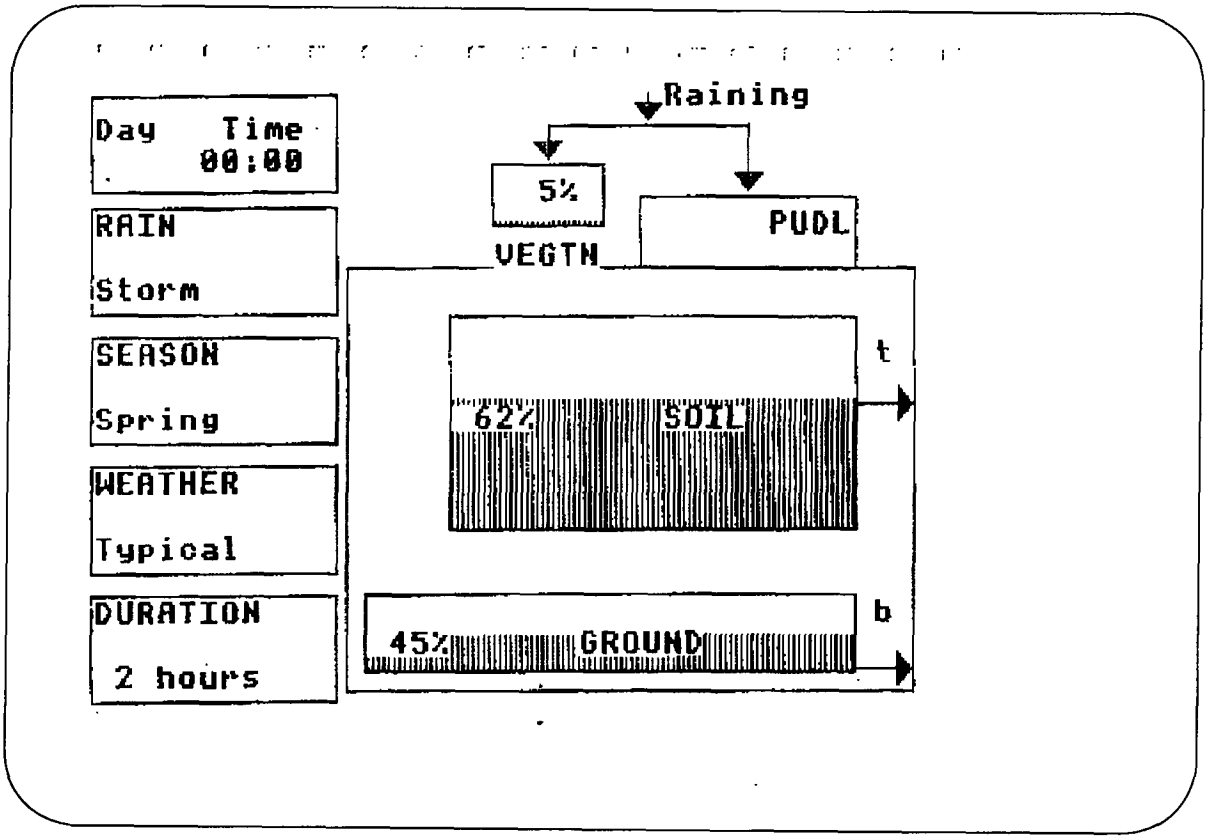


Figure A6

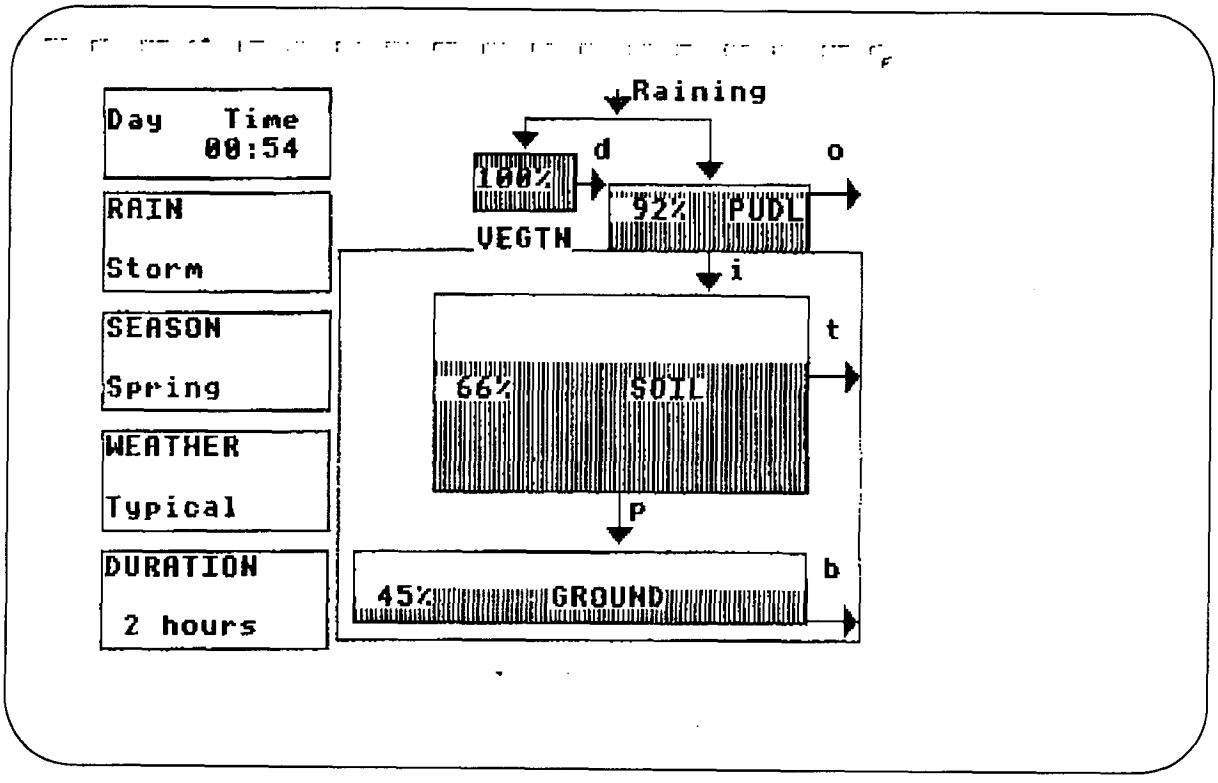


Figure A7

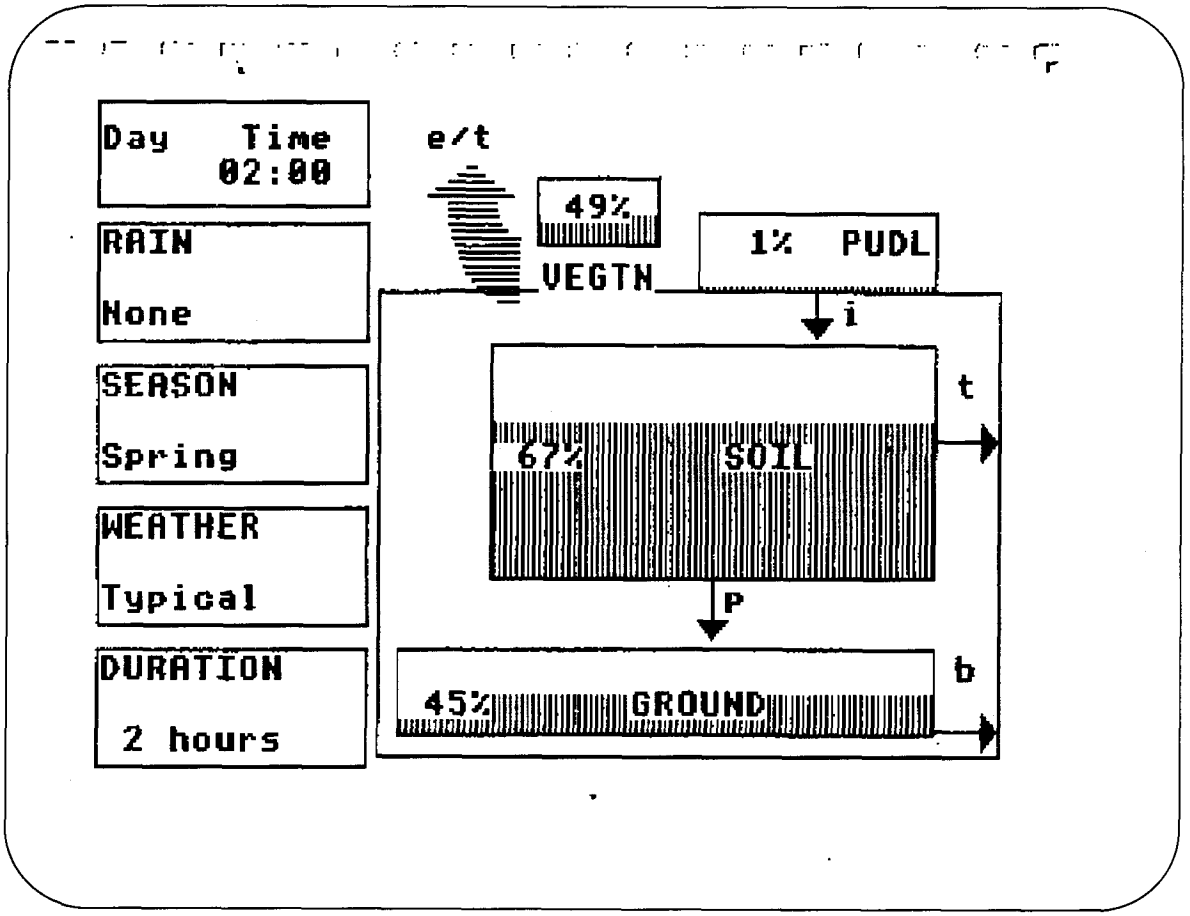

Day Time
02:00
RAIN
None
SEASON
Spring
WEATHER
Typical
DURATION
2 hours
e/t
49%
VEGTN
1% PUDL
i
t
67% SOIL
P
b
45% GROUND

Figure A8

Students' leaflet A
Water on the land

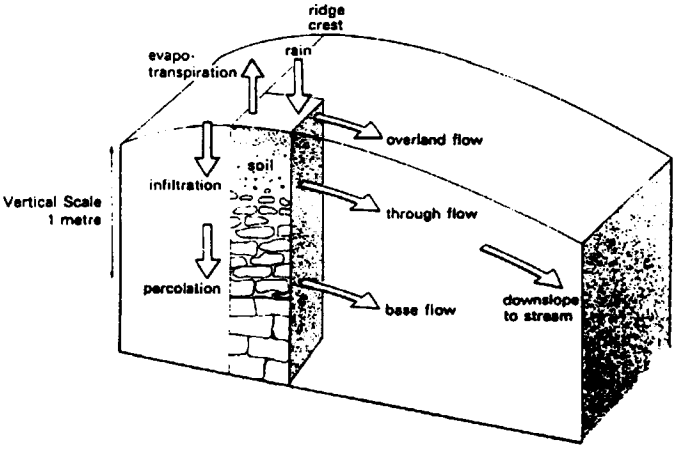
Introduction

After rain or snow falls on the ground, water follows several different paths. Some evaporates into the air, some soaks into the soil and some may run downhill over the surface.

Figure A1 shows these flows on a small area of land. As it is at the top of a slope, no water can drain into it from higher ground.

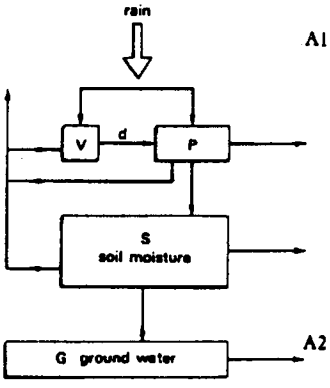
Trees, crops and plants also affect the flow of water. Rain or snow may be trapped on the surfaces of plants and some water may never reach the ground. Plants also take water out of the ground and lose it to the air by transpiration.

Figure A1
Water movement on an area of land at the top of a slope.



The flow diagram

Figure A2
The flow diagram.



The movement of water shown in Figure A1 can also be shown in a flow diagram – see Figure A2. The 'boxes' are stores where the water is held for a while between the flows.

A1 Put the missing labels on the diagram using the key below.

Key

Stores		*Flows*	
V	Vegetation – also known as store	d	Drips – throughfall – & stemflow
P	Puddles – also known as the surface depression/detention store	i	Infiltration
		p	Percolation
		o	Overland flow – surface runoff
S	Soil moisture store	t	Through flow
G	Ground water store	b	Base flow
		e/t	Evapo-transpiration

A2 Draw a new flow diagram to show the flows and stores near the bottom of a slope. (Hint – there should be several extra flows.)

Figure A9

PUDDLE Interview: Martin

MA1 RIGHT, SO MARTIN, WHEN DID YOU USE 'PUDDLE'?
Oh, a couple of months ago.

MA2· THAT WAS BEFORE EASTER?
Yes.

MA3. YES, HOW LONG DID YOU SPEND WORKING WITH IT?
Three or four lessons.

MA4. THREE OR FOUR LESSONS, THAT'S WHAT, HOW MANY HOURS?
About four hours.

MA5· FOUR HOURS, QUITE A LOT OF TIME, HOW DID YOU GO, HOW DID YOU SET ABOUT IT?
What, how you actually did the program?

MA6. OR WHAT DID YOU DO AS AN INTRODUCTION TO THE PROGRAM?
We had, we didn't do much as an introduction to the program, we did a little bit on rainfall and things like temperature and stuff like that. But we actually got, the program was what actually taught us everything about it.

MA7. RIGHT THEN, WHEN YOU GOT TO USING THE PROGRAM, HOW DID YOU START?
Mr. Goble explained it all for us, we hadn't had any computer programs before that. And I can remember that we just ran it a few times and then he told us to change some variables and see what the differences were and then account for the differences.

MA8 DID YOU NOTE DOWN ANY OF THE FINDINGS?
I think I did, yes.

MA9 RIGHT, WHAT DID YOU THINK OF IT - IT'S VERY STRANGE USING A COMPUTER FOR THE FIRST TIME?
It was quite good at first, then had some limitations, the time limitation. I can't remember exactly what it was, but you could extend the amount of evaporation, but couldn't extend the amount of

rainfall. I think that was the problem. It was all on loss of water rather than the gain of water. (Right.) That's about it I think.

MA10 WHAT ELSE DO YOU REMEMBER FROM THE EXERCISE? WHAT DO YOU THINK OF IT IN RETROSPECT?
I remember that you changed certain values of soil, it became moister a lot more, same for the amount of heat as well. I can't remember exactly, I just remember the boxes and that's it.

MA11 YOU REMEMBER THE PICTURE ON THE SCREEN MORE THAN THOSE?
Yes.

MA12 DO YOU COME ACROSS SIMILAR PICTURES IN TEXTBOOKS?
Yes, very similar, one of them in a book at home has got exactly the same thing, with little pie graphs instead of boxes.

MA13 HOW DO YOU THINK THE COMPUTER PROGRAM COMPARES WITH THE BOOK AT HOME?
I don't think it was easier to understand. I didn't take that much notice of the teacher then, it was alright after a time, the same as the other programs.

MA14 SO YOU FOUND THE BOOK EASIER TO UNDERSTAND?
Yes, in 'Puddle' yes.

MA15 WHAT MAKES THE COMPUTER PROGRAM MORE DIFFICULT?
I think it was, when you wanted to change everything, you had two columns of figures and I got mixed up between the figures and the variables - they all sounded a bit the same to me. Whereas in the book it was in the normal written paragraph, it was easier to understand.

MA16 YES, SO THERE WAS MORE EXPLANATION? (YES.) DO YOU THINK THERE ARE THINGS YOU COULD LEARN FROM THE PROGRAM THAT YOU COULDN'T LEARN FROM THE BOOK?
Yes, when we actually ran the program the speed of the changing water was easier to understand than imagining it in the book, you actually saw the water levels and percentage dropping and rising, that was easier to understand.

MA17 DID IT BEHAVE IN A WAY THAT YOU WOULD EXPECT, OR DID IT SURPRISE YOU?
It surprised me in some things, the evaporation was very quick, much quicker than I thought it would be, and when it had a heavy storm it sometimes took a long time for the water to soak into subsoil - which surprised me.

MA18 DOES THAT SORT OF TIE UP WITH WHAT YOU HAVE SEEN IN YOUR GARDEN AT HOME OR ELSEWHERE?
Yes it does, a long amount of rain and the ground is very spongy, even after a sudden shower it's not at all wet in a few hours. It's probably correct.

MA19 YES, DO YOU KNOW WHAT I MEAN BY OVERLAND FLOW?
I think it means when it's too much water in the ground, and the ground is too hard and won't soak up the water and it just stays on the surface like a flooded football pitch.

MA20 WHAT WOULD YOU SAY IF YOU HAD A STORM, AND CAN YOU REMEMBER IF THERE WAS ANY WATER FLOWING OVER THE SURFACE OF THE GROUND?
Yes, there was some, yes there was, I didn't read the change, the evaporation was changed by the seasons, the soil didn't change, so it happened every time there was a storm.

MA21 RIGHT, WELL THAT'S QUITE GOOD THAT YOU REMEMBER THAT MUCH.
Yes, it's all coming back to me.

MA22 DO YOU THINK YOU WOULD HAVE REMEMBERED AS MUCH IF YOU'D JUST BEEN USING A BOOK ON ITS OWN?
No, I cannot remember what it said in the paragraphs, it was just after I did the computer program.

MA23 DO YOU THINK YOU'LL REMEMBER IT A YEAR FROM NOW WHEN YOU DO YOUR FINAL EXAMINATIONS?
Without reading anything, I wouldn't remember a lot, but if I was writing it down in an exam it would come back to me, it always does.
MA24 YES, THAT'S GOOD!

Or bits of it.

MA25 I THINK NOW TO MAKE LIFE EASIER, AND TO JOG YOUR MEMORY AS WELL, I HAVE GOT SOME PHOTOGRAPHS OR IMAGES OF WHAT THE SCREEN SHOWED. SAY FOR EXAMPLE, THERE WAS ONE FACILITY THERE FOR RUNNING THROUGH AN EXAMPLE WHICH WAS SET ALREADY AND IT STARTED OFF WITH A PICTURE LIKE THIS, (FIGURE MR1)- WHAT I WOULD LIKE YOU TO THINK ABOUT IS: SUPPOSING NEXT YEAR YOU WERE ASKED TO TEACH A LOWER SIXTH GROUP AND MR. GOBLE WAS PERHAPS BUSY SOMEWHERE ELSE, AND YOU WERE ASKED TO DO THE CLASS OR TO HELP THE STUDENTS USE THIS PROGRAM. HOW DO YOU THINK YOU WOULD GO ABOUT IT?

Figure MRI Screen image: EXAMPLE - Heavy rain in autumn at time 0.00 hours

With the program?

MA26 WITH THE PROGRAM, YES.

I think I would have to explain it a bit, quite a bit, beforehand, not just tell them to change this and change that. They wouldn't really understand it. I'd explain the differences between the type of rain, and the weather and season.

MA27 I HAVE GOT ANOTHER ONE FROM, AFTER ONE HOUR FIGURE MR2 AND ANOTHER ONE AFTER TWO HOURS (FIGURE MR3)- SO YOU'VE GOT A SEQUENCE THERE OF SCREENS.

There was another screen where there was a list of things you could change. I would need to explain that, because I never understood that until the last lesson, until Manesh explained it to me. It shouldn't be too hard actually. You, the difference between soil and ground you must explain as well, I didn't know the difference between that. I think on the whole there would be quite a lot of explaining beforehand, before you let them have the program.

MA28 WHEN YOU FIRST SAW THE SORT OF BOX DIAGRAM IN THE TEXTBOOK, WAS IT FAIRLY CLEAR TO YOU WHAT IT MEANT, OR WHAT IT REPRESENTED?

No. The same as I got mixed up between soil and ground. I thought it was the same thing, so I thought what's it going into the ground for, if it's already there? But it was a bit easier to look at, the boxes were easier to look at in the pie charts.

MA29 YES SO, SUPPOSING YOUR LOWER SIXTH STUDENTS SAID WE CAN'T QUITE UNDERSTAND THIS DIAGRAM, WHAT DOES THIS BOX HERE REPRESENT, (VEGETATION STORE) HOW DO YOU THINK YOU WOULD EXPLAIN IT TO THEM?
Well, I'd explain it in terms of a jungle or something, saying the vegetation, you've got all the trees; puddle is a pool on the ground. I think they'd understand it, if I went round like that.

MA30 DO YOU THINK IT'S HELPFUL TO REPRESENT THESE THINGS AS BOXES LIKE THIS WITH WATER LEVELS GOING UP AND DOWN?
Yes, it looks like water which is handy, pie charts just looked like sections; they don't, they are not look good.

MA31 DO YOU THINK IT COULD BE MISLEADING FOR US TO SUBSTITUTE THIS?
Yes, I think it could be. Sometimes, I think it's the soil will shoot up. No it's the puddle that shoots up automatically and they may think well it won't be that quick. But I mean it's probably true. (Yes.) It's just a percentage of a puddle that's gone up so, but I think it would be quite easy to understand.

MA32 I WAS BIT WORRIED WHETHER SOME STUDENTS MIGHT THINK THERE WERE ACTUALLY BIG RECTANGULAR HOLES IN THE SOIL BELOW LIKE SOME TANK, AND THEY MIGHT THINK OF IT TOO LITERALLY. DO YOU THINK THAT'S A PROBLEM?
You could do, but I don't think so, not major problems.

MA33 YOU WOULD BE QUITE HAPPY TO THINK OF IT IN THOSE SORT OF TERMS?
You'd tell them it's percentage of the soil and not a box full of it, it should be alright.

MA34 HOW, WHAT IF WE HAD TO PRESENT THE SAME INFORMATION IN A WAY THAT WAS MORE SORT OF LIKE THE REAL SOIL, HOW DO YOU THINK IT COULD BE SHOWN?
You could try and have a lot of labels like bushes and to try and make it sort of like a forest or back garden, to make it easier to understand.

MA35 CAN YOU MAKE THE DIAGRAM MORE PICTORIAL PERHAPS, CAN YOU THINK OF WAYS OF MAKING IT MORE REALISTIC?

No not really, the arrows going to the boxes, the boxes are different sizes which is probably right, so I think it's alright.

MA36 IF WE PERHAPS GO ON FROM THIS FIRST ONE (MR1) TO ONE HOUR LATER AND THIS WAS REMEMBER SHOWING RAIN, HEAVY RAIN IN THE AUTUMN (MR2), AND WE RUNNING TWO HOURS, AT THE END OF THE FIRST HOUR THE RAIN HAS STOPPED AND THE SUN HAS COME OUT OR WHATEVER. HOW WOULD YOU COMPARE THESE TWO DIAGRAMS?

Figure MR2 Screen image: EXAMPLE - Heavy rain in autumn at time 01-00 hours

Well obviously things have got soaked on the vegetation and the puddle because it's an hour long rain isn't it? (Yes.) The soil has begun to fill up with water, the ground hasn't really been affected by, it's not very heavy rain, well it was heavy rain, I think you'd need a bit longer for the ground to be affected, you need, as soon as evaporation starts the vegetation will start dropping dramatically, and the puddle will start dropping, and the soil gradually because it has not been exposed to the heat so much.

MA37 SO THE WAY THESE DIFFERENT PARTS RESPOND IN TIME VARIES?

The nearer the sun the nearer the heat I suppose explains that.

MA38 SOME PEOPLE MIGHT FIND THIS DIAGRAM RATHER STRANGE IN TERMS OF THE ARROWS WHICH ARE SHOWN ON IT, WHEREAS IN YOUR TEXTBOOK EXAMPLE THERE ARE PROBABLY A LOT MORE ARROWS SHOWN?

Yes, there are not that many arrows.

MA39 WHY DO YOU THINK THERE ARE FEWER ARROWS?

Why? Because the vegetation is bound to get full up and so the water level in the vegetation will drop off, the same with the puddle, the puddle will overflow what, if you get too much water in it and it will start sinking into the soil. That's the overflow is it (Pointing at 'b' on Figure MR2). I forget all these.

MA40 NO, THAT WAS THE BASEFLOW!

The baseflow, I got mixed up in the overland flow and the baseflow, I could never understand that.

MA41 WHY DO YOU THINK THERE IS NO ARROW BETWEEN SAY THE SOIL STORE AND GROUNDWATER STORE UNDERNEATH?
I don't know, it is not full up is it? Oh no, I can't agree with that, I thought there was an arrow.

MA42 MAYBE WE'LL COME BACK TO THAT LATER. BUT IN YOUR TEXT BOOK THEY SHOW ALL THE ARROWS SHOWING ALL THE FLOWS.
It's all connected up.

MA43 YES, RIGHT IF WE GO FROM HERE ONTO THE LAST ONE OF THIS SET. AFTER TWO HOURS HOW DOES THAT THEN COMPARE WITH THE ONE BEFORE?
Figure MR3 Screen image: EXAMPLE - Heavy rain in the autumn at time 2.00 hours
It's an hour longer for evaporation, so vegetation has lost half its water and the puddle has almost gone dry, probably a slight exaggeration, I don't think you'd take an hour for the puddle to dry up. Oh yes, the puddle also in time has let water into the soil, soaked into the soil and the soil has gained water instead of losing it unlike vegetation and the puddle.

MA44 SO THAT'S QUITE INTERESTING, ALTHOUGH IT WASN'T RAINING THE ACTUAL WATER IN THE SOIL WAS GOING UP. AGAIN IS THAT SURPRISING AT FIRST?
Yes.

MA45 DO YOU THINK IT REASONABLE NOW?
Well, if there is a puddle there then it is reasonable, it's going to be covered up by the puddle and both the evaporation and the transpiration isn't it? into the soil.... take water out of the puddle. So, but, I mean after 3 or 4 hours and the puddle is completely dry, the soil will start up drying as well.

MA46 IF WE LOOK AT THE VEGETATION STORE HERE, IT IS STILL HALF FULL OF WATER, BUT THERE IS NO DRIPS OR STEMFLOW COMING OUT OF IT. WHY DO YOU THINK THAT IS?
Probably the plants need the water or they have absorbed it, unlike the puddle which moves on a bit, the vegetation will keep a lot of it which it needs.

MA47 THIS SITUATION IN FACT IS SUPPOSED TO MODEL SOME GRASSLAND IN THE ENGLISH MIDLANDS, ON A CLAY SOIL SO THAT IF WE THINK OF VEGETATION AS A FIELD OF GRASS. WHAT DO YOU THINK IT WILL BE LIKE IN SUCH A FIELD AN HOUR AFTER THE RAIN STOPPED IN THE AUTUMN?
In comparison with this, there would be less water in the vegetation, not so dense, it's very near the soil. The puddle would be about the same. In the autumn it wouldn't be very hot so there wouldn't be that much evaporation, the soil would keep a lot of water as well.

MA48 IF WE GO BACK TO THIS VEGETATION, IF THERE IS WATER LEFT ON THE GRASS, HOW WOULD IT APPEAR?
Well it would be quite thick puddles I would imagine, really wouldn't take 50% of vegetation in water would mean it would be quite waterlogged- If you put your hand on the water it would probably just bubble up slightly.

MA49 THAT'S AN EXAMPLE LOOKING AT THE WATER, IF WE GO ONTO THE SCREEN NOW - I'VE GOT THIS OTHER ONE, WHERE WE LOOK AT A STORM IN THE SPRING. WE CAN COMPARE PERHAPS THE BEGINNING OF THE RAIN IN THE AUTUMN (MR1) WITH THE STORM IN THE SPRING (MR4)- THIS IS HOW THE TWO DIAGRAMS START OFF, AGAIN ARE THERE ANY INTERESTING COMPARISONS BETWEEN THEM?
Figure MR4 Screen image: DEMO - image of storm in spring at time 0.00 hours
The ground is far more waterlogged after the winter, the spring is quite soon after the winter and there is a lot more moisture in the soil.

MA50 ARE THERE ANY OTHER DIFFERENCES?
Vegetation has got less water on. I find that surprising, I'd have thought that if there is lots of water in the soil. It probably means that there hasn't been a lot of rainfall beforehand, but it follows the chance for the summer heat to get to it the soil stays soaked. The ground has got a lot of water in.

MA51 WHAT DO YOU MAKE OF THIS FLOW HERE, LABELLED 'T'
I can't tell you that one.

MA52 DO YOU KNOW WHAT THAT ONE WAS?
No I can't.

MA53 ANYWAY WE NEEDN'T BOTHER TOO MUCH ABOUT A TECHNICAL NAME FOR IT, WHAT DOES THAT FLOW REPRESENT, IN THE SPRING EXAMPLE?
Using too much water in the soil, it flows to the ground.

MA54 WHAT DOES THIS BOX HERE REPRESENT, THE BIG BOX? (POINTING AT OUTLINE ENCOMPASSING THE SOIL AND GROUND BELOW.)
I can't remember.

MA55 IT REPRESENTS THE SOIL OR GROUND THE WHOLE LAND.
Everything under the surface.

MA56 THIS IS BELOW THE SURFACE OF THE GROUND, BUT GOING THROUGH THE SOIL SO IT IS CALLED A THROUGHFLOW, WE GOT THE THROUGHFLOW IN THE SPRING EXAMPLE, BUT WE DID THE AUTUMN EXAMPLE AND IT WASN'T THERE. WHY DO YOU THINK THAT WAS?
In the autumn there didn't seem to be enough water in the soil for it to happen. It's been through the long haul of the three months of the summer and so it has gradually lost it through heat, it's gone out to the surface. But in spring it's still all there waiting to be taken out.

MA57 HOW WILL THIS THROUGHFLOW ACTUALLY OCCUR DO YOU THINK. IF YOU SORT OF DUG A HOLE IN THE GROUND, HOW WOULD THIS FLOW APPEAR?
It would gradually seep out and fill up the hole with water. If you were driving a car and it didn't look that wet and you started getting into holes, it would start filling up with water and it would get harder and harder to fill up.

MA58 HOW WOULD THE WATER ACTUALLY MOVE THROUGH THE SOIL, YOU SAY IT SEEPS THROUGH HOW WOULD THAT HAPPEN?
Is there a special word for it?

MA59 DON'T WORRY ABOUT SPECIAL WORDS.
I suppose there would be, we're taking clay aren't we?

MA60 IT'S SUPPOSED TO BE A CLAYEY SOIL.
It would just probably in sort of holes and pockets and stuff it would soak in to a point and once it gets saturated with water, it cannot go up so it would drop down into the ground. (Right.) I can't remember that really.

MA61 THAT'S GETTING INTO DETAILS OF SOIL SCIENCE REALLY, BUT THAT'S INTERESTING JUST TO GET AN IDEA. IT WE GO THROUGH ANYWAY THIS SPRING EXAMPLE, START OF AT TIME ZERO, AFTER 54 MINUTES WE GOT TO THE SITUATION WHERE WE HAVE HAD A STORM, WHAT HAPPENS IN THIS CASE (FIGURE MR5)?

Figure MR5 Screen image: DEMO - Storm in spring at time 0.54 hours

Both the puddle and the vegetation have built up very very quickly with water, vegetation has flowed into the puddle and the puddle has overflowed so you have got overland flow. Then there's also some water in the soil as well. It surprised me that the soil (was) only gained four percent yet already it's dropping into the ground. So it's a very slight difference, then on the other hand it will start leaking into the ground.

MA62 IF YOU LOOK AT THESE ARROWS THAT COME SIDEWAYS FROM THE BOXES, CAN YOU RELATE THEM TO THE WATER LEVEL IN THE BOXES?
It's usually about halfway isn't it, it's a fifty/fifty, that one's just under (soil?), that one's just over (ground?), but I can't remember what it's for though.

MA63 IF YOU LOOK AT THESE ARROWS, SAY HERE THE GROUNDWATER STORE, HOW HIGH UP THE SIDE OF THE BOX DO YOU THINK THE BASEFLOW IS?
It's half way up, oh it's very low isn't it, I didn't know that was in, you know scales like.

MA64 YES, THOSE ARROWS ARE IN FACT SCALES.
Yes, I saw that at the bottom.

MA65 SO WHAT DO YOU THINK THAT MEANS THEN IN PRACTICE?
The ground is not very porous, it can't take any water. If there's an amount in it, it will start to lose it when the soil is quite absorbent. (Yes, right.) When the ground is rock or something.

MA66 HOW DOES THAT THEN COMPARE WITH SAY THE PUDDLE ABOVE AND THE VEGETATION?
Um.

MA67 AGAIN, THINKING OF WHERE THE FLOW ARROW COMES OUT OF THE BOX, WHAT HEIGHT IN THE BOX?
The vegetation seems to be able to contain all of its water at fifty percent and then anything else it starts to lose it, it drips off the leaves. The puddle can be quite full up, it's probably quite understandable, before it starts flowing over land, any bit of water will start going into the soil because it's directly underneath.

MA68 THAT'S GOOD, THAT'S.... THE WAY UP.
I'm not sure about this. (Yes.) I thought any water there would have gone into there.
MA69 THIS IS WHAT QUITE A LOT OF PEOPLE HAVE SAID WHO HAVE LOOKED AT THIS PROGRAM. THE ANSWER IS THAT A LOT OF THE HOLES IN THE SOIL ARE VERY SMALL PORES, ROOT HOLES OR WHERE WORMS HAVE BEEN, AND GET SLOWLY CLOGGED UP WITH CLAY AGAIN SO THEY ARE VERY FINE HOLES AND WATER IS HELD BY CAPILLARY ATTRACTION. SO IT'S ONLY WATER IN THE LARGER HOLES WHICH DRAINS OUT UNDER GRAVITY, SO IT'S TO DO WITH THE SIZE AND DISTRIBUTION OF HOLES IN THE SOIL. FINER SOIL HOLES WILL FILL UP FIRST AND THEY WILL HOLD THE WATER. ANYWAY, ONE SLIGHT VARIATION NOW, I SPENT, DID SOME HOMEWORK THE OTHER DAY AND RECORDED THIS INFORMATION ABOUT THE STORE CONTENTS AND RECORDED IT ON A GRAPH. SO IF WE HAVE A GRAPH LIKE THIS, SAY WE HAVE A STORM AND FILL THAT UP LIKE THAT, THESE BARS REPRESENT THE RAINFALL AT INTERVALS THROUGH .... THEN SUPERIMPOSE THE CONTENTS OF THE GRASS STORE IF YOU LIKE. SO THIS SHOWS HOW THE STORE CONTENTS OF VEGETATION VARY OVER THAT SAME TWO HOURS WHICH WE HAVE JUST SEEN ON THAT EXAMPLE. (STORM) SO THAT WAS A STORM IN SPRING.
Figure MR6 DEMO - Graph of storm in spring showing rainfall and vegetation store contents
The grass contents shot right up to almost 100% almost immediately. It's held it I suppose if it lasts an hour it's held it while it's rained then when it's stopped raining it's dropped very quickly at first to about half way where it begins to contain it and soak into the vegetation, and the drops seem to level out.

MA70 IF WE NOW SUPERIMPOSE WHAT HAPPENS TO THE PUDDLE OVER THE SAME PERIOD OF TIME .... RIGHT, SO IF WE CONTINUE WITH A STORM IN SPRING, NOW WE'RE SUPERIMPOSING THE PUDDLE CONTENTS OVER THE SAME TIME SCALE AS THE VEGETATION- WHAT DO YOU NOTICE FROM THAT?

Figure MR7 demo - graph of storm in spring with rainfall, vegetation and puddle contents

Well it's very similar, it rises very very quickly, to capacity in what's that five minutes or so, five or ten minutes. It stays full up, a little bit less than the grass, probably because the grass rate's .... the overland flow is probably more dramatic I suppose. Maybe the soil soaks in more, more from the puddle than the puddle takes from the vegetation. Drips, vegetation drips into it not so much. It drops down very, very steeply, and it gets rid of all the water by the end of the two hours. Whereas the vegetation contains it.

MA71 YES, THERE'S QUITE A BIG DIFFERENCE THERE, ISN'T THERE?

Yes.

MA72 AND THEN IN FACT, I PUT THE FINAL ONE OF THE SERIES ON. THIS SHOWS THE CONTENTS OF THE SOIL WATER STORE AND THE GROUNDWATER STORE DEEPER DOWN. HOW DO THOSE TWO LINES RELATE TO THE OTHERS?

Figure MR8 DEMO - Graph of storm in spring with rainfall, vegetation, puddle soil and ground store contents

The ground, being a long way down, doesn't seem to be affected by an hour of rain, the soil has gained a lot of rain, but hasn't actually yet had enough to make it go to the ground. It's a slight climb but it won't lose it, for a bit because the puddle's still above it losing all its water. Probably be about four hours or so before the soil starts to lose it.

MA73 SO A TECHNICAL TERM FOR THAT WOULD BE 'TIME LAGS' WOULDN'T IT?

Yes.

MA74 YOU KNOW THE IDEA OF A 'LAG'?

Yes

MA75 THINGS ARE DELAYED.

The deeper down the more time lags.

MA76 RIGHT, DO YOU THINK IT WOULD HAVE BEEN USEFUL TO HAVE THIS SORT OF DISPLAY ON THE SCREEN?

Yes, there was a graph of some sort, I can't remember, but that would have been useful. It was quite easy to understand, as long as you see it with the boxes, otherwise you don't know what, where the water goes.

MA77 SO IT WOULD BE USEFUL TO HAVE THIS COMING UP AFTER YOU'VE SEEN?

Yes.

MA73 RIGHT, WELL THANK YOU VERY MUCH, QUITE A DETAILED SET OF QUESTIONS.

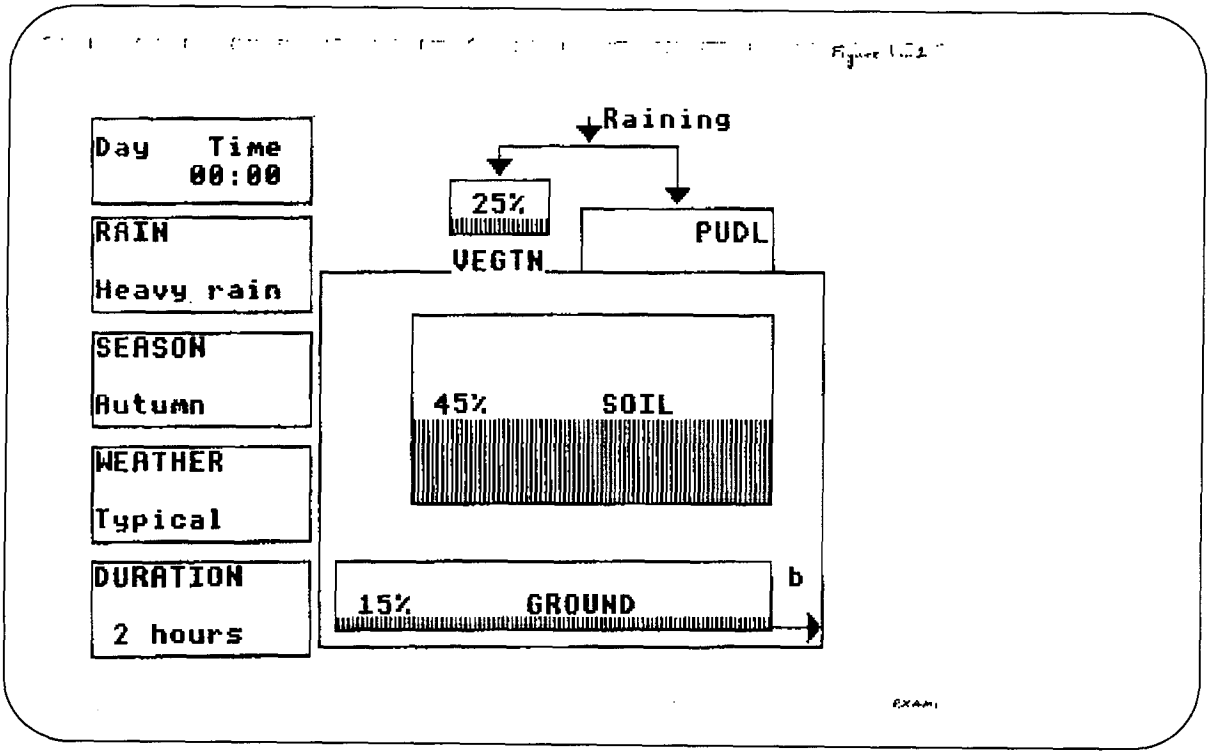
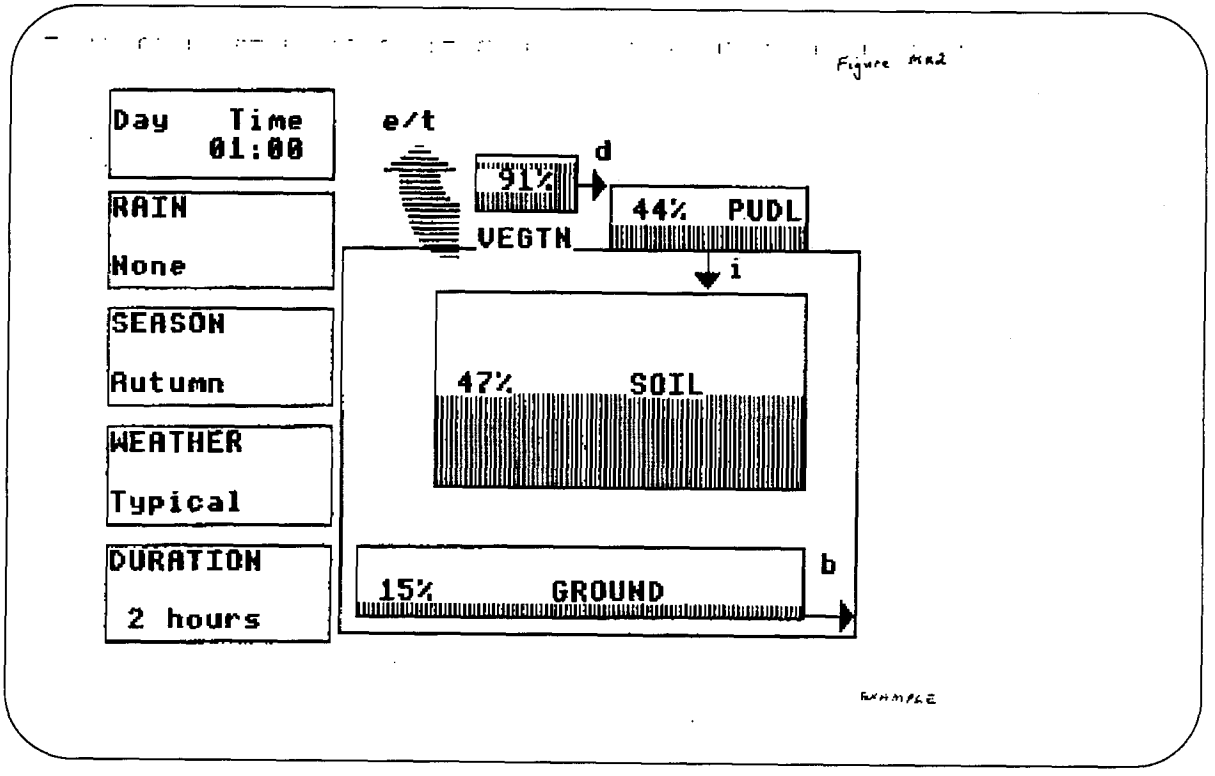


Figure MA1



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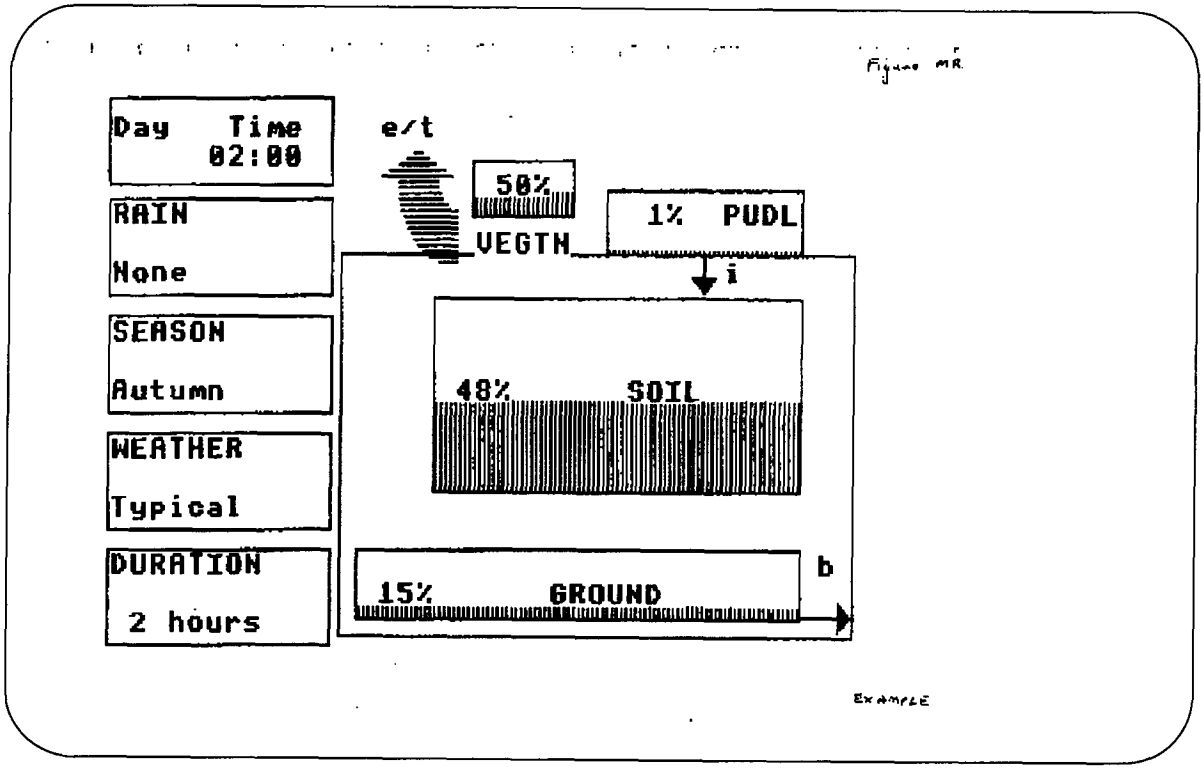

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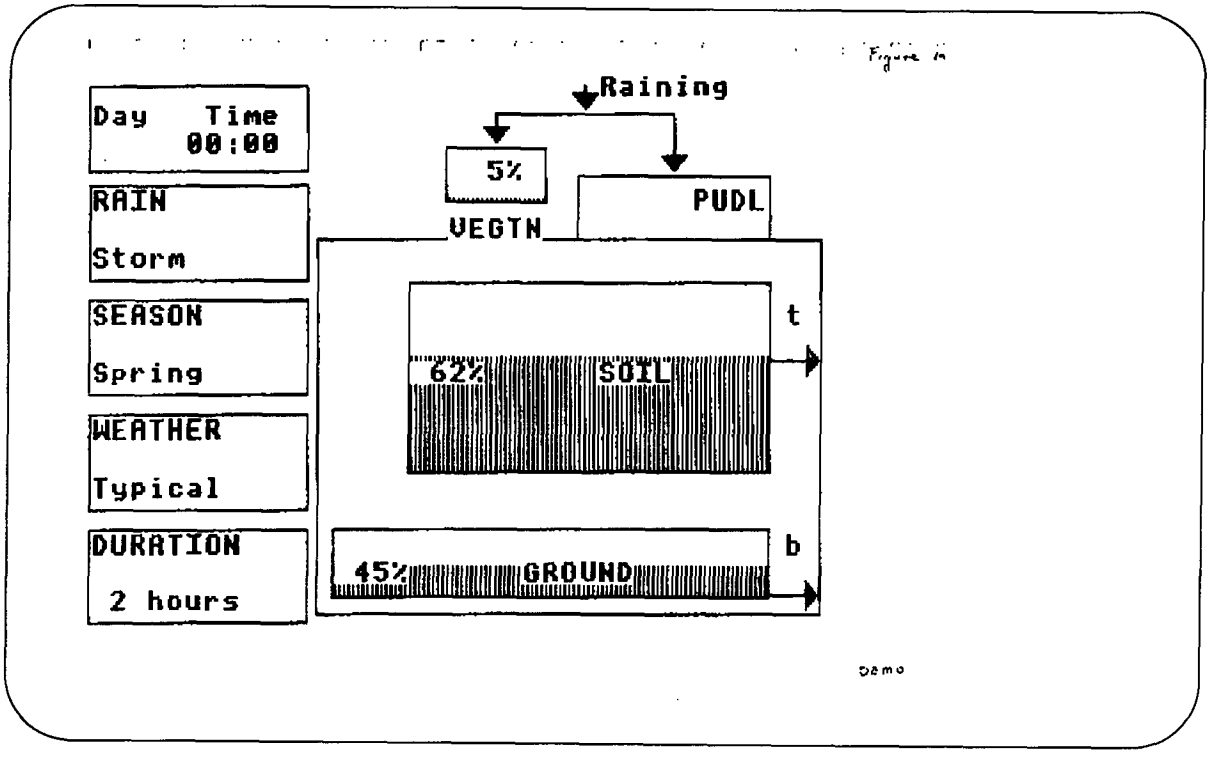

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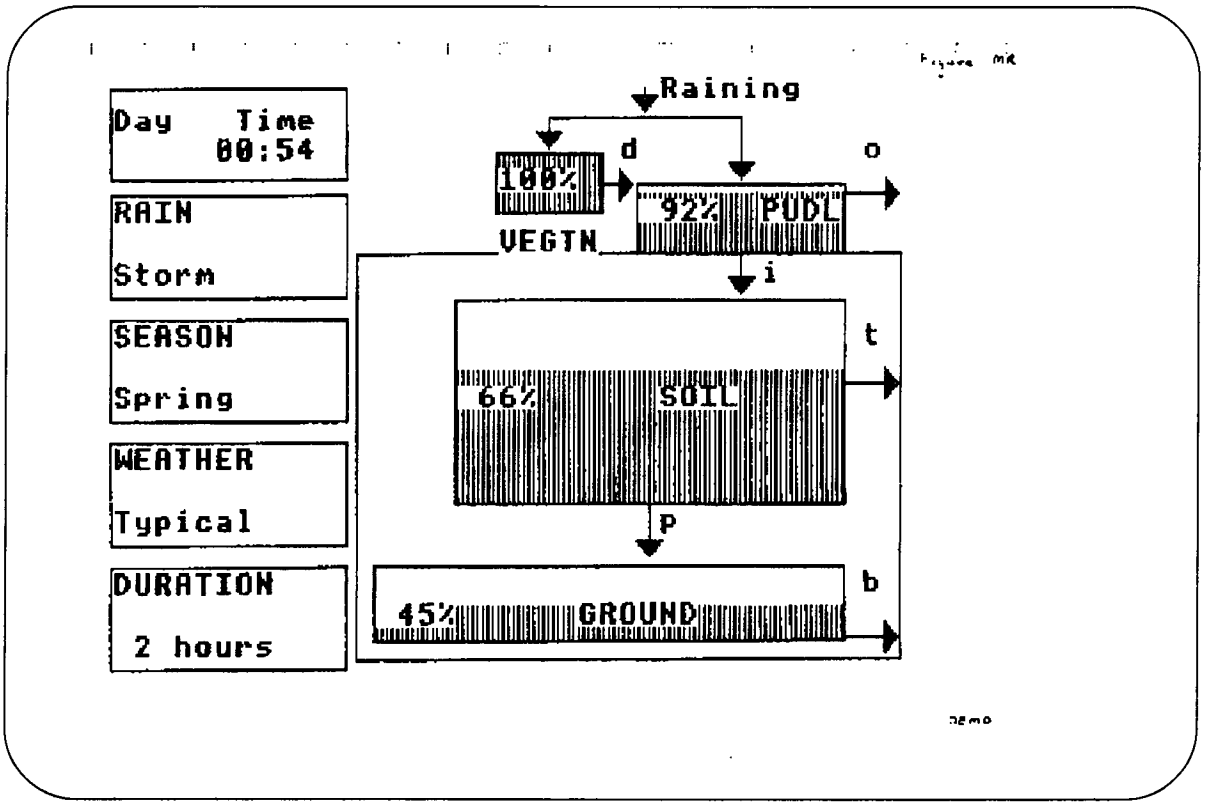

Day Time
00:54
RAIN
Storm
SEASON
Spring
WEATHER
Typical
DURATION
2 hours
Raining
d
o
100%
92%
PUDL
VEGTN
i
t
66%
SOIL
P
b
45%
GROUND

Figure MA5

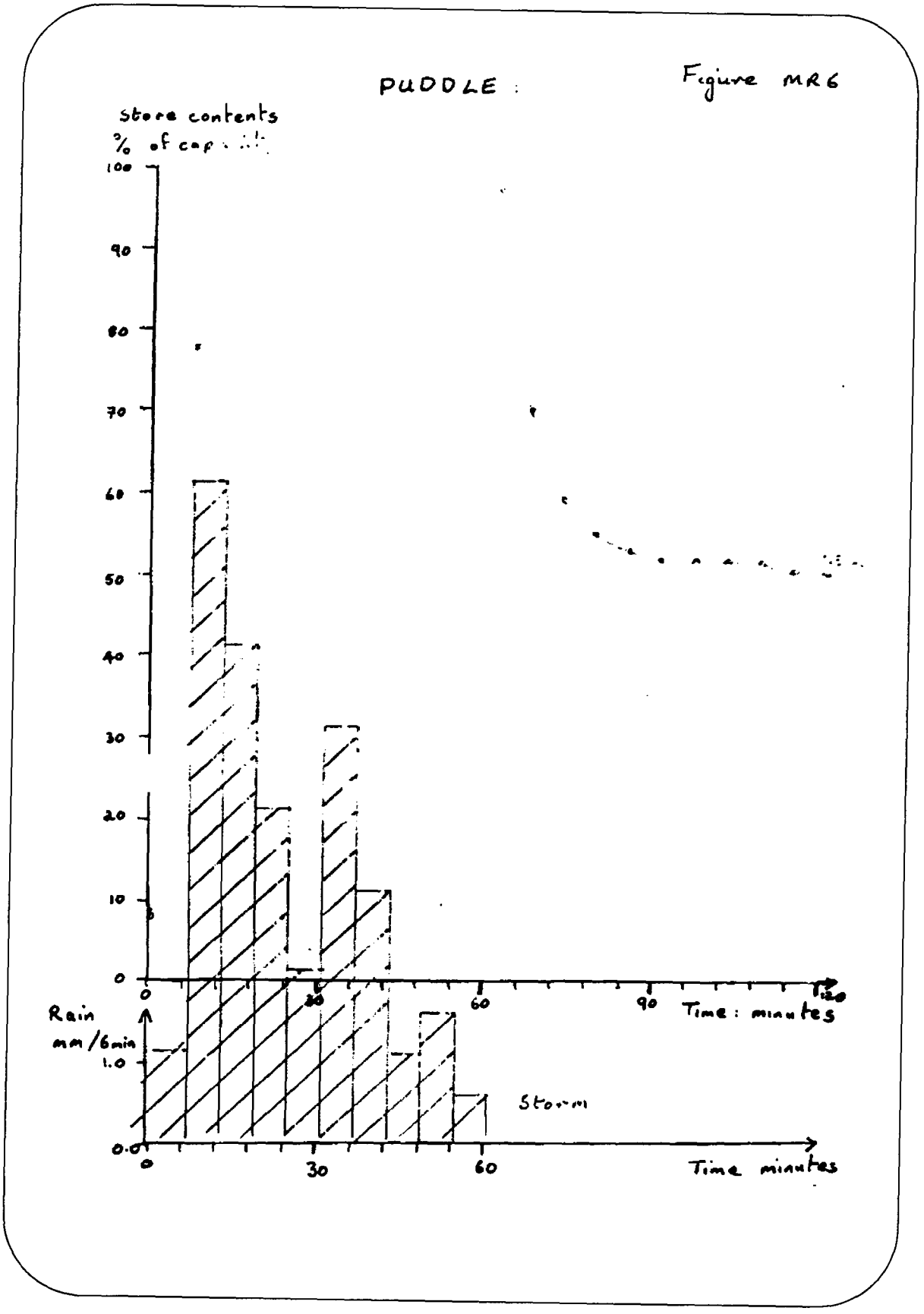
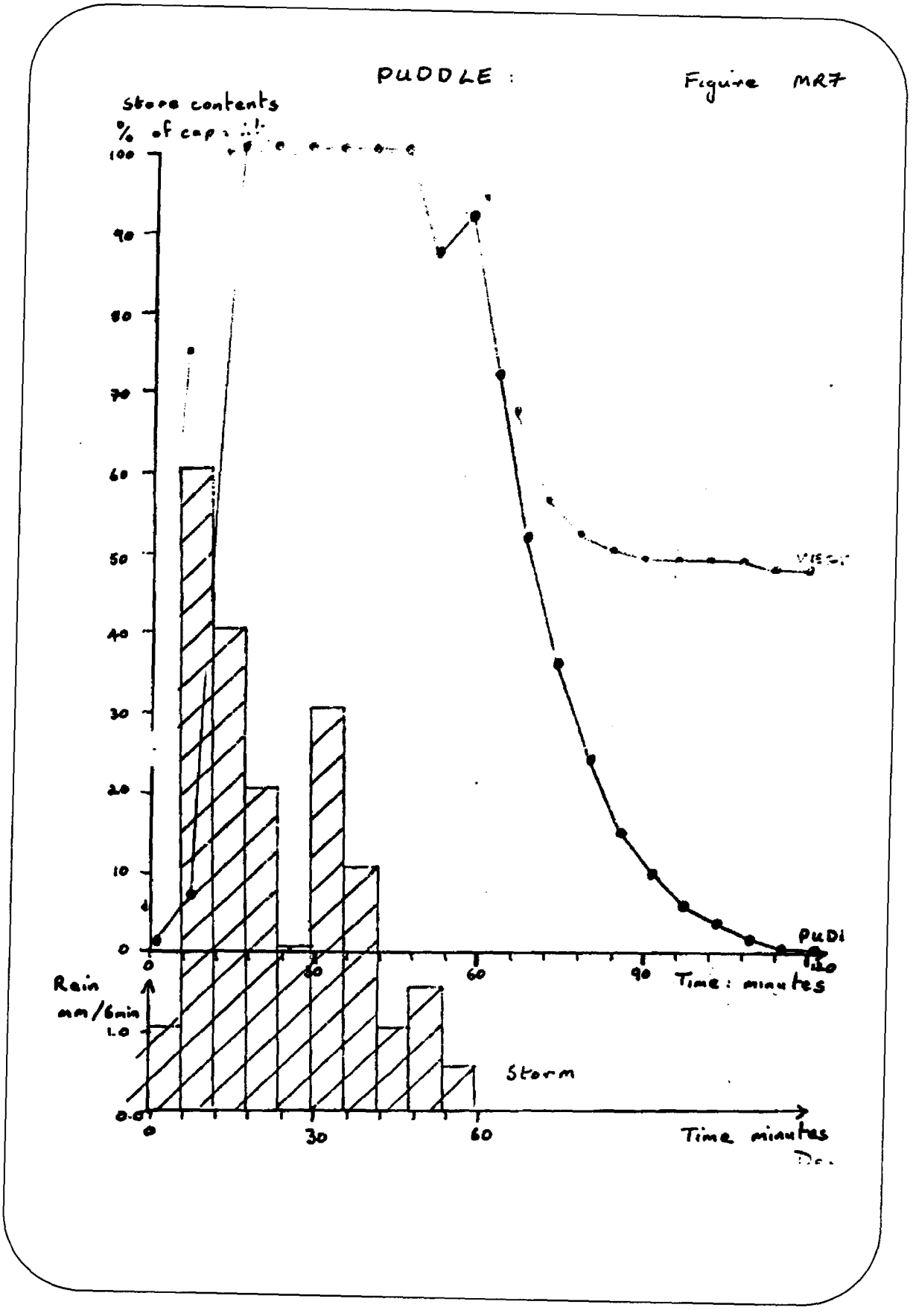

PUDDLE :
Figure MR6
Store contents
% of cap
100
90
80
70
60
50
40
30
20
10
0
0
30
60
90
120
Time : minutes
Rain
mm/6min
1.0
0.0
Storm
0
30
60
Time minutes

Figure MA6


PUDDLE :
Figure MR7
Store contents
% of cap
100
90
80
70
60
50
40
30
20
10
0
0
30
60
90
Time : minutes
PUDI
Rain
mm/6min
1.0
0.0
Storm
0
30
60
Time minutes

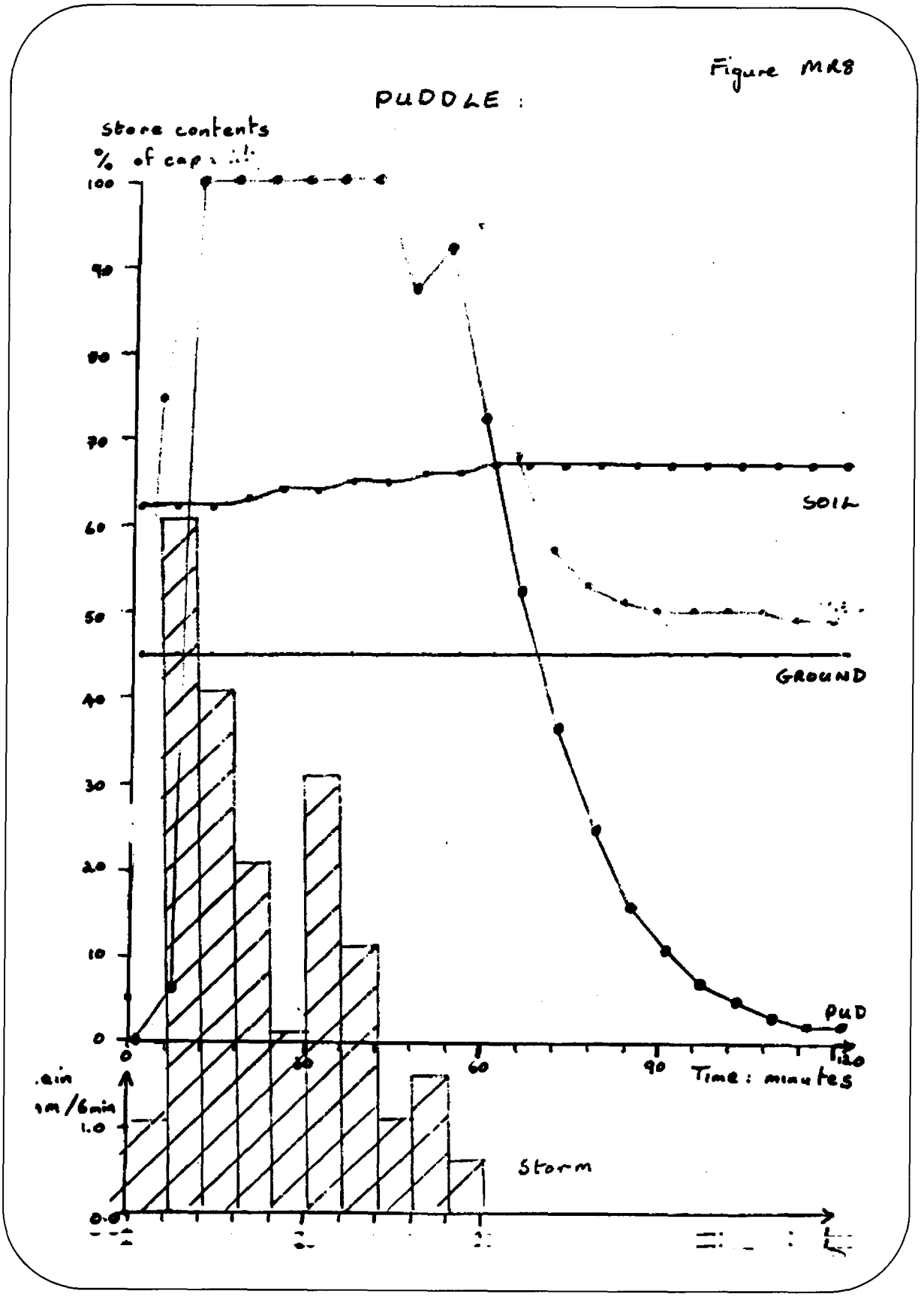


Figure MRT8
PUDDLE :
Store contents
% of cap :
100
90
80
70
60
50
40
30
20
10
0
SOIL
GROUND
PUD
0
60
90
Time : minutes
rain
mm/6min
1.0
0
Storm

Figure MRT8

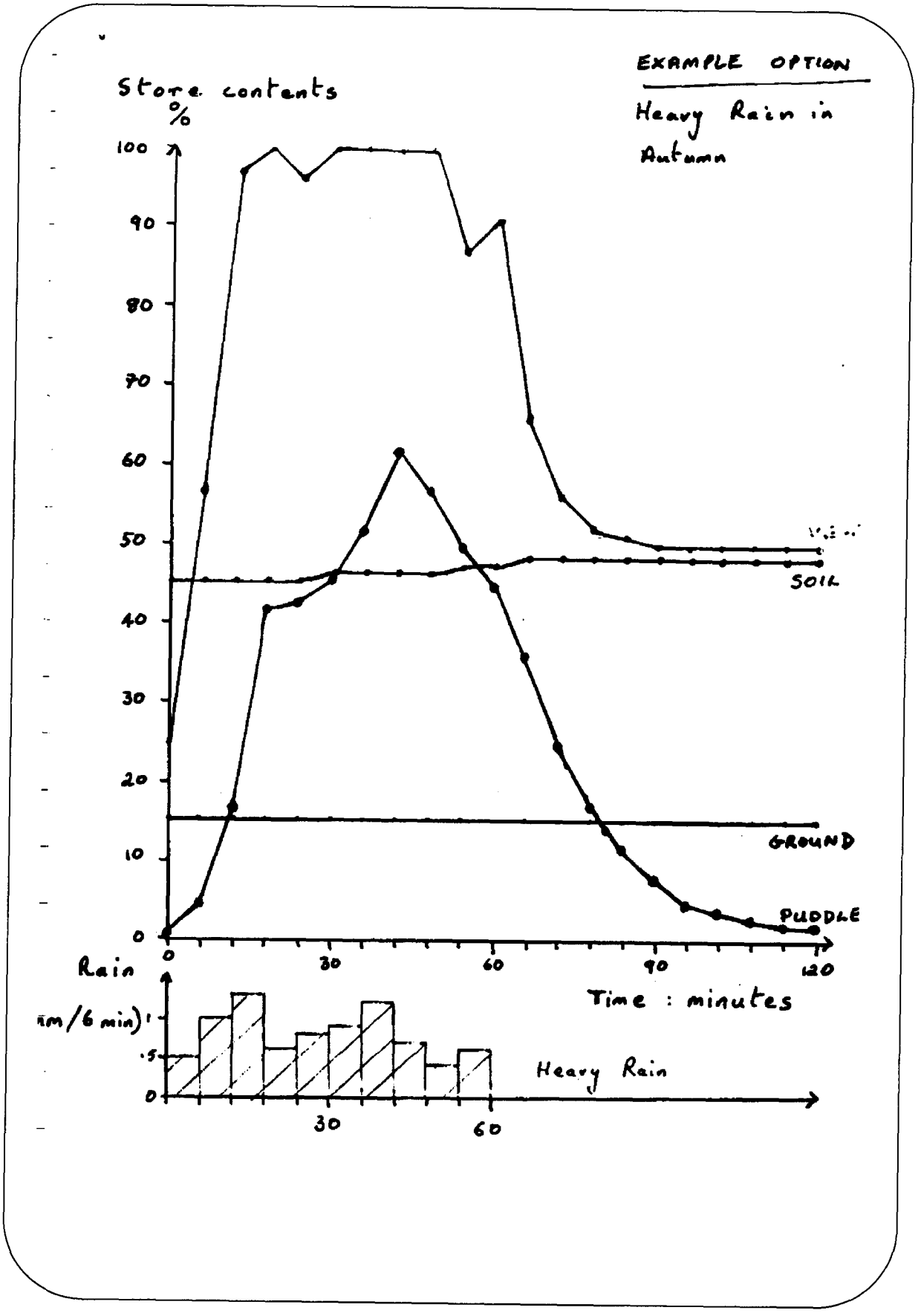

EXAMPLE OPTION
Heavy Rain in Autumn
Store contents
%
100
90
80
70
60
50
40
30
20
10
0
SOIL
GROUND
PUDDLE
0
30
60
90
120
Time : minutes
Rain
(mm/6 min)
1
.5
0
Heavy Rain
30
60

Figure MA 9

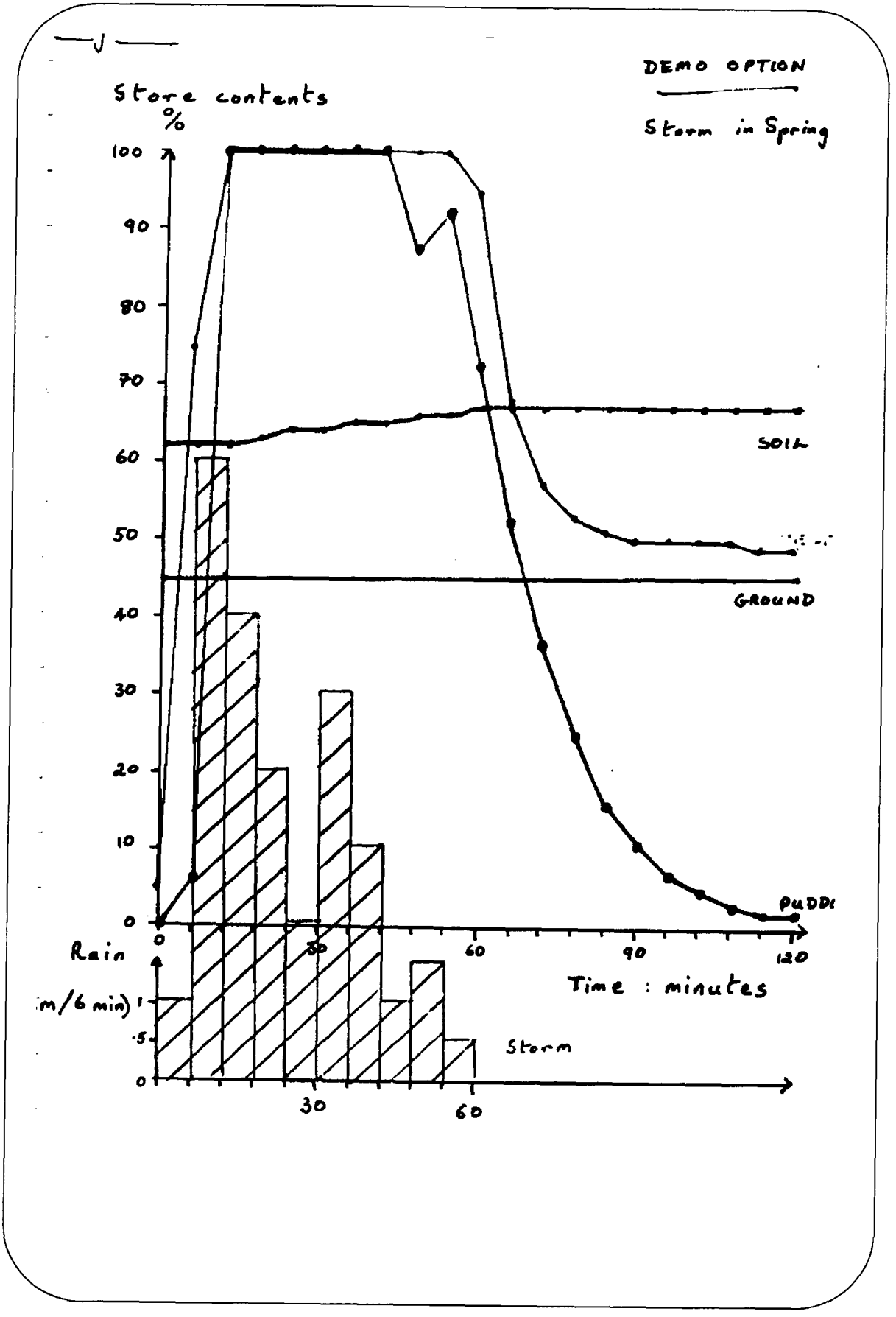

DEMO OPTION
Storm in Spring
Store contents
%
100
90
80
70
60
50
40
30
20
10
0
SOIL
GROUND
PUDDL
0
30
60
90
120
Time : minutes
Rain
(m/6 min)
1
·5
0
Storm
30
60

Figure MA10

PUDDLE Interview: JENNIFER

J1 RIGHT, SO IT'S TWO MONTHS SINCE YOU LOOKED AT 'PUDDLE'. (YES.) AND YOU HAVE FORGOTTEN ALL ABOUT IT (YES.) EXCEPT FOR A LITTLE BIT YOU VAGUELY RECALL. IF YOU CAN TELL ME ABOUT THAT FIRST OF ALL?
What about 'Puddle' , what I remember?

J2 WHAT YOU REMEMBER OF IT?
Well it was basically, how the rain was infiltrated through various, through the soil, vegetation and how it was outputted through various things. And there was quite a lot of limitations, because it was, you didn't know what kind of vegetation we were on. I think you are on a hill. I think you couldn't change the vegetation, I think that was it.

J3 RIGHT, THAT'S RIGHT IN FACT, YOU WERE ON THE TOP OF THE SLOPE, AND ON FACE OF IT THE VEGETATION OF GRASS?
You couldn't change the soil. (No.) And various infiltration rates that I don't think you couldn't change either. And the soil only filled up to I think it was 50%. There was quite a lot of limitations on that.

J4 SO YOU COULDN'T REALLY DO ALL THE THINGS YOU WOULD HAVE LIKED TO HAVE DONE?
No. I couldn't, I wouldn't mind expanding, sort of changing the soil, and it only rained for an hour, however long the duration of the thing was. Which I think it was a bit off-putting.

J5 AN ENGLISH SUMMER ISN'T LIKE THAT?
An English summer isn't like that, no.

J6.... UNCLEAR .... RIGHT OKAY, SUPPOSING YOU HAD A MODELLING TOOL LIKE THE ONE YOU HAD THIS MORNING (DMS); AND YOU COULD BUILD YOUR OWN MODEL OR TAKE THE 'PUDDLE' MODEL AND USE THAT .... NOISE .... WHAT SORT OF THINGS WOULD YOU WANT TO KNOW?
You would be able to change the level of rainfall, you could change that, maybe have a choice of soils, with the different infiltration rates. Also evapotranspiration would be in various degrees of how

much it would evaporate, like it does in the summer and that. Maybe change it, so you are in a valley and you have other sources of rain coming apart from just rainfall, more moisture or something.

J7 SO HOW WOULD THAT, SUPPOSING WE TOOK A COLUMN OF SOIL FURTHER DOWN THE SLOPE THAN THAT DIAGRAM, WHAT OTHER INPUTS WOULD THERE BE THEN TO THE ... ?
Figure J1 - Figure A1 on Students' leaflet A
There would be the rain off, (runoff) overland flow from here, there would be more throughflow, baseflow as well as the rain coming down

J8 SO IT WOULD BE A MORE COMPLICATED MODEL?
Yes, more complicated.

J9 RIGHT, HOW DO YOU THINK THE MATHS WOULD BE IN THE 'PUDDLE' PROGRAM WORKS, AS YOU ARE A MATHEMATICIAN?
I don't know, it's so long ago from doing it, I don't even remember which program was which.

J10 DID YOU, DID YOU LOOK AT THE LISTING OF THE PROGRAM, OR THE MODEL
Yes we did, I remember doing that, because we were trying to check out, how to, if we could change the values.

J11 YES, DID YOU LOOK AT THE DATA STATEMENTS WHICH GIVE THE AMOUNTS OF RAINFALL AND SO ON, OR DID YOU LOOK AT THE MODEL ITSELF?
I think we did, I can't remember. I remember looking at all the sort of work the listings and things like that, but as to what was in it, I couldn't tell you now, it's so long ago.

J12 RIGHT, ALL OF EIGHT WEEKS AGO?
In those eight weeks, because we have done all of this, plus all the other stuff we have done.

J13 RIGHT IT'S A LONG TIME ISN'T IT?
It's a long time, for this sort of thing.

J14 IF WE GO BACK A BIT, TO THE MANUAL HERE (TEACHERS' GUIDE) IN FACT IT, IT SHOWS YOU SOME HERE OF WHAT; HOW THE RAINFALL IS SET IN

THE PROGRAM, AND YOU COULD CHANGE THOSE LINES (FIGURE J2)- RIGHT, AND ALSO IF YOU GO BACK FAR ENOUGH (FIGURE J3), IT GIVES YOU AN IDEA OF HOW THE FLOWS ARE CALCULATED. I WONDER HOW MUCH SENSE YOU COULD MAKE OF THAT INFORMATION IF YOU WERE TO READ IT?

Figure J2 - Page from Teachers' Guide showing listing of rainfall data

Figure J3 - Page from Teachers' Guide showing diagram and model of store

(Long pause) Not much in words. Vaguely, but it's not, no.... mm. (Millimetres, yes.) If I had some figures, I might be able to put it on.

J15 SO IN ABSTRACT IT'S A BIT FUNNY?

Yes, put like that.

J16 IF I TALK YOU THROUGH IT, MAYBE WE COULD GO THROUGH IT NOW, AND WE COULD SEE.... WHAT WE'RE SAYING IS, WE'VE GOT ONE STORE, AND WE CAN THINK ABOUT ONE OUTPUT, ONE FLOW. THEN HOW DO WE CALCULATE THAT FLOW, AND WE USE THE FORMULA AND SAY WELL THERE'LL BE A RATE OF FLOW WHICH WILL DEPEND AN THE NATURE OF THE SAIL, IT'S GOING TO BE RESTRICTED BY THE SIZE OF THE HOLES IN THE SOIL. IF IT'S THE PUDDLE, IT'S GOING TO BE THE SIZE OF THE HOLES GOING THROUGH INTO THE SOIL, AND SO ON.

The amount of water above the output, if we think of this literally as a tank of water with a pipe coming out of the side. (Yes.) The head of water, the height of the water above that output will determine the pressure, won't it? (Yes.) .... And so the more water there is in the store ... ? The more pressure it is.

J17 RIGHT, SO WHEN THE STORE IS FULL RIGHT TO THE TOP (W=I), THEN THAT'S WHEN YOU GET MAXIMUM OUTFLOW. WHEN THE WATER LEVEL COMES DOWN SO IT'S JUST AT THE LEVEL OF THE OUTLET (W=L), THEN THE FLOW WILL COME DOWN TO ZERO. BELOW THAT LEVEL.... (YOU'LL GET NOTHING.) YOU GET NOTHING AT ALL (W<L), SO YOU HAVE A SORT OF THRESHOLD VALUE, LEVEL WITH THE OUTLET PIPE. (YES.) SO THAT'S BASICALLY THE PICTORIAL MODEL.

SO WHAT WE DO, IS WE HAVE AN EQUATION IN MATHS THAT'S EXACTLY THE SAME. NOW WE LOOK AT THE HEIGHT OF THE WATER ABOVE THE OUTLET, WHICH IS THE WATER LEVEL 'W' MINUS THE THRESHOLD LEVEL, THAT'S 'W-L'. AND

WE HAVE TO LOOK AT THAT AS A PROPORTION OF: FROM THE THRESHOLD TO FULL (1-L), SO THAT WHEN THAT VALUE, WHEN THE STORE IS FULL (W=I), THAT WILL BE EQUAL TO THAT; AND THAT EXPRESSION (W-L)/(I-L) WILL BE EQUAL TO ONE.

SO THAT WHEN THE STORE IS FULL THE OUTPUT WILL BE THE FLOW RATE TIMES THE AMOUNT OF TIME YOU ARE RUNNING IT FOR. AND THEN AS, WHEN THIS HAS (W-L), COMES TO ZERO, ZERO OVER ONE WILL BE ZERO, AND SO WHEN WE GET DOWN TO THIS LEVEL (W=L), THAT'S ZERO (W-L)/(I-L). (ZERO, YES.) SO WE HAVE AN EXPRESSION WHICH JUST GIVES US THE OUTPUT IN PROPORTIONS OF THE CONTENTS THERE. SO IT LOOKS QUITE COMPLICATED AT FIRST, BUT ... ?
Once it is explained, and shown yes.

J18 SO IN FACT, YOU COULD PUT THAT EQUATION ONTO THE MODELLING SYSTEM WE WERE USING THIS MORNING, AND MAKE A MODEL OF THE JUST ONE STORE LIKE THAT. THEN YOU WOULD HAVE TO DO TO MAKE THE 'PUDDLE' (UNIT?) IS TO MAKE LOTS OF THOSE, AND JOIN THEM ALL UP TOGETHER.
Yes, explained like that it is easier to understand, yes.

J19 RIGHT, SO IT'S QUITE A SIMPLE EXAMPLE, REALLY, OF A COMPUTER MODEL.
Yes, I think so, compared to what we've been dealing with in class. In a few ways it's much easier.

J20 NOW IT LOOKS TERRIBLY COMPLICATED, BECAUSE YOU'VE GOT THIS LONG EXPRESSION. BUT THE IDEA BEHIND IT IS VERY SIMPLE?
Very simple, yes.

J21 CAN YOU IMAGINE OTHER SUBJECTS, GEOGRAPHY OR ELSEWHERE, WHERE YOU CAN MAKE DIAGRAMS, MODELS, LIKE THIS TO REPRESENT SOME SORT OF SYSTEM?
(Long pause) I suppose, you could use it in glaciation or physical types of geography, sort of how it takes maybe moving glaciers, or when it actually melts you could use it then. Maybe, I suppose you could use it in maths, basic understanding of equations, stuff like that, for say 11 year-olds, as opposed to the A-Level. It could be what is it, economics? You could use it in there for various (?) or graphs, something like that. I suppose you could use that sort of

thing. But for the majority of subjects, you have to depend on the theory.

J22 THE 'PUDDLE' PROGRAM USES A FLOW DIAGRAM TO REPRESENT THE SYSTEMS. CAN YOU IMAGINE A FLOW DIAGRAM BEING USED IN ECONOMICS, RATHER THAN GRAPHS?

In a way yes, I would do, I suppose you could really. I don't think they would be as explanatory or as visual as a graph would be, as easy to understand as the results, but I'd think

J23 YES, SO YOU PREFER WORKING WITH GRAPHS, TO THE PICTURES REALLY?

Yes, because graphs, you can find what you want in various things without having to work with the whole part of thing, rather than with flow diagrams.

J24 RIGHT, ON THAT NOTE, PERHAPS WE CAN GO AND LOOK AT SOME GRAPHS, BECAUSE THE COMPUTER PROGRAM DIDN'T ACTUALLY GIVE YOU ANY GRAPHS, MAINLY BECAUSE THERE WASN'T ANY SPACE ON THE COMPUTER TO PUT IT INTO THE PROGRAM, SO WHAT I'VE DONE IS CHEATED, AND PUT IT ONTO SOME OVERLAYS HERE. SO IF WE TAKE ONE OF THE EXAMPLES FROM THE PROGRAM, WE HAVE A STORM IN SPRING.

Yes.

Figure 34 DEMO: Storm in spring - graph of rainfall and contents of vegetation store

J25 We've got time on our horizontal axis, and we've got the rainfall in six minute intervals represented as a bar chart. So we can see how the rainfall goes during the hour. As you said, it's just one hour of the storm. We can then superimpose on vegetation store. I wonder what you would make of that. Vegetation was very low at B because of the weather, very light. When the storm started within about twelve minutes, 18 minutes or so, it was, rose considerably to maximum store contents, and after coming up for almost the hour it dropped, and after that time it started to go down to what it's original level was, but it only got down to 50% in two hours ..noise..

J26 HOW WOULD YOU EXPLAIN THIS CURVE, HERE FROM THE MAXIMUM CONTENTS DOWNWARDS?

The stopping the rain, means that the expiration (evapotranspiration) rate went, started up, so it was being taken off instead of being put in.

J27 SO YOU'VE GOT AN OUTPUT NOW INSTEAD OF AN INPUT. (YES, AN INPUT.) ARE THERE ANY OTHER OUTPUTS FROM THAT TOP STORE?
There was outputs into the soil ..noise..

J28 THERE IS A DIAGRAM THAT REPRESENTS THE SITUATION AT THE END?
Figure J5 DEMO: Storm in spring - screen image of storm in spring at time 2-00 hours
Once the puddle has actually formed, the vegetation has gone, it went into the puddle.

J29 SO THIS WAS THE SITUATION AFTER 4 MINUTES? (YES.) THIS IS UP HERE WASN'T IT? (YES.) ..UNCLEAR.. SO YOU HAVE THE DRIPS, AND WHY ISN'T IT A STRAIGHT LINE?
Because it doesn't go straight down, it doesn't all suddenly go at once, drops suddenly and then slows down.

J30 WHY DO YOU THINK IT SHOULD SLOW DOWN?
Because there's not, because it's reaching its minimum point, and there's not so much pressure to push it all out.

J31 WHAT'S THE MATHEMATICAL TERM FOR DESCRIBING A CURVE LIKE THAT?
Oh, I can't remember; crumbs, I can't remember.

J32 YOU'VE COME ACROSS CURVES LIKE THIS HAVEN'T YOU BEFORE?
Yes, I can't remember its name.

J31 YOU OFTEN HAVE CURVES LIKE THAT WHEN YOU ARE DEALING WITH LOGARITHMS, DON'T YOU?
Yes logs, ... no, it's gone.

J34 BEGINNING WITH 'E'?
Ex..., we did it, we did it at the beginning of this years I've forgotten ex ...

J35 EXPONENTIAL?

Exponential. That's it, exponential. I remember doing them.

J36 SO IN FACT, THAT FORMULA WE HAD A LOOK AT, GIVES YOU EXPONENTIAL DECLINE, IT'S NOT A LINEAR FORMULA, IT'S A CURVE.

Curve, yes, whereas that would be

J37 SO IF WE QUICKLY MOVE ON, TIME IS RACING AHEAD. THAT'S THE SAME PERIOD OF TIME AND WE HAVE GOT THE PUDDLE CONTENTS, DO YOU SEE ANY SIMILARITIES OR DIFFERENCES THERE ?

Figure J6 DEMO: Storm in spring - graph of rainfall and vegetation and puddle store contents

They're similar, while it's raining still, but once the vegetation starts. No, once the puddle's full, it drops and then as the vegetation reaches maximum contents it pours into the puddle and so increases the puddle again and then falls, much (er) quicker than the vegetation did.

J38 GOES DOWN TO A VERY DIFFERENT LEVEL, DOESN'T IT AS WELL?

Yes, it goes right down to where it started from.

J39 NOW FINALLY, THERE'S THE LAST ONE, THOSE ARE THE TWO STORES BELOW, HOW DO THOSE LOOK, IN COMPARISON?

They don't rise sharply at all, they're very parallel, they remain very steady, the ground doesn't increase at all (?), the soil sort of rises very, very gently.

J40 WHY DO YOU THINK THAT IS, WHEREAS THE PUDDLE AND THE VEGETATION CHANGE GREATLY?

Because after, the soil doesn't increase any because it takes so long for it to filter down and you have to have so much water for it to do. I think if you had a long time with the rain it may get down to the soil, but there's not very much to make it go down to.

J41 RIGHT, SO THE SOIL RESPONDS MORE SLOWLY, IT'S A MUCH LARGER STORE?

Yes, much slower, and it never gets down to the ground, well hardly gets down to the ground at all, so it's very much slower than that one.

J42 DO YOU THINK IT WOULD HAVE BEEN USEFUL TO HAVE THESE SORT OF GRAPHS COMING UP ON THE SCREEN IN THE PROGRAM?
Yes, it would have helped because you would have been able to see visually how they reacted, as opposed to just that picture.

J43 OKAY, FINALLY ONE LAST QUICK ONE, HOW WOULD YOU EXPLAIN WHAT A MODEL WAS TO SOMEONE ELSE?
What, that model, or just a 'model'?

J44 MODELS IN GENERAL.
It's a, giving you a visual explanation of a certain type of geography or mathematics or something like that, and it's an easier way to understand something, and more interesting than taking notes off the blackboard.

J45 RIGHT, THAT'S A GOOD NOTE TO END ON, ISN'T IT. OKAY THANKYOU.

Students' leaflet A
Water on the land

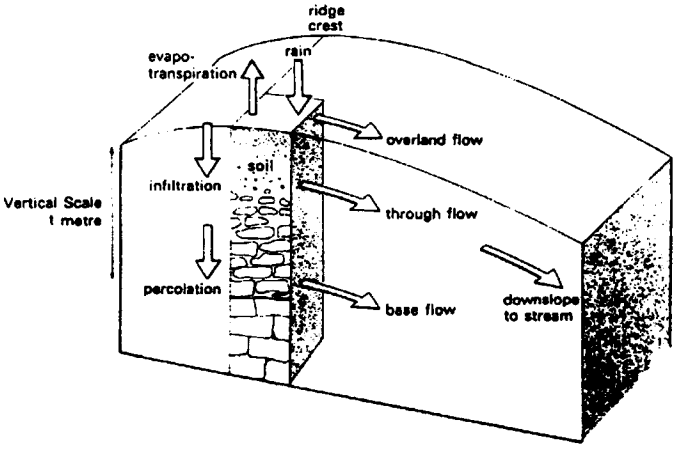
Introduction

After rain or snow falls on the ground, water follows several different paths. Some evaporates into the air, some soaks into the soil and some may run downhill over the surface.

Figure A1 shows these flows on a small area of land. As it is at the top of a slope, no water can drain into it from higher ground.

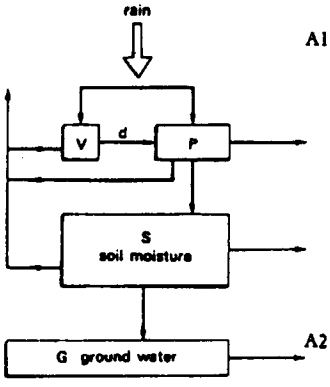
Trees, crops and plants also affect the flow of water. Rain or snow may be trapped on the surfaces of plants and some water may never reach the ground. Plants also take water out of the ground and lose it to the air by transpiration.

Figure A1
Water movement on an area of land at the top of a slope.



The flow diagram

Figure A2
The flow diagram.



The movement of water shown in Figure A1 can also be shown in a flow diagram – see Figure A2. The 'boxes' are stores where the water is held for a while between the flows.

A1 Put the missing labels on the diagram using the key below.

Key

Stores		*Flows*	
V	Vegetation – also known as store	d	Drips – throughfall – & stemflow
P	Puddles – also known as the surface depression/detention store	i	Infiltration
		p	Percolation
		o	Overland flow – surface runoff
		t	Through flow
S	Soil moisture store	b	Base flow
G	Ground water store	e/t	Evapo-transpiration

A2 Draw a new flow diagram to show the flows and stores near the bottom of a slope. (Hint – there should be several extra flows.)

Figure J1

7 Extending the use of the program

These notes give a brief explanation of the program and show how it can be changed to simulate different conditions. To appreciate the notes fully some knowledge of elementary BASIC is required. If you are unfamiliar with computer programming you will probably find a colleague who is ready and able to help.

The program is structured so that you can easily change the values used in the model without disturbing other parts of the program. With care you may also change the calculations in the model but first you must understand them fully.

It is very important to SAVE copies of the original program and to get a listing of the program, before you attempt to make any changes. You should also document the changes for future reference, as you may accidentally disrupt the operation of the program.

Changing the values used in the model

The values for the rainfall, stores and flows are defined in a series of DATA statements which can be typed afresh or EDITed to insert new values. This will be unaffected.

The data for the types of rain are given in millimetres for ten intervals of six minutes, the end of the rain is marked by a zero:

```
5902  REM Drizzle
5904  DATA .04,.06,.06,.05,.04,.04,.06,.05,.05,.05
5906  DATA 0
5908  REM Light rain
5910  DATA .1,.2,.3,.3,.2,.2,.2,.3,.1,.1
5912  DATA 0
5914  REM Heavy rain
5916  DATA .5,1.0,1.3,.6,.8,.9,1.2,.7,.4,.6
5918  DATA 0
5920  REM Storm
5922  DATA 1,8,6,4,2,5,3,1,1.5,.5
5924  DATA 0
5926  REM None
5928  DATA 0
```

The values which vary from season to season are set in the following four lines which represent autumn, winter, spring and summer respectively:

```
5932 DATA  0.25, 0.00, 0.45, 0.15, 0.70, .0009
5934 DATA  0.50, 0.05, 0.75, 0.60, 0.60, .00009
5936 DATA  0.05, 0.00, 0.62, 0.45, 0.80, .0015
5938 DATA  0.00, 0.00, 0.35, 0.10, 0.95, .0021
```

For each line, the first four figures are the contents of the interception, surface water, soil mixture and ground water stores as decimal fractions. The next fraction is the amount of rain intercepted and the final figure is the evapotranspiration in mm/min.

The sizes of the four stores are given in lines 5942 – 5948 for the interception to ground water stores respectively. In each case the first figure is the capacity of the store in mm of rain equivalent. The other figures are the screen coordinates for the flow diagram and should not be changed or deleted.

Figure J2

5 The computer model

The model is merely a series of calculations which repeatedly determine the volumes of the flows and the contents of the stores. It is called by the options GO (2000–2028) and CONTINUE (2100–2120) and it is always initialised in lines 3800–3848. The model itself is in lines 3600–3746.

The volumes of the rain and evapotranspiration are defined in DATA statements but the other flows are based on store contents using Equation 1

Equation 1 $F = R \times (W - L)/(1 - L) \times t$ (W greater than L)

where
F – volume of flow – mm
R – rate of flow from full store – mm/minute
W – water content of store – decimal fraction of capacity
L – level threshold – fraction of capacity
t – period of flow – minutes

The function $(W - L)/(1 - L)$ varies from 1 when a store is full to 0 when the contents have dropped to the threshold level. There is no flow if the water is lower than the threshold – see Figure 1.

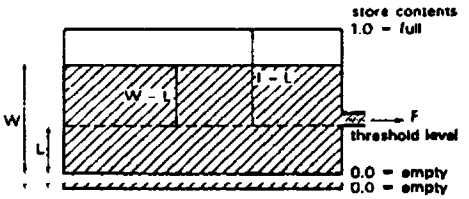


Figure 1
Diagram of a store with the terms used in Equation 1.

Figure J3

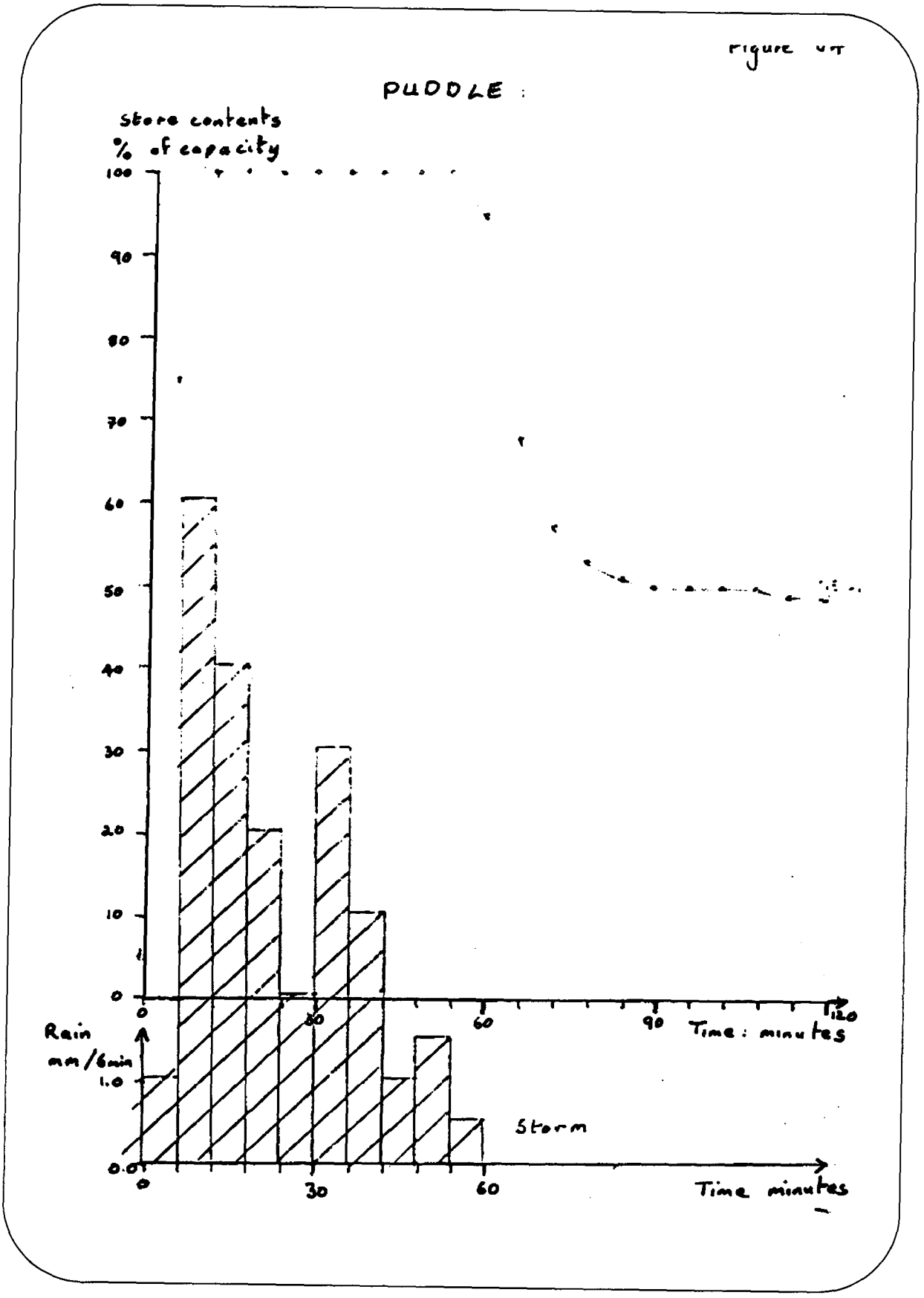

PUDDLE :
Store contents
% of capacity
100
90
80
70
60
50
40
30
20
10
0
0
30
60
90
120
Time : minutes
Rain
mm/6min
1.0
0.0
Storm
0
30
60
Time minutes

Figure J4

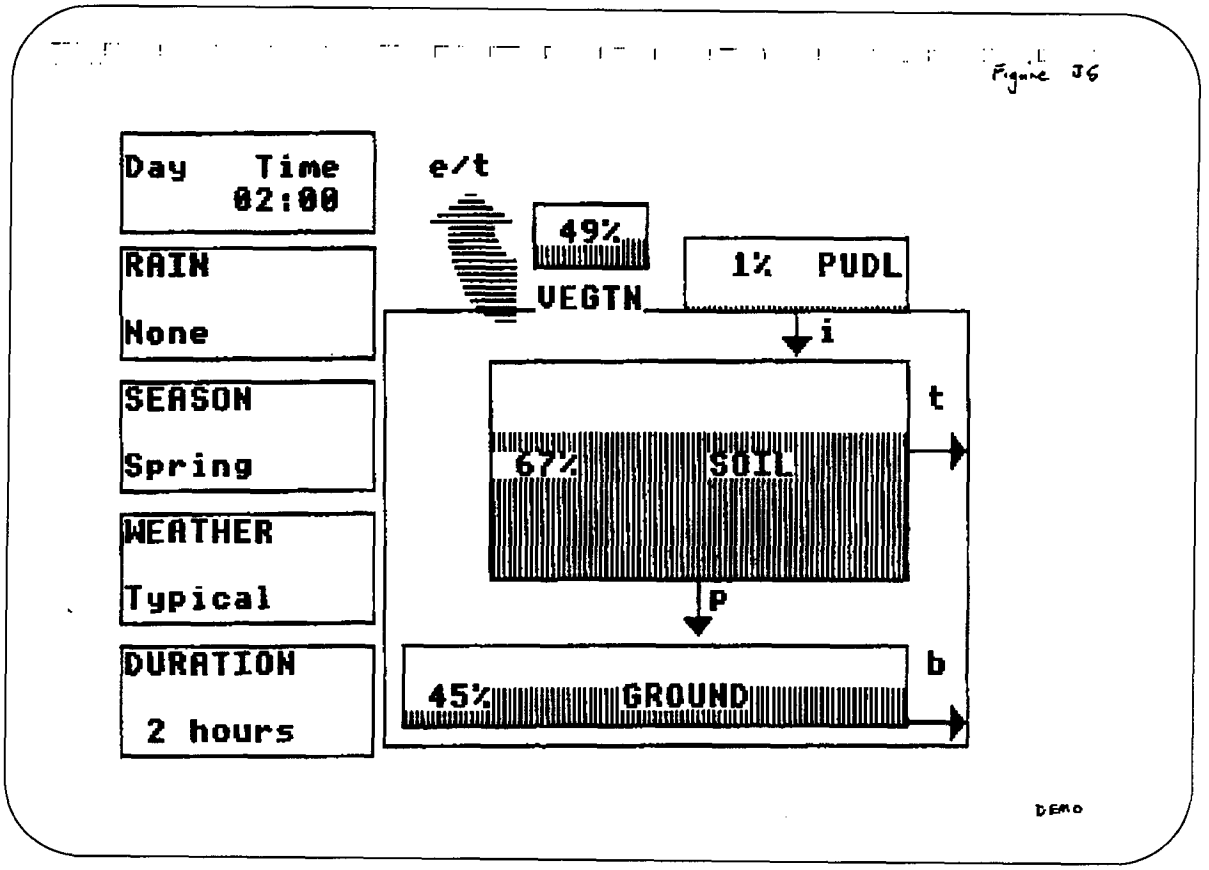


Figure J6
Day Time
02:00
RAIN
None
SEASON
Spring
WEATHER
Typical
DURATION
2 hours
e/t
49%
VEGTN
1% PUDL
i
t
67%
SOIL
P
b
45%
GROUND
DEMO

Figure J5

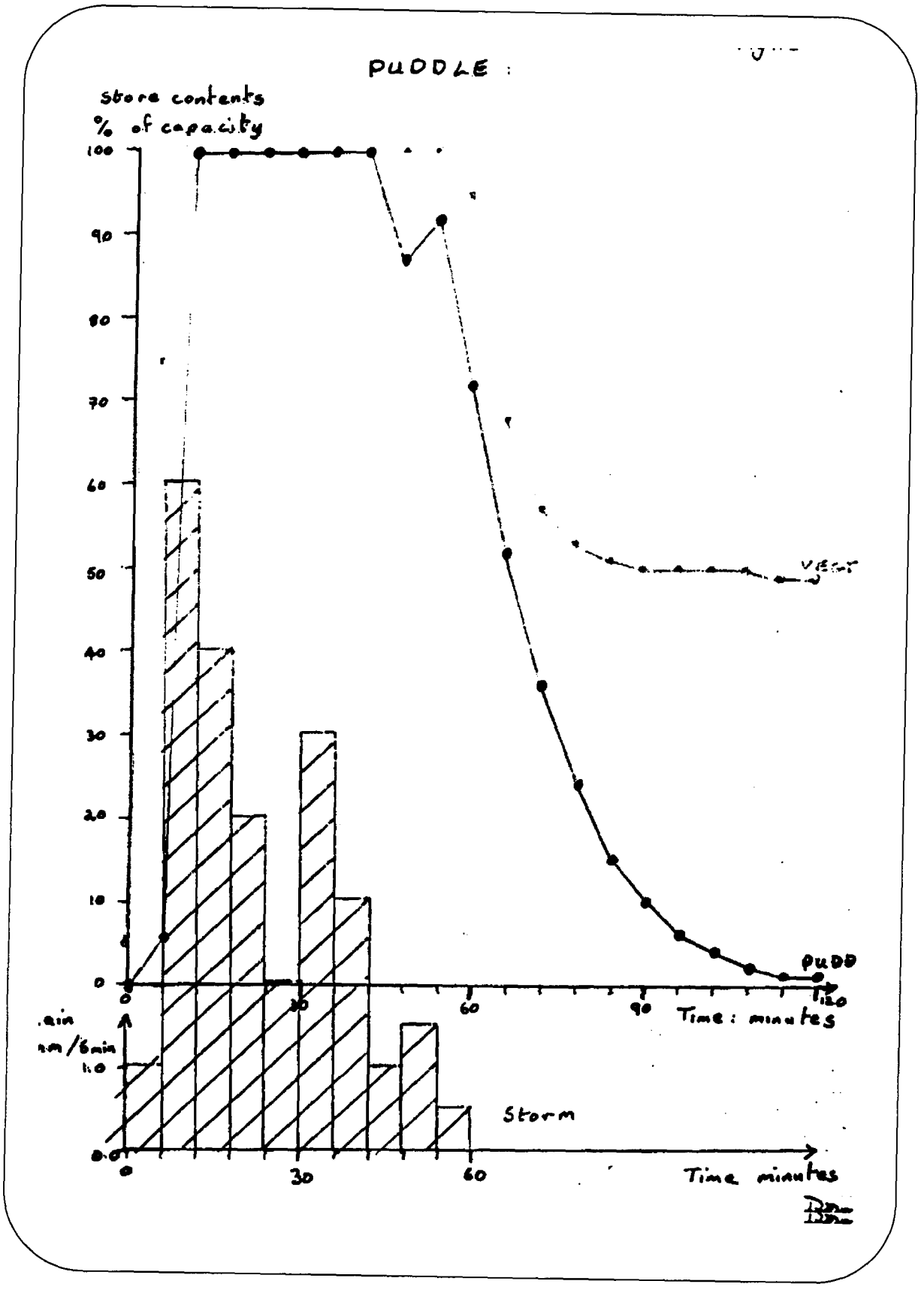

PUDDLE :
store contents
% of capacity
100
90
80
70
60
50
40
30
20
10
0
0
30
60
90
120
Time : minutes
PUDD
Storm
0
30
60
Time minutes

Figure J6

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DMS Interview: Helen

H1. SO YOU'VE USED THIS PROGRAMME SEVERAL TIMES NOW?
Yes, we've done it for a few weeks, about well four weeks ago I think (since) we started using it. I didn't understand it at first, because I have never done any computers at all, but once you get into it, is quite easy.

H2. SO WHAT SORT OF MODELS DO YOU LOOK AT?
We looked at population models, the cost-revenue model, we did about four of these in quite big detail, and them he left us to work on our own. To work out how to vary it. To see what we could do with it really.

H3. HAVE YOU EVER DONE ANYTHING LIKE THIS IN YOUR ECONOMICS A-LEVEL WORK?
No, I have never used a computer but I am used to lots of graphs ....., cost curves and things like that, so it wasn't much of a blow to me.

H4. SO THE IDEA OF HANDLING GRAPHS WAS EASY?
Yes, yes.

H5. SO IT WAS REALLY GETTING THE HANG OF USING THE KEYS?
Yes.

H6. SO YOU'RE USED TO GRADIENTS AND AREAS UNDER CURVES?
Yes.

H7. THAT'S GOOD. HAVE YOU DONE EXERCISES LIKE THIS ON PAPER, WHERE YOU'VE TRIED REDRAWING DIFFERENT .....?
..... The only one we did was when we first started off with weight loss and weight gain. It's the only one we really tried on paper. I have never tried anything like this. About the first time .....

H8. DO YOU THINK IT HELPS HAVING A .....?
Oh yes, because it makes you think, oh .. the work's much more relevant now, you can see how it can be used, and what businesses have to do, and things like that.

H9. CAN YOU IMAGINE WORKING IN AN OFFICE USING SOMETHING LIKE THIS?
Yes.

H10. DO YOU HAVE ANY IDEAS ON WHAT YOU WANT TO DO YET AS A JOB?
I want to get into Geography and to do a degree, but I am not sure what I'd do after that. Be a teacher or something.

H11. HOW ABOUT IMAGINING YOURSELF AS A MARKETING DIRECTOR?
No! (laughing) It depends really ....

H12. DO YOU THINK YOU HAVE GOT MORE EXPERIENCE WORKING WITH GRAPHS NOW, DO YOU FIND IT EASIER TO WORK ON GRAPHS ON PAPER, HAVING USED THIS .....?
Yes I do. Yes, I think it is basically with a beginner, it is a bit difficult to get hold of when you actually set the graph up, but once you have worked that out it is quite easy then. It is just getting basic facts learnt.

H13. IT IS GETTING THE GRAPHS TO DO WHAT YOU WANT THEM TO DO?
Yes. Working out how you can change gradients and things like that.

H14. YOU HAVEN'T DONE ANY PROGRAMMING BEFORE OF COURSE?
No, not at all. We've done a few games ..... in the geography course, but not a lot.

H15. DO YOU THINK YOU WOULD WANT TO LEARN TO PROGRAM AT ALL, HAVING USED THIS, OR DOES IT PUT YOU OFF PROGRAMMING?
I don't think I would really like to go into it in great detail. I don't mind doing it but, I don't (think) I would really take it up.

H16. DO YOU THINK THAT WHAT YOU ARE DOING HERE AS PROGRAMMING, WHEN YOU ARE ALTERING THE GRAPHS AND SO ON?
Yes, it's quite ..... it amazes me that I can write something I think it seems complicated, but then you realise how ..... it is really to get the hang of it. It's more difficult (simple?) that it seems.

H17. WHERE DO WE GO FROM HERE. DO YOU THINK YOU WOULD FIND IT QUITE EASY TO WRITE YOUR OWN MODELS NOW?
I think I would find it hard to do it straight from scratch, but if I get a bit of help to start me off, I think I'd be alright.

H18. SO WHAT SORT OF STAGES DO YOU NORMALLY GO THROUGH WHEN USING THE PROGRAMME?
What when I'm writing my own?

H19. OR, SAY THE ONES YOU HAVE LOOKED AT SO FAR .....?
First of all get the graph, and see what it shows and then you can't really see from the screen what it is all about, you have to read it up on the programme sheet he has given us. Then you can work out what it is showing and then you choose the things you want to alter and see how much it comes out in the actual graph. You know just little differences can make quite a lot of show in the graph which you wouldn't think would.

H20. DO YOU USE THE TABLE IN DMS TO LOOK AT THE NUMBERS?
Yes, we only really use that if something is going drastically wrong, like the lines are coming out and you can work out what has gone wrong from there. That's quite useful but we don't use it very much.

H21. IF YOU COULD TELL SOMEONE TO MAKE A COMPUTER PROGRAMME FOR YOU, TO MAKE THIS JOB EASIER, WHAT DO YOU THINK YOU WOULD WANT THE MACHINE TO DO FOR YOU?
Hmmm, (laughing) I really don't know.

H22. IT'S A DIFFICULT QUESTION THAT, IT'S A BIT UNFAIR PERHAPS TO GIVE YOU SOME IDEAS, WOULD YOU WANT SAY TO TALK TO THE MACHINE RATHER THAN TYPING IN AT THE KEYBOARD.
Yes, if the machine could answer you and give you a bit of help like that. It's just getting going, after that it's OK.

H23. NOW WOULD YOU WANT TO BE ABLE TO SAY 'DRAW A LINE THAT GOES UP'.
Yes, that would be much easier than trying to work out what ....(noise) .....

H24. WHAT ABOUT OTHER IDEAS PERHAPS, BEING ABLE TO SKETCH ON THE SCREEN LIKE THIS .... (NOISE) ..... ?
Yes, that would be good, especially figures like this, but then ..... you wouldn't really be learning how its actually done then. It would be cheating I suppose in a way. A bit too easy I think. It's good when you can work it out yourself and it actually comes out right, you feel quite satisfied. You do somehow.

H25. DO YOU FIND THAT MAKES A CHANGE FROM THE NORMAL LESSONS WHERE PERHAPS YOU HAVE GOT TO LISTEN AND HAVE IT EXPLAINED TO YOU?
Yes, normal ones, they get a bit tedious, but when you can put it into practice it's much more fun, it's good trying to work it out. (More enjoyable? - very faint.)

H26. BUT IF YOU HAD A COMPUTER AT HOME YOU WOULDN'T WANT TO SPEND YOUR EVENINGS DOING THIS?
No, I would start off for a bit, and try them out, but I wouldn't take it up as a hobby or anything.

H27. OK WE WILL STOP THERE, THANK YOU VERY MUCH.

DMS Interview: Manesh

MN1. SO, MANESH ..... YOU'RE MORE FAMILIAR WITH HANDLING COMPUTERS THAN THE OTHERS IN THE GROUP.
Yes, but we haven't programmed as yet with computers, it has been quite a long time since (I did some), I do, but yes I do have background knowledge of them.

MN2. YES, SO YOU HAVE DONE SOME PROGRAMMING IN BASIC?
Yes.

MN3. SO YOU FIND THIS FAMILIAR?
Not this type of system, but I do know how to program. I find it much easier to program rather than actually altering this. You have got to have everything out in the proper fashion to really understand the system. To be able to ... it is much more difficult .... This one I do admit, I'd rather not comment (criticise DMS) ...It is difficult to alter the variables without giving due consideration, but when I program it is not too ..... that's not too ..... (difficult?).

MN4. BECAUSE HERE YOU ARE EFFECTIVELY CHANGING SOMEONE ELSE'S PROGRAM AREN'T YOU?
That's right, yes.

MN5. YOU'VE GOT TO KNOW WHAT IT IS DOING FIRST?
You've got to know every single variable, and what it does. Otherwise you are really stuck. You don't know what to do.

MN6. ARE YOU FAMILIAR WITH CONCEPTS LIKE ITERATION?
Pardon?

MN7. DO YOU KNOW WHAT I MEAN BY THE WORD 'ITERATION'?
No, I don't.

MN8. NO, YOU DON'T KNOW, RIGHT.
What is it?

MN9. IF YOU DO A TASK REPEATEDLY, LIKE A LOOP.

Like a loop, yes I do know.

MN10. RIGHT, SO THE NEXT QUESTION IS, DO YOU ENJOY USING THIS PROGRAM?
It's ..... it's a bit of fun, yes. It's good to use it you know. It can be a bit tedious at times, because when you expect it to work it doesn't do the right thing it should do, and that can be quite annoying.

MN11. WHAT DO YOU MEAN BY THAT?
Well, I was drawing a graph yesterday, and it was about oil production, and I got the most of it right, except one ... and I couldn't get that item done. I tried everything, everything I could think of.

MN12. SO THE PROBLEM WASN'T REALLY WHAT THE PROGRAM DID, BUT IT WAS MORE KNOWING WHAT SORT OF FORMULAE TO USE?
Exactly, exactly but I tried to the best of my knowledge, I couldn't exactly find out what was wrong with it, because I went through line by line and I still couldn't find out what was wrong with it.

MN13. DO YOU THINK YOU WOULD NEED TO LOOK PERHAPS AT A MATHS BOOK, TO LOOK AT DIFFERENT FUNCTIONS OR CURVES?
Well yes maybe, maybe you might need to have an aid, like, such as drawing a curve and might need to have a formula for it, but it shouldn't be too difficult to draw straight lines. It really depends on variables, and .... (other things?) like whether you want to go up or down. It really all depends on that.

MN14. SO .... WHAT DO YOU THINK IS THE MOST DIFFICULT THING ABOUT USING THE PROGRAM AS IT IS AT THE MOMENT?
As it is at the moment, what do you mean? Do you mean ...? The actual thing, actually programming it, or the actual layout of it?

MN15. THE FRAMEWORK IN WHICH YOU WORK?
Oh, I could appreciate it by saying that there's not enough memory ... for it. To be honest, there's only one page for letters, if you want to alter or add more things, more lines to it, things like that,

you can't do that. Which can lead to a quite great disadvantage. But otherwise I can't really see anything which is wrong with it. STATUS - I don't really know ... what it really does, what purpose it does. It doesn't do as much as I would have thought it could have done. It just says 'OK', which doesn't help me out much because if I was stuck, and I needed why I was wrong, or why it doesn't do this, it doesn't give you the answer. Then I would have to find out, to ask someone for help. But really the layout of the TABLE is quite a good idea, there's nothing really too difficult about it, apart from again as I say the variables again, they can be difficult. You've got to really have a bit of knowledge about it ... It could be worse, but it's not bad.

MN16. YOU HAVEN'T COME ACROSS ANYTHING LIKE IT IN ....?

No, I have never actually tried a program like this before. No I have never actually come across it. No, I've, of course you play games, but I don't do much of that, but I try programs, serious programs. It sometimes comes up like this, its something like I did, it reminds me of something I did once before. I'd better not criticise.

DMS Interview: ANDREW

A1. SO ANDREW, YOU DO GEOGRAPHY A LEVEL AND TD, IS THAT RIGHT!
Yes.

A2. DO YOU USE COMPUTERS AT ALL IN TD?
No, until this course I have never used a computer before at all. It's all a bit new to me.

A3. HOW DOES THIS WORK COMPARE WITH YOUR USE OF COMPUTERS EARLIER ON IN THE YEAR - WHEN YOU HAD.... URBAN WELFARE?
It's a lot easier now, now that I can understand it A bit more. Still a few things crop up.

A4. IT'S QUITE A LOT TO LEARN ISN'T 1T - TO USE IT?
Yes, it is I suppose, but it is all new to me.

A5. WHAT, WHAT DO YOU THINK ARE THE MOST DIFFICULT THINGS WHEN YOU ARE USING THIS PROGRAM? WHAT DO YOU THINK ARE .... HAVE BEEN PROBLEMS?
Well, with not knowing anything about computer programming and everything, it's understanding what's actually in the model .... the VALUES. The figures is the main problem.

A6. DO YOU FIND IT DIFFICULT TO TRANSLATE THE GRAPH, WHICH YOU SEE ON THE BLACKBOARD OR ON THE SCREEN, RELATE IT BACK TO THE 'VALUES' AND THE 'MODEL'?
No, when, when you've actually got the MODELS or VALUES alongside the GRAPH it's easy enough to translate the two. When you've got both them together. When you are given them separate, that's the problem.

A7. SO YOU CAN SEE WHY THE LINES GO UP OR GO DOWN. WHAT ABOUT THIS MORNING'S MODEL, DID YOU FIND THAT QUITE A DIFFICULT ONE
I found it a bit difficult at first, but once I started picking it up ....

A8. BY THE TIME WE GOT TO BREAK, YOU HAD GOT THE TWO CURVES IN THE RIGHT PLACE AND GOING THE RIGHT WAY. BY THEN DID YOU FEEL YOU HAD COMPLETE KNOWLEDGE OF WHAT THE 'MODEL' WAS

Yes, all the pieces sort of fitted together and it seemed to be a lot easier, yes.

A9. DO YOU THINK THAT IT IS FAIRLY TYPICAL YOU START OFF SEEING HOW ONE BIT WORKS AND THEN YOU SLOWLY PIECE TOGETHER.... ?
Yes, that's right.

A10. WOULD IT SURPRISE YOU TO KNOW THAT MR. GOBLE SAID IT WAS QUITE DIFFICULT TO MAKE THAT 'MODEL' IN THE FIRST PLACE AND TO GET IT RIGHT.
No, it doesn't surprise me. If it was difficult at first, I found it pretty difficult.

A11. BECAUSE THE ONE YOU ARE DOING NOW, YOU ARE DRAWING ONE LINE AREN'T YOU - POPULATION GROWTH?
Yes we have tried to piece together the birth rates and death rates, and the rate of migration as well to make a single line.

A12. THIS IS WRITING A 'MODEL' STARTING FROM SCRATCH WITH A BLANK SCREEN?
Yes, that's right.

A13. DO YOU FIND THAT QUITE FRIGHTENING WITH NO HELP?
When the word is mentioned - 'On your own, you are starting from scratch.' It gets you a bit.

A14. SO YOU HAVE HAD ABOUT .... TWENTY MINUTES ON THIS SUBJECT, TO WORK ON THIS PROBLEM, HOW FAR HAVE YOU GOT NOW?
Well, we have got our line, and now we have got to the stage where we're altering a few bits.

A15. WOULD YOU CALL THAT FINE TUNING
Or something.

A16. SO IS THAT THE FIRST TIME YOU HAVE MADE A MODEL FROM SCRATCH?
No we did do ... we were working on one or two last week on oil exploration and development.

A17. WHAT WERE YOU DOING THERE, BECAUSE I HAVEN'T SEEN THAT MODEL?

I can't remember now.... We were taking the initial cost of development - exploration - seeing how it increased or decreased over the number of years until oil was actually available.

A18. SO WHAT DO YOU THINK ARE THE PROBLEMS FACING OIL COMPANIES, IN THE NORTH SEA FOR EXAMPLE?
Well the major cost, the problem they are faced with is when is the oil going to run out.

A19. SO DID YOU FIND IT EASIER TO LINK UP WHAT YOU HAVE BEEN DOING WITH YOUR PROGRAM TO WHAT YOU READ IN NEWSPAPERS, OR SEE ON A TELEVISION?
Yes, it does help a lot reading through newspapers and watching the news on the television about what is going on in the world. It does ... put the program to right.

A20. DOES THAT GIVE YOU IDEAS WHEN YOU ARE BUILDING YOUR 'MODEL', OR DOES IT HELP YOU TO UNDERSTAND THE GRAPHS THAT THE 'MODEL' PRODUCES!
It helps understand the GRAPHS, ... it does work the other way as well.

A21. SO IF YOU WERE WORKING IN AN OIL COMPANY, COULD YOU IMAGINE USING A PROGRAM LIKE THIS - BUT PERHAPS A BIT MORE SOPHISTICATED?
I think it would have to be a bit more sophisticated, although, probably it's the easiest I think, but most of the time the graph is predictable because you have got to out all the VALUES and the MODEL and everything into it, you have to tell it what to do. Whereas, if you could just do... draw it (as you would) on a piece of paper

A22. WHAT DO THINK ARE THE ADVANTAGES OF WORKING THIS WAY, COMPARED WITH
WORKING ON PAPER
.. (Laughing).. it's easier I suppose, Whereas you don't get writer's cramp it's not as though you are left on your own to do it, you get a lot of help all the time.

A23. WHO FROM, FROM THE OTHER STUDENTS OR ...
The other students, or from the teacher.

A24. DO YOU FIND IT QUITE USEFUL TO BE IN A GROUP RATHER THAN WORKING ON YOUR OWN?
Yes, it's a lot easier, seeing I haven't used one before.

A25. IN FACT WOULD YOU SAY, IT'S A BAD IDEA TO WORK ON YOUR OWN - DOING THIS SORT OF WORK?
Well yes, especially if it is a new subject. I think it is a lot better way of doing it.

A26. DO YOU FIND IT HELPS HAVING THREE MACHINES SIDE-BY-SIDE LIKE THIS, SO PEOPLE CAN TRY OUT DIFFERENT THINGS AND.... ?
You can always look over and find what you are doing wrong .... other times we all work on one machine.

A27. THEN YOU HAVE TO ARGUE ABOUT WHAT IS GOING TO GO IN NEXT?
It's a split the difference like.

A28. SO WHEN YOU GOT A SITUATION LIKE THAT, WHO DECIDES WHAT GETS TYPED IN?
Whoever is typing, mainly.

A29. THEY MAKE THE DECISIONS?
Yes they type it in before everyone his finished arguing.

A30. DO YOU FIND THAT ONE PERSON TENDS TO HAVE A DOMINANT POSITION, AND LEADS THE WAY FOR THE WHOLE GROUP, OR IS THERE GENUINE.... ?
I think Manesh for most of the time.

A31. SO YOU FOUND THAT ONE PERSON DOES TEND TO ... ?
Yes, mainly because he knows more about them than everybody else.

A32. THAT'S A BIG HELP DO YOU THINK?
Yes.

A33. DO YOU THINK IT WILL HELP HAVING HAD THIS EXPERIENCE, WHEN YOU GO ON COURSES IN FUTURE OR APPLY FOR JOBS?

Not so such, I'm hoping to use Geography for cartography and out of door pursuits, I think the knowledge of using computers will help me a lot in other jobs.

A34. DO YOU THINK THAT MANY OF THE STUDENTS HERE, OR IN OTHER SCHOOLS, WILL HAVE THIS SORT OF EXPERIENCE? OR DO YOU THINK YOU ARE AHEAD OF MOST PEOPLE?
I think a lot of then have had experience of using computers. Because, it is something they wanted to do because computers are used ..(noise).. I haven't really been interested as such.

A35. DOES THIS CHANGE YOUR ATTITUDE TO COMPUTERS?
To be honest about it ..(laughing).. no! It hasn't quite frankly. Because you have still got to .... you're still doing all the work, printing all the information into it. When as you know that information anyway, you've still writing it out.

A36. DO YOU THINK, BECAUSE YOU HAVE TO TELL A MACHINE WHAT TO DO, THAT YOU HAVE LEARNT THINGS YOU WOULDN'T HAVE LEARNT OTHERWISE?
.... Yes, because you have got to put certain little digits and things to actually put it into the computer - so the computer understands it. Not that I understand it myself..... it does help.

A37. THE COMPUTER IS QUITE A STRICT MASTER ISN'T IT, IF YOU GET AN ERROR ...
There's only one little mistake and it says 'No such variable' or .... quite frustrating.

A38. RIGHT, SO, ARE THERE ANY OTHER THINGS YOU WOULD LIKE TO SAY ABOUT THE PROGRAM, OR HOW WOULD YOU LIKE TO SEE IT CHANGED TO MAKE IT BETTER OR MORE USEFUL TO YOU?
The only ways you can change it, are by sort of experimenting, and coming up with the best answer. I think though that generally they are a good idea.

A39. HAVE YOU HEARD OF THINGS CALLED SPREADSHEETS BEFORE?
No. ..(Laughing)..

A40. ..BECAUSE THAT'S THE SORT OF PROGRAM WHICH DOES SIMILAR THINGS. ACCOUNTANTS USE IT, BUT RATHER THAN WORKING ON THE MODEL LIKE THAT YOU WORK ON A TABLE OF FIGURES - THE SAME WAY AS ACCOUNTANTS WORK ON PAPER. IT'S LAID OUT IN COLUMNS AND ROWS. COULD YOU IMAGINE USING A PACKAGE LIKE THAT, OR A PROGRAM LIKE THAT? ... WHERE YOU'RE WORKING WITH TABLES OF FIGURES RATHER THAN A MODEL LIKE THIS ?
It's like a lot of things, it's alright if you can have practice an it.

A41. DO YOU THINK THE 'GRAPH' IS VERY USEFUL, COULD YOU IMAGINE IF THE ANSWERS WERE JUST COMING OUT .... OR THE RESULTS WERE COMING OUT JUST AS A TABLE OF FIGURES. DO YOU THINK THAT WOULD BE AS EASY TO UNDERSTAND OR.... ?
No, the useful thing with the computer is that the TABLE appears, and the GRAPH or the MODEL or the VALUES on either side of the screen. So you can compare them and work out how it is all worked out.

A42. DO YOU THINK IT WOULD BE USEFUL TO HAVE SOME REAL FIGURES WHICH YOU COULD COMPARE YOUR MODEL AGAINST?
Yes, that would be a lot of use, very useful because the only figures you have got on there are the ones you've actually put on yourself.

A43. SO FOR EXAMPLE, IF YOU HAD SOME FIGURES ON POPULATION GROWTH FOR A COUNTRY OVER A PERIOD OF TIME, YOU COULD THEN TRY AND MAKE YOUR MODEL FIT THE REAL DATA PERHAPS?
Yes, that would make it easier to understand. You could go through looking all the way through it and find out where bits actually change.

A44. THANKYOU

DMS interview: Jennifer

J1. JENNIFER, NOW YOU ARE THE MATHEMATICIAN IN THIS GROUP AND YOU DO MATHS A LEVEL AS WELL AS GEOGRAPHY?
Yes.

J2. DO YOU FIND THAT HELPS AT ALL?
In some things yes, for anticipating the graphs, and when he gives us various things you can sort of think where it is going to go ... it does help a bit.

J3. DO YOU THINK OF THIS PROGRAM AS A MATHEMATICAL PROGRAM, OR WHAT?
In some ways, because there's a lot of figures and working out, But in others, because it is based on Geography, and various parts of it, you don't really. ... you don't think it's maths.

J4. SO YOU THINK ABOUT THE POOR CHAP WHO IS TRYING TO MAKE A PROFIT FOR
HIS FIRM?
Yes.

J5. TO KEEP HIS COSTS AND PRICES (DOWN), AND SO ON?
I get into that quite well.

J6. DO YOU FIND IT FAIRLY EASY TO RELATE THE PROGRAM AND THE WORK YOU ARE DOING WITH IT - TO THE REAL WORLD OUTSIDE, IN BUSINESS AND SO ON?
Somethings yes, somethings I do like sort of population, costs increase and all that, the majority of it's all a bit... the limitations put you off a bit. Because you can't change it enough, but otherwise it's like the real world, it's quite okay.

J7. WHAT SORT OF LIMITATIONS DO YOU FEEL .... ?
Well, you can, every time you, . . . I don't know, but on that PUDDLE when there's a lot of those and you couldn't have infiltrate rate after such-and-such and just keep it at that, and you couldn't change it on the graph, what you wanted. Because I'm not very good with

computers and you can't expect to put ... to change what you want in the end. You have to ask Manesh he will get it.

J8. SO YOU'RE TALKING ABOUT NOW PUDDLE ... WHAT WAS THAT THE ... YOU WERE THINKING OF THE PROGRAM YOU USED EARLIER ON IN THE TERM?
Yes, we found a lot of limitations with that, which was annoying, it's quite a good one though.

J9. IF WE CONCENTRATE ON THE ONE WE ARE DOING NOW. AT THE MOMENT YOU ARE BUILDING A POPULATION GROWTH MODEL FROM NOTHING, FROM SCRATCH.
Yes. it's a bit difficult.

J10. HOW DO YOU START? YOU HAVE GOT A BLANK SCREEN, WHERE DO YOU BEGIN?
You begin with, well, I began with the basic sort of equations, the natural increase. You have got to have the birth minus the death rate and you sort of work along that line. You've got population which starts at something and you have got a death rate over, per thousand people and you just sort of try building up your equations and put them into your models and you've done it.

J11. DO YOU FIND YOU DO A BIT AT A TIME AND SEE HOW IT GOES, AND THEN MODIFY IT?
Yes, put a bit in, work that bit out and go along with it until you have got everything.

J12. DO YOU FIND IT EASY TO COPE WITH BIRTH AND DEATH RATES BEING FIGURES PER THOUSAND..?
Yes, they are easier, yes. Because when I'm putting in them I sort of think, if well I have that as say a hundred over thousand, because I do put in figures while I'm working on equations ... it's easy.

J13. DO YOU KNOW WHAT REALISTIC FIGURES ARE FOR BIRTH AND DEATH RATES?
No I don't, I think...

J14. FOR BRITAIN OR IN THIRD WORLD COUNTRIES?

I think per thousand. . (noise) . the average family is 2.2, but I couldn't tell you anything else.

J15. YOU'VE DONE A BIT OF WORK ON DEMOGRAPHY HAVEN'T YOU IN YOUR FIFTH YEAR?
Yes, I've done a little bit.

J16. YOU DO THEN THE CRUDE BIRTH RATE AND DEATH RATE LIKE THIS?
Yes.

J17. WHERE THE CURVE GETS STEEPER ...
Yes, it's very ... we didn't do very much on it.

J18. RIGHT, DO YOU FIND THE 'TABLE' IS VERY USEFUL, FOR LOOKING AT FIGURES FROM YOUR MODEL, AS WELL AS THE 'GRAPH'?
Well yes, if you look at the GRAPH and you don't get everything you want from that, you go to the TABLE and you can see whole. If you have gone wrong somewhere you can see it from the TABLE easier than (from) the GRAPH. We don't often use the TABLES, we just don't think of them. You get everything you want from the GRAPH.

J19. AND DOING MATHS IT'S EASY TO INTERPRET GRAPHS?
Yes.

J20. AND IT'S NATURAL..
Yes it's just a thing you have to do. So it is easier.

J21. DO YOU FIND THAT SOME OF THE OTHERS IN THE GROUP FIND GRAPHS DIFFICULT, OR ARE MOST PEOPLE QUITE HAPPY WITH THEM?
I think the majority are quite happy, because we all sort of did O Level Maths and we passed. We all have a basic understanding of them. It's not too difficult, it's just when you get the harder ones well you sort of think, well it's going to be bad.

J22. DO YOU THINK, YOU KNOW, DOING THIS SORT OF WORK THAT'S PROGRAMMING) AND PLAYING AROUND WITH GRAPHS THIS WAY. DO YOU THINK IT HAS HELPED YOU WITH YOUR MATHEMATICS AT ALL?
Yes.

J23. IT HAS?
Yes, because we did a lot of graphs when we started doing these and it was very much easier to sort of think, ah well that is going to be that, and it's much easier.

J24. COULD YOU IMAGINE USING THIS PROGRAM IN A MATHS LESSON, DO YOU THINK IT WOULD HELP YOU?
I think it might do, say when you start using graphs, it would help you to sort of build up your own knowledge of it, and learn how to program, and draw up a (map?) and everything. It would save space as well.

J25. SAVE SPACE?
Yes, you don't have to do it in your maths book then.

J26. YES, SO YOU PREFER DOING IT ON THE SCREEN TO DOING IT, TO DRAWING GRAPHS ON PAPER?
Yes, it is much easier.

J27. WHY IS THAT?
Well if I do it on screen, if you've gone slightly wrong, I can sort of go back and find out why; and I just correct it. I have not wasted any space and all the rubbing it out and everything else, it's much easier.

J28. DO YOU THINK YOU USE, ... DO YOU END UP SPENDING MORE TIME MAKING ALL THESE CHANGES AND TRYING DIFFERENT THINGS OUT, OR DO YOU THINK IT IS QUICKER BECAUSE YOU DON'T HAVE TO REDRAW IT MANUALLY?
It is quicker , very much quicker, and you can see your results quicker, and they are more accurate than if you were drawing them by hand. Because if you did it by hand you are bound to be a few points off or something. That is ...

J29. THAT IS USEFUL. SO YOU THINK THERE ARE ANY OTHER PROBLEMS WITH THE GRAPHS? PEOPLE WERE DOING FUNNY THINGS THIS MORNING, MOVING THE AXES AROUND AND SO ON, WERE THERE ANY PROBLEMS THERE?
Yes it does, because if you move the axes around, you do upset the whole part of your thing. I don't think you should be able to do that. It really upsets me (laughing). Because your equation goes

right out of the window, otherwise it is okay, it's not many people who have problems.

J30. THIS MORNING LOOKING AT THE MODELS IT WAS SOMETIMES DIFFICULT FOR ME TO KNOW WHICH LINE YOU WERE PLAYING WITH, BECAUSE THE LINES WEREN'T LABELLED ON THE 'GRAPH'.
Yes, that's true. If, . . . I suppose if you are actually doing the graph then, and you keep doing different ones, you know which one you are following. So you can sort of remember which one was for which.

J31. SO YOU ARE INTO IT, .. AND YOU KNOW WHAT YOU ARE DOING?
Yes, roughly (laughing) , after too many though you get a bit stuck. It's not too bad.

J32. HOW LONG DOES IT TAKE YOU TO SORT OUT A MODEL? FOR EXAMPLE, THIS MORNING'S ONE WAS QUITE COMPLICATED AND YOU WERE DRAWING FOUR DIFFERENT LINES: TWO FOR PRICE, TWO FOR COST ...
It depends on what the model is. If it is pretty difficult. You have to go back to the beginning and work through and it will take sometimes, a good half an hour to an hour. But if it is a fairly basic one, it's not too bad if the equations and stuff is (are) easy. You can just go straight through it and find out where you can change it. But I think the first ten minutes you have got to find out what you can change, and how. Then you can go back to your program.

J33. YOU NORMALLY START BY CHANGING 'VALUES'?
Yes, see what I can change and how it does alter the graph. It's the easiest way. Then you go on to, going back to the actual equations and changing that, or adding lines to it,

J34. YOU NORMALLY WOULDN'T CHANGE THE 'MODEL' UNTIL YOU HAVE GOT THE 'VALUES'....?
No, until I knew what was ... I'd change the VALUES.

J35. THAT'S INTERESTING. WHAT WILL HAPPEN NEXT YEAR? DO YOU THINK YOU WILL USE THIS PROGRAM AGAIN IN FUTURE, OR WOULD YOU EXPECT TO?
I expect to use it again. Because you could do some more programs on it you could use it for (... ?). I would enjoy using it again, because it does help a bit.... I wouldn't mind.

J36. YOU DON'T HAVE A COMPUTER AT HOME?
No, I don't.

J37. DO YOU THINK YOU WOULD HAVE ONE IN THE FUTURE - SOME DAY?
Most probably, I reckon everybody will end up getting a computer and it just would be a standard thing, I reckon I will.

J38. DO YOU THINK YOU WILL ACTUALLY BE WRITING YOUR OWN PROGRAMS OR PERHAPS USING PROGRAMS LIKE THIS, WHICH ARE WRITTEN FOR YOU?
I reckon at first that you'd be using ones that are written for you and maybe as your confidence builds up you would begin to do your own. Like what we have here.

J39. TODAY, FOR EXAMPLE, YOU WERE MAKING YOUR OWN MODEL. HOW DO YOU REGARD THAT? DO YOU FIND IT ESSENTIALLY A MATHEMATICAL TASK? OR DO YOU THINK OF IT AS A PROGRAMMING TASK OR HOW DO YOU VIEW IT?
A bit of both, because we started off ... I mean I got my pen and paper and worked out what I was going to do. what was the basic maths about it, and then it was remembering the programming part and putting it in. So it's a bit of both really.

J40. SO, DO YOU SEE IT AS TWO STAGES?
Yes.

J41. THE MATHS FIRST, AND THEN MAKING IT HAPPEN?
Yes, that's the best bit.

J42. SO YOU FIND THAT THE SECOND PART IS MORE DIFFICULT?
Occasionally it is, because you've got to put it up on the screen and it is not so easy. And you can't tell it what to do, because it doesn't understand you. You've got to print it all in. I don't like doing that. It certainly would be better if it talked, I would like that.

J43. YOU WOULD LIKE THAT?
Yes, do it by talking to it.

J44. YES, SO IT IS THE KEYBOARD ... IT'S A BIT UNNATURAL?

Yes, I can type but because you've got the various SHIFT keys and everything else, and then you've got the other RETURN buttons that puts you off a bit. ...But it's not too bad .

J45. SO, IN A WAY THIS WAS YOUR FIRST EXPERIENCE THEN OF PROGRAMMING?
Well, I did computers in the fourth year. But we weren't on it as much as we are now, and there was..... one computer. So it's, I mean I remember basically how each, how to run it all through. But otherwise it's Manesh, he can do it.

J46. SO YOU RELY ON HIM TO GIVE YOU PROMPTS?
Yes, he sort of, you know, tells us what to do next. When we started doing it he was the one that always programmed it. And we just told him what to do.

J47. DO YOU THINK OVER THE LAST FOUR WEEKS WITH THIS PROGRAM THAT YOU ALL ARE GETTING TO THE STAGE NOW WHERE YOU CAN DO IT ON YOUR OWN NEARLY?
Yes, I think we are getting more to that stage. I mean I'm still, ... especially me and Helen, we still stick together, to do it, to come out with it. But I think we could if we needed to.

J48. SO YOU LIKE WORKING IN A GROUP?
I prefer working in a group, yes.

J49. WHY IS THAT?
Well, I mean you've got your own ideas and you get everyone else and it's a bit of a competition really to see who's got the right one, things like that. I prefer it in a group.

J50. SO YOU FIND IT USEFUL HAVING SEVERAL MACHINES, SO THAT YOU CAN COMPARE BETWEEN DIFFERENT SCREENS?
Yes, that is easier, yes. Because you can keep up various parts and they can try something else. And while they are doing that you can try it, to see what you come up with. It does help, but it's not bad on one only.

J51. SO YOU FEEL YOU CAN GET, MAKE QUITE A LOT OF PROGRESS LIKE THIS WORKING SAY IN ONE HOUR?
Yes, you can.

J52. DO YOU THINK A ONE HOUR LESSON IS THE MINIMUM REALLY TO GET ANYWHERE?
Yes, you couldn't so it in half an hour. Because you would just get everything set-up and into your problem when the bell would go and you would have to go to another lesson.

J53. INTERESTING .... RIGHT I'D BETTER GET ONTO MY LAST INTERVIEW. THANKS VERY MUCH.

DMS Interview: Martin

MA1. SO, MARTIN YOU ARE DOING GEOGRAPHY AND TD?
Yes.

MA2. YOU HAVEN'T USED A COMPUTER OUTSIDE OF THE GEOGRAPHY?
That's (not right?). I did computer studies at 'O Level' and I have got a computer at home; but I don't use it that much.

MA3. SO, WHAT SORT OF THINGS DID YOU DO IN 'O LEVEL' COMPUTER STUDIES?
We did small programs like reading figures and display, didn't do any graph work, and just laid them out in tables and that sort of stuff. I didn't learn that much.

MA4. WHAT SORT OF MICRO HAVE YOU GOT AT HOME?
A Commodore 64.

MA5. RIGHT.
Really, it's my brother's really, but I've used it a couple of times.

MA6. FOR GAMES, OR PROGRAMMING OR .... ?
I did a bit of programming, but not a lot. I haven't got time for it.

MA7. OKAY, WHEN YOU COME TO A PROGRAM LIKE THIS (DMS) DO YOU THINK IT HELPS HAVING DONE SOME 'BASIC' PROGRAMMING BEFORE?
Yes it does, because I've been doing some READing DATA, which I knew about but didn't do it before ....

MA8. SO, HOW DO YOU SEE THIS ACTIVITY WHICH YOU HAVE BEEN DOING THE LAST FEW WEEKS, PLAYING THIS PROGRAM? HOW DO YOU THINK IT FITS INTO YOUR NORMAL COURSE HERE?
It's alright. Didn't understand much about it before. I didn't really understand it yesterday , but I got it yesterday that program and found I understand (..stood) it just all twigged.

MA9. WHAT DO YOU FIND IS THE DIFFICULT PART OF, YOU KNOW, OF USING A MODEL LIKE THAT ?

I suppose when you are actually given a model to do yourself. Trying to think it - starting it is a problem. Once you get going it is alright. It is pretty easy to write on that. Models... it is like writing a normal program , it's very easy.

MA10. DO YOU LIKE THE WAY THAT YOU DON'T HAVE TO PROGRAM THE GRAPH, IT IS DONE FOR YOU ?
Yes a lot, I'm not very good at doing graphs at all.

MA11. DO YOU HAVE ANY PROBLEM LABELLING THE GRAPH'S AXES, OR DECIDING WHAT SORT OF MAXIMUM VALUES TO HAVE ?
No they're very quick, and if you do it wrong you can just change it in a minute or so. So, it is very easy to label it.

MA12. WHAT ABOUT CHOOSING SUITABLE MAXIMUM VALUES ON THE GRAPH, DO YOU FIND THAT EASY, TO SORT OF ...?
Not at the moment, it is all guess-work to see what looks good. It all depends on what's in.. the VALUES in the MODEL well, so it's not that hard.
MA13. IF THE LINE DOESN'T APPEAR ON THE GRAPH OR DOESN'T DO QUITE WHAT YOU EXPECT; DO YOU HAVE ANY METHODS FOR SORTING IT OUT.
I look at the TABLE first, to see if anything did happen, usually it means it is so slight that it didn't notice anything. Usually you just sit there, wracking your brains about it. It's quite easy to find out what went wrong. The TABLE helps a lot.

MA14. BUT ONCE YOU HAVE GOT IT ON THE GRAPH YOU DON'T USE THE TABLE SO MUCH THEN?
No, once it works you just ignore the TABLE.

MA15. DO YOU FIND IT EASIER TO INTERPRET THE GRAPHS, AND TO DECIDE WHETHER THEY ARE DOING WHAT YOU WANT THEM TO DO?
No, especially when you ..(noise).. TABLES, it takes too long to look up TABLES, because it's what, a hundred years is a long time to look up. And most of the time I'm doing six hundred years there, so a TABLE would take a long time.

MA16. SO YOU ARE DOING SIX HUNDRED YEARS OF POPULATION GROWTH?

Yes, well I'm experimenting with the maximum levels. It's just a straight line at the moment.

MA17. SO WHAT SORT OF BIRTH RATES AND DEATH RATES ARE YOU USING?
Well a birth rate of about, just 15 in a hundred, no, 15 in a thousand; and a death rate of about 25 per thousand. But I'm experimenting with others as well.

MA18. WHERE DO YOU GET THOSE VALUES FROM?
Well I read them up.

MA19. READ THEM UP?
Yes, well ..(there isn't any?).. information to look up at the moment. It's probably a lot more than that.

MA20. NOW, DO YOU THINK IT WOULD BE HELPFUL TO BE ABLE TO HAVE REAL DATA WHICH YOU COULD COMPARE WITH?
Yes, it would, then the GRAPH would be easier to look at. As well as having the right values on the GRAPH and the maximum values, otherwise it is too slight to notice.

MA21. GOING BACK TO THAT EARLIER QUESTION. DOES THIS LINK IN EASILY WITH WHAT YOU NORMALLY DO IN GEOGRAPHY, SAY YOUR 16-19 WORK ON .... ?
Yes, we did very similar stuff on the (white) boards earlier on, so it's exactly the same. It's easier to do though, more accurate.

MA22. SUPPOSING YOU HAD JUST DONE IT ON THE BOARD AND YOU DIDN'T HAVE THE COMPUTER, DO YOU THINK YOU WOULD BE WORSE OFF?
With the transport one that we did earlier on, we did it on the board, I was lost, I didn't understand any of it so it helped there. I don't understand things like profit margins and stuff, but I understand it now.

MA23. HOW WAS IT THAT YOU CAME TO UNDERSTAND IT USING THE PROGRAM? CAN YOU SORT OF PIN-POINT HOW IT HELPED YOU?
Well reading all the REM statements, in the program explained what it was doing. It just made it a lot easier to understand.

MA24. DID YOU UNDERSTAND IT BY VARYING THE VALUES, AND SEEING HOW EACH OF THEM.. (Yes.) .. HAD AN EFFECT?
MA25. WOULD YOU RECOMMEND OTHER PEOPLE TO USE IT?
Yes, 'A Level' not 'O Level', because it would be a long time to understand it. I'm just understanding it now.

MA26. YES, THAT'S AFTER WHAT, THREE OR FOUR WEEKS WORK?
Yes

MA27. BUT IF YOU CAME TO IT AGAIN NEXT YEAR, YOU WOULD BE MORE CONFIDENT..?
Yes, it is a good program, ... once you get to know it. It takes a long time to ... (noise) ...

MA28. HOW MANY HOURS USE OF IT HAVE YOU HAD SO FAR?
About five hours, quite a lot.

MA29. FIVE HOURS SPREAD OVER SEVERAL WEEKS?
Yes, about what, one lesson a week sometimes.

MA30. OKAY, THANKS VERY MUCH.

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APPENDIX THREE

EXPERT SYSTEM - PROTOTYPE - INDUSTRIAL LOCATION

Decision Table structure for prototype expert system industrial location

```
/*              Inp Mat1,   Inp Mat2,  Inp Mat1,    Inp Mat2, Location */
/*-------------------------------------------------------------------*/
ref_location( very_heavy, very_heavy, restricted, restricted, area).
ref_location( very_heavy, very_heavy, restricted, everywhere, one).
ref_location( very_heavy, very_heavy, everywhere, restricted, two).
ref_location( very_heavy, very_heavy, everywhere, everywhere, market).
ref_location( very_heavy,      heavy, restricted, restricted, one).
ref_location( very_heavy,      heavy, restricted, everywhere, one).
ref_location( very_heavy,      heavy, everywhere, restricted, two).
ref_location( very_heavy,      heavy, everywhere, everywhere, market).
ref_location( very_heavy,   moderate, restricted, restricted, one).
ref_location( very_heavy,   moderate, restricted, everywhere, one).
ref_location( very_heavy,   moderate, everywhere, restricted, two).
ref_location( very_heavy,   moderate, everywhere, everywhere, market).
ref_location( very_heavy, negligible, restricted, restricted, one).
ref_location( very_heavy, negligible, restricted, everywhere, one).
ref_location( very_heavy, negligible, everywhere, restricted, market).
ref_location( very_heavy, negligible, everywhere, everywhere, market).

ref_location(      heavy, very_heavy, restricted, restricted, two).
ref_location(      heavy, very_heavy, restricted, everywhere, one).
ref_location(      heavy, very_heavy, everywhere, restricted, two).
ref_location(      heavy, very_heavy, everywhere, everywhere, market).
ref_location(      heavy,      heavy, restricted, restricted, area).
ref_location(      heavy,      heavy, restricted, everywhere, one).
ref_location(      heavy,      heavy, everywhere, restricted, two).
ref_location(      heavy,      heavy, everywhere, everywhere, market).
ref_location(      heavy,   moderate, restricted, restricted, one).
ref_location(      heavy,   moderate, restricted, everywhere, one).
ref_location(      heavy,   moderate, everywhere, restricted, two).

ref_location(      heavy,   moderate, everywhere, everywhere, market).
ref_location(      heavy, negligible, restricted, restricted, one).
ref_location(      heavy, negligible, restricted, everywhere, one).
ref_location(      heavy, negligible, everywhere, restricted, market).
ref_location(      heavy, negligible, everywhere, everywhere, market).
ref_location(   moderate, very_heavy, restricted, restricted, two).
ref_location(   moderate, very_heavy, restricted, everywhere, one).
ref_location(   moderate, very_heavy, everywhere, restricted, two).
ref_location(   moderate, very_heavy, everywhere, everywhere, market).
ref_location(   moderate,      heavy, restricted, restricted, two).
ref_location(   moderate,      heavy, restricted, everywhere, one).
ref_location(   moderate,      heavy, everywhere, restricted, two).
ref_location(   moderate,      heavy, everywhere, everywhere, market).
ref_location(   moderate,   moderate, restricted, restricted, area).
ref_location(   moderate,   moderate, restricted, everywhere, one).
ref_location(   moderate,   moderate, everywhere, restricted, two).
ref_location(   moderate,   moderate, everywhere, everywhere, market).
ref_location(   moderate, negligible, restricted, restricted, one).
ref_location(   moderate, negligible, restricted, everywhere, one).
ref_location(   moderate, negligible, everywhere, restricted, market).
ref_location(   moderate, negligible, everywhere, everywhere, market).

ref_location( negligible, very_heavy, restricted, restricted, two).
ref_location( negligible, very_heavy, restricted, everywhere, market).
ref_location( negligible, very_heavy, everywhere, restricted, two).
ref_location( negligible, very_heavy, everywhere, everywhere, market).
ref_location( negligible,      heavy, restricted, restricted, two).
ref_location( negligible,      heavy, restricted, everywhere, market).
ref_location( negligible,      heavy, everywhere, restricted, two).
ref_location( negligible,      heavy, everywhere, everywhere, market).
ref_location( negligible,   moderate, restricted, restricted, two).
ref_location( negligible,   moderate, restricted, everywhere, market).
ref_location( negligible,   moderate, everywhere, restricted, two).
ref_location( negligible,   moderate, everywhere, everywhere, market).
ref_location( negligible, negligible, restricted, restricted, market).
ref_location( negligible, negligible, restricted, everywhere, market).
ref_location( negligible, negligible, everywhere, restricted, market).
ref_location( negligible, negligible, everywhere, everywhere, market).
```

```
/*                  Inp Mat1,   Inp Mat2,  Type */
/*-----------------------------------------------*/
ref_industry_type( very_heavy, very_heavy, heavy).
ref_industry_type( very_heavy,      heavy, heavy).
ref_industry_type( very_heavy,   moderate, heavy).
ref_industry_type( very_heavy, negligible, heavy).

ref_industry_type(      heavy, very_heavy, heavy).
ref_industry_type(      heavy,      heavy, heavy).
ref_industry_type(      heavy,   moderate, heavy).
ref_industry_type(      heavy, negligible, heavy).

ref_industry_type(   moderate, very_heavy, heavy).
ref_industry_type(   moderate,      heavy, heavy).
ref_industry_type(   moderate,   moderate, light).
ref_industry_type(   moderate, negligible, light).

ref_industry_type( negligible, very_heavy, heavy).
ref_industry_type( negligible,      heavy, heavy).
ref_industry_type( negligible,   moderate, light).
ref_industry_type( negligible, negligible, light).

/*               Lowyr, Highyr, Size, Technology */
/*-----------------------------------------------*/
ref_tech_develop(  1860,   1899,          _, period_of_inventions).
ref_tech_develop(  1900,   1959,          _, general_mechanisation).
ref_tech_develop(  1960,   1979, very_large, automation).
ref_tech_develop(  1960,   1979,      large, automation).
ref_tech_develop(  1980,   1986, very_large, computerised_automation).
ref_tech_develop(  1980,   1986,      large, computerised_automation).
ref_tech_develop(  1960,   1986,   moderate, small_scale_automation).
ref_tech_develop(  1960,   1986,      small, small_scale_automation).
ref_tech_develop(  1960,   1986,   workshop, mainly_hand_labour).

/*            Lowyr, Highyr,  Type,   Market, Transport */
/*--------------------------------------------------------*/
ref_transport(  1860,   1899, heavy, national, rail_canal).
ref_transport(  1860,   1899, heavy, regional, rail_canal).
ref_transport(  1900,   1986, heavy, national, rail).
ref_transport(  1900,   1986, heavy, regional, rail).
ref_transport(  1900,   1949, light, regional, rail).
ref_transport(  1900,   1949, light, national, rail).
ref_transport(  1950,   1986, light, national, road).
ref_transport(  1950,   1986, light, regional, road).
ref_transport(  1860,   1986, heavy,    local, road).
ref_transport(  1860,   1986, light,    local, road).

/*                  Lowyr, Highyr,   Target,   Market,  Type, Growth */
/*-------------------------------------------------------------------*/
ref_growth_industry(  1860,   1899,        _,        _,     _, rapid_growth).
ref_growth_industry(  1900,   1959,        _,        _,     _, steady_growth).
ref_growth_industry(  1960,   1986, consumer, national, light, fast_growth).
ref_growth_industry(  1960,   1986, consumer, regional, light, fast_growth).
ref_growth_industry(  1960,   1986,     both, national, light, fast_growth).
ref_growth_industry(  1960,   1986,     both, regional, light, fast_growth).
ref_growth_industry(  1960,   1986, industry,        _, heavy, decline).

/*              Lowyr, Highyr, Type, Size, Growth, Management */
/*-------------------------------------------------------------*/
ref_management(  1860,  1899, heavy,          _,           _, entreprenneur).
ref_management(  1860,  1899, light,          _,           _, individual).
ref_management(  1900,  1929,     _,          _,           _, individual_and_family).
ref_management(  1930,  1959,     _,      large,           _, directors).
ref_management(  1930,  1959,     _, very_large,           _, directors).
ref_management(  1930,  1959,     _,   moderate,           _, individual_and_family).
ref_management(  1930,  1959,     _,      small,           _, individual_and_family).
ref_management(  1930,  1959,     _,   workshop,           _, individual).
ref_management(  1960,  1986,     _,      large,           _, corporate).
ref_management(  1960,  1986,     _, very_large,     decline, corporate).
ref_management(  1960,  1986,     _, very_large, fast_growth, multi_national).
ref_management(  1960,  1986,     _,   moderate,           _, small_company_status).
ref_management(  1960,  1986,     _,      small,           _, individual).

ref_management(  1960,  1986,     _,   workshop,           _, individual).
```

Rule base for prototype expert system industrial location including explanation facility for each rule

```
location(Name,Year,specific_location,Im1s):-
     materials(Name,Year,Im1name,Im1rw,Im1s,Im1u,Im2name,Im2rw,Im2s,Im2u,Target,Msize,Isize),
     ref_location(Im1rw,Im2rw,Im1u,Im2u,one).
exp_location(Name,Year,specific_location,Im1s):-
     materials(Name,Year,Im1name,Im1rw,Im1s,Im1u,Im2name,Im2rw,Im2s,Im2u,Target,Msize,Isize),
     ref_location(Im1rw,Im2rw,Im1u,Im2u,one),
     cls,
     write('The Industry Name is..................... '),write(Name),nl,
     write('The Year of Location is.................. '),write(Year),nl,
     write('-----------------------------------------'),nl,
     write('The input material....................... '),write(Im1name),nl,nl,
     write('has a restricted location and is heavier '),nl,
     write('than the other input material which is . '),write(Im2name),nl,nl,
     write('therefore the location is at the source  '),nl,
     write('of the input material namely the ....... '),write(Im1s).

location(Name,Year,specific_location,Im2s):-
     materials(Name,Year,Im1name,Im1rw,Im1s,Im1u,Im2name,Im2rw,Im2s,Im2u,Target,Msize,Isize),
     ref_location(Im1rw,Im2rw,Im1u,Im2u,two).
exp_location(Name,Year,specific_location,Im2s):-
     materials(Name,Year,Im1name,Im1rw,Im1s,Im1u,Im2name,Im2rw,Im2s,Im2u,Target,Msize,Isize),
     ref_location(Im1rw,Im2rw,Im1u,Im2u,two),
     cls,
     write('The Industry Name is..................... '),write(Name),nl,
     write('The Year of Location is.................. '),write(Year),nl,
     write('-----------------------------------------'),nl,
     write('The input material....................... '),write(Im2name),nl,nl,
     write('has a restricted location and is heavier '),nl,
     write('than the other input material which is...'),write(Im1name),nl,nl,
     write('therefore the location is at the source  '),nl,nl,
     write('of the input material namely the ....... '),write(Im2s).


location(Name,Year,area_location,Position):-
     materials(Name,Year,Im1name,Im1rw,Im1s,Im1u,Im2name,Im2rw,Im2s,Im2u,Target,Msize,Isize),
     ref_location(Im1rw,Im2rw,Im1u,Im2u,area),
     Position = Im1s + Im2s.
exp_location(Name,Year,area_location,Position):-
     materials(Name,Year,Im1name,Im1rw,Im1s,Im1u,Im2name,Im2rw,Im2s,Im2u,Target,Msize,Isize),
     ref_location(Im1rw,Im2rw,Im1u,Im2u,area),
     Position = Im1s + Im2s,
     cls,
     write('The Name of the Industry is.............. '),write(Name),nl,
     write('The Year of Location is.................. '),write(Year),nl,
     write('-----------------------------------------'),nl,
     write('The weight of each input material is ..... '),write(Im1rw),nl,nl,
     write('Both input materials are restricted in their '),nl,
     write('location therefore the industry locates in   '),nl,
     write('an area that has both input materials which  '),nl,
     write('are '),write(Im1name),write(' and  '),write(Im2name).

location(Name,Year,market_location,product_market):-
     materials(Name,Year,Im1name,Im1rw,Im1s,Im1u,Im2name,Im2rw,Im2s,Im2u,Target,Msize,Isize),
     ref_location(Im1rw,Im2rw,Im1u,Im2u,market).
exp_location(Name,Year,market_location,product_market):-
     materials(Name,Year,Im1name,Im1rw,Im1s,Im1u,Im2name,Im2rw,Im2s,Im2u,Target,Msize,Isize),
     ref_location(Im1rw,Im2rw,Im1u,Im2u,market),
     cls,
     write('The Name of the Industry is..............  '),write(Name),nl,
     write('The Year of Location is..................  '),write(Year),nl,
     write('-----------------------------------------  '),nl,
     write('The location of the industry is determined by  '),nl,
     write('weight and availability of the input materials '),nl,nl,
     write('the weight of input material one is..... '),
     write(Im1rw),nl,nl,
     write('the availability of input material one is... '),
     write(Im1u),nl,nl,
     write('the weight of input material two is..... '),
     write(Im1rw),nl,nl,
     write('the availability of input material two is... '),
     write(Im1u),nl,nl,
     write('and so the location is at or close to the market ').
```

```
industry_type(Name,Year,Type):-
     materials(Name,Year,Im1name,Im1rw,Im1s,Im1u,Im2name,Im2rw,Im2s,Im2u,Target,Msize,Isize),
     ref_industry_type(Im1rw,Im2rw,Type).

exp_industry_type(Name,Year,Type):-
materials(Name,Year,Im1name,Im1rw,Im1s,Im1u,Im2name,Im2rw,Im2s,Im2u,Target,Msize,Isize),
     ref_industry_type(Im1rw,Im2rw,Type),
     cls,
     write('The Name of the Industry is..... '),write(Name),nl,
     write('The Year of Location is..... '),write(Year),nl,
     write('-----------------------------------------'),nl,
     write('The following factors influence the type of  '),nl,
     write('industry the weight of the input materials   '),nl,
     write('are obtained from the inputs supplied by the '),nl,nl,
     write('user, they are, firstly ..... '),
     write(Im1name),nl,nl,
     write('which is..... '),
     write(Im1rw),nl,nl,
     write('and secondly..... '),
     write(Im2name),nl,nl,
     write('which is..... '),
     write(Im2rw),nl,nl,
     write('if either of them is very_heavy or heavy then '),nl,
     write('the type is heavy and so this industry is.... '),write(Type).


tech_develop(Name,Year,Technology):-
     materials(Name,Year,Im1name,Im1rw,Im1s,Im1u,Im2name,Im2rw,Im2s,Im2u,Target,Msize,Isize),
     ref_tech_develop(Start,Finish,Isize,Technology),
     Year >= Start,
     Year =< Finish.

exp_tech_develop(Name,Year,Technology):-
     materials(Name,Year,Im1name,Im1rw,Im1s,Im1u,Im2name,Im2rw,Im2s,Im2u,Target,Msize,Isize),
     ref_tech_develop(Start,Finish,Isize,Technology),
     Year >= Start,
     Year =< Finish,
     cls,
     write('The Name of the Industry is..... '),write(Name),nl,
     write('The Year of Location is..... '),write(Year),nl,
     write('-----------------------------------------'),nl,
     write('The factors influencing the technological development are:'),nl,nl,
     write('the industry size is deduced and is..... '),write(Isize),nl,nl,
     write('and for the period beginning..... '),write(Start),nl,nl,
     write('and ending..... '),write(Finish),nl,nl,
     write('the typical technology is ..... '),write(Technology).

transport(Name,Year,Transport):-
     industry_type(Name,Year,Type),
     materials(Name,Year,Im1name,Im1rw,Im1s,Im1u,Im2name,Im2rw,Im2s,Im2u,Target,Msize,Isize),
     ref_transport(Start,Finish,Type,Msize,Transport),
     Year >= Start,
     Year =< Finish.

exp_transport(Name,Year,Transport):-
     industry_type(Name,Year,Type),
     materials(Name,Year,Im1name,Im1rw,Im1s,Im1u,Im2name,Im2rw,Im2s,Im2u,Target,Msize,Isize),
     ref_transport(Start,Finish,Type,Msize,Transport),
     Year >= Start,
     Year =< Finish,
     cls,
     write('The Name of the Industry is..... '),write(Name),nl,
     write('The Year of Location is..... '),write(Year),nl,
     write('-----------------------------------------'),nl,
     write('The factors that influence the transport are'),nl,nl,
     write('the industry type is deduced and is..... '),write(Type),nl,nl,
     write('the size of the market obtained from user. '),write(Msize),nl,nl,
     write('the market target obtained from the user.. '),write(Target),nl,nl,
     write('the period of years beginning in..... '),write(Start),nl,nl,
     write('and ending in..... '),write(Finish),nl,nl,
     write('has a transport type of ..... '),write(Transport).
```

```
growth_industry(Name,Year,Growth):-
     materials(Name,Year,Im1name,Im1rw,Im1s,Im1u,Im2name,Im2rw,Im2s,Im2u,Target,Msize,Isize),
     industry_type(Name,Year,Type),
     ref_growth_industry(Start,Finish,Target,Msize,Type,Growth),
     Year >= Start,
     Year =< Finish.

exp_growth_industry(Name,Year,Growth):-
     materials(Name,Year,Im1name,Im1rw,Im1s,Im1u,Im2name,Im2rw,Im2s,Im2u,Target,Msize,Isize),
     industry_type(Name,Year,Type),
     ref_growth_industry(Start,Finish,Target,Msize,Type,Growth),
     Year >= Start,
     Year =< Finish,
     cls,
     write('The Name of the Industry is..... '),write(Name),nl,
     write('The Year of Location is..... '),write(Year),nl,
     write('-----------------------------------------'),nl,
     write('The factors which influence the growth of the industry are'),nl,nl,
     write('the industry type is deduced and iis..... '),write(Type),nl,nl,
     write('the market size is obtained from the user... '),write(Msize),nl,nl,
     write('the market target is obtained from the user. '),write(Target),nl,nl,
     write('for the period beginning ..... '),write(Start),nl,nl,
     write('and ending..... '),write(Finish),nl,nl,
     write('the trend is..... '),write(Growth).


management(Name,Year,Management):-
     growth_industry(Name,Year,Growth),
     materials(Name,Year,Im1name,Im1rw,Im1s,Im1u,Im2name,Im2rw,Im2s,Im2u,Target,Msize,Isize),
     industry_type(Name,Year,Type),
     ref_management(Start,Finish,Type,Isize,Growth,Management),
     Year >= Start,
     Year =< Finish.

exp_management(Name,Year,Management):-
     growth_industry(Name,Year,Growth),
     materials(Name,Year,Im1name,Im1rw,Im1s,Im1u,Im2name,Im2rw,Im2s,Im2u,Target,Msize,Isize),
     industry_type(Name,Year,Type),
     ref_management(Start,Finish,Type,Isize,Growth,Management),
     Year >= Start,
     Year =< Finish,
     cls,
     write('The Name of the Industry is..... '),write(Name),nl,
     write('The Year of Location is..... '),write(Year),nl,
     write('-----------------------------------------'),nl,
     write('the following factors influence the management '),nl,nl,
     write('the industrial growth trend is ..... '),
     write(Growth),nl,nl,
     write('the industry size is obtained from the user... '),
     write(Isize),nl,nl,
     write('the industry type is deduced and is..... '),
     write(Type),nl,nl,
     write('for the period beginning in..... '),
     write(Start),nl,nl,
     write('and ending in..... '),
     write(Finish),nl,nl,
     write('the management style is..... '),
     write(Management).
```

Prolog code to generate answers, explanations and to make comparisons s between students inputs and the system generated answers

```
result:-
     cls,
     materials(Name, Year, Im1name, Im1rw, Im1s, Im1u,
                                        Im2name, Im2rw, Im2s, Im2u, Target, Msize, Isize),
     location(Name, Year, Nature, Source),
     write('The Industry Name is                '),write(Name),nl,
     write('The Year of the Location is         '),write(Year),nl,
     write('================================================='),nl,
     write('The industry is in a.............  '),write(Nature),nl,
     write('The precise location being.......  '),write(Source),nl,nl,

     industry_type(Name,Year,Type),
     write('Industry type is.................  '),write(Type),nl,nl,
     write('The market size is...............  '),write(Msize),nl,
     write('The market target is.............  '),write(Target),nl,nl,

     tech_develop(Name,Year,Tech),
     write('Technological development........  '),write(Tech),nl,

     transport(Name,Year,Transport),
     write('Transport is.....................  '),write(Transport),nl,nl,

     growth_industry(Name,Year,Growth),
     write('Industrial trend is..............  '),write(Growth),nl,

     management(Name,Year,Management),
     write('Management style is.............. '),write(Management),nl,nl,

     write('For an explanation of any of the factors'),nl,nl,
     write('location       (1)    industry_type (2)       transport  (3)'),nl,
     write('industry_trend (4)    technology    (5)       management (6) '),nl,nl,
     write('Please input choice.............. '),read(Choice),
     explain(Name,Year,Choice),nl,pause,menu.

explain(Name,Year,1):-exp_location(Name,Year,Location,Nature).
explain(Name,Year,2):-exp_industry_type(Name,Year,Type).
explain(Name,Year,3):-exp_transport(Name,Year,Type).
explain(Name,Year,4):-exp_growth_industry(Name,Year,Growth).
explain(Name,Year,5):-exp_tech_develop(Name,Year,Technology).
explain(Name,Year,6):-exp_management(Name,Year,Management).
explain(Name,Year,7):-true.

compare:-
     materials(Name, Year, Im1name, Im1rw, Im1s, Im1u,
                           Im2name, Im2rw, Im2s, Im2u, Target, Msize, Isize),
     location(Name, Year, Nature, Source),
     industry_type(Name, Year, Type),
     tech_develop(Name, Year, Tech),
     transport(Name, Year, Transport),
     growth_industry(Name, Year, Growth),
     management(Name, Year, Management),
     answers(Name, Year, Ansloc, Anssource, Anstype,
                         Anstech, Anstrans, Ansgrowth, Ansmanage),
     comparision(Name, Year, Nature, Source, Type, Tech, Transport,
                 Growth, Management, Ansloc, Anssource, Anstype,
                 Anstech, Anstrans, Ansgrowth, Ansmanage),
     difference(loca, Name, Year, Nature, Ansloc, Source, Ansource),
     difference(type, Name, Year, Type, Anstype),
     difference(tech, Name, Year, Tech, Anstech),
     difference(tran, Name, Year, Transport, Anstrans),
     difference(grow, Name, Year, Growth, Ansgrowth),
     difference(mana, Name, Year, Management, Ansmanage),
     menu.

difference(loca, Name, Year, Nature, Nature, Source, Source).
difference(loca, Name, Year, Nature, Ansloc, Source, Ansource):-
     exp_location(Name, Year, Nature, Source), pause.

difference(loca, Name, Year, Nature, Nature, Source, Ansource):-
     exp_location(Name, Year, Nature, Source), pause.
difference(loca, Name, Year, Nature, Ansloc, Source, Source):-
```

```
     exp_location(Name, Year, Nature, Source), pause.

difference(Any, Name, Year, Same, Same).
difference(type, Name, Year, Type, Anstype):-
     exp_industry_type(Name, Year, Type), pause.

difference(tech, Name, Year, Tech, Anstech):-
     exp_tech_develop(Name, Year, Tech),pause.

difference(tran, Name, Year, Transport, Anstrans):-
     exp_transport(Name, Year, Transport), pause.

difference(grow, Name, Year, Growth, Ansgrowth):-
     exp_growth_industry(Name, Year, Growth), pause.

difference(mana, Name, Year, Management, Ansmanage):-
     exp_management(Name, Year, Management), pause.



pause:- nl,nl,nl,write('Press c. to continue.....................'),
         read(Entry).


comparision(Name, Year, Nature, Source, Type, Tech, Transport,
            Growth, Management, Ansloc, Anssource, Anstype, Anstech,
            Anstrans, Ansgrowth, Ansmanage):-
     cls,
     write('The Name of the Industry is              '),write(Name),nl,
     write('The Year of the Location is              '),write(Year),nl,
     write('================================================='),nl,
     write('The location selected by the computer    '),write(Nature),nl,
     write('The location selected by the user        '),write(Ansloc),nl,
     write('-------------------------------------------------'),nl,
     write('The source selected by the computer      '),write(Source),nl,
     write('The source selected by the user          '),write(Anssource),nl,
     write('-------------------------------------------------'),nl,
     write('The type selected by the computer        '),write(Type),nl,
     write('The type selected by the user            '),write(Anstype),nl,
     write('-------------------------------------------------'),nl,
     write('The technology selected by the computer  '),write(Tech),nl,
     write('The technology selected by the user      '),write(Anstech),nl,
     write('-------------------------------------------------'),nl,
     write('The transport selected by the computer   '),write(Transport),nl,
     write('The transport selected by the computer   '),write(Anstrans),nl,
     write('-------------------------------------------------'),nl,
     write('The growth selected by the computer      '),write(Growth),nl,
     write('The growth selected by the use           '),write(Ansgrowth),nl,
     write('-------------------------------------------------'),nl,
     write('The management selected by the computer  '),write(Management),nl,
     write('The management selected by the user      '),write(Ansmanage),nl,
     write('-------------------------------------------------'),nl,
     write('Press c. to continue.....................'),
     read(Entry).


menu :-
     cls,
     nl,nl,
     write(' MENU'),nl,
     write(' ===='),nl,nl,
     write(' Computer selected answers ..................... 1'),
     nl,nl,
     write(' Comparison of computer and users answers ..... 2'),
     nl,nl,
     write(' Enter selection ..............................'),
     read(Selection),
     select(Selection).

select(1):-result.
select(2):-compare.
```

Sample input information for prototype expert system industrial location based on the steel industry

```
materials(/* Industrial Location */
/*Enter name of industry..................... */ steel,
/*Enter year................................. */ 1920,
/*Name of first industry input material...... */ iron_ore,
/*Weight of first input material */
/*very_heavy  heavy  moderate  negligible ... */ very_heavy,
/*Source of input material one............... */ iron_ore_field,
/*Is source restricted or everywhere......... */ restricted,

/*Name of second industry input material..... */ coal,
/*Relative weight of second input material */
/*very_heavy  heavy  moderate  negligible...  */ heavy,
/*Source of input material two.............. */ coalfield,
/*Is source restricted or everywhere........ */ restricted,

/*Is the target market */
/*industry  consumer  both................... */ industry,
/*Is the size of the market */
/*national   regional   local.............. */ national,

/*Is industry_size */
/*very_large large moderate small workshop */ large).
```

Sample input information for prototype expert system industrial location based on the computer industry

```
materials(/* Industrial Location */
/*Enter name of industry..................... */ computers,
/*Enter year................................. */ 1985,
/*Name of first industry input material...... */ chips,
/*Weight of first input material */
/*very_heavy  heavy  moderate  negligible ... */ negligible,
/*Source of input material one............... */ chip_suppliers,
/*Is source restricted or everywhere......... */ everywhere,

/*Name of second industry input material..... */ plastic,
/*Relative weight of second input material */
/*very_heavy  heavy  moderate  negligible...  */ negligible,
/*Source of input material two.............. */ chemical_company,
/*Is source restricted or everywhere........ */ everywhere,

/*Is the target market */
/*industry  consumer  both................... */ both,
/*Is the size of the market */
/*national   regional   local.............. */ national,

/*Is industry_size */
/*very_large large moderate small workshop */ large).
```

Sample inputs for student provided estimated answers for comparison with system generated answers.

```
answers(
/* Name of industry ..............................*/ steel,
/* Year ..........................................*/ 1920,
/* Location : specific_location  area_location
              market_location .....................*/ area_location,
/* Position ......................................*/ coalfield,
/* Type : heavy  light ...........................*/ light,

/* Technological development
   period_of_inventions     general mechanisation
   automation               small_scale_automation
   computerised automation  mainly_hand_labour.....*/ general_mechanisation,

/* Transport : rail_canal    rail    road .........*/ road,

/* Industrial trend :       rapid_growth    decline
   steady_growth            fast_growth ...........*/ decline,

/* Management style :       entreprennuer
   individual               individual_and_famliy
   directors                corporate
   multi_national           small_company_status .. */ corporate).
```

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APPENDIX FOUR

GEOGRAPHY MODELS FOR DMS

MODEL ONE

POPULATION INCREASE

```
MODEL                                   VALUES

Rem Natural Inc.                        NI =  0
NI   BR -DR                             Y  =  I
Rem Add to present                      BR = 160
Rem Population                          DR = 75
POP = POP + NI                          POP= 9000
Y =  Y + I
BR   BR + 20
DR   DR - 10

     Graph axes:  Y (X) POP (Y)
     Max Values:  50    5000
     Origin 3,2 spaces from bottom left
```

MODEL TWO

POPVAR

```
MODEL                                   VALUES

Rem Vary Birth Rate                     Rem  Birth   Rate
IF Y > 50  BR = BR + CB                 BR  =  40
                                        Rem  Death   Rate
Rem Vary Death Rate                     DR  =  30
IF Y > 20  DR = DR + CD                 Rem Original Pop
                                        POP  = 1000
Rem  Nat  Increase                      Rem  Initial Value
NI = BR  -  DR                          Y  = 0
                                        Rem  Change Death Rate
Rem Nat Incre/Thou                      CD = -0.05
NJ  =  NI/1000                          Rem Change Birth Ra
                                        CB   = -0.2
Rem Incr  in  Pop
INC = POP  *  NJ
Rem  Total  New  Pop
POP = POP  +  INC
Y = Y + 1

     Graph   axes:      Y (X) POP   (Y)
     Max   Values:      200         5000
     Origin:      2,2  spaces from bottom left
```

MODEL THREE

POPULATION GROWTH

```
MODEL          VALUES

Rem  Nat  Increase              Rem  Birth   Rate
NI = BR  -  DR                 BR  =  40
                               Rem  Death   Rate
Rem  Nat   Incr/Thou           DR  =  30
NJ = NI  /  1000               Rem Original Pop
                               POP = 1000
Rem Incr  in  Pop              Rem Initial Value
INC = POP *  NJ                Y  =  0

Rem  Total  New  Pop
POP  = POP +  INC

Rem  Add  Year
Y  = Y + I

     Graph   axes:      Y (X) POP   (Y)
     Max   values:      200   5000

Origin:                2,2  spaces  from   left
```

MODEL FOUR

BIRTH AND DEATH RATES

```
MODEL                          VALUES

Rem   Years                    Rem Birth rate
IF Z = I Y = Y + 1             BR  =  40
Rem   Birth Rate               Rem Death Rate
IF Z = I BR = BR +  J          DR  =  35
IF Z = I PP = BR
                               Rem Change in BR
Rem Death Rate                 J  = 0.05
IF Z = 2 DR = DR + K
IF Z = 2 PP = DR               Rem   Change in DR
                               K  =  -0. I
Rem Nat Increase
IF Z = 3 NI = BR - DR          Rem   Initial Value
IF Z = 3 PP = NI               Z = I
                               NI =  0
Rem   Alternate                PP =  0
Z = Z  +  I
IF Z = 4 Z = I

     Graph axes:       Y (X) PP  (Y)
     Max Values:       100   50
     Origin:           2,2  spaces  from  bottom  left
```

MODEL FIVE

TRANSPORT

```
MODEL                          VALUES

Rem  Dist interval             Rem  Term  Cost  Rail
IF TR = I  DST = DST + 10      TI  =  90
                               Rem   Term Cost Road
Rem    Rail                    T2  =  40
M1 = L1 * DST                  Rem   Line
IF TR = 1 CST = T1 + M1        L1  =  0.3
                               Rem   Line Cost Rail
Rem    Road                    L2  =  0.4
M2 = L2 * DST
IF TR = 2 CST = T2 + M2        Rem  Initial   Values
                               CST   =  0
Rem   Reset Value              DST   =  0
TR = TR  + 1                   TR =   1
IF TR = 3 TR = I

      Graph axes: DST (X)      CST (Y)
      Max values: 1000         500

Origin:           0,2 spaces from bottom left
```

MODEL SIX

DISTANCE COST

```
MODEL                          VALUES

D = D  +  1                    D = 0
T = T  - 1                     E = 1
IF D > 16 E = C * T            C = 10
IF D > 10 E = E/10             T = 35
E = C * D

      Graph axes: D (X)        E(Y)
      Max Values: 55           600
      Origin:     1,2 spaces   from bottom left
```

MODEL SEVEN

STEPPED COST

MODEL

```
Rem  Stepped Cost
Rem  Increase   Dst
IF W = I  X1 = X1 + I
Rem  Increase   Est
IF V = I Y1 = YI + I
Rem Value Dst Step
IF X1 = A V = 1 : W = 0
IF X1 = A A = A + P
Rem Value Cst Step
IF Y1 = B  W = 1 : V = 0
IF Y1 = B  B = B  + Q
Rem Line Cost
IF Z = 2  X2 = X2 + 1
IF Z = 2  Y2 = Y2 + 1

Rem Alternate
IF Z = 1 Y = Y1 : X = X1
IF Z = 2 Y = Y2 : X = X2
Z = Z + I
```

VALUES

```
Rem Dst Each Step
P =  20
Rem Cst Each Step
Q =  20
Rem Step Dst Cst
X1 =  0
YI =  5
Rem Line Cost
X2 =  0
Y2 =   0
Rem 1st Price Rise
A  =  P
Rem   1st Cost Lev
B  =  10
Rem   Control Values
W  =  0
V  = I
Z  = I
```

```
Graph   axes:     X (X) Y (Y)
Max   Values:     100   100
Origin:           3,2 spaces  from bottom left
```

MODEL EIGHT

BREAK OF BULK

MODEL

```
Rem Raw to Factory
IF D < P  C = C + L1

Rem  Fact  to   Mark
IF D > P  C = C + L2

Rem  Add  to  Dist
IF T = 0 D = D + 1

Rem   Cost   Process
IF T > 0  C = C + 1
IF D = P  T = T + 1
IF T = F  T = 0
```

VALUES

```
Rem   Cost
C = 0
Rem   Dist
D = 0
Rem   Process Cost
F  =  15
Rem   Factory   Loc
P  =  50
Rem   Raw Mat Rate
L1 = 1
Rem  Fin  Prod  Rate
L2   =0.5
Rem Initial   Value
T =  0
```

```
Graph    axes:    D (X)       C (Y)
Max    Values:    100         150
Origin:     3,2  spaces  from  bottom  left
```

MODEL NINE

COST REVENUE

MODEL

```
Rem   East  Cost
IF Z = 1 Y1 = YI + A
IF Z = 1 X1 = X1 + 1
IF Z = 1 X = X1 : Y = Y1
Rem   West  Cost
IF Z = 2 Y2 = Y2 + A
IF Z = 2 X2 = X2 - 1
IF Z = 2 X = X2 : Y = Y2
Rem   East Price
IF Z = 3 X3 = X3 + 1
IF Z = 3 X = X3 ; Y = Y3
Rem    West Price
IF Z = 4 X4 = X4 - 1
IF Z = 4 X = X4 : Y = Y4
Rem Alternate
Z = Z + 1
IF Z = 5 Z = 1
```

VALUES

```
Rem Initial Cost
Y1  =  20
Y2  =  Y1
Rem Initial Loc
P = 0
X1 = P : X2 = P
X3 = P : X4 = P
Rem  Initial   Price
Y3 = 35 :  Y4  =  Y3
Rem Rate of Change
Rem of Cost
A = 0.3
Rem Initial Control
Z =  1
```

```
Graph    axes:     X (X)      Y  (Y)
Max   Values:      100        100
Origin:   8,3  spaces  from  bottom  left
```

MODEL TEN

CROP YIELD

MODEL

```
Rem Wet to Dry
IF Z = I  DRY = DRY + 1

Rem Line Crop1
M1 = (WYI -  DYI)  /  100
M2 =  MI  *  DRY
IF Z = I  WET = M2 + WY1

Rem Line Crop2
M3 = (WY2 -  DY2)  /  100
M4 =  M3  *  DRY
IF Z = 2  WET = M4 + WY2

Rem    Alternate
Z = Z + 1
IF Z  =  3  Z  = 1
```

VALUES

```
Rem   CPI wet  yield
WY1 = 70
Rem   CP dry  yield
DY    = 49
Rem   CP2 wet  yield
WY2   = 30
Rem   CP2 dry  yield
DY2   = 71

Rem   Initial  Value
DRY   = 0
WET   = 0
Rem   Crop  Number
Z  =  1
```

```
Graph axes: DRY (X)              WET (Y)
Max values: 100                  100
Origin:          2,2 spaces from bottom left
```

MODEL ELEVEN

BIDRENT

MODEL

```
Rem  Dist   Plot
IF Z = 1 DST = DST + 0.1

Rem Z = Diff Zones
IF Z = 1 VL = RET - R * DST
IF Z = 2 VL = COM - C * DST
IF Z = 3 VL = RES - H * DST

Rem Reset Values
Rem For Each Zone
Z = Z + 1
IF Z = 4   Z = 1
IF VL <= 0 THEN VL = 0
```

VALUES

```
Rem  Dst  Centre
DST =  0
Rem Value  of  Land
VL =  0
Rem  Max  Retail
RET   = 100
Rem   Max  Commer
COM   = 60
Rem   Max Resid
RES   = 30
Rem   Ret  Decline
R  =  30
Rem   COm  Decline
C  =  10
Rem   Res  Decline
H  =  3
Rem   First  Zone
Z  =  1
```

Graph axes:	DST (X)	VL (Y)
Max values:	10	100

Origin: 3,2 spaces from bottom left

MODEL TWELVE

OIL EXPLORATION

MODEL

```
Rem Vary Eco Rate
IF Y > 15 E = E  +  LO
IF Y > 10 E = E  +  CB

Rem Normal Eco Rat
E = E + NR

Rem  Year  Inc
Y = Y + 0.6
```

VALUES

```
Rem Eco Rate
E =  1
Rem  NR  Rate
NR =  0.85
Rem  CB  Rate
CB = -1
LO = -0.2
Y =  0
```

Graph axes:	Y (X)	E (Y)
Max values:	35	40

Origin: 2,2 spaces from bottom left

MODEL THIRTEEN

OIL EXPLORATION II

```
MODEL                          VALUES

Rem Vary Eco Rate              Rem Eco Rate
IF Y > 15 E  =  E  +  LO       E =  I
IF Y > 10 E  =  E  +  CB       Rem  NR  Rate
                               NR = 0.85
Rem Normal Eco Rate            Rem  CB  Rate
E = E + NR                     CB = -1
                               LO = -0.2
Rem  Year  Inc                 Y =  0
Y = Y + 0.6

      Graph   axes:     Y (X) E  (Y)
      Max   Values:     35    40
      Origin:     2,2 spaces from bottom
```

MODEL FOURTEEN

RADIATION

```
MODEL                          VALUES

Rem Change   in   Rad          Rem Rad at Equator
Rem Outside Atmos              R =  300
Rem with Latitude              Rem  Absorp   Rate
R  = R  -  (169  /  90)        AB =  18
                               Rem Reflect Rate
Rem Absorp Reflect             RF =  2
Rem Scatter                    Rem Scatter Rate
A1 =  R  *  (AB  /100)         SC =  6
A2 =  R  *  (RF  /100)         Rem  Albedo   Rate
A3 =  R  *  (SC  /100)         AL =  5
A5  = R - A1 - A2  - A3        Rem Initial Value
                               L  =  0
Rem    Albedo
A4 =  A5 * (AL /100)
Rem   Surface   Radiat
SR =  A5  -  A4
Rem    Latitude
L = L + 1

      Graph    axes:    L (X) SR  (Y)
      Max    Values:    90    300
      Origin:     3,3  spaces  from   bottom   left
```

MODEL FIFTEEN

LAPSE RATE

```
MODEL                          VALUES

Rem   1 = DRY  2 = SAT         Rem Dry Bulb
IF  Z = 1  H =  H  +  H1       DY =  30
Rem DALR Decline               Rem Wet Bulb
IF Z = 1 DY = DY - DALR        WT =  20
IF Z = 1 LR = DY               Rem DALR/Height
Rem SALR Decline               DALR = 1
IF Z = 2 WT = WT - SALR
IF Z = 2 LR = WT               Rem SALR/Height
                               SALR = 0.6
Rem Alternate
Z = Z + 1                      Rem Height Inter
IF Z = 3 Z = 1                 HI = 100
                               Rem Initial Values
                               Z = 1
                               H = 0

Graph    axes:    LR (X)       H (Y)
Max    Values:    35           10000

Origin:           9,2  spaces  from  bottom  left
```

MODEL SIXTEEN

GLACIER

```
MODEL                          VALUES
Rem  Read  Temp                Rem Initial Value
READ  T                        MASS = 100
                               MON = 0 : S = 0 : EV = 0
Rem  Calc   Evaporat           MT =  0
IF T > 0 EV = T / 2            RESTORE
IF T <= 0 EV  =  0             Rem Monthly Temps
Rem  Calc Snowfall             DATA  -15
IF T > 0  S = 0                DATA  -8
IF T <= 0 S = -T               DATA  -4
Rem  Calc Meltwater            DATA  0
IF T <= 0 MT  =  0             DATA  4
IF T > 0  MT  =  T / 2         DATA  9
Rem  Calc  Mass                DATA  12
MASS = MASS + S - EV - MT      DATA  13
Rem  Add  Month                DATA  9
MON = MON  +  1                DATA  3
Rem Repeat Year                DATA  - 8
Q1 = MON  /  12                DATA  - 15
Q2 = INT (MON /    12)
```

MODEL SEVENTEEN

PRECIPITATION

```
MODEL                          VALUES

Rem   Read   Monthly          Rem Initial Values
Rem   Temp                     MON =  0
READ  T                        P   =  0
                               RESTORE
Rem   Evap Prop Temp           Rem Monthly Rain
EV = 2 * T                     RN =  50
Rem   Precipitation            Rem Monthly Temps
Rem = Rain  -  Evap            DATA  4
P   =  RN - EV                 DATA  5
                               DATA  9
Rem   Increase Mon             DATA  12
MON   = MON +  1               DATA  14
                               DATA  17
Rem   Reset Value              DATA  18
IF    MON = 12  RESTORE        DATA  14
                               DATA  10
                               DATA  7

Graph axes: MON (X)    P (Y)
Max Values: 12         100
Origin:          3,2 spaces from bottom left
```

MODEL EIGHTEEN

RIVER VELOCITY

```
MODEL                          VALUES

Rem  Root   Gradient     Rem Init Gradient
Z1 = S ^ 0.5             S  = 0.001
Rem  Root Radius         Rem  Hydraul Rad
Z2 = R ^  0.67           R  = 0.1
Rem Formula              Rem Manning Coeff
V = (Z1 * Z2)  /  N      N  = 0.1
Rem  Grad Interval
S =  S  +  0.005

      Graph axes: S (X)    V  (Y)
      Max Values: 0.5      30
      Origin:     3,2  spaces  from   bottom   left
```

MODEL NINETEEN

VON THUNEN

```
MODEL                              VALUES

Rem  Incr   Distance               Rem First Crop
IF Z = 1 DST = DST + .5            Rem Market Price
                                   M1  =  60
Rem First Crop                     Rem Prod Cost/Unit
C1 = (M1 - P1 - T1 * DST)          P1  =  10
LR1 = Y1 * C1                      Rem Tran Cost/Unit
                                   T1  =  3
Rem  Second   Crop                 Rem Yield / Unit
C2 = (M2 - P2 - T2 * DST)          Y1  =  10
LR2 = Y2 * C2
                                   Rem Second Crop
Rem    Alternate                   M2  =  40
IF Z =  1  LR  =  LR1              P2  =  10
IF Z =  2  LR  =  LR2              T2  =  1
IF LR <= 0  LR  =  0               Y2  =  10
Z = Z + I
IF Z =  3  Z  =  1                 Rem Initial Values
                                   Y =  0
                                   DST  =  0

Graph Values: DST (X)              LR (Y)
Max Values:       30               700
Origin:          3,2 spaces from bottom left
```

MODEL TWENTY

QUEUE

```
MODEL                              VALUES

R  =  RND(L)                       Q =  10
IF GO = 0 THEN  Q = Q - 1          P = 0.7
IF R < P THEN Q = Q + 1            S =  10
IF G  = 0 THEN T = T + 1           G = 0
IF G  = 0 THEN S = 0               I = 1
IF G  = 1 THEN T = 0
IF G  = 1 THEN S = S + 1
IF T  = 1 THEN G = 1
IF S  = 10 THEN G = 0
IF Q  <  0  THEN  Q = 0
M =  M  +  1

Graph   axes:     M (X) Q (Y)
Max   Values:     50    50
Origin:     3,2 spaces  From bottom left
```

MODEL TWENTY-ONE

QUEUE ONE

```
MODEL                          VALUES

R  =  RND(L)                   Rem Queue
                               Q = 10
IF R  <  P  Q = Q +  1         Rem   Probability
                               P =   0.7
Rem  Go                        Rem   Time on Go
IF G = 0 Q = Q -  1            X =   30
IF G = 0 T = T +  1            Rem   Time on Stop
IF G = 0 S = 0                 Y =   10
                               Rem   Change Lights
Rem   Stop                     G =   0
IF G = 1 T = 0
IF G = 1 S = S + 1
Rem Change Lights
IF T = X G = 1
IF S = Y G = 0
IF Q < 0 Q  =  0
S =  S  +  1
```

```
      Graph   axes:     SECS (X)     Q (Y)
      Max     Values:   500          50
      Origin: 3,2 spaces from bottom left
```

MODEL TWENTY-TWO

QUEUE TWO

```
MODEL                          VALUES

R = RND(1)                     Rem Queue
IF R < P1 Q1 = Q1 + 1          Q1  =  10
IF R < P2 Q2 = Q2 + 1          Q2  =  10
IF R < P3 G3 = Q3 + 1          Q3  =  10
IF R < P4 Q4 = Q4 + 1          Q4  =  10
IF G = 0  Q1 = Q1 - 1          Rem Probability
IF G = 0  Q3 = Q3 - 1          P1  =  0.6
IF G = 0  T  = T  + 1          P2  =  0.3
IF G = 0  S  = 0               P3  =  0.7
IF G = 1  Q2 = Q2 - 1          P4  =  0.3
IF G = 1  Q4 = Q4 - 1          Rem  Time on Go
IF G = 1  T = 0                X  =  20
IF G = 1  S = S + 1            Rem   Time on Stop
Q = Q1 + Q2 + Q3 + Q4          Y  =  4
Rem Change  Lights             Rem   Change Lights
IF T = X  G  =  1              G  =  0
IF S = Y  G  =  0
IF Q < 0  Q =   0
S = S + 1
```

```
Graph axes:  SEC (X)          Q  (Y)
Max Values:  500              100
Origin:      3,2   spaces  from  bottom   left
```

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APPENDIX FIVE

GEOGRAPHY SPREADSHEET MODELS

POPULATION GROWTH

Description

Population increase is determined by the relative rates of birth and death rates. The difference between birth and deaths rates being the natural increase.

Inputs

1. The YEAR from which the population projection is to start
2. The POPULATION in the first year
3. The BIRTH RATE for the ten year period
4. The DEATH RATE for the ten year period

Popgrowth

POPULATION GROWTH PLACE: SOMEWHERE

START YEAR	START POP	BIRTH RATE	DEATH RATE
1971	2000	.038	.020

YEAR	POP	BIRTHS	DEATHS	NAT INCR	TOTAL
1971	2000	76	40	36	2036
1972	2036	77	41	37	2073
1973	2073	79	41	37	2110
1974	2110	80	42	38	2148
1975	2148	82	43	39	2187
1976	2187	83	44	39	2226
1977	2226	85	45	40	2266
1978	2266	86	45	41	2307
1979	2307	88	46	42	2348
1980	2348	89	47	42	2391

TOTAL POP INCREASE BETWEEN	1971 &	1980	391
TOTAL % INCREASE BETWEEN	1971 &	1980	20

VARIABLE RATE POPULATION GROWTH

Description

Population increase is determined by the relationship between birth and death rates. The difference between birth and death rates being the natural increase. Birth and death rates often gradually change over a period of time.

Inputs

1. The YEAR for which the population projection is to start
2. The POPULATION in the first year
3. The BIRTH RATE at the beginning of the ten year period
4. The ANNUAL CHANGE IN BIRTH RATE
5. The DEATH RATE at the beginning of the ten year period
6. The ANNUAL CHANGE IN DEATH RATE

Vrpopgrowth

VARIABLE RATES POPULATION GROWTH PLACE: SOMEWHERE

Start Year	Start Pop	Birth Rate	B. Rate Change	Death Rate	D. Rate Change
1971	2000	.038	-.002	.020	-.001

YEAR	POP	BIR RATE	BIRTHS	DTH RATE	DEATHS	NAT INCR	TOTAL
1971	2000	.038	76	.020	40	36	2036
1972	2036	.036	73	.019	39	35	2071
1973	2071	.034	70	.018	37	33	2104
1974	2104	.032	67	.017	36	32	2135
1975	2135	.030	64	.016	34	30	2165
1976	2165	.028	61	.015	32	28	2193
1977	2193	.026	57	.014	31	26	2220
1978	2220	.024	53	.013	29	24	2244
1979	2244	.022	49	.012	27	22	2267
1980	2267	.020	45	.011	25	20	2287

TOTAL POP INCREASE BETWEEN	1971 &	1980	287
TOTAL % INCREASE BETWEEN	1971 &	1980	14

COMPOUND POPULATION GROWTH

Description

Population increase is determined by the relationship between birth rate and death rates. The difference between birth and death rates being the natural increase. The period of which the natural increase is crucial in establishing the type of increase. Short period of time produce straight line increase whilst the same rates over longer periods of time produce exponential increases.

Inputs

1. The YEAR for which the population projection is to start
2. The INTERVAL in years between each calculation
3. The POPULATION in the first year
4. The BIRTH RATE for the projection period
5. The DEATH RATE for the projection period

Comppopgrowth

COMPOUND POPULATION GROWTH Place: Somewhere

Start Year	Year Interval	Start Pop	Birth Rate	Death Rate
1971	10	2000	.038	.020

Year	Pop	Nat Incr	Total
1971	2000	391	2391
1981	2391	467	2857
1991	2857	558	3416
2001	3416	667	4083
2011	4083	797	4880
2021	4880	953	5833
2031	5833	1139	6972
2041	6972	1362	8334
2051	8334	1628	9962
2061	9962	1946	11907

Total pop increase between	1971	&	2071	9907
Total % increase between	1981	&	2071	495

BIDRENT ZONES

Description

Urban zones can be determined by the rent that would be bid by the different type of land use. The three principal types of land use being retail, commercial and residential. Zones are determined by the highest bids from each of the possible land uses.

Inputs

1. MAXIMUM RETAIL BID for land at the town centre
2. The CHANGE per unit distance away from town centre for retail
3. MAXIMUM COMMERCIAL BID for land at the town centre
4. The CHANGE per unit distance away from town centre for commercial
5. MAXIMUM RESIDENTIAL BID for land at the town centre
6. The CHANGE per unit distance away from town centre for residential

Bidrent

BIDRENT

Retail		Commercial		Residential	
Max	Change	Max	Change	Max	Change
100	20	80	9	50	4

Distance	Retail	Commer	Resident	Ret	Com	Res
0	100	80	50	***		
1	80	71	46	***		
2	60	62	42		***	
3	40	53	38		***	
4	20	44	34		***	
5	0	35	30		***	
6	0	26	26		***	
7	0	17	22			***
8	0	8	18			***
9	0	0	14			***
10	0	0	10			***

FARM PRODUCTION

Description

Farmer have to make decisions about which crops to grow before they know what the weather will be. They can choose a balance of crops so that a reasonable income can be had regardless of the overall weather pattern for the growing season.

Inputs

1. The YEAR for which the crops are to be grown
2. The CROP NUMBER that is to be planted in each field
3. The CLIMATE NUMBER for the growing season

Associated Materials

Reference Tables :

Crop Number	: Crop Name	Climate	: Description
1	Wheat	1	Warm & Dry
2	Barley	2	Warm & Wet
3	Oats	3	Cool & Dry
4	Beet	4	Cool & Wet

Farm Produce

FARM: BARLEYLANDS YEAR: 1978

CLIMATE: 4

Crop No.	Crop	Field Number	Field Size	Yield /hect	Field Yield	Income /ton	Field Income
1	Wheat	1	10	2	20	20	400
2	Barley	2	20	1	20	27	540
5	Beet	3	15	6	90	18	1620
1	Wheat	4	12	2	24	20	480
4	Beet	5	12	6	72	18	1296
			Total Income for		1978	is	4336

Reference Table for Crop Yields and Income

		Yield for each climate				
Crop No.	Crop	Warm Dry	Warm Wet	Cool Dry	Cool Wet	Income per ton
1	Wheat	5	4	3	2	20
2	Barley	7	5	3	1	27
3	Oats	4	4	5	5	15
4	Beet	4	6	3	6	18

INFILTRATION

Description

Rainfall is either evaporated or becomes surface water. Surface water on a slope will either run off into a stream channel or will infiltrate into the ground. The ground water will then flow into the stream channel, however, there might well be a delay. The relationship between the rate or rainfall and the amount of water in the river channel is a hydrograph.

Inputs

1. The RAINFALL for each HOUR
2. The RATE OF EVAPORATION of the rainfall
3. The RATE OF INFILTRATION of the surface water into the ground
4. The DELAY in hours of the groundwater reaching the river channel

Infiltration

INFILTRATION

Evaporation Rate %	Groundflow Delay	Infiltration Rate %
30	2 hours	75

Hour	Rain	Evap	Surface	Infil	Over	Channel
1	5.00	1.50	3.50	2.63	.88	.88
2	10.00	3.00	7.00	5.25	1.75	1.75
3	10.00	3.00	7.00	5.25	1.75	4.38
4	30.00	9.00	21.00	15.75	5.25	10.50
5	25.00	7.50	17.50	13.13	4.38	9.63
6	20.00	6.00	14.00	10.50	3.50	19.25
7	5.00	1.50	3.50	2.63	.88	14.00
8	5.00	1.50	3.50	2.63	.88	11.38
9	5.00	1.50	3.50	2.63	.88	3.50
10	.00	.00	.00	.00	.00	2.63

MANNING COEFFICIENT

Description

The velocity of a river is dependent on three factors, the gradient, the hydraulic radius and the roughness of the channel, also known as the Manning number. The relationship between these factors is deduced from observations and is complex. The relationship between these factors can be demonstrated by varying the factors over a distance interval in the river.

Inputs

1. The GRADIENT at the beginning of the river section
2. The CHANGE IN GRADIENT per unit distance in the river section
3. The HYDRAULIC RADIUS at the beginning of the river section
4. The CHANGE IN HYDRAULIC RADIUS per unit distance in the river section
5. The MANNING NUMBER at the beginning of the river section
6. The CHANGE IN MANNING NUMBER per unit distance in the river section

Associated Materials

1. Table for Manning numbers
2. Method of calculating hydraulic radius

Manning

MANNNING COEFFICIENT

Gradient	Change in Gradient	Hydral R	Change in Hydral R	Manning	Change in Manning
.001	0	.100	0	.100	.050

Interval	Gradient	Hydral R	Manning	Velocity (m/sec)
1	.001	.100	.100	.068
2	.001	.100	.150	.045
3	.001	.100	.200	.034
4	.001	.100	.250	.027
5	.001	.100	.300	.023
6	.001	.100	.350	.019
7	.001	.100	.400	.017
8	.001	.100	.450	.015
9	.001	.100	.500	.014
10	.001	.100	.550	.012
Total Change %	0	0	450	-81.82

GRAVITY MODEL FOR ROAD BUILDING

Description

The interaction between towns may be predicted with the gravity model. If a
partial network has been established then by using the distance between the
towns and their respective populations the attraction between each of the pairs of towns can be estimated. The next most important link in the network can then be designated.

Inputs

1. The DISTANCE between each pair of towns is entered into a distance table.
2. The POPULATION of each town.

Associated Materials

A map of the partially completed road network.

Gravity

Distance

	A	B	C	D	E
A	*	15	20	5	10
B	15	*	10	20	33
C	20	10	*	18	30
D	5	20	18	*	28
E	10	33	30	28	*

Interaction between settlements

	POP->	A 20	B 10	C 34	D 5	E 9
A	20	*	.89	1.70	4	1.80
B	10	.89	*	3.40	.13	.08
C	34	1.70	3.40	*	.52	.34
D	5	4	.13	.52	*	.06
E	9	1.80	.08	.34	.06	*

CALIBRATE GRAVITY MODEL

Description

In the design of an airline network, the gravity model can be used to predict the likely number of people wishing to fly between centres. If some
actual figures of those flying are known the model can predict the remaining. It also predicts those for which data is known and a comparison between the known and the predicted can give the difference. By adjusting the friction of distance the model can be calibrated to give the lowest percentage error.

Inputs

For a network of towns
1. The DISTance between the towns
2. The POPulation of each town

For the model
3. The FRICTION OF DISTANCE

For at least one of the routes
4. The KNOWN number of people travelling.

Associated Materials

A map of the network of the towns

Cal Gravity

Friction of Distance
1.90

TOWN	TOWN	DIST	GRAVITY	KNOWN	VALUE	ENTRIES	PREDICT	DIFF	% DIFF
1	2	15	117	1000	8.58	1	421	579	57.91
1	3	20	229	2000	8.72	1	828	1172	58.58
1	4	5	470		0	1	1697	1697	
1	5	10	227	2000	8.83	1	818	1182	59.08
2	3	10	428		0	1	1546	1546	
2	4	20	17		0	1	61	61	
2	5	33	12		0	1	42	42	
3	4	18	70	700	9.99	1	253	447	63.85
3	5	30	48		0	1	173	173	
4	5	28	8		0	1	29	29	
					Average Value				Average % diff
					3.61				23.94

Population of Towns

TOWN	POP
1	200
2	100
3	340
4	50
5	90

STEPPED AND LINE COST OF TRANSPORT

Description

The calculation of cost of transport can be done in one of two ways. A charge for each unit distance. The total cost being the charge for each unit distance multiplied by the distance travelled. The second method is to divided the transport area in sections or steps and to charge a fixed amount for anywhere in that section. The size of the steps and rate for each stepped needs to be carefully worked out.

With most forms of transport different numbers of articles need to go to different places and hence the total income from the transport needs to be calculated

Inputs

1. For each of five items the DISTANCE the items have to be transported
2. For each of five items the NUMBER of items to be transported
3. The LINE COST PER KM of the goods to be carried
4. The DISTANCE OF EACH STEP for the calculation of stepped costs
5. The COST OF EACH STEP

Associated Materials

Map of an area with various destinations for goods marked on it. The map should have an appropriate scale. A table showing the number of goods to be delivered to each point

Stepcost

STEPCOST

Balancing the cost of different destinations

		Step costs		Line Costs	
Distance	Number	Item	Total	Item	Total
3	5	£2.00	£10.00	£2.70	£13.50
5	22	£4.00	£88.00	£4.50	£99.00
7	12	£6.00	£72.00	£6.30	£75.60
9	3	£6.00	£18.00	£8.10	£24.30
12	30	£8.00	£240.00	£10.80	£324.00
	Total		£428.00		£536.40

Dist each step 3.50 Line cost
Cost each step £2.00 per Km £.90

Reference table for comparison of step and line costs

	Step	Line	Cheaper	for different distanc	
Distance	Cost	Cost	Step	Line	Equal
1	£2.00	£.90		***	
2	£2.00	£1.80		***	
3	£2.00	£2.70	***		
4	£4.00	£3.60		***	
5	£4.00	£4.50	***		
6	£4.00	£5.40	***		
7	£6.00	£6.30	***		
8	£6.00	£7.20	***		
9	£6.00	£8.10	***		
10	£6.00	£9.00	***		
11	£8.00	£9.90	***		
12	£8.00	£10.80	***		

LEAST COST INDUSTRIAL LOCATION

Description

One of the principal factors that affect industrial location is the cost of transporting raw materials. This is most significant when the raw materials are only available from specific locations. Weight loss industries are when the finished product is lighter than the combined weight of the raw materials. Weight gain industries are those when the finished product is heavier than the raw materials that come from specific locations. Often a universal raw material, e.g. water is added to the location specific raw materials to make the heavier finished goods.

Inputs

1. The NAME of the industry
2. The WEIGHT of raw material A
3. The COST per unit weight per kilometre of transporting raw material A from its location to the factory
4. The WEIGHT of raw material B
5. The COST per unit weight per kilometre of transporting raw material B from its location to the factory
6. The WEIGHT of the finished goods
7. The COST per unit weight per kilometre of transporting the finished goods to market
8. The FACTORY NUMBER
9. The DISTANCE from raw material A to the factory
10. The DISTANCE from raw material B to the factory
11. The DISTANCE from the factory to the market

Associated Materials

Map showing location of raw materials A and B and the location of the market

Ind Loc

```
INDUSTRIAL LOCATION                    Industry:
-------------------

        Raw material A    Raw Material B    Finished Goods

         Weight:    2     Weight:    3      Weight:    1
        Line Cost   3     Line Cost  2      Line Cost  1
-------------------------------------------------------------------------

        Raw material A    Raw Material B    Finished Goods
Factory  Factory          Factory           Factory           Total
 Number Distance   Cost   Distance   Cost   Distance   Cost   Cost
   1       20      120      30       180      40       40     340
   2       10       60      10        60      10       10     130
   3       15       90      23       138      12       12     240
   4       35      210      30       180      56       56     446
5  45      270       12      72        23      23      365
```

LEAST COST LOCATION WITH TERMINALS

Description

One of the principal factors that affect industrial location is the cost of transporting raw materials. This is most significant when the raw materials are only available from specific locations. Weight loss industries are when the finished product is lighter than the combined weight of the raw materials. Weight gain industries are those when the finished product is heavier than the raw materials that come from specific locations. Often a universal raw material, e.g. water is added to the location specific raw materials to make the heavier finished goods. As well as the actual transport cost there is also the cost involved at the terminals with loading and unloading. For bulky goods this is a particularly expensive business.

Inputs

1. The NAME of the industry
2. The WEIGHT of raw material A
3. The TERMINAL cost per unit weight of raw material A
4. The LINE COST per unit weight per kilometre of transporting raw material A from its location to the factory
5. The WEIGHT of raw material B
6. The TERMINAL COST per unit weight of raw material B
7. The LINE COST per unit weight per kilometre of transporting raw material B from its location to the factory
8. The WEIGHT of the finished goods
9. The TERMINAL COST per unit weight of the finished goods
10. The COST per unit weight per kilometre of transporting the finished goods to market
11. The FACTORY NUMBER
12. The DISTANCE from raw material A to the factory
13. The DISTANCE from raw material B to the factory
14. The DISTANCE from the factory to the market

Associated Materials

Map showing location of raw materials A and B and the location of the market

Termindloc

LEAST COST LOCATION WITH TERMINALS Industry:Making things

	Raw material A	Raw Material B	Finished Goods
Weight:	2	3	1
Line Cost:	3	2	1
Term Cost:	4	4	4

	Raw Material A		Raw Material B		Finished Goods		
Factory Number	Factory Distance	Cost	Factory Distance	Cost	Factory Distance	Cost	Total Cost
1	20	124	30	184	40	44	352
2	10	64	10	64	10	14	142
3	15	94	12	76	34	38	208
4	25	154	15	94	3	7	255
5	30	184	30	184	45	49	417

PROFIT AREAS FOR INDUSTRIAL LOCATION

Description

One of the principal factors that affect industrial location is the cost of transporting raw materials. This is most significant when the raw materials are only available from specific locations. Weight loss industries are when the finished product is lighter than the combined weight of the raw materials. Weight gain industries are those when the finished product is heavier than the raw materials that come from specific locations. Often a universal raw material, e.g. water is added to the location specific raw materials to make the heavier finished goods. As well as the actual transport cost there is also the cost involved at the terminals with loading and unloading. For bulky goods this is a particularly expensive business Transport costs represent only one part of the costs. There is also the processing costs. If a profit is to be made then the total costs, transport plus processing must be less than the price for which the goods are to be sold.

Inputs

1. The NAME of the industry
2. The WEIGHT of raw material A
3. The TERMINAL cost per unit weight of raw material A
4. The LINE COST per unit weight per kilometre of transporting raw material A from its location to the factory
5. The WEIGHT of raw material B
6. The TERMINAL COST per unit weight of raw material B
7. The LINE COST per unit weight per kilometre of transporting raw material B from its location to the factory
8. The WEIGHT of the finished goods
9. The TERMINAL COST per unit weight of the finished goods
10. The COST per unit weight per kilometre of transporting the finished goods to market
11. The FACTORY NUMBER
12. The DISTANCE from raw material A to the factory
13. The DISTANCE from raw material B to the factory
14. The DISTANCE from the factory to the market
15. The PROCESSING COST of changing the raw materials into the finished product
16. The PRICE of the goods to be sold at the market

Associated Materials

Map showing location of raw materials A and B and the location of the market

Profit Areas

PROFIT AREAS Industry: Making things

	Raw material A	Raw Material B	Finished Goods
Weight:	2	3	1
Line Cost:	3	2	1
Term Cost:	4	4	4

	Raw Material A		Raw Material B		Finished Goods	
Factory Number	Factory Distance	Cost	Factory Distance	Cost	Factory Distance	Cost
1	20	124	30	184	20	24
2	10	64	10	64	10	14
3	15	94	20	124	10	14
4	20	124	15	94	10	14
5	10	64	10	64	10	14

Costs, Prices and Profit

Processing Cost: 100 Price: 200

	Transport Costs						
Factory Number	Raw A Cost	Raw B Cost	Goods Cost	Process Cost	Total Cost	Price	Profit
1	124	184	24	100	432	200	-232
2	64	64	14	100	242	200	-42
3	94	124	14	100	332	200	-132
4	124	94	14	100	332	200	-132
5	64	64	14	100	242	200	-42

LONGITUDE AND TIME

Description

Time throughout the world is directly related to longitude. From a base anywhere in the world several places will be in front and others behind. Thus the time and the day are important. If the date line has to be crossed to link two place then a day is 'lost' or 'gained'.

Inputs

The details of the base
1. The TIME AT BASE in hours
2. The DEGREES longitude of the BASE
3. The DIRECTION of longitude of the BASE
4. The DAY NUMBER of the week

The details of each of the locations throughout the world

5. The name of the PLACE
6. The DEGREES of longitude
7. The DIRECTION of longitude

Associated Materials

A map of the world showing lines of longitude. A table of the numbers and days of the week.

1. Sunday 2. Monday 3. Tuesday 4. Wednesday
5. Thursday 6. Friday 7. Sunday

LONGITUDE

LONGITUDE AND TIME

Time at base	Base Degrees	Base Direction	Day Number	Day
1	172	E	4	Wed

Place	Degrees	Direction	Degrees Diffrnt	Hours Diffrnt	Place Time	Place Day
Warsaw	22	E	150	-10	15	Tue
New York	75	W	247	-16	9	Tue
Moscow	38	E	134	-8	17	Tue
Peking	118	E	54	-3	22	Tue
San Francisco	125	W	297	-19	6	Tue
Melbourne	148	E	24	-1	0	
Cape Town	20	E	152	-10	15	Tue
Hawaii	155	W	327	-21	4	Tue
Wellington	172	E	0	0	1	Wed

DAYS OF THE WEEK
1 Sun
2 Mon
3 Tue
4 Wed
5 Thr
6 Fri
7 Sat

ROAD BUILDING

Description

The building of new roads involves two important constraints. These two constraints are the concern of various interested parties. They are financial and environmental. Any route that is chosen should attempt to show a balance between the two areas which are often in conflict with each other.

Inputs

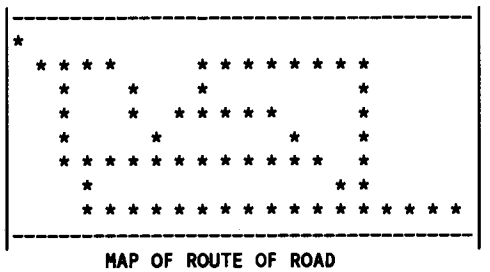
1. The ROUTE, indicated by '*', is entered on the map grid

1.3 Associated Materials

A map of the area showing the relief and the environment values

Road Building

ROAD BUILDING LOCATION: SOMEWHERE



MAP OF ROUTE OF ROAD

Relief Values in area

```
1 1 1 1 1 2 2 2 2 2 2 2 2 2 3 3 3 3 3 3
1 1 1 1 1 2 2 2 2 2 2 2 2 2 1 1 1 1 1 3
3 3 3 3 3 2 2 3 3 3 2 2 2 2 1 1 1 1 1 3
3 3 3 3 3 2 2 2 2 3 2 2 2 2 1 1 1 1 1 3
3 3 3 3 3 2 2 2 2 3 2 2 2 2 1 1 1 1 1 3
3 3 3 3 3 2 2 2 2 2 2 2 2 2 1 1 1 1 1 3
3 3 3 3 3 2 2 2 2 2 2 2 2 2 3 3 3 3 3 3
3 3 3 3 3 2 2 2 2 2 2 2 2 2 3 3 3 3 3 3
```

Environmental Values in area

```
1 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 3 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 4 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3
4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4
```

Relief Values Table

TYPE	NAME	COST
1	LOW	25
2	MEDIUM	50
3	HIGH	100

Cost Factors

	Relief	Environ
	25	9
	450	106
	275	30
	475	72
	225	20
	775	65
	300	21
	1250	51
TOTAL	3775	374

Environmental Values Table

TYPE	NAME	VALUE
1	URBAN	9
2	FARM	5
3	NATURE	7
4	HEATH	3

RELIEF COST CALCULATION

25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25
0	25	25	25	25	0	0	0	50	50	50	50	50	50	25	25	0	0	0	0	450
0	0	100	0	0	50	0	0	100	0	0	0	0	0	0	25	0	0	0	0	275
0	0	100	0	0	50	0	50	50	100	50	50	0	0	0	25	0	0	0	0	475
0	0	100	0	0	0	50	0	0	0	0	0	50	0	0	25	0	0	0	0	225
0	0	100	100	100	50	50	50	50	50	50	50	50	50	0	25	0	0	0	0	775
0	0	0	100	0	0	0	0	0	0	0	0	0	0	100	100	0	0	0	0	300
0	0	0	100	100	50	50	50	50	50	50	50	50	50	100	100	100	100	100	100	1250

ENVIRONMENTAL COST CALCULATION

9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9
0	7	9	9	9	0	0	0	9	9	9	9	9	9	9	9	0	0	0	0	106
0	0	3	0	0	9	0	0	9	0	0	0	0	0	0	9	0	0	0	0	30
0	0	9	0	0	9	0	9	9	9	9	9	0	0	0	9	0	0	0	0	72
0	0	5	0	0	0	5	0	0	0	0	0	5	0	0	5	0	0	0	0	20
0	0	5	5	5	5	5	5	5	5	5	5	5	5	0	5	0	0	0	0	65
0	0	0	7	0	0	0	0	0	0	0	0	0	0	7	7	0	0	0	0	21
0	0	0	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	51

TRAFFIC FLOW

Description

A crossroad junction with traffic lights can be a source of congestion if the light are not correctly timed. Fieldwork data can give the flows of vehicles into each of the four inputs to the crossroads and can give the percentage of each flow that leaves along one of the four output flows.

Inputs

1. NUMBER OF CARS arriving in Queue 1 every minute
2. NUMBER OF CARS arriving in Queue 2 every minute
3. NUMBER OF CARS arriving in Queue 3 every minute
4. NUMBER OF CARS arriving in Queue 4 every minute
5. NUMBER OF SECONDS in each minutes Queue 1 lights are on green

Associated Materials

Diagram of road junction.

Traffic Flow

TRAFFIC FLOW Location: CROSSROADS Date: 3/4/86

Rate of arrivals per minute				Lights Green Seconds			
Queue1	Queue2	Queue3	Queue4	Queue1	Queue2	Queue3	Queue4
29	29	32	23	28	32	28	32

Minutes	Queue1	Queue2	Queue3	Queue4	Route1	Route2	Route3	Route4
1	1	0	4	0	25	30	27	26
2	2	0	8	0	25	30	27	26
3	3	0	12	0	25	30	27	26
4	4	0	16	0	25	30	27	26
5	5	0	20	0	25	30	27	26
6	6	0	24	0	25	30	27	26
7	7	0	28	0	25	30	27	26
8	8	0	32	0	25	30	27	26
9	9	0	36	0	25	30	27	26
10	10	0	40	0	25	30	27	26

DETAILS FOR QUEUE1

		Route Percentages			
		Route1	Route2	Route3	Route4
		0	50	30	20

Minutes	Begin Queue	Arrive	Through	Route1	Route2	Route3	Route4	End Queue
1	0	29	28	0	14	8	6	1
2	1	29	28	0	14	8	6	2
3	2	29	28	0	14	8	6	3
4	3	29	28	0	14	8	6	4
5	4	29	28	0	14	8	6	5
6	5	29	28	0	14	8	6	6
7	6	29	28	0	14	8	6	7
8	7	29	28	0	14	8	6	8
9	8	29	28	0	14	8	6	9
10	9	29	28	0	14	8	6	10

DETAILS FOR QUEUE2

		Route Percentages			
		Route1	Route2	Route3	Route4
		20	0	40	40

Minutes	Begin Queue	Arrive	Through	Route1	Route2	Route3	Route4	End Queue
1	0	29	29	5	0	11	13	0
2	0	29	29	5	0	11	13	0
3	0	29	29	5	0	11	13	0
4	0	29	29	5	0	11	13	0
5	0	29	29	5	0	11	13	0
6	0	29	29	5	0	11	13	0
7	0	29	29	5	0	11	13	0
8	0	29	29	5	0	11	13	0
9	0	29	29	5	0	11	13	0
10	0	29	29	5	0	11	13	0

DETAILS FOR QUEUE3

		Route Percentages			
		Route1	Route2	Route3	Route4
		60	20	0	20

Minutes	Begin Queue	Arrive	Through	Route1	Route2	Route3	Route4	End Queue
1	0	32	28	16	5	0	7	4
2	4	32	28	16	5	0	7	8
3	8	32	28	16	5	0	7	12
4	12	32	28	16	5	0	7	16
5	16	32	28	16	5	0	7	20
6	20	32	28	16	5	0	7	24
7	24	32	28	16	5	0	7	28
8	28	32	28	16	5	0	7	32
9	32	32	28	16	5	0	7	36
10	36	32	28	16	5	0	7	40

DETAILS FOR QUEUE4

		Route Percentages			
		Route1	Route2	Route3	Route4
		20	50	30	0

Minutes	Begin Queue	Arrive	Through	Route1	Route2	Route3	Route4	End Queue
1	0	23	23	4	11	8	0	0
2	0	23	23	4	11	8	0	0
3	0	23	23	4	11	8	0	0
4	0	23	23	4	11	8	0	0
5	0	23	23	4	11	8	0	0
6	0	23	23	4	11	8	0	0
7	0	23	23	4	11	8	0	0
8	0	23	23	4	11	8	0	0
9	0	23	23	4	11	8	0	0
10	0	23	23	4	11	8	0	0

NEAREST NEIGHBOUR ANALYSIS

Description

Nearest neighbour analysis is used to determine the type of settlement layout. An index is generated from the measurements made of the nearest neighbour to each settlement in a given area

Inputs

1. The NUMBER of the measurement
2. The number of the settlement FROM which the measurement is taking place
3. The number of the settlement TO which the measurement is being made
4. The DISTANCE between the two settlements

Associated Materials

A map with the rectangular area under consideration indicated and the settlements numbered.

Nearest Neighbour

NEAREST NEIGHBOUR

Number	From	To	Distance
1	1	2	2
2	2	3	3
3	3	4	4
4	1	2	2
5	2	3	3
6	3	5	5
7	1	2	2
8	2	3	4
9	3	4	4
10	2	3	3
11	3	4	4

Size of area

Length	Width
10	10

Numb of Points

11

Observed Mean

3.27

Nearest Index

2.17

JOURNEY

Description

In a planning of a journey the two most important factors are the cost and the time taken to complete the journey. Long journeys frequently require several changes in the type of transport used. Many journeys can be undertaken by alternative forms of transport and thus a comparison of cost and time of alternative forms of transport is necessary. The cost and time of each section of the journey can be calculated and the total cost and time worked out.

Inputs

1. The STARTING POINT of the journey
2. The FINISHING POINT of the journey
3. The STARTING POINT of each section of the journey
4. The FINISHING POINT of each section of the journey
5. The TYPE NUMBER of the different method of transport used

Associated Materials

A map with various transport systems marked. The table of transport type numbers :

1. Car on normal roads
2. Car on motorway
3. Taxi
4. Rail
5. Bus
6. Coach
7. Plane

Journey Planning

JOURNEY PLANNING From: Somewhere To: Elsewhere

Transport Type	Method	From	To	Dist	Time Hours	Cost £
1	Car/Road	A	B	5	.10	£.75
2	Car/Mway	B	C	200	2.50	£38.00
1	Car/Road	D	E	50	1.04	£7.50
2	Car/Mway	E	F	100	1.25	£19.00
			Total	355	4.90	£65.25

Transport Type	Method	From	To	Dist	Time Hours	Cost £
5	Bus	A	B	2	.13	£.80
4	Rail	B	C	20	.22	£5.00
7	Plane	D	E	280	.93	£112.00
4	Rail	E	F	50	.56	£12.50
3	Taxi	G	H	3	.06	£6.00
			Total	355	1.91	£136.30

Time and cost of different methods of transport

Type	Method	Time Km/hour	Cost £/km
1	Car/Road	48	.15
2	Car/Mway	80	.19
3	Taxi	48	2
4	Rail	90	.25
5	Bus	15	.40
6	Coach	80	.20
7	Plane	300	.40

NETWORK PATERNS

Description

Road networks are made of roads of different types such as normal 'A' class roads and motorways. The average travelling speed on each being different. The journey times are therefore a result of the distance between each point, and the average speed for each of the section along the shortest route.

Inputs

For each journey in the network
1. The STARTING town
2. The FINISHING town
3. The 1ST 2ND 3RD roads used along the ROUTE

For each road
1. The DIST from one end of the road to the other
2. The TYPE of road

For each type of road
1. The TYPE of the road
2. The average SPEED for that type of road

Associated Materials

A map of a road network showing the towns and road. Each should be labelled and the road should be designated a particular type.

Network Speeds

NETWORK SPEEDS

		ROUTE			DIST	TIME	
START	FINISH	1ST	2ND	3RD	MILES	HOURS	MINS
A	B	3	2	0	180	4	17
A	C	4	0	0	150	4	17
A	D	3	0	0	100	2	0
A	E	3	2	1	240	5	29
A	F	3	6	0	300	7	43
B	C	2	5	0	280	6	17
B	D	2	0	0	80	2	17
B	E	1	0	0	60	1	12
B	F	2	6	0	280	8	0
C	D	5	0	0	200	4	0
C	E	5	2	1	340	7	29
C	F	5	6	0	400	9	43
D	E	2	1	0	140	3	29
D	F	6	0	0	200	5	43
E	F	1	2	6	340	9	12

MILES & ROAD TYPE

ROAD	DIST	TYPE
0	0	0
1	60	1
2	80	2
3	100	1
4	150	2
5	200	1
6	70	2

SPEED / ROAD TYPE

TYPE	SPEED
1	50
2	35

MILES				ROAD TYPE		
1ST	2ND	3RD	TOTAL	1ST	2ND	3RD
100	80	0	180	1	2	0
150	0	0	150	2	0	0
100	0	0	100	1	0	0
100	80	60	240	1	2	1
100	200	0	300	1	2	0
80	200	0	280	2	1	0
80	0	0	80	2	0	0
60	0	0	60	1	0	0
80	200	0	280	2	2	0
200	0	0	200	1	0	0
200	80	60	340	1	2	1
200	200	0	400	1	2	0
80	60	0	140	2	1	0
200	0	0	200	2	0	0
60	80	200	340	1	2	2

TIME			
1ST	2ND	3RD	TOTAL
2	2.29	0	4.29
4.29	0	0	4.29
2	0	0	2
2	2.29	1.20	5.49
2	5.71	0	7.71
2.29	4	0	6.29
2.29	0	0	2.29
1.20	0	0	1.20
2.29	5.71	0	8
4	0	0	4
4	2.29	1.20	7.49
4	5.71	0	9.71
2.29	1.20	0	3.49
5.71	0	0	5.71
1.20	2.29	5.71	9.20

ACCESSIBILITY IN NETWORKS

Description

Road networks are made of roads of different types such as normla 'A' class
roads and motorways. The average travelling speed on each being different. The journey times are therefore a result of the distance between each point, and the average speed for each of the section along the shortest route. An important criteria in the study of networks is the determination of the most centrallly accessible place. The accessibility can be determined by distance or time.

Inputs

For each journey in the network
1. The STARTing town
2. The FINISHing town
3. The 1ST 2ND 3RD roads used along the ROUTE

For each road
1. The DIST from one end of the road to the other
2. The TYPE of road

For each type of road
1. The TYPE of the road
2. The average SPEED for that type of road

Associated Materials

A map of a road network showing the towns and road. Each should be labelled and the road should be designated a particular type.

Accessiblity

MILES & ROAD TYPE

ROAD	DIST	TYPE
0	0	0
1	60	1
2	70	2
3	100	2
4	150	1
5	200	1
6	70	2

SPEED / ROAD TYPE

TYPE	SPEED
1	65
2	35

ACCESSIBILITY OF PLACES

PLACE	TOTAL MILES	TOTAL TIME HOURS	MINS
A	950	24	22
B	840	20	34
C	1350	25	15
D	700	16	34
E	1080	24	16
F	1500	39	26

ROUTE DESIGNATION

START	FINISH	ROUTE 1ST	ROUTE 2ND	ROUTE 3RD	DIST MILES	TIME HOURS	TIME MINS
A	B	3	2	0	170	4	51
A	C	4	0	0	150	2	18
A	D	3	0	0	100	2	51
A	E	3	2	1	230	5	47
A	F	3	6	0	300	8	34
B	C	2	5	0	270	5	5
B	D	2	0	0	70	2	0
B	E	1	0	0	60	0	55
B	F	2	6	0	270	7	43
C	D	5	0	0	200	3	5
C	E	5	2	1	330	6	0
C	F	5	6	0	400	8	47
D	E	2	1	0	130	2	55
D	F	6	0	0	200	5	43
E	F	1	2	6	330	8	38

MILES 1ST	MILES 2ND	MILES 3RD	MILES TOTAL	ROAD TYPE 1ST	ROAD TYPE 2ND	ROAD TYPE 3RD
100	70	0	170	2	2	0
150	0	0	150	1	0	0
100	0	0	100	2	0	0
100	70	60	230	2	2	1
100	200	0	300	2	2	0
70	200	0	270	2	1	0
70	0	0	70	2	0	0
60	0	0	60	1	0	0
70	200	0	270	2	2	0
200	0	0	200	1	0	0
200	70	60	330	1	2	1
200	200	0	400	1	2	0
70	60	0	130	2	1	0
200	0	0	200	2	0	0
60	70	200	330	1	2	2

TIME 1ST	TIME 2ND	TIME 3RD	TIME TOTAL
2.86	2	0	4.86
2.31	0	0	2.31
2.86	0	0	2.86
2.86	2	.92	5.78
2.86	5.71	0	8.57
2	3.08	0	5.08
2	0	0	2
.92	0	0	.92
2	5.71	0	7.71
3.08	0	0	3.08
3.08	2	.92	6
3.08	5.71	0	8.79
2	.92	0	2.92
5.71	0	0	5.71
.92	2	5.71	8.64

TOTAL MILEAGE ACCESSIBLITY

	A	B	C	D	E	F	TOTAL
A	*	170	150	100	230	300	950
B	170	*	270	70	60	270	840
C	150	270	*	200	330	400	1350
D	100	70	200	*	130	200	700
E	230	60	330	130	*	330	1080
F	300	270	400	200	330	*	1500

TOTAL TIME ACCESSIBILITY

	A	B	C	D	E	F	TOTAL
A	*	4.86	2.31	2.86	5.78	8.57	24.37
B	4.86	*	5.08	2	.92	7.71	20.57
C	2.31	5.08	*	3.08	6	8.79	25.25
D	2.86	2	3.08	*	2.92	5.71	16.57
E	5.78	.92	6	2.92	*	8.64	24.26
F	8.57	7.71	8.79	5.71	8.64	*	39.43

OIL EXPLORATION

Description

Oil exploration is a risky business with many unknown factors when decisions have to be taken. The original expenditure is for the licence to explore the section. Depending on the location of the section, land or sea will be the running costs associated with it. The total expenditure for a company can be calculated in this manner. The number of barrels to be produced by the location is only known with accuracy at the time of production after all the costs have been committed. The price of the barrels also varies with the market. An original capital is set aside for each group and then the bid for the sections, each of which has a licence fee (payable once) and a running cost payable yearly. Each location also has a probability of the number of barrels to be produced. Up to five location can be purchased. After each group has bought their quota for the year the outputs are decided, and the price per barrel is established. The total income for the year can then be calculated. The cycle can continue for up to five years.

Inputs

1. The Reference of the section purchase
2. The LICENCE fee payable
3. The annual RUNNING costs
4. The BARRELS for each section entered on the map
5. The PRICE for each barrel
6. The YEAR under consideration
7. The COSTS for each year
8. The INCOME for each year

Associated Materials

A map of the area with the grid sections marked and the licence and running fees indicated.

Oil Exploration

OIL EXPLORATION

			Barrels
			0
			0
9			9
	6		6
			0
			0
			0
			0
8	7		15
			0
		4	4
		Total	34

Year: 1981

Costs

Ref	Licence	Running	Total
C6	2	34	36
F7	4	43	47
C12	5	23	28
F12	6	12	18
I14	7	12	19
			148

Income

Price	Barrels	Total
20	34	680

Statement of Balance

Original Capital 70

Year	Costs	Income	Balance
1980	23	25	72
1981	148	680	604
1982	12	56	648
1983	45	67	670
1984	56	23	637

METEOROLOGICAL LAPSE RATES

Description

When a parcel of air rises it cools at either a dry adiabatic lapse or a saturated adiabatic lapse rate depending on whether the parcel of air is below the dew point. The dew point also has a lapse rate on rising, therefore the height of the cloud base and possible rain and / or snow can be deduced from the intersection of the rates. The stability of the air can also be worked out from the adiabatic lapse rates and the environmental lapse rates.

Inputs

1. The DRY adiabatic lapse RATE
2. The SATurated adiabatic lapse RATE
3. The DEW point lapse RATE
4. The ENVIRONmental lapse RATE
5. The TEMPerature of the PARCEL of air at ground level
6. The DEW Point TEMPerature at ground level

Lapse Rates

LAPSE RATES

Dry Rate	Sat Rate	Dew Rate	Environ Rate	Parcel Temp	Dew P Temp
1.00	.60	.20	.95	7.00	3.00

Height	Parcel Temp	Dew P Temp	Lapse Rate	Unstable Air	Rain	Snow
0	7.00	3.00	1.00			
100	6.05	2.80	1.00			
200	5.10	2.60	1.00			
300	4.15	2.40	1.00			
400	3.20	2.20	1.00			
500	2.25	2.00	1.00			
600	1.30	1.80	.60	***	***	
700	.35	1.60	.60	***	***	
800	-.60	1.40	.60	***		***
900	-1.55	1.20	.60	***		***
1000	-2.50	1.00	.60	***		***

STATION LOCATION

Description

When a light urban railway is planned the distribution of the population is taken into account when the station are located. This is to give the optimum accessibility time to reach the nearest station.

Inputs

1. The POPULATION levels for each grid square.
2. The ROUTE of the railway.
2. The proposed LOCATION for each of two stations.

Station Location

STATION LOCATIONS — Station One 22 — Station Two 88

Vert Coord	work one	work two	0	1	2	3	4	5	6	7	8	9
			-2	-1	0	1	2	3	4	5	6	7
			-8	-7	-6	-5	-4	-3	-2	-1	0	1
0	-2	-8	2	2	2	2	2	3	4	5	6	7
1	-1	-7	2	1	1	1	2	3	4	5	6	7
2	0	-6	2	1	0	1	2	3	4	5	6	6
3	1	-5	2	1	1	1	2	3	4	5	5	5
4	2	-4	2	2	2	2	2	3	4	4	4	4
5	3	-3	3	3	3	3	3	3	3	3	3	3
6	4	-2	4	4	4	4	4	3	2	2	2	2
7	5	-1	5	5	5	5	4	3	2	1	1	1
8	6	0	6	6	6	5	4	3	2	1	0	1
9	7	1	7	7	6	5	4	3	2	1	1	1

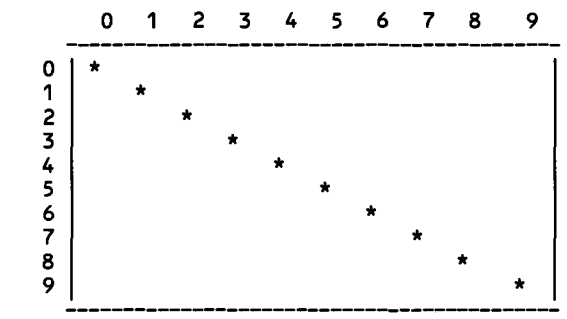
Horiz Coord
work one
work two

Total Pop
4503

Total Time
15005

Average Time
3.33

Route of Light Railway



Population Distribution

	0	1	2	3	4	5	6	7	8	9
0	34	64	65	12	12	76	98	67	88	12
1	45	28	56	7	13	34	64	65	67	65
2	67	6	57	45	98	45	28	56	19	64
3	89	67	23	75	45	67	6	57	63	34
4	45	34	17	75	45	67	6	57	15	12
5	23	12	12	7	13	34	64	65	26	86
6	67	7	13	34	64	65	73	7	54	23
7	12	45	98	45	28	56	156	2	19	12
8	73	75	45	67	6	57	51	34	43	23
9	13	23	87	89	67	23	38	45	12	54

Time for population to reach station

	0	1	2	3	4	5	6	7	8	9	
0	68	128	130	24	24	228	392	335	528	84	Total
1	90	28	56	7	26	102	256	325	402	455	Time
2	134	6	0	45	196	135	112	280	114	384	15005
3	178	67	23	75	90	201	24	285	315	170	Total
4	90	68	34	150	90	201	24	228	60	48	Pop
5	69	36	36	21	39	102	192	195	78	258	4503
6	268	28	52	136	256	195	146	14	108	46	Average
7	60	225	490	225	112	168	312	2	19	12	Time
8	438	450	270	335	24	171	102	34	0	23	3.33
9	91	161	522	445	268	69	76	45	12	54	

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APPENDIX SIX

GEOGRAPHY PROLOG MODELS

POPULATION GROWTH

A simple population growth model where the inputs are the stating population, the first year and the final year of the projection. The birth rate and death rate are fixed as below :

```
growth(End_year,Pop,End_year).

growth(Year,Pop,End_year):-
     birth_rate(Birth_rate),
     death_rate(Death_rate),
     Births is Pop * Birth_rate/1000,
     Deaths is Pop * Death_rate/1000,
     Natural_increase is Births-Deaths,
     Next_year is Year +1,
     New_pop is Pop + Natural_increase,
     printout(Year,Pop,Births,Deaths,Natural_increase,New_pop),
     growth(Next_year,New_pop,End_year).

birth_rate(38).
death_rate(20).

printout(Year,Pop,Births,Deaths,Natural_increase,New_pop):-
     write(Year),write('       '),
     write(Pop),write('       '),
     write(Births),write('       '),
     write(Deaths),write('       '),
     write(Natural_increase),write('       '),
     write(New_pop),
     nl.

begin:-
     data_entry(Year,Pop,End_year),
     print_headings,
     growth(Year,Pop,End_year).

data_entry(Year,Pop,End_year):-
     write('Enter start year..... '),
     read(Year),
     write('Enter start population.. '),
     read(Pop),
     write('Enter end year..... '),
     read(Entry),
     End_year is Entry +1.

print_headings :-
     write('Year.....'),
     write('Pop......'),
     write('Births...'),
     write('Deaths...'),
     write('Incr.....'),
     write('New Pop'),
     nl.
```

LIGHTS

This program simulates the flow of traffic at a crossroads with traffic lights. Q1 and Q3 have the same period of time for green lights, as do Q2 and Q4. The rate of arrival of each of the four queues is entered and the amount of time the lights are green. The rate of arrival is per minute and the green time is the number of seconds in each minute. It is assumed that cars pass through green lights at the rate of one per second.

```
traffic(End_mins,Q1,Q2,Q3,Q4,End_mins).

traffic(Mins,Q1,Q2,Q3,Q4,End_mins):-
     arrival_rate(Q1arr,Q2arr,Q3arr,Q4arr),
     through_rate(Through1),
     Through2 is 60-Through1,
     Newq1 is Q1+Q1arr-Through1,
     Newq2 is Q2+Q2arr-Through2,
     Newq3 is Q3+Q3arr-Through1,
     Newq4 is Q4+Q4arr-Through2,
     printout(Mins,Q1,Q2,Q3,Q4),
     Next_mins is Mins +1,
     traffic(Next_mins,Newq1,Newq2,Newq3,Newq4,End_mins).

begin:-
     write('Input rate of arrival of cars for Queue 1.....'),
     read(Q1),
     write('Input rate of arrival of cars for Queue 2.....'),
     read(Q2),
     write('Input rate of arrival of cars for Queue 3.....'),
     read(Q3),
     write('Input rate of arrival of cars for Queue 4.....'),
     read(Q4),
     write('Input time for green lights for Queues 1&3....'),
     read(Green),
     write('Input number of minutes to run ..............'),
     read(End_mins),
     asserta(arrival_rate(Q1,Q2,Q3,Q4)),
     asserta(through_rate(Green)),
     headings,
     traffic(1,Q1,Q2,Q3,Q4,End_mins),
     retract(arrival_rate(Q1,Q2,Q3,Q4)),
     retract(through_rate(Green)).

headings:-
     write('Mins  '),
     write('Q1    '),
     write('Q2    '),
     write('Q3    '),
     write('Q4    '),
     nl.


printout(Mins,Q1,Q2,Q3,Q4):-
     write(Mins),write('    '),
     write(Q1),write('    '),
     write(Q2),write('    '),
     write(Q3),write('    '),
     write(Q4),nl.
```

TRAFFIC AT TWO SETS OF LIGHTS

This program deals with two queues of traffic and two sets of the lights. The traffic that passes the first queue when the lights are green, reaches and join the second queue after a slight time lag. When the queue at the second set of lights (R1) reaches a threshold, i.e. 30, the feedback halts the flow at the second set of lights. The initial queue lengths are set. The other values are set within the program, as below:

```
traffic(End_mins,Q1,R1,End_mins).

traffic(Mins,Q1,R1,End_mins):-
     arrivals(Q1arr),
     green(Greenq,Greenr),
     feedback(Q1,Q1arr,R1,Newq1,Greenq),
     pos_test(Newq1,Newestq1),
     passed(Q1,R1,Q1arr,Greenq,Passed),
     asserta(en_route(Mins,Passed)),
     delay(Delay),
     rqueue(Mins,Delay,Rarr),
     Newr1 is R1+Rarr-Greenr,
     pos_test(Newr1,Newestr1),
     printout(Mins,Q1,Q1arr,Passed,Newestq1,R1,Rarr,Newestr1),
     Next_mins is Mins +1,
     traffic(Next_mins,Newestq1,Newestr1,End_mins).

feedback(Q1,Q1arr,R1,Newq1,Greenq):-
R1<30,
Newq1 is Q1+Q1arr-Greenq.

feedback(Q1,Q1arr,R1,Newq1,Greenq):-
R1>=30,
Newq1 is Q1+Q1arr.

green(20,10).

pos_test(A,0):-
     A<0.

pos_test(A,A):-
     A>=0.
rqueue(Mins,Delay,Rarr):-
     Mins > Delay,
     Past_mins is Mins-Delay,
     en_route(Past_mins,Rarr).

rqueue(Mins,Delay,0):-
     Mins =< Delay.


passed(Q1,R1,Q1arr,Green,Passed):-
     Totalarr is Q1+Q1arr,
     Totalarr >= Green,
     R1<30,
     Passed is Green.

passed(Q1,R1,Q1arr,Green,Passed):-
     Totalarr is Q1+Q1arr,
     Totalarr < Green,
     R1<30,
     Passed is Totalarr.

passed(Q1,R1,Q1arr,Green,0):-
     R1>=30.

delay(2).
arrivals(40).

print_headings:-
     write('Mins'),
     write('Q1  '),
     write('Q1arriv '),
     write('Passed  '),
     write('New Q1  '),
```

```
     write('R1      '),
     write('R1 arr  '),
     write('New R1  '),nl.


printout(Mins,Q1,Q1arr,Passed,Newq1,R1,Rarr,Newr1):-
     write(Mins),write('    '),
     write(Q1),write('   '),
     write(Q1arr),write('     '),
     write(Passed),write('      '),
     write(Newq1),write('      '),
     write(R1),write('      '),
     write(Rarr),write('     '),
     write(Newr1),nl.

begin:-
     data_entry(Q1,R1,End_mins),
     print_headings,
     traffic(1,Q1,R1,End_mins).

data_entry(Q1,R1,End_mins):-
     write('Length of Queue Q1.............'),
     read(Q1),
     write('Length of Queue R1.............'),
     read(R1),
     write('Number of minutes .............'),
    read(Entry),
     End_mins is Entry +1.
```

REGIONAL POPULATION

The program takes looks up the input region and then produces the population projection for the number of specified years. The inputs select the region from the table of population details and the inputs gives the change in birth and death rates and the number of years the projection is to run. The regions available are at the end of the listing.

```
begin :-
     data_entry(Region,Ch_brate,Ch_drate,Years),
     print_headings,
     pop_details(Region,Pop,Brate,Drate,Area),
     project(1,Pop,Brate,Ch_brate,Drate,Ch_drate,Area,Years).

data_entry(Region,Ch_brate,Ch_drate,Years):-
     write('Region.............'),
     read(Region),
     write('Change in birth rate....'),
     read(Ch_brate),
     write('Change in deaths rate...'),
     read(Ch_drate),
     write('Number of years.........'),
     read(Entry),
     Years is Entry +1.

project(End_year,New_pop,New_brate,Ch_brate,New_drate,Ch_drate,Area,End_year).
project(Year,Pop,Brate,Ch_brate,Drate,Ch_drate,Area,End_year):-
     Births is Pop * Brate/1000,
     Deaths is Pop * Drate/1000,
     New_pop is Pop + Births - Deaths,
     Density is New_pop/(Area/1000),
     printout(Pop,Brate,Births,Drate,Deaths,New_pop,Density),
     New_brate is Brate + Ch_brate,
     New_drate is Drate + Ch_drate,
     New_year is Year + 1,
     project(New_year,New_pop,New_brate,Ch_brate,New_drate,Ch_drate,Area,End_year).

printout(Pop,Brate,Births,Drate,Deaths,New_pop,Density):-
     write(Pop),write('     '),
     write(Brate),write('        '),
     write(Births),write('        '),
     write(Drate),write('        '),
     write(Deaths),write('        '),
     write(New_pop),write('        '),
     write(Density),
     nl.

print_headings:-
     write('Pop'),write('  '),
     write('B_rate'),write(' '),
     write('Births'),write(' '),
     write('D_rate'),write(' '),
     write('Deaths'),write(' '),
     write('New_pop'),write(' '),
     write('Density'),nl.

pop_details(west_africa,104,49,24,6100).
pop_details(east_africa,100,46,22,6200).
pop_details(north_africa,89,47,17,8900).
pop_details(mid_africa,37,45,24,6170).
pop_details(south_africa,23,41,17,2500).
pop_details(north_america,230,18,9,20900).
pop_details(trop_s_america,155,40,10,14100).
pop_details(mid_s_america,96,41,10,9600).
pop_details(temp_s_america,40,25,8,800).
pop_details(east_asia,946,31,14,11800).
pop_details(mid_s_asia,783,44,17,6700).
pop_details(s_e_asia,295,44,16,4500).
pop_details(s_w_asia,79,44,16,4400).
pop_details(w_europe,150,17,11,1000).
pop_details(s_europe,130,19,9,1300).
pop_details(e_europe,105,17,10,1000).
pop_details(n_europe,81,17,11,1600).
pop_details(australia,16,21,9,8000).
pop_details(ussr,245,18,8,22200).
```

SHOP LOCATION

This program take a neighbourhood on a map with 25 grid squares. Each of the 25 squares has a population figure, given at the end of the program. The objective is to locate the shop which give the minimum average travelling time. The integer of the result only is given. The travelling time from one grid square to the next is assumed to be one unit of time

```
begin :-
     write('Enter shop   hoizontal coord.....'),
     read(X),
     write('Enter shop   vertical coord'),
     read(Y),
     asserta(shop_coords(X,Y)),
     headings,
     shop_location(1,0,0),
     retract(shop_coords(X,Y)).

headings:-
     write('X Coord....'),
     write('Y Coord....'),
     write('Population....'),
     write('Time to shop'),nl.

shop_location(26,Total_pop,Total_time):-
     write('Total population on map.................'),
     write(Total_pop),nl,
     write('Total time take for all population.......'),
     write(Total_time),nl,
     Average is Total_time/Total_pop,
     write('Average time per person ................'),
     write(Average),nl.

shop_location(Count,Total_pop,Total_time):-
     map_of_population(Count,X_coord,Y_coord,Pop),
     time_to_shop(X_coord,Y_coord,Time),
     New_total_pop is Total_pop + Pop,
     New_total_time is Total_time +(Pop * Time),
     printout(X_coord,Y_coord,Pop,Time),
     New_count is Count+1,
     shop_location(New_count,New_total_pop,New_total_time).

time_to_shop(X_coord,Y_coord,Time):-
     shop_coords(Shop_x,Shop_y),
     Diff_x is X_coord - Shop_x,
     Diff_y is Y_coord - Shop_y,
     absolute(Diff_x,Abs_diff_x),
     absolute(Diff_y,Abs_diff_y),
     max(Abs_diff_x,Abs_diff_y,Time).

max(Num1, Num2, Num3):-
     Num1 >= Num2,
     Num3 is Num1.
max(Num1, Num2, Num3):-
     Num1 < Num2,
     Num3 is Num2.

absolute(Num1,Num2):-
     Num1 >= 0,
     Num2 is Num1.
absolute(Num1,Num2):-
     Num1 < 0,
     Num2 is Num1 * -1.

printout(X_coord,Y_coord,Pop,Time):-
     write(X_coord),write('           '),
     write(Y_coord),write('           '),
     write(Pop),write('           '),
     write(Time),
     nl.

map_of_population(1,1,1,58).
map_of_population(2,1,2,12).
map_of_population(3,1,3,32).
map_of_population(4,1,4,10).
```

```
map_of_population(5,1,5,51).
map_of_population(6,2,1,99).
map_of_population(7,2,2,52).
map_of_population(8,2,3,19).
map_of_population(9,2,4,18).
map_of_population(10,2,5,21).
map_of_population(11,3,1,45).
map_of_population(12,3,2,67).
map_of_population(13,3,3,42).
map_of_population(14,3,4,10).
map_of_population(15,3,5,12).
map_of_population(16,4,1,23).
map_of_population(17,4,2,45).
map_of_population(18,4,3,15).
map_of_population(19,4,4,10).
map_of_population(20,4,5,38).
map_of_population(21,5,1,45).
map_of_population(22,5,2,11).
map_of_population(23,5,3,19).
map_of_population(24,5,4,12).
map_of_population(25,5,5,23).
```

ROAD BUILDING

This program is to work out the cost of building a road across a section of the country. It determines the monetary cost which is related to the relief values, and the 'environmental' cost which is related to the values give to the bottom of the program. This are 'judgmental values'. The route is chosen and entered before the program is run and the program then gives the two costs

```
count(6,Relief_cost,Environ_cost):-
     write('Total cost caused by relief is ....'),
     write(Relief_cost),nl,
     write('Total environmental cost is .......'),
     write(Environ_cost),nl.

count(Count,Relief_cost,Environ_cost):-
     route(Count,X,Y),
     map(X,Y,Relief_type,Environ_type),
     relief(Relief_type,Relief_value),
     environ(Environ_type,Environ_value),
     New_relief_cost is Relief_cost + Relief_value,
     New_environ_cost is Environ_cost + Environ_value,
     New_count is Count+1,
     printout(X,Y,Relief_type,Relief_value,Environ_type,Environ_value,
              New_relief_cost,New_environ_cost),
     count(New_count,New_relief_cost,New_environ_cost).

route(1,5,1).
route(2,4,2).
route(3,3,3).
route(4,2,4).
route(5,1,5).

map(1,1, hgh, heath).
map(1,2, hgh, heath).
map(1,3, hgh, heath).
map(1,4, hgh, heath).
map(1,5, hgh, heath).
map(2,1, hgh, heath).
map(2,2, hgh, heath).
map(2,3, hgh, marsh).
map(2,4, hgh, marsh).
map(2,5, hgh, marsh).
map(3,1, mod,farm).
map(3,2, mod,farm).
map(3,3, mod,farm).
map(3,4, mod,farm).
map(3,5, mod,farm).
map(4,1, low,town).
map(4,2, low,town).
map(4,3, low,town).
map(4,4, low,nature).
map(4,5, low,nature).
map(5,1, low,town).
map(5,2, low,town).
map(5,3, low,nature).
map(5,4, low,nature).
map(5,5, low,nature).

relief(hgh,300).
relief(mod,200).
relief(low,100).

environ(heath,100).
environ(marsh,50).
environ(farm, 300).
environ(town,400).
environ(nature,350).

begin :-
     headings,
     count(1,0,0).

headings :-
```

```
write('X  Y   Rel Type     Value Cost     Environ  Value Cost'),
     nl.

printout(X,Y,Relief_type,Relief_value,Environ_type,Environ_value,
               New_relief_cost,New_environ_cost):-
     write(X),write('   '),
     write(Y),
     write('   '),
     write(Relief_type),write('   '),
     write(Relief_value),write('   '),
     write(New_relief_cost),write('   '),
     write(Environ_type),write('   '),
     write(Environ_value),write('   '),
     write(New_environ_cost),nl.
```

SLOPE DRAINAGE

This program models the flows of water on a slope, both the overland flow and the water flow that is infiltrated. Evaporation and infiltration rates are set and a delay is set. The delay is the difference in time between the overland flow and the infiltration water reaching the channel.

```
drainage(11).

drainage(Hour):-
     rainfall(Hour,Rain),
     rates(Evap_rate,Delay,Infil_rate),
     Evap is Evap_rate * Rain/100,
     Surface is Rain - Evap,
     Infiltration is Surface * Infil_rate/100,
     Overland is Surface - Infiltration,
     asserta(infiltration(Hour,Infiltration)),
     channel(Hour,Delay,Overland,Channel),
     printout(Hour,Rain,Evap,Surface,Infiltration,Overland,Channel),
     New_hour is Hour +1,
     drainage(New_hour).

channel(Hour,Delay,Overland,Channel):-
     Hour > Delay,
     Past_hour is Hour-Delay,
     infiltration(Past_hour, Past_infil),
     Channel is Overland + Past_infil.

channel(Hour,Delay,Overland,Channel):-
     Hour =< Delay,
     Channel is Overland.

rainfall(1,20).
rainfall(2,20).
rainfall(3,30).
rainfall(4,40).
rainfall(5,50).
rainfall(6,40).
rainfall(7,30).
rainfall(8,20).
rainfall(9,20).
rainfall(10,20).

begin :-
     write('Evaporation rate .................'),
     read(Evap_rate),
     write('Infiltration rate ................'),
     read(Infil_rate),
     write('Delay ............................'),
     read(Delay),
     asserta(rates(Evap_rate,Delay,Infil_rate)),
     headings,
     drainage(1),
     retract(rates(Evap_rate,Delay,Infil_rate)).


headings:-
     write('Hour     '),
     write('Rain     '),
     write('Evap     '),
     write('Surface  '),
     write('Infil    '),
     write('Overland '),
     write('Channel'),nl.

printout(Hour,Rain,Evap,Surface,Infiltration,Overland,Channel):-
     write(Hour),write('        '),
     write(Rain),write('        '),
     write(Evap),write('        '),
     write(Surface),write('         '),
     write(Infiltration),write('        '),
     write(Overland),write('        '),
     write(Channel),nl.
```

TOWNS - GRAVITY MODEL

A simple program to give the relative interaction of five towns. It is based on the traditional gravity formula. The number of the town is entered and the results displayed. The program uses list_position which is defined at the bottom of the program.

```
gravity(6).


gravity(Count):-
town(Town_number),
settlement(Settlement,Town_number,Population,Distance_list),
list_position(Distance,Distance_list,Count),
settlement(Sec_settle,Count,Sec_pop,Sec_dist_list),
interaction(Population,Sec_pop,Distance,Interaction),
printout(Settlement,Population,Sec_settle,Sec_pop,Distance,Interaction),
New_count is Count+1,
gravity(New_count).

begin:-
     write('Input town number required .............'),
     read(Town_number),
     asserta(town(Town_number)),
     headings,
     gravity(1),
     retract(town(Town_number)).

printout(Settlement,Population,Sec_settle,Sec_pop,Distance,Interaction):-
     write(Settlement),write('   '),
     write(Population),write('    '),
     write(Sec_settle),write('   '),
     write(Sec_pop),write('    '),
     write(Distance),write('   '),
     write(Interaction),nl.

headings:-
     write('Settlement '),
     write('Pop      '),
     write('Settlement  '),
     write('Pop      '),
     write('Dist '),
     write('Interaction'),nl.

interaction(Population,Sec_pop,Distance,0):-
     Distance = 0.

interaction(Population,Sec_pop,Distance,Interaction):-
     Interaction is (Population * Sec_pop)/(Distance*Distance).



settlement(flintmere,1,20000,[ 0,20,10,16,32]).
settlement(havenwick,2,10000,[20, 0,12,24,14]).
settlement(southwold,3,34000,[10,12, 0,12,11]).
settlement(chalkdown,4, 5000,[16,24,12, 0,28]).
settlement(marshside,5, 9000,[32,14,11,28, 0]).

list_position(Element,[Element|_],1).

list_position(Element,[_|List],Number):-
     list_position(Element,List,Num_sofar),
     Number is Num_sofar +1.
```

LONGITUDE

This program calculates the time at different places in the world. The list of places is given the program. The input details at the time and longitude at the base, i.e. the point of origin. The base day is the first three letters of the day

```
begin :-
     data_entry(Base_time,Base_deg,Base_dir,Base_day),
     print_headings,
     places(1),
     retract(base(Base_time,Base_deg,Base_dir,Base_day)).

data_entry(Base_time,Base_deg,Base_dir,Base_day):-
     write('Time in hours at base.........'),
     read(Base_time),
     write('Enter day at base ............'),
     read(Base_day),
     write('Degrees longitude of base......'),
     read(Base_deg),
     write('Direction longitude E or W.....'),
     read(Base_dir),
     asserta(base(Base_time,Base_deg,Base_dir,Base_day)).

places(10).

places(Count):-
     base(Base_time,Base_deg,Base_dir,Base_day),
     cities(Count,City,Deg,Dir),
     num_value(Base_deg,Base_dir,Base_value),
     num_value(Deg,Dir,City_value),
     difference(Base_value,City_value,Diff),
     hours_diff(Base_value,City_value,Diff,Hours),
     time_of_day(Base_time,Hours,Time,Base_day,Day),
     printout(Count,City,Deg,Dir,Hours,Time,Day),
     New_count is Count +1,
     places(New_count).

time_of_day(Base_time,Hours,Time,Base_day,Base_day):-
     Base_time + Hours =< 24,
     Base_time + Hours >=  0,
     Time is Base_time + Hours.

time_of_day(Base_time,Hours,Time,Base_day,Day):-
     Base_time + Hours < 0,
     Time is (Base_time + Hours)+24,
     days(Day,Base_day).

time_of_day(Base_time,Hours,Time,Base_day,Day):-
     Base_time + Hours > 24,
     Time is (Base_time + Hours)-24,
     days(Base_day,Day).

days(sun,mon).
days(mon,tue).
days(tue,wed).
days(wed,thu).
days(thu,fri).
days(fri,sat).
days(sat,sun).

hours_diff(Base_value,City_value,Diff,Hours):-
     City_value > Base_value,
     Hours is (Diff/15) * -1.

hours_diff(Base_value,City_value,Diff,Hours):-
     City_value =< Base_value,
     Hours is Diff/15.

difference(Base_value,City_value,Diff):-
     Temp is Base_value - City_value,
     pos_test(Temp, Diff).

pos_test(Temp,Diff):-
     Temp < 0,
```

```
     Diff is Temp * -1.
pos_test(Temp,Diff):-
     Temp >= 0,
     Diff is Temp.


num_value(Degrees,e,Numerical):-
     Numerical is Degrees * -1.

num_value(Degrees,w,Numerical):-
     Numerical is Degrees.

cities(1,warsaw,22,e).
cities(2,new_york,75,w).
cities(3,moscow,38,e).
cities(4,peking,118,e).
cities(5,san_francisco,125,w).
cities(6,melbourne,158,e).
cities(7,cape_town,20,e).
cities(8,hawaii,155,w).
cities(9,wellington,172,e).

print_headings:-
     write('Deg    '),
     write('Dir    '),
     write('Hours  '),
     write('Time   '),
     write('Day    '),
     write('City   '),nl.

printout(Count,City,Deg,Dir,Hours,Time,Day):-
     write(Deg),write('       '),
     write(Dir),write('     '),
     write(Hours),write('     '),
     write(Time),write('      '),
     write(Day),write('      '),
     write(City),nl.
```

FARM

Similar to the farm game. The crop are entered for each field. The climate is then decided and the yields and subsequent incomes calculated. There are a restricted number of crops, these are listed at the end of the program.

```
field(5,Income).

field(Field,Income):-
     field_size(Field,Hectares),
     crops(List_of_crops),
     list_position(Crop,List_of_crops,Field),
     climate(Climate),
     list_of_climates(List_of_climates),
     list_position(Climate,List_of_climates,Position),
     yields(Crop,List_of_yields,Price),
     list_position(Yield,List_of_yields,Position),
     F_income is Hectares*Yield*Price,
     Total is Income+F_income,
     print_out(Climate,Field,Hectares,Crop,Yield,Price,F_income,Total),
     Next_field is Field+1,
     field(Next_field,Total).


print_out(Climate,Field,Hectares,Crop,Yield,Price,F_income,Total):-
     write(Climate),write(' '),
     write(Crop),write(' '),
     write(Field),write('    '),
     write(Hectares),write('   '),
     write(Yield),write('    '),
     write(Price),write('    '),
     write(F_income),write('    '),
     write(Total),nl.


headings:-
     write('Climate   '),
     write('Crop '),
     write('Fld  '),
     write('Hect '),
     write('Yld  '),
     write('Prce '),
     write('Incm '),
     write('Tot'),nl.


begin:-
     write('Enter crop for field one.........'),
     read(Crop1),
     write('Enter crop for field two.........'),
     read(Crop2),
     write('Enter crop for field three.......'),
     read(Crop3),
     write('Enter crop for field four........'),
     read(Crop4),
     write('Climate types are : warm_dry warm_wet cool_dry cool_wet'),
     nl,
     write('Enter climate ...................'),
     read(Climate),
     asserta(climate(Climate)),
     asserta(crops([Crop1,Crop2,Crop3,Crop4])),
     headings,
     field(1,0),
     retract(climate(Climate)),
     retract(crops([Crop1,Crop2,Crop3,Crop4])).


field_size(1,20).
field_size(2,30).
field_size(3,40).
field_size(4,50).
```

```
list_of_climates([warm_dry,warm_wet,cool_dry,cool_wet]).

/* warm_dry warm_wet cool_dry cool_wet price */

yields(wheat, [4,2,5,2],10).
yields(barley,[3,2,2,1],9).
yields(oats,  [1,2,2,3],7).
yields(beet,  [3,3,2,1],8).

list_position(Element,[Element|_],1).
list_position(Element,[_|List],Number):-
     list_position(Element,List,Num_sofar),
     Number is Num_sofar +1.
```

LEAST COST LOCATION

There is a map with the source of two raw materials and a market located. Give the various transport charges in the program there are three chances to locate the factory at the cheapest location. The distance from the raw materials and the factory give the location of the factory.

```
location(4).

location(Count):-
     raw_material(1,Name1,Weight1,Line1,Term1),
     raw_material(2,Name2,Weight2,Line2,Term2),
     finish_goods(Name,Fgwt,Fgline),
     processing(Proc),
     price(Price),
     factory(Count,Dist1,Dist2,Dist_mar),
     Costrm1 is ((Weight1 * Line1) * Dist1) + Term1,
     Costrm2 is ((Weight2 * Line2) * Dist2) + Term2,
     Costfg  is  (Fgwt * Fgline) * Dist_mar,
     Total is ((Costrm1 + Costrm2)+(Costfg + Proc)),
     Profit  is Price - Total,
     printout(Costrm1,Costrm2,Costfg,Total,Profit),
     Newcount is Count + 1,
     location(Newcount).

factory(Count,Dist1,Dist2,Dist_mar):-
     write('Factory number ..............'),write(Count),nl,
     write('Distance 1...................'),read(Dist1),
     write('Distance 2...................'),read(Dist2),
     write('Finish Goods distance.........'),read(Dist_mar).
printout(Costrm1,Costrm2,Costfg,Total,Profit) :-
     write('Rm1..........................'),write(Costrm1),nl,
     write('Rm2..........................'),write(Costrm2),nl,
     write('Fg...........................'),write(Costfg),nl,
     write('Total........................'),write(Total),nl,
     write('Profit.......................'),write(Profit),nl,nl,nl.


raw_material(1,iron_ore,10,5,5).
raw_material(2,coal,5,2,4).
finish_goods(steel,2,2).
processing(20).
price(1000).

begin :- location (1).
```

LAND VALUES

This program represents the idea of bidrent zones in towns. Each land use zone in a towns is characterised by the highest bid from competing uses. Each type of land use starts with a maximum and then has a rate at the which the value of the bid declines.

```
bidrent(11,_,_,_).

bidrent(Distance,Retail,Commercial,Residential):-
     changes(Ret_change,Com_change,Res_change),
     New_retail is Retail - Ret_change,
     New_commercial is Commercial - Com_change,
     New_residential is Residential - Res_change,
     positive_test(New_retail,Pos_retail),
     positive_test(New_commercial,Pos_commercial),
     positive_test(New_residential,Pos_residential),
     printout(Distance,Retail,Commercial,Residential),
     New_distance is Distance + 1,
     bidrent(New_distance,Pos_retail,Pos_commercial,Pos_residential).

positive_test(Number,0):-
     Number<0.
positive_test(Number,Number):-
     Number>=0.

begin:-
     write('Maximum retail bid.................'),
     read(Retail),
     write('Change in retail bid per km.........'),
     read(Ret_change),
     write('Maximum commercial bid.............'),
     read(Commercial),
     write('Change in commerical bid per km.....'),
     read(Com_change),
     write('Maximum residential bid............'),
     read(Residential),
     write('Change in residential bid per km....'),
     read(Res_change),
     asserta(changes(Ret_change,Com_change,Res_change)),
     headings,
     bidrent(1,Retail,Commercial,Residential),
     retract(changes(Ret_change,Com_change,Res_change)).

headings:-
     write('Distance '),
     write('Retail '),
     write('Commercial '),
     write('Residential'),
     nl.

printout(Distance,Retail,Commercial,Residential):-
     write(Distance),write('          '),
     write(Retail),write('    '),
     write(Commercial),write('         '),
     write(Residential),
     nl.
```

LAND DRAINAGE

This program shows a model to monitor the storage and flow of water through a store within the hydrological cycle. It is based on the model for Puddle.

```
puddle(End_mins,Content,End_mins).

puddle(Mins,Content,End_mins):-
     arrival(Arrival),
     max_size(Max_size),
     restriction(Arrival,Content,Max_size,Entry),
     flow(Entry,Content,Max_size,Flow,New_content),
     printout(Mins,Content,Entry,New_content,Flow),
     Next_mins is Mins +1,
     puddle(Next_mins,New_content,End_mins).

max_size(100).
rate(10).
threshold(40).


flow(Entry,Content,Max_size,Flow,New_content):-
     rate(R),
     threshold(L),
     Temp_content is Content+Entry,
     Temp_content  >= L,
     Flow is (R * (Temp_content - L))/(Max_size - L),
     New_content is Temp_content-Flow.

flow(Entry,Content,Max_size,Flow,New_content):-
     rate(R),
     threshold(L),
     Temp_content is Content+Entry,
     Temp_content < L,
     Flow is 0,
     New_content is Temp_content-Flow.


restriction(Arrival,Content,Max_size,Entry):-
     Amount is Content + Arrival,
     Amount =< Max_size,
     Entry is Arrival.

restriction(Arrival,Content,Max_size,Entry):-
     Amount is Content + Arrival,
     Amount > Max_size,
     Entry is Max_size-Content.

printout(Mins,Content,Entry,New_content,Flow):-
     write('   '),
     write(Mins),write('      '),
     write(Content),write('      '),
     write(Entry),write('      '),
     write(New_content),write('      '),
     write(Flow),nl.

headings:-
     write('Mins    '),
     write('Content '),
     write('Entry   '),
     write('New Cont'),
     write(' Flow   '),nl.

begin :-
     write('Rate of arrival of water per minute.....'),
     read(Arrival),
     asserta(arrival(Arrival)),
     write('Number of number of minutes.............'),
     read(End_minute),
     headings,
     puddle(1,0,End_minute),
     retract(arrival(Arrival)).
```

SAHEL ONE

It assumes that deaths are affected by warfare/public_health/food and the population level is affected by deaths. There is no pre_written input routine and the population level is called by population (Level).

```
/* warfare       yes/no */
warfare(yes).

/* public health good/bad  */
public_health(bad).

/* food per capita  high/low  */
food(low).

/* deaths  rapid decrease/decrease/increase/rapid increase */
/*          warfare      health      food     deaths       */
ref_deaths(     yes,       good,       low,    increase).
ref_deaths(     yes,       good,      high,    decrease).
ref_deaths(     yes,        bad,       low,    rapid_increase).
ref_deaths(     yes,        bad,      high,    increase).
ref_deaths(      no,       good,       low,    decrease).
ref_deaths(      no,       good,      high,    rapid_decrease).
ref_detahs(      no,        bad,       low,    increase).
ref_deaths(      no,        bad,      high,    decrease).

deaths(Trend):-
     warfare(Warfare),
     public_health(Health),
     food(Food),
     ref_deaths(Warfare,Health,Food,Trend).

/* population     rising/falling     */
/*          deaths            population    */
ref_pop(     rapid_increase,   falling ).
ref_pop(           increase,   falling ).
ref_pop(     rapid_decrease,   rising  ).
ref_pop(           decrease,   rising  ).

population (Level):-
     deaths(Trend),
     ref_pop(Trend,Level).
```

SAHEL TWO

A development of Sahel1, this program closes a loop to give a cyclical effect. The start and stop point is on food. The prefixes on warfare etc represent the value for each of the cycle. The system may be started by food(2,Food).

```
/* warfare      yes/no */
warfare(1,yes).
warfare(2,no).
warfare(3,yes).
warfare(4,yes).

/* public health good/bad  */
public_health(1,bad).
public_health(2,bad).
public_health(3,bad).
public_health(4,good).

/* food per capita  high/low  */
/*        population      Food   */
ref_food(  rising,         low).
ref_food( falling,        high).
food(1,low).
food(Num,Food):-
     Newnum is Num-1,
     population(Newnum,Level),
     ref_food(Level,Food).

/* deaths  rapid decrease/decrease/increase/rapid increase */
/*          warfare      health      food     deaths       */
ref_deaths(     yes,       good,       low,    increase).
ref_deaths(     yes,       good,      high,    decrease).
ref_deaths(     yes,        bad,       low,    rapid_increase).
ref_deaths(     yes,        bad,      high,    increase).
ref_deaths(      no,       good,       low,    decrease).
ref_deaths(      no,       good,      high,    rapid_decrease).
ref_detahs(      no,        bad,       low,    increase).
ref_deaths(      no,        bad,      high,    decrease).

deaths(Newnum,Trend):-
     warfare(Newnum,Warfare),
     public_health(Newnum,Health),
     food(Newnum,Food),
     ref_deaths(Warfare,Health,Food,Trend).

/* population     rising/falling     */
/*          deaths            population    */
ref_pop(     rapid_increase,   falling ).
ref_pop(           increase,   falling ).
ref_pop(     rapid_decrease,   rising  ).
ref_pop(           decrease,   rising  ).

population (Newnum,Level):-
     deaths(Newnum,Trend),
     ref_pop(Trend,Level).
```

PUPIL TEACHER INTERACTION - PUPIL MODEL

```
begin:-
     data_entry(Year,Pop,End_year),
     print_headings,
     pgrowth(Year,Pop,End_year).

data_entry(Year,Pop,End_year):-
     write('Enter start year '),nl,
     read(Year),
     write('Enter start population'),nl,
     read(Pop),
     write('Enter end year'),nl,
     read(End_year),
     asserta(pupil_input(Year,Pop,End_year)).

print_headings :-
     write('Year.....'),
     write('Pop......'),
     write('Births...'),
     write('Deaths...'),
     write('Incr.....'),
     write('New Pop'),
     nl.


printout(Year,Pop,Births,Deaths,Natural_increase,New_pop):-
     write(Year),
     write(Pop),write('     '),
     write(Births),write('       '),
     write(Deaths),write('       '),
     write(Natural_increase),write('       '),
     write(New_pop),
     nl.

pgrowth(End_year,Pop,End_year).

pgrowth(Year,Pop,End_year):-
     pbirth_rate(Birth_rate),
     pdeath_rate(Death_rate),
     Births is Pop * Birth_rate/1000,
     Deaths is Pop * Death_rate/1000,
     Natural_increase is Births+Deaths,
     Next_year is Year +1,
     New_pop is Pop + Natural_increase,
     printout(Year,Pop,Births,Deaths,Natural_increase,New_pop),
     asserta(answer(Year,Pop,Births,Deaths,Natural_increase,New_pop)),
     pgrowth(Next_year,New_pop,End_year).

pbirth_rate(38).

pdeath_rate(20).
```

PUPIL TEACHER INTERACTION - TEACHER MODEL

```
explain:-
     pupil_input(Year,Pop,End_year),
     print_headings,
     growth(Year,Pop,End_year).

growth(End_year,Pop,End_year).

growth(Year,Pop,End_year):-
     birth_rate(Birth_rate),
     death_rate(Death_rate),
     Births is Pop * Birth_rate/1000,
     Deaths is Pop * Death_rate/1000,
     Natural_increase is Births-Deaths,
     Next_year is Year +1,
     New_pop is Pop + Natural_increase,
     explain(Year,Pop,Births,Deaths,Natural_increase,New_pop),
     growth(Next_year,New_pop,End_year).

birth_rate(38).
death_rate(20).

explain(Year,Pop,Births,Deaths,Natural_increase,New_pop):-
     answer(Year,Ppop,Pbirths,Pdeaths,Pnatural_increase,Pnew_pop),
     explain_births(Births, Pbirths, Nbirths),
     explain_deaths(Deaths, Pdeaths, Ndeaths),
     explain_nat_inc(Natural_increase,Pnatural_increase,Nnatural_increase),
     printout(Year,Pop,Nbirths,Ndeaths,Nnatural_increase,New_pop),nl,nl.

explain_births(Births, Births,Births).
explain_births(Births,Pbirths,0):-
     write('There is a difference in the births'),nl,
     write('Births are population X birth rate'),nl.

explain_deaths(Deaths, Deaths, Deaths).

explain_deaths(Deaths, Pdeaths, 0):-
     write('There is a difference in the deaths'),nl,
     write('Deaths are population X death rate'),nl.

explain_nat_inc(Natural_increase,Natural_increase,Natural_increase).

explain_nat_inc(Natural_increase,Pnatural_increase,0):-
     write('There is a difference in natural increase'),nl,
     write('Natural increase is births - deaths'),nl.
```

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APPNENDIX SEVEN

STUDENT TRIALS - DRAINAGE MODELS IN PROLOG

LIZALI DRAINAGE MODEL

```
drainage(Rain,Time).
drainage(Rain,Time):-
infiltration_rate(Infiltration_rate),
evaporation_rate(Evaporation_rate),
evaporation is Rain * Evaporation_rate/1000,
Surface_water is Rain-Evaporation,
infiltration is surface_water * Infiltration_rate/1000,
Overland_flow is Surface_water-infiltration,
asserta(infiltration(Time,Infiltration)):-
Delay is Time-2,
infiltration(Delay,Delay_infiltration),
Channel_water is Overland_flow+infiltration,
printout(Rain,Time,Infiltration_rate,Evaporation_rate,Overland_flow,Channel_water),
New_time is Time+1,
drainage(Rain,New_time).
infiltration_rate(24).
evaporation_rate(30).
printout(Rain,Time,Infiltration_rate,Evaporation_rate,Overland_flow,Channel_water):-
write(Rain),write(     ),
write(Time),write(     ),
write(Inf._rate),write(         ),
write(Evap._rate),write(          ),
write(Over._flow),write(          ),
write(Ch._wat),write(       ),
nl
begin:-
data_entry(Rain,Time),
print_headings,
drainage(Rain,Time),
data_entry(Rain,Time):-
write('Enter rainfall intensity           '),
read(Rain),
write('Enter period of rain            '),
read(Time),
print_headings:-
write('Rain      '),
write('Time      '),
write('Inf._rate       '),
write('Evap._rate       '),
write('Ov._flow       '),
write('Ch._wat       '),
nl.
```

BANAN - DRAINAGE MODEL

```
drainage(Rain,End_mins,End_mins).

drainage(Rain,Mins,End_mins):-.
evaporation_rate(Evaporation_rate).
infiltration_rate(Infiltration_rate).
Evaporation is Evaporation_rate * Rain / 100,
Infiltration is Infiltration_rate * Surface_water / 100,
Surface_water is Rain - Evaporation,
Overland_flow is Surface_water - Infiltration,
Channel_water is Overland_flow + Infiltration,
Next mins is Mins+1
printout(Mins,Rain,Evaporation,Infiltration,Surface_water,Overland_flow,Channel_water),
drainage(Rain,Next_mins,End_mins).

Evaporation_rate(30),
Infiltration_rate(30).

printout(Mins,Rain,Evaporation,Infiltration,Surface_water,Overland-flow,Channel_water),
write(Mins),write('       '),
write(Rain),write('       '),
write(Evaporation),write('       '),
write(Infiltration),write('       '),
write(Surface_water),write('       '),
write(Overland_flow),write('       '),
write(Channel_water),
nl.

begin:-
data_entry(Rain,Mins,End_mins),
print_headings,
drainage(Rain,Mins,End_mins).

data_entry(Rain,Mins,End_mins):-
write('Enter start mins........'),
read(Mins),
write('Enter start rain         '),
read(Rain),
write('Enter end_mins........'),
read(Entry),
End_mins is Entry + 1.

print_headings:-
write('Rain.....'),
write('Mins.....'),
write('Evaporation......'),
write('Infiltration......'),
write('Surface_water......'),
write('Overland_flow......'),
write('Channel_water'),
nl.
```

WATER 1 DRAINAGE MODEL

```
drainage(End_hour,End_hour).

drainage(Hour,End_hour):-
       rainfall(Hour,Rainfall),
       evaporation(Hour,Evaporation),
       infiltration(Hour,Infiltration_rate),
       Surface_water is Rainfall*Evaporation/100,
       Infiltration is Surface_water-Infiltration_rate/100,
       Overland_flow is Surface_water-Infiltration,
       River_channel is Infiltration+Overland_flow,

printout(Hour,Rainfall,Evaporation,Surface_water,Infiltration,Overland_flow,River_channel),
Next_hour is Hour+1,
       drainage(Next_hour,End_hour).

rainfall(1,20).
rainfall(2,30).
rainfall(3,40).
evaporation(1,10).
evaporation(2,15).
evaporation(3,20).
infiltration(1,5).
infiltration(2,7.5).
infiltration(3,10).

printout(Hour,Rainfall,Evaporation,Surface_water,Infiltration,Overland_flow,River_channel):-
      write(Hour),write('     '),
      write(Rainfall),write('     '),
      write(Evaporation),write('    '),
      write(Surface_water),write('    '),
      write(Infiltration),write('    '),
      write(Overland_flow),write('    '),
      write(River_channel),write('     '),
nl.

begin:-
      data_entry(Hour,End_hour),
      print_headings,
      drainage(Hour,End_hour).

data_entry(Hour,End_hour):-
       write('Enter start hour..... '),
       read(Hour),
       write('Enter end hour      '),
       read(Entry),
       End_hour is Entry +1.

print_headings:-
      write('Hour     '),
      write('Rainfall    '),
      write('Evaporation   '),
      write('Surface_water    '),
      write('Infiltration    '),
      write('Overland_flow    '),
      write('River_channel     '),
nl.
```

WATER 2 DRAINAGE MODEL

```
drainage(End_minute,End_minute).

drainage(Minute,End_minute):-
infiltration_rate(Infiltration_rate),
evaporation_rate(Evaporation_rate),
rain(Rain),
Surface_water is Rain,
Infiltration is Infiltration_rate * Surface_water/100,
Evaporation is Evaporation_rate * Surface_water/100,
Overland_flow is Surface_water-(Evaporation+Infiltration),
Channel_water is Overland_flow+Infiltration,
Next_minute is Minute +1,
New_rain is Rain+10,
printout(Minute,Rain,Surface_water,Infiltration,Evaporation,Overland_flow,Channel_water),
drainage(Next_minute,New_rain,End_minute).

infiltration_rate(40).
evaporation_rate(40).
rain(10).

printout(Minute,Rain,Surface_water,Infiltration,Evaporation,Overland_flow,Channel_water):-
       write(Minute),write('   '),
       write(Rain),write('   '),
       write(Surface_water),write('   '),
        write(Infiltration),write('   '),
       write(Evaporation),write('   '),
      write(Overland_flow),write('   '),
      write(Channel_water),
      nl

begin:-
data entry(Minute,End_minute),
print_headings,
drainage(Minute,End_minute).

data_entry(Minute,End_minute):-
write('Enter start minute    '),
read(Minute),
write('Enter end minute    '),
read(Entry),
End_minute is Entry +1.

print_headings:-
write('Minute    '),
write('Surface_water  '),
write('Infiltration  '),
write('Evaporation  '),
write('Overland_flow  '),
write('Channel_water  '),
nl.
```

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APPENDIX EIGHT

GEOGRAPHY MODELS IN SMALLTALK

NOTES - GEOGRAPHY AND POPULATION GROWTH

Geography is set as the principal class, and deals specifically with the drawing of graphs and tables.

CLASS GEOGRAPHY

Instance Variables used:

graphtitle	pen	outputstream	maxy
incrementonx	endx	beginx	colour
startonx	a (name)	f (maxysecond)	
g (maxyfirst)			

Methods:

```
aspect             - returns value of global aspect
aspect:            - sets global aspect
doubleaxes         - set doubleline graph axes
drawstep:          - single step on single line graph
drawstepfirst:  second: - single step double line graph
graph:             - initialise form and pen
graphtitle         - return graph title
graphtitle:        -  set graph title
graphvalues        - returns values associated with single line graph
incrementonx       - returns step on x-axis
incrementonx:      - set step on x-axis
maxy               - return max for y on single line graph
maxy:              - set max y for single line graph
maxyfirst          - return max of left y-axis double line graph
maxyfirst          - set max of left y-axis double line graph
maxysecond         - return max of right y axis double line graph
maxysecond:        - set max of right y-axis double line graph
name               - return name for graph table windows
name:              - set name for graph table windows
nl                 - carriage feed on table
opengraph          - open window for graphs (single and double)
opentable          - open window for table
setaxes            - set single line graph axes and labels
startonx           - return starting point on x-axis
startonx:          - set starting point on x-axis
tab                - output tab spacing to table
table:             - put single value into table
```

```
CLASS GEOGRAPHY
SUB CLASS POPULATION

Instance Variables used

     birthrate      deathrate        pop

Methods

birthrate          - returns birthrate/1000
birthrate:         - set birthrate/1000
deathrate          - returns deathrate/1000
deathrate:         - sets deathrate/1000
endyear            - returns end year of model
endyear:           - sets end year of model
growthdouble       - double graph births and deaths lines
growthgraph        - single line graph population
growthtable        - table for population growth
pop                - returns value of starting population
pop:               - sets value of starting population
startyear          - returns valie for start year of model
startyear:         - sets value for start year of model
values             - returns initial population values
```

```
Object subclass: #Geography
  instanceVariableNames:
    'graphtitle pen outputstream maxy incrementonx startonx
          colour beginx endx a b c d e f g h i j k '
  classVariableNames: ''
  poolDictionaries: '' !

!Geography class methods ! !


!Geography methods !

aspect
    ^Aspect!

aspect: value
    Aspect := (5/2) / (11/2)!

doubleaxes
     | size  width height l r t b p1 p2 p3 p4 w h|
    size := pen frame.
    t := size top.
    b := size bottom.
    l := size left.
    r := size right.
    width := size width.
    height := size height.
    w := width//10.
    h := height//10.

    p1:= (l + w) @ (b - h).
    p2:= (l + w) @ (t + h).
    p3:= (r - w) @ (b - h).
    p4:= (r - w) @ (t + h).
    pen black; defaultNib: 3.
    pen drawFrom: p1 to: p2.
    pen drawFrom: p1 to: p3.
    pen drawFrom: p3 to: p4.

    pen place: (l + w)  @ (t +h) - pen frame origin;
        centerText: self maxyfirst printString font: Font eightLine.

    pen place: (r - w)  @ (t +h) - pen frame origin;
        centerText: self maxysecond printString font: Font eightLine.

    pen place: (l + w) @ b - (h//2) - pen frame origin ;
        centerText: beginx printString font: Font eightLine.

    pen place: (r -w) @ b - (h//2) - pen frame origin;
        centerText: endx printString font: Font eightLine.

    pen place: (l + (width//2)) @ t + (h//2) - pen frame origin;
        centerText: graphtitle font: Font eightLine!

drawstep: value
    | size t b l r width height w h p1 temp1 temp2 temp3 temp4|
    size := pen frame.
    t := size top.
    b := size bottom.
    l := size left.
    r := size right.
    width := size width.
    height := size height.
    w := width //10.
    h := height//10.

    p1 := (l + w) @ (b - h).
    pen place: p1 + ((self incrementonx * startonx) @ 0).

    temp1 := (height - (height//5)).
    temp2 :=  temp1/ (self maxy // (5//2)).

    pen direction: 270.
    self colour = 'black'
        ifTrue:[pen black]
        ifFalse:[pen white].
```

```
    pen up; defaultNib: 1.
    pen go: value * temp2.
    temp4 := pen location.
    (startonx > 1)
        ifTrue:[ pen down. pen drawFrom: k to: temp4].
    k := temp4.
    startonx := startonx + 1!

drawstepfirst: value1  second: value2
    | size t b l r width height w h p1 temp1 temp2 temp3 temp4|
    size := pen frame.
    t := size top.
    b := size bottom.
    l := size left.
    r := size right.
    width := size width.
    height := size height.
    w := width //10.
    h := height//10.

    p1 := (l + w) @ (b - h).
    pen place: p1 + ((self incrementonx * startonx) @ 0).

    temp1 := (height - (height//5)).
    temp2 :=  temp1/ (self maxyfirst // (5//2)).
    temp3 :=  temp1/ (self maxysecond // (5//2)).

    pen direction: 270.
    pen black.
    pen up; defaultNib: 1.
    pen go: value1 * temp2.
    temp4 := pen location.
    (startonx > 1)
        ifTrue:[ pen down. pen drawFrom: i to: temp4].
    i := temp4.
    pen place: p1 + ((self incrementonx * startonx) @ 0).
     pen direction: 270.
    pen white.
    pen up; defaultNib: 1.
    pen go: value2 * temp3.
    temp4 := pen location.
    (startonx > 1)
        ifTrue:[ pen down. pen drawFrom: j to: temp4].
    j := temp4.
 startonx := startonx + 1!

graph: aRect
    | aForm |
    aForm := Form width: aRect width height: aRect height.
    aForm gray.
    aForm displayAt: aRect origin.
    pen := Pen new frame: aRect.
    ^ aForm!

graphtitle
    ^ graphtitle!

graphtitle: value
     graphtitle := value!

graphvalues
 Transcript
nextPutAll: self name, ' maxy:          ', self maxy printString, '.' ; cr ;
nextPutAll: self name, ' incrementonx:  ', self incrementonx printString, '.' ; cr;
nextPutAll: self name, ' startonx:      ', self startonx
printString, '.' ; cr ;
nextPutAll: self name, ' colour:        ', self colour, '.' ; cr;
nextPutAll: self name, ' graphtitle:    ', self graphtitle, '.' ;
cr!

incrementonx
    ^ incrementonx!

incrementonx: value
    incrementonx := value!
```

```
maxy
    ^maxy!

maxy: value
    maxy := value!

maxyfirst
    ^ g!

maxyfirst: value
    g := value!

maxysecond
    ^f!

maxysecond: value
    f := value!

name
    ^a!

name: value
    a := value!

nl
    outputstream nextPutAll: ' ';cr!

opengraph
    | graphtop |
    graphtop := TopPane new label: self name.
    graphtop addSubpane:
        (GraphPane new
                model: self;
                name: #graph:;
                framingRatio: (0 @ 0 extent: 1 @ 1)).
    graphtop dispatcher open scheduleWindow!

opentable
    | tabletop outputtab |
    tabletop := TopPane new label: self name.
    tabletop addSubpane:
            (outputtab := TextPane new
                framingRatio:(0 @ 0 extent: 1 @ 1)).
    outputstream := outputtab dispatcher.
    tabletop dispatcher open scheduleWindow.!

setaxes
    | size  width height l r t b p1 p2 p3 w h|
    size := pen frame.
    t := size top.
    b := size bottom.
    l := size left.
    r := size right.
    width := size width.
    height := size height.
    w := width//10.
    h := height//10.

    p1:= (l + w) @ (b - h).
    p2:= (l + w) @ (t + h).
    p3:= (r - w) @ (b - h).

    pen black; defaultNib: 3.
    pen drawFrom: p1 to: p2.
    pen drawFrom: p1 to: p3.

    pen place: (l + w)  @ (t +h) - pen frame origin;
        centerText: maxy printString font: Font eightLine.

    pen place: (l + w) @ b - (h//2) - pen frame origin ;
        centerText: beginx printString font: Font eightLine.

    pen place: (r -w) @ b - (h//2) - pen frame origin;
        centerText: endx printString font: Font eightLine.

    pen place: (l + (width//2)) @ t + (h//2) - pen frame origin;
```

```
        centerText: graphtitle font: Font eightLine!

startonx
    ^ startonx!

startonx: value
    startonx := value!

tab
    outputstream nextPutAll:' ';tab!

table: value
    outputstream nextPutAll: value printString! !
```

```
Geography subclass: #Population
  instanceVariableNames:
    'birthrate deathrate pop '
  classVariableNames: ''
  poolDictionaries: '' !

!Population class methods ! !


!Population methods !

birthrate
    ^ birthrate * 1000!

birthrate: value
    birthrate := value /1000!

deathrate
    ^ deathrate * 1000!

deathrate: value
    deathrate := value/1000!

endyear
    ^ endx!

endyear: value
    endx := value!

growthdouble
    | size total births deaths span width|
    self startonx: 1.
    span := endx - beginx.
    size := pen frame.
    width  := size width.
    self incrementonx: ((width - (width//5))// span).
    total := pop.
    self colour = 'black'
        ifTrue:[self colour: 'white']
        ifFalse:[self colour: 'black'].

    0 to: span do: [: step |
        births := (total * birthrate) floor.
        deaths := (total * deathrate) floor.
        total := total + (births - deaths).
        self drawstepfirst: births second: deaths]!

growthgraph
    | size total births deaths span width|
    self startonx: 1.
    span := endx - beginx.
    size := pen frame.
    width  := size width.
    self incrementonx: ((width - (width//5))// span).
    total := pop.
    self colour = 'black'
        ifTrue:[self colour: 'white']
        ifFalse:[self colour: 'black'].

    0 to: span do: [: step |
        births := (total * birthrate) floor.
        deaths := (total * deathrate) floor.
        total := total + (births - deaths).
        self drawstep: total]!

growthtable
    | total births deaths span |
    total := pop.
    span := endx - beginx.

    self table: ' Year '; tab;
         table: 'Births'; tab;
         table: 'Deaths'; tab;
         table: 'Pop';
         nl.
```

```
    0 to: span do: [ :step |
        births := (total * birthrate) floor.
        deaths := (total * deathrate) floor.
        total  := total + (births - deaths).

    self table: (step + beginx); tab; tab; tab;
         table: births; tab; tab; tab;
         table: deaths; tab; tab; tab;
         table: total; nl]!

pop
    ^ pop!

pop: value
    pop := value!

startyear
    ^ beginx!

startyear: value
    beginx := value!

values
    Transcript
nextPutAll: self name, ' birthrate:     ', self birthrate
printString, '.' ; cr;
nextPutAll: self name, ' deathrate:     ', self deathrate
printString, '.' ; cr;
nextPutAll: self name, ' startyear:     ', self startyear
printString, '.' ; cr;
nextPutAll: self name, ' endyear:       ', self endyear
printString, '.' ; cr;
nextPutAll: self name, ' pop:           ', self pop printString,
'.' ; cr! !
```

NOTES INFILTRATION

Infiltration is a subclass of Geography and uses the methods of that class to draw the double line graphs.

CLASS GEOGRAPHY
SUB CLASS INFILTRATION

Instance Variables Used:

rain	evaporation	infilrate
infiltration	delay	hours
channel		

Methods

```
channel          - returns array of output to river channel
channeldouble    - draws double line graph of rainfall and channel
                       water following from method drainage
channelgraph     - draws single line graph of channel water
delay            - returns the value of the infiltration delay
delay:           - sets the value of the infiltration delay
drainage         - 'runs' the process to produce the results
endtime          - returns the value for the end of x-axis
endtime:         - sets the value for the end of the x-axis
evaporation      - returns the percentage value of evaporation
evaporation:     - sets the percentage value of evaporation
hours            - returns the number of hours process is to run
hours:           - sets the number of hours the process is to run
infilrate        - returns the precentage value of infiltration
infilrate:       - sets the percentage value of infiltration rate
rain             - returns the array of rainfall values
raintime:        - returns value of rain for given hour
raintime: amount: - sets the rainfall for each hour
reset            - resets the arrays rain, infiltration, channel
starttime        - returns the starting value for the x-axis
starttime        - sets the starting value for the x-axis
```

```
Geography subclass: #Infiltration
  instanceVariableNames:
    'rain evaporation infilrate infiltration delay hours channel'
  classVariableNames: ''
  poolDictionaries: '' !

!Infiltration class methods ! !


!Infiltration methods !

channel
    ^channel!

channeldouble
    |size span width |
    self startonx: 1.
    span := self hours.
    size := pen frame.
    width := size width.
    self incrementonx: ((width - (width // 5)) // hours).

    1 to: hours do:[: step|
        self drawstepfirst: (channel at: step) second: (rain at: step)]!

channelgraph
    |size span width |
    self startonx: 1.
    span := self hours.
    size := pen frame.
    width := size width.
    self incrementonx: ((width - (width // 5)) // hours).

    channel do:[: water|
        self drawstep: water]!

delay
    ^delay!

delay: hours
    delay := hours!

drainage
    |surfacewater evaporated overland |

    1 to: hours do: [:step |
        evaporated := ((rain at: step) * evaporation)floor.
        surfacewater := (rain at: step) - evaporated.
        infiltration at: step put: (surfacewater * infilrate)floor.
        overland := surfacewater - (surfacewater * infilrate)floor.

        (step - delay) > 0
 ifTrue:[ channel at: step put: (overland +( infiltration at:(step-delay)))]
            ifFalse:[channel at: step put: overland]]!

endtime
    ^endx!

endtime: value
    endx := value!

evaporation
    ^ evaporation * 100!

evaporation: rate
    evaporation := rate/100!

hours
    ^hours!

hours: value
    hours := value!

infilrate
    ^infilrate * 100!
```

```
infilrate: rate
    infilrate := rate/100!

infiltration
    ^infiltration!

rain
    ^rain!

raintime: hour
    ^ rain at: hour!

raintime: time amount: value
    rain size = 0
        ifTrue:[rain := Array new: self hours.
                infiltration := Array new: self hours.
                channel := Array new: self hours].
    rain at: time put: value!

reset
    channel := nil.
    infiltration := nil.
    rain := nil!

starttime
    ^ beginx!

starttime: value
    beginx := value! !
```

NOTES REGIONAL LOCATION OF INDUSTRY

The Prolog systesm has been installed within Smalltalk and the decision procedures are in the Prolog sub-class "Industry". The initial decision areas have a common structure.

- two questions posed
- a rule to make the decision
- a decision table to lookup the decision

The subsequent decision use as input the outputs from previous decisions and therefore have a structure

- a rule to make the decision
- a decision table to lookup the decision

CLASS PROLOG
SUB CLASS INDUSTRY

Logic Methods

capital	- poses the question on capital
decisionref	- decision table for final decision
economicanalysis	- rule for economic analysis
economicref	- decision table for economic analysis
finaldecision	- rule for final decision
financialanalysis	- ruel for financial analysis
financialref	- decision table for financial analysis
humanresources	- rule for human resources decision
humresref	- decision table for human resources decision
inputmaterials	- poses question on input materials
land	- poses question on land
marketcapability	- rule for market capability decision
marketdemand	- poses question for market demand
marketref	- decision table for market capability
materiallinks	- poses quesiton for material links
phyresref	- decision table for physical resource
physicalresources	- rule for physical resource decision
resourceanalysis	- rule for resource analysis decision
resourcesref	- decision table for resource analysis
skilledlabour	- poses question for skilled labour
transport	- poses question for transport
unskilledlabour	- poses question for unskilled labour

```
Prolog subclass: #Industry
  instanceVariableNames: ''
  classVariableNames: ''
  poolDictionaries: '' !

!Industry class logicMethods ! !


!Industry logicMethods !

capital(capital):-
    is(capital, Prompter prompt:'Capital - Development / Normal'
default:'development').!

"/* Decision Analysis      */
/*              resanalysis    resanalysis   Decision    */
/*                                          suitable/never */"
decisionref(           'good',         'sound',    'suitable').
decisionref(           'good',          'weak',       'never').
decisionref(           'poor',         'sound',       'never').
decisionref(           'poor',          'weak',       'never').!

economicanalysis(econanalysis):-
        financialanalysis(financial),
        marketcapability(market),
        economicref(financial,market,econanalysis).!

"/* Economic Analysis      */
/*                fin analysis    market cap   Econanalysis */
/*                                            sound / weak  */"
economicref(          'sound',      'growth',     'sound').
economicref(          'sound',      'stable',     'sound').
economicref(         'shakey',      'growth',     'sound').
economicref(         'shakey',      'stable',     'weak').!

finaldecision():-
        resourceanalysis(resanalysis),
        economicanalysis(econanalysis),
        decisionref(resanalysis,econanalysis,decision),
        is(a, Prompter prompt:'The final decision is ' default: decision printString).!

financialanalysis(financial):-
        capital(capital),
        land(land),
        financialref(capital,land,financial).!

"/* Financial Analysis     */
/*                 capital   land          Financial    */
/*                                         sound/shaky  */"
financialref(    'development', 'plentiful',    'sound').
financialref(    'development',    'scarce',    'sound').
financialref(         'normal', 'plentiful',   'shakey').
financialref(         'normal',    'scarce',   'shakey').!

humanresource(human):-
        skilledlabour(skilled),
        unskilledlabour(unskilled),
        humresref(skilled,unskilled,human).!

"/* Human Resource        */
/*          skilled_labour  unskilled_labour  Human      */
/*                                            normal/good*/ "
humresref(          'large',          'large',       'good').
humresref(          'large',          'small',     'normal').
humresref(          'small',          'large',     'normal').
humresref(          'small',          'small',     'normal').!

inputmaterials(input):-
       is(input, Prompter prompt: 'Input materials - yes / no' default:'yes').!

land(land):-
    is(land, Prompter prompt:'Land - plentiful / scarce' default: 'plentiful').!

marketcapability(market):-
        marketdemand(demand),
        transport(transport),
```

```
        marketref(demand,transport,market).!

marketdemand(demand):-
    is(demand, Prompter prompt:'Market Demand - high / low' default:'high').!

"/* Market Capability      */
/*                market_demand    transport   Market     */
/*                                             growth/stable */
"
marketref(          'high',     'network',  'growth').
marketref(          'high',     'insular',  'growth').
marketref(           'low',     'network',  'stable').
marketref(           'low',     'insular',  'stable').!

materiallinks(links):-
        is(links, Prompter prompt:'Material links - good / bad' default:'good').!

"   /* Physical References   */
/*           input_materials  material_links    Physical  */
/*                                              good/bad  */  "
phyresref(             'yes',           'good',       'good').
phyresref(             'yes',            'bad',       'good').
phyresref(              'no',          ' good',       'good').
phyresref(              'no',           'bad',       'poor').!

physicalresources(physical):-
        inputmaterials(input),
        materiallinks(links),
        phyresref(input,links,physical).!

resourceanalysis(resanalysis):-
        physicalresources(physical),
        humanresource(human),
        resourcesref(physical,human,resanalysis).!

"/* Resource Analysis     */
/*               phyresources    human res  resourceanalysis*/
/*                                           good/poor    */"
resourcesref(             'good',        'good',     'good').
resourcesref(             'good',      'normal',     'good').
resourcesref(             'poor',        'good',     'good').
resourcesref(             'poor',      'normal',     'poor').!

skilledlabour(skilled):-
    is(skilled, Prompter prompt:'Skilled Labour - large / small' default: 'large').!

transport(transport):-
    is(transport, Prompter prompt:'Transport - network / insular' default:'network').!

unskilledlabour(unskilled):-
    is(unskilled, Prompter prompt:'Unskilled Labour - large / small' default:'small').!
!
```

Notes Industrial Location Expert System

The Prolog system has been installed within Smalltalk. The Geography subclass 'Location' performs the entry and printing, and passes the values to the Prolog subclass 'Indlocate' for deduction.

```
Geography subclass: #Location
        instanceVariableNames:  'nameofIndustry year name1 name2 weight1 weight2
distribution1 distribution2 source1 source2 target markSize industSize locSource nature
type technology transport growth management '
        classVariableNames: ''
        poolDictionaries: '' !

!Location class methods ! !

!Location methods !

distribution1
        ^distribution1!

distribution1: value
        distribution1 := value!

distribution2
        ^distribution2!

distribution2: value
        distribution2 := value!

enterInputs
        nameofIndustry := Prompter prompt:'Name of Industry '
                default: nameofIndustry.
        year := Prompter prompt: 'Year  1860 - 1986'
                        defaultExpression: year printString.
        weight1 := Prompter prompt: 'Weight material one  heavy moderate negligible'
                default: weight1.
        distribution1 := Prompter prompt:'Distribution of onerestricted everywhere'
                default: distribution1.
        source1 := Prompter prompt: 'Source of one'
                default: source1.
        weight2 := Prompter prompt: 'Weight material two heavy moderate negligible'
                default: weight2.
        distribution2 := Prompter prompt: 'Distribution of two  restricted everywhere'
                default: distribution2.
        source2 := Prompter prompt:'Source of two'
                default: source2.
        industSize := Prompter prompt:'Size of Industry  veryLarge large moderate small
                                workshop'
                default: industSize.
                markSize := Prompter prompt:'Market size national regional local'
                default: markSize.
        target := Prompter prompt:'Market target  industry consumer both'
                default: target.!
explainInputs
        Transcript nextPutAll:'" Ind nameofIndustry:'' steel''.
        Ind year:          1920.
        Ind weight1:       ''heavy''.
        Ind distribution1: ''restricted''.
        Ind source1:       ''coalfield''.
        Ind weight2:       ''moderate''.
        Ind distribution2: ''restricted''.
        Ind source2:       ''ironfield''.
        Ind industrySize:  ''large''.
        Ind marketSize:    ''national''.
        Ind marketTarget:  ''industry''        "'.!

growth
        ^growth!

industrySize
        ^industSize!

industrySize: value
```

```
        industSize := value!

loc nature := IndLocate new :
        ? refLocation(weight1, distribution1, source1, weight2, distribution2, source2,
ans1,                   ans2).
type := IndLocate new :
        ? refIndustryType ( weight1, weight2, indtype).
technology := IndLocate new :
        ? techDevelop( year, industSize, tech).
transport := IndLocate new :
        ? transport(year, markSize, weight1, weight2, trans).
growth := IndLocate new :
        ? growthIndustry( year, target, markSize, weight1, weight2, grow).
management := IndLocate new :
        ? management( year, weight1, weight2, markSize, target, man).!

management
        ^management!

management: value
        management := value!

marketSize
        ^markSize!

marketSize: value
        markSize := value!

marketTarget
        ^target!

marketTarget: value
        target := value!

nameofIndustry
        ^nameofIndustry!

nameofIndustry: name
        nameofIndustry := name!

nature
        ^nature!

results
        self loc. outputstream nextPutAll: 'Industrial Location for '.
        outputstream nextPutAll:  nameofIndustry printString. outputstream nextPutAll:
'  in                   year  '.
        outputstream nextPutAll:  year printString ; cr;cr.
        outputstream nextPutAll: 'Weight one.........'. outputstream nextPutAll:
weight1                         printString; tab;tab;tab.
        outputstream nextPutAll: 'Weight two.........'. outputstream nextPutAll:
weight2                         printString;cr.
        outputstream nextPutAll: 'Distribution one ..'. outputstream nextPutAll:
distribution1                   printString;tab;tab.
        outputstream nextPutAll: 'Distribution two ..'. outputstream nextPutAll:
distribution2                   printString;cr.
        outputstream nextPutAll: 'Source one.........'. outputstream nextPutAll:
source1                         printString; tab;tab.
        outputstream nextPutAll: 'Source two.........'. outputstream nextPutAll:
source2                         printString;cr.
        outputstream nextPutAll: 'Industry size......'. outputstream nextPutAll:
industSize                      printString;cr.
        outputstream nextPutAll: 'Market size........'. outputstream nextPutAll:
markSize                                printString; tab;tab.
        outputstream nextPutAll: 'Target............'.
        outputstream nextPutAll: target printString;cr;cr.
        outputstream nextPutAll: 'Location....'.
        outputstream nextPutAll:  nature printString;cr.
        outputstream nextPutAll: 'Type........'.
        outputstream nextPutAll:  type printString; cr.
        outputstream nextPutAll: 'Technology..'.
        outputstream nextPutAll:  technology printString; cr.
        outputstream nextPutAll: 'Transport...'.
        outputstream nextPutAll:  transport printString; cr.
        outputstream nextPutAll: 'Growth......'.
```

```
        outputstream nextPutAll:  growth printString; cr.
        outputstream nextPutAll: 'Management..'.
        outputstream nextPutAll:  management printString; cr.!

source1
        ^source1!
source1: value
        source1 := value!
source2
        ^source2!
source2: value
        source2 := value!

technology
        ^technology!

transport
        ^transport!

type
        ^type!

weight1
        ^weight1!

weight1: value
        weight1 := value!

weight2
        ^weight2!

weight2: value
        weight2 := value!

year
        ^year!

year: value
        year := value! !
```

```
Prolog subclass: #IndLocate
        instanceVariableNames: ''
        classVariableNames: ''
        poolDictionaries: '' !

!IndLocate class methods ! !

!IndLocate methods !

growthIndustry( year, target, markSize, weight1, weight2, growth):-
        refIndustryType(weight1, weight2, type),
        refGrowthIndustry( start, end, target, markSize, type, growth),
        ge(year, start),
        le(year, end).!

management( year, weight1, weight2, markSize, target, management):-
        refIndustryType( weight1, weight2, type),
        growthIndustry(year, target, markSize, weight1, weight2, growth),
        refManagement( start, end, type, markSize, growth, management),
        ge( year, start),    le( year, end).!

refGrowthIndustry( 1860, 1899,          _,          _,       _, 'rapidGrowth').
refGrowthIndustry( 1900, 1959,          _,          _,       _, 'steadyGrowth').
refGrowthIndustry( 1960, 1986,          _,          _, 'heavy', 'decline').
refGrowthIndustry( 1960, 1986,          _, 'national', 'light', 'fastGrowth').
refGrowthIndustry( 1960, 1986, 'consumer', 'regional', 'light', 'fastGrowth').
refGrowthIndustry( 1960, 1986, 'consumer',    'local', 'light', 'growth').
refGrowthIndustry( 1960, 1986, 'industry', 'regional', 'light', 'steadyGrowth').
refGrowthIndustry( 1960, 1986, 'industry',    'local', 'light', 'oftenDecline').
refGrowthIndustry( 1960, 1986,     'both', 'regional', 'light', 'fastGrowth').
refGrowthIndustry( 1960, 1986,     'both',    'local', 'light', 'growth').!

refIndustryType(     'heavy',      'heavy',   'heavy').
refIndustryType(     'heavy',   'moderate',   'heavy').
refIndustryType(     'heavy', 'negligible',   'heavy').
refIndustryType(  'moderate',      'heavy',   'heavy').
refIndustryType(  'moderate',   'moderate',   'light').
refIndustryType(  'moderate', 'negligible',   'light').
refIndustryType('negligible',      'heavy',   'heavy').
refIndustryType('negligible',   'moderate',   'light').
refIndustryType('negligible', 'negligible',   'light').!

refLocation(      'heavy',    'restricted',  source1,  'moderate'  ,           _,
source2, source1, 'specificLocation').
refLocation(      'heavy',    'restricted',  source1,  'negligible',           _,
source2, source1, 'specificLocation').
refLocation(   'moderate',    'restricted',  source1,  'negligible',           _,
source2, source1, 'specificLocation').
refLocation(      'heavy',    'restricted',  source1,       'heavy', 'everywhere',
source2, source1, 'specificLocation').
refLocation(   'moderate',    'restricted',  source1,       'heavy', 'everywhere',
source2, source1, 'specificLocation').
refLocation(   'moderate',    'restricted',  source1,    'moderate', 'everywhere',
source2, source1, 'specificLocation').
refLocation(   'moderate',              _,  source1,       'heavy', 'restricted',
source2, source2, 'specificLocation').
refLocation( 'negligible',              _,  source1,       'heavy', 'restricted',
source2, source2, 'specificLocation').
refLocation( 'negligible',              _,  source1,    'moderate', 'restricted',
source2, source2, 'specificLocation').
refLocation(      'heavy',    'everywhere',  source1,       'heavy', 'restricted',
source2, source2, 'specificLocation').
refLocation(      'heavy',    'everywhere',  source1,    'moderate', 'restricted',
source2, source2, 'specificLocation').
refLocation(   'moderate',    'everywhere',  source1,    'moderate', 'restricted',
source2, source2, 'specificLocation').
refLocation( 'negligible',    'restricted',  source1,            _, 'everywhere',
source2, 'market','marketLocation').
refLocation(            _,    'everywhere',  source1,            _, 'everywhere',
source2, 'market','marketLocation').
refLocation( 'negligible',    'restricted',  source1,  'negligible', 'restricted',
source2, 'market','marketLocation').
refLocation(            _,    'everywhere',  source1,  'negligible', 'restricted',
source2, 'market','marketLocation').
refLocation(      'heavy',    'restricted',  source1,       'heavy', 'restricted',
source2,   'both','areaLocation').
```

```
refLocation(  'moderate',   'restricted',  source1,   'moderate', 'restricted',
source2,   'both','areaLocation').!

refManagement( 1860, 1899, 'heavy',          _,            _, 'entreprenneur').
refManagement( 1860, 1899, 'light',          _,            _, 'individual').
refManagement( 1900, 1929,       _,          _,            _,
'individualAndFamily'). refManagement( 1930, 1959,      _, 'veryLarge',
_, 'directors').
refManagement( 1930, 1959,       _,    'large',            _, 'directors').
refManagement( 1930, 1959,       _, 'moderate',            _, 'indivdualAndFamily').
refManagement( 1930, 1959,       _,    'small',            _, 'individulAndFamily').
refManagement( 1930, 1959,       _, 'workshop',            _, 'individual').
refManagement( 1960, 1980,       _, 'veryLarge', 'rapidGrowth', 'multinational').
refManagement( 1960, 1980,       _, 'veryLarge', 'steadyGrowth', 'corporation').
refManagement( 1960, 1980,       _, 'veryLarge',      'growth', 'corporation').
refManagement( 1960, 1980,       _, 'veryLarge',     'decline',
'nationalisedCorporation'). refManagement( 1960, 1980,       _, 'veryLarge',
'oftenDecline', 'nationalisedCorporation'). refManagement( 1960, 1980,      _,
'large',            _, 'corporate').
refManagement( 1960, 1980,       _, 'moderate',            _,
'limitedCompanyStatus'). refManagement( 1960, 1980,      _,    'small',
_, 'individual').
refManagement( 1960, 1980,       _,  'workshop',           _, 'individual').!

refTechDevelop( 1860, 1899,          _, 'periodOfInventions').
refTechDevelop( 1900, 1959,          _, 'generalMechanisation').
refTechDevelop( 1960, 1979, 'veryLarge', 'automation').
refTechDevelop( 1980, 1986, 'veryLarge', 'computerisedAutomation').
refTechDevelop( 1960, 1979,    'large', 'automation').
refTechDevelop( 1980, 1986,    'large', 'computerisedAutomation').
refTechDevelop( 1960, 1986, 'moderate', 'smallScaleAutomation').
refTechDevelop( 1960, 1986,    'small', 'smallScaleAutomation').
refTechDevelop( 1960, 1986, 'workshop', 'mainlyHandLabour').!

refTransport( 1860, 1899, 'heavy', 'national',  'railAndCanal').
refTransport( 1900, 1986, 'heavy', 'national',  'rail').
refTransport( 1860, 1899, 'heavy', 'regional',  'railAndCanal').
refTransport( 1900, 1986, 'heavy', 'regional',  'rail').
refTransport( 1860, 1986, 'heavy',    'local',  'road').
refTransport( 1860, 1949, 'light', 'national',  'rail').
refTransport( 1950, 1986, 'light', 'national',  'road').
refTransport( 1860, 1949, 'light', 'regional',  'rail').
refTransport( 1950, 1986, 'light', 'regional',  'rail').
refTransport( 1860, 1986, 'light',    'local',  'road').!

techDevelop(year, industSize, technology):-
        refTechDevelop(start, end, industSize, technology),
        ge(year, start),
        le(year, end).!

transport( year, markSize, weight1, weight2,trans):-
        refIndustryType(weight1,weight2, type),
        refTransport( start, end, type, markSize, trans),
        ge(year, start),    le(year, end).! !
```

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APPENDIX NINE

SMALLTALK TRIAL LOGS

```
GROUP JT LOG
        "evaluate" Village := Population new.!
        "evaluate" Village birthrate: 19.!
        "evaluate" Village deathrate: 10.!
        "evaluate" Village pop: 1000.!
        "evaluate" Village startyear: 1980.!
        "evaluate" Village endyear: 2050.!
        "evaluate" Village name:'Village'!
        "evaluate" Village graphtitle: 'Villagepopulation'!
        "evaluate" Village maxy: 2000.!
        "evaluate" Village maxy: 2000.!
        "evaluate" Village setaxes!
        "evaluate" Village growthgraph!
        "evaluate" Village growthtable.!

        "evaluate"
        "evaluate" Village growthgraph.!

        "evaluate"
        "evaluate" Village growthgraph.!
        "evaluate" Village growthgraph.!
        "evaluate" Village setaxes.!
        "evaluate" Village growthgraph.!
        "evaluate" Village setaxes.!
        "evaluate" Village growthgraph.!
        "evaluate" Village setaxes.!
        "evaluate" Village growthgraph.!
        "evaluate" Village birthrate: 10.!
        "evaluate" Village deathrate: 10.!
        "evaluate" Village setaxes.!
        "evaluate" Village := Population new.!
        "evaluate" Village birthrate: 10.!
        "evaluate" Village deathrate: 10.!
        "evaluate" Village pop: 1000.!
        "evaluate" Village startyear: 1980.!
        "evaluate" Village endyear: 2050.!
        "evaluate" Village name:'Village'!

        "evaluate"
        "evaluate" Runoff := Infiltration new.!
        "evaluate" Runoff hours: 10.!
        "evaluate"
        "evaluate"
        Runoff raintime: 3 amount:30.          Runoff raintime: 4 amount:40.
        Runoff raintime: 5 amount:50.          Runoff raintime: 6 amount:30.
        Runoff raintime: 7 amount:10.          Runoff raintime: 8 amount:10.
        Runoff raintime: 9 amount:30.          Runoff raintime:10 amount:40.
        Runoff evaporation: 40.                Runoff delay: 1.
        Runoff infilrate: 5.

        Runoff drainage.!
```

```
GROUP SS LOG
        "evaluate" Village setaxes.!
        "evaluate" Village growthgraph.!
        "evaluate" Village growthtable.!
        "evaluate" !
        "evaluate" Village birthrate: 20.!
        "evaluate" Village deathrate: 18.!
        "evaluate" Village growthgraph.!
        "evaluate" Village growthtable.!
        "evaluate" Village birthrate: 40.!
        "evaluate" Village deathrate: 25.!
        "evaluate" Village growthgraph.!
        "evaluate" Village growthgraph.!
        "evaluate" Village setaxes.!
        "evaluate" Runoff := Infiltration new.!
        "evaluate" Runoff hours: 10.
         Runoff raintime: 1 amount:10.        Runoff raintime: 2 amount:20.
         Runoff raintime: 3 amount:30.        Runoff raintime: 4 amount:40.
         Runoff raintime: 5 amount:50.        Runoff raintime: 6 amount:30.
         Runoff raintime: 7 amount:10.        Runoff raintime: 8 amount:10.
         Runoff raintime: 9 amount:30.        Runoff raintime: 10 amount:40.!
        "evaluate" Runoff evaporation: 20.
         Runoff infilrate: 50.                Runoff delay: 1.
         Runoff drainage.!
        "evaluate" Runoff rain.!
        "evaluate" !
        "evaluate" Runoff rain.!
        "evaluate" Runoff infiltration.!
        "evaluate" Runoff channel.!
        "evaluate" Runoff doubleaxes.!
        "evaluate" Runoff maxyfirst: 50.!
        "evaluate" Runoff maxyfirst: 50.!
        "evaluate" Runoff name:'Runoff'.!
        "evaluate" Runoff maxyfirst: 50.!
        "evaluate" Runoff doubleaxes.!
        "evaluate" Runoff graphtitle:'Rain   Channel'.!
        "evaluate" Runoff maxysecond: 50.!
        "evaluate" Runoff drainage.!
        "evaluate" Runoff channeldouble.!
        "evaluate" Runoff starttime: 1.!
        "evaluate" Runoff channeldouble.!
        "evaluate" Runoff endtime: 10.!
        "evaluate" Runoff := Infiltration new.
        Runoff hours: 10.
        Runoff raintime: 1 amount:10.          Runoff raintime: 2 amount:20.
        Runoff raintime: 3 amount:30.          Runoff raintime: 4 amount:40.
        Runoff raintime: 5 amount:50.          Runoff raintime: 6 amount:30.
        Runoff raintime: 7 amount:10.          Runoff raintime: 8 amount:10.
        Runoff raintime: 9 amount:30.          Runoff raintime:10 amount:40.
        Runoff evaporation: 20.                Runoff delay: 1.
        Runoff infilrate: 50.
        Runoff drainage.!
        "evaluate" Runoff starttime: 1.!
        "evaluate" Runoff name:'Runoff'.!
        "evaluate" Runoff maxyfirst: 50.!
        "evaluate" Runoff doubleaxes.!
        "evaluate" Runoff drainage.!
        "evaluate" Runoff rain.!
        "evaluate" Runoff rain.!
        "evaluate" Runoff infiltration.!
        "evaluate" Runoff channel.!
        "evaluate" Runoff starttime: 1.                Runoff endtime: 10.
        Runoff name:'Runoff'.!
        "evaluate" Runoff graphtitle:'Rain Channel'!
        "evaluate" Runoff maxyfirst: 50.!
        "evaluate" Runoff maxysecond: 50.!
        "evaluate" Runoff drainage.!
        "evaluate" Runoff doubleaxes.!
        "evaluate" Runoff channeldouble.!
        "evaluate" Runoff doubleaxes.
        Runoff channeldouble.!
        "evaluate" Runoff := Infiltration new.
        Runoff hours: 10.
        Runoff raintime: 1 amount:10.          Runoff raintime: 2 amount:20.
        Runoff raintime: 3 amount:30.          Runoff raintime: 4 amount:40.
```

```
Runoff raintime: 5 amount:50.
Runoff raintime: 7 amount:10.
Runoff raintime: 9 amount:30.
Runoff evaporation: 40.
Runoff infilrate: 5.
Runoff drainage.!
Runoff raintime: 6 amount:30.
Runoff raintime: 8 amount:10.
Runoff raintime:10 amount:40.
Runoff delay: 1.
```

```
GROUP KE LOG
        "evaluate" Village := Population new.!
        "evaluate" Village birthrate: 19.!
        "evaluate" Village deathrate: 10.!
        "evaluate" Village pop: 1000.!
        "evaluate" Village startyear: 1980.!
        "evaluate" Village endyear: 2050.!
        "evaluate" Village endyear: 2050.!
        "evaluate" Village name:'Village'.!
        "evaluate" !
        "evaluate" !
        "evaluate" !
        "evaluate" !
        "evaluate" Village maxy: 2000.!
        "evaluate" Village setaxes.!
        "evaluate" Village growthgraph.!
        "evaluate" Village setaxes.!
        "evaluate" Village growthgraph.!
        "evaluate" Village growthtable.!
        "evaluate" !
        "evaluate" Village birthrate: 20.!
        "evaluate" Village deathrate: 18.!
        "evaluate" Village growthgraph.!
        "evaluate" Village growthtable.!
        "evaluate" Village birthrate: 40.!
        "evaluate" Village deathrate: 25.!
        "evaluate" Village growthgraph.!
        "evaluate" Village growthgraph.!
        "evaluate" Village setaxes.!
        "evaluate" Runoff := Infiltration new.!
        "evaluate" Runoff hours: 10.
         Runoff raintime: 1 amount:10.        Runoff raintime: 2 amount:20.
         Runoff raintime: 3 amount:30.        Runoff raintime: 4 amount:40.
         Runoff raintime: 5 amount:50.        Runoff raintime: 6 amount:30.
         Runoff raintime: 7 amount:10.        Runoff raintime: 8 amount:10.
         Runoff raintime: 9 amount:30.        Runoff raintime: 10 amount:40.!
        "evaluate" Runoff evaporation: 20.
         Runoff infilrate: 50.                Runoff delay: 1.
         Runoff drainage.!
        "evaluate" Runoff rain.!
        "evaluate" !
        "evaluate" Runoff rain.!
        "evaluate" Runoff infiltration.!
        "evaluate" Runoff channel.!
        "evaluate" Runoff doubleaxes.!
        "evaluate" Runoff maxyfirst: 50.!
        "evaluate" Runoff maxyfirst: 50.!
        "evaluate" Runoff name:'Runoff'.!
        "evaluate" Runoff maxyfirst: 50.!
        "evaluate" Runoff doubleaxes.!
        "evaluate" Runoff graphtitle:'Rain   Channel'.!
        "evaluate" Runoff maxysecond: 50.!
        "evaluate" Runoff drainage.!
        "evaluate" Runoff channeldouble.!
        "evaluate" Runoff starttime: 1.!
        "evaluate" Runoff channeldouble.!
        "evaluate" Runoff endtime: 10.!
        "evaluate" Runoff := Infiltration new.
        Runoff hours: 10.
        Runoff raintime: 1 amount:10.          Runoff raintime: 2 amount:20.
        Runoff raintime: 3 amount:30.          Runoff raintime: 4 amount:40.
        Runoff raintime: 5 amount:50.          Runoff raintime: 6 amount:30.
        Runoff raintime: 7 amount:10.          Runoff raintime: 8 amount:10.
        Runoff raintime: 9 amount:30.          Runoff raintime:10 amount:40.
        Runoff evaporation: 20.                Runoff delay: 1.
        Runoff infilrate: 50.
        Runoff drainage.!
        "evaluate" Runoff starttime: 1.!
        "evaluate" Runoff name:'Runoff'.!
        "evaluate" Runoff maxyfirst: 50.!
        "evaluate" Runoff doubleaxes.!
        "evaluate" Runoff drainage.!
        "evaluate" Runoff rain.!
        "evaluate" Runoff rain.!
        "evaluate" Runoff infiltration.!
        "evaluate" Runoff channel.!
```

```
"evaluate" Runoff starttime: 1.                    Runoff endtime: 10.
Runoff name:'Runoff'.!
"evaluate" Runoff graphtitle:'Rain Channel'!
"evaluate" Runoff maxyfirst: 50.!
"evaluate" Runoff maxysecond: 50.!
"evaluate" Runoff drainage.!
"evaluate" Runoff doubleaxes.!
"evaluate" Runoff channeldouble.!
"evaluate" Runoff doubleaxes.
Runoff channeldouble.!
"evaluate" Runoff := Infiltration new.
Runoff hours: 10.
Runoff raintime: 1 amount:10.          Runoff raintime: 2 amount:20.
Runoff raintime: 3 amount:30.          Runoff raintime: 4 amount:40.
Runoff raintime: 5 amount:50.          Runoff raintime: 6 amount:30.
Runoff raintime: 7 amount:10.          Runoff raintime: 8 amount:10.
Runoff raintime: 9 amount:30.          Runoff raintime:10 amount:40.
Runoff evaporation: 40.                Runoff delay: 1.
Runoff infilrate: 5.

Runoff drainage.!
```

```
GROUP ST LOG
        "evaluate" Village := Population new!
        "evaluate" Village birthrate: 19!
        "evaluate" Village deathrate: 10!
        "evaluate" Village pop: 1000!
        "evaluate" Village startyear: 1980!
        "evaluate" Village endyear: 2050!
        "evaluate" Village name:'Village'!
        "evaluate" Village graphtitle: 'Village population'!
        "evaluate" Village maxy: 2000.!
        "evaluate" Village setaxes.!
        "evaluate" Village growthgraph.!
        "evaluate" Village growthtable.!
        "evaluate" Village birthrate: 38!
        "evaluate" Village growthgraph.!
        "evaluate" Village growthtable.!
        "evaluate" Village birthrate: 10!
        "evaluate" Village growthgraph.!
        "evaluate" Village growthtable.!
        "evaluate" Village birthrate: 50!
        "evaluate" Village deathrate: 38!
        "evaluate" Village growthgraph.!
        "evaluate" Village growthgraph.!
        "evaluate" Village growthtable.!
        "evaluate" Village growthgraph.!
        "evaluate" Village setaxes.!
        "evaluate" Village growthgraph.!
        "evaluate" !
        "evaluate" Village birthrate: 19!
        "evaluate" Village deathrate: 10!
        "evaluate" Village growthgraph.!
        "evaluate" Runoff := Infiltration new!
        "evaluate" Runoff evaporation: 20.              Runoff delay: 1.!
        "evaluate" Runoff infilrate: 50.!
        "evaluate" Runoff infilrate: 50.!
        "evaluate" Runoff :=Infiltration new.!
        "evaluate" Runoff hours:10.!
        "evaluate" Runoff raintime: 1 amount: 10. Runoff raintime: 2 amount: 20. Runoff
        raintime: 3 amount: 30.       Runoff raintime: 4 amount: 40.   Runoff raintime: 5
        amount: 50.  Runoff raintime: 6 amount: 30. Runoff raintime: 7 amount: 10.       Runoff
        raintime: 8 amount: 10. Runoff raintime: 9 amount: 30.       Runoff raintime: 10
        amount: 40.
        Runoff evaporation: 20.              Runoff delay: 1.!
        "evaluate" Runoff infilrate: 50.!
        "evaluate" Runoff drainage.!
        "evaluate" Runoff rain.!
        "evaluate" !
        "evaluate" !
        "evaluate" !
        "evaluate" !
        "evaluate" !
        "evaluate" Runoff rain.!
        "evaluate" Runoff infiltration.!
        "evaluate" Runoff channel.!
        "evaluate" !
        "evaluate" Runoff doubleaxes.                    Runoff drainage. Runoff channeldouble.!
        "evaluate" Runoff :=Infiltration new.!
        "evaluate" Runoff hours:3.!
        "evaluate" Runoff raintime: 1 amount: 30.        Runoff raintime: 2 amount: 50. Runoff
        raintime: 3 amount: 45.!
        "evaluate" Runoff hours:10.!
        "evaluate" Runoff raintime: 1 amount: 30.        Runoff raintime: 2 amount: 50. Runoff
        raintime: 3 amount: 45.!
        "evaluate" Runoff reset!
        "evaluate" Runoff hours:10.!
        "evaluate" Runoff raintime: 1 amount: 30.        Runoff raintime: 2 amount: 50. Runoff
        raintime: 3 amount: 45.       Runoff raintime: 4 amount: 1.   Runoff raintime: 5
        amount: 0.     Runoff raintime: 6 amount: 0. Runoff raintime: 7 amount: 0.
        Runoff raintime: 8 amount: 0. Runoff raintime: 9 amount: 0.        Runoff raintime: 10
        amount: 0.!
        "evaluate" Runoff rain.!
        "evaluate" Runoff infiltration.!
        "evaluate" Runoff channel.!
        "evaluate" Runoff evaporation:40 .              Runoff delay:0.3 .!
        "evaluate" Runoff infilrate: 5.!
        "evaluate" Runoff delay:1 .!
```

```
"evaluate" Runoff infilrate: 5. Runoff drainage.!
"evaluate" Runoff starttime: 1.                Runoff endtime: 3. Runoff
name:'Runoff'.              Runoff graphtitle:'Rain   Channel'. Runoff maxyfirst: 50.
            Runoff maxysecond: 50.!
"evaluate" Runoff drainage.!
"evaluate" Runoff infiltration.!
"evaluate" Runoff channel.!
"evaluate" Runoff doubleaxes.!
"evaluate" Runoff drainage. Runoff channeldouble.!
"evaluate" Runoff delay:5 .!
"evaluate" Runoff channeldouble.!
"evaluate" Runoff drainage.!
"evaluate" Runoff doubleaxes.                  Runoff drainage. Runoff channeldouble.!
"evaluate" Runoff rain.!
"evaluate" Runoff infiltration.!
"evaluate" Runoff channel.!
"evaluate" Runoff :=Infiltration new.!
"evaluate" Runoff hours:10.!
"evaluate" Runoff raintime: 1 amount: 10.       Runoff raintime: 2 amount:15. Runoff
raintime: 3 amount: 10.       Runoff raintime: 4 amount: 5.   Runoff raintime: 5
amount:13 .     Runoff raintime: 6 amount:19. Runoff raintime: 7 amount:12.
Runoff raintime: 8 amount:4. Runoff raintime: 9 amount:5.       Runoff raintime: 10
amount:1.!
"evaluate" Runoff evaporation:5 .             Runoff delay:1 . Runoff infilrate:70.
Runoff drainage.
Runoff starttime: 1.              Runoff endtime:10. Runoff name:'Runoff'.
      Runoff graphtitle:'Rain   Channel'. Runoff maxyfirst: 50.              Runoff
maxysecond: 50.!
"evaluate" Runoff doubleaxes.                  Runoff drainage. Runoff channeldouble.!
```

RM GROUP LOG

```
"evaluate" Village :=Population new.!
"evaluate" Village birthrate: 19.!
"evaluate" Village birthrate: 19.!
"evaluate" Village deathrate: 10.!
"evaluate" Village pop: 1000!
"evaluate" Village startyear: 1980!
"evaluate" Village endyear: 2050.!
"evaluate" Village name:'Village'.!
"evaluate" !
"evaluate" Village graphtitle: 'Village population'!
"evaluate" Village maxy: 2000.!
"evaluate" Village setaxes.!
"evaluate" Village growthgraph.!
"evaluate" Village growtht ble.!
"evaluate" Village birthrate: 38!
"evaluate" Village growthgraph.!
"evaluate" Village growthtable.!
"evaluate" Village deathrate: 29!
"evaluate" Village setaxes.!
"evaluate" Village growthgraph.!
"evaluate" Village birthrate: 11!
"evaluate" Village deathrate: 12!
"evaluate" Village growthgraph.!
"evaluate" Village growthtable.!
"evaluate" Village := Population new.
   Village birthrate: 19.
Village deathrate: 10.
Village pop:1000.
Village startyear: 1980.
Village endyear: 2020.!
"evaluate" Village maxy: 2000.!
"evaluate" Runoff :=Infiltration new.!
"evaluate" Runoff :=Infiltration new.!
 "evaluate" Runoff hours:10.!
"evaluate" Runoff raintime: 1 amount: 10!
"evaluate" Runoff raintime: 2 amount: 20.
Runoff raintime: 3 amount: 30.       Runoff raintime: 4 amount: 40.!
"evaluate" Runoff raintime: 5 amount: 50.       Runoff raintime: 6 amount: 30.
Runoff raintime: 7 amount: 10.       Runoff raintime: 8 amount: 10.
Runoff raintime: 9 amount: 30.       Runoff raintime: 10 amount: 40.!
"evaluate" Runoff evaporation: 20.!
"evaluate" Runoff delay: 1.!
"evaluate" !
"evaluate" Runoff rain.!
"evaluate" Runoff infiltration.!
"evaluate" Runoff channel.!
"evaluate" Runoff endtime: 10!
"evaluate" Runoff hours:10.
Runoff raintime: 1 amount: 10.       Runoff raintime: 2 amount: 20.
Runoff raintime: 3 amount: 30.       Runoff raintime: 4 amount: 40.
   Runoff raintime: 5 amount: 50.       Runoff raintime: 6 amount: 30.
Runoff raintime: 7 amount: 10.       Runoff raintime: 8 amount: 10.
Runoff raintime: 9 amount: 30.       Runoff raintime: 10 amount: 40.!
"evaluate" Runoff evaporation: 20.             Runoff delay: 1.
Runoff infilrate: 50.!
"evaluate" Runoff drainage.!
"evaluate" Runoff channel.!
"evaluate" Runoff infiltration.!
"evaluate" Runoff doubleaxes.!
"evaluate" Runoff channeldouble.!
"evaluate" Runoff hours:2!
"evaluate" Runoff raintime: 1 amount: 50.       Runoff raintime: 2 amount: 70.
Runoff raintime: 3 amount: 0.     Runoff raintime: 4 amount: 0.
   Runoff raintime: 5 amount: 0.       Runoff raintime: 6 amount: 0.
Runoff raintime: 7 amount: 0.    Runoff raintime: 8 amount: 0.
Runoff raintime: 9 amount: 0.     Runoff raintime: 10 amount: 0.!
"evaluate" Runoff evaporation: 50.             Runoff delay: 5.
Runoff infilrate: 1.
Runoff drainage.!
"evaluate" Runoff rain.!
"evaluate" Runoff infiltration.!
"evaluate" Runoff channel.!
"evaluate" Runoff starttime: 1.
```

```
              Runoff endtime:   10.
  Runoff name:'Runoff'.              Runoff graphtitle:'Rain   Channel'.
  Runoff maxyfirst:
 50.              Runoff maxysecond: 50.!
"evaluate" Runoff doubleaxes.!
"evaluate" Runoff drainage.!
"evaluate" Runoff channeldouble.!
"evaluate" Runoff channeldouble.!
"evaluate" Runoff drainage.!
"evaluate" Runoff hours:10.!
"evaluate" Runoff  doubleaxes.!
"evaluate" Runoff drainage.!
"evaluate" Runoff channeldouble.!
"evaluate" Runoff hours:10.!
"evaluate" Runoff raintime: 1 amount: 20.       Runoff raintime: 2 amount: 10.
Runoff raintime: 3 amount: 0.     Runoff raintime: 4 amount: 15.
   Runoff raintime: 5 amount: 8.     Runoff raintime: 6 amount: 2.
Runoff raintime: 7 amount: 0.    Runoff raintime: 8 amount: 7.
Runoff raintime: 9 amount: 12.    Runoff raintime: 10 amount:10.!
"evaluate" Runoff evaporation: 10.           Runoff delay: 10.
Runoff infilrate: 60.!
"evaluate" Runoff rain.!
"evaluate" Runoff infiltration.!
"evaluate" Runoff channel.!
"evaluate" !
"evaluate" Runoff doubleaxes.!
"evaluate" Runoff doubleaxes.                Runoff drainage.!
"evaluate" Runoff channeldouble.!
"evaluate" Runoff doubleaxes.                Runoff drainage.
  Runoff channeldouble.!
"evaluate" !

"evaluate" !
```

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APPENDIX TEN

SMALLTALK QUESTIONNAIRE RESPONSES

QUESTIONNAIRE

Please answer the question below and give any other information that you consider helpful. All the question relate to how helpful such computer software is to learning and understanding geography.

WHAT ARE THE STRENGTHS OF THE SYSTEM IN HELPING TO LEARN GEOGRAPHY ?

WHAT ARE THE WEAKNESSES OF THE SYSTEM IN HELPING TO LEARN GEOGRAPHY ?

DO YOU CONSIDER THE SYSTEM WORTH LEARNING TO HELP IN YOUR UNDERSTANDING OF GEOGRAPHY. PLEASE GIVE REASONS.

DID YOU ENJOY THE DAY ?

DID YOU FIND IT INTELLECTUALLY DIFFICULT ?

WOULD YOU RECOMMEND SUCH A DAY TO YOU FELLOW GEOGRAPHY STUDENTS ?

RESPONSE - Katie

Please answer the question below and give any other information that you consider helpful.All the question relate to how helpful such computer software is to learning and understanding geography.

WHAT ARE THE STRENGTHS OF THE SYSTEM IN HELPING TO LEARN GEOGRAPHY ?

I think that it will help geographers learn how things are related to one another, and also as it will encourage people to experiment with things it will probably increase their understanding e.g. being able to change conditions it will help people understand how they relate to conditions in an are and which variables affect which.

WHAT ARE THE WEAKNESSES OF THE SYSTEM IN HELPING TO LEARN GEOGRAPHY ?

I think it may take a long time to programme some results in, which is unhelpful as time on computers is very short in schools, but otherwise I think it is very good and I can't think of any weaknesses.

DO YOU CONSIDER THE SYSTEM WORTH LEARNING TO HELP IN YOUR UNDERSTANDING OF GEOGRAPHY. PLEASE GIVE REASONS.

Yes, because when people are experimenting they often come across things they otherwise would not have considered. It will help teachers tie the threads of lesson together.

DID YOU ENJOY THE DAY ?

Yes very interesting and good fun

DID YOU FIND IT INTELLECTUALLY DIFFICULT ?

It made me think particular this afternoon (table construction)

WOULD YOU RECOMMEND SUCH A DAY TO YOU FELLOW GEOGRAPHY STUDENTS ?

Yes

RESPONSE - Emma

Please answer the question below and give any other information that you consider helpful. All the question relate to how helpful such computer software is to learning and understanding geography.

WHAT ARE THE STRENGTHS OF THE SYSTEM IN HELPING TO LEARN GEOGRAPHY ?

It makes you think because you are not only answering the question but are actually making up the questions as well. You are expanding on what you already know and using the information in different ways.

WHAT ARE THE WEAKNESSES OF THE SYSTEM IN HELPING TO LEARN GEOGRAPHY ?

Its a bit limited as the system does not deal with opinions, everything has to be classed as a value. However, this is not a real weakness just a slight drawback.

DO YOU CONSIDER THE SYSTEM WORTH LEARNING TO HELP IN YOUR UNDERSTANDING OF GEOGRAPHY. PLEASE GIVE REASONS.

The system is worthwhile - its get you thinking more and is much different to a normal geography lesson

DID YOU ENJOY THE DAY ?

Yes it was really interesting and I enjoyed it.

DID YOU FIND IT INTELLECTUALLY DIFFICULT ?

Not really, the most difficult thing was working the computer

WOULD YOU RECOMMEND SUCH A DAY TO YOU FELLOW GEOGRAPHY STUDENTS ?

Yes. You are using what you already know in different ways. I've now realised how I can use different things and how different things interact.

RESPONSE - Tony

Please answer the question below and give any other information that you consider helpful. All the question relate to how helpful such computer software is to learning and understanding geography.

WHAT ARE THE STRENGTHS OF THE SYSTEM IN HELPING TO LEARN GEOGRAPHY ?

I would class this particular software as an aid to project work and revision as it helps display data in a clear and easily understandable way.

WHAT ARE THE WEAKNESSES OF THE SYSTEM IN HELPING TO LEARN GEOGRAPHY ?

The operating system was difficult to get to grips with at first. My previous computer experience did come in useful.

DO YOU CONSIDER THE SYSTEM WORTH LEARNING TO HELP IN YOUR UNDERSTANDING OF GEOGRAPHY. PLEASE GIVE REASONS.

Learning the system itself would not help, however, software such as this is ideal for representing data in projects and notes.

DID YOU ENJOY THE DAY ?

Yes

DID YOU FIND IT INTELLECTUALLY DIFFICULT ?

At first it is as it is a different approach to learning.

WOULD YOU RECOMMEND SUCH A DAY TO YOU FELLOW GEOGRAPHY STUDENTS ?

Yes

RESPONSE - James

Please answer the question below and give any other information that you consider helpful. All the question relate to how helpful such computer software is to learning and understanding geography.

WHAT ARE THE STRENGTHS OF THE SYSTEM IN HELPING TO LEARN GEOGRAPHY ?

It allows you to manipulate your knowledge and to show results in a clear way. It allows you to reach your own decisions about issues.

WHAT ARE THE WEAKNESSES OF THE SYSTEM IN HELPING TO LEARN GEOGRAPHY ?

It is perhaps too confined in the logic program as there are no in-betweens(yes and no are extremes). This is not reality but the computers capabilities which limit the pupils' understanding.

DO YOU CONSIDER THE SYSTEM WORTH LEARNING TO HELP IN YOUR UNDERSTANDING OF GEOGRAPHY. PLEASE GIVE REASONS.

Not really, I am interested in passing exams only and feel that this is possible from reading books etc. The system is not essential for a full grasp of the subject.

DID YOU ENJOY THE DAY ?

Yes

DID YOU FIND IT INTELLECTUALLY DIFFICULT ?

No, only mechanically.

WOULD YOU RECOMMEND SUCH A DAY TO YOU FELLOW GEOGRAPHY STUDENTS ?

Yes, it is good to obtain experience by working with computers as higher education courses demand at least some knowledge of their operation.

RESPONSE - Robert

Please answer the question below and give any other information that you consider helpful. All the question relate to how helpful such computer software is to learning and understanding geography.

WHAT ARE THE STRENGTHS OF THE SYSTEM IN HELPING TO LEARN GEOGRAPHY ?

It can be seen how things inter-relate with each other as it appears on the screen and experimentation helps you remember the relationships as you 'discovered' them yourself as opposed to being told.

WHAT ARE THE WEAKNESSES OF THE SYSTEM IN HELPING TO LEARN GEOGRAPHY ?

The time that would be taken up in setting up the programmes each lesson and a relatively large amount of time in teaching the use of computers. Some people may be left behind because of a lack of computing skills as opposed to geographical skills.

DO YOU CONSIDER THE SYSTEM WORTH LEARNING TO HELP IN YOUR UNDERSTANDING OF GEOGRAPHY. PLEASE GIVE REASONS.

The system may not help teach geography in lower school due to the time needed and other restrictions such as pupil distraction and the lack of control the teacher would have, but is would be useful to save time for analysing projects etc. that had to be completed by pupils.

DID YOU ENJOY THE DAY ?

Yes. I do not usually use computers so I was interested in what was going on.

DID YOU FIND IT INTELLECTUALLY DIFFICULT ?

No.

WOULD YOU RECOMMEND SUCH A DAY TO YOU FELLOW GEOGRAPHY STUDENTS ?

If they did not get a chance to use computers often then yes as there is a dual purpose for the day.

RESPONSE - Matthew

Please answer the question below and give any other information that you consider helpful.All the question relate to how helpful such computer software is to learning and understanding geography.

WHAT ARE THE STRENGTHS OF THE SYSTEM IN HELPING TO LEARN GEOGRAPHY ?

You can see all the information in a clear and easy format. It draws all the graphs and tables for you. It helps to show relationships between certain points in geography.

WHAT ARE THE WEAKNESSES OF THE SYSTEM IN HELPING TO LEARN GEOGRAPHY ?

Takes a little time to get used to but once you have the grip of it its pretty easy to follow. Takes a long time to key in the data if you are not used to a keyboard.

DO YOU CONSIDER THE SYSTEM WORTH LEARNING TO HELP IN YOUR UNDERSTANDING OF GEOGRAPHY. PLEASE GIVE REASONS.

No, at the moment it is to time consuming and teachers have to get through a syllabus so they will not waste time. You could be told the information quicker than the computer could tell you, its a pretty basic level of geography as it cannot evaluate.

DID YOU ENJOY THE DAY ?

Its good to see computer at work which we don't usually use. Normally its just textbooks. Yes I did.

DID YOU FIND IT INTELLECTUALLY DIFFICULT ?

No.

WOULD YOU RECOMMEND SUCH A DAY TO YOU FELLOW GEOGRAPHY STUDENTS ?

Maybe to GCSE students but not A-level in the 16-19 course.

RESPONSE - Sauni

Please answer the question below and give any other information that you consider helpful.All the question relate to how helpful such computer software is to learning and understanding geography.

WHAT ARE THE STRENGTHS OF THE SYSTEM IN HELPING TO LEARN GEOGRAPHY ?

It shows geography working in real live systems. By using examples you can see the effects of an action rather than being told that this is what will happen.

WHAT ARE THE WEAKNESSES OF THE SYSTEM IN HELPING TO LEARN GEOGRAPHY ?

Only weaknesses is that the geography is simplified. It is not in-depth. Although it deals with specific situations it does not go into them in great detail.

DO YOU CONSIDER THE SYSTEM WORTH LEARNING TO HELP IN YOUR UNDERSTANDING OF GEOGRAPHY. PLEASE GIVE REASONS.

It is helpful because we can view what is happening during a particular circumstance. You can remember principles better if they are visual and you enjoy yourself and if you are thinking rather than is you are told geographical principles.

DID YOU ENJOY THE DAY ?

Yes

DID YOU FIND IT INTELLECTUALLY DIFFICULT ?

No

WOULD YOU RECOMMEND SUCH A DAY TO YOU FELLOW GEOGRAPHY STUDENTS ?

Yes

RESPONSE - Stephen

Please answer the question below and give any other information that you consider helpful.All the question relate to how helpful such computer software is to learning and understanding geography.

WHAT ARE THE STRENGTHS OF THE SYSTEM IN HELPING TO LEARN GEOGRAPHY ?

It gives a sound base in general ideas of each section of geography e.g. what ecosystems are about, factors affecting location of development etc.

WHAT ARE THE WEAKNESSES OF THE SYSTEM IN HELPING TO LEARN GEOGRAPHY ?

Some of the question may not be specific enough in some cases you may need more than two state questions and answers because some are border line.

DO YOU CONSIDER THE SYSTEM WORTH LEARNING TO HELP IN YOUR UNDERSTANDING OF GEOGRAPHY. PLEASE GIVE REASONS.

Yes because the ways you can actually see what the outcome of a certain set of circumstances to any particular situation to get a reasonable answer. The facts are argued through for you, you just have to understanding the reasoning behind the computer's answer.

DID YOU ENJOY THE DAY ?

Yes

DID YOU FIND IT INTELLECTUALLY DIFFICULT ?

Not at all

WOULD YOU RECOMMEND SUCH A DAY TO YOU FELLOW GEOGRAPHY STUDENTS ?

Yes

BIBL LONDON UNIV