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TITLE: BOREHOLE DILUTION FOR AMARGOSA FARM CRITICAL GROUP: NEAR-FIELD FOCUS

PEOPLE: Randy Fedors
Gordon Wittmeyer
Amit Armstrong

PROJECT:

This will be a detailed study of borehole dilution on the scale of individual wells or well-fields as in the area of Amargosa Farms agricultural district. This work is part of the ARDES KTI and is complementary to the larger scale study by Amit and Gordon to determine the likely fate and transport of radionuclides from the repository at Yucca Mountain to the critical group downgradient approximately 25 kilometers.

Preliminary scoping work has already been started for the near-field focus. Literature review and software scoping along with the collection of pertinent data from federal and state databases have focused the work plan. There is a workplan, a preliminary scoping report, and a reference list attached on subsequent pages. This format for the scientific notebook was determined per discussions with Bob Brient and as it become apparent that a software package has been identified and that scientific calculations would soon be going beyond a scoping effort.

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Preliminary Report on Borehole Dilution in Amargosa Springs Area
(RFedors: edit version May 26, 1997; printed July 11, 1997))

1. INTRODUCTION

The concept of borehole dilution in the literature addresses the areas of sampling bias and well design, effectiveness of pump & treat systems, and capture zone analysis. Our perspective is the latter. Borehole dilution is used to explain 1-2 orders of magnitude difference in concentrations between well samples and measured concentrations in the aquifer; either concentration value may be greater than the other. "Borehole dilution" is also the name of a procedure to estimate permeabilities in a single well bore through analysis of the dilution rate after release of a solute in the well bore. Borehole dilution in our work here refers to dilution of the aquifer concentrations of a solute in a wellbore due to pumping in a well which may capture both contaminated and uncontaminated portions of the aquifer.

Borehole dilution refers to near-field affects of pumping wells on the flow field and the capture of both contaminated and uncontaminated waters. In the vicinity of Amargosa Valley (previously Lathrop Wells) and Amargosa Farms (irrigated farmland area south of Amargosa Valley), dilution of the aquifer concentration in any wellbore may occur due to the creation of both vertical and horizontal gradients towards the actively pumping well or wellfield. An important feature of the wells in this area is that they partially penetrate the aquifer.

Five categories of influence which may significantly effect the borehole concentration are:

1. well pump rate and well distribution in the well field;
2. regional hydraulic gradient;
3. hydrostratigraphy and anisotropy;
4. well penetration depth and length of screen;
5. solute plume distribution, vertically & horizontally.

The last three lose significance if the plume is larger than the area of influence in a horizontal sense (capture area) and if the wells are fully penetrating an aquifer which is contaminated top to bottom. All 5 effects are inter-related, but it is convenient to group the first two and the last three. Analytical solutions can incorporate the effects of well pump rates, well spacing, and regional gradients under certain restrictions for a sensitivity analysis. Complex numerical models are generally required to analyze the effects of the hydrogeology, the plume configuration, and the well design especially if 3-dimensional effects are considered to be important. Modeling scales to consider are: 1) well field area of Amargosa Valley of approximately 100 square kilometers; and, 2) single well area of approximately 10-1000 meters capture zone.

2. BACKGROUND

Total System Performance (TSP) reports in 1995 (TRW) and 1996 (EPRI) put forth dilution factors as attributed to regional or far-field mixing and dispersion. TSP-95 focused on sub-basin contributions of water and lateral dispersion for a prediction of a centerline concentration dilution factor of 1×10^6 and a plume configuration of 7.7 km laterally and 2.9 km vertically. TSP-95 used a 3-dimensional solution of the advective-dispersive equation for a line source. Their sub-basin mixing model used large-scale basin estimates of flow rates to arrive at a dilution factor. TSP-96 (EPRI) used the Domineco-Robbins (1985) model which is for 1-dimensional flow and 3-dimensional transport with dispersion and first order kinetic loss. TSP-96 reported on a sensitivity analysis of lateral dispersivity as well as plume width and depth at 5 km. Instead of using an unbounded, scale-dependency model for dispersivity, TSP-96 used values approximately an order of magnitude less than the TSP-95 values. The base simulation plume width at 25 km was reported as 3.5 km wide with no reported depth. As compared with TSP-95, TSP-96 reported

Attached to this page (1) is a 5-page preliminary report written at onset of literature review stage of project. It is included here for background purposes.
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a more conservative 15x dilution factor prior to an uncertainty adjustment to +/- 2x dilution factor. Neither TSP incorporates near field (to Amargosa Valley wells) effects of borehole dilution as defined in the Introduction section.

The NRC HLW Annual Report of 1996 noted that TPA-95 estimates of dilution factor were optimistic. The scoping study in the 1996 annual report used the 2-dimensional flow model MAGNUM-2D along with the radionuclide transport code CHAINT.

The effect each category on borehole dilution can be described in qualitative terms. Determination can be separated into a two step process. First determine the effect on the capture area. Second analyze the spatial configuration of the plume in relation to the capture area. The effect of each category on the capture zone can be generalized. An increase in the pump rate will increase the capture area. An increase in the spacing of the wells may increase the capture zone horizontally but it may decrease the capture zone vertically and may introduce gaps in the capture zone between wells. An increase in the regional hydraulic gradient will act to decrease the capture area. An increase in the anisotropy will increase the capture zone horizontally but decrease it vertically. An increase in the horizontal variability of porous media will channelize the plume. However, wells may be preferentially placed the channels of higher permeability. In increase in the depth of a partially penetrating well will increase the vertical capture area but decrease the horizontal capture area. The position and distribution of the plume in relation to the capture zone will control the dilution of the solute in the well bore.

Before elaborating on the mathematical approximations to the physical system at Amargosa Springs area, it is useful to distinguish three concentration values. First is the concentration of a solute anywhere in the aquifer; this is a point value. A useful measure is the maximum concentration, $C_{AQ,MAX}$. A second type of value is the vertically averaged concentration for a column in the aquifer, C_{AQ}. The third type is the concentration in the well bore, C_{WELL}, which is usually taken as an average value since the well can be viewed as a CSTR (continuously stirred tank reactor).

2.1 Analytical Models

Analytical solutions are appropriate for quick estimates of simple hydrogeologic systems to determine capture zones for wells. These solutions are generally restricted to uniform (steady) flow in isotropic, homogeneous domains in a horizontal 2-dimensional plane. Vertical flow is ignored and vertical averaging of aquifer concentrations is required. Multiple stresses on the system (multiple wells, rivers, infiltration) utilize superposition.

Analytic solutions for capture zone estimates can be obtained for 2-dimensional scenarios (CZAEM; Strack, 1989) or for 3-dimensional scenarios incorporating the effects of a partially penetrating well. The analytic element method solves a form of the flow equation which uses hydraulic potential as the dependent variable. Superposition is used to model multiple stresses in study domain. CZAEM is the underlying code to the EPA wellhead capture zone code WhAEM (described in Strack, 1989; and in EPA, 1994 WhAEM User Manual). As a 2-dimensional code, CZAEM is applicable for isotropic, homogeneous domains where vertical flow can be ignored. It can be used to ascertain sensitivity to hydraulic conductivity as well as the distribution of wells and the magnitude of their pump rates. To address the effects of vertical flow near partially penetrating wells, another code must be used or written. Analytic solutions have been published for 3-dimensional flow fields for partially penetrating wells and estimation of their capture zones (Schafer, 1996;Faybishenko, et al., 1995; Grubb, 1993). Codes may be available for 3-dimensional capture zones from Hendrik Haitjema as related to his book "Analytic Element Method for Groundwater Modeling" (1995).

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Heterogeneous domains in vertical direction are incorporated by the approximation of a layered system with a single layer. Schafer (1996) describes an extension to 3-dimensional delineation of capture zones and incorporates a method to approximate a heterogeneous domain for partially penetrating wells. He illustrates the effect on a capture zone of anisotropy ratios, pumping rates, and well configuration. Strack (1989) suggests a transformation of the vertical axis and hydraulic conductivity. Analytical solutions which could incorporate the transformed conductivity are not included in the CZAEM model.

2.2 Numerical Models

Sensitivity analyses of effects which include vertical movement of water or solute in a heterogeneous domain require the use of numerical models. A good illustration of the influences which affect a capture zone is found in Bair & Lahm (1996). They simulated a well field and its effect on capture zone size and shape using a finite difference method for steady state analysis of flow along with a particle tracking scheme. They determined the magnitude of effect due to regional gradient, well penetration, pump rates, well configuration, and anisotropy of porous media all from the perspective of an idealized pump and treat design.

Three published articles on numerical simulation of 3-dimensional flow in and around a wellbore contain pertinent information for refined modeling in the vicinity of a single well. Chiang, et al. (1995) simulated 3-dimensional flow and solute transport (advection only) in the vicinity of a partially penetrating well in order to understand an order of magnitude difference between well samples and point aquifer samples. The concentration profile in the aquifer was known. The well bore was modeled as separate elements with a permeability in the range of that predicted for laminar flow in a tube. They attributed a majority of the difference to vertical contribution of clean water. They noted that their transient simulation results asymptotically approached the simple, mass balance-based result which assumes a flat water table. Therefore, concentration in the well is proportional the degree of penetration (the so-called "penetration factor") at long times.

Akindunni, et al. (1995) simulated 3-dimensional flow near a well for various screen positions and plume positions. They approximated the well with a neumann boundary condition at the edge of the domain by apportioning the discharge uniformly to the number of nodes along the screened length of the well. They compared vertically averaged values of concentration for both the wellbore and the aquifer. In there transient simulations, concentrations differed significantly in the well and aquifer. Dependent on the plume depth and the screened portion, the concentration in the wellbore was higher or lower than the vertically averaged aquifer value. However, over long times, the concentration in the wellbore asymptotically approached the vertically averaged aquifer value. In addition to screen position and plume position, they also looked at screen length and anisotropy. Again, initial concentrations differed significantly but long time concentrations appear to trend towards the vertically averaged aquifer value. As expected, simulations with large anisotropic ratios exhibited the less vertical mixing as compared low ratios.

Reilly, et al. (1989) also modeled the wellbore as a column of hydraulically connected cells. Their focus was on wellbore flow in a monitoring well with implications for sampling bias and cross-contamination. In a monitoring well, cross-contamination will act to dilute the plume. Of note was their conclusion that greater than half the aquifer-to-wellbore flow occurred in the top 10 percent of the screened length while greater than half the wellbore-to-aquifer flow occurred in the bottom 10 percent of the screened length. Hence, solute plumes approaching the top of the screened portion will enter the wellbore while plumes approaching the bottom will tend to flow around the well. This may be pertinent for Amargosa Springs area when irrigation wells are shut down but is probably irrelevant during periods of pumping.

3. NOTES ON WORK PLAN

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3.1 Data Availability

The pertinent area of Amargosa Desert is 25-30 km from the repository. Active pumping wells are located near and in the town of Amargosa Valley and the nearby irrigated fields. Saturated hydraulic conductivity, pumpage rates, well distributions, well construction, amount of irrigation (recharge), vertical and horizontal hydrostratigraphy not well documented, as per usual, are not well documented. Data may be available from the large scale USGS modeling projects or from various state and federal data bases.

The size of the plume as it enters the Amargosa Valley area is also unknown. Horizontal and vertical distributions as well as the concentration (uniform or non-uniform) estimates will have to be determined from other modeling efforts.

3.2 Ranges for Sensitivity Analyses

First phase of sensitivity analysis is to prioritize the features of Amargosa which affect borehole dilution. This will be accomplished by perturbations of each component individually. The ranges will be based on reasonable ranges. The categories listed in the Introduction section can be separated into perturbable (do not get them mad!) components:

- permeability, magnitude
- permeability, vertical variation
- anisotropic ratio
- regional hydraulic gradient
- well distribution (spatial, clusters)
- well pump rates (vary spatially, overall magnitude)
- well design (screen length and depth of screen)
- plume source concentration
- plume distribution (vertically and horizontally)

A second phase could be a more sophisticated perturbation selection procedure amongst the most significant components.

3.3 Analytical Model

Initial software evaluation led to the EPA WhAEM modeling environment. The underlying CZAEM model can be used for sensitivity analyses for well pump rates, well distributions spatially, and regional hydraulic gradients. In addition, an infiltration recharge from irrigation can be added. The number of stresses appears to be limited to approximately 150; total number of pumping wells and recharge areas. Quantitative output appears to be limited (check screen output during trace). Graphical output is simplistic, though I haven't explored the full utility of the GAEP program.

CZAEM

- calibrate
- sensitivity on K, Q, well distribution
- produce percentage of plume capture

3.4 Numerical Model

The real system is a transient flow field in a heterogeneous, uncertain domain with variable and uncertain stresses (well, recharge, etc...). Given the available data and the time frame to be simulated, what are some appropriate approximations. One approximation is to assume a steady state flow field. The flow field

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could then be used for particle tracking. This approach ignores dispersion as a first approximation and leads to a conservative estimate for dilution. A trial-and-error determination of number of particles to release is an approach towards determination of a meaningful concentration in the wellbore nodes/cells.

How a model handles flow and transport near a well is critical. Finite difference models may be extremely cumbersome for approximating each pumping well. Finite element models are preferable. Alternatives for modeling wellbore dilution using discretized flow field and particle tracking:

- point source (neumann b.c.) in one cell/node;
- line source (neumann b.c.) in multiple cells/nodes along a vertical column,
  apportion discharge between cells/nodes based on permeability of each strata;
- point source (neumann b.c.) with vertical column of hydraulically connected nodes (high K),
  avoid because of difficulties numerically;
- line source (dirichlet) in vertical column, heads chosen so as to get correct discharge at steady
  state.

The line source will better represent the system in terms of aquifer-wellbore interaction as well as screen lengths and depths in relation to plume distribution. The single point source in one cell/node is the simplest to implement and easiest in terms of post-processing.

MAGNUM-3D & PTM

- calibrate steady state flow;
- particle track; determine number of particles to release & assign mass;
- sensitivity on everything;
- output is percentage dilution factor:
  (minimum dilution at any location, average for all wells);
- pre- and post-processing needed:
  depends on how MAGNUM incorporates wells;
  well-by-well concentration comparison with $C_{AQ,MAX}$ and C_{AQ};
- small scale focus on single or multiple wells (10 to 1000 meter):
  well design versus plume stratification or configuration;
  treat well as line source (multiple layer representation);
- larger scale (1000 sq.km.) appears to be on backburner:
  does point source/sink for well approximate line source at this scale.

4. SUMMARY

There is a limited amount data for the Amargosa Valley and Amargosa Farms in terms of the hydraulic parameters, well design, and well usage parameters. In addition, the predicted plume magnitude and configuration are uncertain parameters obtained from larger scale modeling. A focus on well design and plume configuration may be justified based on the availability of data.

Acronyms

NRC	Nuclear Regulatory Commission
EPA	Environmental Protection Agency
CZAEM	Capture Zone Analytic Element Method
WhAEM	Wellhead Analytic Element Method
HLW	High Level Waste
USGS	U.S. Geological Survey

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Work plan per Gordon Wittmeyer after discussions with NRC staff (McCartin, Codell, Leslie) is attached on this page.

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Borehole Dilution at the Amargosa Farms Critical Group Area

Dilution in individual boreholes depends in part on the fractions of water drawn from contaminated and uncontaminated production zones, which in turn depend on the depth of the well and the location, length, and number of screened and uncased intervals. A study will be undertaken to quantitatively assess the effects of borehole dilution on radionuclide doses in the Amargosa Farms critical group area. Fundamental questions to be addressed by this study include: (i) how variations in well construction practices (depth, screen placement, etc.), borehole spacing, and pumping rates affect capture of a radionuclide plume of specified shape; (ii) the magnitude of well-to-well variations in radionuclide doses; and (iii) for the purposes of computing doses, the reasonableness of assuming that all radionuclides released from the repository are completely mixed in all of the water pumped in the Amargosa Farms area.

Specific analyses to be conducted include:

- A detailed statistical analysis of borehole depths, well depths, screened or uncased section positions and lengths will be conducted for the Amargosa Farms area. An evaluation will also be conducted to determine if variations in well construction methods can be directly tied to hydrostratigraphic facies changes.

- A parametric study to evaluate the sensitivity of borehole dilution to reasonable variations in well depth, screening practices, and radionuclide plume depth.

- An assessment of the sensitivity of plume capture to reasonable variations in pumping rates and spatial arrangements of irrigation and domestic supply wells.

- An assessment of the magnitude of well-to-well variations in radionuclide doses for reasonable variations in pumping rates and spatial arrangements of irrigation and domestic supply wells.

Where effects of pumping on dose are quantitatively examined, reported numerical results will be relative to the normalized concentration for the radionuclide plume—no absolute radionuclide concentrations or doses will be reported.

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Printout of references pertinent to Amargosa Farms & borehole dilution in attached on this pages; 4 pages included

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Printout of references pertinent to Amargosa Farms & borehole dilution is attached on this page; 4 pages included.

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Status to date: (1) Software selection
(2) data collection

(1) Software Selection
At this stage in the project, an analytic element model with capture zone analysis is the chosen approach. Given the uncertainty of parameters, or the outright lack of data, a numerical model does not seem warranted for an initial phase sensitivity analysis.
Henk Haitjema's GFLOW model was chosen over other analytic element models due to it's incorporation of partially penetrating wells and their associated vertical flow.
Other analytic element models include:

CAPZONE	(Scott Bair)
AgModel	(Wellware)
QuickFlow	(Geraghty-Miller)
TWODPLUME	(Slotta Engineering)
WINFLOW }	(ESI)
WINTRAN }	
TWODAN	(Charles Fitts)
CZAEM	(Otto Strack)

(2) Data Collection
The following databases or tables will be used to develop reasonable hydraulic parameters, hydrostratigraphy, and well design and usage:

a) The USGS GWIS database extraction for the Yucca Mountain area. The extraction was procured by Gordon Wittmeyer at least 3 years ago. The file obtain from Gordon is stored in /home2/bren/rfedors/Bore/Data and is still called "gw2.fil"
b) Xerox copy of well permits dating from 1905 to 1995 as obtained by Gordon from Pat LaPlante (CNWRA-Washington office). Presumably, the tables originated from the Nevada State Engineer's Office.
c.) xerox copies of water use estimates for Amargosa Desert from the Nevada State Engineer's Office as obtained by Chad Glenn (NRC-Las Vegas Office).
d.) Xerox copies of well driller's logs as obtained by Chad Glenn from the Nevada State Engineer's Office
e.) published literature specific to Amargosa Farms area which may or may not have used category a)-d.) databases as a source.

All categories of data listed above are "existing" data per QAP-015

It is anticipated that a combination of fortran (SUN fortran 77) codes, awk scripts, & spreadsheets will be used to extract pertinent data and analyze on a statistical basis. Depending on machine availability, the spreadsheet program to be used is EXCEL either on an IBM-compatible DOS machine or on the WABI interface on the SUN workstation running SOLARIS

The analytic element model GFLOW will be installed and tested on IBM-compatibles which have a DOS overlay on OS/2, or which are running Windows95. Preliminary work with CZAEM code for delineation of capture zone suggest that GFLOW work will be successful. There are strong connections between the codes.

Amargosa Desert = Hydrographic Basin 230

⟹ Well Permit & Water Use databases
xerox copies from Nevada Division of Water Resources
Bob Coache – Nevada State Engineers Office
(702) 486-2770

(1) Annual tables of water-use estimates made by state engineer. Chad Glenn xeroxed copies from 1983, 1985-1996 July 1997 and sent to SWRI.

(2) Well Permit table from 1905 to 1995 obtained from Pat LaPlante (CNWRA) via Gordon Wittmeyer

Both of these data tables are catalogued by well permit number. If approved permits are utilized 5 years, they become certificated. There has been a general rejection of new permits since the early 1990's due to aquifer mining. However, large industrial (mining) operation at ~~Bullfrog (near Beatty)~~ did not appear on ~~permit~~ water-use list but has apparently been extracting since 1987. Apparently, when the Annual summary is prepared by the State Engineer, the large mining companies were not included in the detailed tables but they are in the summary page for the year. This is important to note if a spatial distribution of the water-use estimates is needed. The American Borate, IMV, and BullFrog companies should be checked and added in if missing for any particular year. The location of each can be determined from the Well Permit database.

RF 7/16/97 American Borate

Since the water-use database will be used to spatial distribution and magnitude of pumpage in the Amargosa Farms area, the detailed information was entered into a computer file. Checks on data entry was accomplished by starting with the well permit database (itself entered into a computer file), verifying that the water-use database had the same permit number and location. The irrigated amount was then added to appropriate column. During this data entry, typo's were noted in the Nevada State Engineers table of well permits: the location of a large groundwater user (American Borate) in the Amargosa Farms area was obscured and grossly misplaced. The reasonableness of the location for

American Borate operations as listed in the water-use tables suggested that the well Permit database was incorrect.

There are entries in the databases from Nevada Div of Water Resources which are in Amargosa Desert, but not near the Amargosa Farms area.

These are the ranges and townships which are being considered as Amargosa Farms area:

R47E ; T16S
R48E ; T15-17S
R49E ; T15-17S
R50E ; T15-17S
(predominantly western half of R50E)

Per this definition of the Amargosa Farms area, the following users of groundwater are removed from my computer file:

	Permit #	Section	Township	Range	Description
	22140	8	17S	52E	irrigation
	22141	7	17S	52E	irrigation
	51841-51848 }				
	58268 }		12S	46-47E	St. Joe's Bull Frog operation
NoPer = Not Permitted	61412 }		13S	46E	near Beatty
AB = American Borate	61413 }				
IMV = Industrial Mineral Ventures	53596	7	18S	51E	U.S. Fish & Wildlife
BF = St. Joe's BullFrog operation	54271	7	17S	52E	Nye Cty

Other = domestic, municipal, commercial

The original and the adjusted values of annual water use are in the table below:

Summaries of Groundwater Pumpage - Nevada State Engineer's Office
Adjustments to State Engineers data removes non-Amargosa Farms wells.
Borehole Dilution ARDES KTI -- RFedors

RF 16 July 97

	Actual State Engineer Tabulation				Remove non-Amargosa Farms Wells				
Year	Irrigation Ac-Ft	Irr/NoPer Ac-Ft	AB/IMV/BF Ac-Ft	Other Ac-Ft	Irrigation Ac-Ft	Irr/NoPer Ac-Ft	AB/IMV Ac-Ft	Other Ac-Ft	Total Ac-Ft
1996	9263	1780	2285	285	9253	1780	1019	253.8	12305.8
1995	10839	1515	2571	110	10839	1515	780	110	13244
1994	8892	1085	2508	110	8892	1085	717	110	10804
1993	8558.8	150	2481	110	8508.8	150	1007	110	9775.8
1992	5711	50	2292.5	110	5661	50	653.5	110	6474.5
1991	4716.5	225	1070	110	4716.5	225	450	110	5501.5
1990	4603.1	350	2719.29	135	4603.1	350	886.69	135	5974.79
1989	1266	300	2220	135	1266	300	1413	135	3114
1988	2666	312	996	135	2666	312	996	135	4109
1987	4500	1200	302	135	4500	1200	302	135	6137
1986	5552.9	1000	550	135	5552.9	1000	550	135	7237.9
1985	5807	2665	950	250	5807	2665	950	250	9672
1983	5893	3212	125	270	5893	3212	125	270	9500

The 1996 Water Use data as added to the well permit data :

Well Permit & Estimated Water Use (data entry) RFedors
Added Water Use data to permit spreadsheet file (permit.xls) 16Jul97
Borehole Dilution for ARDES KTI
add'l ==> PC=certificate & permit
RFA,RFP=ready for action (protested)
APP=application
A1,A2,A3=special case of 3 permits same number
Water Use => entries are put under 1st permit number unless original.
permits are split, then put under 2nd listed permit number.
water use category not (!) modified from Well Permit database.

permit#	add'l	yr	qq	qtr	sec	twn	rng	cfs rate	irrig acres	use	1996 ~~irrig~~ acre-ft
15702	PC	54	ne	se	14	16	48	1	35	irr	175
15893	PC	54	ne	ne	23	16	48	3.5	160	irr	625
15929	PC	54	ne	ne	9	17	49	2.228	80	irr	700
16545	PC	55	ne	ne	28	16	49	2.5	21.98	ird	183.4
16562	PC	55	ne	ne	16	16	48	2.2	120	ird	125
17657	A3	58	ne	nw	15	16	48	0.04	2.5	irr	5
17657	A1	58	ne	nw	15	16	48	2.14	147.5	irr	7.5
17694	PC	58	ne	nw	15	17	49	2	38.2	irr	25
18222	PC	59	ne	nw	30	16	49	5.4	268	irr	665
18764	PC	60	ne	ne	8	16	48	4.01	71.4	irr	5
18772	PC	60	sw	nw	20	16	48	3.01	199	irr	17.5
19448	PC	61	sw	nw	7	16	48	0.63	37	ird	92.5
19916	PC	61	ne	ne	24	16	48	2.5	160	irr	227.5
19917	PC	61	ne	se	24	16	48	2.5	160	irr	625
20352	PC	62	xx	xx	36	16	48	3.5	233.9	ird	799.5
22233	PC	64	ne	ne	36	16	48	1	38	irr	25
22746	PC	65	ne	se	19	16	49	2.5	160	irr	625
24585	PC	68	se	sw	9	16	49	0.75	23.75	irr	105
24725	PC	68	se	nw	18	16	48	2.7	155.49	irr	657.75
24763	PC	68	ne	ne	8	16	49	0.59	26.69	irr	27.5
25009	PC	69	se	sw	10	16	48	1.22	3.5	irr	5
25742	PC	70	nw	sw	10	16	48	0.14	3.5	irr	17.5
25743	PC	70	nw	sw	10	16	48	0.14	3.5	irr	11.25
26152	PC	71	sw	se	8	16	48	1	12	irr	24
26283	PC	71	nw	nw	18	16	48	2.2	160	ird	400
26673	PC	72	nw	ne	24	15	49	0.004	0	qm	8
26718	PC	72	ne	se	8	16	48	0.1	3.78	irr	5
27812	PC	73	ne	nw	12	17	48	2.54	0	mm	272
28062	PC	74	se	sw	2	18	49	0.79	0	qm	16
28828	PC	74	se	nw	35	16	49	0.43	13.14	irr	26.28
29521	PC	75	se	sw	9	16	49	0.16	5	irr	25
29649	PC	75	ne	ne	9	17	49	1.32	125.6	irr	170
30411	PC	76	ne	se	23	16	49	2.67	151	irr	625
31727	PC	77	se	sw	9	16	49	0.16	5	irr	25
35592	PC	78	se	sw	1	17	48	0.5	0	qm	7.5
36584	PC	79	nw	nw	15	16	48	0.08	5	irr	12.5
38127	PC	79	se	nw	26	16	48	1.667	116.67	irr	583.5
38363	PC	79	se	ne	26	16	48	1.666	116.67	irr	233.4
40954	PC	80	se	se	22	16	49	0.178	9.54	irr	5

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RF 7/17/97 changed in pump.x file

continued

permit#	add'l	yr	qq	qtr	sec	twn	rng	cfs rate	irrig acres	use	1996 ~~irrig~~ acre-ft
42171	PC	80	sw	se	8	16	48	0.275	60	irr	70.7
43524	PC	81	ne	ne	9	17	49	1.454	125.6	irr	628
43873	PC	81	sw	nw	24	16	48	1.667	116.67	irr	583.5
45162	PC	81	se	sw	2	17	49	0.446	0	qm	10
45740	PC	82	ne	nw	27	16	49	0.02	0	qm	3.4
46748	PC	83	sw	nw	15	16	48	0.16	8.42	irr	10
47205	PC	83	sw	se	31	16	49	0.2	0	qm	10.5
49885	PC	86	se	nw	12	17	48	0.25	13	irr	65
50385	PC	86	nw	ne	16	16	49	0.1	0	qm	20
53181	PC	89	sw	sw	2	18	49	0.08	0	qm	50
53189	PC	89	se	ne	16	16	48	0.3	0	com	2
59180	PC	93	xx	se	16	35	49	0.07	0	com	1
60433	PC	94	nw	nw	15	16	48	0.039	2.5	irr	12.5
60442	APP	94	ne	nw	15	16	48	0.023	1.5	irr	5
60443	APP	94	ne	nw	15	16	48	0.025	1.61	irr	1
60471	APP	94	nw	nw	15	16	48	0.016	1	irr	5
60474	APP	94	ne	nw	15	16	48	0.029	1.84	irr	1
48479	PC	84	xx	sw	36	17	49	.26	0	com	746.5
60450	APP	94	nw	nw	15	16	48	-999	1.5	irr	7.5
61080	PC	96	nw	ne	10	17	49	-999	0	com	50
61219	PC	96	sw	ne	3	18	50	-999	0	qm	2

RF 7/16/97

The spreadsheet file /home2/bren/rfedors/Bore/Data/pump.xls (EXCEL format) includes all well permit entries. However, only a fraction of historical permits used groundwater (as estimated by Nevada State Engineers Office) during 1996. Only those with estimated usage are included in the table above

qq = quarter-quarter section
qtr = quarter section
sec = section
twn = township south
rng = range east
cfs rate = cubic ft/second well rating (not actual use rate)
dom = domestic
irr = irrigation
ird = irrigation (DLE)
qm = municipal and quasi-municipal
mm = milling & mining
com = commercial

RF 7/30/97

GFLOW analytic element model from Henk Haitjema

documentation includes:

(1) postscript file sent with disks & tutorial
chapters 1-7, appendix B, C

(2) book ⇒ Analytic Element Modeling of Groundwater Flow
Henk Haitjema (1995)
Academic Press, New York
ISBN 0-12-316550-4
purchased for CNWRA library

The story of the diskettes:
An educational version comes with the book. However, Henk Haitjema sent me the "basic" version 1.10

Henk Haitjema (Indiana University)
Haitjema Software (812) 336-2464
2738 Briggs Rd
Bloomington IN 47401

The educational version has some of the capabilities turned off.

Installation testing

To install this windows 3.x executable on "c" drive in directory "GFLOW":

(1) add following lines to autoexec.bat
```
C:\path...\mouse.com
set GFLOW = C:\GFLOW
set PATH = ...; C:\GFLOW
```
(2) add to config.sys
```
DEVICE = C:\ANSI.SYS
```
(assuming ansi.sys is in root directory)

(3) Use install.exe which comes with package (on diskettes)

For the IBM's running OS/2, just make sure that the mouse and the ansi.sys are installed for DOS overlay so that this program will run in a full DOS window.

It is anticipated that most of the simulations will be done on the IBM running a DOS overlay on OS/2 (machine is PS/2 95). This machine has the 32 bit extensions installed.

The installation test will be done using data extracted from a solution file (demo.sol) which comes with the package and a solution created on my installed program version using the input file "demo.dat". This is a complicated groundwater problem which includes many of GFLOW's capabilities (43 line sinks without resistance, 19 line sinks with resistance, and 16 line doublets for inhomogeneities). The domain coverage for the plot is:

x_1 = -21522.
y_1 = -34509.
x_2 = 71832.
y_2 = 73526.

The plot of solutions appear to be identical; Using the "sol S" command to create a solution, the same max error 0.4416% for line sinks w/ resistance results as was stated in demo/tutorial text.

Direct comparison between my solution & Henk's (distributed) solution for location x=0, y=0 (middle of lower left quadrant)

	x	y	z		Henk's	My Solution
head	0	0	-	⇒	275.1672	275.2815
potential	0	0	-	⇒	56501.03	56685.03
discharge	0	0	-		Q_x = 5.333770	5.383546
					Q_y = 0.3924446	0.4011707
specific discharge	0	0	-		q_x = 0.7095877E-1	0.7150465E-1
					q_y = 0.5220957E-2	0.5328378E-2
					q_z = -0.125312E-2	-0.1257065E-2
velocity	0	0	-		V_x = 0.3547938	0.3575293
					V_y = 0.2610478E-1	0.2664189
					V_z = -0.626560 E-2	-0.6385327E-2

Z locations automatically taken as water table; note that there is a slight difference in heads at location (0,0). The differences in the results are probably due to the 32 bit extension (prior to pentiums, IBM-compatibles ran a 16 bit Operating System & hardware). The differences are not considered significant.

GFLOW simulations — Approach (mechanically-speaking)

Data Entry (interactive Mode)
> C:\GFLOW\gflow to start program in full DOS screen mode
AQ
→ permeability Ksat
→ porosity (use default) not used for this work
→ thickness 1000 meters
→ base 0 meters
→ reference x=0 y=-10000 H=1000 meters
→ Uniform Q_x = ~~[illegible]~~, Q_y = 0

RF 3/23/99

PPWELL
→ DISCHARGE
→ x y Z1 Z2, discharge radius
SOLVE
GRID choose appropriate window
horizontal resolution of grid ⇒ 100
TRACE
→ direction (backward or forward)
→ contour on
→ cursor on

Notes on this process:
(1) after solving, check darcy velocities in main menu for a point upgradient along centerline to determine reasonable window for gridding & tracing. There is a tradeoff between window size and mouse resolution (for location of releases). For a range of problems 1½% difference between GFLOW calculated q_x at upgradient point and $q_x = K \nabla h$ hand calculation seems to give a reasonable length at which the horizontal width of plume no longer varies.

RF 3/23/99

(2) check reference point to make sure it is not impinging on solution (check head values across symmetry line, centerline)
(3) Estimate area of capture by obtaining maximum height and maximum width, then assume elliptical cross-sectional shape at upgradient point where flow can be assumed to be 2-D (no significant vertical component due to partially penetrating well).

TOP-018 for PATCHI

RF 3/23/99

See TOP-018 folder under QA control (Bruce Mabrito) ~~for installation tests~~. A copy of the memo put into the QA folder is attached below for a background introduction.

Wexler, E.J. (1992). Analytical Solutions for One-, Two-, and Three-Dimensional Solute Transport in Ground-Water Systems with Uniform Flow; USGS Techniques of Water-Resources Investigations Chapter B7, Book 3.

TO: Bruce Mabrito
FROM: R. Fedors
SUBJECT: Modifications and Installation for PATCHI
DATE: August 6, 1997

RF 8/6/97

PATCHI is one of a series of Fortran source codes made available by the U.S. Geological Survey (USGS) for analytical solutions to the advection-dispersion transport equation. All of the codes are fully documented in Wexler (1992); pertinent pages are attached to the TOP-018 folder. The printout of a readme file which comes with the distribution is also included here. PATCHI is the solution for a 2-dimensional patch source of constant concentration perpendicular to a 1-dimensional flow field. The solution is for 1-dimensional advection and 3-dimensional dispersion along with decay and first order adsorption.

The floppy diskette contains the original source files in UNIX tar and gzip compression form as obtained from the USGS software internet web site: http://water.usgs.gov/software/ground_water.html. Also contained on the diskette are the modifications made to the make file and two of the source code modules (title.f and subs3.f). The modifications are necessary in order to compile the software on a CNWRA SUN workstation. The modifications to the source code are commented, dated, initialed, and described in the source code. The modifications are:

1. Edit the make file so that only the patchi code is compiled and add the compile option "-lv77" to the Fortran command to get the VMS extensions for date and time system calls;
2. Change the system calls for date and time in the "title.f" file;
3. Comment out the graphics call for DISSPLA in the pltnc3 subroutine of the "subs3.f" file.

Note that CNWRA does not have a license for the DISSPLA program.

The installation test included here is "sample11" from the U.S. Geological Survey distribution. The input file is labeled sample11.dat, the USGS output file is labeled sample11.prt, and my installation test output is labeled sample11.out. The output files match exactly indicating a proper installation of the PATCHI code.

RF 8/6/97

PATCHI is installed so that plume configuration bounds may be made for the Amargosa Farms wellbore dilution, especially limits on thickness and width at the 25 and 30 kilometer critical area. ~~EPRI's~~ TRW TSPA (1995) included width and depth for the plume at 25 km however their dispersivity values were poorly chosen. EPRI's 1996 TSPA used better dispersivity values but did not report plume thicknesses.

GFLOW data Inputs - Ranges for sensitivities

Assume 1000 meter thick aquifer

Screen Height & length - from statistics on well construction, database was the GWIS assembled by the U.S. Geol. Survey. Summary output table attached on following page(s).

113 wells in Amargosa Farms area
52 = average length of screened portion (meters)
33 = standard deviation of screen length (m)
1 = minimum screen length (m)
191 = maximum screen length (m)

11 = water table to top of screen distance (m), average
0 = " , minimum
66 = " , maximum

Regional Gradients range 0.001 to 0.01
These values for the range are reported in the literature. In addition, measurements were made on water table maps to verify this range as appropriate and to get a feel for the distribution within this range

Nichols & Akers (1985) Plate 1
- 1984 map
  - near Hwy 29 ⇒ 0.01 $\frac{10 ft}{(0.25 cm)(4010 ft/cm)}$
  - typical from north ⇒ 0.0017
  - western edge, lowest ⇒ 0.0012
- 1962 map
  - near Hwy 29 ⇒ 0.01
  - western edge, lowest ⇒ 0.0007

DOE Site Characterization 1988
Fig 3-9, p. 3-62 Yucca Mtn to Amargosa ⇒ 0.0032

Kilroy (1991)
east of Hwy 29, off Specter Range area ⇒ 0.010
into Amargosa Farms area (from north) ⇒ 0.0017
within Amargosa Farms area ⇒ 0.0014

Literature ⇒ Bedinger et al (1989) ⇒ 0.003 generic basin fill Death Valley Region

Pump Rates
domestic/municipal 2-200 gallons per day
1800 gpd/household (DOE Site Characteriz. 1988)
irrigation 1 - 799.5 Ac-ft from 1996 water use table State Engineer's Office

Transmissivity 10-400 m^2/d

Appears to be standard range reported for basin-fill alluvium (Plume 1996; Winograd & Thordarson 1975; DOE Site Characterization Plan 1988). After extracting the specific capacity data and approximating the transmissivity (using chart from Ground-Water Manual 1981), I can see where that range came from. The draft D'Agnese modeling report for the U.S.G.S. also contains a chart with ranges for two types of alluvium.

Since Amargosa Farm is more in the area of lower fans and lowlands (rather than the coarser sediments of the upper and middle fans), the Ksat should show a wider range and be more heterogeneous (layered, lenses) and better sorted compared to sediments closer to the highland source.

Plume 1996 ⇒ K_{sat} = 0.02-140 ft/day
DOE Site Charact (1988) ⇒ K_{sat} = 0.21-2.9 m/d

1/11/97

Data Extraction from GWIS database (U.S.GS)

Database was delivered by Gordon Wittmeyer who got them from a formal request to the U.S. Geol. Survey. The 3 files are

gw1.fil
gw2.fil
nts.fil

Only "gw2.fil" had any data from the Amargosa Farms area.

Gordon's search area 36.3480 to 36.5708 latitude
-116.3740 to -116.6190 longitude

Using Gordon's area; 182 wells were extracted from gw2.fil

Inspection of maps suggested a slightly larger area would be appropriate to capture all of the wells in the Amargosa Farms area; extending to the north & to the west.

RF 3/23/99

New area 36.3480 to 36.6694 latitude ⇒ 36°40'10" to 36°20'53"
-116.3594 to -116.6208 longitude ⇒ -116° 21' 34" to -116° 37' 15"

224 wells were extracted from gw2.fil

A description of the database can be found in the
U.S.G.S. Open-File Report 89-587
National Water Information System User's Manual
Volume 2, Chapter 4. Ground-Water Site Inventory System

The program "amarg.f" (see next page) was written in Fortran 77. The program checks each record of the gw2.fil file, if location is within the bounds mentioned above, then information from that well is written to a new output file.

Two comments: ① since variables are re-used for each record, they must be reset to the flag value prior to reading the record; ② the records are read as characters, then divided up → thanks to Gordon's example. Otherwise, the comment lines should help in readibility of code.

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"amarg.f" along with the GWIS (original) files, gw1.fil, gw2.fil and nts.fil were put into ~/Archive/Bore for later copying to tape

RF 8/11/97


```
************************************************************************
*** Program reads data from the amarg.gwis file which was            ***
*** Amargosa Farms extract of USGS GWSI database file "gw2.fil"      ***
*** "amarg.gwis" ==> 36.3480 to 36.6694 and 116.3594 to 116.6208     ***
***                                                                  ***
*** Modify as needed to reformat well log info.                      ***
***    RFedors (3July97)                                             ***
************************************************************************
      program amarg

      implicit  none
      character  record*80 , code*4 , wellid*2
      character  infile*12, outfile*12
      integer*4  xdeg , xmin , xsec , ydeg , ymin , ysec
      integer*4  numwells, screen
      real*4  lat , long, land
      real*4 dhole, dwell, dwater, dischg, dprod, dstatic
      real*4 diam, diam2, diam3, diam4, dtop, dtop2
      real*4 dtop3, dtop4, dbot, dbot2, dbot3, dbot4
      logical start

      infile = 'amarg.gwis'
      outfile = 'amarg.all'
      open(8,file=infile,status='unknown')
      open(9,file=outfile,status='unknown')

c Start reading and processing records using internal files.
c Check first part of record for code.
c   C001 = Well ID,
c   C009 = latitude (deg,min,sec)
c   C010 = Longitude (positive value)  C083 = Depth to Top of Open Interval
c   C024 = primary use(not in gw2.fil) C084 = Depth to Bottom of Open Interval
c   C027 = Hole Depth (ft)             C087 = diameter of opening (inches)
c   C028 = Depth of Well (ft)          C272 = specfic capacity (gpm/ft)
c   C030 = Depth to Water Level        C153 = depth to production water level
c   C016 = land elevation (ft)         C154 = depth to static water level (ft)
         call out(start,lat,long,land,dhole,dwell,dwater,dischg,dprod
     &            ,dstatic,diam,diam2,diam3,diam4,dtop,dtop2
     &            ,dtop3,dtop4,dbot,dbot2,dbot3,dbot4,wellid)

         call reset(xdeg,ydeg,land,dhole,dwell,dwater,dischg,dprod
     &            ,dstatic,diam,diam2,diam3,diam4,dtop,dtop2
     &            ,dtop3,dtop4,dbot,dbot2,dbot3,dbot4)
      start = .false.
      numwells = 0
   10 read(8,'(a80)',end=30) record
      read(record(2:5),'(a4)') code
      if(start .and. code .eq. 'C001') then
         call out(start,lat,long,land,dhole,dwell,dwater,dischg,dprod
     &            ,dstatic,diam,diam2,diam3,diam4,dtop,dtop2
     &            ,dtop3,dtop4,dbot,dbot2,dbot3,dbot4,wellid)
         call reset(xdeg,ydeg,land,dhole,dwell,dwater,dischg,dprod
     &            ,dstatic,diam,diam2,diam3,diam4,dtop,dtop2
     &            ,dtop3,dtop4,dbot,dbot2,dbot3,dbot4)
      endif
      if(code .eq. 'C001')  then
         read(record(25:26),'(a2)') wellid
         screen = 1
         start = .true.
      endif

c Chose which categories to add to data array.
      if(code .ne. 'C001') then
         if(code .eq. 'C009') then
              read(record(13:18),'(3i2)') xdeg , xmin , xsec
              lat = xdeg + xmin/60. + xsec/3600.
              goto 20
         endif
         if(code .eq. 'C010') then
```



```
              read(record(13:19),'(i3,2i2)')  ydeg , ymin , ysec
              long = ydeg + ymin/60. + ysec/3600.
              goto 20
         endif
         if(code .eq. 'C016') then
              read(record(12:19),'(g8)') land
              goto 20
         endif
         if(code .eq. 'C027') then
              read(record(12:19),'(g8)')  dhole
              goto 20
         endif
         if(code .eq. 'C028') then
              read(record(12:19),'(g8)') dwell
              goto 20
         endif
         if(code .eq. 'C030') then
              read(record(12:19),'(g8)')  dwater
              goto 20
         endif
         if(code .eq. 'C083') then
              if(screen .eq. 1) read(record(12:18),'(g8)') dtop
              if(screen .eq. 2) read(record(12:18),'(g8)') dtop2
              if(screen .eq. 3) read(record(12:18),'(g8)') dtop3
              if(screen .eq. 4) read(record(12:18),'(g8)') dtop4
              if(screen .gt. 4) write(6,*)'el problemo con screens'
              goto 20
         endif
         if(code .eq. 'C084') then
          if(screen .eq. 1) read(record(12:18),'(g8)') dbot
          if(screen .eq. 2) read(record(12:18),'(g8)') dbot2
              if(screen .eq. 3) read(record(12:18),'(g8)') dbot3
              if(screen .eq. 4) read(record(12:18),'(g8)') dbot4
              goto 20
         endif
         if(code .eq. 'C087') then
              if(screen .eq. 1) read(record(12:18),'(g8)') diam
              if(screen .eq. 2) read(record(12:18),'(g8)') diam2
              if(screen .eq. 3) read(record(12:18),'(g8)') diam3
              if(screen .eq. 4) read(record(12:18),'(g8)') diam4
              screen = screen + 1
              goto 20
         endif
         if(code .eq. 'C153') then
              read(record(12:18),'(g8)') dprod
              goto 20
         endif
         if(code .eq. 'C154') then
              read(record(12:19),'(g8)')  dstatic
              goto 20
         endif
         if(code .eq. 'C272') then
              read(record(12:19),'(g8)')  dischg
              numwells = numwells + 1
             goto 20
         endif
      endif

   20 goto 10
   30 continue
      write(6,*) 'number of wells w/ spec. capacity= ', numwells

      stop
      end
c======================================================================
      subroutine reset(xdeg,ydeg,land,dhole,dwell,dwater,dischg,dprod
     &            ,dstatic,diam,diam2,diam3,diam4,dtop,dtop2
     &            ,dtop3,dtop4,dbot,dbot2,dbot3,dbot4)
c Resets all variables to -999. for next well to avoid carry-over.
```

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"amarg.f" along with the GWIS (original) files, gw1.fil, gw2.fil and nts.fil were put into ~/Archive/Bore for later copying to tape.

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```
      real*4 xdeg,ydeg, land, dhole, dwell, dwater, dischg
      real*4 dprod, dstatic, diam, diam2, diam3, diam4
      real*4 dtop, dtop2, dtop3, dtop4, dbot, dbot2, dbot3, dbot4

      xdeg = -9.
      ydeg = -9.
      land = -9.
      dhole = -9.
      dwell  = -9.
      dwater = -9.
      dstatic = -9.
      dprod = -9.
      dischg = -9.
      diam = -9.
      diam2 = -9.
      diam3 = -9.
      diam4 = -9.
      dtop = -9.
      dtop2 = -9.
      dtop3 = -9.
      dtop4 = -9.
      dbot = -9.
      dbot2 = -9.
      dbot3 = -9.
      dbot4 = -9.

      return
      end
c=====================================================================
      subroutine out(start,lat,long,land,dhole,dwell,dwater,dischg,dprod
     &             ,dstatic,diam,diam2,diam3,diam4,dtop,dtop2
     &             ,dtop3,dtop4,dbot,dbot2,dbot3,dbot4,wellid)
c Prints to file
      character wellid*2
      real*4 lat, long, land, dhole, dwell, dwater, dischg
      real*4 dprod, dstatic, diam, diam2, diam3, diam4
      real*4 dtop, dtop2, dtop3, dtop4, dbot, dbot2, dbot3, dbot4
      logical start

      if(start) then
         write(9,111)  long, lat, wellid, land, dhole, dwell
     &      , dwater, dstatic, dprod, dischg, diam, diam2, diam3, diam4
     &      , dtop, dtop2, dtop3, dtop4, dbot, dbot2, dbot3, dbot4
       else
         write(9,121)
      endif

 111  format(f9.4,f8.4,1x,a2,f6.0,5f7.1,5f6.2,8f7.1)
 121  format('longitude latitude # land dhole dwell dwater dstat'
     &     ,' dprod dschg diam diam2 diam3 diam4'
     &     ,' dtop dtop2 dtop3 dtop4 dbot dbot2 dbot3 dbot4')
      return
      end
```

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The data from the wells extracted from GWIS file "gw2.fil" was imported into the spreadsheet program EXCEL. Statistics are on the bottom of the 3rd page; 4 wells were excluded → unlikely that they were production wells, they were only screened below ~500 meters depth even though water table was at 20 m.

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in units of meters

longitude	latitude	id	land	dhole	dwell	dwater	dstat	dprod	m^2/hr dschg	meter diam	diam2	diam3	diam4	dtop	dtop2	dtop3	dtop4	dbot	dbot2	dbot3	dbot4	sum of screen	composite screen	center line	water to top scrn	water to bot scrn
116.5092	36.5647	1	727.3	76.2	76.2	33.5																				
116.535	36.5667	1	725.7	106.4	89.9	30.5				0.36	0.32	0.32	0.32	18.3	44.5	51.8	73.2	42.7	48.2	59.4	89.9	52	72	54	0	59
116.4303	36.5633	1	743.7	118.9	118.9	45.7				0.32				45.7				118.9				73	73	82	0	73
116.4381	36.5669	1	740.7	128.0	118.9	57.9	57.9	106.7	3.5	0.32				45.7				128.0				82	82	87	0	70
116.4958	36.5656	1	726.9	128.0	128.0	36.6				0.32				42.7				128.0				85	85	85	8	91
116.4178	36.5678	1	746.8	91.4	88.4	46.3				0.30				15.5				88.4				73	73	52	0	42
116.4303	36.5653	1	742.2	139.3	139.3	51.8				0.32	0.32			61.6	131.7			108.8	139.3			55	78	100	10	87
116.5783	36.5672	1	721.5			31.9																				
116.5375	36.5744	1	740.7	92.0	87.8	36.0				0.32				39.6				92.0				52	52	66	4	56
116.5444	36.5681	0																								
116.5975	36.5681	1	726.9	125.0	125.0					0.30				43.9				125.0				81	81	84	44	125
116.4144	36.575	1	762.0		136.6	53.0																				
116.5783	36.5756	1	723.3	106.7	105.8	32.0				0.36				32.0				105.8				74	74	69	0	74
116.4261	36.5728	1	755.9		61.0	42.7																				
116.4	36.5694	1	749.8	91.4	53.6	43.9				0.32	0.32			44.8	72.5			64.9	87.2			35	42	66	2	43
116.4008	36.5694	1	748.6	61.0	61.0	27.7				0.17				50.3				57.9				8	8	54	24	30
116.4364	36.5694	1	743.7	213.4	204.2	52.5				0.36				64.6				204.2				140	140	134	14	152
116.4597	36.5694	0																								
116.4464	36.575	1	745.2		51.2	55.7																				
116.4642	36.5761	1	741.9	91.4	91.4	45.7																				
116.4583	36.5714	1	740.7		57.9	48.7																				
116.4617	36.5717	0																								
116.3972	36.5736	0																								
116.5556	36.5736	0																								
116.3964	36.5744	1	755.3	112.5	82.0	43.9				0.32	0.32			44.8	72.5			64.9	82.0			30	37	63	2	38
116.4008	36.5744	1	754.4	187.1	95.1	45.7				0.32				54.3				91.1				37	37	73	10	45
116.47	36.5744	1	738.2			47.8																				
116.3928	36.5747	1	755.3			39.6																				
116.5331	36.5747	1	729.1	91.4	91.4	39.6				0.41	0.41			53.6	84.4			78.0	91.4			31	38	73	16	52
116.5903	36.5822	1	726.9	76.2	74.1	32.9	33.9	37.0	104.3	0.30				30.5				76.2				46	46	53	0	43
116.5525	36.5825	1	731.5	91.4	91.4	11.6				0.32				61.0				91.4				30	30	76	50	80
116.5731	36.5825	1	740.7	76.2	73.8	34.7				0.30				30.5				76.2				46	46	53	0	41
116.5831	36.5819	1	726.0	96.0	83.2	33.0				0.32				57.6				96.0				38	38	77	26	63
116.5461	36.5792	1	727.9	97.5	97.5	29.9	32.7	40.9	82.8	0.32				45.7				97.5				52	52	72	16	68
116.4733	36.5778	1	731.5		88.7	45.1																				
116.6092	36.5783	1	725.7	61.0	61.0	36.6				0.22				42.7				61.0				18	18	52	8	24
116.5283	36.5864	1	733.7	128.6	128.6	19.8				0.36				64.6				128.6				64	64	97	46	109
116.4781	36.5822	0																								
116.5653	36.5875	1	740.7	93.9	93.9	33.5	33.0	39.1	70.8	0.32				61.9				90.8				29	29	76	30	57
116.5867	36.5867	1	740.7		15.5																					
116.4778	36.5842	1	740.7	61.0	61.0	45.7				0.20				48.8				61.0				12	12	55	4	15
116.5875	36.5842	1	727.9	50.3	50.3	36.6				0.22				42.7				48.8				6	6	46	8	12
116.5642	36.5864	1	729.4																							
116.5358	36.5958	1	737.0	121.9	101.2	40.9				0.37				61.0				121.9				61	61	91	22	81
116.5903	36.5892	1	729.7	78.0	78.0	38.1	38.1	45.1	71.3	0.41				36.6				76.2				40	40	56	0	38
116.5936	36.5967	1	731.8	76.2	76.2	37.8				0.32				39.6				76.2				37	37	58	2	38
116.5453	36.5964	1	735.2	76.2	76.2	41.1	41.1	50.3	22.4	0.32				36.6				76.2				40	40	56	0	35
116.4903	36.5908	1	744.0		106.7	45.4																				
116.4783	36.5911	0																								
116.4022	36.5944	1	771.1	131.1	94.8	45.1				0.32				46.0				94.8				49	49	70	2	50
116.5139	36.5969	1	742.2	248.4	159.4	50.9				0.36				47.2				159.4				112	112	103	0	109
116.4444	36.6169	1	774.2	134.7	134.7	69.8				0.32				91.4				128.0				37	37	110	22	58
116.4461	36.6192	1	775.7																							
116.4436	36.6289	1	783.9	152.4	151.8	74.7	74.7	152.4	2.3	0.36	0.25			0.0	80.2			82.3	151.8			154	152	76	0	77
116.4125	36.6208	0	853.4	32.0	32.0																					
116.4442	36.6278	0																								
116.4422	36.6403	1	795.5	173.7	173.7	89.0				0.25				115.8				173.7				58	58	145	28	85
116.4092	36.6403	1	804.4	309.1	228.6	88.4				0.36				109.7				236.8				127	127	173	22	148
116.3944	36.6431	1	809.9	150.9	150.9	111.3				0.22				120.4				150.9				30	30	136	10	40
116.3981	36.645	1	811.4	163.1	163.1	111.3				0.23	0.23			109.4	155.8			147.8	163.1			46	54	136	0	52
116.4281	36.6494	1	804.7	27.4	23.8																					
116.3947	36.6439	1	811.4		109.7																					
116.3958	36.6439	1	811.4	154.5	154.5	109.7				0.25				115.8				154.5				39	39	135	8	45
116.3944	36.6444	1	810.8	120.4	120.4	105.2				0.15	.31			102.1				120.4				18	18	111	0	15
116.3972	36.6444	0	813.8	153.9	153.9	109.7				0.25	.08			109.7				153.9				44	44	132	0	44
116.4328	36.6594	1	816.6		74.1																					
average					83	29	35	54	32.33	~~0.34~~	0.30	0.31	0.34	42	80	64	79	88	110	73	91	52	53	68	11	62
std. dev. --> sqrt{var/(n-1)}					42.6	19.3	14.9	35.2	33.4	0.2	0.1	.05 0.1	0.0	23.9	36.0	11.0	8.6	39.7	45.1	14.6	1.1	33.2	33.1	29.2	13.0	36.7
n	227		199	137	172	188	16	17	15	113	18	3	2	113	19	3	2	113	19	3	2	113	113	113	113	113
min					0.914	2.134	15.67	9.144	2.34	0.032	0.203	0.254	0.324	0	44.5	51.82	73.15	7.01	48.16	59.44	89.92	0.9	0.9	6.6	0.0	1.7
max					228.6	111.3	74.68	152.4	104.3	~~3.966~~ 0.406	0.406	0.356	0.356	120.4	160.3	73.15	85.34	236.8	221	88.39	91.44	190.5	190.5	173.3	66.0	218.8
Four removed wells (unlikely as production wells)																										
116.4361	36.3611	1	646.2	603.5	603.5	20.9				0.05				594.4				597.4				3	3	596	574	576
116.4475	36.3806	1	664.5	512.1	512.1	22.8				0.05				502.9				506.0				3	3	504	482	483
116.4619	36.4236	1	667.8	332.2	332.2	2.1				0.05				324.0				324.9				1	1	324	322	323
116.4825	36.46	1	691.9	600.5	536.8	17.3				0.05				591.0				594.1				3	3	593	574	577

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statistics summary changes due to deleting errant diameter=4 meters

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The data from the wells extracted from GWIS file "gw2.fil" was imported into the spreadsheet program EXCEL. Statistics are on the bottom of the 3rd page; 4 wells were excluded → unlikely that they were production wells, they were only screened below ~500 meters depth even though water table was at 20 m.

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in units of meters									m^2/hr	meter													sum of	composite	center	water to	water to
longitude	latitude	id	land	dhole	dwell	dwater	dstat	dprod	dschg	diam	diam2	diam3	diam4	dtop	dtop2	dtop3	dtop4	dbot	dbot2	dbot3	dbot4		screen	screen	line	top scrn	bot scrn
116.4528	36.5147	1	704.7			27.7																					
116.4556	36.5147	1	706.5	92.0	92.0	24.4				0.36				32.3				89.0					57	57	61	8	65
116.4511	36.515	1	706.5	91.4	91.4	27.7				0.36				32.0				91.4					59	59	62	6	64
116.4514	36.5161	1	707.1	113.4	113.4	21.6				0.36				48.8				113.4					65	65	81	28	92
116.5244	36.5161	1	703.8	91.4	91.4	15.2				0.36				21.3				91.4					70	70	56	8	76
116.4239	36.5192	1	708.1	61.0	61.0	30.5				0.41				33.5				61.0					27	27	47	4	30
116.4253	36.5244	1	713.5	99.1	68.0	25.9				0.36				30.5				68.0					37	37	49	6	42
116.4656	36.5197	1	712.0	91.4	91.4	22.9				0.36				30.5				91.4					61	61	61	8	69
116.4839	36.5197	1	709.6	26.8	26.8	21.0																					
116.5	36.5231	1	709.0		46.6	21.2																					
116.4056	36.5208	1	740.7																								
116.51	36.5214	1	709.0	61.0	49.1	14.0				0.36				16.8	49.1			49.1	61.0				44	44	39	4	47
116.5	36.5222	1	708.7		49.4	20.1																					
116.5067	36.5244	0																									
116.4047	36.5247	1	713.2	61.0	61.0	36.0				0.22				30.5				61.0					30	30	46	0	25
116.4069	36.5247	1	712.6	61.0	61.0	38.1				0.19				45.7				61.0					15	15	53	8	23
116.4247	36.5247	1	713.2	61.0	61.0	35.1				0.22				53.3				61.0					8	8	57	20	26
116.4	36.5256	0																									
116.4811	36.5256	1	710.8			25.5																					
116.4169	36.5258	1	713.2		48.8	37.9																					
116.4889	36.5261	1	710.2	55.2	55.2	25.0				0.22	0.22			31.1	48.8			37.5	55.2				13	24	43	8	30
116.4556	36.5294	1	717.5	91.4	91.4	30.5				0.41				35.7				91.4					56	56	64	6	61
116.4181	36.5272	1		91.4	91.4	36.6				0.27				42.7				91.4					49	49	67	8	55
116.4181	36.5272	2		61.0	61.0	38.1				0.17				45.7				61.0					15	15	53	8	23
116.4242	36.5294	1	716.6	91.4	91.4	23.8																					
116.4825	36.5256	1	712.6	29.6	25.0	23.5																					
116.5211	36.5306	1	709.3	54.6	15.5	20.5	20.5	25.9	20.7																		
116.5439	36.53	1	708.7		57.3	17.8																					
116.4647	36.5256	1	716.0	61.0	61.0	28.3				0.41				32.6				61.0					28	28	47	6	33
116.5183	36.5292	1	710.2		61.0	19.9																					
116.4194	36.53	1	716.3	76.2	59.4	39.6				0.20				41.1				59.4					18	18	50	2	20
116.5425	36.5319	1	707.7	71.9	71.9	18.3				0.30				32.3				71.9					40	40	52	16	54
116.37	36.5325	1	725.4			30.6																					
116.5089	36.5364	1	714.5	51.8	50.0	25.6				0.41				18.3				45.7					27	27	32	0	20
116.5261	36.5383	1	712.0		42.1	23.1																					
116.5425	36.5333	1	710.2	61.0	61.0	16.5				0.30				19.8				61.0					41	41	40	4	45
116.4994	36.5386	1	715.7	96.0	90.2	27.4				0.36				57.9				81.7					24	24	70	32	54
116.455	36.5381	1	721.8	91.4	91.4	32.3				0.41				36.6				91.4					55	55	64	6	59
116.5278	36.5358	1	701.0		60.4																						
116.5272	36.5361	1	712.6		61.0	23.7																					
116.4961	36.5364	1	715.7		54.9	25.3																					
116.4494	36.5381	1	721.8	76.2	76.2	32.0				0.41				30.5				74.7					44	44	53	0	43
116.48	36.5372	1	717.8	61.0	61.0	27.4				0.17				53.3				61.0					8	8	57	26	34
116.5381	36.5428	1	713.5	155.4	147.8	18.9				0.36				51.8				147.8					96	96	100	34	129
116.5067	36.5386	0																									
116.5289	36.5442	1	746.8	153.3	153.3	18.3				0.36				82.3				153.3					71	71	118	66	135
116.4894	36.5461	1	720.2		93.6	30.0																					
116.5053	36.545	1	718.7	91.4	91.4	30.5				3.9				30.5				91.4					61	61	61	0	61
116.5092	36.5436	1	718.4	128.3	128.3	27.2				0.36				42.7				128.3					86	86	85	16	101
116.5831	36.5397	1	2341	111.6	80.5	20.1	20.1	51.8	10.7	0.41				36.3				77.7					41	41	57	18	58
116.4419	36.5433	1	722.4	112.2	112.2	34.4				0.41	0.41			37.2	77.4			65.2	112.2				63	75	75	4	78
116.4775	36.545	1	721.2	125.0	125.0	33.5				0.30				47.5				125.0					77	77	86	16	91
116.5192	36.5442	1	715.4		88.1	25.6																					
116.4347	36.5417	1	723.3			36.8																					
116.4914	36.5436	1	720.2	93.6	91.4	24.4				0.36				36.6				93.6					57	57	65	14	69
116.5947	36.5453	1	714.5			26.7																					
116.5383	36.5506	1	718.7	100.6	100.6	28.7				0.30				30.5				100.6					70	70	66	2	72
116.5247	36.5464	1	715.7	91.4	91.4	25.3				0.36	0.32			27.4	53.3			54.9	91.4				66	64	59	4	66
116.5078	36.5467	1	718.4			32.6																					
116.5086	36.5542	1	721.8	146.3		28.8																					
116.4886	36.5469	0																									
116.4203	36.5508	1	732.4	152.4	152.4	31.9				0.30	0.20			36.6	105.2			106.7	152.4				117	116	94	6	121
116.4472	36.5525	1	730.0	106.7	106.7	39.6				0.30				45.7				106.7					61	61	76	8	67
116.4914	36.5508	1	723.6	146.3	146.3	24.4				0.36				39.6				146.3					107	107	93	16	122
116.5417	36.5478	0																									
116.5003	36.5508	1	722.7	221.0	221.0	2.1				0.36	0.20			30.5	160.3			160.3	221.0				191	191	126	30	219
116.5275	36.5531	1	718.7	100.6	100.6	25.6	25.6	65.2	8.0	0.36				24.4				100.6					76	76	62	0	75
116.4725	36.5525	1	726.6	91.4	91.4	30.5				0.36	0.36	0.36	0.36	33.5	51.8	67.1	85.3	45.7	57.9	70.1	91.4		27	58	62	4	61
116.4944	36.5528	1	724.2		106.1	31.7																					
116.5069	36.5536	0																									
116.6067	36.5544	1	719.3	53.3	53.3	30.8	30.8	30.8		0.22				30.5				53.3					23	23	42	0	23
116.4917	36.56	1	726.3		75.6	35.3																					
116.4692	36.5556	0																									
116.4956	36.5564	0																									
116.5472	36.5589	1	720.5	61.0	61.0	27.4				0.22				27.4				61.0					34	34	44	0	34
116.5086	36.5606	1	722.4	91.4	91.4	28.0	34.1	42.4	26.3	0.30	0.30	0.25		30.5	45.7	73.2		73.2	73.2	88.4			85	58	59	4	60
116.5533	36.5678	1	724.2	92.0	92.0	28.0				0.32				45.1				89.0					44	44	67	18	61
116.6078	36.5644	1	720.2	115.8	110.0	27.4	27.4	57.0	5.8	0.41	0.41			42.7	78.6			66.4	115.8				61	73	79	16	88
116.5442	36.5678	1	724.2	45.7	45.7	29.6	29.1	41.3	14.9																		
116.5625	36.5681	1	723.9	76.2	76.2	27.4																					
116.5861	36.5669	1	722.1	85.3	85.3	30.2				0.30				36.6				85.3					49	49	61	8	55

apparent typo in GWSI database

delete RF 8/26/97

18 RF 8/11/97

The data from the wells extracted from GWIS file "gw2.fil" was imported into the spreadsheet program EXCEL. Statistics are on the bottom of the 3rd page; 4 wells were excluded → unlikely that they were production wells, they were only screened below ~500 meters depth even though water table was at 20 m.

RF 8/11/97

in units of meters									m^2/hr	meter													sum of	composite	center	water to	water to
longitude	latitude	id	land	dhole	dwell	dwater	dstat	dprod	dschg	diam	diam2	diam3	diam4	dtop	dtop2	dtop3	dtop4	dbot	dbot2	dbot3	dbot4		screen	screen	line	top scrn	bot scrn
116.5244	36.3514	1	703.8	77.7	62.8	19.5				0.30				0.0				62.8					63	63	31	0	43
116.4475	36.3806	2	664.5	512.1	37.8	22.1				0.03				30.5				31.4					1	1	31	10	9
116.4514	36.4042	1	659.9			9.2																					
116.4433	36.4119	1	669.0		0.9																						
116.4433	36.4119	2	658.4			7.6																					
116.4194	36.4144	1	665.4		122.5	21.8																					
116.4281	36.4142	0																									
116.4194	36.4164	0																									
116.375	36.4181	1	664.5	30.5	30.5	4.6				0.36				4.6				30.5					26	26	18	0	26
116.3944	36.4214	1	731.5		6.4	4.4																					
116.4619	36.4236	2	664.5	332.2	14.3	5.3				0.03				6.1				7.0					1	1	7	2	2
116.4625	36.4236	1	665.1		3.0	2.8																					
116.4117	36.4264	0																									
116.4133	36.4264	1	670.6																								
116.3569	36.445	1	661.7	161.5	156.7	2.7		9.1		0.41				45.7				152.4					107	107	99	44	150
116.4628	36.4467	1	688.8	46.0	46.0	12.8				0.15				36.3				46.0					10	10	41	24	33
116.5208	36.4472	1	681.2		91.4	9.8																					
116.5394	36.4506	1	684.3		86.6	12.4																					
116.5025	36.4514	1	680.0		7.0	6.3																					
116.5306	36.4514	1	682.8			9.4																					
116.5397	36.4514	1	684.3			9.0																					
116.5397	36.4542	1	684.9		91.4	13.7																					
116.5164	36.4569	1	681.8		119.8	7.7																					
116.5289	36.4572	1	683.4		91.4	11.2																					
116.5394	36.4575	1	684.0		37.8	13.0																					
116.4825	36.46	2	691.9	600.5	30.5	17.2				0.03				29.6				30.5					1	1	30	14	13
116.5261	36.4619	1	684.0																								
116.4447	36.4764	1	691.0	157.0	126.5	15.2				0.25	0.24			16.8	61.0			61.0	126.5				110	110	72	2	111
116.4436	36.4775	0																									
116.4461	36.48	1	690.4	120.7	120.7	18.9				0.32	0.32			18.3	46.9			27.4	120.7				83	102	69	0	102
116.4911	36.4864	1	701.0		121.9	17.5																					
116.5042	36.4856	1	701.0		62.5	15.5																					
116.4706	36.4861	1	701.0	18.3	15.2	14.3																					
116.4969	36.4864	1	701.0	18.6		13.4																					
116.4783	36.4858	1	701.0	19.8	18.6	15.5																					
116.5131	36.4839	1	696.5		62.5	21.6																					
116.4689	36.4844	0																									
116.4611	36.4847	1	692.8			19.3																					
116.4997	36.4928	1	701.0		152.4	12.4																					
116.5131	36.4881	1	698.0			14.5																					
116.5194	36.4889	0																									
116.47	36.4933	1	696.5	23.8	18.0	19.2																					
116.5069	36.4931	1	701.0	25.9	25.9	12.8																					
116.5069	36.4892	2	696.2		25.9																						
116.4614	36.4922	1	696.8	152.4	146.3	24.4	47.4	94.6	3.9	0.41	0.30			45.7	100.6			106.7	146.3				107	101	96	22	122
116.4919	36.4939	1	701.0	65.2	64.0	16.8				0.36				9.1				64.0					55	55	37	0	47
116.4258	36.4936	1	693.4	56.4	48.8	13.7				0.25				13.7				48.8					35	35	31	0	35
116.4997	36.4917	1	698.0			21.8																					
116.4208	36.4933	0		91.4	91.4	18.0				0.36				24.4				91.4					67	67	58	8	73
116.45	36.4939	1	695.2	115.8	91.4	18.3				0.36				30.5				91.4					61	61	61	14	73
116.5003	36.4939	0		15.2		11.9																					
116.4483	36.4942	1	688.8			21.1																					
116.4494	36.4944	0																									
116.4281	36.5003	1	698.6		58.2	21.6																					
116.4567	36.4961	1	698.0	168.9		19.5																					
116.5061	36.4994	1	701.0	61.9	61.9	12.2				0.30				18.3				61.6					43	43	40	8	49
116.5064	36.4961	1	701.0	32.0	32.0	12.2				0.36				13.1				32.0					19	19	23	2	20
116.5064	36.4961	2	698.9	65.5	60.0	12.2				0.36				9.1				60.0					51	51	35	0	48
116.4222	36.4964	1	694.0	64.0	64.0	19.5				0.22				32.0				64.0					32	32	48	14	45
116.4303	36.4992	1	698.0			24.3																					
116.5133	36.5006	1	698.0			17.4																					
116.5186	36.5006	1	694.9		65.2	13.3																					
116.4861	36.5014	1	2298	24.4		17.4																					
116.49	36.5081	1	704.1	20.7	20.7																						
116.5075	36.5025	1	702.6	41.1	34.1	14.6	15.7	20.1	37.3	0.41				22.3				34.1					12	12	28	8	20
116.4678	36.5081	1	706.2	28.7	27.7	24.1																					
116.425	36.5078	1	701.3	91.4	91.4	25.9				0.41				27.4				61.0					34	34	44	2	35
116.425	36.5047	2	702.6	61.0	61.0	18.3				0.30				36.6				61.0					24	24	49	20	43
116.4833	36.5056	1	701.0	24.4	24.4	19.5																					
116.4656	36.5072	1	705.6	80.5	80.5	28.3				0.36				50.6				77.4					27	27	64	24	49
116.45	36.5075	1	702.3	192.0	179.8	25.0				0.27				67.1				179.8					113	113	123	44	155
116.4978	36.5075	1	702.6	47.2	47.2	13.4				0.32				20.1				47.2					27	27	34	8	34
116.4506	36.5078	1	702.3	182.9	106.7	21.6				0.36				48.8				106.7					58	58	78	28	85
116.5069	36.5078	0																									
116.4667	36.5083	1	706.2	25.3		20.7																					
116.5097	36.5108	1	702.9			16.0																					
116.4589	36.5122	1	740.7		97.8	25.5																					
116.5139	36.5122	1	702.0	124.1	124.1	12.8				0.30				50.3				124.1					74	74	87	38	111
116.4706	36.5167	1	707.1	77.1	77.1	21.3				0.32				28.7				75.6					47	47	52	8	54
116.4825	36.5161	1	706.2	24.4	24.4	18.6																					

Notes on using GFLOW & defining capture zones for 3-D problems

(1.) Calculation of a gradient

GFLOW uses discharge potential as a dependent variable. For the uniform regional gradient, or rather the potential due to the uniform regional gradient, the transmissivity is multiplied times the gradient. The gradient itself can be calculated assuming a confined or an unconfined aquifer (H or H^2 dependence) (H = head). However, since this is a thick aquifer (thickness = 1000 m), the difference is insignificant, hence just use $DH = (H_2 - H)/(x_2 - x_1)$ where x is horizontal distance.

(2.) The "specific velocity" in GFLOW is the darcy velocity. Hence, the further from the well, the closer this specific velocity should come to the velocity hand-calculated from the uniform regional gradient

$$|q| = |-K\ DH| \quad \text{which ignoring vectors} \Rightarrow q = K\ DH$$

This is the basis for the 1½% error allowed in determining how far to go away from the well to delineate a capture zone. The particle traces are essentially going straight (in horizontal plane) by the time

$$\frac{q_{\text{hand calc.}} - q_{\text{GFLOW}}}{q_{\text{GFLOW}}} < 1\tfrac{1}{2}\%$$

RF 8/12/97 Trial & error particle tracing led to choice of 1½% error; this is where traces stopped significantly changing for a range of problems.

In the vertical plane, the particle traces indicate that the vertical effect diminishes much sooner, approx. ½ to ⅓ the distance for the horizontal

Also note that the usual idiom of at 1-2 aquifer thickness, the effect of partially penetration ~~are~~ no longer present; i.e. the solution for a fully penetrating well is the same for a partially penetrating well at that distance. This idiom should not be used due to the extremes at which we are pumping, the thickness, and the small degree of partial penetration of the well.

(3.) The width may be more realistic of actual situation due to the layering having a profound effect.

GFLOW Base Case

PF 3/23/98

Parameters which typically will not be changed:

- porosity = use default (no time dependent analyses) = 0.2
- thickness = 1000 meters
- base = 0
- reference = x=0, y=-10,000, head = 1000 m
- well location = x=0, y=0
- well radius = 0.34 meters

Base case parameters (those that will change in sensitivity analyses):

- permeability = 0.1 m/day
- uniform flow = 0.5 $\frac{m^2}{day}$ $T = 100 \frac{m^2}{d}$ $\nabla H = 0.005$
- pump rate = 300 $\frac{m^3}{day}$ mid-range for irrigation
- Screen ⇒ $z_1 = 940$ m $z_2 = 1000$ m

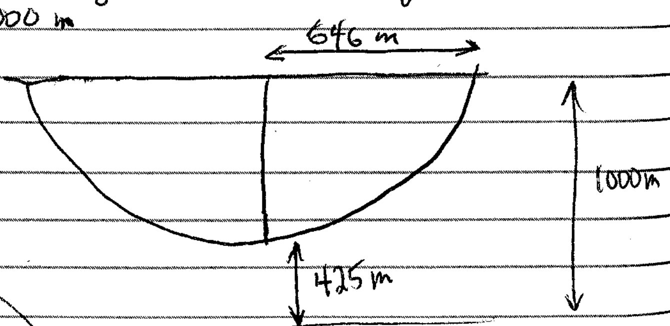
Head @ (0, 9000) = 999.9 m hence reference head is not signif. impacting

$[q_{GFLOW}]_{x=-6350} = .5075E-3 \frac{m}{d}$ ⇒ 1½% difference

$[q_{calc}]_{\text{uniform flow field}} = .50E-3 \frac{m}{d}$ ⇒ $q = K_{sat} \nabla h$ ignoring vector's direction

particle trace in horizontal plane, y-value not changing at x = -6350 m as suggested by 1½% rule, confirmed vertical not changing at x = -2000 m

half-width = 646 m
elevation = 425 m

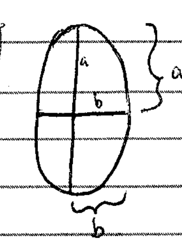


Should use $q = .5 \times 10^{-3}$ m/d PF 9/18/97

~~plot~~ capture zone
width = 1292 m
thickness = 575 m

area of ellipse = $\pi \cdot a \cdot b$

hence $\frac{\pi a b}{2}$



cross-check [area * q] = $Q_{pumping}$

$\left[\frac{\pi(646m)(575m)}{2}\right] * \left[.5075E-3 \frac{m}{d}\right] = 300 \frac{m^3}{d}$

$296 \frac{m^3}{d} \approx 300 \frac{m^3}{d}$

units = meters

	half-width	elev	capture zone width	capture zone thick	Note
Base Case	646	425	1292	575	—
Screen ⇒ 810-1000	619	400	1238	600	max screen length
Screen ⇒ 500-1000	470	248	940	752	artificial screen
fully penetrating well	287	0	574	1000	fully penetrating

defining a window (in which to delineate the capture zone) means that GFLOW will calculate all parameters at the resolution (grid) requested (now using 100 nodes in horizontal plane). Hence, defining a window closer to the closer leads to better mouse resolution in releasing particles. The starting and ending points of each release are recorded at the top of the screen. If the window covers too much area (far-field), the mouse location resolution suffers. However, for strong wells and weak uniform regional gradients, large windows are needed to delineate the capture zone at the point where it becomes essentially 2-D

scoping for future reference (units are meters, days) radius = .34 m
aquifer thickness = 1000 m

Screen	Q pump	Q uniform	∇h	Trans.	K_{sat}	½ width	elev	
940-1000	1380	0.1	0.01	10	.01	6358	<16	← entire capture
940-1000	1380	0.5	.005	100	0.1	1691	59	
940-1000	1380	~~2.0~~	.005	400	0.4	707	391	
880-940	690	0.5	.005	100	0.1	1046	203	

GFLOW Simulations – Domestic Wells

1 Ac-ft/household or 1800 gal/day/household

This is DOE (Site Characterization 1988) estimate. Plus Nevada Division of Water Resources uses this value (personal communication via telephone) for their water use estimates. Thomas Buqo (1996) report acknowledges that this value is high, a more reasonable estimate is probably less than half that value based on some metering at selected wells.

Use range 1 – 6.625 m³/d [1, 2, 3, 4, 6.625 m³/d = Qpump]

Base Case: (Domestic)
Screen 940-1000 — units meters, days
Q_p = 3
radius = 0.34 — partially penetrating well at x=0, y=0
Quniform = 0.5 — aquifer thickness = 1000
K_{sat} = 0.1
Transmiss. = 100
∇h = 0.005
reference ⇒ x=0, y=-70000 h=1000

	head at well	1/2 width	elev
(1.) Base Case window [-250 -75 50 50]	999.555	38	912.2
(2.) Screened at 930-940 thin layer 999.2 – 999.8 not captured	999.835	34.6	902.5 to 999.2
(3.) Qpump = 2 (Screen at 940-1000) window x=-200 (1½% of Quniform)	999.703	27	918.5
(4.) Qpump = 1 1½% of Quniform ⇒ x = -138 screen @ 940-1000	999.852	14.3	927.4
(5.) Qpump = 4 1½ of Quniform ⇒ x = -389 ditto screen	999.406	48.7	904.4

	head @ well	1/2 width	elev	
(6) Qpump = 6.625 screen 940-1000 1½% Quniform ⇒ x = -375	999.016	71.7 71.3	888.4 888.7	backward forward trace
(7) K_{sat} = 0.1 ∇h = 0.001 ⇐ Q_p = 3 Screen ⇒ 940-1000 1½ of Quniform ⇒ x = -575	999.555	124 123.4	848.8 849.2	backward forward
(8.) ditto case (7) K_{sat} = 0.01 ∇h = 0.005 (T=10) Quniform = 0.05 1½% of Quniform ⇒ x = -855	995.54	184.5 183.4	796.9 798.1	backward forward
(9.) ditto case (8) K_{sat} = 0.05 (T = 10 m²/d) 1½% of Quniform ⇒ x = -357	999.109	66.6 66.1	891.8 892.1	backward forward
(10.) ditto case (8) K_{sat} = 0.4 (T = 400 m²/d) 1½% of Quniform ⇒ x = -120	999.889	10.9 10.88	929.7 929.8	backward forward
(11.) ditto case (1) ∇h = 0.01 (K_{sat} = 0.1) Quniform = 1.0 1½% of Quniform ⇒ x = -173	999.555	~~20.6~~ 20.5	~~922.7~~ 922.5	backward forward

Quniform = darcy velocity
∇h = gradient of head

PATCH I Simulations (Analytic solution 3-D dispersion)

Parameter values needed for input
Concentration - C_o
particle velocity - v
dispersivity longitudinal - α_L
" transverse horizontal - α_{Ty}
" transverse vertical - α_{Tz}
retardation factor - R_d
half-life - $T_{1/2}$
z_1 & z_2 vertical coordinates of patch source
y_1 & y_2 horizontal coordinates of patch source

Dispersion $= v\alpha$
i.e.
$D_x = v\alpha_L$
$D_y = v\alpha_{Ty}$
$D_z = v\alpha_{Tz}$

The base values of these parameters used in the EPRI TSP (which used the Domenico-Robbins solution)

$C_o = 10{,}000$ | $R_d = 1.0$ ($K_d = 0$)
$v = 1.7\times10^{-6}$ m/s | $T_{1/2} = 1\times10^{20}$ s
$\alpha_L = 20$ m | $\Delta z = 50$ m
$\alpha_T = 5$ m | $\Delta y = 800$ m

modeled from "accessible environment through alluvium"

The long half-life sets decay = 0 essentially
The distribution coef = 0 = K_d sets simulation to neglect adsorption

They defined the plume at 10^{-4} concentration
(which I guess means 8 orders of magnitude to define plume).
No, actually they use $10^{-4} * C_o$ to define the plume. RF 3/23/99

What are reasonable values for these parameters.

(1.) For starters, just normalize the initial concentration to 1
$C_o = 1$

(2.) Keep adsorption set to zero; decay as well.

(3.) seepage velocity (v) ⇒ q/ϕ for saturated q = darcy velocity

1.76×10^{-6} m/s ⇒ 55.4 m/yr

Annual NRC report 1996 states ranges of velocities (darcy)

footprint tuff ⇒ 0.5 - 1.9 m/yr
tuff ⇒ 0.01 - 3.7 m/yr
alluvium ⇒ 0.4 - 0.7 m/yr

assuming porosity = 0.1 for tuffs
= 0.3 for alluvium

footprint tuff v ⇒ 5 - 19 m/yr
tuff v ⇒ 0.1 - 37 m/yr
alluvium v ⇒ 1.33 - 2.33 m/yr

Based on these values, the EPRI study used a much larger value of velocity. This causes a longer time to breakthrough but increases the dispersion (thus larger dilution factors) as compared to using a smaller velocity.

Clearly a sensitivity will have to be done for seepage velocity.

There is another question about the choice of velocity which includes the length of the x-direction (principal direction of flow).
At what distance to calculate plume configuration.

a) start from repository and go 30 km to Amargosa Valley (junction of highways, the town) and include flow through the tuffs as well as the alluvium.
- what should the patch size be?
- what value of velocity is representative of all units?
- what dispersivity values are representative of all units?

b.) Start from the "accessible environment" or fence and essentially only model the plume through the alluvium
- sensivity on plume dimensions (EPRI did this)
- then it's only ~15 km to Amargosa Valley junction

(4) What values of dispersivity to use for the 3 dispersion values needed

EPRI used a 4:1 ratio α_L/α_T with $\alpha_L = 20$ m for their base case; and they varied their α_T (horizontal dispersivity) from 2.5 to 10 meters.

Based on Gelhar et al 1992 (Water Resources Research 28(7) p. 1955-1974) a generic set of dispersivity values can be ascertained,

The popular modeling ratio $\frac{\alpha_L}{\alpha_T} = 3:1$ was not supported by the Gelhar et al work, his tabulations indicated:

$\frac{\alpha_L}{\alpha_T}$ range 1:1 to 50:1
mostly between 3:1 and 20:1

$\frac{\alpha_L}{\alpha_{T_z}}$ range 10:1 and 650:1

α_L generally between 0.01 and 1000 m } length scale
α_{T_y} " 0.005 and 100 m } dependence

α_{T_z} generally between 0.003 and 0.06 m } no length scale dependence

most α_L values are less than 200 m, but for the "reliable" data max $\alpha_L = 4$ for length scales less than 250 m (no "reliable" data for larger length scales)

Gelhar's rule of thumb $\alpha_L : \alpha_{T_y} : \alpha_{T_z}$

use order of magnitude differences
especially for $\alpha_{T_y} : \alpha_{T_z}$ ratio

Obviously we don't have any site-specific data for Amargosa Valley & Amargosa Farms area.

RF 3/23/99

Sample input files & methodology

Two sample input files are attached at the bottom of this page.

(1) The 1st one is used to approximate the plume configuration. 10^{-4} cutoff is approximated from pairs of y values & z values from simulation results. Since a linear interpolation is used on this non-linear data set, a second simulation is used.

(2) The second ~~set~~ simulation attempts to input the exact point at which $C = 10^{-4}$ is reached, the results of simulation verify the guess (from interpolated estimate.

The 1st interpolations are done in a spreadsheet program (EXCEL, designed for business use!).

RF 8/15/97

```
File: farms7.dat

7th Run, scoping  - Amargosa Farms;  for new output file y=15 & only 1 time!
patchi code: aquifer of infinite width and height with a 'patch' source
Model Data:  Y1=-250 m, Y2=250 m, Z1=0 m, Z2=25 m, V=10 m/yr
DX=1000, DY=100, DZ=10 m**2/yr, DK=1E-16 per yr, C0=1.0 mg/L

====
   1  15  16   5 104   0
mg/l        m/yr       m**2/yr    per yr     meter      yr
       1.0       10.0     1000.0      100.0       10.0     1.E-16
    -250.0      250.0        0.0       25.0
   15000.0
       0.0     1000.0     1500.0     2000.0     2400.0     2600.0     2800.0     3000.0
    3200.0     3400.0     3600.0     3800.0     4000.0     4500.0     5000.0
       0.0      200.0      400.0      600.0      800.0     1000.0     1200.0     1400.0
    1600.0     1800.0     2000.0     2200.0     2400.0     2600.0     3000.0     4000.0
    4000.0     5000.0     6000.0     8000.0    10000.0


file: f.dat

Detailed - Amargosa Farms
patchi code: aquifer of infinite width and height with a 'patch' source
Model Data:  Y1=-250 m, Y2=250 m, Z1=0 m, Z2=25 m, V=10 m/yr
DX=1000, DY=100, DZ=10 m**2/yr, DK=1E-16 per yr, C0=1.0 mg/L

====
   1  15  16   1 104   0
mg/l        m/yr       m**2/yr    per yr     meter      yr
       1.0       10.0     1000.0      100.0       10.0     1.E-16
    -250.0      250.0        0.0       25.0
   15000.0
       0.0     1023.0     1024.0     1025.0     1026.0     1027.0     1430.0     1851.0
    2683.0     2684.0     2685.0     2686.0     2500.0     2291.0     2292.0
       0.0      295.0      296.0      297.0      298.0      299.0      300.0      450.0
     260.0      763.0      653.0      654.0      685.0      850.0     1000.0     2000.0
    5000.0
```

3/25/98 PK

Attached to this page is the spreadsheet printout which is used to track simulation results as well as intermediate calculations.

8/15/97
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PK

patchi transport mini calculations, units=meters,years										dispersity
FILE.dat	y1	y2	z1	z2	v	Dx	Dy	Dz	Dk	L:Ty:Tz
farms4	-250	250	0	25	55	1100	275	1.00E-06	1.00E-16	20:5:0
farms4a	-250	250	0	25	54.64	1093	273	1.00E-06	1.00E-16	20:5:0
farms5	-250	250	0	25	10	1000	200	20	1.00E-16	100:20:2
farms6	-250	250	0	25	10	1000	200	10	1.00E-16	100:20:1
farms7	-250	250	0	25	10	1000	100	10	1.00E-16	100:10:1
farms8	-250	250	0	25	10	1000	100	1	1.00E-16	100:10:0.1
farms9	-250	250	0	25	10	500	50	5	1.00E-16	50:5:.5
farms10	-250	250	0	25	10	200	20	2	1.00E-16	20:2:.2
farms11	-250	250	0	25	10				1.00E-16	
farms12	-250	250	0	25	10				1.00E-16	
					Interpolated estimates		Final simulated estimates			Centerline
RUN	half width range		thickness range		half-width	thickness	half-width	thickness	width	conc.
#4, 15 km	1500	2000	25	25	1611	25	1625	25	3250	2.41E-01
	3.19E-04	1.75E-06								
#4, 25 km	2000	2100	25	25	2021	25	2021	25	4042	1.92E-01
	1.17E-04	5.49E-05								
#4a, 25km	2000	2021	25	25	2015	25	2015	25	4030	1.92E-01
	1.12E-04	9.56E-05								
#5, 15 km	2400	2600	600	800	2405	757	2405	761	4810	1.04E-02
	1.02E-04	4.69E-05	5.77E-04	6.20E-05						
#5, 20 km	2600	2800	800	1000	2676	845	2676	848	5352	7.38E-03
	1.28E-04	6.70E-05	1.63E-04	1.88E-05						
#5, 25 km	2800	3000	800	1000	2905	918	2906	922	5812	6.27E-03
	1.34E-04	7.68E-05	2.80E-04	4.88E-05						
#5, 30 km	3000	3200	800	1000	3107	986	3106	986	6212	5.23E-03
	1.31E-04	7.90E-05	3.90E-04	9.02E-05						
#6, 15 km	2400	2600	400	600	2494	556	2495	562	4990	1.47E-02
	1.44E-04	6.63E-05	1.18E-03	5.03E-05						
#6, 20 km	2600	2800	600	800	2783	625	2782	627	5564	1.11E-02
	1.80E-04	9.46E-05	1.50E-04	5.50E-06						
#6, 25 km	3000	3200	600	800	3026	661	3027	683	6054	8.86E-03
	1.08E-04	5.98E-05	2.08E-04	1.91E-05						
#6, 30 km	3200	3400	600	800	3242	726	3241	731	6482	7.39E-03
	1.12E-04	6.55E-05	4.13E-04	4.31E-05						
#7, 15 km	1500	2000	400	600	1839	577	1852	580	3704	2.04E-02
	6.05E-04	4.25E-05	1.65E-03	7.00E-05						
#7, 20 km	2000	2400	600	800	2059	645	2062	649	4124	1.54E-02
	1.35E-04	1.76E-05	2.09E-04	7.69E-06						
#7, 25 km	2000	2400	600	800	2235	702	2242	708	4484	1.24E-02
	2.65E-04	5.04E-05	3.92E-04	2.67E-05						
#7, 30 km	2400	2600	600	800	2403	756	2402	759	4804	1.04E-02
	1.01E-04	4.56E-05	5.80E-04	6.05E-05						
#8, 15 km	2000	2400	200	400	2041	209	2044	212	4088	6.26E-02
	1.31E-04	9.70E-06	2.15E-04	1.64E-11						
#8, 20 km	2000	2400	200	400	2281	228	2287	237	4574	4.77E-02
	4.16E-04	5.46E-05	6.39E-04	1.33E-09						
#8, 25 km	2400	2600	200	400	2496	246	2497	259	4994	3.85E-02
	1.57E-04	6.14E-05	1.20E-03	2.42E-08						
#8, 30 km	2600	2800	200	400	2683	263	2684	278	5368	3.22E-02
	1.42E-04	6.07E-05	1.77E-03	1.83E-07						
#9, 15 km	1000	1500	400	600	1413	432	1425	438	2850	3.92E-02
	2.08E-03	5.29E-05	2.73E-04	5.39E-07						
#10, 15km	1000	1500	200	400	1020	283	1025	299	2050	8.78E-02
	1.41E-04	2.54E-08	4.86E-03	4.17E-07						

The file is called ./Bore/Analytic/Amargosa/patchi.xls

The point of making 2 simulations (1st to get interpolated estimate, 2nd to verify) is that of reproducibility. Certainly, the ~~accura~~ precision is dependent on the grid chosen in the 1st simulation. The second simulation just removes the grid size choice as a dependent variable. With all of the guess-estimation on dispersivity and seepage velocity, the added precision in results is not warranted.

RF 3/23/99

Also noted that some of the simulations pushed the method used to calculate the integrals of the analytic solution. The default value of Legendre quadrature points is 104. This had to be increased to 256 quadrature points when it was noted that oscillations occurred from time step to time step

Farms4.dat approximates the EPRI implementation (Domenico-Robbins) by setting α_{Tz} to essentially zero. EPRI actually set $\alpha_{Ty} = \alpha_{Tz} \doteq 5$ m (for the base case) which leads to increased amount of dispersion

			plume width	dilution factor
15 km	Patchi code	$\alpha_{Tz} \cong 0$	3250 m	4.1
25 km	"	$\hookrightarrow = 1\times10^{-6}$ m	4042 m	5.2
15 km	Patchi code	$\alpha_{Tz} = 0.5$	2846 m	25.6
25 km	"		3442 m	41.5
15 km	EPRI results	$\alpha_{Tz} = \alpha_{Ty} = 5$m	?	20
25 km	"		3.3 km	33

not included on table of previous page (refers to the two $\alpha_{Tz} = 0.5$ rows)

I could not reproduce EPRI's results (I got df=141 for 25 km case). Given the layering of the alluvial sediments, α_{Tz}=5m does not seem reasonable. The choice of $\alpha_{Tz} = 0.5$ m (an order of magnitude less than horizontal transverse dispersivity) is the reasonable choice between the other two extremes.

Water Use Estimates

Handwritten & computer tables were obtained from State Engineers office (Nevada) of water use estimates for Basin 230 - Amargosa Desert, Chad Glenn (NRC - Las Vegas office) made the xeroxes. Robert Coache (Bob) (702)-486-2770 is now the chief engineer, he puts together the tables. The xeroxed tables will be in the CNWRA library system; the years included are 1983-1996; 1984 is not available. The engineers annual summaries are tabulated below for the entire Amargosa Desert followed by a table which I removed non-Amargosa Farms wells. The wells which are

Summaries of Groundwater Pumpage - Nevada State Engineer's Office
Adjustments to State Engineers data removes non-Amargosa Farms wells.
Borehole Dilution ARDES KTI -- RFedors

RF 8/21/97

Actual State Engineer Tabulation

Year	Irrigation Ac-Ft	Irr/NoPer Ac-Ft	AB/IMV/BF Ac-Ft	QM/COM Ac-Ft	QM/DOM Ac-Ft	Other Ac-Ft
1996	9263	1780	2285	205	50	30
1995	10839	1515	2571	10	100	0
1994	8892	1085	2508	10	100	0
1993	8558.8	150	2481	10	100	0
1992	5711	50	2292.5	10	100	0
1991	4716.5	225	1070	10	100	0
1990	4603.1	350	2719.29	10	125	0
1989	1266	300	2220	10	125	0
1988	2666	312	996	10	125	0
1987	4500	1200	302	10	125	0
1986	5552.9	1000	550	10	125	0
1985	5807	2665	950	20	230	0
1983	5893	3212	125	20	250	0

Remove non-Amargosa Farms Wells

Irrigation Ac-Ft	Ind-IVM/AB Ac-Ft	QM/COM Ac-Ft	Domestic Ac-Ft	Other Ac-Ft	Total Ac-Ft
11033	1019	203.8	50	0	12305.8
12354	780	10	100	0	13244
9977	717	10	100	0	10804
8658.8	1007	10	100	0	9775.8
5711	653.5	10	100	0	6474.5
4941.5	450	10	100	0	5501.5
4953.1	886.69	10	125	0	5974.79
1566	1413	10	125	0	3114
2978	996	10	125	0	4109
5700	302	10	125	0	6137
6552.9	550	10	125	0	7237.9
8472	950	20	230	0	9672
9105	125	20	250	0	9500

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part of Amargosa Desert, Basin 230 in state and federal nomenclature, are listed below

permit #		sec	Township	Range
22140		8	17 S	52 E
22141		7	17 S	52 E
51841 - 51848	Bullfrog mining operation			
58268	Bullfrog mining operation		12-13 S	46 E
61412	Bullfrog mining operation			
61413	Bullfrog mining operation	~~7~~	~~18 S~~	~~51~~ E
53596		7	18 S	51 E
54271		7	17 S	52 E

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There were no other non-zero water use estimates for wells outside of the Amargosa Farms area. For simplicity, I defined the Amargosa Farms area by range and township as Townships 15-18 S and Ranges 46-50 E.

Detailed tables listing water use by well permit followed each annual summary. According to the State Engineer, the domestic wells are not tracked, only an annual estimate is given. Also, many of the wells are not metered; these are to be considered estimates, not actual pumpage. They use acreage under irrigation, type of crop to estimate.

RF 3/23/99

The detailed water use information was entered into a spreadsheet (pumpixls) for years 1983, 1985-1996.
A copy of the spreadsheet is attached to the following page and it includes various averages and summations including a separate table on the page 33 of this notebook.

Notes: ① "assumed # of wells" = the number of permits listed under 1 water use estimate, assumes 1 well/permit
② no domestic wells are listed in the tables, the state engineer said domestic wells are limited to 1800 gal/min, though often the actual use is less than half that.

(3) The major user deleted from tables is Bullfrog mining operation

RF 8/21/97

Well Permit & Estimated Water Use (data entry) RFedors
Added Water Use data to permit spreadsheet file (permit.xls) 16Jul97; other years added 20Aug97
Borehole Dilution for ARDES KTI
add'l ==> PC=certificate & permit
RFA,RFP=ready for action (protested)
APP=application
A1,A2,A3=special case of 3 permits same number
Water Use => entries are put under 1st permit number unless original.
permits are split, then put under 2nd listed permit number.
water use category not (!) modified from Well Permit database.
pump ratings are for specific permit; other wells included for water use estimate are not included in pump ratings column total

permit#	qq	qtr	sec	twn	rng	rate,cfs	acres	use	1996Ac-ft	1995Ac-ft	1994Ac-ft	1993Ac-ft	1992Ac-ft	1991Ac-ft	1990Ac-ft	1989Ac-ft	1988Ac-ft	1987Ac-ft	1986Ac-ft	1985Ac-ft	1983Ac-ft	avg83-96	assumed #of wells
27812	ne	nw	12	17	48	2.54	0	mm	272.00	349.00	340.00	232.00	347.50	335.00	383.60	525.00	569.00	298.00	284.00	110.00	255.00	330.78	3
32279	ne	nw	25	18	50	0.1	0	com									0.50	0.50	0.60			0.53	
46218	ne	ne	14	16	49	0.019	0	com	0.10													0.10	1
47528	se	se	13	15	49	0.075	0	com	0.50													0.50	1
53189	se	ne	16	16	48	0.3	0	com	2.00													2.00	1
59180	xx	se	35	16	49	0.07	0	com	1.00													1.00	1
48479	xx	sw	36	17	49	.26	0	com	746.50	431.00	377.00	512.00	306.00	115.00	503.09	888.00	427.00	4.00	266.00	840.00		451.30	5
61080	nw	ne	10	17	49		0	com	50.00													50.00	1
15881	ne	nw	10	16	48	0.845	90.62	ird		300.00	60.00						385.00	385.00	385.00	375.00	400.00	327.14	
16178	ne	nw	8	16	48	2.6	40	ird													150.00	150.00	
16545	ne	ne	28	16	49	2.5	21.98	ird	183.40	183.40	183.40	183.40	183.40		75.00	75.00	183.40	183.40	183.40	109.90	210.00	161.43	2
16562	ne	ne	16	16	48	2.2	120	ird	125.00	400.00	280.00	290.00	600.00	400.00	400.00	50.00	700.00	100.00	600.00	400.00		362.08	1
17241	ne	nw	9	17	49	2.45	158	ird				690.00	540.00	550.00	790.00	400.00	300.00	200.00				495.71	
19448	sw	nw	7	16	48	0.63	37	ird	92.50	185.00	185.00	185.00	37.00	37.00								120.25	1
20352	xx	xx	36	16	48	3.5	233.9	ird	799.50	864.50	1169.50	1169.50	994.50	1169.50	25.00			860.00	864.50	864.50	625.00	855.09	1
26283	nw	nw	18	16	48	2.2	160	ird	400.00	400.00	480.00	200.00					200.00		600.00	300.00		368.57	2
14054	se	ne	12	17	48	1.52	25.4	irr													25.00	25.00	
15702	ne	se	14	16	48	1	35	irr	175.00	175.00	175.00	175.00										175.00	1
15893	ne	ne	23	16	48	3.5	160	irr	625.00	625.00	625.00	668.80	625.00	800.00						325.00	625.00	614.85	1
15929	ne	ne	9	17	49	2.228	80	irr	700.00	700.00	700.00											700.00	2
16047	ne	sw	9	16	49	2.005	60	irr													5.00	5.00	
17340	ne	se	32	16	49	0.5	27.9	irr							139.50							139.50	
17348	ne	ne	14	16	49	0.313	40	irr				55.00	55.00									55.00	
17404	ne	sw	25	16	48	2.5	160	irr					625.00							625.00	625.00	625.00	1
17417	nw	ne	17	16	48	2	45.82	irr			50.00									128.90	75.00	84.63	
17657	ne	nw	15	16	48	0.04	2.5	irr	5.00	12.50	15.00	2.00	2.00		10.00							7.75	1
17657	ne	nw	15	16	48	2.14	147.5	irr	7.50	2.50	2.50	1.00	4.00				6.30					3.97	1
17694	ne	nw	15	17	49	2	38.2	irr	25.00	25.00	20.00	16.00	16.00		12.00	12.00	12.00	12.00		25.00		17.50	1
18222	ne	nw	30	16	49	5.4	268	irr	665.00	665.00	665.00	665.00			677.50			266.00				600.58	1
18764	ne	ne	8	16	48	4.01	71.4	irr	5.00	90.00	75.00	90.00					50.00		195.00			84.17	2
18772	sw	nw	20	16	48	3.01	199	irr	17.50	17.50	10.00	20.00	40.00	20.00							300.00	60.71	1
19034	se	se	8	17	49	2.5	185.95	irr		118.80					181.10							149.95	
19916	ne	ne	24	16	48	2.5	160	irr	227.50	300.00	200.00	175.00	175.00	175.00	150.00	175.00	175.00	175.00				192.75	1
19917	ne	se	24	16	48	2.5	160	irr	625.00	625.00	625.00		200.00	200.00								455.00	2
20162	ne	nw	35	16	49	0.57	70	irr				2.00	2.00									2.00	
22233	ne	ne	36	16	48	1	38	irr	25.00	50.00	50.00	190.00	16.00		25.00	25.00						54.43	1
22746	ne	se	19	16	49	2.5	160	irr	625.00	625.00	625.00	625.00	625.00	625.00	400.00	250.00						550.00	1
23797	se	sw	10	16	48	1.35	80	irr		400.00		200.00										300.00	
24585	se	sw	9	16	49	0.75	23.75	irr	105.00	118.75	50.00	118.30	118.75		118.75	118.80	75.00	75.00	75.00	50.00	118.80	95.18	1
24725	se	nw	18	16	48	2.7	155.49	irr	657.75	683.00	540.80	328.50					47.20		777.25	656.25		527.25	1
24763	ne	ne	8	16	49	0.59	26.69	irr	27.50	90.00	15.00	10.00	10.00		25.00	25.00					98.50	37.63	1
25009	se	sw	10	16	48	1.22	3.5	irr	5.00	5.00												5.00	
25636	sw	se	5	16	49	1.3	40	irr			1.00											1.00	
25742	nw	sw	10	16	48	0.14	3.5	irr	17.50	17.50	17.50	17.50	17.50		5.00	5.00	2.50	2.50	2.50			10.50	1
25743	nw	sw	10	16	48	0.14	3.5	irr	11.25													11.25	1
25744	nw	sw	10	16	48	0.21	4.5	irr					1.00		22.50							11.75	

(3) The major user deleted from tables is Bullfrog mining operation

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permit#	qq	qtr	sec	twn	rng	rate,cfs	acres	use	1996Ac-ft	1995Ac-ft	1994Ac-ft	1993Ac-ft	1992Ac-ft	1991Ac-ft	1990Ac-ft	1989Ac-ft	1988Ac-ft	1987Ac-ft	1986Ac-ft	1985Ac-ft	1983Ac-ft	avg83-96	assumed #of wells
26152	sw	se	8	16	48	1	12	irr	24.00	99.00	99.00	54.00					5.00				60.00	56.83	2
26718	ne	se	8	16	49	0.1	3.78	irr	5.00	2.00		4.00	4.00									3.75	1
28828	se	nw	35	16	49	0.43	13.14	irr	26.28	26.20	18.20	18.20	18.24									21.42	2
29521	se	sw	9	16	49	0.16	5	irr	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	1
29649	ne	ne	9	17	49	1.32	125.6	irr	170.00	170.00												170.00	1
30411	ne	se	23	16	49	2.67	151	irr	625.00	625.00	625.00	625.00	625.00	625.00							625.00	625.00	1
31204	nw	ne	8	16	49	0.125	4.56	irr				13.70									22.80	18.25	
31727	se	sw	9	16	49	0.16	5	irr	25.00	25.00	25.00	25.00	25.00	25.00	25.00		25.00	25.00	25.00	25.00	25.00	25.00	1
36584	nw	nw	15	16	48	0.08	5	irr	12.50	10.00	10.00	2.00	6.00								20.00	10.08	1
38127	se	nw	26	16	48	1.667	116.67	irr	583.50	583.50	233.34	250.00			250.00			583.35	583.50	583.35	584.00	470.50	1
38363	se	ne	26	16	48	1.666	116.67	irr	233.40	233.40					583.35			583.35	583.50	583.35	584.00	483.48	1
40954	se	se	22	16	49	0.178	9.54	irr	5.00		35.00	47.70			15.00	15.00	10.00	10.00		22.70		20.05	1
42171	sw	se	8	16	48	0.275	60	irr	70.70	75.00	60.00	30.00										58.93	1
43524	ne	ne	9	17	49	1.454	125.6	irr	628.00	628.00	312.50	628.00										549.13	1
43873	sw	nw	24	16	48	1.667	116.67	irr	583.50	583.50	583.50	583.40			583.35			583.35	583.35	583.35		583.41	1
46748	sw	nw	15	16	48	0.16	8.42	irr	10.00	10.00	20.65	6.00	6.00				34.40			25.00		16.01	1
49885	se	nw	12	17	48	0.25	13	irr	65.00	65.00	65.00	65.00	65.00	65.00	65.00	65.00	45.00	45.00	45.00	75.00		60.83	1
60433	nw	nw	15	16	48	0.039	2.5	irr	12.50													12.50	1
60442	ne	nw	15	16	48	0.023	1.5	irr	5.00													5.00	1
60443	ne	nw	15	16	48	0.025	1.61	irr	1.00													1.00	1
60471	nw	nw	15	16	48	0.016	1	irr	5.00													5.00	1
60474	ne	nw	15	16	48	0.029	1.84	irr	1.00													1.00	1
29341	xx	sw	4	16	48			irr									375.00					375.00	
36762	xx	nw	23	16	48			irr													625.00	625.00	1
36764	xx	nw	25	16	48			irr													625.00	625.00	1
60450	nw	nw	15	16	48		1.5	irr	7.50													7.50	1
bettles	nw	se	1	17	48			irr													625.00	625.00	
bray	sw	se	32	16	49			irr			100.00	100.00		175.00	175.00	175.00						145.00	
Burke	ne	ne	28	16	49			irr												100.00		100.00	
cost	xx	nw	25	26	48			irr	625.00	625.00	625.00									625.00		625.00	1
dairy	sw	ne	9	17	49			irr	40.00	40.00												40.00	
dairy	se	ne	9	17	49			irr	40.00	40.00												40.00	
david rau	se	nw	12	17	48			irr													300.00	300.00	
DeLee	xx	nw	25	16	48			irr	625.00	625.00												625.00	1
fruit	ne	se	12	17	48			irr	50.00	50.00	50.00	50.00	50.00	50.00	125.00	125.00						68.75	1
R&F	xx	se	7	17	49			irr										200.00		625.00		412.50	
Richards	xx	sw	7	17	49			irr	625.00	625.00					50.00		312.50	625.00	625.00	625.00		498.21	
sod	ne	sw	9	17	49			irr	200.00	200.00	200.00											200.00	1
sod	nw	sw	9	17	49			irr	200.00	200.00	50.00											150.00	1
Tharp	xx	se	1	17	48			irr	40.00	40.00								375.00	375.00	375.00		241.00	
unk	nw	se	7	17	49			irr													625.00	625.00	1
unknown	nw	sw	7	17	49			irr													312.50	312.50	1
unknwn	ne	nw	17	16	48			irr		60.00	60.00									240.00		120.00	
26673	nw	ne	24	15	49	0.004	0	qm	8.00													8.00	
28062	se	sw	2	18	49	0.79	0	qm	16.00													16.00	2
35592	se	sw	1	17	48	0.5	0	qm	7.50													7.50	2
45162	se	sw	2	17	49	0.446	0	qm	10.00													10.00	2
45740	ne	nw	27	16	49	0.02	0	qm	3.40													3.40	1
47205	sw	se	31	16	49	0.2	0	qm	10.50													10.50	2
49804	se	se	26	16	49	0.01	0	qm	0.10													0.10	1
50385	nw	ne	16	16	49	0.1	0	qm	20.00													20.00	1
53181	sw	sw	2	18	49	0.08	0	qm	50.00													50.00	2
61219	sw	ne	3	18	50		0	qm	2.00													2.00	1

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near Beatty

(4.) unpermitted irrigation users have a descriptive word in place of a permit number

(5.) The summary statistics tables ⇒ Ac-ft units, another table with m3/day units (spread over entire year of irrigation)

(6.) State engineer says that water use on permit can change,

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Water Use

		pump rating																		
		m^3/d	cfs		all years	1996Ac-ft	1995Ac-ft	1994Ac-ft	1993Ac-ft	1992Ac-ft	1991Ac-ft	1990Ac-ft	1989Ac-ft	1988Ac-ft	1987Ac-ft	1986Ac-ft	1985Ac-ft	1983Ac-ft
	qm/mun	584	0.239	average	13	13												
permitted		9	9	count		10	0	0	0	0	0	0	0	0	0	0	0	0
acreage				sum		128	0	0	0	0	0	0	0	0	0	0	0	0
irrigation		10	0.004	min		0.1												
4237		1933	0.790	max		50.0												
	com/mm	1266	0.517	average	332	153	390	359	372	327	225	443	707	332	101	184	475	255
		6	6	count		7	2	2	2	2	2	2	2	3	3	3	2	1
				sum		1072	780	717	744	654	450	887	1413	997	303	551	950	255
		46	0.019	min		0.1	349	340	232	306	115	384	525	1	1	1	110	255
		6214	2.540	max		746.5	431	377	512	348	335	503	888	569	298	284	840	255
	irr/d	3366	1.376	average	244	213	262	228	210	190	329	191	103	148	266	384	335	320
		60	60	count		55	51	44	41	30	15	26	15	20	20	17	25	26
				sum		11721	13344	10017	8604	5711	4942	4953	1541	2968	5314	6528	8372	8316
		39	0.016	min		1.0	2	1	1	1	20	5	5	3	3	3	23	5
		13212	5.400	max		799.5	865	1170	1170	995	1170	790	400	700	860	865	865	625
	total	2864	1.171	average	248	179	266	233	217	199	317	209	174	172	244	354	345	317
		75	75	count		72	53	46	43	32	17	28	17	23	23	20	27	27
				sum		12920	14124	10734	9348	6365	5392	5840	2954	3965	5616	7079	9322	8571
		10	0.004	min		0.1	2	1	1	1	20	5	5	1	1	1	23	5
		13212	5.400	max		799.5	865	1170	1170	995	1170	790	888	700	860	865	865	625

cubic meters/day

		pump rating																		
		m^3/d	cfs		all years	996 m3/d	1995m3/d	1994m3/d	1993m3/d	1992m3/d	1991m3/d	1990m3/d	1989m3/d	1988m3/d	1987m3/d	1986m3/d	198m3/d	1983m3/d
	qm/mun	584	0.239	average	43	43												
permitted		9	9	count		10	Ø (2)	0	0	0	0	0	0	0	0	0	0	0
acreage				sum		432	0	0	0	0	0	0	0	0	0	0	0	0
irrigation		10	0.004	min		0.3												
4237		1933	0.790	max		169.3	RF 8/21/97											
	com/mm	1266	0.517	average	1126	519	1321	1214	1260	1107	762	1501	2392	1125	341	622	1609	864
		6	6	count		7	2	2	2	2	2	2	2	3	3	3	2	1
				sum		3631	2641	2428	2519	2213	1524	3003	4785	3375	1024	1865	3217	864
		46	0.019	min		0.3	1181.9	1151.4	785.6	1036.2	389.4	1299.0	1777.9	1.7	1.7	2.0	372.5	863.5
		6214	2.540	max		2527.9	1459.5	1276.7	1733.8	1176.8	1134.4	1703.7	3007.1	1926.9	1009.1	961.7	2844.6	863.5
	irr/d	3366	1.376	average	828	722	886	771	711	645	1116	645	348	503	900	1300	1134	1083
		60	60	count		55	51	44	41	30	15	26	15	20	20	17	25	26
				sum		39691	45188	33921	29137	19341	16734	16773	5218	10052	17995	22106	28352	28160
		39	0.016	min		3.4	6.8	3.4	3.4	3.4	67.7	16.9	16.9	8.5	8.5	8.5	76.9	16.9
		13212	5.400	max		2707.4	2927.5	3960.4	3960.4	3367.8	3960.4	2675.3	1354.6	2370.5	2912.3	2927.5	2927.5	2116.5
	total	2864	1.171	average	841	608	902	790	736	674	1074	706	588	584	827	1199	1169	1075
		75	75	count		72	53	46	43	32	17	28	17	23	23	20	27	27
				sum		43754	47830	36349	31656	21554	18258	19776	10003	13426	19020	23971	31569	29023
		10	0.004	min		0.3	6.8	3.4	3.4	3.4	67.7	16.9	16.9	1.7	1.7	2.0	76.9	16.9
		13212	5.400	max		2707.4	2927.5	3960.4	3960.4	3367.8	3960.4	2675.3	3007.1	2370.5	2912.3	2927.5	2927.5	2116.5

(7.) some observations on comments column in xeroxed tables :

5 Ac-ft ⇒ alfalfa, pasture, sod, garden, fruit trees, dairy

2½ Ac-ft ⇒ fruit trees, grapes, garden

2 Ac-ft ⇒ grains, pistachio trees, fruit trees, pasture

1 Ac-ft ⇒ wind breaks gardens

0.5 Ac-ft ⇒ mobile home / trailers (~450 gpd)

(8) The increased number of wells which are active increases in the mid-90's probably due to threat of losing water rights brought on by golf course / community development project which anticipated a need for 24,000 Ac-ft/yr pumped water.
(Valle de Sol development, Amargosa Resources, Inc.)

(9.) Highest pumpage listed 1169.5 Ac-ft apparently uses 1 well (there is only 1 permit); other high pumpage users have 2 or 3 wells (permits) ⇒ 600-700 Ac-ft range.

(10.) The "permitted acreage irrigation" = 4237 Acres is the sum of acres for all actual water users where the acres are ~~appro~~ from the permit.

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(11.) These tables are a more complete version of the tables listed on scientific notebook pages 6&7.

→ (12.) Permit database (Scientific Notebook pages 6&7)
Total permitted acreage for all active [certificated, ~~perm~~ permitted (but not certificated), & application pending categories]

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6757 Acres Irrigation for 176 permits

(13) Bugo (consultant) report to Nye County 1996

Reports ⇒ Basin 230 28,600 Ac-ft/yr committed groundwater for irrigation ; (total committed is 41,093 Ac-ft/yr).

```
************************************************************************
** Main purpose is to convert Range & Township locations to UTM        **
** coordinates assuming the center of quarter-quarter setions.         **
** Program reads data from the Well Permit & Water Use databases as    **
** created from data entry spreadsheet files permit.xls & pump.xls     **
** Xerox copies of tables obtained from Nevada Engineers Office.       **
**                                                                      **
** Should work for any Range & Township as long as lower left coord    **
** are input and range() & twnshp() dimensionings are changed.         **
**    RFedors (17July97)                                                **
************************************************************************
*        1         2         3         4         5         6         7
*23456789012345678901234567890123456789012345678901234567890123456789012
      program rangee

      implicit  none
      character  qq*2, qtr*2
      character  infile*12, outfile*12
      integer*4  ipermit, section, twn, rang, i, j, ir, numrec
      integer*4  range(46:50,15:18), twnshp(46:50,15:18)
      real*4  dmile, dqtr, dqq, utmnorth, utmeast, water
      real*4  x, x1, y1, xx1, yy1, sect
      parameter ( numrec=60 )

      infile = 'pump96.prn'
      outfile = 'pump.dat'
      open(8,file=infile,status='unknown')
      open(9,file=outfile,status='unknown')

c Assume 6x6 square mile Range and Townships, hardcode in the
c lower left corner of each Range & Township in terms of UTM
c coordinates; hence, work in units of meters.
      dmile = 5280 * .3048
      dqtr = dmile * 0.25
      dqq = dqtr * 0.25

      range(47,15) = 524845
      twnshp(47,15) = 4050075
      range(47,16) = 524892
      twnshp(47,16) = 4040442

      range(48,15) = 534548
      twnshp(48,15) = 4050098
      range(48,16) = 534548
      twnshp(48,16) = 4040422
      range(48,17) = 534956
      twnshp(48,17) = 4030608

      range(49,15) = 544172
      twnshp(49,15) = 4050188
      range(49,16) = 544252
      twnshp(49,16) = 4040264
      range(49,17) = 544607
      twnshp(49,17) = 4030608
      range(49,18) = 544801
      twnshp(49,18) = 4021390

      range(50,15) = 553516
      twnshp(50,15) = 4050250
      range(50,16) = 553888
      twnshp(50,16) = 4040288
      range(50,17) = 554457
      twnshp(50,17) = 4031046
      range(50,18) = 554457
      twnshp(50,18) = 4021390

c Determine which Range and Township (most are in R48,49 E).
      do 90 ir = 1,numrec
       read(8,101) ipermit, qq, qtr, section, twn, rang, water
```



```
101   format(i8,1x,a2,2x,a2,1x,3i4,f7.3)

      utmnorth = twnshp(rang,twn)
      utmeast = range(rang,twn)

c Sections.
      if(section.le.6) sect = 5.5 * dmile
      if(section.gt.6.and.section.le.12) sect = 4.5 * dmile
      if(section.gt.12.and.section.le.18) sect = 3.5 * dmile
      if(section.gt.18.and.section.le.24) sect = 2.5 * dmile
      if(section.gt.24.and.section.le.30) sect = 1.5 * dmile
      if(section.gt.30.and.section.le.36) sect = 0.5 * dmile
      utmnorth = utmnorth + sect

      x = dmile * ( 6. - 0.5 )
      do 40 j = 1,5,2
        do 30 i = 1,6
          if(section.eq.(j-1)*6+i) utmeast = utmeast + x
          x = x - dmile
30      continue
        x = dmile * ( 6. - 0.5 )
40    continue

      x = dmile * 0.5
      do 60 j = 2,6,2
        do 50 i = 1,6
          if(section.eq.(j-1)*6+i) utmeast = utmeast + x
          x = x + dmile
50      continue
        x = dmile * 0.5
60    continue

c Quarter sections and Quarter-Quarter; any other entry ('xx'), left at => 0.
      x1 = 0.
      y1 = 0.
      xx1 = 0.
      yy1 = 0.
      if(qtr.eq.'nw'.or.qtr.eq.'sw') x1 = -dqtr
      if(qtr.eq.'ne'.or.qtr.eq.'se') x1 = dqtr
      if(qtr.eq.'nw'.or.qtr.eq.'ne') y1 = dqtr
      if(qtr.eq.'sw'.or.qtr.eq.'se') y1 = -dqtr

      if(qq.eq.'nw'.or.qq.eq.'sw') xx1 = -dqq
      if(qq.eq.'ne'.or.qq.eq.'se') xx1 = dqq
      if(qq.eq.'nw'.or.qq.eq.'ne') yy1 = dqq
      if(qq.eq.'sw'.or.qq.eq.'se') yy1 = -dqq

      utmnorth = utmnorth + y1 + yy1
      utmeast = utmeast + x1 + xx1
      write(9,'(2f10.0,f10.3,i10)') utmeast, utmnorth, water, ipermit

90    continue

      stop
      end
```

RF 8/21/97

range.f

In order to plot the water use data to illustrate spatial distribution, a conversion utility was used to go from Range & Township coordinates to UTM coordinates. This is used only for graphical purposes because the transformation is inexact

1. Lower left (SW) corner of each range & township is given an UTM coordinate (read/approximated from 7½ and 15' topo maps)
2. assume 6 mile × 6 mile square range & townships.
3. assume well is in center of section, quarter section, or quarter-quarter section (this choice depends on the amount of information available).
4. other plotted data is also in the UTM coordinates (NAD 27 conversion); UTM coordinates for 7½' quad map outline, coordinates for roads (highways 29 and 95); GWSI database in longitude and latitude converted to UTM; The streamtubes of Gordon Wittmeyer
5. output is ready for tecplot by adding appropriate header line for ~~geometry~~ scattered data.

RF 3/23/99

The code to accomplish this conversion is attached to this page. It is used on SUN workstation & should also work on a PC, using fortran 77

Well Driller Reports

Xeroxed by Chad Glenn (NRC, Las Vegas office) at Nevada Division of Water Resources. Made arrangements to reduce usual $1.00/report plus 20¢ add'l pages of report (many reports are 2 pages) to free if Chad brings his own paper & does xeroxing himself. The logs can not leave the office.

535 Reports were xeroxed in Amargosa Farms area (Ranges 47-50E, Townships 15-17S)

27 Excluded as being in Ash Meadows (eastern half of Range 50E)

16 described as "test" wells

18 with no "use" category noted

Remaining = 474 wells drilled (since at least 1921)

		Domestic	Dom/Irrig	Irrigation	Indust/Commercial	Mun
South	T 17 S	52	6	62	1	1
↕	T 16 S	199	18	111	1	3
north	T 15 S	12	Ø	5	2	1

Mun to quasi-municipal

Discrepancies may occur due to changes from original use category on a permit to present day usage.

PF 3/23/99

current tables (~~Pao~~ (Site Characterization 1988 DOE)
9 quasi-municipal
5 commercial
3 industrial

Also note dual use designations for 24 wells domestic & irrigation

Hot spots for domestic wells

Quantity	section	Township	Range
40	15	16 S	49 E
33	35	16 S	49 E
30	12	17 S	48 E
25	8	16 S	49 E
15	10	16 S	48 E
14	22	16 S	49 E

Distribution of Domestic wells (includes dual dom/irrigation wells)

		R47 S	R48 E	R49E	R50E
north	T15 S	Ø	2	2	9
↕	T16 S	1	105	110	4
south	T17 S	Ø	37	17	5

Total domestic (plus dom/irrig) = 287 wells drilled
Total irrigation (plus dom/irrig) = 202 wells drilled

Comments on Lithologies:
1. well drillers are notoriously bad at logging core (understandable)
2. most of the descriptions are variations of sand, gravel, clay
3. other noted types: limestone layers, cemented sands and/or gravels, boulder/gravel (3-4 ft thick) → streambeds?, sands with beds of clay!, caliche; volcanic tuff, red clay, brown clay, loam
4. units vary from a few feet to tens of feet
5. numerous notations of multiple water-bearing units and numerous clay beds

ARC-INFO

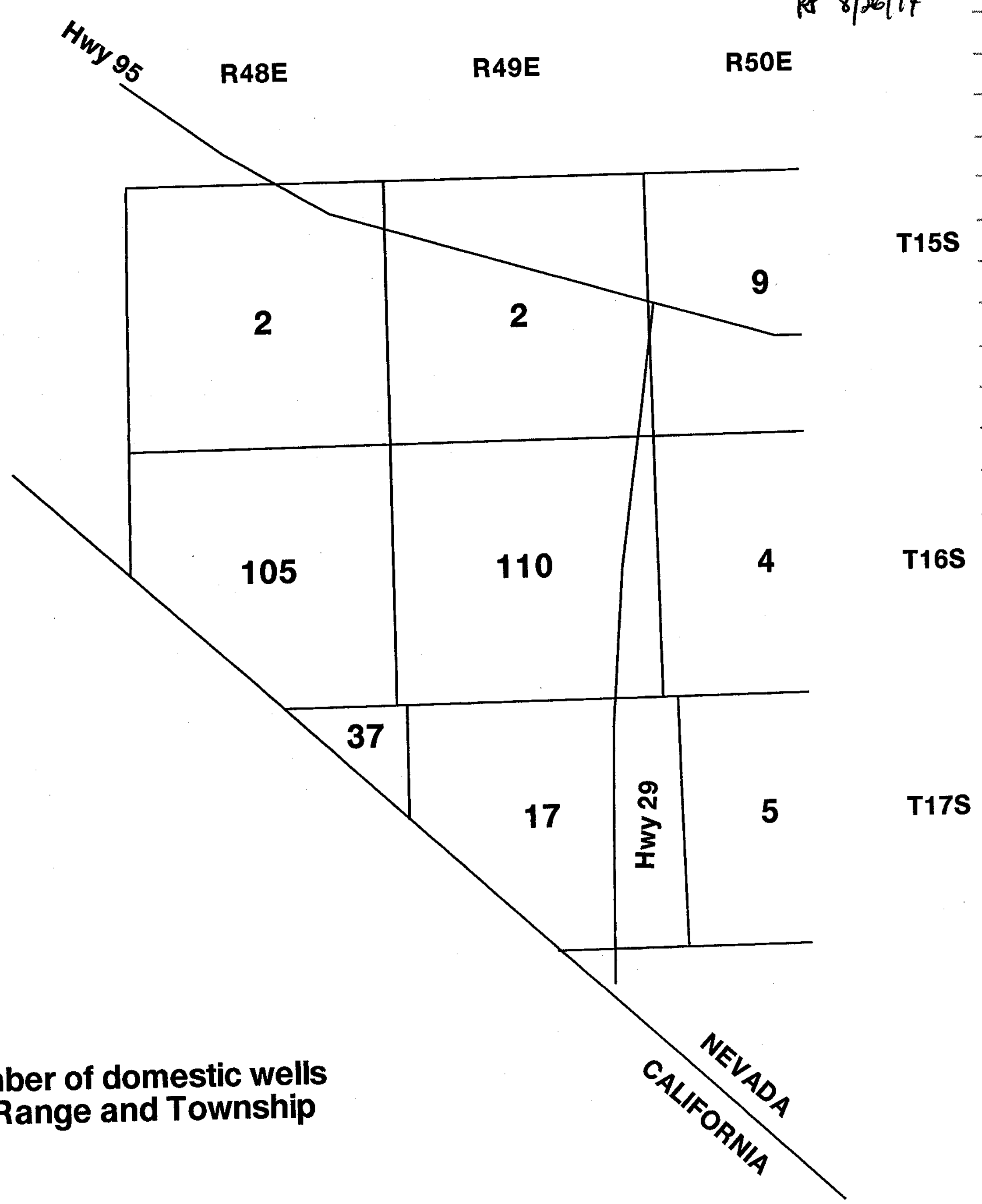
Ron Martin helped

Extraction of UTM coordinates for roads, state line, and for digitized range & township lines to aid perspective when plotting well locations or quantity & distribution of domestic wells drilled.

ARC-INFO, R. Martin has Beatty satellite image, and roads from DV junction coverage. Both files are kept in a library of databases directory for general staff usage.

We digitized the range & township (also roads, to check for reliability against their existing roads database) from Figure 1 of Oatfield & Czarnecki (1991).
I can then extract UTM coordinates for all of the features I want to plot in Tecplot to use a frame of references.
Here's an example of the result;

RF 8/26/97



Number of domestic wells by Range and Township

STRIPI code → Put under TOP-018 control

In order to model horizontal transverse dispersion, the stripi.f code was compiled. Patchi.f code is designed to model 3-D dispersion. However, the plumes obtained were 300 m to 1 km or more thick. Since many existing plumes remain thin, but do spread out laterally (due to stratification of sediments), a code which simulated 2-D dispersion (α_L and α_{Ty}) from a line source was found. Stripi.f is one of codes found at the USGS web site

http://water.usgs.gov/software/ground.html

and documented in Wexler, E.J. (1992) ⇒ Analytical Solutions for One-, Two-, and Three-Dimensional Solute Transport in Ground-Water Systems with Uniform Flow; USGS Tech of Water-Resource Investigations Chapter B7, Book 3.

Installation: similar to that for patchi.f (see page 13 of this book) except changes to files sub02.f for the time stamp. Sample problem 7 was used as verification of proper installation. Results of USGS generated output are identical to my output; paper copies are in TOP-018 folder

Stripi.f is used because of peculiarities in patchi.f results when vertical dispersion was set to something near zero (10^{-6}, relatively speaking). Stripi.f was compiled so as to verify adaptation of patchi to 2D, but then, heh, why not just use stripi.f for thin plumes where no vertical dispersion is occurring.

Sample input file:

```
Thin plume - Amargosa Farms; dispersivities 20:2 meters
stripi code: aquifer of infinite width with a finite width source (line)
Model Data:  Y1=-250 m, Y2=250 m, V=10 m/yr
DX=200  , DY=20   m**2/yr, DK=1E-16 per yr, C0=1.0 mg/L

====
   2  15   1 256   0
mg/l       m/yr      m**2/yr   per yr    meter      yr
       1.0      10.0      200.0      20.0     1.E-16
    -250.0     250.0
   15000.0   25000.0
       0.0    1000.0     1100.0     1200.0     1400.0     1600.0     1800.0     2000.0
    2200.0    2400.0     2600.0     2800.0     3000.0     3500.0     4000.0
    5000.0
```

RF 9/9/97

Plume Widths & Thicknesses (patchi & stripi results)

[Spreadsheet File ⇒ ./Bore/~~Analytic~~/Amargosa/patchi.xls]

Summary of scenarios included in report on Borehole Dilution. Methods are described on pages 24-29 of this scientific notebook. This chart supercedes (replaces) the chart on page 28; the differences are (1) more entries; and (2) centerline concentrations properly account for water table boundary condition (spreading only in 1 vertical direction).

RF 9/10/97

		25x500		6.05E-04	4.25E-05	1.65E-03	7.00E-05								
#7, 20 km	100:10:1	25x500	20	2000	2400	600	800	2059	645	2062	649	4124	1.54E-02	0.0308	32.5
	100:10:1	25x500		1.35E-04	1.76E-05	2.09E-04	7.69E-06								
#7, 25 km	100:10:1	25x500	25	2000	2400	600	800	2235	702	2242	708	4484	1.24E-02	0.0248	40.3
	100:10:1	25x500		2.65E-04	5.04E-05	3.92E-04	2.67E-05								
#7, 30 km	100:10:1	25x500	30	2400	2600	600	800	2403	756	2402	759	4804	1.04E-02	0.0208	48.1
	100:10:1	25x500		1.01E-04	4.56E-05	5.80E-04	6.05E-05								
#8, 15 km	100:10:0.1	25x500	15	2000	2400	200	400	2041	209	2044	212	4088	6.26E-02	0.1252	8.0
	100:10:1	25x500		1.31E-04	9.70E-06	2.15E-04	1.64E-11								
#8, 20 km	100:10:0.1	25x500	20	2000	2400	200	400	2281	228	2287	237	4574	4.77E-02	0.0954	10.5
	100:10:0.1	25x500		4.16E-04	5.46E-05	6.39E-04	1.33E-09								
#8, 25 km	100:10:0.1	25x500	25	2400	2600	200	400	2496	246	2497	259	4994	3.85E-02	0.077	13.0
	100:10:0.1	25x500		1.57E-04	6.14E-05	1.20E-03	2.42E-08								
#8, 30 km	100:10:0.1	25x500	30	2600	2800	200	400	2683	263	2684	278	5368	3.22E-02	0.0644	15.5
		25x500		1.42E-04	6.07E-05	1.77E-03	1.83E-07								
#9, 15 km	50:5:0.5	25x500	15	1000	1500	400	600	1413	432	1425	438	2850	3.92E-02	0.0784	12.8
		25x500		2.08E-03	5.29E-05	2.73E-04	5.39E-07								
#9, 25 km	50:5:0.5	25x500	25	1500	2000	400	600	1706	529	1723	537	3446	2.41E-02	0.0482	20.7
		25x500		3.77E-04	1.51E-05	1.20E-03	2.57E-05								
#10, 15km	20:2:0.2	25x500	15	1000	1500	200	400	1020	283	1025	299	2050	8.78E-02	0.1756	5.7
		25x500		1.41E-04	2.54E-08	4.86E-03	4.17E-07								
#10, 25km	20:2:0.2	25x500	25	1000	1500	200	400	1201	361	1226	370	2452	5.64E-02	0.1128	8.9
		25x500		8.71E-04	3.95E-06	9.86E-03	3.31E-05								
#11, 25 km		25x500	25	1000	1500	200	400	1201	361			0	5.64E-02	0.1128	8.9
				8.71E-04	3.95E-06	9.86E-03	3.31E-05								
CODE: stripi.f	CODE: stripi.f														
#20, 15km	20:2	25x500	15	1100	1200			1163		1164		2328	6.93E-01	6.93E-01	1.4
		25x500		2.70E-04	5.60E-05										
#20, 25km	20:2	25x500	25	1400	1600			1427		1428		2856	5.71E-01	5.71E-01	1.8
		25x500		1.42E-04	1.04E-05										
#21, 15km	50:5	25x500	15	1700	1710			1703		1703		3406	4.82E-01	4.82E-01	2.1
		25x500		1.03E-04	9.32E-05										
#21, 25km	50:5	25x500	25	2000	2200			2116		2117		4234	3.83E-01	3.83E-01	2.6
		25x500		2.43E-04	5.23E-05										
#22, 15km	100:10	25x500	15	2200	2400			2318		2319		4638	3.53E-01	3.53E-01	2.8
		25x500		2.20E-04	5.75E-05										
#22, 25km	100:10	25x500	25	2800	3000			2896		2897		5794	2.77E-01	2.77E-01	3.6
				1.67E-04	5.73E-05										

Plume Widths & Thicknesses (patchi & stripi results)

[Spreadsheet File ⇒ ./Bore/Analytic/Amargosa/patchi.xls)

Summary of scenarios included in report on Borehole Dilution. Methods are described on pages 24-29 of this scientific notebook. This chart supercedes (replaces) the chart on page 28; the differences are (1) more entries; and (2) centerline concentrations properly account for water table boundary condition (spreading only in 1 vertical direction).

patchi transport mini calculations, units=meters,years													dispersity		PF 9/10/97
note that the results are simulated to steady state, thus results do not depend on velocity															
FILE.dat				y1	y2	z1	z2	v	Dx	Dy	Dz	Dk	L:Ty:Tz		
farms4				-250	250	0	25	55	1100	275	1.00E-06	1.00E-16	20:5:0		
farms4b				-250	250	0	25	55	1100	275	27.5	1.00E-16	20:5:.5		
farms4c				-250	250	0	25	55	1100	275	275	1.00E-16	20:5:5		
farms4d				-250	250	0	50	55	1100	275	275	1.00E-16	20:5:5		
farms5				-250	250	0	25	10	1000	200	20	1.00E-16	100:20:2		
farms6				-250	250	0	25	10	1000	200	10	1.00E-16	100:20:1		
farms7				-250	250	0	25	10	1000	100	10	1.00E-16	100:10:1		
farms8				-250	250	0	25	10	1000	100	1	1.00E-16	100:10:0.1		
farms9				-250	250	0	25	10	500	50	5	1.00E-16	50:5:.5		
farms10				-250	250	0	25	10	200	20	2	1.00E-16	20:2:.2		
note that the following results are not dependent on velocity in steady state case															
strip#20				-250	250			10	200	20		1.00E-16	20:2		
strip#21				-250	250			10	500	50		1.00E-16	50:5		
strip#22				-250	250			10	1000	100		1.00E-16	100:10		
Code: patchi.f	Code: patchi.f		Plume												
	Dispersivities	Source Size	Distance					Interpolated estimates		Final simulated estimates			Centerline	Centerline	dilution
RUN		sq.meter	(m)	half width range		thickness range		half-width	thickness	half-width	thickness	width	half-conc.	conc	factor
#4, 15 km	20:5:0	25x500	15	1500	2000	25	25	1611	25	1625	25	3250	2.41E-01	0.482	2.1
				3.19E-04	1.75E-06										
#4, 25 km	20:5:0	25x500	25	2000	2100	25	25	2021	25	2021	25	4042	1.92E-01	0.384	2.6
		25x500		1.17E-04	5.49E-05										
#4b, 15km	20:5:0.5	25x500	15	1000	1500	250	500	1410	421	1423	437	2846	3.90E-02	0.078	12.8
	20:5:0	25x500		2.09E-03	5.13E-05	5.99E-03	1.52E-05								
#4b, 25km	20:5:0.5	25x500	25	1625	2000	500	600	1714	532	1721	537	3442	2.41E-02	0.0482	20.7
	20:5:0	25x500		1.82E-04	1.47E-05	2.11E-04	2.05E-05								
#4c, 25km	20:5:5	25x500	25	1500	1625	1000	1500	1530	1483	1531	1485	3062	7.65E-03	0.0153	65.4
	20:5:0			1.19E-04	5.79E-05	1.08E-03	9.18E-05								
#4d, 25km	20:5:5	50x500	25	1625	2000	1500	2000	1647	1600	1649	1612	3298	1.53E-02	0.0306	32.7
	20:5:0			1.16E-04	9.30E-06	1.98E-04	6.45E-06								
delineate @	20:5:0	25x500	25	1625	2000	1500	2000	1750	1701	1759	1718	3518	1.53E-02	0.0306	32.7
5.00E-04		25x500		1.16E-04	9.30E-06	1.98E-04	6.45E-06								
#5, 15 km	100:20:2	25x500	15	2400	2600	600	800	2405	757	2405	761	4810	1.04E-02	0.0208	48.1
	100:20:2	25x500		1.02E-04	4.69E-05	5.77E-04	6.20E-05								
#5, 20 km	100:20:2	25x500	20	2600	2800	800	1000	2676	845	2676	848	5352	7.38E-03	0.01476	67.8
	100:20:2	25x500		1.28E-04	6.70E-05	1.63E-04	1.88E-05								
#5, 25 km	100:20:2	25x500	25	2800	3000	800	1000	2905	918	2906	922	5812	6.27E-03	0.01254	79.7
	100:20:2	25x500		1.34E-04	7.68E-05	2.80E-04	4.88E-05								
#5, 30 km	100:20:2	25x500	30	3000	3200	800	1000	3107	986	3106	986	6212	5.23E-03	0.01046	95.6
		25x500		1.31E-04	7.90E-05	3.90E-04	9.02E-05								
#6, 15 km	100:20:1	25x500	15	2400	2600	400	600	2494	556	2495	562	4990	1.47E-02	0.0294	34.0
		25x500		1.44E-04	6.63E-05	1.18E-03	5.03E-05								
#6, 20 km	100:20:1	25x500	20	2600	2800	600	800	2783	625	2782	627	5564	1.11E-02	0.0222	45.0
	100:20:1	25x500		1.80E-04	9.46E-05	1.50E-04	5.50E-06								
#6, 25 km	100:20:1	25x500	25	3000	3200	600	800	3026	661	3027	683	6054	8.86E-03	0.01772	56.4
	100:20:1	25x500		1.08E-04	5.98E-05	2.08E-04	1.91E-05								
#6, 30 km	100:20:1	25x500	30	3200	3400	600	800	3242	726	3241	731	6482	7.39E-03	0.01478	67.7
		25x500		1.12E-04	6.55E-05	4.13E-04	4.31E-05								
#7, 15 km	100:10:1	25x500	15	1500	2000	400	600	1839	577	1852	580	3704	2.04E-02	0.0408	24.5

Capture Zone Results (./Bore/Data/capture.xls)

Summary of Results, previously discussed pages 10-12, 14-15, 20-23 this notebook.

Capture Zone tabulation
units are in meters, days

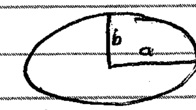
input (RF 10/24/97) — output (RF 9/10/97)

In Report #ID	ID #	Description	Screen	Qp	head grad	Transmis	Width	Thick	not captured on top
1	1	dom base, Qp=1	940-1000	1	0.005	100	29	73	
2	2	dom base, Qp=2	940-1000	2	0.005	100	54	82	
3	3	dom base, Qp=3	940-1000	3	0.005	100	76	88	
4	4	dom base, Qp=4	940-1000	4	0.005	100	97	96	
5	5	dom base, Qp=6.815	940-1000	6.815	0.005	100	146	113	
6	6	dom, Qp=37.5, 11 well	940-1000	37.5	0.005	100	418	224	
7	7	dom,Qp=75, 11 well	940-1000	75	0.005	100	607	309	
8	8	irr base, Qp=300	940-1000	300	0.005	100	1292	575	
9	9	irr base, Qp=800	940-1000	800	0.005	100	2330	825	
10	10	irr base, Qp=1380	940-1000	1380	0.005	100	3382	941	
11	11	irr base, Qp=2000	940-1000	2000	0.005	100	4450	985	
12	12	dom, Ksat=.01	940-1000	3	0.005	10	369	203	
13	13	dom, Ksat=.05	940-1000	3	0.005	50	133	108	
14	14	dom, Ksat=.1	940-1000	3	0.005	100	76	88	
15	15	dom, Ksat=.4	940-1000	3	0.005	400	22	70	
16	16	dom, grad=.001	940-1000	3	0.001	100	248	151	
17	17	dom, grad=.0025	940-1000	3	0.0025	100	133	108	
18	18	dom, grad=.005	940-1000	3	0.005	100	76	88	
19	19	dom, grad=.01	940-1000	3	0.01	100	41	78	
20	20	dom, screen position a	940-1000	3	0.005	100	76	88	
21	21	dom, screen position b	930-990	3	0.005	100	69	98	0
22	22	dom, screen position c	920-980	3	0.005	100	67	107	5
23	42	dom, screen position d	900-960	3	0.005	100	68	127	21
24	23	dom, screen length a	980-1000	3	0.005	100	115	65	
25	24	dom, screen length b	940-1000	3	0.005	100	76	88	
26	25	dom, screen length c	900-1000	3	0.005	100	51	122	
27	26	fully penetrating	0-1000	300	0.005	100	574	1000	
28	27	half penetration	500-1000	300	0.005	100	940	752	
29	28	max actual screen	810-1000	300	0.005	100	1238	601	
30	29	base screen length	940-1000	300	0.005	100	1292	575	
31	30	irrig Ksat=.05	940-1000	300	0.005	50	1944	751	
32	31	irrig, Ksat=.1	940-1000	300	0.005	100	1292	575	
33	32	irrig, Ksat=.2	940-1000	300	0.005	200	876	424	
34	33	irrig, Ksat=.3	940-1000	300	0.005	300	705	352	
35	34	irrig, Ksat=.4	940-1000	300	0.005	400	607	309	
36	35	irrig, Ksat=.2	940-1000	2116	0.005	200	2810	890	
37	36	irrig, Ksat=.3	940-1000	2116	0.005	300	2146	793	
38	37	irrig, Ksat=.4	940-1000	2116	0.005	400	1798	719	
39	38	irrig, grad=.001	940-1000	2116	0.001	400	5596	1000	
40	39	irrig, grad=.002	940-1000	2116	0.002	400	3282	934	
41	40	irrig, grad=.003	940-1000	2116	0.003	400	2486	850	
42	41	irrig, grad=.005	940-1000	2116	0.005	400	1798	719	
	42	see above							

Dilution Factor Calculations

Calculation of Areas, general comments:

(1.) area of an ellipse = $\pi a b$



(i) since plume shapes (3D-dispersed plumes) are approximated here as half ellipses as are capture areas for large pumpage wells

area ~~half-ellipse~~ $= \frac{\pi a b}{2}$

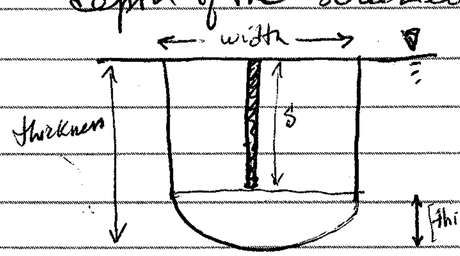
and widths $= 2a$, thickness $= b$

Hence capture area large ~~pumpage~~ pumpage wells & plumes (3D)

$$\frac{\pi}{2}\left[\frac{\text{width}}{2}\right]\left[\text{thickness}\right]$$

(ii) domestic wells (small pumpage) are not approximated very well by an ellipse due to the relative size of the screened portion to the capture area (especially thickness). So, break apart the areas depending upon the depth of the screened portion

RF 3/23/99

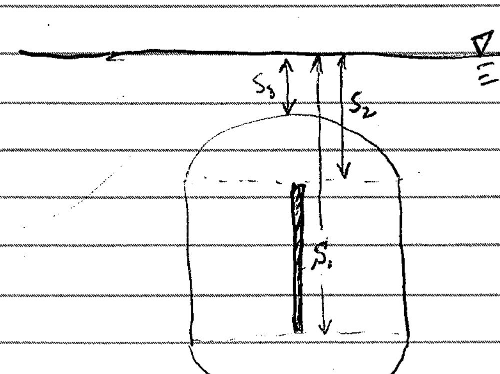


RF 9/10/97

area = [width × ~~thickness~~ S] + $\left[\frac{\pi}{2}\left(\frac{\text{width}}{2}\right)(\text{thick} - S)\right]$

where S = screened length = distance of bottom of screen from ground surface (water table)

RF 3/23/99



For the case where the screen is significantly below the water table,

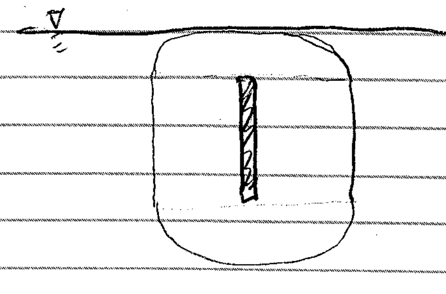
S_3 = length not captured on top

~~area = [width × (thickness~~

area = [width × $(S_1 - S_2)$]

$+\left[\frac{\pi}{2}\left(\frac{\text{width}}{2}\right)(S_2 - S_3)\right]$

$+\left[\frac{\pi}{2}\left(\frac{\text{width}}{2}\right)(\text{thickness} - S_1)\right]$



For domestic well case where screen is near but not at water table, the top portion may not be well approximated by an half ellipse nor a rectangle. So I used the average of those two shapes (their areas) for the top or portion of capture area above the screen. This is the "average" noted in the spreadsheet tables for domestic well capture areas.

(2.) scenarios for intersection of areas of plume and capture area

RF 3/23/99

(i) For the thin plumes, the plume area is simply the width times the specified thickness. The thin plumes are ~~def~~ defined as those modeled with no vertical dispersion, hence the thickness never changes (and is uniform across the width of the plume).

RF 3/23/99

~~(ii) 3D plume~~ The intersection area of the thin plume with domestic wells is ⇒ plume ~~thickness~~ thickness × capture zone width

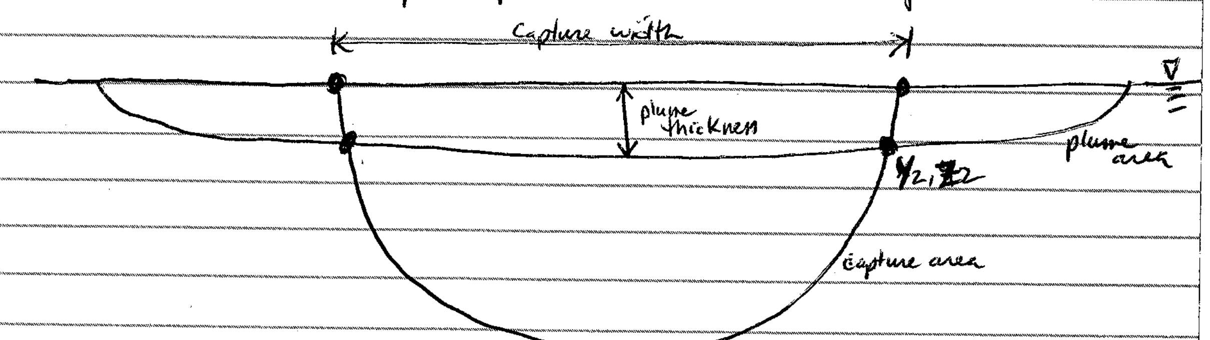
The intersection area of the thin plume with irrigation wells depends on which is wider

⇒ plume thickness × Max | capture width, Plume width |

RF 3/23/99

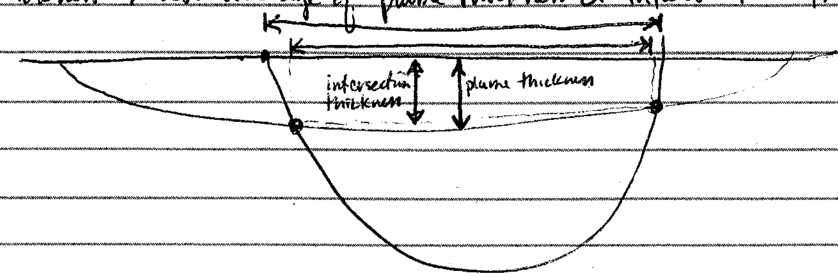
(ii) 3D plume intersection with capture areas

This is typically a comparison of an ellipse which is wide and thin (plume) to an ellipse which is narrow and thick (capture). This intersection may be approximated as a rectangle

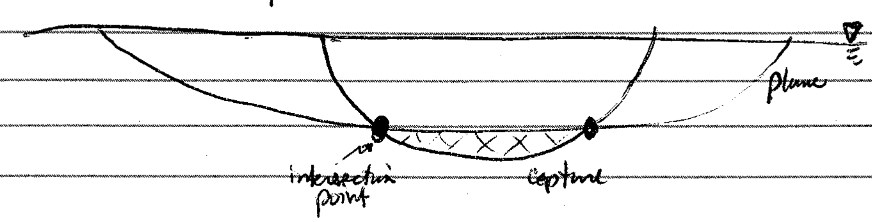


The first step is to determine the intersection points of the two ellipses (y_2, z_2) using the graphical package tecplot which can create ellipses of specified dimensions, then allows zooming in to get precision on cursor location of intersection of the two curves).

To get the area of the rectangle
width ⇒ use average of capture width & intersection width
thickness ⇒ use average of plume thickness & intersection thickness



(iii) 3D plume & capture area where the thicknesses of each are nearly the same



Calculate the plume contribution to the pumping by subtracting the shaded area from the capture area. The shaded area is approximated as an ellipse with the width and thickness obtained from the intersection points of the two big ellipses.

The following two pages contain the spreadsheet printout of the scenarios
./Bore/Data/intersec.xls

followed by a record by record notation of how the plume contribution was calculated

PF 9/10/97

Intersection data table for plume and capture zone
Equation for calculation of insection area depends on which is wider, plume or capture zone
Tecplot file intersect.lay is used to graphically determine intersection of the two ellipses.
units are in meters

	Plume Description	Capture Description	plume width(m)	plume thick(m)	capture width(m)	capture thick(m)	normalized to capture width tecplot a_p	tecplot b_p	tecplot a_c	tecplot b_c	tecplot x_i	tecplot y_i	half width x_i	thick y_i	Area capture	Area of Plume contrib	borehole conc	dispersion conc	total df	Borehole Dilution Facotr
	Pump Rates, Irrigation																			
1	#10 @25km,20:2:.2	#8, base,Qp=300	2452	370	1292	575	1.898	0.143	1.000	0.223	0.815	0.129	526.6	333.3	5.83E+05	4.12E+05	0.71	0.113	13	1.4
2	#10 @25km,20:2:.2	#9, base,Qp=800	2452	370	2330	825	1.052	0.079	1.000	0.177	0.987	0.027	1150.3	127.2	1.51E+06	5.76E+05	0.38	0.113	23	2.6
3	#10 @25km,20:2:.2	#10, base,Qp=1380	2452	370	3382	941	0.725	0.055	1.000	0.139				N/A	2.50E+06	7.13E+05	0.29	0.113	31	3.5
4	#10 @25km,20:2:.2	#11, base,Qp=2000	2452	370	4450	985	0.551	0.042	1.000	0.111				N/A	3.44E+06	7.13E+05	0.21	0.113	43	4.8
	smaller irrigation well																			
5	#10 @25km,20:2:.2	#30, K=.05	2452	370	1944	751	1.261	0.095	1.000	0.193	0.950	0.063	923.4	244.2	1.15E+06	4.40E+05	0.38	0.113	23	2.6
6	#10 @25km,20:2:.2	#31, K=.1	2452	370	1292	575	1.898	0.143	1.000	0.222	0.831	0.129	536.8	333.6	5.83E+05	3.22E+05	0.55	0.113	16	1.8
7	#10 @25km,20:2:.2	#32, K=.2	2452	370	876	424	2.799	0.211	1.000	0.242	0.515	0.207	225.4	363.4	2.92E+05	2.02E+05	0.69	0.113	13	1.4
8	#10 @25km,20:2:.2	#33, K=.3	2452	370	705	352	3.479	0.262	1.000	0.250				N/A	1.95E+05	1.95E+05	1.00	0.113	9	1.0
9	#10 @25km,20:2:.2	#34, K=.4	2452	370	607	309	4.041	0.305	1.000	0.254				N/A	1.47E+05	1.47E+05	1.00	0.113	9	1.0
	large pumpage well																			
10	#10 @25km,20:2:.2	#35, K=.2	2452	370	2810	890	0.873	0.066	1.000	0.158				N/A	1.96E+06	7.13E+05	0.36	0.113	24	2.8
11	#10 @25km,20:2:.2	#36, K=.3	2452	370	2146	793	1.143	0.086	1.000	0.185	0.969	0.045	1039.6	195.0	1.34E+06	4.50E+05	0.34	0.113	26	3.0
12	#10 @25km,20:2:.2	#37, K=.4	2452	370	1798	719	1.364	0.103	1.000	0.200	0.925	0.076	831.4	271.9	1.01E+06	4.22E+05	0.42	0.113	21	2.4
	large pumpage well																			
13	#10 @25km,20:2:.2	#38, grad=.001	2452	370	5596	1000	0.438	0.033	1.000	0.089				N/A	4.40E+06	7.13E+05	0.16	0.113	55	6.2
14	#10 @25km,20:2:.2	#39, grad=.002	2452	370	3282	934	0.747	0.056	1.000	0.142				N/A	2.41E+06	7.13E+05	0.30	0.113	30	3.4
15	#10 @25km,20:2:.2	#40, grad=.003	2452	370	2486	850	0.986	0.074	1.000	0.171				N/A	1.66E+06	7.13E+05	0.43	0.113	21	2.3
16	#10 @25km,20:2:.2	#41, grad=.005	2452	370	1798	719	1.364	0.103	1.000	0.200	0.925	0.076	831.4	271.9	1.01E+06	1.01E+06	1.00	0.113	9	1.0
	Pump Rates, Irrigation																			
17	#8 @25km,100:10:0.1	#8, base,Qp=300	4994	259	1292	575	3.865	0.100	1.000	0.223	0.900	0.097	581.3	250.9	5.83E+05	3.13E+05	0.54	0.077	24	1.9
18	#8 @25km,100:10:0.1	#9, base,Qp=800	4994	259	2330	825	2.143	0.056	1.000	0.177	0.959	0.050	1116.9	232.3	1.51E+06	5.61E+05	0.37	0.077	35	2.7
19	#8 @25km,100:10:0.1	#10, base,Qp=1380	4994	259	3382	941	1.477	0.038	1.000	0.139	0.978	0.029	1654.0	193.0	2.50E+06	7.56E+05	0.30	0.077	43	3.3
20	#8 @25km,100:10:0.1	#11, base,Qp=2000	4994	259	4450	985	1.122	0.029	1.000	0.111	0.992	0.013	2206.8	119.4	3.44E+06	8.39E+05	0.24	0.077	53	4.1
	smaller irrigation well																			
21	#8 @25km,100:10:0.1	#30, K=.05	4994	259	1944	751	2.569	0.067	1.000	0.193	0.946	0.062	919.8	241.3	1.15E+06	3.58E+05	0.31	0.077	42	3.2
22	#8 @25km,100:10:0.1	#31, K=.1	4994	259	1292	575	3.865	0.100	1.000	0.222	0.899	0.097	580.4	251.2	5.83E+05	2.39E+05	0.41	0.077	32	2.4
23	#8 @25km,100:10:0.1	#32, K=.2	4994	259	876	424	5.701	0.148	1.000	0.242	0.795	0.146	348.2	256.5	2.92E+05	1.58E+05	0.54	0.077	24	1.8
24	#8 @25km,100:10:0.1	#33, K=.3	4994	259	705	352	7.086	0.184	1.000	0.250	0.681	0.183	239.8	258.0	1.95E+05	1.22E+05	0.63	0.077	21	1.6
25	#8 @25km,100:10:0.1	#34, K=.4	4994	259	607	309	8.230	0.213	1.000	0.254	0.547	0.212	165.8	257.6	1.47E+05	9.98E+04	0.68	0.077	19	1.5
	large pumpage well																			
26	#8 @25km,100:10:0.1	#35, K=.2	4994	259	2810	890	1.777	0.046	1.000	0.158	0.970	0.038	1362.1	215.2	1.96E+06	6.56E+05	0.33	0.077	39	3.0
27	#8 @25km,100:10:0.1	#36, K=.3	4994	259	2146	793	2.327	0.060	1.000	0.185	0.955	0.055	1024.5	233.9	1.34E+06	5.17E+05	0.39	0.077	34	2.6
28	#8 @25km,100:10:0.1	#37, K=.4	4994	259	1798	719	2.778	0.072	1.000	0.200	0.941	0.068	845.7	242.9	1.01E+06	4.38E+05	0.43	0.077	30	2.3
	large pumpage well																			
29	#8 @25km,100:10:0.1	#38, grad=.001	4994	259	5596	1000	0.892	0.023	1.000	0.089				N/A	4.40E+06	1.02E+06	0.23	0.077	56	4.3
30	#8 @25km,100:10:0.1	#39, grad=.002	4994	259	3282	934	1.522	0.039	1.000	0.142	0.977	0.030	1603.3	195.6	2.41E+06	7.37E+05	0.31	0.077	42	3.3
31	#8 @25km,100:10:0.1	#40, grad=.003	4994	259	2486	850	2.009	0.052	1.000	0.171	0.964	0.045	1197.8	225.7	1.66E+06	5.92E+05	0.36	0.077	36	2.8
32	#8 @25km,100:10:0.1	#41, grad=.005	4994	259	1798	719	2.778	0.072	1.000	0.200	0.941	0.068	845.7	243.4	1.01E+06	4.38E+05	0.43	0.077	30	2.3

	plume scenario	well capture scenario	plume width(m)	plume thick(m)	capture width(m)	capture thick(m)	Thickness Not Captured					note avg for 2nd record below		Area capture	Area Plume contrib	borehole conc	dispersion conc	total df	Borehole Borehole Factor
33	#20, 25 m thick @25km	#21, 940-1000	2856	25	76	87.8	0.0					6.32E+03	6.18E+03	6.22E+03	1.90E+03	0.31	0.571	6	3.3
34	#20, 25 m thick @25km	#22, 930-990	2856	25	69	97.5	0.2	1.000	0.286	0.864	0.143	59.8		6.25E+03	1.46E+03	0.23	0.571	7	4.3
35	#20, 25 m thick @25km	#23, 920-980	2856	25	67	107.2	4.7							6.28E+03	1.17E+03	0.19	0.571	9	5.4
36	#20, 25 m thick @25km	#42, 900-960	2856	25	68	126.6	20.5	1.000	0.288	0.639	0.222	43.2		6.50E+03	1.53E+02	0.02	0.571	75	42.6
37	#20, 25 m thick @ 15km	#21, 940-1000	2328	25	76	87.8	0.0					6.32E+03	6.18E+03	6.22E+03	1.90E+03	0.31	0.693	5	3.3
38	#20, 25 m thick @ 15km	#22, 930-990	2328	25	69	97.5	0.2	1.000	0.286	0.864	0.143	59.8		6.25E+03	1.46E+03	0.23	0.693	6	4.3
39	#20, 25 m thick @ 15km	#23, 920-980	2328	25	67	107.2	4.7							6.28E+03	1.17E+03	0.19	0.693	8	5.4
40	#20, 25 m thick @ 15km	#42, 900-960	2328	25	68	126.6	20.5	1.000	0.288	0.639	0.222	43.2		6.50E+03	1.53E+02	0.02	0.693	62	42.6
41	10 m thick	#21, 940-1000		10	76	87.8	0.0					6.32E+03	6.18E+03	6.22E+03	7.60E+02	0.12			8.2
42	10 m thick	#22, 930-990		10	69	97.5	0.2					6.78E+02	5.33E+02	6.25E+03	6.05E+02	0.10			10.3
43	10 m thick	#23, 920-980		10	67	107.2	4.7					58.1		6.28E+03	2.42E+02	0.04			25.9
45	10 m thick	#42, 900-960		10	68	126.6	20.5							6.50E+03	0.00E+00	0.00			N/A
46	25 m thick	#1, Q=1		25	28.6	72.6	0.0							2.00E+03	7.15E+02	0.36			2.8
47	25 m thick	#2, Q=2		25	54.0	81.5	0.0							4.15E+03	1.35E+03	0.33			3.1
48	25 m thick	#3, Q=3		25	76.0	87.8	0.0							6.22E+03	1.90E+03	0.31			3.3
49	25 m thick	#4, Q=4		25	97.4	95.6	0.0							8.57E+03	2.44E+03	0.28			3.5
50	25 m thick	#5, Q=6.815		25	146.2	112.3	0.0							1.48E+04	3.66E+03	0.25			4.0
51	25 m thick	#6, Q=37.5		25	417.6	224.3	0.0							7.89E+04	1.04E+04	0.13			7.6
52	25 m thick	#7, Q=75		25	607.4	308.6	0.0							1.55E+05	1.52E+04	0.10			10.2
53	10 m thick	#1, Q=1		10	28.6	72.6	0.0							2.00E+03	2.86E+02	0.14			7.0
54	10 m thick	#2, Q=2		10	54.0	81.5	0.0							4.15E+03	5.40E+02	0.13			7.7
55	10 m thick	#3, Q=3		10	76.0	87.8	0.0							6.22E+03	7.60E+02	0.12			8.2
56	10 m thick	#4, Q=4		10	97.4	95.6	0.0							8.57E+03	9.74E+02	0.11			8.8
57	10 m thick	#5, Q=6.815		10	146.2	112.3	0.0							1.48E+04	1.46E+03	0.10			10.1
58	10 m thick	#6, Q=37.5		10	417.6	224.3	0.0							7.89E+04	4.18E+03	0.05			18.9
59	10 m thick	#7, Q=75		10	607.4	308.6	0.0							1.55E+05	6.07E+03	0.04			25.5
60	25 m thick	#12, K=.01		25	369.0	203.1	0.0							6.36E+04	9.23E+03	0.15			6.9
61	25 m thick	#13, K=0.5		25	133.2	108.2	0.0							1.30E+04	3.33E+03	0.26			3.9
62	25 m thick	#14 K=01		25	76.0	87.8	0.0							6.22E+03	1.90E+03	0.31			3.3
63	25 m thick	#15, K=.4		25	21.8	70.3	0.0							1.48E+03	5.45E+02	0.37			2.7
64	25 m thick	#16, grad=.001		25	248.0	151.2	0.0							3.26E+04	6.20E+03	0.19			5.3
65	25 m thick	#17, grad=.0025		25	133.4	108.2	0.0							1.31E+04	3.34E+03	0.26			3.9
66	25 m thick	#18, grad=.005		25	76.0	87.8	0.0							6.22E+03	1.90E+03	0.31			3.3
67	25 m thick	#19, grad=.01		25	41.2	77.5	0.0							3.04E+03	1.03E+03	0.34			2.9
68	10 m thick	#12, K=.01		10	369.0	203.1	0.0							6.36E+04	3.69E+03	0.06			17.2
69	10 m thick	#13, K=0.5		10	133.2	108.2	0.0							1.30E+04	1.33E+03	0.10			9.8
70	10 m thick	#14 K=01		10	76.0	87.8	0.0							6.22E+03	7.60E+02	0.12			8.2
71	10 m thick	#15, K=.4		10	21.8	70.3	0.0							1.48E+03	2.18E+02	0.15			6.8
72	10 m thick	#16, grad=.001		10	248.0	151.2	0.0							3.26E+04	2.48E+03	0.08			13.2
73	10 m thick	#17, grad=.0025		10	133.4	108.2	0.0							1.31E+04	1.33E+03	0.10			9.8
74	10 m thick	#18, grad=.005		10	76.0	87.8	0.0							6.22E+03	7.60E+02	0.12			8.2
75	10 m thick	#19, grad=.01		10	41.2	77.5	0.0							3.04E+03	4.12E+02	0.14			7.4
	Pump Rates, Irrigation																		
76	25 m thick; 20:2	#8, base,Qp=300	2856	25	1292	575								6.00E+05	3.23E+04	0.05			18.6
77	25 m thick; 20:2	#9, base,Qp=800	2856	25	2330	825								1.54E+06	5.83E+04	0.04			26.4
78	25 m thick; 20:2	#10, base,Qp=1380	2856	25	3382	941								2.54E+06	7.14E+04	0.03			35.6
79	25 m thick; 20:2	#11, base,Qp=2000	2856	25	4450	985								3.50E+06	7.14E+04	0.02			49.0
80	25 m thick; 50:5	#8, base,Qp=300	4234	25	1292	575								6.00E+05	3.23E+04	0.05			18.6
81	25 m thick; 50:5	#9, base,Qp=800	4234	25	2330	825								1.54E+06	5.83E+04	0.04			26.4
82	25 m thick; 50:5	#10, base,Qp=1380	4234	25	3382	941								2.54E+06	8.46E+04	0.03			30.1
83	25 m thick; 50:5	#11, base,Qp=2000	4234	25	4450	985								3.50E+06	1.06E+05	0.03			33.1
84	25 m thick; 100:10	#8, base,Qp=300	5796	25	1292	575								6.00E+05	3.23E+04	0.05			18.6
85	25 m thick; 100:10	#9, base,Qp=800	5796	25	2330	825								1.54E+06	5.83E+04	0.04			26.4
86	25 m thick; 100:10	#10, base,Qp=1380	5796	25	3382	941								2.54E+06	8.46E+04	0.03			30.1
87	25 m thick; 100:10	#11, base,Qp=2000	5796	25	4450	985								3.50E+06	1.11E+05	0.03			31.5

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1	R	31	R	61	R2
2	R	32	R	62	↓
3	e	33	R2	63	↓
4	e	34	SC	64	↓
5	e	35	SC	65	↓
6	e	36	SC	66	↓
7	e	37	R2	67	↓
8	p	38	SC	68	↓
9	p	39	SC	69	↓
10	e	40	SC	70	↓
11	R	41	R2	71	↓
12	R	42	↓	72	↓
13	e	43	↓	73	↓
14	e	44	↓	74	↓
15	e	45	↓	75	↓
16	p	46	↓	76	↓
17	R	47	↓	77	↓
18	↓	48	↓	78	R3
19	↓	49	↓	79	R3
20	↓	50	↓	80	R2
21	↓	51	↓	81	R2
22	↓	52	↓	82	R2
23	↓	53	↓	83	R3
24	↓	54	↓	84	R2
25	↓	55	↓	85	↓
26	↓	56	↓	86	↓
27	↓	57	↓	87	↓
28	↓	58	↓		
29	e	59	↓		
30	R	60	↓		

e = ellipse ⇒ $\frac{\pi}{2}\left(\frac{\text{plume width}}{2}\right)(\text{plume thickness})$
area of capture greater than plume area

R = area of rectangle as described page 47, item 2(ii)

p ⇒ plume larger than capture area, use area of ellipse of plume

R2 ⇒ plume thickness × capture width
rectangular shape

R3 ⇒ plume thickness × plume width
rectangular shape

SC ⇒ screen complex area combining items 1(ii) and item 2(i) and 2(iii)

Y2K compliance (change date on computer to greater than 2001)

Year 2001 compliance check for software packages

GFLOW ver 1.1
patchi ver 1.1
stripi ver 1.1

GFLOW pc-DOS based program, executable only
① has no date stamp for output or interactive on screen
② calculations verified before and after year change - okay.

patchi fortran 77 code, currently compiled on UNIX, SUN platform
① I had to change the system calls to get a time stamp when I first compiled the program
(USGS compiler has different system calls for the date)
The change I made is not Y2K compliant. This is something I have to fix, not something wrong with the code as distributed by the USGS
② calculations are correct regardless of time stamp ~~as~~ indicated by running same problem before and after the year change.
credits to IMS staff for changing the date for me since I do not have access (root).
Of course this caused WABI to be very slow until I found IMS staff to reboot the machine again after changing back the date (after they changed the date back).

RF 3/23/99

stripi - ditto comments from patchi

Source Term or Boundary Condition for Plume Configuration.

In response to Bob Baca's comment on Technical Review of report to account for dilution due to "passive transport" (dispersion during transport), additional approaches need to be determined. Baca wanted the concentration distribution within the plume to be accounted for in the dilution factor due to pumping wells.

However, Gordon & I had removed all mention of concentration in the plume (we had used centerline concentration as conservative representation of the plume) because Schwartz in the EPRI TSPA-96 (Kessler and McGuire, 1996) had already analyzed the passive dispersion and this report was not intending to re-do Schwartz's analysis. We were only trying to obtain the plume shape & dimensions.

In the technical review, Baca also wanted to make a better connection with the TPA approach for dilution factor (df):

$$df = \frac{\dot{M}}{Q}$$

The mass release rate from the repository ($\dot{M}$) is divided by the largest of 3 possible volumetric fluxes
① infiltrating water through repository
② Q in the aquifer below the footprint in which the release is introduced
③ total pumping of the critical group (at 5 km or 30 km location).

To make any connection with the TPA code, a mass release rate should be used as a source term for the advective-dispersive transport - not a constant concentration boundary as in Wexler (1992) used so far in this work (and as used by Schwartz in Kessler and McGuire (1996) in the EPRI TSPA-96). Hence there is no reason to integrate a non-uniform plume and it's contribution within the capture zone. Rather, new solutions for advective-dispersive equations

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are needed. Analytical solutions of Codell and others (1982) in NUREG-0868 are for mass release rate as a source term. Then the dilution factors for passive transport and borehole (pumping) dilution would link the mass release of TPA to the pumping amount in Amargosa Farms. This is something which could not be done with dirichlet boundary condition for advective-dispersive transport since it is comparing apples and oranges (dirichlet b.c. to mass release rate; the mass release rate is similar to a flux boundary condition, just a conversion of mass to concentration at the source area of the domain).

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Codell and others (1982) NUREG-0868 analytical solutions use the approach of an instantaneous release of mass for a wide variety of point source, line source, depth averaged solution result, and horizontal patch source. Any of these solutions can then use the convolution integral to integrate over time for a mass release rate. The mass release rate can be uniform (constant) or some function since a numerical integrator is used (Simpson's Rule).

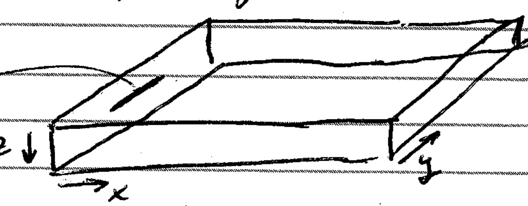
None of Codell's solutions are comparable in source configuration in terms of:

1. my 3-D solution is for a vertical patch source oriented perpendicular to flow
2. My 2-D solutions (really Wexler's) are a line source at the water table with no vertical dispersion

One possible usage is to assume Codell's horizontal patch source at the water table is similar to Wexler's line source at the water table. ~~The~~ For long distances (x-distance from source), the line ~~versus~~ patch is no problem. However, Codell uses vertically averaged solution in z-direction (vertical). To use Codell's solution, I would have to assume that the aquifer is a unit thickness (=1) and that this would be the same as no vertical dispersion in my "thin" plumes from Wexler's 2-D line solutions.

The reason I am trying to mimic my previous source sizes (patch for 3-D dispersion problem and line for "thin" plume) is that I only want to model advective-dispersion from the "accessible environment or fence" which is about 5 km from repository. Somewhere beyond this point, the flow would enter the alluvial aquifer. To model advective-dispersive transport from this "accessible environ or fence", I would like to use a vertical patch.

Another possibility to utilize Codell's approach is to analytically or numerically integrate his line source



The numerical approach would be similar to the approach used by Domenico & Robbins (as used by Schwartz in TSPA-96 EPRI). Since modifying Codell and others (1982) solution would mean more extensive TOP-018 work (code verification, validation) and not just installation testing, it would be much more efficient if an existing code could be used. Here's the collection of the primary references for analytical solutions as used in the groundwater field: (3-dimensional)

3D analytical solution for solute transport

G-T Yeh, 1981: AT123D: Analytical transient one-, two-, and three-dimensional simulation of waste transport in an aquifer system. ORNL-5602. OAK Ridge National Lab.

Chris Neville developed one 3-d analytical solution for transport from a patch boundary several years ago. See Zheng and Bennett (1995) " Applied Contaminant tranposrt modeling", by Van Nostrand Reinhold.

Domenico and Schwartz 1990 "Physical and Chemical Hydrogeology", Chapter 17. The new edition (1997) has better solutions and examples.

Javandel et al., 1984 "Ground water Transport: Handbook of mathematical models" has some analytical solutions.

Wexler's (1992) technical publication for the USGS (my copy).

Codell's (1982) NUREG-0868 has instantaneous mass release solutions which he then uses the convolution integral (Simpson's Rule) to integrate over time to get a mass release rate source term.

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Development of 2-D vertical patch source from Codell's (NUREG-0868) line source

The solution for an instantaneous mass release solved using Green's functions is (for the general case)

$$C_i = \frac{1}{n_e R_d} X(x,t)\, Y(y,t)\, Z(z,t)$$

C = concentration of species i at some downgradient point
n_e: effective porosity
R_d = retardation = $1 + \frac{\rho_b K_d}{n}$ { n = porosity, ρ_b = bulk density, K_d = distribution coefficient }

For a line source at depth Z_s in an aquifer of infinite ~~lateral extent and depth extent thickness "h"~~ RF 9/29/97
lateral extent and depth [p. 3.7, case (6) of NUREG-0868]

$C_i = \frac{1}{n_e R_d} X_1 Y_2 Z_3$ where

$$X_1 = \frac{1}{\sqrt{4\pi E_x t/R_d}} \exp\left[-\frac{\left(x - \frac{ut}{R_d}\right)^2}{4E_x t/R_d} - \lambda t\right]$$

$$Y_2 = \frac{1}{2b}\left\{\operatorname{erf}\frac{\left(\frac{b}{2}+y\right)}{\sqrt{4E_y t/R_d}} + \operatorname{erf}\frac{\left(\frac{b}{2}-y\right)}{\sqrt{4E_y t/R_d}}\right\}$$

$$Z_3 = \frac{1}{\sqrt{4\pi E_z \frac{t}{R_d}}}\left\{\exp\left(-\frac{[z-z_s]^2}{4E_z t/R_d}\right) + \exp\left(-\frac{[z+z_s]^2}{4E_z \frac{t}{R_d}}\right)\right\}$$

where exp = exponential
erf = error function
E_x, E_y, E_z = dispersion coefficients in x, y, z, directions
t = time
b = entire width of line source in y-direction
u = velocity (from Codell's development, this has to be seepage or particle velocity)

So far, nothing new has been developed. Everything on previous page is from NUREG-0868

I would like to have a vertically-oriented patch source instead of Codell's line source. All I have to do is integrate the Z component (Green function) from a line at depth z_s to a patch from depth z_{s1} to z_{s2}. Both line & patch are of width ~~??~~ b, but of course, we are not changing the X or Y components of the solution. Use Z_4 to denote patch solution.

For the patch solution $C_i = \frac{1}{n_e R_d} X_1 Y_2 Z_4$

where Z_4 is the integral of Codell's Z_3

$$Z_4 = \int_{z_{s1}}^{z_{s2}} \frac{1}{4\pi E_z t/R_d}\left\{\exp\left(-\frac{[z-z_s]^2}{4E_z t/R_d}\right) + \exp\left(-\frac{[z+z_s]^2}{4E_z t/R_d}\right)\right\} dz_s$$

which can be broken-down into

$$Z_4 = \frac{1}{4\pi E_z t/R_d}\left\{\int_{z_{s1}}^{z_{s2}} \exp\left(-\frac{[z-z_s]^2}{4E_z t/R_d}\right) + \int_{z_{s1}}^{z_{s2}} \exp\left(-\frac{[z+z_s]^2}{4E_z t/R_d}\right)\right\}$$

Now these are nice looking integrals (they are of the same form); but, fortunately I can look up the result of the integration in integral tables (according to Wexler (1992) reference to Abramowitz & Stegun (1964) p. 303, eq 7.4.32)

$$\int \exp\left[-(ax^2 + 2bx + c)\right] dx = \frac{1}{2}\sqrt{\frac{\pi}{a}} \exp\left[\frac{b^2 - ac}{a}\right] \operatorname{erf}\left(\sqrt{a}\,x + \frac{b}{\sqrt{a}}\right) + C^*$$

where C^* is an arbitrary integration constant which I am dropping now by saying it's arbitrarily equal to zero.

Note that

$$\frac{-[z-z_s]^2}{4E_z t/R_d} = \frac{-[z^2 - 2zz_s + z_s^2]}{4E_z t/R_d} = -\left[\frac{z_s^2}{4E_z t/R_d} - \frac{2zz_s}{4E_z t/R_d} + \frac{z^2}{4E_z t/R_d}\right]$$

Hence for this problem $x \Rightarrow \mathfrak{z}_s$ $a \Rightarrow \frac{1}{4E_z t/R_d}$ $b \Rightarrow \frac{-z}{4E_z t/R_d}$ $c \Rightarrow \frac{z^2}{4E_z t/R_d}$

for simplicity, let $\eta = 4E_z t/R_d$ $a = 1/\eta$

Z_4 has been separated into two integrals; the result of the first integral

$$\int_{z_{s1}}^{z_{s2}} \exp\left(-\frac{[z-\mathfrak{z}_s]^2}{\eta}\right) d\mathfrak{z}_s = \frac{1}{2}\sqrt{\eta\pi}\ \exp\left[\frac{\left(\frac{z}{\eta}\right)^2 - \frac{1}{\eta}\frac{z^2}{\eta}}{1/\eta}\right] \operatorname{erf}\left[\sqrt{\tfrac{1}{\eta}}\ \mathfrak{z}_s + \frac{(-z/\eta)}{\sqrt{1/\eta}}\right] + C^*$$

$$= \left\{\frac{\sqrt{\eta\pi}}{2}\exp\left[\frac{(z^2 - z^2)}{\eta}\right] \operatorname{erf}\left[\frac{\mathfrak{z}_s}{\sqrt{\eta}} - \frac{z}{\sqrt{\eta}}\right]\right\}\Bigg|_{z_{s1}}^{z_{s2}}$$

(zero) (evaluated at)

note: $\exp(0) = 1$

$$= \frac{\sqrt{\eta\pi}}{2}\operatorname{erf}\left[\frac{\mathfrak{z}_s - z}{\sqrt{\eta}}\right]\Bigg|_{z_{s1}}^{z_{s2}}$$

$$= \frac{\sqrt{4E_z\pi\frac{t}{R_d}}}{2}\left\{\operatorname{erf}\left[\frac{z_{s2}-z}{\sqrt{4E_z t/R_d}}\right] - \operatorname{erf}\left[\frac{z_{s1}-z}{\sqrt{4E_z t/R_d}}\right]\right\}$$

Changing to complementary error function $\Rightarrow$ erfc = 1 - erf

$$\int_{z_{s1}}^{z_{s2}} \exp\left(-\frac{[z-\mathfrak{z}_s]^2}{4E_z t/R_d}\right) d\mathfrak{z}_s = \sqrt{\pi E_z t/R_d}\left\{\operatorname{erfc}\left[\frac{z_{s1}-z}{2\sqrt{E_z t/R_d}}\right] - \operatorname{erfc}\left[\frac{z_{s2}-z}{2\sqrt{E_z t/R_d}}\right]\right\}$$

Now, similarly for the second integral

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$$\int_{z_{s1}}^{z_{s2}} \exp\left(-\frac{[z+\mathfrak{z}_s]^2}{4E_z t/R_d}\right) d\mathfrak{z}_s \qquad \text{note that } \frac{(z+\mathfrak{z}_s)^2}{4E_z t/R_d} = \frac{\mathfrak{z}_s^2 + 2z\mathfrak{z}_s + z^2}{4E_z t/R_d}$$

Then using the solution from the integral table, letting

$x \Rightarrow \mathfrak{z}_s$ $a = \frac{1}{4E_z t/R_d} = \frac{1}{\eta}$ $b \Rightarrow \frac{z}{\eta}$ $c \Rightarrow \frac{z^2}{\eta}$

then

$$\int_{z_{s1}}^{z_{s2}} \exp\left(-\frac{[z+\mathfrak{z}_s]^2}{4E_z t/R_d}\right) d\mathfrak{z}_s = \frac{1}{2}\sqrt{\eta\pi}\ \exp\left[\frac{\frac{z^2}{\eta^2} - \frac{1}{\eta}\frac{z^2}{\eta}}{(1/\eta)}\right] \operatorname{erf}\left[\frac{1}{\sqrt{\eta}}\mathfrak{z}_s + \frac{z/\eta}{\sqrt{1/\eta}}\right] + C^*$$

(zero)

letting integration constant C^* be equal to zero and noting that exp(0) = 1

$$= \frac{\sqrt{\eta\pi}}{2}\cdot\exp(\emptyset)\cdot\operatorname{erf}\left[\frac{\mathfrak{z}_s}{\sqrt{\eta}} + \frac{z}{\sqrt{\eta}}\right] \quad \text{evaluated from } z_{s1} \text{ to } z_{s2}$$

evaluate at limits and use erfc = 1 - erf

$$= \sqrt{\pi E_z t/R_d}\left\{\operatorname{erfc}\left(\frac{z_{s1}+z}{2\sqrt{E_z t/R_d}}\right) - \operatorname{erfc}\left(\frac{z_{s2}+z}{2\sqrt{E_z t/R_d}}\right)\right\}$$

Now combine all of the components   note: $\frac{\sqrt{\pi E_z t/R_d}}{4\{\pi E_z t/R_d\}} = \frac{1}{4\sqrt{\pi E_z t/R_d}}$

$$C_i = \frac{1}{n_e R_d} X_1 Y_2 Z_4$$

$$C(x,y,z,t) = \frac{1}{n_e R_d}\left[\frac{1}{\sqrt{4\pi E_x t/R_d}}\exp\left\{\frac{\left(x - \frac{ut}{R_d}\right)^2}{(4E_x t/R_d)} - \lambda t\right\}\right]$$

$$\cdot\left[\frac{1}{2b}\left\{\operatorname{erf}\left(\frac{\frac{b}{2}+y}{\sqrt{4E_y t/R_d}}\right) + \operatorname{erf}\left(\frac{\frac{b}{2}-y}{\sqrt{4E_y t/R_d}}\right)\right\}\right]$$

$$\cdot\left[\frac{1}{\sqrt{16\pi E_z t/R_d}}\left\{\operatorname{erfc}\left(\frac{z_{s1}-z}{\sqrt{4E_z t/R_d}}\right) - \operatorname{erfc}\left(\frac{z_{s2}-z}{\sqrt{4E_z t/R_d}}\right) + \operatorname{erfc}\left(\frac{z_{s1}+z}{\sqrt{4E_z t/R_d}}\right) - \operatorname{erfc}\left(\frac{z_{s2}+z}{\sqrt{4E_z t/R_d}}\right)\right\}\right]$$

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coefficient "16" changed by RF 9/29/97

where the Z_4 term above is repeated below for clarity

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$$Z_4 = \left(16\pi E_z \frac{t}{R_d}\right)^{-1/2}\left\{\operatorname{erfc}\left(\frac{z_{s1}-z}{(4E_z t/R_d)^{1/2}}\right) - \operatorname{erfc}\left(\frac{z_{s2}-z}{(4E_z t/R_d)^{1/2}}\right) + \operatorname{erfc}\left(\frac{z_{s1}+z}{(4E_z t/R_d)^{1/2}}\right) - \operatorname{erfc}\left(\frac{z_{s2}-z}{(4E_z t/R_d)^{1/2}}\right)\right\}$$

Switch back to Dirichlet ~~boundary~~ condition for analytical transport solution for plume delineation

Assume that dispersion component coming off source patch is negligible compared to advective flux of source, then

$\dot{M}$ = mass rate

$$\dot{M} = C_o \, q \, A_{source}$$

A_{source} = Source area = [500 m x 25 m] x 2 = 25,000 m²

the 2 accounts for the mirroring at the water table

$q = (2.4 \frac{m}{y}) \phi$ for capture zone analysis

$\partial h = 0.005$

$v = 2.4$ m/yr (used in Wexler transport runs patchi, stripi)

$T = 400 \frac{m^2}{d} \Rightarrow K_{sat} = 0.4 \frac{m}{d}$

assume $\phi = 0.3$

$v = q/\phi$

$q = .7 \frac{m}{yr}$

Hence, for $\dot{M} = 10 \frac{Ci}{yr}$

$$C_o = \frac{\dot{M}}{q A_{source}} = \frac{10 \frac{Ci}{yr}}{(0.7 \frac{m}{yr})(25000 \, m^2)} \left(\frac{10^{-3} m^3}{l}\right)$$

$$C_o = 57.1 \times 10^{-8} \frac{Ci}{l} \cong 0.57 \frac{mCi}{l}$$

Hence the C_o should be recalculated for changes in patch size, darcy velocity, and desired mass release rate.

Note the dilution factor scale for scaling of C_o & plume width & thick.

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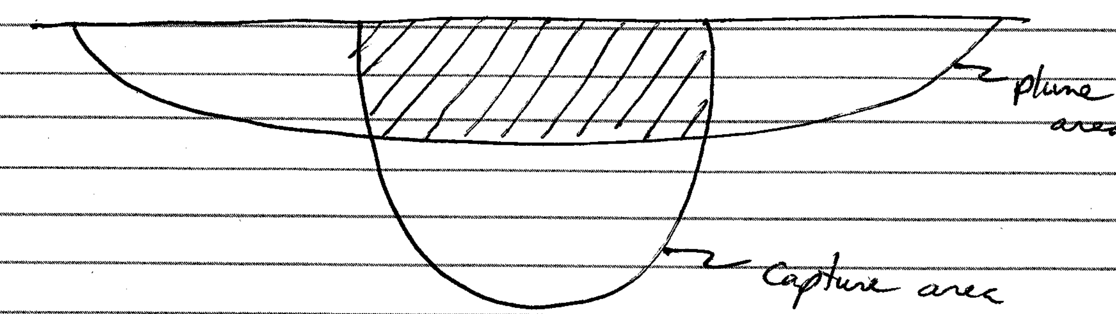
Note that the C_o was incorrectly estimated here; but it doesn't matter since all results are presented as normalized (C/C_o) concentrations

correction

$$C_o = \frac{\dot{M}}{qA} = \frac{10 \frac{Ci}{yr} \left(10^{-3} \frac{m^3}{l}\right)}{\left[0.72 \frac{m}{y}\right]\left[500 \times 25\right] m^2}$$

$$C_o = 1.11 \times 10^{-6} \frac{Ci}{l}$$

Program to calculate areal average of intercepted portion of plume captured by a pumping well



The shaded area has a concentration average, this average is used instead of the centerline concentration as used by Schwartz in EPRI-TSPA-96

Whereas the volumetric-flux based dilution factor is solely based on the comparison of the shaded area and the entire area of the capture, a more representative concentration than the centerline value is the areal average.

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The ~~post~~processor "itsec.f" was written ~~to~~ to calculate the areal average by discretizing the plume and capture areas into cells of area = 1 m² (dy = 1, dz = 1)

The modular post-processor includes

(1) main
a) reads input files for plume & capture information
b) calls subroutines "interpol" and "domest" or "irrig"
c) multiplies the capture matrix times the plume matrix and sums the results then divides by the area (or number of 1 m² cells which contributed to summation (this is not a matrix multiply!)
d) prints results

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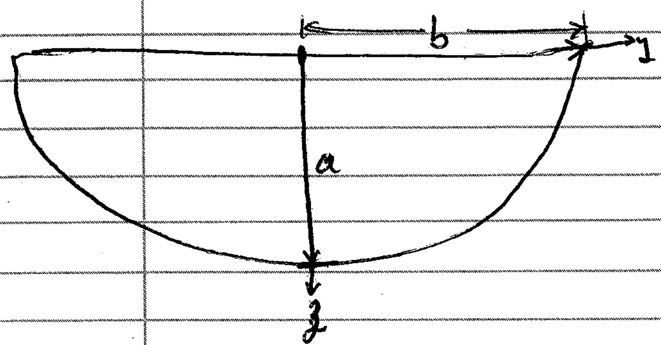
(2) interpol subroutine — interpolates the input file of plume concentrations to every 1 m² cell of plume; the input file contains two header lines plus the output from Wexler simulations printed out for one x-value, the vertical plain perpendicular to flow (the y-z plane). Simple linear interpolation is used.

(3) domest. subroutine — creates a binary matrix where
1 = inside capture area
0 = outside capture area
based on the input values of capture width and thickness and the equation for an ellipse.

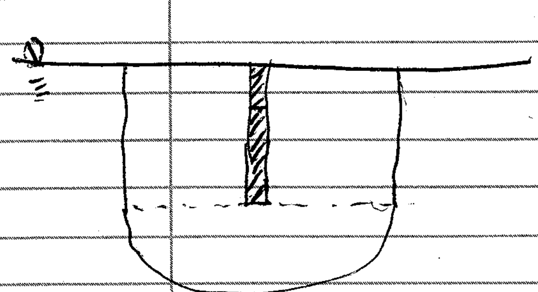


$$1 = \frac{z^2}{a^2} + \frac{y^2}{b^2}$$

rearranged to

$$y = \left[b^2 \left(1 - \frac{z^2}{a^2} \right) \right]^{1/2}$$

where b = capture zone width divided by 2
a = capture zone thickness



The Domestic subroutine accounts for multiple geometries used to get the area: a rectangle and an ellipse (half ellipse)

(4.) irrig — creates binary matrix as does "domest" subroutine except only has to calculate for half-ellipse since screened portion is not significantly affecting shape as a half-ellipse

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```
**********************************************************************
** Post-processor for Wexler output and capture area output.        **
**                                                                  **
** Calculates intersection of a plume and each capture zone         **
** for dilution factors. Assumes a grid where dy=1 and dz=1.        **
** Code is written for clarity at the expense of efficiency.        **
** Compiled on SUN using:  f77 -r8 -o itsec itsec.f                 **
**                                                                  **
** Borehole Dilution for ARDES KTI                                  **
**                                                                  **
**    RFedors (Oct97)   CNWRA                                        **
**********************************************************************
*  INPUT FILES:
* Read plume input file, list concentrations from centerline to edge of plume.
* Format based on Wexler, 1992 output plus my headers (records 1&2).
*           1. ny, nz, conc_o   initial concentration         (2i5,f10.6)
*           2. flag for thin(=0) or 3D(=1) plume, thickness   (i10,f10.3)
*           3  y-values                                              (*)
*           4-(nz+4). z-value and concentrations for each y-position. (*)
* For all measurements, assume that ground=0 and z-axis is vertical down.
*
* Read capture input file, 2 records each capture area;
* if flag=1 then domestic, if iflag=2 then irrigation, if flag=99999, then stop
*           1.  iflag                             (i5)
*           2.  width, thick, darcy velocity      (3f6.3)
*           3.  screentop, screenbot, ctop        (3f6.3)
*           4-? repeat 1-3 for each capture area or just iflag=99999 to stop.
* For all measurements, assume that ground=0 and z-axis is vertical down.
**********************************************************************
*        1         2         3         4         5         6         7
*234567890123456789012345678901234567890123456789012345678901234567890123456789012
      program itsec

      parameter  (max=100, maxy=3400, maxz=2000, maxny=50, maxnz=50)
      implicit real (a-h,o-z)
      implicit integer (i-n)
      character  infile*12, infile2*12, outfile*12
      dimension  capture(0:maxy,0:maxz), plume(0:maxy,0:maxz)
     &          , concp(0:maxny,0:maxnz), yp(0:maxny), zp(0:maxnz)


      infile = 'plume.dat'
      infile2 = 'capture.dat'
      outfile = 'intersec.out'
      open(8,file=infile,status='unknown')
      open(9,file=infile2,status='unknown')
      open(10,file=outfile,status='unknown')

      zero = 1.e-10
      dy = 1.
      dz = 1.
c Read plume input file.
      read(8,'(2i5,f10.6)') ny, nz, conc_o
      read(8,'(i10,f10.3)') iflag2, pthick
      read(8,*) time, ( yp(j), j = 0,ny-1 )
      do 20 k = 0,nz-1
         read(8,*)  zp(k), ( concp(j,k), j = 0,ny-1 )
 20   continue
      close(8)
c Fill in plume matrix.
      call interpol(plume,concp,yp,zp,ny,nz,iflag2,pthick,conc_o,cPlume)

c Read capture input file, 3 records for each capture area.
      do 200 i = 1,max
        read (9,'(i5)') iflag
        if(iflag.eq.99999) stop
        read (9,'(3f6.3)') cwidth, cthick, darcy
        read (9,'(3f6.3)') scntop, scnbot, ctop
```



```
c Fill in capture matrices.

        cwidth2 = cwidth * 0.5
        if(iflag.eq.1)
     &        call domest(cwidth2,cthick,capture,scntop,scnbot,ctop,icap)
        if(iflag.eq.2)
     &        call irrig(cwidth2,cthick,capture,icap)

c Calculate factors doing both mirrored sides of ellipse.
        intersect = 0
        conc = 0.
        do 100 iz = 0,maxz
          do 100 iy = 0,maxy
            conc_tmp = capture(iy,iz) * plume(iy,iz)
            if(conc_tmp.gt.zero) then
               intersect = intersect + 1
               conc = conc + conc_tmp
            else
            endif
 100    continue
        do 110 iz = 0,maxz
          do 110 iy = 1,maxy
            conc_tmp = capture(iy,iz) * plume(iy,iz)
            if(conc_tmp.gt.zero) then
               intersect = intersect + 1
               conc = conc + conc_tmp
            else
            endif
 110    continue

        areaIntersect = float(intersect)
        conc = conc / areaIntersect
        qfactor = float(icap) / areaIntersect

        write(10,1003)  i, cwidth, cthick
        write(10,*) 'Intersect area=' , icap
        write(10,1007)  conc
        transfactor = conc_o / conc
        centerlinefactor = conc_o / concp(0,0)

        write(10,1011)  qfactor, transfactor, centerlinefactor
        write(10,1017)

        write(6,*) 'done with capture ', i
 200    continue

 1003   format('For capture zone',i5, ' with width=', f7.0
     &                                          , ' & thick=', f7.0)
 1007   format('Representative concentration for intersection area',e11.3)
 1011   format('qfactor=',f8.3,' trans df=',f8.3,' centerline df=',f8.3)
 1017   format('=======================================================')
        stop
        end
c=====================================================================
        subroutine interpol(plume,concp,yp,zp,ny,nz,iflag2
     &                   ,pthick,conc_o,cPlume)
c Interpolates concentration values focussing on the plume area of matrix.
c Uses row by row linear interpolation.
        parameter  (maxy=3400, maxz=2000, maxny=50, maxnz=50)
        implicit real (a-h,o-z)
        implicit integer (i-n)
        dimension plume(0:maxy,0:maxz), concp(0:maxny,0:maxnz)
     &          , yp(0:maxny), zp(0:maxnz), ypts(0:maxny), zpts(0:maxnz)

        threshld = conc_o * 1.e-4
c Initial plume matrix
        do 10 iz = 0,maxz
         do 10 iy = 0,maxy
            plume(iy,iz) = 0.
```

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```
 10    continue

       do 20 i = 0,ny-2
         ypts(i) = yp(i+1) - yp(i)
 20    continue

c Do different calculation for thin plume versus 3D plume, if-then.

       if(iflag2.eq.1) then

       do 30 i = 0,nz-2
         zpts(i) = zp(i+1) - zp(i)
 30    continue
c Interpolate z-columns where y-position is known.
       do 70 ky = 0,ny-2
        iy = nint( yp(ky) )
        iz = 0
        do 60 kz = 0,nz-2
          plume(iy,iz) = concp(ky,kz)
          a = (concp(ky,kz+1) - concp(ky,kz)) / (zp(kz+1) - zp(kz))
          b = concp(ky,kz) - a * zp(kz)
          do 50 i = 1,nint(zpts(kz))-1
             iz = iz + 1
             plume(iy,iz) = a * ( float(i) + zp(kz) ) + b
 50       continue
          iz = iz + 1
 60     continue
        iz = iz + 1
        plume(iy,iz) = concp(iy,ny-1)
 70    continue

c Row by row, skipping appropriately.
       iy = 0
       iz = 0
       do 140 kz = 0,nz-2
        do 130 j = 1,nint(zpts(kz))

         do 120 ky = 0,ny-2
          ky2 = int(yp(ky+1))
          ky1 = int(yp(ky))
          a = (plume(ky2,iz) - plume(ky1,iz)) / (yp(ky+1) - yp(ky))
          b = plume(ky1,iz) - a * yp(ky)
          do 110 i = 1,nint(ypts(ky))-1
             iy = iy + 1
             plume(iy,iz) = a * ( float(i) + yp(ky) ) + b
 110      continue
         iy = iy + 1
 120    continue
        iz = iz + 1
        iy = 0
 130    continue
 140   continue

c Figure out plume width and zero-out remainder.
c Also calculate total mass in plume from concentrations.
c The variable "cPlume" is (concentration * area).
        do 150 j = 0,maxz
         do 150 i = 0,maxy
           if(plume(i,j).lt.threshld) plume(i,j) = 0.
 150    continue
        concPlume = 0.
        do 160 j = 0,maxz
         do 160 i = 0,maxy
           concPlume = concPlume + plume(i,j)
 160    continue
        concMid = 0.
        do 162 j = 0,maxz
           concMid = concMid + plume(0,j)
 162    continue
```



```
        cPlume = ( concPlume * 2. ) - concMid
        do 170 i = 0,maxy
          if(plume(i,0).lt.threshld) then
            pwidth = float(i) * 2.
            goto 175
          else
          endif
 170    continue
 175    do 180 j = 0,maxz
          if(plume(0,j).lt.threshld) then
            pthickness = float(j)
            goto 300
          else
          endif
 180    continue

       else

         iy = 0
         do 210 ky = 0,ny-2
           plume(iy,0) = concp(ky,0)
           a = (concp(ky+1,0) - concp(ky,0)) / (yp(ky+1) - yp(ky))
           b = concp(ky,0) - a * yp(ky)
           do 210 i = 1,nint(ypts(ky))-1
              iy = iy + 1
              plume(iy,0) = a * ( float(i) + yp(ky) ) + b
 210     continue
         plume(iy+1,0) = concp(ny-1,0)

c Figure out plume width and zero-out remainder.
c Also calculate total mass in plume from concentrations, after zeroing out.
c The variable "cPlume" is (concentration * area).
        pthickness = pthick
        do 220 i = 0,maxy
          if(plume(i,0).lt.threshld) plume(i,0) = 0.
 220    continue
        ip = int(pthick)
        do 240 j = 1,ip
          do 240 i = 0,maxy
            plume(i,j) = plume(i,j-1)
 240    continue
        concPlume = 0.
        do 250 i = 0,maxy
          concPlume = concPlume + plume(i,0)
 250    continue
        concMid =  plume(0,0) * pthick
        cPlume = ( concPlume * pthick * 2. ) - concMid
        do 260 i = 0,maxy
          if(plume(i,0).lt.threshld) then
            pwidth = float(i) * 2.
            goto 300
          else
          endif
 260    continue

       endif

 300   write(10,*) 'Interpolated plume.'
c      do 400 j = 0,15
c        write(10,'(12e10.2)') ( plume(i,j), i=0,11 )
c400   continue

       write(10,1100) pwidth, pthickness
       write(10,1117)
 1100  format(' plume width =',f7.0,' plume thickness =',f7.0)
 1117  format('*********************************************************')
       return
       end
c==================================================================
```

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Printed by Randall S. Fedors


```
      subroutine domest(cwidth2,cthick,capture,scntop,scnbot,ctop,icap)
c Calculates the number of nodes in the capture area of a domestic well
c assuming dy=dz=1 for extrapolation to a capture area.
      parameter  (maxy=3400, maxz=2000)
      implicit real (a-h,o-z)
      implicit integer (i-n)
      dimension capture(0:maxy,0:maxz)

      do 10 iz = 0,maxz
        do 10 iy = 0,maxy
          capture(iy,iz) = 0.
 10   continue
      iscnbot = nint(scnbot)
      iscntop = nint(scntop)

c Top of capture area (half-ellipse); mirror the half-ellipse to fill capture().
      icap1 = 0
      if(ctop.le.1.e-4) goto 50
      topthick = scntop - ctop
      itop = nint(topthick)
      izz = iscntop
      do 30 iz = 1,itop
        z = float(iz)
        if(iz.ge.iscntop) goto 50
        ytmp = sqrt( cwidth2**2 * ( 1. - z**2 / topthick**2 ) )
        izz = izz - 1
        do 20 iy = 0,maxy
          y = float(iy)
          if(y.le.ytmp) then
            capture(iy,izz) = 1.
            icap1 = icap1 + 1
          else
            goto 30
          endif
 20     continue
 30   continue
 50   write(10,*) 'Top of domestic capture area, nodes = ', icap1

c Middle of capture area, screen elevation (rectangle).
      icap2 = 0
      do 130 iz = iscntop,maxz
        if(iz.gt.iscnbot) goto 150
        do 120 iy = 0,maxy
          if(float(iy).le.cwidth2) then
            capture(iy,iz) = 1.
            icap2 = icap2 + 1
          else
            goto 125
          endif
 120    continue
 125    continue
 130  continue
 150  write(10,*) 'Middle plus top domestic capture nodes = ', icap2

c Bottom of capture area (half-ellipse).
      icap3 = 0
      do 230 iz = iscnbot+1,maxz
        z = float(iz)
        if(z.gt.cthick) goto 250
        ytmp = sqrt( cwidth2**2 * ( 1. - z**2 / cthick**2 ) )
        do 220 iy = 0,maxy
          y = float(iy)
          if(y.le.ytmp) then
            capture(iy,iz) = 1.
            icap3 = icap3 + 1
          else
            goto 225
          endif
 220    continue
```



```
 225    continue
 230  continue

 250  write(10,*) 'Bottom half ellipse= ', icap3
      mirror = 0
      do 260 j = 1,maxz
        if(capture(0,j).gt.0.1) mirror = mirror + 1
 260  continue
      icap = ( ( icap1 + icap2 + icap3 ) * 2 ) - mirror
      write(10,*) 'Domestic well capture area (all) = ', icap

c     do 300 j = 0,15
c       write(10,'(15f3.0)') ( capture(i,j), i=0,14 )
c300  continue

      return
      end
c=======================================================================
      subroutine irrig(cwidth2,cthick,capture,icap)
c Calculates the number of nodes in an irrigation well assuming that
c dy=dz=1 for extrapolation to a capture area.
      parameter  (maxy=3400, maxz=2000)
      implicit real (a-h,o-z)
      implicit integer (i-n)
      dimension capture(0:maxy,0:maxz)

      icap = 0
      do 10 iz = 0,maxz
        do 10 iy = 0,maxy
          capture(iy,iz) = 0.
 10   continue

      do 30 iz = 0,maxz
        z = float(iz)
        if(z.gt.cthick) goto 50
        ytmp = sqrt( cwidth2**2 * ( 1. - z**2 / cthick**2 ) )
        do 20 iy = 0,maxy
          y = float(iy)
          if(y.le.ytmp) then
            capture(iy,iz) = 1.
            icap = icap + 1
          else
            goto 25
          endif
 20     continue
 25     continue
 30   continue

 50   icap = icap + icap - cthick
      write(10,*) 'Irrigation well capture area = ', icap

c     do 200 j = 0,15
c       write(10,'(15f3.0)') ( capture(i,j), i=0,14 )
c200  continue

      return
      end
```

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example input file → plume.dat

Printed by Randall S. Fedors

15 22 0.00438

1 10.

20000.	0.	200.	400.	600.	800.	900.	1100.	1300.	1500.	1700.	1900.	2100.	2300.	2500.	2700.
0.	0.317E-03	0.305E-03	0.271E-03	0.223E-03	0.170E-03	0.144E-03	0.982E-04	0.618E-04	0.361E-04	0.196E-04	0.985E-05	0.461E-05	0.201E-05	0.817E-06	0.310E-06
60.	0.299E-03	0.288E-03	0.256E-03	0.211E-03	0.161E-03	0.136E-03	0.926E-04	0.583E-04	0.341E-04	0.185E-04	0.931E-05	0.436E-05	0.190E-05	0.773E-06	0.293E-06
75.	0.264E-03	0.254E-03	0.226E-03	0.186E-03	0.142E-03	0.121E-03	0.819E-04	0.516E-04	0.302E-04	0.164E-04	0.825E-05	0.387E-05	0.169E-05	0.686E-06	0.261E-06
100.	0.195E-03	0.188E-03	0.167E-03	0.138E-03	0.105E-03	0.891E-04	0.606E-04	0.382E-04	0.224E-04	0.122E-04	0.613E-05	0.288E-05	0.126E-05	0.513E-06	0.195E-06
125.	0.128E-03	0.123E-03	0.109E-03	0.902E-04	0.689E-04	0.585E-04	0.398E-04	0.252E-04	0.147E-04	0.802E-05	0.406E-05	0.191E-05	0.837E-06	0.342E-06	0.131E-06
150.	0.742E-04	0.714E-04	0.636E-04	0.525E-04	0.401E-04	0.341E-04	0.233E-04	0.147E-04	0.864E-05	0.471E-05	0.239E-05	0.113E-05	0.496E-06	0.203E-06	0.779E-07
175.	0.383E-04	0.369E-04	0.329E-04	0.272E-04	0.208E-04	0.177E-04	0.121E-04	0.766E-05	0.451E-05	0.247E-05	0.125E-05	0.594E-06	0.262E-06	0.108E-06	0.415E-07
200.	0.176E-04	0.170E-04	0.151E-04	0.125E-04	0.958E-05	0.816E-05	0.559E-05	0.355E-05	0.210E-05	0.115E-05	0.587E-06	0.279E-06	0.124E-06	0.512E-07	0.198E-07
225.	0.722E-05	0.695E-05	0.620E-05	0.513E-05	0.394E-05	0.336E-05	0.231E-05	0.147E-05	0.871E-06	0.480E-06	0.246E-06	0.117E-06	0.523E-07	0.217E-07	0.845E-08
250.	0.264E-05	0.254E-05	0.227E-05	0.188E-05	0.145E-05	0.124E-05	0.851E-06	0.544E-06	0.324E-06	0.179E-06	0.922E-07	0.443E-07	0.198E-07	0.829E-08	0.324E-08
275.	0.866E-06	0.835E-06	0.746E-06	0.620E-06	0.478E-06	0.408E-06	0.282E-06	0.181E-06	0.108E-06	0.599E-07	0.310E-07	0.150E-07	0.675E-08	0.284E-08	0.112E-08
300.	0.255E-06	0.246E-06	0.220E-06	0.183E-06	0.141E-06	0.121E-06	0.837E-07	0.539E-07	0.323E-07	0.181E-07	0.940E-08	0.456E-08	0.207E-08	0.878E-09	0.348E-09
325.	0.676E-07	0.652E-07	0.584E-07	0.486E-07	0.377E-07	0.323E-07	0.224E-07	0.145E-07	0.873E-08	0.490E-08	0.257E-08	0.125E-08	0.573E-09	0.245E-09	0.979E-10
350.	0.162E-07	0.156E-07	0.140E-07	0.117E-07	0.906E-08	0.778E-08	0.542E-08	0.352E-08	0.213E-08	0.120E-08	0.634E-09	0.312E-09	0.144E-09	0.618E-10	0.250E-10
375.	0.350E-08	0.338E-08	0.304E-08	0.254E-08	0.198E-08	0.170E-08	0.119E-08	0.775E-09	0.472E-09	0.268E-09	0.142E-09	0.704E-10	0.327E-10	0.142E-10	0.577E-11
400.	0.689E-09	0.665E-09	0.598E-09	0.501E-09	0.391E-09	0.337E-09	0.237E-09	0.155E-09	0.949E-10	0.542E-10	0.289E-10	0.145E-10	0.676E-11	0.296E-11	0.122E-11
425.	0.124E-09	0.119E-09	0.107E-09	0.902E-10	0.706E-10	0.608E-10	0.429E-10	0.283E-10	0.174E-10	0.100E-10	0.538E-11	0.271E-11	0.128E-11	0.565E-12	0.234E-12
450.	0.202E-10	0.196E-10	0.176E-10	0.148E-10	0.116E-10	0.101E-10	0.712E-11	0.472E-11	0.292E-11	0.169E-11	0.915E-12	0.464E-12	0.221E-12	0.986E-13	0.413E-13
475.	0.304E-11	0.294E-11	0.265E-11	0.224E-11	0.176E-11	0.152E-11	0.108E-11	0.722E-12	0.449E-12	0.262E-12	0.143E-12	0.731E-13	0.351E-13	0.158E-13	0.669E-14
500.	0.420E-12	0.406E-12	0.367E-12	0.310E-12	0.245E-12	0.213E-12	0.152E-12	0.102E-12	0.636E-13	0.373E-13	0.205E-13	0.106E-13	0.513E-14	0.233E-14	0.999E-15
550.	0.634E-14	0.613E-14	0.556E-14	0.471E-14	0.375E-14	0.326E-14	0.235E-14	0.159E-14	0.101E-14	0.600E-15	0.335E-15	0.176E-15	0.868E-16	0.403E-16	0.176E-16
600.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

RF 10/21/97

$x = 25$ km

$C_0 = .438 \times 10^{-2}$ mg/l

time = 20,000 yrs

$\alpha_L = 100$ m

$\alpha_{Ty} = 10$ m

$\alpha_{Tz} = 0.1$ m

1st page of capture inputs (large pumping)
(multiple capture areas can be run at one time).

63 10/21/97 RF

Oct 15, 97 17:05 **caps3D.input** Page 1/1

```
   2
1292.  575.  .244     #8     capture ID#
   0.   60.    0.
   2
2330.  825.  .244     #9
   0.   60.    0.
   2
3382.  941.  .244     #10
   0.   60.    0.
   2
4450.  985.  .244     #11
   0.   60.    0.
   2
1944.  751.  .244     #30
   0.   60.    0.
   2
1292.  575.  .244     #31
   0.   60.    0.
   2
 876.  424.  .244     #32
   0.   60.    0.
   2
 705.  352.  .244     #33
   0.   60.    0.
   2
 607.  309.  .244     #34
   0.   60.    0.
   2
2810.  890.  .244     # 35
   0.   60.    0.
   2
2146.  793.  .244     # 36
   0.   60.    0.
   2
1798.  719.  .244     # 37
   0.   60.    0.
   2
5596. 1000.  .244     # 38
   0.   60.    0.
   2
3282.  934.  .244     # 39
   0.   60.    0.
   2
2486.  850.  .244     # 40
   0.   60.    0.
   2
1798.  719.  .244     # 41
   0.   60.    0.
99999
```

RF
10/21/97

2nd page of capture.dat inputs (small pumping capture areas)

Oct 16, 97 8:19 **caps2D.input** Page 1/1

```
   1
 76.   87.8  .244
  0.   60.    0.
   1
 69.   97.5  .244
 10.   70.    .2
   1
 67.   107.  .244
 20.   80.   4.7
   1
 68.   127.  .244
 40.   100.  20.5
   1
28.6   72.6  .244
  0.   60.    0.
   1
54.0   81.5  .244
  0.   60.    0.
   1
76.0   87.8  .244
  0.   60.    0.
   1
97.4   95.6  .244
  0.   60.    0.
   1
146.   112.  .244
  0.   60.    0.
   1
418.   224.  .244
  0.   60.    0.
   1
607.   309.  .244
  0.   60.    0.
   1
369.   203.  .244
  0.   60.    0.
   1
133.   108.  .244
  0.   60.    0.
   1
76.0   87.8  .244
  0.   60.    0.
   1
21.8   70.3  .244
  0.   60.    0.
   1
248.   151.  .244
  0.   60.    0.
   1
133.   108.  .244
  0.   60.    0.
   1
76.0   87.8  .244
  0.   60.    0.
   1
41.2   77.5  .244
  0.   60.    0.
99999
```

RF 10/21/97

Thursday October 16, 97 caps2D.input

test input files to check programs for proper operation; more complex domestic well is used here

Oct 16, 97 17:19 **plume.dat.small** Page 1/1

```
   4     4   0.00438
         1         10.
20000.        0.         5.        10.        20.
   0.  0.4E-03   0.4E-04   0.4E-05   0.4E-09
   5.  0.4E-04   0.4E-05   0.1E-06   0.1E-09
  12.  0.1E-06   0.1E-07   0.1E-08   0.1E-10
  30.  0.1E-08   0.1E-09   0.1E-10   0.1E-11
```

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Oct 16, 97 17:19 **capture.dat.small** Page 1/1

```
   1
 20.  14.0  .244
 10.  12.    8.
99999
```

RF 10/21/97

Output from test example from previous page.
Results as expected.


```
 Interpolated plume.
  0.40E-03  0.33E-03  0.26E-03  0.18E-03  0.11E-03  0.40E-04  0.33E-04  0.26E-04  0.18E-04  0.11E-04  0.40E-05  0.36E-05
  0.33E-03  0.27E-03  0.21E-03  0.15E-03  0.92E-04  0.33E-04  0.27E-04  0.21E-04  0.15E-04  0.91E-05  0.32E-05  0.29E-05
  0.26E-03  0.21E-03  0.16E-03  0.12E-03  0.72E-04  0.26E-04  0.21E-04  0.16E-04  0.12E-04  0.71E-05  0.24E-05  0.22E-05
  0.18E-03  0.15E-03  0.12E-03  0.85E-04  0.52E-04  0.18E-04  0.15E-04  0.12E-04  0.84E-05  0.50E-05  0.17E-05  0.15E-05
  0.11E-03  0.92E-04  0.72E-04  0.52E-04  0.31E-04  0.11E-04  0.91E-05  0.71E-05  0.50E-05  0.29E-05  0.88E-06  0.79E-06
  0.40E-04  0.33E-04  0.26E-04  0.18E-04  0.11E-04  0.40E-05  0.32E-05  0.24E-05  0.17E-05  0.88E-06  0.00E+00  0.00E+00
  0.34E-04  0.28E-04  0.22E-04  0.16E-04  0.96E-05  0.34E-05  0.28E-05  0.21E-05  0.14E-05  0.75E-06  0.00E+00  0.00E+00
  0.29E-04  0.23E-04  0.18E-04  0.13E-04  0.80E-05  0.29E-05  0.23E-05  0.17E-05  0.12E-05  0.63E-06  0.00E+00  0.00E+00
  0.23E-04  0.19E-04  0.15E-04  0.11E-04  0.64E-05  0.23E-05  0.18E-05  0.14E-05  0.95E-06  0.50E-06  0.00E+00  0.00E+00
  0.17E-04  0.14E-04  0.11E-04  0.79E-05  0.48E-05  0.17E-05  0.14E-05  0.10E-05  0.71E-06  0.00E+00  0.00E+00  0.00E+00
  0.12E-04  0.94E-05  0.74E-05  0.53E-05  0.32E-05  0.12E-05  0.93E-06  0.70E-06  0.48E-06  0.00E+00  0.00E+00  0.00E+00
  0.58E-05  0.48E-05  0.37E-05  0.27E-05  0.16E-05  0.58E-06  0.47E-06  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
 plume width =    38. plume thickness =    12.
*******************************************************
 Top of domestic capture area, nodes =   10
 Middle plus top domestic capture nodes =   33
 Bottom half ellipse=   5
 Domestic well capture area (all) =   89
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 1. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 1. 1. 1. 1. 1. 1. 1. 1. 1. 0. 0. 0. 0. 0. 0.
 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 0. 0. 0. 0.
 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 0. 0. 0. 0.
 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 0. 0. 0. 0.
 1. 1. 1. 1. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 1. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
For capture zone    1 with width =    20. & thick =    14.
Representative concentration for intersection area  0.474E-05
 trans df = 923.967 centerline df =  10.950
=======================================================
```

RF 10/21/97

General instruction for itsec.f processing

(1) Run patchi or stripi to get distrib of concentration
(2) edit file.out from (1) to add required header lines as described in top of itsec.f ; file-out is y-z cross-section created from patchi/stripi runs ; copy edit to file = plume.dat
(3) copy caps3D.input or caps2D.input into a file called capture.dat
(4) run itsec (type itsec at prompt, then carriage return)
(5) results are put into a file called intersec.out
T-BDF = dispersion based dilution factor = $C_o/\bar{C}$
C_o/C_c = inverse of normalized centerline concentration
V-BDF = copy from previous pages of scientific notebook for capture zone vs intercepted portion of plume areas (See page 45-46)
(6) Results in intersec.out have been transfered to table below

The following pages are a table of the results

Plume Description	Capture Description	V-BDF	C_o/C_c	T-BDF
3D plume 1 (ff 10/21/97)				
20:2:0.2 m	#8, Q = 300	1.4	9.1	34
20:2:0.2 m	#9, Q = 800	2.6	9.1	55
20:2:0.2 m	#10, Q = 1,380	3.5	9.1	57
20:2:0.2 m	#11, Q = 2,000	4.8	9.1	57
Small irrigation well, 3D plume 1				
20:2:0.2 m	#31, T = 50	2.6	9.1	48
20:2:0.2 m	#32, T = 100	1.8	9.1	34
20:2:0.2 m	#33, T = 200	1.4	9.1	26
20:2:0.2 m	#34, T = 300	1.0	9.1	20
20:2:0.2 m	#35, T = 400	1.0	9.1	18
Large irrigation well, 3D plume 1				
20:2:0.2 m	#36, T = 200	2.8	9.1	57
20:2:0.2 m	#37, T = 300	3.0	9.1	52
20:2:0.2 m	#38, T = 400	2.4	9.1	45
20:2:0.2 m	#39, grad = 0.001	6.2	9.1	57.5
20:2:0.2 m	#40, grad = 0.002	3.4	9.1	57.5
20:2:0.2 m	#41, grad = 0.003	2.3	9.1	56.6
20:2:0.2 m	#42, grad = 0.005	1.0	9.1	45
Domestic wells, 3D plume 1				
20:2:0.2m	#21, 940–1,000	9.1	9.5	1
20:2:0.2 m	#22, 930–990	9.1	9.7	1
20:2:0.2 m	#23, 920–980	9.1	9.9	1
20:2:0.2 m	#24, 900–960	9.1	10.4	1
20:2:0.2 m	#1, Q = 1	9.1	9.36	1

continued

Plume Description	Capture Description	V-BDF	C_o/C_c	T-BDF
20:2:0.2 m	#2, Q = 2	9.1	9.44	1
20:2:0.2 m	#3, Q = 3	9.1	9.5	1
20:2:0.2 m	#4, Q = 4	9.1	9.6	1
20:2:0.2 m	#5, Q = 6.8	9.1	9.9	1
20:2:0.2 m	#6, Q = 37.5	9.1	13	1
20:2:0.2 m	#7, Q = 75	9.1	18	1
20:2:0.2 m	#12, T = 10	9.1	12	1
20:2:0.2 m	#13, T = 50	9.1	9.8	1
20:2:0.2 m	#14, T = 100	9.1	9.5	1
20:2:0.2 m	#15, T = 400	9.1	9.3	1
20:2:0.2 m	#16, grad = 0.001	9.1	11	1
20:2:0.2 m	#17, grad = 0.0025	9.1	9.8	1
20:2:0.2 m	#18, grad = 0.005	9.1	9.5	1
20:2:0.2 m	#19, grad = 0.01	9.1	9.4	1
3D plume 2 RF 10/21/97				
100:10:0.1 m	#8, Q = 300	1.9	14	37
100:10:0.1 m	#9, Q = 800	2.7	14	47
100:10:0.1 m	#10, Q = 1,380	3.3	14	60
100:10:0.1 m	#11, Q = 2,000	4.1	14	73
Small irrigation well, 3D plume 2				
100:10:0.1 m	#31, T = 50	3.2	14	43
100:10:0.1 m	#32, T = 100	2.4	14	37
100:10:0.1 m	#33, T = 200	1.8	14	34
100:10:0.1 m	#34, T = 300	1.6	14	32
100:10:0.1 m	#35, T = 400	1.5	14	30

continued

Plume Description	Capture Description	V-BDF	C_o/C_c	T-BDF
				RF
Large irrigation well, plume 2				10/21/97
100:10:0.1 m	#36, T = 200	3.0	14	53
100:10:0.1 m	#37, T = 300	2.6	14	45
100:10:0.1 m	#38, T = 400	2.3	14	41
100:10:0.1 m	#39, grad = 0.001	4.3	14	—
100:10:0.1 m	#40, grad = 0.002	3.3	14	59
100:10:0.1 m	#41, grad = 0.003	2.8	14	49
100:10:0.1 m	#42, grad = 0.005	2.3	14	41
Thin plumes, Domestic wells at 25 km, 20:2 m dispersivity ratio				
25 m thick; 20:2 m	#21, 940-1,000	3.3	1.8	1.78
25 m thick; 20:2 m	#22, 930-990	4.3	1.8	1.77
25 m thick; 20:2 m	#23, 920-980	5.4	1.8	1.77
25 m thick; 20:2 m	#24, 900-960	43	1.8	1.76
10 m thick; 20:2 m	#21, S = 940-1,000	8.2	1.8	1.78
10 m thick; 20:2 m	#22, S = 930-990	10.3	1.8	1.77
10 m thick; 20:2 m	#23, S = 920-980	26	1.8	1.70
10 m thick; 20:2 m	#24, S = 900-960	N/A	1.8	N/A
25 m thick; 20:2 m	#1, Q = 1	2.8	1.8	1.76
25 m thick; 20:2 m	#2, Q = 2	3.1	1.8	1.77
25 m thick; 20:2 m	#3, Q = 3	3.3	1.8	1.78
25 m thick; 20:2 m	#4, Q = 4	3.5	1.8	1.78
25 m thick; 20:2 m	#5, Q = 6.8	4.0	1.8	1.80
25 m thick; 20:2 m	#6, Q = 37.5	7.6	1.8	1.90
25 m thick; 20:2 m	#7, Q = 75	10.2	1.8	2.01

continued

Plume Description	Capture Description	V-BDF	C_o/C_c	T-BDF
10 m thick; 20:2 m	#1, Q = 1	7.0	1.8	1.76
10 m thick; 20:2 m	#2, Q = 2	7.7	1.8	1.77
10 m thick; 20:2 m	#3, Q = 3	8.2	1.8	1.78
10 m thick; 20:2 m	#4, Q = 4	8.8	1.8	1.78
10 m thick; 20:2 m	#5, Q = 6.8	10.1	1.8	1.80
10 m thick; 20:2 m	#6, Q = 37.5	19	1.8	1.90
10 m thick; 20:2 m	#7, Q = 75	26	1.8	2.01
25 m thick; 20:2 m	#12, T = 10	6.9	1.8	1.88
25 m thick; 20:2 m	#13, T = 50	3.9	1.8	1.80
25 m thick; 20:2 m	#14, T = 100	3.3	1.8	1.78
25 m thick; 20:2 m	#15, T = 400	2.7	1.8	1.76
25 m thick; 20:2 m	#16, grad = 0.001	5.3	1.8	1.84
25 m thick; 20:2 m	#17, grad = 0.0025	3.9	1.8	1.80
25 m thick; 20:2 m	#18, grad = 0.005	3.3	1.8	1.78
25 m thick; 20:2 m	#19, grad = 0.01	2.9	1.8	1.77
10 m thick; 20:2 m	#12, T = 10	17	1.8	1.88
10 m thick; 20:2 m	#13, T = 50	9.8	1.8	1.80
10 m thick; 20:2 m	#14, T = 100	8.2	1.8	1.78
10 m thick; 20:2 m	#15, T = 400	6.8	1.8	1.76
10 m thick; 20:2 m	#16, grad = 0.001	13.2	1.8	1.84
10 m thick; 20:2 m	#17, grad = 0.0025	9.8	1.8	1.80
10 m thick; 20:2 m	#18, grad = 0.005	8.2	1.8	1.78
10 m thick; 20:2 m	#19, grad = 0.01	7.4	1.8	1.77
Thin plumes irrigation wells @ 25 km				
25m thick; 20:2 m	#8, Q = 300	19	1.8	2.8

RF 10/21/97

continued

Plume Description	Capture Description	V-BDF	C_o/C_c	T-BDF
25m thick; 20:2 m	#9, Q = 800	26	1.8	4.8
25m thick; 20:2 m	#10, Q = 1,380	36	1.8	5.9
25m thick; 20:2 m	#11, Q = 2,000	49	1.8	5.9
25m thick; 50:5 m	#8, Q = 300	19	2.6	3.3
25m thick; 50:5 m	#9, Q = 800	26	2.6	4.8
25m thick; 50:5 m	#10, Q = 1,380	30	2.6	6.8
25m thick; 50:5 m	#11, Q = 2,000	33	2.6	8.8
25m thick; 100:10 m	#8, Q = 300	19	3.6	4.1
25m thick; 100:10 m	#9, Q = 800	26	3.6	5.2
25m thick; 100:10 m	#10, Q = 1,380	30	3.6	6.9
25m thick; 100:10 m	#11, Q = 2,000	32	3.6	8.9

RF 10/21/97

Plot Files:

Data Files plus xvgr "all" files (complete plot file with axis instructions)

Figures 4-2 to 4-13 ./Bore/Data/XVGR/*

(data for 4-2 to 4-13 reported on page 41 and pages 45-46)

Figures 4-14 - 4-17 ./Bore/Analytic/Intersect/XVGR/*

(data for ~~figures~~ 4-14 to 4-17 reported on pages 67-71)

Input Files for Plumes

All plume scenarios were re-run through Wexler's (1992) patchi and stripi programs. A new output file from ~~[illegible]~~ RF 10/21/97 The patchi program outputs the data in an y-z plane instead of an x-y plane. Corresponding data locations were checked between

The 2 output files to ensure that my creation of a new output file had no effect on the calculated values at any point in the x-y-z area of the plume.

Note that a patch thickness of 50 m is used as input to obtain a patch source of 25 m thick at the water table (mirror the 25 m thick source to account for no flow boundary condition at water table). Dispersion coefficients are input values, note that $D_{x,y,z} = v\alpha$ where α is the appropriate dispersivity for that direction (x, y, or z) and v is the seepage or particle velocity ($v = q/\phi$)

Input files for "stripi" simulations:

Oct 16, 97 8:43 — wexler100Thin.dat — Page 1/1

```
Thin plume - Amargosa Farms; dispersivities 20:2 meters
stripi code: aquifer of infinite width with a finite width source (line)
Model Data:  Y1=-250 m, Y2=250 m,  V=2.44 m/yr
DX=  , DY=   m**2/yr, DK=1E-16 per yr, C0=0.00438 mg/L

====
    2  15   1 256   0
mg/l        m/yr        m**2/yr   per yr    meter       yr
    .00438      2.44      244.        24.4     1.E-16
   -250.0     250.0
  15000.0   25000.0                                                  1000.0
      0.0     200.0     300.0     400.0     500.0     600.0     800.0
   1200.0    1500.0    1800.0    2100.0    2400.0    2700.0    3000.0
  15000.0
```

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Oct 16, 97 8:43 — wexler50Thin.dat — Page 1/1

```
Thin plume - Amargosa Farms; dispersivities 20:2 meters
stripi code: aquifer of infinite width with a finite width source (line)
Model Data:  Y1=-250 m, Y2=250 m,  V=2.44 m/yr
DX=  , DY=   m**2/yr, DK=1E-16 per yr, C0=0.00438 mg/L

====
    2  15   1 256   0
mg/l        m/yr        m**2/yr   per yr    meter       yr
    .00438      2.44      122.        12.2     1.E-16
   -250.0     250.0
  15000.0   25000.0                                                   800.0
      0.0     200.0     300.0     400.0     500.0     600.0     700.0
    900.0    1000.0    1200.0    1400.0    1700.0    2000.0    2300.0
  15000.0
```

RF 10/21/97

Oct 16, 97 8:32 — wexler20Thin.dat — Page 1/1

```
Thin plume - Amargosa Farms; dispersivities 20:2 meters
stripi code: aquifer of infinite width with a finite width source (line)
Model Data:  Y1=-250 m, Y2=250 m,  V=2.44 m/yr
DX=  , DY=   m**2/yr, DK=1E-16 per yr, C0=0.00438 mg/L

====
    2  15   1 256   0
mg/l        m/yr        m**2/yr   per yr    meter       yr
    .00438      2.44      48.8        4.88     1.E-16
   -250.0     250.0
  15000.0   25000.0                                                   800.0
      0.0     200.0     300.0     400.0     500.0     600.0     700.0
    900.0    1000.0    1200.0    1400.0    1600.0    1800.0    2000.0
  15000.0
```

RF 10/21/97

input file for patchi

20:2:0.2 m case

Oct 16, 97 7:30 **wexlerfarms10.dat** Page 1/1

```
10th Run, scoping  - Amargosa Farms;  for new output file y=15 & only 1 time!
patchi code: aquifer of infinite width and height with a 'patch' source
Model Data:  Y1=-250 m, Y2=250 m, Z1=0 m, Z2=25 m, V= m/yr
DX= , DY=  , DZ=  m**2/yr, DK=1E-16 per yr, C0=1.0 mg/L

====
   2  15  22   1 256   0
mg/l       m/yr      m**2/yr   per yr    meter      yr
   .00438      2.44      48.8      4.88       .488     1.E-16
   -250.0     250.0       0.0      50.0
  15000.0   25000.0
      0.0     200.0     300.0     400.0     500.0     600.0     700.0     800.0
    900.0    1000.0    1100.0    1200.0    1300.0    1400.0    1500.0
      0.0      60.0      75.0     100.0     125.0     150.0     175.0     200.0
    225.0     250.0     275.0     300.0     325.0     350.0     375.0     400.0
    425.0     450.0     475.0     500.0     550.0     600.0
  20000.0
```

RF 10/21/97

100:10:0.1m case

Oct 16, 97 7:27 **wexlerfarms8.dat** Page 1/1

```
10th Run, scoping  - Amargosa Farms;  for new output file y=15 & only 1 time!
patchi code: aquifer of infinite width and height with a 'patch' source
Model Data:  Y1=-250 m, Y2=250 m, Z1=0 m, Z2=25 m, V= m/yr
DX= , DY=  , DZ=  m**2/yr, DK=1E-16 per yr, C0=1.0 mg/L

====
   2  15  22   1 256   0
mg/l       m/yr      m**2/yr   per yr    meter      yr
   .00438      2.44     244.0     24.40       .244     1.E-16
   -250.0     250.0       0.0      50.0
  15000.0   25000.0
      0.0     200.0     400.0     600.0     800.0     900.0    1100.0    1300.0
   1500.0    1700.0    1900.0    2100.0    2300.0    2500.0    2700.0
      0.0      60.0      75.0     100.0     125.0     150.0     175.0     200.0
    225.0     250.0     275.0     300.0     325.0     350.0     375.0     400.0
    425.0     450.0     475.0     500.0     550.0     600.0
  20000.0
```

RF 10/21/97

Sample Output file from 100:10:0.1m case

added 10/24/97 RF

Oct 24, 97 15:49 **farms8.out** Page 1/1

20000.	0.	200.	400.	600.	800.	900.	1100.	1300.	1500.	1700.	1900.	2100.	2300.	2500.	2700.
0.	0.497E-03	0.466E-03	0.385E-03	0.281E-03	0.181E-03	0.138E-03	0.740E-04	0.351E-04	0.148E-04	0.556E-05	0.187E-05	0.566E-06	0.154E-06	0.381E-07	0.858E-08
60.	0.452E-03	0.424E-03	0.351E-03	0.256E-03	0.164E-03	0.126E-03	0.674E-04	0.320E-04	0.135E-04	0.508E-05	0.171E-05	0.518E-06	0.141E-06	0.350E-07	0.788E-08
75.	0.369E-03	0.346E-03	0.287E-03	0.209E-03	0.135E-03	0.103E-03	0.553E-04	0.263E-04	0.111E-04	0.419E-05	0.142E-05	0.430E-06	0.118E-06	0.292E-07	0.659E-08
100.	0.225E-03	0.211E-03	0.175E-03	0.128E-03	0.826E-04	0.634E-04	0.341E-04	0.163E-04	0.691E-05	0.262E-05	0.890E-06	0.272E-06	0.749E-07	0.187E-07	0.425E-08
125.	0.113E-03	0.106E-03	0.882E-04	0.646E-04	0.419E-04	0.322E-04	0.174E-04	0.835E-05	0.357E-05	0.136E-05	0.466E-06	0.144E-06	0.399E-07	0.101E-07	0.231E-08
150.	0.471E-04	0.442E-04	0.368E-04	0.270E-04	0.176E-04	0.136E-04	0.737E-05	0.356E-05	0.153E-05	0.591E-06	0.204E-06	0.636E-07	0.179E-07	0.456E-08	0.106E-08
175.	0.163E-04	0.153E-04	0.127E-04	0.940E-05	0.615E-05	0.475E-05	0.260E-05	0.127E-05	0.552E-06	0.215E-06	0.752E-07	0.237E-07	0.675E-08	0.175E-08	0.412E-09
200.	0.470E-05	0.443E-05	0.370E-05	0.274E-05	0.180E-05	0.140E-05	0.771E-06	0.379E-06	0.167E-06	0.658E-07	0.233E-07	0.746E-08	0.216E-08	0.568E-09	0.136E-09
225.	0.114E-05	0.108E-05	0.903E-06	0.672E-06	0.445E-06	0.346E-06	0.193E-06	0.960E-07	0.427E-07	0.171E-07	0.615E-08	0.200E-08	0.588E-09	0.158E-09	0.385E-10
250.	0.236E-06	0.223E-06	0.187E-06	0.140E-06	0.933E-07	0.730E-07	0.410E-07	0.207E-07	0.933E-08	0.378E-08	0.138E-08	0.458E-09	0.137E-09	0.375E-10	0.937E-11
275.	0.417E-07	0.394E-07	0.332E-07	0.250E-07	0.168E-07	0.132E-07	0.749E-08	0.382E-08	0.175E-08	0.720E-09	0.268E-09	0.904E-10	0.277E-10	0.772E-11	0.197E-11
300.	0.635E-08	0.601E-08	0.508E-08	0.384E-08	0.260E-08	0.205E-08	0.118E-08	0.609E-09	0.283E-09	0.119E-09	0.450E-10	0.155E-10	0.484E-11	0.138E-11	0.361E-12
325.	0.843E-09	0.798E-09	0.677E-09	0.515E-09	0.351E-09	0.279E-09	0.162E-09	0.848E-10	0.400E-10	0.171E-10	0.660E-11	0.232E-11	0.741E-12	0.216E-12	0.579E-13
350.	0.981E-10	0.930E-10	0.792E-10	0.606E-10	0.417E-10	0.333E-10	0.196E-10	0.104E-10	0.498E-11	0.216E-11	0.852E-12	0.306E-12	0.100E-12	0.299E-13	0.821E-14
375.	0.101E-10	0.960E-11	0.821E-11	0.632E-11	0.439E-11	0.352E-11	0.209E-11	0.113E-11	0.549E-12	0.243E-12	0.976E-13	0.358E-13	0.120E-13	0.367E-14	0.103E-14
400.	0.932E-12	0.886E-12	0.760E-12	0.589E-12	0.412E-12	0.332E-12	0.200E-12	0.109E-12	0.541E-13	0.244E-13	0.999E-14	0.374E-14	0.128E-14	0.403E-15	0.116E-15
425.	0.773E-13	0.736E-13	0.633E-13	0.494E-13	0.348E-13	0.282E-13	0.172E-13	0.953E-14	0.480E-14	0.220E-14	0.921E-15	0.352E-15	0.124E-15	0.398E-16	0.118E-16
450.	0.582E-14	0.554E-14	0.479E-14	0.375E-14	0.267E-14	0.218E-14	0.134E-14	0.754E-15	0.386E-15	0.180E-15	0.769E-16	0.301E-16	0.108E-16	0.357E-17	0.109E-17
475.	0.400E-15	0.382E-15	0.331E-15	0.261E-15	0.187E-15	0.153E-15	0.957E-16	0.545E-16	0.283E-16	0.135E-16	0.587E-17	0.235E-17	0.862E-18	0.292E-18	0.913E-19
500.	0.253E-16	0.242E-16	0.210E-16	0.167E-16	0.121E-16	0.993E-17	0.627E-17	0.362E-17	0.191E-17	0.926E-18	0.411E-18	0.168E-18	0.631E-19	0.219E-19	0.703E-20
550.	0.776E-19	0.743E-19	0.652E-19	0.524E-19	0.386E-19	0.321E-19	0.208E-19	0.124E-19	0.676E-20	0.340E-20	0.157E-20	0.672E-21	0.265E-21	0.968E-22	0.327E-22
600.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

0.	0.317E-03	0.305E-03	0.271E-03	0.223E-03	0.170E-03	0.144E-03	0.982E-04	0.618E-04	0.361E-04	0.196E-04	0.985E-05	0.461E-05	0.201E-05	0.817E-06	0.310E-06
60.	0.299E-03	0.288E-03	0.256E-03	0.211E-03	0.161E-03	0.136E-03	0.926E-04	0.583E-04	0.341E-04	0.185E-04	0.931E-05	0.436E-05	0.190E-05	0.773E-06	0.293E-06
75.	0.264E-03	0.254E-03	0.226E-03	0.186E-03	0.142E-03	0.121E-03	0.819E-04	0.516E-04	0.302E-04	0.164E-04	0.825E-05	0.387E-05	0.169E-05	0.686E-06	0.261E-06
100.	0.195E-03	0.188E-03	0.167E-03	0.138E-03	0.105E-03	0.891E-04	0.606E-04	0.382E-04	0.224E-04	0.122E-04	0.613E-05	0.288E-05	0.126E-05	0.513E-06	0.195E-06
125.	0.128E-03	0.123E-03	0.109E-03	0.902E-04	0.689E-04	0.585E-04	0.398E-04	0.252E-04	0.147E-04	0.802E-05	0.406E-05	0.191E-05	0.837E-06	0.342E-06	0.131E-06
150.	0.742E-04	0.714E-04	0.636E-04	0.525E-04	0.401E-04	0.341E-04	0.233E-04	0.147E-04	0.864E-05	0.471E-05	0.239E-05	0.113E-05	0.496E-06	0.203E-06	0.779E-07
175.	0.383E-04	0.369E-04	0.329E-04	0.272E-04	0.208E-04	0.177E-04	0.121E-04	0.766E-05	0.451E-05	0.247E-05	0.125E-05	0.594E-06	0.262E-06	0.108E-06	0.415E-07
200.	0.176E-04	0.170E-04	0.151E-04	0.125E-04	0.958E-05	0.816E-05	0.559E-05	0.355E-05	0.210E-05	0.115E-05	0.587E-06	0.279E-06	0.124E-06	0.512E-07	0.198E-07
225.	0.722E-05	0.695E-05	0.620E-05	0.513E-05	0.394E-05	0.336E-05	0.231E-05	0.147E-05	0.871E-06	0.480E-06	0.246E-06	0.117E-06	0.523E-07	0.217E-07	0.845E-08
250.	0.264E-05	0.254E-05	0.227E-05	0.188E-05	0.145E-05	0.124E-05	0.851E-06	0.544E-06	0.324E-06	0.179E-06	0.922E-07	0.443E-07	0.198E-07	0.829E-08	0.324E-08
275.	0.866E-06	0.835E-06	0.746E-06	0.620E-06	0.478E-06	0.408E-06	0.282E-06	0.181E-06	0.108E-06	0.599E-07	0.310E-07	0.150E-07	0.675E-08	0.284E-08	0.112E-08
300.	0.255E-06	0.246E-06	0.220E-06	0.183E-06	0.141E-06	0.121E-06	0.837E-07	0.539E-07	0.323E-07	0.181E-07	0.940E-08	0.456E-08	0.207E-08	0.878E-09	0.348E-09
325.	0.676E-07	0.652E-07	0.584E-07	0.486E-07	0.377E-07	0.323E-07	0.224E-07	0.145E-07	0.873E-08	0.490E-08	0.257E-08	0.125E-08	0.573E-09	0.245E-09	0.979E-10
350.	0.162E-07	0.156E-07	0.140E-07	0.117E-07	0.906E-08	0.778E-08	0.542E-08	0.352E-08	0.213E-08	0.120E-08	0.634E-09	0.312E-09	0.144E-09	0.618E-10	0.250E-10
375.	0.350E-08	0.338E-08	0.304E-08	0.254E-08	0.198E-08	0.170E-08	0.119E-08	0.775E-09	0.472E-09	0.268E-09	0.142E-09	0.704E-10	0.327E-10	0.142E-10	0.577E-11
400.	0.689E-09	0.665E-09	0.598E-09	0.501E-09	0.391E-09	0.337E-09	0.237E-09	0.155E-09	0.949E-10	0.542E-10	0.289E-10	0.145E-10	0.676E-11	0.296E-11	0.122E-11
425.	0.124E-09	0.119E-09	0.107E-09	0.902E-10	0.706E-10	0.608E-10	0.429E-10	0.283E-10	0.174E-10	0.100E-10	0.538E-11	0.271E-11	0.128E-11	0.565E-12	0.234E-12
450.	0.202E-10	0.196E-10	0.176E-10	0.148E-10	0.116E-10	0.101E-10	0.712E-11	0.472E-11	0.292E-11	0.169E-11	0.915E-12	0.464E-12	0.221E-12	0.986E-13	0.413E-13
475.	0.304E-11	0.294E-11	0.265E-11	0.224E-11	0.176E-11	0.152E-11	0.108E-11	0.722E-12	0.449E-12	0.262E-12	0.143E-12	0.731E-13	0.351E-13	0.158E-13	0.669E-14
500.	0.420E-12	0.406E-12	0.367E-12	0.310E-12	0.245E-12	0.213E-12	0.152E-12	0.102E-12	0.636E-13	0.373E-13	0.205E-13	0.106E-13	0.513E-14	0.233E-14	0.999E-15
550.	0.634E-14	0.613E-14	0.556E-14	0.471E-14	0.375E-14	0.326E-14	0.235E-14	0.159E-14	0.101E-14	0.600E-15	0.335E-15	0.176E-15	0.868E-16	0.403E-16	0.176E-16
600.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

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Sample output file for itsee.f preprocessor

Once the 2 headers have been added to one of the matrices in the Wexler (patchi or stripi) output files (bottom of previous page), & the file renamed plume.dat. Below is an output file of itsee.f using "wexlerfarms10.dat" for the plume definition and caps3D.input for capture.dat.

Oct 20, 97 17:10 **df–f10.25km.output** Page 1/2

```
f10.25km       (100:10:0.1)

 Interpolated plume.
 plume width =  2586. plume thickness =   406.
*******************************************************
 Irrigation well capture area =    584079
For capture zone    1 with width =  1292. & thick =   575.
 Intersect area =  584079
Representative concentration for intersection area  0.128E-03
qfactor=   1.245 trans df=  34.314 centerline df=   9.144
=====================================================
 Irrigation well capture area =   1510867
For capture zone    2 with width =  2330. & thick =   825.
 Intersect area =  1510867
Representative concentration for intersection area  0.802E-04
qfactor=   1.881 trans df=  54.629 centerline df=   9.144
=====================================================
 Irrigation well capture area =   2501163
For capture zone    3 with width =  3382. & thick =   941.
 Intersect area =  2501163
Representative concentration for intersection area  0.762E-04
qfactor=   2.959 trans df=  57.462 centerline df=   9.144
=====================================================
 Irrigation well capture area =   3444785
For capture zone    4 with width =  4450. & thick =   985.
 Intersect area =  3444785
Representative concentration for intersection area  0.762E-04
qfactor=   4.076 trans df=  57.462 centerline df=   9.144
=====================================================
 Irrigation well capture area =   1147589
For capture zone    5 with width =  1944. & thick =   751.
 Intersect area =  1147589
Representative concentration for intersection area  0.915E-04
qfactor=   1.639 trans df=  47.851 centerline df=   9.144
=====================================================
 Irrigation well capture area =    584079
For capture zone    6 with width =  1292. & thick =   575.
 Intersect area =  584079
Representative concentration for intersection area  0.128E-03
qfactor=   1.245 trans df=  34.314 centerline df=   9.144
=====================================================
 Irrigation well capture area =    292146
For capture zone    7 with width =   876. & thick =   424.
 Intersect area =  292146
Representative concentration for intersection area  0.172E-03
qfactor=   1.012 trans df=  25.532 centerline df=   9.144
=====================================================
 Irrigation well capture area =    195246
For capture zone    8 with width =   705. & thick =   352.
 Intersect area =  195246
Representative concentration for intersection area  0.215E-03
qfactor=   1.000 trans df=  20.333 centerline df=   9.144
=====================================================
 Irrigation well capture area =    147621
For capture zone    9 with width =   607. & thick =   309.
 Intersect area =  147621
Representative concentration for intersection area  0.249E-03
qfactor=   1.000 trans df=  17.593 centerline df=   9.144
=====================================================
 Irrigation well capture area =   1965590
For capture zone   10 with width =  2810. & thick =   890.
 Intersect area =  1965590
Representative concentration for intersection area  0.762E-04
qfactor=   2.326 trans df=  57.462 centerline df=   9.144
=====================================================
 Irrigation well capture area =   1337611
For capture zone   11 with width =  2146. & thick =   793.
 Intersect area =  1337611
Representative concentration for intersection area  0.848E-04
```

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cont'd.

Oct 20, 97 17:10 **df–f10.25km.output** Page 2/2

```
qfactor=   1.764 trans df=  51.643 centerline df=   9.144
=====================================================
 Irrigation well capture area =   1016213
For capture zone   12 with width =  1798. & thick =   719.
 Intersect area =  1016213
Representative concentration for intersection area  0.975E-04
qfactor=   1.555 trans df=  44.902 centerline df=   9.144
=====================================================
 Irrigation well capture area =   4397848
For capture zone   13 with width =  5596. & thick =  1000.
 Intersect area =  4397848
Representative concentration for intersection area  0.762E-04
qfactor=   5.203 trans df=  57.462 centerline df=   9.144
=====================================================
 Irrigation well capture area =   2409164
For capture zone   14 with width =  3282. & thick =   934.
 Intersect area =  2409164
Representative concentration for intersection area  0.762E-04
qfactor=   2.850 trans df=  57.462 centerline df=   9.144
=====================================================
 Irrigation well capture area =   1660822
For capture zone   15 with width =  2486. & thick =   850.
 Intersect area =  1660822
Representative concentration for intersection area  0.774E-04
qfactor=   1.994 trans df=  56.617 centerline df=   9.144
=====================================================
 Irrigation well capture area =   1016213
For capture zone   16 with width =  1798. & thick =   719.
 Intersect area =  1016213
Representative concentration for intersection area  0.975E-04
qfactor=   1.555 trans df=  44.902 centerline df=   9.144
=====================================================
```

PF 10/21/97

Below is a list of files run through itsee.f
All of these files are in ./Bore/Analytic/Intersec/*

plume.dat	capture.dat	output	comments
st100.25km	caps2D.input	df-st100.25km.10m,	plume=10 m thick
st100.25km	↓	df-st100.25km.25m,	plume = 25 m thick
f8.25km	↓	df-f8.25km.dom,	3D plume
st20.25km	caps2.input	df-st20.25km.10m,	plume=10m thick
st20.25km	↓	df-st20.25km.25m,	plume = 25m thick
f10.25km	↓	df-f10.25.km.dom,	3D plume
f10.25km	caps3D.input	df-f10.25km.output	} 3D plume
f9.25km	↓	df-f9.25km.output	}
f8.25km	↓	df-f8.25km.output	}
st20.25km	caps3D.input	df-st20.25km.25m,	} plume 25 m thick
st50.25km	↓	df-st50.25km.25m.	}
st100.25km	↓	df-st100.25km.25m.	}

76 10/24/97 QAP-014 Review (Memo)

Memo

For: Dr. Robert Baca
From: Jeff Bogan
Subject: QAP-014 Review of Assessment of Dilution Effects Induced by Water Well Pumping in the Amargosa Farms Area and documentation in scientific notebook
Date: Oct 21, 1997
cc: R. Fedors

This memo is to inform you of the review performed on the quality assessment (as specified in QAP-014) of the dilution effects induced by water well pumping in the Amargosa Farms area. There are three steps that are required to solve for the dilution effects. First the dilution of the nuclides as it exits the repository and the subsequent dispersal of the plume is computed. Next, the orthogonal capture zone is delineated by a trial and error process with GFLOW1 software. Lastly, the results from the previous two steps are used to determine the quantity of nuclides, drawn by the either an irrigation well or a domestic well. A review of the documentation in the scientific notebook and verification of the controlled and uncontrolled software used in each of these steps is given.

The dilution of the nuclides as it exits the repository, is computed by either patchi.exe or stripi.exe executable. These are based on analytical solutions of Wexler (1992). To produce a suitable range of values that include the most significant portion of the plume, several iteration of the program may be necessary. The boundary of the plume is delineated by the iso-cline that equals the concentration of nuclides at their introduction into the water table. A file is produced by the patchi executable that give the plume distribution at the critical points. The user is responsible for fitting this plume so that it boundaries are at the edges of the matrix given in this file.

As based on the QAP-014 Sect 3.1 a review of the documentation in the scientific notebook was performed. Input parameters (p27), name, version and justification for usage were included. However, some of the input parameters were not fully defined especially as formatted in the file, and no sample output file was included.As based on QAP-014 Sect 3.2 verification of the patchi executable was performed. Based on the sample parameters and parameters created by the reviewer, the software gave reasonable results.

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The orthogonal capture zone was delineated with GFLOW, (Haitjema Software). Aquifer, partially penetrating well and region of interest characteristics were used as input for the software. Certain values were conjectural at this point as the true values based on data from Amargosa Valley are not available. A backwards particle trace was then performed with software. This procedure was to define the capture zone by determining with a trial and error basis, the extent of upstream particles that will be captured by the well. This defines the capture zone by determine particles on the boundary of the well capture area. This procedure was performed for both downward(z) and perpendicular(y) directions.

As based on the QAP-014 a review of the documentation in the scientific notebook was performed. Input parameters(p12, 20, 21), name, version and justification for usage were included. 41 sample runs were included in the scientific notebook (p41). The reviewer checked Report ID #8, #18, #28 and #38 on this page against given results with good agreement in every case. However, on this table's header, a note might be included as to which columns are parameters and which are results. GFLOW is commercial software, and validation is given in its documentation. The purpose to which it was put is within its capabilities and the results were reasonable, as results from an internal error checking routine within the program were small.

An intersection calculation was determined with a program called itsec (R. Fedors) to combine the results of the previous two steps. To prepare the input files, output files from patchi must be edited and results from GFLOW entered into a second data file. Specifically the "file.out" file must be edited to include two lines at the head of the file for dimensions of the matrix, threshold concentration, flags for capture zone, and thickness. The name must be changed to "plume.dat". The second file is constructed of information derived from the GFLOW, This information includes dimensions of the capture zone, darcy velocity and well screen information. More than one well may be specified in this file. The program then postprocesses the information to determine the quantity of nuclides captured by the well.

The itsec source code is commented throughout. This includes a description of all of the input file and output file parameters. The development and rational for the model and its sources is documented in the scientific notebook. Input files and output is included. Several runs were done independent of the previous files to gage the performance of this program. For the most part it performed properly as described in the scientific notebook. There are some concerns, however, based on accuracy. These are detailed on the following page.

cont'd

For the input file plume.dat:

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```
   3    3     0.00438
         1         10.
80000.        0.         5.         10.
     0. 0.688E-04 0.187E-04 0.267E-04
     5. 0.410E-04 0.210E-04 0.457E-04
    10. 0.210E-04 0.250E-04 0.367E-04
```

and capture.dat:

```
   1
   5.    5.    .244         c Width, Thick, Darcy
  12.   12.    8.           c Screen top, Screen bottom, C Top
99999
```

The following output file was outputted

intersec.out :

```
Interpolated plume.
 0.69E-04  0.59E-04  0.49E-04  0.39E-04  0.29E-04  0.19E-04  0.15E-04  0.11E-04  0.75E-05  0.37E-05  0.00E+00  0.00E+00
 0.63E-04  0.54E-04  0.46E-04  0.37E-04  0.28E-04  0.19E-04  0.15E-04  0.11E-04  0.77E-05  0.38E-05  0.00E+00  0.00E+00
 0.58E-04  0.50E-04  0.42E-04  0.35E-04  0.27E-04  0.20E-04  0.16E-04  0.12E-04  0.78E-05  0.39E-05  0.00E+00  0.00E+00
 0.52E-04  0.46E-04  0.39E-04  0.33E-04  0.26E-04  0.20E-04  0.16E-04  0.12E-04  0.80E-05  0.40E-05  0.00E+00  0.00E+00
 0.47E-04  0.41E-04  0.36E-04  0.31E-04  0.26E-04  0.21E-04  0.16E-04  0.12E-04  0.82E-05  0.41E-05  0.00E+00  0.00E+00
 0.41E-04  0.37E-04  0.33E-04  0.29E-04  0.25E-04  0.21E-04  0.17E-04  0.13E-04  0.84E-05  0.42E-05  0.00E+00  0.00E+00
 0.37E-04  0.34E-04  0.31E-04  0.28E-04  0.25E-04  0.22E-04  0.17E-04  0.13E-04  0.87E-05  0.44E-05  0.00E+00  0.00E+00
 0.33E-04  0.31E-04  0.29E-04  0.27E-04  0.25E-04  0.23E-04  0.18E-04  0.14E-04  0.90E-05  0.45E-05  0.00E+00  0.00E+00
 0.29E-04  0.28E-04  0.27E-04  0.26E-04  0.25E-04  0.23E-04  0.19E-04  0.14E-04  0.94E-05  0.47E-05  0.00E+00  0.00E+00
 0.25E-04  0.25E-04  0.25E-04  0.25E-04  0.24E-04  0.24E-04  0.19E-04  0.15E-04  0.97E-05  0.48E-05  0.00E+00  0.00E+00
 0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
 0.21E-04  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
 0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
 0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
 0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
 0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
plume width =    20. plume thickness =    10.
*******************************************************
Top of domestic capture area, nodes =   9
Middle plus top domestic capture nodes =   3
Bottom half ellipse=   0
Domestic well capture area (all) =   19
0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
1. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
1. 1. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
1. 1. 1. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
1. 1. 1. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
1. 1. 1. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
```


cont'd

```
0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
For capture zone    1 with width =     5. & thick =     5.
Representative concentration for intersection area  0.249E-04
 trans df = 172.441 centerline df =  62.500
==========================================================
```

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Because the value in the upper left most corner is used in this case to represent the total concentration for the block that is interpolated over (being an integer value) instead of interpolating to the center of each block, there may be some kind of error in the this respect. In addition there was a random number that showed up outside of the matrix in this case, which in itself is not that much of an innaccuracy, but may indicate some kind of other problem.

Jeff Bogan

Resolution of this QAP-014 review by Jeff Bogan is included on the following pages

RF 10/24/97

Input instructions for patchi code

Table 10.—Input data format for the program PATCHI

RF 10/24/97

Data set	Columns	Format	Variable name	Description
1	1 - 60	A60	TITLE	Data to be printed in a title box on the first page of program output. Last line in data set must have an "=" in column 1. First four lines are also used as titles for plot.
2	1 - 4	I4	NX	Number of x-coordinates at which solution will be evaluated.
	5 - 8	I4	NY	Number of y-coordinates at which solution will be evaluated.
	9 - 12	I4	NZ	Number of z-coordinates at which solution will be evaluated.
	13 - 16	I4	NT	Number of time values at which solution will be evaluated.
	17 - 20	I4	NMAX	Number of terms to be used in numerical integration technique (must be equal to 4, 20, 60, 104, or 256).
	21 - 24	I4	IPLT	Plot control variable. Contours of normalized concentration will be plotted if IPLT is greater than 0.
3	1 - 10	A10	CUNITS	Character variable used as label for units of concentration in program output.
	11 - 20	A10	VUNITS	Units of ground-water velocity.
	21 - 30	A10	DUNITS	Units of dispersion coefficient.
	31 - 40	A10	KUNITS	Units of solute-decay coefficient.
	41 - 50	A10	LUNITS	Units of length.
	51 - 60	A10	TUNITS	Units of time.
4	1 - 10	F10.0	CO	Solute concentration at inflow boundary.
	11 - 20	F10.0	VX	Ground-water velocity in x-direction.
	21 - 30	F10.0	DX	Longitudinal dispersion coefficient.
	31 - 40	F10.0	DY	Transverse dispersion coefficient in y-direction.
	41 - 50	F10.0	DZ	Transverse dispersion coefficient in z-direction.
	51 - 60	F10.0	DK	First-order solute-decay coefficient.
5	1 - 10	F10.0	Y1	Y-coordinate of lower limit of finite width and height solute source.
	11 - 20	F10.0	Y2	Y-coordinate of upper limit of finite width and height solute source.
	21 - 30	F10.0	Z1	Z-coordinate of lower limit of finite width and height solute source.
	31 - 40	F10.0	Z2	Z-coordinate of upper limit of finite width and height solute source.
6	1 - 80	8F10.0	X(I)	X-coordinates at which solution will be evaluated (eight values per line).
7	1 - 80	8F10.0	Y(I)	Y-coordinates at which solution will be evaluated (eight values per line).
8	1 - 80	8F10.0	Z(I)	Z-coordinates at which solution will be evaluated (eight values per line).
9	1 - 80	8F10.0	T(I)	Time values at which solution will be evaluated (eight values per line).
[1]10	1 - 10	F10.0	XSCLP	Scaling factor by which to divide x-coordinate values are divided to convert them to plotter inches.
	11 - 20	F10.0	YSCLP	Scaling factor used to convert y-coordinates into plotter inches.
	21 - 30	F10.0	DELTA	Contour increment for plot of normalized concentration (must be between 0.0 and 1.0).

[1]Data line is needed only if IPLT (in data set 2) is greater than 0.

10/24/97 RF

Input instructions for stripi

Table 5.—Input data format for the program STRIPI

RF 10/24/97

Data set	Columns	Format	Variable name	Description
1	1 - 60	A60	TITLE	Data to be printed in a title box on the first page of program output. Last line in data set must have an "=" in column 1. First four lines are also used as title for plot.
2	1 - 4	I4	NX	Number of x-coordinates at which solution will be evaluated.
	5 - 8	I4	NY	Number of y-coordinates at which solution will be evaluated.
	9 - 12	I4	NT	Number of time values at which solution will be evaluated.
	13 - 16	I4	NMAX	Number of terms used in the numerical integration techniques (must be equal to 4, 20, 60, 104, or 256).
	17 - 20	I4	IPLT	Plot control variable. Contours of normalized concentration will be plotted if IPLT is greater than 0.
3	1 - 10	A10	CUNITS	Character variable used as label for units of concentration in program output.
	11 - 20	A10	VUNITS	Units of ground-water velocity.
	21 - 30	A10	DUNITS	Units of dispersion coefficient.
	31 - 40	A10	KUNITS	Units of solute-decay coefficient.
	41 - 50	A10	LUNITS	Units of length.
	51 - 60	A10	TUNITS	Units of time.
4	1 - 10	F10.0	CO	Solute concentration at inflow boundary.
	11 - 20	F10.0	VX	Ground-water velocity in x-direction.
	21 - 30	F10.0	DX	Longitudinal dispersion coefficient.
	31 - 40	F10.0	DY	Transverse dispersion coefficient.
	41 - 50	F10.0	DK	First-order solute-decay coefficient.
5	1 - 10	F10.0	Y1	Y-coordinate of lower limit of finite-width solute source.
	11 - 20	F10.0	Y2	Y-coordinate of upper limit of finite-width solute source.
6	1 - 80	8F10.0	X(I)	X-coordinates at which solution will be evaluated (eight values per line).
7	1 - 80	8F10.0	Y(I)	Y-coordinates at which solution will be evaluated (eight values per line).
8	1 - 80	8F10.0	T(I)	Time values at which solution will be evaluated (eight values per line).
[1]9	1 - 10	F10.0	XSCLP	Scaling factor by which x-coordinate values are divided to convert them to plotter inches.
	11 - 20	F10.0	YSCLP	Scaling factor used to convert y-coordinates into plotter inches.
	21 - 30	F10.0	DELTA	Contour increment for plot of normalized concentration (must be between 0.0 and 1.0).

[1]Data line is needed only if IPLT (in data set 2) is greater than 0.

Input and output files for "patchi" and "stripi"
(see also pages 72 & 73) ./Bore/Analytic/Intersect/*

stripi input	output	itsec. input for plume.dat	
wexler100Thin.dat ($\alpha_L : \alpha_T \Rightarrow$ 100:10 m)	file.out	st100.15km	(at 15 km)
		st100.25km	(at 25 km)

(then edit plume.dat for 10 m or 25 m thick plume)
(also add 2 header lines as indicated in itsec.f comments)
(do 1 plume at a time [one matrix input])

stripi input	output	itsec. input for plume.dat
wexler50Thin.dat ($\alpha_L : \alpha_T \Rightarrow$ 50:5 m)	file.out	st50.15km
		st50.25km
wexler20Thin.dat (20:2 m)	file.out	st20.15km
		st20.25km
wexlerfarms10.dat (20:2:0.2 m)	file.out	f10.15km
		f10.25km
wexlerfarms8.dat (100:10:0.1 m)	file.out	f8.15km
		f8.25km

The output files ~~from~~ itsec.f are descriptive of inputs

capture.dat = caps3D.input {
df-st100.25km.10m.out (10 m thick plume)
df-st100.25km.25m.out (25 m thick plume)
df-f8.25km.dom.out
df-st20.25km.10m.out
df-st20.25km.25m.out
}

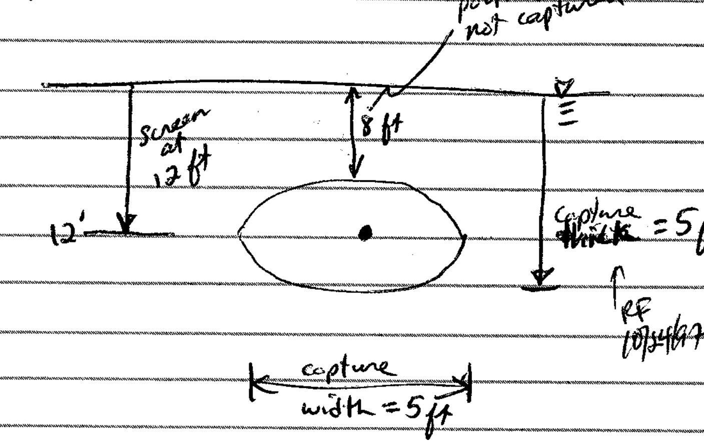
capture.dat = caps3D.input {
df-f10.25km.out
df-f9.25km.out
df-f8.25km.out
df-st20.25km.large.out
df-st50.25km.large.out
df-st100.25km.large.out
} 3-dimensional plume ⇒ "large"

Comments on test example of J. Bogan (in memo)

① capture description did not properly utilize the input instructions, specifically the meaning of capture width and capture thickness. See capture thickness as defined on page 42 of scientific notebook.

Test example ⇒

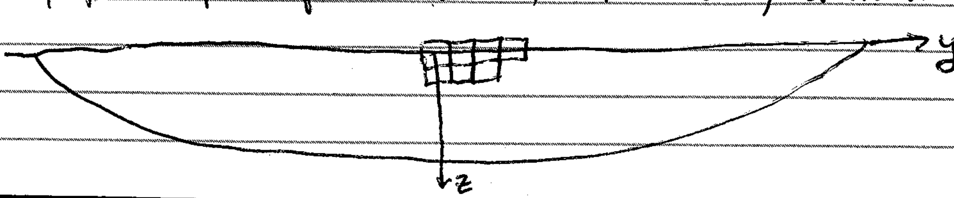
screened portion is point
capture thickness (5 ft) did not fit with screened portion of 12 ft depth



② Only a portion of the plume was entered; input instructions specifically specify that the entire plume be entered.

Other comments on memo

① Plume delineation is at $C_0 \times 10^{-4}$ not at C_0 iso-cline
② User does not have to "fitting this plume so that its boundaries are at edges of the matrix." Rather, just make sure that y and z values are large enough so that $C_0 \times 10^{-4}$ threshold is included somewhere within matrix. There is no reason to be accurate, just don't go too far so that interpolation is weakened, or don't cut it too short so that extrapolation is expected (there will be none!)
③ GFLOW "trial & error" basis included both forward and backward tracking.
④ Account for top half-cells (above) water table, as illustrated below.



Memo for Resolution of QAP-014 review with J. Bogan concurrence

To: J. Bogan
B. Baca
From: R. Fedors
Subject: Resolution of Items in QAP-014 Review by J. Bogan of Oct 21, 1997 on Borehole Dilution Effects in the Amargosa Farms Area
Date: October 25, 1997

R Fedors 10/25/97

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Item 1 (page 1 of QAP-014 review memo)
Input parameters for Wexler (1992) patchi and stripi codes were not fully defined especially as formatted in the file, and no sample output file was included in the scientific notebook.

Resolution:
Input parameters and formats are defined in Wexler (1992) page 56 for patchi and page 27 for stripi. Xerox copies of the input instructions are now added to the scientific notebook. Input and output files for the transport simulations are referenced by path/name. These will be tar'd to tape at the conclusion of the borehole dilution scoping report. A sample output file is now added to the scientific notebook so that a clear connection is evident with the patchi/stripi output and the input for the postprocessor itsec.f for which two header lines are added. A sample input file for the itsec.f postprocessor was already incorporated into the scientific notebook.

Item 2 (page 4 of QAP-014 review memo)
An extraneous value (non-zero) of concentration noted outside the plume may be indicative of some kind of other problem.

Resolution:
An error in the interpolation algorithm left a non-zero value of concentration outside the plume area as delineated by $1x10^{-4}$ times the source concentration. This error was indicative of an interpolation error at the edge of the plume which was magnified when only a small portion of the plume was input as in the test case of J. Bogan in his memo. The error was corrected and all of the cases were re-run with no significant changes (to the 4th significant figure or less) to the results. This was expected since the input criteria specified that the entire plume must be entered, the error at the outside edges (low concentration relative to the interior) was insignificant. The test case of J. Bogan was also re-run and the results included in the scientific notebook. In addition, input checks have been added to 'stop' the calculation if improper plume inputs are attempted.

continued

Item 3 (page 4 of QAP-014 review memo)
There may be an error associated with the choice of the discretization grid.

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Resolution:
J. Bogan is suggesting a shift of the grid placement. A grid refinement check as suggested by B. Baca was attempted. However since the code uses integer location values as pointers in matrices, the refinement most readily implemented is that by a factor of ten. This creates a problem size which is beyond the memory plus swap currently on the SUN server bigbend. Rather than involving IMS staff or modifying the code significantly, J. Bogan concurred that accounting for the half-cells above the water table would sufficiently address his concerns. The accounting is literally a subtraction of the mass and area in the half-cells above the water table from the interpolated portion of the plume. The half-cells along the vertical mirror plane of the plume were already accounted for in the itsec.f code. In re-runs of 34 different combinations of plumes and capture zones, the results did not significantly change. Some results changed in the 3rd significant figure, however the results in the borehole dilution scoping report are generally reported to 2 significant figures. The conclusion is that the grid was sufficiently refined to avoid any grid configuration effects. Output from the itsec.f postprocessor for the 34 re-runs are included in the scientific notebook as is the printout of the itsec.f code.

Wexler, E.J. 1992. Analytic Solutions for One-, Two-, and Three-Dimensional Solute Transport in Ground-Water Systems with Uniform Flow. Techniques of Water-Resources Investigations of the USGS, Book 3, Chapter B7.

I CONSIDER THIS TO BE IN ACCORDANCE WITH QAP 014 NOW.

Jeff Bogan
CONSULTANT.

10/25/97 RF


```
 Interpolated plume.
 plume width =  5300. plume thickness =   293.
*******************************************************
 Irrigation well capture area =   584079
For capture zone    1 with width =  1292. & thick =   575.
Representative concentration for intersection area  0.118E-03
trans df=  37.249 centerline df=  13.817
=======================================================
 Irrigation well capture area =   1510867
For capture zone    2 with width =  2330. & thick =   825.
Representative concentration for intersection area  0.930E-04
trans df=  47.089 centerline df=  13.817
=======================================================
 Irrigation well capture area =   2501163
For capture zone    3 with width =  3382. & thick =   941.
Representative concentration for intersection area  0.727E-04
trans df=  60.254 centerline df=  13.817
=======================================================
 Irrigation well capture area =   3444785
For capture zone    4 with width =  4450. & thick =   985.
Representative concentration for intersection area  0.596E-04
trans df=  73.508 centerline df=  13.817
=======================================================
 Irrigation well capture area =   1147589
For capture zone    5 with width =  1944. & thick =   751.
Representative concentration for intersection area  0.102E-03
trans df=  42.984 centerline df=  13.817
=======================================================
 Irrigation well capture area =   584079
For capture zone    6 with width =  1292. & thick =   575.
Representative concentration for intersection area  0.118E-03
trans df=  37.249 centerline df=  13.817
=======================================================
 Irrigation well capture area =   292146
For capture zone    7 with width =   876. & thick =   424.
Representative concentration for intersection area  0.130E-03
trans df=  33.817 centerline df=  13.817
=======================================================
 Irrigation well capture area =   195246
For capture zone    8 with width =   705. & thick =   352.
Representative concentration for intersection area  0.138E-03
trans df=  31.836 centerline df=  13.817
=======================================================
 Irrigation well capture area =   147621
For capture zone    9 with width =   607. & thick =   309.
Representative concentration for intersection area  0.146E-03
trans df=  29.977 centerline df=  13.817
=======================================================
 Irrigation well capture area =   1965590
For capture zone   10 with width =  2810. & thick =   890.
Representative concentration for intersection area  0.829E-04
trans df=  52.859 centerline df=  13.817
=======================================================
 Irrigation well capture area =   1337611
For capture zone   11 with width =  2146. & thick =   793.
Representative concentration for intersection area  0.972E-04
trans df=  45.056 centerline df=  13.817
=======================================================
 Irrigation well capture area =   1016213
For capture zone   12 with width =  1798. & thick =   719.
Representative concentration for intersection area  0.105E-03
trans df=  41.594 centerline df=  13.817
=======================================================
 Irrigation well capture area =   4397848
For capture zone   13 with width =  5596. & thick =  1000.
Representative concentration for intersection area  0.544E-04
trans df=  80.487 centerline df=  13.817
=======================================================
 Irrigation well capture area =   2409164
```



```
For capture zone   14 with width =  3282. & thick =   934.
Representative concentration for intersection area  0.743E-04
trans df=  58.934 centerline df=  13.817
=======================================================
 Irrigation well capture area =   1660822
For capture zone   15 with width =  2486. & thick =   850.
Representative concentration for intersection area  0.896E-04
trans df=  48.897 centerline df=  13.817
=======================================================
 Irrigation well capture area =   1016213
For capture zone   16 with width =  1798. & thick =   719.
Representative concentration for intersection area  0.105E-03
trans df=  41.594 centerline df=  13.817
=======================================================
```

RF 10/25/97

Printed by Randall S. Fedors


```
 Interpolated plume.
 plume width =  5884. plume thickness =    25.
*****************************************************
 Domestic well capture area (all) =    5739
For capture zone    1 with width =    76. & thick =    88.
Representative concentration for intersection area  0.121E-02
trans df=   3.631 centerline df=   3.620
=====================================================
 Domestic well capture area (all) =    5591
For capture zone    2 with width =    69. & thick =    98.
Representative concentration for intersection area  0.121E-02
trans df=   3.630 centerline df=   3.620
=====================================================
 Domestic well capture area (all) =    5663
For capture zone    3 with width =    67. & thick =   107.
Representative concentration for intersection area  0.121E-02
trans df=   3.629 centerline df=   3.620
=====================================================
 Domestic well capture area (all) =    5969
For capture zone    4 with width =    68. & thick =   127.
Representative concentration for intersection area  0.121E-02
trans df=   3.625 centerline df=   3.620
=====================================================
 Domestic well capture area (all) =    1898
For capture zone    5 with width =    29. & thick =    73.
Representative concentration for intersection area  0.121E-02
trans df=   3.624 centerline df=   3.620
=====================================================
 Domestic well capture area (all) =    3875
For capture zone    6 with width =    54. & thick =    82.
Representative concentration for intersection area  0.121E-02
trans df=   3.628 centerline df=   3.620
=====================================================
 Domestic well capture area (all) =    5739
For capture zone    7 with width =    76. & thick =    88.
Representative concentration for intersection area  0.121E-02
trans df=   3.631 centerline df=   3.620
=====================================================
 Domestic well capture area (all) =    7765
For capture zone    8 with width =    97. & thick =    96.
Representative concentration for intersection area  0.121E-02
trans df=   3.634 centerline df=   3.620
=====================================================
 Domestic well capture area (all) =   13424
For capture zone    9 with width =   146. & thick =   112.
Representative concentration for intersection area  0.120E-02
trans df=   3.642 centerline df=   3.620
=====================================================
 Domestic well capture area (all) =   74122
For capture zone   10 with width =   418. & thick =   224.
Representative concentration for intersection area  0.119E-02
trans df=   3.684 centerline df=   3.620
=====================================================
 Domestic well capture area (all) =  147855
For capture zone   11 with width =   607. & thick =   309.
Representative concentration for intersection area  0.117E-02
trans df=   3.735 centerline df=   3.620
=====================================================
 Domestic well capture area (all) =   59343
For capture zone   12 with width =   369. & thick =   203.
Representative concentration for intersection area  0.119E-02
trans df=   3.676 centerline df=   3.620
=====================================================
 Domestic well capture area (all) =   11786
For capture zone   13 with width =   133. & thick =   108.
Representative concentration for intersection area  0.120E-02
trans df=   3.640 centerline df=   3.620
=====================================================
 Domestic well capture area (all) =    5739
```



```
For capture zone   14 with width =    76. & thick =    88.
Representative concentration for intersection area  0.121E-02
trans df=   3.631 centerline df=   3.620
=====================================================
 Domestic well capture area (all) =    1358
For capture zone   15 with width =    22. & thick =    70.
Representative concentration for intersection area  0.121E-02
trans df=   3.623 centerline df=   3.620
=====================================================
 Domestic well capture area (all) =   30013
For capture zone   16 with width =   248. & thick =   151.
Representative concentration for intersection area  0.120E-02
trans df=   3.657 centerline df=   3.620
=====================================================
 Domestic well capture area (all) =   11786
For capture zone   17 with width =   133. & thick =   108.
Representative concentration for intersection area  0.120E-02
trans df=   3.640 centerline df=   3.620
=====================================================
 Domestic well capture area (all) =    5739
For capture zone   18 with width =    76. & thick =    88.
Representative concentration for intersection area  0.121E-02
trans df=   3.631 centerline df=   3.620
=====================================================
 Domestic well capture area (all) =    2801
For capture zone   19 with width =    41. & thick =    78.
Representative concentration for intersection area  0.121E-02
trans df=   3.626 centerline df=   3.620
=====================================================
```

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Input files and output file for itsec.f run for J. Bogan test case; illustrates that itsec.f is doing as expected.

Oct 22, 97 15:21 **plume.dat.bogan**

```
      3     3   0.00438
            1        10.
 20000.          0.         5.        10.
      0.  0.688E-04  0.187E-04  0.267E-04
      5.  0.410E-04  0.210E-04  0.457E-04
     10.  0.210E-04  0.250E-04  0.367E-04
```

RF 10/25/97

Oct 22, 97 14:55 RF **capture.dat.bogan**

```
     1
     5.      5.   .244
    12.     12.     8.
 99999
```

Oct 22, 97 16:20 **intersec.out**

```
 Interpolated plume.
  0.69E-04  0.59E-04  0.49E-04  0.39E-04  0.29E-04  0.19E-04  0.20E-04  0.22E-04  0.23E-04  0.25E-04  0.27E-04  0.00E+00
  0.63E-04  0.54E-04  0.46E-04  0.37E-04  0.28E-04  0.19E-04  0.21E-04  0.24E-04  0.26E-04  0.28E-04  0.30E-04  0.00E+00
  0.58E-04  0.50E-04  0.42E-04  0.35E-04  0.27E-04  0.20E-04  0.23E-04  0.25E-04  0.28E-04  0.31E-04  0.34E-04  0.00E+00
  0.52E-04  0.46E-04  0.39E-04  0.33E-04  0.26E-04  0.20E-04  0.24E-04  0.27E-04  0.31E-04  0.34E-04  0.38E-04  0.00E+00
  0.47E-04  0.41E-04  0.36E-04  0.31E-04  0.26E-04  0.21E-04  0.25E-04  0.29E-04  0.33E-04  0.38E-04  0.42E-04  0.00E+00
  0.41E-04  0.37E-04  0.33E-04  0.29E-04  0.25E-04  0.21E-04  0.26E-04  0.31E-04  0.36E-04  0.41E-04  0.46E-04  0.00E+00
  0.37E-04  0.34E-04  0.31E-04  0.28E-04  0.25E-04  0.22E-04  0.26E-04  0.31E-04  0.35E-04  0.39E-04  0.44E-04  0.00E+00
  0.33E-04  0.31E-04  0.29E-04  0.27E-04  0.25E-04  0.23E-04  0.27E-04  0.30E-04  0.34E-04  0.38E-04  0.42E-04  0.00E+00
  0.29E-04  0.28E-04  0.27E-04  0.26E-04  0.25E-04  0.23E-04  0.27E-04  0.30E-04  0.34E-04  0.37E-04  0.40E-04  0.00E+00
  0.25E-04  0.25E-04  0.25E-04  0.25E-04  0.24E-04  0.24E-04  0.27E-04  0.30E-04  0.33E-04  0.36E-04  0.39E-04  0.00E+00
  0.21E-04  0.22E-04  0.23E-04  0.23E-04  0.24E-04  0.25E-04  0.27E-04  0.30E-04  0.32E-04  0.34E-04  0.37E-04  0.00E+00
  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
 plume width =    22. plume thickness =    11.
*********************************************************
 Top of domestic capture area, nodes =    9
 Middle plus top domestic capture nodes =    3
 Bottom half ellipse=    0
 Domestic well capture area (all) =    19
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 1. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 1. 1. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 1. 1. 1. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 1. 1. 1. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 1. 1. 1. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
For capture zone    1 with width =      5. & thick =      5.
 Intersect area =   19
Representative concentration for intersection area  0.237E-04
qfactor=   2.111 trans df= 184.654 centerline df=  63.663
=========================================================
```

RF 10/25/97

Code "itsec.f" as modified

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```
***********************************************************************
** Post-processor for Wexler output and capture area output.        **
**                                                                   **
** Calculates intersection of a plume and each capture zone         **
** for dilution factors. Assumes a grid where dy=1 and dz=1.        **
** Cells (1m^2) are centered around input data points to get        **
** representative concentration for each cell.                      **
** Code is written for clarity at the expense of efficiency.        **
** Compiled on SUN using:  f77 -r8 -o itsec itsec.f                 **
**                                                                   **
** Borehole Dilution for ARDES KTI                                   **
**                                                                   **
**    RFedors (Oct97)   CNWRA                                        **
***********************************************************************
*  INPUT FILES:
* Read plume input file, list concentrations from centerline to edge of plume.
* Format based on Wexler, 1992 output plus my headers (records 1&2).
*            1. ny, nz, conc_o   initial concentration        (2i5,f10.6)
*            2. flag for thin(=0) or 3D(=1) plume, thickness  (i10,f10.3)
*            3  y-values                                           (*)
*            4-(nz+4). z-value and concentrations for each y-position. (*)
* For all measurements, assume that ground=0 and z-axis is vertical down.
*
* Read capture input file, 2 records each capture area;
* if flag=1 then domestic, if iflag=2 then irrigation, if flag=99999, then stop
*            1.  iflag                          (i5)
*            2.  width, thick, darcy velocity   (3f6.3)
*            3.  screentop, screenbot, ctop     (3f6.3)
*            4-? repeat 1-3 for each capture area or just iflag=99999 to stop.
* For all measurements, assume that ground=0 and z-axis is vertical down.
***********************************************************************
*        1         2         3         4         5         6         7
*234567890123456789012345678901234567890123456789012345678901234567890123456789012
      program itsec

      parameter  (max=100, maxy=3400, maxz=2000, maxny=50, maxnz=50)
      implicit real (a-h,o-z)
      implicit integer (i-n)
      character  infile*12, infile2*12, outfile*12
      dimension  capture(0:maxy,0:maxz), plume(0:maxy,0:maxz)
     &          , concp(0:maxny,0:maxnz), yp(0:maxny), zp(0:maxnz)


      infile = 'plume.dat'
      infile2 = 'capture.dat'
      outfile = 'intersec.out'
      open(8,file=infile,status='unknown')
      open(9,file=infile2,status='unknown')
      open(10,file=outfile,status='unknown')

      zero = 1.e-10
      dy = 1.
      dz = 1.
c Read plume input file.
      read(8,'(2i5,f10.6)') ny, nz, conc_o
      read(8,'(i10,f10.3)') iflag2, pthick
      read(8,*) time, ( yp(j), j = 0,ny-1 )
      do 20 k = 0,nz-1
         read(8,*)  zp(k), ( concp(j,k), j = 0,ny-1 )
 20   continue
      close(8)
c Make sure entire plume is entered in the input file, else exit
      if(concp(ny-1,0).gt.conc_o*1.e-4) then
        write(6,*)'Inputs are incorrect, inputs must cover entire plume'
        stop
      endif
      if(iflag2.ne.0.and.concp(0,nz-1).gt.conc_o*1.e-4) then
        write(6,*)'Inputs are incorrect, inputs must cover entire plume'
        stop
```



```
      endif

c Fill in plume matrix.
      call interpol(plume,concp,yp,zp,ny,nz,iflag2,pthick,conc_o,cPlume)

c Read capture input file, 3 records for each capture area.
      do 200 i = 1,max
        read (9,'(i5)') iflag
        if(iflag.eq.99999) stop
        read (9,'(3f6.3)') cwidth, cthick, darcy
        read (9,'(3f6.3)') scntop, scnbot, ctop

c Fill in capture matrices.

      cwidth2 = cwidth * 0.5
      if(iflag.eq.1)
     &        call domest(cwidth2,cthick,capture,scntop,scnbot,ctop,icap)
      if(iflag.eq.2)
     &        call irrig(cwidth2,cthick,capture,icap)

c Calculate factors doing both mirrored sides of ellipse; account for extra
c half-cells along water table and along centerline vertical plane by
c looping through mirrored half from 1,maxy(z) instead of 0,maxy(z).
      intersect = 0
      conc = 0.
      do 100 iz = 0,maxz
        do 100 iy = 0,maxy
          conc_tmp = capture(iy,iz) * plume(iy,iz)
          if(conc_tmp.gt.zero) then
             intersect = intersect + 1
             conc = conc + conc_tmp
          else
          endif
 100  continue
      do 110 iz = 1,maxz
        do 110 iy = 1,maxy
          conc_tmp = capture(iy,iz) * plume(iy,iz)
          if(conc_tmp.gt.zero) then
             intersect = intersect + 1
             conc = conc + conc_tmp
          else
          endif
 110  continue

      areaIntersect = float(intersect)
      conc = conc / areaIntersect

      write(10,1003)  i, cwidth, cthick
      write(10,1007)  conc
      transfactor = conc_o / conc
      centerlinefactor = conc_o / concp(0,0)

      write(10,1011)  transfactor, centerlinefactor
      write(10,1017)

      write(6,*) 'done with capture ', i
 200  continue

 1003 format('For capture zone',i5, ' with width =', f7.0
     &                                       , ' & thick =', f7.0)
 1007 format('Representative concentration for intersection area',e11.3)
 1011 format('trans df=',f8.3,' centerline df=',f8.3)
 1017 format('=====================================================')
      stop
      end
c==================================================================
      subroutine interpol(plume,concp,yp,zp,ny,nz,iflag2
     &                    ,pthick,conc_o,cPlume)
c Interpolates concentration values focussing on the plume area of matrix.
```

Continued


```
c Uses row by row linear interpolation.
      parameter  (maxy=3400, maxz=2000, maxny=50, maxnz=50)
      implicit real (a-h,o-z)
      implicit integer (i-n)
      dimension plume(0:maxy,0:maxz), concp(0:maxny,0:maxnz)
     &          , yp(0:maxny), zp(0:maxnz), ypts(0:maxny), zpts(0:maxnz)

      threshld = conc_o * 1.e-4
c Initial plume matrix
      do 10 iz = 0,maxz
       do 10 iy = 0,maxy
          plume(iy,iz) = 0.
 10   continue

      do 20 i = 0,ny-2
        ypts(i) = yp(i+1) - yp(i)
 20   continue

c Do different calculation for thin plume versus 3D plume, if-then.

      if(iflag2.eq.1) then

      do 30 i = 0,nz-2
        zpts(i) = zp(i+1) - zp(i)
 30   continue
c Interpolate z-columns where y-position is known.
      do 70 ky = 0,ny-1
       iy = nint( yp(ky) )
       iz = 0
       do 60 kz = 0,nz-2
         plume(iy,iz) = concp(ky,kz)
         a = (concp(ky,kz+1) - concp(ky,kz)) / (zp(kz+1) - zp(kz))
         b = concp(ky,kz) - a * zp(kz)
         do 50 i = 1,nint(zpts(kz))-1
            iz = iz + 1
            plume(iy,iz) = a * ( float(i) + zp(kz) ) + b
 50      continue
         iz = iz + 1
 60    continue
       plume(iy,iz) = concp(ky,nz-1)
 70   continue

c Row by row, skipping appropriately.
      iy = 0
      iz = 0
      do 140 kz = 0,nz-2
       do 130 j = 1,nint(zpts(kz))

        do 120 ky = 0,ny-2
         ky2 = int(yp(ky+1))
         ky1 = int(yp(ky))
         a = (plume(ky2,iz) - plume(ky1,iz)) / (yp(ky+1) - yp(ky))
         b = plume(ky1,iz) - a * yp(ky)
         do 110 i = 1,nint(ypts(ky))-1
            iy = iy + 1
            plume(iy,iz) = a * ( float(i) + yp(ky) ) + b
 110     continue
        iy = iy + 1
 120   continue
       iz = iz + 1
       iy = 0
 130   continue
 140  continue
c Added to get bottom edge of plume correct.
      iy = 0
      iz = int(zp(nz-1))
      do 146 ky = 0,ny-2
        ky2 = int(yp(ky+1))
        ky1 = int(yp(ky))
```



```
        a = (plume(ky2,iz) - plume(ky1,iz)) / (yp(ky+1) - yp(ky))
        b = plume(ky1,iz) - a * yp(ky)
        do 145 i = 1,nint(ypts(ky))-1
           iy = iy + 1
           plume(iy,iz) = a * ( float(i) + yp(ky) ) + b
 145    continue
        iy = iy + 1
 146  continue

c Figure out plume width and zero-out remainder.
c Also calculate total mass in plume from concentrations.
c The variable "cPlume" is (concentration * area).
      do 150 j = 0,maxz
       do 150 i = 0,maxy
         if(plume(i,j).lt.threshld) plume(i,j) = 0.
 150  continue
      concPlume = 0.
      do 160 j = 0,maxz
       do 160 i = 0,maxy
         concPlume = concPlume + plume(i,j)
 160  continue
      concMidY = 0.
      concMidZ = 0.
      do 170 i = 1,maxy
         concMidY = concMidY + plume(i,0)
 170  continue
      do 175 j = 1,maxz
         concMidZ = concMidZ + plume(0,j)
 175  continue
      cPlume = ( concPlume * 2. ) - concMidZ - concMidY
      do 180 i = 0,maxy
         if(plume(i,0).lt.threshld) then
           pwidth = float(i) * 2.
           goto 185
         else
         endif
 180  continue
 185  do 190 j = 0,maxz
         if(plume(0,j).lt.threshld) then
           pthickness = float(j)
           goto 300
         else
         endif
 190  continue

     else

       iy = 0
       do 215 ky = 0,ny-2
         plume(iy,0) = concp(ky,0)
         a = (concp(ky+1,0) - concp(ky,0)) / (yp(ky+1) - yp(ky))
         b = concp(ky,0) - a * yp(ky)
         do 210 i = 1,nint(ypts(ky))-1
            iy = iy + 1
            plume(iy,0) = a * ( float(i) + yp(ky) ) + b
 210     continue
         iy = iy + 1
 215   continue
       plume(iy,0) = concp(ny-1,0)

c Figure out plume width and zero-out remainder.
c Also calculate total mass in plume from concentrations, after zeroing out.
c The variable "cPlume" is (concentration * area).
      pthickness = pthick
      do 220 i = 0,maxy
         if(plume(i,0).lt.threshld) plume(i,0) = 0.
 220  continue
      ip = int(pthick)
      do 240 j = 1,ip
```

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Continued.

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```
        do 240 i = 0,maxy
           plume(i,j) = plume(i,j-1)
 240    continue
        concPlume = 0.
        do 250 i = 0,maxy
           concPlume = concPlume + plume(i,0)
 250    continue
        concMidY = cPlume
        concMidZ = plume(0,0) * pthick
        cPlume = ( concPlume * pthick * 2. ) - concMidY - concMidZ
        do 260 i = 0,maxy
           if(plume(i,0).lt.threshld) then
             pwidth = float(i) * 2.
             goto 300
           else
           endif
 260    continue

      endif

 300  write(10,*) 'Interpolated plume.'
c     do 400 j = 0,15
c       write(10,'(12e10.2)') ( plume(i,j), i=0,11 )
c400  continue

      write(10,1100) pwidth, pthickness
      write(10,1117)
 1100 format(' plume width =',f7.0,' plume thickness =',f7.0)
 1117 format('*******************************************************')
      return
      end
c=======================================================================
       subroutine domest(cwidth2,cthick,capture,scntop,scnbot,ctop,icap)
c Calculates the number of nodes in the capture area of a domestic well
c assuming dy=dz=1 for extrapolation to a capture area.
      parameter  (maxy=3400, maxz=2000)
      implicit real (a-h,o-z)
      implicit integer (i-n)
      dimension capture(0:maxy,0:maxz)

      do 10 iz = 0,maxz
        do 10 iy = 0,maxy
          capture(iy,iz) = 0.
 10   continue
      iscnbot = nint(scnbot)
      iscntop = nint(scntop)

c Top of capture area (half-ellipse); mirror the half-ellipse to fill capture().
      icap1 = 0
      if(ctop.le.1.e-4) goto 50
      topthick = scntop - ctop
      itop = nint(topthick)
      izz = iscntop
      do 30 iz = 1,itop
        z = float(iz)
        if(iz.ge.iscntop) goto 50
        ytmp = sqrt( cwidth2**2 * ( 1. - z**2 / topthick**2 ) )
        izz = izz - 1
        do 20 iy = 0,maxy
           y = float(iy)
           if(y.le.ytmp) then
              capture(iy,izz) = 1.
              icap1 = icap1 + 1
           else
              goto 30
           endif
 20     continue
 30   continue
c50   write(10,*) 'Top of domestic capture area, nodes = ', icap1
```



```
 50   continue

c Middle of capture area, screen elevation (rectangle).
      icap2 = 0
      do 130 iz = iscntop,maxz
        if(iz.gt.iscnbot) goto 150
        do 120 iy = 0,maxy
          if(float(iy).le.cwidth2) then
             capture(iy,iz) = 1.
             icap2 = icap2 + 1
          else
             goto 125
          endif
 120    continue
 125    continue
 130  continue
c150  write(10,*) 'Middle plus top domestic capture nodes = ', icap2
 150  continue

c Bottom of capture area (half-ellipse).
      icap3 = 0
      do 230 iz = iscnbot+1,maxz
        z = float(iz)
        if(z.gt.cthick) goto 250
        ytmp = sqrt( cwidth2**2 * ( 1. - z**2 / cthick**2 ) )
        do 220 iy = 0,maxy
           y = float(iy)
           if(y.le.ytmp) then
              capture(iy,iz) = 1.
              icap3 = icap3 + 1
           else
              goto 225
           endif
 220    continue
 225    continue
 230  continue

c250  write(10,*) 'Bottom half ellipse= ', icap3
 250  continue
      mirror = 0
      do 260 j = 1,maxz
        if(capture(0,j).gt.0.1) mirror = mirror + 1
 260  continue
      icap = ( ( icap1 + icap2 + icap3 ) * 2 ) - mirror - nint(cwidth)
      write(10,*) 'Domestic well capture area (all) = ', icap

c     do 300 j = 0,15
c       write(10,'(15f3.0)') ( capture(i,j), i=0,14 )
c300  continue

      return
      end
c=======================================================================
       subroutine irrig(cwidth2,cthick,capture,icap)
c Calculates the number of nodes in an irrigation well assuming that
c dy=dz=1 for extrapolation to a capture area.
      parameter  (maxy=3400, maxz=2000)
      implicit real (a-h,o-z)
      implicit integer (i-n)
      dimension capture(0:maxy,0:maxz)

      icap = 0
      do 10 iz = 0,maxz
        do 10 iy = 0,maxy
          capture(iy,iz) = 0.
 10   continue

      do 30 iz = 0,maxz
        z = float(iz)
```

Continued


```
      if(z.gt.cthick) goto 50
      ytmp = sqrt( cwidth2**2 * ( 1. - z**2 / cthick**2 ) )
      do 20 iy = 0,maxy
         y = float(iy)
         if(y.le.ytmp) then
            capture(iy,iz) = 1.
            icap = icap + 1
          else
            goto 25
         endif
 20   continue
 25   continue
 30  continue

 50  icap = icap + icap - nint(cthick) - nint(cwidth)
     write(10,*) 'Irrigation well capture area = ', icap

c    do 200 j = 0,15
c      write(10,'(15f3.0)') ( capture(i,j), i=0,14 )
c200 continue

     return
     end
```

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Tape (8mm) written of directories ~/Bore and ~/WP/Bore on SUN (bigbend)
File listing on the tape is included below (bore.tar.gz is file on tape)


```
a Bore/ 0K
a Bore/Data/ 0K
a Bore/Data/nts.fil 11098K
a Bore/Data/gw1.fil 2463K
a Bore/Data/gw2.fil 6765K
a Bore/Data/CodesGordon/ 0K
a Bore/Data/CodesGordon/depth_form_log.f 3K
a Bore/Data/CodesGordon/depth_log.f 2K
a Bore/Data/CodesGordon/depth_log_gw.f 2K
a Bore/Data/CodesGordon/farms.f 3K
a Bore/Data/CodesGordon/form_log.f 3K
a Bore/Data/CodesGordon/form_log_2.f 3K
a Bore/Data/CodesGordon/lithval.f 4K
a Bore/Data/CodesGordon/ss_lith.f 2K
a Bore/Data/CodesGordon/ss_log.f 3K
a Bore/Data/CodesGordon/stufform.f 1K
a Bore/Data/CodesGordon/well_log.f 2K
a Bore/Data/CodesGordon/well_log_gw.f 2K
a Bore/Data/CodesGordon/nts.fil.gz 584K
a Bore/Data/CodesGordon/gw1.fil.gz 287K
a Bore/Data/CodesGordon/gw2.fil.gz 747K
a Bore/Data/permit.amg 11K
a Bore/Data/UTM/ 0K
a Bore/Data/UTM/zone1.dat 3K
a Bore/Data/UTM/zone2.dat 3K
a Bore/Data/UTM/zone3.dat 3K
a Bore/Data/UTM/zone4.dat 3K
a Bore/Data/UTM/zone5.dat 3K
a Bore/Data/UTM/Readme 1K
a Bore/Data/UTM/amgQuads.dat 1K
a Bore/Data/UTM/amg.water.dat 7K
a Bore/Data/UTM/pump96.dat 3K
a Bore/Data/UTM/quad_tube.lay 9K
a Bore/Data/UTM/tecplot.phy 1K
a Bore/Data/UTM/qm96.plt 1K
a Bore/Data/UTM/print.out 7K
a Bore/Data/UTM/locat_tmp.lay 12K
a Bore/Data/UTM/town.dat 1K
a Bore/Data/UTM/wateruse96.lay 10K
a Bore/Data/UTM/print1.out 22K
a Bore/Data/UTM/roadstate.dat 1K
a Bore/Data/UTM/comm96.plt 1K
a Bore/Data/UTM/irrig96.plt 3K
a Bore/Data/UTM/town1.lay 5K
a Bore/Data/UTM/town2.lay 6K
a Bore/Data/UTM/pump96.plt 4K
a Bore/Data/UTM/roadState.lay 10K
a Bore/Data/UTM/fig3-1.ps 7K
a Bore/Data/UTM/fig3-1.lay 7K
a Bore/Data/UTM/pump96.lay 12K
a Bore/Data/UTM/pumpageTR.lay 7K
a Bore/Data/UTM/fig3-2.ps 10K
a Bore/Data/UTM/fig3-3.lay 12K
a Bore/Data/UTM/print3-3.out 15K
a Bore/Data/UTM/newroad.lay 9K
a Bore/Data/UTM/fig3-2.lay 7K
a Bore/Data/UTM/print3-2.out 10K
a Bore/Data/UTM/fig4-1.lay 4K
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a Bore/Data/UTM/newdat.plt 8K
a Bore/Data/UTM/fig4-1.ps 4K
a Bore/Data/UTM/newerTubeRoad.lay 9K
a Bore/Data/UTM/new96Scaled.lay 12K
a Bore/Data/UTM/new96Scaled.ps 16K
a Bore/Data/gwis_ext.f 3K
a Bore/Data/zone 16K
a Bore/Data/tecplot.phy 1K
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RF

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a Bore/Data/plt.csh 1K
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a Bore/Data/Spreadsheet_orig/ 0K
a Bore/Data/Spreadsheet_orig/amg.txt 38K
a Bore/Data/Spreadsheet_orig/amgg.txt 37K
a Bore/Data/amarg2.gwis 1308K
a Bore/Data/gwis.f 2K
a Bore/Data/wat.prn 16K
a Bore/Data/gwis 17K
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a Bore/Data/amarg.all 34K
a Bore/Data/amarg.all.wp 35K
a Bore/Data/amarg.all.blank 34K
a Bore/Data/amargQuads 3K
a Bore/Data/amarg.f.all 8K
a Bore/Data/permit.wq1 50K
a Bore/Data/Readme 2K
a Bore/Data/zone.ann 13K
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a Bore/Data/pump.amg 8K
a Bore/Data/amarg.water.meters 7K
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a Bore/Data/sys_call.f 1K
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a Bore/Data/print.out 26K
a Bore/Data/pump.prn 26K
a Bore/Data/water93.lay 3K
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a Bore/Data/pump.xls 126K
a Bore/Data/permit.xls 41K
a Bore/Data/ann_pump.xls 25K
a Bore/Data/pump96.xls 36K
a Bore/Data/pump96.prn 3K
a Bore/Data/range.f 5K
a Bore/Data/dataedit.xls 3982K
a Bore/Data/pump96.wq1 39K
a Bore/Data/range 19K
a Bore/Data/pump.dat 1K
a Bore/Data/amg_all.wq1 44K
a Bore/Data/pump.wq1 47K
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a Bore/Data/comm.prn 1K
a Bore/Data/irrig.prn 2K
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a Bore/Data/intersec.xls 77K
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a Bore/Data/XVGR/capQ.ps 5K
a Bore/Data/XVGR/q300.xvgr 1K
a Bore/Data/XVGR/q300.parm 14K
a Bore/Data/XVGR/q300.allxvgr 15K
a Bore/Data/XVGR/domQ-df.ps 5K
a Bore/Data/XVGR/q300.ps 5K
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a Bore/Data/XVGR/dom-10-25plume.ps 5K
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a Bore/Data/XVGR/q2116capture.xvgr 1K
a Bore/Data/XVGR/dom-10-25plume.parm 14K
a Bore/Data/XVGR/dom-10-25plume.allxvgr 14K
a Bore/Data/XVGR/q2116capture.parm 13K
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Tape (8mm) written of directories ~/Bore and ~/WP/Bore on SUN (bigbend)
File listing on the tape is included below (bore.tar.gz is file on tape)

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a Bore/Data/XVGR/domCapture.allxvgr 14K
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a Bore/Data/XVGR/domQ-df.allxvgr 15K
a Bore/Data/XVGR/domQ-df.parm 14K
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a Bore/Analytic/analgwst.1/src/locsubs.DMY.f 2K
a Bore/Analytic/analgwst.1/src/locsubs.Solaris.f 3K
a Bore/Analytic/analgwst.1/src/stripi.o 14K
a Bore/Analytic/analgwst.1/src/tmp/ 0K
a Bore/Analytic/analgwst.1/src/Orig/ 0K
a Bore/Analytic/analgwst.1/src/Orig/Makefile 7K
a Bore/Analytic/analgwst.1/src/Orig/cntour.f 15K
a Bore/Analytic/analgwst.1/src/Orig/dgdiss.f 2K
a Bore/Analytic/analgwst.1/src/Orig/dimens.inc 1K
a Bore/Analytic/analgwst.1/src/Orig/exerfc.f 4K
a Bore/Analytic/analgwst.1/src/Orig/finite.f 15K
a Bore/Analytic/analgwst.1/src/Orig/gauss.f 10K
a Bore/Analytic/analgwst.1/src/Orig/glqpts.f 3K
a Bore/Analytic/analgwst.1/src/Orig/lenchr.f 1K
a Bore/Analytic/analgwst.1/src/Orig/locsubs.DGUX.f 2K
a Bore/Analytic/analgwst.1/src/Orig/locsubs.DMY.f 2K
a Bore/Analytic/analgwst.1/src/Orig/locsubs.PRIMOS.f 3K
a Bore/Analytic/analgwst.1/src/Orig/locsubs.SIG.f 2K
a Bore/Analytic/analgwst.1/src/Orig/locsubs.Solaris.f 3K
a Bore/Analytic/analgwst.1/src/Orig/locsubs.lahey.f 2K
a Bore/Analytic/analgwst.1/src/Orig/ofile.f 2K
a Bore/Analytic/analgwst.1/src/Orig/patchf.f 13K
a Bore/Analytic/analgwst.1/src/Orig/patchi.f 11K
a Bore/Analytic/analgwst.1/src/Orig/plot1d.f 4K
a Bore/Analytic/analgwst.1/src/Orig/plot2d.f 5K
a Bore/Analytic/analgwst.1/src/Orig/pltdat.inc 1K
a Bore/Analytic/analgwst.1/src/Orig/point2.f 9K
a Bore/Analytic/analgwst.1/src/Orig/point3.f 10K
a Bore/Analytic/analgwst.1/src/Orig/point3_mod.f 10K
a Bore/Analytic/analgwst.1/src/Orig/rdplot.f 1K
a Bore/Analytic/analgwst.1/src/Orig/seminf.f 9K
a Bore/Analytic/analgwst.1/src/Orig/stripf.f 10K
a Bore/Analytic/analgwst.1/src/Orig/stripi.f 9K
a Bore/Analytic/analgwst.1/src/Orig/subs1.f 3K
a Bore/Analytic/analgwst.1/src/Orig/subs2.f 3K
a Bore/Analytic/analgwst.1/src/Orig/subs3.f 4K
a Bore/Analytic/analgwst.1/src/Orig/title.f 2K
a Bore/Analytic/analgwst.1/src/Orig/units.inc 1K
a Bore/Analytic/analgwst.1/src/patchi.f.orig 11K
a Bore/Analytic/analgwst.1/src/subs2.o 8K
a Bore/Analytic/analgwst.1/src/rdplot.o 3K
a Bore/Analytic/analgwst.1/src/glqpts.o 4K
a Bore/Analytic/analgwst.1/src/exerfc.o 3K
a Bore/Analytic/analgwst.1/src/ofile.o 4K
a Bore/Analytic/analgwst.1/src/title.o 6K
a Bore/Analytic/analgwst.1/src/lenchr.o 2K
a Bore/Analytic/analgwst.1/src/locsubs.Solaris.o 2K
a Bore/Analytic/analgwst.1/src/makefile 5K
a Bore/Analytic/analgwst.1/src/Makefile.old 7K
a Bore/Analytic/analgwst.1/src/makefile.patchi 5K
a Bore/Analytic/analgwst.1/src/makefile.stripi 5K
a Bore/Analytic/analgwst.1/src/strip.header 4K
a Bore/Analytic/analgwst.1/README 21K
a Bore/Analytic/analgwst.1/NOTICE 3K
a Bore/Analytic/analgwst.1/data/ 0K
a Bore/Analytic/analgwst.1/data/sample1a.dat 1K
a Bore/Analytic/analgwst.1/data/sample1a.prt 6K
a Bore/Analytic/analgwst.1/data/sample1b.dat 1K
a Bore/Analytic/analgwst.1/data/sample1b.prt 6K
a Bore/Analytic/analgwst.1/data/sample3a.dat 1K
a Bore/Analytic/analgwst.1/data/sample3a.prt 6K
a Bore/Analytic/analgwst.1/data/sample3b.dat 1K
a Bore/Analytic/analgwst.1/data/sample3b.prt 5K
a Bore/Analytic/analgwst.1/data/sample8a.dat 2K
a Bore/Analytic/analgwst.1/data/sample8a.prt 26K
a Bore/Analytic/analgwst.1/data/sample8b.dat 2K
a Bore/Analytic/analgwst.1/data/sample8b.prt 26K
```

12/10/97

93 RF

Tape (8mm) written of directories ~/Bore and ~/WP/Bore on SUN (bigbend)
File listing on the tape is included below (bore.tar.gz is file on tape)


```
a Bore/Analytic/analgwst.1/data/sample2.dat 1K
a Bore/Analytic/analgwst.1/data/sample2.prt 6K
a Bore/Analytic/analgwst.1/data/sample4.dat 1K
a Bore/Analytic/analgwst.1/data/sample4.prt 6K
a Bore/Analytic/analgwst.1/data/sample5.dat 1K
a Bore/Analytic/analgwst.1/data/sample5.prt 24K
a Bore/Analytic/analgwst.1/data/sample6.dat 2K
a Bore/Analytic/analgwst.1/data/sample6.prt 32K
a Bore/Analytic/analgwst.1/data/sample7.dat 2K
a Bore/Analytic/analgwst.1/data/sample7.prt 21K
a Bore/Analytic/analgwst.1/data/sample9.dat 1K
a Bore/Analytic/analgwst.1/data/sample9.prt 13K
a Bore/Analytic/analgwst.1/data/sample10.dat 2K
a Bore/Analytic/analgwst.1/data/sample10.prt 31K
a Bore/Analytic/analgwst.1/data/sample11.dat 2K
a Bore/Analytic/analgwst.1/data/sample11.prt 42K
a Bore/Analytic/analgwst.1/data/sample9a.dat 1K
a Bore/Analytic/analgwst.1/data/sample9a.prt 13K
a Bore/Analytic/analgwst.1/doc/ 0K
a Bore/Analytic/analgwst.1/doc/finite.txt 5K
a Bore/Analytic/analgwst.1/doc/seminf.txt 5K
a Bore/Analytic/analgwst.1/doc/point2.txt 5K
a Bore/Analytic/analgwst.1/doc/stripf.txt 5K
a Bore/Analytic/analgwst.1/doc/stripi.txt 5K
a Bore/Analytic/analgwst.1/doc/gauss.txt 5K
a Bore/Analytic/analgwst.1/doc/point3.txt 5K
a Bore/Analytic/analgwst.1/doc/patchf.txt 5K
a Bore/Analytic/analgwst.1/doc/patchi.txt 5K
a Bore/Analytic/analgwst.1/doc/analgwst.txt 5K
a Bore/Analytic/analgwst.1/bin/ 0K
a Bore/Analytic/analgwst.1/bin/patchi 1K
a Bore/Analytic/analgwst.1/bin/stripi 1K
a Bore/Analytic/analgwst.1/bin/gauss 1K
a Bore/Analytic/analgwst.1/bin/point2 1K
a Bore/Analytic/analgwst.1/bin/patchi.exe 47K
a Bore/Analytic/analgwst.1/bin/p3.tmp 1K
a Bore/Analytic/analgwst.1/bin/p6.tmp 1K
a Bore/Analytic/analgwst.1/bin/sample11.dat 2K
a Bore/Analytic/analgwst.1/bin/sample11.out 42K
a Bore/Analytic/analgwst.1/bin/print.ps 57K
a Bore/Analytic/analgwst.1/bin/patchi.exe.std 45K
a Bore/Analytic/analgwst.1/bin/glq.pts 10K
a Bore/Analytic/analgwst.1/bin/stripi.exe 44K
a Bore/Analytic/analgwst.1/bin/patchi.exe.yz-15y 47K
a Bore/Analytic/analgwst.1/bin_data/ 0K
a Bore/Analytic/analgwst.1/bin_data/glq.pts 10K
a Bore/Analytic/analgwst.1/test/ 0K
a Bore/Analytic/analgwst.1/test/test.sh 4K
a Bore/Analytic/analgwst.1/test/check.sh 2K
a Bore/Analytic/analgwst.1/test/clean.sh 1K
a Bore/Analytic/Amargosa/ 0K
a Bore/Analytic/Amargosa/patchi 1K
a Bore/Analytic/Amargosa/patchi.exe 47K
a Bore/Analytic/Amargosa/f.dat 1K
a Bore/Analytic/Amargosa/sample11.dat 2K
a Bore/Analytic/Amargosa/farms1.dat 1K
a Bore/Analytic/Amargosa/t10.dat 1K
a Bore/Analytic/Amargosa/farms11.dat 1K
a Bore/Analytic/Amargosa/patchi.exe.std 45K
a Bore/Analytic/Amargosa/ten10.dat 1K
a Bore/Analytic/Amargosa/file.out 7K
a Bore/Analytic/Amargosa/farms2.dat 1K
a Bore/Analytic/Amargosa/ten55.dat 1K
a Bore/Analytic/Amargosa/farms3.dat 1K
a Bore/Analytic/Amargosa/ten2.dat 1K
a Bore/Analytic/Amargosa/farms4.dat 1K
a Bore/Analytic/Amargosa/patchi.xls 54K
a Bore/Analytic/Amargosa/farms5.dat 1K
a Bore/Analytic/Amargosa/Gradient/ 0K
```


RF

```
a Bore/Analytic/Amargosa/Gradient/t.dat 1K
a Bore/Analytic/Amargosa/Gradient/patchi symbolic link to ../patchi
a Bore/Analytic/Amargosa/Gradient/f10.dat 1K
a Bore/Analytic/Amargosa/Gradient/f10.prt 15K
a Bore/Analytic/Amargosa/Gradient/file.out 5K
a Bore/Analytic/Amargosa/farms4a.dat 1K
a Bore/Analytic/Amargosa/farms5a.dat 1K
a Bore/Analytic/Amargosa/farms11.prt 70K
a Bore/Analytic/Amargosa/f3000.800 1K
a Bore/Analytic/Amargosa/STRIPI/ 0K
a Bore/Analytic/Amargosa/STRIPI/stripi 1K
a Bore/Analytic/Amargosa/STRIPI/stripi.exe 44K
a Bore/Analytic/Amargosa/STRIPI/sample5.dat 1K
a Bore/Analytic/Amargosa/STRIPI/sample5.prt 24K
a Bore/Analytic/Amargosa/STRIPI/s.dat 1K
a Bore/Analytic/Amargosa/STRIPI/s10.dat 1K
a Bore/Analytic/Amargosa/STRIPI/print.ps 33K
a Bore/Analytic/Amargosa/STRIPI/sample7.dat 2K
a Bore/Analytic/Amargosa/STRIPI/sample7.prt 21K
a Bore/Analytic/Amargosa/STRIPI/rfedors.sample7 21K
a Bore/Analytic/Amargosa/STRIPI/s10.prt 5K
a Bore/Analytic/Amargosa/STRIPI/file.out 1K
a Bore/Analytic/Amargosa/STRIPI/s2.dat 1K
a Bore/Analytic/Amargosa/STRIPI/s55.dat 1K
a Bore/Analytic/Amargosa/STRIPI/n2.dat 1K
a Bore/Analytic/Amargosa/STRIPI/s.prt 5K
a Bore/Analytic/Amargosa/STRIPI/s2.prt 5K
a Bore/Analytic/Amargosa/STRIPI/new2.dat 1K
a Bore/Analytic/Amargosa/STRIPI/new2.prt 5K
a Bore/Analytic/Amargosa/STRIPI/n2.prt 5K
a Bore/Analytic/Amargosa/STRIPI/wexler50Thin.dat 1K
a Bore/Analytic/Amargosa/STRIPI/st20.prt 5K
a Bore/Analytic/Amargosa/STRIPI/wexler20Thin.dat 1K
a Bore/Analytic/Amargosa/STRIPI/wexler20Thin.prt 5K
a Bore/Analytic/Amargosa/STRIPI/wexler50Thin.prt 5K
a Bore/Analytic/Amargosa/STRIPI/wexler100Thin.dat 1K
a Bore/Analytic/Amargosa/STRIPI/wexler100Thin.prt 5K
a Bore/Analytic/Amargosa/farms6.dat 1K
a Bore/Analytic/Amargosa/t.dat 1K
a Bore/Analytic/Amargosa/test.plt 8K
a Bore/Analytic/Amargosa/farms7.dat 1K
a Bore/Analytic/Amargosa/farms10.prt 39K
a Bore/Analytic/Amargosa/farms8.dat 1K
a Bore/Analytic/Amargosa/patchi.xls.1 50K
a Bore/Analytic/Amargosa/farms10.10.out 3K
a Bore/Analytic/Amargosa/farms9.dat 1K
a Bore/Analytic/Amargosa/farms8.prt 39K
a Bore/Analytic/Amargosa/farms10.dat 1K
a Bore/Analytic/Amargosa/farms10.2.out 3K
a Bore/Analytic/Amargosa/farms4b.dat 1K
a Bore/Analytic/Amargosa/farms4c.dat 1K
a Bore/Analytic/Amargosa/intersect.lay 2K
a Bore/Analytic/Amargosa/farms4d.dat 1K
a Bore/Analytic/Amargosa/print.out 7K
a Bore/Analytic/Amargosa/plume8.lay 4K
a Bore/Analytic/Amargosa/tecplot.phy 1K
a Bore/Analytic/Amargosa/farms10.Co.out 3K
a Bore/Analytic/internet.solns 2K
a Bore/Analytic/analgwst.1.source.tar.gz 111K
a Bore/Analytic/Rood/ 0K
a Bore/Analytic/Rood/data.fil 2K
a Bore/Analytic/Rood/gwscreen.out 8K
a Bore/Analytic/Rood/rood.for 106K
a Bore/Analytic/Rood/rood.f 103K
a Bore/Analytic/Rood/rood.header 3K
a Bore/Analytic/Codell2/ 0K
a Bore/Analytic/Codell2/ground.f 15K
a Bore/Analytic/Codell2/out 33K
a Bore/Analytic/soln-3d.note 1K
```

12/10/97
93 RF

Tape (8mm) written of directories ~/Bore and ~/WP/Bore on SUN (bigbend)
File listing on the tape is included below (bore.tar.gz is file on tape)

Printed by Randall S. Fedors


```
a Bore/Analytic/Codell/ 0K
a Bore/Analytic/Codell/ex2.inp 15K
a Bore/Analytic/Codell/ex2.out 97K
a Bore/Analytic/Codell/rf1.in% 1K
a Bore/Analytic/Codell/out 4K
a Bore/Analytic/Codell/grr 1K
a Bore/Analytic/Codell/gr.single 65K
a Bore/Analytic/Codell/codell.xls 20K
a Bore/Analytic/Codell/gr 49K
a Bore/Analytic/Codell/gr.double 49K
a Bore/Analytic/Codell/rf2.in 1K
a Bore/Analytic/Codell/rf2.in% 1K
a Bore/Analytic/Codell/final20.in 1K
a Bore/Analytic/Codell/rf1.in 1K
a Bore/Analytic/Codell/Orig/ 0K
a Bore/Analytic/Codell/Orig/gr.tar 40K
a Bore/Analytic/Codell/Orig/daught.f 2K
a Bore/Analytic/Codell/Orig/erff.f 1K
a Bore/Analytic/Codell/Orig/expf.f 1K
a Bore/Analytic/Codell/Orig/fun.f 5K
a Bore/Analytic/Codell/Orig/gather.f 2K
a Bore/Analytic/Codell/Orig/gr.f 1K
a Bore/Analytic/Codell/Orig/grdflx.f 19K
a Bore/Analytic/Codell/Orig/interp.f 4K
a Bore/Analytic/Codell/Orig/wlist.f 1K
a Bore/Analytic/Codell/Orig/Readme.email 1K
a Bore/Analytic/Codell/Orig/ex2.inp 15K
a Bore/Analytic/Codell/Orig/ex2.out 97K
a Bore/Analytic/Codell/Orig/rf.out 97K
a Bore/Analytic/Intersect/ 0K
a Bore/Analytic/Intersect/f10.dat 7K
a Bore/Analytic/Intersect/itsec.f 15K
a Bore/Analytic/Intersect/QAP/ 0K
a Bore/Analytic/Intersect/QAP/itsec.f 14K
a Bore/Analytic/Intersect/QAP/Grid/ 0K
a Bore/Analytic/Intersect/QAP/Grid/itsec_grid 39K
a Bore/Analytic/Intersect/QAP/Grid/f8.25km 4K
a Bore/Analytic/Intersect/QAP/Grid/caps3D.input 1K
a Bore/Analytic/Intersect/QAP/Grid/capture.dat 1K
a Bore/Analytic/Intersect/QAP/Grid/plume.dat 4K
a Bore/Analytic/Intersect/QAP/Grid/itsec_grid.f 14K
a Bore/Analytic/Intersect/QAP/Grid/f10.25km 4K
a Bore/Analytic/Intersect/QAP/Grid/its 39K
a Bore/Analytic/Intersect/QAP/Grid/output 1K
a Bore/Analytic/Intersect/QAP/Grid/itsd 39K
a Bore/Analytic/Intersect/QAP/f10.15km 4K
a Bore/Analytic/Intersect/QAP/f10.25km 4K
a Bore/Analytic/Intersect/QAP/f10.dat 7K
a Bore/Analytic/Intersect/QAP/f5.15km 4K
a Bore/Analytic/Intersect/QAP/f5.25km 4K
a Bore/Analytic/Intersect/QAP/f5.dat 7K
a Bore/Analytic/Intersect/QAP/f7.15km 4K
a Bore/Analytic/Intersect/QAP/f7.25km 4K
a Bore/Analytic/Intersect/QAP/f7.dat 7K
a Bore/Analytic/Intersect/QAP/f8.15km 4K
a Bore/Analytic/Intersect/QAP/f8.dat 7K
a Bore/Analytic/Intersect/QAP/f9.15km 4K
a Bore/Analytic/Intersect/QAP/f9.25km 4K
a Bore/Analytic/Intersect/QAP/f9.dat 7K
a Bore/Analytic/Intersect/QAP/st100.15km 1K
a Bore/Analytic/Intersect/QAP/st100.25km 1K
a Bore/Analytic/Intersect/QAP/st100.dat 1K
a Bore/Analytic/Intersect/QAP/st20.15km 1K
a Bore/Analytic/Intersect/QAP/st20.25km 1K
a Bore/Analytic/Intersect/QAP/st20.dat 1K
a Bore/Analytic/Intersect/QAP/st50.15km 1K
a Bore/Analytic/Intersect/QAP/st50.25km 1K
a Bore/Analytic/Intersect/QAP/st50.dat 1K
a Bore/Analytic/Intersect/QAP/caps2D.input 1K
```


RF

```
a Bore/Analytic/Intersect/QAP/caps3D.input 1K
a Bore/Analytic/Intersect/QAP/itsec 38K
a Bore/Analytic/Intersect/QAP/capture.dat 1K
a Bore/Analytic/Intersect/QAP/plume.dat 1K
a Bore/Analytic/Intersect/QAP/df-st100.25km.25m.out 9K
a Bore/Analytic/Intersect/QAP/df-st100.25km.10m.out 9K
a Bore/Analytic/Intersect/QAP/df-f8.25km.dom.out 9K
a Bore/Analytic/Intersect/QAP/df-st100.25km.25m.large.out 5K
a Bore/Analytic/Intersect/QAP/df-f10.25km.out 5K
a Bore/Analytic/Intersect/QAP/df-st20.25km.10m.out 9K
a Bore/Analytic/Intersect/QAP/df-st20.25km.25m.out 9K
a Bore/Analytic/Intersect/QAP/df-f10.25km.dom.out 9K
a Bore/Analytic/Intersect/QAP/df-f9.25km.out 5K
a Bore/Analytic/Intersect/QAP/df-f8.25km.out 5K
a Bore/Analytic/Intersect/QAP/df-st20.25km.25m.large.out 5K
a Bore/Analytic/Intersect/QAP/df-st50.25km.25m.large.out 5K
a Bore/Analytic/Intersect/tecplot.phy 1K
a Bore/Analytic/Intersect/df-f8.25km.dom.output 10K
a Bore/Analytic/Intersect/plume.dat 1K
a Bore/Analytic/Intersect/capture.dat 1K
a Bore/Analytic/Intersect/intersec.out 4K
a Bore/Analytic/Intersect/plume.dat2 1K
a Bore/Analytic/Intersect/df-st100.25km.25m.output 10K
a Bore/Analytic/Intersect/XVGR/ 0K
a Bore/Analytic/Intersect/XVGR/tdf-Q-irr.xvgr 1K
a Bore/Analytic/Intersect/XVGR/tdf-T-irr.parm 13K
a Bore/Analytic/Intersect/XVGR/tdf-Q-irr.parm 14K
a Bore/Analytic/Intersect/XVGR/tdf-Q-irr.all 15K
a Bore/Analytic/Intersect/XVGR/tdf-Q-irr.ps 6K
a Bore/Analytic/Intersect/XVGR/tdf-T-irr.xvgr 1K
a Bore/Analytic/Intersect/XVGR/tdf-T-irr.all 14K
a Bore/Analytic/Intersect/XVGR/tdf-T-irr.ps 5K
a Bore/Analytic/Intersect/XVGR/tdf-Q-dom.xvgr% 1K
a Bore/Analytic/Intersect/XVGR/tdf-Q-dom.xvgr 1K
a Bore/Analytic/Intersect/XVGR/tdf-T-dom.xvgr 1K
a Bore/Analytic/Intersect/XVGR/tdf-Q-dom.all 14K
a Bore/Analytic/Intersect/XVGR/tdf-Q-dom.parm 13K
a Bore/Analytic/Intersect/XVGR/tdf-Q-dom.ps 5K
a Bore/Analytic/Intersect/XVGR/tdf-T-dom.ps 5K
a Bore/Analytic/Intersect/XVGR/tdf-T-dom.all 14K
a Bore/Analytic/Intersect/XVGR/tdf-T-dom.parm 13K
a Bore/Analytic/Intersect/XVGR/tdf-Q-irr.xvgr.old 1K
a Bore/Analytic/Intersect/f9.dat 7K
a Bore/Analytic/Intersect/f7.dat 7K
a Bore/Analytic/Intersect/f8.dat 7K
a Bore/Analytic/Intersect/f5.dat 7K
a Bore/Analytic/Intersect/f10.15km 4K
a Bore/Analytic/Intersect/f10.25km 4K
a Bore/Analytic/Intersect/f9.15km 4K
a Bore/Analytic/Intersect/f9.25km 4K
a Bore/Analytic/Intersect/f5.15km 4K
a Bore/Analytic/Intersect/f5.25km 4K
a Bore/Analytic/Intersect/f7.15km 4K
a Bore/Analytic/Intersect/f8.15km 4K
a Bore/Analytic/Intersect/f7.25km 4K
a Bore/Analytic/Intersect/f8.25km 4K
a Bore/Analytic/Intersect/print.ps 17K
a Bore/Analytic/Intersect/plumes.output 2K
a Bore/Analytic/Intersect/caps3D.input 1K
a Bore/Analytic/Intersect/df-f10.25km.output 5K
a Bore/Analytic/Intersect/caps2D.input 1K
a Bore/Analytic/Intersect/st20.dat 1K
a Bore/Analytic/Intersect/df-f8.25km.output 7K
a Bore/Analytic/Intersect/wexlerfarms8.dat 1K
a Bore/Analytic/Intersect/wexler20Thin.dat 1K
a Bore/Analytic/Intersect/wexlerfarms10.dat 1K
a Bore/Analytic/Intersect/st50.dat 1K
a Bore/Analytic/Intersect/wexler100Thin.dat 1K
a Bore/Analytic/Intersect/wexler50Thin.dat 1K
```

12/10/97
93 RF

Tape (8mm) written of directories ~/Bore and ~/WP/Bore on SUN (bigbend)
File listing on the tape is included below (bore.tar.gz is file on tape)

Printed by Randall S. Fedors


```
a Bore/Analytic/Intersect/st20.15km 1K
a Bore/Analytic/Intersect/st20.25km 1K
a Bore/Analytic/Intersect/st50.15km 1K
a Bore/Analytic/Intersect/st50.25km 1K
a Bore/Analytic/Intersect/st100.dat 1K
a Bore/Analytic/Intersect/st100.15km 1K
a Bore/Analytic/Intersect/st100.25km 1K
a Bore/Analytic/Intersect/Readme 1K
a Bore/Analytic/Intersect/df-st20.25km.25m.output 10K
a Bore/Analytic/Intersect/tmp/ 0K
a Bore/Analytic/Intersect/tmp/itsec 38K
a Bore/Analytic/Intersect/tmp/f10.15km 4K
a Bore/Analytic/Intersect/tmp/f10.25km 4K
a Bore/Analytic/Intersect/tmp/f10.dat 7K
a Bore/Analytic/Intersect/tmp/f5.15km 4K
a Bore/Analytic/Intersect/tmp/f5.25km 4K
a Bore/Analytic/Intersect/tmp/f5.dat 7K
a Bore/Analytic/Intersect/tmp/f7.15km 4K
a Bore/Analytic/Intersect/tmp/f7.25km 4K
a Bore/Analytic/Intersect/tmp/f7.dat 7K
a Bore/Analytic/Intersect/tmp/f8.15km 4K
a Bore/Analytic/Intersect/tmp/f8.25km 4K
a Bore/Analytic/Intersect/tmp/f8.dat 7K
a Bore/Analytic/Intersect/tmp/f9.15km 4K
a Bore/Analytic/Intersect/tmp/f9.25km 4K
a Bore/Analytic/Intersect/tmp/f9.dat 7K
a Bore/Analytic/Intersect/tmp/st100.15km 1K
a Bore/Analytic/Intersect/tmp/st100.25km 1K
a Bore/Analytic/Intersect/tmp/st100.dat 1K
a Bore/Analytic/Intersect/tmp/st20.15km 1K
a Bore/Analytic/Intersect/tmp/st20.25km 1K
a Bore/Analytic/Intersect/tmp/st20.dat 1K
a Bore/Analytic/Intersect/tmp/st50.15km 1K
a Bore/Analytic/Intersect/tmp/st50.25km 1K
a Bore/Analytic/Intersect/tmp/st50.dat 1K
a Bore/Analytic/Intersect/tmp/plume.dat 4K
a Bore/Analytic/Intersect/tmp/caps2D.input 1K
a Bore/Analytic/Intersect/tmp/caps3D.input 1K
a Bore/Analytic/Intersect/tmp/capture.dat 1K
a Bore/Analytic/Intersect/tmp/intersec.out 7K
a Bore/Analytic/Intersect/result3D.small 4K
a Bore/Analytic/Intersect/df-f10.25km.dom.output 10K
a Bore/Analytic/Intersect/df-st20.25km.10m.output 10K
a Bore/Analytic/Intersect/plume.dat.small 1K
a Bore/Analytic/Intersect/capture.dat.small 1K
a Bore/Analytic/Intersect/results.small 2K
a Bore/Analytic/Intersect/df-f9.25km.output 7K
a Bore/Analytic/Intersect/df-st100.25km.10m.output 10K
a Bore/Analytic/Intersect/df-st50.25km.25m.large.output 7K
a Bore/Analytic/Intersect/df-st20.25km.25m.large.output 7K
a Bore/Analytic/Intersect/df-st100.25km.25m.large.output 7K
a Bore/Analytic/Intersect/plumes2.output 2K
a Bore/Analytic/Intersect/itsec.f.1 14K
a Bore/Analytic/Intersect/capture.dat.bogan 1K
a Bore/Analytic/Intersect/itsec1 38K
a Bore/Analytic/Intersect/plume.dat.bogan 1K
a Bore/Analytic/Intersect/df-f10.25km.output.old 7K
a Bore/Analytic/Intersect/itsec.old 37K
a Bore/Analytic/Intersect/plume.dat.stripi.small 1K
a Bore/Analytic/Intersect/QAP2/ 0K
a Bore/Analytic/Intersect/QAP2/itsec.f 15K
a Bore/Analytic/Intersect/QAP2/f10.dat 7K
a Bore/Analytic/Intersect/QAP2/itsec 38K
a Bore/Analytic/Intersect/QAP2/f10.15km 4K
a Bore/Analytic/Intersect/QAP2/f10.25km 4K
a Bore/Analytic/Intersect/QAP2/f5.15km 4K
a Bore/Analytic/Intersect/QAP2/f5.25km 4K
a Bore/Analytic/Intersect/QAP2/f5.dat 7K
a Bore/Analytic/Intersect/QAP2/f7.15km 4K
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RF

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a Bore/Analytic/Intersect/QAP2/f7.25km 4K
a Bore/Analytic/Intersect/QAP2/f7.dat 7K
a Bore/Analytic/Intersect/QAP2/f8.15km 4K
a Bore/Analytic/Intersect/QAP2/f8.25km 4K
a Bore/Analytic/Intersect/QAP2/f8.dat 7K
a Bore/Analytic/Intersect/QAP2/f9.15km 4K
a Bore/Analytic/Intersect/QAP2/f9.25km 4K
a Bore/Analytic/Intersect/QAP2/f9.dat 7K
a Bore/Analytic/Intersect/QAP2/st100.15km 1K
a Bore/Analytic/Intersect/QAP2/st100.25km 1K
a Bore/Analytic/Intersect/QAP2/st100.dat 1K
a Bore/Analytic/Intersect/QAP2/st20.15km 1K
a Bore/Analytic/Intersect/QAP2/st20.25km 1K
a Bore/Analytic/Intersect/QAP2/st20.dat 1K
a Bore/Analytic/Intersect/QAP2/st50.15km 1K
a Bore/Analytic/Intersect/QAP2/st50.25km 1K
a Bore/Analytic/Intersect/QAP2/st50.dat 1K
a Bore/Analytic/Intersect/QAP2/caps2D.input 1K
a Bore/Analytic/Intersect/QAP2/caps3D.input 1K
a Bore/Analytic/Intersect/QAP2/capture.dat 1K
a Bore/Analytic/Intersect/QAP2/plume.dat 4K
a Bore/Analytic/Intersect/QAP2/intersec.out 5K
a Bore/Analytic/Intersect/QAP2/df-f8.25km.out 5K
a Bore/Analytic/Intersect/QAP2/df-st100.25km.25m.dom.out 5K
a Bore/Analytic/Intersect/farms8.out 7K
a Bore/WUSE/ 0K
a Bore/WUSE/wucirc90.ps.gz 4530K
a Bore/WUSE/wudict.ps 38K
a Bore/WUSE/nv85w8 109K
a Bore/WUSE/nv90co 32K
a Bore/WUSE/nv90w8 109K
a Bore/WUSE/water-use.ps 37K
a Bore/WUSE/bib_nv.ps 33K
a Bore/WUSE/biblio.asc 28K
a Bore/WUSE/biblio.tmp 1K
a Bore/WUSE/amarg.txt 3K
a WP/Bore/ 0K
a WP/Bore/bore.wp 21K
a WP/Bore/outline.bore.wp 11K
a WP/Bore/outline.bore.wp1 16K
a WP/Bore/bore.ref 15K
a WP/Bore/wplexsup.us 1K
a WP/Bore/bib.2 3K
a WP/Bore/bib.3 1K
a WP/Bore/gord.outline 8K
a WP/Bore/bored.wp.1 68K
a WP/Bore/top018.pat 4K
a WP/Bore/new.wp 2K
a WP/Bore/bored.wp 131K
a WP/Bore/bored.wp.2 72K
a WP/Bore/bored.wp.3 79K
a WP/Bore/bored.wp5 91K
a WP/Bore/capture.txt 10K
a WP/Bore/geol.wp5 3K
a WP/Bore/cap.wp 106K
a WP/Bore/bored.wp.4 107K
a WP/Bore/inserts.wp5 8K
a WP/Bore/inserts.wp 11K
a WP/Bore/top018.str 4K
a WP/Bore/dilution2.txt 128K
a WP/Bore/captur~1.doc 130K
a WP/Bore/capture.wp5 11K
a WP/Bore/capture.wp 40K
a WP/Bore/dilution3.txt 125K
a WP/Bore/pump.wp 88K
a WP/Bore/dilution4.txt 129K
a WP/Bore/dilut4.wp 129K
a WP/Bore/wp}00047.tmp 18K
a WP/Bore/dilut4.wp5 103K
```

12/10/97
93 RF

Tape (8mm) written of directories ~/Bore and ~/WP/Bore on SUN (bigbend)
File listing on the tape is included below (bore.tar.gz is file on tape)

Printed by Randall S. Fedors


```
a WP/Bore/plume.wp 16K
a WP/Bore/tecplot.phy 1K
a WP/Bore/pump.wp5 73K
a WP/Bore/plume.wp5 6K
a WP/Bore/dfactor.wp5 74K
a WP/Bore/dfactor.wp 84K
a WP/Bore/abstract.wp 4K
a WP/Bore/inserts-2.wp5 4K
a WP/Bore/missing.paragraph 2K
a WP/Bore/intersect.ou 0K
a WP/Bore/section4.4 8K
a WP/Bore/section5 5K
a WP/Bore/qap-014 6K
a WP/Bore/tmp.wp6 19K
a WP/Bore/rf.wp6 8K
a WP/Bore/insert.pag 3K
```