EXPLORATORY SHAFT FACILITY TESTS

Test Title	SCP Section Reference
1. Geologic Mapping of the Exploratory Shaft & Drifts	8.3.1.4.2.2.4
2. Mineralogy & Petrology of Candidate Host Rock	8.3.1.3.2.1-2
3. Seismic Tomography/Vertical Seismic Profiling	8.3.1.4.2.2.5
4. Shaft Convergence	8.3.1.15.1.5.1
5. Demonstration Breakout Rooms	8.3.1.15.1.5.2
6. Sequential Drift Mining	8.3.1.15.1.5.3
7. Heater Experiment in Unit TSw1	8.3.1.15.1.6.1
8. Canister-Scale Heater Experiment	8.3.1.15.1.6.2
9. Yucca Mountain Heated Block	8.3.1.15.1.6.3
10. Thermal Stress Measurements	8.3.1.15.1.6.4
11. Heated Room Experiment	8.3.1.15.1.6.5
12. Development & Demonstration of Required Equipment	8.3.2.5.6
13. Plate Loading Tests	8.3.1.15.1.7.1
14. Rock-Mass Strength Experiment	8.3.1.15.1.7.2
15. Evaluation of Mining Methods	8.3.1.15.1.8.1
16. Monitoring of Ground Support Systems	8.3.1.15.1.8.2
17. Monitoring Drift Stability	8.3.1.15.1.8.3
18. Air Quality and Ventilation Experiment	8.3.1.15.1.8.4
19. In-Situ Testing of Seal Components	8.3.3.2.2.3
20. Overcore Stress Experiment in the Exploratory Shaft Facility	8.3.1.15.2.1.2
21. Matrix Hydrologic Properties Testing	8.3.1.2.2.3.1
22. Intact-Fracture Test in the Exploratory Shaft Facility	8.3.1.2.2.4.1

EXPLORATORY SHAFT FACILITY TESTS
(Continued)

Test Title	SCP Section Reference
23. Percolation Tests in the Exploratory Shaft Facility	8.3.1.2.2.4.2
24. Bulk-Permeability Test in the Exploratory Shaft Facility	8.3.1.2.2.4.3
25. Radial Borehole Tests in the Exploratory Shaft Facility	8.3.1.2.2.4.4
26. Excavation Effects in the Exploratory Shaft Facility	8.3.1.2.2.4.5
27. Calico Hills Test in the Exploratory Shaft Facility	8.3.1.2.2.4.6
28. Perched-Water Test in the Exploratory Shaft Facility	8.3.1.2.2.4.7
29. Hydrochemistry Tests in the Exploratory Shaft Facility	8.3.1.2.2.4.8
30. Diffusion Tests in the Exploratory Shaft Facility	8.3.1.2.2.5.1
31. Chloride and Chlorine -36 Measurements of Percolation at Yucca Mountain	8.3.1.2.2.2.1
32. Engineered Barrier System Field Tests System Field Tests	8.3.4.2.4.4
33. Laboratory Tests (Thermal & Mechanical) using samples obtained from the ESF-Con.& In.	8.3.1.15.1.1-.4
34. Multipurpose-Borehole Testing Near the Exploratory Shaft Facility	8.3.1.2.2.4.9
35. Hydrologic Properties of Major Faults Encountered in Main Test Level of the Exploratory Shaft Facility	8.3.1.2.2.4.10

ESF TESTS

(BY PRIMARY LOCATION)

ACCESS (SHAFT OR RAMP):

MINERAL/PETROLOGY
DEMONSTRATION BREAKOUT ROOM (UPPER)
SHORT RADIAL BOREHOLES
PERCHED WATER
GEOLOGIC MAPPING
VERTICAL SEISMIC PROFILING
HEATER EXPERIMENT IN TSw1
LONG RADIAL BOREHOLES
HYDROCHEMISTRY
MATRIX HYDROLOGIC PROPERTIES
SHAFT CONVERGENCE
INTACT FRACTURE
EXCAVATION EFFECTS
CHLORINE-36

MAIN TEST LEVEL:

CANISTER SCALE HEATER
DEMONSTRATION BREAKOUT ROOM (LOWER)
EQUIPMENT/DEVELOPMENT
EVALUATION OF MINING METHODS
AIR QUALITY/VENTILATION
PERCOLATION
ENGINEERED BARRIER
HEATED BLOCK
THERMAL STRESS
PLATE LOADING
GROUND SUPPORT MONITORING
IN SITU SEALS
BULK PERMEABILITY
LAB TESTS
HEATED ROOM
OVERCORE STRESS
ROCK-MASS RESPONSE
MONITORING DRIFT STABILITY
SEQUENTIAL DRIFT MINING
DIFFUSION

MULTIPURPOSE BOREHOLE:

MPBH'S

CALICO HILLS:

TEST SUITE

EXPLORATORY DRIFTS:

MAJOR FAULT PROPERTIES
OTHER TESTS

TESTING GROUPS AND SEQUENCES FOR EARLY/LATE EXPLORATION AND TESTING

	OPTIONS 1-17	OPTIONS 18-34
EARLY TESTING+	1. TESTS IN ACCESSES 2. EXPLORATION OF 3 FAULTS IN TS AND EAST-WEST EXPLORATORY DRIFTING	1. CRITICAL* TESTS IN SCIENCE ACCESS 2. EXPLORATION OF 3 FAULT CROSSINGS IN CH
LATE TESTING	3. TESTS IN MTL IN TS 4. EXPLORATION OF 3 FAULTS IN CH 5. OTHER EXPLORATION & TESTS IN CH, INCLUDING SOLITARIO CANYON FAULT 6. DEFERRED TESTS IN ACCESSES	3. EXPLORATION OF 3 FAULTS IN TS, INCLUDING EAST-WEST EXPLORATORY DRIFTING 4. OTHER EXPLORATION & TESTING IN CH 5. TESTS IN MTL IN TS 6. DEFERRED TESTS IN ACCESSES

+ CONDUCT 1 & 2 AS MINIMUM (CONDUCT 3, 4, 5, AND 6 ON A NON-INTERFERENCE BASIS WITH 1 & 2 AS OPTIONS PERMIT).

* CRITICAL TESTS ARE SITE SUITABILITY TESTS IN WHICH DATA ARE IRRETRIEVABLE IF NOT OBTAINED AS CONSTRUCTION EXPOSES THE AREAS TO BE TESTED.

NNOAS5P.A42/11-19-90

ESF ALTERNATIVES STUDY

COMPARISON OF ACCESS TESTING PROGRAM BETWEEN STRATEGY 1 AND STRATEGY 2

(CONTINUED)

ACCESS TESTS:	STRATEGY 1 (EARLY TS TESTING)	STRATEGY 2 (EARLY CH TESTING)
*SHAFT CONVERGENCE	TEST + CONST. (R)	DEFERRED
*INTACT FRACTURES	TEST + CONST. (R)	DEFERRED
*EXCAVATION EFFECTS	TEST + CONST. (R)	DEFERRED
CHLORINE-36	SAMPLING	SAMPLING (R)
*PERCHED WATER	TEST + CONST. (ALL)	TEST + CONST. (ALL)

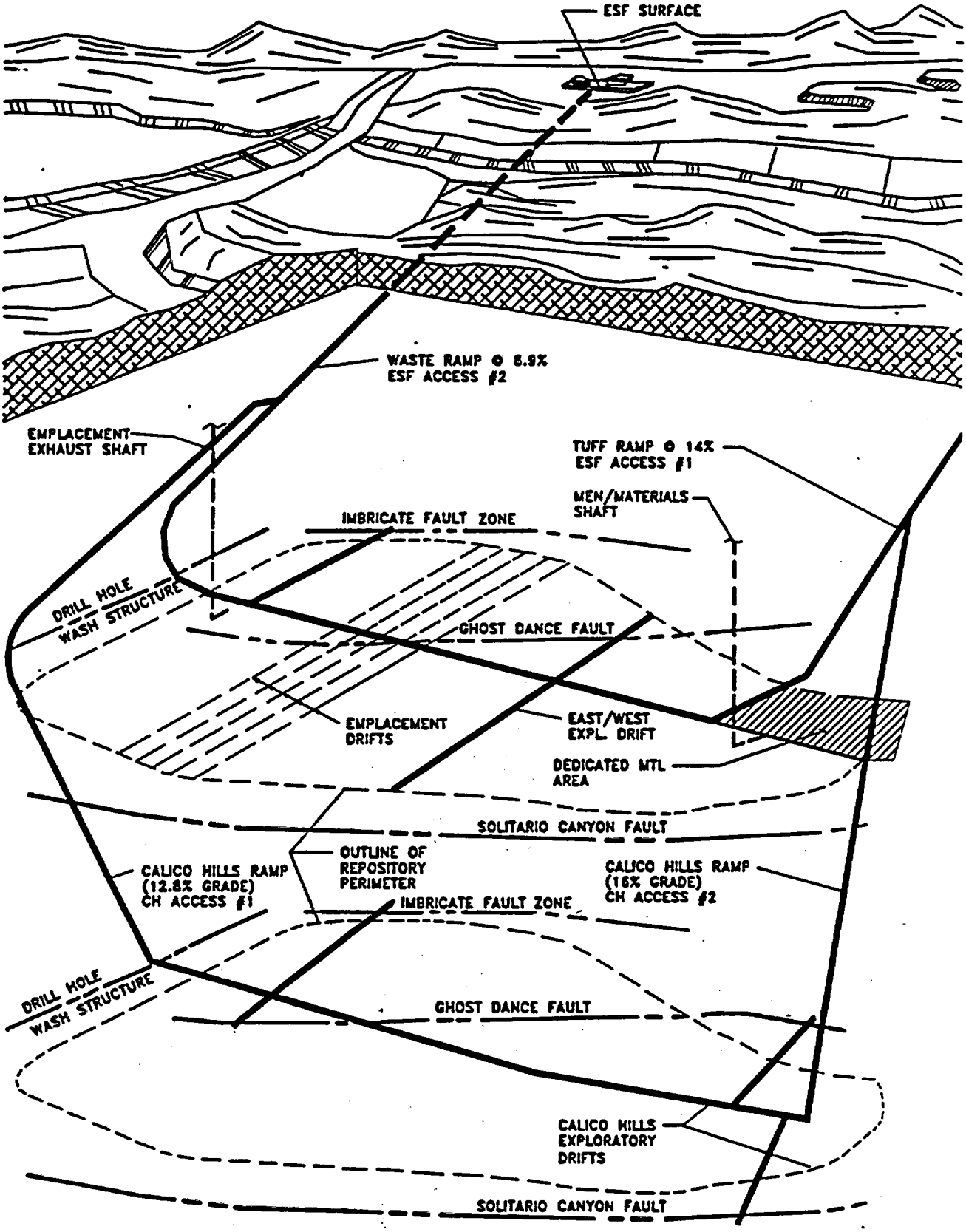
*TEST OR CONSTRUCTION SUPPORT IMPACTS CONSTRUCTION SCHEDULE
(R) ASSUMPTION OF REPLICATION IN SHAFT/RAMP AND RAMP/RAMP OPTIONS
(ALL) DENOTES THAT TEST WOULD BE PERFORMED IN ALL ACCESSES

ESF ALTERNATIVES STUDY

COMPARISON OF ACCESS TESTING PROGRAM BETWEEN STRATEGY 1 AND STRATEGY 2

ACCESS TESTS:	STRATEGY 1 (EARLY TS TESTING)	STRATEGY 2 (EARLY CH TESTING)
*GEOLOGIC MAPPING	TEST + CONST. (ALL)	TEST + CONST. (ALL)
*UDBR	DEFERRED	DEFERRED
*SHORT RADIAL BOREHOLES	TEST + CONST. (R)	TEST + CONST. (1)
*LONG RADIAL BOREHOLES	CONST. (R)	DEFERRED
*VERTICAL SEISMIC PROFILING	CONST. (ALL)	DEFERRED
HEATER EXPERIMENT IN TSw1	DEFERRED	DEFERRED
*HYDROCHEMISTRY	TEST + CONST. (R)	TEST + CONST. (1)
MINERALOGY/PETROLOGY	SAMPLING (R)	SAMPLING (R)
MATRIX HYDROLOGIC PROPERTIES	SAMPLING (R)	SAMPLING (R)

*TEST OR CONSTRUCTION SUPPORT IMPACTS CONSTRUCTION SCHEDULE
(R) ASSUMPTION OF REPLICATION IN SHAFT/RAMP AND RAMP/RAMP OPTIONS
(ALL) DENOTES THAT TEST WOULD BE PERFORMED IN ALL ACCESSES



30

ESF ALTERNATIVES STUDY
TASK NO. 4

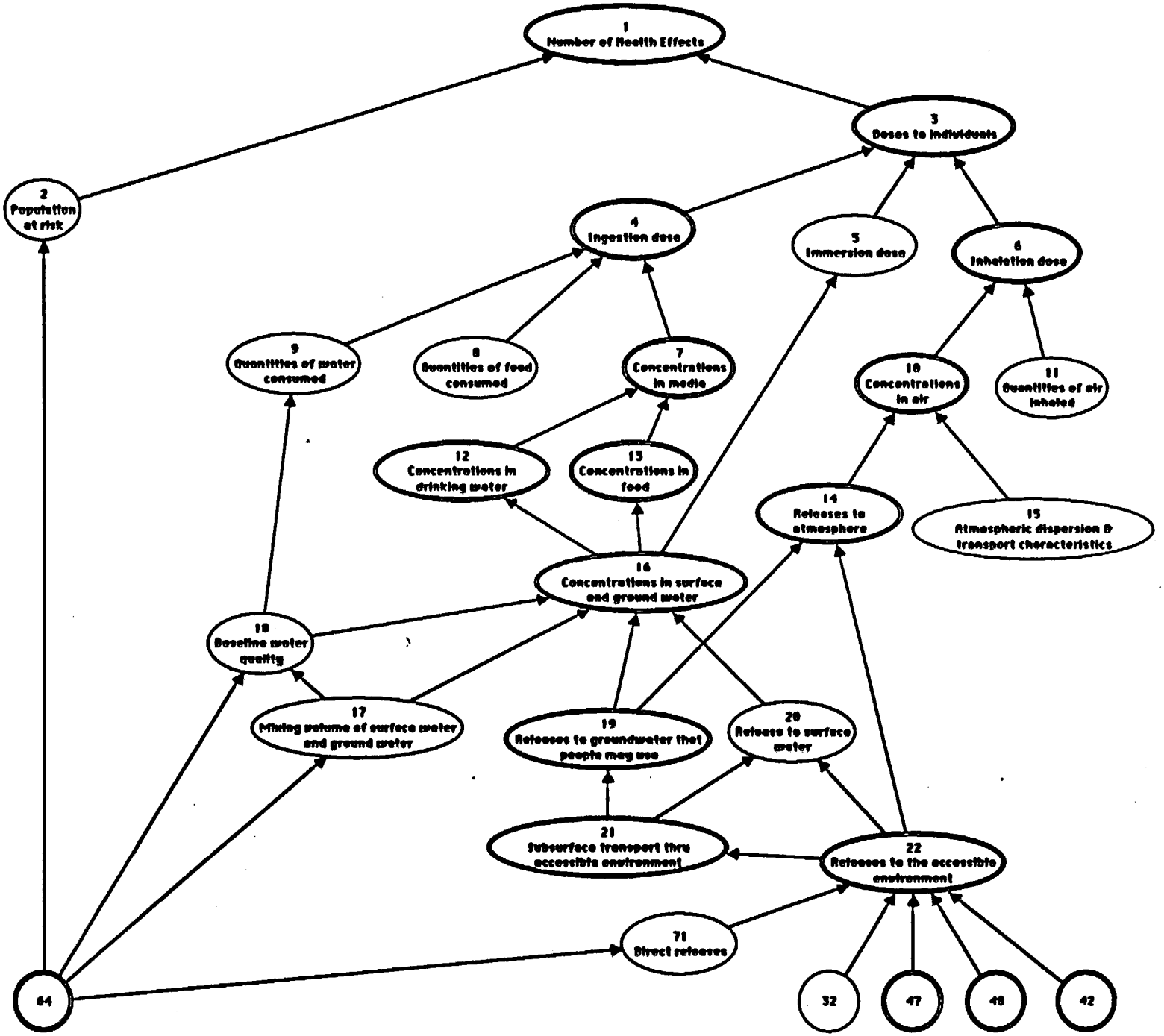
OPTION NO. B7

ISOMETRIC SCENARIO #2

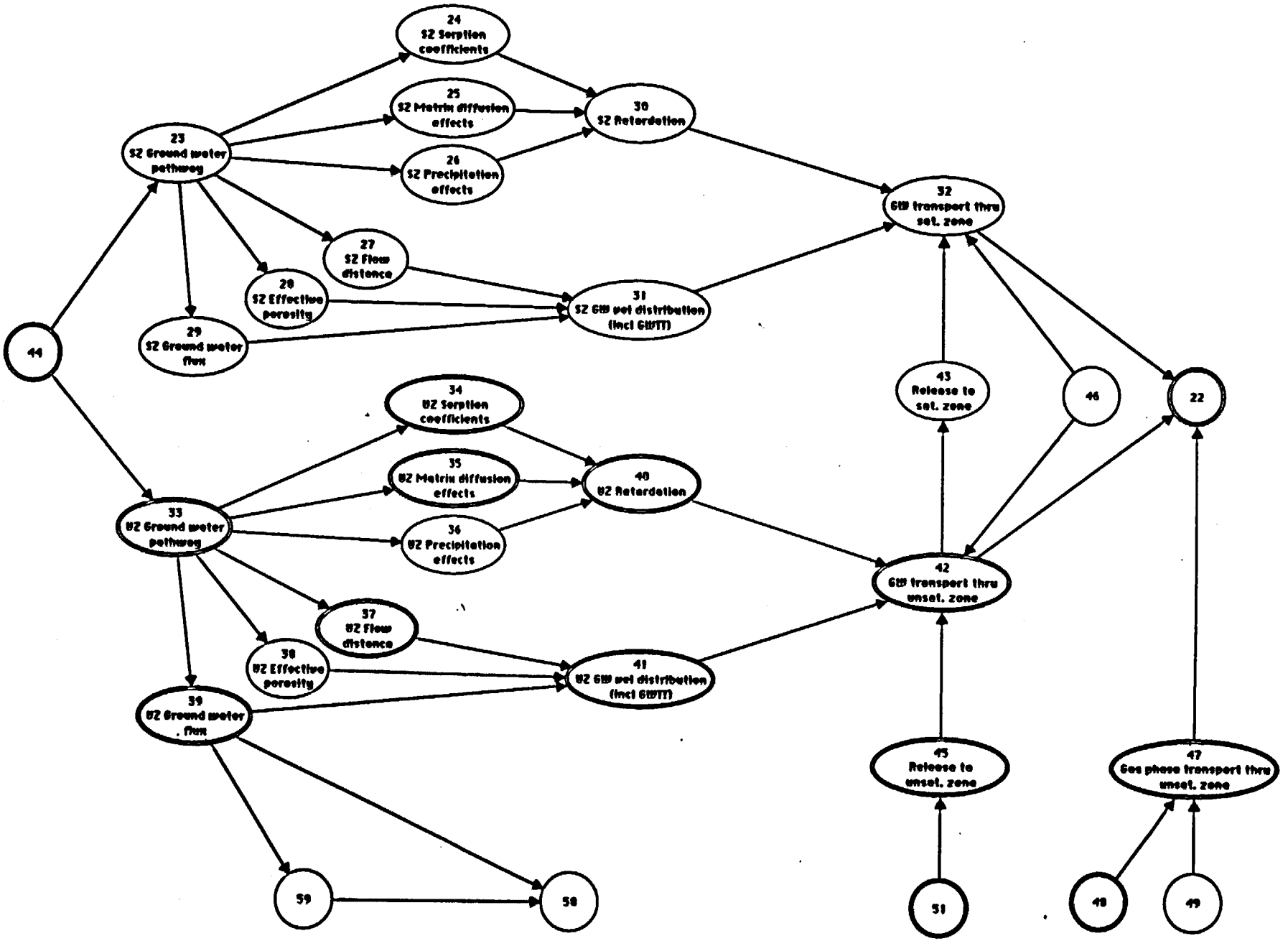
DATE

INFLUENCE DIAGRAMS USED IN THE ESF ALTERNATIVES STUDY

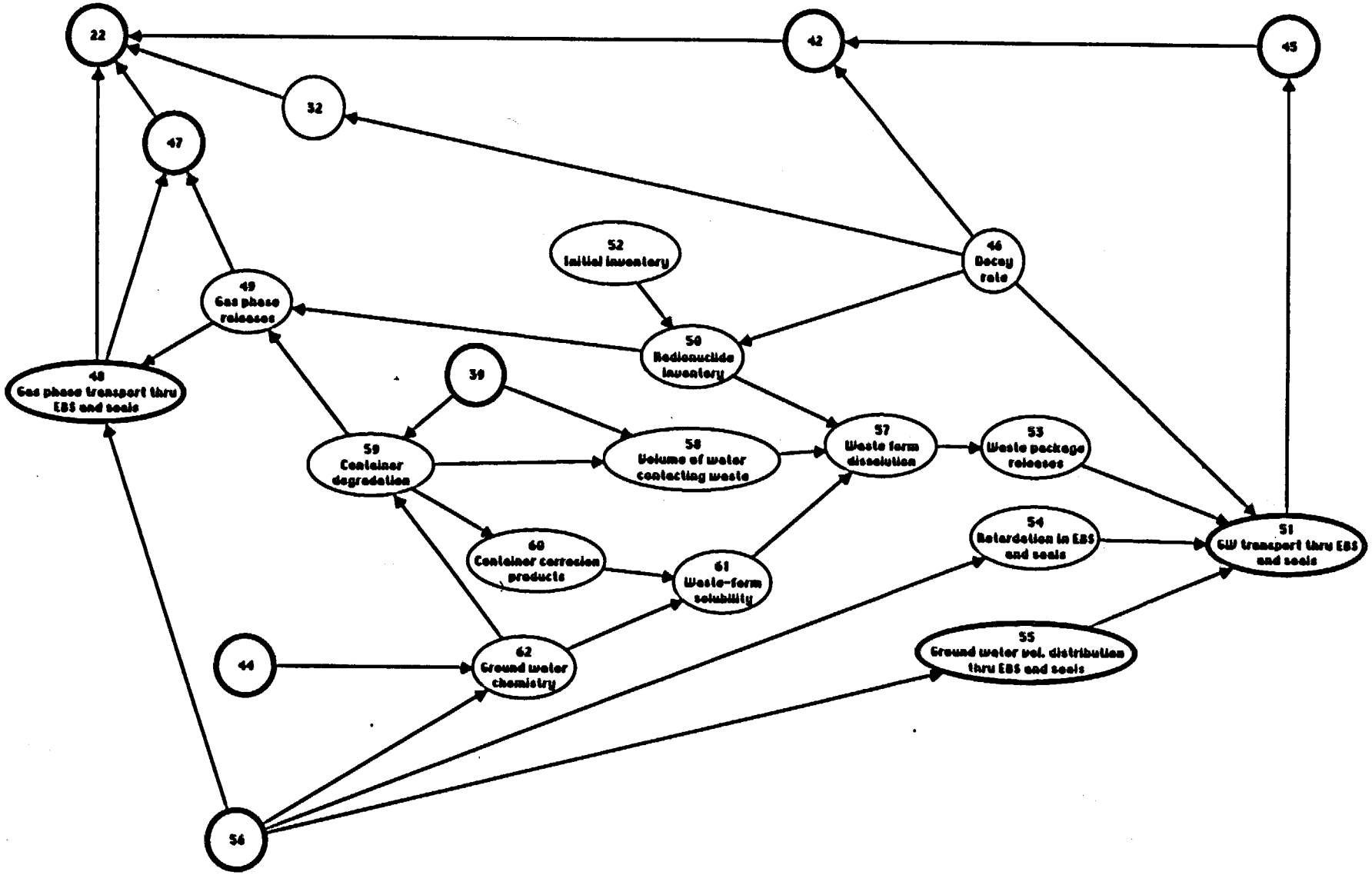
Attachment 16



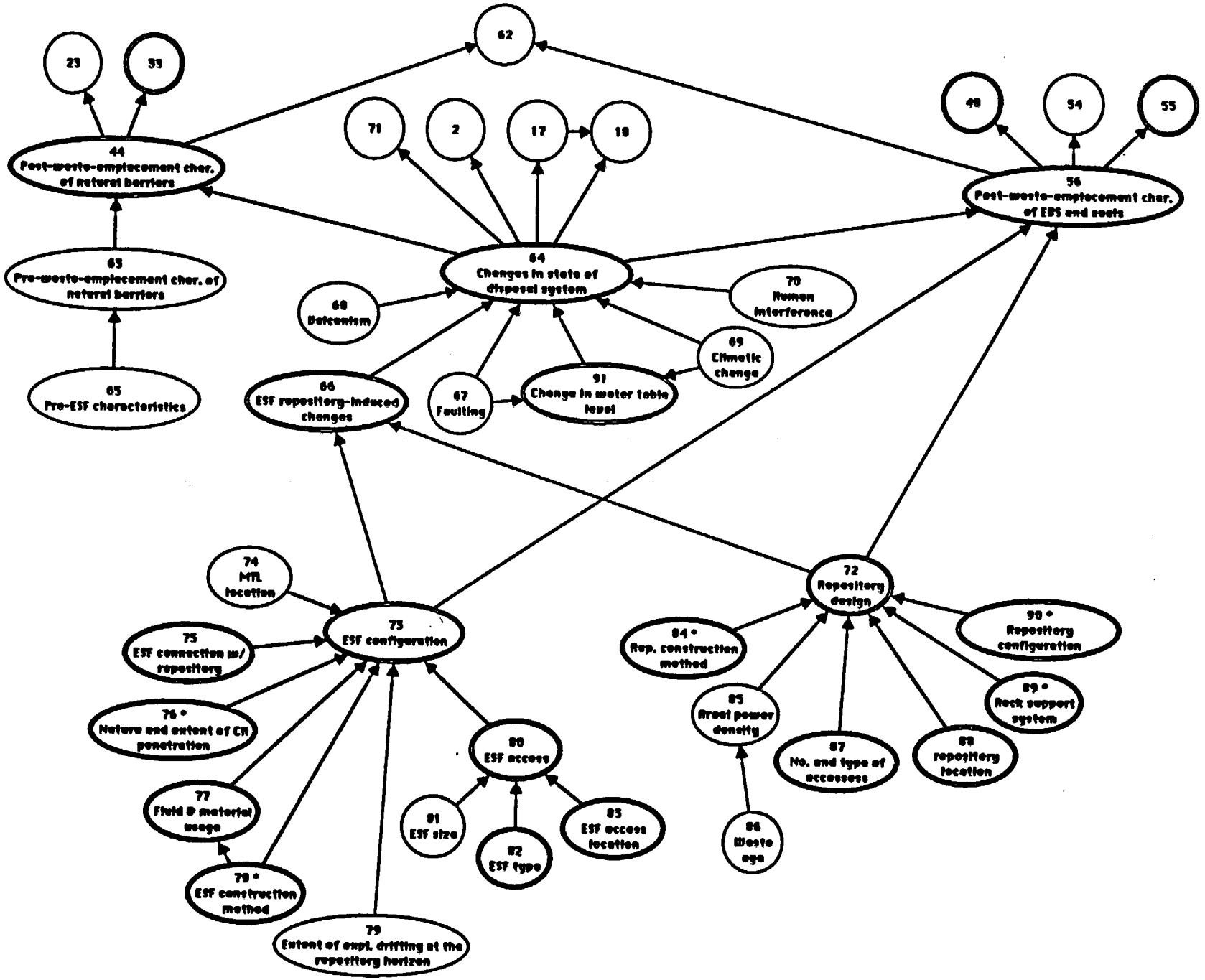
Influence Diagram Draft 8 [9/05/90] - Health Effects Portion (pg 1 of 4)



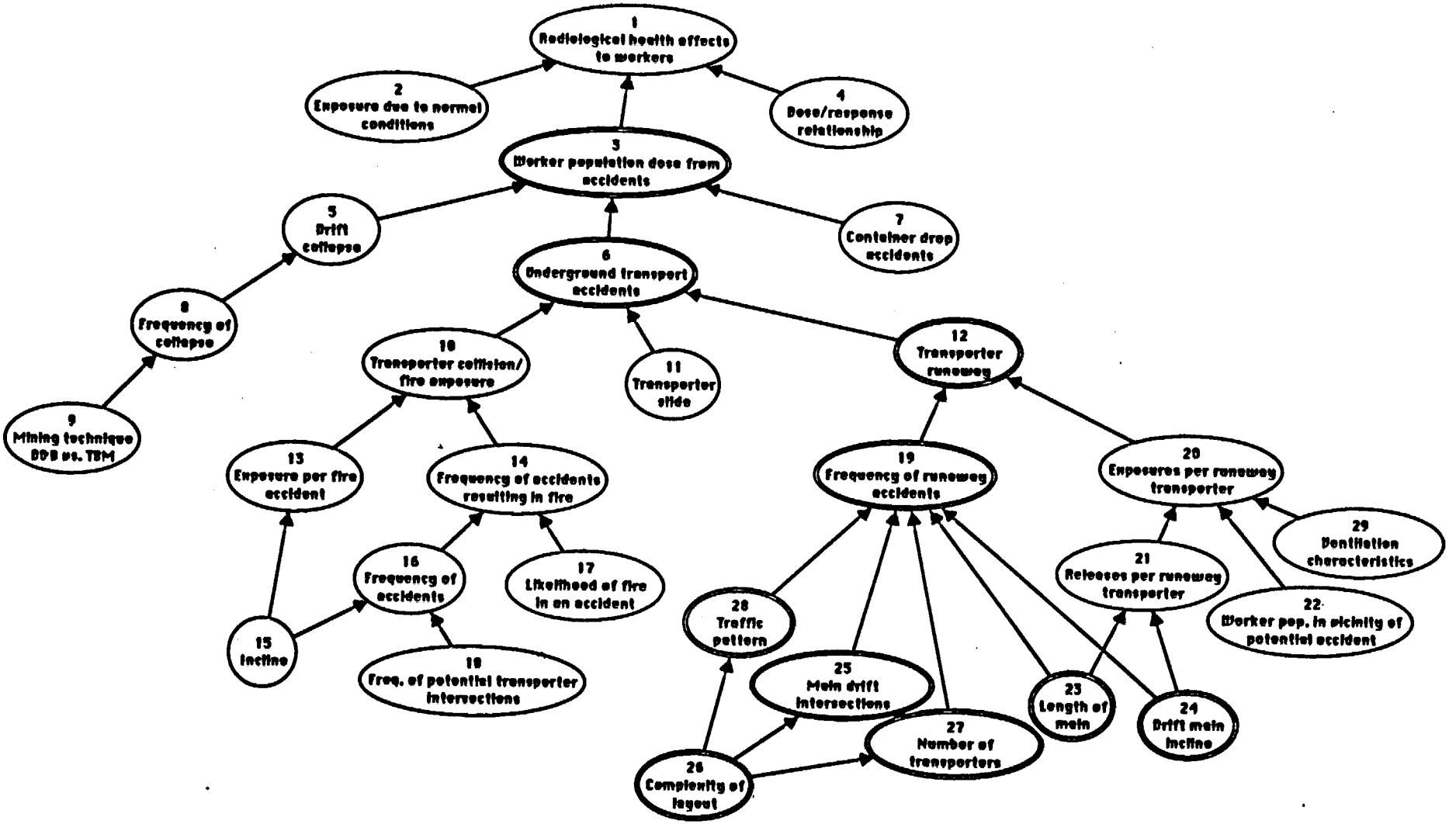
Influence Diagram Draft 14 [8/15/90] - Transport thru Nat. Barriers Portion (pg 2 of 4)



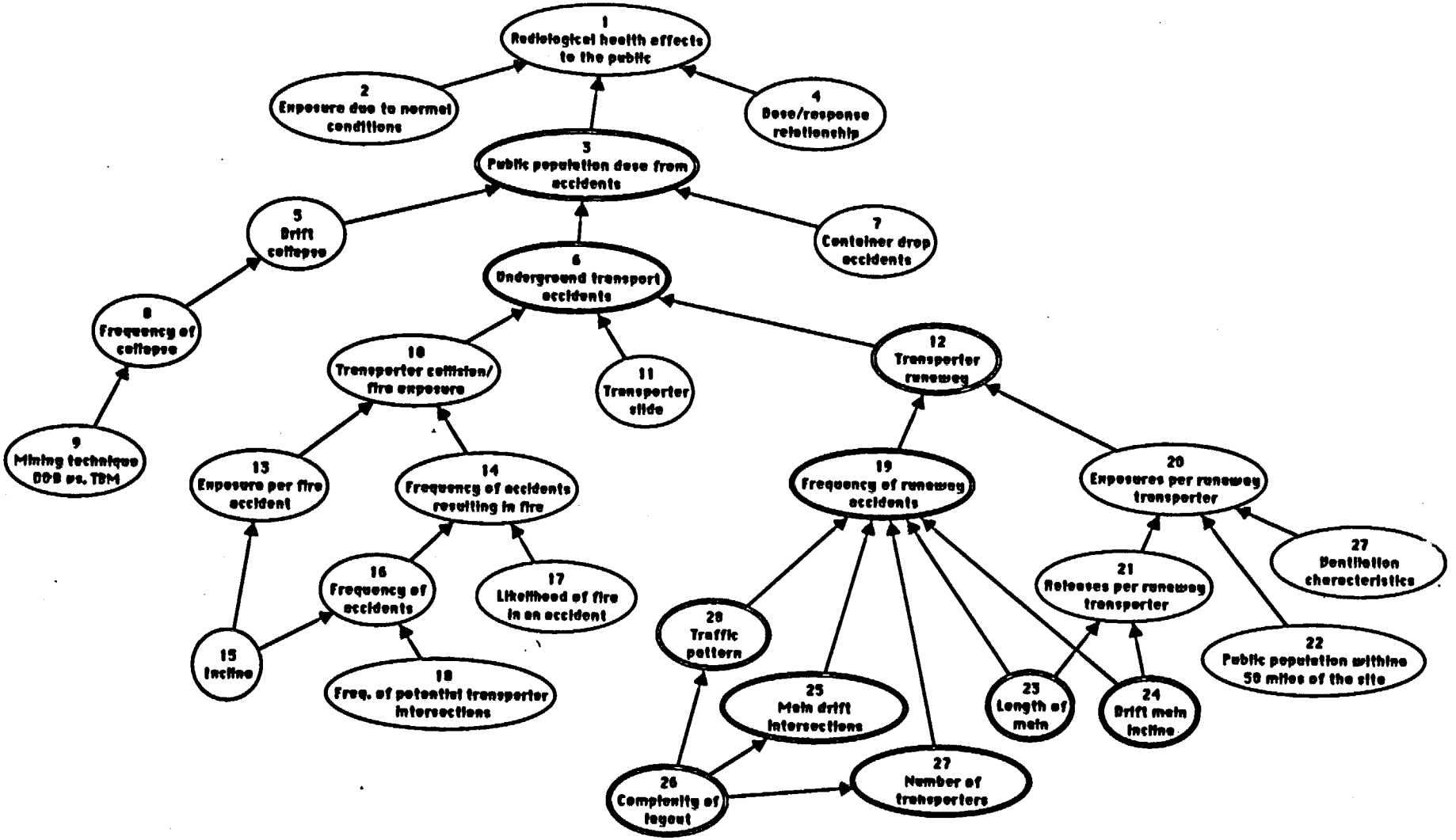
Influence Diagram Draft 14 [8/15/90] - Eng. Barrier System Portion (pg 3 of 4)



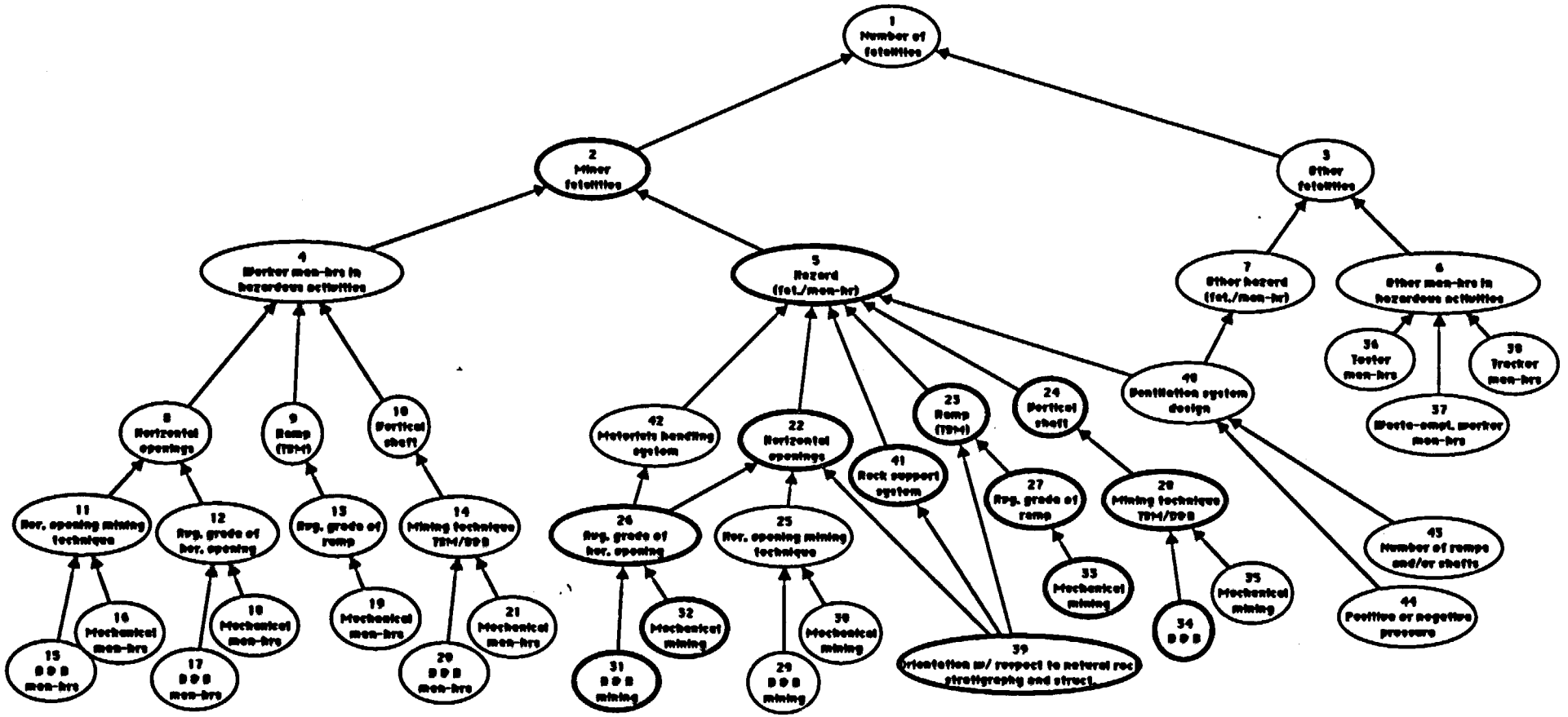
Influence Diagram Draft 8 [9/5/90] - Scenario Portion (pg 4 of 4)



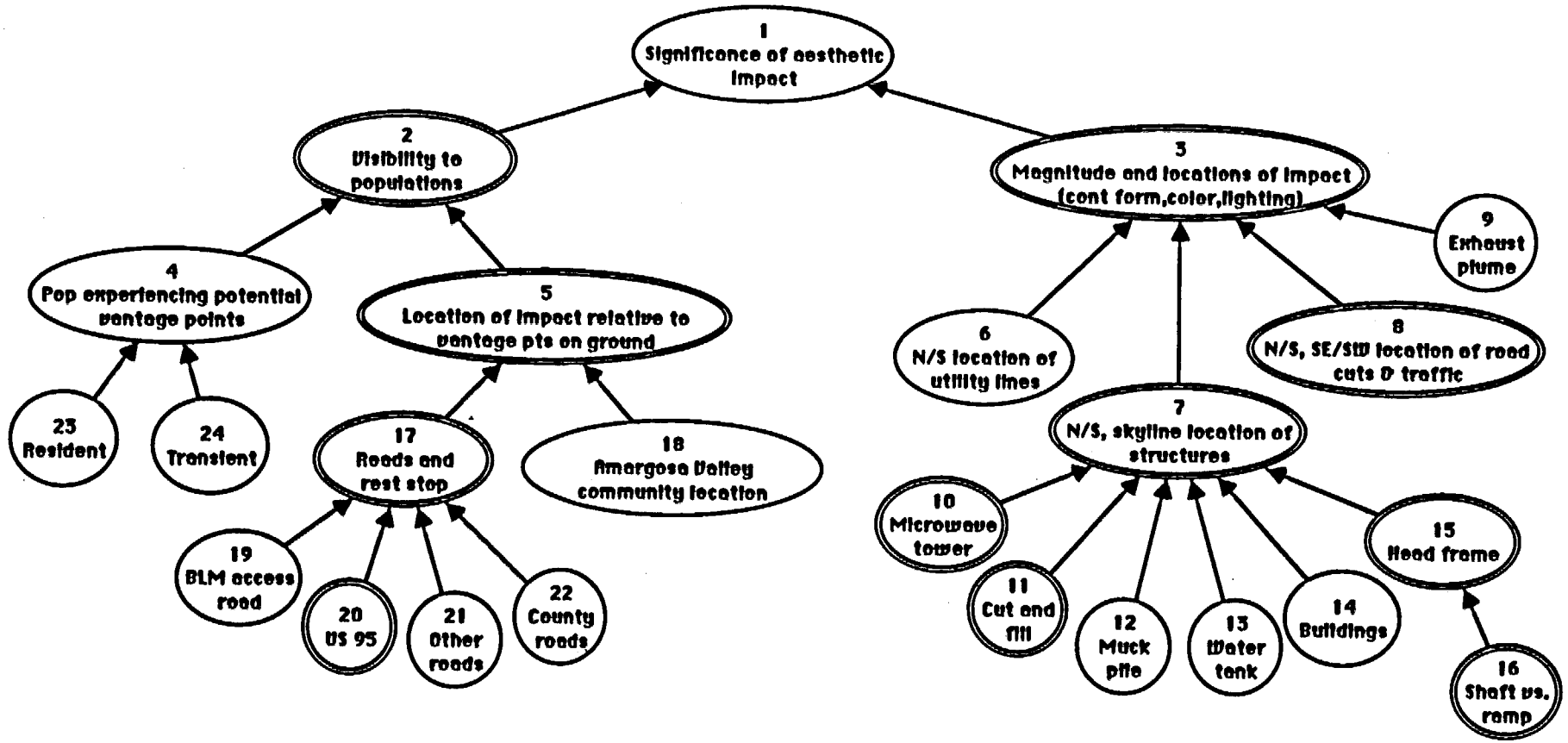
Influence Diagram Draft 4 [5/14/90] - Radiological Worker Health



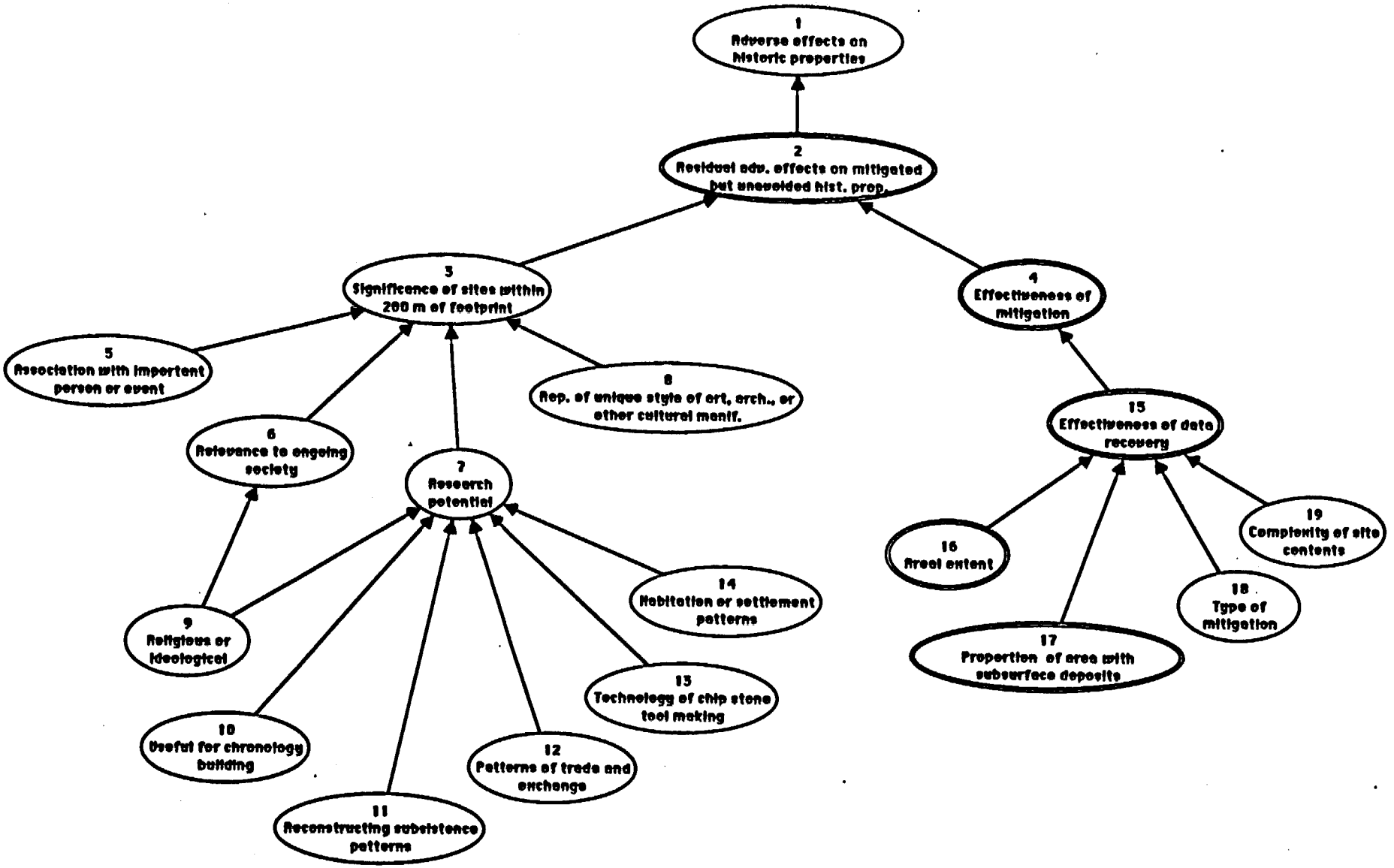
Influence Diagram Draft 4 [6/18/90] - Radiological Public Health



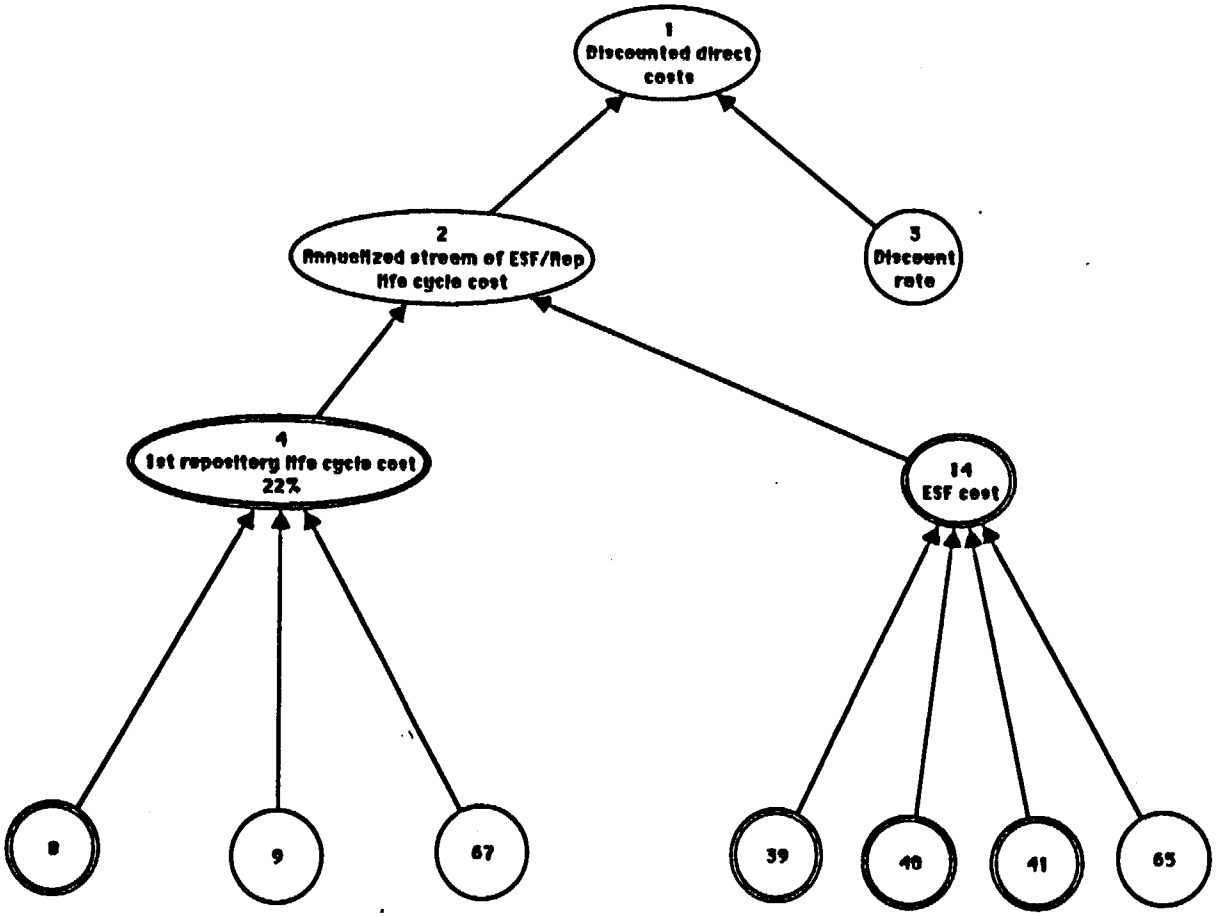
Influence Diagram Draft 5 [5/14/90] - Nonradiological Worker Safety



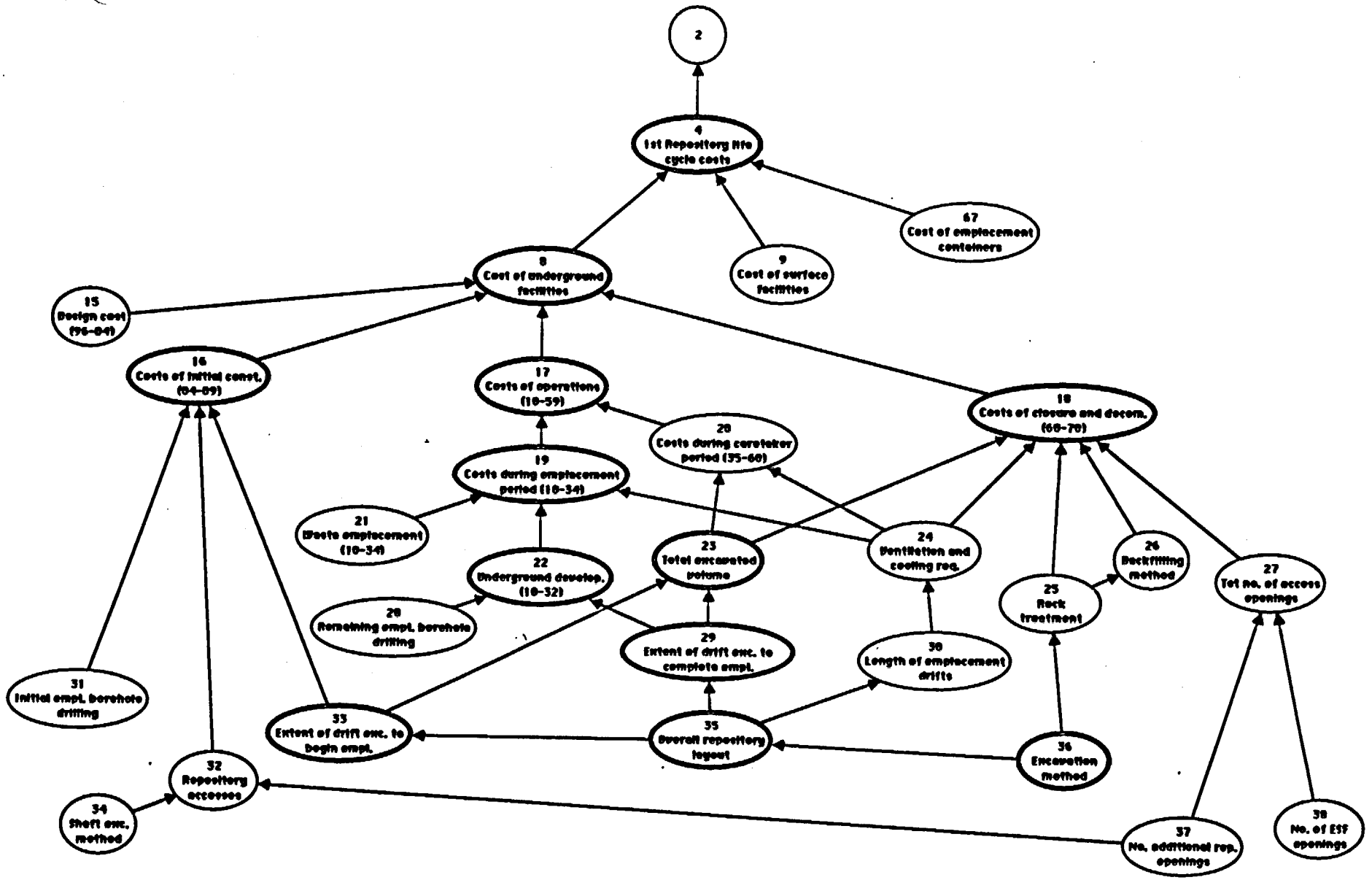
Influence Diagram Draft 4 [6/19/90] - Aesthetics



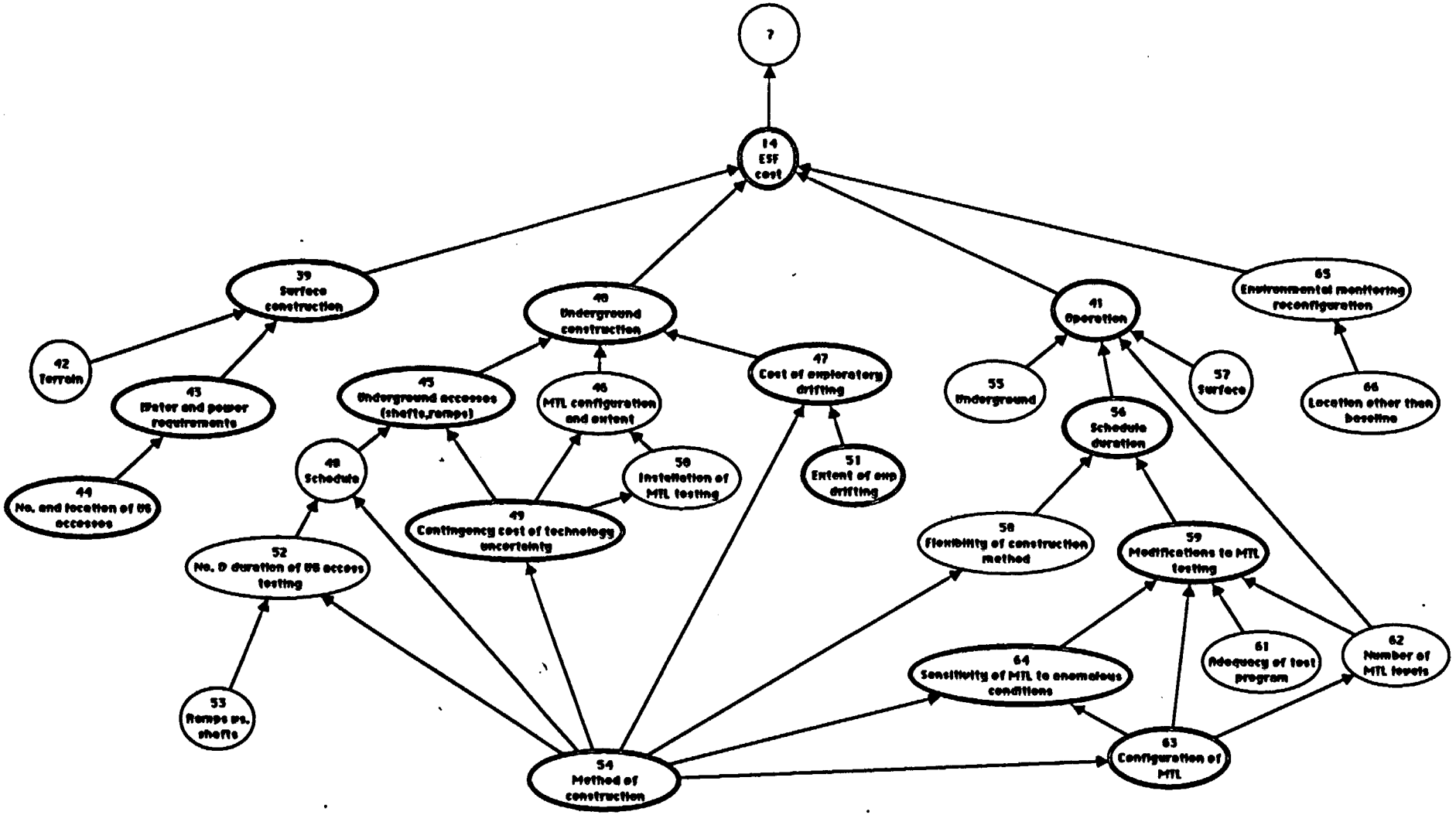
Influence Diagram Draft 11 [5/24/90] - Historical Properties



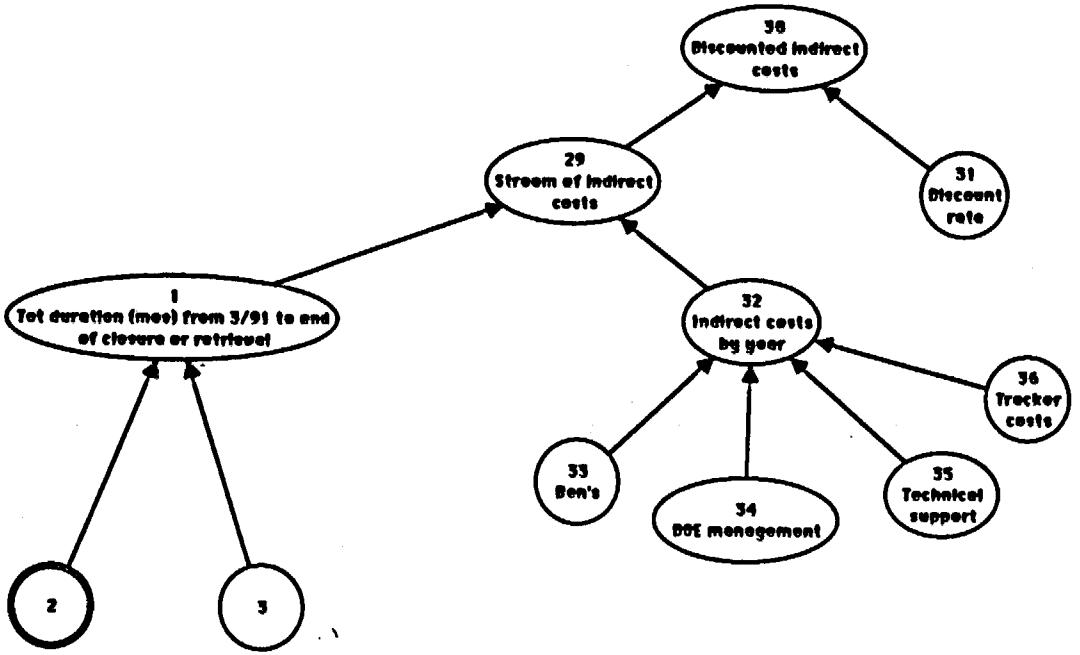
Influence Diagram Draft 5 [8/01/90] - Total System Life Cycle Cost (pg 1 of 3)



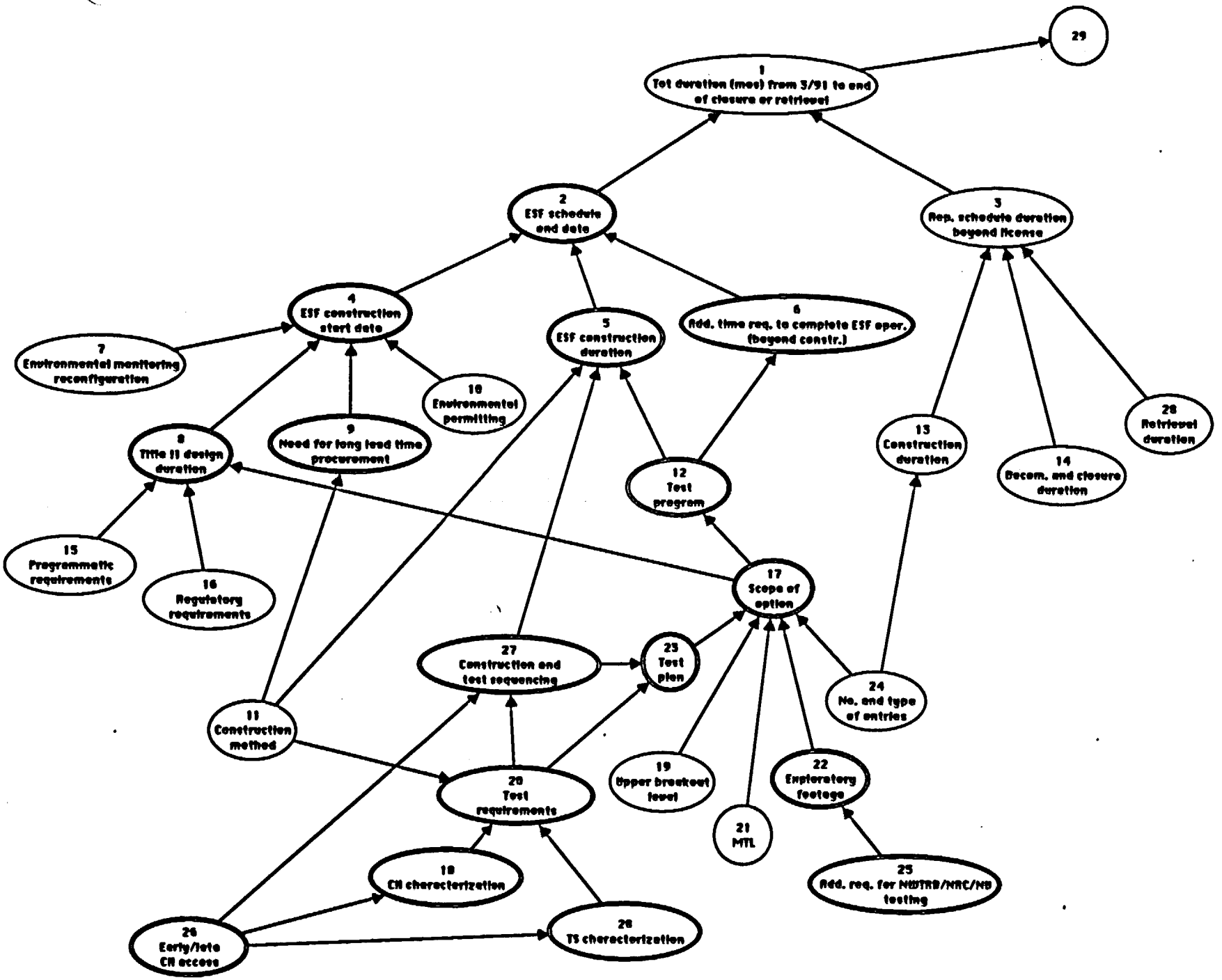
Influence Diagram Draft 5 [8/01/90] - Repository Life Cycle Cost (pg 2 of 3)



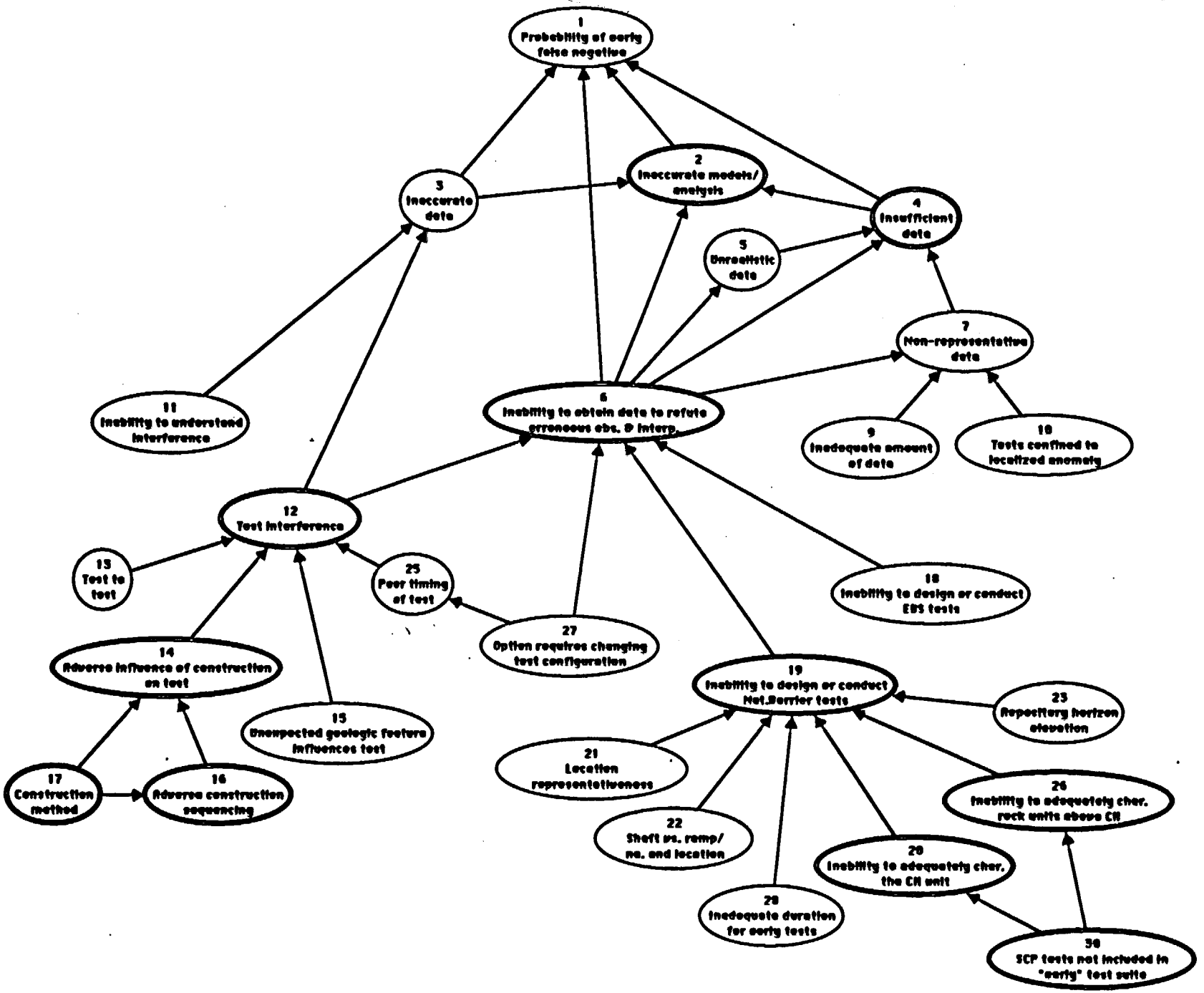
Influence Diagram Draft 5 [8/01/90] - ESF Cost (pg 3 of 3)



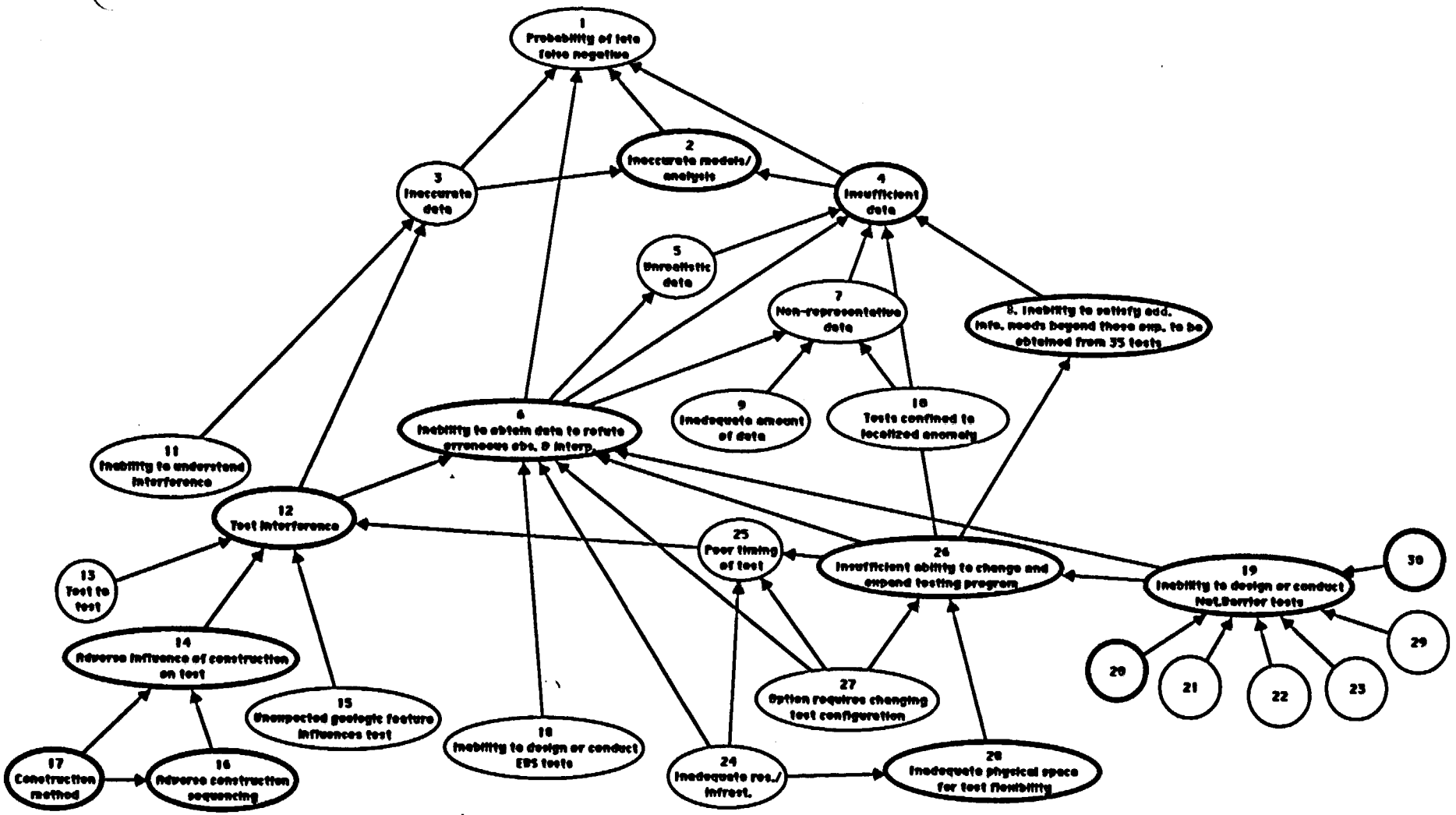
Influence Diagram Draft 8 [8/01/90] - Schedule - Ind. Costs (pg 1 of 2)



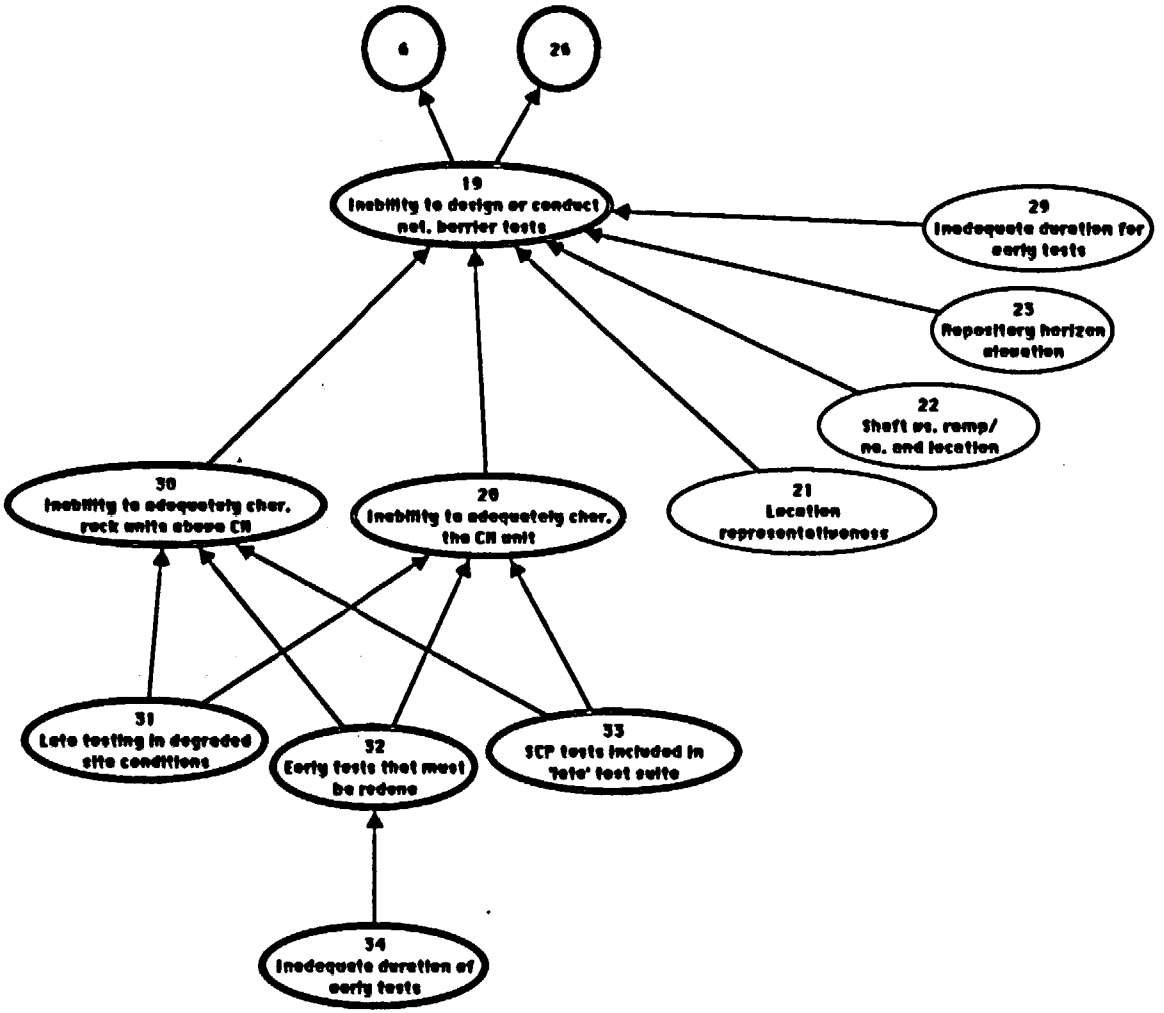
Influence Diagram Draft 9 [1/04/91] - Schedule (pg 2 of 2)



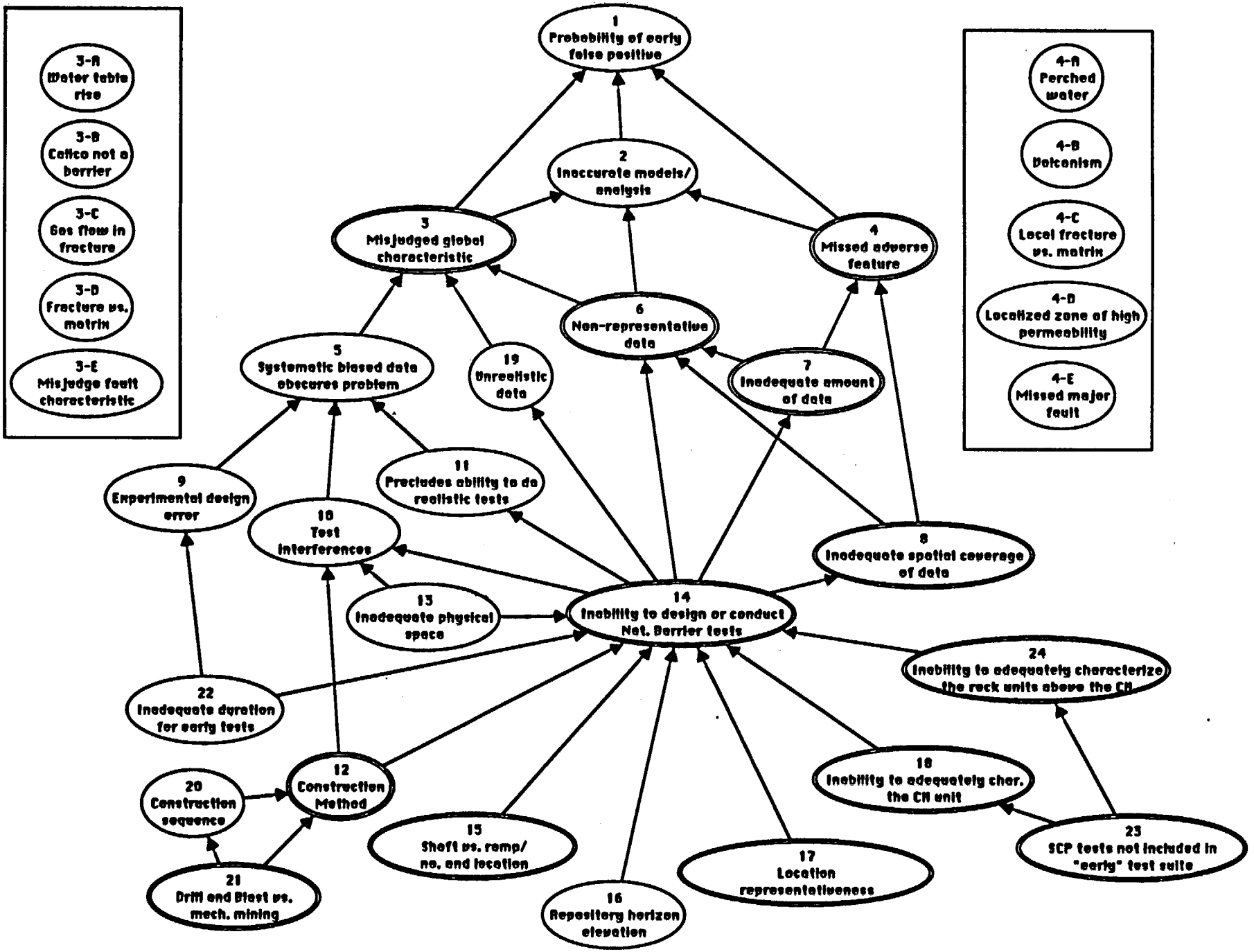
Influence Diagram Draft 11 [8/14/90] - Probability of Early False Negative



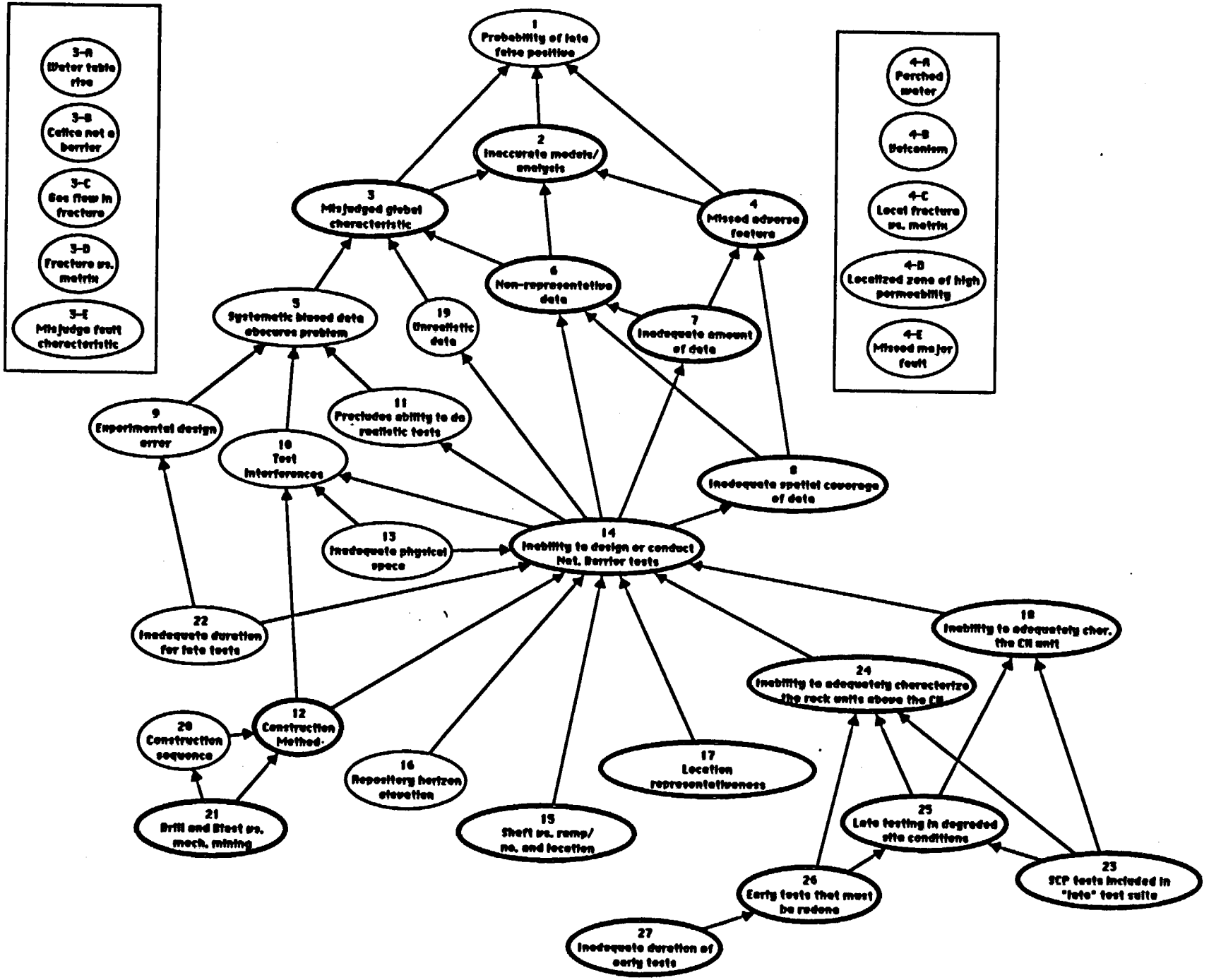
Influence Diagram Draft 11 [8/14/90] - Probability of Late False Negative (pg 1 of 2)



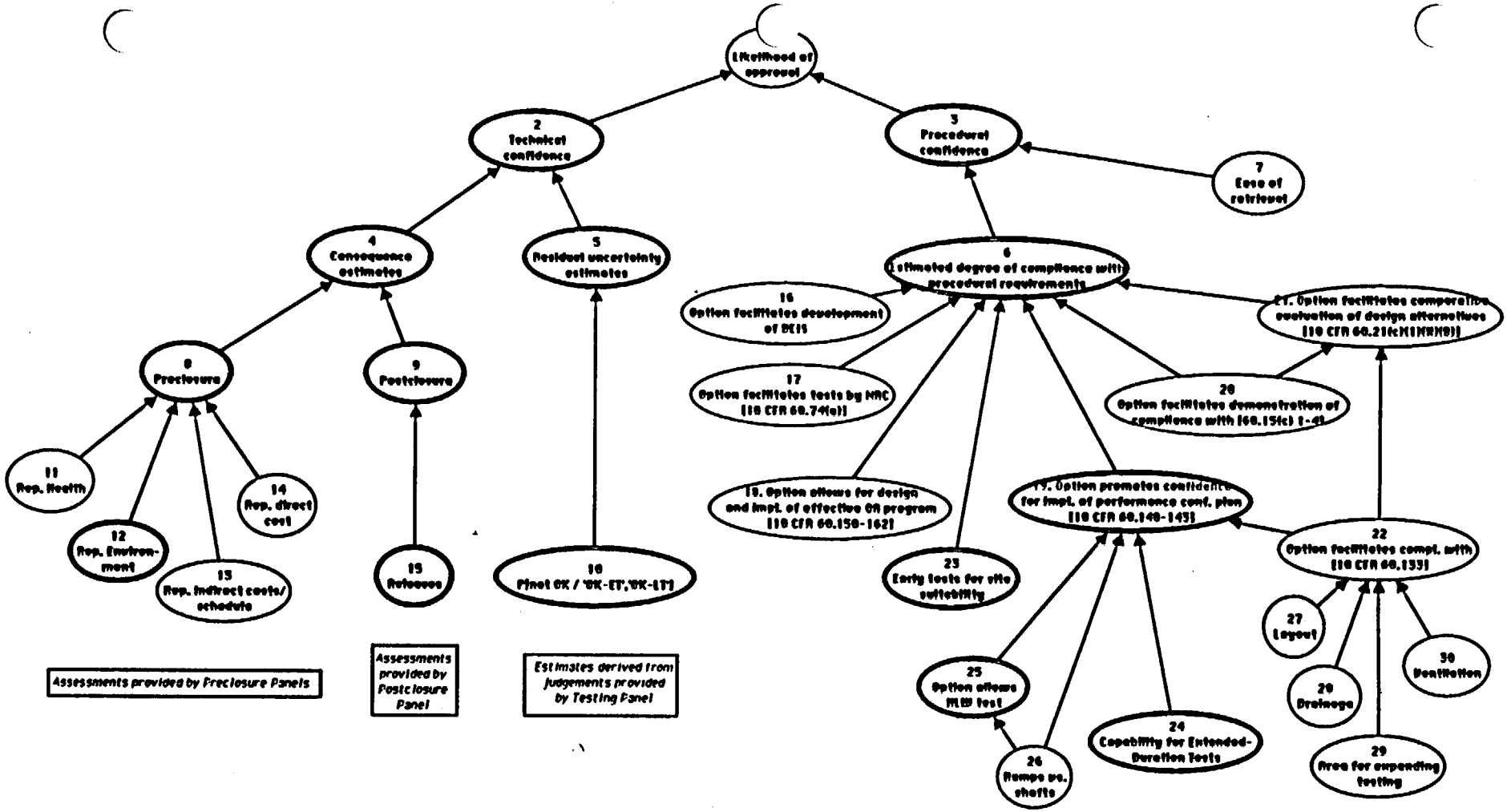
Influence Diagram Draft 11 [8/14/90] - Probability of Late False Negative (pg 2 of 2)



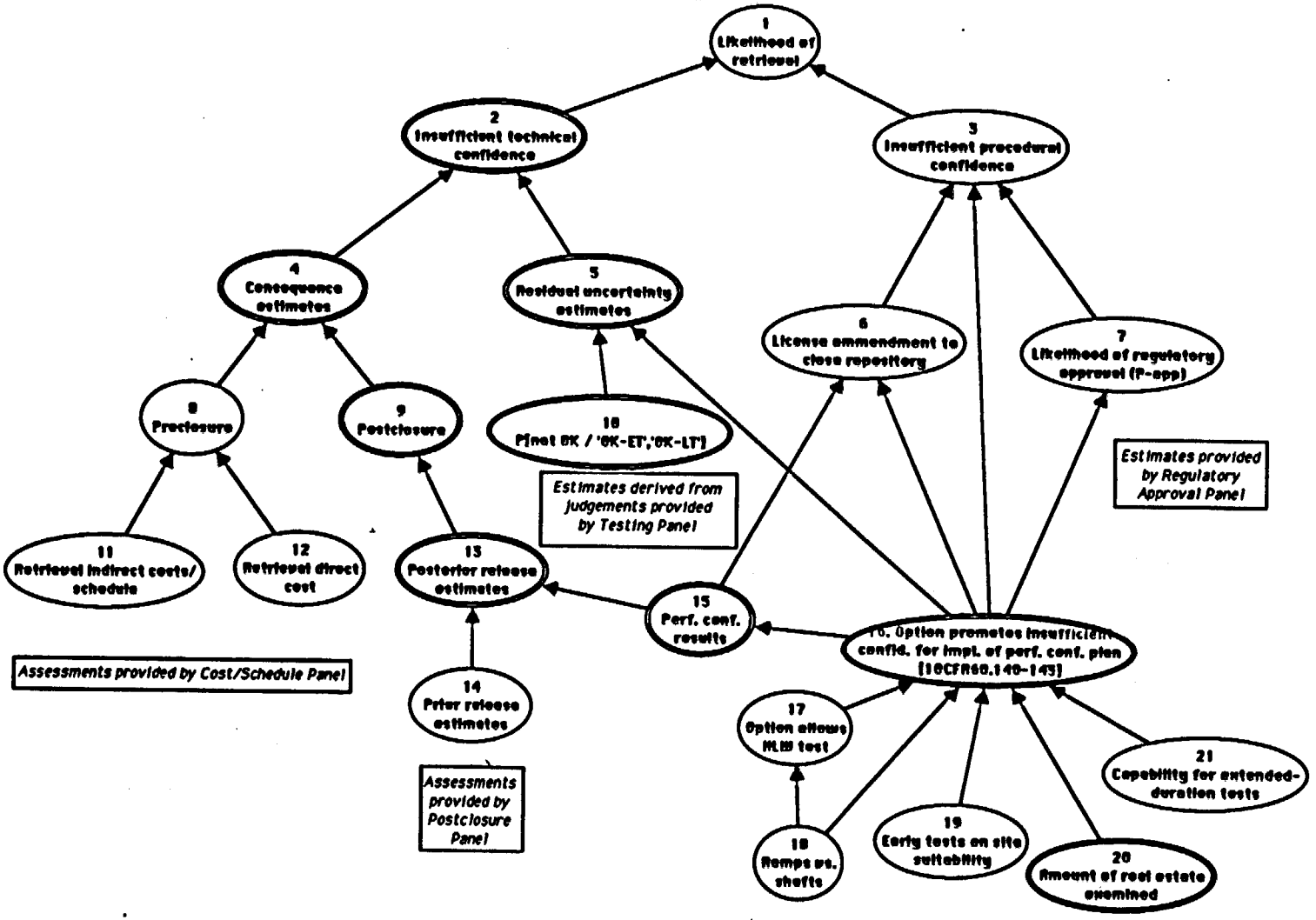
Influence Diagram Draft 6 [8/14/90] - Probability of Early False Positive



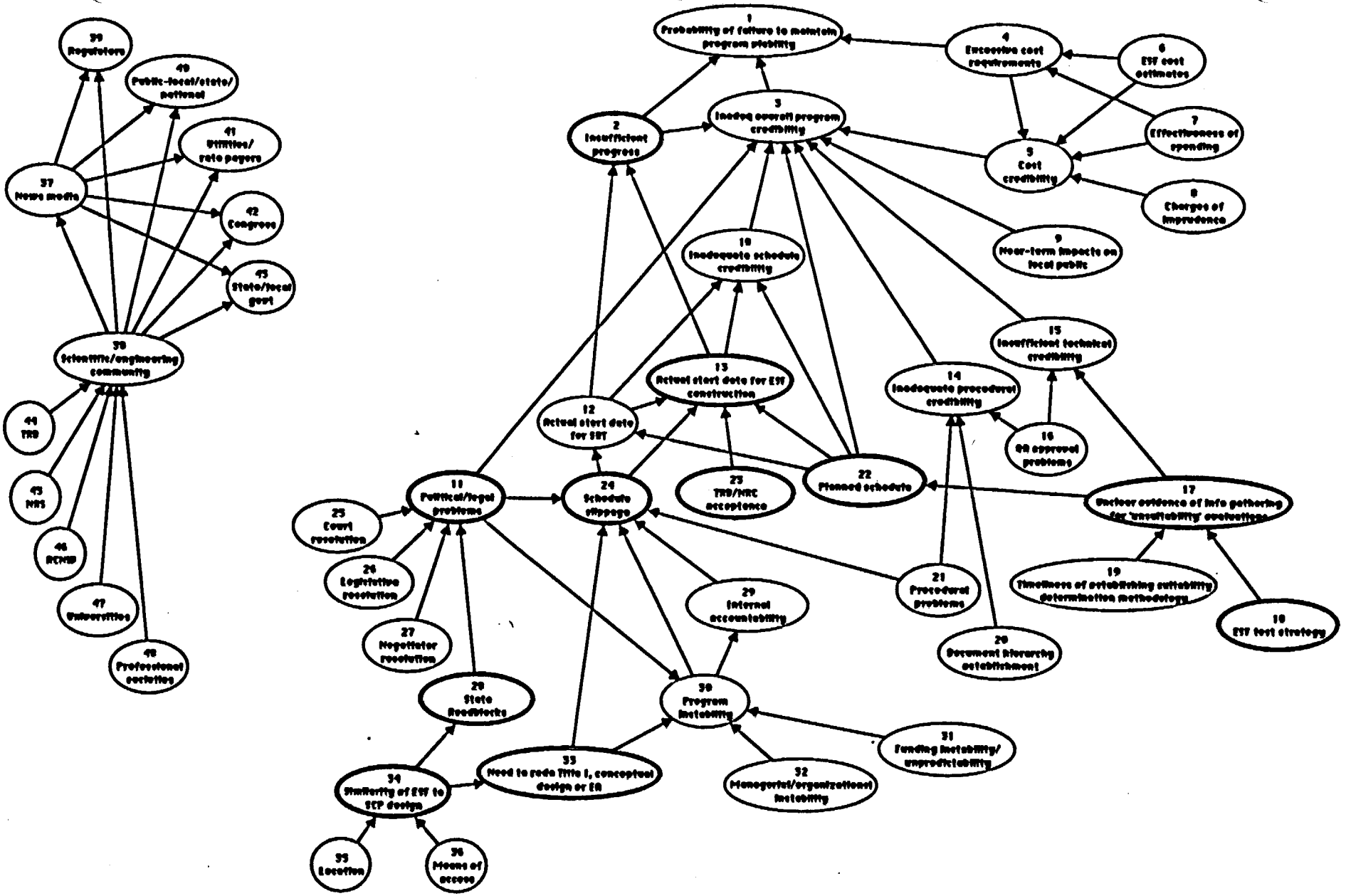
Influence Diagram Draft 5 [8/14/90] - Probability of Late False Positive



Influence Diagram Draft 7 [11/01/90] - Likelihood of Construction/Operation Approval



Influence Diagram Draft 5 [8/02/90] - Likelihood of Retrieval



Influence Diagram Draft 7 [8/28/90] - Probability of Programmatic Viability

ESF ALTERNATIVES STUDY
CROSSWALK OF
10 CFR 60 REQUIREMENTS TO
INFLUENCE DIAGRAMS

INFLUENCE DIAGRAM NAME/NO.	I. D. ELEMENT No.	I. D. ELEMENT STATEMENT	REQUIREMENT REFERENCE	REQUIREMENT STATEMENT (or NOTE)	RR
			60.15(c)	Site Characterization - The program of site characterization shall be conducted in accord with the following:	1
			(1)	Investigations to obtain the required informa shall be conducted in such a manner as to lim adverse effects on the long-term performance the geologic repository to the extent practic	
Schedule, Draft 8	05 ESF construction duration				
	18 CH characterization				
TSLC Cost, Draft 5	14 ESF				
ESF Cost, Draft 5	14 ESF				
	52 No. & duration of UG access testing				
	58 Flexibility of construction method				
Postclosure H & S Scenario Portion, Draft 6	66 ESF repository-induced changes				
	73 ESF configuration				
	75 ESF connection w/repository				
	76 Nature and extent of CH penetration				
	77 Fluid & material usage				
	78 ESF construction method				
	79 Extent of exploratory drifting at the repository horizon				
Probability of Early False Negative, Draft 11	06 Inability to obtain data to refute erroneous obs. and interpretations				
	11 Inability to understand interference				
	12 Test interference				

INFLUENCE DIAGRAM NAME/NO.	I. D. ELEMENT No.	I. D. ELEMENT STATEMENT	REQUIREMENT REFERENCE	REQUIREMENT STATEMENT (or NOTE)	RK
	14	Adverse influence of construction on test			
	18	Inability to design or conduct EBS tests			
	19	Inability to design or conduct nat. barrier tests			
	20	Inability to adequately char. the CM unit			
	22	Shaft vs ramp/no. and location			
Probability of Late False Negative, Draft 11	06	Inability to obtain data to refute erroneous obs. and interpretations			
	08	Inability to satisfy add. info. needs beyond those expected to be obtained from 35 tests			
	11	Inability to understand interference			
	12	Test interference			
	14	Adverse influence of construction on test			
	18	Inability to design or conduct EBS tests			
	19	Inability to design or conduct nat. barrier tests			
	20	Inability to adequately char. the CM unit			
	22	Shaft vs ramp/no. and location			
	26	Insufficient ability to change and expand testing program			
Probability of Early False Positive, Draft 6	10	Test interferences			
	11	Precludes ability to do realistic tests			

INFLUENCE DIAGRAM NAME/NO.	I. D. ELEMENT No.	I. D. ELEMENT STATEMENT	REQUIREMENT REFERENCE	REQUIREMENT STATEMENT (or NOTE)	RK
	12	Construction method			
	13	Inadequate physical space			
	14	Inability to design or conduct nat. barrier tests			
	15	Shaft vs ramp/no. and location			
	18	Inability to adequately char. the CH unit			
	21	Drill and blast vs mech. mining			
Probability of Late False Positive, Draft 5	10	Test interferences			
	11	Precludes ability to do realistic tests			
	12	Construction method			
	13	Inadequate physical space			
	14	Inability to design or conduct nat. barrier tests			
	15	Shaft vs ramp/no. and location			
	18	Inability to adequately char. the CH unit			
	21	Drill and blast vs mech. mining			
Likelihood of Const/Opn Approval, Draft 6	22	Option facilitates demonstration of compliance with 60.15(c)(1-4)			
			(2)	The number of exploratory boreholes and shaft shall be limited to the extent practical consistent with obtaining the information nee for site characterization.	
Schedule, Draft 8	05	ESF construction duration			
	11	Construction method			
	18	CH characterization			
TSLC Cost, Draft 5	14	ESF			

INFLUENCE DIAGRAM NAME/NO.	I. D. ELEMENT No.	I. D. ELEMENT STATEMENT	REQUIREMENT REFERENCE	REQUIREMENT STATEMENT (or NOTE)	RK
Repository LCC, Draft 5	38	No. of ESF openings			
ESF cost, Draft 5	44	No. and location of UG accesses			
	52	No. & duration of UG access testing			
	58	Flexibility of construction method			
Postclosure Health & Safety Scenario Portion, Draft 6	73	ESF configuration			
	76	Nature and extent of CH penetration			
	80	ESF access			
	87	No. and type of accesses			
Preclosure Health & Safety Nonradiological Worker Safety, Draft 5	08	Horizontal openings			
	09	Ramp (TBM)			
	10	Vertical shaft			
	22	Horizontal openings			
	23	Ramp (TBM)			
	24	Vertical shaft			
Probability of Early False Negative, Draft 11	12	Test interference			
	14	Adverse influence of construction on test			
Probability of Late False Negative, Draft 11	12	Test interference			
	14	Adverse influence of construction on test			
Probability of Early False Positive, Draft 6	03	Misjudged global charac.			
	04	Missed adverse feature			
	06	Non-representative data			
	07	Inadequate amount of data			
	08	Inadequate spatial coverage of data			

INFLUENCE DIAGRAM NAME/NO.	I. D. ELEMENT No.	I. D. ELEMENT STATEMENT	REQUIREMENT REFERENCE	REQUIREMENT STATEMENT (or NOTE)	RR
	10	Test interferences			
	15	Shaft vs. ramp/no. and location			
	18	Inability to adequately char. the CH unit			
Probability of Late False Positive, Draft 5	03	Misjudged global charac.			
	04	Missed adverse feature			
	06	Non-representative data			
	07	Inadequate amount of data			
	08	Inadequate spatial coverage of data			
	10	Test interferences			
	15	Shaft vs. ramp/no. and location			
	18	Inability to adequately char. the CH unit			
	24	Inability to adequately char. rock units above the CH			
Likelihood of Const/Opn Approval, Draft 6	22	Option facilitates demonstration of compliance with 60.15(c)(1-4)			
			(3).	To the extent practical, exploratory borehole shafts in the geologic repository operations shall be located where shafts are planned for underground facility construction and operati where large unexcavated pillars are planned.	
Schedule, Draft 8	05	ESF construction duration			
	11	Construction method			
TSLC Cost, Draft 5	14	ESF			
Repository LCC, Draft 5	38	No. of ESF openings			
ESF Cost, Draft 5	44	No. & location of UG accesses			

INFLUENCE DIAGRAM NAME/NO.	I. D. ELEMENT No.	I. D. ELEMENT STATEMENT	REQUIREMENT REFERENCE	REQUIREMENT STATEMENT (or NOTE)	RK
	52	No. & duration of UG access testing			
	58	Flexibility of construction method			
Postclosure Health & Safety Scenario Portion, Draft 6	73	ESF configuration			
	83	ESF access location			
	90	Repository configuration			
Preclosure Health & Safety Nonradiological Worker Safety, Draft 5	08	Horizontal openings			
	10	Vertical shaft			
	22	Horizontal openings			
	24	Vertical shaft			
Probability of Early False Negative, Draft 11	12	Test interference			
	14	Adverse influence of construction on test			
	21	Location representativeness			
	22	Shaft vs ramp/no. and location			
Probability of Late False Negative, Draft 11	12	Test interference			
	14	Adverse influence of construction on test			
	21	Location representativeness			
	22	Shaft vs ramp/no. and location			
Probability of Early False Positive, Draft 6	08	Inadequate spatial coverage of data			
	10	Test interferences			
	15	Shaft vs ramp/no. and location			
	17	Location representativeness			

INFLUENCE DIAGRAM NAME/NO.	I. D. ELEMENT No.	I. D. ELEMENT STATEMENT	REQUIREMENT REFERENCE	REQUIREMENT STATEMENT (or NOTE)	RK
Probability of Late False Positive, Draft 5	08	Inadequate spatial coverage of data			
	10	Test interferences			
	15	Shaft vs ramp/no. and location			
	17	Location representativeness			
Likelihood of Const/Opn Approval, Draft 6	22	Option facilitates demonstration of compliance with 60.15(c)(1-4)			
			(4)	Subsurface exploratory drilling, excavating, in situ testing before and during constructio shall be planned and coordinated with geologi operations area design and construction.	
Schedule, Draft 8	05	ESF construction duration			
	11	Construction duration			
	18	CH characterization			
TSLC Cost, Draft 5	14	ESF			
ESF Cost, Draft 5	52	No. & duration of UG access testing			
	58	Flexibility of construction method			
Postclosure Health & Safety Scenario Portion, Draft 6	73	ESF configuration			
	76	Nature & extent of CH penetration			
	77	Fluid & material usage			
	78	ESF construction method			
	79	Extent of expl. drifting at the repository horizon			
	80	ESF access			

INFLUENCE DIAGRAM NAME/NO.	I. D. ELEMENT No.	I. D. ELEMENT STATEMENT	REQUIREMENT REFERENCE	REQUIREMENT STATEMENT (or NOTE)	RK
Preclosure Health & Safety Nonradiological Worker Safety, Draft 5	09	Ramp (TBM)			
	23	Ramp (TBM)			
Probability of Early False Negative, Draft 11	12	Test interference			
	14	Adverse influence of construction on test			
	16	Adverse construction sequencing			
	20	Inability to adequately char. the CH unit			
	27	Option requires changing test configuration			
Probability of Late False Negative, Draft 11	12	Test interference			
	14	Adverse influence of construction on test			
	16	Adverse construction sequencing			
	20	Inability to adequately char. the CH unit			
	27	Option requires changing test configuration			
Probability of Early False Positive, Draft 6	10	Test interferences			
	18	Inability to adequately char. the CH unit			
Probability of Late False Positive, Draft 5	10	Test interferences			
	18	Inability to adequately char. the CH unit			

INFLUENCE DIAGRAM NAME/NO.	I. D. ELEMENT No.	I. D. ELEMENT STATEMENT	REQUIREMENT REFERENCE	REQUIREMENT STATEMENT (or NOTE)	RK
Likelihood of Const/Opn Approval, Draft 6	22	Option facilitates demonstration of compliance with 60.15(c)(1-4)	60.21(c)(1)(ii)(E)	The Safety Analysis Report shall includ A description and assessment of the site at w the proposed geologic repository operations a is to be located with appropriate attention t those features of the site that might affect geologic repository operations area design an performance. The description of the site sha identify the location of the geologic reposit operations area with respect to the boundary the accessible environment. The assessment shall contain— An analysis of the performance of the major d structures, systems, and components, both sur and subsurface, to identify those that are important to safety. For the purposes of thi analysis, it shall be assumed that operations geologic repository operations area will be c out at the maximum capacity and rate of recei radioactive waste stated in the application.	
Postclosure Health & Safety Scenario Portion, Draft 6	64 66 72 73	Changes in state of disposal system ESF repository-induced changes Repository design ESF configuration	60.21(c)(11)	The Safety Analysis Report shall include: A description of design considerations that a intended to facilitate permanent closure and decontamination or dismantlement of surface facilities.	

INFLUENCE DIAGRAM NAME/NO.	I. D. ELEMENT No.	I. D. ELEMENT STATEMENT	REQUIREMENT REFERENCE	REQUIREMENT STATEMENT (or NOTE)	RK
Schedule, Draft 8	14	Decom. and closure duration			
Repository LCC, Draft 5	18	Costs of closure and decommissioning			
Postclosure Health & Safety Scenario Portion, Draft 6	72	Repository design			
	73	ESF configuration			
	90	Repository configuration			
			60.74(a)	Tests. DOE shall perform, or permit the Commission to perform, such tests as the Commission deems appropriate or necessary for administration of the regulations of this par These may include tests of: (1) Radioactive (2) the geologic repository including its structures, systems, and components, (3) radi detection and monitoring instruments, and (4) equipment and devices used in connection with receipt, handling, or storage of radioactive	1
Schedule, Draft 8	20	Test requirements			
	23	Test plan			
	25	Add. req. for NWTRB/NRC/NV testing			
Postclosure Health & Safety Scenario Portion, Draft 6	64	Changes in state of disposal system			
	66	ESF repository induced changes			
	72	Repository design			
	73	ESF configuration			
	80	ESF access			
	85	Areal power density			
	86	Waste age			

INFLUENCE DIAGRAM NAME/NO.	I. D. ELEMENT No.	I. D. ELEMENT STATEMENT	REQUIREMENT REFERENCE	REQUIREMENT STATEMENT (or NOTE)	RK
Postclosure Health & Safety Eng. Barrier System Portion, Draft 11	59	Container degradation			
Preclosure Health & Safety Radiological Public Health, Draft 4	03	Public population dose from accidents			
Preclosure Health & Safety Radiological Worker Health, Draft 4	03	Worker population dose from accidents			
Probability of Early False Negative, Draft 11	06	Inability to obtain data to refute erroneous obs. and interpretations			
	20	Inability to adequately char. the CH unit			
	26	Insufficient ability to change and expand testing program			
Probability of Late False Negative, Draft 11	06	Inability to obtain data to refute erroneous obs. and interpretations			
	08	Inability to satisfy add. info. needs beyond those exp. to be obtained from 35 tests			
	20	Inability to adequately char. the CH unit			
	26	Insufficient ability to change and expand testing program			
Probability of Early False Positive, Draft 6	11	Precludes ability to do realistic tests			
	14	Inability to design or conduct nat. barrier tests			

INFLUENCE DIAGRAM NAME/NO.	I. D. ELEMENT No.	I. D. ELEMENT STATEMENT	REQUIREMENT REFERENCE	REQUIREMENT STATEMENT (or NOTE)	RK
Probability of Late False Positive, Draft 5	11	Precludes ability to do realistic tests			
	14	Inability to design or conduct nat. barrier tests			
Likelihood of Const/Opn Approval, Draft 6	17	Option facilitates tests by NRC per 10 CFR 74(a)			
			60.74(b)	The tests required under this section shall include a performance confirmation program ca out in accordance with Subpart F of this part	
Schedule, Draft 8	25	Add. req. for NWTRB/NRC/NV testing			
Postclosure Health & Safety Eng. Barrier System Portion, Draft 11	49	Gas phase releases			
	55	Groundwater vel. distribution thru EBS and seals			
	59	Container degradation			
Postclosure Health & Safety Transport Thru Nat. Barriers Portion, Draft 12	23	SZ groundwater pathway			
	33	UZ groundwater pathway			
	44	Post-waste emplacement char. of natural barriers			
Likelihood of Const/Opn Approval, Draft 6	19	Option promotes confidence for impl. of performance confirmation plan per 10 CFR 60.140-143			
	24	Capability for extended duration tests			

INFLUENCE DIAGRAM NAME/NO.	I. D. ELEMENT No.	I. D. ELEMENT STATEMENT	REQUIREMENT REFERENCE	REQUIREMENT STATEMENT (or NOTE)	RK
			60.112	OVERALL SYSTEM PERFORMANCE OBJECTIVE FOR THE GEOLOGIC REPOSITORY AFTER PERMANENT CLOSURE. The geologic setting shall be selected and the en barrier system and the shafts, boreholes and their seals shall be designed to assure that releases of radioactive materials to the acce environment following permanent closure confo such generally applicable environmental stand for radioactivity as may have been establishe the Environmental Protection Agency with resp both anticipated processes and events and unanticipated processes and events.	1
Postclosure Health & Safety Scenario Portion, Draft 6	64	Changes in state of disposal system			
	66	ESF-induced changes			
	72	Repository design			
	73	ESF configuration			
	90	Repository configuration			
Postclosure Health & Safety Eng. Barrier System Portion, Draft 11	47	Gas phase transport thru unsaturated zone			
	48	Gas phase transport thru EBS and seals			
	49	Gas phase releases			
	53	Waste package releases			
	54	Retardation in EBS and seals			
	55	Ground water vel. distribution thru EBS and seals			
	56	Post-waste-emplacement char. of EBS and seals			
	59	Container degradation			

INFLUENCE DIAGRAM NAME/NO.	I. D. ELEMENT No.	I. D. ELEMENT STATEMENT	REQUIREMENT REFERENCE	REQUIREMENT STATEMENT (or NOTE)	RK
Postclosure Health & Safety Transport Thru Nat. Barriers Portion, Draft 12	23	SZ ground water pathway			
	33	UZ ground water pathway			
	42	GW transport thru UZ			
	44	Post-waste-emplacement char. of natural barriers			
Postclosure Health & Safety Health Effects Portion, Draft 6	14	Releases to atmosphere			
	16	Concentrations in surface and ground water			
	19	Releases to ground water that people may use			
	20	Release to surface water			
	21	Subsurface transport thru accessible environment			
	22	Releases to the accessible environment			
	71	Direct releases			
Likelihood of Const/Opn Approval, Draft 6	15	Releases			

INFLUENCE DIAGRAM NAME/NO.	I. D. ELEMENT No.	I. D. ELEMENT STATEMENT	REQUIREMENT REFERENCE	REQUIREMENT STATEMENT (or NOTE)	RK
			60.113(a)(1)	PERFORMANCE OF PARTICULAR BARRIERS AFTER PERMANENT CLOSURE. General provisions. (1) Engineered barrier system. (i) The engineered barrier s shall be designed so that assuming anticipate processes and events: (A) Containment of HLW substantially complete during the period when radiation and thermal conditions in the engin barrier system are dominated by fission produ decay; and (B) Any release of radionuclides engineered barrier system shall be a gradual which results in small fractional releases to geologic setting over long times. For dispos saturated zone, both the partial and complete with groundwater of available void spaces in underground facility shall be appropriately c and analyzed among the anticipated processes events in designing the engineered barrier sy	1
Postclosure Health and Safety Eng. Barrier System Portion, Draft 11	48	Gas phase transport thru EBS and seals			
	51	Transport thru EBS and seals			
	53	Waste package releases			
	57	Waste form dissolution			
	59	Container degradation			
Likelihood of Const/Opn Approval, Draft 6	15	Releases			
			60.122(a)(2)	If any of the potentially adverse conditions specified in paragraph (c) of this section is present, it may compromise the ability of the repository to meet the performance objectives relating to isolation of the waste. In order	

INFLUENCE DIAGRAM NAME/NO.	I. D. ELEMENT No.	I. D. ELEMENT STATEMENT	REQUIREMENT REFERENCE	REQUIREMENT STATEMENT (or NOTE)	RK
				show that a potentially adverse condition doe not so compromise the performance of the repo the following must be demonstrated: (i) The potentially adverse human activity or nat condition has been adequately investigated, i the extent to which the condition may be pres still be undetected taking into account the d resolution achieved by the investigations; an (ii) The effect of the potentially adverse human a or natural condition of the site has been ade evaluated using analyses which are sensitive potentially adverse human activity or natural condition and assumptions which are not likel underestimate its effect; and (iii)(A) The potentially adverse human activity or condition is shown by analysis pursuant to pa (a)(2)(ii) of this section not to affect sign the ability of the geologic repository to mee performance objectives relating to isolation waste, or (B) The effect of the potentially adverse human a or natural condition is compensated by the pr a combination of the favorable characteristic the performance objectives relating to isolat the waste are met, or (C) The potentially adverse human activity or nat condition can be remedied.	
Postclosure Health & Safety Scenario Portion, Draft 6	64 Changes in state of disposal system 72 Repository design 73 ESF configuration				
Probability of Early False Positive, Draft 6	04 Missed adverse feature				
Probability of Late False Positive, Draft 5	04 Missed adverse feature				

INFLUENCE DIAGRAM NAME/NO.	I. D. No.	I. D. STATEMENT	REQUIREMENT REFERENCE	REQUIREMENT STATEMENT (or NOTE)	RK
			60.122(b)(1)	Favorable conditions. (1) The nature and rates of tectonic, hydrogeologic, geochemical, and geomorphic processes (or any of such processe operating within the geologic setting during Quaternary Period, when projected, would not affect or would favorably affect the ability geologic repository to isolate the waste.	2
Postclosure Health & Safety Transport Thru Nat. Barriers Portion, Draft 12	30	SZ retardation			
	31	SZ ground water vel. distribution (incl. GWTT)			
	40	UZ retardation			
	41	UZ ground water vel. distribution (incl. GWTT)			
			60.130	SCOPE OF DESIGN CRITERIA FOR THE GEOLOGIC REPOSITORY OPERATIONS AREA. Sections 60.131 through 60.134 specify minimum criteria for the design of th geologic repository operations area. These d criteria are not intended to be exhaustive, h Omissions in 60.131 through 60.134 do not relieve DOE from any obligation to provide su features in a specific facility needed to ach performance objectives. All design bases mus consistent with the results of site character activities.	2
Postclosure Health & Safety Scenario Portion, Draft 6	72	Repository design			
	73	ESF configuration			
Postclosure Health & Safety Eng. Barrier System Portion, Draft 11	56	Post-waste-emplacement char. of EBS and seals			

INFLUENCE DIAGRAM NAME/NO.	I. D. ELEMENT No.	I. D. ELEMENT STATEMENT	REQUIREMENT REFERENCE	REQUIREMENT STATEMENT (or NOTE)	RK
Preclosure Health & Safety Nonradiological Worker Safety, Draft 5	40	Ventilation system design			
Likelihood of Const/Opn Approval, Draft 6	22	Option facilitates compl. with 10 CFR 60.133			
			60.131	GENERAL DESIGN CRITERIA FOR THE GEOLOGIC REPO OPERATIONS AREA	
			(b)	Structures, systems, and components important safety. (1) Protection against natural pheno environmental conditions. The structures, sys components important to safety shall be desig that natural phenomena and environmental cond anticipated at the geologic repository operat will not interfere with necessary safety func	
Postclosure Health & Safety Scenario Portion, Draft 6	72	Repository design			
	73	ESF configuration			
			60.133(a)(1)	ADDITIONAL DESIGN CRITERIA FOR THE UNDERGROUND FACILITY (10 CFR 60.133). General criteria for the underground facility. (1) The orientation, ge layout, and depth of the underground facility and the design of any engineered barriers tha part of the underground facility shall contri the containment and isolation of radionuclide	1
Repository LCC, Draft 5	24	Ventilation and cooling req.			
Postclosure Health & Safety Scenario Portion, Draft 6	66	ESF repository induced changes			
	72	Repository design			
	73	ESF configuration			
	88	Repository location			
	90	Repository configuration			

INFLUENCE DIAGRAM NAME/NO.	I. D. ELEMENT No.	I. D. ELEMENT STATEMENT	REQUIREMENT REFERENCE	REQUIREMENT STATEMENT (or NOTE)	RK
Postclosure Health & Safety Eng. Barrier System Portion, Draft 11	56	Post-waste-emplacement char. of EBS and seals			
Likelihood of Const/Opn Approval, Draft 6	22	Option facilitates compl. with 10 CFR 60.133			
			60.133(a)(2)	The underground facility shall be designed so the effects of credible disruptive events dur period of operations, such as flooding, fires explosions, will not spread through the facil	
Repository LCC, Draft 5	24	Ventilation and cooling req.			
Postclosure Health & Safety Scenario Portion, Draft, 6	72	Repository design			
	73	ESF configuration			
Postclosure Health & Safety Eng. Barrier System Portion, Draft 11	56	Post-waste-emplacement char. of EBS and seals			
Preclosure Health & Safety Nonradiological Worker Safety, Draft 5	40	Ventilation system design			
Likelihood of Const/Opn Approval, Draft 6	22	Option facilitates compl. with 10 CFR 60.133			
			60.133(b)	Flexibility of design. The underground facility shall be designed with sufficient flexibility allow adjustments where necessary to accommod specific site conditions identified through i monitoring, testing, or excavation.	1

INFLUENCE DIAGRAM NAME/NO.	I. D. ELEMENT No.	I. D. ELEMENT STATEMENT	REQUIREMENT REFERENCE	REQUIREMENT STATEMENT (or NOTE)	RR
Postclosure Health & Safety Scenario Portion, Draft 6	72	Repository design			
	73	ESF configuration			
Likelihood of Const/Opn Approval, Draft 6	22	Option facilitates compl. with 10 CFR 60.133			
			60.133(e)(1)	Underground openings. (1) Openings in the underground facility shall be designed so tha operations can be carried out safely and the retrievability option maintained.	2
ESF Cost, Draft 4	45	Underground accesses (shafts and ramps)			
	46	MTL configuration and extent			
Postclosure Health & Safety Scenario Portion, Draft 6	72	Repository design			
	73	ESF configuration			
	89	Rock support system			
Likelihood of Const/Opn Approval, Draft 6	22	Option facilitates compl. with 10 CFR 60.133			
Likelihood of Retrieval, Draft 5	02	Insufficient technical confidence			
			60.133(e)(2)	Openings in the underground facility shall be designed to reduce the potential for deleteri rock movement or fracturing of overlying or surrounding rock.	
ESF Cost, Draft 4	45	Underground accesses (shafts and ramps)			
	46	MTL configuration and extent			
Repository LCC, Draft 5	25	Rock Treatment			
	36	Excavation method			

INFLUENCE DIAGRAM NAME/NO.	I. D. ELEMENT No.	I. D. ELEMENT STATEMENT	REQUIREMENT REFERENCE	REQUIREMENT STATEMENT (or NOTE)	RK
Postclosure Health & Safety Scenario Portion, Draft 6	72	Repository design			
	73	ESF configuration			
	89	Rock support system			
Preclosure Health & Safety Nonradiological Worker Safety, Draft 5	05	Hazard			
	22	Horizontal openings			
	23	Ramp (TBM)			
	24	Vertical shaft			
	42	Materials handling system			
Likelihood of Rejecting a Site that is OK, Draft 9	22	Shaft vs ramp/no. and location			
Probability of Early False Positive, Draft 6	15	Shaft vs ramp/no. and location			
Probability of Late False Positive, Draft 5	15	Shaft vs ramp/no. and location			
Likelihood of Const/Opn Approval, Draft 6	22	Option facilitates compliance with 10 CFR 60.133			
			60.133(f)	Rock excavation. The design of the underground facility shall incorporate excavation methods will limit the potential for creating a prefe pathway for groundwater to contact the waste or radionuclide migration to the accessible environment.	1
ESF Costs, Draft 4	54	Method of construction			
Repository LCC, Draft 5	36	Excavation method			
Postclosure Health & Safety Scenario Portion, Draft 6	72	Repository design			
	73	ESF configuration			
	84	Rep. construction method			

INFLUENCE DIAGRAM NAME/NO.	I. D. ELEMENT No.	I. D. ELEMENT STATEMENT	REQUIREMENT REFERENCE	REQUIREMENT STATEMENT (or NOTE)	RK
Likelihood of Const/Opn Approval, Draft 6	22	Option facilitates compl. with 10 CFR 60.133			
			60.133(g)(1)	Underground facility ventilation. The ventilation system shall be designed to - (1) Control the transport of radioactive particulates and gas within and releases from the underground faci in accordance with the performance objectives 60.111(a).	1
			(2)	Assure continued function during normal opera under accident conditions; and	
			(3)	Separate the ventilation of excavation and wa emplacement areas.	
Repository LCC, Draft 5	24	Ventilation and cooling requirement			
Postclosure Health & Safety Scenario Portion, Draft 6	72	Repository design			
	73	ESF configuration			
Preclosure Health & Safety Nonradiological Worker Safety, Draft 5	40	Ventilation system design			
Likelihood of Const/Opn Approval, Draft 6	22	Option facilitates compl. with 10 CFR 60.133			
			60.133(h)	Engineered barriers. Engineered barriers shall be designed to assist the geologic setting in meeting the performance objectives for the pe following permanent closure.	1
Postclosure Health & Safety Scenario Portion, Draft 6	72	Repository design			
	73	ESF configuration			

INFLUENCE DIAGRAM NAME/NO.	I. D. ELEMENT No.	I. D. ELEMENT STATEMENT	REQUIREMENT REFERENCE	REQUIREMENT STATEMENT (or NOTE)	RR
Postclosure Health & Safety Eng. Barrier System Portion, Draft 11	45	Release to unsat. zone			
	48	Gas phase transport thru EBS and seals			
Likelihood of Const/Opn Approval, Draft 6	22	Option facilitates compl. with 10 CFR 60.133			
			60.133(i)	Thermal loads. The underground facility shall be designed so that the performance objectives w be met taking into account the predicted ther and thermomechanical response of the host roc and surrounding strata, groundwater system	2
Postclosure Health & Safety Scenario Portion, Draft 6	72	Repository design			
	73	ESF Configuration			
	85	Areal power density			
Postclosure Health & Safety Transport Thru Nat Barriers Portion, Draft 12	32	GW transport thru SZ			
	42	GW transport thru UZ			
Likelihood of Const/Opn Approval, Draft 6	22	Option facilitates compl. with 10 CFR 60.133			
			60.134(a)	General design criterion. Seals for shafts and boreholes shall be designed so that following permanent closure, they do not become pathway that compromise the geologic repository's abi to meet the performance objectives for the pe following permanent closure.	1
Postclosure Health & Safety Scenario Portion, Draft 6	72	Repository design			
	73	ESF Configuration			

INFLUENCE DIAGRAM NAME/NO.	I. D. ELEMENT No.	I. D. ELEMENT STATEMENT	REQUIREMENT REFERENCE	REQUIREMENT STATEMENT (or NOTE)	RK
Postclosure Health & Safety Eng. Barrier System Portion. Draft 11	48	Gas phase transport thru EBS and seals			
	51	Transport thru EBS and seals			
			60.137	GENERAL REQUIREMENTS FOR PERFORMANCE CONFIRMATION. The geologic repository operations area shall designed so as to permit implementation of a performance confirmation program that meets t requirements of Subpart F of this part.	2
Schedule, Draft 8	25	Add. req. for MWTRB/NRC/NV testing			
Postclosure Health & Safety Scenario Portion, Draft 6	72	Repository design			
	73	ESF Configuration			
Postclosure Health & Safety Eng. Barrier System Portion, Draft 11	49	Gas phase releases			
	59	Container degradation			
Postclosure Health & Safety Transport Thru Nat. Barriers Portion, Draft 12	23	SZ ground water pathway			
	33	UZ ground water pathway			
	44	Post-waste-emplacement char. of natural barriers			

INFLUENCE DIAGRAM NAME/NO.	I. D. ELEMENT No.	I. D. ELEMENT STATEMENT	REQUIREMENT REFERENCE	REQUIREMENT STATEMENT (or NOTE)	RK

U.S. DEPARTMENT OF ENERGY

OCRWM

YUCCA MOUNTAIN

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

ESF ALTERNATIVES STUDY
OPTIONS EVALUATED

PRESENTED AT

DOE/NRC MEETING ON
CALICO HILLS RISK/BENEFIT ANALYSIS
AND ESF ALTERNATIVES STUDY

PRESENTED BY

WILLIAM R. KENNEDY
SENIOR MINING ENGINEER
RAYTHEON SERVICES NEVADA

JANUARY 29-31, 1991

Attachment 18

MAJOR REGULATORY CONCERNS ADDRESSED IN DESIGN

1. CONDUCT SITE CHARACTERIZATION PROGRAM IN A MANNER THAT LIMITS ADVERSE EFFECTS, LIMITS NUMBER OF BOREHOLES AND SHAFTS AND COORDINATES WITH GROA DESIGN

2. PERFORM COMPARATIVE EVALUATIONS OF MAJOR DESIGN FEATURES

3. LIMIT TEST/TEST AND CONSTRUCTION/TEST INTERFERENCE

4. LIMIT IMPACTS AND INTERFERENCES FROM CONSTRUCTION METHOD

5. ENSURE ADEQUATE EXTENT OF CHARACTERIZATION PROGRAM TO EVALUATE FAVORABLE AND POTENTIALLY ADVERSE CONDITIONS

KEY FEATURES OF ESF CONCEPTS

MEANS OF ACCESS

- TOPOPAH SPRING (TS) LEVEL
  - SHAFTS ONLY
  - RAMPS ONLY
  - SHAFT/RAMP COMBINATION
- CALICO HILLS (CH) LEVEL
  - SHAFT EXTENSIONS
  - INTERNAL SHAFTS
  - INTERNAL RAMPS

LOCATION OF ACCESSES

- ALL NORTH EAST
- ALL SOUTH
- NORTH EAST/SOUTH

KEY FEATURES OF ESF CONCEPTS

(CONTINUED)

MAIN TEST FACILITY

- TWO LOCATIONS
  - NORTHEAST
  - SOUTH
- LARGER MTL CORE AREA TO AVOID INTERFERENCES
  - INCREASED FROM 27 ACRES TO 92 ACRES

EXCAVATION METHODS

- SHAFTS
  - DRILL AND BLAST
  - SHAFT BORING MACHINE
  - BLIND HOLE DRILL
  - V-MOLE
  - RAISE BORE

KEY FEATURES OF ESF CONCEPTS

(CONTINUED)

EXCAVATION METHODS

- **RAMPS**
  - TUNNEL BORING MACHINE
  - DRILL AND BLAST/ROAD HEADER
- **MAIN TEST LEVEL CORE AREA (TS)**
  - DRILL AND BLAST
  - MOBILE MINER
- **EXPLORATORY DRIFTING (TS AND CH)**
  - DRILL AND BLAST
  - MOBILE MINER
  - TUNNEL BORING MACHINE
  - ROAD HEADER

KEY FEATURES OF ESF CONCEPTS

(CONTINUED)

EXPLORATORY DRIFTING

- **TOPOPAH SPRING LEVEL**
  - LONG N-S DRIFT
  - E-W DRIFT
  - 4 FAULT CROSSINGS
  - 15,000 - 20,000 LINEAR FEET OF EXPLORATORY DRIFTING
- **CALICO HILLS LEVEL**
  - 5 FAULT CROSSINGS
  - 19,000 LINEAR FEET OF EXPLORATORY DRIFTING

SUMMARY OF ESF/REPOSITORY OPTIONS

OPTION #			E.S.F.								REPOSITORY				
			ACCESS 1		ACCESS-2		MAIN TEST LEVEL				ACCESSES		CONSTRUCTION METHOD		
			SIZE	CONST. METHOD	SIZE	CONST. METHOD	LAYOUT	CONST. METHOD	LOCATION	ELEVATION	SHAFTS	RAMPS (TBM)	RAMPS & DRIFTS	EMPL. AREA	TOTAL ACCESSES
18	1	BASE CASE	12' SHAFT	DRILL & BLAST	12' SHAFT	DRILL & BLAST	TITLE II G.A.	DRILL & BLAST	NE	SAME AS REPOS.	2-20'	1-25' 1-23'	TBM	DRILL & BLAST	6
19	2	A1	16' SHAFT	〃	25' RAMP	TBM	MODIFIED T II G.A.	〃	〃	〃	2-25'	1-25' +ESF	〃	〃	5
20	3	A2	16' SHAFT	〃	16' SHAFT	DRILL & BLAST	〃	〃	〃	〃	〃	2-25'	〃	〃	6
21	4	A4 REV.1	16' SHAFT	〃	12' SHAFT 25' RAMP	D&B TBM	〃	〃	〃	〃	1-25' ENLARGE ES-1-25'	1-25' +ESF	〃	〃	5
22	5	A5	16' SHAFT	〃	25' RAMP	TBM	〃	〃	S	〃	2-25'	〃	〃	〃	5
23	6	A7	25' RAMP	TBM	25' RAMP	〃	〃	〃	NE	〃	〃	IN ESF	〃	〃	4
24	7	B3, REV. 2-	16' SHAFT	SBM	〃	〃	〃	MECH.	〃	〃	〃	1-25' +ESF	〃	TBM	5
25	8	B3,REV.3-		V-MOLE											
26	9	B3,REV. 4-		BLIND BORE											
27	10	B3,REV. 5-		RAISE BORE											
28	11	B3, REV. 6-		DRILL & BLAST											
29	12	B4	16' SHAFT	DRILL & BLAST	〃	〃	〃	〃	S	〃	〃	〃	〃	〃	5
30	13	B7	25' RAMP	TBM	〃	〃	〃	〃	〃	〃	〃	IN ESF	〃	〃	4
31	14	B8	16' SHAFT	DRILL & BLAST	〃	〃	〃	〃	〃	〃	1-25'	2-25' +ESF	〃	〃	5
32	15	C1	16' SHAFT	〃	〃	〃	TWO LEVEL	〃	NE	TWO LEVELS SAME AS REPOS.	2-25' ENLARGE ES-1-25'	1-25' +ESF	〃	〃	4
33	16	C4	16' SHAFT	〃	〃	〃	〃	〃	S	〃	2-25'	〃	〃	〃	5
34	17	R11	12' SHAFT	〃	12' SHAFT	DRILL & BLAST	TITLE II G.A.	DRILL & BLAST	NE	SAME AS REPOS.	2-25'	2-25'	〃	〃	6

ESFSUM6P.126/11-20-90

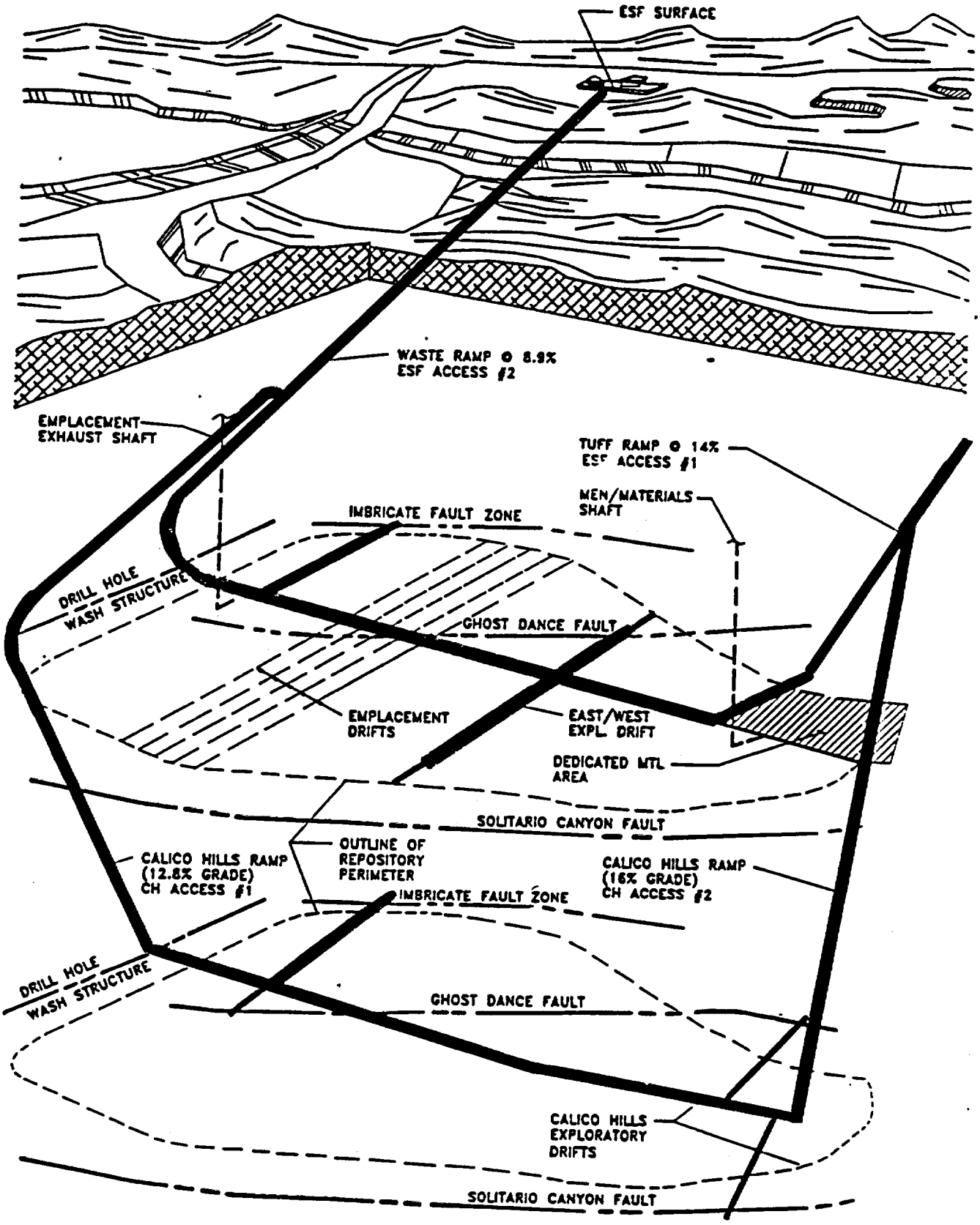
DESCRIPTION OF COLOR CODING USED IN DEFINITIONAL ISOMETRICS

THREE BASIC COLORS WERE USED TO DEFINE THE EARLY EXCAVATION PHASE AND ASSOCIATED TEST PROGRAMS FOR THE 34 ESF OPTIONS.

RED: FOR ESF ACCESSES (SHAFTS AND RAMPS) AND SEGMENTS, THE COLOR RED INDICATES THE ACCESS OR SEGMENT IS A "PRIMARY" TESTING ACCESS. ANY EARLY PHASE TEST WHICH IS NOT DEFERRED UNDER THE SPECIFIC OPTION (EITHER SCENARIO 1 OR 2), WOULD BE PERFORMED DURING CONSTRUCTION. ALL DEFERRED TESTS WOULD BE PERFORMED DURING LATE TESTING PHASE

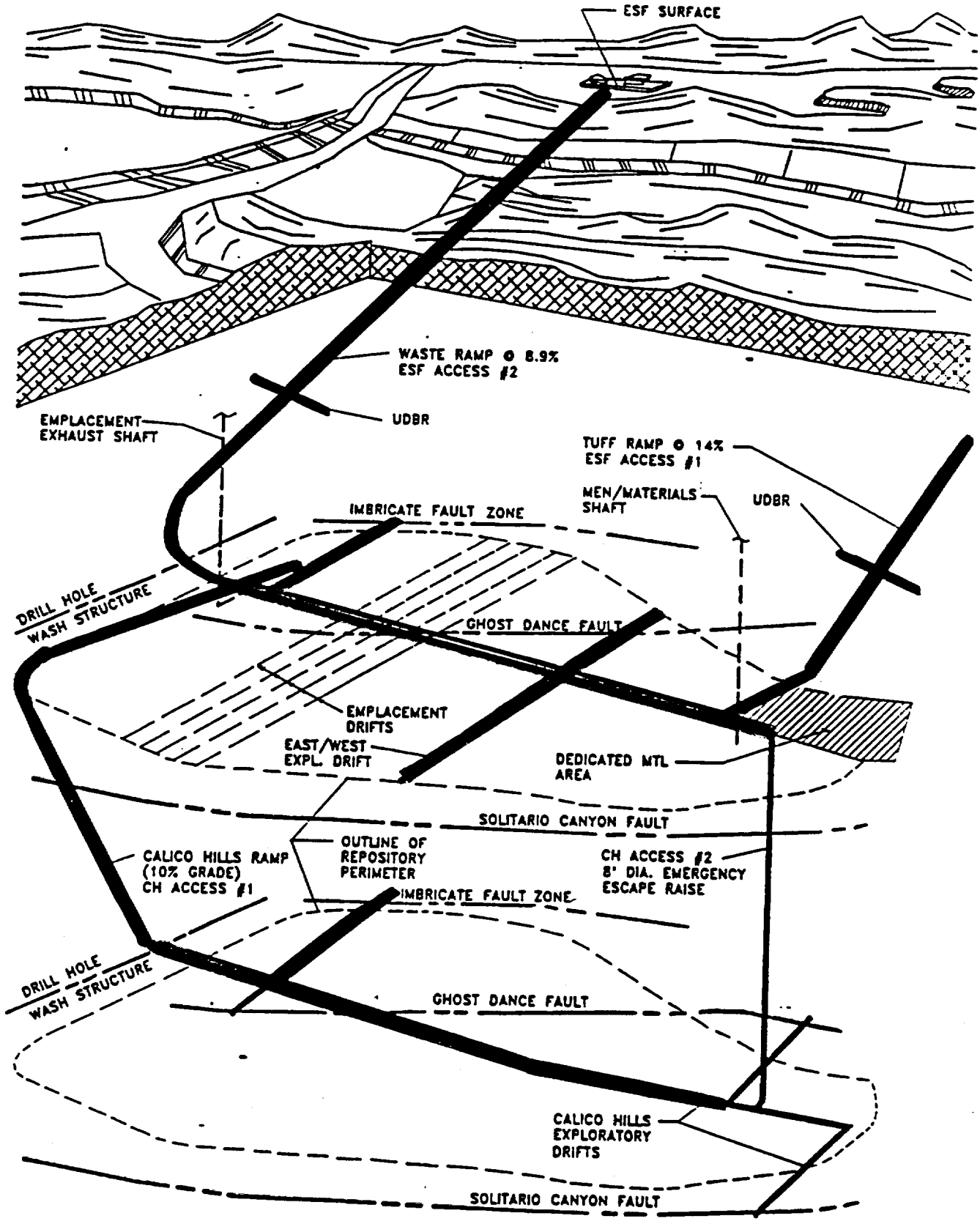
BLUE: FOR ESF ACCESSES, THE COLOR BLUE INDICATES THE ACCESS OR ACCESS SEGMENT IS NOT A PRIMARY TESTING ACCESS. ONLY MAPPING, NON-INTERFERING SAMPLING, AND PERCHED WATER OR FAULT TESTING (IF APPLICABLE) WOULD BE PERFORMED.

GREEN: FOR DRIFTS ON A TARGET HORIZON, EITHER MAIN TEST LEVEL OR CALICO HILLS, THE COLOR GREEN INDICATES DRIFTING AND ASSOCIATED TESTING TO BE PERFORMED DURING THE EARLY TEST PHASE.



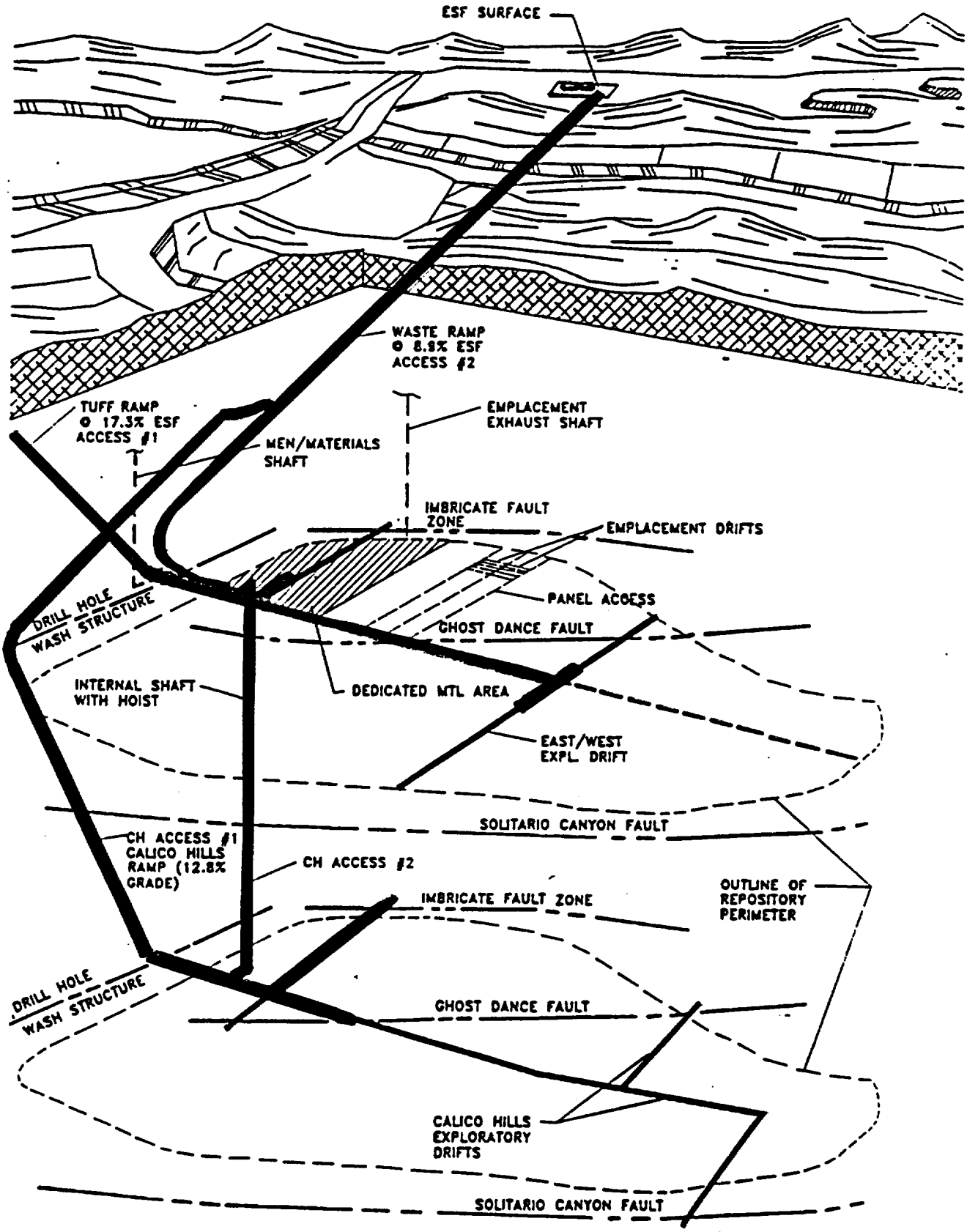
30

ESF ALTERNATIVES STUDY
TASK NO. 4
OPTION NO. 87
ISOMETRIC SCENARIO #2
DATE



13

ESF ALTERNATIVES STUDY
TASK NO. 4
OPTION NO. B7
ISOMETRIC SCENARIO #1
DATE



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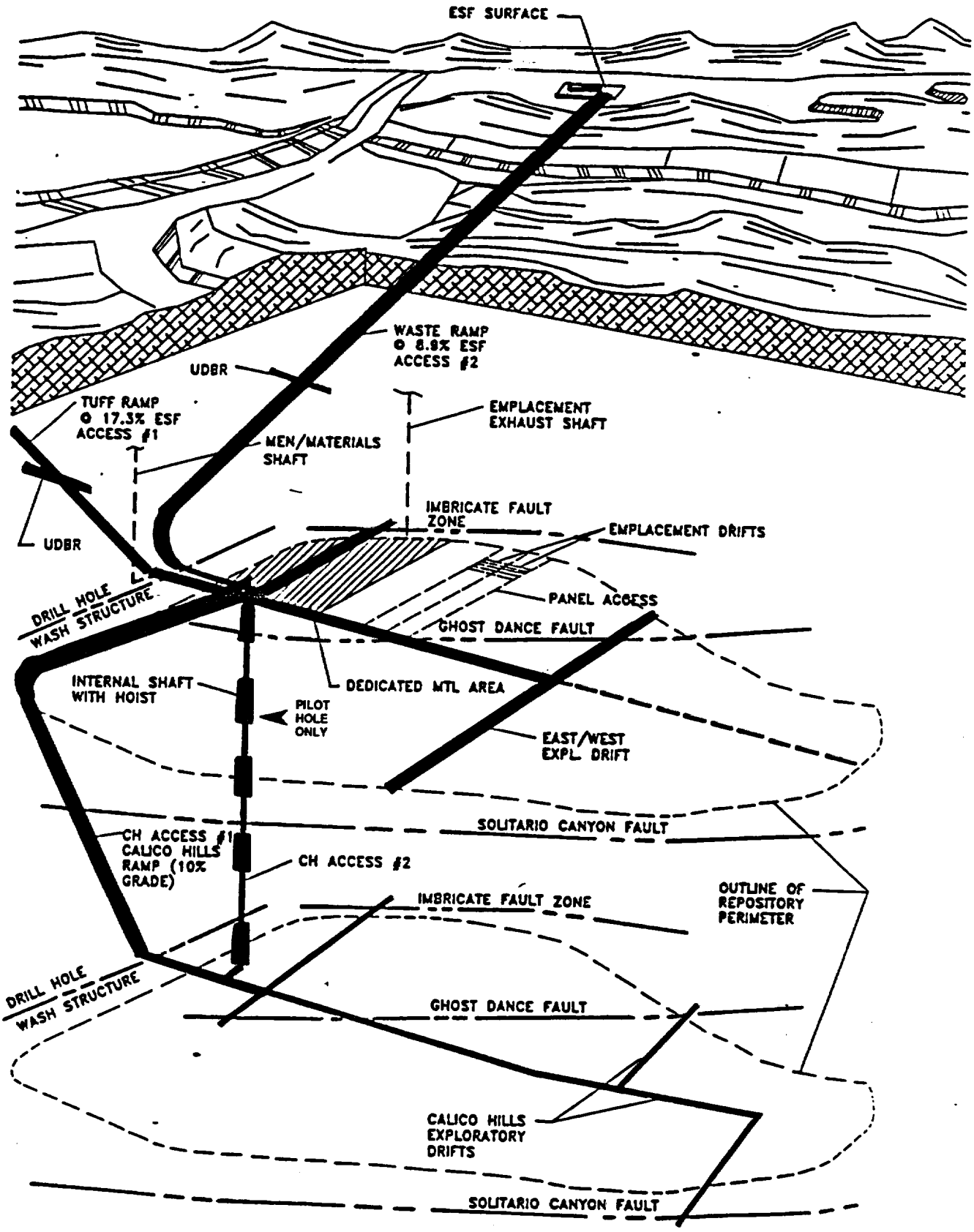
ESF ALTERNATIVES STUDY
TASK NO. 4
OPTION NO. A7
ISOMETRIC SCENARIO #2
DATE



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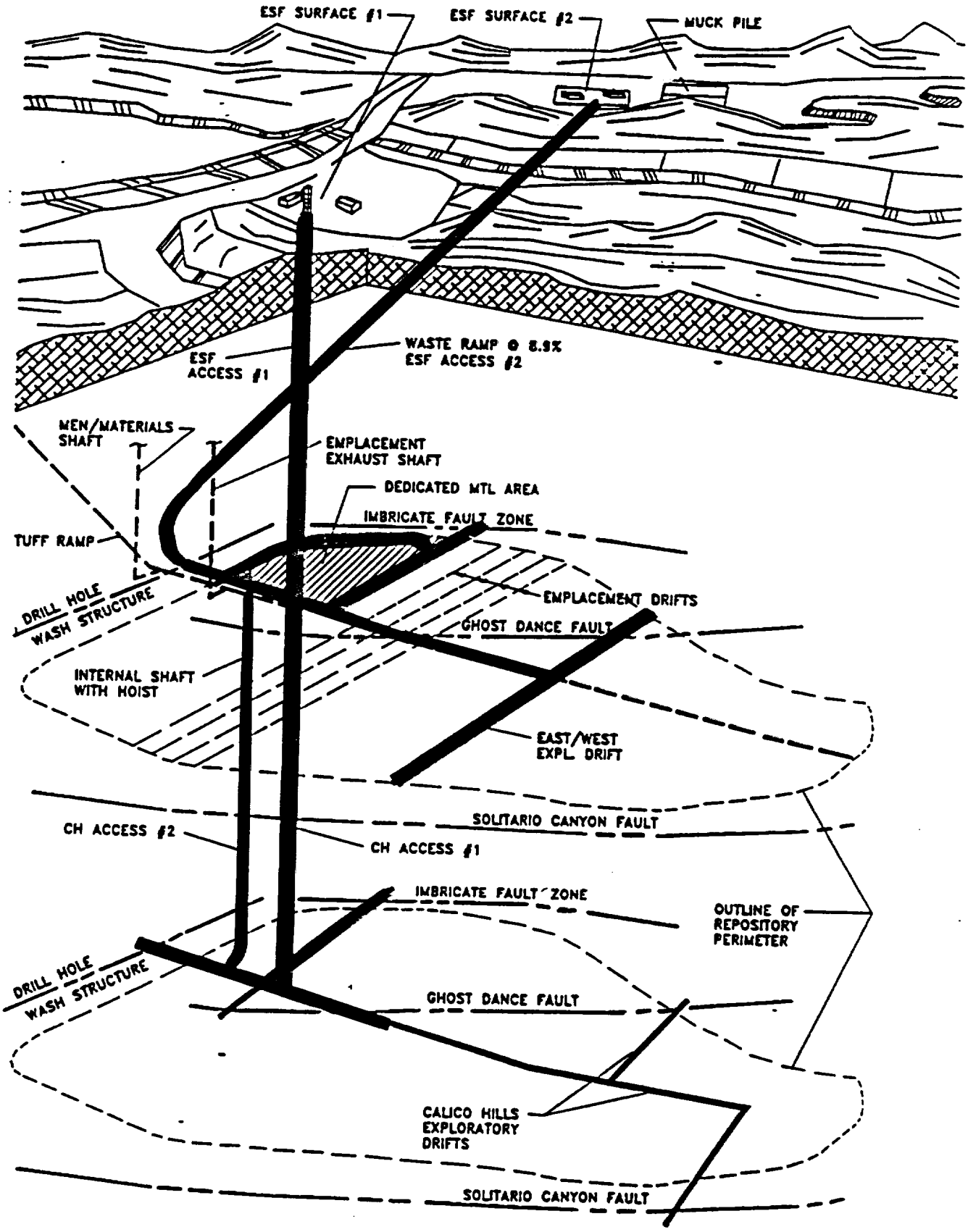
ESF ALTERNATIVES STUDY
TASK NO. 4
OPTION NO. A7
ISOMETRIC SCENARIO #1
DATE



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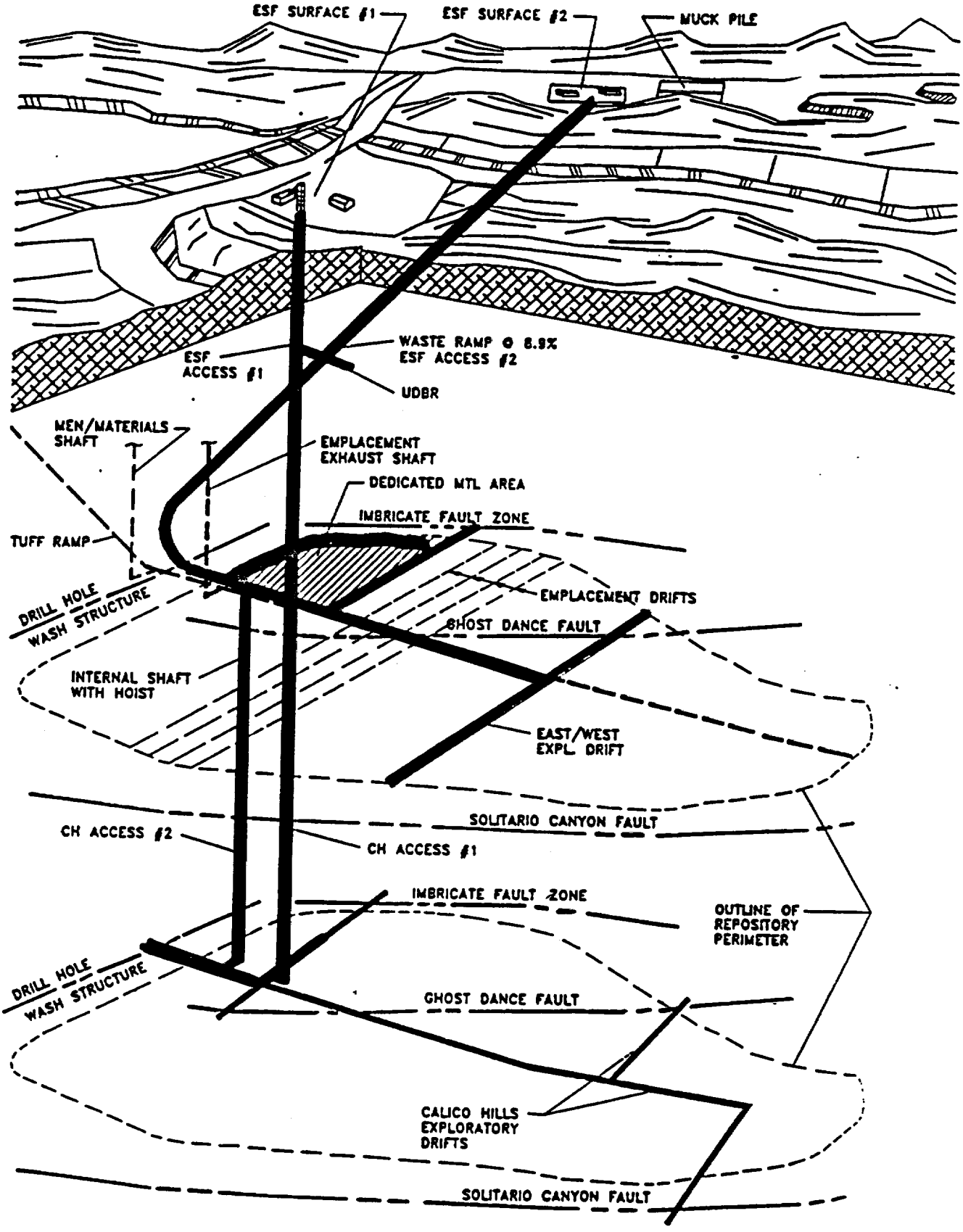
ESF ALTERNATIVES STUDY
TASK NO. 4
OPTION NO. B3 REV. 2
(SBM)
ISOMETRIC SCENARIO #2
DATE



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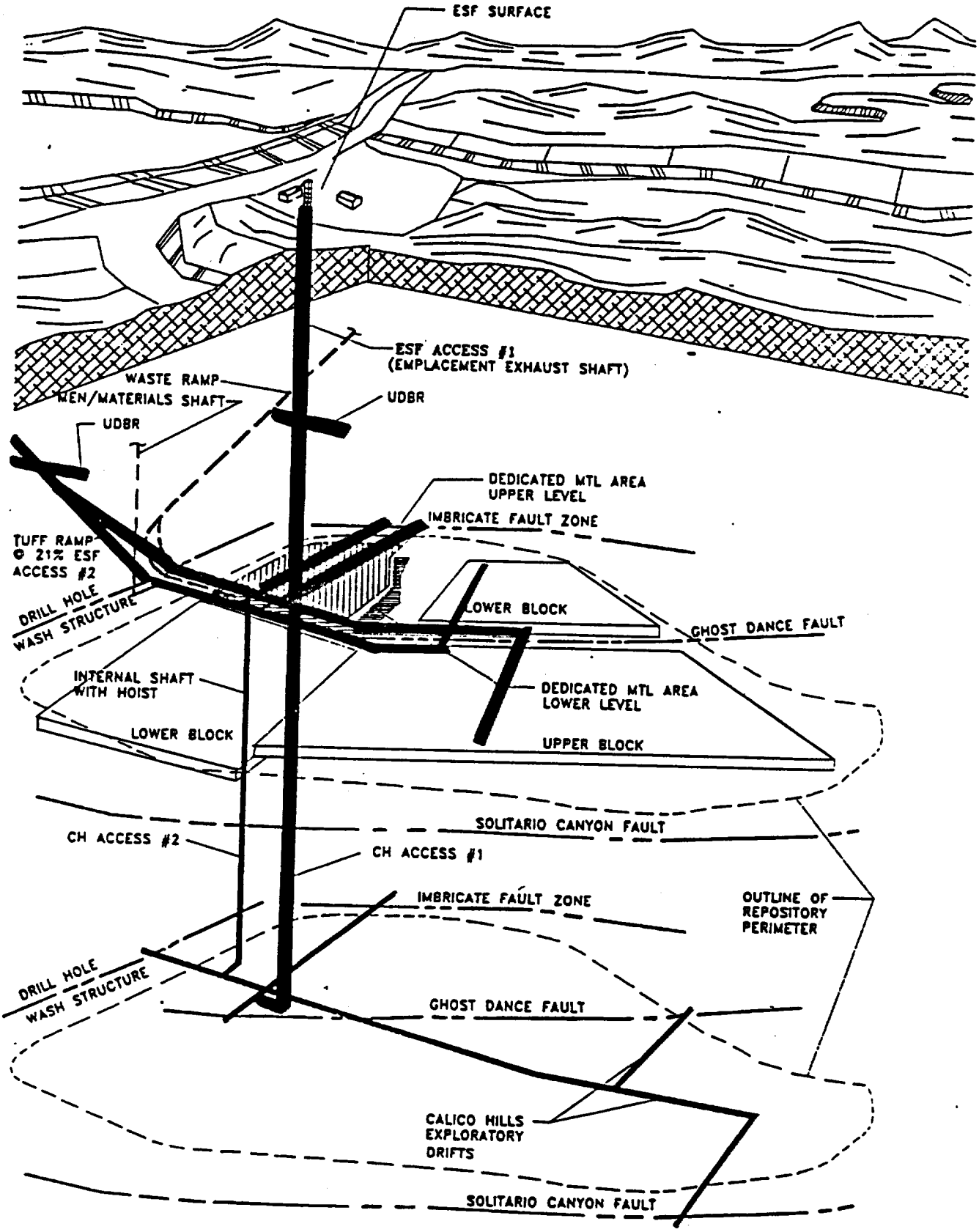
ESF ALTERNATIVES STUDY
TASK NO. 4
OPTION NO. B3 REV. 2
(SBM)
ISOMETRIC SCENARIO #1
DATE



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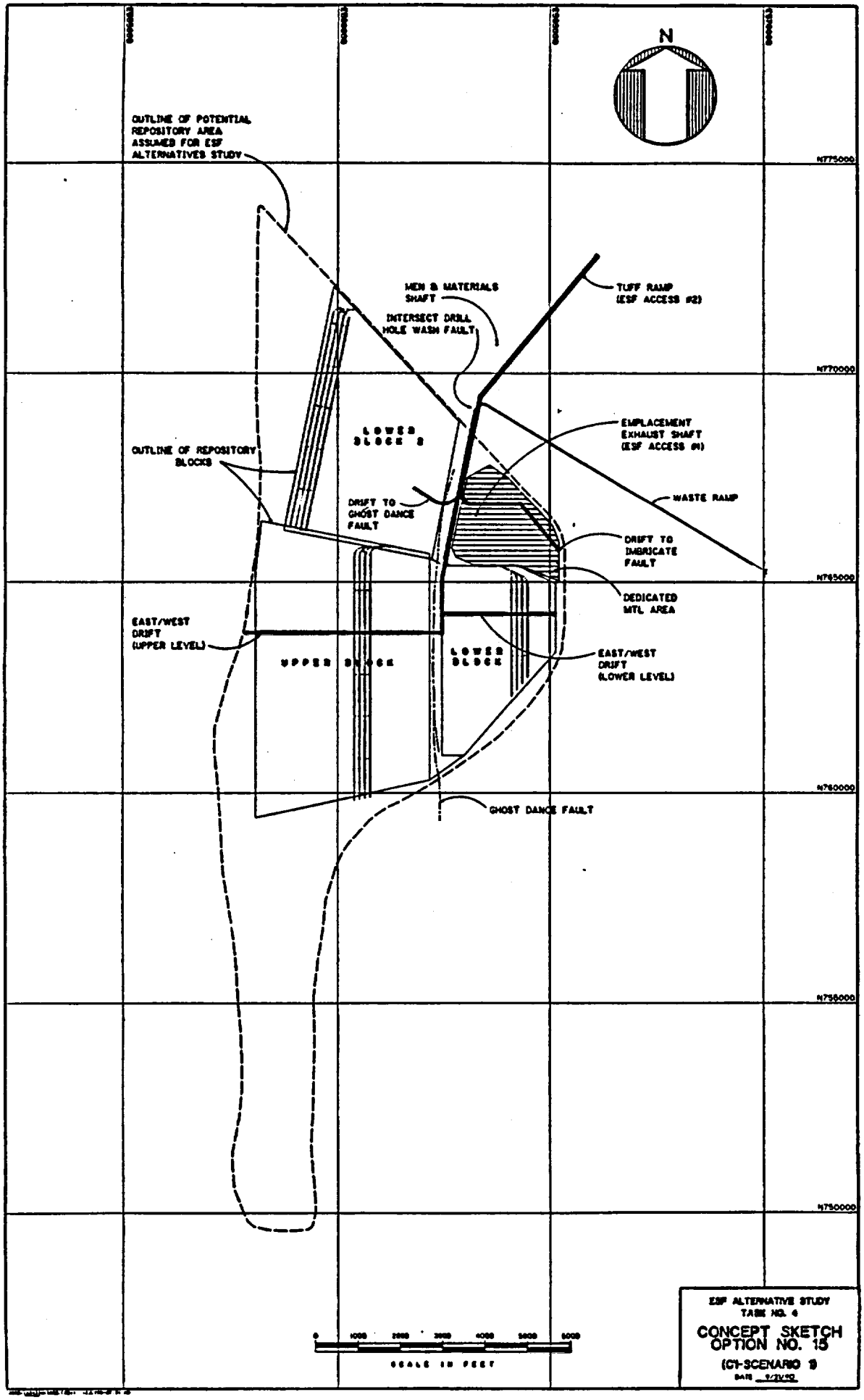
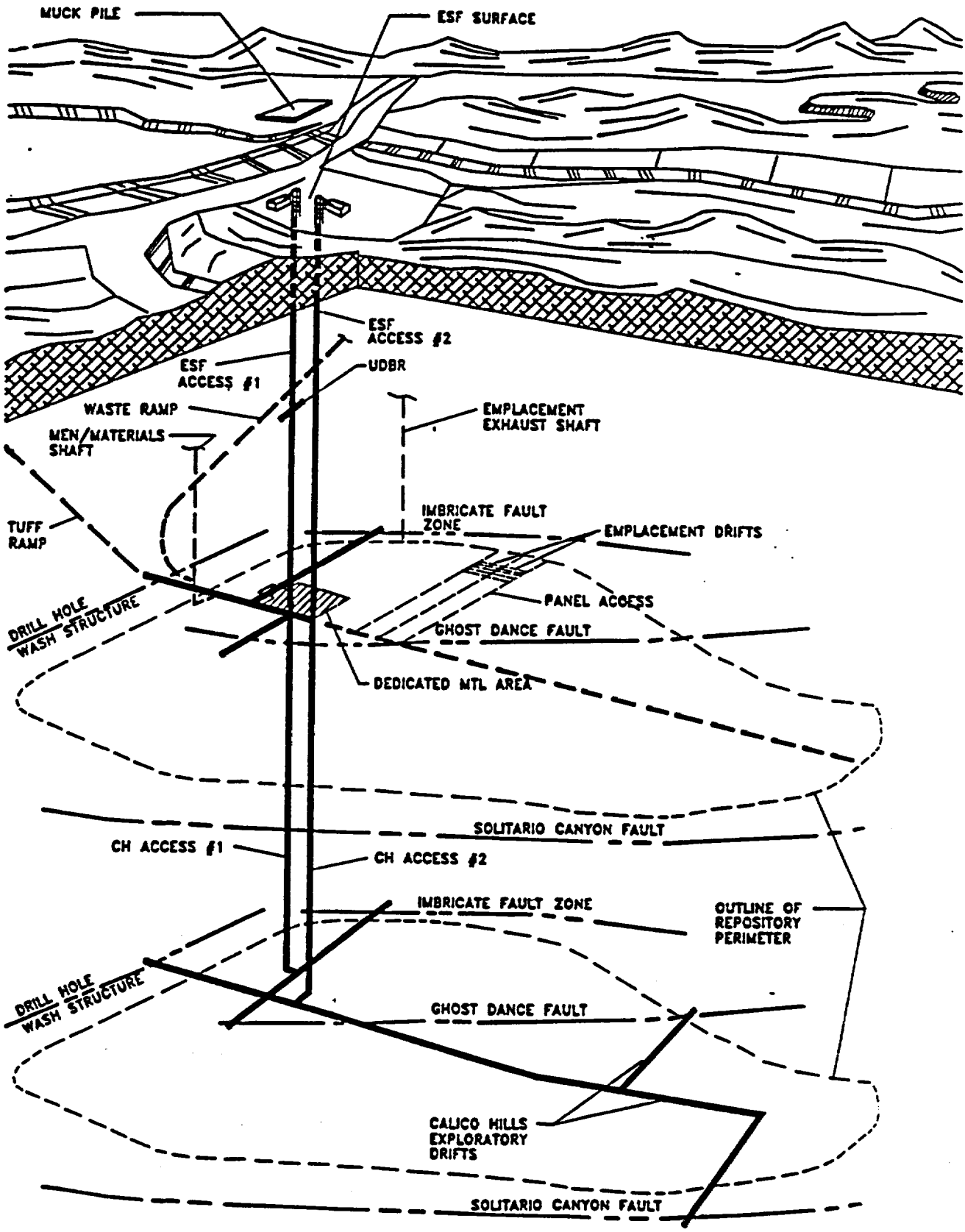
ESF ALTERNATIVES STUDY
TASK NO. 4
OPTION NO. C1
ISOMETRIC SCENARIO #1
DATE


N
OUTLINE OF POTENTIAL REPOSITORY AREA ASSUMED FOR ESF ALTERNATIVES STUDY
MEN & MATERIALS SHAFT
INTERSECT DRILL HOLE WASH FAULT
TUFF RAMP (ESF ACCESS #2)
EMPLACEMENT EXHAUST SHAFT (ESF ACCESS #1)
OUTLINE OF REPOSITORY BLOCKS
LOWER BLOCK 2
DRIFT TO GHOST DANCE FAULT
WASTE RAMP
DRIFT TO IMBRICATE FAULT
DEDICATED MTL AREA
EAST/WEST DRIFT (UPPER LEVEL)
UPPER BLOCK
LOWER BLOCK
EAST/WEST DRIFT (LOWER LEVEL)
GHOST DANCE FAULT
N775000
N770000
N765000
N760000
N755000
N750000
0 1000 2000 3000 4000 5000 6000
SCALE IN FEET
ESF ALTERNATIVE STUDY
TASK NO. 4
CONCEPT SKETCH
OPTION NO. 15
(C1-SCENARIO 1)
DATE 9/21/92

OPTIONS EVALUATED IN THE ESF ALTERNATIVES STUDY

Attachment 19



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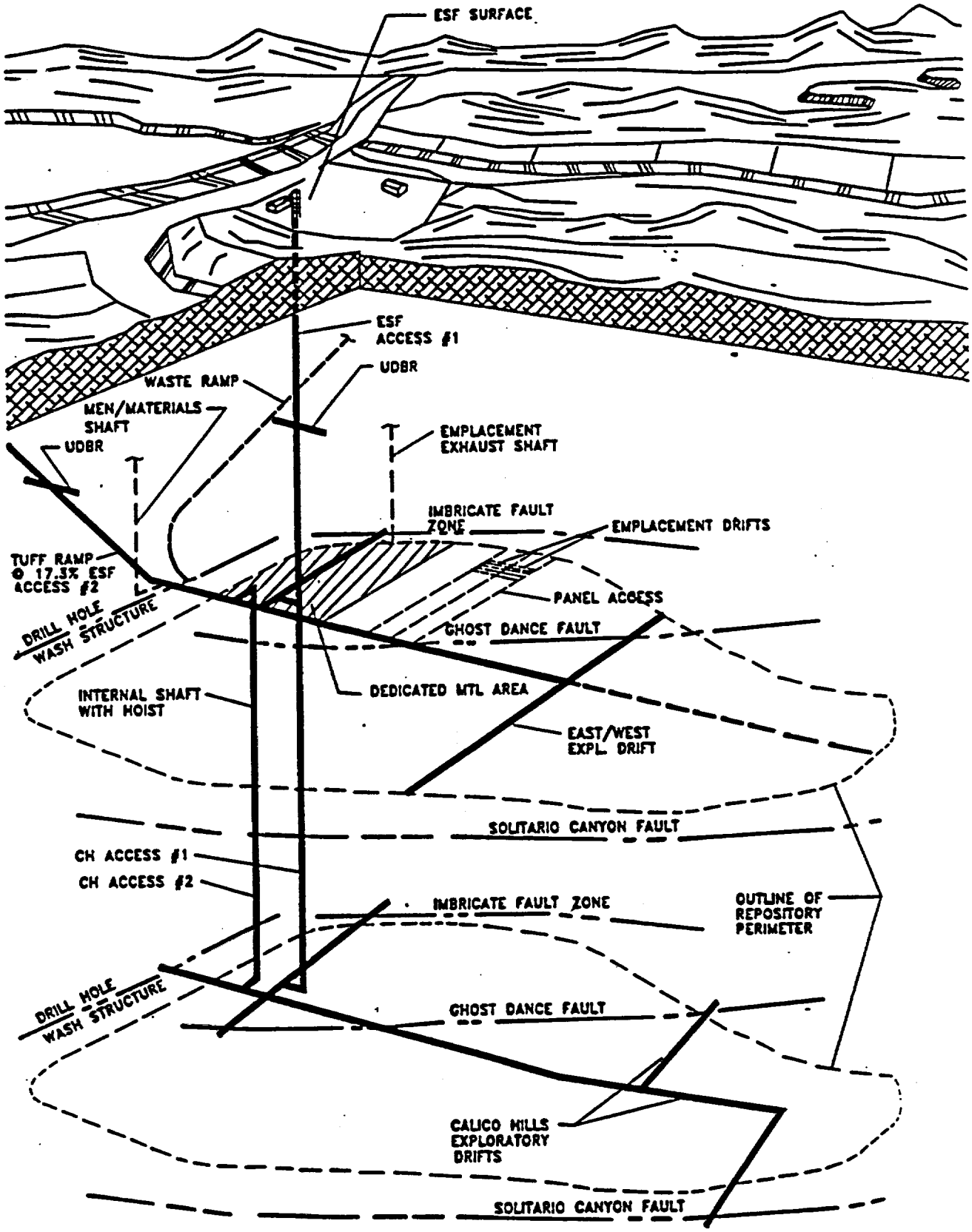
ESF ALTERNATIVES STUDY
TASK NO. 4

BASE CASE

ISOMETRIC SCENARIO #1

DATE



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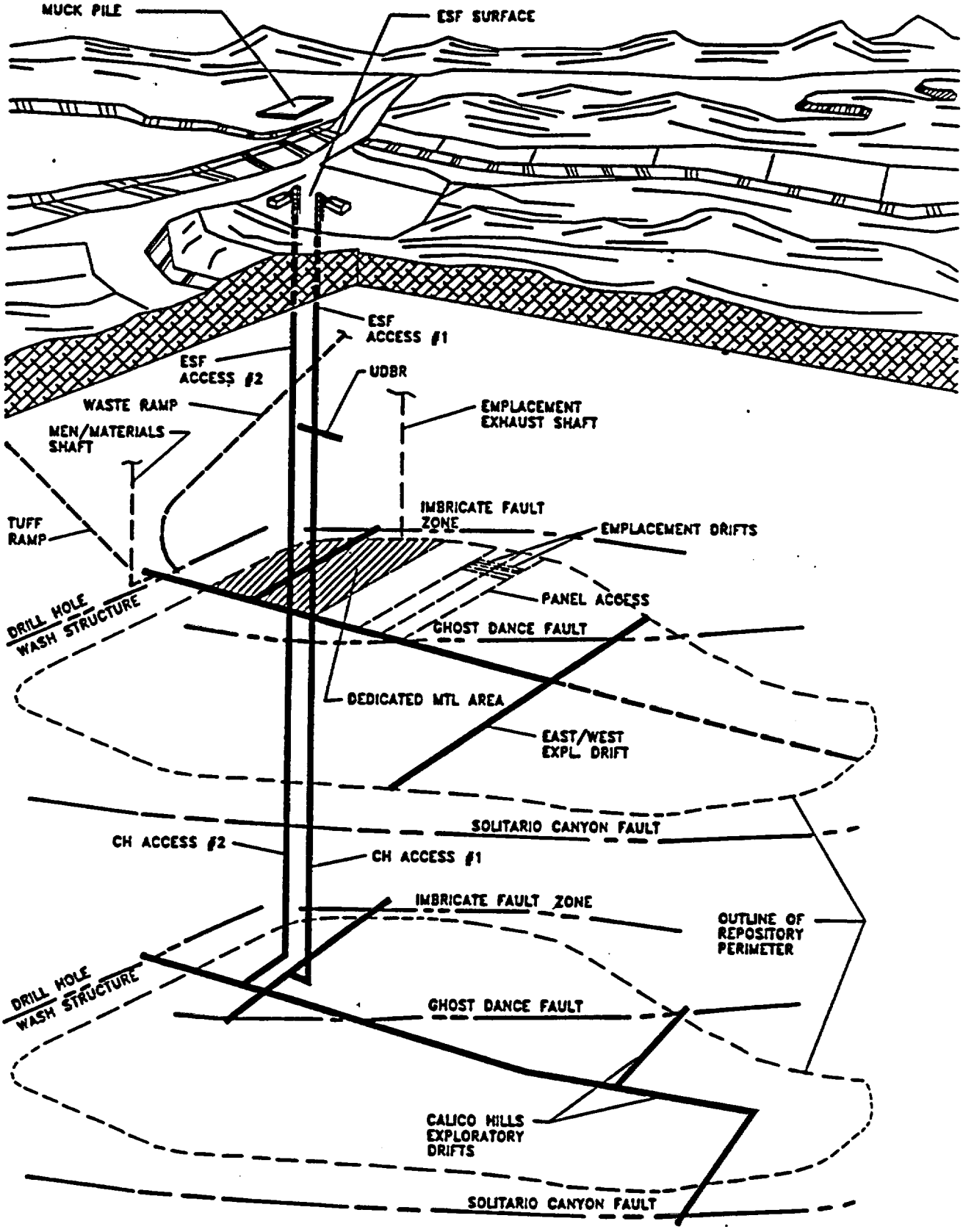
ESF ALTERNATIVES STUDY
TASK NO. 4
OPTION NO. A1
ISOMETRIC SCENARIO #1
DATE



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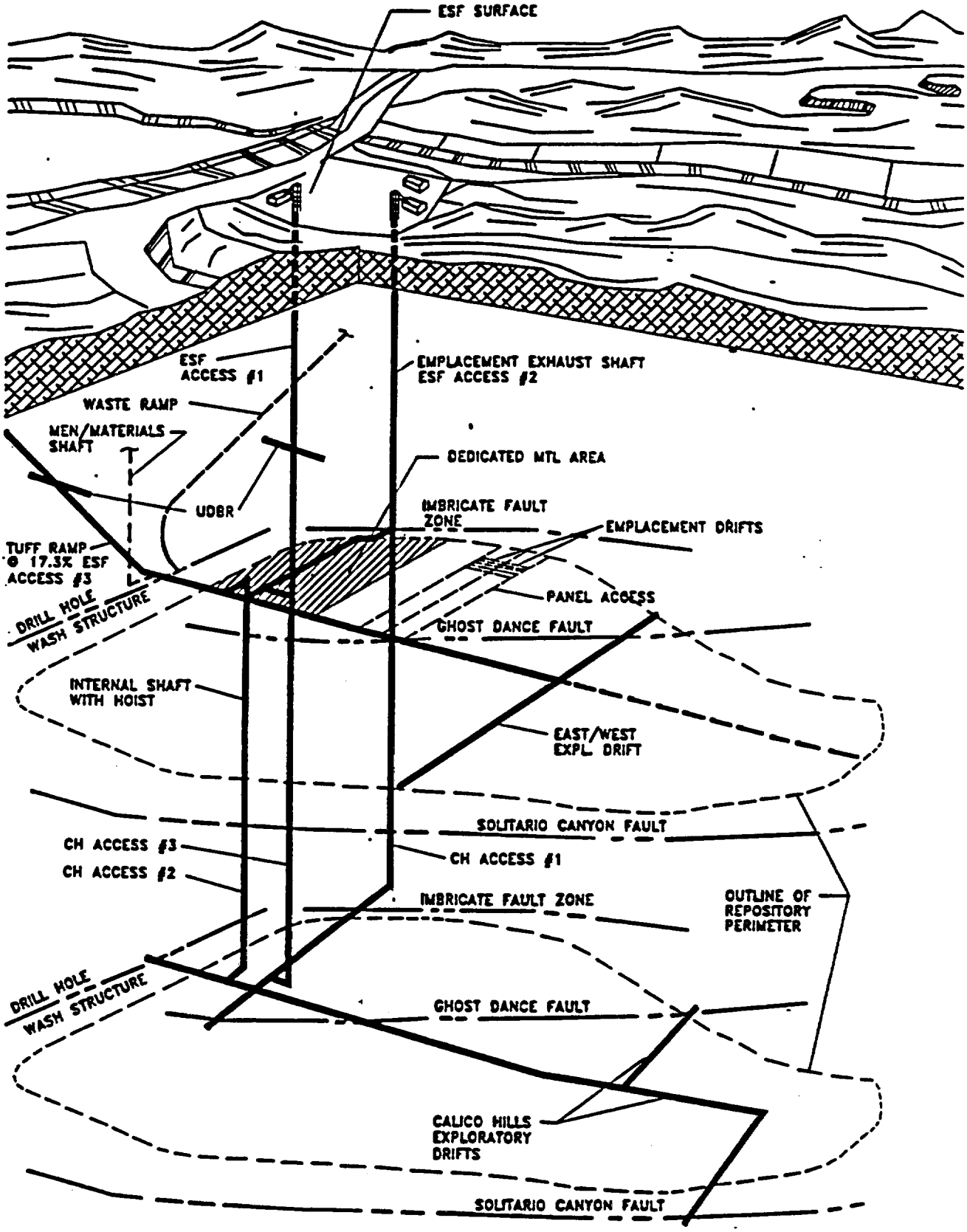
ESF ALTERNATIVES STUDY
TASK NO. 4

OPTION NO. A2

ISOMETRIC SCENARIO #1

DATE



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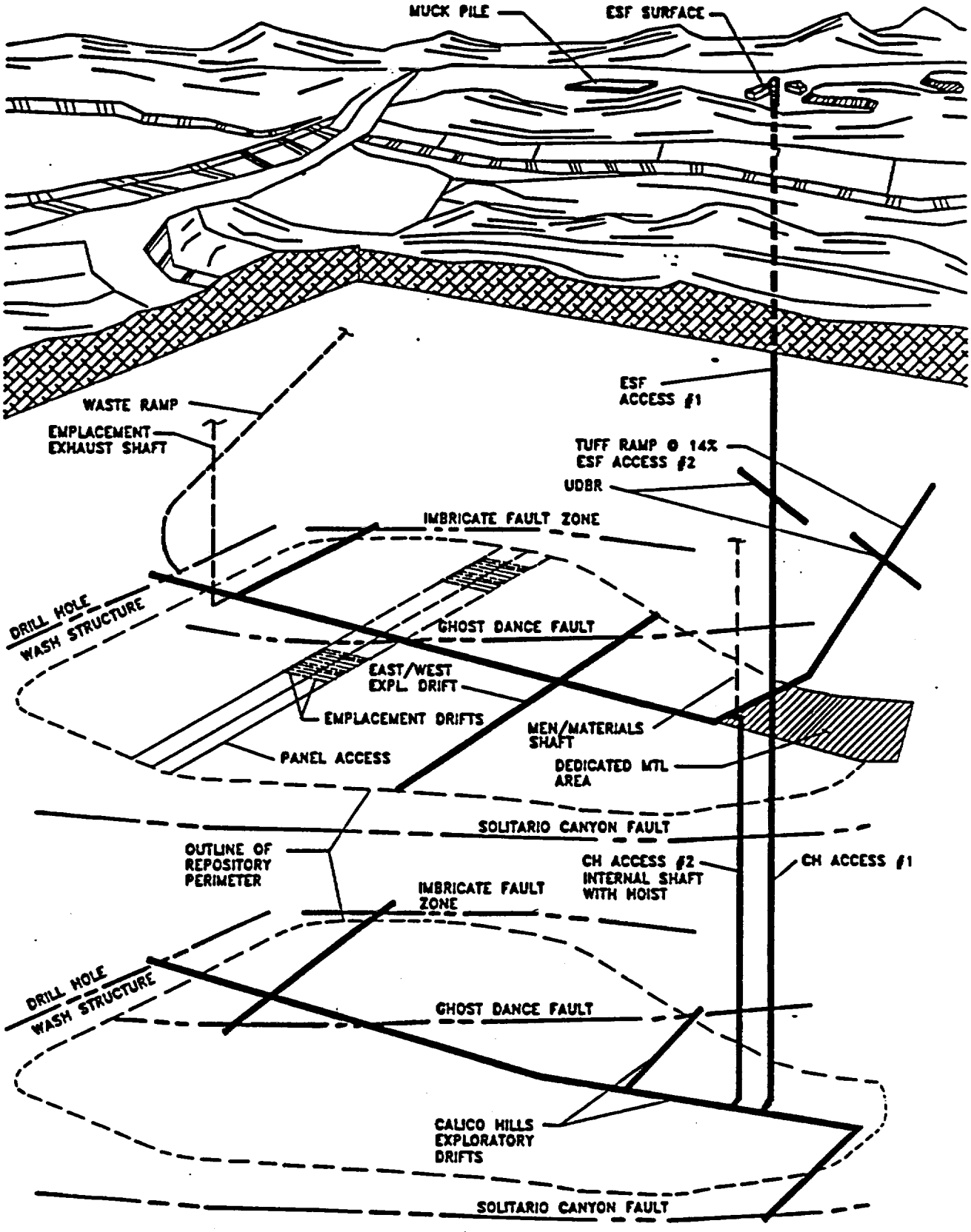
ESF ALTERNATIVES STUDY
TASK NO. 4
OPTION NO. A4 REV. 1
ISOMETRIC SCENARIO #1
DATE



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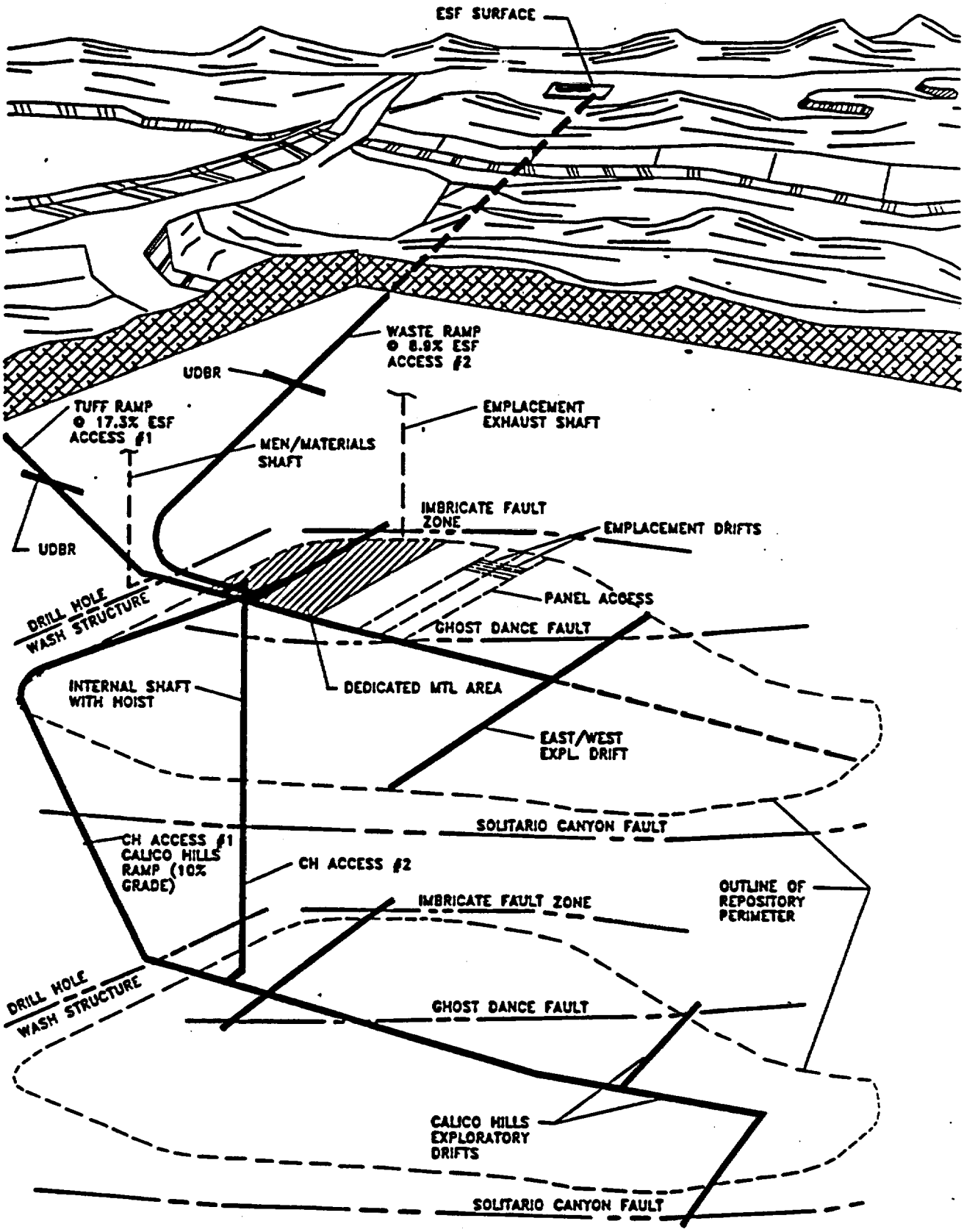
ESF ALTERNATIVES STUDY
TASK NO. 4

OPTION NO. A5

ISOMETRIC SCENARIO #1

DATE



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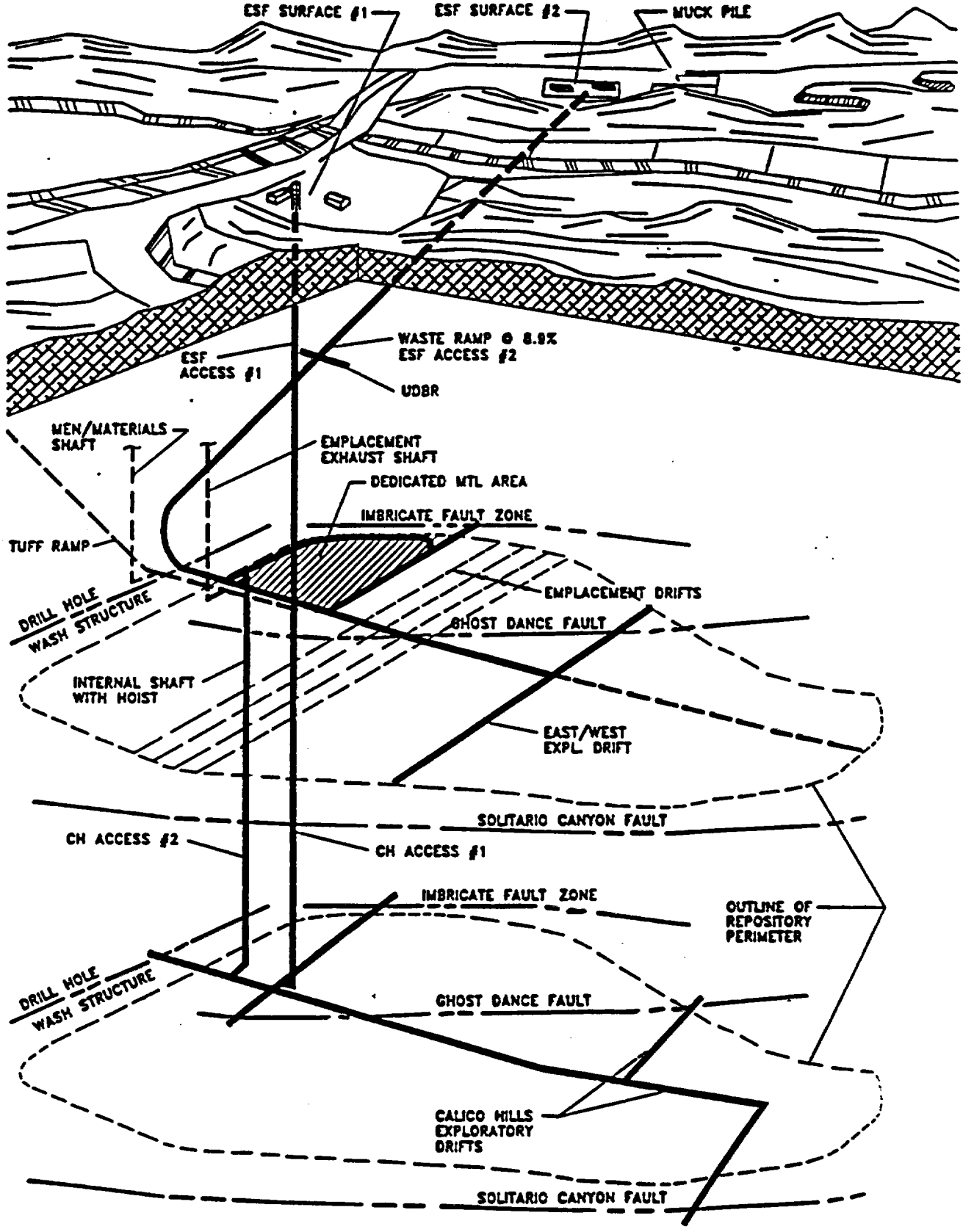
ESF ALTERNATIVES STUDY
TASK NO. 4
OPTION NO. A7
ISOMETRIC SCENARIO #1
DATE



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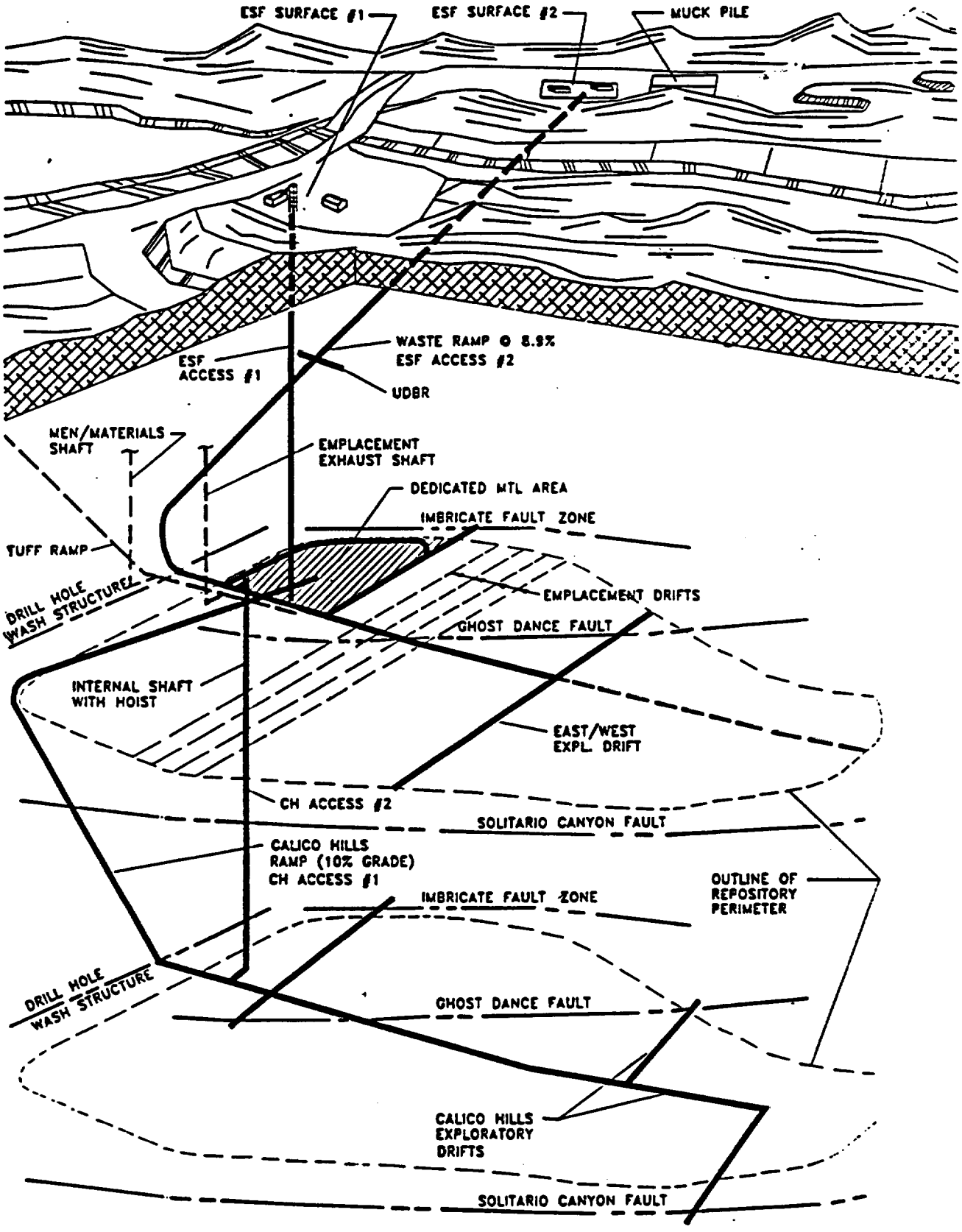
ESF ALTERNATIVES STUDY
TASK NO. 4
OPTION NO. B3 REV. 2
(SBM)
ISOMETRIC SCENARIO #1
DATE



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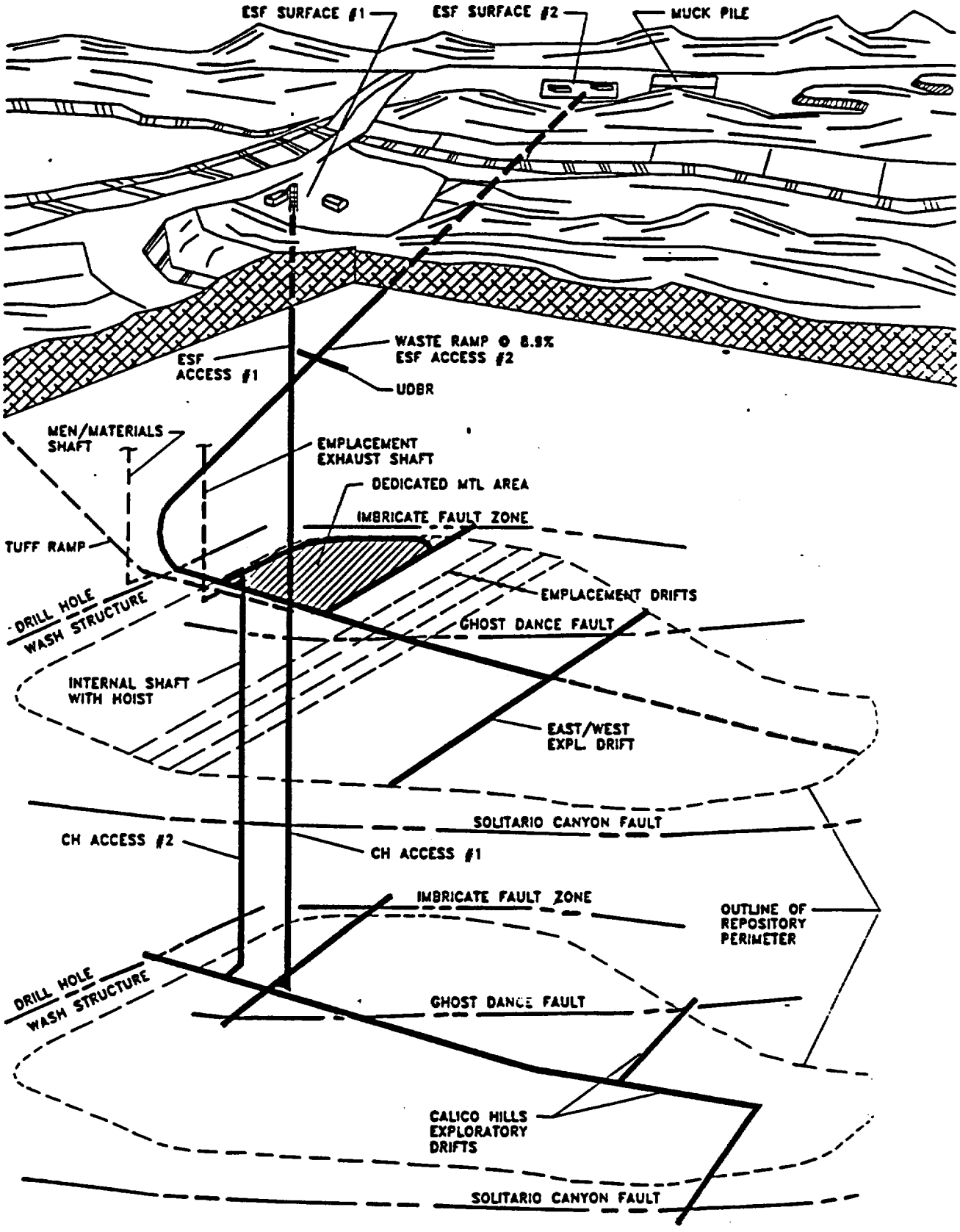
ESF ALTERNATIVES STUDY
TASK NO. 4
OPTION NO. B3 REV. 3
(V-MOLE)
ISOMETRIC SCENARIO #1
DATE



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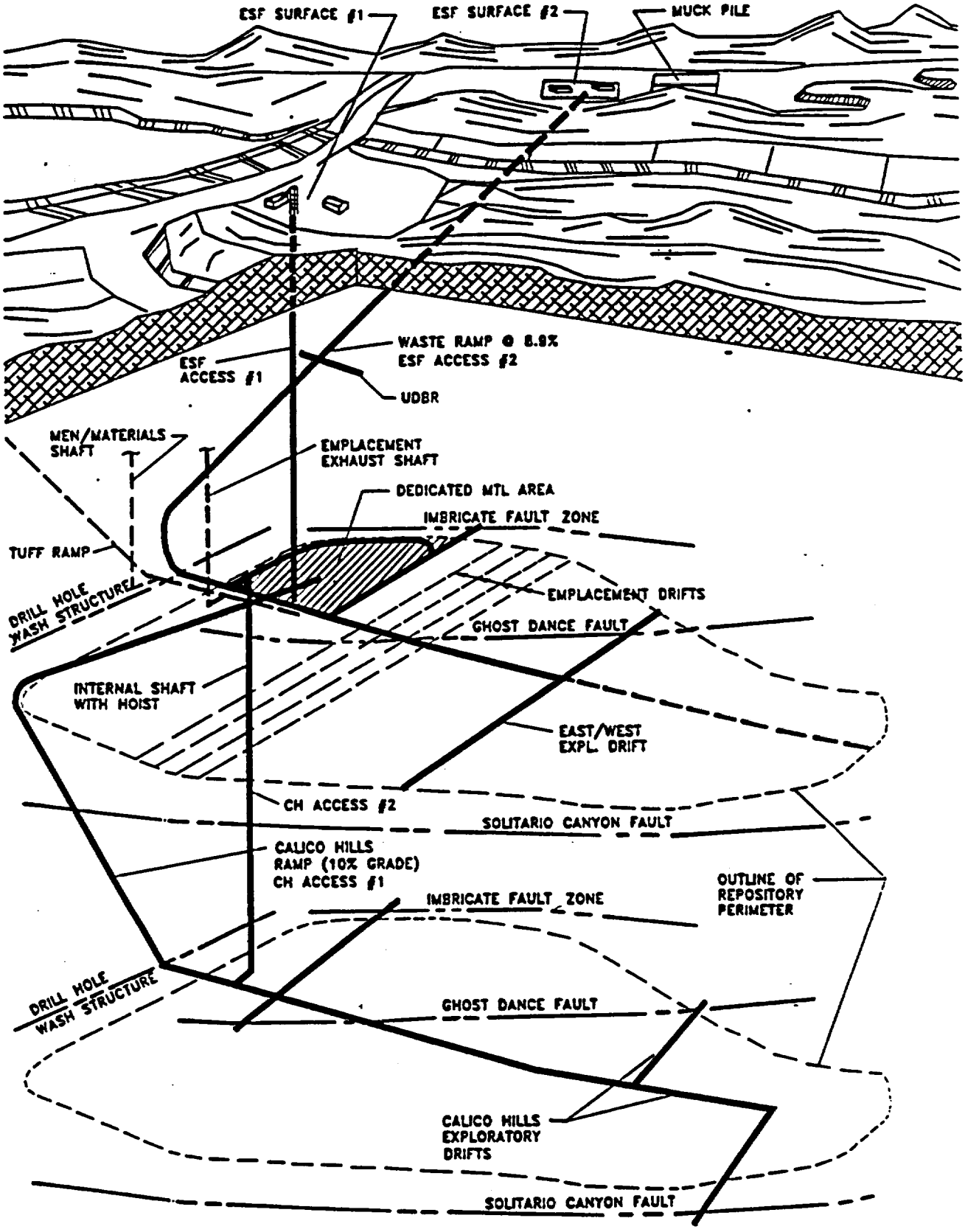
ESF ALTERNATIVES STUDY
TASK NO. 4
OPTION NO. B3 REV. 4
(BLIND BORE)
ISOMETRIC SCENARIO #1
DATE



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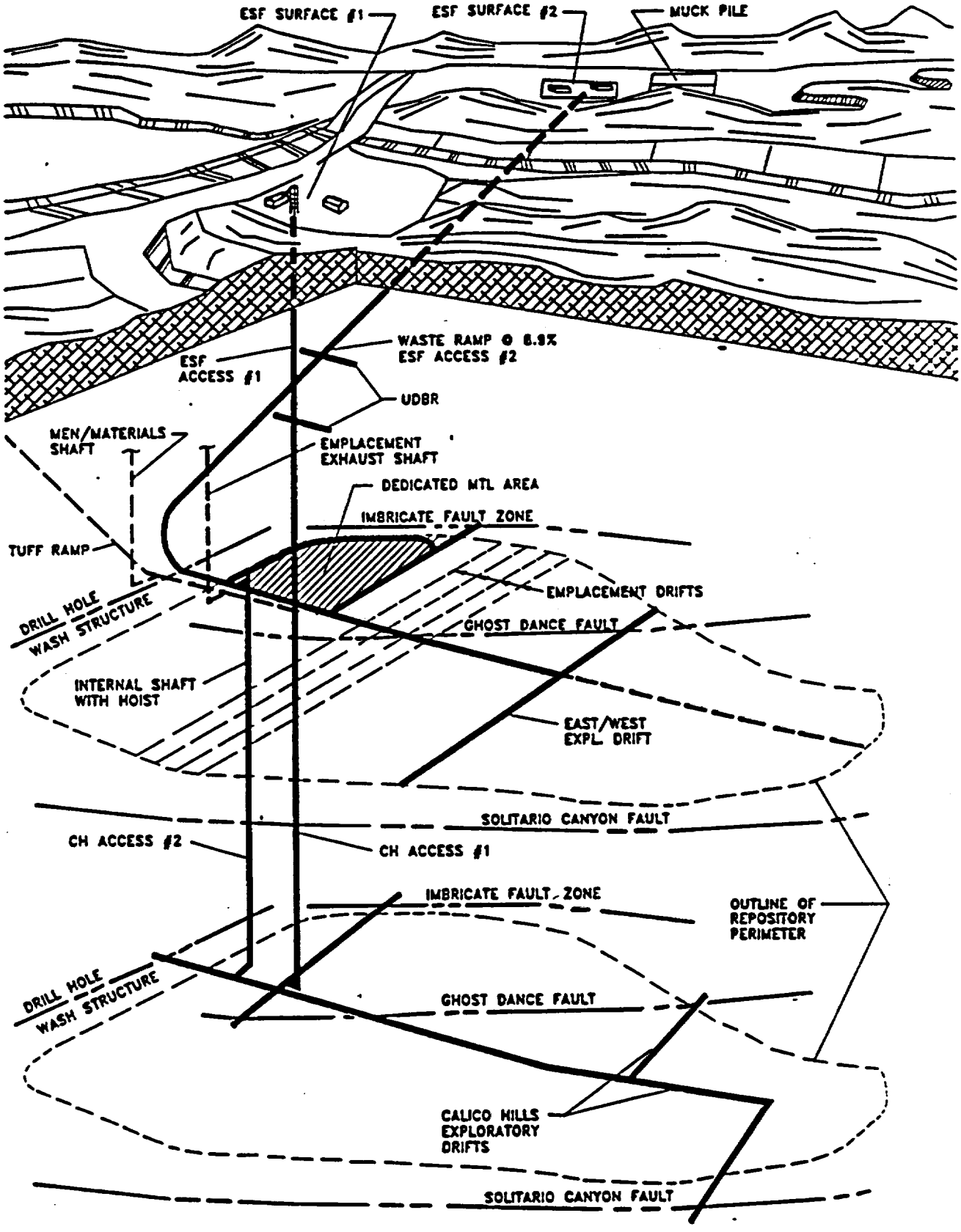
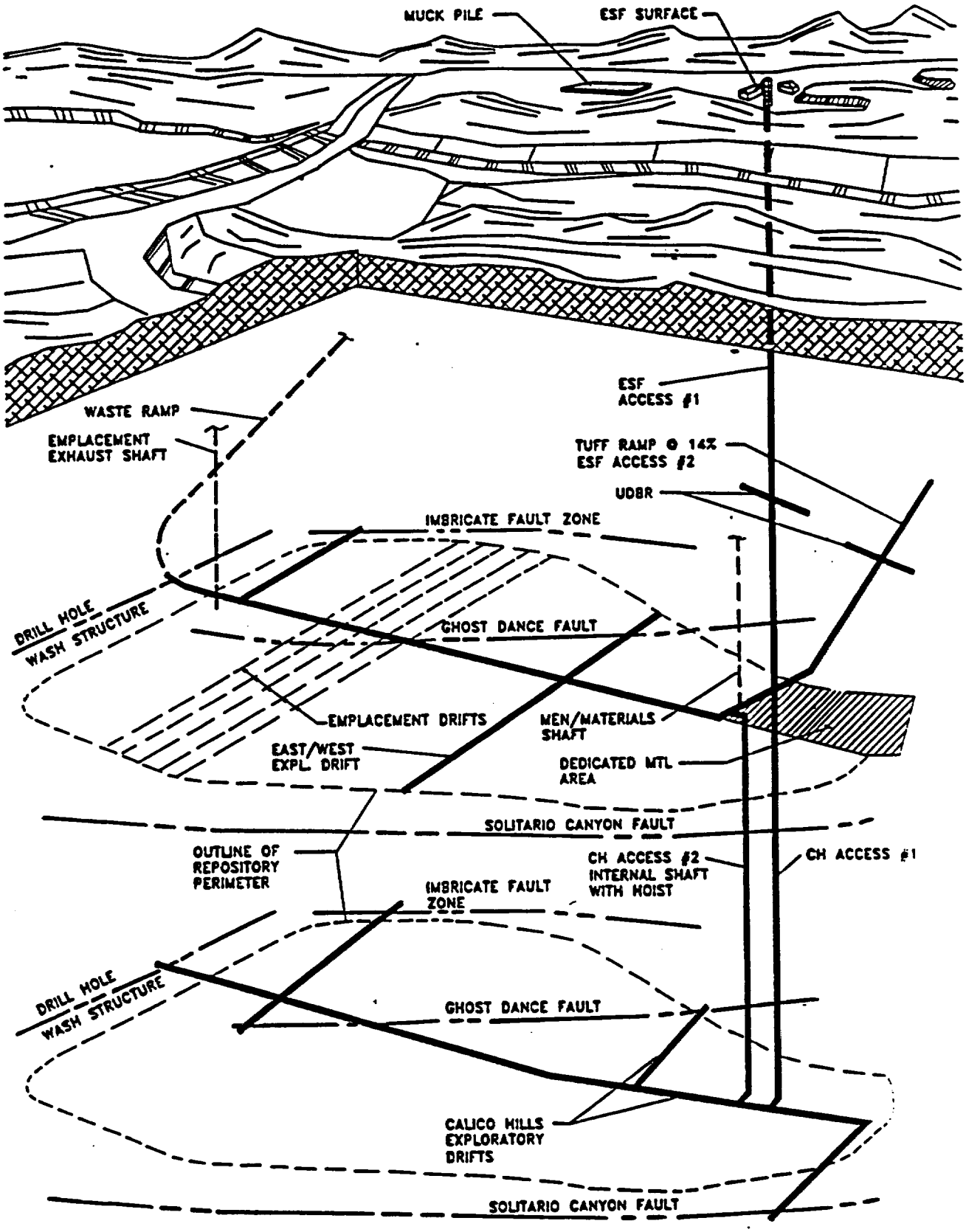
ESF ALTERNATIVES STUDY
TASK NO. 4
OPTION NO. B3 REV. 5
(RAISE BORE)
ISOMETRIC SCENARIO #1
DATE



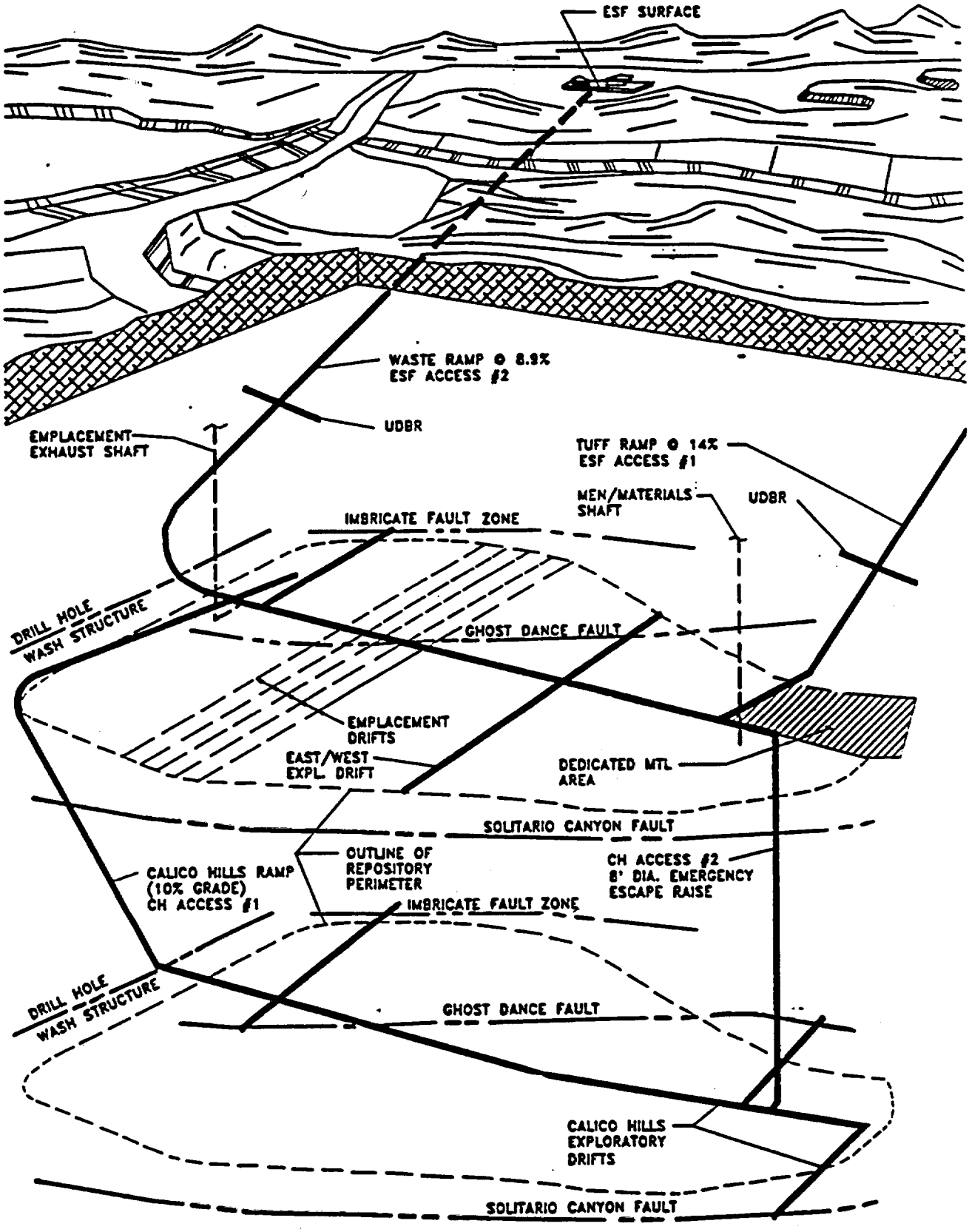
11

ESF ALTERNATIVES STUDY
TASK NO. 4
OPTION NO. 83 REV. 6
(DRILL & BLAST)
ISOMETRIC SCENARIO #1
DATE



12

ESF ALTERNATIVES STUDY
TAS NO. 4
OPTION NO. B4
ISOMETRIC SCENARIO #1
DATE



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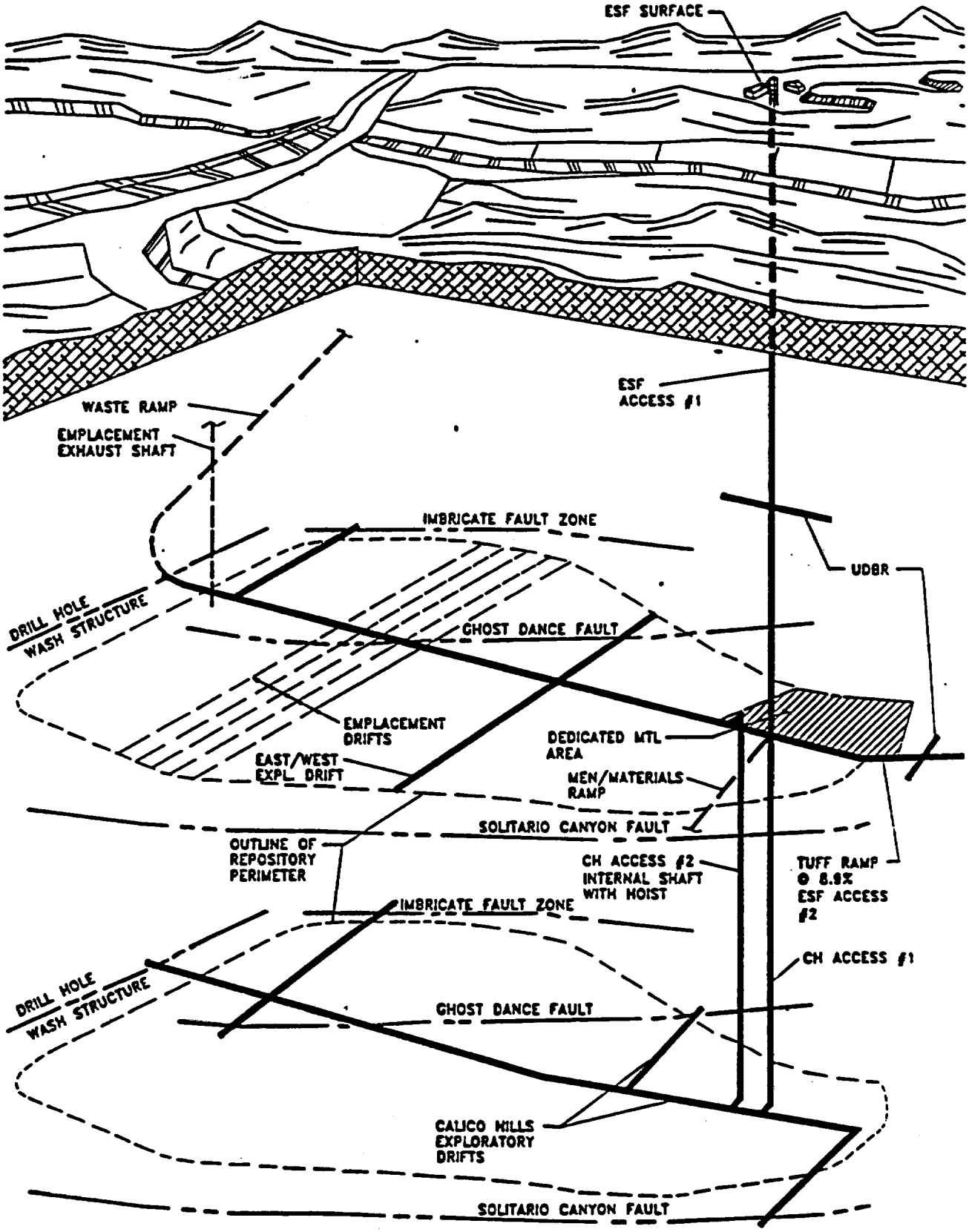
ESF ALTERNATIVES STUDY
TASK NO. 4
OPTION NO. B7
ISOMETRIC SCENARIO #1
DATE



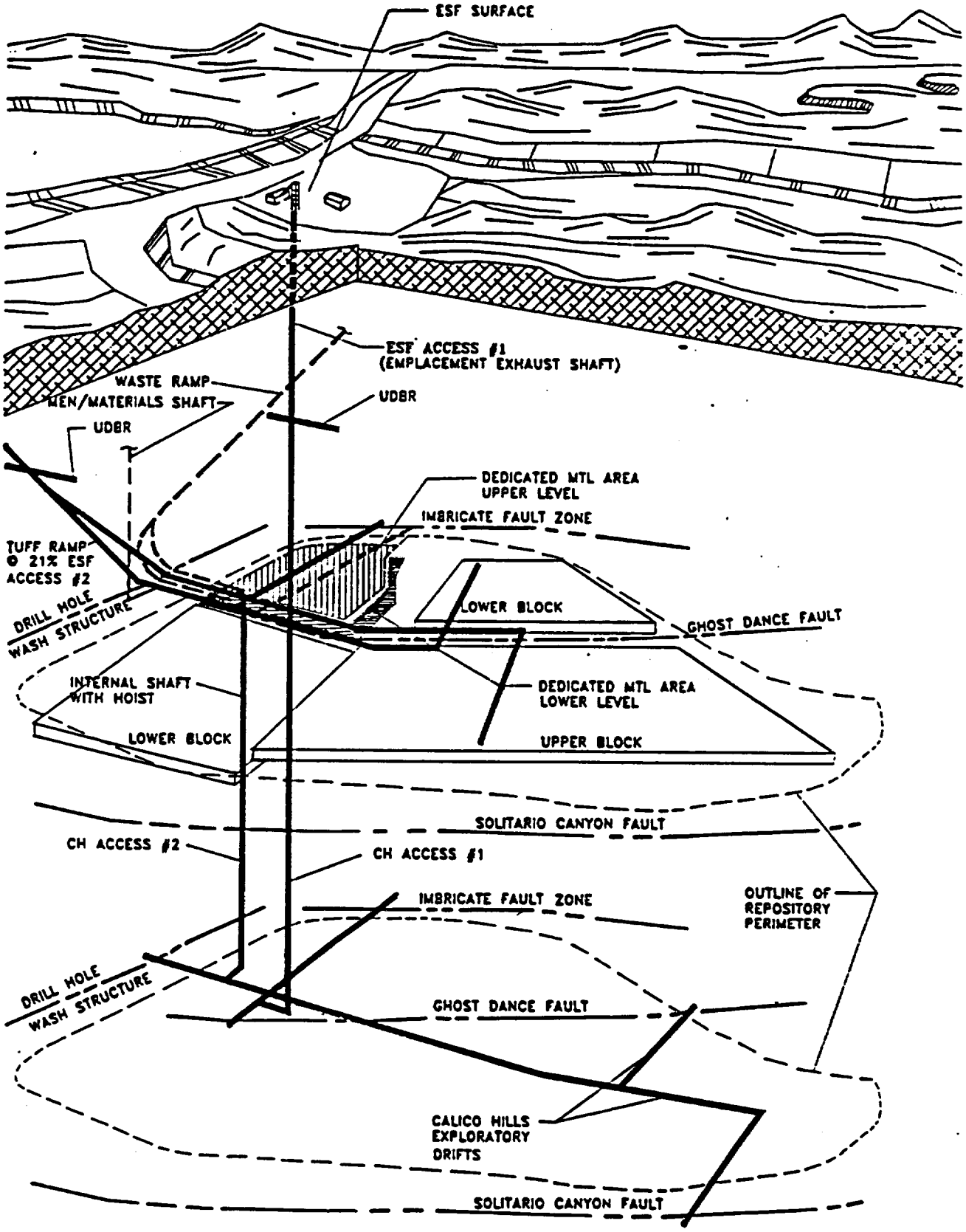
14

ESF ALTERNATIVES STUDY
TASK NO. 4

OPTION NO. B8

ISOMETRIC SCENARIO #1

DATE _____



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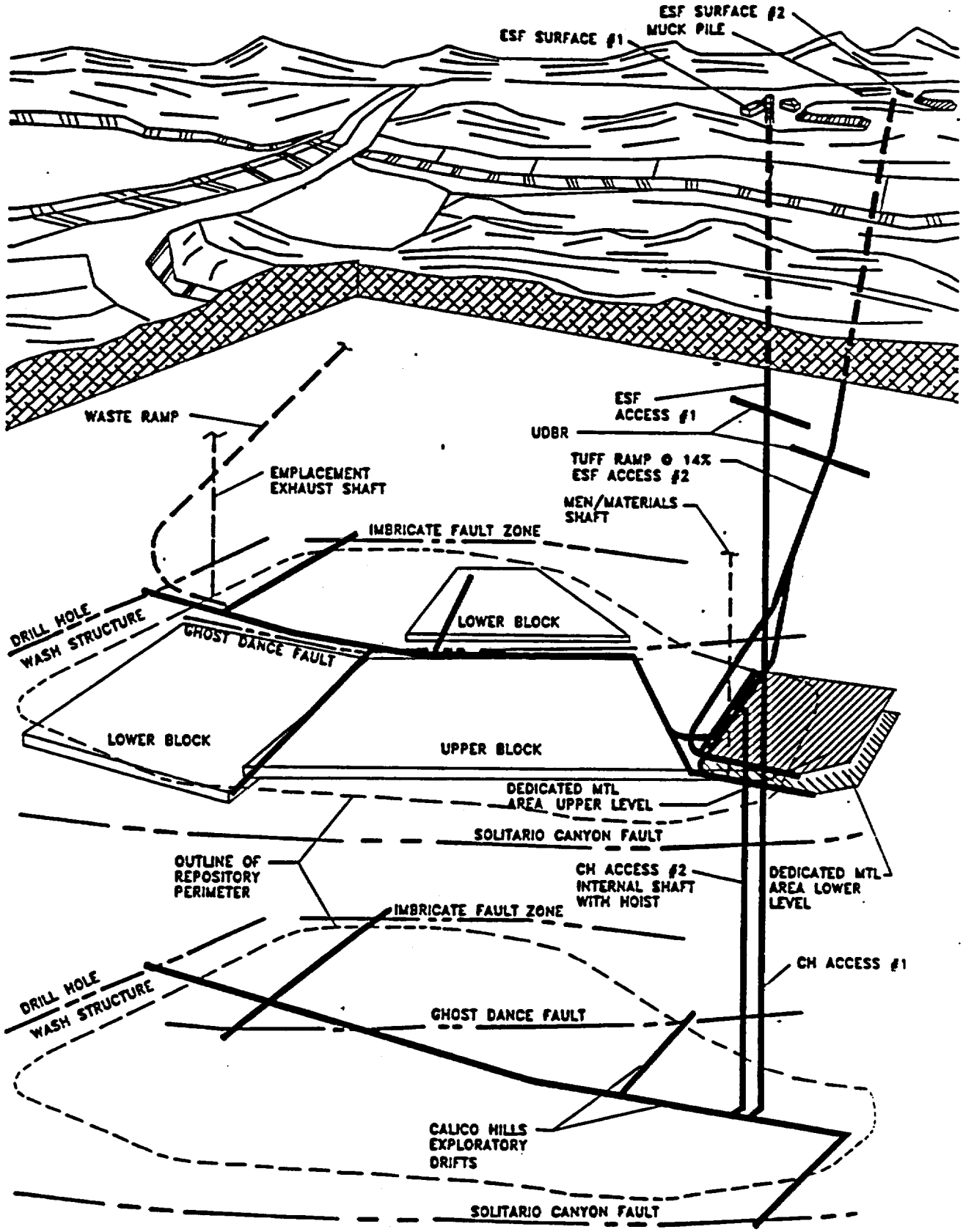
ESF ALTERNATIVES STUDY
TASK NO. 4
OPTION NO. C1
ISOMETRIC SCENARIO #1
DATE



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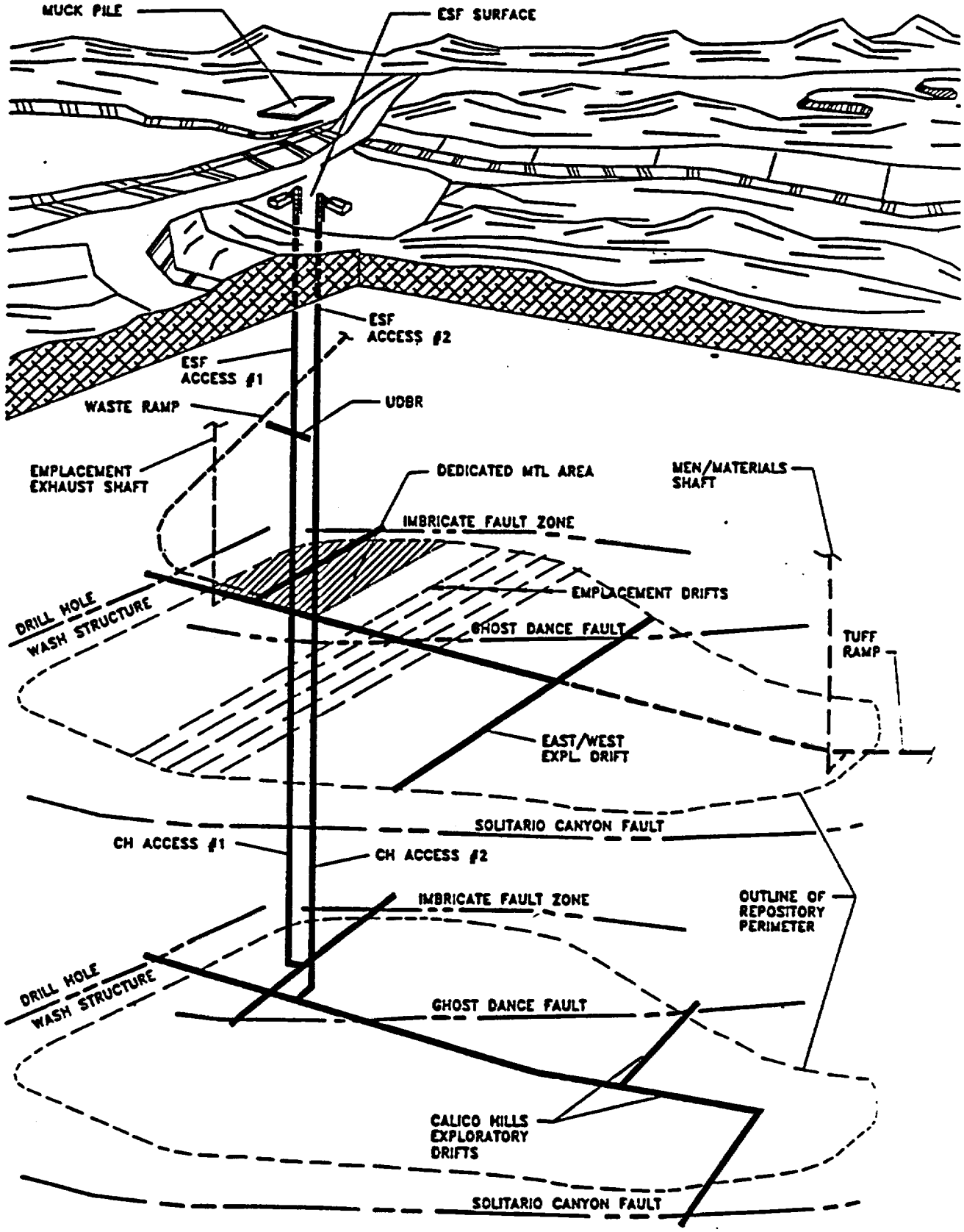
ESF ALTERNATIVES STUDY
TASK NO. 4
OPTION NO. C4
ISOMETRIC SCENARIO #1
DATE



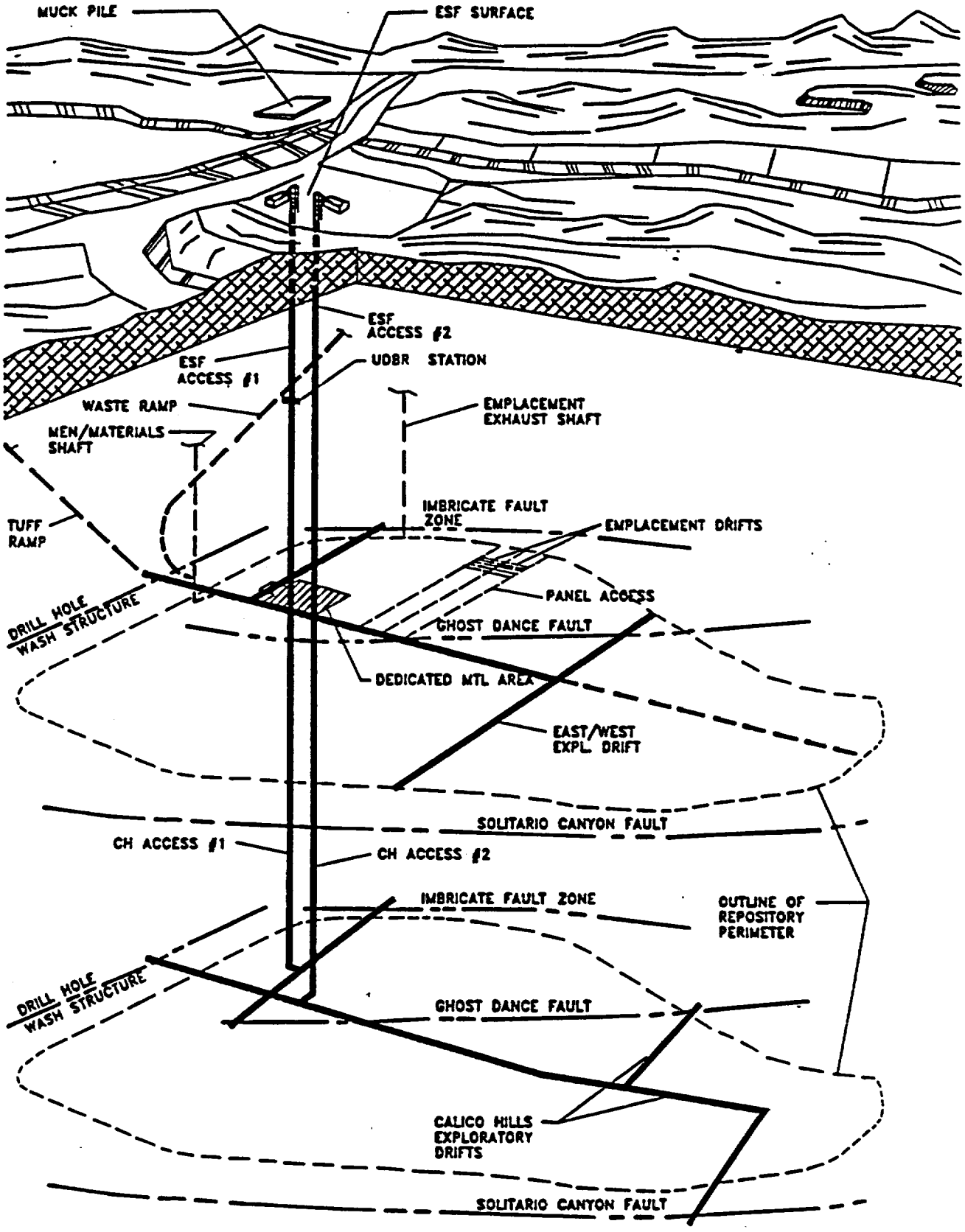
17

ESF ALTERNATIVES. STUDY
TASK NO. 4

OPTION NO. R-11

ISOMETRIC SCENARIO #1

DATE



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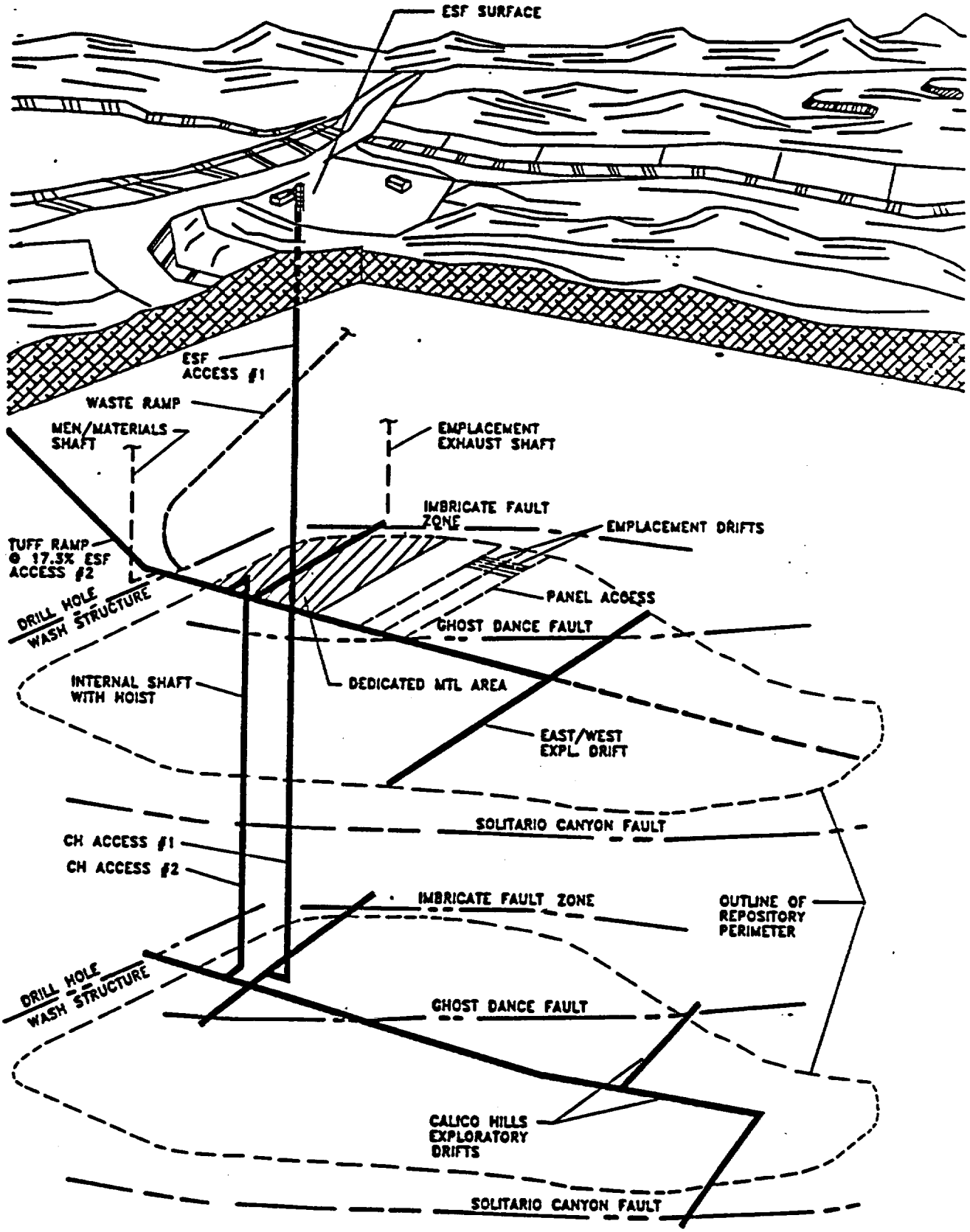
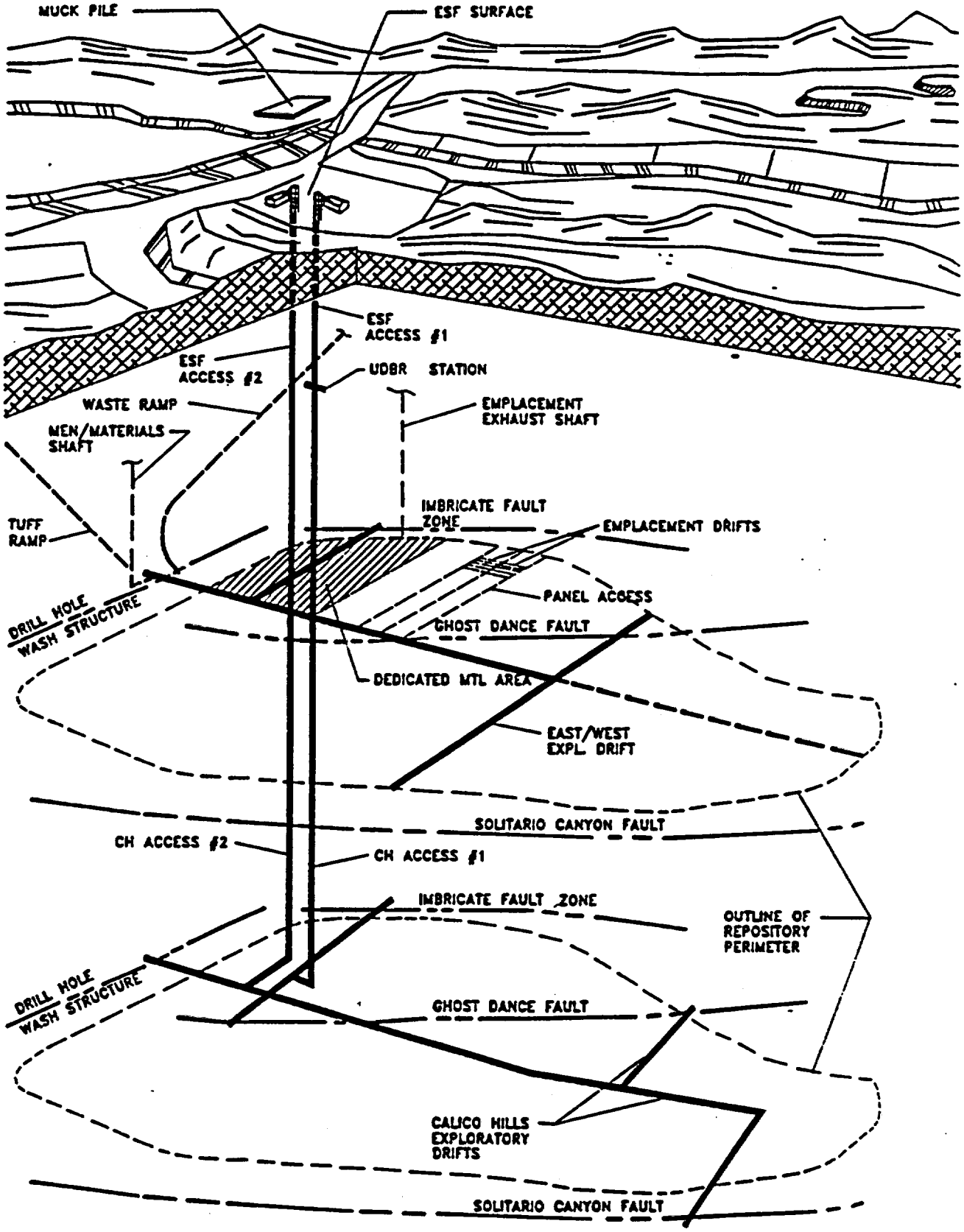
ESF ALTERNATIVES STUDY
TASK NO. 4
BASE CASE
ISOMETRIC SCENARIO #2
DATE



19

ESF ALTERNATIVES STUDY
TASK NO. 4
OPTION NO. A1
ISOMETRIC SCENARIO #2
DATE



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ESF ALTERNATIVES STUDY
TASK NO. 4
OPTION NO. A2
ISOMETRIC SCENARIO #2
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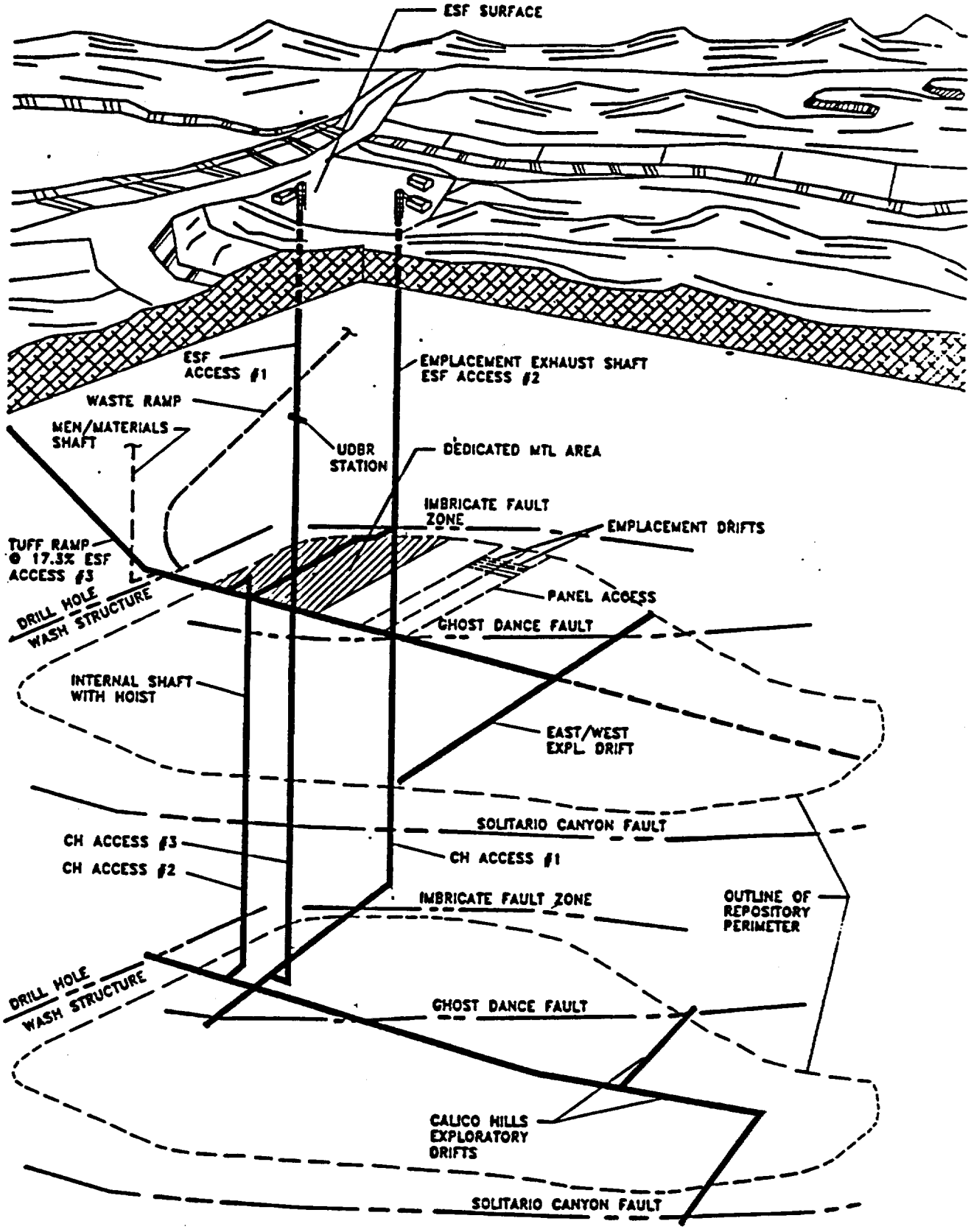

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ESF ALTERNATIVES--STUDY
TASK NO. 4
OPTION NO. A4 REV. 1
ISOMETRIC SCENARIO #2
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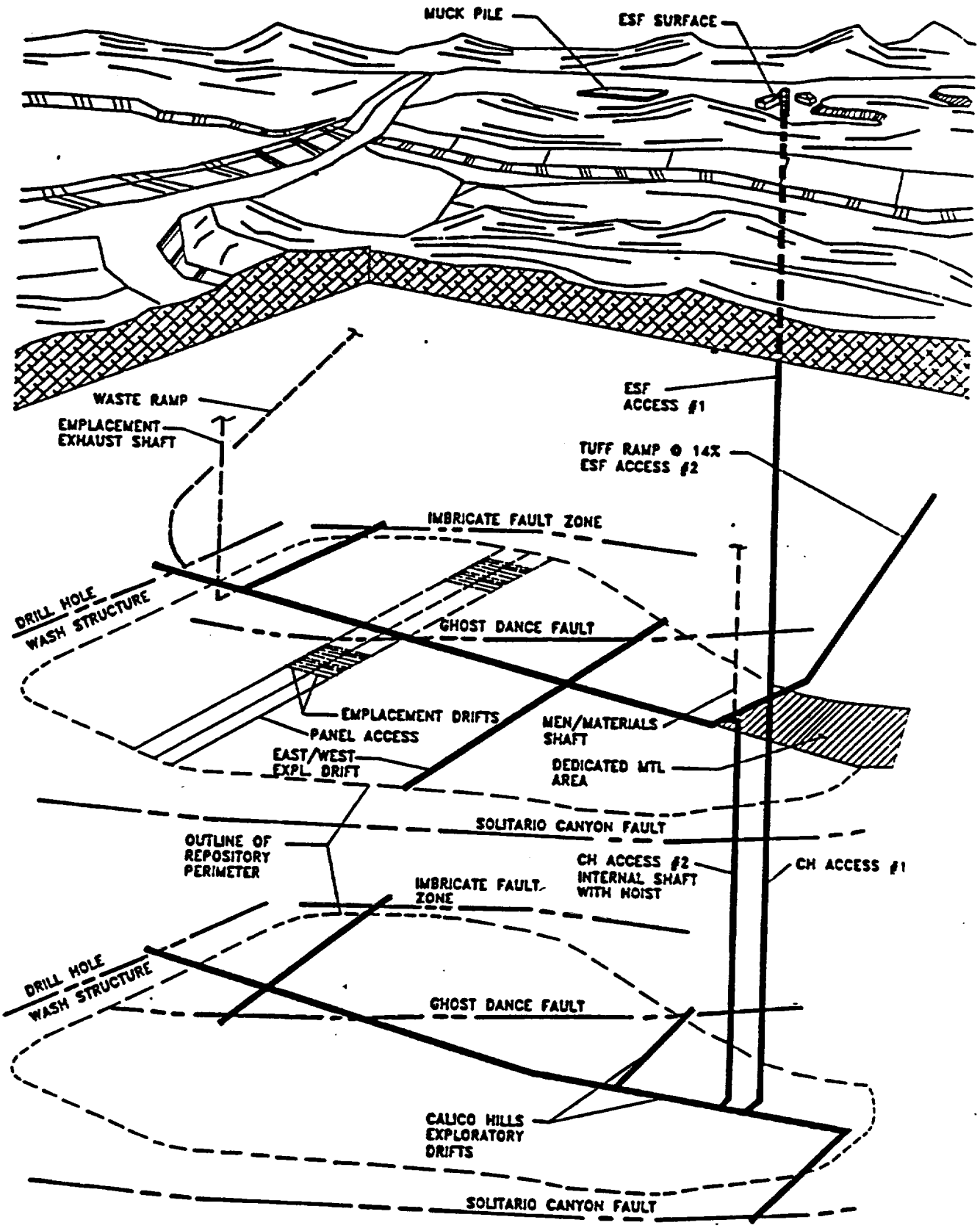

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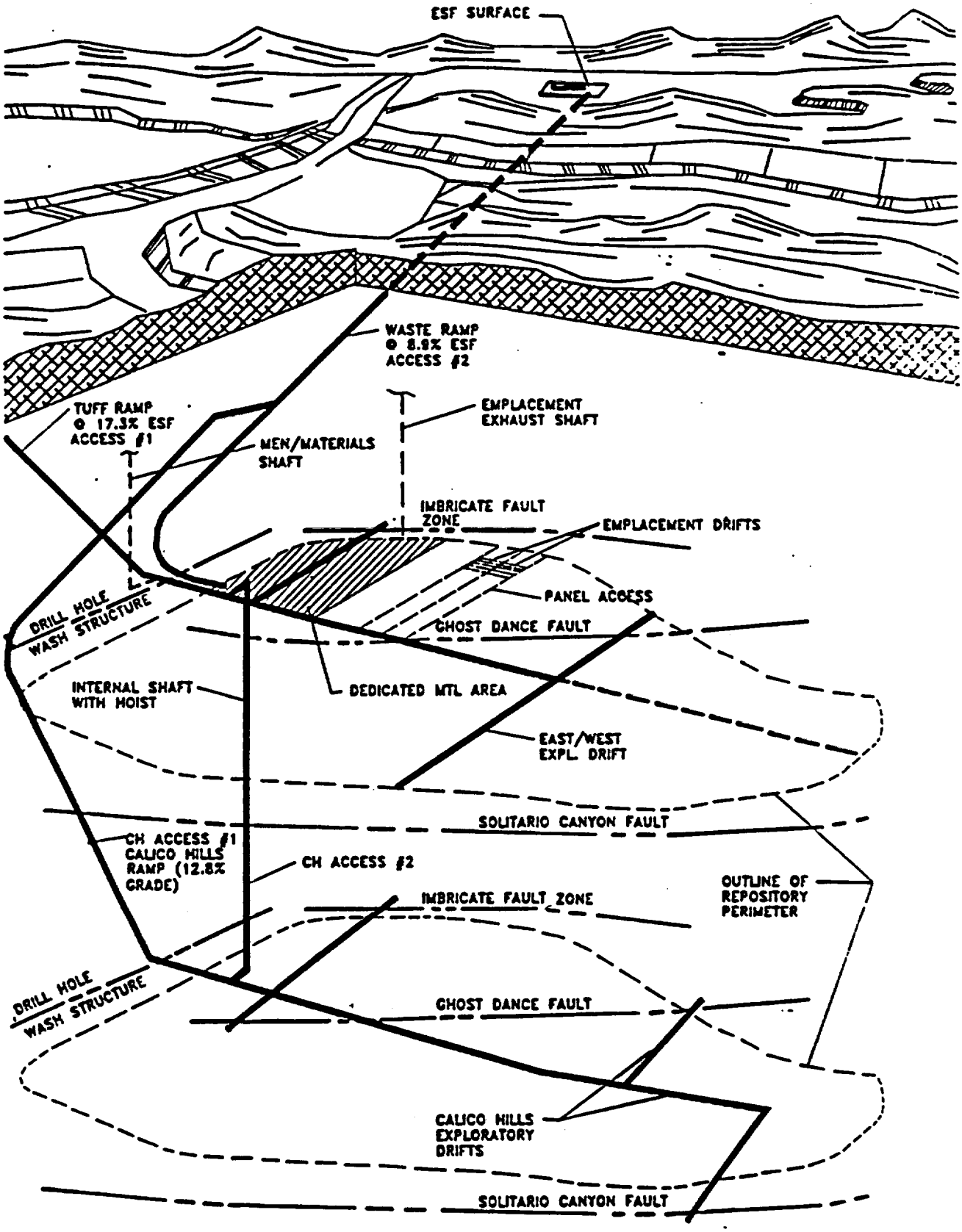
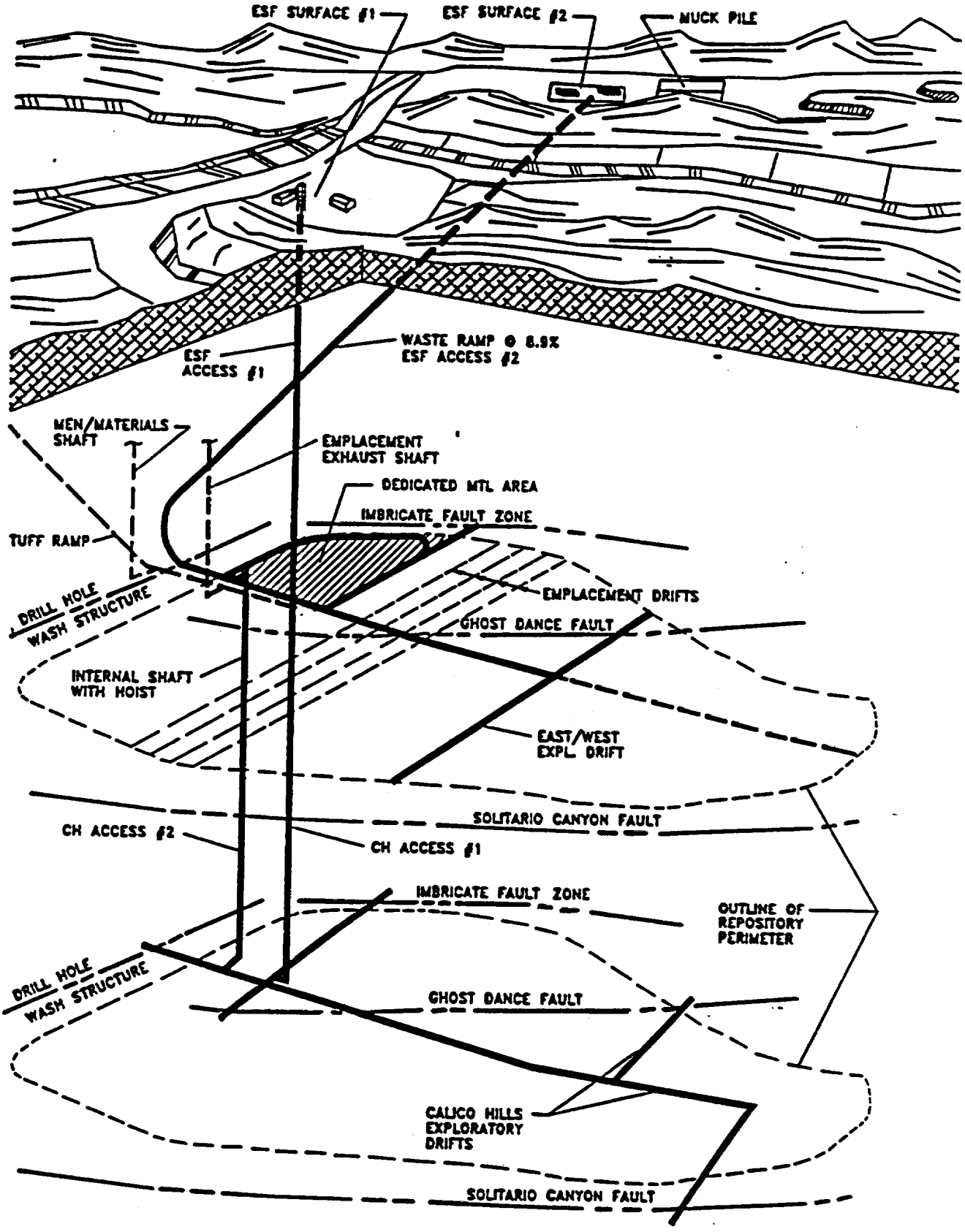
ESF ALTERNATIVES-STUDY
TASK NO. 4
OPTION NO. A5
ISOMETRIC SCENARIO #2
DATE



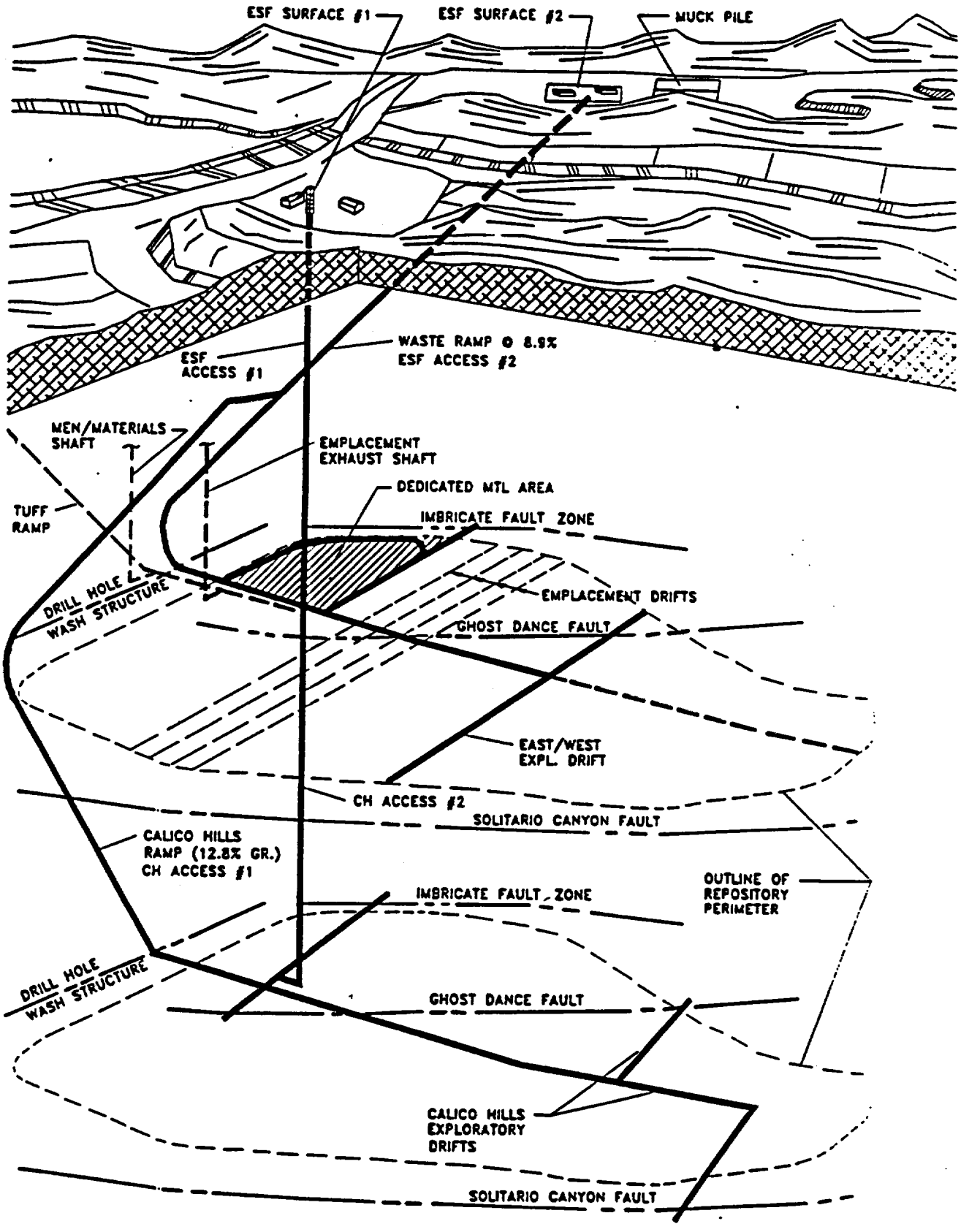
23

ESF ALTERNATIVES STUDY
TASK NO. 4
OPTION NO. A7
ISOMETRIC SCENARIO #2
DATE



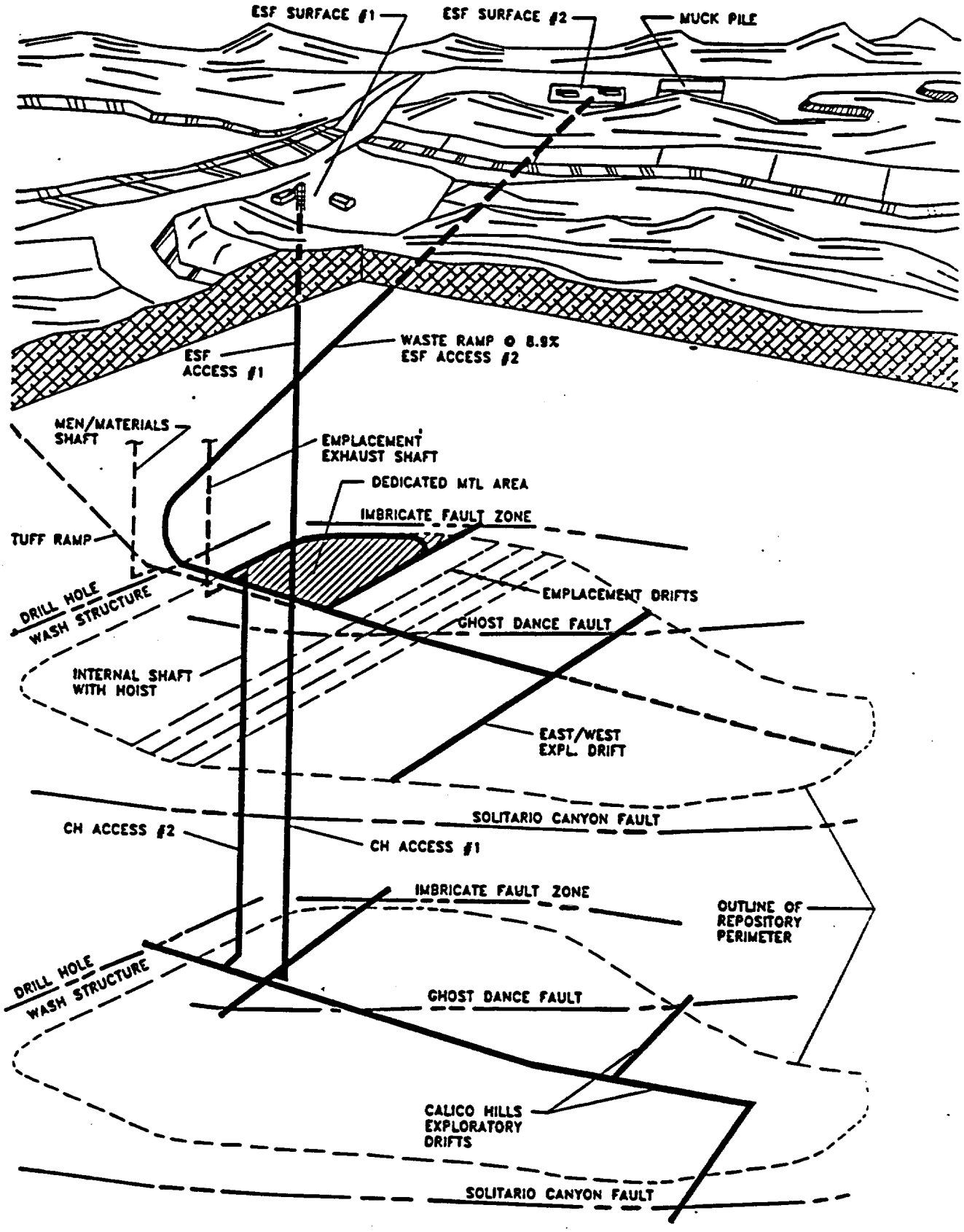
24

ESF ALTERNATIVES STUDY
TASK NO. 4
OPTION NO. B3 REV. 2
(SBM)
ISOMETRIC SCENARIO #2
DATE



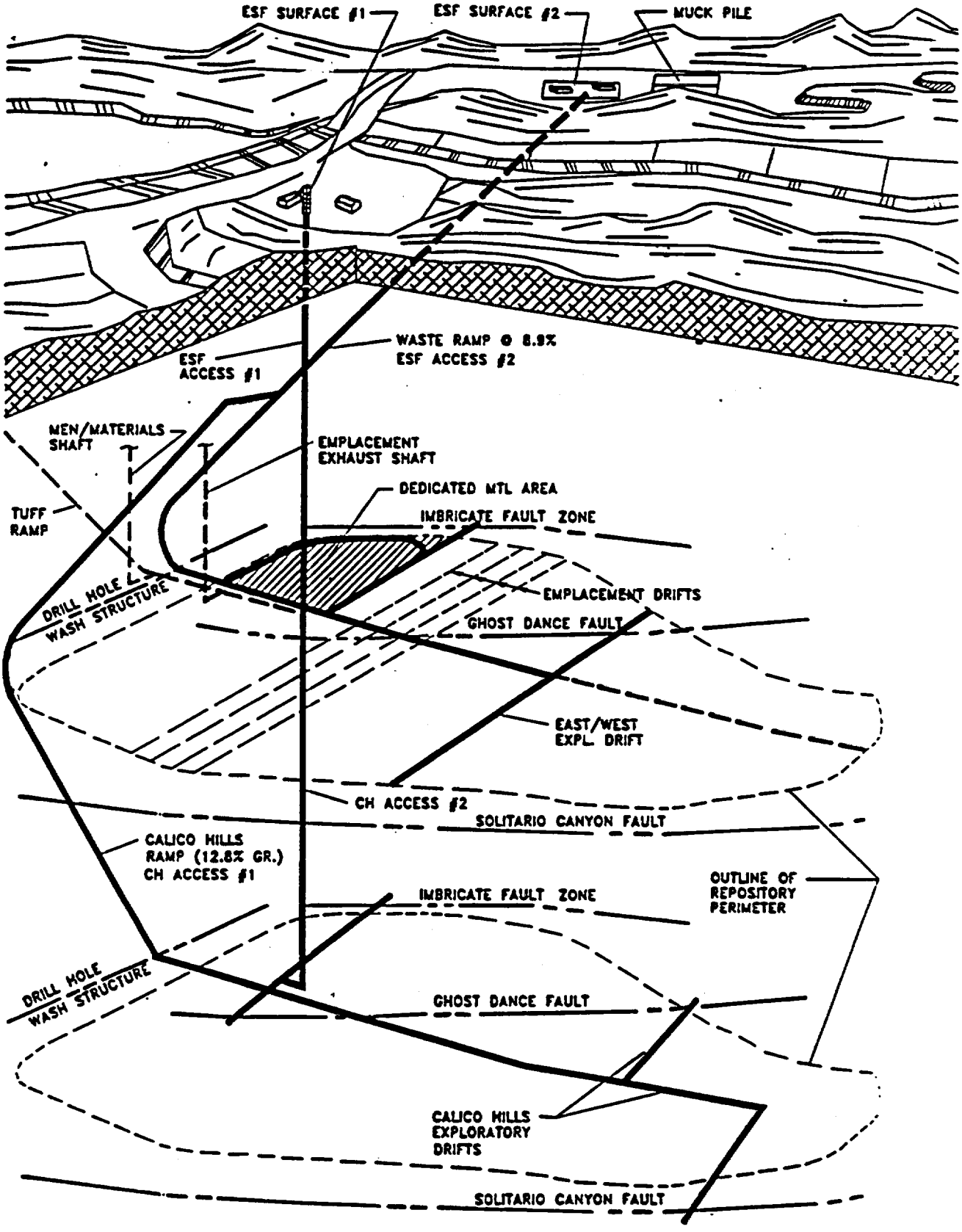
25

ESF ALTERNATIVES STUDY
TASK NO. 4
OPTION NO. B3 REV. 3
(V-MOLE)
ISOMETRIC SCENARIO #2
DATE



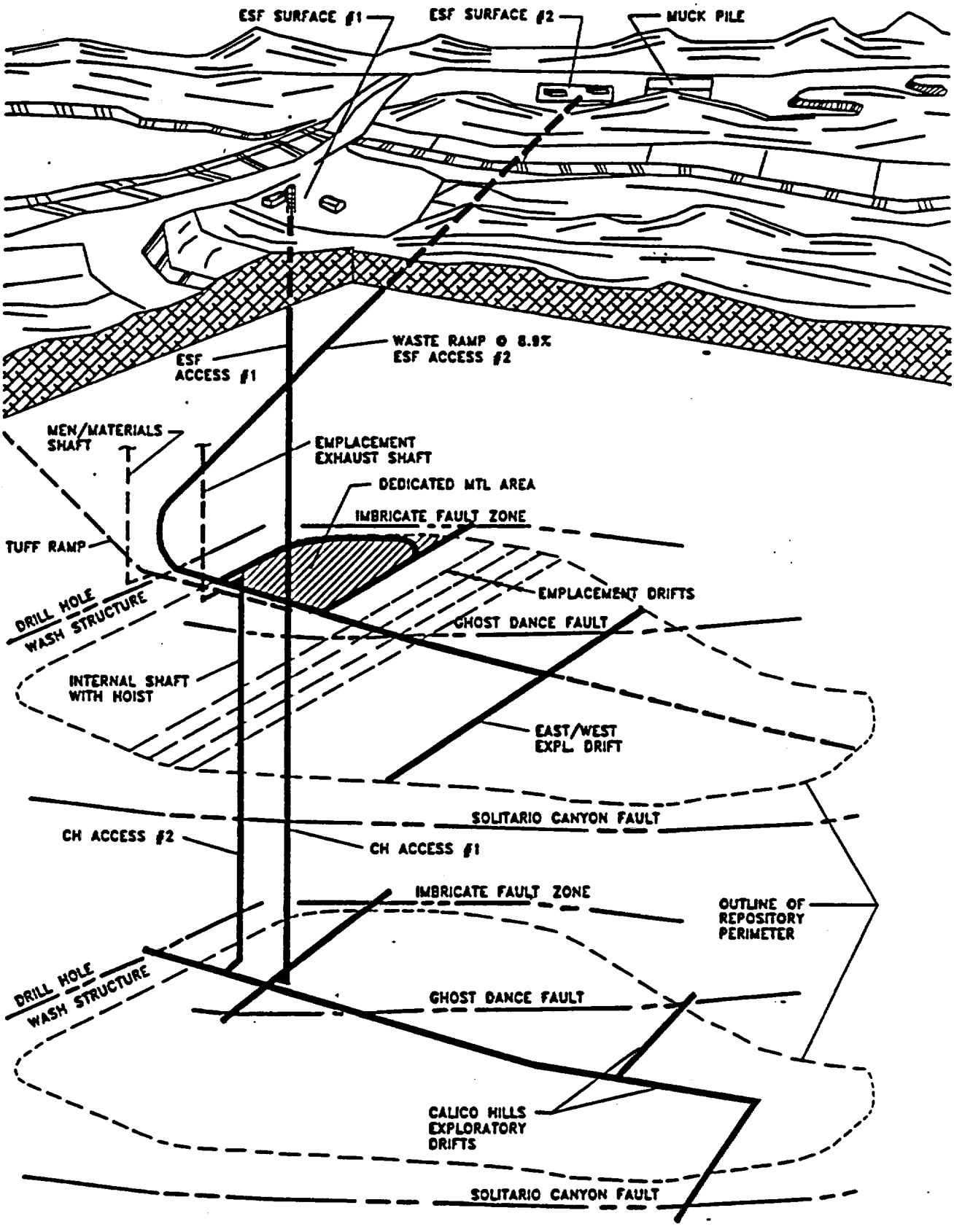
26

ESF ALTERNATIVES-STUDY
TASK NO. 4
OPTION NO. B3 REV. 4
(BLIND BORE)
ISOMETRIC SCENARIO #2
DATE



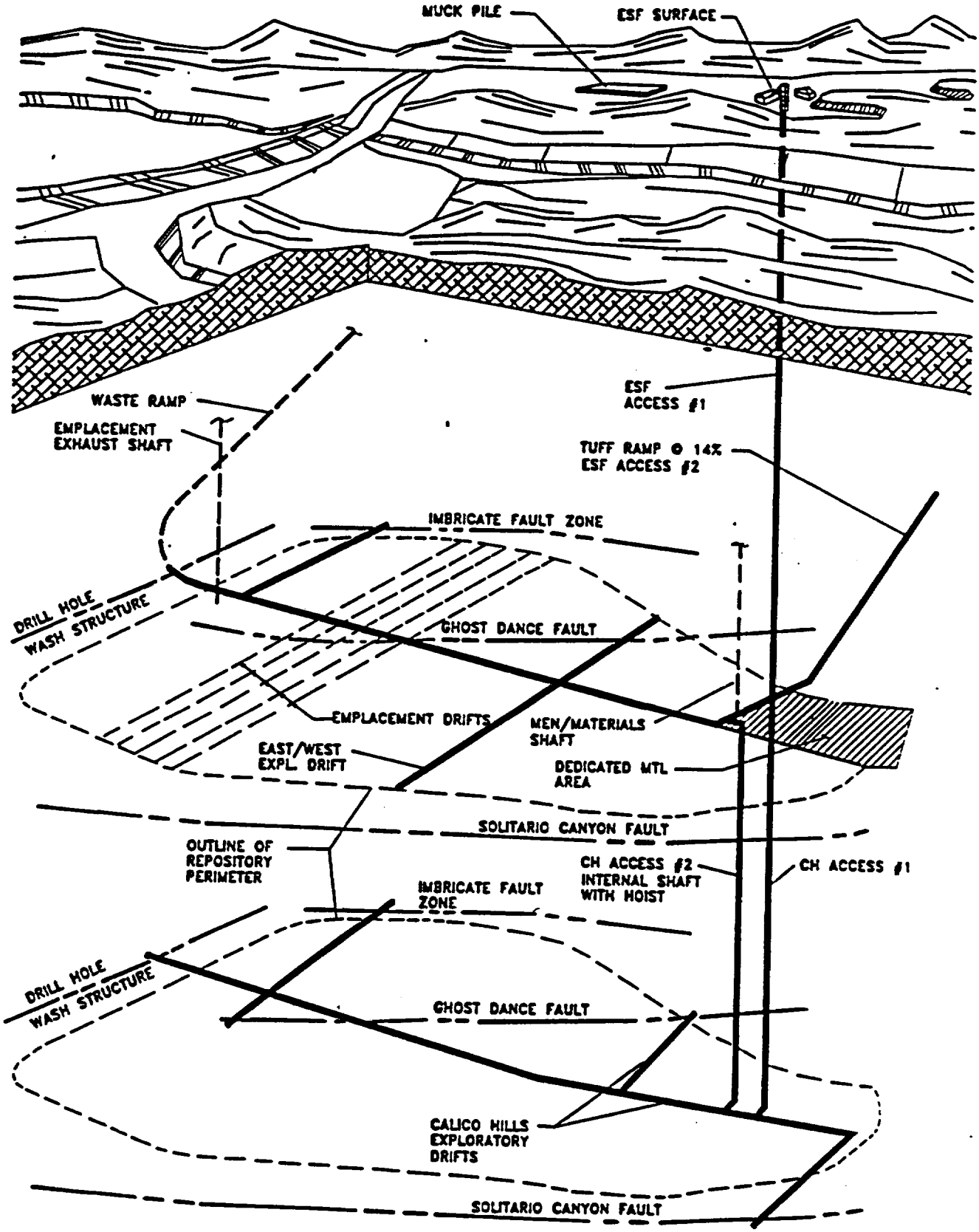
27

ESF ALTERNATIVES STUDY
TASK NO. 4
OPTION NO. B3 REV. 5
(RAISE BORE)
ISOMETRIC SCENARIO #2
DATE



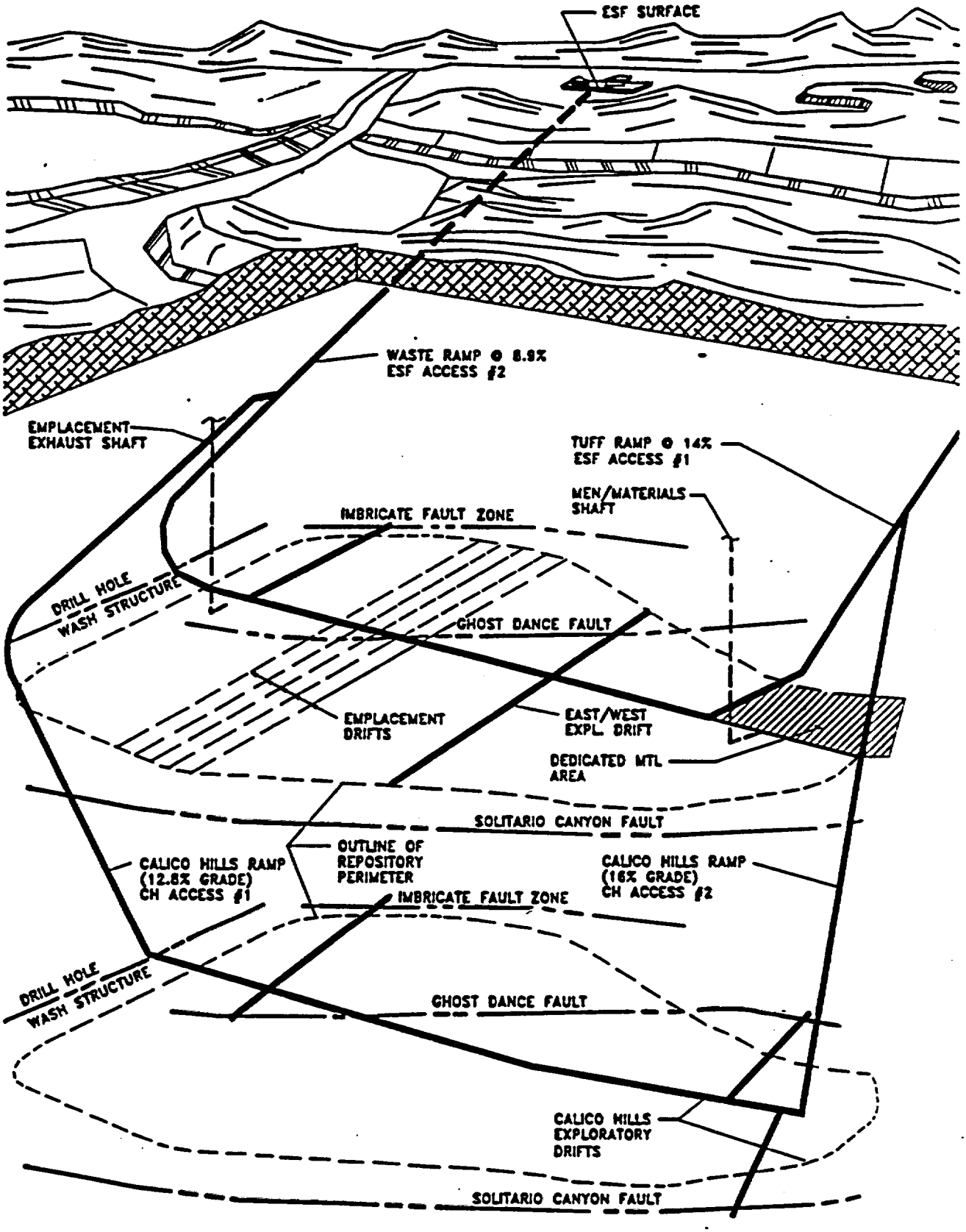
28

ESF ALTERNATIVES STUDY
TASK NO. 4
OPTION NO. B3 REV. 6
(DRILL & BLAST)
ISOMETRIC SCENARIO #2
DATE



29

ESF ALTERNATIVES STUDY
TASK NO. 4
OPTION NO. B4
ISOMETRIC SCENARIO #2
DATE



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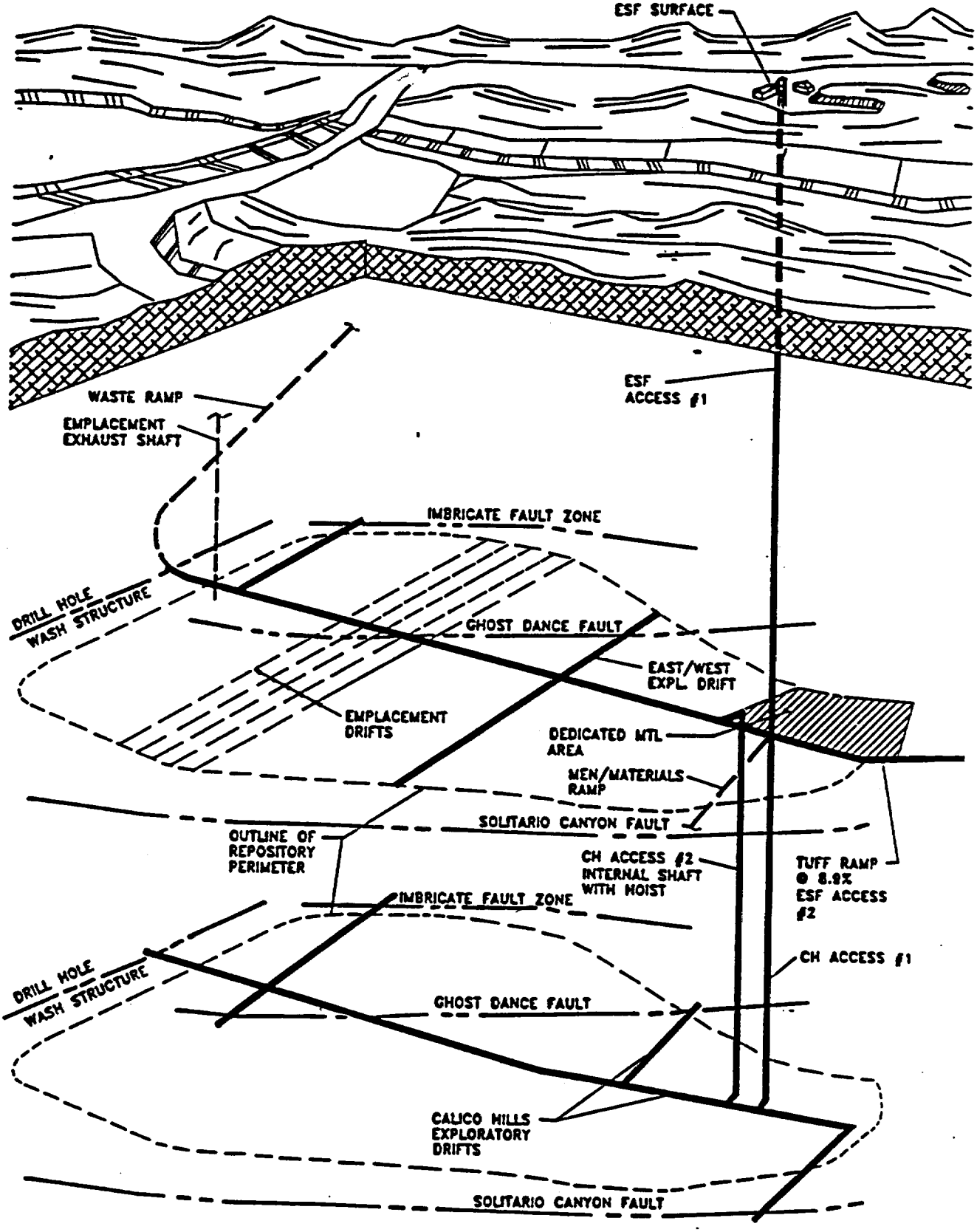
ESF ALTERNATIVES STUDY
TASK NO. 4
OPTION NO. B7
ISOMETRIC SCENARIO #2
DATE



31

ESF ALTERNATIVES STUDY
TASK NO. 4
OPTION NO. 88
ISOMETRIC SCENARIO #2
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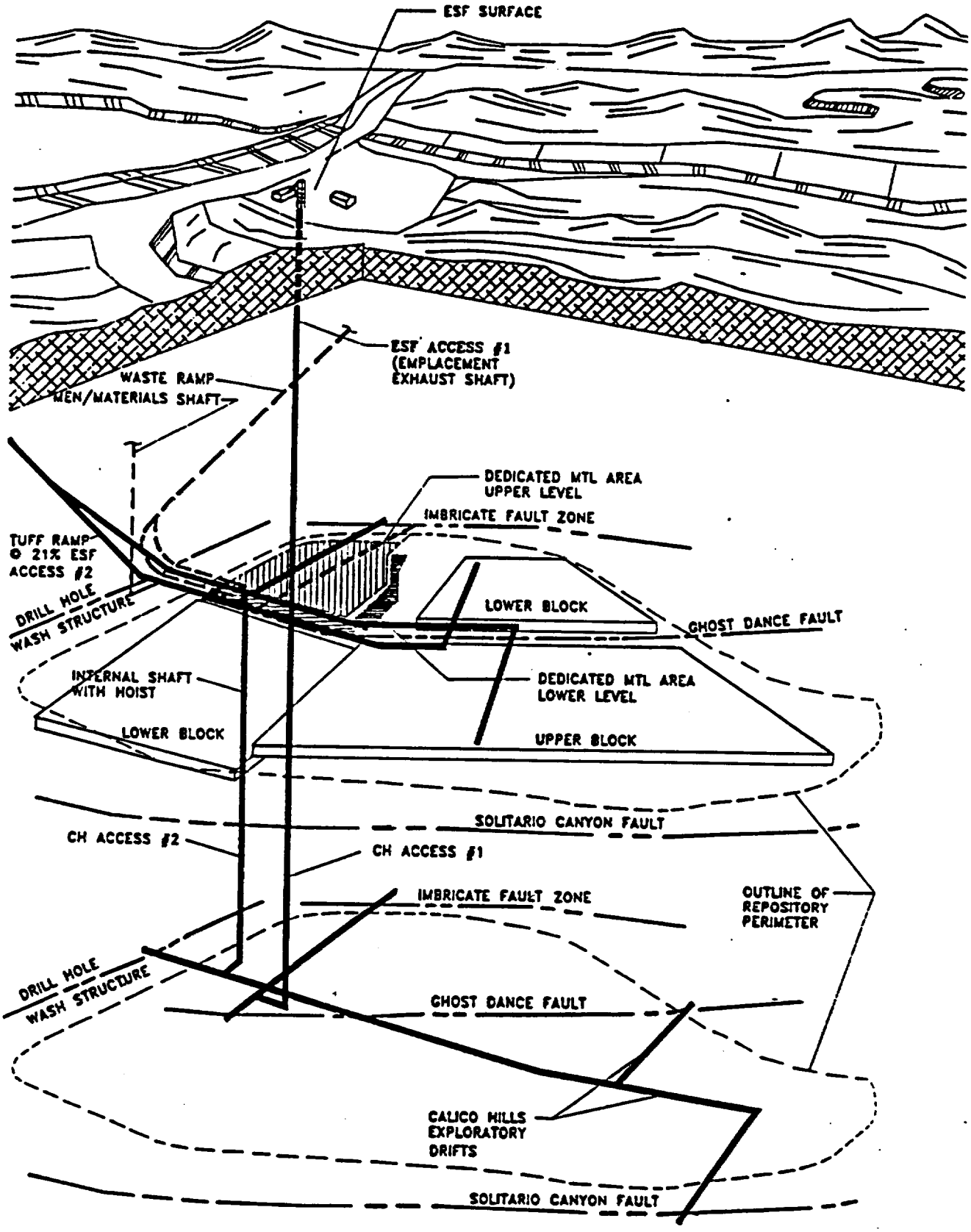
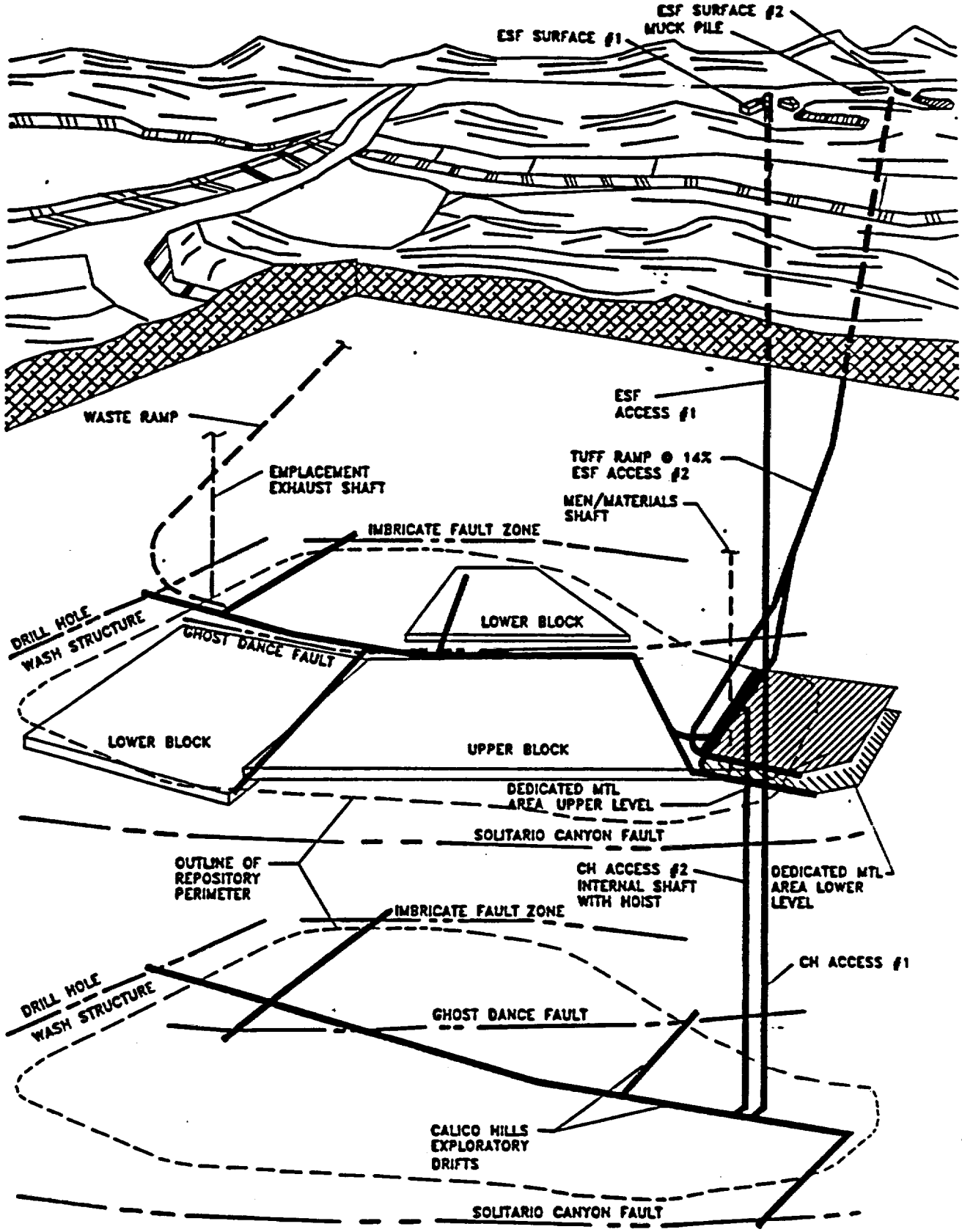


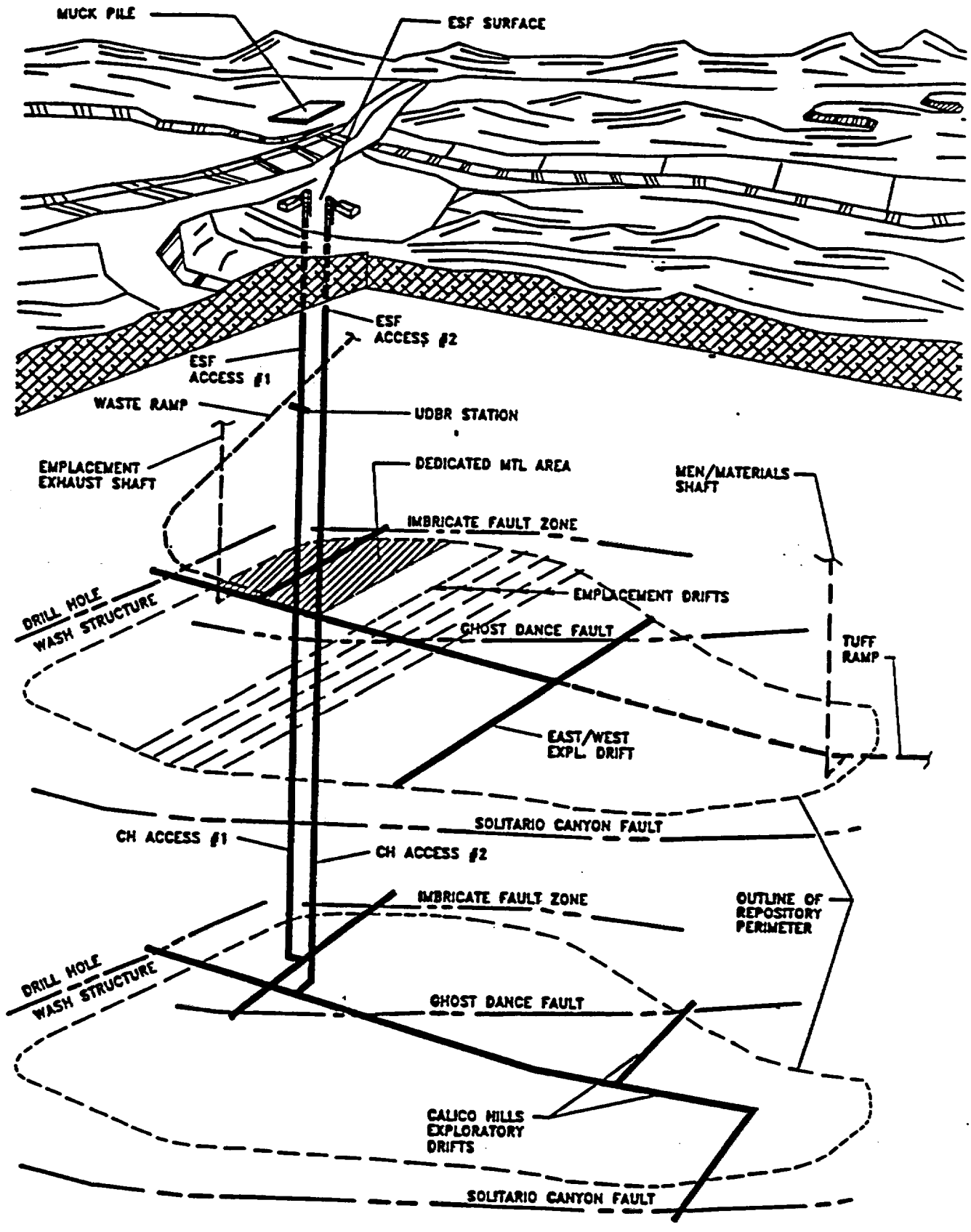
32

ESF ALTERNATIVES STUDY
TASK NO. 4
OPTION NO. C1
ISOMETRIC SCENARIO #2
DATE



33

ESF ALTERNATIVES STUDY
TASK NO. 4
OPTION NO. C4
ISOMETRIC SCENARIO #2
DATE

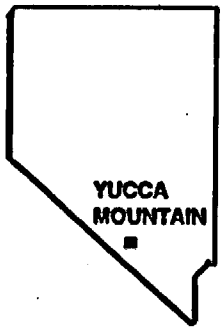


34

ESF ALTERNATIVES STUDY
TASK NO. 4
OPTION NO. R-11
ISOMETRIC SCENARIO #2
DATE

U.S. DEPARTMENT OF ENERGY

OCRWM



YUCCA MOUNTAIN
SITE CHARACTERIZATION
PROJECT

ESF ALTERNATIVES STUDY
RESULTS OF EVALUATION
SENSITIVITY INFORMATION

PRESENTED AT

DOE/NRC MEETING ON
CALICO HILLS RISK/BENEFIT ANALYSIS
AND ESF ALTERNATIVES STUDY

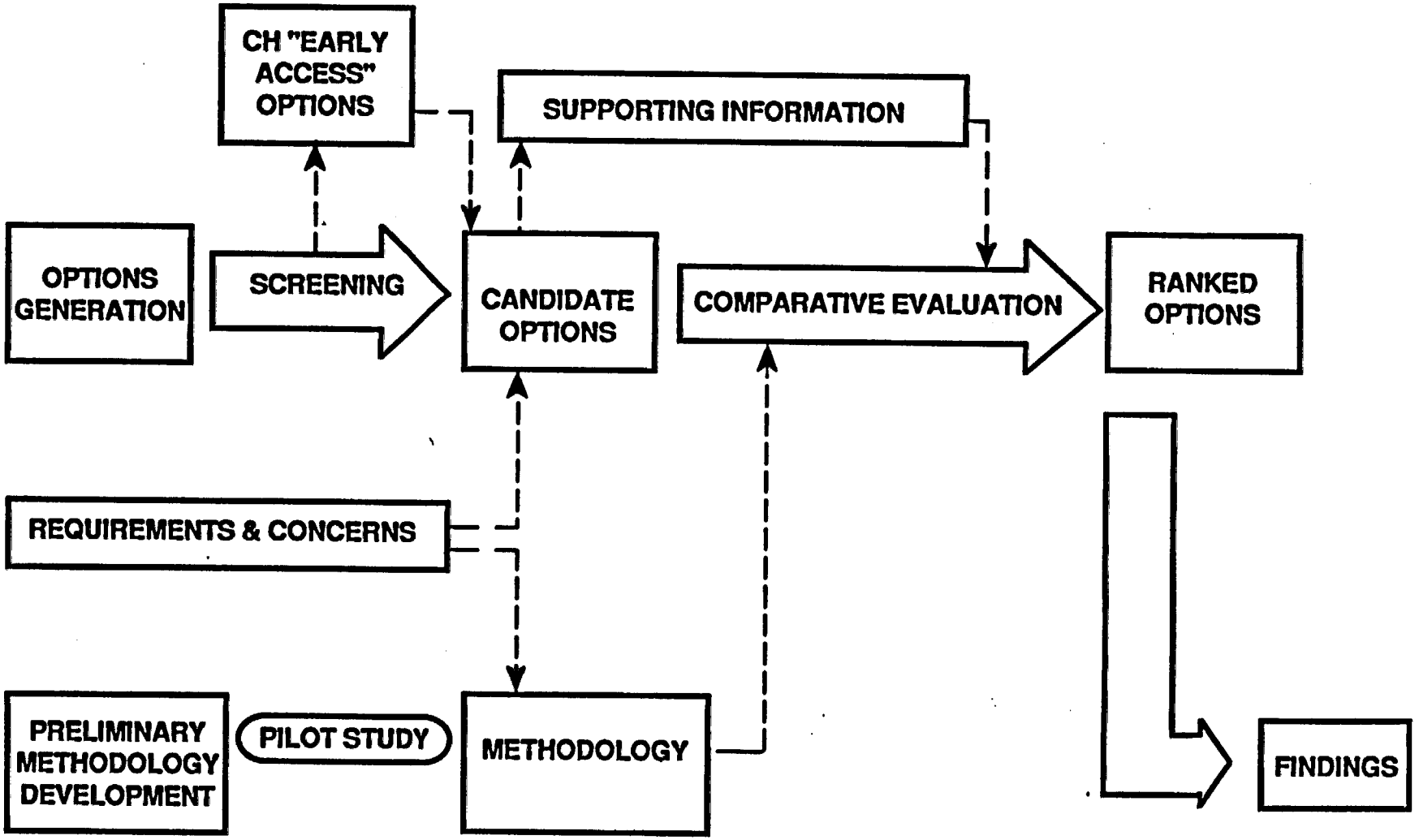
PRESENTED BY

DR. PAUL GNIRK
PRINCIPAL CONSULTANT
RE/SPEC INC.

JANUARY 29-31, 1991

Attachment 20

ESF ALTERNATIVES STUDY



ESOVTH5P.125/1-29-91

PERSONNEL COMPONENTS

SANDIA MANAGEMENT LEAD GROUP

AL STEVENS
AL DENNIS
LARRY COSTIN
STEVEN BAUER

DECISION METHODOLOGY GROUP

LEE MERKHOFER (ADA)
PHIL BECCUE (ADA)
JESSICA ROTHBERG (ADA)
PAUL GNIRK (RE/SPEC)
DAVID PARRISH (RE/SPEC)
WILLIAM BOYLE (RE/SPEC)

MANAGEMENT PANEL

TOM ISAACS (DOE)
STEPHAN BROCOUM (DOE)
RALPH STEIN (DOE)
LAKE BARRETT (DOE)
CARL GERTZ (DOE)
MAX BLANCHARD (DOE)
TED PETRIE (DOE)
LEO LITTLE (DOE)
TOM HUNTER (SNL)
TOM BLEJWAS (SNL
WENDELL WEART (SNL)
DICK LYNCH (SNL)

PERSONNEL COMPONENTS

(CONTINUED)

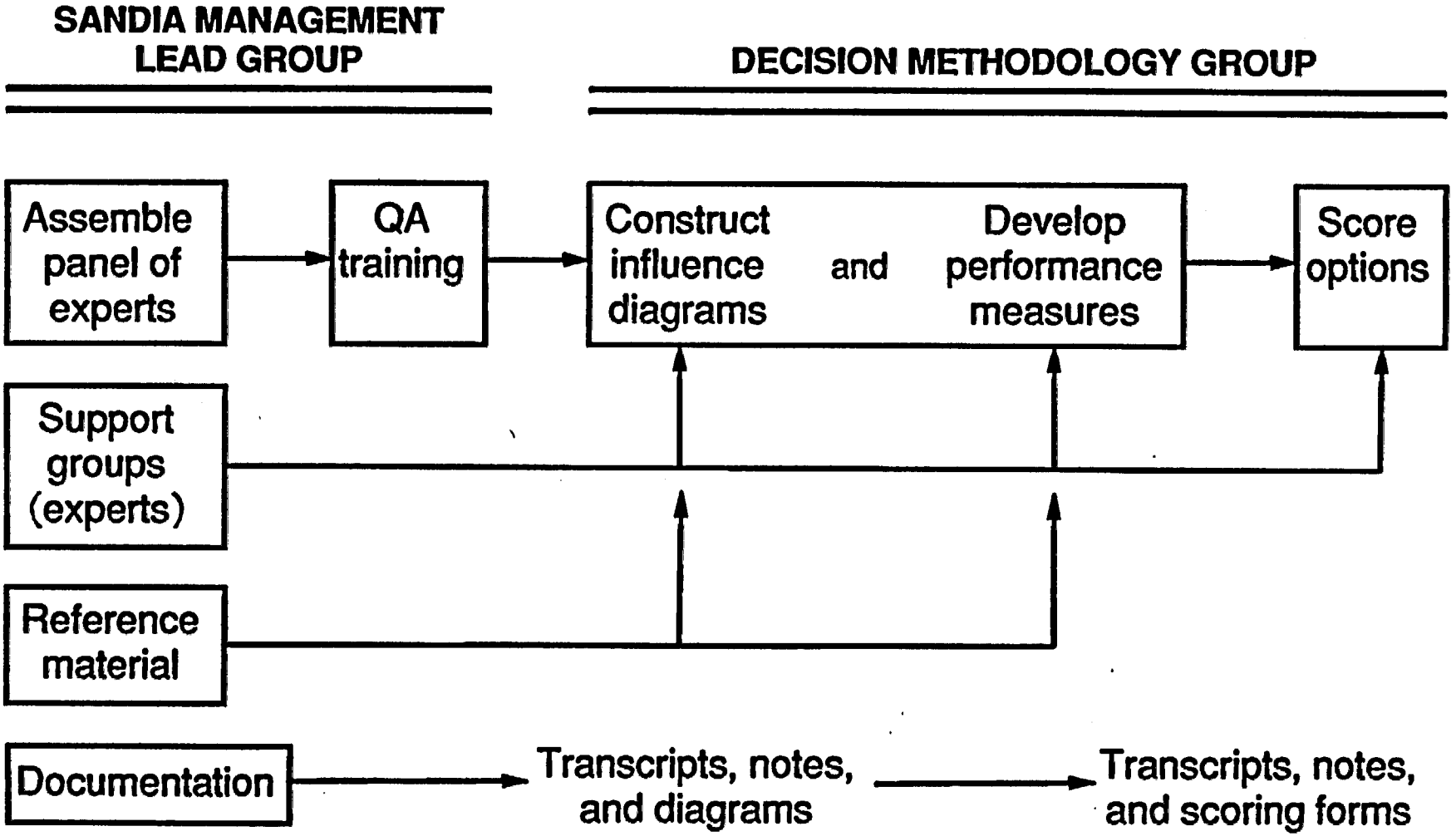
EXPERT PANELS

- POSTCLOSURE HEALTH
- PRECLOSURE RADIOLOGICAL HEALTH
- PRECLOSURE NON-RADIOLOGICAL HEALTH AND SAFETY
- ENVIRONMENT
  - AESTHETIC PROPERTIES
  - HISTORICAL PROPERTIES
  - BIOLOGICAL PROPERTIES (NON-DISCRIMINATORY)
- SOCIOECONOMICS (NON-DISCRIMINATORY)
- COST AND SCHEDULE
- CHARACTERIZATION TESTING
- REGULATORY APPROVAL
- PROGRAM VIABILITY

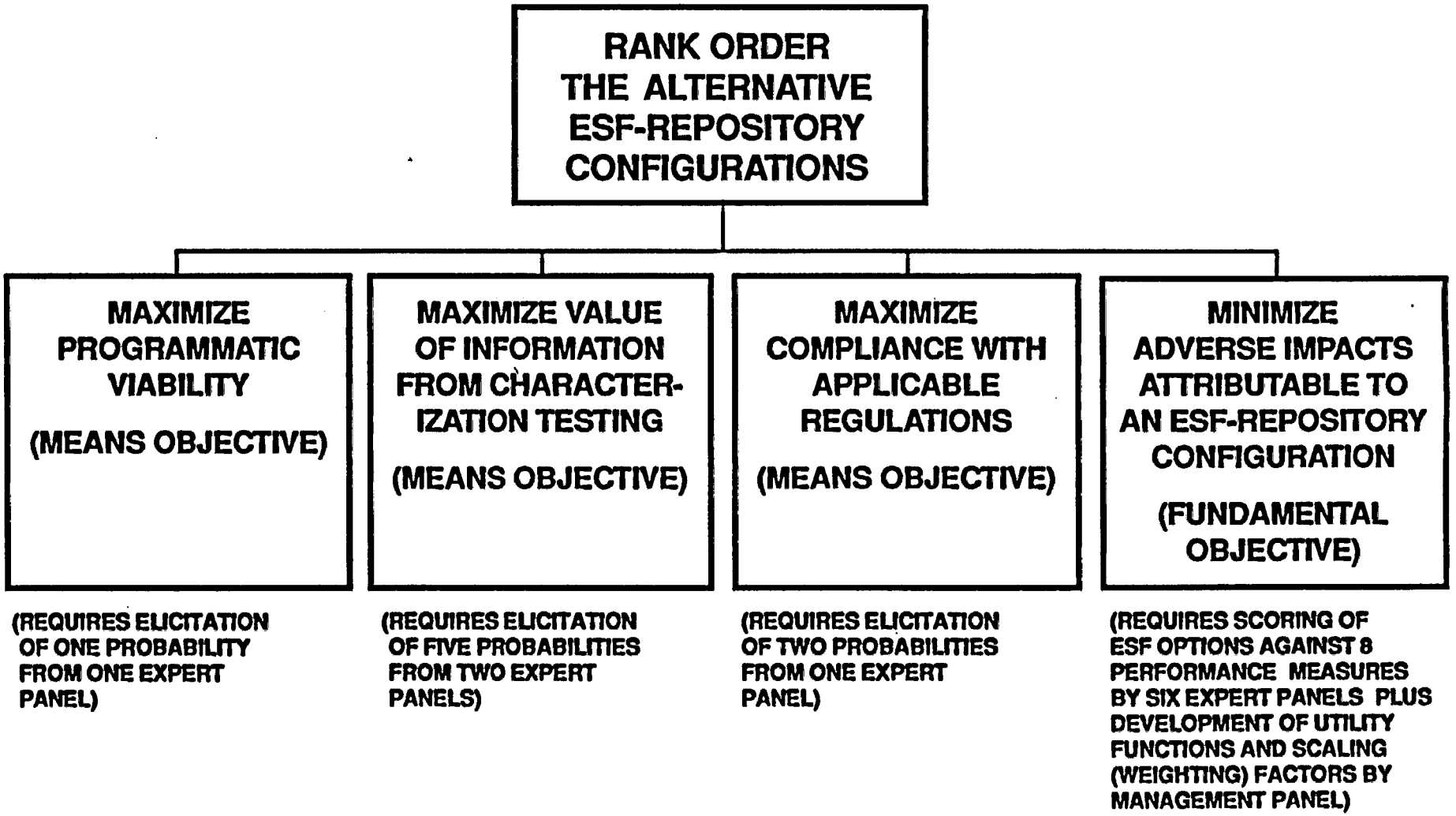
SUPPORT GROUPS

- SURFACE DESIGN
- UNDERGROUND DESIGN
- COST/SCHEDULE
- TESTING
- REQUIREMENTS

EXPERT PANEL INVOLVEMENT (FOR EACH OBJECTIVE)



HIGHEST-LEVEL OBJECTIVES FOR THE COMPARATIVE EVALUATION OF ESF ALTERNATIVES



ESDPPG5P.A33/1-29-91

THE METHODOLOGY HAS DISTINCTIVE CHARACTERISTICS DELIBERATELY SELECTED TO MEET SPECIAL NEEDS OF THE STUDY

- EXPLICIT CONSIDERATION OF IMPACT OF ESF CHOICE ON DOWN-STREAM REPOSITORY DECISIONS (e.g. CONSTRUCTION AUTHORIZATION)
- RELIANCE ON TECHNICAL PANELS TO PROVIDE INPUTS BASED ON INFORMED PROFESSIONAL JUDGEMENT
- EXTENSIVE DOCUMENTATION OF PROCESS
- USE OF FORMAL DECISION ANALYSIS LOGIC (e.g. MULTI-ATTRIBUTE UTILITY ANALYSIS)

THE DESIRE FOR AN UNBIASED AND LOGICALLY DEFENSIBLE ANALYSIS REQUIRED MODIFICATIONS TO THE TYPICAL MULTIATTRIBUTE UTILITY ANALYSIS (MUA) APPROACH

- THE TYPICAL MUA APPROACH (SCORE, WEIGHT, AND ADD) IS STRICTLY CORRECT ONLY IF THE OBJECTIVES ARE "ADDITIVE INDEPENDENT", i.e.:

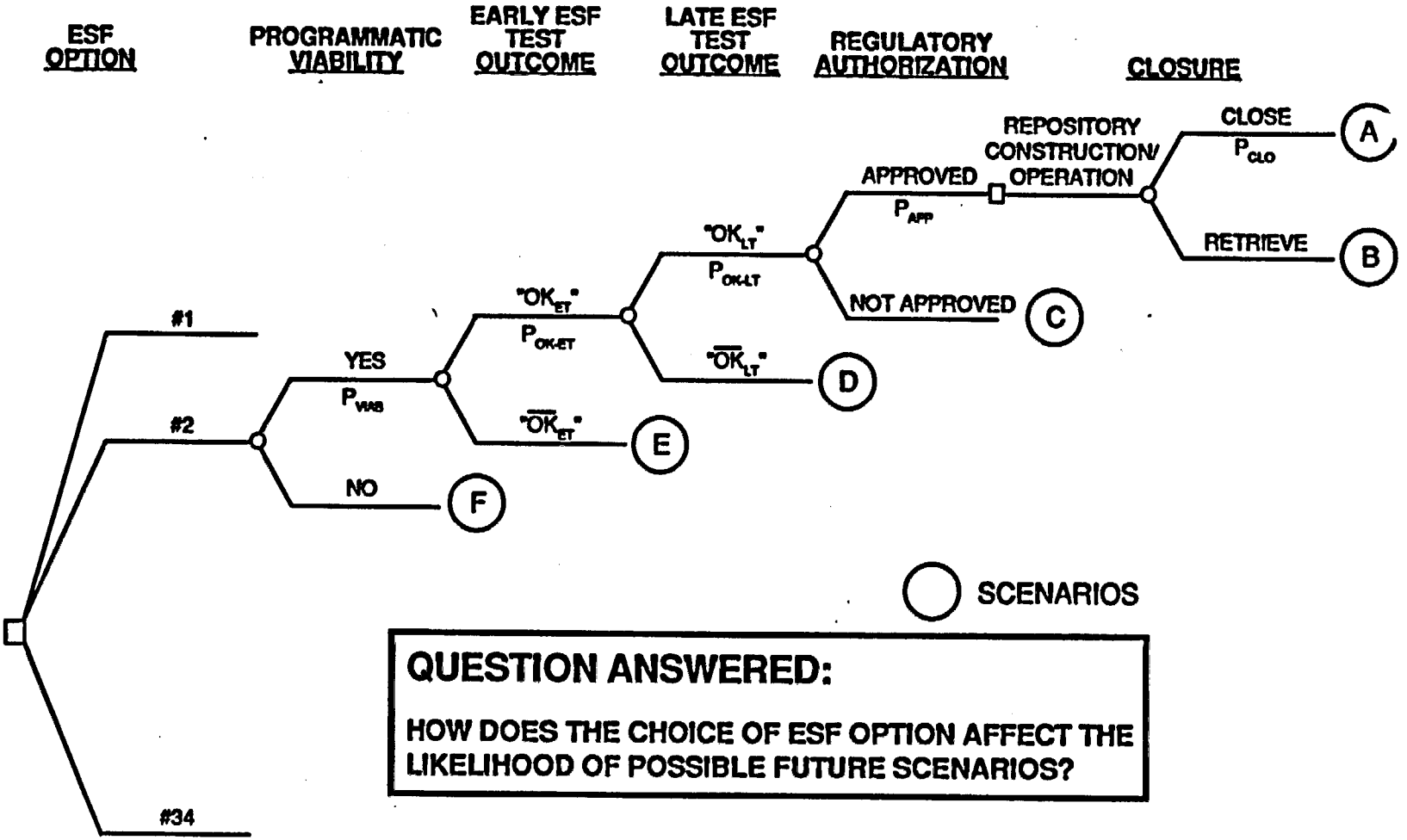
  IMPORTANCE OF DOING WELL ON ANY ONE OBJECTIVE DOES NOT DEPEND ON HOW WELL YOU DO ON ANY OTHER OBJECTIVE (PREFERENTIAL INDEPENDENCE)

- MEANS OBJECTIVES CLEARLY FAIL THIS TEST BECAUSE THE IMPORTANCE OF DOING WELL ON ANY ONE OBJECTIVE DOES DEPEND ON HOW WELL YOU DO ON ANY OTHER OBJECTIVE

- THEREFORE, DECISION TREE APPROACH USED TO CORRECTLY DEAL WITH OBJECTIVES THAT CANNOT BE HANDLED BY TYPICAL MUA APPROACH

ESF OPTIONS ARE EVALUATED BY ESTIMATING:

1. THE IMPACT OF THE ESF OPTION ON THE LIKELIHOOD OF IMPORTANT DOWN-STREAM REPOSITORY DECISIONS



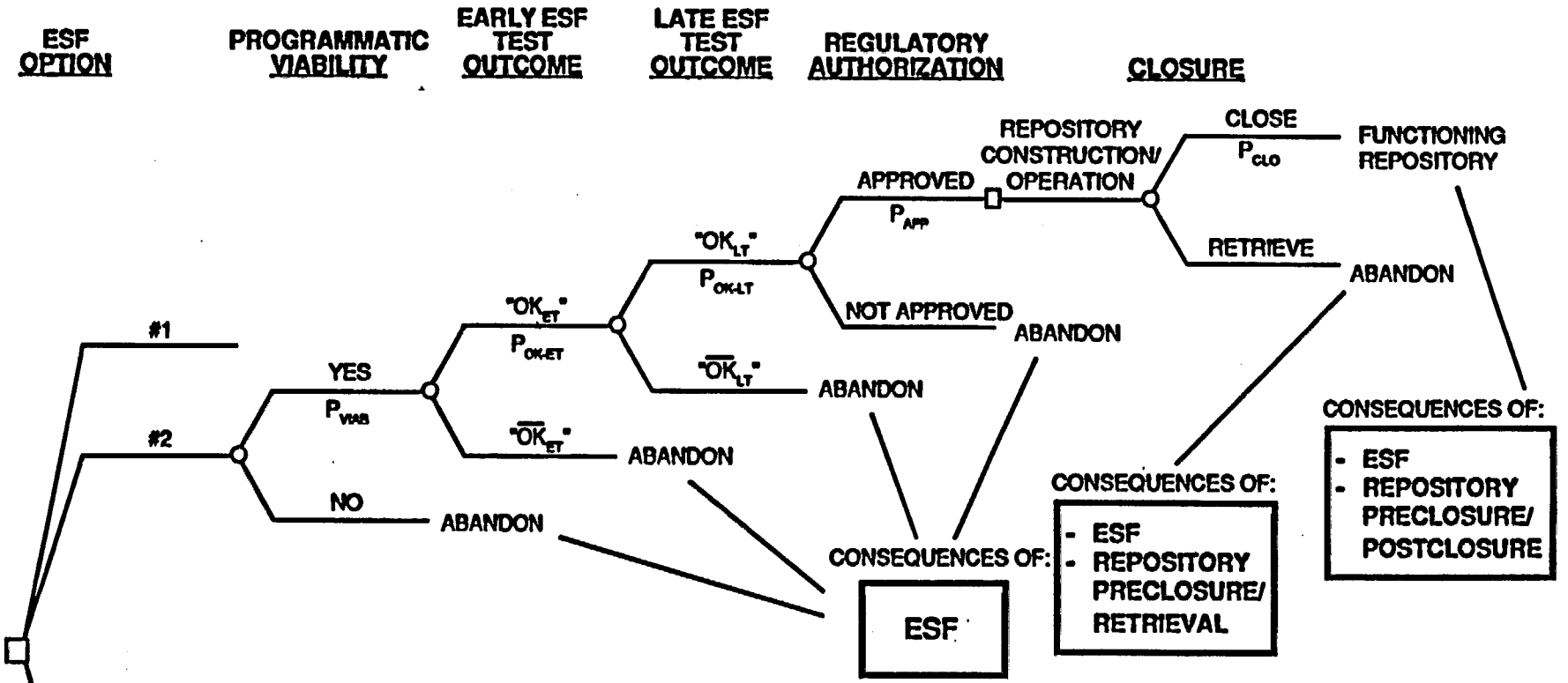
QUESTION ANSWERED:

HOW DOES THE CHOICE OF ESF OPTION AFFECT THE LIKELIHOOD OF POSSIBLE FUTURE SCENARIOS?

ESDPPG5P.A33/1-29-91

ESF OPTIONS ARE EVALUATED BY ESTIMATING:

2. THE END CONSEQUENCES OF EACH OF THE POSSIBLE FUTURE SCENARIOS

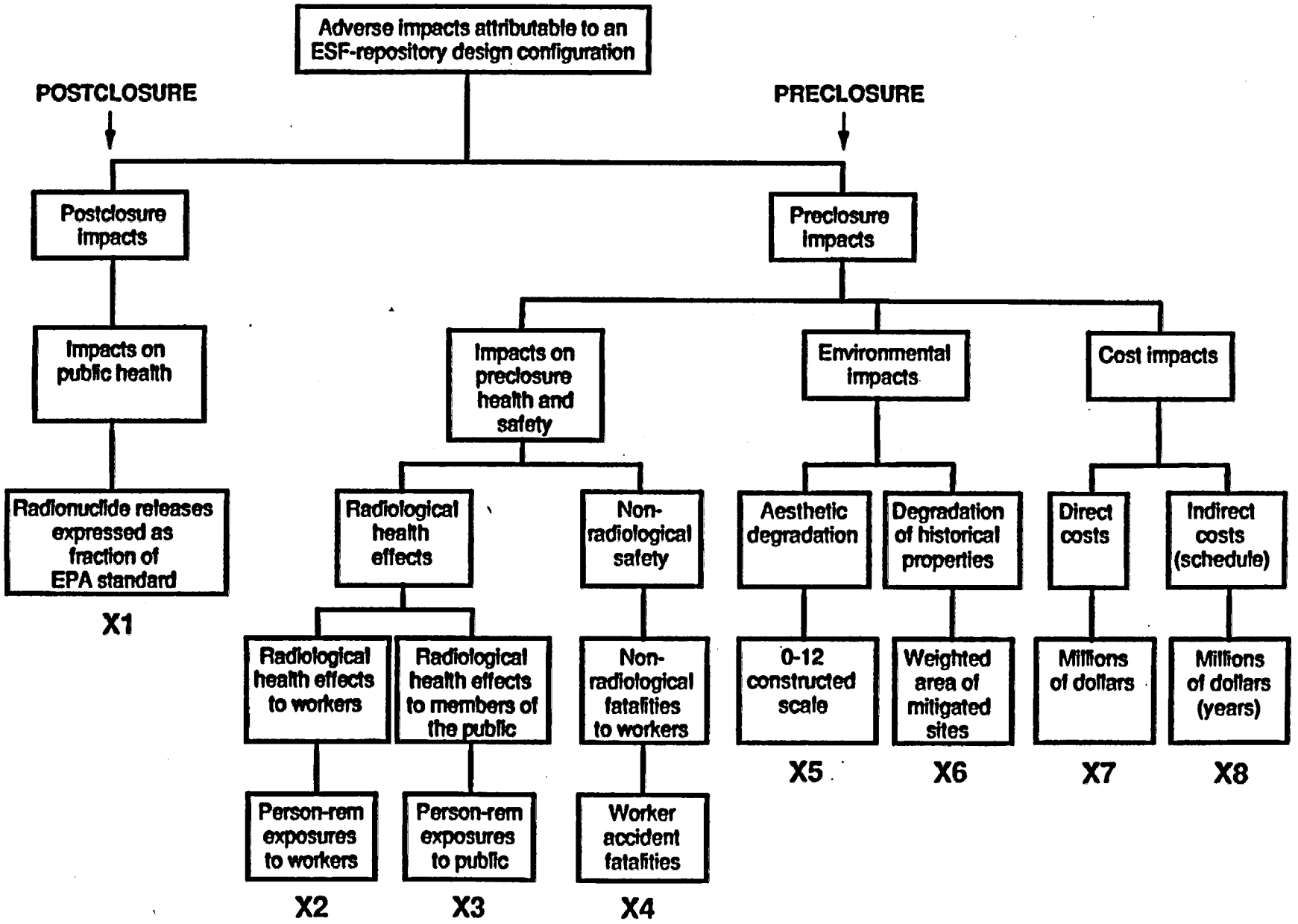


QUESTION ANSWERED:

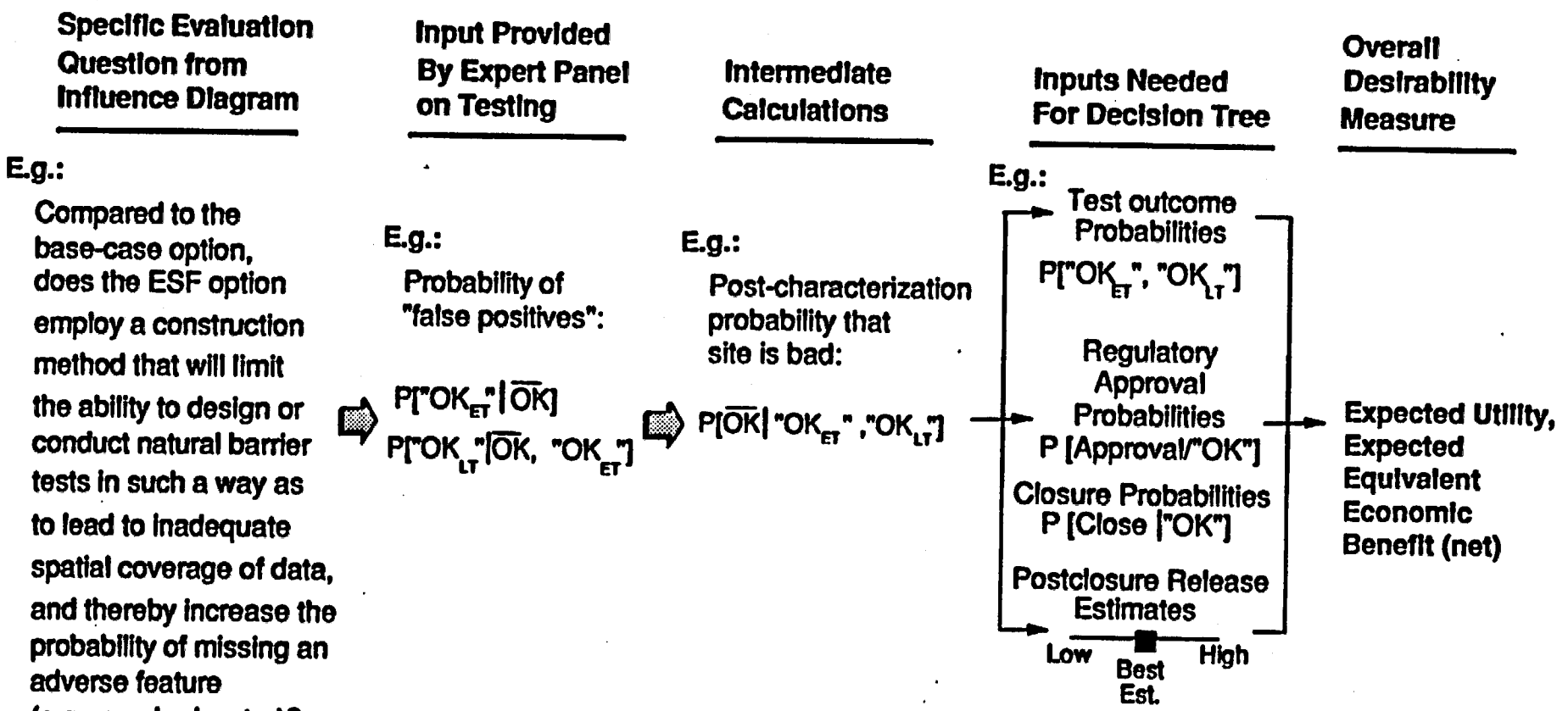
e.g., SUPPOSE A GIVEN ESF CHOICE LEADS TO A CLOSED REPOSITORY -- WHAT IS THE ESTIMATE OF POSTCLOSURE RELEASES?

ESDPPG5P.A33/1-29-91

MEASURES DEFINED FOR QUANTIFYING END CONSEQUENCES



INFLUENCE DIAGRAMS (AND OTHER TECHNIQUES) ARE USED TO RELATE PROBABILITY AND CONSEQUENCE ESTIMATES TO SPECIFIC OPTION CHARACTERISTICS

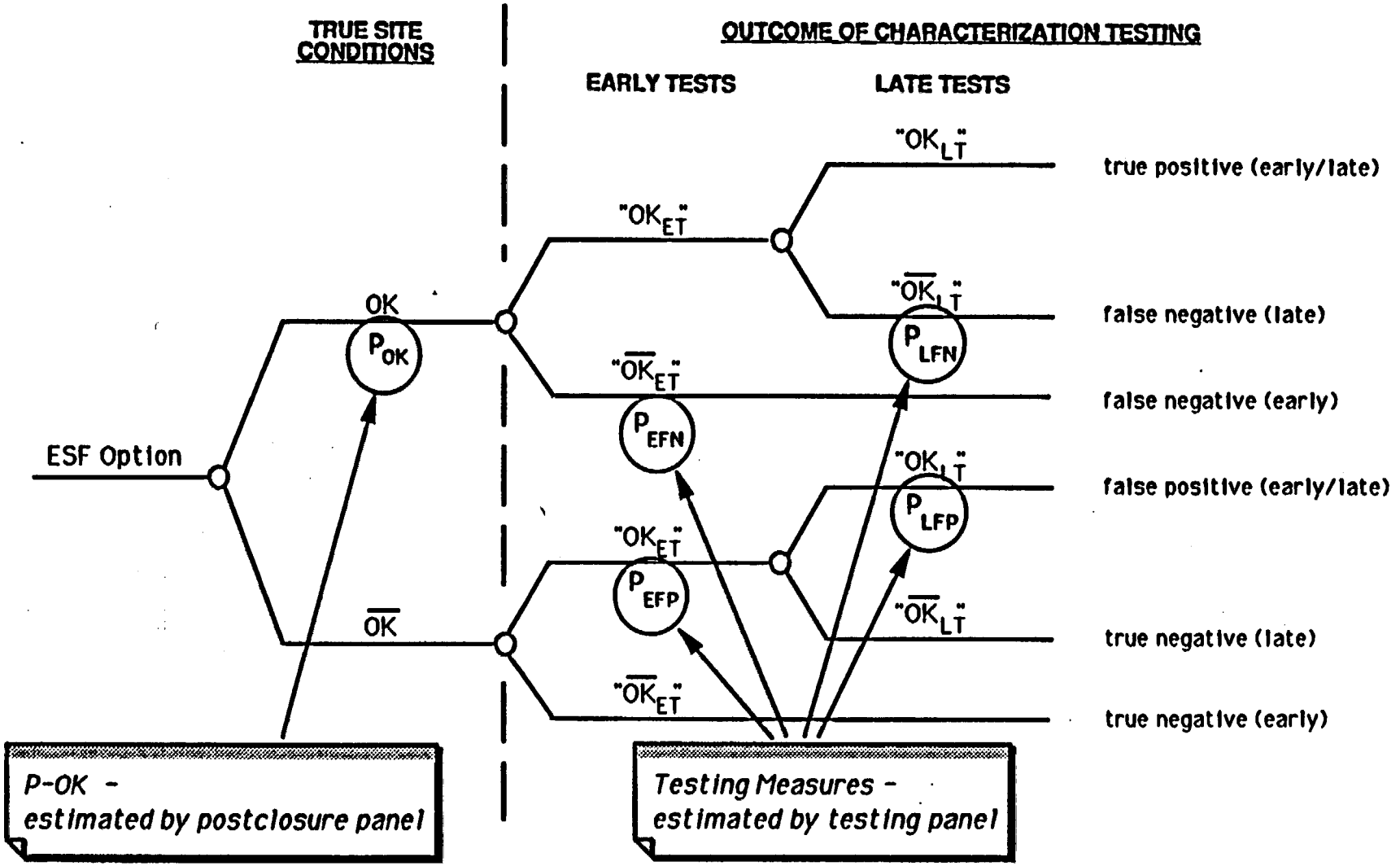


CHARACTERIZATION TESTING

IMPACT OF ESF OPTIONS ON TESTING

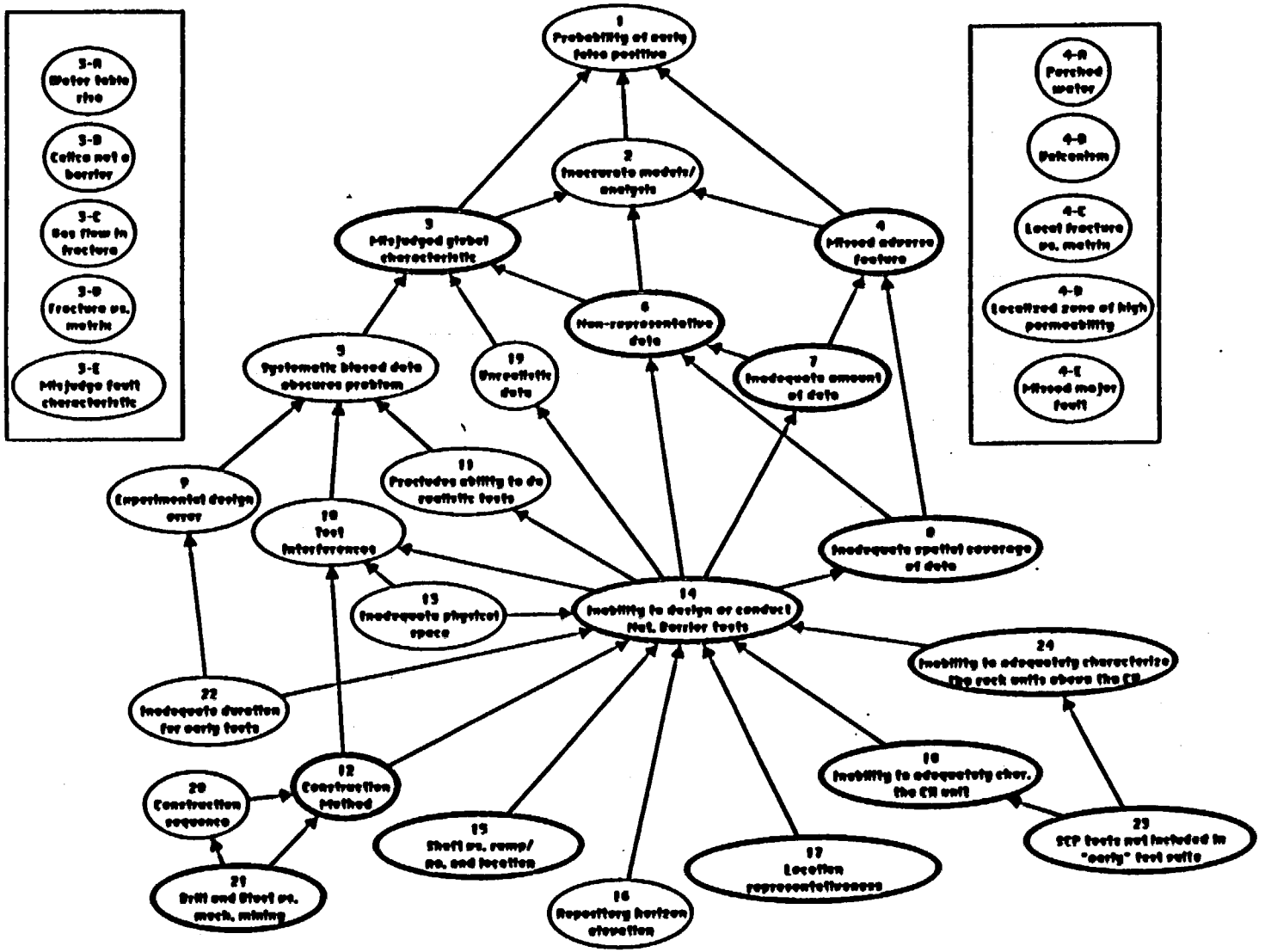
1. PERFORMANCE MEASURES
2. INFLUENCE DIAGRAMS AND EVALUATION QUESTIONS
3. EVALUATION PROCESS
4. RESULTS

TREE SHOWING POSSIBLE TRUE SITE CONDITIONS AND POSSIBLE TEST OUTCOMES



INFLUENCE DIAGRAM (AND OTHER TECHNIQUES) ARE USED TO RELATE PROBABILITY AND CONSEQUENCE ESTIMATES TO SPECIFIC OPTION CHARATERISTICS

EXAMPLE MEASURE: PROBABILITY OF EARLY FALSE POSITIVE



POSTCLOSURE RELEASES RESULTS

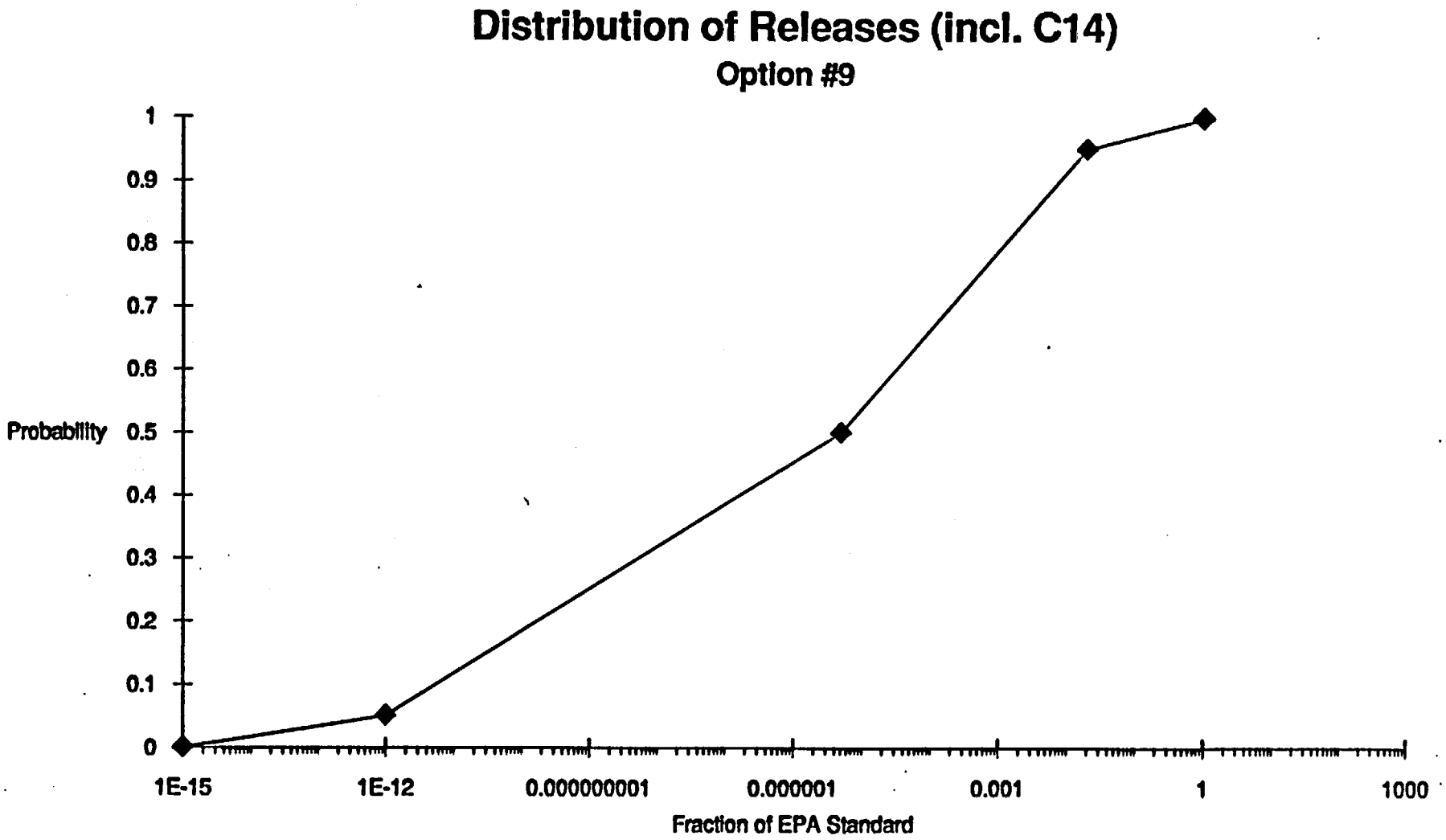
Assessed Variable: **POSTCLOSURE RELEASES**
Units: **fraction of EPA standard**

Includes C14+aqueous releases

Option	Low	Best	High	Max
6,23	0.00001	0.017	0.20	2.00
13,30	0.00001	0.017	0.20	2.00
5,22	0.00001	0.017	0.20	2.00
12,29	0.00001	0.017	0.20	2.00
14,31	0.00001	0.017	0.20	2.00
15,32	0.00001	0.017	0.20	2.00
16,33	0.00001	0.017	0.20	2.00
2,19	0.00001	0.019	0.20	2.00
4,21	0.00001	0.019	0.20	2.00
1,18	0.00001	0.020	0.20	2.00
3,20	0.00001	0.020	0.20	2.00
7,24	0.00001	0.020	0.20	2.00
8,25	0.00001	0.020	0.20	2.00
10,27	0.00001	0.020	0.20	2.00
11,28	0.00001	0.020	0.20	2.00
17,34	0.00001	0.020	0.20	2.00
9,26	0.00001	0.023	0.20	2.00

Includes aqueous releases only

Option	Low	Best	High	Max
16,33	1E-12	2E-07	0.01	1.00
15,32	1E-12	3E-07	0.01	1.00
6,23	1E-12	6E-07	0.01	1.00
3,20	1E-12	6E-07	0.01	1.00
13,30	1E-12	6E-07	0.01	1.00
2,19	1E-12	7E-07	0.01	1.00
5,22	1E-12	8E-07	0.01	1.00
7,24	1E-12	8E-07	0.01	1.00
11,28	1E-12	8E-07	0.01	1.00
12,29	1E-12	8E-07	0.01	1.00
8,25	1E-12	9E-07	0.01	1.00
10,27	1E-12	9E-07	0.01	1.00
1,18	1E-12	1E-06	0.01	1.00
4,21	1E-12	2E-06	0.01	1.00
14,31	1E-12	2E-06	0.01	1.00
17,34	1E-12	2E-06	0.01	1.00
9,26	1E-12	5E-06	0.02	1.00


Distribution of Releases (incl. C14)
Option #9
Probability
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1E-15
1E-12
0.000000001
0.000001
0.001
1
1000
Fraction of EPA Standard

PROGRAMMATIC VIABILITY

IMPACT OF ESF OPTIONS ON LIKELIHOOD OF PROGRAMMATIC VIABILITY

1. PERFORMANCE MEASURE AND INFLUENCE DIAGRAM

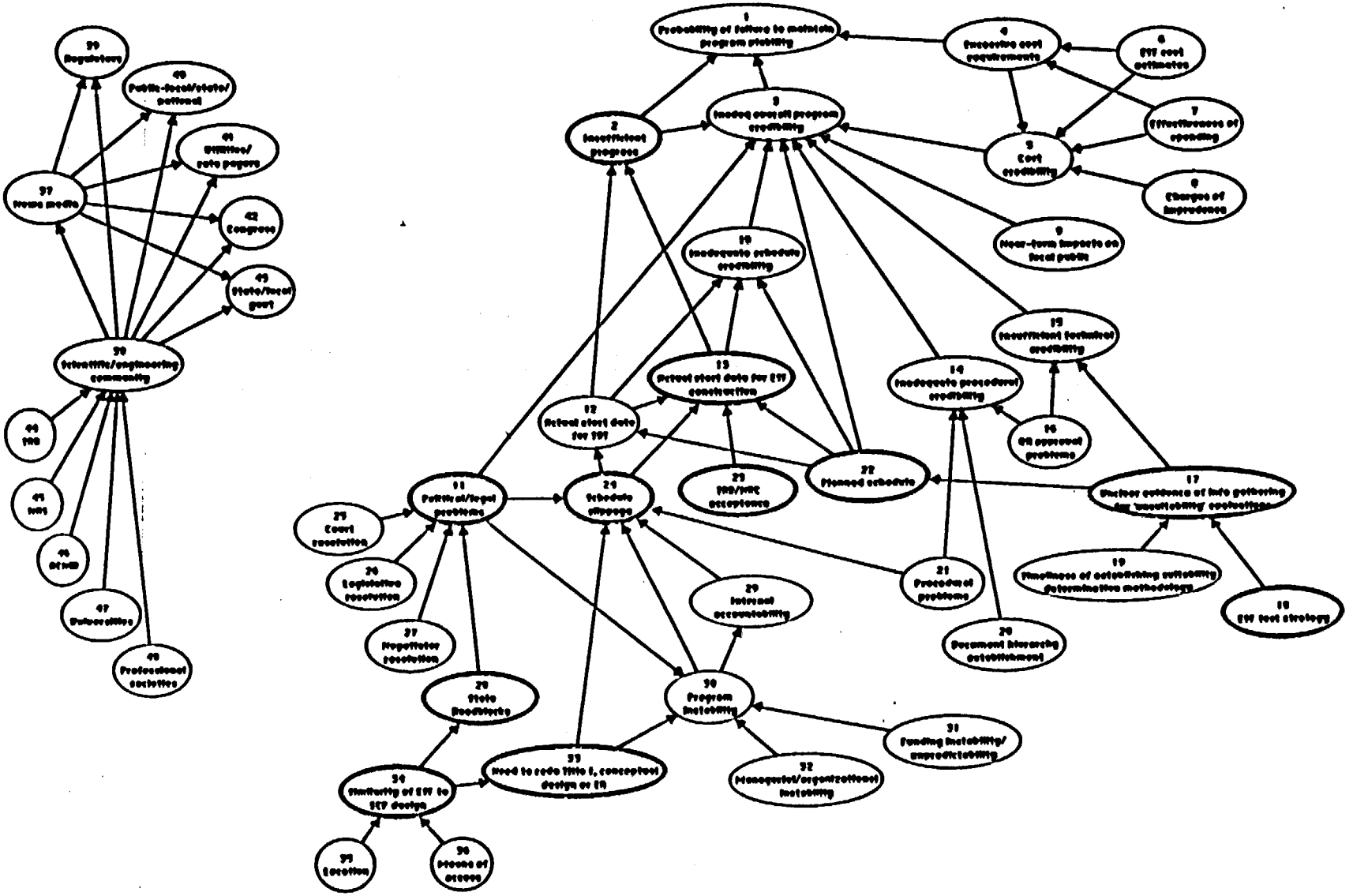
2. INFLUENCE DIAGRAM AND EVALUATION PROCESS

3. EVALUATION PROCESS

4. RESULTS

MEASURE AND INFLUENCE DIAGRAM FOR LIKELIHOOD OF FAILURE TO MAINTAIN PROGRAMMATIC VIABILITY

MEASURE: ESTIMATED PROBABILITY OF CONTINUED NEAR-TERM PROGRAMMATIC VIABILITY

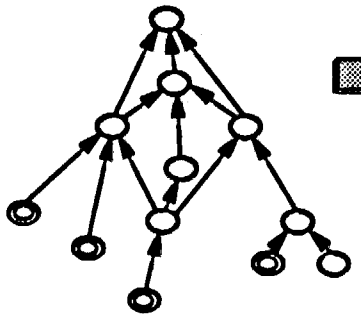


PROGRAMMATIC VIABILITY

Option	$ M/ month (average)	Compared to ESF original Title II Design (w/o CH), what is potential for: Design Dissimilarity?	Schedule Slippage in Re-Design?	What is potential for resolution of concerns by: NWTRB	NRC	Prob of site not OK given "OK-ET","OK-LT" (%)	Probability of Regulatory Approval (%)	Option
1	4.6	☹☹	☹	•	☺	1.0	78	1
2	5.7	☹☹☹☹	☹☹	• • •	☺☺	0.7	93	2
3	4.9	☹☹☹	☹	•	☺☺	0.8	89	3
4	6.2	☹☹☹☹	☹☹	• • •	☺☺☺	0.6	87	4
5	6.0	☹☹☹☹	☹☹	• • •	☺☺☺	0.7	85	5
6	6.2	☹☹☹☹	☹☹	• • • •	☺☺☺☺	0.8	93	6
7	6.4	☹☹☹☹	☹☹	• • • •	☺☺☺	0.8	92	7
8	6.3	☹☹☹☹	☹☹	• • • • •	☺☺☺	0.9	85	8
9	6.4	☹☹☹☹	☹☹	• •	☺☺	2.6	67	9
10	6.2	☹☹☹☹	☹☹	• •	☺☺	1.3	74	10
11	5.9	☹☹☹☹	☹☹	• • •	☺☺	0.9	83	11
12	6.5	☹☹☹☹	☹☹	• • •	☺☺☺	0.7	81	12
13	7.3	☹☹☹☹	☹☹	• • • •	☺☺☺☺	0.8	89	13
14	6.1	☹☹☹☹	☹☹	• • •	☺☺☺	0.7	78	14
15	7.1	☹☹☹☹☹	☹☹☹	• • •	☺☺☺	0.5	95	15
16	6.8	☹☹☹☹☹	☹☹☹	• • •	☺☺☺☺	0.6	90	16
17	4.8	☹☹	☹	•	☺☺	0.9	70	17
18	5.7	☹☹	☹☹	•	☺	1.0	77	18
19	6.1	☹☹☹☹	☹☹	• • •	☺☺	0.9	90	19
20	5.5	☹☹☹	☹☹	•	☺☺	0.9	83	20
21	6.8	☹☹☹☹	☹☹	• • •	☺☺☺	0.8	84	21
22	6.3	☹☹☹☹	☹☹	• • •	☺☺☺	0.9	78	22
23	7.1	☹☹☹☹	☹☹	• • • •	☺☺☺☺	0.9	90	23
24	6.7	☹☹☹☹	☹☹	• • • •	☺☺☺	1.0	86	24
25	6.1	☹☹☹☹	☹☹	• • • •	☺☺☺	1.0	80	25
26	6.8	☹☹☹☹	☹☹☹☹	• •	☺☺	2.5	66	26
27	6.1	☹☹☹☹	☹☹☹☹	• •	☺☺	1.2	73	27
28	6.2	☹☹☹☹	☹☹	• •	☺☺	0.9	82	28
29	6.7	☹☹☹☹	☹☹	• • •	☺☺☺	0.9	79	29
30	7.4	☹☹☹☹	☹☹☹☹	• • • •	☺☺☺☺	0.8	87	30
31	6.4	☹☹☹☹	☹☹	• •	☺☺☺	0.9	77	31
32	7.5	☹☹☹☹☹	☹☹☹☹	• • •	☺☺☺	0.7	94	32
33	6.4	☹☹☹☹☹	☹☹☹☹	• • •	☺☺☺	0.7	88	33
34	4.5	☹☹	☹☹	•	☺☺	1.1	69	34

PROCESS FOR GENERATING PROBABILITY ESTIMATES OF PROGRAMMATIC VIABILITY

Influence Diagram



Comparative Evaluation

Factor	Performance Compared to Base Case
Design similarity, redesign requirements, resolution of NWTRB/NRC concerns	Design and Testing Support Groups (11/90)
Early Testing/ Late Testing cost/schedule	Cost/Schedule Support Group (11/90)
$P[\overline{OK} \mid "OK_{ET}", "OK_{LT}"]$	Provided by Characterization Testing Panel (11/90)
Aggregate evaluation of factors	MW (W) S B MB

Qualitative Ranking

Option	Rank
12	1st
23	2nd
4	3rd
⋮	⋮

Probability Estimate

Option	Prob
12	.99
23	.97
4	.96
⋮	⋮

Panel meets to identify influencing factors (9/90)

Individual panel members conduct comparative evaluations (11/90)

Panel develops qualitative ranking (11/90)

Consensus probabilities estimated (11/90)

Table 1

FORM FOR CONDUCTING THE OVERALL EVALUATION: PROBABILITY OF PROGRAM VIABILITY

When compared to the ESF Base Case (option 1), does this ESF option offer a _____ likelihood for near-term success in maintaining a viable OCRWM program, considering its (1) early/late testing schedule, (2) projected costs, (3) design dis-similarity and schedule slippage due to re-design requirements, (4) resolution of NWTRB and NRC concerns, (5) residual outcome of characterization testing, and (6) expected success with regulatory approval? Choose one of the following:

much lower (ML), *lower* (L), about the *same* (S), *higher* (H), or *much higher* (MH)

[circle one].

Option	Range of Likelihood				
2	ML	L	S	H	MH
3	ML	L	S	H	MH
4	ML	L	S	H	MH
5	ML	L	S	H	MH
6	ML	L	S	H	MH
7	ML	L	S	H	MH
8	ML	L	S	H	MH
9	ML	L	S	H	MH
10	ML	L	S	H	MH
11	ML	L	S	H	MH
12	ML	L	S	H	MH
13	ML	L	S	H	MH
14	ML	L	S	H	MH
15	ML	L	S	H	MH
16	ML	L	S	H	MH
17	ML	L	S	H	MH
18	ML	L	S	H	MH
19	ML	L	S	H	MH
20	ML	L	S	H	MH
21	ML	L	S	H	MH
22	ML	L	S	H	MH
23	ML	L	S	H	MH
24	ML	L	S	H	MH
25	ML	L	S	H	MH
26	ML	L	S	H	MH
27	ML	L	S	H	MH
28	ML	L	S	H	MH
29	ML	L	S	H	MH
30	ML	L	S	H	MH
31	ML	L	S	H	MH
32	ML	L	S	H	MH
33	ML	L	S	H	MH
34	ML	L	S	H	MH

PROGRAM VIABILITY RESULTS

Assessed Variable: **PROBABILITY OF PROGRAMMATIC VIABILITY**

Option	BEST JUDGEMENT SCORE
24	0.90
30	0.89
23	0.87
25	0.84
27	0.83
13	0.81
7	0.79
28	0.79
6	0.78
19	0.77
22	0.77
21	0.77
4	0.74
29	0.73
2	0.73
31	0.70
20	0.67
8	0.64
32	0.62
33	0.59
5	0.58
10	0.58
12	0.58
11	0.56
17	0.56
Base Case	0.55
26	0.55
15	0.54
16	0.53
34	0.53
18	0.52
3	0.52
14	0.51
9	0.45

CONSEQUENCE ESTIMATES AND WEIGHTING FACTORS

Summary of Consequence Estimates
(Rank Order Based on Decision Tree Calculations)

Rank Order	ESF Option	X_1 RN Releases Fraction EPA Limit		X_2 Rad Worker	X_3 Rad Public	X_4 Non-Rad Worker	X_5 Aesthetic Prop.	X_6 Historical Prop.	X_7 Direct Costs	X_8 Indirect Costs
		Aqueous	Aq. + C-14	person-rem	person-rem	fatalities	constr. scale	hectares	Billion $	Billion $
1	30	6×10^{-7}	.017	.20	2×10^{-6}	12.6	1	.03	1.39	5.36
2	23	6×10^{-7}	.017	.05	1×10^{-6}	13.9	8	2.93	1.40	5.71
3	24	8×10^{-7}	.020	.10	1×10^{-6}	12.6	8	2.93	1.37	5.38
4	13	6×10^{-7}	.017	.20	2×10^{-6}	12.6	1	.03	.79	5.36
5	6	6×10^{-7}	.017	.05	1×10^{-6}	13.9	8	2.93	.71	5.34
6	7	8×10^{-7}	.020	.10	1×10^{-6}	12.6	8	2.93	.71	5.34
7	2	7×10^{-7}	.019	.05	1×10^{-6}	13.9	8	2.93	.67	5.34
8	19	7×10^{-7}	.019	.05	1×10^{-6}	13.9	8	2.93	1.31	5.71
9	4	2×10^{-6}	.019	.05	1×10^{-6}	14.0	8	2.93	.73	5.68
10	25	2×10^{-6}	.020	.10	1×10^{-6}	12.6	8	2.93	1.31	5.35
11	21	2×10^{-6}	.019	.05	1×10^{-6}	14.0	8	2.93	1.38	5.38
12	28	8×10^{-7}	.020	.10	1×10^{-6}	12.6	8	2.93	1.31	5.37
13	22	8×10^{-7}	.017	.10	2×10^{-6}	13.5	0.5	.03	1.29	5.37
14	29	8×10^{-7}	.017	.20	2×10^{-6}	12.7	0.5	.03	1.36	5.38
15	32	3×10^{-7}	.017	.01	2×10^{-7}	14.1	8	2.94	1.38	5.32
16	20	6×10^{-7}	.020	.05	1×10^{-6}	13.9	8	2.93	.67	5.37
17	27	9×10^{-7}	.020	.10	1×10^{-6}	12.6	8	2.93	1.26	5.34
18	8	9×10^{-7}	.020	.10	1×10^{-6}	12.6	8	2.93	1.23	5.31
19	31	2×10^{-6}	.017	.20	2×10^{-6}	12.3	1	2.41	1.29	5.37
20	15	3×10^{-7}	.017	.01	2×10^{-7}	14.2	8	2.94	1.29	5.30
21	33	2×10^{-7}	.017	.01	2×10^{-7}	14.7	0.5	.03	1.21	5.27
22	5	8×10^{-7}	.017	.10	2×10^{-6}	13.6	0.5	.03	.68	5.34
23	12	8×10^{-7}	.017	.20	2×10^{-6}	12.8	0.5	.03	.71	5.35
24	3	6×10^{-7}	.020	.05	1×10^{-6}	13.9	8	2.93	.61	5.34
25	16	2×10^{-7}	.017	.01	2×10^{-7}	14.7	0.5	.03	1.17	5.26
26	11	8×10^{-7}	.020	.10	1×10^{-6}	12.6	8	2.93	.68	5.32
27	1	1×10^{-6}	.020	.05	1×10^{-6}	13.2	8	2.92	.58	5.34
28	14	2×10^{-6}	.017	.20	2×10^{-6}	12.3	1	2.41	.68	5.35
29	10	9×10^{-7}	.020	.10	1×10^{-6}	12.6	8	2.93	.69	5.31
30	17	2×10^{-6}	.020	.10	1×10^{-6}	12.7	1	.03	.60	5.34
31	18	1×10^{-6}	.020	.05	1×10^{-6}	13.2	8	2.92	1.16	5.29
32	34	2×10^{-6}	.020	.10	1×10^{-6}	12.7	1	.03	1.08	5.31
33	26	5×10^{-6}	.023	.10	1×10^{-6}	12.6	8	2.93	1.36	5.36
34	9	5×10^{-6}	.023	.10	1×10^{-6}	12.6	8	2.93	.74	5.68

RANGE OF CONSEQUENCE ESTIMATES

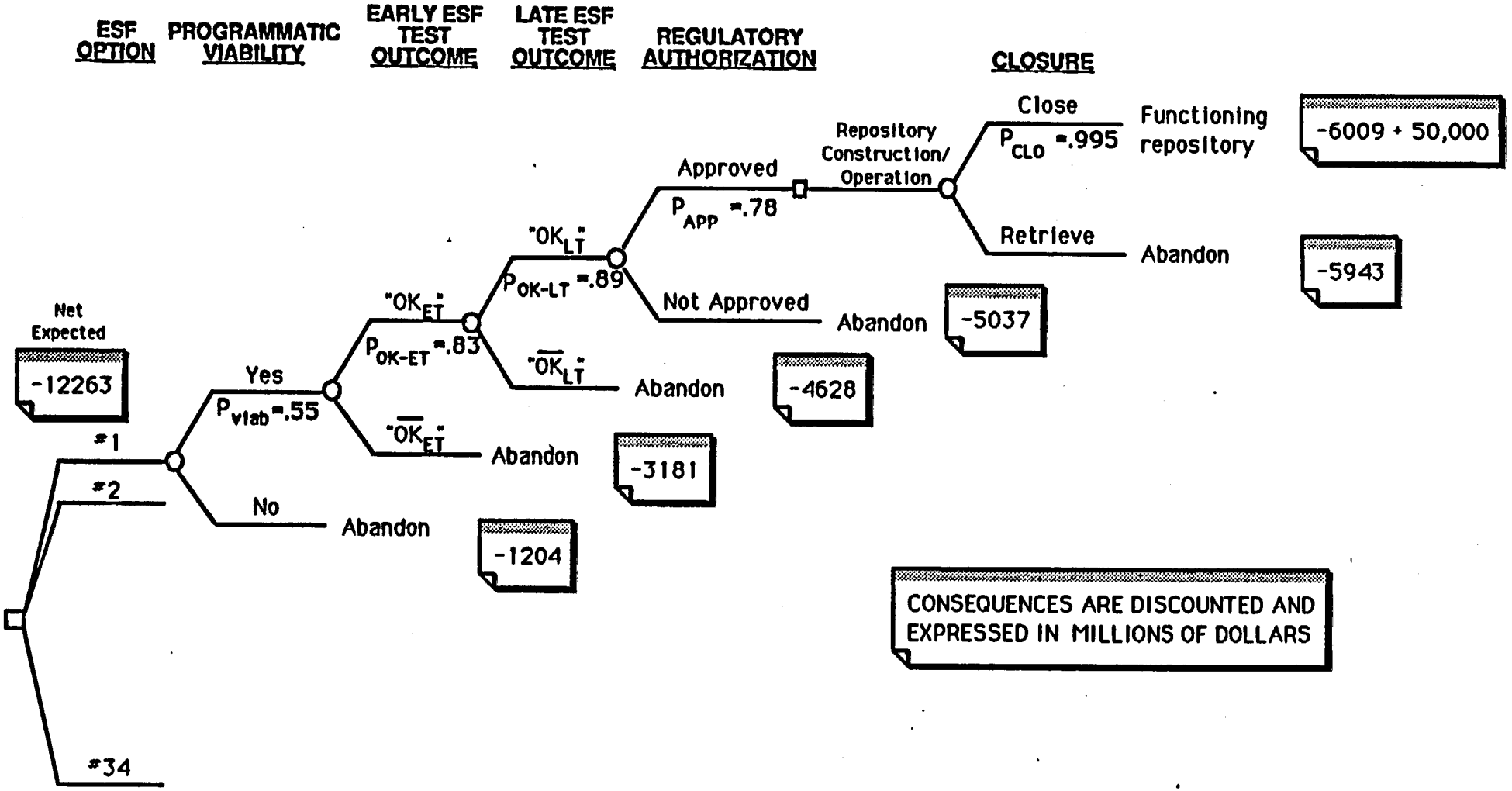
MEASURE	RANGE FOR EIGHT HIGHEST-RANKED ESF OPTIONS			RANGE FOR ALL OPTIONS		
	BEST	WORST	Δ	BEST	WORST	Δ
POSTCLOSURE RADIONUCLIDE RELEASES						
• Aqueous (fraction EPA limit)	6E-7	8E-7	2E-7	2E-7	5E-6	4.8E-6
• Aqueous + C-14 (fraction EPA limit)	.017	.020	.003	.017	.023	.006
PRECLOSURE RADIONUCLIDE RELEASES						
• Repository Workers (person-rem)	.05	.20	.15	.01	.20	.19
• Members of Public (person-rem)	1E-6	2E-6	1E-6	2E-7	2E-6	1.8E-6
PRECLOSURE CONSEQUENCES						
• Repository Worker Safety (fatalities)	12.6	13.9	1.3	12.3	14.7	2.4
• Aesthetic Properties (constructed scale)	8	1	7	8	0.5	7.5
• Historical Properties (hectares)	.03	2.93	2.9	.03	2.94	2.91
• Direct ESF Costs (discounted Billion$)	.67	1.40	.73	.58	1.40	.82
• Indirect Costs (discounted Billion$)	5.34	5.71	.37	5.26	5.71	.45

WEIGHTING FACTORS

MEASURE	UNITS	WEIGHT	BASIS
POSTCLOSURE RELEASES	EPA STANDARD	$3.5 B	$5 M/CANCER DEATH X 700 CANCER DEATHS/EPA STD
RADIOLOGICAL WORKER HEALTH	PERSON-REMS	$4,000	NRC GUIDELINES OF EARLY 70s ($1000/person-rem) INFLATED
RADIOLOGICAL PUBLIC HEALTH	PERSON-REMS	$4,000	NRC GUIDELINES OF EARLY 70s ($1000/person-rem) INFLATED
NON-RADIOLOGICAL WORKER SAFETY	FATALITIES	$1.25M	25% ADDED TO WEIGHT FROM RW/0074 TO ACCOUNT FOR INFLATION
AESTHETICS	CONSTRUCTED SCALE	$4M (full scale)	ASSESSED FROM DOE MANAGERS
HISTORICAL PROPERTIES	SQUARE METER	$30	ASSESSED FROM DOE MANAGERS
DIRECT COSTS	DISCOUNTED $	1	10% DISCOUNT RATE
INDIRECT COSTS	DISCOUNTED $	1	10% DISCOUNT RATE

DECISION TREE ANALYSIS

BASE CASE CONSEQUENCES AND PROBABILITIES



Summary of Decision Tree Calculations

Rank Order	ESF Option	Expected Net Benefit (Billion $)	Probabilities						RN Releases Fraction EPA Limit	
			Scenario A (Closed Repository)	Programmatic Viability	Characterization Testing "OK-ET"	Characterization Testing "OK-LT"/"OK-ET"	Regulatory Approval	Repository Closure	Aqueous	Aqueous + C-14
1	30	24.3	.60	.89	.85	.91	.87	.999	6×10^{-7}	.017
2	23	23.3	.58	.87	.83	.89	.90	.998	6×10^{-7}	.017
3	24	23.0	.57	.90	.82	.89	.86	.997	8×10^{-7}	.020
4	13	22.9	.55	.81	.85	.91	.89	.999	6×10^{-7}	.017
5	6	22.5	.54	.78	.83	.90	.93	.999	6×10^{-7}	.017
6	7	22.3	.54	.79	.82	.90	.92	.998	8×10^{-7}	.020
7	2	21.1	.51	.73	.83	.91	.93	.998	7×10^{-7}	.019
8	19	20.4	.51	.77	.83	.89	.90	.997	7×10^{-7}	.019
9	4	20.0	.49	.74	.83	.92	.87	.999	2×10^{-6}	.019
10	25	19.9	.50	.84	.83	.90	.80	.997	2×10^{-6}	.020
11	21	19.6	.49	.77	.84	.90	.84	.998	2×10^{-6}	.019
12	28	19.2	.48	.79	.83	.90	.82	.997	8×10^{-7}	.020
13	22	17.8	.45	.77	.84	.90	.78	.997	8×10^{-7}	.017
14	29	16.9	.43	.73	.84	.90	.79	.997	8×10^{-7}	.017
15	32	16.8	.42	.62	.80	.90	.94	.998	3×10^{-7}	.017
16	20	16.6	.41	.67	.83	.89	.83	.997	6×10^{-7}	.020
17	27	16.3	.42	.83	.79	.89	.73	.996	9×10^{-7}	.020
18	8	16.0	.40	.64	.83	.90	.85	.998	9×10^{-7}	.020
19	31	15.9	.41	.70	.84	.90	.77	.997	2×10^{-6}	.017
20	15	15.5	.38	.54	.83	.90	.95	.999	3×10^{-7}	.017
21	33	15.4	.39	.59	.83	.90	.88	.998	2×10^{-7}	.017
22	5	14.7	.37	.58	.84	.90	.85	.999	8×10^{-7}	.017
23	12	14.0	.35	.58	.84	.90	.81	.998	8×10^{-7}	.017
24	3	13.9	.35	.52	.83	.90	.89	.998	6×10^{-7}	.020
25	16	13.8	.35	.53	.81	.89	.90	.999	2×10^{-7}	.017
26	11	13.7	.35	.56	.82	.90	.83	.997	8×10^{-7}	.020
27	1	12.3	.31	.55	.83	.89	.78	.995	1×10^{-6}	.020
28	14	11.6	.30	.51	.84	.90	.78	.998	2×10^{-6}	.017
29	10	11.3	.30	.58	.78	.89	.74	.996	9×10^{-7}	.020
30	17	11.2	.29	.56	.83	.90	.70	.997	2×10^{-6}	.020
31	18	11.0	.29	.52	.82	.88	.77	.995	1×10^{-6}	.020
32	34	9.8	.26	.53	.83	.89	.69	.995	2×10^{-6}	.020
33	26	7.7	.22	.55	.74	.83	.66	.991	5×10^{-6}	.023
34	9	6.3	.19	.45	.74	.84	.67	.991	5×10^{-6}	.023

RANGE OF PROBABILITY AND CONSEQUENCE ESTIMATES

MEASURE	RANGE FOR EIGHT HIGHEST-RANKED ESF OPTIONS			RANGE FOR ALL OPTIONS		
	HIGH	LOW	Δ	HIGH	LOW	Δ
EXPECTED NET BENEFIT (Billion$)	24.3	20.4	3.9	24.3	6.3	18.0
PROBABILITIES						
• Scenario A (closed repository)	.60	.51	.09	.60	.19	.41
• Programmatic Viability	.90	.73	.17	.90	.45	.45
• "OK-ET"	.85	.82	.03	.85	.74	.11
• "OK-LT"/"OK-ET"	.91	.89	02	.92	.83	.09
• Regulatory Approval	.93	.86	.07	.95	.66	.29
• Repository Closure	.999	.997	.002	.999	.991	.008
POSTCLOSURE RADIONUCLIDE RELEASES						
• Aqueous (fraction EPA limit)	6E-7	8E-7	2E-7	2E-7	5E-6	4.8E-6
• Aqueous • C-14 (fraction EPA limit)	.017	.020	.003	.017	.023	.006

SENSITIVITY INFORMATION

RANK ORDER OF OPTIONS UNDER VARIOUS MAJORITY/MINORITY REPORTS

MAJORITY BEST JUDGEMENT RANKING		Minority View for Prog. Viab.		Minority EFN View #1 (7 experts)		Minority EFN View #2 (2 experts)		Minority View on Retrieval		Revised Estimates for Testing Probabilities	
30	1st	13	1st	30	1st	23	1st	30	1st	30	1st
23	2nd	2	2nd	13	2nd	24	2nd	23	2nd	23	2nd
24	3rd	6	3rd	23	3rd	6	3rd	24	3rd	24	3rd
13	4th	23	4th	24	4th	30	4th	13	4th	13	4th
6	5th	19	5th	7	5th	7	5th	6	5th	6	5th
7	6th	4	6th	6	6th	2	6th	7	6th	7	6th
2	7th	7	7th	4	7th	13	7th	2	7th	2	7th
19	8th	5	8th	19	8th	19	8th	19	8th	19	8th
4	9th	21	9th	2	9th	25	9th	25	9th	4	9th
25	10th	24	10th	25	10th	28	10th	4	10th	25	10th
21	11th	15	11th	21	11th	21	11th	21	11th	21	11th
28	12th	12	12th	28	12th	32	12th	28	12th	28	12th
22	13th	3	13th	22	13th	27	13th	22	13th	22	13th
29	14th	20	14th	29	14th	4	14th	29	14th	29	14th
32	15th	29	15th	8	15th	20	15th	32	15th	32	15th
20	16th	32	16th	32	16th	22	16th	27	16th	27	16th
27	17th	14	17th	20	17th	29	17th	20	17th	20	17th
8	18th	22	18th	27	18th	8	18th	8	18th	8	18th
31	19th	28	19th	33	19th	15	19th	31	19th	31	19th
15	20th	31	20th	5	20th	33	20th	15	20th	33	20th
33	21st	30	21st	15	21st	31	21st	33	21st	15	21st
5	22nd	8	22nd	31	22nd	16	22nd	5	22nd	5	22nd
12	23rd	25	23rd	3	23rd	5	23rd	12	23rd	16	23rd
3	24th	16	24th	12	24th	11	24th	16	24th	12	24th
16	25th	11	25th	16	25th	1	25th	3	25th	3	25th
11	26th	33	26th	11	26th	12	26th	11	26th	11	26th
1	27th	18	27th	1	27th	3	27th	1	27th	1	27th
14	28th	1	28th	18	28th	10	28th	14	28th	14	28th
10	29th	17	29th	14	29th	18	29th	10	29th	10	29th
17	30th	10	30th	10	30th	17	30th	17	30th	17	30th
18	31st	27	31st	17	31st	14	31st	18	31st	18	31st
34	32nd	34	32nd	34	32nd	34	32nd	34	32nd	34	32nd
26	33rd	9	33rd	26	33rd	26	33rd	26	33rd	26	33rd
9	34th	26	34th	9	34th	9	34th	9	34th	9	34th

KEY MEASURES FROM SENSITIVITY ANALYSIS OF EXPERT PANEL JUDGEMENTS

HIGHLY RANKED ESF OPTIONS ARE LIKELY TO:

1.	ENSURE NEAR-TERM PROGRAMMATIC VIABILITY	0.910
2.	ACHIEVE REGULATORY APPROVAL	0.636
3.	LEAD TO REPOSITORY CLOSURE	0.534
4.	PRODUCE LOW RADIONUCLIDE RELEASES	0.511
5.	LEAD TO A LOW P_{EFP}	0.381
6.	LEAD TO A LOW P_{LFN}	0.315
7.	LEAD TO A LOW P_{EFN}	0.307

CORRELATION COEFFICIENT

EPOPG6P.126/1-29-91

CORRELATION OF JUDGEMENTS BY EXPERT PANEL ON PROGRAMMATIC VIABILITY WITH PRINCIPAL FACTORS IN INFLUENCE DIAGRAM

FACTOR	CORRELATION COEFFICIENT
NWTRB CONCERNS	0.628
NRC CONCERNS	0.485
END OF LATE TESTING	0.404
DURATION OF EARLY TESTING	0.278
PENALTY DELAY BETWEEN ET/LT END/START	0.220
COSTS TO END OF LT	-0.156
SCHEDULE SLIPPAGE DUE TO REDESIGN REQUIREMENTS	0.065
DESIGN DISSIMILARITY	0.027

KEY INSIGHTS FROM COMPARATIVE EVALUATION OF ESF OPTIONS

- THROUGHOUT ALL OF THE FORMAL DELIBERATIONS BY THE EXPERT PANELS, THERE WERE NO JUDGEMENTS THAT ANY OF THE ESF OPTIONS WOULD NOT MEET ALL OF THE APPLICABLE REQUIREMENTS

- ALTHOUGH UNCERTAINTIES EXIST ABOUT THE PROJECTED PERFORMANCE OF ANY ESF OPTION, A SINGLE, OVERALL RANKING OF THE 34 ESF OPTIONS WAS OBTAINED CONSISTENT WITH THE MAJORITY JUDGEMENTS OF THE EXPERT PANELS

- THE RANK ORDER OF ANY GIVEN ESF OPTION WAS DETERMINED ALMOST ENTIRELY BY THE RELATIVE LIKELIHOOD THAT THE OPTION WOULD LEAD SUCCESSFULLY TO A CLOSED REPOSITORY (SCENARIO A ON THE DECISION TREE)

KEY INSIGHTS FROM COMPARATIVE EVALUATION OF ESF OPTIONS

(CONTINUED)

- THE PROBABILITY OF PROGRAMMATIC VIABILITY WAS THE SINGLE MOST INFLUENTIAL MEASURE IN DETERMINING THE RANK ORDER OF THE 34 ESF OPTIONS

- THE PRINCIPAL FACTORS THAT INFLUENCED THE PROBABILITY JUDGEMENTS BY THE EXPERT PANEL ON PROGRAMMATIC VIABILITY WERE THE RESOLUTION OF NWTRB AND NRC CONCERNS AND DURATION OF CHARACTERIZATION TESTING

- THE RANK ORDER OF THE 34 ESF OPTIONS WAS FOUND TO BE ESSENTIALLY INSENSITIVE TO HIGH/LOW UNCERTAINTY (1 CHANCE IN 20) ESTIMATES OF END CONSEQUENCES

KEY INSIGHTS FROM COMPARATIVE EVALUATION OF ESF OPTIONS

(CONTINUED)

- APART FROM PROGRAMMATIC VIABILITY, THE RANK ORDER OF THE ESF OPTIONS WAS NOT SIGNIFICANTLY INFLUENCED BY MINORITY JUDGEMENTS FOR PROBABILITIES RELATED TO CHARACTERIZATION TESTING AND REPOSITORY CLOSURE

- THE GROUP OF EIGHT HIGHEST RANKED ESF OPTIONS

  - REPRESENT FOUR PAIRS OF ESF DESIGNS (i.e., EACH PAIR FEATURES EARLY ACCESS TO THE TS UNIT AND EARLY ACCESS TO THE CH UNIT)

  - WERE JUDGED, ON AVERAGE, TO HAVE -

$P_{VIAB} > 82\%$ $\qquad$ $P_{\text{"OK-ET"}} > 83\%$

$P_{APP} = 90\%$ $\qquad$ $P_{\text{"OK-LT"}/\text{"OK-ET"}} = 90\%$

$P_{CLO} > 99.8\%$

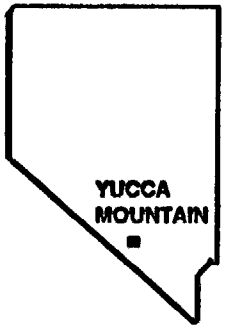
KEY INSIGHTS FROM COMPARATIVE EVALUATION OF ESF OPTIONS

(CONTINUED)

- THE GROUP OF EIGHT HIGHEST RANKED ESF OPTIONS
  - WERE JUDGED, INDIVIDUALLY, TO RELEASE LESS THAN 0.0001% OF THE EPA RN LIMIT TO THE ACCESSIBLE ENVIRONMENT BY AQUEOUS TRANSPORT DURING THE FIRST 10,000 YEARS AFTER CLOSURE
  - WERE JUDGED, INDIVIDUALLY, TO PRODUCE RADIATION DOSES, BECAUSE OF UNDERGROUND ACCIDENTS, OF NO MORE THAN 0.2 PERSON-REM TO REPOSITORY WORKERS AND 0.000002 PERSON-REM TO MEMBERS OF THE PUBLIC

U.S. DEPARTMENT OF ENERGY

OCRWM



YUCCA MOUNTAIN
SITE CHARACTERIZATION
PROJECT

ESF ALTERNATIVES STUDY
EVALUATION OF FEATURES

PRESENTED AT

DOE/NRC MEETING ON
CALICO HILLS RISK/BENEFIT ANALYSIS
AND ESF ALTERNATIVES STUDY

PRESENTED BY

DR. LAWRENCE S. COSTIN
DIVISION SUPERVISOR
GEOMECHANICS ANALYSIS AND TESTING DIVISION
SANDIA NATIONAL LABORATORIES

JANUARY 29-31, 1991

Attachment 21

OVERVIEW

- **DOE APPROACH TO ADDRESSING 10 CFR 60.21**

  - STATEMENT OF CONSIDERATIONS
    "THE COMMISSION HAS STRESSED THE IMPORTANCE OF EVALUATING ALTERNATIVES TO MAJOR DESIGN FEATURES THAT ARE IMPORTANT TO WASTE ISOLATION, SEE 10 CFR 60.21 (c) (1) (ii) (D), AND IN THE CASE OF THE DESIGN AND LOCATION OF THE EXPLORATORY SHAFTS, THIS CAN ONLY BE DONE PRIOR TO THEIR SINKING"
  - COMMENTS IN SCA
  - COMMENTS ON DAA
  - NRC LETTER TO DOE - CONCERNS REGARDING DOE APPROACH

- **RESULTS OF EVALUATION**

INTRODUCTORY REMARKS ON APPROACH

- AS AN INTEGRAL PART OF THE ESF ALTERNATIVES STUDY, MAJOR DESIGN FEATURES WERE INCORPORATED IN 17 BASIC CONFIGURATIONS, WHICH WERE COMPARATIVELY EVALUATED

- FEATURES WERE EVALUATED IN THE CONTEXT OF AN ESF/REPOSITORY SYSTEM

  - INDIVIDUAL FEATURES CANNOT BE EVALUATED SEPARATELY BECAUSE THEIR IMPACTS MAY NOT BE INDEPENDENT
  - THE TOTAL EFFECT OF A NUMBER OF FEATURES COMBINED INTO AN OPTION MAY BE QUITE DIFFERENT THAN THE SUM OF INDIVIDUAL IMPACTS

- EVALUATION WAS MULTI-DIMENSIONAL

GENERAL APPROACH

- FIVE MAJOR DESIGN FEATURES WERE IDENTIFIED FOR SPECIFIC INCLUSION IN THE OPTIONS IN VARIOUS ALTERNATIVE WAYS AND COMBINATIONS

- ALL EXISTING ESF AND REPOSITORY CONFIGURATIONS WERE COMBINED WITH A NUMBER OF NEW CONFIGURATIONS TO FORM AN INITIAL POOL OF OPTIONS

- NEW CONFIGURATIONS WERE SPECIFICALLY CREATED TO
  - HAVE VARIOUS COMBINATIONS OF ALTERNATIVE DESIGN FEATURES
  - INCORPORATE A NUMBER OF FEATURES THAT WERE IDENTIFIED BY NRC AND NWTRB CONCERNS

GENERAL APPROACH

(CONTINUED)

- INITIAL SCREENING PROCESS WAS DESIGNED TO ENSURE THAT THE PROPER RANGE OF ALTERNATIVE MAJOR FEATURES WAS INCORPORATED IN THE SET OF OPTIONS TO BE EVALUATED

- DETAILED COMPARATIVE EVALUATION OF OPTIONS WAS PERFORMED CONSIDERING A NUMBER OF DIMENSIONS
  - POSTCLOSURE PERFORMANCE
  - CHARACTERIZATION TESTING
  - REGULATORY APPROVAL
  - PROGRAMMATIC VIABILITY
  - ETC

GENERAL APPROACH

(CONTINUED)

- ADDITIONAL PERFORMANCE EVALUATIONS WERE DONE TO DETERMINE WHICH MAJOR FEATURES WERE POTENTIAL DISCRIMINATORS FOR POSTCLOSURE PERFORMANCE
  - BEST AVAILABLE ANALYSES AND DATA WERE USED
  - RESULTS PROVIDED TO THE POSTCLOSURE PANEL

GENERAL APPROACH

(CONTINUED)

- **POST-EVALUATION ANALYSIS WAS PERFORMED TO:**
  - DETERMINE WHICH ALTERNATIVE FORMS OF THE MAJOR FEATURES CONTRIBUTED TO AN OPTION'S ABILITY TO PERFORM WELL IN THE OVERALL EVALUATION
  - IDENTIFY ANY NEW FEATURES THAT CONTRIBUTED TO GOOD OVERALL PERFORMANCE

FIVE MAJOR DESIGN FEATURES CONSIDERED

MAJOR DESIGN FEATURE	ALTERNATIVES	
1. MEANS OF ACCESS	SHAFTS ONLY RAMPS ONLY SHAFT/RAMP COMBINATION	
2. LOCATION OF ACCESSES	ALL IN NORTHEAST ALL IN SOUTH COMBINATION OF LOCATIONS	
3. LOCATION OF MAIN TEST LEVEL (MTL) CORE AREA IN TOPOPAH SPRING (TS)	NORTHEAST SOUTH	
4. EXCAVATION METHOD OF OPENINGS	SHAFTS	- DRILL AND BLAST - SHAFT BORING MACHINE - BLIND HOLE DRILL - V-MOLE - RAISE BORE
	RAMPS	- TUNNEL BORING MACHINE (TBM) - ROAD HEADER - DRILL AND BLAST

FIVE MAJOR DESIGN FEATURES CONSIDERED

(CONTINUED)

MAJOR DESIGN FEATURE	ALTERNATIVES	
4. EXCAVATION METHOD OF OPENINGS (CONT.)	MTL (TS) CORE AREA	- DRILL AND BLAST - MOBILE MINER - TBM*
	EXPLORATORY DRIFTING IN TS & CH	- DRILL AND BLAST - MOBILE MINER - TBM - ROAD HEADER
5. TOTAL NUMBER OF ACCESSES	ESF ACCESSES ARE AN INTEGRATED SUBSET OF THE TOTAL NUMBER OF ACCESSES FOR THE REPOSITORY	

* TBM NOT SPECIFICALLY CONSIDERED FOR MTL EXCAVATION BUT IS EXPECTED TO BE AN ACCEPTABLE ALTERNATIVE FOR PART OF THE EXCAVATION

POST-EVALUATION ANALYSIS OF FEATURES

- A QUALITATIVE EVALUATION OF FEATURES WAS ACCOMPLISHED BY ASSESSING THE RELATIVE MERIT OF THE INDIVIDUAL FORMS OF THE FEATURE IN CONJUNCTION WITH THE RANK ORDER OF THE OPTIONS

  - MAJOR DESIGN FEATURES
  - FEATURES INCLUDED BY GUIDANCE
  - ADDITIONAL FEATURES IDENTIFIED AS A RESULT OF THE EVALUATION

- SYSTEMATIC ANALYSIS OF FEATURE EFFECTIVENESS

  - KEY MEASURES
  - FACTORS RELATED TO KEY MEASURES
  - DESIGN FEATURES RELATED TO KEY MEASURES

- CORRELATION OF POTENTIALLY FAVORABLE FEATURES WITH THE FEATURES CONTAINED IN THE HIGHLY RANKED OPTIONS

QUALITATIVE EVALUATION

MAJOR DESIGN FEATURES

- **MEANS OF ACCESS**
  - OPTIONS WITH TWO RAMPS PREFERRED
  - SHAFT PREFERRED FOR SITE CHARACTERIZATION
- **LOCATION OF ACCESSES**
  - FROM A CHARACTERIZATION TESTING PERSPECTIVE, ACCESS LOCATION COMBINATIONS THAT PERMIT BROAD SPATIAL DISTRIBUTION OF EXPOSED ROCK ARE PREFERRED
    - * LARGE SPATIAL COVERAGE OF DATA
    - * REDUCED POTENTIAL FOR INTERFERENCES
    - * LOCATIONALLY REPRESENTATIVE DATA

QUALITATIVE EVALUATION

(CONTINUED)

- LOCATION OF MAIN (CORE) TESTING AREA (MTL)
  - NO PREFERENCE IDENTIFIED
- SOME OPTIONS HAVE THE FLEXIBILITY TO MOVE THE MTL TO EITHER THE NORTH OR SOUTH, THIS MAY BE OF SOME ADVANTAGE IN THE DESIGN PROCESS
- EXCAVATION METHODS
  - MECHANICAL EXCAVATION OF ACCESSES AND DRIFTS WAS PREFERRED
- TOTAL NUMBER OF ESF/REPOSITORY ACCESSES
  - FEWER ACCESSES WERE PREFERRED

FEATURES INCLUDED BY GUIDANCE

THREE FEATURES WERE INCLUDED IN ALL OPTIONS EXCEPT THE BASE CASE (OPTION 1) AS A RESULT OF THE DESIRE TO ADDRESS SPECIFIC CONCERNS OF THE NRC AND NWTRB

- **TWO INTERCEPTS (MINIMUM) OF THE GHOST DANCE FAULT**
  - ONE TOWARD NORTH END OF BLOCK, ONE TOWARD THE SOUTH
- **EAST-WEST DRIFT IN THE TOPOPAH SPRING ROCK UNIT**
- **LARGER DEDICATED MAIN TEST LEVEL (EXCEPT OPTION 18)**

ADDITIONAL FEATURES IDENTIFIED BY STUDY

- NO CONSTRUCTED PATHWAY FOR DIRECT GRAVITY FLOW OF WATER FROM THE REPOSITORY (TS) LEVEL TO THE CALICO HILLS (CH) LEVEL (OPTION 30)
- INCREASE THE DISTANCE FROM THE WASTE EMPLACEMENT LEVEL TO THE WATER TABLE (OPTIONS 15, 16, 32, AND 33)
- AVOID EMPLACEMENT DRIFTS CROSSING THE GHOST DANCE FAULT (OPTIONS 15, 16, 32, AND 33)
- LARGE EXPOSURE OF ROCK, BOTH ON AND OFF THE BLOCK (OPTIONS 30, 13, 4, et al.)
- ATTRIBUTES THAT ALLOW FOR EARLY EXPLORATION OF BOTH THE TS AND CH ROCK UNITS (OPTIONS 4,13, 24, 25, 30, et al.)

ANALYSIS OF SIGNIFICANCE OF FEATURES WITHIN THE COMPARATIVE EVALUATION OF OPTIONS

- KEY MEASURES IDENTIFIED
  - RANKING OF OPTIONS RELATIVE TO EACH MEASURE WAS CORRELATED WITH THE OVERALL RANKING
  - MEASURES WITH HIGH CORRELATIONS ARE JUDGED TO BE MOST INFLUENTIAL IN DETERMINING OVERALL RANKING
- FACTORS THAT SIGNIFICANTLY INFLUENCED THE KEY MEASURES WERE IDENTIFIED FROM THE INFLUENCE DIAGRAMS AND OTHER MATERIAL
- SIGNIFICANT FACTORS WERE RELATED TO SPECIFIC DESIGN FEATURES THAT ADDRESSED THESE FACTORS

IDENTIFICATION OF FAVORABLE FEATURES IN HIGHLY RATED OPTIONS

		1	2	3	4	5	6	7	8	9	10	11a	11b	11c
RANK	TOP-RANKED OPTIONS OPTION	NUMBER OF RAMP(S)	NUMBER OF SHAFT(S)	NUMBER OF ACCESSES	MTL LOCATION FLEXIBILITY	MECHANICAL MINED ACCESSES	NO GRAVITY FLOW PATHWAY FROM TS UNIT TO CHn	MAXIMIZE DISTANCE FROM EMPLACEMENT LEVEL TO WATER TABLE	AVOID EMPLACEMENT DRIFTS CROSSING GHOST DANCE FAULT	MAXIMIZE EXPOSED ROCK-ON AND OFF BLOCK	FLEXIBILITY FOR EARLY DRIFTING IN TS OR CH OR BOTH	2 INTERCEPTS OF GHOST DANCE FAULT IN TS	E-W DRIFT IN TS	LARGER MTL AREA TO AVOID INTERFERENCES
1	30	2	0	4	✓	✓	✓			✓	✓	✓	✓	✓
2	23	2	0	4		✓						✓	✓	✓
3	24	1	1	5		✓					✓	✓	✓	✓
4	13	2	0	4	✓	✓				✓	✓	✓	✓	✓
5	6	2	0	4		✓						✓	✓	✓
6	7	1	1	5		✓						✓	✓	✓
7	2	1	1	5								✓	✓	✓
8	19	1	1	5								✓	✓	✓
9	25	1	1	5		✓					✓	✓	✓	✓
10	4	1	2	5						✓	✓	✓	✓	✓
20	15	1	1	4				✓	✓			✓	✓	✓

FEATCHRTP.126/1-29-91

FEATURES INCLUDED IN HIGHLY-RATED OPTIONS

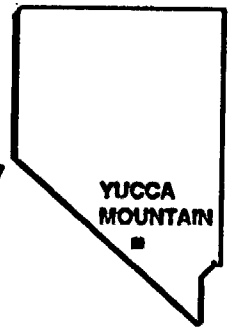
- POTENTIALLY FAVORABLY FEATURES THAT WERE IDENTIFIED WERE CORRELATED WITH THE HIGHLY RATED OPTIONS
- HIGHLY RATED OPTIONS CONTAIN MANY FAVORABLE FEATURES
- NO OPTION HAS ALL FEATURES IDENTIFIED AS POTENTIALLY FAVORABLE
- SOME MODIFICATION OF HIGHLY RATED OPTIONS COULD IMPROVE CERTAIN FEATURES WITHOUT SIGNIFICANT CHANCE OF DEGRADING THE OPTION OVERALL
- IN GENERAL, THE ADDITION OF MAJOR FEATURES WOULD REQUIRE DETAILED ANALYSES TO BALANCE THE FAVORABLE AND ADVERSE EFFECTS OF THE FEATURE AS INCORPORATED IN A SPECIFIC CONFIGURATION

ENHANCING THE ESF DESIGN

- SUBJECT TO DESIGN CONTROL PROCESS
- SELECTED KEY FEATURES WILL BE SUBJECT TO ENGINEERING TRADE-OFF STUDIES DURING DESIGN PHASE
- ENGINEERING DESIGN METHODOLOGIES WILL BE USED TO REFINE OR IMPROVE ALL FEATURES OF THE BASELINED OPTION

U.S. DEPARTMENT OF ENERGY

OCRWM



YUCCA MOUNTAIN
SITE CHARACTERIZATION
PROJECT

ESF ALTERNATIVES STUDY
STATUS OF EXECUTIVE REPORT REVIEW AND ACCEPTANCE PROCESS

PRESENTED AT

DOE/NRC MEETING ON CALICO HILLS RISK/BENEFIT ANALYSIS AND ESF ALTERNATIVES STUDY

PRESENTED BY

EDGAR H. PETRIE
ACTING DIRECTOR-ENGINEERING & DEVELOPMENT DIVISION
YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

JANUARY 29-31, 1991

Attachment 22

STATUS OF EXECUTIVE REPORT

- SANDIA INTERNAL TECHNICAL AND MANAGEMENT REVIEW COMPLETED ON DECEMBER 19, 1990
- PROJECT OFFICE RECEIVED SANDIA REPORT "FINDINGS OF THE ESF ALTERNATIVES STUDY" SAND90-3232 ON DECEMBER 21, 1990
- PROJECT OFFICE MANAGEMENT REVIEW COMPLETED ON JANUARY 5, 1991

STATUS OF EXECUTIVE REPORT

(CONTINUED)

- SNL SUBMITTED FINAL FINDINGS REPORT TO PROJECT OFFICE ON JANUARY 9, 1991

- OGD REPORT PRESENTED TO DR. J. BARTLETT ON JANUARY 14, 1991

FINDINGS OF ESF ALTERNATIVES STUDY

- THE STUDY CONSIDERED AND SCREENED A LARGE NUMBER OF ALTERNATIVES TO PRODUCE 34 ESF/REPOSITORY OPTIONS WHICH WERE THEN FORMALLY EVALUATED AGAINST A WIDE RANGE OF CRITERIA

- THE RANK ORDER OF THE OPTIONS WAS DETERMINED PRIMARILY FROM THE RELATIVE PROBABILITIES ASSESSED FOR PROGRAMMATIC VIABILITY. OTHER KEY MEASURES, SUCH AS REGULATORY APPROVAL, LIKELIHOOD OF REPOSITORY CLOSURE, POSTCLOSURE PERFORMANCE AND CHARACTERIZATION TESTING WERE CONSIDERED IN ASSESSING PROGRAMMATIC VIABILITY

- THE RANKINGS UNDER THE MAJORITY AND MINORITY VIEWS ARE AS EXPRESSED IN TABLE 3-4

FINDINGS OF ESF ALTERNATIVES STUDY

(CONTINUED)

- THE TOP RANKED OPTION INDICATED IN TABLE 3-4 IS CONSISTENT WITH THE VALUE JUDGEMENT EXPRESSED BY THE MANAGEMENT PANEL AND THE TECHNICAL JUDGEMENTS EXPRESSED BY ALL BUT THREE MEMBERS OF THE TECHNICAL PANELS. ONLY ONE TECHNICAL PANEL MEMBER PROVIDED A VIEW THAT PRODUCES A DIFFERENT RANKING. EVEN UNDER THIS VIEW, MANY OF THE SAME OPTIONS ARE CONCLUDED TO BE HIGHLY RATED.

- A NUMBER OF DESIGN FEATURES WERE IDENTIFIED THAT APPEAR TO ENHANCE THE OVERALL PERFORMANCE OF PARTICULAR OPTIONS

Table 3-4

RANK ORDER OF OPTIONS UNDER VARIOUS MAJORITY/MINORITY REPORTS

MAJORITY BEST JUDGEMENT RANKING		Minority View for Prog. Viab.		Minority EFN View #1 (7 experts)		Minority EFN View #2 (2 experts)		Minority View on Retrieval		Revised Estimates for Testing Probabilities	
30	1st	13	1st	30	1st	23	1st	30	1st	30	1st
23	2nd	2	2nd	13	2nd	24	2nd	23	2nd	23	2nd
24	3rd	6	3rd	23	3rd	6	3rd	24	3rd	24	3rd
13	4th	23	4th	24	4th	30	4th	13	4th	13	4th
6	5th	19	5th	7	5th	7	5th	6	5th	6	5th
7	6th	4	6th	6	6th	2	6th	7	6th	7	6th
2	7th	7	7th	4	7th	13	7th	2	7th	2	7th
19	8th	5	8th	19	8th	19	8th	19	8th	19	8th
4	9th	21	9th	2	9th	25	9th	25	9th	4	9th
25	10th	24	10th	25	10th	28	10th	4	10th	25	10th
21	11th	15	11th	21	11th	21	11th	21	11th	21	11th
28	12th	12	12th	28	12th	32	12th	28	12th	28	12th
22	13th	3	13th	22	13th	27	13th	22	13th	22	13th
29	14th	20	14th	29	14th	4	14th	29	14th	29	14th
32	15th	29	15th	8	15th	20	15th	32	15th	32	15th
20	16th	32	16th	32	16th	22	16th	27	16th	27	16th
27	17th	14	17th	20	17th	29	17th	20	17th	20	17th
8	18th	22	18th	27	18th	8	18th	8	18th	8	18th
31	19th	28	19th	33	19th	15	19th	31	19th	31	19th
15	20th	31	20th	5	20th	33	20th	15	20th	33	20th
33	21st	30	21st	15	21st	31	21st	33	21st	15	21st
5	22nd	8	22nd	31	22nd	16	22nd	5	22nd	5	22nd
12	23rd	25	23rd	3	23rd	5	23rd	12	23rd	16	23rd
3	24th	16	24th	12	24th	11	24th	16	24th	12	24th
16	25th	11	25th	16	25th	1	25th	3	25th	3	25th
11	26th	33	26th	11	26th	12	26th	11	26th	11	26th
1	27th	18	27th	1	27th	3	27th	1	27th	1	27th
14	28th	1	28th	18	28th	10	28th	14	28th	14	28th
10	29th	17	29th	14	29th	18	29th	10	29th	10	29th
17	30th	10	30th	10	30th	17	30th	17	30th	17	30th
18	31st	27	31st	17	31st	14	31st	18	31st	18	31st
34	32nd	34	32nd	34	32nd	34	32nd	34	32nd	34	32nd
26	33rd	9	33rd	26	33rd	26	33rd	26	33rd	26	33rd
9	34th	26	34th	9	34th	9	34th	9	34th	9	34th

RnnkOrdor 12/17/90

REVIEW AND ACCEPTANCE PROCESS

MANAGEMENT REVIEW PER QMP-06-04 INITIATED (12-21-91)

- **PROJECT OFFICE REVIEWERS**

M.B. BLANCHARD	ACTING DEPUTY PROJECT MANAGER
E.H. PETRIE	ACTING DIRECTOR, ENGINEERING AND DEVELOPMENT DIVISION
D.G. HORTON	DIRECTOR, QUALITY ASSURANCE
W.R. DIXON	DIRECTOR, PROJECT OPERATIONS AND CONTROL DIVISION
D.C.DOBSON	ACTING DIRECTOR, REGULATORY AND SITE EVALUATION DIVISION
S. BROCOUM	DIRECTOR, ANALYSIS AND VERIFICATION DIVISION

- **INDEPENDENT REVIEWERS (GEOTECHNICAL CONSULTANTS)**

H.W. PARKER	V.P. SHANNON AND WILSON INC. MEMBER - NATIONAL ACADEMY OF SCIENCES
C. FAIRHURST	PROFESSOR - CIVIL AND MINERAL ENGINEERING DEPARTMENT UNIVERSITY OF MINNESOTA MEMBER - NATIONAL ACADEMY OF SCIENCES

REVIEW AND ACCEPTANCE PROCESS

(CONTINUED)

REVIEW CRITERA

- BASED ON THE INFORMATION IN THE REPORT, IS THE CONCLUSION DRAWN LOGICAL AND REASONABLE?

- ARE THERE ANY MANAGEMENT OR TECHNICAL REASONS FOR NOT ACCEPTING THE CONCLUSIONS DRAWN IN THE ESFAS?

- WHERE THE ESFAS FINDINGS AFFECT THE PO, ARE THE MANAGEMENT AND ADMINISTRATIVE IMPACTS ACCEPTABLE?

- WAS THE DOE GUIDANCE PROVIDED TO SNL IN THE IMPLEMENTATION PLAN PROPERLY IMPLEMENTED, AND DOES THE REPORT REFLECT THE IMPLEMENTATION OF THAT GUIDANCE?

- DID SNL PERFORM A TECHNICAL AND QA REVIEW PIOR TO SUBMITTING THE FINDINGS REPORT?

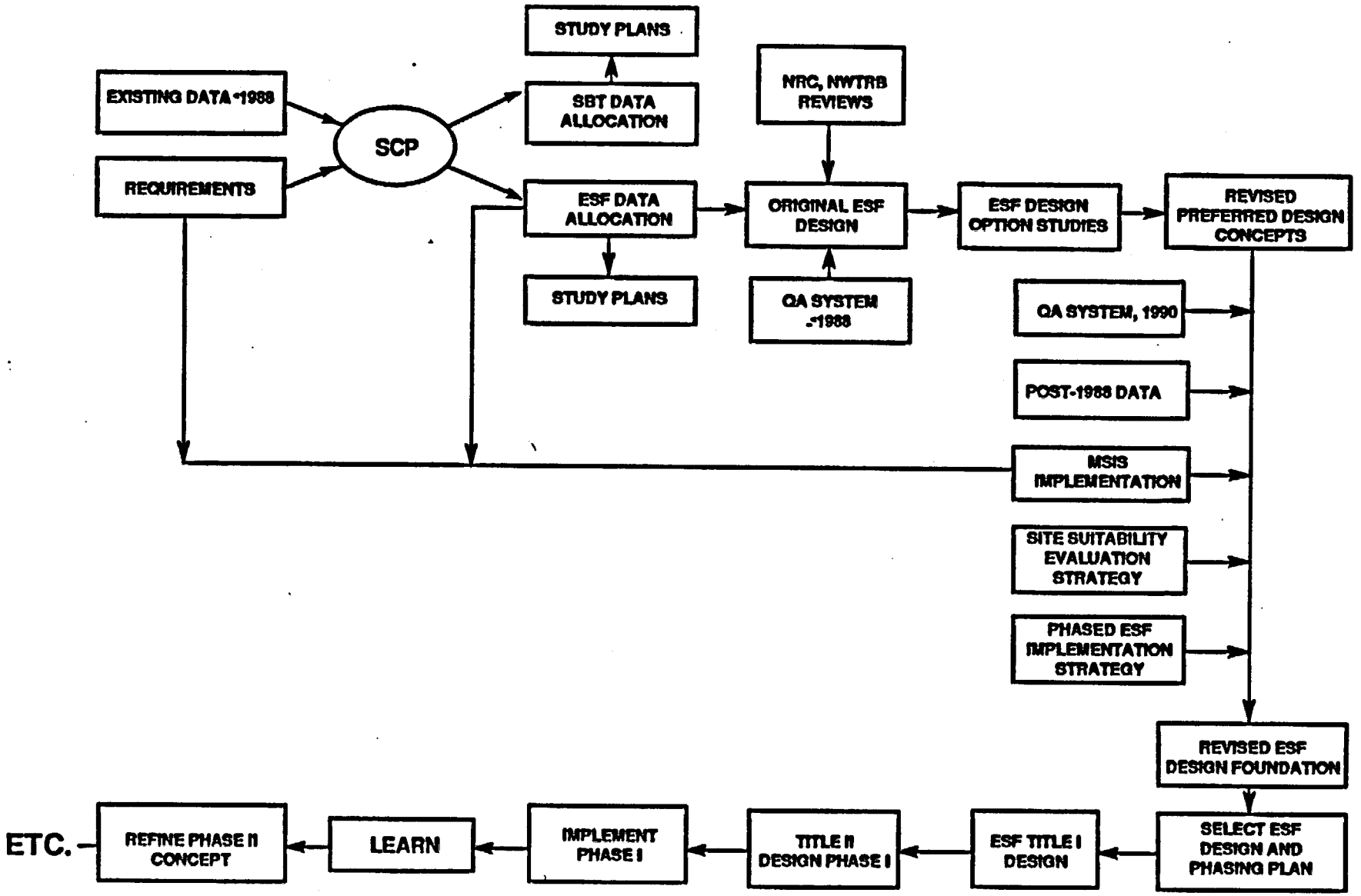
REVIEW AND ACCEPTANCE PROCESS

(CONTINUED)

- SNL AUTHORS RESOLVED ALL COMMENTS (1-4-91)
- THERE WERE NO TECHNICAL CHANGES TO THE REPORT AS A RESULT OF THE MANAGEMENT REVIEW
- REVISED DOCUMENT PROVIDED TO PO (1-9-91)
- REVIEWERS VERIFIED INCORPORATION OF COMMENTS (1-10-91)

OCRWM REVIEW AND SELECTION PROCESS

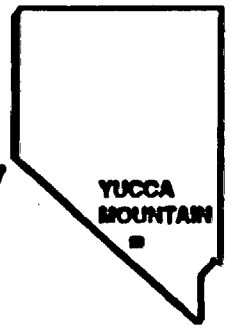
DOE APPROACH TO ESF DESIGN AND UTILIZATION



ESFTLEIP.126/1-29,30,31-91

U.S. DEPARTMENT OF ENERGY

OCRWM



YUCCA MOUNTAIN
SITE CHARACTERIZATION
PROJECT

ESF ALTERNATIVES STUDY
STATUS OF SCA CONCERNS

PRESENTED AT

DOE/NRC MEETING ON
CALICO HILLS RISK/BENEFIT ANALYSIS
AND ESF ALTERNATIVES STUDY

PRESENTED BY

DR. JERRY L. KING
ASST. PROJECT MANAGER - REGULATORY & LICENSING SUPPORT
TECHNICAL & MANAGEMENT SUPPORT SERVICES/SAIC

JANUARY 29-31, 1991

Attachment 23

OVERVIEW

- RESPONSES TO NRC'S SITE CHARACTERIZATION ANALYSIS (SCA) WERE TRANSMITTED TO NRC ON DECEMBER 14, 1990
- RESPONSES FOCUSED ON WAYS OF IMPROVING THE SITE CHARACTERIZATION PROGRAM RATHER THAN ON RETROSPECTIVE ACTIONS TO "IMPROVE" THE SCP
- MANY SCA CONCERNS CANNOT BE FULLY RESOLVED IN THE ABSENCE OF NEW SITE INFORMATION
- ALL SCA CONCERNS ARE BEING TRACKED IN A SYSTEMATIC MANNER
- SINCE ISSUANCE OF THE SCP AND SCA, SEVERAL INITIATIVES HAVE BEEN UNDERTAKEN THAT WILL ADDRESS MANY SCA CONCERNS:
  - EXPLORATORY SHAFT FACILITY ALTERNATIVES STUDY
  - CALICO HILLS RISK/BENEFIT ANALYSIS
  - TEST PRIORITIZATION TASK
  - SITE SUITABILITY TASK

SCA CONCERNS RELATED TO ESF

- SCA CONCERNS RELATED TO THE ESF HAVE BEEN SPECIFICALLY EXTRACTED FOR EVALUATION
- THE MAJORITY OF THESE CONCERNS HAVE BEEN ADDRESSED BY THE ESF ALTERNATIVES STUDY OR CALICO HILLS RISK/ BENEFIT ANALYSIS
- OTHER CONCERNS WILL BE ADDRESSED AS PART OF SUBSEQUENT DESIGN ACTIVITIES
- AS ABOVE INITIATIVES ARE COMPLETED, DOE–NRC CAN RESOLVE CERTAIN SCA CONCERNS

60.21 EVALUATION

- 10 CFR 60.21(c)(1)(ii)(D) REQUIRES THE LICENSE APPLICATION TO INCLUDE A COMPARATIVE EVALUATION OF ALTERNATIVES TO THE MAJOR DESIGN FEATURES THAT ARE IMPORTANT TO WASTE ISOLATION

- DOE BELIEVES THE ESF ALTERNATIVES STUDY EXPLICITLY ADDRESSES THE 60.21 ISSUE

- THE ESF ALTERNATIVES STUDY EVALUATED 17 DIFFERENT ESF/ REPOSITORY CONFIGURATIONS

- POSTCLOSURE PERFORMANCE WAS USED AS AN EXPLICIT FACTOR IN DETERMINING PREFERRED CONFIGURATIONS

60.21 EVALUATION

(CONTINUED)

- MAJOR DESIGN FEATURES WERE INCLUDED IN THE EVALUATION OF AND COMPARISON AMONG THE 17 CONFIGURATIONS
- POTENTIALLY FAVORABLE DESIGN FEATURES WERE IDENTIFIED AND THE HIGHLY RATED OPTIONS CONTAIN MANY OF THESE FEATURES
- IN SUMMARY DOE BELIEVES IT HAS SATISFIED THE REQUIREMENTS OF 60.21 TO THE EXTENT IT IS APPLICABLE AT THIS STAGE OF THE ESF AND REPOSITORY DESIGN

CONSIDERATION OF SCA CONCERNS

- 10 CFR 60.16 REQUIRES DOE TO CONSIDER THE NRC's COMMENTS ON THE SCP PRIOR TO SINKING THE EXPLORATORY SHAFT

- DOE CONSIDERS THAT NRC's CONCERNS RELATED TO SINKING THE EXPLORATORY SHAFT HAVE BEEN ADDRESSED

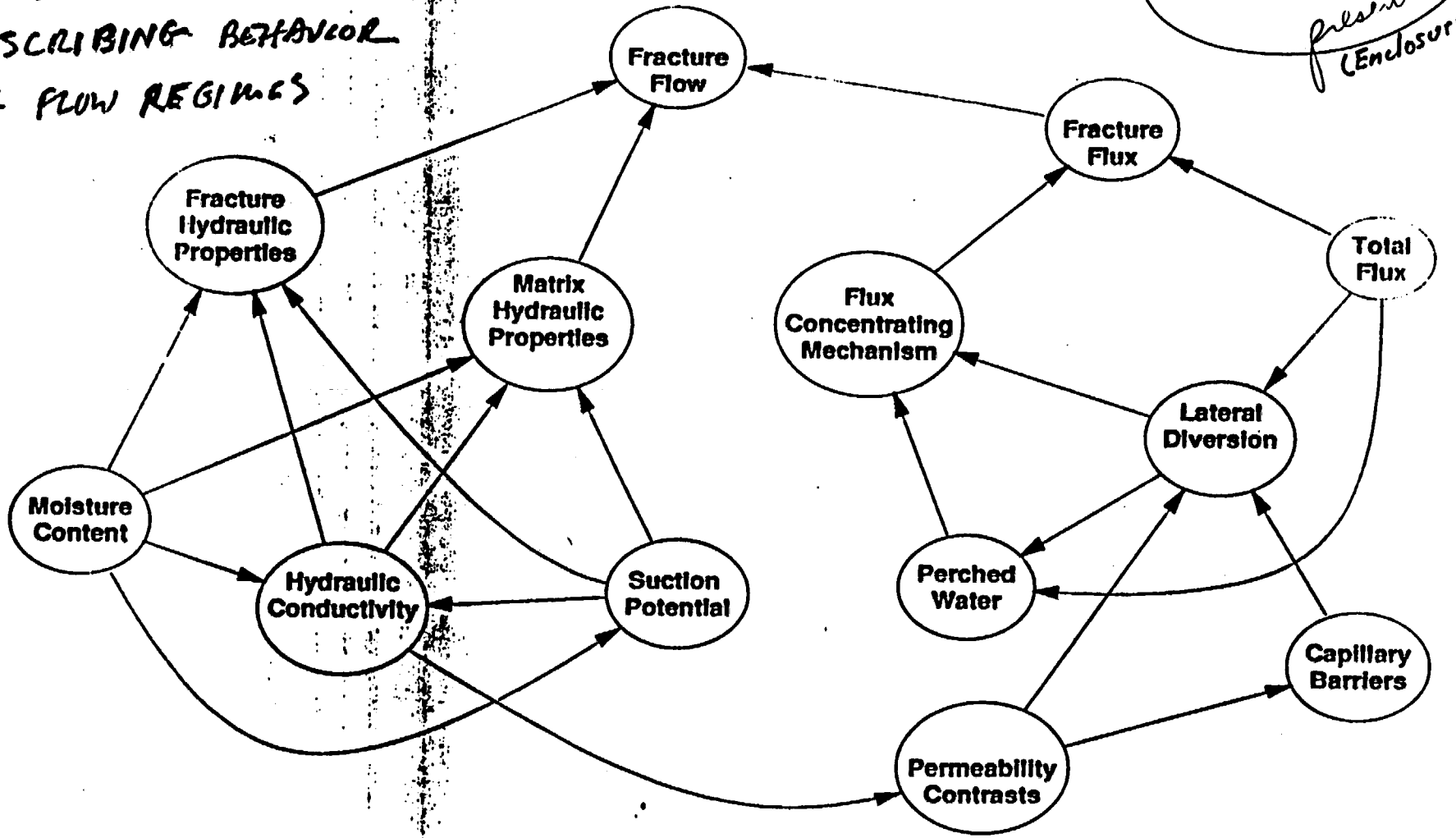
- DOE INTENDS TO MOVE FORWARD WITH ESF DESIGN

ENCLOSURE 24 CONSISTS OF ADDITIONAL FIGURES USED BY
VARIOUS DOE REPRESENTATIVES.
THESE FIGURES SUPPLEMENT ENCLOSURES 8, 10, 11, AND 15.
EACH FIGURE IS LABELED FOR READY ASSOCIATION
WITH THE APPROPRIATE ENCLOSURE.

DEFINE CONCEPTUAL MODEL FOR DESCRIBING BEHAVIOR OF FLOW REGIMES

Influence Diagram for Fracture Flow Conditions

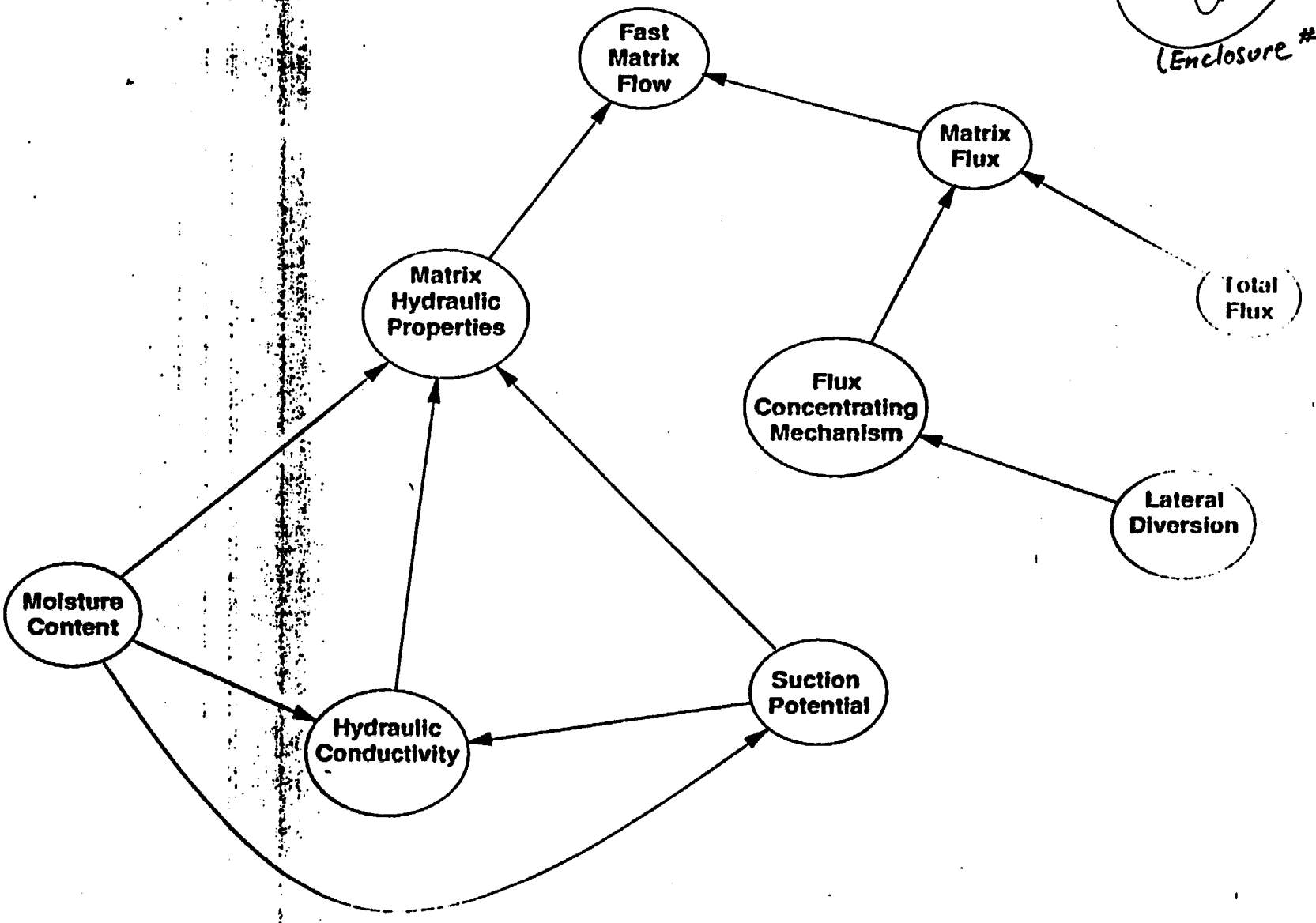
Hollis Call's present. (Enclosure #8)



Attachment 24

Influence Diagram for Fast Matrix Flow Condition

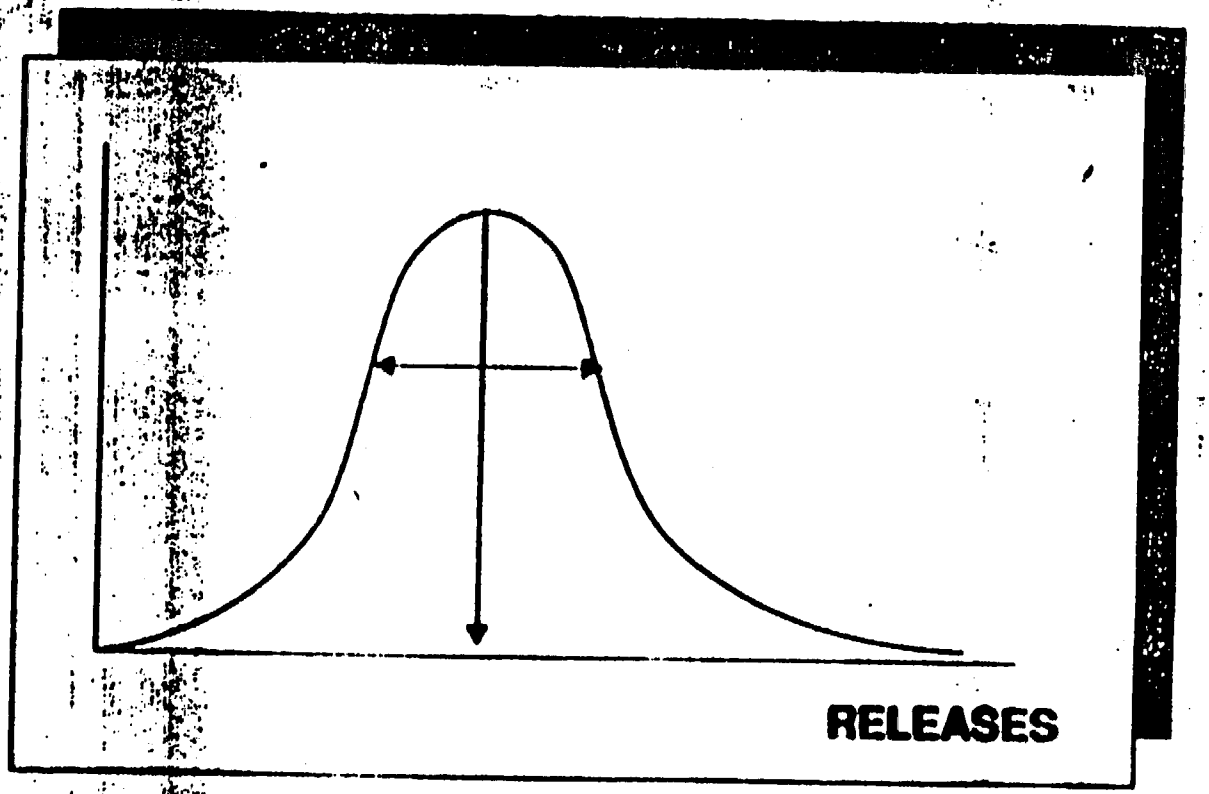
Hollis Call
(Enclosure #8)

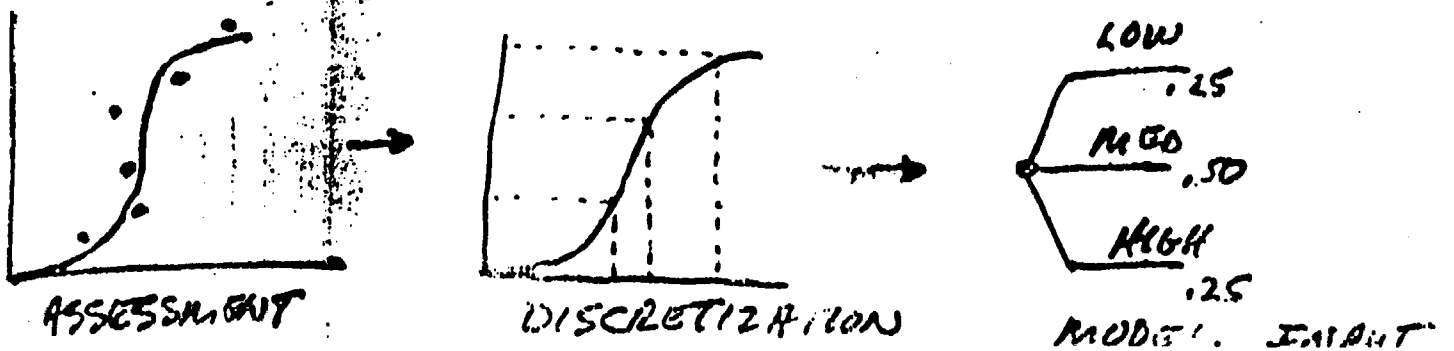


THE PURPOSE OF THE ASSESSMENT PROCESS IS TO QUANTIFY THE EXPERT'S UNCERTAINTY

Hollis Call

(Enclosure #8)

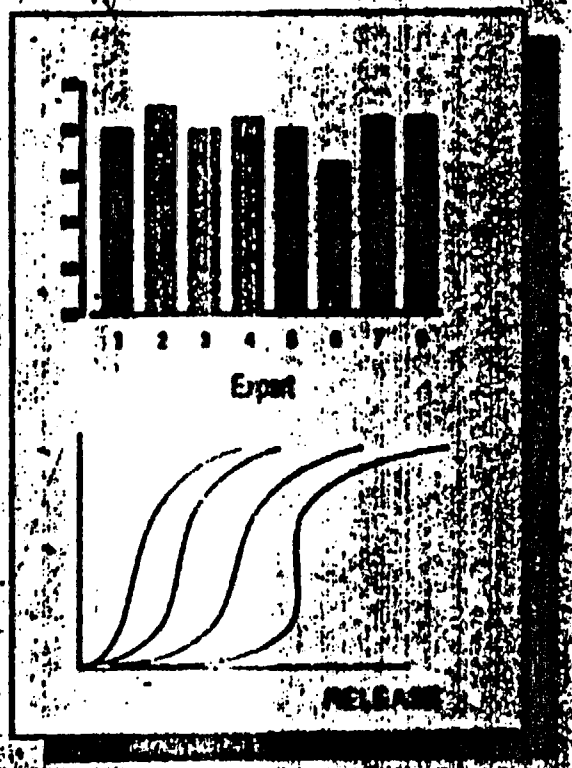




THE JUDGMENTS OF THE EXPERTS WERE DISCUSSED AT LENGTH, AND THEN AGGREGATED INTO SINGLE "GROUP RECOMMENDATION" JUDGMENTS

Hollis Call (Enclosure #8)

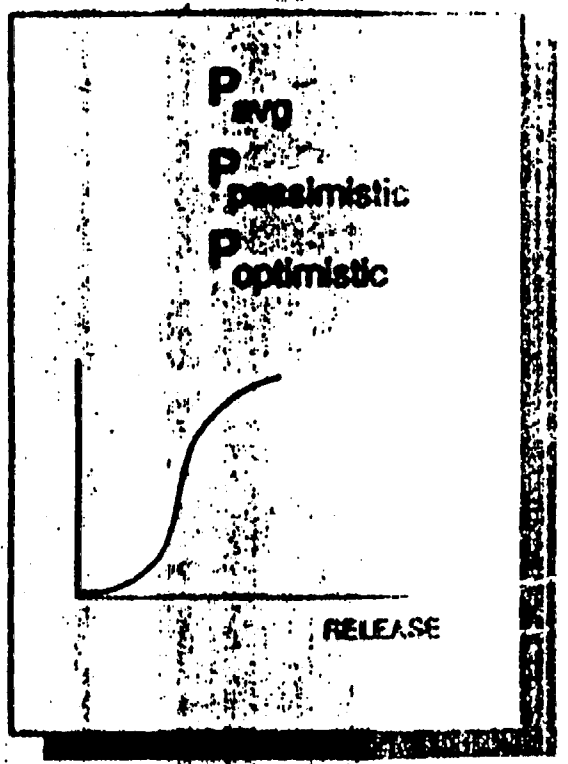
Group Judgments



Aggregation Techniques

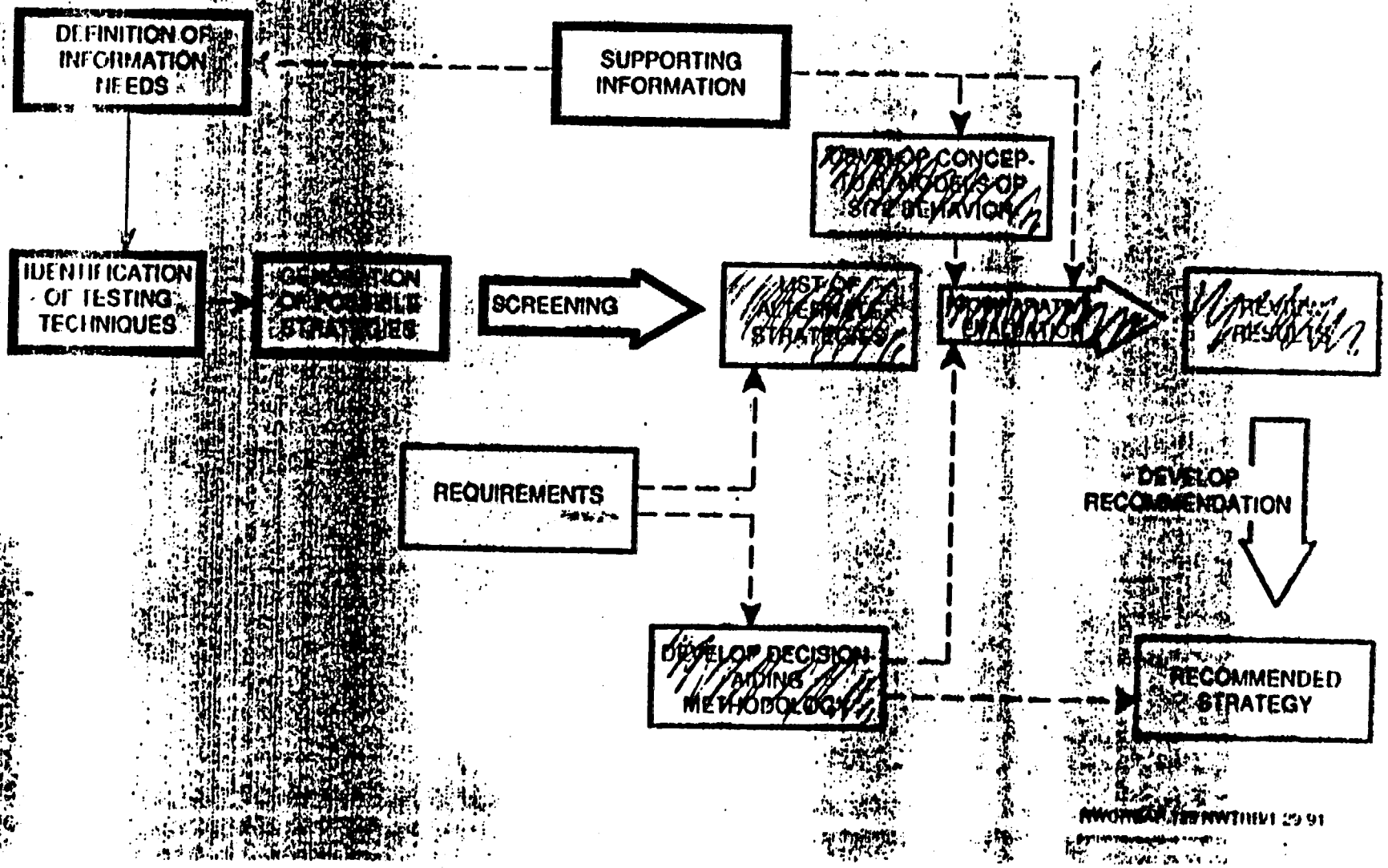
- Arithmetic Average
- Geometric Average
- Max/Min of Endpoints, Geometric Mean of Interior Pts
- "Optimistic"/ "Pessimistic" Opinions

Resulting Distribution



STRUCTURE OF THE ANALYSIS

Hollis Call
(Enclosure #8)



John Lathrop's presentation (Enclosure #10) — goes after MUA vs VOI

Two Different Paradigms of Learning

VOI:

- Analyze test accuracy and decision outcomes to derive best decision for each test outcome.
- Go to rock, conduct tests.
- Decide action based on test data.
- Value with test - value without test = test value.
- Each strategy has value to extent that it results in better decisions.

MUA:

- Go to rock, collect data.
- Learn from data in ways that cannot be anticipated.
- Each strategy has value simply because it exposes rock.

John Lathrop's presentation (Enclosure #10)

Contrasting Strategies 2,5 vs 1

- goes after "Contrasting Test Strategies 1 vs 2,5

"Going from Strategy 2,5 to 1," You come out behind:

PRO:		CON:	
- risk	(+.05)	+ cost	(-.06)
+ confidence	(+.02)	+ potential delay	(-.03)
	(+.07)		(-.09)

But that depends on relative weight given to risk

(note other value perspectives)

That is a <u>difficult</u> value tradeoff.

We can finesse that tradeoff

by transforming the contrast to <u>cost per life saved</u>.

Strategies 2,5 to 1 Transformed to Cost Per Life Saved

John Lathrop's presentation (Enclosure #10) goes after "Contrasting Test Strategies ....."

	1	2,5		1'	2',5'
Confidence	8.6	8.0	=>	8.3	8.3
Delay	4	5	diff'c in MAU	5	5
Cost	174	116	=	177	116
Phasing	4	2	.068	4	4
Resid'l Risk	.0047	.020	=>		

=> 4-Attribute Difference is Equivalent to $61 million

That is,

Moving from Strategy 2,5 to 1 is equivalent to:

spending $61 million to reduce expected fatalities by .015,

Which amounts to over $4 billion per life saved.

Charlie Voss presentation (Enclosure "H") before Conclusions

CONCENTRATED FLOW CONDITIONS

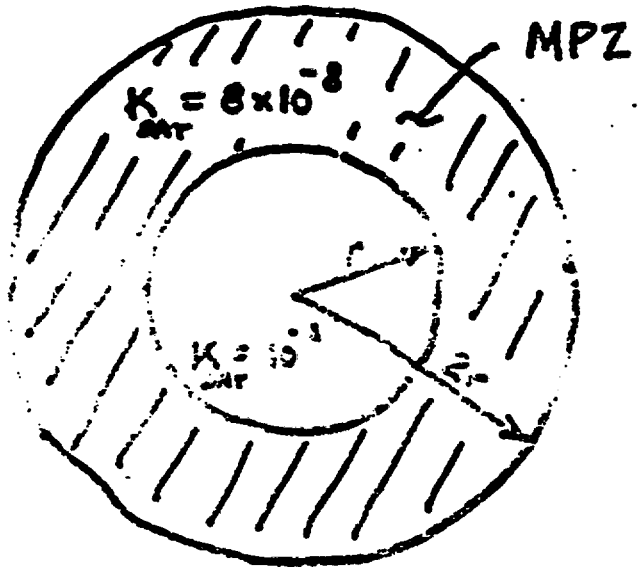
ASSUMPTIONS:

CLAY/CRUSHED TUFF BACKFILL
w/ $K_{SAT} = 10^{-8}$ m/sec

EXTENT OF MPZ = RADIUS OF THE OPENING

K_{SAT} = 30 x INTRINSIC

K_{SAT} OF CH_4 = 10^{-9} m/sec



CASE 1: KELSALL

FLOW POTENTIAL GRADIENT = 1.

DRIFT & RAMP GRADIENT = 0.15

NEW SLIDE

STEP 1: DEFINE PERFORMANCE MEASURE

CONCEPTUAL MODELS

PERFORMANCE MEASURE

Charlie Voss Presentation (Enclosure #11) was also in Ernie Hardin's

- **TOTAL SYSTEM PERFORMANCE (40 CFR 191)**

$$\text{"R"} = \sum \frac{R_i}{A_i}$$

R_i ← RELEASE, RADIONUCLIDE i

A_i ← TABULATED RELEASE LEVEL

"R" IS ASSESSED DIRECTLY BY CHRBA

- **ASSUMED "MIX" OF RADIONUCLIDES AVAILABLE FOR TRANSPORT:**
  - **VOLUME FRACTION**
  - **ENRICHED IN MOBILE SPECIES, e.g., Tc-99**

FR → R

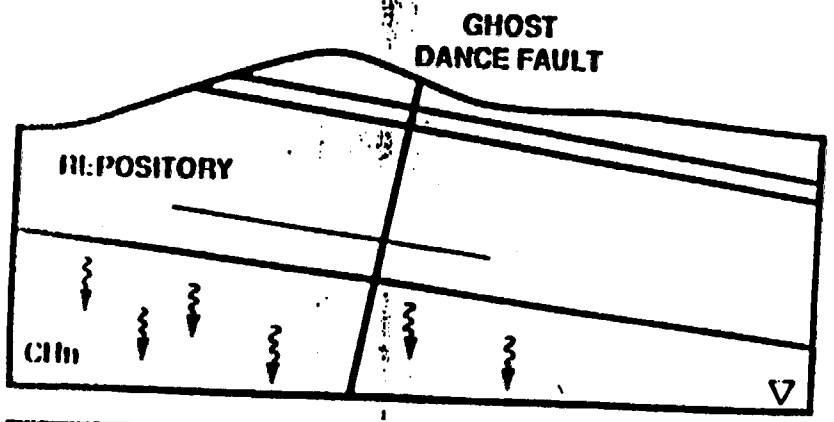
NEW SLIDE

DEFINE FLOW REGIMES

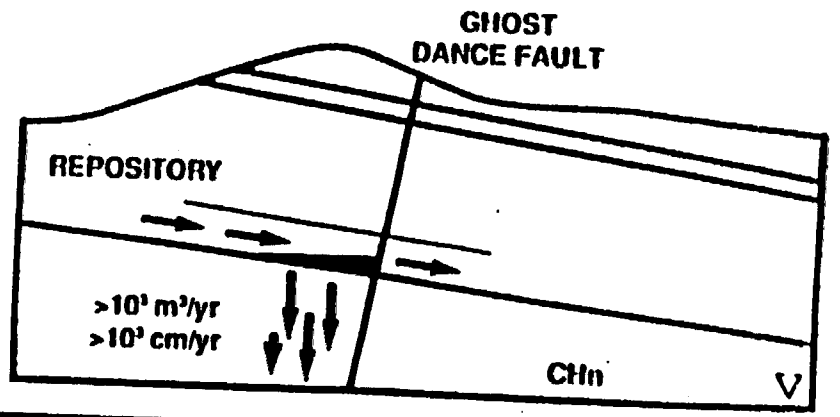
CONCEPTUAL MODELS
FLOW REGIMES

Charlie Voss presentation was also in Ernie's (Enclosure #1)

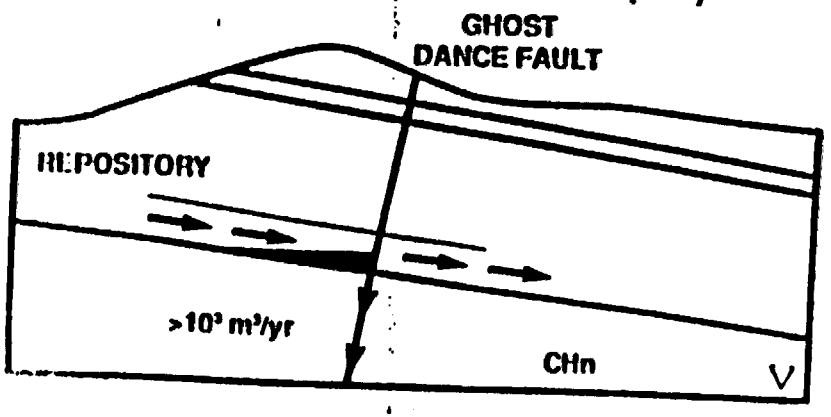
SLOW MATRIX (SM)



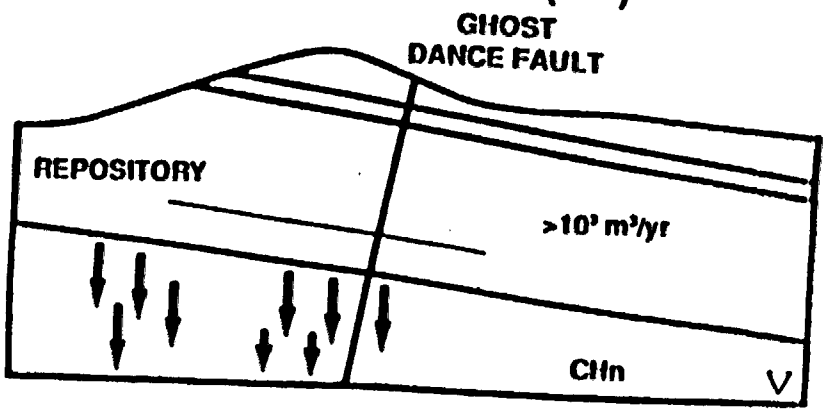
FAST MATRIX (FM)



CONCENTRATED FRACTURE (CF)



DISTRIBUTED FRACTURE (DF)



ESF DISCRIMINATORS 1 and 2

(Enclosure 15) Al Stevens regrets presentation after "Testing Groups and Sequences..."

10 CFR 60 REFERENCES	INFLUENCE DIAGRAM NUMBERS* 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
60.15 (c) (1)				X						X	O	X	X	X	X	X	X	X	X	X		O
60.15 (c) (2)				X			X	O	O	X	X	X	X	X	X	X	X	X	X	X		O
60.15 (c) (3)			O	X			X	O	O	X	X	X	X	X	X	X	X	X	X	X		O
60.15 (c) (4)			O	X			X	O	O	X	O	X	X	X	X	X	X	X	X	X		O
60.21 (c) (1) (ii) (D)			O	X						O	O	O	O	O						O		O
60.21 (c) (1) (ii) (E)				X	O	O														O		O
60.21 (c) 11				X				O	O	O	X		X	X						O		
60.74 (a)			X	X	X	X						X	X	X	X	X	X	X	X	X	O	O
60.74 (b)		X	X									X	X	X	O	O	O	O	X	X	O	O
60.111 (a)					X	X														O		
60.111 (b)					O	O	O	O	O												X	
60.112	X	X	X	X																X	O	
60.113 (a) (1)			X	O																X	O	
60.113 (a) (2)			O	O																		
60.122 [(a) (2) and (b) (1)]		X		X											O	O	O	X	X	O	O	O
60.130			X	X			X								O	O	O	O	O	X	O	O
60.133 (a) (1)			X	X	O	O				O	X	O								X		
60.133 (a) (2)			X	X			X			O	X				O	O	O	O	O	X	O	O
60.133 (b)			O	X	O	O				O	O	O			O	O	O	O	O	X	O	O
60.133 (e) (1)				X	O	O				O	O	X								X	X	
60.133 (e) (2)				X			X			O	X	X			X	X	X	X	X	X	O	O
60.133 (f)				X						O	X	X			O	O	O	O	O	X	O	O
60.133 (g)			O	X	O	O	X	O	O	O	X	X								X		
60.133 (h)			X	X						O	O	O								X		
60.133 (i)		X	O	X						O	O									X		
60.134			X	X																O		
60.137		X	X	X									X	X	O	O	O	O	O	O	O	O

LEGEND

The following titles relate to the "INFLUENCE DIAGRAM NUMBERS.

Postclosure Health and Safety
1 Health Effects Portion
2 Transport Through Natural Barriers Portion
3 Engineered Barrier System Portion
4 Scenario Portion

Preclosure Health and Safety
5 Radiological Worker Health
6 Radiological Public Health
7 Nonradiological Worker Safety

Environment
8 Aesthetics
9 Historical Properties

Cost
10 Total System Life Cycle Cost
11 Repository Life Cycle Cost
12 ESF Cost

Schedule
13 Schedule - Indirect Costs
14 Schedule

Probabilities
15 Probability of Early False Negative
16 Probability of Late False Negative (Page 1 of 2)
17 Probability of Late False Negative (Page 2 of 2)
18 Probability of Early False Positive
19 Probability of Late False Positive
20 Likelihood of Construction/Operation Approval
21 Likelihood of Retrieval
22 Probability of Programmatic Viability