Resource Conservation and Recovery Act
Post-Closure Care
Permit Application

For U.S.D.O.E.-Rocky Flats Plant
Hazardous & Radioactive Mixed Wastes

CO7890010526

5 October 1988

Volume IX

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PRESENT LANDFILL

CLOSURE PLAN

U.S. DEPARTMENT OF ENERGY
ROCKY FLATS PLANT
GOLDEN, COLORADO

JULY 1, 1988

ROCKWELL INTERNATIONAL
NORTH AMERICAN SPACE OPERATIONS
ROCKY FLATS PLANT

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1.0 INTRODUCTION

1.1 Description of the Rocky Flats Plant

1.1.1 Location and Operator

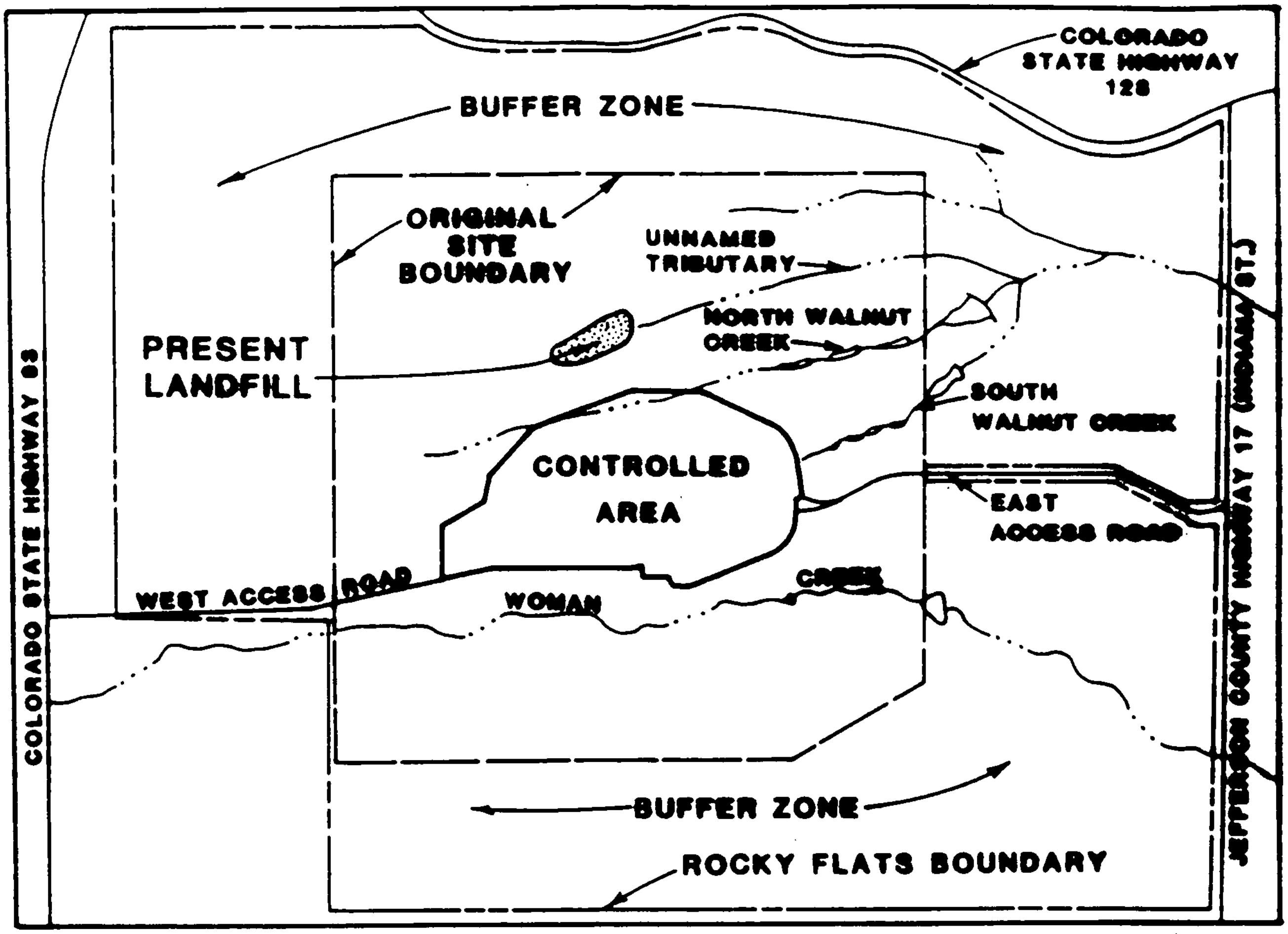
The U.S. Department of Energy's Rocky Flats Plant is located in north-central Colorado, northwest of the City of Denver (Figure 1). The Plant is located in Sections 1 through 4 and 9 through 15 of T. 2 S., R. 70 W. The facility's EPA identification number is CO7890010526. The mailing address is:

U.S. Department of Energy
Rocky Flats Plant
P.O. Box 928
Golden, Colorado 80402

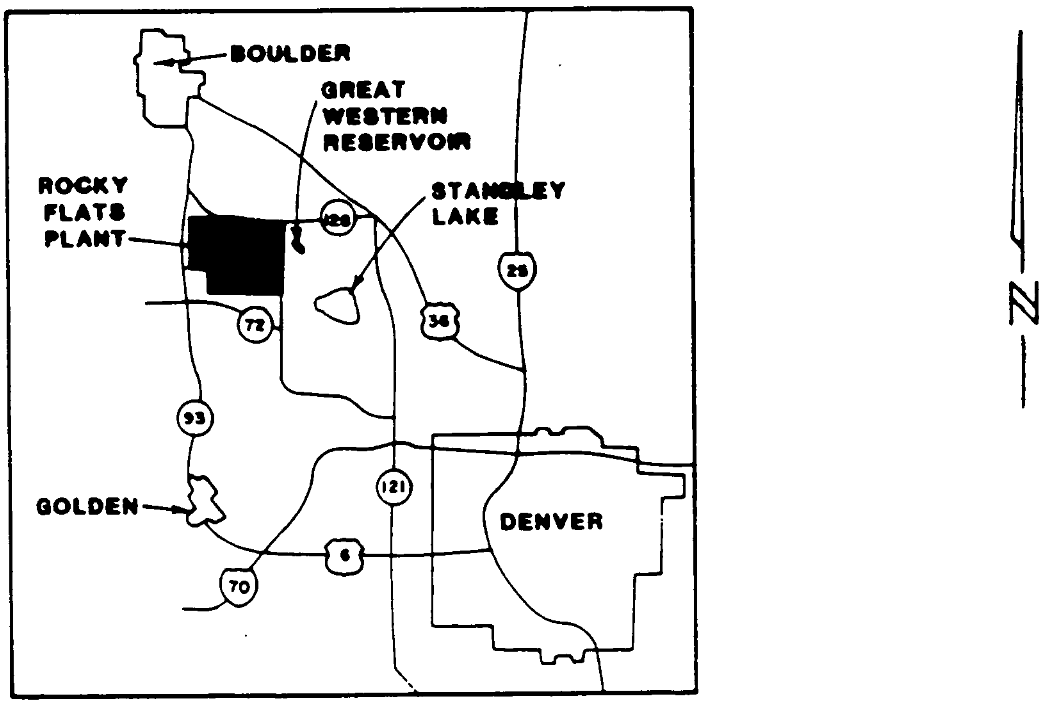
The facility contact is:

Albert E. Whiteman, Area Manager
Phone: (303) 966-2025

The facility covers approximately 6,550 acres of federally owned land in northern Jefferson County, Colorado, which is centered at 105° 11' 30" west longitude, 39° 53' 30" north latitude. The facility is approximately 16 miles northwest



APPROXIMATE SCALE 1"=3,300'



APPROXIMATE SCALE 1"=40,000'

6 032 88	Chen & Associates	VICINITY MAP	Fig. 1

of Denver and nine to 12 miles from the neighboring communities of Boulder, Broomfield, Golden and Arvada. It is bounded on the north by State Highway 128, on the west by a parcel of land east of State Highway 93, on the south by a parcel of land north of State Highway 72 and on the east by Jefferson County Highway 17. Access to the plant is from an east access road exiting from Jefferson County Highway 17 and a west access road exiting from State Highway 93.

The facility is situated at an elevation of approximately 6,000 feet. It is on the eastern edge of a geological bench known locally as Rocky Flats. The bench is approximately five miles wide and flanks the eastern edge of the foothills of the Rocky Mountains.

1.1.2 Mission

The Rocky Flats Plant is a government-owned and contractor-operated facility. It is part of a nationwide nuclear weapons research, development and production complex administered by the Albuquerque Operations Office of the U.S. Department of Energy (DOE). The prime operating contractor for the Rocky Flats Plant is Aerospace Operations of Rockwell International.

The facility produces metal components for nuclear weapons; therefore, its product is directly related to national defense. The facility fabricates components from plutonium, uranium, beryllium and stainless steel. Other production activities include chemical recovery and purification of recyclable transuranic radionuclides, metal fabrication and assembly and related quality control functions. Other activities include research and development in metallurgy, machining, non-destructive testing, coatings, remote engineering, chemistry and physics. Parts made at the plant are shipped elsewhere for final assembly (U.S. Department of Energy, 1987a).

1.1.3 Brief History

Construction of the Rocky Flats Plant was approved by the U.S. Government in 1951 as an addition to the nation's nuclear weapons production complex. Operations began in 1952 under direction of the Atomic Energy Commission. The original facility covered an area of approximately 2,520 acres (Figure 1).

A buffer zone was added in 1974-1975 to enlarge the plant to its present size of approximately 6,550 acres. The buffer zone had been used for grazing cattle and horses and is enclosed within a cattle fence which is posted with signs indicating restricted access. Two office buildings, a warehouse, firebreaks, holding ponds along three water courses, environmental monitoring instrumentation, a sanitary landfill area, a salvage yard, power lines, inactive gravel pits, clay pits and two target ranges are located in the buffer zone. Additionally, a former wind energy test site now used as an office building and a Ground Wave Emergency Network (GWEN) tower being installed by the U.S. Air Force are located in the buffer zone.

Major facility structures are located in a 400-acre controlled area near the center of the property. Production, research and development facilities at the plant are located in the controlled area which contains approximately 134 structures with a combined floor space of approximately 2.67 million square feet.

1.2 Summary of the Landfill Closure Plan

A description of the construction and operations at the landfill historically and presently is presented in Section 2.0. Decontamination procedures for equipment and north sprayfield, potentially, are presented in Section 3.0. Sections 4.0, 5.0 and 6.0 discuss primarily the proposed closure design for the landfill which include a multi-layer cover, ground water and gas collection systems, respectively. Sections 7.0 and 8.0 discuss the security at the landfill and certification of closure.

2.0 PRESENT LANDFILL

2.1 Introduction

The present landfill was placed in operation on August 14, 1968, after a study determined that a landfill operation would be the most efficient and economical means to dispose of the plant's nonradioactive solid waste. A number of available sites within the plant's boundaries were evaluated. The site selected was located on the western end of an unnamed tributary to North Walnut Creek as shown on Figure 1.

Currently, the landfill is accepting nonhazardous solid waste at a rate of approximately 115 cubic yards per work day. At this time, the landfill covers approximately 765,000 square feet of land, as shown on Figure 2.

In areas where disposal is no longer occurring, generally three feet of compacted soil was placed on top of the waste. This soil material reduces wind dispersion and infiltration. There is presently little vegetative growth on this soil layer.

2.2 Construction History

When the landfill was initially placed in operation in 1968, the west end of the drainage channel was filled with on-site soils from a borrow area, to a depth of five feet and approximately 20 feet in length across the channel.

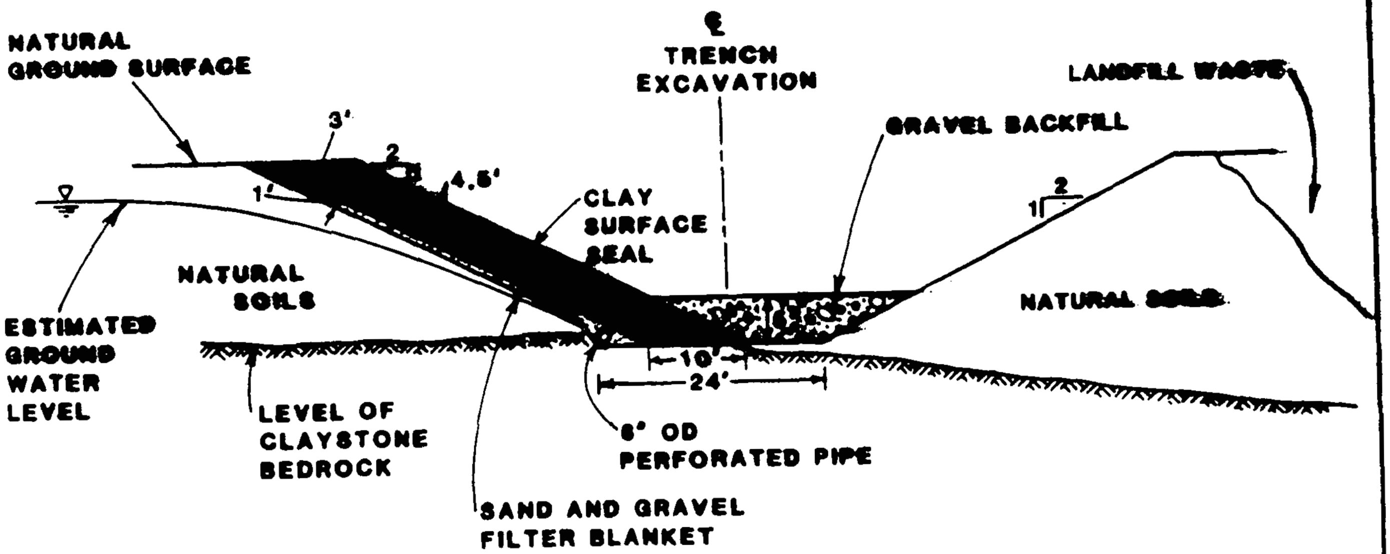
In September 1973, tritium was detected at the drainage of the Rocky Flats landfill. In response, approximately 57 monitoring wells were installed directly into the landfill waste or immediately below the waste materials. In addition, two temporary berms were constructed to provide management capability for any leachate or surface water generated by the landfill. The two ponds were named Pond #1 and Pond #2, and were located east of the landfill, as shown on Figure 2. These ponds consisted of a drainage barrier across the channel, which reduced the flow in the tributary. There was a sprinkler pumping station located adjacent to the west pond, Pond #1.

Through the installation of the monitoring wells, the source of tritium was fairly well identified. The depth and configuration of the source remain unknown. It was estimated in 1974 that the tritium was disposed of in the landfill in 1970. Several options were evaluated for the correction of the problem, including excavation. The selected action was to construct a series of collection systems around the landfill.

By 1974, the landfill had expanded in surface area to approximately 300,000 square feet (Figure 2). At that time, a project was undertaken to perform the renovations at the landfill selected in response to the discovery of the tritium source (Zeff, 1974). These renovations included the construction of a permanent pond embankment east of the landfill, a ground-water intercept system for uncontaminated ground water, a leachate collection system and surface water control ditches. The purpose of the west pond, Pond #1, was to provide a permanent structure to impound any leachate generated by the landfill for management purposes. The east pond, Pond #2, was the larger pond, and was intended as a backup system for any overflow from Pond #1. Pond #2 also was to allow collection of intercepted ground water, if necessary. The area of each pond was approximately 0.5 acre. The intent of these systems was to protect surface water and ground water from any leachate generated by the landfill. Construction of these systems began in October 1974, and was completed in January 1975.

The collection systems consisted of a surface water interceptor ditch and a combined leachate and ground-water interceptor ditch. The purpose of the surface water collection system was to intercept any surface water runoff flowing toward the landfill, and then to direct this water away from the landfill. The ditch was constructed around the exterior of the landfill as shown on Figure 3. In cross-section, the ditch was trapezoidal and approximately three feet deep, with steep side slopes.

The leachate and ground-water collection systems were constructed between the surface water interceptor ditch and the landfill, to divert ground-water flow around the landfill, to collect leachate generated in the landfill, and to provide an additional disposal area (Figure 3). The two-part system was constructed by excavating around the perimeter of the solid wastes to depths of ten to 25 feet. The trench excavation for the system was 24 feet wide at the base, as shown on Figure 4. The ground-water collection portion of the system was installed on the side of the trench away from the landfill waste. This system consisted of a one foot sand and gravel blanket, installed along the trench face. This blanket was designed to intercept ground water and drained to a six-inch OD perforated pipe installed



SCALE 1"=20'

AS-BUILT SECTION

6 032 88	Chen & Associates	TYPICAL LEACHATE AND GROUND-WATER COLLECTION SYSTEM	Fig. 4

in the bottom of the trench. The intercepted waters could then be discharged to the west pond, east pond or to surface drainages downgradient of the east pond by a series of valves. On top of the sand and gravel blanket, a ten-foot wide clay surface seal was placed, which separated the ground-water collection system from the leachate collection system. This clay seal was designed to be cut into bedrock. The leachate collection system consisted of a five-foot thick gravel backfill placed in the bottom of the trench on the landfill side.

The collected leachate and ground water and surface runoff were diverted into the west pond. The west pond was constructed to retain the waters without discharging to the east pond.

The new east pond embankment was constructed in approximately the same location as the barrier for Pond #2, 1,500 feet east of the 1974 position of the landfill. The new embankment had a spillway, and was designed to retain the majority of the water in the channel. A cutoff trench, set in bedrock, was constructed within the east pond embankment to reduce seepage through the embankment foundation. The previous Pond #1 was subsequently referred to as the West Pond.

In 1977, another geotechnical study (Lord, 1977) was conducted for expansion of the landfill, and to locate an additional borrow area north of the landfill.

At the request of Rockwell International, the Colorado Department of Health inspected the landfill in 1978 and 1979. The Department of Health stated the landfill appeared to comply with state and federal minimum standards and department regulations (Colorado Department of Health, 1979). The Department of Health determined that a certificate of designation for landfilling of wastes was not required.

Between 1977 and 1981, the leachate and ground-water collection system was buried during landfill expansion. The eastward expansion covered the discharge points of the leachate collection system. The west embankment and pond were removed in May of 1981 to allow further eastward expansion of the landfill. In addition, two slurry walls were constructed in 1981 to extend the ground-water barriers already in place. The slurry walls were constructed to reduce ground-water migration into the expanded landfill. Design drawings of the construction are presented in Appendix 1. These slurry walls were connected to the eastern ends of the ground-water interceptor ditch on the north and south arms of the ditch (Figure 3). The slurry walls were to tie-in to the clay liner constructed in 1974. The details of the connection (Appendix 1) indicate the wall would extend into the leachate collection system and cut-off the sand drain at the connection. The slurry walls extended eastward approximately 700 feet from this point. Based on design drawings, the slurry walls varied in depth from ten to 25 feet and were to be seated in bedrock.

2.3 Previous Landfill Operations

2.3.1 Disposal Policies

Operations at the landfill have continuously evolved since the landfill commenced operations in 1968, in response to changes in the regulatory statutes. The landfill was originally constructed to provide an efficient and economical means for disposing of the plant's non-contaminated solid wastes. These wastes included paper, rags, floor sweepings, cartons, mixed garbage and rubbish, demolition materials and miscellaneous items. In October 1972 the policies concerning disposal of waste at the landfill were reviewed and judged to be in accordance with applicable state and federal regulations.

The landfill was not intended to be used for disposal of radioactive wastes, and in December 1972 guidelines were issued which addressed burial of radioactively contaminated wastes. These guidelines set levels for the permissible radiation limits of wastes to be buried, as well as the minimum depth of burial and the maximum number of burials per year.

Additional guidelines were issued in February 1973 to control the burial of solid and liquid wastes in the landfill. Detectable contaminant concentrations were established for specific radioactive materials, such as plutonium, in both solid and liquid phases. In addition, prior approval was required for the burial of "non-contaminated but potentially hazardous solid materials," and for all liquids to be disposed in the landfill.

The Health Physics Operation began a program in 1973 of radioactive monitoring and scanning of the waste after it had been dumped and prior to compaction and burial. A logging procedure was instituted at that time to maintain control on where the wastes were originating in case of potential radioactive contamination.

In July 1977, a solid waste management plan was prepared to establish guidelines and procedures for landfill disposal. This plan was prepared in compliance with 40 CFR 241 and IAD 0510-35. Material acceptability standards were addressed, and guidelines were established for radioactive waste disposal. These guidelines stated that "no radioactive materials shall be deposited in the landfill," and set the basis for acceptance as the limits of radioactive material detectability. Further guidelines were established to prohibit liquids, "special items" and "nonroutine wastes" from being disposed of in the landfill, except by special permit. Permits were issued by the Waste Management Section and the Hazardous Materials Committee of Rockwell International.

Procedures established by the 1977 Solid Waste Management plan included both radiation monitoring and ground-water monitoring programs. Radiation monitoring included measurements at the point of waste origination and at the landfill. The ground-water monitoring program consisted of sampling those wells at the landfill site once every five months. The water samples were analyzed for plutonium, gross alpha, conductivity, pH and nitrate.

The July 1977 solid waste management plan is currently in effect.

2.3.2 Disposal Procedures

The disposal procedures utilized at the landfill have not significantly changed since the landfill went into operation in 1968. Waste is delivered to the landfill throughout the morning and early afternoon. In mid-afternoon, the delivery of waste stops and the waste is spread across the work area. In 1973, a monitoring program was initiated at this stage of disposal. Measurements of the spread waste are made using a FIDLER probe (Field Instrument for Detection of Low Energy Radiation). Radioactive items have occasionally been found since the monitoring procedure was instituted. All such items have been removed, packaged and shipped to an out-of-state U.S. Department of Energy disposal facility. These monitoring practices were developed after the discovery of a tritium source within the landfill wastes.

After the monitoring is complete, the waste layer is compacted and covered with six inches of soil from on-site stockpiles. The disposal of wastes continues in this manner until the waste layer is within three feet of the final elevation. The lift is then completed by the addition of a three-foot thick layer of compacted soil. In different sections of the landfill, the total landfill thickness consists of between one and three such lifts. Based on visual observation, some areas of the landfill surface may not have received a full three-foot layer of compacted soil.

2.3.3 Disposal of Solid and Hazardous Wastes

The landfill was designed for disposal of the plant's non-radioactive solid waste, including office trash, garbage, demolition materials and miscellaneous items. The exclusion of detectable radioactive materials from disposal has been accomplished by monitoring procedures established in 1973.

In 1986 and 1987, studies were conducted to identify waste streams generated at the Rocky Flats plant (Weston, 1986a, b, c and d). At that time, approximately 1,500 waste streams were identified. At the time of the study, 338 of these waste streams were being sent to the landfill for disposal. This included 241 waste streams identified as nonhazardous solid waste, and 97 solid waste streams which contained hazardous waste or hazardous constituents.

The nonhazardous solid waste streams being disposed of in the landfill included office trash, empty cans and containers, used filters and various electrical components. Also included in this waste stream were dried sanitary sewage sludge, solid sump sludge and other miscellaneous sludges. A summary of these waste streams is given in Table I.

The waste streams identified as hazardous fell into four general categories. The first consisted of containers partially filled with paint, solvents, degreasing agents and foam polymers. Another category was kimwipes and rags which were contaminated with the same materials. Filters were also included in the hazardous waste streams and were typically silicone oil filters, paint filters, oil filters, and other used filters which may have contained hazardous constituents. The final category consisted of metal cuttings and shavings, including mineral and asbestos dust, and miscellaneous metal chips coated with hydraulic oil and

Table I
Solid Waste Stream to Landfill
(1986)

BUILDING NO.	WASTE NO.	WASTE NAME	WASTE TYPE	QUANTITY GENERATED	UNITS	GENERATION FREQUENCY
111	06780	developer and fixer containers	empty containers	10	lbs/yr	as needed
111	06630	kimwipes and rags	solid	240		continous
111	06610	toner and dispersant containers	empty containers	3		2 per month
111	06820	empty developer and fixer container	empty containers	100		as needed
111	06680	empty solvent containers	empty containers	3		1 per month
111	06640	empty toner containers	empty containers	10		3 per week
111	06690	kimwipes and rags	solid	240		continous
111	06670	empty ink cans	empty containers	12		3-4 per month
111	06800	kimwipes and filmpacks	solid	100		as needed
111	06650	demineralizer system filters	solid	24		1 per month
111	06760	kimwipes and rags	solid	100		
111	06740	empty chemical containers	empty containers	100		as needed
121	04810	solid waste	solid	100		intermittant
121	04780	gun patches	solid	50		continuous
123	02830	waste resin	aqueous	3		batch
123	03080	batteries,metalwire,used elec.comp.	solid	500		continuous
123	03000	empty vials	solid	100		batch
123	02880	waste resin	solid	50		batch
123	03070	kimwipes	solid	200		continuous
124	01910	settling basin sludge	aqueous	500000	gal/yr	batch
124	00010	microstrainer backwash	aqueous	180000	gal/yr	summer operation
124	00020	clarifier underflow	aqueous	1500000	gal/yr	continuous
124	00030	sand filter backwash	aqueous	1500000	gal/yr	intermittent
124	01660	dried sludge	solid	5000	lbs/yr	once/ 6 months
125	02550	kimwipes	solid	100		continuous
125	02730	oil filters	solid	5		intermittant
130	07350	copy machine toner	empty containers	100		as needed
130	07400	rejected bags	solid	200		as needed
130	07330	polaroid film backings	solid	100		as needed
130	07390	kimwipes	solid	100		as needed
130	07360	packing materials	solid	100		intermittent
130	07380	water conditioning filters	solid	5		twice per month
130	07340	floor sweepings	solid	100		as needed
223	06840	compressor oil filter	solid	1		1 filter/2 years
331	06430	oil filters and used parts	solid	500		daily
331	06440	paint and body-filler cans	solid	200		as needed
333	06230	shavings	solid	100		daily
333	06220	sawdust	solid	100		as needed
333	06110	filters	solid	200		weekly
333	06210	blast waste	solid	1500		as needed
333	06140	empty cans	empty containers	100		as needed
333	06080	empty paint cans	solid	200		as needed
333	06200	scrapings	solid	200		as needed
333	06180	empty cans	empty containers	100		as needed
333	06130	rags	solid	300		as needed
333	06150	disposed equipment	solid	1000		as needed
333	06090	empty paint cans	solid	500		as needed
334	07050	wood/plastic shavings	solid	500		continous
334	07060	floor scrap	solid	200		daily
334	07110	other metal waste	metal	500		
334	06950	enamel residue	solid	100		intermittent
334	07250	miscellaneous solid waste	metal	500		daily
334	07140	scrap metal	metal	500		daily
334	07160	fluorescent light tubes	solid	1000		as needed
334	07120	used filters	solid	2		as needed
334	07130	metal and silica waste	solid	500		intermittent
335	07040	fire extinguisher chemicals	aqueous	200	gal/yr	as needed
373	11640	sump sludge	solid	100	lbs/yr	yearly
439	00070	kimwipes and rags	solid	200		as needed
439	00110	empty cans and containers	empty containers	100		as needed
439	00060	metal chips	metal	500		daily

CO7890010526

Date: June 1, 1988
Revision No.: 0

Table I
Solid Waste Stream to Landfill
(1986)

BUILDING NO.	WASTE NO.	WASTE NAME	WASTE TYPE	QUANTITY GENERATED	UNITS	GENERATION FREQUENCY
439	00090	kimwipes	solid	200	lbs/yr	as needed
440	00140	aluminum and sst chips	metal	500		
440	00180	kimwipes and rags	solid	500		as needed
440	00160	empty containers	empty containers	100		as needed
440	01390	kimwipes and rags	solid	500		
440	00200	kimwipes and rags	solid	500		as needed
441	00220	toner	empty containers	100		as needed
442	00260	respirator cartridges	solid	100		
442	00250	defective HEPA filters	solid	50		as appropriate
445	15340	trash	solid	500		continuous
445	15280	trash	solid	500		continuous
445	15260	carbon dust	solid	20800		continuous
445	15290	steel shavings	metal	5000		continuous
445	15270	carbon scraps	solid	10000		continuous
445	15300	steel scraps	metal	5000		continuous
449	11070	rags	organic	200		
449	11060	empty paint cans and containers	empty containers	10		
449	11090	miscellaneous trash	solid	660		
454	11890	sump sludge	solid	800		intermittent
457	11860	sump sludge	solid	200		intermittent
460	00910	used kimwipes and floor dry	solid	0		as needed
460	00940	used kimwipes	solid	302		as needed
460	23630	bijur filter screen	solid	2		once/6 mon
460	00600	used kimwipes and rags	solid	200		as needed
460	23770	bijur filter screen	solid			once/6 mon
460	00770	used oil filters	solid	70		as needed
460	23690	air filter	solid	2		once/6 mon
460	00880	metal chips	metal	0		to be determined
460	01000	used kimwipes	solid	55		as needed
460	23710	bijur filter screen	solid	2		once/6 mon
460	00370	used oil filters	solid	20		4 per year
460	01080	kimwipes	solid	150		as needed
460	00840	used kimwipes and floor dry	solid	0		as needed
460	01250	kimwipes and rags	solid	165		as needed
460	23800	bijur filter screen	solid			
460	00460	used kimwipes and rags (vap)	solid	280		as needed
460	01310	kimwipes	solid	50		as needed
460	23680	hydraulic intake filter	solid	2		once/6 mon
460	00640	kimwipes and rags	solid	110		
460	23850	air inlet filter	solid			once/6 mon
460	00810	metal chips	metal	0		to be determined
460	01090	empty paint cans	empty containers	100		
460	23700	bijur filter screen	solid	2		once/6 mon
460	00930	used filters	solid	1800		to be determined
460	01360	kimwipes and floor dry	solid	20		as needed
460	23660	hydraulic system filter	solid	2		once/6 mon
460	01060	discarded containers	empty containers	100		intermittent
460	00890	used kimwipes	solid	0		as needed
460	01050	metal chips	metal	300		to be determined
460	01200	empty chem. and solvent containers	empty containers	100		intermittent
460	01230	kimwipes w/Freon	solid	165		as needed
460	00710	kimwipes, gloves and gauze	solid	0		as needed
460	00710	used kimwipes, gloves and gauze	solid	580		as needed
460	00490	used kimwipes and gloves	solid	110		as needed
460	00950	used kimwipes and floor dry	solid	110		as needed
460	01140	kimwipes and rags	solid	165		as needed
460	00570	nuocure	solid	100		
460	00750	metal chips	metal	0		to be determined
460	23780	bijur filter screen	solid			
460	00380	used kimwipes and gauze	solid	150		as needed
460	01280	kimwipes and floor dry	solid	40		as needed

Table I
Solid Waste Stream to Landfill
(1986)

BUILDING NO.	WASTE NO.	WASTE NAME	WASTE TYPE	QUANTITY GENERATED	UNITS	GENERATION FREQUENCY
460	00820	used kimwipes	solid	0	lbs/yr	as needed
460	00830	used oil filters	solid	0		as needed
460	01110	empty containers	empty containers	100		intermittent
460	01100	kimwipes and rags	solid	165		as needed
460	00450	used kimwipes and rags (ult)	solid	280		as needed
460	01270	kimwipes	solid	40		as needed
460	23650	apron filter	solid	2		once/6 mon
460	23790	bijur filter screen	solid			once 6/mon
460	01240	empty containers	empty containers	100		as needed
460	09000	used oil filters	solid	0		to be determined
460	23640	turret res. filter	solid	2		once/6 mon
460	23750	inline coolant filter	solid	2		once/6 mon
460	01190	kimwipes	solid	100		as needed
460	01340	kimwipes and rags	solid	60		as needed
460	01170	sludge	solid	1200		to be determined
460	01120	kimwipes and rags	solid	165		as needed
460	00630	film packs	solid	48		
460	01110	empty containers	empty containers	100		intermittent
460	23740	rough inline filter	solid	2		once/6 mon
460	23720	oil filter	solid	2		once/6 mon
460	01070	used kimwipes and floor dry	solid	48		as needed
460	00760	used kimwipes	solid	24000		as needed
460	01320	kimwipes	solid	200		as needed
460	01180	used oil filters	solid	2000		weekly
460	00780	used kimwipes and floor dry	solid	350		as needed
460	00980	metal chips	metal	40		
460	01010	used oil filters	solid	15		as needed
551	06320	metal cuttings	metal	300		
551	06310	spray paint cans	empty containers	100		
551	06300	kimwipes and degreasing residue	solid	300		
560	11810	sump sludge	solid	200		1 to 2 years
563	20580	sump sludge	solid	200		intermittent
662	04040	used filters	solid	20		intermittnat
662	04000	kimwipes	solid	200		continuous
662	04030	broken parts	solid	100		as occurs
664	17500	empty containers	empty containers	100		daily
664	17510	used rags	solid	200		daily
664	17590	solid waste	solid	500		continuous
701	17620	solid waste	solid	200		daily
705	20280	kimwipes	solid	1		as needed
705	20240	polishing pads	solid	2		as needed
705	20300	metal and glass scraps	solid	100		daily
705	20250	kimwipes	solid	3		as needed
705	20620	dumpster	solid			
705	20060	kimwipes	solid	20		as needed
705	20310	office trash	solid	1000		daily
705	20410	sump sludge	solid	20		continuous
708	10650	HEPA filters	solid	200		PMO schedule
709	11700	sump sludge	solid	200		varies
711	20530	sump sludge	solid	200		varies
712	20590	sump sludge	solid	200		varies
713	20600	sump sludge	solid	200		varies
732	15020	filters	solid	300		once per month
750	09100	empty toner/developer containers	empty containers	3		intermittent
750	09020	empty fixer/developer containers	empty containers	100		as required
750	09110	kimwipes	solid	100		intermittent
750	09070	microfilm wrapper	solid	100		continuous
750	09060	empty containers	empty containers	100		intermittent
750	09090	kimwipes	solid	100		intermittent
770	22570	rags	solid	365		occasionally
770	22650	combustibles	solid	4700		daily

Table I
Solid Waste Stream to Landfill
(1986)

BUILDING NO.	WASTE NO.	WASTE NAME	WASTE TYPE	QUANTITY GENERATED	UNITS	GENERATION FREQUENCY
770	22640	metal chips/scraps	metal	3276	lbs/yr	biweekly
771	22250	empty containers & surgical gloves	solid	5000		every 2 weeks
771	22470	plastic scraps	solid	2900		daily
771	22450	metal chips	metal	3275		weekly
771	22460	combustibles	solid	5000		daily
776	12020	wood & plastic chips/dust	solid	10400		weekly (200 lbs./wk)
776	12010	empty containers	empty containers	100		occasionally
776	12030	soiled kimwipes	solid	2080		weekly (40 lbs/wk)
776	12040	empty containers	empty containers	2080		weekly (40 lbs/wk)
778	15040	trash in canisters	solid	800		continuous
778	15210	sanitary trash	solid	500		continuous
778	15050	metal/wood shavings	solid	2000		continuous
778	15060	sanitary trash	solid	500		continuous
778	15090	sanitary trash	solid	500		continuous
778	15210	metal/wood shavings	solid	2000		continuous
778	15140	trash	solid	1000		continuous
778	15310	sanitary trash	solid	500		continuous
779	19050	sanitary trash	solid	1300		continuous
779	15480	trash	solid	1000		continuous
779	15400	kimwipes	solid	480		periodically
779	19060	metal shavings/fines	metal	300		continuous
779	15730	water chiller filters	solid	10		monthly
779	15460	plastics grindings	organic	500	gal/yr	continuous
779	19200	machine fines	metal	300	lbs/yr	continuous
779	15410	mixed trash	solid	500		continuous
779	19190	sanitary trash	solid	500		continuous
779	15450	grindings metal	metal	1000		continuous
783	11780	sump sludge	solid	200		intermittent
850	04940	toner and dispersant bottles	empty containers	5		intermittant
865	04240	stainless steel grinding paper	solid	6		per year
865	04280	mold compound	solid	50		
865	04290	photography lab solid wastes	solid	240		
865	04330	metal scraps	metal	260		
881	04670	aerosol, paint and thinner cans	empty containers	200		
881	04620	dirty kimwipes	solid	200		as needed
881	04710	uncontaminated solid waste	solid	5000		
881	04610	other metal chips	metal	600		
881	05070	rags and kimwipes	solid	100		
885	05110	rags	solid	100		
886	03190	copy machine waste	solid	40		
910	06360	diatomaceous earth	solid	54750		weekly/monthly
910	07560	wastewater sludge	solid	0		intermittant
966	06840	empty containers	empty containers	100		intermittent
980	06550	kimwipes	solid	1500		daily
980	06980	sawdust soaked with oil seepage	solid	900		daily
980	06590	metal scrap	metal	5000		daily
980	06530	metal scrap	metal	2000		daily
980	06520	fiberglass resins and catalysts	solid	1000		intermittent
980	06500	metal scraps	metal	5000		daily
980	06570	oily rags	solid	480		daily
980	06510	rags with mineral spirits	solid	1480		daily
980	06490	empty containers	empty containers	100		intermittent
980	06580	oily rags	solid	480		daily
991	07510	toner & dispersant containers	empty containers	100		monthly
991	07500	empty paint containers	empty containers	100		
T750	06010	empty toner/dispersant containers	empty containers	100		monthly
T750	06040	kimwipes	solid	100		as needed
T750	06020	soiled kimwipes	solid	100		as needed

carbon tetrachloride. A summary of the hazardous waste streams is shown in Table II.

2.3.4 Volumes of Waste

The landfill began operation in 1968, and for the following ten years received approximately 20 cubic yards of compacted waste per work day. After that time, the daily volume the landfill received increased to approximately 30 cubic yards of compacted waste per work day.

Using available topographical maps, reported daily disposal rates and geotechnical reports (Woodward-Clevenger, 1974), the volume of the landfill was calculated at three stages of the landfill's history.

In 1974, the landfill occupied an area of approximately 300,000 square feet. Using the Woodward-Clevenger report and the average end area method, the volume occupied by the landfill was calculated to be about 95,000 cubic yards. Of this total, the cover material occupied 30,000 cubic yards. The remaining 65,000 cubic yards consisted of compacted waste intermixed with the daily cover material placed during disposal.

Table II
Hazardous Waste Stream to Landfill
(1986)

BUILDING NO.	WASTE NO.	WASTE NAME	WASTE TYPE	QUANTITY GENERATED	UNITS	GENERATION FREQUENCY
111	06700	film packs and positives	solid	50	lbs/yr	
123	03100	broken badges	solid	200		as occurs
123	03120	waste vials	solid	100		batch
123	02930	waste resin	solid	5		batch
123	03160	waste resin	solid	100		as required
125	02560	filters	solid	5		Change once/year
125	02640	silicone oil filters	solid	5		
125	02580	kimwipes	solid	100		continuous
334	07070	mineral and asbestos dust	solid	200		as appropriate
367	06930	empty cans, bags and containers	empty containers	100		as needed
377	09960	oil filters	solid	5		pmo schedule
440	01500	kimwipes and rags from paint booth	solid	500		
440	00120	composite kimwipe drum	solid	600		
440	01460	foam trimmings	solid	200		
440	01410	empty paint cans	empty containers	100		
440	00390	metal chip dumpster	solid	2000		
440	00170	R-compound	organic	2640		
440	01470	kimwipes and rags	solid	500		
440	01480	kimwipes and rags	solid	500		
440	01440	kimwipes and rags	solid	500		
440	01420	paint filters	solid	300		
443	00320	contaminated rags	solid	200		as needed
444	14120	sst, iron metal chips	metal	1200		continuous
444	11920	sump sludge	solid	200		varies
453	11130	paper towels	solid	2		intermittent
460	23520	metal chips	metal	0		
460	23560	metal chips	metal	0		
460	01640	air filters	solid	0		
460	23540	metal chips	metal	0		
460	23610	metal chips	metal	0		
460	02350	metal chips	metal	0		
460	02460	metal chips	metal	0		
460	23620	metal chips	metal	0		
460	02300	metal chips	metal	0		
460	01750	metal chip composite	metal	100000		
460	23510	metal chips	metal	0		
460	02290	metal chips	metal	0		
460	02480	metal chips	metal	0		
460	02440	metal chips	metal	0		
460	01650	water filters	solid	0		
460	01830	water filters (x-ray)	solid	50		
460	02280	metal chips	metal	0		
460	01600	compressor filters	solid	40		
460	23580	metal chips	metal	0		
460	02270	metal chips	metal	0		
460	02370	metal chips	metal	0		
460	23550	metal chips	metal	0		
460	01370	film packs	solid	30		
460	02390	metal chips	metal	0		

Table II
Hazardous Waste Stream to Landfill
(1986)

BUILDING NO.	WASTE NO.	WASTE NAME	WASTE TYPE	QUANTITY GENERATED	UNITS	GENERATION FREQUENCY
460	02410	metal chips	metal	0		
460	02500	metal chips	metal	0		
460	23570	metal chips	metal	0		
460	02340	metal chips	metal	0		
460	00590	mercury light bulbs	solid	5		
460	02320	metal chips	metal	0		
460	02400	metal chips	metal	0		
460	23590	metal chips	metal	0		
460	01780	empty containers	empty containers	100		
460	02380	metal chips	metal	0		
460	02330	metal chips	metal	0		
460	01580	kimwipes and rags	solid	165		
460	02360	metal chips	metal	0		
460	02450	metal chips	metal	0		
460	23600	metal chips	metal	0		
460	23530	metal chips	metal	0		
460	02310	metal chips	metal	0		
460	23470	metal chips	metal	0		
460	02430	metal chips	metal	0		
460	02490	metal chips	metal	0		
460	02420	metal chips	metal	0		
528	15360	kimwipes	solid	10		periodically
549	07300	empty containers	empty containers	100		as needed
562	09840	paper towels with oil	solid	20		varies
668	09570	rags with methyl alcohol	solid	50		intermittant
705	20180	kimwipes	solid	15		as needed
708	10690	rags w/freon and trichloroethane	solid	200		
727	09520	paper towels with oil/freon TF	solid	100		intermittant
771	22010	deionizer exchange resin column	solid	5		yearly
771	22230	bottles, cartons, gloves, kimwipes	solid	15000		continuous
771	22210	liquid chemical containers	solid	4000		continuous
775	22030	trash paper	solid	200		none
776	12120	soiled kimwipes	solid	365		daily
776	12130	empty containers	empty containers	365		daily
776	12100	empty containers	empty containers	365		daily
776	12000	soiled kimwipes	solid	1200		once per day
776	12180	soiled kimwipes	solid	4000		daily
776	12090	soiled kimwipes	solid	365		daily
779	19730	metal chips	metal	10000		2/week
780	09590	rags with trichloroethane	solid	50		infrequent
780	09580	empty paint cans	solid	50		infrequent
881	04660	metal and plastic chips	solid	10000		
881	04760	dirty kimwipes	solid	100		
881	03240	waste resin	solid	4		continuous
886	03180	kimwipes	solid	10		
886	03200	chemicals in cabinet	organic	50		infrequent
910	06340	filter backwash	aqueous	100000		weekly
991	07490	reject rings	solid	1880		weekly

As disposal continued after 1974, material was placed in the collection trenches and the face of the material was advanced, eventually filling in the west pond area. The volume of the landfill in 1986 was calculated by using topographical maps and by calculating the volume of the collection trenches. This calculation showed that approximately 160,000 cubic yards of material had been dumped between 1974 and 1986, for a total landfill volume of 255,000 cubic yards. This volume of material includes solid wastes, wastes with hazardous constituents, and soil cover material.

Between 1986 and 1988, waste has reportedly been disposed at a rate of 115 cubic yards per work day. Assuming 260 work days per year for two years, approximately 60,000 cubic yards of waste material have been disposed since 1986. This waste material consists of solid waste streams. Wastes with hazardous constituents ceased to be disposed of in the landfill in November, 1986. It is estimated that daily cover volumes are about 25 percent of the volume of material disposed. The total volume of material in the landfill at present is estimated to be approximately 330,000 cubic yards.

2.3.5 Spray Fields and Collection Systems

After construction of the two retention ponds in 1973, surface runoff and ground water and leachate collected in the systems discharged to these ponds. There is no documentation of the flow of waters collected by the collection systems. When the landfill was expanded in 1981, the leachate collection system and west pond were buried.

Until January of 1974, the water collected in the ponds was pumped to the solar evaporation ponds. At that time it became necessary to dispose of the water elsewhere, and the water was diverted to a manhole northwest of Building 990. This line discharged to Pond B-2.

By September 1975, the water was no longer pumped to the manhole but was sprayed on sprayfields adjacent to the landfill. One of these sprayfields was a 3- to 3 1/2-acre plot, located approximately 1,000 feet northwest of the east pond, as shown on Figure 2. This north sprayfield was used for spraying water collected in the west pond. Initially the spray line ran approximately north-south; however, in about 1975 the line was moved to an east-west direction as shown on Figure 2.

Two other sprayfields were located along the banks of the east pond, as shown on Figure 2. These sprayfields were used for spray evaporation of water collected in the east pond.

Prior to spraying activities, the water was tested to ensure that the acceptability criteria for spraying were met. Water quality testing, summarized in Appendix 6, indicates leachate collection and some organic constituents in the west pond waters. East pond water showed no impacts from the landfill.

Guidelines for acceptability for spraying were issued by the Environmental Control and Analysis Group of Rockwell, to ensure that water sprayed from the pond would not cause erosion or other harm to the environment in, around or downstream of the site. These guidelines included weekly water grab samples and procedures for obtaining authorization for spraying. Authorization was obtained from the Manager of Environmental Analysis and Control's office. The weekly grab samples were analyzed for gross alpha, gross beta, gamma emitting isotopes and tritium. Control guides were established for each parameter.

Spraying on the north sprayfield ceased in to 1981.

2.3.6 Monitoring Activities

After the discovery in 1973 of tritium in the landfill drainage, over 50 monitoring wells were installed in the landfill. These wells, leachate generated by the landfill, and ground water intercepted by the installed system were monitored and analyzed for tritium.

It was found that the tritium concentrations within the landfill decreased to the east. The intercepted ground water, when analyzed in 1974, was found to have tritium concentrations in the range of background values.

The surface water collected in the western pond was monitored from 1974 until removal of the pond in 1981. The tritium concentration measured steadily decreased with time, and were within measured background values when the pond was removed.

Monitoring of tritium levels in the surface waters and ground water in the landfill area ceased in 1981.

2.4 Current Landfill Operations

2.4.1 Disposal Policies and Procedures

The solid waste management plan established in 1977 is still the basis for disposal policies at the landfill. additionally, in November 1986, the waste streams identified as hazardous in the 1986 studies (Weston, 1986a, b, c and d) were no longer disposed of in the landfill.

The disposal procedures outlined in Section 2.3.2 are the procedures used for landfill disposal at this time. The solid waste streams designated for the landfill are typically placed in trash cans, drums, dumpsters or plastic bags. The waste containers are collected throughout the day, and are then disposed of as discussed in Section 2.3.2.

In October of 1988, an independent off-site contractor will begin removal and disposal of portions of the wastes currently going to the landfill. The amount of wastes removed and disposed of off-site will increase over time. By June 1, 1989, all currently landfilled wastes will be disposed of off-site and the existing landfill will become inactive.

2.4.2 Disposal of Solid and Hazardous Wastes

The studies performed in 1986 identified 338 waste streams being disposed of in the landfill (Weston, 1986a, b, c and d). Of these waste streams, 97 reportedly contained hazardous constituents or hazardous waste.

In 1987, recommendations were made which outlined where the waste streams identified at the Rocky Flats Plant should be disposed (Weston, 1987). The recommendations for the landfill identified 144 waste streams to continue to be disposed of in the landfill. These waste streams were solid waste with no hazardous constituents, as shown in Table III.

In the fall of 1986, wastes with hazardous constituents ceased to be disposed of in the landfill. This policy was implemented through the tightening of administrative procedures and the implementation of the findings of the Waste Stream Identification and Characterization Reports (Weston, 1986a, b, c, d, 1987).

Table III
Recommended Solid Waste Stream to Landfill
(1987)

Bldg. No.	Waste No.	Waste Name	Quant. Gen.	Generation Frequency
111	06610	Toner and dispersant containers	3 lbs/yr.	2 per month
111	06640	Empty toner containers	10 "	3 per week
111	06650	Demineralizer system filters	24	1 per month
111	06670	Empty ink cans	12	3-4 per month
111	06680	Empty solvent containers	3	1 per month
111	06700	Film packs	50	intermittent
111	06740	Empty chemical containers	100	as needed
111	06780	Developer and fixer containers	10	as needed
111	06820	Empty developer and fixer containers	100	as needed
121	04810	Solid waste	100	intermittent
123	03000	Empty vials	100	batch
123	03120	Waste vials	100	batch
124	00010	Microstrainer backwash	180000 gal/yr.	summer operation
124	00020	Clarifier underflow	1500000 "	continuous
124	00030	Sand filter backwash	1500000 "	intermittent
124	01660	Dried Sludge	5000 lbs/yr.	once/ 6 months
124	01910	Settling basin sludge	500000 gal/yr.	batch
130	07350	Copy machine toner	100 lbs/yr.	as needed
130	07360	Packing materials	100 "	intermittent
130	07380	Water conditioning filters	5	twice per month
130	07400	Rejected bags	200	as needed
130	07430	Floor sweepings	100	as needed
331	06430	Oil filters and used parts	500	daily
331	06440	Paint and body-filler cans	200	as needed
333	06080	Empty paint cans	200	as needed
333	06090	Empty paint cans	500	as needed
333	06110	Filters	200	weekly
333	06140	Empty cans	100	as needed
333	06180	Empty cans	100	as needed
333	06200	Scrapings	200	as needed
333	06210	Blast waste	1500	as needed
333	06220	Sawdust	100	as needed
333	06230	Shavings	100	daily
334	07050	Wood/plastic shavings	500	continuous
334	07060	Floor scrap	200	daily
334	07070	Mineral and asbestos dust	200	as appropriate
334	07130	Metal and silica waste	500	intermittent
334	07250	Miscellaneous solid waste	500	daily
335	07040	Fire extinguisher chemicals	200 gal/yr.	as needed
367	06930	Empty cans, bags and containers	100 lbs/yr.	as needed
439	00110	Empty cans and containers	100 "	as needed
440	01440	Kimwipes and rags	500	none
440	01410	Empty paint cans	100	as needed

Table III - continued
Recommended Solid Waste Stream to Landfill
(1987)

Bldg. No.	Waste No.	Waste Name	Quant. Gen.	Generation Frequency
440	01420	Paint filters	300 lbs/yr.	as needed
440	00160	Empty containers	100 "	as needed
440	00170	R-compound	2640 gal/yr.	as needed
440	01460	Foam trimmings	200 lbs/yr.	as needed
442	00250	Defective HEPA filters	50 "	as appropriate
442	00260	Respirator cartridges	100	as needed
445	15260	Carbon dust	20800	continuous
445	15270	Carbon scraps	10000	continuous
445	15280	Trash	500	continuous
445	15340	Trash	500 lbs/yr.	continuous
445	15290	Steel shavings	5000 "	continuous
445	15300	Steel scraps	5000	continuous
449	11060	Empty paint cans and containers	10	intermittent
449	11090	Miscellaneous trash	660	daily
453	11130	Paper towels	0	intermittent
457	11860	Sump sludge	200	intermittent
460	00370	Used oil filters	20	4 per year
460	00570	Nuoclure	100	continuous
460	00630	Film packs	48	intermittent
460	01370	Film packs	30	intermittent
460	23680	Hydraulic intake filter	2	once/ 6 month
460	23690	Air filter	2	once/year
460	00930	Argon filters	1800	once/year
460	01640	Air filters	25	once/year
460	23810	Coolant filter	100 gal/yr.	on preventive maint.
460	23820	Coolant filter	100 "	p.m.o.
460	01060	Discarded containers	100 lbs/yr.	intermittent
460	01090	Empty paint cans	100 "	as needed
460	01110	Empty containers	100	intermittent
460	01130	Empty containers	100	intermittent
460	01240	Empty containers	100	as needed
460	01270	Kimwipes	40	as needed
460	01280	Kimwipes and floor dry	40	as needed
460	01310	Kimwipes	50	as needed
460	01320	Kimwipes	200	as needed
460	01200	Empty chem. and solvent containers	100	intermittent
460	09060	Empty containers	100	intermittent
460	09070	Microfilm wrappers	100	continuous
549	07300	Empty containers	100	as needed
551	06310	Spray paint cans	100	weekly
551	06320	Metal cuttings	300	weekly
560	11810	Sump sludge	200	1 to 2 years
662	04030	Broken parts	100	as occurs

Table III - continued
Recommended Solid Waste Stream to Landfill
(1987)

Bldg. No.	Waste No.	Waste Name	Quant. Gen.		Generation Frequency
664	17500	Empty containers	100	lbs/yr.	daily
664	17590	Solid waste	500	"	continuous
701	17620	Solid waste	200		daily
705	20180	Kimwipes	15		as needed
705	20300	Metal and glass scraps	100		daily
705	20310	Office trash	1000		daily
708	10650	HEPA filters	200		PMO schedule
711	20530	Sump sludge	200		varies
750	09020	Empty fixer/developer containers	100		as required
750	09100	Empty toner/developer containers	3		intermittent
750T	06010	Empty toner/dispersant containers	100		monthly
771	22210	liquid chemical containers	4000		continuous
771	22230	Bottles, cartons, gloves, kimwipes	15000		continuous
771	22250	Empty containers and surgical gloves	5000		every 2 weeks
776	12010	Empty containers	100		occasionally
776	12040	Empty containers	2080		weekly (40lbs./week)
776	12100	Empty containers	365		daily
776	12130	Empty containers	365		daily
778	15040	Trash in containers	800	lbs/yr.	continuous
778	15050	Metal/wood shavings	2000	"	continuous
778	15060	sanitary trash	500		continuous
778	15090	sanitary trash	500		continuous
778	15120	Metal/wood shavings	2000		continuous
778	15130	Sanitary trash	500		continuous
778	15140	Trash	1000		continuous
778	15210	Sanitary trash	500		continuous
779	19080	Batting paper filters	50		PMO
779	19100	Furnace filters	100		PMO
779	19190	Sanitary trash	500		continuous
779	19350	Sanitary trash	500		continuous
779	19630	Furnace filters	400		periodic
779	19050	Sanitary trash	1300		continuous
779	19060	Metal shavings/fines	300		continuous
779	15450	Grindings metal	1000		continuous
779	15460	Plastic grindings	500	gal/yr.	continuous
779	15480	trash	1000	lbs/yr.	continuous
779	19730	metal chips	10000	"	2/week
779	15410	Trash	500		continuous
779	15730	Water chiller filters	10		monthly
779	19200	Machine fines	300		continuous
780	09580	Empty paint cans	50		infrequent
850	04940	Toner and dispersant bottles	5		intermittent
865	04280	Mold compound	50		continuous

Table III - continued
Recommended Solid Waste Stream to Landfill
(1987)

Bldg. No.	Waste No.	Waste Name	Quant. Gen.		Generation Frequency
865	04290	Photography lab solid wastes	240	lbs/yr.	continuous
881	03240	Waste resin	4		continuous
881	04670	Aerosol, paint and thinner cans	200	"	
881	04710	Uncontaminated solid waste	5000		daily
886	03190	Copy machine waste	40		
910	06340	Filter backwash	100000	gal/yr.	weekly
910	06360	Diamataceous earth	54750	lbs/yr.	weekly/monthly
966	06480	Empty containers	100	"	intermittent
980	06490	Empty containers	100		intermittent
980	06520	Fiberglas resins and catalysts	1000		intermittent
980	06530	Metal scrap	2000		daily
980	06590	metal scrap	5000		daily
991	07500	Empty paint containers	100		as needed
991	07510	Toner and Dispersant containers	100		monthly
995	20620	Dumpster	10000		

2.4.3 Volumes of Waste

At the present time, 115 cubic yards are disposed of in the landfill every work day. It is anticipated that this volume will continue through October 1988 and diminish for the remainder of the landfill life.

Based on previous calculations of the landfill volume and projecting present disposal amounts, the total volume of material disposed of in the landfill when operations cease in 1989 will be 410,000 cubic yards. The actual volume will be less due to off-site disposal of some wastes beginning in October 1988. The landfill will have a surface area of approximately 765,000 square feet.

2.4.4 Spray Fields and Collection Systems

Water collected in the east pond is routinely sprayed on the banks of the pond, immediately above the waterline. Spraying occurs on both the north and south sides. The guidelines established in 1980, including weekly water grab samples and analyses, are still in use. Analysis of weekly samples, presented in Appendix 6, continue to show no impact from the landfill on the impounded waters.

Based on recent water level measurements in monitoring wells at the landfill, the ground-water and leachate collection systems do not appear functional.

2.5 Maximum Waste Inventory

Throughout the life of the landfill, the disposal technique has been to deliver waste materials to the site until mid-afternoon, and then spread and compact the material. The longest time waste inventory is stored prior to final disposal is approximately six hours. At the current disposal rate of 115 cubic yards per work day, the maximum inventory at any time is 115 cubic yards.

2.6 Description of Auxiliary Equipment

The equipment used in the landfilling operations consists of Caterpillar D-8 dozer, a Terrex dozer, and an International dozer.

2.7 Final Closure Plan Summary

The existing landfill has received nonhazardous solid wastes after November 28, 1986. To ensure that no RCRA hazardous wastes are sent to this landfill, source control was implemented through satellite collection, secured containers and a RCRA training program. Areas of the landfill activities after 1986 were delineated from past areas. Uses of the existing landfill will be in compliance with the Colorado Solid Waste Act Regulations.

The closure plan will address the solid waste management units (SWMU) numbers 114 and 167.1 presented in Appendix 1 of the Rocky Flats Plant Part B RCRA Permit. If clean closure is not achieved for SWMU Number 203, the closure plan will also address this unit.

2.7.1 Closure Objectives

This closure plan has been prepared to meet the performance standards of 6 CCR 1007-3, Section 265.111. The promulgated standards require a facility must be closed in a manner that:

- minimizes the need for further maintenance, and
- controls, minimizes or eliminates, to the extent necessary to protect human health and the environment, post-closure escape of hazardous waste, hazardous waste constituents, leachate, contaminated rainfall, or waste decomposition

products to the ground or surface waters or to the atmosphere.

2.7.2 Closure Plan

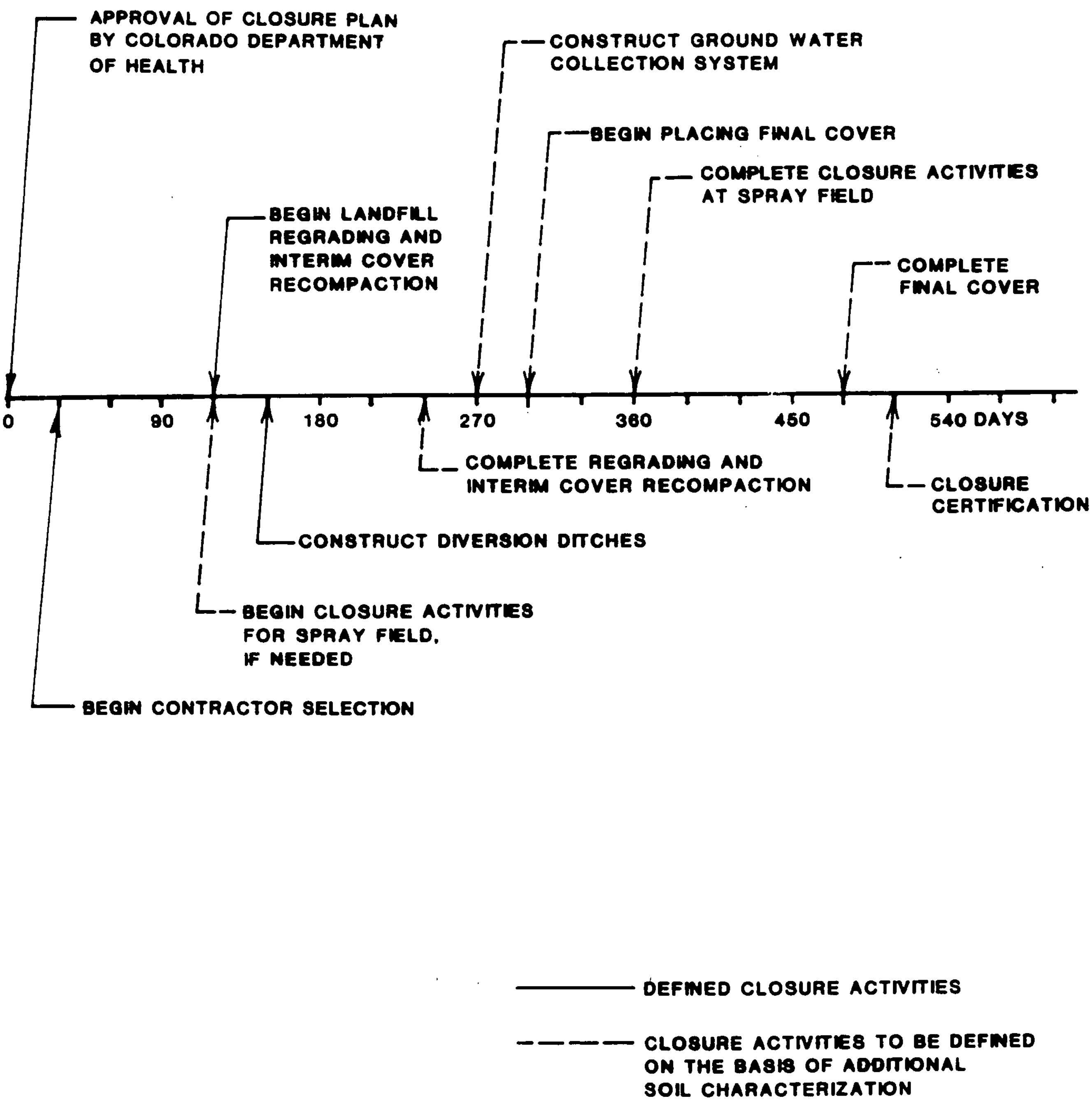
The activities necessary to complete closure and comply with the ground-water corrective action requirements of 6 CCR 1007-3 264 Subpart F are shown on the diagram in Figure 5. The closure activities include:

- analysis of north sprayfield area,
- grading of the landfill,
- placement of the cap,
- placement of a vegetative cover,
- maintenance of the closed area,
- evaluation of existing ground-water collection system, and
- installation of a ground-water collection system.

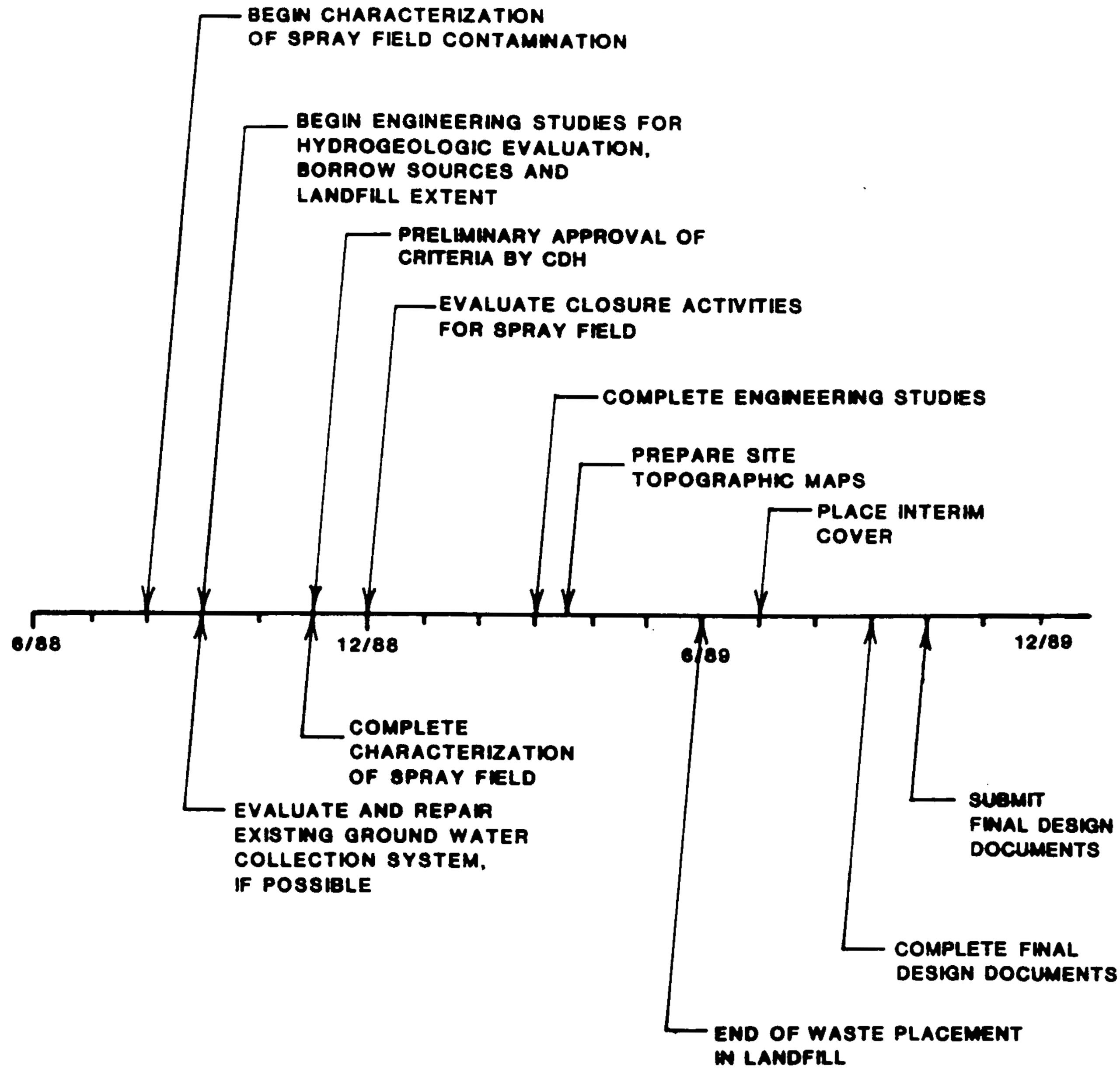
The quality of the ground water will be evaluated to determine if corrective action is required to meet 6 CCR 1007-3, Section 264 Subpart F. If necessary, the type of ground-water corrective action will be determined and implemented.

2.7.3 Closure Schedule

Anticipated schedules for closure activities are presented on Figures 6 and 7. Figure 6 presents activities to be



6 032 88	Chen & Associates	SUMMARY OF LANDFILL CLOSURE ACTIVITIES	Fig. 6



6 032 88	Chen & Associates	SUMMARY OF LANDFILL DESIGN ACTIVITIES	Fig. 7

conducted during closure of the landfill. Figure 7 presents the schedule for activities to be completed for final design. The site characterization and engineering studies necessary to define closure activities for the north sprayfield are anticipated to be completed prior to the end of deposition at the landfill. Preliminary acceptance of performance and closure design criteria is anticipated prior to initiating conceptual design documents. The final schedule of activities required for closure will be defined upon completion of additional site investigations and engineering studies.

2.7.4 Justification for Extension of Schedule

The regulations of 6 CCR 1007-3, Section 265.113(a) require:

> "Within 90 days after receiving the final volume of hazardous wastes at a hazardous waste management unit or facility, or within 90 days after approval of the closure plan, whichever is later, the owner or operator must treat, remove from the unit or facility, or dispose of on-site, all hazardous wastes in accordance with the approved closure plan."

The intent of this regulation is to avoid causing serious environmental damage due to accumulating inventory over long periods of time. In part 6 CCR 1007-3, Section 265.113(b) states that closure activities will be completed within 180 days after approval of the closure plan unless closure activities will, by necessity, take longer than 180 days to complete. If closure activities will take longer than 180 days, then steps must be taken to prevent threats to human health and the environment from the unclosed facility.

The activities required to complete final closure at the present landfill will take longer than schedules required by the referenced regulations. Before the installation of the final cover and cap can begin, field studies must be completed.

2.7.5 Protection of Human Health and the Environment

Threats to human health and the environment are prevented by the routine monitoring activities conducted at Rocky Flats and by restricted access to the facility. Specific details of the routine monitoring program are summarized in the "Annual Environmental Monitoring Report" (Rockwell, 1986b). This document is reviewed and updated on an annual basis. Brief discussions of the monitoring activities that are conducted and the security procedures at the plant are presented below.

The routine environmental monitoring program includes the sampling and analysis of airborne effluents, ambient air, surface and ground water, and soil. External penetrating gamma radiation exposures are also measured using thermoluminescent dosimeters. Samples are collected from on-site, boundary and off-site locations.

Particulate and tritium sampling of building exhaust systems is conducted continuously. For immediate detection of abnormal conditions, ventilation systems that service areas containing plutonium are equipped with Selective Alpha Air Monitors. These monitors trigger an alarm automatically if out-of-tolerance conditions are experienced. Particulate samples are collected from ambient air samplers operated continuously on site. The ambient air samples are analyzed for Total Long-Lived (TLL) Alpha activity or for plutonium activity. There are currently 51 of these ambient air samplers. Twenty-three are located within and adjacent to the Rocky Flats exclusion area, 14 are located along or near the plant's perimeter and 14 are located in nearby communities.

The majority of the water used for plant process operations and sanitary purposes is treated and evaporated and/or reused for cooling tower makeup or steam plant use. The discharge of water off-site is minimized to the greatest extent possible. Water discharges from the Rocky Flats Plant are monitored for compliance with appropriate CDH standards and EPA National Pollutant Discharge Elimination System (NPDES) permit limitations. Surface runoff from precipitation is collected in surface water control ponds and discharged off site after monitoring. Routine water monitoring is conducted for two downstream reservoirs and for drinking water sources in nine communities. Ground-water monitoring was conducted during 1987 at approximately 160 ground-water sampling locations.

Soil samples are routinely collected on an annual basis from 40 sites located on radii from Rocky Flats at distances of 1.6 and 3.2 kilometers (one and two miles). The purpose of this soil sampling is to determine if there are any changes in plutonium concentrations in the soil around the plant.

When higher concentrations than usual are found in any of the routine monitoring activities or when out-of-compliance conditions are identified, the cause of the problem is investigated. If the present landfill facility is found to be the cause of an out-of-compliance condition, then this closure plan will be revised within 30 days.

Access to the landfill is limited by:

- a three-strand barbed wire cattle fence surrounding the facility (Figure 1) posted to identify the land as a government reservation/ restricted area,
- guards patrolling the controlled area and the PSZ 24 hours per day, and
- surveillance by security cameras 24 hours per day.

The existing fences and gates are operated and maintained by the U.S. Department of Energy.

The monitoring and security measures outlined above are designed to protect human health and the environment by threats posed by the plant as a whole. In addition, they protect human health and the environment from threats posed by the present landfill. Additionally, the majority of the landfill has an interim three-foot soil cover. This cover minimizes potential direct contact and wind dispersal of contamination material and reduces contamination of runoff. Surface runoff, sediments and ground water are collected by the east pond. Ground water at the landfill is monitored quarterly by monitoring wells. These specific measures at the landfill further protect human health and the environment from threats posed by the landfill.

2.7.6 Final Design

Activities required to complete final design of the landfill closure will include the following:

- Characterization of soil contamination at the north sprayfield;
- Preparation of topographic maps;
- Delineation of landfilled material, exclusive of interim cover;
- Conduct engineering studies to evaluate horizontal and vertical gradients and ground-water flow at the landfill and geologic conditions influencing flow;
- Conduct engineering studies of potential borrow sites for cover construction material;
- Investigation discharge lines for the existing ground-water collection and diversion system; and
- Prepare design drawings, specifications, quality control and quality assurance plan, and site specific health and safety plan.

Activities for final design will be completed prior to July 1989. The general scope of work of these activities is presented below.

Characterization of the north sprayfield contamination will entail sampling of soil. Samples will be submitted for analysis of potential contaminants. Additional discussion of site characterization is presented in Section 3.1.

The topography of the landfill prior to closure activities will be mapped. The topographic mapping will be done at a scale of one inch equals 100 feet or less, with minimum two-foot contour intervals. The prepared maps will be utilized for final design drawings.

To assure that the final cover extends over all landfilled materials, a geophysical study will be conducted to evaluate the extent of the interim cover, landfilled materials and limits of the 1974 trench excavation. The study will use surficial geophysical techniques to delineate subsurface characteristics. Geophysical interpretations will be correlated to exploratory borings. The scope of the investigation will initially be to confirm the limits of the landfill presented herein. Should the study indicate the landfill extent to be significantly different from those presented, the scope of the study will be extended to redefine the limits of the landfill.

The hydrogeologic characterization presented in Appendix 6, is limited to available wells to determine the ground-water elevation and vertical and horizontal flow directions. Existing monitoring wells installed indicate a vertical component within the ground-water flow; however, the information is limited. Water levels within the main portion of the landfill are unknown at present. To evaluate these conditions and to determine what measures could be implemented to remove or reduce ground-water flows within the landfill, additional studies will be conducted. The study will entail installation of four to six nested monitoring well series. The nested series will have two to four wells installed in relatively close proximity with screen intervals placed at different elevations. The geologic characteristics of the soil and bedrock will be logged at each nested well location. Within the landfill, two to three monitoring wells will be installed with screen intervals at or near the bottom of the landfilled material. At the downstream toe of the landfill, subsurface conditions will be evaluated by drilling exploratory borings and completing selected borings as monitoring wells. The purpose of the borings will be to evaluate the overall effectiveness of the proposed ground-water collection system discussed in Section 5.3.4. The studies will be directed to develop sufficient information to evaluate alternatives for dewatering the landfill, interception of ground-water flows from the landfill and the potential impacts of the landfill to ground-water quality. Established monitoring wells will be sampled for ground-water quality as part of the quarterly monitoring program for the landfill.

An investigation will be conducted of potential borrow areas for suitable material for use in final cover construction. The investigation will delineate sufficient borrow volume for regrading of the landfill, compacted soil layer and topsoil within the final cover and evaluate potential on-site sources for sand and riprap, if present. The investigation will entail drilling between ten to 20 exploratory borings or test pits to obtain samples of potential borrow material at each potential borrow source. Materials obtained from the borrow sources will be tested, as appropriate, for their gradations, Atterberg limits, specific gravity, durability and moisture-density relationship. Additionally, material identified for use as potential topsoil on the final cover will be tested for suitability for plant growth. Testing will include pH, cation exchange capacity, sodium absorption ratio and calcium carbonate content. Identified borrow areas will be presented in the final design drawings as well as estimated reclaimed borrow contours.

Evaluation of the existing ground-water collection and diversion system will entail exposing valves on the drain line to determine their operating position, and exposing the drain line near the slurry wall. Additional discussion of the evaluation is presented in Section 5.3.2.

As presented on the schedule for closure in Section 2.7.3, these activities will be conducted prior to preparing the final design for closure.

2.8 Administration of Closure Plan

The closure plan for the present landfill will be kept at the Rocky Flats Area Office, Building 111, U.S. Department of Energy. The person responsible for storing and updating this copy of the closure plan is:

Mr. Albert E. Whiteman
Area Manager

His address and phone number are:

U.S. Department of Energy
Rocky Flats Plant
P.O. Box 928
Golden, Colorado 80402
Phone: (303) 966-2025

Mr. Whiteman is also responsible for updating other copies of the closure plan held off-site by sending additions or revisions by registered mail.

2.9 Closure Cost Estimates and Financial Assurance

State and Federal governments are exempt from the financial requirements imposed by Subpart H of 40 CFR 265.140(c). Therefore, no financial assurance documentation has been prepared for the landfill closure plan.

The estimated cost for landfill closure is presented on Table IV.

TABLE IV

LANDFILL CLOSURE
ESTIMATED CONSTRUCTION COSTS

Item	Quantity	Unit Cost ($)	Total Cost ($)
Regrading	50,000 cy	3/cy	$ 150,000
Interim Cover Recompaction	31,300 cy	3/cy	93,900
Sand Layers	31,400 cy	25/cy	785,000
HDPE Membrane	845,000 ft^2	0.65/ft^2	549,300
Compacted Soil	62,700 cy	5/cy	313,500
Topsoil	31,300 cy	3.50/cy	109,600
Riprap	1,700 cy	40/cy	68,000
Diversion Ditches	33,300 cy	4/cy	133,200
Revegetation	850,000 ft^2	0.13/ft^2	110,500
	CONSTRUCTION TOTAL		$2,313,000
	ENGINEERING DESIGN (10%)		231,300
	CONTINGENCY (15%)		347,000
TOTAL			$2,891,300

3.0 DECONTAMINATION PROCEDURES

3.1 North Sprayfield Area

For a period of approximately seven years, water collected in Pond #1 or west pond was routinely sprayed onto the north sprayfield. Prior to beginning the installation of the final cap and cover at the landfill, soil samples from the north sprayfield will be analyzed to evaluate if contamination has occurred. A flow diagram of the sprayfield activities is shown on Figure 8.

3.1.1 Sprayfield Boundary

The north sprayfield is located northwest of the east pond, and was used for spraying water contained in the west pond. The location of this sprayfield is shown on Figure 2. The dimensions of this sprayfield are approximately 280 feet by 480 feet.

3.1.2 Soil Sampling

Prior to installation of the final cap and cover of the landfill, soil samples from the north sprayfield area will be collected and analyzed, to evaluate if contamination has occurred. Based on water analyses from the west pond, contamination is not anticipated. The soil characterization plan for this study is to confirm the absence of contamination and is presented in Appendix 4.

The basis for this soil sampling program is random sampling points, in conjunction with a direct radiation survey. Because any contaminants in the pond water would have been distributed due to the spraying action in a uniform dispersed area adjacent to the previous spray lines, only a limited number of samples are necessary to evaluate if contamination has occurred.

A direct gamma radiation survey will be with a FIDLER conducted over the ground surface to detect measurable amounts of radioactivity. The assessment will be conducted in accordance with Rocky Flat radiation monitoring procedures (Rockwell, 1986c).

Within the sprayfield, samples will be taken at the approximate locations shown on Figure 2. The locations to be sampled are relatively evenly sampled along the previous spray lines. Because any contamination which may have occurred is expected to be uniform and dispersed along the spray line, localized hot spots are not anticipated nor does the sampling require the exact location of the spray lines. A total of three soil samples will be obtained in the sprayfield during the Phase I study.

3.1.3 Laboratory Analysis

The soil samples collected at the sprayfield will be analyzed for the following:

- Volatile Organic Compounds (EPA 624)
- Semi-Volatile Organic Compounds (EPA 625)
- Metals
- Radionuclides.

3.1.4 Criteria for Evaluating Soil Contamination

To evaluate whether soils in the sprayfield area have been contaminated, the laboratory results from the samples collected in the sprayfield will be compared to background soil values. The specific methods of comparison are outlined in the sampling plan, in Appendix 4.

3.1.5 Method of Treatment or Disposal

It is anticipated that the sampling program will show that the sprayfield area has not been contaminated. However, if the field work indicates the sprayfield has been contaminated, remedial alternatives will be evaluated, based on the types of contaminants present. Alternatives include:

- In-place treatment of contaminated soils.
- Removal of contaminated soils, with disposal in the present landfill.
- Removal of contaminated soil with off-site disposal.
- Closure of the sprayfield with the contaminated soils left in place.

3.1.6 Schedule

The study performed at the sprayfield will begin in August 1988, and will be completed by November, 1988. Any necessary remedial activities will be selected in December 1988. Anticipated implementation and completion times are shown on Figure 7.

3.2 Decontamination of Equipment

3.2.1 Introduction

As required by 6 CCR 1007-3, Sections 265.112(b)(4) and 265.114, construction equipment used during closure activities will be decontaminated. Currently, there is auxiliary equipment associated with the present landfill, as given in Section 2.6. Decontamination of construction equipment and the auxiliary equipment will involve the procedures described in the following section.

3.2.2 Decontamination Procedures

All construction equipment involved with activities at the landfill which contact contaminated soils, the interim cover materials or rinsate will be scraped or brushed to remove chunks of soil or debris whenever the equipment leaves the construction area. The area used for scraping or brushing will have tarpaulins spread over the ground and will be raked and/or swept to collect all removed materials. The collected material will be placed in the landfill beneath the final cover. Construction equipment will then move to an adjacent one foot thick gravel decontamination pad. The pad will be at least 50 feet square to accommodate heavy construction equipment. The top of the gravel pad will be at least one foot below the final grade for the interim cover.

At the decontamination pad, equipment will be triple rinsed with a spray system. The decontamination spray system to be used will heat water to approximately 350^{O}F under 250 pounds per square inch gauge pressure. The super-heated, high-pressure stream will be sprayed on the contaminated surface through a series of nozzles incorporated into the vacuum/ spray cleaning head. The exact equipment used for decontamination will vary depending on contractor selection. The decontamination equipment used will provide for adequate decontamination of the construction equipment.

Upon completing decontamination of equipment used for interim cover recompaction, the gravel pad will be covered with at least one foot of uncontaminated borrow soils compacted to interim cover specifications. Equipment used in this construction will either work only on uncontaminated soils or be of proper size to be subsequently decontaminated at Building 889.

Smaller construction equipment may also be decontaminated by a similar arrangement in Building 889.

3.2.3 Auxiliary Equipment

The auxiliary equipment at the landfill will be decontaminated using the same procedures outlined in Section 3.3.2.

3.2.4 Construction Equipment Used During Closure

Construction equipment used during closure may include dozers, backhoes, front-end loaders, soil compactors, water trucks and liner seaming equipment. If large quantities of soil are to be removed, additional equipment, such as haul trucks and scrapers, may be used. Additional equipment may be used during closure, if necessary. All construction equipment used at the site contacting contaminated soils, rinsate or the landfill interim cover materials will require decontamination as outlined in Section 3.3.2.

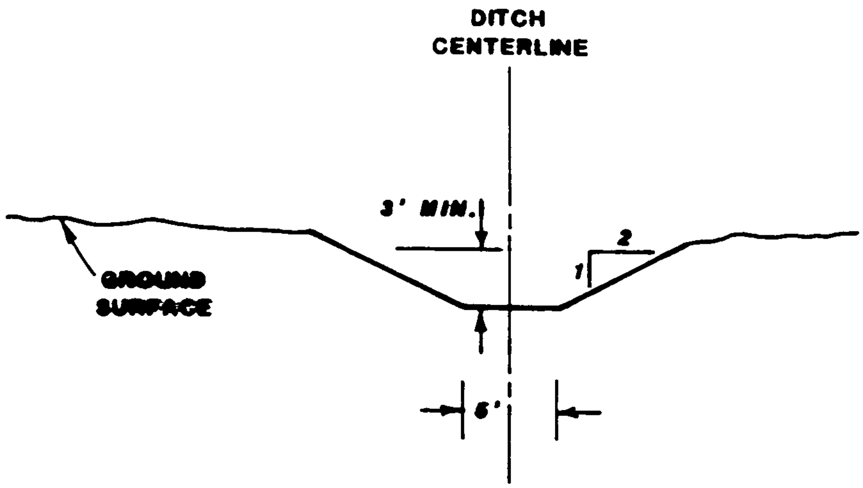
4.0 FINAL COVER

4.1 Regrading

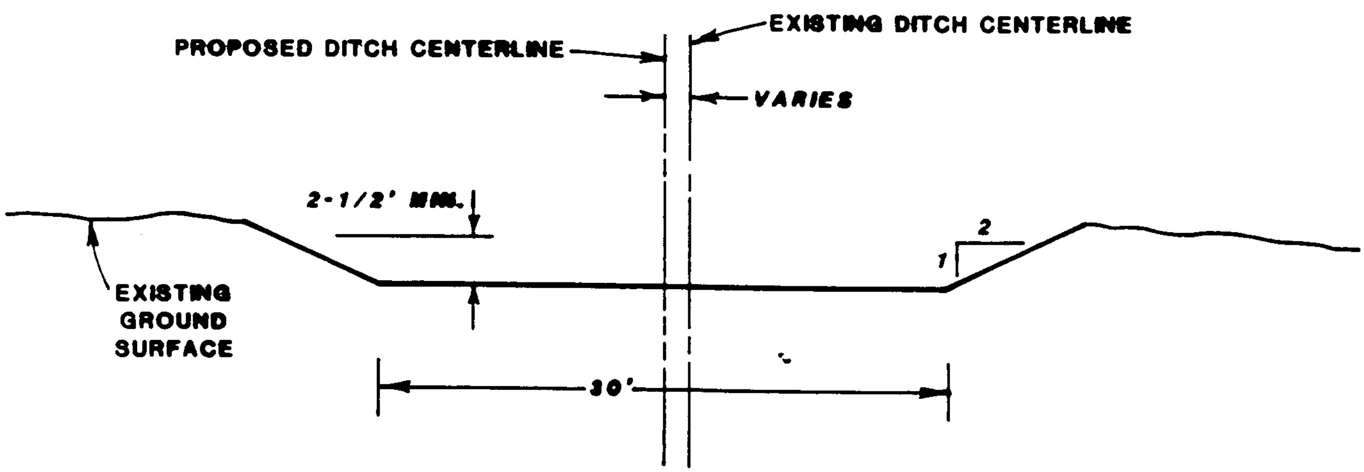
4.1.1 Surface Runon Control

Regrading of the ground surface adjacent to the landfill will be conducted as part of closure to reduce impacts of surface runon on the final cover. Regrading will involve enlargement and renovation of existing diversion ditches around the landfill. The existing diversion ditch locations, cross sections and proposed enlarged section are shown on Figures 3 and 9. The proposed diversion ditches will be designed to divert the peak storm runoff from the one-hour, 100-year storm event in each drainage, depending on the time of concentration of the drainage. A six-inch compacted clayey soil layer will be placed in the bottom of the diversion ditches for erosion control from the design storm.

Control of surface runon to the landfill for flows in excess of the 100-year design storm will be provided by surface



EXISTING DIVERSION DITCH SECTION



PROPOSED DIVERSION DITCH SECTION

SCALE 1"=10'

6 032 88	Chen & Associates	DIVERSION DITCH SECTIONS	Fig. 9

grading and final cover of landfill. Surface regrading of the landfill is presented in Section 4.1.2.

4.1.2 Landfill Regrading

The existing landfill surface will be regraded to divert surface runoff on the landfill to the center of the top, down the eastern face and into the east pond. Topography for the conceptual cover design is presented on Figure 10. The final cover elevations will be based on actual ground surface of the landfill at time of final design.

In designing final cover contours, consideration was given to cambering of the cover to drain surface runoff off the cover and into adjacent diversion ditches. However, such a design will be adversely affected by settlement of the landfill material. Such a design would also require placement of fill material to provide drainage. Additional fill material on the cover would result in additional settlement again adversely affecting the cover performance. As proposed, the effects of settlement on the cover will be to improve surface drainage. The final cover will have an approximate two percent grade. Based on computer modeling using the HELP computer program (Schroeder, 1983), the proposed grade would provide the necessary runoff and cover drainage control. It is anticipated that the landfill material will experience approximately ten percent settlement of the overall fill height as a result of self-weight consolidation, dewatering, and additional consolidation under cover loading. As a result, final cover grade will be approximately three percent after settlement.

Around the perimeter of the existing landfill, the ground surface will be graded to provide an approximate two-foot high berm prior to cover placement. The berm and cover placement will provide additional runon control for the landfill should storm events exceed the one-hour, 100-year design storm. The berm will also provide a point for ventilation of the gas collection system.

4.2 Final Cover

The final cover has been designed to meet performance standards set forth in Sections 265.228 and 265.310. The final cover will be a multi-layered section, designed and constructed to:

- Provide long-term minimization of the migration of liquids through the closed landfill;

- Function with minimum maintenance;
- Promote drainage and minimize erosion or abrasion of the cover;
- Accommodate settling and subsidence so that the covers integrity is maintained; and
- Have a permeability less than or equal to the permeability of any bottom liner system or natural subsoils present.

To meet these standards, the cover will be comprised of three components:

- Erosion control in the form of minimum slope grades and vegetation;
- Drainage layer to expedite removal of surface infiltration and maintain cover stability;
- Infiltration barrier, including both a flexible membrane liner (FML) and low permeability compacted soil.

Due to the presence of biodegradable materials within the landfill, the cover will also contain a gas collection component, this component is discussed separately in Section 6.0.

4.2.1 Final Cover Extent

The final cover will extend beyond the existing landfill boundary indicated on Figure 2. As shown on Figure 11, the

the cover will extend beyond the ground-water control and leachate collection system installed in 1974. The approximate area of the final cover will be 845,000 square feet.

4.2.2 Type of Materials

The design of the multi-layered cap will conform to the performance standards in 6 CCR 1007-3, Section 265.310. The specified performance standards will be achieved on the landfill by utilizing a multi-layered cap. A typical cross section of the final cover is shown on Figure 12.

Sand: The sand layers will be comprised of hard, durable sands or gravels having no more than five percent passing the U.S. standard No. 200 sieve. Final gradation of the sand drain material will be based on the gradations of the compacted soil layer material selected in final design. The sand drain layer will be designed to act as a filter against the compacted soil layer. During final design, characteristics of the compacted soil layer, anticipated hydraulic heads at the interface with the filter and required hydraulic conductivities for the drain material will be considered in selecting filter design criteria.

The sand layers will also serve a dual function as a bedding layer against the underlying synthetic membrane preventing the membrane from being damaged during the placement and compaction of the erosion control layers. The sand specified for the layers may be obtained from on-site borrow, if available, or will be imported to the site.

Since the drain material will be placed against the synthetic membrane of the multi-layer cover, the maximum aggregate size is limited to 1/4 inch to prevent punctures.

On the landfill top, flows within the drain will be collected by a six-inch diameter perforated drain pipe placed beneath the center surface drainage swale. The drain pipe will discharge into the riprap protection on the eastern face of the landfill, as shown on Figure 12.

<u>Interim Cover</u>: The existing interim cover soils are the on-site clayey soils. These soils are similar to the materials proposed for the compacted soil discussed herein. Additionally, the interim cover materials contain some asphalt and concrete construction debris. During regrading and recompaction, material larger than the six inches in size will be removed from the upper 12 inches of the interim

cover. Removal of the large material will allow more uniform compaction of the material. After initial surface grading, the upper one foot of interim soil cover will be scarified, moistened and recompacted to at least 95 percent of the maximum standard Proctor dry density with a moisture content of between two percent above and two percent below optimum moisture content.

Compacted Soil: Published data and site investigation reports indicate that natural clayey soils available on the site classify as A-6 and A-7 in accordance with the AASHTO classification system (U.S. Department of Agriculture, 1984 and Woodward-Clevenger, 1974). The A-6 and A-7 soils are silty and sandy clays. The 24-inch compacted soil zone in the final cover section service the following purposes:

- Provides protection of the low permeability sections from surface damage;
- Insulates the "functioning" sections, i.e., sand drain and low permeability barrier, from frost penetration.
- Fortifies erosion protection beneath the topsoil by affording increased water erosion velocities; and
- Permits deep root penetration without affecting the "functioning" sections to promote vigorous vegetation growth in an arid climate.

The on-site soil used in the compacted zone beneath the topsoil and above the sand drain will have more than 35 percent passing the No. 200 sieve, with a liquid limit greater than 30 and a plasticity index greater than 10. This soil layer will be placed in uniform 12-inch loose lifts, compacted to at least 95 percent of the maximum standard Proctor density. The material will be placed at a moisture content at or below optimum; however, strict moisture control will not be required because at the shallow depth of placement these soils will experience natural variations in moisture content.

Topsoil: The topsoil layer will be constructed using on-site soils. The topsoil mixture will then be spread over the entire cover area to be vegetated. Vegetation of the cover is discussed in Section 4.4. The topsoil will be placed in a single uniform 12-inch loose (uncompacted) lift.

Riprap: The area where the collected surface runoff from the landfill top discharges to the eastern face of the landfill will be riprap protected in order to prevent erosion of the final cover due to concentrated flows. The material will be hard, durable rock having no more than five percent passing the U.S. standard No. 200 sieve. The average size (D_{50}) of riprap material required to resist flow velocities will be about eight inches based on Stephenson's method of analysis (Nelson, 1986). This method of analysis considers sheet flow conditions and accounts for flows within the riprap material. The maximum size of riprap will be 18-inches equal to the thickness of the riprap layer. The riprap will be imported to the site.

Estimated flow velocity within the riprap material is about 1 fps which is less than those permissible for the compacted soil layer. As a result, riprap bedding will not be required. Supporting calculations for runoff and erosion control design are presented in Appendix 2.

Synthetic Membrane: A 30-mil high density polyethylene (HDPE) synthetic membrane will be placed above the gas collection layer and beneath the sand drain as shown on the cross section on Figure 12. The membrane will be manufactured from virgin first quality resin, designed and formulated specifically for use in hazardous waste environments. The HDPE membrane will meet the following minimum specifications:

Property	Test Method	Test Value
Density (g/cc)	ASTM D-792	0.935
Environmental Stress Crack (min., hrs.)	ASTM D-1693 Condition C	1,500
Low Temp Brittleness	ASTM D-746	-75°C
Thickness	ASTM D-2103	-5% to +10%
Tensile Strength at Yield (psi)	ASTM D-638	2,000
Elongation at Yield	ASTM D-638	13%
Tear Resistance (lb)	ASTM D-1004 Die C	20 for 30-mil 40 for 60-mil
Carbon Black	ASTM D-1603	2% to 3%

4.2.3 Depth of Materials

The depth of the materials were determined to provide the specified performance for protection of human health and the environment while maintaining an efficient design. The 12-inch topsoil depth is typical for support of native vegetation in the semi-arid region. The compacted on-site soil below the topsoil will be placed 24 inches thick. Adequate frost protection and protection from surface abrasion is provided by the combined 12 inches of topsoil and 24 inches of compacted on-site soil.

The sand drain layer will be six inches thick. The sand drain above the synthetic membrane is sized based on infiltration and drainage calculations using the HELP computer model (Schroeder, 1983). Results of the modeling are presented in Appendix 2. Based on the maximum drain length and initial slopes, and using a conservative hydraulic conductivity on the order of 1×10^{-3} centimeters per second, the six-inch sand drain will accommodate design flows.

A 30-mil HDPE membrane will be placed below the sand drain to limit infiltration into the landfill. The membrane will be enclosed by sand layers to minimize potential damage and below frost depth, therefore, a heavier membrane was not justified.

A six-inch sand layer will underlie the synthetic membrane. This layer will collect gases generated by the landfill and allow controlled venting of the gases through the final cover.

The recompacted interim cover material is a "second" component beneath the synthetic membrane to minimize surface infiltration. The interim soil cover is comprised of sandy clay materials and is between three and nine feet in depth (Woodward-Clyde, 1974). The 12-inch thick recompacted layer will have a reduced hydraulic conductivity in comparison to the overlying gas layer.

4.2.4 Volume of Materials

The material volumes for the final cover are estimated as follows:

Material	Quantity
Sand Drain	15,700 yd^3
Gas Collection Layer	15,700 yd^3
Recompacted Interim Cover	31,300 yd^3
Compacted On-Site Soil (A-6 or A-7; compacted volume)	62,700 yd^3
Topsoil	31,300 yd^3
30-mil HDPE	845,000 ft^2
Riprap	1,700 yd^3

The material volumes may vary depending on final design and construction.

4.2.5 Source of Materials

Prior to final design, borrow source investigations will be conducted to identify and quantify materials for cover construction. If available, all natural cover material will be obtained from on-site borrows. Anticipated borrow sources at the Rocky Flats Plant will be in the vicinity of the landfill, in the buffer zone and/or west sprayfield. The distance to these borrow sources ranges from less than 0.25 to approximately 1.0 mile.

If sand material and riprap are unavailable on-site or processing is uneconomical, the sand drain material and riprap will be imported to the site. The materials specified are commonly available through local suppliers from borrow sources in the region. Maximum haul distances will range up to 15 miles.

Materials will be brought to the site and placed in sequence from construction of the final cover to avoid stockpiling and double handling.

4.2.6 Final Cover Design

Slope of Cover: The minimum slope of the cover will be two percent to promote surface runoff and reduce ponding and surface water infiltration. The minimum slopes will occur on the landfill top where existing slopes are nearly level. The maximum slope for the cover is 20 percent and will occur on the eastern face of the landfill.

Erosion Protection: Final cover vegetation will provide erosion protection from surface runoff. Calculations to determine maximum surface velocities relative to permissible velocities for vegetated soil cover are presented in Appendix 2. Velocities were calculated using the rational formula for surface runoff assuming a 100-year, one-hour storm event, adjusted for the time of concentration for the central drainage swale. Flow velocities of 2.6 to 4.0 feet per second (fps) were calculated using Manning's equation. Maximum velocities will occur as slopes increase upon settlement of the cover. Permissible flow velocities below which surface erosion will not occur were obtained from referenced sources (Nelson, 1986; NAVFAC, 1982). The range of permissible velocity for the cover is 4 to 5 fps.

Therefore, the erosion of the soil and vegetation cover is not anticipated as a result of the design storm event.

In addition, the compacted on-site soil beneath the 12 inches of topsoil contains sand and gravel sized particles, which are generally present in the colluvium near the landfill. In addition to the higher flow velocities permitted for compacted soil, the larger particles will provide self-armoring should flow velocities increase until the on-site compacted soil layer begins to erode. As a result, the compacted soil layer will provide additional erosion control for the final cover in the event the vegetative cover is eroded or lost on portions of the cover between maintenance periods.

4.2.7 Final Cover Stability

Sliding Stability: The stability of the proposed final cover was evaluated for the maximum slope of five to one. An infinite slope analysis was performed to evaluate the sliding potential of the overlying drainage and erosional layers on the synthetic membrane. This point of the cover is considered critical for sliding as the frictional resistance between the synthetic membrane and the overlying sand material is only approximately 60 percent of that of the sand and seepage forces may be present within the sand drain.

Using conservative assumptions for sliding resistance and seepage forces within the sand drain, the final cover has a factor of safety against sliding in excess of 1.5.

Settlement Stability: Final cover stability was also evaluated with respect to differential settlement. If the landfill material were to settle at a constant ratio to the height of fill material, settlement across the landfill would result in minimal strains on the synthetic membrane. However, due to the nature of the landfill construction, differential settlement of the cover is anticipated. Where differential settlements occur in short areas, the synthetic membrane might fail under strain. The synthetic membrane is quite elastic in comparison to the other natural materials in final cover design. Typically, a 30-mil HDPE membrane can withstand elongations of ten to 15 percent prior to yielding. Yield of the membrane is the point at which the membrane thickness is significantly reduced; however, the membrane is still intact. Rupture of the material requires strains greater than 100 percent. Evaluation of strain stability of the membrane was made by comparing the tensile strength of the synthetic membrane at yield to the sliding resistance on the membrane. The analysis indicated that the liner would slide on the sand layer prior to reaching yield strength. Calculations are presented in Appendix 2.

Due to the elastic characteristics of the synthetic membrane, yielding of the membrane would require differential settlements on the order of five feet across a ten-foot span. Based on the operating history of the landfill, it is not anticipated that differential settlements of this order of magnitude would occur within the landfill.

In summary, the synthetic membrane is capable of withstanding large strains resulting from differential settlement. Due to cover loads and high yield strength of the membrane material, the membrane will slide along the underlying sand layer prior to reaching yield strains. The membrane movement will redistribute stresses over a greater portion of the membrane and thus reduce strains. The membrane will therefore accommodate landfill settlement and retain its integrity.

4.2.8 Infiltration Control

Infiltration through the final cover will initially be reduced by surface grading, evapotranspiration from the vegetation cover and the reduced permeability of the compacted soil layer. However, it is recognized that some waters will infiltrate beneath the compacted soil layer. Further infiltration of the water will be reduced by placing a 30-mil HDPE synthetic membrane below the six-inch sand drain layer. Most infiltrating waters will therefore be diverted through the sand drain and out the cover. The synthetic membrane will provide the cover with a permeability less than the natural soils underlying the landfill.

Although the intact HDPE material is for practical purposes impermeable, field seaming of the membrane panels, other construction defects and damage may occur to the membrane. As a result, there will be an effective permeability of the membrane based on the percentage area of defects to the overall membrane area. For purposes of the computer modeling, it was conservatively assumed that for every 100 feet of seam, there was one foot having a hairline opening or an equivalent hole opening of 0.001 square foot. Based on the proposed final cover and the assumed inefficiency of the synthetic membrane, the HELP computer model was run and an estimated 1,000 cubic feet of water infiltrated through the synthetic membrane on a yearly basis. In comparison it is estimated that 144,000 cubic feet of water per year infiltrate the existing cover.

The synthetic membrane will be underlain by a six-inch sand layer which will act as a gas collection layer. However, the gas collection layer will also provide drainage below the synthetic membrane should waters pond on the underlying interim cover. Drainage collected by this layer will be discharged into the proposed water collection system along the eastern boundary of the landfill as shown on Figures 10 and 13. The gas collection system will also serve as bedding layer for the synthetic membrane preventing damage to the synthetic membrane as a result of construction of the overlying cover components.

4.2.9 Cover Equipment

For construction of the final cover, standard construction equipment will be utilized. Equipment utilized in construction which contacts the interim cover will be decontaminated as presented in Section 3.3.2 prior to reuse in construction of the final cover. Decontamination of the equipment will preclude the possibility of contamination of the upper components of the cover by equipment. Actual construction equipment and amount required to construct the final cover will, for the most part, be at the contractor's discretion.

Equipment required to recompact the interim cover and place the gas collection layer may consist of a water truck, dozers, front end loaders, compactors (sheeps-foot), harrowing disks and dump trucks for transporting of material. During construction, only that equipment essential for landfill regrading and interim cover recompaction will be placed on the interim cover. As practical, equipment currently used in operation of the landfill will be utilized for regrading and recompacting. This will minimize the equipment requiring decontamination. During construction of the gas collection layer, equipment will, as much as practical, work on top of the imported sand and thus, will not require decontamination.

Installation of the synthetic membrane will require the use of front end loaders to transport roll stock for field seaming. Field seaming equipment will be in accordance with liner manufacturer's specifications.

Construction equipment used for installation of the sand drain and erosion control layers will be similar to the equipment used for recompaction of the interim cover and installation of gas collection layer. However, only smooth drum compactors will be utilized for placement of the drain layer and the first 12 inches of compacted soil material overlying the drain. The sheeps-foot compactor will be prohibited from use in order to preclude damage to the synthetic membrane during compaction. Stopping or turning of equipment on the five to one slope will not be permitted until the first 12 inches of compacted soil has been placed.

Placement of the topsoil, seed and mulch on the vegetative cover require dozers or tractors with crimping and harrowing discs, trucks for hay mulching and seed application equipment.

4.4 Vegetation

The surface of the cap will be stabilized to decrease erosion by wind and water, and in a manner which will contribute to the development of a stable surface environment. This will be accomplished by establishing a vegetative cover on the cap. The total area requiring revegetation will be approximately 850,000 square feet.

Vegetation of the cover will be conducted by seeding with a mixture of native grasses. The mixture will consist of:

Grass	Quantity (pounds)
Western Wheatgrass	6.0
Thickspike Wheatgrass	3.0
Little Bluestem	2.0
Green Needlegrass	2.0
Canby or Canada Bluegrass	1.0
	14.0 pure live seed/acre

The properties of the native grass mix are:

- A root structure which will not penetrate the cover,
- Require no irrigation after the grass has been established,
- Be capable of withstanding the temperature range experienced at Rocky Flats,
- Require little fertilization after initial seeding, and

- Be compatible with the soil properties, such as pH, of the vegetative layer.

Preparation of the topsoil layer will include ripping of the upper six inches, applying two tons per acre of weed free native hay mulch and crimping the mulch with a crimper disc. The fertility of the topsoil layer will be analyzed in the first year and appropriate fertilizers applied to the cover in the second year, if needed. Irrigation will not be required. Additional periodic maintenance will be performed, including reseeding and weed control, as necessary. The landfill cover and vegetative growth will be inspected quarterly as specified in the Part B Post-Closure Care Permit. During this inspection, trees and bushes will be removed, and the condition of the vegetation will be observed.

4.5 Final Cover Maintenance

Maintenance of the cover will include filling and regrading of surface erosion and reseeding to maintain the vegetative cover. If required, replacement of riprap material on the face of the embankment will be performed. Gas ventilation pipes will be repaired or replaced as required to provide positive ventilation. Details of cover maintenance are presented in the post-closure care permit.

4.6 Health and Safety Plan

A site specific Health and Safety Plan, or such health and safety procedures identified in the Rocky Flats Plant Operational Safety Analysis (OSA), covering landfill closure activities will be prepared during final design. The plan will be submitted to the Colorado Department of Health for review and will comply with all applicable requirements. The procedures presented below are guidelines that will be followed during closure activities. Additional procedures and details will be presented in the site specific Health and Safety Plan or the OSA. Worker safety guidelines, such as OSHA regulations, DOE orders and Rocky Flats Plant policies will be followed. Protective clothing will be similar in nature to:

- hardhats,
- hard-toe boots,
- Tyvek overboots,
- Tyvek suits,
- dust masks, and
- air-purifying respirators or self-contained breathing apparatus (optional).

The intent of this equipment is to provide a barrier to inhalation, ingestion and absorption of contaminated materials. Appropriate protective gloves will be used based on the contamination found at any particular site.

Air monitoring will be conducted in the work area. Portable high-volume (40 cfm) samplers or fixed radioactive ambient air samplers (25 cfm) will be located around the excavation area, including at probable downwind locations.

Air monitoring will also be conducted using hand-held photoionization detectors. The site specific health and safety plan or OSA will present levels, which if exceeded, will require some action be taken, such as increasing respiratory protection or work cessation.

A Rocky Flats Environmental Sciences representative will be monitoring conditions during excavation activities. This person will have the authority and responsibility to terminate the work if any of the following events occur:

- Wind speeds exceed 24 km/hr (15 mph).
- Any visible dust is present or there is any indication that dust control measures are inadequate.

- The total long-lived alpha concentrations measured on filters from high-volume samplers exceed 0.06 pCi/m^3. Dust control procedures will then be re-evaluated.
- Power failure.
- Heavy rainfall or snow.

Airborne contamination may require upgrading dust masks to air-purifying respirators or self-contained breathing apparatus. Sudden increases in airborne contamination due to excavation in localized highly contaminated areas may be addressed by a temporary cessation of work until natural dissipation reduces contamination.

4.7 Quality Assurance and Quality Control

4.7.1 Quality Control

Quality control of the landfill closure will include materials, lines and grades, and placement. The specific method for controlling the quality of material in each of these areas will be presented in the final construction specifications, general quality control guidelines are presented below.

Control of material quality will be by random sampling at specified intervals. Earthen materials may be tested for their characteristics such as gradation, Atterberg limits, moisture-density relation, specific gravity and durability. Manufactured materials will be certified by the manufacturer that it meets the project specifications. Throughout the closure of the landfill, materials utilized will be visually observed during placement to see that the materials meet the intended use and project specifications.

Control of lines and grades during closure will be by surveying. Surveys will be conducted under the supervision of a registered land surveyor. Deviation from construction drawings will be indicated and as-built drawings showing constructed lines and grades will be prepared upon completion.

Control of placement will overall be by visual observation of the methods, equipment and practices utilized for placement of materials. Earthen materials will also be tested for proper placement by in-place testing of moisture, densities and gradations, as applicable. Control of imported materials, sand and riprap, will be by random sampling of trucks. These materials will be sampled at least every 1,000 cubic yards (cy) and tested for gradation and durability. Additional testing will be conducted if materials appear to vary significantly between truck loads. The riprap material will also be tested in at least in two locations for the in-place gradation. On-site materials will be tested for gradation and Atterberg limits every 1,000 cy. If gradations or Atterberg limits vary significantly, from previous materials a standard Proctor density curve shall will developed for the material. In-place density and moisture content will be tested for every 1,000 cy of material placed. As a minimum, one in-place moisture-density test will be taken per day per lift during fill compaction. Manufactured materials will be tested, as appropriate, to determine that field installation methods have produced the required quality of product. The synthetic membrane will have all field seams tested in accordance with the manufacturer's recommendations. As a minimum, all field seams will be visually inspected.

Quality control testing will be performed in accordance with ASTM or other recognized test procedures.

4.7.2 Quality Assurance

To assure that the quality control plan is being implemented during closure of the facility, a quality assurance plan will also be set forth as part of the final construction documents. The quality assurance plan will set forth the time intervals between quality assurance reviews, information to be reviewed and procedures for correction of quality control problems if present. As a minimum, the quality control program will be reviewed at a point when approximately 20 percent of the work is completed, at approximately 60 percent completion and at completion. The quality assurance reviews shall include all test results subsequent to the previous review, observation of test procedures, review of randomly selected test worksheets and evaluation of the procedures for quality control checks.

The quality assurance plan will be dependent on the quality control specifications and the time schedule for closure. It is anticipated that the certifying engineer for closure will provide quality assurance reviews.

5.0 COLLECTION, REMOVAL AND TREATMENT OF LEACHATE AND GROUND-WATER

5.1 Introduction

A system was installed around the perimeter of the landfill in 1974 as part of the landfill expansion. The system was designed to collect and remove leachate from within the landfill and to intercept and divert uncontaminated ground-water flow outside of the landfill away from the landfill area. The leachate collection system was intended to intercept leachate and lower ground-water levels within the landfill. For the subsequent expansion of the landfill in 1982, the ground-water diversion was extended using a soil-bentonite slurry wall as shown on Figure 3. The slurry wall was intended to reduce migration of ground water into the landfill area only, no provisions were made for collection and diversion of the ground water.

5.2 Existing Leachate Collection System

The existing leachate collection system was constructed in 1974, as shown on Figures 3 and 4. The construction of the leachate collection system is discussed in more detail in Section 2.2. At present, the leachate collection system is covered by landfill wastes and the original discharge points for the system were covered during expansion of the landfill. Based on current water level measurements within the landfill, presented in Appendix 6, it does not appear that the leachate collection system is lowering water levels within the landfill. Causes of disfunctioning may include blockage of the discharge points by landfill material, migration of the landfilled material into the collection system and migration or installation of slurry wall material through the collection system.

5.2.1 Maintenance of Leachate Collection Systems

Based on current ground-water levels, the existing leachate collection system does not appear to be functioning. Several factors may be influencing the functioning of the system. Based on the overall closure plan for the landfill, the existing leachate collection system would not be of significant benefit. Therefore, the evaluation and remedial construction necessary to re-establish functioning of the drain is not justified.

5.2.2 Volume of Leachate

The existing leachate collection system may have collected some leachate initially; however, there is no documentation of the volume of water collected by the system.

5.3 Ground-Water Control System

5.3.1 Existing Ground-Water Control System

A system to control ground-water migration into the existing landfill was constructed at the site in 1974 and extended in 1982. Details regarding the design and construction of the system are presented in Section 2.2. The existing ground-water control system is comprised of two components. The first component is a drainage blanket extending through the overburden soils to or near to the top of bedrock. Ground-water flow intercepted by the blanket drain was designed to be collected in drainage pipe and discharged into downstream ponds or the surface drainage downgradient of the ponds. The second component of the system is a soil-bentonite slurry wall tying in with the drain system and extending downstream of the landfill.

5.3.1.1 Blanket Drain

As originally intended, the blanket drain system would intercept and divert shallow ground-water flows away from the landfill. With the expansion of the landfill into the trench containing the blanket drain, the drain may have collected leachate which migrates through the clay liner overlying the blanket drain.

Based on water level measurements in the first quarter of 1988 (Appendix 6), the drain appears only partially effective. Monitoring wells placed at the western end of the landfill indicate a drawdown in ground-water levels adjacent to the drain. However, water levels in the monitoring wells established at the north and south sides of the landfill near the intersection of the slurry wall and blanket drain show no appreciable effect of the drain. As a result, water collected by the blanket drain system is impounded at the eastern ends of the system. As the drain pipe provides the only outlet of discharge from the system, the improper functioning of the system may be the result of the outlet being closed.

The blanket drain system, if functional, would aid in reducing water levels within the landfill. During final design, this system will be evaluated to see if it can be made functional. Evaluation of the system will include locating the discharge system valves, shown on Figure 3, to determine their operating position. The valves will be positioned such that all discharge is routed to the east pond. The discharge pipe in the vicinity of the slurry wall will be exposed and the piping upgradient and downgradient checked for blockage. As practical, valves and piping will be repaired or replaced to return the blanket drain system to working order. If the system cannot be made functional, the drain pipe outlet will be permanently blocked to reduce pathways for leachate migration out of the landfill.

5.3.1.2 Slurry Wall

The actual effectiveness of the slurry wall component cannot be evaluated because as-built documents are not available. However, as originally designed, the slurry wall will provide a barrier to ground-water migration into the landfill and thus reduce overall water levels within the landfill.

5.3.2 Proposed Ground-Water Collection System

5.3.2.1 Introduction

Based on recent ground-water quality sampling and analysis, Appendix 6, the landfill does appear to have had some impact to ground-water quality. Impacts to ground-water quality from hazardous constituents is limited to inconsistent, low-level concentrations up and downgradient of the landfill. Therefore, the landfill does not appear to be directly impacting ground water with hazardous constituents.

Because there are impacts to ground-water quality at the site, relatively high water levels within the landfill and as closure activities could result in changes in the quality of water from beneath the landfill, a ground-water collection system is proposed for closure.

5.3.2.2 Proposed Collection System

The ground-water collection system will be constructed at the downstream toe of the final landfill cover as shown on Figure 9. The collection system will be a gravel drain excavated through the surface colluvial and alluvial material into the underlying claystone bedrock as shown on Figure 12. The drain will lower water levels within the landfill and collect potentially impacted ground-water flows within the surface soils and shallow bedrock. Collected water will be pumped to the east pond area.

The proposed collection system will be designed using criteria for water storage projects. Such criteria have proven successful for construction of long-term, no maintenance drainage systems. Based on current water quality information, no significant chemical reactions such as oxidation, reduction or precipitation would occur as intercepted waters enter the drain system which could affect drain functioning. Pump and piping repair and/or replacement may be required during the operating life of the collection system. It is anticipated that stable ground-water levels and water quality will be achieved during closure of the landfill such that long-term pumping operation of the collection system will not be required.

The proposed ground-water collection system is estimated to have a discharge of about one gallon per minute. The actual volume collected by the system will be dependent on subsurface conditions encountered during construction of the drain. The presence of more pervious soils and sandstone lenses within the bedrock may increase flows. Other factors influencing volumes collected by the system are long-term stabilized water levels within the landfill and the effectiveness of repairs to the existing ground-water control system. A 30-mil HDPE membrane will be placed on the downstream side of the drain to reduce inflow from the east pond.

During final design, an evaluation of the site will be made to determine if a cut off wall extending deeper than the existing systems can be installed to eliminate ground-water migration into the landfill. Based on the engineering studies during final design, the cut off wall may be installed to effect additional ground-water control.

5.4 Water Storage

The water collected by the ground-water control systems will be discharged to the existing east pond for storage and evaporation. The east pond will be operated as a zero discharge impoundment to surface drainages for the 100-year, 24-hour storm event after closure.

During closure of the landfill, the water elevation in the east pond will be lowered to a maximum elevation of about 5915. This maximum pool elevation will be maintained during post-closure resulting in approximately 11 acre-feet of excess storage in the pond. This excess storage will hold all the runoff from the 100-year design storm. Excess pond water will be spray evaporated, pumped to an existing COPDES permitted discharge point or discharged under a new COPDES permit for the east pond. Final excess storage volume and water elevations will be determined during final design.

5.5 Water Treatment

Based on recent sampling and analysis (Appendix 6), the quality of water collected by the ground-water interception systems would not require treatment prior to discharge into the east pond. However, closure activities for the landfill will result in reduction of ground-water levels within the landfill area. Changes in ground-water conditions within the landfill may result in variations in water quality. Water collected by the systems will be analyzed on a routine basis at the discharge point and in the east pond, and appropriate management methods instituted if contamination is found. Criteria for evaluating water contamination is presented in Appendix 6.

Should variations in the water quality be sufficient to require treatment of the east pond waters, a treatment system will be constructed to handle contaminated waters at the plant site.

5.6 Ground-Water Monitoring

Assessment and monitoring of ground-water quality and contamination will be conducted utilizing the existing monitoring wells at the landfill. Monitoring wells installed for additional engineering studies will also be utilized as appropriate. Monitoring prior to and during closure of the landfill will be by routine quarterly monitoring of all existing wells and those selected from additional studies. In addition, the east pond will be sampled quarterly at the west and east ends.

Post-closure monitoring of ground-water is discussed in Section E of the Post-Closure Care Permit.

6.0 GAS COLLECTION

6.1 Introduction

The disposal of solid waste by landfilling employs engineering principles and construction methods to confine waste to the smallest area practical, compact the waste into the lowest volume possible, and cover the waste with layers of soil to limit exposure of the materials to the environment. This method inadvertently creates conditions in which gases may be produced, vented to the atmosphere and migrate laterally through the soil to outlying areas.

Gas production is stimulated by biodegradable materials such as food wastes, paper, textiles and wood. The period of gas generation from a solid waste landfill may range from a few years to tens of years. The active gas production life is dependent on site-specific conditions including the levels of oxygen present, moisture content of the wastes, pH, temperature and waste composition. Some components of landfill-generated gas are methane, hydrogen sulfide and carbon dioxide.

6.2 Soil-Gas Survey

A soil-gas survey was conducted at the landfill to evaluate levels of methane and hydrogen sulfide being generated by the landfill. The results of the survey are presented in the report by Chen & Associates in Appendix 3. The results of the survey indicated little or no methane and hydrogen sulfide generation from the landfill. However, readings from the portable gas chromatograph utilized in the survey did indicate the presence of other volatile compounds. The unknown compounds were not identified nor quantified as part of the survey.

6.3 Gas Collection System

Based on the results of the soil-gas survey, a large active gas collection and ventilation system appears unnecessary for the landfill closure. However, some low levels of methane were detected in the survey and other unknown compounds were present in the landfill soil-gas. Due to the presence of the synthetic membrane, low level gas concentrations could collect beneath the membrane. Collected gases would migrate through the membrane at flaws or defects within the membrane. It is not anticipated that the gas leakage would be significant enough to result in a health or environmental hazard; however, leakage could adversely affect the vegetative cover.

Although the soil-gas survey indicated low levels of methane and hydrogen sulfide at the landfill, closure activities will lower water levels within the landfill. Landfill material previously below the water surface may undergo aerobic digestion upon dewatering, resulting in gas generation. The amount of gas generated during water level drawdowns will be dependent on the amount of drawdown achieved, types of landfill material within the area of drawdown and amount of previous biodegradation which has occurred in the materials.

As a precaution against future generation of landfill gases and to reduce the potential for vegetative cover stress due to concentrated leakage of gases through the membrane, a passive gas collection and venting system will be installed on the landfill. The system will consist of a six-inch layer of sand placed below the synthetic membrane and vented around the perimeter and across the front crest of the landfill at a 200-foot spacing. The vent pipes will be placed approximately two feet above the final cover which even in low wind situations will provide a negative pressure gradient on the vent to exhaust collected gases. The proposed gas collection and ventilation system is shown on Figure 11. The gas vent pipes will be constructed of HDPE material in order to ease sealing with the synthetic membrane.

6.4 Gas Collection System Maintenance

As part of the post-closure maintenance of the cover, explosimeter measurements will be taken in the gas vent pipes to monitor the performance of the system and potential changes in gas generation from the landfill. If monitoring indicates significant increases in the gas generation from the landfill, modification of the gas collection and ventilation system may be implemented. Modifications may include the addition of turbines to the ventilation pipes to actively draw gases from the collection layer and/or installation of additional vent pipes in the final cover. Intervals and criteria for evaluating changes in gases will be set forth in the post-closure permit.

7.0 INSTALLATION AND MAINTENANCE OF FENCE

The existing security measures at the Rocky Flats Plant include:

- a three-strand barbed wire cattle fence surrounding the facility (Figure 1) posted to identify the land as a government reservation/ restricted area,
- a fence surrounding and guards posted 24 hours per day at two gates to the controlled area of the facility (Figure 1),
- a 6-foot high chain link fence topped by 2 feet of three-strand barbed wire surrounding and guards posted 24 hours per day at gates to the perimeter security zone (PSZ),
- guards patrolling the controlled area and the PSZ 24 hours per day, and
- surveillance by security cameras 24 hours per day.

At the landfill, a four-foot high fence has been installed around the perimeter of the landfill. The fence has an access gate and posted warning signs. This fence and the existing fences and gates are operated and maintained by U.S. DOE. Maintenance requirements will be performed by U.S. DOE, regardless of the activities at the landfill.

The security measures are sufficient to meet the requirements of 6 CCR 1007-3, Section 265.14.

8.0 CLOSURE CERTIFICATION

8.1 Certification Requirements

Closure certification requirements are outlined in 6 CCR 1007-3, Section 265.115 and 40 CFR 265.115:

> "Within 60 days of completion of closure of each hazardous waste surface impoundment, waste pile, land treatment, and landfill unit, and within 60 days of completion of final closure, the owner or operator must submit to the (Department of Health/Regional Administrator), by registered mail, a certification that the hazardous waste management unit or facility, as applicable, has been closed in accordance with the specifications in the approved closure plan. The certification must be signed by the owner or operator and by an independent registered professional engineer."

Certification by an independent registered professional engineer does not guarantee the adequacy of the closure procedures and does not necessarily involve detailed testing and analyses. It implies that, based on periodic facility inspections, closure has been completed in accordance with the specifications in the approved closure plan (U.S. Environmental Protection Agency, 1981).

8.2 Activities Requiring Inspections by a Registered Professional Engineer

The following closure activities will be inspected by a registered professional engineer:

- removal, treatment and disposal of contaminated soil, if necessary,
- grading of landfill,
- installation of gas collection system,
- placement of cap,
- installation of ground-water collection system,
- repair of the existing ground-water collection system,
- vegetation, and
- Decontamination of the equipment used at the landfill.

A summary of these activities and the dates when they occurred will be presented in the closure certification report. As a minimum, these activities will be inspected near the start of work, at approximately half completion and at completion. Inspections will incude visual observation of the work and review of quality control testing.

The engineer will obtain and review the results of chemical and engineering testing which provide a record of the progress and effectiveness of the implemented closure plan. Documentation supporting closure certification will be included in the certification report. This documentation will include surveying records verifying final slopes and contours, and records of equipment decontamination. Any deviations from the closure plan and their resolutions will be documented by the engineer performing the closure certification.

8.3 Anticipated Schedule of Inspections by a Registered Professional Engineer

An independent registered engineer will periodically review the closure operations listed in Section 8.2 in order that a final certification of closure can be developed which states that the closure has been carried out according to the plan. The engineer will observe construction activities and be present during performance and completion of key closure activities.

The independent registered professional engineer and the owner will, at the end of closure, inspect the site and certify that the closure plan was carried out as described. Prior to final certification, deficiencies noted by the engineer will be corrected. When deficiencies have been corrected, the engineer will issue a written report to the regulatory agencies certifying that the facility has been closed according to this closure document. The certification of closure, signed by the owner and the independent registered professional engineer, will be mailed to the CDH within 60 days after completing closure of the landfill.

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APPENDIX 1

ENGINEERING DRAWINGS

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JOB NO. 6-032-88 JOB TITLE Rocky Flats - Landfill DATE 5/23/88 BY JAS
SUBJECT Volumes for Cover CHECKED ____ SHEET 1 OF ____

Area of Cover 845,000 Ft²

Estimated Volume of Regrading
50,000 cy or ~ 1½' of regrading overall

Volume of Riprap
$300' \times 100' \times \frac{1.5'}{27} = 1700$ cy

Volume of material
$845{,}000\ \text{ft}^2 * 1\ \text{ft} / 27 = 31{,}300$ cy

Compacted Soil Layer 2½'

2.5 * 31,300 = 78,250 cy

Top Soil Layer 0.5'
0.5 * 31,300 = 15,650 cy

Sand Layers 1'
31,300 cy

Recompacted interim cover 1'
31,300 cy

HDPE - 845,000 Ft² ≐ 94,000 sq yd

HDPE pipe = 1300 Ft

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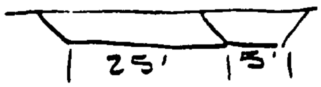
JOB NO. 6-032-88 JOB TITLE Rocky Flats - Landfill DATE 5/23/88 BY JAS
SUBJECT Volumes of cover CHECKED ____ SHEET 2 OF ____

EXCAVATION IN DIVERSION DITCH

LENGTH 4000'

VOLUME of EXCAVATION



A = 3 · 75' 225 ft^2

Volume = 225 ft^2 × 4000/27 = 33,300 cy

Summary

IMPORTED SAND = 31,300 cy
IMPORTED RIPRAP = 1700 cy
HDPE LINER = 94,000 sy
HDPE PIPE = 1300 ft
COMPACTED SOIL = 78,300 cy
TOP SOIL = 15,700 cy

TOTAL ON-SITE REQUIRED = 94,000 cy
DITCH BORROW = 33,300 cy
ADDITIONAL BORROW = 60,700 cy

REGRADING - 50,000 cy
RECOMPACTED = 31,300 cy

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JOB TITLE ______ DATE ______ BY ______
SUBJECT ______ CHECKED JAS SHEET 1 OF 3

C-C': Area of Trash Fill = 1758 ft²
Area of Top Fill = 1018 ft²

D-D': Area of Trash Fill = 472.5 ft²
Area of Top Fill = 498 ft²

B-B': Area of Trash Fill = 4033 ft²
Area of Top Fill = 2018 ft²

E-E': Area of Trash Fill = 5488 ft²
Area of Top Fill = 1380 ft²

F-F': Area of Trash Fill = 448 ft²
Area of Top Fill = 675 ft²

Pnt A to Xsection F = 180'
F - D = 97'
D - C = 196'
C - B = 207'
B - E = 79'
E - A' = ~~240~~' 150' TO PRACTICAL EDGE of FILL BY TOPO. MAP
Pnt A'. Assume Area = ~~T2(A)E~~ 0

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JOB NO. [illegible] JOB TITLE [illegible] DATE 5-13-88 BY [illegible]
SUBJECT [illegible] CHECKED ____ SHEET [illegible] OF [illegible]

① A = 0
F = 448 ft²

Volume = $\left(\frac{0+448}{2}\right) \times 180' = 40{,}320$ ft3

② F = 448 ft²
D = 473 ft²

Volume = $\left(\frac{448+473}{2}\right) \times 97' = 44{,}669$ ft3

③ D = 473 ft²
C = 1758 ft²

Volume = $\frac{(473+1758)}{2} \times 196 = 218{,}638.$ ft3

④ C = 1758 ft²
B = 4033 ft²

Volume = $\left(\frac{4033+1758}{2}\right) \times 207' = 599{,}369$ ft3

⑤ B = 4033 ft²
E = 5488 ft²

Volume = $\left(\frac{4033+5488}{2}\right) \times 79 = 376{,}080$ ft3

⑥ E = 5488 ft² 0
A' = 1/2 E = 2744 ft²

Volume = $\left(\frac{5488+2744}{2}\right) \times 240' = 987{,}840$ ft3

$\frac{5488}{2} \times 150' =$ 411,600 ft³

TOTAL VOLUME = ~~2,266,916~~ ft3 = ~~83,959.9~~ yd3.

1,690,676 ft³

62,618 CY

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NO. [illegible] JOB TITLE [illegible] DATE 5-17-88 BY [illegible]

PROJECT [illegible] CHECKED ____ SHEET 3 OF 3

[illegible]

(1) A = C
F = 675 ft²

Volume = (675/2) x 180' = 60,750 ft³

(2) F = 675 ft²
D = 498 ft²

Volume = ((675 + 498)/2) x 97 = 56,891 ft³

(3) D = 498 ft²
C = 1018 ft²

Volume = ((498 + 1018)/2) x 196 = 148,568 ft³

(4) C = 1018 ft²
B = 2018 ft²

Volume = ((1018 + 2018)/2) x 207' = 314,226 ft³

(5) B = 2018 ft²
E = 1380 ft²

Volume = ((2018 + 1380)/2) x 79 = 134,221 ft³

(6) E = 1380
A' = 1/2 E = ~~690~~ 0

Volume = ((1380 + ~~690~~ 0)/2) x ~~240'~~ 150 = ~~248,400~~ 103,500 ft³

Total = ~~963,056~~ 818,156 ft³ = ~~35,669~~ 30,302 cy yd³

TOTAL VOLUME LANDFILL = ~~[illegible]~~ 92,920 yd³.

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JOB NO. ______ JOB TITLE ______ DATE ______ BY ______
SUBJECT ______ CHECKED AS SHEET — OF —

G-G' – Area of fill material = 10,540 ft²

(1) Calculate from E-E' in 1974

E-E' – Total area of fill = 6868 ft²

Distance from E → G = 245'.

Volume = $\left(\frac{10,540 + 6868}{2}\right)245$ = 2,132,480 ft³.

Additional fill since 1974 = $V_{1986} - V_{1974}$ ⇒

V_{1974} = 987,840 ft³ + 248,400 ft³ = 1,235,840 ft³

$V_{add.\ fill}$ = 2,132,480 – 1,235,840 = 896,640 ft³.

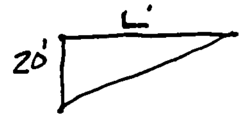
(2) Calculate from G-G' to Landfill face (H)
Assume equal areas.

Volume = 10,540 × 30' = 316,200 ft³.

(3) Add two small sections – A & B

G-G': $\frac{10,540\ ft^2}{760\ ft} = \frac{13.87\ ft^2}{ft}$

Assume



A. Surface 1 = 160' long = ~~2,219~~ 1600 ft²
Surface 2 = 80' long = ~~1,109~~ 800 .5ft²
Distance between = 40'

Volume = $\frac{1600 + 800}{2}$ ~~2219 + 1109.5~~ × 40 = 48,000 ~~66,520~~ ft³

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JOB NO. [illegible] JOB TITLE [illegible] DATE [illegible] BY [illegible]
SUBJECT [illegible] CHECKED JAS SHEET [illegible] OF 4

[illegible] 3,000 [illegible] L
[illegible] 1188 [illegible] 8'
[illegible] 1700

Volume = [illegible]
355,980

Total Additional Volume from 1974-1986 =

896,640 ft3
316,200 ft3
~~48,000~~ ft3 48,000
~~244,910~~ ft3 355,980
~~1,504,320~~ ft3 =
1,616,820
~~62,612~~ 59,882 yd3

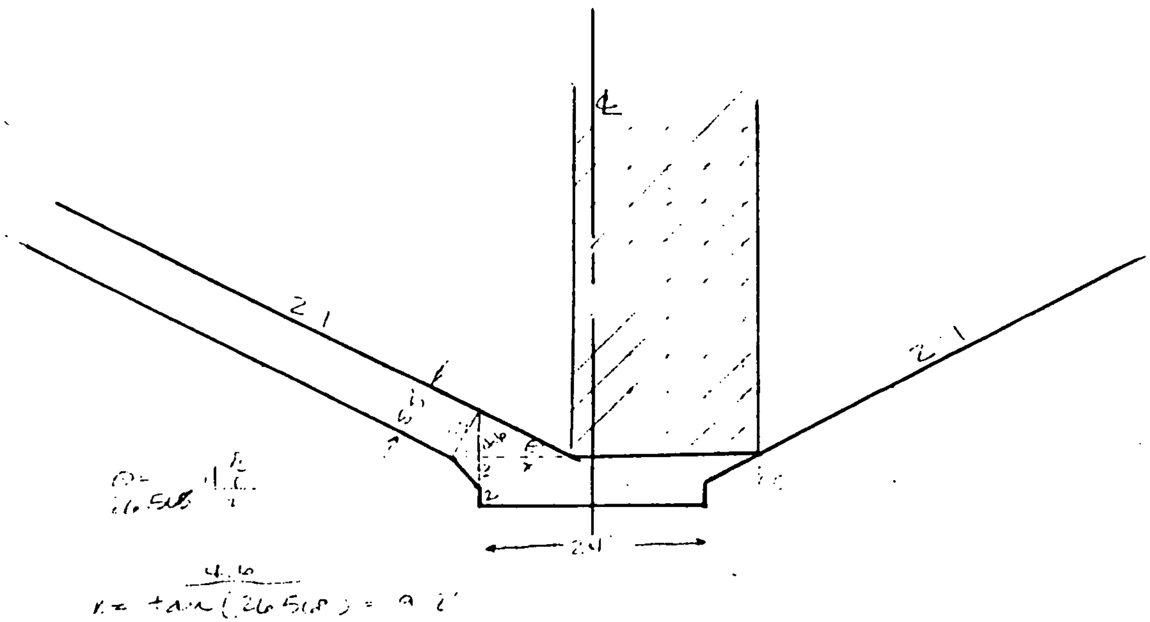
This does not include volume added at sides, only at face! (not from E-E' west)

Volumes on sides resulted from drainage trenches being filled. Calculate volume of trench by area of trench times length of trench.

Volume in trenches = 97,928 yd3

Total Volume Disposed, 1974-1986

~~159,940~~ 157,810 cy yd3



Area of Trench = 2(1/2 b·h) + Arect

Arect = (12 + (12 - 9.2))h = 14.8h

Atriangle = 1/2 b·h   b = 2·h
= h²

Both tria. = 2h²

Area = 14.8h + 2h²

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JOB NO. [illegible] JOB TITLE [illegible] DATE [illegible] BY [illegible]
PROJECT [illegible] CHECKED JAS SHEET [illegible] OF [illegible]

[illegible]

[illegible]	Depth	Area	Volume	Σ Volume
1+00	12	465.6	46560	46,560
2+00	11.2	414.7	41,466	88,026
3+00	21.7	1260	126,000	214,026
4+00	20.3	1128	112,800	326,826
5+00	21.7	1260	126,000	452,826
6+00	22.7	1363	136,300	589,126
7+00	23.2	1416	141,600	730,726
8+00	22.3	1434	143,400	874,126
9+00	22.7	1470	147,000	1,021,126
10+00	23.3	1434	143,400	1,164,526
11+00	22.7	1363	136,300	1,300,826
12+00	22.0	1398	139,800	1,440,626
13+00	22.8	1381	138,100	1,578,726
14+00	21.3	1226	122,600	1,701,326
15+00	19.0	1003	100,300	1,801,626
16+00	17.3	857	85,700	1,887,326
17+00	19.8	1080	108,000	1,995,326
18+00	19.2	1018	101,800	2,097,126
19+00	18.8	988	98,800	2,195,926
20+00	18.0	914	91,440	2,287,366
21+00	17.5	871.5	87,150	2,374,516
22+00	16.5	788.7	78,870	2,453,386
23+00	15.3	697	69,700	2,523,086
24+00	16.0	914.4	91,440	2,614,526
25+00	9.0	295.2	29,520	2,644,046
26+00				

Total Volume in trench: 2,644,046

= 97,928 yd³.

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JOB NO. ______ JOB TITLE ______ DATE ______ BY ______
SUBJECT ______ -1989 CHECKED JAS SHEET 1 OF ______

2500 $\frac{yd^3}{mo}$ of disposal (Verbal from Rockwell).

24 mos × 2500 $\frac{yd^3}{mo}$ = 60,000 yd^3

Total Volume in Landfill from 1986 – 6/88 =
~~159,940~~ 157,810 yd^3 + 60,000 yd^3 = ~~219,940~~ 217,810 yd^3

Future Disposal

6-88 to 6-89 (Date Disposal will End)

12 mos. × 2500 $\frac{yd^3}{mo}$ = 30,000 yd^3

Total Volume that will have been disposed at Landfill as of 6/89 =

~~219,940~~ 217,810 yd3 + 30,000 yd^3 = ~~249,940~~ 247,810

ADD ~ 10% FOR INTERIM COVER MATERIALS FROM 6/86 – 6/89 0.1 * 90,000 = 9,000 cy

TOTAL VOLUME IN LANDFILL

256,810 cy

use 260,000 cy

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JOB NO. 6-032-86 JOB TITLE Rocky Flats - Landfill DATE 5/12/88 BY JAS
SUBJECT Infinite Slope Analysis CHECKED GTJ SHEET 1 OF 2

PROBLEM: SLIDING RESISTANCE OF COVER SOILS ON SYNTHETIC MEMBRANE

ASSUME: SOIL HAS $\gamma = 120$ pcf
SAND LAYER $\phi = 30°$
SYNTHETIC MEMBRANE EFFECTIVE ϕ IS $\tan\phi_e = 0.6 \tan\phi$ OR $\phi_e = 19°$

SOLUTION

MAXIMUM SLOPE IS 5:1 OR $\tan i = 0.2$

$$F.S. = \tan\phi_e / \tan i = 1.72$$

PROPOSED COVER HAS ADEQUATE FACTOR OF SAFETY AGAINST SLIDING.

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NO. 6-232-86 JOB TITLE Rocky Flats-Landfill DATE 5/12/88 BY JAS
SUBJECT Cover Membrane Yield CHECKED ____ SHEET 2 OF 2

or Resistance: R = 2 * 420 * TAN(19°)

R = 289#/LIN. FT.

Yield Force for 1 foot of membrane is 70#/in * 12 in/ft = 840#/LIN. FT.

Therefore the liner would not be able to reach its yield stress prior sliding against the sand.

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JOB NO. 6-032-88 JOB TITLE Rocky Flats DATE 5/11/88 BY BJB
SUBJECT Surface Hydrology CHECKED JKS SHEET 1 OF

Areas shown on fig. 1

Area 1 = $17.75\ in^2 \times \left(\frac{299.15\ ft}{in}\right)^2 \times \frac{1\ ac}{43,560\ ft^2}$ = 36.47 acres

Area 2 = $10.49 \times (299.15)^2 \left(\frac{1}{43560}\right)$ = 21.55 acres

Area 3 = $7.978 \times (299.15)^2 \left(\frac{1}{43560}\right)$ = 16.39 acres

Area 4 = $(11.42)(299.15)^2 \left(\frac{1}{43560}\right)$ = 23.46 acres

Area 5 = $(6.48)(299.15)^2 \left(\frac{1}{43560}\right)$ = 13.31 acres

Total Area = 111.18 acres

However, Area 4 is larger than assumed area of landfill cover.

Assumed limits of landfill cover (see fig. 2)
= 14.1 acres.

Total Area contributing to perimeter ditches

= 111.18	- total area
<14.1>	- area of landfill cover
<13.34>	- area 5 fig. 1

83.74 acres.

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JOB NO. 6-032-88 JOB TITLE Rocky Flats DATE 5/11/88 BY EVE
SUBJECT Surface hydrology CHECKED JAS SHEET 2 OF

Distance A-C (Fig 1) ≈ A-D (Fig 1) ≈ 4500 ft.

Elevation Difference ~ 6038 - 5925 = 113 ft

Avg slope = $\frac{113}{4500}$ = 0.025

time of concentration for perimeter ditches.

$$t_c = 0.00013 \frac{(L)^{0.77}}{(S)^{0.385}}$$ NUREG/CR-4620 ORNL/TM-10067

L in ft
t_c in hours

$$t_c = (0.00013) \frac{(4517)^{0.77}}{(0.025)^{0.385}} = 0.35 \text{ hours} = 21 \text{ minutes}$$

Rainfall Data From NOAA Atlas 2 Volume III - Colorado

Region = 1 (fig. 19)

Y_{100} = 100 yr 1hr estimated value from regression eq.

X_1 = 2-yr 6 hr value (fig 20) = 1.6 in
X_2 = 2-yr 24 hr value (fig 26) = 2.2 in
X_3 = 100-yr 6 hr value (fig 25) = 3.6 in
X_4 = 100-yr 24 hr value (fig. 31) = 5.0 in

Z = elevation in hundreds of ft = 60

Regression Equations, Table 11 p.15

$$Y_{100} = 1.897 + 0.439 \left[(X_3)(X_3/X_4) \right] - 0.008 Z$$

$$Y_{100} = 1.897 + (0.439)(3.6)\left(\frac{3.6}{5.0}\right) - (0.008)(60)$$

$$Y_{100} = 2.55 \text{ inches.}$$

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JOB NO. 6-032-88 JOB TITLE Rocky Flats DATE 5/1/85 BY BJB
SUBJECT Surface Hydrology CHECKED JWS SHEET 3 OF

Assume 2 perimeter channels, one north & the other south of the landfill cover discharging @ Pt. D & Pt C (see Fig. 1) respectively

Each channel carries 1/2 of total runoff.

$Q_{total} = CiA$ (Rational formula)

i = intensity (in/hr) for t_c = 20 minutes.

from NOAA atlas table 12 - % of 1 hour rainfall for 20 min duration : $0.57 + (\frac{5}{15})(0.79 - 0.57) = 0.643$

$i = (0.643)(2.55 \text{ inches}) \times \frac{1}{20 \text{min}} \times \frac{60 \text{ min}}{\text{hr}} = 4.92 \text{ in/hr.}$

from NUREG reference (see attached) (tables 4.5, 4.6)

C for Average infiltration rates - Cultivated Cover = 0.40 to 0.50

use C = 0.45

$Q_{total} = (0.45)(83.74)(4.92) = 185$ cfs

assume Q for each channel = 1/2 Q_{total} = 92.5 cfs

<u>use Q = 100 cfs for preliminary design.</u>

Design of diversion channel.

From Henderson, see attached.

Manning's Roughness Coefficient

Smooth earth, no weeds $n = 0.020$
Earth, some stones & weeds $n = 0.025$
Grassed channel (length grass < 2 in, VR ≈ 5-10)
type E $n = 0.025$
Armored channel (d_{50} ~ 3 to 6 in) $n = 0.035$

assume no channel armoring will be required.

use $n = 0.025$ for design.

Average slope ≈ 0.02 (along ground surface)
(channel slope may be reduced somewhat by excavating deeper near u.s end)

use slope = 0.02 for preliminary design.

Summary of computer solution of mannings equation $V = \frac{1.486}{n} R^{2/3} S^{1/2}$

Flow (cfs)	slope	Manning's n	bottom width ft	Side slope	flow depth (ft)	Critical Depth (ft)	Velocity (fps)
100	0.02	0.025	5	2	1.48	1.81	8.5
100	0.02	0.025	5	3	1.38	1.67	8.0
100	0.02	0.025	7.5	2	1.24	1.53	8.1
100	0.02	0.025	7.5	3	1.18	1.46	7.7
100	0.02	0.025	10.0	2	1.07	1.33	7.7
100	0.02	0.025	10.0	3	1.03	1.28	7.4
100	0.02	0.025	12.5	2	0.95	1.18	7.3
100	0.02	0.025	12.5	3	0.92	1.14	7.1
100	0.02	0.025	15.0	3	0.84	1.04	6.8
100	0.02	0.025	20.0	3	0.72	0.88	6.3
100	0.02	0.025	30.0	3	0.57	0.69	5.6

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JOB NO. 6-032-88 JOB TITLE Rocky Flats DATE 5/11/88 BY EJB.
SUBJECT Surface Hydrology CHECKED JAS SHEET 5 OF

Typical channel velocities in range of 6 to 8 ft/sec.

from NUREG

material type	Max. Permissible Velocity ft/sec.
Sandy loam	2.5 - 2.8
sandy clay	5 - 6 (very compact)
w/ well maintained Grass covers	
Erosion Resistant Soils	3 - 8
Easily-Eroded Soils	2.5 - 6

Check use of rip rap armorment as alternative for high velocity.

assume $n = 0.035$
$Q = 100$ cfs
side slope: 3:1
base width = 10 feet.

from computer run (see attached) $Y_f = 1.25$ ft. $\tau_o = 1.57$

using F.S method (see NUREG reference)

$$S.F = \frac{\cos\theta \tan\phi}{\eta' \tan\phi + \sin\theta \cos\beta}$$

$$\eta = (21\ \tau_o)\left(\frac{1}{(S_s - 1)\gamma D}\right)$$

$$\eta' = \eta\left[\frac{1 + \sin(\lambda + \beta)}{2}\right]$$

$$\beta = \tan^{-1}\left[\frac{\cos\lambda}{\frac{2\sin\theta}{\eta\tan\phi} + \sin\lambda}\right]$$

$\tau_o = \gamma \times$ Slope $\times$ Depth

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JOB NO. 6-032-88 JOB TITLE Rocky Flats DATE 5/11/88 BY RJB
SUBJECT Surface Hydrology CHECKED JAS SHEET 6 OF

along Bed:

$\theta = \tan^{-1} 0.02 = 1.1458^\circ$

$\lambda = 90^\circ \Rightarrow \beta = 0^\circ \Rightarrow \eta' = \eta$

$D = 4.73$ in (see printout)

$\tau_o = (1.25)(62.4)(0.02) = 1.56$ psf

$$\eta = \frac{(21)(1.56)}{(2.5-1)(62.4)(4.73)(1/12)} \frac{lb/ft^2}{lb/ft^2} = 0.8879$$

$$S.F = \frac{\cos 1.1458 \tan 40^\circ}{0.8879 \tan 40^\circ + \sin 1.1458 \cos 0^\circ} = 1.1$$

(agrees w/ printout)

along side slope

$\theta = \tan^{-1} \frac{1}{3} = 18.435^\circ$

$\lambda = \tan^{-1} 0.02 = 1.1458^\circ$

$D = 6.05$ in $= 0.50417$ ft.

$$\eta = \frac{(21)(1.56)}{(1.5)(62.4)(0.50417)} = 0.6942$$

$$\beta = \tan^{-1}\left[\frac{\cos 1.1458}{\frac{2 \sin 18.435}{0.6942 \tan 40^\circ} + \sin 1.1458^\circ}\right] = 42.119^\circ$$

$$\eta' = 0.6942 \left[\frac{1 + \sin(1.1458 + 42.119)}{2}\right] = 0.58499$$

$$S.F = \frac{\cos 18.435 \tan 40^\circ}{0.58499 \tan 40^\circ + \sin 18.435^\circ \cos 42.119^\circ} = 1.1$$

(agrees w/ printout)

so rip rap w/ $D_{50} \doteq 6$ in required to armor 10 ft wide channel

Check Configuration of Landfill cover.

assume top surface will be slopped toward middle to form a "V" channel which slopes Downward toward the face of the cover at 1.5 % slope

prior to settlement of land fill material.

Area of surface = 14.1 acres (see fig 2)
assume "C" for rational formula = 0.45

Determine time of concentration:

Length of cover = 1200 ft
Slope = 0.015

$t_c = (0.00013)\frac{(1200)^{0.77}}{(0.015)^{0.385}}(60) = 9.23$ minutes

use $t_c = 10$ min

from NOAA atlas table 12

rainfall = 0.45 × 2.55 in = 1.1475 inches

$i = (1.1475)\left(\frac{1}{10\text{ min}}\right)\left(\frac{60\text{ min}}{\text{hr}}\right) = 6.88$ in/hr.

$Q = CiA = (0.45)(14.1)(6.88) = 43.7$ cfs.

design for $Q = 45$ cfs.

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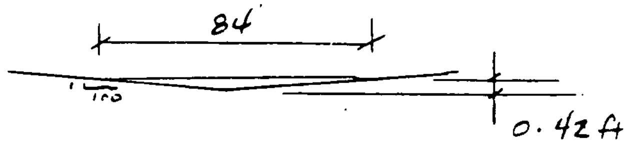
JOB NO. 6-032-88 JOB TITLE Rocky Flats DATE 5/11/88 BY BJB
SUBJECT Surface Hydrology CHECKED JAS SHEET 8 OF

use $n = 0.025$ for mannings eqn



$A = (1/2)(84)(0.42) = 17.64$
$P = 2\sqrt{100^2+1}\,(0.42) = 84.0$
$R = A/P = 0.210 \Rightarrow R^{2/3} = 0.35333$
$S = 0.015 \Rightarrow S^{1/2} = 0.12247$

$V = \left(\frac{1.486}{0.025}\right)(0.3533)(0.12247) = 2.57$ ft/sec

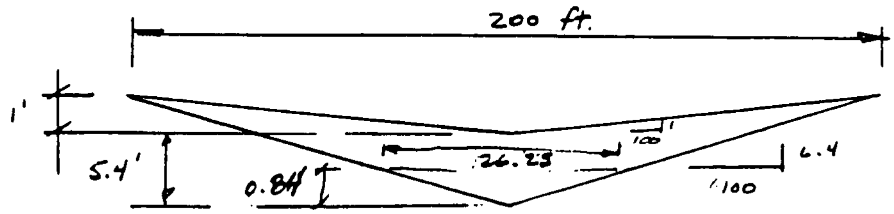
$Q = VA = (17.64)(2.57) = 45.4$ ok

After settlement of landfill

assume 20% settlement
max depth ≈ 27 ft (see fig. 2)

max diff. settlement ≈ (0.2)(27) = 5.4 ft.

assume differential settlement occurs ~~at~~ over lateral distance of 100 ft.



side slope = 15.6 :1
$Q = 70$ cfs
$n = 0.025$
$S = 1.5\%$

assume flow depth = 0.84 ft : $A = (1/2)(26.25)(0.84) = 11.025$ ft^2
$P = 2\sqrt{(15.6)^2+1}\,(0.84) = 26.26$ ft
$R = 0.4198 \Rightarrow R^{2/3} = 0.5607$
$S^{1/2} = 0.12247$
$V = \left(\frac{1.486}{0.025}\right)(0.5607)(0.12247) = 4.08$ ft/sec
$Q = VA = (4.08)(11.025) = 45.0$ cfs, ok.

Chen & Associates

Consulting Geotechnical Engineers

JOB NO. 6-C32-88 JOB TITLE Rocky Flats DATE 5/11/88 BY BJB

SUBJECT Surface Hydrology CHECKED VAS SHEET 9 OF

With settlement at top surface

projected increase in velocity from approx 2.5 ft/sec to approx 4 ft/sec, which is less than maximum permissible velocity for very compact sandy clay AND GRASSED EROSION RESISTANT SOILS

Determine Requirements for Armoring Front Face of Land fill.

Assume maximum face slope of 5:1 (h:v)

assume uniform flow of 45 cfs spread uniformly over lateral distance of 100 ft.

determine rock requirements using factor of safety method and Stephenson's method (see p.48 of NUREG)

-----PRIMARY INPUT----- ---------OUTPUT--------

FLOW Q (cfs)	SLOPE S	n	z	BOT WIDTH b (ft.)	CRIT. DEPTH Yc (ft.)	FLOW DEPTH Yf (ft.)	VEL v (fps)	TRACT FORCE To (psf)
45.0	0.200	0.0400	0	100.0	0.18	0.11	3.9	1.38

D50B (in.)= 6.97264 ← required along face by F.S method F.S = 1.2.

D50S (in.)=-.8563674

RIP RAP VOLUME (cu.yd./ft.)= 4.231813

RIP RAP FACTOR OF SAFETY= 1.25

RIP RAP SPECIFIC GRAVITY= 2.5

RIP RAP FRICTION ANGLE= 40

determine rock requirements - stephensons method.

$Q = 45$ cfs
$q = 45$ cfs / 100 ft = 0.45 cfs per foot width
$\theta = \tan^{-1} 0.2 = 11.31°$
n = porocity = 0.4
S = specific gravity = 2.7
$\phi = 40°$
$C = 0.25$
$g = 32.2$

assume flow concentration = 2.5 ∴ use $q = (0.45)(2.5) = 1.125$

$$d = \left[\frac{q(\tan\theta)^{7/6} n^{1/6}}{C g^{1/2} [(1-n)(S-1)\cos\theta(\tan\phi - \tan\theta)]^{5/3}}\right]^{2/3}$$

$$= \left[\frac{(1.125)(0.15295)(0.8584)}{(0.25)(5.6745)[(0.6)(1.7)(0.98058)(0.63910)]^{5/3}}\right]^{2/3}$$

$$= \left[\frac{0.1477}{(0.25)(5.6745)(0.47434)}\right]^{2/3} = 0.364 \text{ ft} = 4.37 \text{ in}$$

mult. by Oliver's const = 1.5 ~~conservative~~

$d_{50} = (4.37)(1.5) = 6.5$ inches.

∴ Use rock w/ median size = 7 inches along face of slope

if slope flatter than 5:1 a reduction in median size can be allowed.

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JOB NO. 6-032-88 JOB TITLE Rocky Flats DATE 5/1/88 BY RVB
SUBJECT Surface Hydrology CHECKED HS SHEET 10 A OF

Check flow through rock along front face:

See NUREG reference p. 57

for $D_{50} = 6$ in $\Rightarrow$ $W_m^{0.5} = 28$ in/sec

$i = 0.2$

$$V_v = W_m^{0.5} \, i^{0.54}$$
$$= 28\,(0.2)^{0.54} = 11.74 \text{ in/sec} = 0.98 \text{ ft}$$

assume thickness ≈ 12 inches & porosity = 0.4

Area voids = (1 ft)(100 ft)(0.4) = 40 ft²

flow within voids = (40 ft²)(0.98 ft/sec) =
= 39.2 cfs

or 87 % of total.

USING 18 INCHES

FLOW WITHIN VOIDS = 60 ft² (.98) = 58.8

ALL FLOW WITHIN RIPRAP

USE $D_{50} = 8''$

$D_{100} = 18''$

LAYER THICKNESS = 18"

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JOB NO. 6-032-88 JOB TITLE Rocky Flats DATE 5/11/88 BY BVB
SUBJECT Surface Hydrology CHECKED [initials] SHEET 11 OF

Maximum Runoff to Storage Ponds for 100 year storm

assume runoff from top of cover and area 5 (fig. 1)

Area = 14.1 acres + 13.31 acres = 27.4 acres

100 year 24 hour event = 5.0 inches (fig 31, NOAA)
assume runoff coefficient = 1.0 (INFILTRATION IS OFF-SET BY DRAINAGE

runoff = (1.0)(5)(1/12)(27.4) = 11.4 acre-feet

Maximum Runoff rate to storage Pond - 100 year storm

for duration of 5 min - % of 1 hour 100 yr event = 0.29

rainfall = 0.29 × 2.55 = 0.74 inches

$$\text{rate} = (0.74)(1.0)(27.4)(1/12)(43{,}560)\ ft^3 \times \frac{1}{5\,min} \times \frac{1\,min}{60\,sec}$$

rate = 245 cfs.

max. spillway capacity ≅ 350 cfs.

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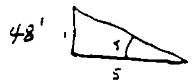
Consulting Geotechnical Engineers

JOB NO. 6-032-88 JOB TITLE Rocky Flats DATE 5/19/88 BY JJB
SUBJECT Surface Hydrology CHECKED JAS SHEET 12 OF

Flow along face of front slope, not carrying concentrated flow:

$\Delta H \approx 5978 - 5930 = 48$ ft
Conservative



Slope (ft/ft)		Length along Slope (ft)	Sheet flow Veloc
0.20	(5:1)	245	2.2 ft/sec
0.1667	(6:1)	292	
0.1429	(7:1)	340	2.3 ft/sec
0.1250	(8:1)	387	
0.1000	(10:1)	482	2.4 ft/sec

* assumes Runoff Coeff. = 0.45
i = 6.88 in/hr
Concentration Factor = 3.1

Check using Tributary Drainage Area Method (Nureg Ref. p. 31)

$D = 0.909 + 22.418\,(S_i) = 0.909 + 22.418\,(0.20)$
$D = 5.39$ ft²/ft of channel

Total area = (5.39)(245) = 1,320.6 ft² = 0.0303 acres

$Q = CiA = (0.45)(6.88)(0.0303) = 0.0939$ cfs.

Width of channel = 5.4 ft

assume 0.0939 cfs distributed for a unit flow

manning's n =	[illegible]	[illegible]	.025	[illegible]
runoff factor, C =	[illegible]	[illegible]	2.1	[illegible]
rainfall intensity (in/hr), i =	6.88	[illegible]	[illegible]	[illegible]
total length along slope (ft.), L =	245	[illegible]	245	[illegible]
slope (ft/ft), S =	[illegible]	[illegible]	[illegible]	0.2
sheet flow velocity (ft/sec) =	[illegible]	[illegible]	[illegible]	[illegible]

5:1 slope

Rational formula runoff coefficient x Concentration factor

manning's n =	0.025	[illegible]	.025	[illegible]
runoff factor, C =	0.7	1.4	2.1	2.8
rainfall intensity (in/hr), i =	6.88	6.88	6.88	6.88
total length along slope (ft.), L =	340	340	340	340
slope (ft/ft), S =	0.1429	0.1429	0.1429	0.1429
sheet flow velocity (ft/sec) =	1.741776	2.298287	2.702967	3.032608

7:1 slope

manning's n =	0.025	0.025	0.025	0.025
runoff factor, C =	0.7	1.4	2.1	2.8
rainfall intensity (in/hr), i =	6.88	6.88	6.88	6.88
total length along slope (ft.), L =	482	482	482	482
slope (ft/ft), S =	0.1	0.1	0.1	0.1

19-May-88 11:48 PM

H21: 0.017684/H16^0.5*H20^0.3*(H17*H18*H19)^0.4 READY

	E	F	G	H
manning's n =	0.025	0.025	0.025	0.025
runoff factor, C =	0.7	1.4	2.1	2.8
rainfall intensity (in/hr), i =	6.88	6.88	6.88	6.88
total length along slope (ft.), L =	340	340	340	340
slope (ft/ft), S =	0.1429	0.1429	0.1429	0.1429
sheet flow velocity (ft/sec) =	1.741776	2.298287	2.702967	3.032608
manning's n =	0.025	0.025	0.025	0.025
runoff factor, C =	0.7	1.4	2.1	2.8
rainfall intensity (in/hr), i =	6.88	6.88	6.88	6.88
total length along slope (ft.), L =	482	482	482	482
slope (ft/ft), S =	0.1	0.1	0.1	0.1
sheet flow velocity (ft/sec) =	1.799326	2.374225	2.792276	3.132808

10:1 slope

19-May-88 11:49 PM

6-032-88 Rocky Flats
RJZ 5/19/88 - Surface hydrology

Sheet 13

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JOB NO. 6-032-88 JOB TITLE Rocky Flats DATE 5/19/88 BY BVB
SUBJECT Surface Hydrology CHECKED ____ SHEET 14 OF ____

$A = (y)(1)$
$P = 1$
$R = y$

$V = \frac{1.486}{n} R^{2/3} S^{1/2}$

$Q = \frac{1.486}{n} R^{2/3} S^{1/2} A = \frac{1.486}{0.025} y^{2/3} (0.2)^{1/2} y = 0.0939$

$26.582 \, y^{5/3} = 0.0939$

$y = 0.0338$

$V = \frac{1.486}{0.025} (0.0338)^{2/3} (0.2)^{1/2}$

V = 2.78 ft/sec. (compare w/ 2.2 ft/sec assuming Concentr. Factor = 3)

note slope length of 245 ft is conservative.

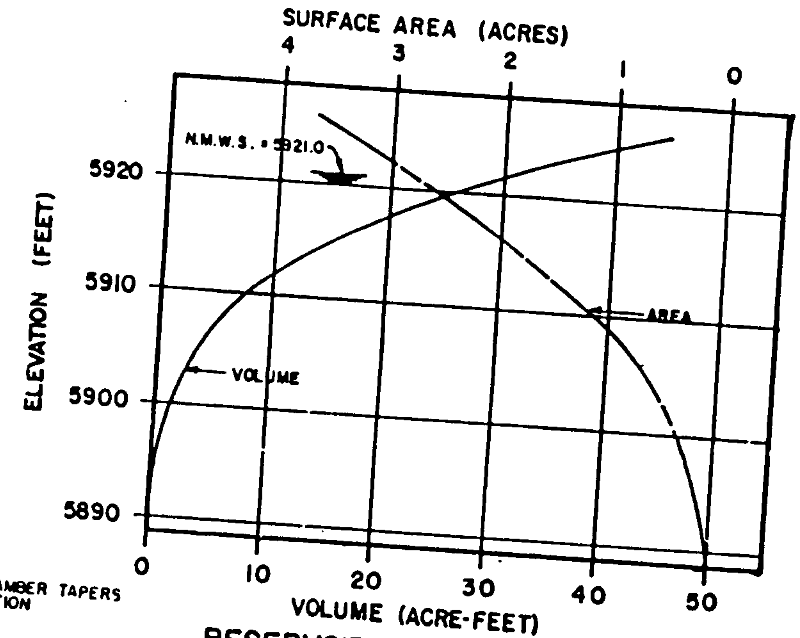
FINAL MAXIMUM SLOPE IS ABOUT 180 FT.

∴ VELOCITIES CALCULATED ARE CONSERVATIVE

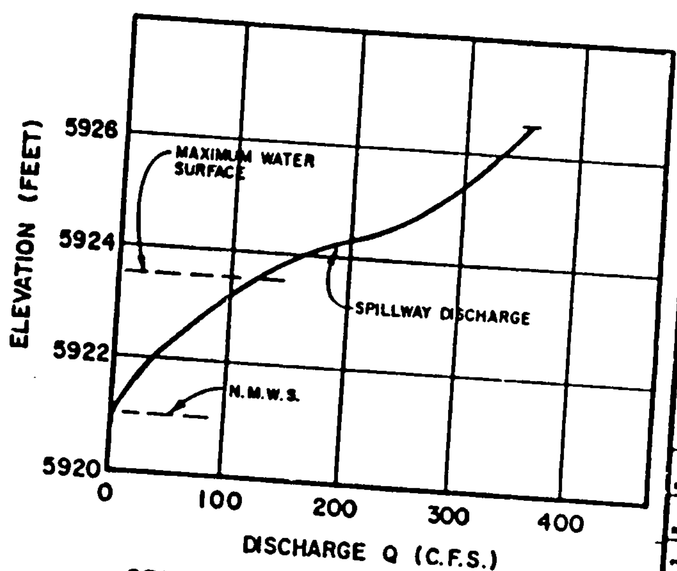
℄ DAM PROFILE

(LOOKING UPSTREAM)

SCALE: HORIZ.- 1" = 40'
VERT- 1" = 10'



RESERVOIR CAPACITY CHART



SPILLWAY DISCHARGE CURVE

SCALE: 1" = 100' - HORIZ.
1" = 2' - VERT.

5913.50 WHERE CAMBER TAPERS INTO NORMAL SECTION

STRIP TOPSOIL

Note:
Elevations shown are approximate and were not verified after construction unless noted otherwise.

REVIEWED FOR CLASSIFICATION
By [signature]
Date 6-24-86

ISSUE	DESCRIPTION		LOC.	DATE	BY	APP'D		
A	"As Built", Per Construction AT(29-2)3508			12-26-74	R.L.H.	[signature]		
0	ORIGINAL ISSUE			8-9-74		[signature]		3456K

	BY	DATE
DESIGNED	R.L.H.	7/29/74
DRAWN	G.E.C.	7/29/74
CHECKED	W.P.R.	7/29/74
APPROVED	[signature]	7/29/74
SUBMITTED	C.O.S.	7/29/74
APP'D	[signature]	7/29/74
APP'D	[signature]	7/29/74

U. S. ATOMIC ENERGY COMMISSION
ROCKY FLATS AREA OFFICE
GOLDEN, COLORADO

ZEFF, COGORNO & SEALY INC.
TRI-CONSULTANTS INC.
HYDRO-TRIAD LTD.
Denver, Colo.

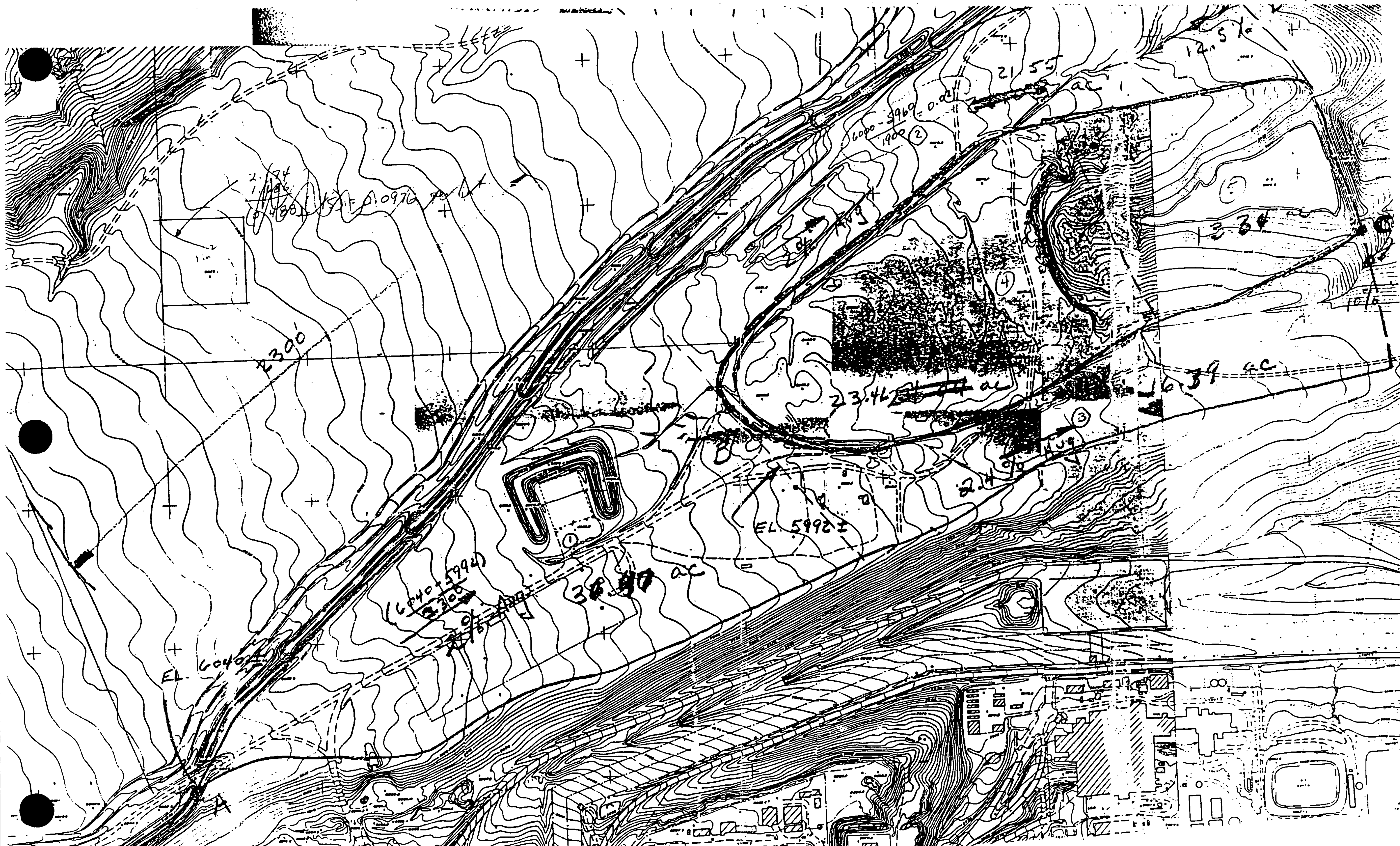
SANITARY LANDFILL RENOVATIONS
SAMPLING STRUCTURE
PLAN, PROFILE & SECTIONS-DAM

AEC CONT. NO. AT(29-2)3442

SCALE AS SHOWN

SIZE	DRAWING NUMBER	ISSUE	SHEET
D	27318-2	A	8 • 12

219



11.7" = 3500'

Scale 1" = 299.15 ft.

Fig. 1

100.0	0.020	0.0250	2	10.0	1.33	1.07	7.7	1.29

D50B (in.)= 4.052269
D50S (in.)= 7.834827
RIP RAP VOLUME (cu.yd./ft.)= 1.248731
RAP FACTOR OF SAFETY= 1.1
RAP SPECIFIC GRAVITY= 2.5
RIP RAP FRICTION ANGLE= 40
MANNING'S EQUATION AND CRITICAL FLOW EQUATION

-----PRIMARY INPUT-----				---------OUTPUT--------				
				BOT	CRIT.	FLOW		TRACT
FLOW	SLOPE			WIDTH	DEPTH	DEPTH	VEL	FORCE
Q	S	n	z	b	Yc	Yf	v	To
(cfs)				(ft.)	(ft.)	(ft.)	(fps)	(psf)
100.0	0.020	0.0250	3	10.0	1.28	1.03	7.4	1.25

D50B (in.)= 3.927078
D50S (in.)= 5.024853
RIP RAP VOLUME (cu.yd./ft.)= .8742856
RIP RAP FACTOR OF SAFETY= 1.1
RIP RAP SPECIFIC GRAVITY= 2.5
RIP RAP FRICTION ANGLE= 40
MANNING'S EQUATION AND CRITICAL FLOW EQUATION

-----PRIMARY INPUT-----				---------OUTPUT--------				
				BOT	CRIT.	FLOW		TRACT
FLOW	SLOPE			WIDTH	DEPTH	DEPTH	VEL	FORCE
Q	S	n	z	b	Yc	Yf	v	To
(cfs)				(ft.)	(ft.)	(ft.)	(fps)	(psf)
100.0	0.020	0.0250	2	12.5	1.18	0.95	7.3	1.14

D50B (in.)= 3.590287
D50S (in.)= 6.941612
RIP RAP VOLUME (cu.yd./ft.)= 1.124203
RIP RAP FACTOR OF SAFETY= 1.1
RIP RAP SPECIFIC GRAVITY= 2.5
RIP RAP FRICTION ANGLE= 40
MANNING'S EQUATION AND CRITICAL FLOW EQUATION

-----PRIMARY INPUT-----				---------OUTPUT--------				
				BOT	CRIT.	FLOW		TRACT
FLOW	SLOPE			WIDTH	DEPTH	DEPTH	VEL	FORCE
Q	S	n	z	b	Yc	Yf	v	To
(cfs)				(ft.)	(ft.)	(ft.)	(fps)	(psf)
100.0	0.020	0.0250	3	12.5	1.14	0.92	7.1	1.12

D50B (in.)= 3.51013
D50S (in.)= 4.49135
RIP RAP VOLUME (cu.yd./ft.)= .8139041
RIP RAP FACTOR OF SAFETY= 1.1
RIP RAP SPECIFIC GRAVITY= 2.5
RIP RAP FRICTION ANGLE= 40
MANNING'S EQUATION AND CRITICAL FLOW EQUATION

-----PRIMARY INPUT-----				---------OUTPUT--------				
				BOT	CRIT.	FLOW		TRACT
FLOW	SLOPE			WIDTH	DEPTH	DEPTH	VEL	FORCE
Q	S	n	z	b	Yc	Yf	v	To
(cfs)				(ft.)	(ft.)	(ft.)	(fps)	(psf)
100.0	0.020	0.0250	3	15.0	1.04	0.84	6.8	1.02

D50B (in.)= 3.1861[illegible]

RIP RAP VOLUME (CU.YD./FT.)= .772492
RIP RAP FACTOR OF SAFETY= 1.1
RIP RAP SPECIFIC GRAVITY= 2.5
RIP RAP FRICTION ANGLE= 40

MANNING'S EQUATION AND CRITICAL FLOW EQUATION

--PRIMARY INPUT-----				---------OUTPUT--------				
FLOW	SLOPE			BOT WIDTH	CRIT. DEPTH	FLOW DEPTH	VEL	TRACT FORCE
Q (cfs)	S	n	z	b (ft.)	Yc (ft.)	Yf (ft.)	v (fps)	To (psf)
100.0	0.020	0.0250	3	20.0	0.66	0.72	6.3	0.87

D50B (in.)= 2.718449
D50S (in.)= 3.479364
RIP RAP VOLUME (cu.yd./ft.)= .7236023
RIP RAP FACTOR OF SAFETY= 1.1
RIP RAP SPECIFIC GRAVITY= 2.5
RIP RAP FRICTION ANGLE= 40

MANNING'S EQUATION AND CRITICAL FLOW EQUATION

-----PRIMARY INPUT-----					---------OUTPUT--------			
				BOT	CRIT.	FLOW		TRACT
FLOW	SLOPE			WIDTH	DEPTH	DEPTH	VEL	FORCE
Q	S	n	z	b	Yc	Yf	v	To
(cfs)				(ft.)	(ft.)	(ft.)	(fps)	(psf)
100.0	0.020	0.0250	2	5.0	1.81	1.48	8.5	1.79

D50B (in.)= 5.61148
D50S (in.)= 10.84947
RIP RAP VOLUME (cu.yd./ft.)= 1.748995
RIP RAP FACTOR OF SAFETY= 1.1
RIP RAP SPECIFIC GRAVITY= 2.5
RIP RAP FRICTION ANGLE= 40

MANNING'S EQUATION AND CRITICAL FLOW EQUATION

-----PRIMARY INPUT-----					---------OUTPUT--------			
				BOT	CRIT.	FLOW		TRACT
FLOW	SLOPE			WIDTH	DEPTH	DEPTH	VEL	FORCE
Q	S	n	z	b	Yc	Yf	v	To
(cfs)				(ft.)	(ft.)	(ft.)	(fps)	(psf)
100.0	0.020	0.0250	3	5.0	1.67	1.38	8.0	1.67

D50B (in.)= 5.226376
D50S (in.)= 6.687355
RIP RAP VOLUME (cu.yd./ft.)= 1.100658
RIP RAP FACTOR OF SAFETY= 1.1
RIP RAP SPECIFIC GRAVITY= 2.5
RIP RAP FRICTION ANGLE= 40

MANNING'S EQUATION AND CRITICAL FLOW EQUATION

-----PRIMARY INPUT-----					---------OUTPUT--------			
				BOT	CRIT.	FLOW		TRACT
FLOW	SLOPE			WIDTH	DEPTH	DEPTH	VEL	FORCE
Q	S	n	z	b	Yc	Yf	v	To
(cfs)				(ft.)	(ft.)	(ft.)	(fps)	(psf)
100.0	0.020	0.0250	2	7.5	1.53	1.24	8.1	1.50

D50B (in.)= 4.689267
D50S (in.)= 9.066426
RIP RAP VOLUME (cu.yd./ft.)= 1.439325
RIP RAP FACTOR OF SAFETY= 1.1
RIP RAP SPECIFIC GRAVITY= 2.5
RIP RAP FRICTION ANGLE= 40

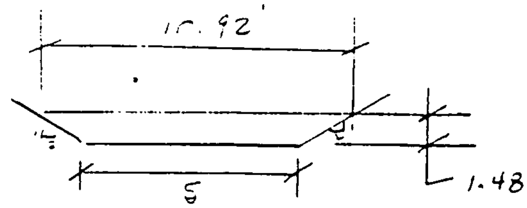
MANNING'S EQUATION AND CRITICAL FLOW EQUATION

-----PRIMARY INPUT-----					---------OUTPUT--------			
				BOT	CRIT.	FLOW		TRACT
FLOW	SLOPE			WIDTH	DEPTH	DEPTH	VEL	FORCE
Q	S	n	z	b	Yc	Yf	v	To
(cfs)				(ft.)	(ft.)	(ft.)	(fps)	(psf)
100.0	0.020	0.0250	3	7.5	1.45	1.18	7.7	1.43

D50B (in.)= 4.476967
D50S (in.)= 5.728456
RIP RAP VOLUME (cu.yd./ft.)= .9636738
RIP RAP FACTOR OF SAFETY= 1.1
RIP RAP SPECIFIC GRAVITY= 2.5
RIP RAP FRICTION ANGLE= 40

MANNING'S EQUATION AND CRITICAL FLOW EQUATION

-----PRIMARY INPUT-----					---------OUTPUT--------			
				BOT	CRIT.	FLOW		TRACT



$A = (15.92)(1/2)(1.48) = 11.78\ ft^2$

$P = 5 + 2\sqrt{5}\,(1.48) = 11.62$

$R = 1.0139 \Rightarrow R^{2/3} = 1.0092$

$V = \frac{1.486}{0.025}(1.0092)\sqrt{.02} = 8.48\ ft/sec$

$Q = VA = (11.78)(8.48) = 99.9\ cfs.$

MANNING'S EQUATION AND CRITICAL FLOW EQUATION

-----PRIMARY INPUT-----				---------OUTPUT--------				
FLOW Q (cfs)	SLOPE S	n	z	BOT WIDTH b (ft.)	CRIT. DEPTH Yc (ft.)	FLOW DEPTH Yf (ft.)	VEL v (fps)	TRACT FORCE To (psf)
100.0	[illegible]	0.0250	3	30.0	0.69	0.57	5.6	0.69

D50B (in.) = 2.153919

D50S (in.) = 2.756024

RIP RAP VOLUME (cu.yd./ft.)= .6874994

RIP RAP FACTOR OF SAFETY= 1.1

RIP RAP SPECIFIC GRAVITY= 2.5

RIP RAP FRICTION ANGLE= 40

-----PRIMARY INPUT----- ---------OUTPUT--------

FLOW Q (cfs)	SLOPE S	n	z	BOT WIDTH b (ft.)	CRIT. DEPTH Yc (ft.)	FLOW DEPTH Yf (ft.)	VEL v (fps)	TRACT FORCE To (psf)
100.0	0.020	0.0350	3	5.0	1.67	1.63	6.2	1.97

D50B (in.)= 6.174527
D50S (in.)= 7.900553
RIP RAP VOLUME (cu.yd./ft.)= 1.36556
RIP RAP FACTOR OF SAFETY= 1.1
RIP RAP SPECIFIC GRAVITY= 2.5
RIP RAP FRICTION ANGLE= 40
MANNING'S EQUATION AND CRITICAL FLOW EQUATION

-----PRIMARY INPUT----- ---------OUTPUT--------

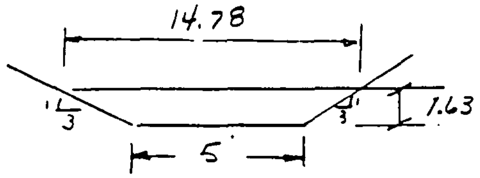
FLOW Q (cfs)	SLOPE S	n	z	BOT WIDTH b (ft.)	CRIT. DEPTH Yc (ft.)	FLOW DEPTH Yf (ft.)	VEL v (fps)	TRACT FORCE To (psf)
100.0	0.020	0.0350	3	7.5	1.45	1.41	6.0	1.71

D50B (in.)= 5.350492
D50S (in.)= 6.846166
RIP RAP VOLUME (cu.yd./ft.)= 1.20429
RIP RAP FACTOR OF SAFETY= 1.1
RIP RAP SPECIFIC GRAVITY= 2.5
RIP RAP FRICTION ANGLE= 40
MANNING'S EQUATION AND CRITICAL FLOW EQUATION

-----PRIMARY INPUT----- ---------OUTPUT--------

FLOW Q (cfs)	SLOPE S	n	z	BOT WIDTH b (ft.)	CRIT. DEPTH Yc (ft.)	FLOW DEPTH Yf (ft.)	VEL v (fps)	TRACT FORCE To (psf)
100.0	0.020	0.0350	3	10.0	1.28	1.25	5.8	1.51

D50B (in.)= 4.72793
D50S (in.)= 6.049574
RIP RAP VOLUME (cu.yd./ft.)= 1.09548
RIP RAP FACTOR OF SAFETY= 1.1
RIP RAP SPECIFIC GRAVITY= 2.5
RIP RAP FRICTION ANGLE= 40



$A = (14.78 + 5)(1/2)(1.63) = 16.121 \text{ ft}^2$

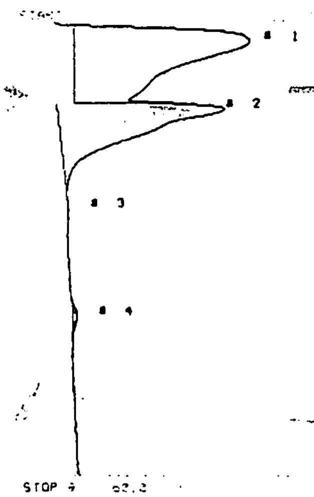
$P = 5 + 2\sqrt{10}(1.63) = 15.309$

$R = \frac{A}{P} = 1.0530 \Rightarrow R^{2/3} = 1.0350$

$V = \frac{1.486}{n} R^{2/3} S^{1/2} = \frac{1.486}{0.035}(1.0350)(0.02)^{1/2}$

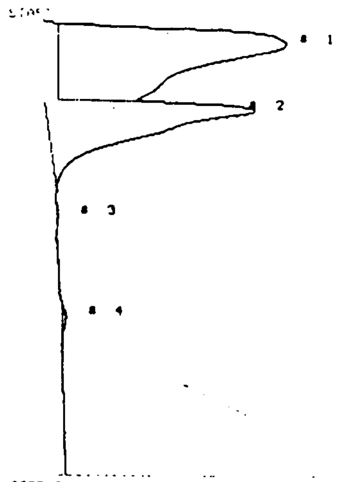
$V = 6.2$ ft/sec

$Q = VA = (6.2)(16.121) = 100.2$ cfs.



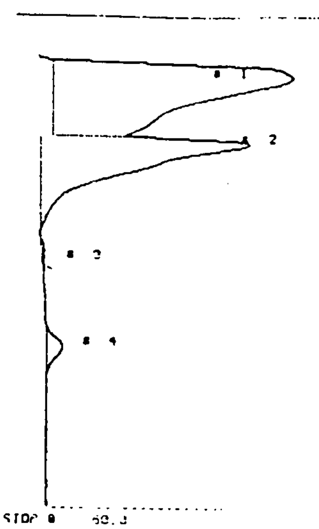
STOP 9 62.2
SAMPLE RUN SEP 1 1987 10:20
ANALYSIS # 31 ROCKY FLATS
TEMPERATURE 24 KMM OCC
GAIN 100 601:87
COMPOUND [illegible]

1



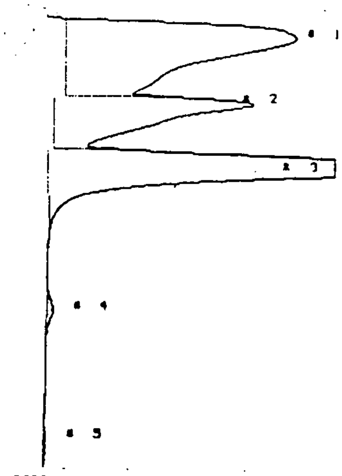
STOP 6 [illegible]
SAMPLE RUN SEP 1 1987 10:29
ANALYSIS # 32 ROCKY FLATS
TEMPERATURE 24 KMM OCC
GAIN 100 601:87
COMPOUND [illegible]

2



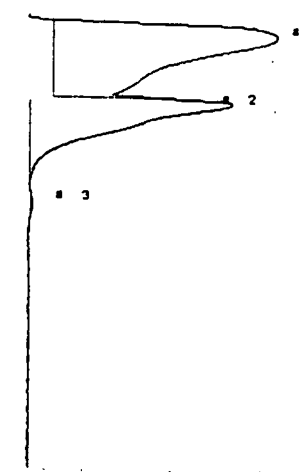
STOP 8 [illegible]
SAMPLE RUN SEP 1 1987 10:33
ANALYSIS # 33 ROCKY FLATS
TEMPERATURE 23 KMM OCC
GAIN 100 601:87
COMPOUND [illegible]

3



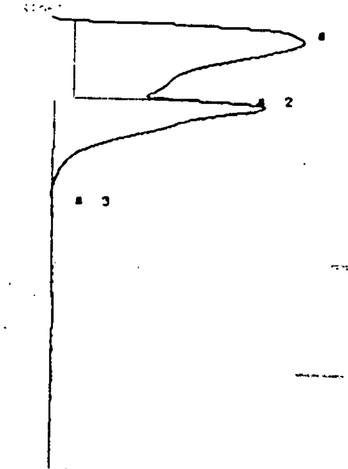
STOP 9 ... 60.0
SAMPLE RUN ... SEP 1 1987 10:42
ANALYSIS # 36 ROCKY FLATS
TEMPERATURE 24 KMM OCC
GAIN 100 601187

COMPOUND NAME



STOP 0 ... 60.0
SAMPLE RUN ... SEP 1 1987 10:44
ANALYSIS # 37 ROCKY FLATS
TEMPERATURE 24 KMM OCC
GAIN 100 601187

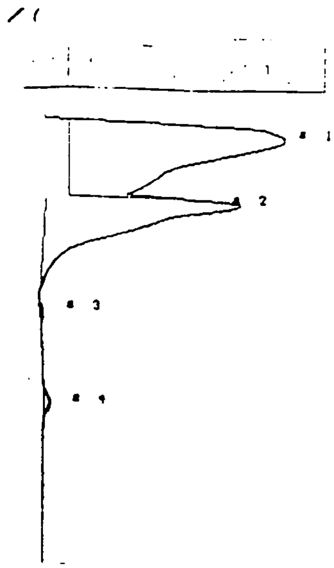
COMPOUND NAME



STOP 0 ... 60.0
SAMPLE RUN ... SEP 1 1987 10:52
ANALYSIS # 38 ROCKY FLATS
TEMPERATURE 24 KMM OCC
GAIN 100 601187

COMPOUND NAME

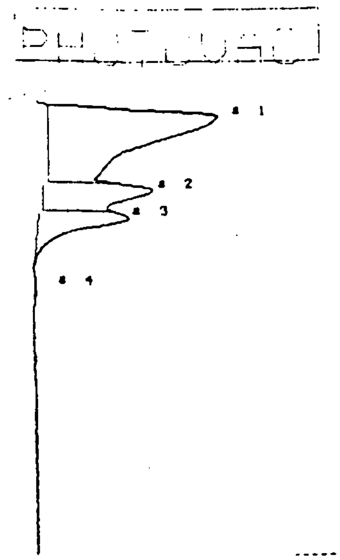
4 Air Check 5



STOP @ [illegible]

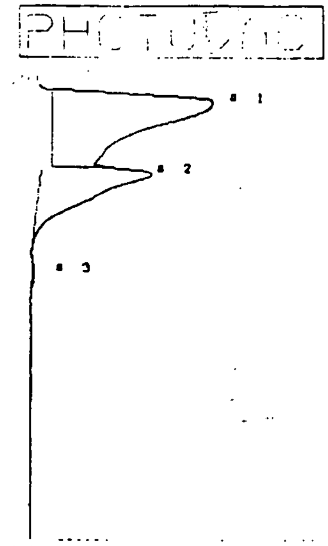
SAMPLE RUN SEP 1 1987 11:14
ANALYSIS # 43 ROCKY FLATS
TEMPERATURE 25 KMM OCC
GAIN 100 601187

COMPOUND NAME [illegible]



SAMPLE RUN SEP 2 1987 8:56
ANALYSIS # 6 ROCKY FLATS
TEMPERATURE 22 KMM OCC
GAIN 100 601187

COMPOUND NAME PEAK [illegible] AREA



STOP @ [illegible]

SAMPLE RUN SEP 2 1987 8:52
ANALYSIS # 5 ROCKY FLATS
TEMPERATURE 21 KMM OCC
GAIN 100 601187

COMPOUND [illegible]

7

Air Check

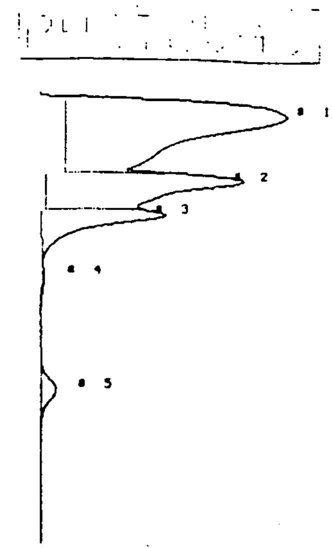
PHOTOVAC

CALIBRATED PEAK 3,H2S

SAMPLE RUN SEP 2 1987 8:56
ANALYSIS # 6 ROCKY FLATS
TEMPERATURE 21 KMM OCC
GAIN 100 601187

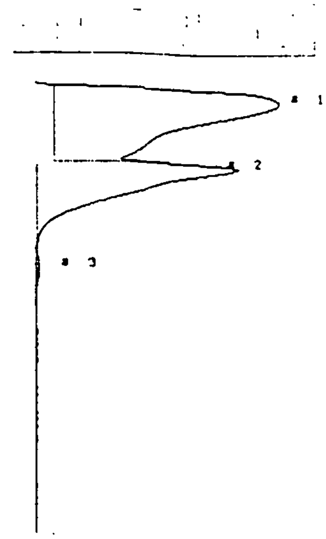
COMPOUND [illegible]

H_2S Calibration



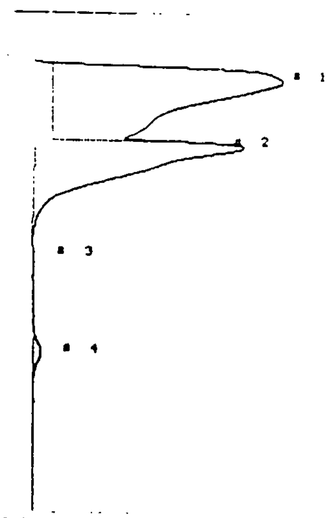
STOP # 60.0
SAMPLE RUN SEP 1 1987 10:54
ANALYSIS # 39 ROCKY FLATS
TEMPERATURE 25 KMM DCC
GAIN 100 601187

COMPOUND NAME



STOP # 62.0
SAMPLE RUN SEP 1 1987 10:57
ANALYSIS # 40 ROCKY FLATS
TEMPERATURE 24 KMM DCC
GAIN 100 601187

COMPOUND NAME



STOP # 62.2
SAMPLE RUN SEP 1 1987 11:4
ANALYSIS # 41 ROCKY FLATS
TEMPERATURE 24 KMM DCC
GAIN 100 601187

COMPOUND NAME

PHOTOVAC

CALIBRATED PEAK 3,H2S

SAMPLE RUN SEP 1 1987 10:55
ANALYSIS # 33 ROCKY FLATS
TEMPERATURE 24 KMM DCC
GAIN 100 631187

COMPOUND NAME

Air Check

6

H_2S Calibration

START

STOP 0 60.0

SAMPLE RUN SEP 2 1987 11: 0

ANALYSIS # 5 ROCKY FLATS

TEMPERATURE 30 KMM OCC

GAIN 100 081187

COMPOUND NAME	PEAK	R.T.	AREA/PPM	
UNKNOWN	1	3.3	5.5	US
UNKNOWN	2	12.0	3.0	US
UNKNOWN	3	25.8	16.0	*US
UNKNOWN	4	35.2	142.4	*US

8

START

STOP 0 60.0

SAMPLE RUN SEP 2 1987 10:58

ANALYSIS # 4 ROCKY FLATS

TEMPERATURE 30 KMM OCC

GAIN 100 081187

COMPOUND NAME	PEAK	R.T.	AREA/PPM	
UNKNOWN	1	3.3	5.2	US
UNKNOWN	2	12.0	3.1	US
UNKNOWN	3	25.3	16.7	*US
UNKNOWN	4	36.5	31.5	*US

9

START

STOP 0 60.0

SAMPLE RUN SEP 2 1987 11: 6

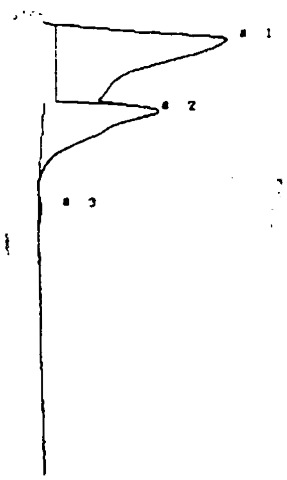
ANALYSIS # 6 ROCKY FLATS

TEMPERATURE 32 KMM OCC

GAIN 100 081187

COMPOUND NAME	PEAK	R.T.	AREA/PPM	
UNKNOWN	1	3.3	6.2	US
UNKNOWN	2	12.0	3.2	US
UNKNOWN	3	20.2	9.7	US
UNKNOWN	4	35.5	1.2	US

10



GAIN 100 601187

Sampling Equipment Check

STOP @ 60.0

SAMPLE RUN SEP 2 1987 10:44
ANALYSIS # 2 ROCKY FLATS
TEMPERATURE 27 KMM OCC
GAIN 100 601187

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	1	3.2	4.5 US
UNKNOWN	2	12.0	2.4 US

Air Check

STOP @ 60.0

SAMPLE RUN SEP 2 1987 10:47

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	1	3.4	4.6 US
UNKNOWN	2	12.0	1.9 US
H2S	3	16.1	13.56 PPM
UNKNOWN	4	25.0	13.7 mUS

PHOTOVAC

CALIBRATED PEAK

SAMPLE RUN SEP 2 1987 10:48
ANALYSIS # 3 ROCKY FLATS
TEMPERATURE 28 KMM OCC
GAIN 100 601187

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	1	3.4	4.6 US
UNKNOWN	2	12.0	1.9 US
H2S	3	16.1	9.999 PPM
UNKNOWN	4	25.0	13.7 mUS

Reference
NUREG/CR-4620
ORNL/TM-10067

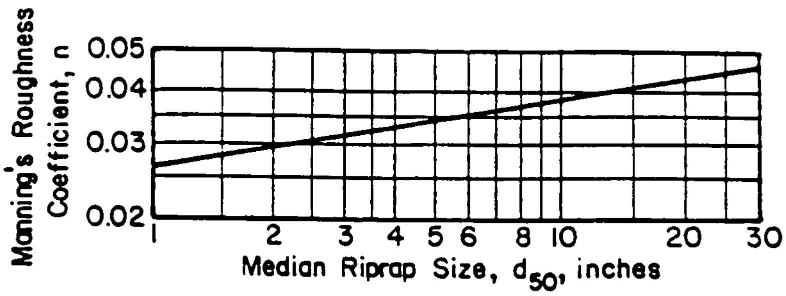


Fig. 4.12. Manning's coefficient for riprap. *Source:* SCS, 1975.

that a conservative value of C be applied for PMF estimation since infiltration and storage comprise a low percentage of the runoff. Furthermore, the C values presented were derived for storms of 5-100 year frequencies. Therefore, less frequent, higher intensity storms will require the use of a higher C value (Chow, 1964). It is recommended that a runoff coefficient of 1.0 be used for PMF applications in very small watersheds since the effects of localized storage and infiltration will be small.

Table 4.5. Values of C for Use in Rational Formula.

Soil Type	Watershed Cover		
	Cultivated	Pasture	Woodlands
With above-average infiltration rates; usually sandy or gravelly	0.20	0.15	0.10
With average infiltration rates; no clay pans; loams and similar soils	0.40	0.35	0.30
With below-average infiltration rates; heavy clay soils or soils with a clay pan near the surface; shallow soils above impervious rock	0.50	0.45	0.40

Source: Chow, 1964.

4.8.2 Rainfall Intensity

In order to determine the rainfall intensity, i, the time of concentration, t, must be estimated. The time of concentration can be approximated by:

(a) Applying one of the many accepted empirical formulae such as

$$t_c = 0.00013 \frac{L^{0.77}}{S^{0.385}} \qquad (4.44)$$

where L is the length of the basin in feet measured along the watercourse from the upper end of the watercourse to the drainage basin outlet and S is the average slope of the basin. Time of concentration is expressed in hours. This procedure is not applicable to rock covered slopes. This expression was

Table 4.6. Values of runoff coefficient C.

Character of Surface	Runoff Coefficients: Range	Runoff Coefficients: Recommended
Pavement--asphalt or concrete	0.70-0.95	0.90
Gravel, from clean and loose to clayey and compact	0.25-0.70	0.50
Roofs	0.70-0.95	0.90
Lawns (irrigated) sandy soil		
Flat, 2 percent	0.05-0.15	0.10
Average, 2 to 7 percent	0.15-0.20	0.17
Steep, 7 percent or more	0.20-0.30	0.25
Lawns (irrigated) heavy soil		
Flat, 2 percent	0.13-0.17	0.15
Average, 2 to 7 percent	0.18-0.22	0.20
Steep, 7 percent	0.25-0.35	0.30
Pasture and non-irrigated lawns		
Sand		
Bare	0.15-0.50	0.30
Light vegetation	0.10-0.40	0.25
Loam		
Bare	0.20-0.60	0.40
Light vegetation	0.10-0.45	0.30
Clay		
Bare	0.30-0.75	0.50
Light vegetation	0.20-0.60	0.40
Composite areas		
Urban		
Single-family, 4-6 units/acre	0.25-0.50	0.40
Multi-family, >6 units/acre	0.50-0.75	0.60
Rural (mostly non-irrigated lawn area)		
<1/2 acre - 1 acre	0.20-0.50	0.35
1 acre - 3 acres	0.15-0.50	0.30
Industrial		
Light	0.50-0.80	0.65
Heavy	0.60-0.90	0.75
Business		
Downtown	0.70-0.95	0.85
Neighborhood	0.50-0.70	0.60
Parks	0.10-0.40	0.20

Source: ASCE, 1970 and Seelye, 1960.

Table 4.7. Maximum permissible velocities in erodible channels.

Channel Material	Water Transporting Colloidal Silts v (ft/sec)
Fine sand, colloidal	2.50
Sandy loam, non-colloidal	2.50
Silty loam, non-colloidal	3.00
Alluvial silts, non-colloidal	3.50
Firm loam	3.50
Volcanic ash	3.50
Stiff clay, colloidal	5.00
Alluvial silts, colloidal	5.00
Shales and hardpans	6.00
Fine gravel	5.00
Graded loam to cobbles, non-colloidal	5.00
Graded silts to cobble, colloidal	5.50
Coarse gravel, non-colloidal	6.00
Cobbles and shingles	5.50

Source: Lane 1955.

Table 4.8. Maximum allowable velocities in sand-based material.

Material	Velocity (ft/sec)
Very light sand of quicksand character	0.75 to 1.00
Very light loose sand	1.00 to 1.50
Coarse sand to light sandy soil	1.50 to 2.00
Sandy soil	2.00 to 2.50
Sandy loam	2.50 to 2.75
Average loam, alluvial soil, volcanic ash	2.75 to 3.00
Firm loam, clay loam	3.00 to 3.75
Stiff clay soil, gravel soil	4.00 to 5.00
Coarse gravel, cobbles and shingles	5.00 to 6.00
Conglomerate, cemented gravel, soft slate, tough hardpan, soft sedimentary rock	6.00 to 8.00

Source: Lane, 1955.

Therefore, the permissible velocities developed for channels is usually extended to overland flow situations. When design velocities reach or exceed those indicated in Tables 4.7 through 4.10, protection is warranted.

Table 4.9. Limiting Velocities in Cohesive Materials.

	Compactness of Bed			
	Loose	Fairly Compact	Compact	Very Compact
Principle Cohesive Material	Velocity (ft/sec)	Velocity (ft/sec)	Velocity (ft/sec)	Velocity (ft/sec)
Sandy clay	1.48	2.95	4.26	5.90
Heavy clayey soils	1.31	2.79	4.10	5.58
Clays	1.15	2.62	3.94	5.41
Lean clayey soils	1.05	2.30	3.44	4.43

Source: Lane, 1955.

The materials presented in Tables 4.7 through 4.9 can be referenced to the Unified Soil Classification System as presented by Wagner (1957). An engineering analysis of the cover material can provide an approximation of the permissible velocities that the alternative cover materials may withstand without supplemental protection.

4.11 PERMISSIBLE VELOCITY EXAMPLE

A tailings disposal site located in the northwest corner of New Mexico has prepared a reclamation plan for review. The reclamation plan indicates that a 10 foot thick cap will be placed atop the tailings at a slope of 2.4% with a compaction of 95% of optimum. The cap will be graded as shown in Figure 4.14 and shall transition into side slopes of 1V:10H. It is proposed that the cap will be composed of a sandy clay with a coarse gravel cover. Along the crest, a 12 inch thick layer of riprap will be placed for at least 8 feet upslope and downslope of the crest to stabilize the transition. The riprap will have a median stone size of 6 inches. The gravel cover will have a median rock size of 1.5 inches. The design reviewer must verify that the gravel cover will resist the potential velocities that may result on the cap.

Table 4.10. Maximum Permissible Velocities in Feet per Second (fps) for Channels Lined With Uniform Stands of Various Well-Maintained Grass Covers.

Cover	Maximum Permissible Velocities[a]		
	Slope Range %	Erosion-Resistant Soils	Easily-Eroded Soils
Bermudagrass	0-5	8	6
	5-10	7	5
	Over 10	6	4
Buffalograss, Kentucky bluegrass, Smooth brome, Blue grama[b]	0-5	7	5
	5-10	6	4
	Over 10	5	3
Grass mixture[b]	0-5	5	4
	5-10	4	3
Lespedeza sericea, Weeping lovegrass, Yellow bluestem[c], Kudzu, Alfalfa, Crabgrass	0-5	3.5	2.5
Common lespedeza[c,d], Sudangrass[d]	0-5	3.5	2.5

[a]Use velocities over 5 fps only where good covers and proper maintenance can be obtained.

[b]Do not use on slopes steeper than 10 percent.

[c]Use on slopes steeper than 5 percent is not recommended.

[d]Annuals are used on mild slopes or as temporary protection until permanent covers are established.

Source: SCS, 1984.

From Open Channel Fl[ow]
F.M Henderson
McMillan Publish 1966

of Eq. (4–23) should be reduced by a factor of the sixth root of a number between two and three—i.e., by between 10 and 20 percent. The effect is to make the agreement between the two equations even closer than it appears at first.

We conclude that there is a remarkably close correspondence between Eq. (4–11), based initially on quite small-scale pipe experiments (Nikuradse's largest pipe was $2\frac{1}{2}$ in. in diameter), and the Manning and Strickler equations, based on quite large-scale field observations. It follows that the Manning equation is suitable for all fully rough flow, although there will be a range of *intermediate* channel sizes for which Eq. (4–11) is equally suitable, within normally acceptable limits of accuracy. For transition flow, as described by Eq. (4–13), the Manning equation is no longer suitable, unless the coefficient n is recognized as dependent on Re, as in Fig. 4-5 (see notes on Table 4–2); the boundary between transition flow and fully rough flow is given by Eq. (4–16), and may conveniently be expressed in terms of the Manning equation parameters. Equations (4–14), (4–16), and (4–22) may be combined (Prob. 4.3) to give the result

$$n^6\sqrt{RS_f} \geq 1.9 \times 10^{-13} \qquad (4\text{–}24)$$

for fully rough flow. If this inequality is true the Manning equation is applicable.

Typical values of the coefficient n are listed in Table 4–2.

TABLE 4–2 Values of Manning's Roughness Coefficient n

Glass, plastic, machined metal	0.010
Dressed timber, joints flush	0.011
Sawn timber, joints uneven	0.014
Cement plaster	0.011
Concrete, steel troweled	0.012
Concrete, timber forms, unfinished	0.014
Untreated gunite	0.015–0.017
Brickwork or dressed masonry	0.014
Rubble set in cement	0.017
Earth, smooth, no weeds	0.020
Earth, some stones and weeds	0.025
Natural river channels:	
Clean and straight	0.025–0.030
Winding, with pools and shoals	0.033–0.040
Very weedy, winding and overgrown	0.075–0.150
Clean straight alluvial channels	$0.031d^{1/6}$ (d = D-75 size in ft.)

Notes on Table 4.2

When a single value of n is given in the table, it is the mean value of a range of approximately ± 0.001. The categories such as "clean straight river channels" described at the end of the table clearly cover such a wide range of conditions that some field experience is desirable before a value of n can be estimated with reasonable confidence. However, the photographs given by Ven Te Chow [6] form a useful supplement to, or even substitute for, field experience.

The last entry in the table gives the result of Eq. (4–22), applicable mainly to alluvial channels of coarse noncohesive gravel or cobbles (known as *shingle* in British countries). The D-75 size may be taken as a good approximation to the value of d (larger than the median) with which the bed tends to become armored.

The reader will easily be able to verify that the values of k_s in Table 4-1 are generally consistent, via Eq. (4–22), with the above values of n.

When the channel bed and banks are thickly covered with vegetation an appreciable part of the flow takes place through the vegetation at low velocities. If the growth is of fine material such as grass the Reynolds number Re defined with respect to the stalk thickness will be low, and the resistance, and therefore the Manning n, will be dependent on Re. Since n will therefore depend on the velocity, it may possibly depend on Re defined with respect to the channel size as well as with respect to the stalk thickness. This has been shown to be true by the experiments of the U. S. Soil Conservation Service [3];

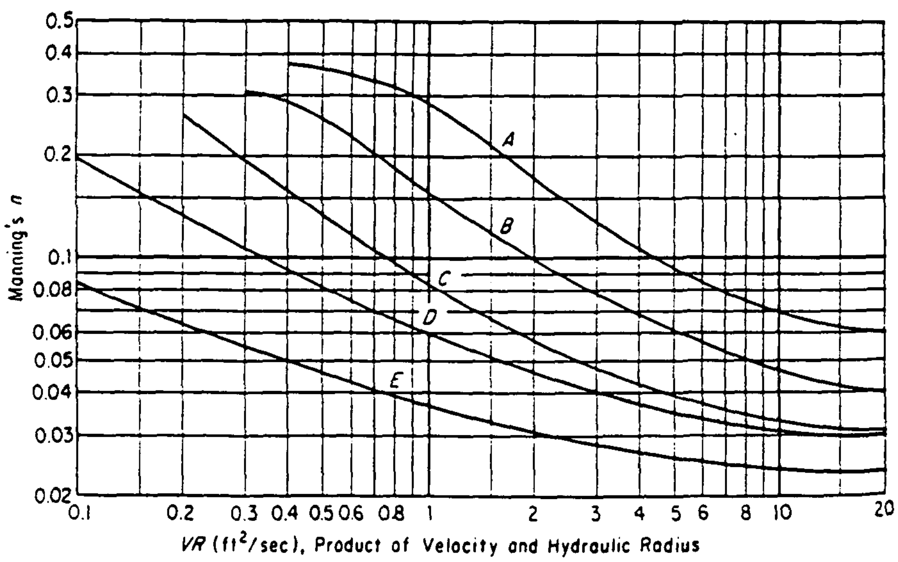


Figure 4-5. The Behavior of Manning's n in Grassed Channels

their results, for a number of North American grass species, are summarized in Fig. 4-5. The division into classes depends mainly on the length and the "stand"—i.e., the vigour and thickness of growth, according to the following table:

TABLE 4-3

Average length of grass	*Class*	
	Good stand	*Fair stand*
More than 30 in.	A	B
11–24 in.	B	C
6–10 in.	C	D
2–6 in.	D	D
less than 2 in.	E	E

Wide shallow grassed channels are a popular solution to the problem of passing large discharges down steep slopes without developing unduly high velocities.

4.3 Uniform Flow: Its Computation and Applications

Significance of Uniform Flow

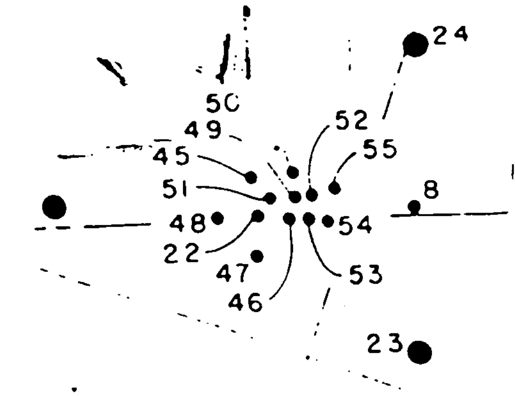
Uniform flow has now been defined and a dynamic equation developed—the Manning equation—which adequately describes both uniform and nonuniform flow.

Uniform flow seldom occurs in nature, since natural channels are usually irregular. Even in artificial channels of uniform section, the occurrence of uniform flow may be relatively infrequent because of the existence of controls, such as weirs, sluice gates, etc., which dictate a depth-discharge relationship different from that appropriate to uniform flow.

However, uniform flow is a condition of such basic importance that it must be considered in all channel-design problems. For example, if it is proposed to instal certain controls in an irrigation canal it is necessary to compare their depth-discharge relation with those of uniform flow; as we shall see, the whole character of the flow in the canal will depend on the form this comparison takes. Again, if a canal is to be laid on a certain slope, is to have a lining of a certain coefficient n, and is to take a certain discharge, then the uniform-flow condition is the criterion governing the *minimum* cross-sectional area required. Other criteria may of course determine that the section must be greater than this minimum, but the section cannot conceivably be any smaller or the canal will be unable to take the required discharge.

Economical Design of a Channel Cross Section

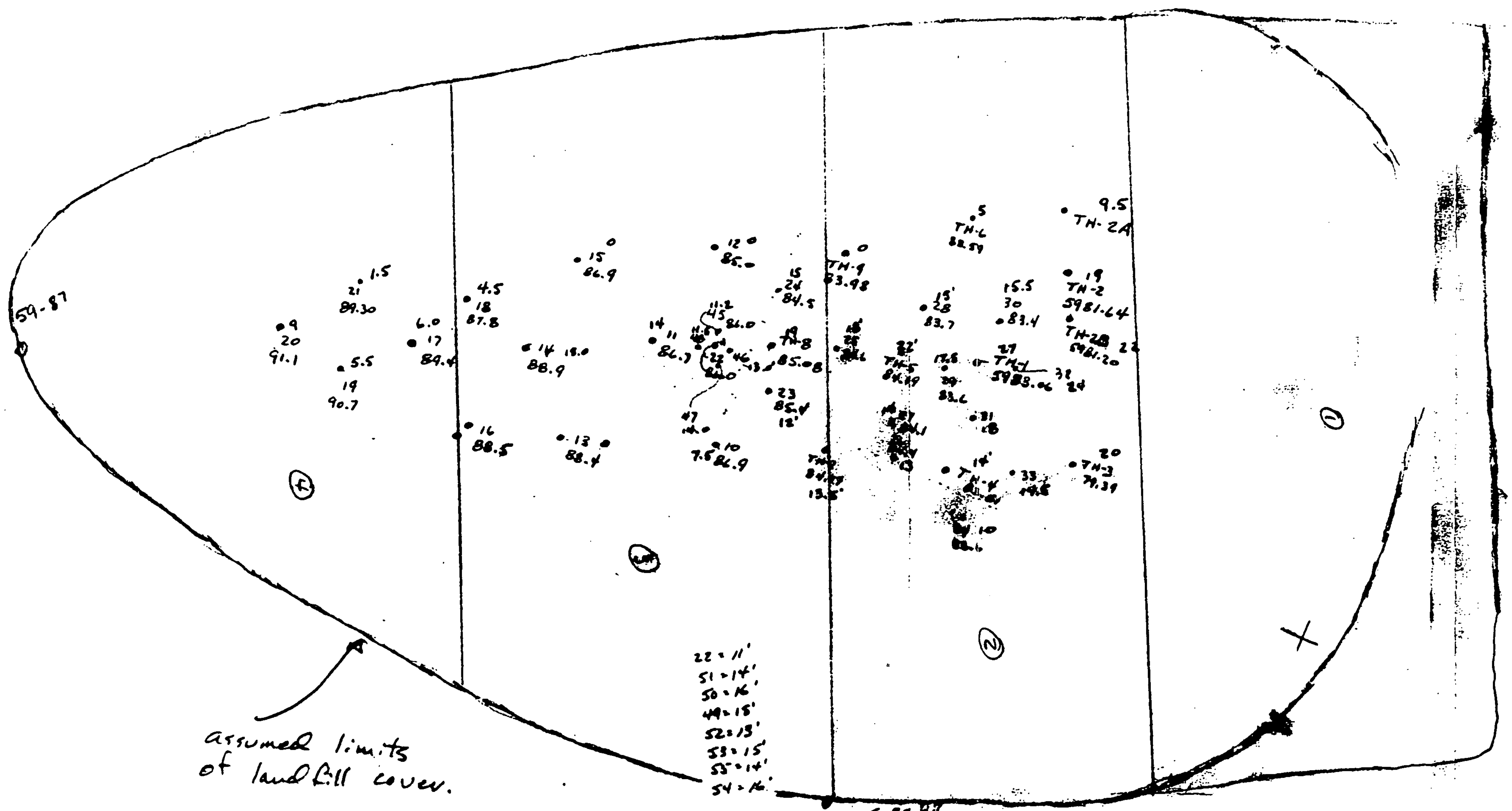
A typical uniform-flow problem in the design of artificial canals is the economical proportioning of the cross section. A canal having a given Manning coefficient n and slope S_0 is to carry a certain discharge Q, and



Values in red are thicknesses of landfill noted in Woodward's boring logs 1/17/74

③
4.045 1.680
5.725 1.700
7.425 1.698
9.123
1.693
= 16.93 in²

④
9.781 1.15
10.932 1.155
12.087 1.161
13.248 1.155
14.403
1.156
= 11.56 in²



139,500

20,500
40,000

Total Area: 17.09
15.83
16.93
11.56
61.41 in² × (100 ft/in)² × 1 ac/43,560 ft²

= 14.1 acres.

②
7.860 1.583
9.443 1.580
11.023 1.585
12.608 1.583
14.191
1.583
= 15.83 in²

①
8.435 1.712
10.147 1.699
11.846 1.721
13.567 1.704
15.271
1.709
= 17.09 in²

20,000
39,000

6-032-88
BJB 5/11/88 Scale 1:100'

Fig. 2

Chen & Associates
Consulting Geotechnical Engineers

NO. 6-032-88 JOB TITLE Rocky Flats - Landfill DATE 5/13/88 BY JAS
SUBJECT Estimation of FML Efficiency CHECKED GTJ SHEET 1 OF 2

PROBLEM

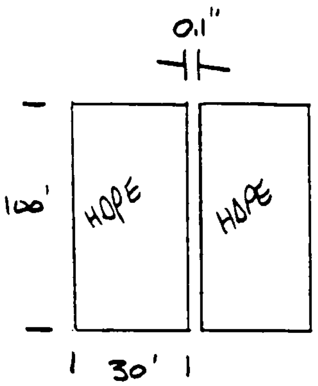
HELP computer model uses an effective % for synthetic membranes to evaluate infiltration

SOLUTION

LANDFILL AREA IS 230,000 ft^2

WORST CASE - MEMBRANES ARE LAID SIDE BY SIDE WITH NO SEAMING AND AN AVERAGE OF 0.1" GAP BETWEEN SHEETS

I.E.



∴ OPEN AREA IS EQUAL TO

$230{,}000\ ft^2 / 3000\ ft^2/roll \doteq 77$ ROLLS

$GAP/roll = 130' * 0.1" = 1.083\ ft^2$

OR EFFICIENCY IS $77 \cdot 1.083\ ft^2 / 230{,}000\ ft^2 \doteq 0.03\%$

Chen & Associates
Consulting Geotechnical Engineers

NO. 6-032-88 JOB TITLE Rocky Flats - Landfill DATE 5/13/88 BY JAS
SUBJECT Estimation of FML Efficiency CHECKED GTJ SHEET 2 OF 2

CONSERVATIVE ESTIMATE

ASSUME EVEN AFTER VISUAL INSPECT 1' PER 100' OF SEAM HAS A HAIRLINE (0.01") GAP

OR TOTAL OPENING OF

77 * 130' * 0.01 = 100.1 FT OF DEFECT

100.1' * 0.01" = 0.083 FT² TOTAL OPENING

EFFICIENCY IS

0.083 FT² / 230,000 FT² = 0.000036 %

GUNDLE HDPE - 1 ROLL 22.5' x 840'

ASSUME 22' x 840' w/seam overlap

∴ 18,480 ft²/ROLL

230,000 ft² / 18,480 ft²/ROLL = 12.45 ROLLS

Seam LENGTH/ROLL = 840 + 22 = 862'

LENGTH OF DEFECT: 12.45 * 862' * 0.01 = 107.3'
(1'/100')

TOTAL OPENING: 107.3' * 0.01" = 0.089 ft²

EFFICIENCY IS

0.089 ft² / 230,000 ft² = 0.000039 %

****
****

Existing Cover
Rocky Flats - Present Landfill
May 26, 1988

****
****

FAIR GRASS

LAYER 1

VERTICAL PERCOLATION LAYER		
THICKNESS	=	36.00 INCHES
EVAPORATION COEFFICIENT	=	3.100 MM/DAY**0.5
POROSITY	=	0.4292 VOL/VOL
FIELD CAPACITY	=	0.2718 VOL/VOL
WILTING POINT	=	0.1840 VOL/VOL
EFFECTIVE HYDRAULIC CONDUCTIVITY	=	0.04950000 INCHES/HR

LAYER 2

WASTE LAYER		
THICKNESS	=	300.00 INCHES
EVAPORATION COEFFICIENT	=	3.300 MM/DAY**0.5
POROSITY	=	0.5200 VOL/VOL
FIELD CAPACITY	=	0.3200 VOL/VOL
WILTING POINT	=	0.1900 VOL/VOL
EFFECTIVE HYDRAULIC CONDUCTIVITY	=	0.28299999 INCHES/HR

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	76.21
TOTAL AREA OF COVER	=	383000. SQ. FT
EVAPORATIVE ZONE DEPTH	=	5.00 INCHES
EFFECTIVE EVAPORATION COEFFICIENT	=	3.100 MM/DAY**0.5
UPPER LIMIT VEG. STORAGE	=	2.1460 INCHES
INITIAL VEG. STORAGE	=	1.1395 INCHES

CLIMATOLOGIC DATA FOR DENVER COLORADO

MONTHLY MEAN TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
28.90	30.56	37.46	47.76	58.69	67.33
71.35	69.69	62.79	52.49	41.56	32.92

MONTHLY MEANS SOLAR RADIATION, LANGLEYS PER DAY

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
218.56	274.45	355.05	438.77	503.16	530.98
514.77	458.88	378.28	294.57	230.17	202.35

LEAF AREA INDEX TABLE

DATE	LAI
1	0.00
124	0.00
140	0.31
156	0.51
172	0.51
188	0.51
205	0.51
221	0.51
237	0.46
253	0.33
269	0.16
285	0.09
366	0.00

POOR GRASS

WINTER COVER FACTOR = 0.30

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AVERAGE MONTHLY TOTALS FOR 74 THROUGH 78

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PITATION (INCHES)	0.38	0.45	1.23	1.65	1.68	1.39
	2.19	1.17	0.67	0.89	0.94	0.35
RUNOFF (INCHES)	0.000	0.000	0.005	0.000	0.007	0.087
	0.010	0.093	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION	0.421	0.505	0.853	1.353	1.403	1.218
(INCHES)	1.695	0.845	0.567	0.560	0.713	0.439
PERCOLATION FROM BASE	0.0009	0.0001	0.0725	0.3193	0.3711	0.2692
OF LANDFILL (INCHES)	0.1788	0.5188	0.0489	0.1234	0.2708	0.0837
DRAINAGE FROM BASE OF	0.000	0.000	0.000	0.000	0.000	0.000
LANDFILL (INCHES)	0.000	0.000	0.000	0.000	0.000	0.000

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AVERAGE ANNUAL TOTALS FOR 74 THROUGH 78

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	12.99	414661.	100.00
RUNOFF	0.202	6451.	1.56
EVAPOTRANSPIRATION	10.572	337417.	81.37
PERCOLATION FROM BASE OF LANDFILL	2.2573	72044.	17.37
DRAINAGE FROM BASE OF LANDFILL	0.000	0.	0.00

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PEAK DAILY VALUES FOR 74 THROUGH 78

	(INCHES)	(CU. FT.)
PRECIPITATION	1.79	57130.8
RUNOFF	0.436	13909.7
PERCOLATION FROM BASE OF LANDFILL	0.0848	2706.6
DRAINAGE FROM BASE OF LANDFILL	0.000	0.0
HEAD ON BASE OF LANDFILL	0.0	
SNOW WATER	0.63	20198.8

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3867
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1815

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Proposed Cover
Rocky Flats - Present Landfill
May 26, 1988

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FAIR GRASS

LAYER 1

VERTICAL PERCOLATION LAYER THICKNESS	=	6.00 INCHES
EVAPORATION COEFFICIENT	=	5.000 MM/DAY**0.5
POROSITY	=	0.5110 VOL/VOL
FIELD CAPACITY	=	0.3010 VOL/VOL
WILTING POINT	=	0.1840 VOL/VOL
EFFECTIVE HYDRAULIC CONDUCTIVITY	=	0.99000001 INCHES/HR

LAYER 2

VERTICAL PERCOLATION LAYER THICKNESS	=	30.00 INCHES
EVAPORATION COEFFICIENT	=	3.100 MM/DAY**0.5
POROSITY	=	0.3898 VOL/VOL
FIELD CAPACITY	=	0.2893 VOL/VOL
WILTING POINT	=	0.2000 VOL/VOL
EFFECTIVE HYDRAULIC CONDUCTIVITY	=	0.00420000 INCHES/HR

LAYER 3

LATERAL DRAINAGE LAYER

SLOPE	=	2.00 PERCENT
DRAINAGE LENGTH	=	600.0 FEET
THICKNESS	=	6.00 INCHES
EVAPORATION COEFFICIENT	=	3.300 MM/DAY**0.5
POROSITY	=	0.3710 VOL/VOL
FIELD CAPACITY	=	0.1720 VOL/VOL
WILTING POINT	=	0.0500 VOL/VOL
EFFECTIVE HYDRAULIC CONDUCTIVITY	=	5.40000010 INCHES/HR

LAYER 4

BARRIER SOIL LAYER WITH LINER

THICKNESS	=	6.00 INCHES
EVAPORATION COEFFICIENT	=	3.100 MM/DAY**0.5
POROSITY	=	0.2907 VOL/VOL
FIELD CAPACITY	=	0.1415 VOL/VOL
WILTING POINT	=	0.0500 VOL/VOL
EFFECTIVE HYDRAULIC CONDUCTIVITY	=	0.27000001 INCHES/HR

LAYER 5

VERTICAL PERCOLATION LAYER

THICKNESS	=	36.00 INCHES
EVAPORATION COEFFICIENT	=	3.100 MM/DAY**0.5
POROSITY	=	0.4292 VOL/VOL
FIELD CAPACITY	=	0.2718 VOL/VOL
WILTING POINT	=	0.1840 VOL/VOL
EFFECTIVE HYDRAULIC CONDUCTIVITY	=	0.01650000 INCHES/HR

LAYER 6

WASTE LAYER

THICKNESS	=	300.00 INCHES
EVAPORATION COEFFICIENT	=	3.300 MM/DAY**0.5
POROSITY	=	0.5200 VOL/VOL
FIELD CAPACITY	=	0.3200 VOL/VOL
WILTING POINT	=	0.1900 VOL/VOL

EFFECTIVE HYDRAULIC CONDUCTIVITY = 0.28299999 INCHES/HR

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	76.21
TOTAL AREA OF COVER	=	403000. SQ. FT
EVAPORATIVE ZONE DEPTH	=	5.00 INCHES
LINER LEAKAGE FRACTION	=	0.000001
EFFECTIVE EVAPORATION COEFFICIENT	=	5.000 MM/DAY**0.5
UPPER LIMIT VEG. STORAGE	=	2.5550 INCHES
INITIAL VEG. STORAGE	=	1.2125 INCHES

CLIMATOLOGIC DATA FOR DENVER COLORADO

MONTHLY MEAN TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
28.90	30.56	37.46	47.76	58.69	67.33
71.35	69.69	62.79	52.49	41.56	32.92

MONTHLY MEANS SOLAR RADIATION, LANGLEYS PER DAY

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
218.56	274.45	355.05	438.77	503.16	530.98
514.77	458.88	378.28	294.57	230.17	202.35

LEAF AREA INDEX TABLE

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140	0.31
156	0.51
172	0.51
188	0.51
205	0.51
221	0.51
237	0.46
253	0.33
269	0.16
285	0.09
366	0.00

POOR GRASS

WINTER COVER FACTOR = 0.30

****

AVERAGE MONTHLY TOTALS FOR 74 THROUGH 78

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION (INCHES)	0.38	0.45	1.23	1.65	1.68	1.39
	2.19	1.17	0.67	0.89	0.94	0.35
RUNOFF (INCHES)	0.000	0.000	0.000	0.000	0.030	0.005
	0.000	0.034	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION (INCHES)	0.421	0.524	0.833	1.297	1.538	1.149
	1.543	1.233	0.598	0.520	0.569	0.308
PERCOLATION FROM BASE OF COVER (INCHES)	0.0010	0.0009	0.0016	0.0011	0.0011	0.0012
	0.0012	0.0013	0.0012	0.0013	0.0013	0.0013
PERCOLATION FROM BASE OF LANDFILL (INCHES)	0.0009	0.0008	0.0013	0.0012	0.0011	0.0011
	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012
DRAINAGE FROM BASE OF COVER (INCHES)	0.104	0.094	0.103	0.111	0.122	0.125
	0.127	0.137	0.126	0.132	0.129	0.132
DRAINAGE FROM BASE OF LANDFILL (INCHES)	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000

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AVERAGE ANNUAL TOTALS FOR 74 THROUGH 78

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	12.99	436315.	100.00
RUNOFF	0.069	2332.	0.53
EVAPOTRANSPIRATION	10.534	353779.	81.08
PERCOLATION FROM BASE OF COVER	0.0148	498.	0.11
PERCOLATION FROM BASE OF LANDFILL	0.0134	449.	0.10
DRAINAGE FROM BASE OF COVER	1.440	48366.	11.09
DRAINAGE FROM BASE OF LANDFILL	0.000	0.	0.00

PEAK DAILY VALUES FOR 74 THROUGH 78

	(INCHES)	(CU. FT.)
PRECIPITATION	1.79	60114.2
RUNOFF	0.152	5100.3
PERCOLATION FROM BASE OF COVER	0.0024	81.0
PERCOLATION FROM BASE OF LANDFILL	0.0006	20.5
DRAINAGE FROM BASE OF COVER	0.014	480.1
DRAINAGE FROM BASE OF LANDFILL	0.000	0.0
HEAD ON BASE OF COVER	42.0	
HEAD ON BASE OF LANDFILL	0.0	
SNOW WATER	0.63	21253.5

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.5110
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1833

Chen & Associates
Consulting Geotechnical Engineers

96 South Zuni
Denver, Colorado 80223
303/744-7105

Casper
Colorado Springs
Ft. Collins
Glenwood Springs
Phoenix
Rock Springs
Salt Lake City
San Antonio

September 10, 1987

Subject: Real Time Soil-Gas, Rocky Flats Landfill, Rocky Flats Plant, Golden, Colorado

Job No. 6 011 87

Rockwell International
Rocky Flats Plant
North American Space Operations
P.O. Box 464
Golden, Colorado 80402-0464

Attention: Mr. Tom Greengard

As requested, Chen & Associates conducted a real time soil-gas survey at the Rocky Flats landfill on September 1 and 2, 1987. Twenty points were measured in the landfill for methane and hydrogen sulfide. The location of those points are shown on Figure 1.

Methane was analyzed by a Century OVA 128 flame ionization detector in the gas chromatography mode. Hydrogen sulfide was analyzed by a Photovac 10S50 gas chromatograph with a photoionization detector. The summary of the analyzed compounds are shown in Table I. All sample and QA/QC Photovac 10S50 chromatograms are shown in Attachment 1.

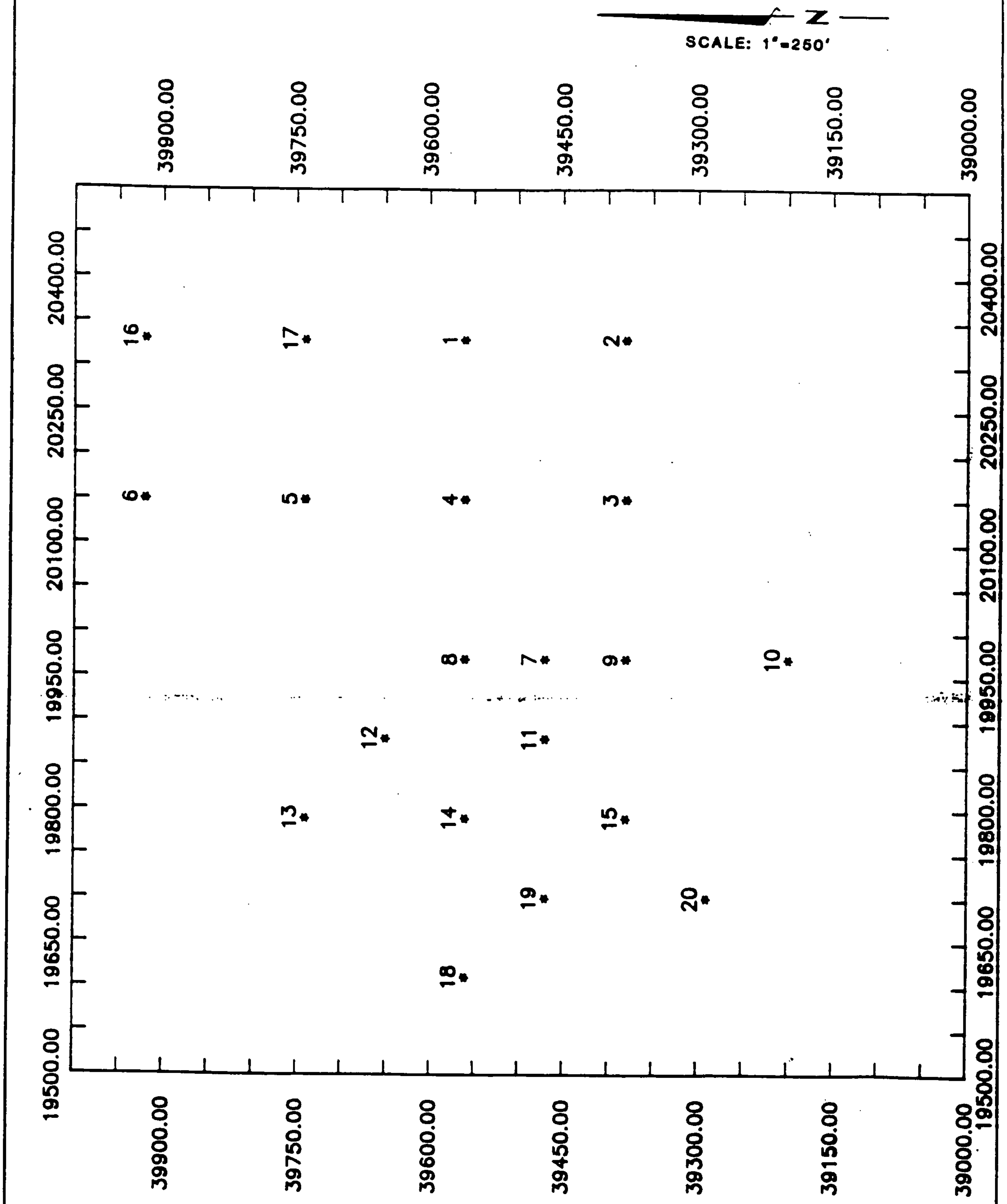
If you have any questions or if we may be of further service, please do not hesitate to contact us.

Sincerely,

CHEN & ASSOCIATES, INC.

By________________________
David C. Constant

DCC/eac
Rev. By: DRG
Encs.



6 011 87	**Chen & Associates**	SOIL GAS SAMPLING POINTS	Fig. 1

TABLE I

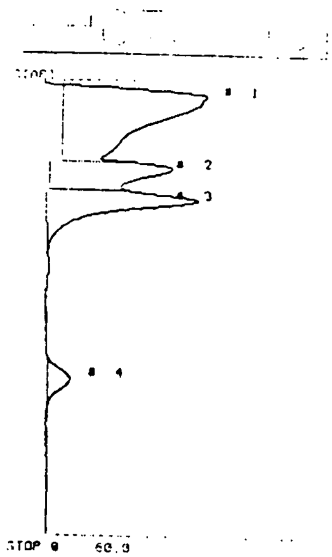
SUMMARY OF HYDROGEN SULFIDE AND METHANE RESULTS

Soil-Gas Sampling Point	Location	Hydrogen Sulfide Value (ppm)	Methane Value (ppm)
1	N39560 E20330	0	0
2	N39380 E20330	0	0.2
3	N39380 E20150	0	0
4	N39560 E20150	0	0
5	N39740 E20150	0	0.4
6	N39920 E20150	0	0
7	N39740 E19970	0	0
8	N39560 E19970	0	0
9	N39380 E19970	0	0
10	N39200 E19970	0	0
11	N39470 E19880	0	0
12	N39650 E19880	0	0
13	N39740 E19790	0	0
14	N39560 E19790	0	0

TABLE I (cont.)

SUMMARY OF HYDROGEN SULFIDE AND METHANE RESULTS

Soil-Gas Sampling Point	Location	Hydrogen Sulfide Value (ppm)	Methane Value (ppm)
15	N39380 E19790	0	0
16	N39920 E20330	0	0
17	N39740 E20330	0	0
18	N39560 E19610	0	0
19	N39470 E19700	0	0
20	N39290 E19700	0	0



STOP @ 60.0
SAMPLE RUN SEP 1 1987 10: 4
ANALYSIS # 27 ROCKY FLATS
TEMPERATURE 24 KMM OCC
GAIN 100 601187

COMPOUND NAME

UNKNOWN PPM

PHOTOVAC

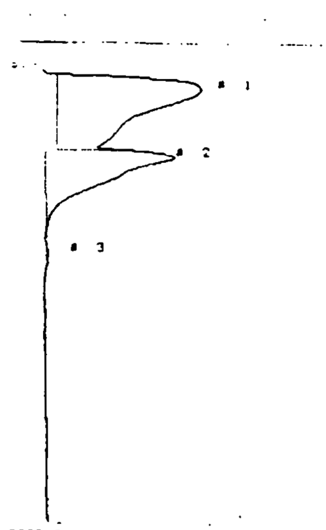
CALIBRATED PEAK 3,H2S

SAMPLE RUN SEP 1 1987 10: 5
ANALYSIS # 27 ROCKY FLATS
TEMPERATURE 24 KMM OCC
GAIN 100 601187

COMPOUND NAME

PPM

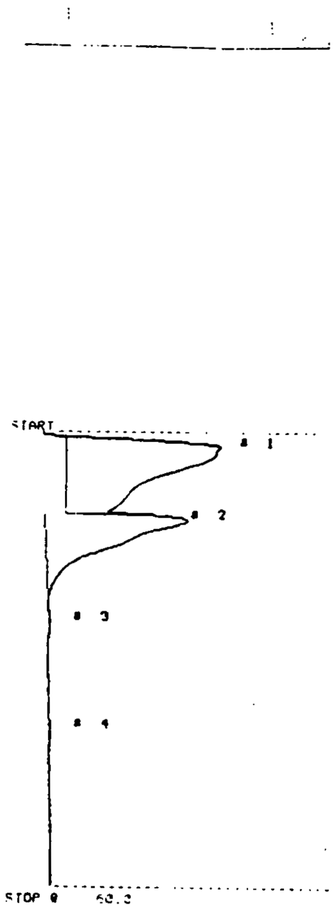
H_2S Calibration



STOP @
SAMPLE RUN SEP 1987 10: 7
ANALYSIS # 28 ROCKY FLATS
TEMPERATURE 24 KMM OCC
GAIN 100 601187

COMPOUND

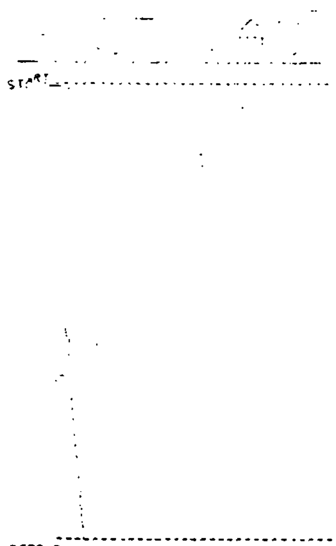
Air Check



STOP @ 60.0
SAMPLE RUN SEP 1 1987 10:10
ANALYSIS # 29 ROCKY FLATS
TEMPERATURE 23 KMM OCC
GAIN 100 621187

COMPOUND

Sample Equipment Check



STOP 0 60.0
SAMPLE RUN SEP 2 1987 11:11
ANALYSIS # 8 ROCKY FLATS
TEMPERATURE 33 KMM OCC
GAIN 100 091187

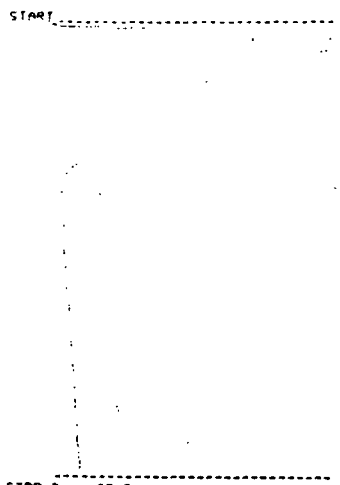
COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	1	3.1	7.1 US
UNKNOWN	2	12.0	3.7 US
UNKNOWN	3	25.7	25.9 mUS
UNKNOWN	4	35.2	14.1 mUS

11

STOP 0 60.0
[illegible] 3 [illegible] 11:17
TEMPERATURE 35 KMM OCC
GAIN 100 091187

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	1	3.2	10.7 US
UNKNOWN	2	11.8	4.5 US
UNKNOWN	3	25.5	15.1 mUS

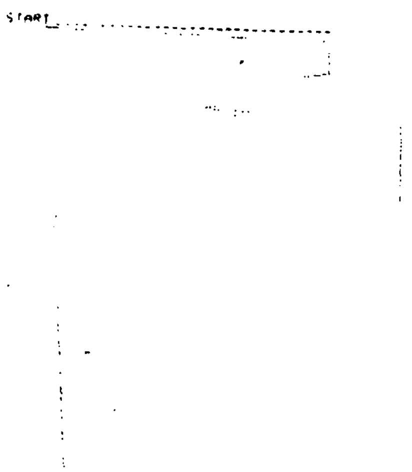
12



STOP 0 60.0
SAMPLE RUN SEP 2 1987 11:9
ANALYSIS # 7 ROCKY FLATS
TEMPERATURE 32 KMM OCC
GAIN 100 091187

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	1	2.9	6.3 US
UNKNOWN	2	12.0	3.4 US
UNKNOWN	3	25.3	15.1 mUS

Air Check

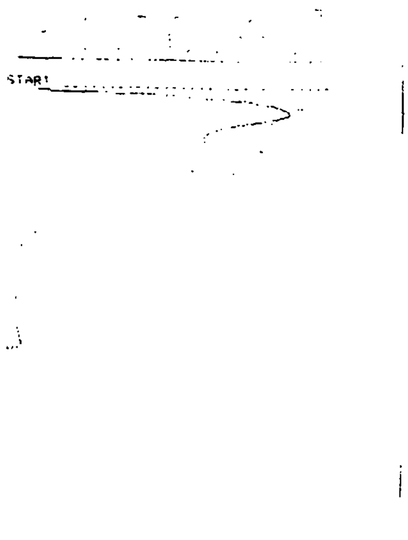


TOP 0 60.0

SAMPLE RUN		SEP 2 1987	11:22
ANALYSIS #	18	ROCKY FLATS	
TEMPERATURE	37	KMM OCC	
GAIN	100	001187	

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	1	3.4	13.1 US
UNKNOWN	2	11.9	5.0 US
UNKNOWN	3	25.4	38.3 mUS
UNKNOWN	4	33.6	59.9 mUS

13



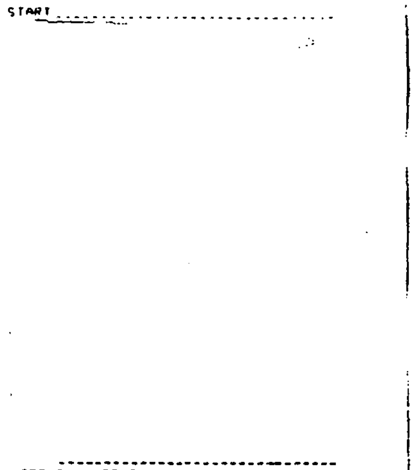
STOP 0 60.0

SAMPLE RUN		SEP 2 1987	11:43
ANALYSIS #	18	ROCKY FLATS	
TEMPERATURE	37	KMM OCC	
GAIN	100	001187	

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	2	8.6	2.0 US
UNKNOWN	3	12.1	1.3 US
UNKNOWN	4	14.4	2.0 US
UNKNOWN	5	25.7	30.3 mUS
UNKNOWN	6	34.4	65.1 mUS

14

PHOTOVAC



STOP 0 60.0

SAMPLE RUN		SEP 2 1987	11:37
ANALYSIS #	17	ROCKY FLATS	
TEMPERATURE	38	KMM OCC	
GAIN	100	001187	

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	2	8.6	0.0 US
UNKNOWN	3	12.0	1.3 US
H2S	4	14.4	11.41 PPM
H2S	5	16.6	14.31 PPM
UNKNOWN	6	25.1	20.7 mUS
UNKNOWN	7	34.3	45.7 mUS

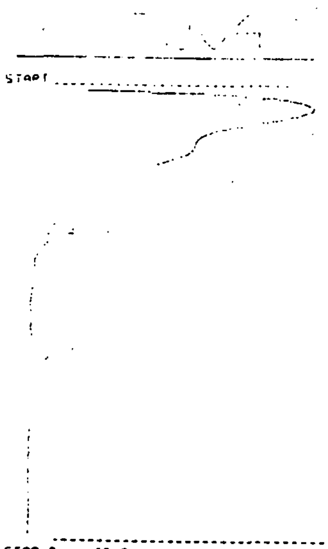
PHOTOVAC

CALIB...

SAMPLE RUN		SEP 2 1987	10:38
ANALYSIS #	17	ROCKY FLATS	
TEMPERATURE	37	KMM OCC	
GAIN	100	001187	

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	1	3.5	4.4 US
UNKNOWN	2	8.6	2.0 US
UNKNOWN	3	12.0	1.3 US
UNKNOWN	4	14.4	1.2 US
H2S	5	16.6	10.00 PPM
UNKNOWN	6	25.1	20.7 mUS
UNKNOWN	7	34.3	45.7 mUS

Air Check

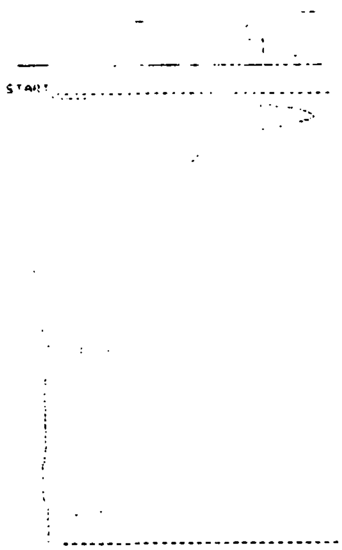


STOP @ 60.0

SAMPLE RUN SEP 2 1987 12:11
ANALYSIS # 21 ROCKY FLATS
TEMPERATURE 35 KMM OCC
GAIN 100 601187

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	1	3.3	6.1 US
UNKNOWN	2	12.0	3.4 US
UNKNOWN	3	20.6	75.5 mUS
UNKNOWN	4	35.5	176.6 mUS

15

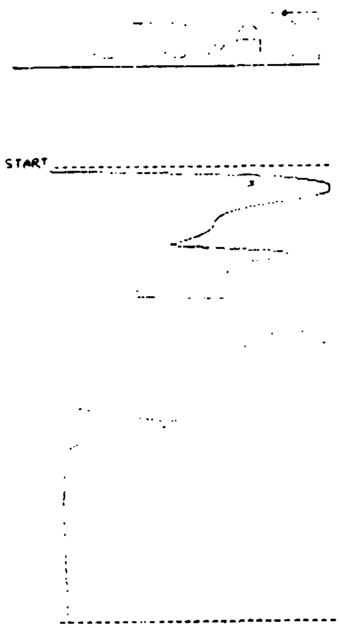


STOP @ 60.0

SAMPLE RUN SEP 2 1987 12:19
ANALYSIS # 22 ROCKY FLATS
TEMPERATURE 36 KMM OCC
GAIN 100 601187

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	1	3.3	6.0 US
UNKNOWN	2	12.1	3.7 US
UNKNOWN	3	26.4	30.1 mUS
UNKNOWN	4	35.0	93.3 mUS
UNKNOWN	5	57.3	17.1 mUS

16



STOP @ 60.0

SAMPLE RUN SEP 2 1987 12:28
ANALYSIS # 23 ROCKY FLATS
TEMPERATURE 37 KMM OCC
GAIN 100 601187

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	1	3.0	6.4 US
UNKNOWN	2	12.1	3.5 US
UNKNOWN	3	20.5	11.6 US
UNKNOWN	4	34.4	976.2 mUS

17

STOP @ 60.0			
SAMPLE RUN		SEP 2 1987	12:28
ANALYSIS #	24	ROCKY FLATS	
TEMPERATURE	38	KMM DCC	
GAIN	100	001187	

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	1	3.0	6.6 US
UNKNOWN	2	12.0	3.2 US
H2S	3	16.8	7.253 PPM
UNKNOWN	4	25..	6.5 mUS
UNKNOWN	5	34.6	36.6 mUS

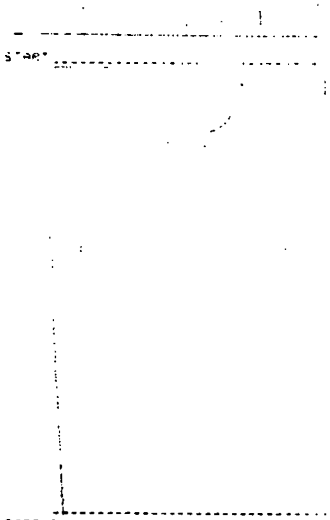
PHOTOVAC

CAL.[illegible]

SAMPLE RUN		SEP 2 1987	12:29
ANALYSIS #	24	ROCKY FLATS	
TEMPERATURE	38	KMM DCC	
GAIN	100	001187	

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	1	3.0	6.6 US
UNKNOWN	2	12.0	3.2 US
H2S	3	16.8	9.999 PPM
UNKNOWN	5	34.6	36.6 mUS

H_2S Calibration



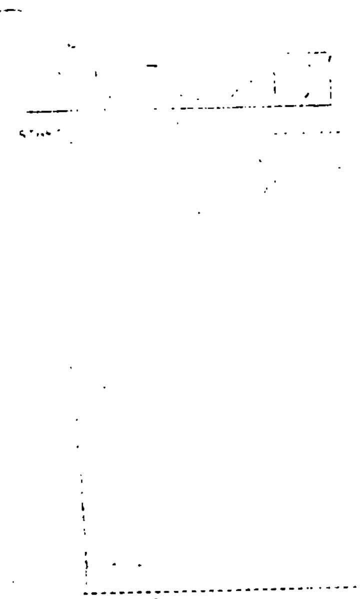
STOP @ 60.0			
SAMPLE RUN		SEP 2 1987	12:31
ANALYSIS #	25	ROCKY FLATS	
TEMPERATURE	39	KMM DCC	
GAIN	100	001187	

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	1	2.9	2.1 US
UNKNOWN	2	12.0	3.8 US
UNKNOWN	3	25.6	18.2 mUS

Air Check

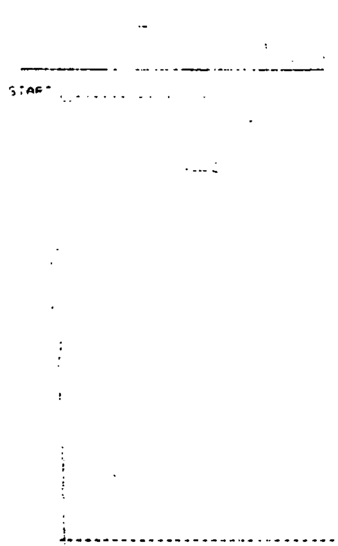
STOP @ 60.0			
SAMPLE RUN		SEP 2 1987	12:35
ANALYSIS #	26	ROCKY FLATS	
TEMPERATURE	40	KMM DCC	
GAIN	100	001187	

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	1	3.0	8.4 US
UNKNOWN	2	12.0	3.8 US
UNKNOWN	3	20.3	9.1 US
UNKNOWN	4	33.7	300.3 mUS



STOP @ 60.0
SAMPLE RUN SEP 2 1987 12:40
ANALYSIS # 28 ROCKY FLATS
TEMPERATURE 41 KMM OCC
GAIN 100 601187

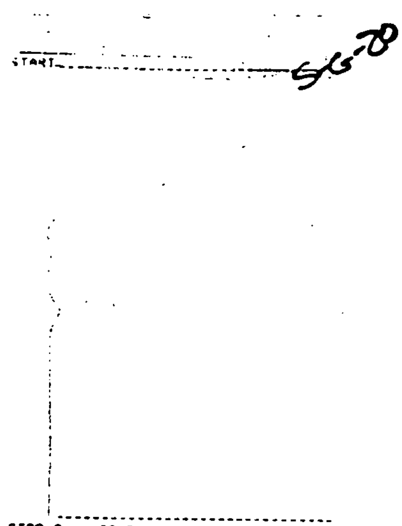
COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	1	3.6	3.4 US
HNKNOWN	[illegible]	12.6	[illegible]
H2S	[illegible]	16.6	14.70 [illegible]
UNKNOWN	[illegible]	25.6	[illegible]
UN	6	34.6	26.8 mUS



STOP @ 60.0
SAMPLE RUN SEP 2 1987 12:38
ANALYSIS # 27 ROCKY FLATS
TEMPERATURE 41 KMM OCC
GAIN 100 601187

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	1	3.0	5.3 US
UNKNOWN	2	12.0	4.2 US
UNKNOWN	3	25.6	42.7 mUS
UNKNOWN	4	34.0	25.8 mUS

19



STOP @ 60.0
SAMPLE RUN SEP 2 1987 12:46
ANALYSIS # 29 ROCKY FLATS
TEMPERATURE 41 KMM OCC
GAIN 100 601187

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	1	3.2	3.5 US
UNKNOWN	2	11.7	4.6 US
UNKNOWN	3	25.3	30.0 mUS
UNKNOWN	4	33.1	89.2 mUS

20

PHOTOVAC

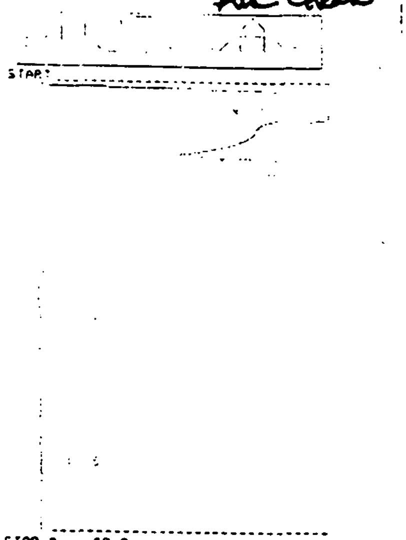
SAMPLE RUN SE[illegible] 12:43
ANALYSIS # 28 ROCKY FLATS

TEMPERATURE 41 KMM OCC
GAIN 100 601187

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	[illegible]	[illegible]	[illegible]
UNKNOWN	[illegible]	[illegible]	[illegible]
H2S	3	16.6	10.00 ppm
UNKNOWN	4	25.4	84.8 mUS
UNKNOWN	5	34.0	16.2 mUS
UNKNOWN	6	57.3	28.8 mUS

H_2S Calibration

Pump ~~Air~~ Check



STOP @ 60.0

SAMPLE RUN SEP 2 1987 12:40

ANALYSIS # 30 ROCKY FLATS

TEMPERATURE 41 KMM OCC

GAIN 1.00 091187

COMPOUND NAME	PEAK	R.T.	AREA/PPM	
UNKNOWN	1	3.1	10.0	US
UNKNOWN	2	11.9	4.3	US
UNKNOWN	3	25.5	34.7	MUS
UNKNOWN	4	33.2	6.6	MUS

Pump Check

APPENDIX 4

SITE CHARACTERIZATION PLAN
NORTH SPRAYFIELD

1.0 INTRODUCTION

The north sprayfield area located adjacent to the landfill will be studied under this closure plan, to evaluate if contamination has occurred in the area.

The sprayfield is located northwest of the east pond. The sprayfield measures approximately 280 by 480 feet. Water sprayed onto this field was pumped from the west pond. This sprayfield has not been used since the west pond was removed in May, 1981.

Soil sampling will be performed in the north sprayfield area in 1988.

Based on the method of application of waters to the sprayfield and uniformity of pond water it is assumed that the contamination, if present, will be relatively uniform in distribution adjacent to spray lines. Therefore, the sampling plan will be designed to characterize uniform contamination in the areas adjacent to previous spray lines.

2.0 INDICATOR PARAMETERS FOR SOIL SAMPLING

Because of the wide variety of materials which had the potential to be disposed of in the landfill and limited previous sampling, specific indicator parameters can not be identified at this time. The soil samples collected in the sprayfield will be analyzed for:

- Volatile Organic Compounds (EPA Method 624)
- Semi-Volatile Organic Compounds (EPA Method 625)
- Metals
- Radionuclides

APPENDIX 2

VOLUMES AND ENGINEERING CALCULATIONS

3.0 CHARACTERIZATION OF NORTH SPRAYFIELD

Characterization of the soils in the sprayfield will be conducted in a phased assessment. The first phase of characterization will consist of limited soil sampling and direct radiation surveys of each sprayfield in order to evaluate if soil contamination exists. If contamination is identified in the Phase I assessment, a second phase will be conducted in order to further define the extent of contamination.

3.1 Direct Radiation Survey

The direct gamma radiation survey will be conducted over the ground surface to detect measurable amounts of radioactivity. The assessment will be conducted in accordance with Rocky Flats radiation monitoring procedures (Rockwell, 1986c).

The gamma survey will be with a Field Instrument for Detection of Low Energy Radiation (FIDLER). Measurements will be compared to background radiation levels for evaluation of potential contamination.

3.2 Phase I Soil Sampling

3.2.1 Introduction

The Phase I survey, consisting of surface soil sampling and direct radiation survey, will be conducted of the sprayfield. The surveys are intended to evaluate if the soils in the sprayfield are contaminated.

The sampling program will consist of approximately evenly spaced sampling points adjacent to previous spray lines. This sampling program, to characterize the contamination at the facility was selected as spraying operations will have resulted in a uniform and dispersed contamination around the previous spray lines. It is assumed the results of this survey will directly indicate if contamination is or is not present.

The major soil series over much of the Rocky Flats Plant site is the Flatirons very cobbly sandy loam. This is the soil series present at the sprayfield. This soil has a high rock fragment content ranging to 80 percent with a thick clay matrix horizon ranging up to 60 percent clay. The clay is predominantly montmorillonite, with a high cation exchange capacity and a moderate shrink/swell potential. The top 13 inches is a very cobbly sandy loam with a permeability ranging from two to six inches per hour. From 13 to 47 inches, the soil is a very gravelly clay with a permeability range of 0.06 to 0.2 inches per hour. Below 47 inches, the soil is a sandy clay loam with a permeability that ranges from 0.6 to 2.0 inches per hour. This data is from Soil Conservation Service report and has been confirmed by previous site investigations the Rocky Flats Plant.

The above soil characteristics and the noncontinuous input of contaminants to the sprayfield currently indicates contaminated soil may be limited to the soils. The relatively low permeability clay layer, extending from a depth of 13 to 47 inches, is anticipated to have restricted the migration of any contaminants that may have been released from sprayfield. Therefore, preliminary sampling and analyses of soils will be limited to shallow soils up to and including the contact with the clay layer.

3.2.2 Sampling Procedures

At each sampling location, an approximate one-foot deep boring will be made with hand implements or a bucket auger, depending upon soil conditions. Samples will be comprised of the composite of materials exposed over the length of the boring. Sampling for volatile organic compounds will be grab samples at the contact with the clay layer.

All samples will be properly labeled, stored on ice, and delivered to an off-site laboratory for analyses and to permanent storage for holding extra samples. Detailed procedures for soil sampling are proved in Appendix A of the CEARP, Phase 2: Rocky Flats Plant (Appendix 5).

3.2.3 Locations and Number of Borings

Within the sprayfield the sampling pattern will be as shown on Figure 2 of the Landfill Closure Plan. The sampling pattern was selected as it provides a evenly spaced sampling grid in the vicinity of the previous spray lines.

3.2 Quality Assurance/Quality Control

The Quality Assurance/Quality Control (QA/QC) procedures to be used for soil sampling and analyses are presented in the CEARP, Phase 2: Rocky Flats Plant. The QA/QC Plan is reproduce in Appendix 5 of the Present Landfill Closure Plan.

3.3 Data Analysis

An assessment of soil contamination for the sprayfield will be based on comparing concentrations of soils with the following:

- Metals - Average trace element concentrations in soils, as presented in "Hazardous Waste Land Treatment," Table 6.46 (U.S. Environmental Protection Agency, 1983), or average background levels determined from existing background soil data whichever is more.

- Volatile and Semi-Volatile Organics - Any standards for these compounds in water, whether proposed, interim, or recommended, will be directly applied to soil and sediment. Therefore, if a standard of 0.200 ppm exists for a VOC in water, this standard will be applied to concentrations of this VOC in soil. This is a conservative standard for soils. If a standard for a VOC does not exist, then the Certified Lab Protocol (CLP) Contract Required Detection Limit (CRDL) for low soil/sediment will be used. If this CRDL is not achievable due to analytical interference, then the medium soil/sediment CRDL, which is 100 times the low soil/sediment CRDL, will be used. These limits will define the maximum allowable levels for clean soils.

- Plutonium - The U.S. EPA, in consultation with other federal agencies, has developed interim recommendations to be used for protection of public health by Pu and other transuranium elements exist. The recommendations are intended to provide long-term radiation protection for all exposed persons in a "critical segment of the population" and specify that both the individual and collective radiation doses should be "as-low-as-reasonably-achievable (ALARA)." These interim recommendations present a soil screening level of 0.2 microcuries of transuranium per square meter in the upper 1 cm of soil. This presents a combined inhalation and ingestion risk of 1×10^{-6}. At activity levels greater than this, additional evaluation is recommended to determine the actual dose rates to exposed persons (U.S. Environmental Protection Agency, 1986. Assuming a soil density of 1 gm/cm^3, this activity level translates to 20 picocuries per gram (pCi/gm) of soil. This limit will be applied to the soil and sediment sampling conducted under this characterization plan.

- Uranium - The International Committee of Radiological Protection presents an acceptable standard of 100 millirems (mrem) of effective dose equivalent per year to exposure for long-term exposure for radionuclides from man-made sources (ICRP, 1977). The National Council on Radiological Protection (NCRP) has published soil guides for uranium, radium and lead-210 based on a dose rate of 500 mrem/year. Adjusting these guides to reflect the 100 mrem/year effective dose equivalent (reducing each guide by a factor of five) results in adjust guides of 320 pCi of uranium per gram of soil, 8 pCi of radium per gram of soil, and 3 pCi of lead-210 per gram of soil (NCRP, 1984). Since all of these materials are found in soil, the sum of the fractions (the observed concentration divided by the concentration limit) must not exceed unity (one). The sum of the fractions technique is used by the Nuclear Regulatory Commission (NRC), U.S. DOE, and Colorado regulations when addressing mixtures. If any fraction is less than ten percent, the material is considered non-existent for the purposes of the sum of fractions calculation. Based on the above guides, preliminary analyses will be for uranium only. If the uranium concentration exceeds ten percent of the guide (32 pCi/gm), the radium and lead-210 concentrations in the soil sample will be determined. If the sum of the fractions is found to exceed unity, and the activity at the unit is significantly greater than the background activity for these compounds, soil removal will be used to reduce the sum of fractions to unity or less.

- Tritium - The current USEPA and Colorado standard for tritium in drinking water is 20,000 pCi/l. this will be the standard applied for tritium in soil, sediment and water.

The use of detection limits for volatile and semi-volatile organics in soil is quite conservative based on the results of the risk assessment performed as part of the feasibility study for the 881 Hillside (U.S. Department of Energy, 1988). The results of the risk assessment indicate acceptable soil concentrations far in excess of water standards or detection limits. The concentrations based on water standards or detection limits have been adopted for the purposes of ground-water protection.

The results of individual soil samples taken from the sprayfield will be compared with the applicable criteria to determine if soil contamination exists. The soil will be considered contaminated by metals or radionuclides if the individual results exceed the applicable standard by more than two standard deviations. The soil will be considered contaminated by volatile or semi-volatile organics if the individual results exceed the applicable standard, or if no standard exists, the detection limit of the parameter.

If no soil contamination is found, no further soil analyses will be performed. Where no soil contamination is found the sprayfield will be considered clean and closure certified.

3.4 Phase II Sampling

If the sampling activities at the sprayfield indicates contamination is present, further analyses will be conducted to define the extent of contamination and to determine further actions. The additional sampling will be conducted to determine both vertical and horizontal extent of contamination and/or to identify the contamination at a 90 percent confidence level based on a statistically valid analysis. The vertical extent of contamination will be determined by extending the sampling to uncontaminated materials or to the ground-water table, whichever is shallower.

If required, the Phase II sampling plan will be developed and submitted to the CDH for their approval within 30 days after determining Phase II sampling is required. If necessary, the closure plan for the landfill will be revised based on the Phase I study. In that case, the Phase II sampling plan will be part of the revised closure plan. The Phase II sampling plan will follow the general guidelines presented in Appendix I-2 of the RCRA Part B Operating Permit Application (U.S. Department of Energy, 1987a).

Phase II sampling will continue until the limits of contaminated soil have been identified.

APPENDIX 5

QUALITY ASSURANCE/QUALITY CONTROL PROCEDURES FOR SOIL CHARACTERIZATION

DEPARTMENT OF ENERGY
ALBUQUERQUE OPERATIONS OFFICE
ENVIRONMENT, SAFETY AND HEALTH DIVISION
ENVIRONMENTAL PROGRAMS BRANCH

COMPREHENSIVE ENVIRONMENTAL ASSESSMENT AND RESPONSE PROGRAM

PHASE 2:
ROCKY FLATS PLANT
INSTALLATION GENERIC MONITORING PLAN
(Comprehensive Source and Plume Characterization Plan)

QUALITY ASSURANCE/QUALITY CONTROL PLAN

February 1987

DRAFT

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TABLES

FIGURES

QUALITY ASSURANCE/QUALITY CONTROL PLAN

1. INTRODUCTION

CEARP Phase 2 consists of CEARP Phase 2a, Monitoring Plan, and CEARP Phase 2b, Site Characterization (Remedial Investigation). This Quality Assurance/Quality Control (QA/QC) Plan is one component of the Monitoring Plan for Rocky Flats Plant. The Monitoring Plan typically consists of five parts: Synopsis, Sampling Plan, Technical Data Management Plan, Health and Safety Plan, and Quality Assurance/Quality Control Plan. Because of the Compliance Agreement made by the State of Colorado, Environmental Protection Agency, and the DOE, this Monitoring Plan also includes a Feasibility Study Plan. The Synopsis provides a discussion of the current situation and serves as an introduction to the other plans.

CEARP uses a three-tiered approach in preparing the monitoring plans: the CEARP Generic Monitoring Plan (CGMP) (DOE, 1986b), the Installation Generic Monitoring Plan (IGMP), and the Site-Specific Monitoring Plans (SSMPs). The CGMP Quality Assurance/Quality Control (QA/QC) Plan provides the generic guidelines and procedures that will be employed during CEARP Phase 2 site characterization (remedial investigation) to ensure the reliability of data collected at CEARP sites. It is intended to establish a general quality assurance/quality control policy and to provide the framework for more specific quality assurance/quality control requirements to be employed at each installation and at each site. This IGMP Quality Assurance/Quality Control Plan provides installation generic information and procedures, whereas the SSMPs will provide site-specific detail regarding locations, types and number of samples.

This IGMP is the Comprehensive Source and Plume Characterization Plan required by the Compliance Agreement. Therefore, the acronym used to refer to this plan is IGMP/CSPCP.

According to DOE policy, DOE activities shall maintain programs of quality assurance (DOE Order 5700.6B). In the area of environmental protection, quality assurance plans must be integrated with the DOE implementation of CERCLA (DOE Order 5480.14).

CEARP Phase 2b site characterizations (remedial investigations) will be implemented using procedures to assure that the precision, accuracy, completeness, and representativeness of data are known and documented. At a minimum, this will include adherence to the CEARP CGMP, IGMP/CSPCP, and SSMP Quality Assurance/Quality Control Plans, and may include preparation of written Quality Assurance/Quality Control Plans covering each aspect of the project performed.

This IGMP/CSPCP Quality Assurance/Quality Control Plan presents the organization, objectives, functional activities, and specific quality assurance and quality control activities associated with the CEARP Phase 2b site characterizations (remedial investigations) at Rocky Flats Plant. The Quality Assurance/Quality Control Plan is designed to achieve specific data quality goals for CEARP Phase 2b site characterizations (remedial investigations). Appendix A includes the quality assurance protocols for all laboratory services to be provided under CEARP Phase 2b site characterizations (remedial investigations).

A brief description of the CEARP Phase 2b site characterization (remedial investigation) and background can be found in the Synopsis. For a more in-depth background description, see the CEARP Phase 1 report.

2. PROJECT ORGANIZATION AND RESPONSIBILITY

Project organization and responsibility are divided among DOE, Los Alamos National Laboratory, and Rockwell International as described below. Los Alamos National Laboratory has the primary responsibility to implement CEARP under the guidance of DOE-Albuquerque Operations Office. However, operational responsibilities have been assigned to Rockwell International at Rocky Flats Plant for the site characterizations (remedial investigations). The DOE-Rocky Flats Plant Area Office is responsible for the function of the Rocky Flats Plant. Because of this responsibility, the DOE-Rocky Flats Plant Area Office will provide additional guidance to its contractor, Rockwell International, in implementation of the CEARP Phase 2b site characterizations (remedial investigations).

Project organization is shown in Figure 2.1. The responsibilities of the various personnel can be divided into operational, laboratory, and quality assurance responsibilities, as follows.

2.1. OPERATIONAL RESPONSIBILITIES

Assistant Secretary for the Environment. The DOE Assistant Secretary for the Environment appoints Headquarters investigation boards and establishes the scope of Headquarters investigations (DOE Order 5484.1). DOE-wide Environmental Surveys and Audits originate from the Assistant Secretary.

Environmental Surveys and Audits. Headquarters Environmental Survey Teams have been directed to conduct one-time environmental surveys and sampling of DOE facilities. These surveys are independent of CEARP activities at Rocky Flats Plant, but data from survey team sampling will be utilized in the CEARP characterization of Rocky Flats Plant. A Headquarters environmental survey team visited the Rocky Flats Plant site in 1986. The results of the survey will be used as an internal management tool by the Secretary and Undersecretary of DOE.

Audits are a function of the Office of the Assistant Secretary for the Environment. Audit teams provide quality control for the implementation of environmental monitoring at DOE facilities. Although independent of CEARP, audit teams complement CEARP activities by providing additional quality assurance.

DOE-Albuquerque Operations Office Environmental Programs Branch. The DOE-Albuquerque Operations Office, Environmental Programs Branch, is responsible for overseeing all environmental programs within DOE-Albuquerque Operations and conducting special assessments such as CEARP.

DOE-Rocky Flats Area Office. The DOE Rocky Flats Area Office is responsible for the missions of the Rocky Flats Plant, including environmental protection. The DOE Rocky Flats Area Office oversees the integration of Rocky Flats Plant resources with CEARP activities at Rocky Flats Plant.

Rockwell International. Rockwell International, as prime contractor to DOE, provides support to DOE in accomplishing the mission of Rocky Flats Plant, including environmental protection. Rockwell International will perform the CEARP Phase 2b site characterizations (remedial investigations) at Rocky Flats Plant.

Los Alamos National Laboratory. Los Alamos National Laboratory manages the CEARP program, providing direction, oversight and review, and preparing final reports.

2.2. ANALYTICAL LABORATORY RESPONSIBILITIES

Analytical laboratory responsibilities include performing analytical services, and providing quality assurance. Rockwell International will perform the CEARP Phase 2b site characterizations (remedial investigations) at Rocky Flats Plant. This IGMP/CSPCP provides guidance for quality assurance programs to be implemented by

- field laboratory operations
- analytical laboratories
- geotechnical laboratories
- radiological laboratories.

2.3. QA RESPONSIBILITY

Quality assurance responsibilities are to monitor and review the procedures used to perform all aspects of site characterizations (remedial investigations), including data collection, analytical services, data analysis, and report preparations. Primary responsibility for project quality rests with the Rockwell International CEARP Manager. Ultimate responsibility for project quality rests with DOE.

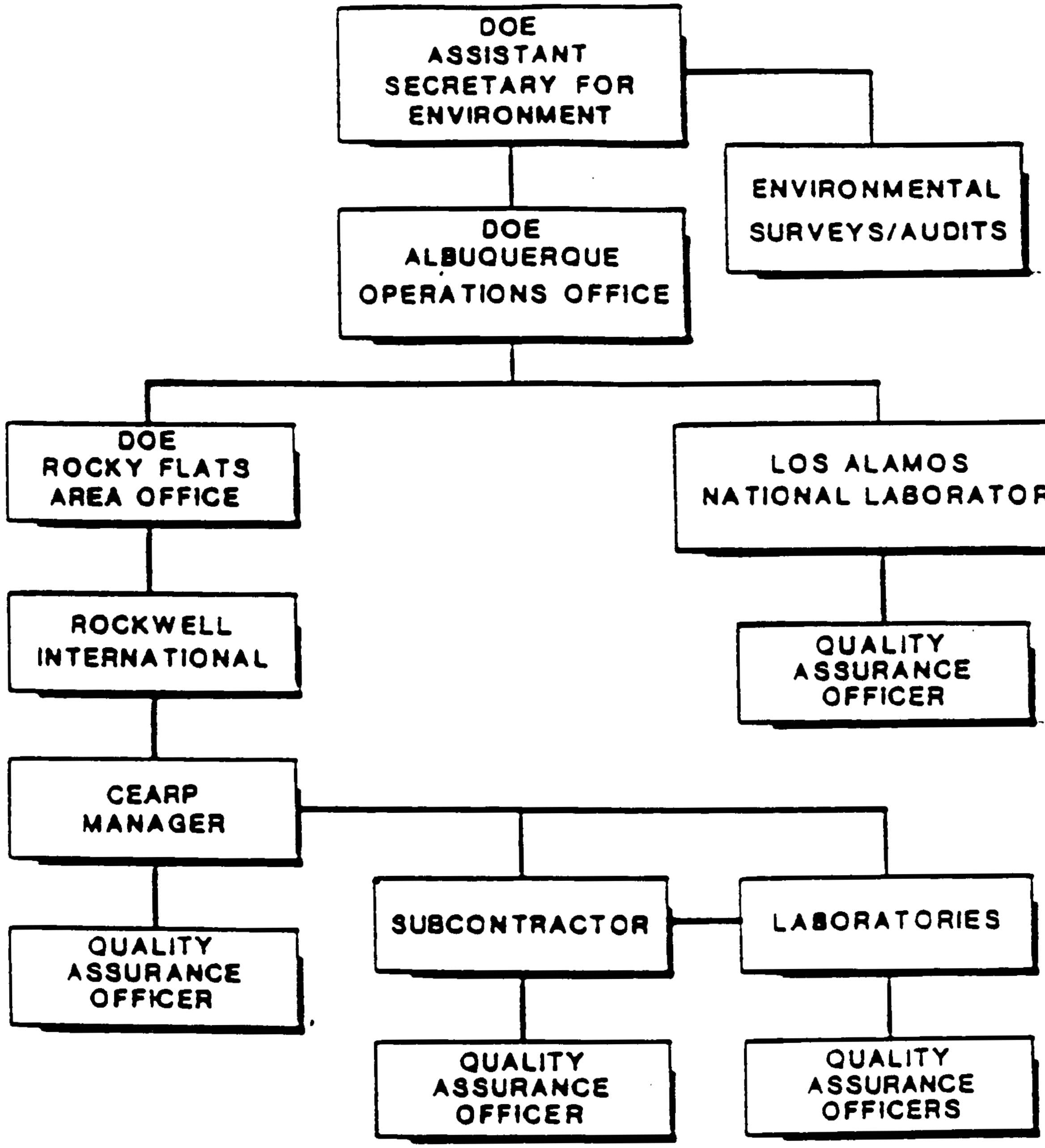


Figure 2.1. Quality Assurance/Quality Control Organization Chart.

Because volatile organic compounds are a class of contaminants most likely to be introduced to the sample by the sample container, there will be one trip blank per batch of samples designated for volatile organic compound analysis (shipping container). There will be one duplicate and one field blank for every 10 investigative samples collected. For laboratory organic analysis, matrix spikes and matrix spike duplicates will be used. The general level of quality assurance effort for organic analysis will be one matrix spike and one matrix spike duplicate prepared for every 20 samples of similar concentration and/or similar sample matrix, whichever is greater. In addition to field check samples, water samples of known concentration traceable to either EPA or NBS standards will be prepared for inorganic and radiological analyses. The general level of quality assurance effort for inorganic analyses will be one duplicate known sample and one duplicate field sample for every 10 investigative samples to check analytical reproducibility.

Soil samples selected for geotechnical testing will include one field duplicate for each 20 analyses being performed, if possible, but will not include blanks.

The groundwater, surface water, and soil samples collected at Rocky Flats Plant during CEARP Phase 2 will be analyzed using the analytical methods specified in Tables 3.1, 3.2, 3.3, and 3.4. The level of laboratory quality assurance effort will correspond to the procedures outlined in Appendix A.

3.3. ACCURACY, PRECISION, AND SENSITIVITY OF ANALYSES

The fundamental quality assurance objective with respect to accuracy, precision, and sensitivity of laboratory analytical data is to achieve the quality control acceptance criteria of the analytical protocols. Sensitivities required for analyses of radionuclides, organics, metals, and other inorganic compounds, in both aqueous and solid matrices will be the detection limits shown in Tables 3.1, 3.2, 3.3, 3.4, 3.5, and 3.6. Achieving these detection limits depends on the sample matrix. Highly contaminated samples requiring dilution will have detection limits higher than those detected.

The accuracy of field laboratory measurements of groundwater and surface water pH will be assessed through pre-measurement calibrations and post-measurement verifications using at least two standard buffer solutions. The two measurements must each be within +0.05 standard units of buffer solution values. Precision will be

3. QUALITY ASSURANCE OBJECTIVES FOR MEASUREMENT DATA

The overall quality assurance objective is to develop and implement procedures for field sampling, field testing, chain of custody, laboratory analysis, and reporting that will assure quality as specified in DOE orders governing quality assurance and environmental protection. Specific procedures to be used for sampling, chain-of-custody, audits, preventive maintenance, and corrective actions are described in other sections of this IGMP Quality Assurance/Quality Control Plan. The purpose of this section is to define quality assurance goals for accuracy; precision and sensitivity of analysis; and completeness, representativeness, and comparability of measurement data from all analytical laboratories. Quality assurance objectives for field measurements are also discussed.

For some field activities, samples will not be collected, but measurements will be taken where quality assurance concerns are appropriate (e.g., field measurements of pH, temperature, and elevations). The primary quality assurance objective in activities where samples are not collected is to obtain reproducible measurements to a degree of accuracy consistent with their intended use and to document measurement procedures.

3.1. REGULATORY AND LEGAL REQUIREMENTS

Data used to evaluate compliance with the National Interim Primary Drinking Water Standards, State of Colorado water-quality standards, or water-quality criteria for agricultural or industrial use will have method detection limits as specified by the analytical method used, as appropriate.

3.2. LEVEL OF QUALITY ASSURANCE EFFORT

Field duplicates, field blanks, and trip blanks will be taken and submitted to the analytical laboratories to provide a means to assess data quality resulting from field sampling. Duplicate samples will be analyzed to check for sampling reproducibility. Field and trip blanks will be analyzed to check for procedural contamination and/or ambient site conditions that are causing sample contamination. Trip blanks will be analyzed to check for contamination during packaging and shipment.

assessed through replicate measurements of every tenth sample. The standard deviation of four replicate measurements must be less than or equal to 0.1 standard units. (The electrode will be withdrawn, deionized-rinsed and re-immersed between each replicate. The calibration and verification will be done before the first replicate and after the last replicate.) The instrument used will be capable of providing measurements to 0.01 standard units.

The geotechnical and field data will be considered accurate if the quality assurance criteria with respect to equipment, solutions, and calculations are met, and if adherence to appropriate methods can be documented during a systems audit.

3.4. COMPLETENESS, REPRESENTATIVENESS AND COMPARABILITY

The laboratories will provide data meeting quality control acceptance criteria as described in Appendix A. Laboratories will provide completely valid data (IGMP/CSPCP QA/QC Plan, Section 8); the reasons for any variances from 100 percent completeness will be documented in writing.

3.5. FIELD MEASUREMENTS

Measurement data will be generated in many field activities. These activities may include, but are not limited to, the following:

- using geophysical surveys
- documenting time and weather conditions
- locating and determining the elevation of sampling stations
- measuring pH, conductivity, and temperature of water samples
- qualitative organic vapor screening of solid samples using a photoionization detector (PID) or an organic vapor analyzer (OVA)
- measuring water levels in a borehole or well
- standard penetration testing
- calculating pumping rates
- verifying well-development and presampling purge volumes
- performing hydraulic conductivity tests

The general quality assurance objective for such measurement data is to obtain reproducible and comparable measurements to a degree of accuracy consistent with the intended use of the data through the documented use of standardized procedures. Procedures for performing these activities and standardized formats for documenting them are presented in the CGMP and IGMP/CSPCP Sampling Plans. These procedures may be incorporated by reference (EPA methods) or included as appendices. Standardized formats for documenting data collection are included in the Technical Data Management Plan.

Table 3.1. Analysis Plan for Aqueous Samples*

Analyte	Method	Detection Limit	Sample Container	Sample Volume	Preservations	Holding Time (days)	Reporting Units
HSL Volatile	Ref. 1	x[3]	40 ml vial (2) w/teflon lined silicone rubber septum	40 ml	Cold, $4^{\circ}C$[9]	14	ug/L
HSL Base/Neutral/Acid[1]	Ref. 2	x[3]	Amber G, 1L	1 L	Cold, $4^{\circ}C$[9]	7/40[7]	ug/L
HSL Pesticide/PCB	Ref. 3	x[3]	Amber G, 1L	1 L	Cold, $4^{\circ}C$[9]	7/40	ug/L
HSL Inorganic[2]	EPA 200.7[8]	x[3]	P, G, 1L	1 L	pH<2, w/HNO_3[9]	180	ug/L
Cyanide	EPA 335[8]	x[3]	P, G, 1L	0.5 L	pH>11, w/NaOH[9]	14	ug/L
pH[4]	EPA 150.1[8]	0.1 pH unit	P, G	N/A	None	Field Meas.	pH unit
Sp. Conductivity[4]	EPA 120.1[8]	1	P, G	N/A	None	Field Meas.	umho/cm
Temperature[4]	EPA 170.1[8]	0.1	P, G	N/A	None	Field Meas.	$^{\circ}C$
Diss. Oxygen[4]	EPA 360.1[8]	0.5	G	N/A	None	Field Meas.	mg/l
TDS	EPA 160[8]	5	P, G 1L	0.1 L	Cold $4^{\circ}C$[9]	7	mg/l
TSS	EPA 160[8]	10	P, G 1L	0.1 L	Cold $4^{\circ}C$[9]	7	mg/l
Total Phosphate	EPA 365.4[8]	0.01	P, G 1L	1 L	Cold $4^{\circ}C$, pH<2[9] w/H_2SO_4	28	mg/l

Table 3.1. (Continued)

Analyte	Method	Detection Limit	Sample Container	Sample Volume	Preservations	Holding Time (days)	Reporting Units
Chloride, Sulfate	EPA 352.2[8] 375.2[8]	5	P, G, 1L	1 L	Cold 4°C[9]	28	mg/l
Carbonate/Biocarbonate[5]	S.M. 403[6]	10	P, G, 1L	1 L	Cold 4°C[9]	14	mg/l
Nitrate	EPA 300.0[8]	5	P, G, 1L	1 L	Cold 4°C[9]	2	mg/l
Hexavalent Chromium	S.M. 312B[6]	0.01	P, G, 1L	1 L	Cold 4°C[9]	1	mg/l

[1]The HSL Base/Neutral/Acid fractions analytical parameters are the HSL semivolatiles.
[2]Includes Cesium, Molybdenum, Strontium which are non-HSL metals.
[3]See Tables 3.5 and 3.6.
[4]Field Measurements.
[5]These are reported as carbonate and biocarbonate alkalinity.
[6]Standard Methods for Examination of Water and Wastewater, 15th Edition.
[7]7 days to extraction, analysis within 40 days of extraction.
[8]Methods for Chemical Analysis of Water and Wastes, 1983; EPA 600/4-79-020.
[9]All samples with the exception of VOA's will be filtered within 4 hours of sample collection, and preservatives added to the filtrate as specified. All samples will be kept at 4°C until delivered to the laboratory.
*The SSMP Sampling Plans will define the actual suite of parameters to be analyzed for specific samples.

Method References

Ref. 1. Method 624 - "Methods for Organic Chemical Analysis of Municipal and Industrial Waste Water," EPA 600/4-82-057 plus additions, 1984.

Ref. 2. Method 625 - "Methods for Organic Chemical Analysis of Municipal and Industrial Waste Water," EPA 600/4-82-057 plus additions, 1984.

Ref. 3. Method 608 - "Methods for Organic Chemical Analysis of Municipal and Industrial Waste Water," EPA 600/4-82-057 plus additions, 1984.

Table 3.2. Analysis Plan for Soil/Sediment/Waste Samples*

Analyte	Method	Detection Limit	Sample Container	Sample Volume	Preservations	Holding Time (days)	Reporting Units
HSL Volatile	Ref. 2	X[2]	40-ml vial (2) w/teflon lined silicon rubber septa	5	Cold, 4°C	14	ug/kg
HSL Base/Neutral/Acid	Ref. 3	X[2]	Amber G, 1 L	10-30	Cold, 4°C	7/40[3]	ug/kg
HSL Pesticide/PCB	Ref. 4	X[2]	Amber G, 1 L	10-30	Cold, 4°C	7/40[3]	ug/kg
HSL Inorganic[1]	Ref. 5	X[2]	P G, 1 L	200	Cold, 4°C	180	mg/kg
Reactivity	Ref. 6	Ref. 8	Amber G	---	Cold 4°C	N/A	ug/l
EP Toxicity	Ref. 7	Ref. 9	Amber G	100 g	Cold 4°C	N/A	ug/l in leachate
Chloride	EPA 300.0[5]	60 ug/g[6]	G, 1 L	20	Cold, 4°C	N/A	mg/kg
Sulfate	EPA 300.0[5]	60 ug/g[6]	G, 1 L	20	Cold, 4°C	N/A	mg/kg
Nitrate	EPA 300.0[5]	60 ug/g[6]	G, 1 L	20	Cold, 4°C	N/A	mg/kg
Cyanide	Ref. 1	X[2]	G, 1 L	200	Cold, 4°C	14	mg/kg
Hexavalent Chromium	S. M. 312B[7]	1 ug/g[6]	G, 1 L	100	Cold 4°C	1	mg/kg

[1] Includes Cesium, Molybdenum, and Strontium which are non-HSL metals.
[2] See Tables 3.5 and 3.6.
[3] Extract within 7 days, analysis within 40 days of extraction.
[4] Reported as dry weight, % moisture reported separately.
[5] Soil/Sediments will be leached with Laboratory Reagent Water (20 g soil to 50 ml water) and water extract analyzed using referenced procedure. Procedure referen
Methods for Chemical Analysis of Water and Wastes, 1983; EPA 600/4-79-020.

Table 3.2. (Continued)

[6]These are estimated detection limits.
[7]Soil/sediment will be leached with Laboratory Reagent Water (5 g soil and 100 ml of water) by shaking for 2 hours, and the water extract filtered and subsequen analyzed. This is in accordance with method 312B in Standard Methods for Examination of Water and Wastewater, 15th Edition.
*The SSMP Sampling Plans will define the actual suite of parameters to be analyzed for specific samples.

Method References

Ref. 1. Method 9010 - "Test Methods for Evaluating Solid Wastes," Office of Solid Waste and Emergency Response, Washington, DC 20460, Revised April 1984.

Ref. 2. Method 8240 - "Test Methods for Evaluating Solid Wastes," Office of Solid Waste and Emergency Response, Washington, DC 20460, Revised April 1984.

Ref. 3. Method 8270 - "Test Methods for Evaluating Solid Wastes," Office of Solid Waste and Emergency Response, Washington, DC 20460, Revised April 1984.

Ref. 4. Method 8080 - "Test Methods for Evaluating Solid Wastes," Office of Solid Waste and Emergency Response, Washington, DC 20460, Revised April 1984.

Ref. 5. Method 6010 or 7000 Series Methods - "Test Methods for Evaluating Solid Wastes," Office of Solid Waste and Emergency Response, Washington, DC 20460, Re April 1984.

Ref. 6. Method 9010, 9030 - "Test Methods for Evaluating Solid Wastes," Office of Solid Waste and Emergency Response, Washington, DC 20460, Revised April 1984.

Ref. 7. Method 1310 - "Test Methods for Evaluating Solid Wastes," Office of Solid Waste and Emergency Response, Washington, DC 20460, Revised April 1984.

Table 3.3. Analysis Plan for Radiological Analysis for Aqueous Samples

Analyte	Method*	Detection Limit**	Sample Container	Sample Volume	Preservations	Holding Time (days)	Reporting Units
Gross alpha/beta	1,2,3,4,6,7,8,9	Gross a = 2pCi/L	P, 1 gal	0.2 L	HNO_3 to pH <2	180	pCi/L
Tritium	1,2,3,8	400 pCi/L	G, 100 ml	0.008 L	No preservation	NA	pCi/L
Pu-239	10,11	0.3 pCi/L	P, 1 gal	1.000 L	HNO_3 to pH <2	180	pCi/L
Am-241	11,12	0.4 pCi/L	P, 1 gal	1.000 L	HNO_3 to pH <2	180	pCi/L
Isotopic U	1,3,4,7,8,9	U-233 + 234 = 0.6 pCi/L U-238 = 0.6 pCi/L	P, 1 gal	0.500 L	HNO_3 to pH <2	180	pCi/L
Sr-90	1,3,4,8	1 pCi/L	P, 1 gal	1.000 L	HNO_3 to pH <2	180	pCi/L

*See Attachment 1
**See Attachment 2

ATTACHMENT 1

Method References

1. U.S. Environmental Protection Agency, 1979. Radiochemical Analytical Procedures for Analysis of Environmental Samples, Report No. EMSL-LY-0539-1, Las Vegas, NV, U.S. Environmental Protection Agency.

2. American Public Health Association, American Water Works Association, Water Pollution Control Federation, 1985. Standard Methods for the Examination of Water and Wastewater, 16th ed., Washington, D.C., Am. Public Health Association.

3. U.S. Environmental Protection Agency, 1976. Interim Radiochemical Methodology for Drinking Water, Report No. EPA-600/4-75-008. Cincinnati U.S. Environmental Protection Agency.

4. Harley, J. H., ed., 1975, HASL Procedures Manual, HASL-300; Washington, D.C., U.S. Energy Research and Development Administration.

5. Misaqi, Fazlelleh L., Monitoring Radon-222 Content of Mine Waters Informational Report 1026, U.S. Department of Interior, Mining Enforcement and Safety Administration, Denver, CO, 1975.

6. "Radioassay Procedures for Environmental Samples," 1967, USDHEW, Section 7.2.3.

7. "Handbook of Analytical Procedures," USAEC, Grand Junction Lab. 1970, page 196.

8. "Prescribed Procedures for Measurement of Radioactivity in Drinking Water," EPA-600/4-80-032, Auguat 1980, Environmental Monitoring and Support Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Cincinnati, Ohio 45268.

9. "Methods for Determination of Radioactive Substances in Water and Fluvial Sediments," U.S.G.S. Book 5, Chapter A5, 1977.

10. "Acid Dissolution Method for the Analysis of Plutonium in Soil," EPA-600/7-79-081, March 1979, U.S. EPA Environmental Monitoring and Support Laboratory, Las Vegas, Nevada, 1979.

11. "Procedures for the Isolation of Alpha Spectrometrically Pure Plutonium, Uranium and Americium," by E. H. Essington and B. J. Drennon, Los Alamos National Laboratory, a private communication.

12. "Isolation of Americium from Urine Samples," Rocky Flats Plant, Health, Safety, and Environmental Laboratories.

ATTACHMENT 2

Lower Limits of Detection

The detection limits presented were calculated using the formula in N.R.C. Regulatory Guide 4.14, Appendix Lower Limit of Detection, pg. 21, and follow:

$$LLD = \frac{4.66 \left(\frac{BKG}{DUR}\right)^{1/2}}{(2.22)\,(Eff)\,(CR)\,(SR)\,(e^{-xt})\,(Aliq)},$$

Where

LLD	=	Lower Limit of Detection in pCi per sample unit
BKG	=	Instrument Background in counts per minute (cpm)
DUR	=	Duration of sample counting in minutes
Eff	=	Counting efficiency in cpm/disintegration per minute (dpm)
CR	=	Fractional radiochemical yield
SR	=	Fractional radiochemical yield of a known solution
x	=	The radioactive decay constant for the particular radionuclide
t	=	the elapsed time between sample collection and counting.

In that LLD is a function of many variables including sample matrix, sample volume, and other factors, the limits presented are only intended as guides to order-of-magnitude sensitivities and, in practice, can easily change by a factor of two or more even for the conditions specified.

Table 3.4. Analysis Plan for Radiological Analysis for Soils/Sediments

Analyte	Method*	Detection Limit**	Sample Container	Sample Size (g)	Preservations	Holding Time (days)	Reporting Units
Gross alpha/beta	1,2,3,4,6,7,8,9	Gross a = 4 pCi/g Gross b = 10 pCi/g	G, 1 L	0.1	NA	NA	pCi/g
Pu-239	10,11	0.3 pCi/g	G, 1 L	1	NA	NA	pCi/g
Am-241	11,12	0.3 pCi/g	G, 1 L	1	NA	NA	pCi/g
Isotopic U	1,3,4,7,8,9	U-233 + 234 = 0.3 pCi/g U-238 = 0.3 pCi/g	G, 1 L	1	NA	NA	pCi/g
Sr-90	1,3,4,8	1 pCi/g	G, 1 L	1	NA	NA	Pci/g

*See Attachment 1
**See Attachment 2

ATTACHMENT 1

Method References

1. U.S. Environmental Protection Agency, 1979, Radiochemical Analytical Procedures for Analysis of Environmental Samples. Report No. EMSL-LY-0539-1, Las Vegas, NV, U.S. Environmental Protection Agency.

2. American Public Health Association, American Water Works Association, Water Pollution Control Federation, 1985. Standard Methods for the Examination of Water and Wastewater, 16th ed., Washington, D.C., Am. Public Health Association.

3. U.S. Environmental Protection Agency, 1976. Interim Radiochemical Methodology for Drinking Water, Report No. EPA-600/4-75-008. Cincinnati U.S. Environmental Protection Agency.

4. Harley, J. H., ed., 1975, HASL Procedures Manual, HASL-300; Washington, D.C., U.S. Energy Research and Development Administration.

5. Misaqi, Fazlelleh L., Monitoring Radon-222 Content of Mine Waters Informational Report 1026, U.S. Department of Interior, Mining Enforcement and Safety Administration, Denver, CO, 1975.

6. "Radioassay Procedures for Environmental Samples," 1967, USDHEW, Section 7.2.3.

7. "Handbook of Analytical Procedures," USAEC, Grand Junction Lab. 1970, page 196.

8. "Prescribed Procedures for Measurement of Radioactivity in Drinking Water," EPA-600/4-80-032, Auguat 1980, Environmental Monitoring and Support Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Cincinnati, Ohio 45268.

9. "Methods for Determination of Radioactive Substances in Water and Fluvial Sediments," U.S.G.S. Book 5, Chapter A5, 1977.

10. "Acid Dissolution Method for the Analysis of Plutonium in Soil," EPA-600/7-79-081, March 1979, U.S. EPA Environmental Monitoring and Support Laboratory, Las Vegas, Nevada, 1979.

11. "Procedures for the Isolation of Alpha Spectrometrically Pure Plutonium, Uranium and Americium," by E. H. Essington and B. J. Drennon, Los Alamos National Laboratory, a private communication.

12. "Isolation of Americium from Urine Samples," Rocky Flats Plant, Health, Safety, and Environmental Laboratories.

ATTACHMENT 2

Lower Limits of Detection

The detection limits presented were calculated using the formula in N.R.C. Regulatory Guide 4.14, Appendix Lower Limit of Detection, pg. 21, and follow:

$$LLD = \frac{4.66 \left(\frac{BKG}{DUR}\right)^{1/2}}{(2.22)\ (Eff)\ (CR)\ (SR)\ (e\text{-}xt)\ (Aliq),}$$

Where

LLD	=	Lower Limit of Detection in pCi per sample unit
BKG	=	Instrument Background in counts per minute (cpm)
DUR	=	Duration of sample counting in minutes
Eff	=	Counting efficiency in cpm/disintegration per minute (dpm)
CR	=	Fractional radiochemical yield
SR	=	Fractional radiochemical yield of a known solution
x	=	The radioactive decay constant for the particular radionuclide
t	=	the elapsed time between sample collection and counting.

In that LLD is a function of many variables including sample matrix, sample volume, and other factors, the limits presented are only intended as guides to order-of-magnitude sensitivities and, in practice, can easily change by a factor of two or more even for the conditions specified.

Table 3.5. Hazardous Substance List (HSL) and Contract Required Detection Limits (CRDL)**

Volatiles	CAS Number	Detection Limits* Low Water[a] ug/L	Low Soil/Sediment[b] ug/Kg
1. Chloromethane	74-87-3	10	10
2. Bromomethane	74-83-9	10	10
3. Vinyl Chloride	75-01-4	10	10
4. Chloroethane	75-00-3	10	10
5. Methylene Chloride	75-09-2	6	5
6. Acetone	67-64-1	10	10
7. Carbon Disulfide	75-15-01	5	5
8. 1,1-Dichloroethene	75-35-4	5	5
9. 1,1-Dichloroethane	75-35-3	5	5
10. trans-1,2-Dichloroethene	156-60-5	5	5
11. Chloroform	67-66-3	5	5
12. 1,2-Dichloroethane	107-06-2	5	5
13. 2-Butanone	78-93-3	10	10
14. 1,1,1-Trichloroethane	71-55-6	5	5
15. Carbon Tetrachloride	56-23-5	5	5
16. Vinyl Acetate	108-05-4	10	10
17. Bromodichloromethane	75-27-4	5	5
18. 1,1,2,2-Tetrachloroethane	79-34-5	5	5
19. 1,2-Dichloropropane	78-87-5	5	5
20. trans-1,3-Dichloropropene	100061-02-6	5	5
21. Trichloroethene	79-01-6	5	5
22. Dibromochloromethane	124-48-1	5	5
23. 1,1,2-Trichloroethane	79-00-5	5	5
24. Benzene	71-43-2	5	5
25. cis-1,3-Dichloropropene	10061-01-5	5	5
26. 2-Chloroethyl Vinyl Ether	110-75-8	10	10
27. Bromoform	75-25-2	5	5
28. 2-Hexanone	591-78-6	10	10
29. 4-Methyl-2-pentanone	108-10-1	10	10
30. Tetrachloroethene	127-18-4	5	5
31. Toluene	108-88-3	5	5
32. Chlorobenzene	108-90-7	5	5
33. Ethyl Benzene	100-41-4	5	5
34. Styrene	100-42-5	5	5
35. Total Xylenes	100-42-5	5	5

Table 3.5. (Continued)

Semi-Volatiles	CAS Number	Detection Limits[a] Low Water[c] ug/L	Low Soil/Sediment[d] ug/Kg
36. N-Nitrosodimethylamine	62-75-9	10	330
37. Phenol	108-95-2	10	330
38. Aniline	62-53-3	10	330
39. bis(2-Chloroethyl) ether	111-44-4	10	330
40. 2-Chlorophenol	95-57-8	10	330
41. 1,3-Dichlorobenzene	541-73-1	10	330
42. 1,4-Dichlorobenzene	106-46-7	10	330
43. Benzyl Alcohol	100-51-6	10	330
44. 1,2-Dichlorobenzene	95-50-1	10	330
45. 2-Methylphenol	95-48-7	10	330
46. bis(2-Chloroisopropyl ether	39638-32-9	10	330
47. 4-Methylphenol	106-44-5	10	330
48. N-Nitroso-Dipropylamine	621-64-7	10	330
49. Hexachloroethane	67-72-1	10	330
50. Nitrobenzene	98-95-3	10	330
51. Isophorone	78-59-1	10	330
52. 2-Nitrophenol	88-75-5	10	330
53. 2,4-Dimethylphenol	105-67-9	10	330
54. Benzoic Acid	65-85-0	50	1600
55. bis(2-Chloroethoxy) methane	111-91-1	10	330
56. 2,4-Dichlorophenol	120-83-2	10	330
57. 1,2,4-Trichlorobenzene	120-82-1	10	330
58. Naphthalene	91-20-1	10	330
59. 4-Chloroaniline	106-47-8	10	330
60. Hexachlorobutadiene	87-68-3	10	330
61. 4-Chloro-3-methylphenol (para-chloro-meta-cresol)	59-50-7	10	330
62. 2-Methylnaphthalene	91-57-6	10	330
63. Hexachlorocyclopentadiene	77-47-4	10	330
64. 2,4,6-Trichlorophenol	88-06-2	10	330
65. 2,4,5-Trichlorophenol	95-95-4	50	1600
66. 2-Chloronaphthalene	91-58-7	10	330
67. 2-Nitroaniline	88-74-4	50	1600
68. Dimethyl Phthalate	131-11-3	10	330
69. Acenaphthylene	208-96-8	10	330
70. 3-Nitroaniline	99-09-2	50	1600

Table 3.5. (Continued)

Semi-Volatiles	CAS Number	Detection Limits[a] Low Water[c] ug/L	Low Soil/Sediment[d] ug/Kg
71. Acenaphthene	83-32-9	10	330
72. 2,4-Dinitrophenol	51-28-5	50	1600
73. 4-Nitrophenol	100-02-7	50	1600
74. Dibenzofuran	132-64-9	10	330
75. 2,4-Dinitrotoluene	121-14-2	10	330
76. 2,6-Dinitrotuluene	606-20-2	10	330
77. Diethylphthalate	84-66-2	10	330
78. 4-Chlorophenyl Phenyl ether	7005-72-3	10	330
79. Fluorene	86-73-7	10	330
80. 4-Nitroaniline	100-01-6	50	1600
81. 4,6-Dinitro-2-methyl-phenol	534-52-1	50	1600
82. N-nitrosodiphenylamine	86-30-6	10	330
83. 4-Bromophenyl Phenyl ether	101-55-3	10	330
84. Hexachlorobenzene	118-74-1	10	330
85. Pentachloropphenol	87-86-5	50	1600
86. Phenanthrene	85-01-8	10	330
87. Anthracene	120-12-7	10	330
88. Di-n-butylphthalate	84-74-2	10	330
89. Fluoranthene	206-44-0	10	330
90. Benzidine	92-87-5	50	1600
91. Pyrene	129-00-0	10	330
92. Butyl Benzyl Phthalate	85-68-7	10	330
93. 3,3'-Dichlorobenzidine	91-94-1	20	660
94. Benzo(a)anthracene	56-55-3	10	330
95. bis(2-ethylhexyl) phthalate	117-81-7	10	330
96. Chrysene	218-01-9	10	330
97. Di-n-octyl Phthalate	117-84-0	10	330
98. Benzo(b)fluoranthene	205-99-2	10	330
99. Benzo(k)fluoranthene	207-08-9	10	330
100. Benzo(a)pyrene	50-32-8	10	330
101. Indeno(1,2,3-cd)pyrene	193-39-5	10	330
102. Dibenz(a,h)anthracene	53-70-3	10	330
103. Benzo(g,h,i)perylene	191-24-2	10	330

Table 3.5. (Continued)

Pesticides	CAS Number	Detection Limits[a] Low Water[c] ug/L	Low Soil/Sediment[f] ug/Kg
104. alpha-BHC	319-84-6	0.05	8.0
105. beta-BHC	319-85-7	0.05	8.0
106. delta-BHC	319-86-8	0.05	8.0
107. gamma-BHC (Lindane)	58-89-9	0.05	8.0
108. Heptachlor	76-44-8	0.05	8.0
109. Aldrin	309-00-2	0.05	8.0
110. Heptachlor Epoxide	1024-57-3	0.05	8.0
111. Endosulfan I	959-98-8	0.05	8.0
112. Dieldrin	60-57-1	0.10	16.0
113. 4,4'-DOE	72-55-9	0.10	16.0
114. Endrin	72-20-8	0.10	16.0
115. Endosulfan II	33213-65-9	0.10	16.0
116. 4,4'-DDD	72-54-8	0.10	16.0
117. Endrin Aldehyde	7421-93-4	0.10	16.0
118. Endosulfan Sulfate	1031-07-8	0.10	16.0
119. 4,4-'DDT	50-29-3	0.10	16.0
120. Endrin Ketone	53494-70-5	0.10	16.0
121. Methoxychlor	72-43-5	0.5	80.0
122. Chlordane	57-74-9	0.5	80.0
123. Toxaphene	8001-35-2	1.0	160.0
124. AROCLOR-1016	12674-11-2	0.5	80.0
125. AROCLOR-1221	11104-28-2	0.5	80.0
126. AROCLOR-1232	11141-16-5	0.5	80.0
127. AROCLOR-1242	53469-21-9	0.5	80.0
128. AROCLOR-1248	12672-29-6	0.5	80.0
129. AROCLOR-1254	11097-69-1	1.0	160.0
130. AROCLOR-1260	11096-82-5	1.0	160.0

[a] Medium Water Contract Required Detection Limits (CRDL) for Volatile HSL Compounds are 100 times the individual Low Water CRDL.

[b] Medium Soil/Sediment Contract Required Detection Limits (CRDL) for Volatile HSL Compounds are 100 times the individual Low Soil/Sediment CRDL.

[c] Medium Water Contract Required Detection Limits (CRDL) for Semi-Volatile HSL Compounds are 100 times the individual Low Water CRDL.

[d] Medium Soil/Sediment Contract Required Detection Limits (CRDL) for Semi-Volatile HSL Compounds are 60 times the individual Low Soil/Sediment CRDL.

Table 3.5. (Continued)

[e]Medium Water Contract Required Detection Limits (CRDL) for Pesticide HSL Compounds are 100 times the individual Low Water CRDL.
[f]Medium Soil/Sediment Contract Required Detection Limits (CRDL) for Pesticide HSL compounds are 60 times the individual Low Soil/Sediment CRDL.

*Detection limits listed for soil/sediment are based on wet weight. The detection limits calculated by the laboratory for soil/sediment, calculated on dry weight basis, as required by the contract, will be higher.

**These are the EPA detection limits under the Contract Laboratory Program. Specific detection limits are highly matrix dependent. The detection limits listed herein are provided for guidance and may not always be achievable.

Table 3.6. Elements Determined by Inductively Coupled Plasma Emission or Atomic Absorption Spectroscopy

Element	Contract Required Detection Level[1,2] (ug/L)
Aluminum	200
Antimony	60
Arsenic	10
Barium	200
Beryllium	5
Cadmium	5
Calcium	5000
Chromium	10
Cobalt	50
Copper	25
Iron	100
Lead	5
Magnesium	5000
Manganese	15
Mercury	0.2
Nickel	40
Potassium	5000
Selenium	5
Silver	10
Sodium	5000
Thallium	10
Vanadium	50
Zinc	20
Cesium	200
Molybdenum	40
Strontium	200
Cyanide	10

Note: Detection limits in soil/sediment are numerically equivalent to those listed above with concentration units of mg/kg.

[1] Higher detection levels may also be used in the following circumstances.

If the sample concentration exceeds two times the detection limit of the instrument or method in use, the value may be reported even though the instrument or method detection limit may not equal the contract required detection limit. This is illustrated in the example below:

Table 3.6. (Continued)

For lead:

Method in use - ICP
Instrument Detection Limit (IDL) = 40
Sample Concentration = 85
Contract Required Detection Limit (CRDL) = 5

The value of 85 may be reported even though instrument detection limit is greater than required detection level. The instrument or method detection limit must be documented.

[2]These CRDL are the instrument detection limits obtained in pure water. met using the procedure in Exhibit E. The detection limits for samples may be considerably higher depending on the sample matrix.

4. SAMPLING PROCEDURES

Procedures for collecting samples and for performing all related field activities are described in detail in Appendix A of the IGMP/CSPCP Sampling Plan. Adherence to these procedures will be confirmed by the CEARP Quality Assurance Officers (Rockwell International and subcontractor) by quality assurance audits.

5. SAMPLE CUSTODY

CEARP field custody procedures are described in Section 7.2 of the IGMP/CSPCP Sampling Plan. Laboratory custody procedures for the analytical laboratories are described in Appendix A.

6. CALIBRATION PROCEDURES AND FREQUENCY

Standard commercial calibration procedures will be used by the analytical laboratories, as specified in Appendix A.

Calibration of equipment used to perform geotechnical testing will be in accordance with that specified in the ASTM Method D 422-63 for hydrometer and sieve analyses (Annual Book of ASTM Standards, Volume 04.08, 1984). The equipment calibrations, including those for ovens, thermometers and balances, shall be done at a minimum of every six months and prior to large scale testing.

Field instruments will be calibrated according to procedures presented in Appendixes A and B of the IGMP/CSPCP Sampling Plan. A calibration log book will be assigned to each field instrument, and all calibrations will be documented in the log books.

7. ANALYTICAL PROCEDURES

Laboratory analyses will follow methods described in Tables 3.1, 3.2, 3.3, and 3.4. Deviation from those methods, if required, will be presented in the SSMPs.

8. DATA REDUCTION, VALIDATION, AND REPORTING

Analytical laboratories will provide results to the Rockwell International CEARP Manager, the Subcontractor Project Manager, and Quality Assurance Officers. These data will include results and documentation for blanks and duplicates, matrix spikes, and forms summarizing analytical precision and accuracy.

Analytical data, including quality control sample analysis, will be entered into the technical data base. The analyses will be grouped into lots, with quality control samples associated with a particular lot. The analyses of quality control samples will be compared to theoretical known concentrations of those samples. If analyses do not meet acceptance criteria, the analytical laboratory may be asked to re-analyze the samples for parameters which do not exceed holding times. Analyses which cannot meet acceptance criteria, will be labelled as unacceptable. All parameter-specific values for a lot in which the quality control analyses did not meet acceptance criteria, will be removed from the technical data base.

Acceptance criteria for analyses of parameters for quality control samples (knowns) will be based on the theoretical known value furnished by the laboratory that prepared the sample. The theoretical known value is stated as a range of values. The analysis of the sample must be within the stated range of the theoretical known, plus or minus 10% of the range. An exception is analyses at or near the limit of detection. If the lower limit of the range of the theoretical known value is less than twice the limit of detection, an acceptable analysis includes the range from the limit of detection to the upper limit of the theoretical range, plus 10%.

Analytical reports from a field laboratory, if used, and the geotechnical laboratory will include all raw data, documentation of reduction methods, and related quality assurance/quality control data. These data will be assessed by verification of reduction results and confirmation of compliance with quality assurance/quality control requirements.

Raw data from field measurements and sample collection activities used in project reports will be appropriately identified. Where data have been reduced or summarized, the method of reduction will be documented.

The Quality Assurance Officers will review results of Quality Control-acceptance evaluations and will document acceptance or non-acceptance of data. The Quality Assurance Officers will maintain records of quality control-acceptance tests. These records will be subject to independent audit, which may include Los Alamos National Laboratory.

9. INTERNAL QUALITY CONTROL PROCEDURES

Internal quality control procedures for the laboratory are those specified in Appendix A. These specifications include types of audits required (e.g., sample spikes, surrogate spikes, reference samples, controls, and blanks), frequency of audits, compounds to be used for sample spikes and surrogate spikes, and quality control acceptance criteria for audits.

The quality control checks and acceptance for data from a field laboratory, if used, and the geotechnical laboratory are described above in Sections 3.2 and 3.3. Quality control procedures for field measurements (pH, conductivity, and temperature) are limited to checking the reproducibility of the measurement in the field by obtaining multiple readings and/or by calibrating the instruments (where appropriate). Quality control of field sampling will involve collecting field duplicates and blanks.

10. PERFORMANCE AND SYSTEMS AUDITS

For each activity where samples are collected, a performance audit investigating conformance with quality control procedures will be conducted (Appendix A) at the discretion of the Rockwell International CEARP manager, Subcontractor Project Manager, and Quality Assurance Officers. This audit will be scheduled to allow oversight of as many different field activities as possible. This audit will be performed by the Quality Assurance Officers or their designees. A written report of the results of this audit, along with a notice of nonconformity (if necessary), will be submitted to the following individuals:

- Rockwell International CEARP Manager
- Subcontractor Project Manager
- Subcontractor Site Manager

At least one systems audit will be performed during the project. The audit will verify that a system of quality control measures, procedures, reviews, and approvals was established for all activities and is being used by project personnel. It will also verify that the system for project documentation is being used and that all quality control records, along with required quality control reviews, approvals, and activity records are being maintained. A standard checklist for systems audits will be used. The systems audit will be conducted by the Quality Assurance Officers and/or Los Alamos National Laboratory. A final report will be prepared which summarizes any deviations from approved methods and their impacts on the project results.

After consultation with the CEARP Manager (and Subcontractor Project Manager), the Quality Assurance Officers may schedule systems audits of the participating laboratories. At a minimum, the systems audit would include inspection of laboratory notebooks, control sheets, logsheets, computer files, and equipment calibration and maintenance records. If scheduled, system audits will be executed by individuals identified in Section 2.3 of this document.

Performance and systems audits of analytical laboratories will be scheduled and executed by the laboratory Quality Assurance Officers. Performance audits are conducted at least semiannually.

11. PREVENTIVE MAINTENANCE

This section applies solely to field equipment. Preventive maintenance will be addressed by checks of equipment prior to initiation of field operations, to allow time for replacement of malfunctioning equipment. The Subcontractor Site Manager will be responsible for implementing and documenting these procedures on a weekly basis during the period of use.

12. LABORATORY DATA ASSESSMENT PROCEDURES

Analytical data from laboratories is assessed for accuracy, precision and completeness by the laboratory Quality Assurance Officers, using standard procedures.

Assessment of data generated by analytical laboratories is initiated and continued at three administrative levels. The bench chemist directly responsible for the test knows current operating acceptance limits. He/she can directly accept or reject generated data and consult with his/her immediate supervisor for any corrective action. Once the bench chemist has reported the data as acceptable, he/she initials the report sheet. Any out-of-control results are flagged and a note is made as to why the results were reported.

The chief chemist receives the data sheets and reviews the quality control data that accompanied the sample run. After checking the reported data for completeness and quality control results, the chief chemist either initials the report sheet or sends it back to the bench chemist for rerunning of samples. The Quality Control Coordinator reviews data forwarded to him/her as acceptable by the chief chemist. Any remaining out-of-control results that, in the opinion of the Quality Control Coordinator, do not necessitate rerunning of the sample, are flagged, and a memo is written to the data user regarding utility of the data. Data generated from all analyses are given a final review by the laboratory Quality Assurance Officers.

13. CORRECTIVE ACTION PROCEDURES

The Quality Assurance Officers and their audit teams will prepare a report describing the results of the performance and/or system audits. If unacceptable conditions (e.g., failure to have/use procedures), unacceptable data, nonconformity with the quality control procedures, or a deficiency are identified, the Quality Assurance Officers will notify the Rockwell International CEARP Manager of the results of the audit in writing. They will also state if the nonconformity is of significance for the program and recommend appropriate corrective actions. The Rockwell International CEARP Manager will be responsible for ensuring that correcitve is developed and initiated and that, if necessary, special expertise not normally available to the project team is made available. The subcontractor will be responsible for carrying out corrective actions. The subcontractor will also ensure that additional work is not performed until the nonconformity is corrected. Corrective action may include

- reanalyzing the samples if holding time permits,
- resampling and reanalyzing,
- evaluating and amending the sampling and analytical procedures, and
- accepting the data and acknowledging its level of uncertainty.

The Rockwell International CEARP Manager will be responsible for ensuring that corrective action was taken, and that it adequately addressed the nonconformity.

After corrective action is taken, the Quality Assurance Officer responsible for the audit will document its completion in a written report. The report will indicate any identified findings, corrective action taken, follow-up action, and final recommendations. The report will be sent to the Rockwell International CEARP Manager. Project staff will be responsible for initiating reports on suspected nonconformities in field activities and deliverables or documents.

14. QUALITY ASSURANCE REPORTS

The Rockwell International CEARP Manager will rely on written reports/memoranda documenting data assessment activities, performance and systems audits, nonconformity notices, corrective action reports, and quality assurance notices to enforce quality assurance requirements. The Los Alamos National Laboratory will be issued a written quality assurance report at the end of each stage of site characterization (remedial investigation) by the Rockwell International CEARP Manager.

Records will be maintained to provide evidence of quality assurance activities. Proper maintenance of quality assurance records is essential to provide support for evidential proceedings and to assure overall quality of the investigation. A quality assurance records index will be started at the beginning of the project. All information received from outside sources or developed during the project will be retained by the project team. Upon termination of an individual task or work assignment, working files will be processed for storage as quality assurance records. Upon termination of the project, complete documentation records (for example, chromatograms, spectra, and calibration records) will be archived as required by DOE Order 1324.2A (Records Deposition). The Rockwell International CEARP Manager and the Los Alamos National Laboratory CEARP Rocky Flats Plant Team Leader will be responsible for ensuring that the Quality Assurance records are being properly stored and that they can be retrieved.

15. REFERENCES

DOE 1986b: "Comprehensive Environmental Assessment and Response Program Phase I: Draft Installation Assessment Rocky Flats Plant," US Department of Energy unnumbered draft report, April 1986.

APPENDIX A

QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

1. LABORATORY QA/QC PROGRAM

This appendix to the quality assurance/quality control plan describes the organization and procedures used to produce reliable analytical data. These procedures are applicable to performing chemical, radiological, and geotechnical analyses on waste or environmental samples as appropriate.

The ultimate responsibility for the generation of reliable laboratory data rests with the laboratory management. Laboratory management is vested with the authority to establish those policies and procedures to ensure that only data of the highest attainable caliber are produced. Laboratory management, as well as the laboratory Quality Assurance/Quality Control Officer are responsible for the implementation of the established policies and procedures.

Laboratory management has the following responsibilities:

- direct implementation of the quality assurance program,
- ensure that their personnel are adequately trained to perform analyses,
- ensure that equipment and instrumentation under their control are calibrated and functioning properly, and
- review and perform subsequent corrective action on internal and external audits.

The Quality Assurance/Quality Control Officer has the following responsibilities:

- on-going review of individual quality assurance procedures,
- providing assistance in the development and implementation of specific quality assurance plans for special analytical programs,
- coordination of internal and external quality assurance audits,
- coordination of quality assurance training,
- review of special project plans for consistency with organizational requirements and advising laboratory management of inconsistencies, and
- overall coordination of the laboratories' quality assurance program manual.

1.2. SAMPLE MANAGEMENT

On notification of the sampling and analyses effort, the laboratory will create a file to maintain records associated with the activity. In addition to administrative information, requests for sample containers, preservatives, and required analyses will be included in the file.

Sample bottles will be prepared by the laboratory and made available to the sampling team. The bottles will be prepared according to the analysis plan procedures and will include sample preservatives appropriate to the analytes and matrices of concern. Addition of preservatives to sample shall be recorded on chain-of-custody forms.

Samples received at the laboratories will be inspected for integrity, and any field documentation will be reviewed for accuracy and completeness.

Chain-of-custody and sample integrity problems will be noted and recorded on the chain-of-custody forms during sample log-in. Chain-of-custody forms and deficiency notices will be maintained in the file. Any deficiencies will be brought to the attention of the Rockwell International CEARP Manager who will advise the laboratory on the desired disposition of the samples.

Each sample that is received by the laboratory will be assigned a unique sequential sample number which will identify the sample in the laboratory's internal tracking system. References to a sample in any communication will include the assigned sample number.

Samples will be stored in a locked refrigerator at 4°C. The temperature of the storage refrigerators will be monitored and recorded daily by the sample custodian. Sample fractions and extracts will also be stored under these same conditions.

1.3. ANALYTICAL SYSTEMS

1.3.1. Instrument Maintenance

Instruments will be maintained in accordance with manufacturers' specifications. More frequent maintenance may be dictated dependent on operational performance. Instrument logs will be maintained to document the date, type, and reason for any maintenance performed.

Contracts on major instruments with manufacturers and service agencies may be used to provide routine preventive maintenance and to ensure rapid response to emergency repair service.

1.3.2. Instrument Calibration

Before any instrument is used, it will be calibrated using known reference materials. All sample measurements will be made within the calibrated range of the instrument. A record of calibration will be kept in an equipment log.

1.3.3. Personnel Training

Prior to conducting analyses on an independent basis, analysts will be trained by experienced personnel in the complete performance of the analytical method. Analysts may require training at instrument manufacturers' training courses. The analyst will be required to independently generate data on several method and/or matrix spikes to demonstrate proficiency in that analytical method. The type of data to be generated will be dependent on the analytical method to be performed. Results of this "certification" will be reviewed by laboratory management for adequacy.

Method blanks and method spikes will be required in every lot of samples analyzed, thus performance on a day-to-day basis can be monitored. Laboratory management and the Laboratory Quality Assurance/Quality Control Officer are responsible for ensuring that samples are analyzed by only competent analysts.

1.4. ANALYTICAL METHODS

1.4.1. Gas Chromatography/Mass Spectroscopy

Mass spectrometers will be tuned on a daily basis to manufacturer's specifications with FC-43. In addition, once per shift (8 hours) these instruments will be tuned with decafluorotriphenylphosphine (DFTPP) or 4-bromo-fluorobenzene (BFB) for semi-volatiles or volatiles, respectively. Ion abundance will be within the window dictated by the requirements of the specific protocols. Once an instrument has been tuned, initial calibration curves for analytes (appropriate to the analyses to be performed) will be generated for at least three solutions containing known concentrations of authentic standards of compounds of concern.

The calibration curve will bracket the anticipated working range of analyses.

Calibration data, to include the correlation coefficient, will be entered into laboratory notebooks to maintain a permanent record of instrument calibrations.

During each operating shift, a midpoint calibration standard will be analyzed to verify that the instrument responses are still within the initial calibration determinations. The calibration check compounds will be those analytes used in the EPA contract laboratory program's multicomponent analyses (e.g., priority pollutants and hazardous substances list) with the exception that benzene will be used in place of vinyl chloride (volatiles) and di-n-octyl phthalate will be deleted from the semi-volatile list.

The response factor drift will be calculated and recorded. If significant (>30%) response factor drift is observed, appropriate corrective action will be taken to restore confidence in the instrumental measurements.

All GC/MS analyses will include analyses of a method blank, a method spike, and a method spike duplicate in each lot of samples. In addition, appropriate surrogate compounds specified in EPA methods will spiked into each sample. Recoveries from method spikes and surrogate compounds will be calculated and recorded on control charts to maintain a history of system performance.

Duplicate samples will be analyzed for analytical lots of twenty (20) or more samples.

Audit samples will be analyzed periodically to compare and verify laboratory performance against standards prepared by outside sources.

1.4.2. Gas Chromatography and High Performance Liquid Chromatography

Gas chromatographs and high performance liquid chromatographs will be calibrated prior to each day of use. Calibration standard mixtures will be prepared from appropriate reference materials and will contain analytes appropriate for the method of analysis.

Working calibration standards will be prepared fresh daily. The working standards will include a blank and a minimum of three concentrations to cover the anticipated range of measurement. At least one of the calibration standards will be at or below the desired instrument detection limit. The correlation coefficient of the plot of "known" versus "found" concentrations must be at least 0.996 in order to consider the responses linear over a range. If a correlation coefficient of 0.996 cannot be obtained, additional standards must be analyzed to define the calibration curve. A midpoint calibration check standard will be analyzed each operating shift (8 hours) to confirm the validity of the initial calibration curve. The check standard must be within twenty (20) percent of the initial response curve to demonstrate that the initial calibration curve is still valid.

Calibration data, to include the correlation coefficient, will be entered into laboratory notebooks to maintain a permanent record of instrument calibrations.

At least one method blank and two method spikes will be included in each laboratory lot of samples. Regardless of the matrix being processed, the method spikes and blanks will be in aqueous media. Method spikes will be at a concentration of approximately five (5) times the detection limit.

The method blanks will be examined to determined if contamination is being introduced in the laboratory. The method spikes will be examined to determine both precision and accuracy.

Accuracy will be measured by the percent recovery of the spikes; precision will be measured by the reproducibility of method spikes.

1.4.3. Atomic Absorption Spectrophotometry

Atomic absorption spectrophotometers will be calibrated prior to each day of use.

Calibration standards will be prepared from appropriate reference materials, and working calibration standards will be prepared fresh weekly. The working standards will include a blank and a minimum of five concentrations to cover the anticipated range of measurement.

Duplicate injections will be made for each concentration. At least one of the calibration standards will be at or below the desired instrument detection limit. The correlation coefficient of the plot of "known" versus "found" concentrations will be at least 0.996 in order to consider the responses linear over a range. If a correlation coefficient of 0.996 cannot be achieved, the instrument will be recalibrated prior to analysis of samples. Calibration data, to include the correlation coefficient, will be entered into laboratory notebooks to maintain a permanent record of instrument calibrations.

At least one method blank and two method spikes will be included in each laboratory lot of samples. Regardless of the matrix being processed, the method spikes and blanks will be in aqueous media. Method spikes will be at a concentration of approximately five (5) times the detection limit.

The method blanks will be examined to determine if contamination is being introduced in the laboratory and will be introduced at a frequency of one per analytical lot or five (5) percent of the samples, whichever is more. The method spikes will be examined to determine both precision and accuracy. Accuracy will be measured by the percent recovery of the spikes. The recovery must be within the range of 75-125 percent to be considered acceptable.

Precision will be measured by the reproducibility of both method spikes. Results must agree within twenty (20) percent in order to be considered acceptable.

1.4.4. Spectrophotometric Methods

Spectrophotometers will be calibrated prior to each day of use. Calibration standards will be prepared from reference materials appropriate to the analyses being performed, and working standards will include a blank and a minimum of five (5) concentrations to cover the anticipated range of measurement. At least one of the calibration standards will be at or below the desired instrument detection limit. The correlation coefficient of the plot of "known" versus "found" concentration will be at least 0.996 in order to consider the responses linear over a range. If a correlation coefficient of 0.996 cannot be achieved, the instrument will be recalibrated prior to the analysis of samples.

Calibration data, to include the correlation coefficient, will be entered into laboratory notebooks to maintain a permanent record of instrument calibrations.

At least one method blank and two method spikes will be included in each laboratory lot of samples. Regardless of the matrix being processed, the method spikes will be at a concentration of approximately five (5) times the detection limit.

The method blanks will be examined to determine if contamination is being introduced in the laboratory.

Accuracy will be measured by the percent recovery of the spikes. The recovery must be in an acceptable range (based on EPA data for the method of interest) in order to be considered acceptable. Precision will be measured by the reproducibility of both method spikes.

Results must agree within acceptable limits (based on EPA data) in order to be considered acceptable.

1.5. REFERENCE MATERIALS

Whenever possible, primary reference materials will obtained from the National Bureau of Standards (NBS) or the U.S. Environmental Protection Agency (EPA). In absence of available reference materials from these organizations, other reliable sources may be sought. Reference materials will be used for instrument calibrations, quality control spikes, and/or performance evaluations. Secondary reference material may be used for these functions provided that they are traceable to an NBS standard or have been to an NBS standard within the laboratory.

1.6. REAGENTS

Laboratory reagents will be of a quality to minimize or eliminate background concentrations of the analyte to be measured. Reagents must also not contain other contaminants that will interfere with the analyte of concern.

1.7. CORRECTIVE ACTIONS

When an analytical system is deemed to be questionable or out-of-control at any level of review, corrective action will be taken. If possible, the cause of the out-of-control situation will be determined, and efforts will be made to bring the system back into control. Demonstration of the restoration of a reliable analytical system will normally be accomplished by generating satisfactory calibration and/or quality control sample data. The major consideration in performing corrective action will be to ensure that only reliable data are reported from the laboratory. The Rockwell International CEARP Manager will be informed of the problem and all corrective actions taken.

1.8. DATA MANAGEMENT

1.8.1. Data Collection

All data will be recorded in laboratory notebooks. Laboratory notebooks will contain:

- Date and time of processing
- Sample numbers
- Project
- Analyses or operation performed
- Calibration data
- Quality control samples included
- Concentrations/dilutions required
- Instrument readings
- Special observations
- Analyst's signature.

Copies of laboratory notebooks will be provided to the Rockwell International CEARP Manager on request.

1.8.2. Data Reduction

Data reduction will be performed by the individual analysts. The complexity of the data reduction will be dependent on the specific analytical method and the number of discrete operations (extractions, dilutions, and concentrations) involved.

For those methods utilizing a calibration curve, sample responses will be applied to the linear regression line to obtain an initial raw result which will be factored into equations to obtain the estimate of the concentration in the original sample. Rounding will not be performed until after the final result is obtained, to minimize rounding errors, and results will not normally be expressed in more than two (2) significant figures.

Copies of all raw data and the calculations used to generate the final results will be retained in the laboratory file to allow reconstruction of the data reduction process at a later date. Copies of these records will be provided to the Rockwell International CEARP Manager on request.

1.8.3. Data Review

System reviews will be performed at all levels. The individual analyst will review the quality of data through calibration checks, quality control sample results, and performance evaluation samples. These reviews will be performed prior to submission of data to the laboratory management.

Laboratory management will review data for consistency and validity to determine if program requirements have been satisfied. Selected hard copy output of data (chromatograms, spectra, etc.) will be reviewed to ensure that results are interpreted correctly. Unusual or unexpected results will be reviewed, and a resolution will be made as to whether the analysis should be repeated. In addition, laboratory management, will recalculate selected results to verify the calculation procedure. Any abnormalities will be brought to the attention of the Rockwell International CEARP Manager.

The Quality Assurance Officer will independently conduct a complete review of results from randomly selected samples to determine if laboratory and program quality assurance/quality control requirements have been met. Deviations from requirements will be reported to the laboratory management and Rockwell International CEARP Manager for resolution.

Non-routine audits may be performed.

1.8.4. Data Reporting

Reports will contain final results (uncorrected for blanks and recoveries), methods of analysis, levels of detection, surrogate recovery data, and method blanks data. In addition, special analytical problems, and/or any modifications of referenced methods will be noted. The number of significant figures reported will be consistent with the limits of uncertainty inherent in the analytical method. Consequently, most analytical results will be reported to no more than two (2) significant figures.

Data will be reported in units commonly used for the analyses performed. Concentrations in liquids will be expressed in terms of weight per unit volume (e.g., milligrams per liter). Concentrations in solid or semi-solid matrices will be expressed in terms of weight per unit weight of sample (e.g., micrograms per grams).

Reported detection limits will be those specified by the analytical method.

1.8.5. Data Archiving

The laboratory will maintain on file all of the raw data (including calibration data), laboratory notebooks, and other pertinent documentation. This file will be maintained at the laboratory for a period of time consistent with Rocky Flats Plant's requirements. At the end of that time frame, all these records will be given to Rocky Flats Plant.

2. PERFORMANCE AND SYSTEM AUDITS

Quality assurance audits will be conducted. System audits will be conducted at random, unscheduled intervals at least annually.

Audits will be planned, organized, and clearly defined before they are initiated. Auditors will identify nonconformances or deficiencies. These will be reported and documented so that corrective actions can be initiated through appropriate channels. Corrective actions will be followed up with a compliance review. A report on each audit will be sent to the Rockwell International CEARP Manager.

2.1. FIELD AUDITS

Unannounced field audits, investigating conformance with QA/QC procedures, will be performed. A typical checklist for this type of audit is shown in Table A-1. A written report on the results of this audit will be submitted to the Rockwell International CEARP Manager.

2.2. CORRECTIVE ACTION

After each audit, auditors will identify nonconformances in a written nonconformance notice and initiate corrective action through the Rockwell International CEARP Manager. The nonconformance notice will describe any nonconforming conditions and set a date for response and corrective action(s). The Subcontractor Project Manager will prepare a written proposal for corrective action for review and approval by the Rockwell International CEARP Manager. When approved, the proposed corrective action(s) will be implemented. Follow-up review will be performed by the auditor to confirm that the corrective actions have been implemented.

Table A.1. Field Audit

Project ____________________ Site Manager ____________________

Site Location ____________________ Field Team Leader ____________________

Auditor ____________________ Date ____________________

Audit Question	Yes	No	Comment/Documentation
1. Was a site-specific sampling and analytical plan followed?			
2. Was a field team leader appointed?			
3. Was the site health and safety coordinator present?			
4. Were field team members familiar with the sampling plan?			
5. Was a briefing held offsite, before any site work was begun, to acquaint personnel with sampling equipment and assign field responsibilities?			
6. Was the daily briefing and safety check conducted?			
7. Was a completed "Site Personnel Protection and Safety Evaluation Form" read and signed by all visitors and personnel entering the site?			
8. Was a field notebook assigned to the field team leader?			
9. Were entries made in the field notebook?			
10. Were sampling stations located correctly?			
11. Did the number and location of samples collected follow the site-specific sampling plan?			

Table A.1. (Continued)

Project ____________________ Site Manager ____________________

Site Location ____________________ Field Team Leader ____________________

Auditor ____________________ Date ____________________

Audit Question	Yes	No	Comment/Documentation
12. Were samples identified as described in the site-specific sampling plan?			
13. Were samples collected following procedures specified in the site-specific plan?			
14. Was a chain-of-custody form filled out for all samples collected? Were all sample transfers documented?			
15. Were samples preserved as specified in the site-specific sampling plan?			
16. Were the number, frequency, and type of samples (including blanks and duplicates) collected as described in the site-specific sampling plan?			
17. Were the number, frequency, and type of measurements and observations taken as specified in the site-specific sampling plan?			
18. Were blank and duplicate samples properly identified?			
19. Was a record maintained of calibration of field equipment?			
20. Was field equipment calibrated as required?			

Table A.1. (Continued)

Project ____________________ Site Manager ____________________

Site Location ________________ Field Team Leader ______________

Auditor ____________________ Date ______________________

Audit Question	Yes	No	Comment/Documentation
21. Have any procedures been revised?			
22. Are revisions to procedures adequately documented?			
23. Was the document log for chain-of-custody records and other sample traffic control forms maintained?			
24. Have any accountable documents been lost?			
25. Did drilling and well construction follow procedures outlined in the sampling plan?			
26. Were the activities being conducted compatible with the environmental conditions?			

APPENDIX A

1. DRILLING AND SAMPLING

1.1. PURPOSE

To provide procedures for borehole drilling and sampling.

1.2. DEFINITIONS

- Monitor Wells: Two-inch wells designed for monitoring water levels and groundwater quality.
- Alluvial Wells: Monitor wells completed in surficial materials (Rocky Flats Alluvium, colluvium, or valley fill alluvium).
- Bedrock Wells: Monitor wells completed in saturated sandstone of the Arapahoe or Laramie Formations.
- Piezometers: Two-inch wells completed in claystone of the Arapahoe or Laramie Formations for monitoring water levels.
- Surface Casing: Casing set and grouted through surficial materials in bedrock wells to prevent interconnection of shallow and deep flow systems.

1.3. RESPONSIBILITY

The Rockwell International CEARP Manager is responsible for the drilling and sampling program.

The Subcontractor Site Manager is responsible for direct supervision of drilling and sampling. The Subcontractor Site Manager will report daily to the Rockwell International CEARP Manager on drilling and sampling progress including any problems encountered implementing the field program.

The Field Team Leader is responsible for supervision of drilling, verification of drilled depths, and approval of the Driller's daily logs. The Field Team Leader is also responsible for sample collection, handling, and field screening.

The Driller is responsible for operating and maintaining the rig and auxiliary equipment, for keeping a clean and safe working environment, and for assisting the Field Team Leader with sampling.

1.4. EQUIPMENT AND MATERIALS

- Drilling rig with auger, rotary tricone, and diamond coring systems
- Water truck
- Rod trailer
- Maintenance and access vehicles
- Miscellaneous drilling equipment
- Volatile organic-free water
- Electric well sounder
- Glass jars and lids
- Labels
- Core boxes
- Plastic wrap
- Pipe wrenches
- Rock hammer
- Pocket knife
- Hand lens
- Tape measure divided in tenths of a foot
- Dropper bottle of hydrochloric acid
- Protractor
- Marking pens and pencils
- Field notebook
- Log of boring form

1.5. PROCEDURES

1.5.1. Alluvial Wells

(1) Alluvial wells will be drilled with hollow stem augers where practical. Boulders in the Rocky Flats Alluvium may prohibit the use of hollow stem augers, in which case alternative drilling methods such as tricone rotary will be used. Sampling through surficial materials will be performed by continuous sampling through the hollow stem augers (with split tube inner barrel) or by split spoon, depending on the materials.

(2) Alluvial wells will be drilled approximately one to three feet into bedrock. They will be terminated after confirming the presence and lithology of bedrock.

(3) The hole diameter will be a minimum of four inches. The use of hollow stem augers eliminates the need for drilling fluids; however, some volatile organic-free water may be used if hole stability is a problem. In no event will mud or foaming agents be used.

1.5.2. Bedrock Wells

(1) Bedrock wells will be augered and rotary drilled through surficial materials and weathered bedrock as described above.

(2) Upon penetration of unweathered bedrock, steel surface casing will be set and neat cement grout will be placed in the annulus through a tremie pipe or by pushing a plug of cement through the surface casing. The surface casing will be approximately 6 in. in diameter.

(3) Grout will be neat Type I or Type II Portland cement, mixed with volatile organic-free water at a mix ratio of 6 to 9 gal. of water per 94-lb bag of cement. Grout will be allowed to set at least twenty-four hours before drilling resumes.

(4) The hole will proceed through bedrock by rotary coring (size NX or larger), using bentonite mud, volatile organic-free water, air mist (air and volatile organic-free water), or filtered air.

(5) Drilling will progress into bedrock until at least 3 ft of saturated sandstone within a 10-ft interval of bedrock is encountered, or until the well is approximately 100 ft deep. Wells may be drilled deeper than 100 ft to fully penetrate a sandstone.

(6) After drilling through sufficient sandstone thickness (as defined above), the hole will be cleaned and stabilized for packer testing.

(7) Geophysical logging may be performed in some holes after packer testing.

(8) After packer testing and geophysical logging are completed, the hole will be reamed, if necessary, to a minimum of 4 in. for well installation.

1.5.3. Sampling and Logging

(1) The Driller will provide either continuous samples from a split tube sampler, split-spoon samples, rotary cuttings, or NX core, depending on the drilling method.

(2) As drilling progresses, the Field Team Leader will confirm sample depths with the Driller, describe the samples, and field screen the sample for organic or radioactive contamination. Descriptions and screening results will be recorded in the field notebook and on a log of boring form. The Field Team Leader will also note the depth at which groundwater is encountered.

(3) Sample descriptions will include the following items as appropriate:

- Borehole designation
- Time and date
- Interval footage and recovered footage
- Name of unit and/or brief rock name
- Characteristic structures of the unit
- Fossils
- Lithologic description
- Nature of contacts
- Water content
- Organic and radioactive field screening results.

(4) Auger and rotary cuttings will be bottled in glass jars and labeled. Intervals designated for chemical analyses will be placed in jars and stored on ice in coolers. These samples will be delivered to the onsite laboratory, if an onsite laboratory is used, within 3 hours of collection.

(5) Core continuous split tube samples, and split-spoon samples will be wrapped with clear plastic to prevent rapid drying and cracking and placed in NX or NC size core boxes as appropriate. Wooden blocks will be inserted in the boxes at the beginning and end of runs to mark footages and will indicate lost core zones. Core boxes will be labeled and stored.

(6) The Driller will keep a daily log detailing footage drilled, material used, and stand-by time. The Field Team Leader will keep an independent record of drilling activities in the field notebook to verify the daily logs. One copy of the daily logs will be submitted to the Subcontractor Site

Manager and Rockwell International CEARP Manager by the Field Team Leader on a weekly basis.

1.6. RECORDS

- Log of boring
- Driller's daily logs
- Field notebook

2. MATERIALS DESCRIPTION

2.1. PURPOSE

To provide procedures for field descriptions of surficial and bedrock materials.

2.2. RESPONSIBILITY

The Field Team Leader is responsible for describing core and samples following this work procedure.

2.3. EQUIPMENT AND MATERIALS

- Log of boring
- Field notebooks
- Clipboard
- Rulers
- Rock-color chart, Geological Society of America
- Waterproof pens
- Colored pencils
- Protractor
- Hand lens
- Dropper bottle of hydrochloric acid
- Rock hammer
- Grain-size chart/scale

2.4. PROCEDURES

(1) All surficial materials and bedrock samples will be described using the following sequence of parameters:

- Footage
- Sample type
- Percent recovery
- General material type
- Color
- Structural characteristics
- Grain sizes
- Composition of grains
- Degree of sorting
- Grain shapes
- Minor characteristics

- Degree and nature of cementation
- Moisture content

Procedures for describing each of these parameters are presented below.

(a) Footage: Depth of sample interval.

(b) Sample Type: Continuous drive, cuttings, core, or split spoon.

(c) Percent Recovery: Percent of sample recovered from borehole.

(d) General Material Type: Clay, clayey sand, sandy clay, Silt, sand, gravel, sand and gravel, shale, sandstone, or siltstone.

(e) Color: Color of samples will be described by comparing samples with a standard color chart. Either a Munsel soil color chart or USGS standard color chart will be used. Colors will be described from moistened samples. Any color abbreviations shall follow those set by the standard color chart used.

(f) Structural Characteristics: This parameter describes bedding and other primary features of the sample, including nature of bedding (e.g., massive, tabular, lenticular, laminated, graded, or even); primary features within beds or other structures (e.g., grading, laminations, cross bedding, channeling, distorted flow banding, and inclusions); and characteristic secondary features (e.g., cleavage, prominent weathering effects, and fracturing) (Compton 1962).

(g) Grain Size: Grain sizes will be classified according to the Wentworth scale (Dresser Atlas 1982). The percentage of each grain size will be denoted by the following descriptive terms.

Descriptive Term	Percentage
Trace	1-10%
Some	10-20%
Adjective (sandy, silty, etc.)	20-35%
"And"	35-50%

(h) Composition of Grains: Composition of grains will be described by using the major or dominant grain component first, followed by minor component percentages or the appropriate descriptive term (Compton 1962).

(i) Degree of Sorting: The degree of sorting is a measure of particle size uniformity. It will be visually estimated in the field using sorting charts (Dresser Atlas 1982).

(j) Grain Shapes (Roundness): Roundness is the degree of a clastic particle abrasion and is reflected in the sharpness of its edges and corners. Grain shapes will be determined visually in the field using grain shape charts (Dresser Atlas 1982).

(k) Minor Characteristics: Minor and/or unusual characteristics of a sample will be noted in the description including weathering.

(l) Degree and Nature of Cementation: The degree of cementation will be recorded as uncemented or unconsolidated, poorly cemented or consolidated, or well cemented, based on visual inspection. The nature of calcium carbonate will be determined based on the reaction of samples to dilute hydrochloric acid. The intensity of the hydrochloric acid reaction will be described as no reaction, weak reaction, or strong reaction.

(m) Moisture Content: A general qualitative description will be used to describe moisture content.

Dry: No discernible moisture present.

Damp: Enough moisture present to darken the color of the sample, but does not feel moist to the touch.

Moist: Sample feels moist to the touch.

Wet: Visible water is present.

(2) Geologic descriptions of core will follow the same procedures as outlined above. Additional records required for core are: the cored (run) interval, the footage of recovered core and percent recovery, and the Rock Quality Designation (RQD) of the cored interval. RQD is the percent of sound core recovered in pieces greater than four inches in length (Deere 1964).

2.5 RECORDS

- Field Notebooks
- Log of Boring

2.6. REFERENCES

Compton, R. R., 1962, *Manual of Field Geology*: John Wiley and Sons, Inc., New York, 378 pp.

Deere, D. U., 1964, Technical Description of Rock Cores for Engineering Purposes: Rock Mechanics and Engineering Geology, Vol. 1, pp. 16-22.

Dresser Atlas, 1982, *Well Logging and Interpretation Techniques*: Dresser Atlas, Inc., 228 pp.

3. FIELD SCREENING FOR TOTAL ORGANIC COMPOUNDS IN SOIL SAMPLES

3.1. PURPOSE

To field screen soil samples for volatile organic compounds.

3.2. RESPONSIBILITY

The Field Team Leader is responsible for field screening of samples following this work procedure.

3.3. EQUIPMENT AND MATERIALS

- Field notebooks
- Log of boring
- Adhesive labels
- Waterproof pen
- Sample bottles (500-ml amber glass) with lids
- Photoionization detector (PID)
- Organic vapor analyzer (OVA)

3.4. PROCEDURES

(1) Approximately 50 to 100 ml of soil will be placed in 500-ml amber glass jars, and an equal amount of deionized water will be added to the jar. The jar will then be shaken and allowed to stand for 30 minutes allowing organic compounds to volatilize.

(2) The sample jars will be labeled with the date, time, borehole number, sample depth, and Field Team Leader's.

(3) Field screening of the samples for total organic vapor concentrations will be conducted using an OVA and a PID. The instruments will be calibrated to the volatile organic compounds of concern at each site (Roffman et al. 1986).

(4) The lid of the sample jar will be opened slightly and the probes of the instruments will be placed inside the jar. Values registered on each instrument will then be recorded in the field notebook. The

date and time of the reading, the borehole number, and the sample depth will also be recorded in the field notebook and log of boring.

3.5. RECORDS

Field notebooks
Logs of borings

3.6. REFERENCES

Roffman, H. K., M. D. Neptune, J. W. Harris, A. Carter, and T. Thomas, Field Screening for Organic Contaminants in Samples from Hazardous Waste Sites, 1986, Abstract from: Conference on Petroleum Hydrocarbons and Organic Chemicals in Groundwater-Prevention, Detection, and Restoration, Houston, Texas, 8 p.

4. LABELING AND TORAGE OF SAMPLES

4.1. PURPOSE

To provide procedures for labelir and storage of boxed cores and jarred samples.

4.2. DEFINITIONS

- Storage Facility: The locatior vhere boxed cores and/or jarred samples will be stored without fre .ing.

4.3. RESPONSIBILITY

The Field Team Leader is respon ble for labeling and storage of all samples.

4.4. EQUIPMENT AND MATERIALS

- Labeling Pens
- Adhesive Labels
- Inventory Sheets
- Field Notebook

4.5. PROCEDURES

(1) Label core boxes and sampl ars in the field as samples are collected. All samples will be labeled with

(a) location
(b) borehole designation
(c) date
(d) depth
(e) box or jar number
(f) total number of boxes o jars for the borehole
(g) Field Team Leader initi s

Check that all information is co ect before leaving the field with samples.

(2) Transport samples to storag acility.

(3) Place samples in storage facility. Samples should be stacked in order by hole number and in neat and orderly arrangement for accessibility. All samples from each well should be placed in one location, and the labels should be visible.

4.6. RECORDS

- Field Notebook

5. DECONTAMINATION OF DRILLING, TESTING, AND SAMPLING EQUIPMENT

5.1. PURPOSE

To provide procedures for equipment decontamination.

5.2. DEFINITIONS

Equipment: Augers, drill pipe, bits, sampling devices, tools, tremie pipe, packers, water pipe, geophysical logging equipment, casing, electric well sounders, pumps, and all other miscellaneous equipment used in drilling, sampling, testing, logging, installing, and developing monitor wells.

Decontamination: Decontamination is the process of cleaning equipment to avoid transport of contamination.

5.3. RESPONSIBILITY

The Field Team Leader is responsible for supervising and approving the decontamination cleaning of equipment.

The Driller is responsible for cleaning all drilling, sampling and well construction equipment and assisting the geophysicist in cleaning geophysical probes and cables.

5.4. EQUIPMENT AND MATERIALS

- Portable Steam Cleaner
- Brushes and Buckets
- Organic-free Water
- Alkaline Detergent

5.5. PROCEDURES

5.5.1. Drilling and Well Installation Equipment

(1) Decontaminate all drilling equipment before starting the first borehole.

(2) Upon termination of a borehole, decontaminate all drilling, packer testing, and geophysical logging equipment as well as stainless steel well casing and screen.

(3) Decontamination will include:

(a) a rinse with the steam cleaner using organic-free water;
(b) scrubbing with brushes using a solution of organic-free water and an alkaline detergent; and
(c) a final rinse with the steam cleaner using organic-free water.

(4) Cover drilling equipment with a clean sheet of plastic after it is decontaminated. Install wet casing and screen in the borehole.

(5) Decontaminate all equipment and tools used in well installation.

(6) Before moving to the next drill site, decontaminate the wireline cable by pulling it off the drum to the appropriate length. Also decontaminate the rig table and mast.

5.5.2. Sampling Equipment

(1) Decontaminate all sampling equipment before collecting the first sample and after each sample collected.

(2) Decontamination will include:

(a) scrubbing with brushes using a solution of organic-free water and an alkaline detergent; and

(b) a rinse with organic-free water (a steam cleaner may be used).

(3) Decontaminate the electric well sounder probe and cable before and after measuring water levels.

(4) Decontaminate pumps and pump line exteriors before and after pumping a monitor well. Decontaminate the internal system of pumps and tubing by pumping at least 1 tubing volume of organic free water through the pump.

(5) Discard bailer rope after each use. Attach new polypropylene rope to the bailer at each well.

5.6. RECORDS

- Field Notebook

8. WELL INSTALLATION

8.1. PURPOSE

To provide procedures for monitor well construction and installation.

8.2. DEFINITIONS

Monitor Well: Two-inch well designed for monitoring water levels and groundwater quality.

Alluvial Well: Monitor well completed in surficial materials (Rocky Flats Alluvium, colluvium, or valley fill alluvium).

Bedrock Well: Monitor well completed in saturated sandstone of the Arapahoe or Laramie Formations.

Piezometers: Two-inch well completed in claystone of the Arapahoe or Laramie Formations for monitoring water levels.

8.3. RESPONSIBILITIES

The Subcontractor Site Manager is responsible for selecting completion intervals and well designs. Completion intervals and well designs will be approved by the Rockwell International CEARP Manager prior to well construction.

The Field Team Leader is responsible for supervision and documentation of well completions.

The Driller will assemble and install all materials.

8.4. EQUIPMENT AND MATERIALS

- Schedule 5 Type 316 stainless steel casing
- Schedule 5 Type 316 stainless steel wire wrap screen
- Type 316 stainless steel centralizers
- Bentonite pellets
- Appropriate filter pack
- Neat Type I or II Portland cement

- Concrete mix
- Organic-free water
- Five-gallon buckets
- Tremie pipe
- Hoses and pump
- Shovel
- Trowel
- Protective surface casing
- Padlock
- 100-ft tape measure divided in tenths of a foot with a weight on the end
- Electric well sounder
- Well construction summary data sheets
- Field notebook

8.5. PROCEDURES

(1) Pull all augers and drill pipe from borehole. If borehole stability is a problem, the wells may be completed inside the hollow stem augers.

(2) Decontaminate drilling equipment and casing.

(3) Measure depth to water and design well construction.

Alluvial Wells. The screened interval in alluvial wells will extend from approximately 1 ft below the top of bedrock to 2 to 5 ft above the water table. A filter pack designed for the grain size of the formation will be placed around the screened interval and will not extend more than 2 ft above the top of the screened interval. A 1-ft-thick bentonite seal will be placed above the filter pack, and the annulus will be tremie grouted with neat Portland Type I or II cement to the surface. Cement may be poured from the surface if the cemented interval is within 5 ft of the surface. A locking steel protective casing will be placed over the well, and a concrete surface pad, approximately 3 ft in diameter, will be poured around the surface casing. The pad will be sloped so as to drain away from the well.

Bedrock Wells. Bedrock monitor wells will be screened across the entire interval of saturated sandstone with a minimum screened interval of 5 ft. Filter pack, bentonite, cement grout, protective casing, and a concrete pad will be placed as described above.

Piezometers. Deep boreholes which do not encounter sufficient sandstone thickness after drilling through 70 ft of claystone with an average hydraulic conductivity of 5 x 10^{-7} centimeters per second will be completed as piezometers with two-inch, Schedule 80, threaded and flush jointed, polyvinylchloride (PVC) casing. Ten ft of machine slotted casing will be placed at the base of the casing string. The remainder of the well completion will be as discussed above for alluvial monitor wells.

(4) Calculate the amount of filter pack, bentonite, and cement that will be required for well construction.

(5) Weld end cap on the bottom of the well screen with a stainless steel welding rod, and thread the casing string together.

(6) Place centralizer in the center of the screened interval, and determine its location on the casing string to the nearest 1/100th foot.

(7) Measure the length of the screened interval and the blank casing to the nearest 1/100th ft.

(8) Measure total depth of the open borehole. If the bottom of the borehole is below the base of the screen, backfill it with bentonite pellets or tremie cement grout to the base of the screen. If the open borehole is backfilled with grout, allow it to set for 24 hours before well completion. Measure total depth of the open borehole again.

(9) Place casing string in open borehole. Place slip-on cap on top of the casing string. Measure stick up to determine total well depth. Check well design for correct total depth.

(10) Slowly pour filter pack into borehole annulus, making sure it is evenly distributed around the well casing. Gently shake the casing as filter pack is added to avoid bridging of the filter pack. Measure depth to the top of the filter pack after each bag is added. Make more frequent measurements as filter pack approaches the top of the screened interval.

(11) Record the final depth to the top of the filter pack on well construction summary sheet. Record amount of filter pack used in the field notebook.

(12) Pour bentonite pellets into borehole annulus, making sure they are evenly distributed around the well casing.

(13) Measure depth to the top of the bentonite seal and record on well construction summary sheet. Record amount of bentonite used in the field notebook.

(14) If the bentonite pellets are above the water table, add 1 to 2 gal. of organic-free water to the hole. Allow the bentonite to swell for approximately 15 minutes before grouting to the surface.

(15) Mix neat Type I or II Portland cement (as directed by the Subcontractor Site Manager) at a mix ratio of 6 to 9 gal. of water per 94-lb bag of cement.

(16) Place tremie pipe in borehole annulus and attach appropriate hoses and pump.

(17) Pump grout down borehole annulus. Pour grout from the surface if the cemented interval is within 5 ft of the surface. Record amount of cement used in field notebook.

(18) Measure final stick-up of well casing and record on well construction summary sheet.

(19) Set protective surface casing over stainless steel well casing.

(20) Allow grout to set for 24 hr.

(21) Place form for concrete surface pad around well casing.

(22) Mix concrete and pour surface pad around well casing. Slope pad away from the well with a trowel.

(23) Weld well number on protective surface casing.

8.6. RECORDS

- Well Construction Summary
- Field notebook

9. WELL DEVELOPMENT

9.1. PURPOSE

To provide procedures for well development.

9.2. DEFINITIONS

Well Development: Well development is the process by which fines from the formation and/or filter pack are removed from the vicinity of the well bore in order to increase the efficiency of the well (UOP Johnson Division 1975).

9.3. RESPONSIBILITY

The Subcontractor Site Manager is responsible for determining which method of development will be used. Well development methods will be approved by the Rockwell International CEARP Manager prior to well development.

The Field Team Leader is responsible for well development.

The Driller will be responsible for supplying an air compressor with an air filter if the well is developed by the air lift method.

9.4. EQUIPMENT AND MATERIALS

- Electric well sounder
- Tape measure calibrated in tenths of feet
- Stainless steel pump*
- Air compressor*
- Teflon bailer*
- Bailer rope*
- PVC drop pipe*
- Gasoline powered generator*
- One liter beaker
- Watch
- Calculator
- Well development summary sheets
- Field notebook

*NOTE: The use of these materials will depend on the method of well development selected.

9.5. PROCEDURES

The well will be developed by pumping, bailing, or air-lifting. Pumping is the preferred method of well development and will be used wherever possible. Air-lifting is less desirable because the potential exists for oils from the air compressor to enter the wells, but may be necessary to adequately stress the wells. An air filter will be used if air-lifting is necessary. Bailing is not an efficient method of well development because of the low flow rates induced by bailing. Bailing will only be done in the event of pump failure and to remove sediments in the bottom of the casing.

(1) Decontaminate all equipment prior to well development.

(2) Measure the water level in the well.

(3) Record the water level on the water level data sheet. Record the date, time, well, and development methods on the well development summary sheet.

9.5.1. Pumping

Well development by pumping will be accomplished by means of a two-inch stainless steel piston pump. The pump will be lowered to approximately 1 ft above the bottom of the well. The well will then be pumped until ten casing volumes of water have been removed from the well, until the well water is clear, or until 4 h have elapsed. The pump will be raised 2 ft at periodic intervals until the entire screened interval is developed.

9.5.2. Air Lifting

Well development by air lifting will be accomplished by using an air compressor and 1-in. PVC air line. An air filter will be attached to the air line from the air compressor to prevent the introduction of compressor oils or other foreign materials into the well.

The 1-in. PVC air line will be lowered until within approximately 2 ft of the bottom of the well. The air line from the air compressor will then be attached to the top section of PVC pipe. The well will then be developed by the introduction of compressed air into the well for approximately fifteen minutes, or until a column of water is removed from the well. The well will then be allowed to recover and another column of water discharged to the surface. This process will be repeated until 10 casing volumes of water have been removed from the well, until the produced water is clear, or until 4 h have elapsed. At periodic intervals, the air line will be raised 2 ft until the entire screened interval is developed.

9.5.3. Bailing

Well development by bailing will be accomplished using a Teflon bailer and small diameter polypropylene bailing rope. Water, formation and/or filter pack materials will be removed from the well by bailing until 10 casing volumes of water have been removed from the well, until the well water is clear, or until 4 h have elapsed. The bailing rope will be discarded following well development.

9.6. RECORDS

- Well development summary sheets
- Field notebook

9.7. REFERENCES

Johnson, E. E., Inc., *Groundwater and Wells - A Reference Book for the Water-Well Industry*, 1980, Johnson Division, UOP, Inc., Saint Paul, Minnesota, 440 p.

11. WELL PURGING

11.1. PURPOSE

To provide procedures for well purging.

11.2. DEFINITIONS

Casing Volume: The casing volume is the volume of water standing inside the casing, i.e., the distance between the water level and the bottom of the casing (length of the water column in the well) multiplied by the inner cross-sectional area of the casing.

Well Purging: Purging is the removal of sufficient water from the well so that representative formation waters enter the well and can be sampled. Purging will consist of removing three casing volumes.

11.3. RESPONSIBILITY

The Subcontractor Site Manager is responsible for selecting well purging methods. Well purging methods will be approved by the Rockwell International CEARP Manager prior to purging.

The Field Team Leader is responsible for purging wells prior to sampling.

11.4. EQUIPMENT AND MATERIALS

Wells will be purged using dedicated bladder pumps, dedicated Teflon bailers, or portable sampling pumps. Because of the various purging methods, some or all of the following equipment will be needed.

- Bladder pump
- Oil-less air compressor
- Stainless steel piston pump
- Polypropylene rope
- Large container of known volume
- Deionized water
- Watch
- Calculator

- Pencil
- Field Water Quality Data Sheet
- Field notebook

11.5. PROCEDURES

11.5.1. Calculations

(1) Calculate the casing volume using the formula

Casing volume (gallons) = (TD - WL) * (A),

where

TD	=	total depth of the well from ground surface (ft),
WL	=	depth to water from ground surface (ft),
A	=	cross sectional area of the well (gallons/ft),
	=	0.163 for a 2-in. well,
	=	0.367 for a 3-in. well,
	=	0.652 for a 4-in. well, and
	=	1.468 for a 6-in. well.

Note that total depth and depth to water must be measured from the same datum. The total depth of the casing is usually reported as depth below ground surface and the depth to water is measured from the top of the inner casing. In order to correct the depth to water measurement, subtract the height of casing above ground from the depth to water measured from the top of casing.

(2) Multiply the casing volume by three. This is the volume of water to be purged.

(3) Record calculations in the field notebook and on Field Water Quality Data Sheet.

11.5.2. Purging

Remove three casing volumes of water from the well using the pump, the dedicated Teflon bailer, or the portable sampling pump. Regardless of the methods used to purge the well, record the total volume purged and the time when purging begins and ends.

Dedicated Pump System. The dedicated pump system will consist of an air-actuated bladder pump with downward flow checking valves on the inlet to the inside of the bladder and on the tubing above the outlet from the inside of the bladder. Air is delivered to the outside of the bladder and pressure is maintained long enough that the bladder is compressed and water inside it is forced into the discharge tubing. Water is kept from exiting the bottom of the pump by the lower check valve. The air pressure is vented to surface through the same pressurizing tube (requiring a time dependent on length of tubing, required air pressure, and depth of submergence of the pump). Water forced into the discharge tubing is held by the upper check valve. The cycle is repeated until discharge reaches the surface and purging begins. Because of this pumping mechanism, the discharge is delivered to the surface in cyclic slugs, but the pressurizing air is never in contact with the water.

The upper check valve has a small-diameter bypass so that water in the discharge tubing will drain back into well and not freeze.

(1) Attach compressor to Pump Pressure Inlet on controller (use oil-less compressor to protect pneumatic logic components inside controller).

(2) Connect red air hose between well cap and Pump Supply on controller.

(3) Position Refill and Discharge knobs to center position (12 o'clock) and start compressor. Record the time at the start of pumping in the field notebook.

(4) Set gas pressure level to a pressure sufficient to lift the column of water in the discharge tubing plus 30 psi, but do not exceed 125 psi total.

(5) Adjust Discharge knob so that venting occurs at the end of the slug discharge.

(6) Decrease Refill cycle time until volume discharged in each cycle begins to decrease. If decrease is immediate, lengthen both Refill and Discharge cycle times and repeat steps 5 and 6.

(7) Measure volume produced in a container of known volume (e.g., plastic trash can or plastic bucket).

(8) Continue pumping until the appropriate volume has been purged. Record time at end of pumping as well as the total volume pumped in the field notebook and on the Field Water Quality Data Sheet.

(9) Measure and record water level at the end of pumping.

Bailing

(1) Put on surgical gloves. New cotton gloves may be worn over the surgical gloves if desired.

(2) Place a sheet of plastic over the casing. Cut a hole in the plastic for the casing and spread sheet on ground around the well. The plastic and equipment should be arranged in such a manner to enable the samplers to do all work while standing on the plastic.

(3) Attach new polypropylene rope to bailer inspect the check valve, top bail, knot, and rope. Do not allow bailer or rope to contact anything but clean plastic. If any components are loose or damaged, replace them. Decontaminate equipment if any new parts are used.

(4) Lower bailer into well, fill with water, and hoist to surface, coiling the rope into the hands.

(5) Empty bailer into a container of known volume (e.g., 5-gal. bucket).

(6) Continue bailing until appropriate volume has been purged, as determined by volume in container.

(7) Record volume purged in the field notebook and on Field Water Quality Data Sheet.

Portable Pump

(1) Decontaminate the pump and sufficient tubing by scrubbing with an al-alkaline detergent solution followed by a deionized water rinse. Pump at least one tubing volume of deionized water through the pump.

(2) Place decontaminated pump approximately 1 ft above the bottom of the well.

(3) Place up-hole end of the discharge line in container of known volume (e.g., plastic trash can or 5-gal. bucket).

(4) Connect compressor to pump controller.

(5) Turn on compressor and pump appropriate volume as measured in container.

(6) Record purged volume on the Field Water Quality Sheet.

(7) After collecting the sample, decontaminate pump by scrubbing all tubing that has been pulled off the reel and the pump itself with an alkaline detergent solution and rinsing with deionized water. Pump at least one tubing volume of deionized water through the pump.

11.6. RECORDS

- Field water quality sampling and analysis form
- Field notebook

11.7. REFERENCES

U.S. Environmental Protection Agency, 1986, *Hazardous Waste Groundwater Task Force Protocol for Groundwater Evaluation*, Office of Solid Waste and Emergency Response, Washington, D.C., DIR 9080.0-1.

12. GROUNDWATER SAMPLING

12.1. PURPOSE

To provide procedures for groundwater sample collection.

12.2. RESPONSIBILITIES

The Subcontractor Site Manager is responsible for assigning specific wells to be sampled. The sampling schedule will be approved by the Rockwell International CEARP Manager prior to implementation.

The Field Team Leader is responsible for sampling monitor wells, field water quality measurements, and transportation of samples to the onsite laboratory.

12.3. EQUIPMENT AND MATERIALS

- Sample bottles provided by on-site laboratory
- Thermometer inscribed in degrees Centigrade
- pH meter
- Portable electrical conductivity meter
- Field notebook

12.4. PROCEDURE

(1) Pick up sample bottles, cooler, blue ice packs, sample labels, and chain-of-custody form at the laboratory.

(2) Pre-label bottles before leaving the laboratory. Place sample bottles on ice.

(3) Produce the sample with the same device used to purge the well.

(4) Collect the sample immediately after purging if possible. If the well is essentially dry after pumping, measure the water level in the well on a periodic basis (approximately every three hours). Collect the volatile organic samples within three hours of purging. Collect the rest of the samples as soon as there is sufficient volume in the well to sample as soon as there is sufficient volume in the well to fill the sample bottles (approximately 4

gallons). Attempt to collect an aliquot for field tests and laboratory analysis (in that order) 24 hours after purging even if there is insufficient water in the well to fill all sample bottles.

(5) Produce sufficient sample for performance of four field water quality tests (two 500 milliliter beakers - one for temperature and conductivity and one for pH). Perform one field water quality test before sampling, two during sampling, and one after sampling following procedures in this document.

(6) Rinse each bottle with formation water directly from the pump discharge or bailer. Fill the bottle about one-quarter full, cap the bottles, and rinse both bottle and cap with a swirling motion. Discard rinse water. Immediately fill bottle with sample, cap, complete label, rinse bottle exterior with deionized water, place in plastic bag, and return bottle to cooler. Remove only one bottle from the cooler at a time for filling.

(7) After rinsing the volatile organics vials and caps with sample, fill each vial to overflowing with sample. Carefully place the cap on the vial so that air is not captured, and tighten. Invert the vial and tap lightly. If bubbles are observed, repeat the process.

(8) Record time of sampling on Field Water Quality Sheet and in field notebook. Also note weather conditions and any other observations (e.g., insufficient sample to fill all bottles, bottles broken, etc.).

(9) Complete chain-of-custody form and indicate analyses to be performed in the laboratory.

(10) Deliver samples to the on-site laboratory within 3 hours of collection for filtration and/or preservation of appropriate bottles.

12.5. RECORDS

- Field water quality and analysis sampling form
- Field notebook

12.6. REFERENCES

U.S. Environmental Protection Agency, 1986, *RCRA Ground-Water Monitoring Technical Enforcement Guidance Document*, Office of Solid Waste and Emergency Response, Washington, D.C.

13. FIELD MEASUREMENTS

13.1. PURPOSE

To provide procedures for field measurements made at the site of monitor wells and surface water stations.

13.2. DEFINITIONS

Field Measurements: These measurements consist of temperature, pH, conductivity, dissolved oxygen, organic vapors, and qualitative observations of color and odor.

13.3. RESPONSIBILITY

The Field Team Leader is responsible for measurement of field parameters.

13.4. EQUIPMENT AND MATERIALS

The equipment used for field measurements has been selected based on proven durability in field applications; however, field equipment is still rather fragile. Equipment should be kept spotlessly clean at all times and protected from temperature extremes. Conductivity meters and pH meters will be calibrated daily following the manufacturers' instructions. All other instruments will be calibrated weekly. Each instrument will have its own calibration log book, and all calibrations will be documented. The following equipment is normally used:

- Thermometer inscribed in degrees Centigrade
- pH Meter - with calibration buffer solutions
- Portable electrical conductivity meter - with calibration
- Standard solutions
- Photoionization Detector (PID)
- Organic Vapor Analyzer (OVA)
- Deionized water
- Pencil
- Field Water Quality Sheets
- Field notebook
- Calibration notebooks

13.5. PROCEDURE

13.5.1. Temperature Measurement

Immerse the thermometer bulb in a beaker filled with sample. Make the measurement immediately after sampling so that the temperature will not have time to change. Read the thermometer while it is still immersed, to the nearest degree Centigrade, and record the reading in the field notebook and on the Field Water Quality Data Sheet. Rinse the thermometer with deionized water and put it away.

Calibrate the thermometer on a weekly basis against a National Bureau of Standards certified thermometer. Document calibrations in the calibration log book.

13.5.2 pH Measurement (VWR Scientific 1976)

(1) Turn on meter.

(2) Check battery.

(3) Place partially filled 50-milliliter beakers containing pH 4 and pH 7 buffer solutions into a water bath (well water) to maintain the temperature of the buffers as close as possible to the temperature of the well water. The water bath will need to be refilled periodically with water removed from the well.

(4) Remove boot from electrode.

(5) Rinse electrode with deionized water. Be sure any salts are removed.

(6) Immerse bulb in pH 7 buffer.

(7) Adjust using calibration knob to read 7.

(8) Rinse electrode with deionized water.

(9) Immerse bulb in pH 4 buffer.

(10) Adjust using temperature knob to read 4 (this is a span adjustment and not a true temperature correction).

(11) Measure the temperature of the buffers using a thermometer, following the procedures described previously. Be sure to rinse the thermometer with deionized water between solutions.

(12) Collect some sample in a beaker (rinse the beaker with sample).

(13) Rinse the thermometer with deionized water, and measure the temperature of the sample. If the buffer solutions are not at the same temperature as the samples, put fresh formation water in the water bath, allow time for temperature equalization, and repeat the calibration procedure.

(14) Rinse the electrode in deionized water.

(15) Immerse the bulb in the sample.

(16) Read the pH to the nearest tenth of a pH unit. Stir the sample with the electrode to hasten reading stability.

(17) If the pH is greater than 7, re-calibrate using the pH 10 buffer instead of the pH 4. Perform steps 5 through 16 above. If most samples have pH values greater than 7, pH 10 buffer should be routinely substituted for pH 4.

(18) Record the pH reading on the data sheet and in the field notebook. Document calibrations in the calibration log book.

(19) Rinse the electrode with deionized water and replace plastic boot.

(20) Turn off meter.

13.5.3 Conductivity Measurement (YSI 1976b)

(1) With conductivity meter off, check zero position. Adjust if necessary.

(2) Switch to red line and adjust.

(3) Calibrate meter against standard solutions and record calibrations in the calibration log book.

(4) Collect a sample in a beaker (rinse beaker with sample before collecting).

(5) Rinse probe with deionized water.

(6) Immerse probe in the sample.

(7) Switch to temperature. Record the temperature on Field Water Quality Sheet and in field notebook (may be different from earlier temperature measurement).

(8) Switch to conductivity and record both the needle reading and scale knob setting. Do not perform any calculations. Record the two values on the Field Water Quality Sheet and in field notebook.

(9) Turn meter off.

(10) Remove probe from sample and rinse with deionized water.

(11) Rinse beaker with deionized water.

13.5.4. Dissolved Oxygen Measurement (YSI 1976a)

(1) Place meter in intended operating position. Do not move without calibrating.

(2) With meter off, adjust meter to zero using center screw.

(3) Switch meter to zero and adjust to zero with zero knob.

(4) Switch meter to full scale and adjust to "15" on ppm scale using full scale knob.

(5) Attach probe to the meter and wait 15 min to polarize probe.

(6) Perform air calibration:

- Switch to calib O2 position;
- Place the probe in moist air (small calibration bottle with a few drops of water) and allow 10 min for temperature stabilization (can be same as polarization wait); and

- Set meter to local altitude (6,000 ft amsl) using calib knob -- be sure reading is steady;

Calibrate meter against standard solutions (on a weekly basis). Document calibrations in calibration log book.

(7) Place probe in sample and stir by raising and lowering the probe about 1 ft per s. Allow probe to equilibrate to sample temperature and dissolved oxygen.

(8) Turn switch to temp and read temperature from lower scale.

(9) Set O2 solubility factor dial to observed temperature, using the salinity index scale on the dial (salinity determined using SCT meter - each bar on index represents 5,000 ppm chloride concentration).

(10) Turn switch to read O2 and read dissolved oxygen value in ppm directly from the meter.

(11) Turn off meter, rinse probe with deionized water, add a few drops of deionized water to the sponge in the probe holder, and return probe to holder.

13.5.5. Photoionization Detector Measurements (HNU Systems 1975)

(1) Remove plate on the top half of the case by pulling up on the two fasteners. The extension tube and battery charger are located under this plate.

(2) Attach extension tube to the end of the probe.

(3) Check to see if the instrument's function switch is in the "OFF" position.

(4) Install the 12 pin interface connector for the probe into the connector on the instrument box by carefully matching the alignment key of the probe connector to the slots in the box connector. Twist the connector in a clockwise manner until a distinct snap and lock is felt.

(5) Check the battery supply by turning the function switch to the "BATT" position. The meter needle should deflect to the far right or well within

the green zone (NOTE: The battery check indicator will not function unless the probe is attached). If the needle is below or just in the green zone or the red LED light is on, the battery should be recharged.

(6) To zero the instrument, turn the function switch to the "STANDBY" position and rotate the "ZERO" potentiometer until the meter reads zero. This is an electronic zero adjustment. Calibration gases are not needed.

(7) Turn the function switch to the selected scale. There should be a humming sound emanating from the probe. This is the fan which pulls air into the probe. A blue glow should be seen through the end of the probe. Do not stare at this glow, as it is an ultraviolet light source which can damage the eyes. An overall check can also be done by passing a magic marker past the tip of the probe. This should generate a reading or jump of the needle.

(8) Place the function switch in the 0 - 20-ppm range for the most sensitive monitoring.

(9) Before entering a work area, determine the background concentration. This concentration should be used as a reference to readings made in the work area. Under no circumstances should one attempt to adjust the "ZERO" or "SPAN" adjustments while the instrument is being used in the work area (NOTE: When using the 0 - 20 ppm range, background concentrations up to 1.0 ppm are common in clean environments. This reading is generated internally by the instrument and should be referred to as zero ppm).

(10) Take PID readings in the headspace of a well before making water level measurements. Condensation and dust on the lamp can interfere with proper readings. PIDs do not function well during precipitation events or sudden temperature changes which can fog up the lamp.

(11) Record all readings in the field notebook.

13.5.6. Organic Vapor Analyzer Measurements (Foxboro Analytical)

(1) Remove top cover of the instrument.

(2) Move the INSTR switch to ON and allow five minutes for warm up.

(3) Set the audible alarm to a predetermined level by turning the PUMP switch to ON. Adjust the meter pointer to the desired alarm level using the CALIBRATE ALARM (zero) knob. Turn the ALARM LEVEL ADJUST knob on the back of the readout assembly until the audible alarm comes on. Adjust speaker volume with VOLUME knob. The instrument is then preset to activate the alarm when the organic vapor level exceeds that of the setting.

(4) Move the CALIBRATE switch to 10X and adjust the meter reading to zero with the CALIBRATE ADJUST (zero) knob.

(5) Ensure the PUMP switch is ON and observe the SAMPLE FLOW RATE indicator. The flow rate should be approximately 2 units.

(6) Open H2 TANK VALVE one turn and observe the reading on the H2 TANK PRESSURE indicator (approximately 150 psi of pressure is needed for each hour of operation).

(7) Open H2 SUPPLY VALVE one-half to one turn and observe the reading on the H2 SUPPLY PRESSURE indicator.

Caution: Do not leave H2 SUPPLY VALVE open when the pump is not running, as this will allow hydrogen to accumulate in the detector chamber.

(8) Confirm that meter is still reading zero (readjust if required).

(9) Depress the igniter button. There will be a slight "pop" as the hydrogen ignites, and the meter pointer will move upscale of zero. Do not depress igniter button for more than 6 seconds. If burner does not ignite, let instrument run for several minutes and try again.

(10) Move instrument to an area representative of the "lowest ambient background concentration" to be surveyed. Move the CALIBRATE switch to 1X and adjust the meter to read 1 ppm with the CALIBRATE ADJUST (zero) knob.

(11) If the alarm level is to be set above background levels, turn the ALARM LEVEL ADJUST knob on the back of the readout assembly until it activities slightly above background.

(12) Set the CALIBRATE switch to the desired range.

(13) Using one hand operation, survey the areas of interest while observing the meter and/or listening for the audible alarm indication.

(14) Record readings in the field notebook.

13.5.7. <u>Color and Odor</u>

Record any observations regarding the general condition of the samples. Especially note color, turbidity and odor.

13.6. RECORDS

- Field water quality data sheets
- Field notebook

13.7. REFERENCES

Foxboro Analytical Century Systems Portable Organic Vapor Analyzer Instructions and Service Manual.

HNU Systems Inc., 1975, Instruction Manual for Model PI101 Photoionization Analyzer.

VWR Scientific, 1976, Care and Feeding of the Mini and Digital pH Meters, Model 47.

Yellow Springs Instrument Co., 1976a, Instruction Manual, YSI Model 51B Dissolved Oxygen Meter.

Yellow Springs Instrument Co., 1976b, Instructions for YSI Models 33 and 33M S-C-T Meters.

14. WATER LEVEL MEASUREMENTS

14.1. PURPOSE

To provide procedures for measuring water levels in monitor wells and piezometers.

14.2. DEFINITIONS

Electric Water Level Sounder: An electric water level sounder is a device to measure the depth from a reference point (usually top of casing) to the water level in a well. The sounder consists of a two-wire cable on a reel with a double electrode tip. The reel houses a battery and voltmeter (or other device such as a light or buzzer) so that electrical continuity is indicated between the electrodes when submerged. The cable is graduated, indicating the length of cable in the well (Todd 1980).

14.3. RESPONSIBILITY

The Field Team Leader is responsible for water level measurements and accurate recording of data.

14.4. EQUIPMENT AND MATERIALS

- Electric water level sounder
- Deionized water
- Extra batteries
- Tape measure graduated in hundredths of feet
- Watch
- Pencil
- Photoionization Detector (PID)
- Field Water Quality Data Sheet
- Water Level Data Sheet
- Field notebook

14.5. PROCEDURES

(1) Record well location, identification number, date, time, and Field Team Member initials in field notebook and on data sheets.

(2) Check headspace of the well for any organic vapors with a PID. Record reading in field notebook.

(3) Decontaminate electrode on sounder and sufficient length of cable by washing with an alkaline detergent solution and rinsing with deionized water so that only clean cable enters the well.

(4) Turn on sounder, check battery, and lower cable into well until the presence of water is indicated.

(5) Hold wire so thumb and index finger are touching the top of casing when probe just enters the water (alarm will sound). Use the north rim of the inner casing for the depth to water reference point.

(6) Raise cable until alarm stops (i.e., probe is just above water level). Lower cable until alarm sound again. Check to see if thumb and index finger are at the same location as before.

(7) Still holding the cable at the measurement point, pull an arm's length of cable from the well. With other hand, push the zero end of tape measure against thumb, holding the measurement point, and measure distance to the first downhole graduation on the cable. Measure to the nearest 1/100th of a foot.

(8) Record the time, cable and tape measure readings in the field notebook. Transfer readings to the Field Water Quality Data Sheet and the Water Level Data Sheet.

(9) Coil the downhole cable into hands to minimize contamination of the entire sounder.

(10) Decontaminate all of the cable that was downhole plus 5 ft by washing with an alkaline detergent solution and rinsing with deionized water. Decontaminate equipment between wells and at the end of each day.

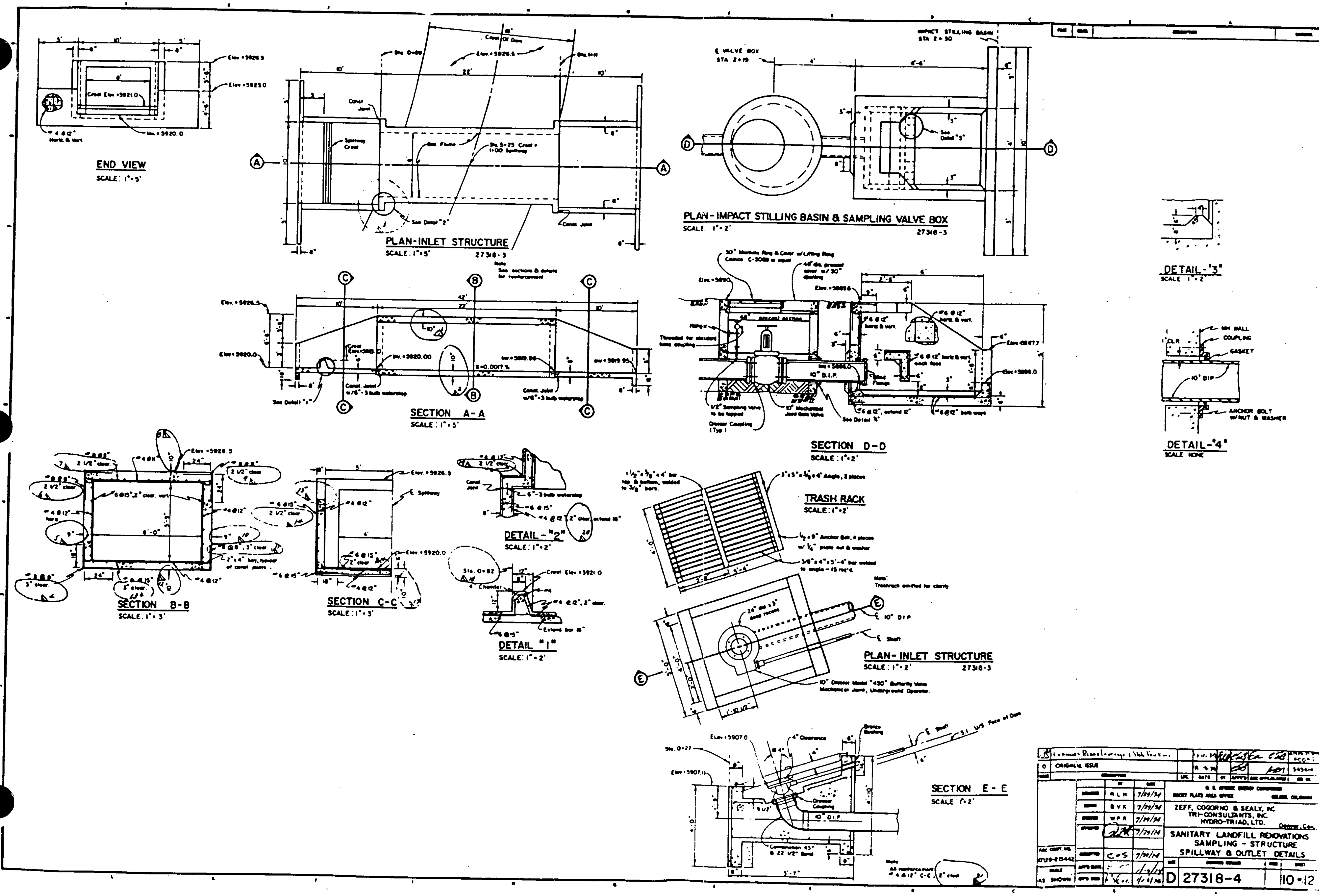
(11) Wrap sounder in clean plastic after decontaminating.

14.6. RECORDS

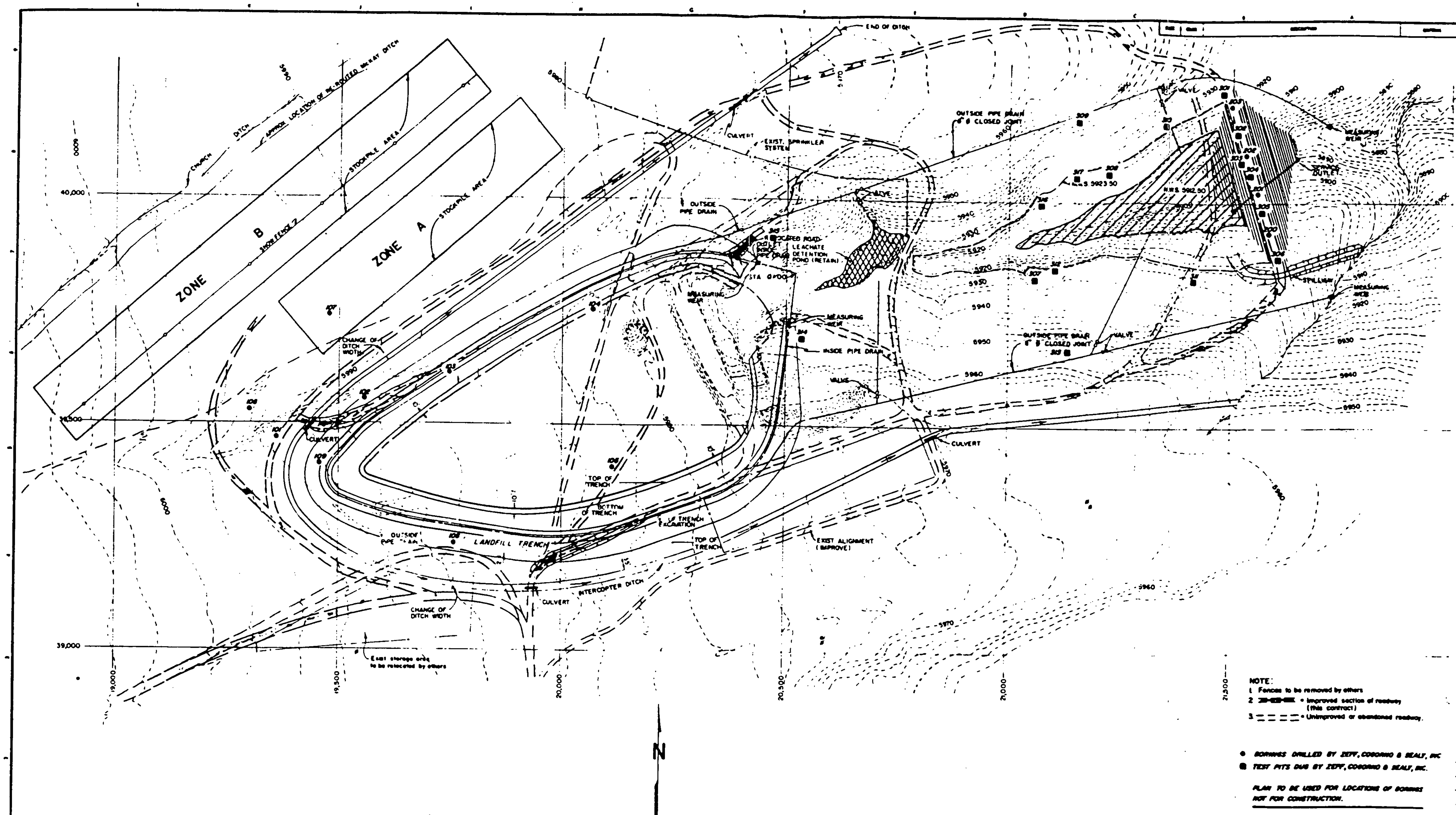
- Water level data sheets
- Field notebook

14.7. REFERENCES

Todd, David Keith, 1980, Subsurface Investigations of Groundwater; in *Groundwater Hydrology*, Second Edition, John Wiley and Sons, Inc., New York, pp. 434-435.



END VIEW
SCALE: 1" = 5'
PLAN-INLET STRUCTURE
SCALE: 1" = 5'
27318-3
PLAN-IMPACT STILLING BASIN & SAMPLING VALVE BOX
SCALE 1" = 2'
27318-3
DETAIL-"3"
SCALE 1" = 2'
SECTION A-A
SCALE: 1" = 5'
SECTION D-D
SCALE: 1" = 2'
DETAIL-"4"
SCALE NONE
SECTION B-B
SCALE: 1" = 3'
SECTION C-C
SCALE: 1" = 3'
DETAIL-"2"
SCALE: 1" = 2'
DETAIL "1"
SCALE: 1" = 2'
TRASH RACK
SCALE: 1" = 2'
PLAN-INLET STRUCTURE
SCALE: 1" = 2'
27318-3
SECTION E-E
SCALE: 1" = 2'
0 ORIGINAL ISSUE
ZEFF, COGORNO & SEALY, INC.
TRI-CONSULTANTS, INC.
HYDRO-TRIAD, LTD.
SANITARY LANDFILL RENOVATIONS
SAMPLING - STRUCTURE
SPILLWAY & OUTLET DETAILS
AS SHOWN
D 27318-4
10 of 12



NOTE:

1. Fences to be removed by others
2. ▬▬▬ = Improved section of roadway (this contract)
3. = = = = = Unimproved or abandoned roadway.

● BORINGS DRILLED BY ZEFF, COGORNO & SEALY, INC

■ TEST PITS DUG BY ZEFF, COGORNO & SEALY, INC.

PLAN TO BE USED FOR LOCATIONS OF BORINGS NOT FOR CONSTRUCTION.

0	ORIGINAL ISSUE		8-4-74		345644

	RLH	7/29/74
		7/29/74
	RLH	7/29/74
		1/29/74
		7/29/74

ZEFF, COGORNO & SEALY INC
TRI-CONSULTANTS INC
HYDRO-TRIAD LTD

Denver, C.

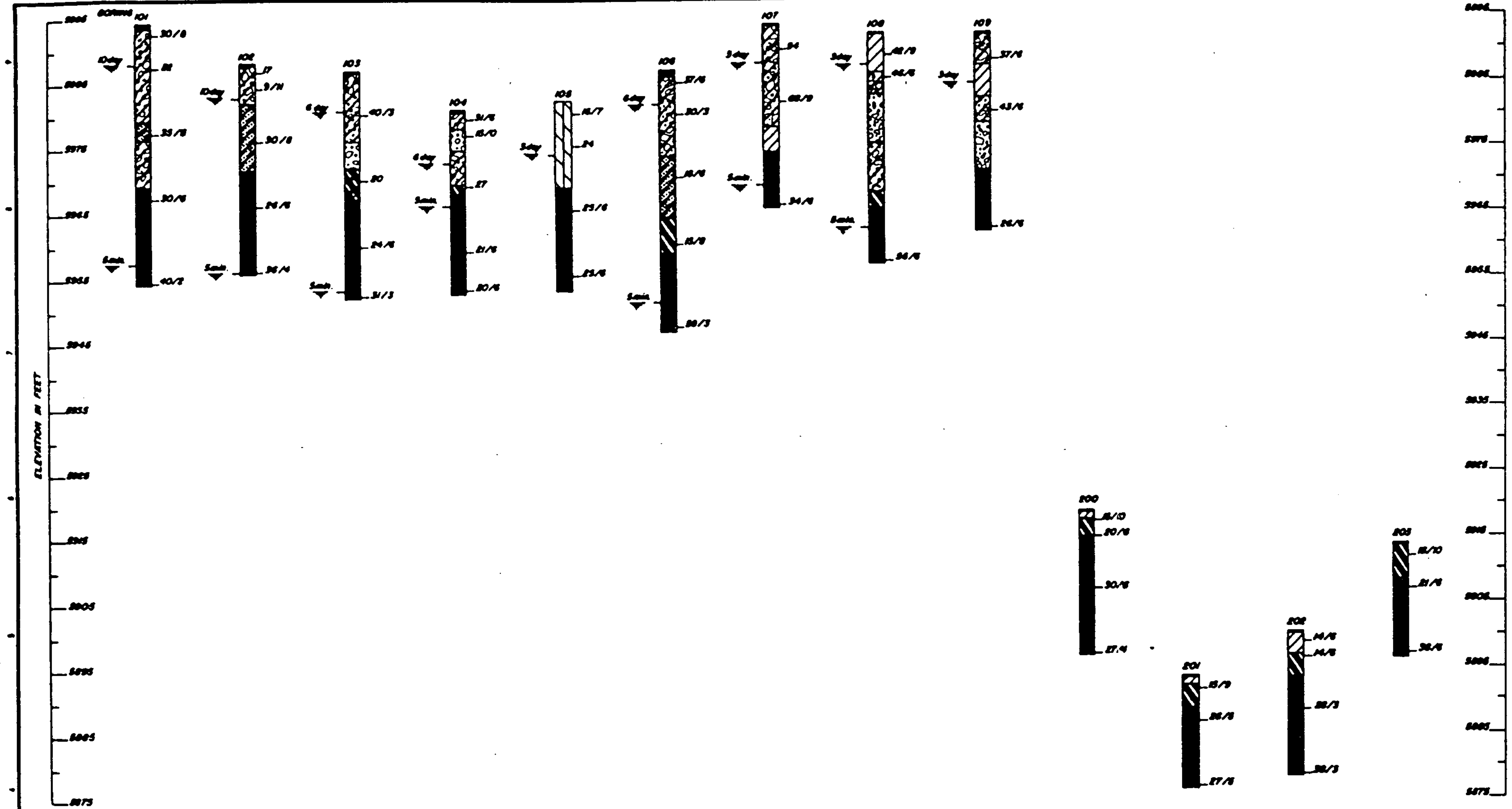
SANITARY LANDFILL RENOVATIONS TEST BORING AND TEST PIT LOCATION PLAN

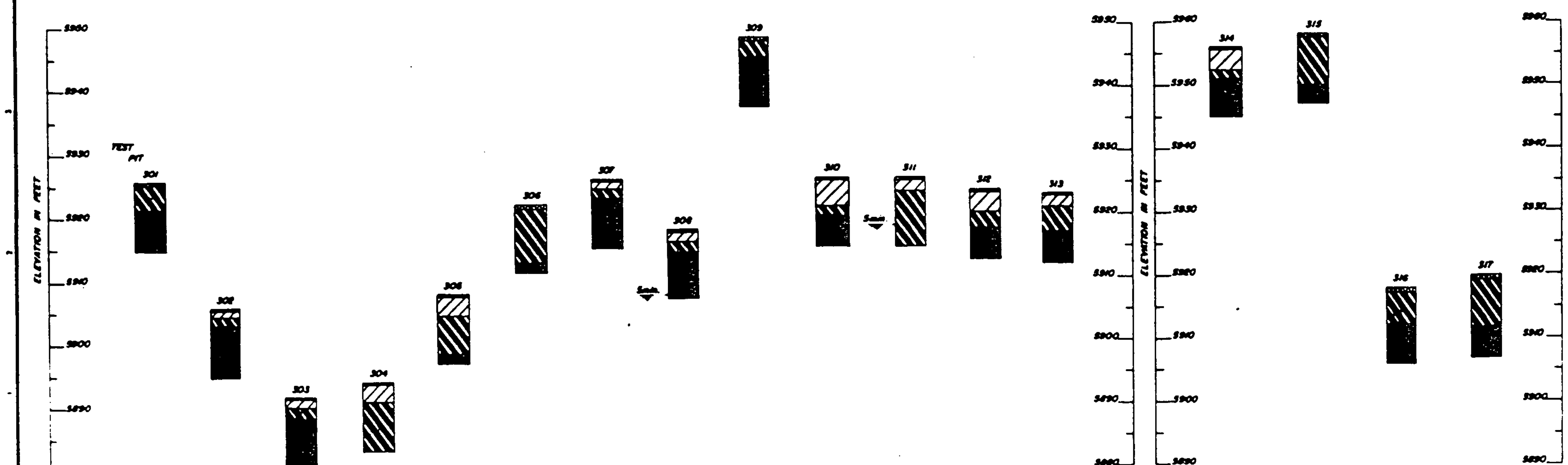
AEC CONT NO. AT(29-2)-3442

SCALE 1" = 100'

D 27318-5

11 of 12





LEGEND:

- TOPSOIL
- FILL - CLAY, SANDY WITH GRAVELS AND COBBLES
- SANITARY LANDFILL
- ALLUVIUM CONSISTING OF MIXTURES OF CLAYS, SANDS AND GRAVELS WITH RANDOM AMOUNTS OF COBBLES AND BOULDERS
- CLAY, SANDY TO VERY SANDY, SILTY, VERY STIFF, MEDIUM MOIST TO MOIST, BROWN, GRAVEL
- SAND, CLAYEY WITH CLAY LAYERS, MEDIUM DENSE TO DENSE, MEDIUM MOIST TO WET, RANDOM GRAVELS AND COBBLES
- SAND AND GRAVEL, DENSE TO VERY DENSE, MEDIUM MOIST TO WET, SOME COBBLES AND BOULDERS
- SAND AND GRAVEL, SLIGHTY CLAYEY TO CLAYEY, DENSE TO VERY DENSE, SOME COBBLES AND BOULDERS
- CLAY (SEVERELY WEATHERED CLAYSTONE), VERY STIFF, MOIST
- CLAYSTONE BEDROCK (SHALE), WEATHERED, MEDIUM HARD TO VERY HARD, MOIST, VARICOLORED, YELLOW, BROWN AND GRAY
- CLAYSTONE BEDROCK (SHALE), WEATHERED, HARD TO VERY HARD, MOIST, YELLOW AND GRAY
- WATER TABLE, TIME AFTER DRILLING

NOTES:

(1). THE BORINGS WERE DRILLED MAY 29 THROUGH JUNE 3, 1974, WITH A 4" DIAMETER, CONTINUOUS FLIGHT, POWER AUGER.

(2). THE TEST PITS WERE DUG MAY 30 AND 31, 1974 WITH A BACKHOE.

(3). 30 INDICATES THAT 30 BLOWS OF A 140-LB. HAMMER FALLING 30" WERE REQUIRED TO DRIVE THE SAMPLER 6".

(4). THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY BETWEEN SOIL TYPES AND THE TRANSITION MAY BE GRADUAL.

(5). THE BORING LOGS SHOW SUBSURFACE CONDITIONS AT THE DATES AND LOCATIONS INDICATED, AND IT IS NOT WARRANTED THAT THEY ARE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

0	ORIGINAL ISSUE	8-4-74		[illegible]	[illegible]	345614

	BY	DATE
	RLH	7/29/74
	JMD	7/29/74
	RLH	7/29/74
	[illegible]	7/29/74
	[illegible]	7/29/74
	[illegible]	[illegible]
	[illegible]	[illegible]

AEC CONT. NO. AT(29-2)-1544

U. S. ATOMIC ENERGY COMMISSION
ROCKY FLATS AREA OFFICE GOLDEN, COLORADO

ZEFF, COGORNO & SEALY, INC
TRI-CONSULTANTS, INC
HYDRO-TRIAD, LTD
Denver, Colo

SANITARY LANDFILL RENOVATIONS
LOGS OF EXPLORATORY BORINGS
AND TEST PITS

D 27318-6 12-12

UNITED STATES

DEPARTMENT OF ENERGY

ALBUQUERQUE OPERATIONS OFFICE

ROCKY FLATS AREA OFFICE

SANITARY LANDFILL EXTENSION SLURRY TRENCH

WRIGHT-McLAUGHLIN ENGINEERS
in conjunction with
A. G. WASSENAAR, INC.
2420 ALCOTT ST. DENVER, COLORADO

INVITATION NO.
DE-AC04-82AL18828

INDEX OF DRAWINGS

ISSUE	DESCRIPTION	DATE	DOE	CLASS	JOB NO
0	ORIGINAL ISSUE	9 Aug 82	RCB	[illegible]	325011

	BY	DATE
DESIGNED	CRANDELL	6-82
DRAWN	NELSON	6-82
CHECKED	REC	7/20/82
APPROVED	[illegible]	8-3-82
SUBMITTED		
APPROVED A/E	[illegible]	4 Aug 82
APPROVED DOE	[illegible]	[illegible]

TOLERANCES: FRACT. ± ANGLE ± DEC. ± UNLESS NOTED OTHERWISE

REMOVE BURRS AND SHARP EDGES

NEXT ASSEMBLY

DOE CONT. NO

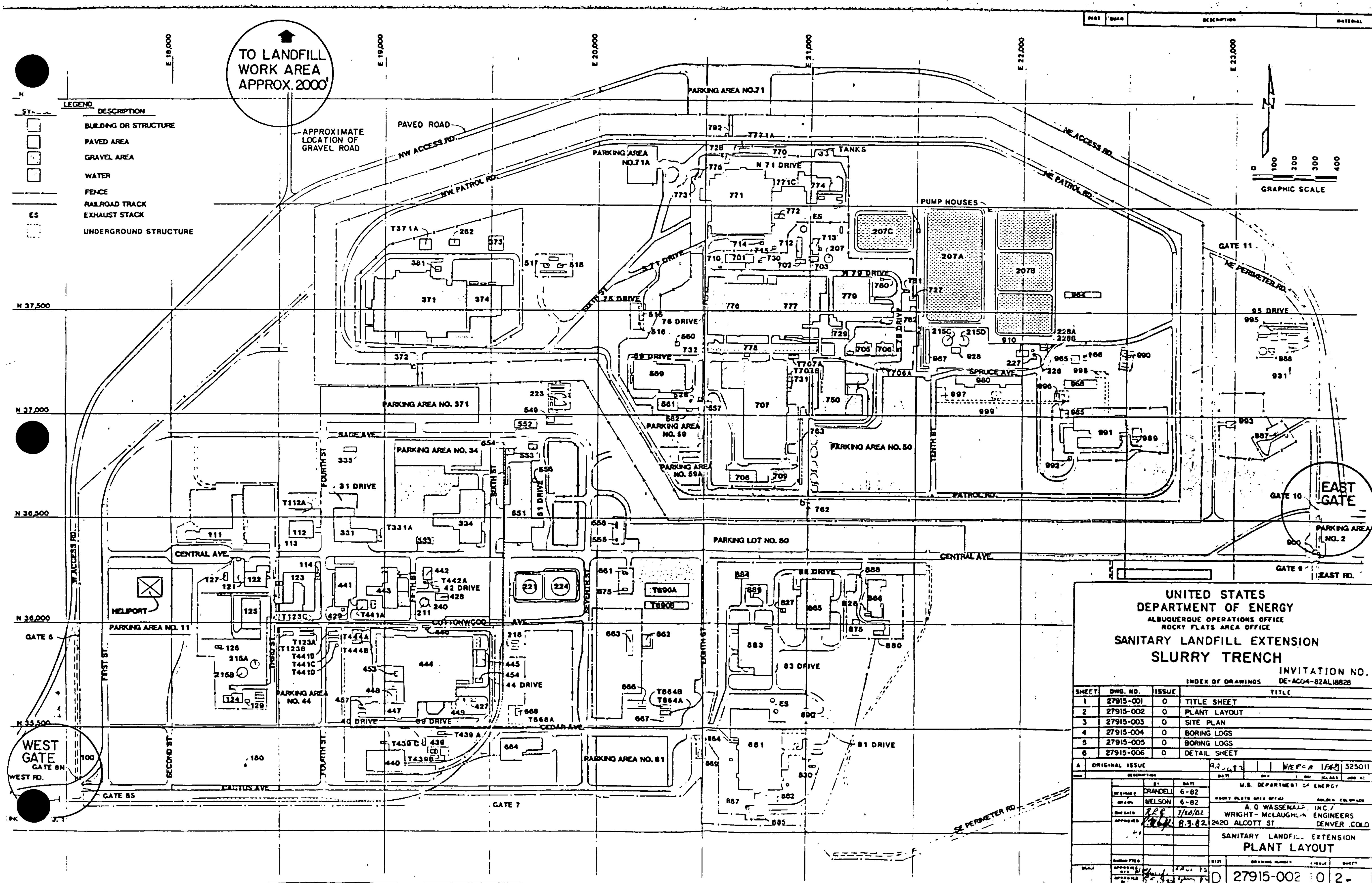
SCALE

U.S. DEPARTMENT OF ENERGY
ROCKY FLATS AREA OFFICE GOLDEN, COLORADO

A G WASSENAAR, INC./
WRIGHT-McLAUGHLIN ENGINEERS
2420 ALCOTT ST DENVER, COLO

SANITARY LANDFILL EXTENSION
TITLE SHEET

SIZE	DRAWING NUMBER	ISSUE	SHEET
D	27915-001	0	1 of 6



UNITED STATES
DEPARTMENT OF ENERGY
ALBUQUERQUE OPERATIONS OFFICE
ROCKY FLATS AREA OFFICE

SANITARY LANDFILL EXTENSION
SLURRY TRENCH

INVITATION NO. DE-AC04-82AL18828

INDEX OF DRAWINGS

SHEET	DWG. NO.	ISSUE	TITLE
1	27915-001	0	TITLE SHEET
2	27915-002	0	PLANT LAYOUT
3	27915-003	0	SITE PLAN
4	27915-004	0	BORING LOGS
5	27915-005	0	BORING LOGS
6	27915-006	0	DETAIL SHEET

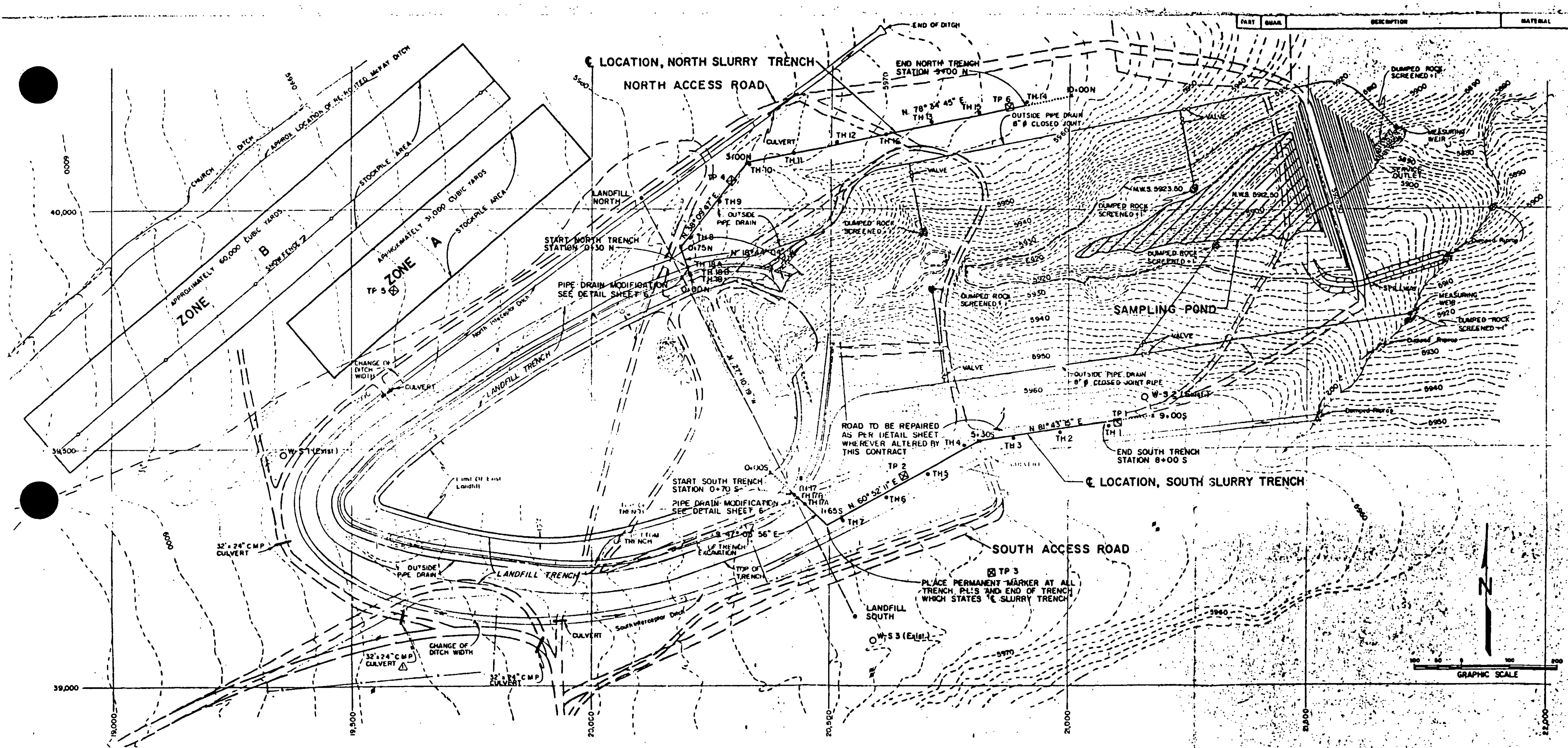
A ORIGINAL ISSUE 325011

	BY	DATE
DESIGNED	CRANDELL	6-82
DRAWN	NELSON	6-82
CHECKED		7/20/82
APPROVED		8-3-82

U.S. DEPARTMENT OF ENERGY
ROCKY FLATS AREA OFFICE GOLDEN, COLORADO
A. G. WASSENAAR, INC. / WRIGHT-McLAUGHLIN ENGINEERS
2420 ALCOTT ST DENVER, COLO

SANITARY LANDFILL EXTENSION
PLANT LAYOUT

D 27915-002 0 2



TEST HOLE COORDINATES

LOCATION	NORTH	EAST	ELEVATION
TH1	39545.5	21082.0	5986.4
TH2	39532.0	20981.5	5987.6
TH3	39519.0	20882.5	5969.6
TH4	39503.5	20781.5	5970.9
TH5	39444.5	20702.5	5972.3
TH6	39397.0	20615.5	5974.2
TH7	39348.5	20527.0	5976.3
TH8	39943.5	20201.5	5978.2
TH9	40018.0	20264.5	5976.4
TH10	40097.0	20326.0	5975.9
TH11	40126.0	20423.5	5974.5
TH12	40145.0	20510.5	5972.4
TH13	40184.0	20708.5	5968.7
TH14	40225.5	20909.5	5965.0
TH15	40203.5	20807.0	5966.9
TH16	40156.0	20617.5	5970.0
TH17	39400.0	20417.5	5974.7
TH17A	39393.5	20428.5	5975.7
TH17B	39400.0	20425.0	5974.5
TH18	39864.0	20202.5	5976.0
TH18A	39881.0	20197.0	5975.7
TH18B	39871.0	20200.0	5975.7

TEST PIT COORDINATES

LOCATION	NORTH	EAST	ELEVATION
TP 1	39554.0	21105.0	5966.2
TP 2	39442.5	20655.0	5972.3
TP 3	39238.0	20899.0	5970.3
TP 4	40061.0	20290.0	5976.9
TP 5	39835.0	19588.0	5997.7
TP 6	40216.0	20975.0	5966.3

STATION COORDINATES

STATION	NORTH	EAST
STA 0+30N	39857.75	20416.45
STA 0+75N	39925.78	20182.34
STA 5+00N	40103.69	20521.37
STA 10+00N	40259.50	21007.51
STA 0+00S	39448.88	20572.68
STA 1+65S	39336.49	20495.48
STA 5+30S	39514.17	20812.31
STA 9+00S	39567.45	21178.40

BENCH MARK COORDINATES

	NORTH	EAST	ELEVATION
LANDFILL NORTH	40020.76	20101.93	5979.62
LANDFILL SOUTH	39140.55	20553.75	5976.57

NOTES:

"LANDFILL NORTH" IS A #3 REBAR THAT PROJECTS 3" ABOVE THE GROUND, ON THE NORTH SIDE OF THE LANDFILL, 293' SOUTHWEST OF A CULVERT FOR THE NORTH INTERCEPTOR DITCH, ON THE MIDDLE OF THE BERM BETWEEN ROAD AND DITCH, 18' SOUTHEAST OF CENTER OF ROAD, 12' NORTHWEST OF CENTER OF DITCH.

"LANDFILL SOUTH" IS A #3 REBAR THAT PROJECTS 1" ABOVE THE GROUND, ON THE SOUTH SIDE OF THE LANDFILL, 121.5' SOUTH SOUTHEAST OF THE CENTER OF THE ROAD, 115.0' NORTH NORTHWEST OF THE NORTH POLE OF A DOUBLE POWER LINE POLE, IN RANGE WITH THE WEST EDGE OF NORTH POLE AND THE HIGHEST STACK OF THE 700 COMPLEX.

NOTES:

EXISTING SITE CONDITIONS SHOWN AS LIGHT BACKGROUND
TOPOGRAPHIC ELEVATIONS ARE ONLY APPROXIMATE
● TH 1 TEST HOLE
⊠ TP 1 TEST PIT
○ W-S1 GROUNDWATER MONITORING HOLE
········ COMPLETION OF ORIGINAL SURVEY LINE

ISSUE	DESCRIPTION	DATE		DOE	SCALE	JOB NO.
0	ORIGINAL ISSUE	9 Aug 82		RCB		325011

		BY	DATE
TOLERANCES FRACT. ± ANGLE ± DEC. ± UNLESS NOTED OTHERWISE	DESIGNED	CESARE	6-82
	DRAWN	FRAGUA	6-82
	CHECKED	RPB	7/28/82
	APPROVED	[illegible]	8-5-82
REMOVE BURRS AND SHARP EDGES			
NEXT ASSEMBLY			
DOE CONT. NO.	SUBMITTED		
	APPROVED RFP	[illegible]	4 Aug 82
SCALE 1" = 100'	APPROVED DOE	[illegible]	[illegible]

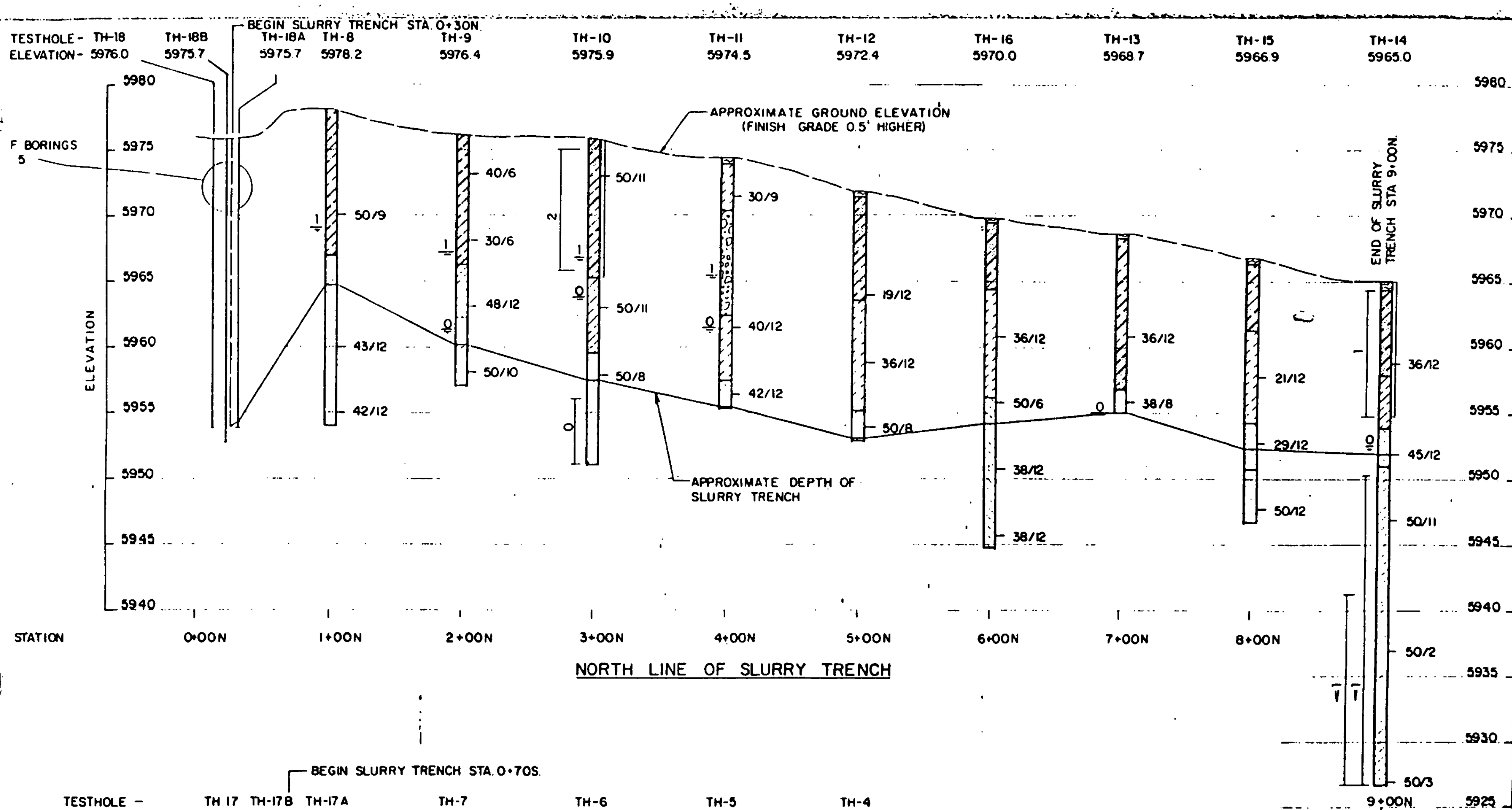
U.S. DEPARTMENT OF ENERGY
ROCKY FLATS AREA OFFICE — GOLDEN, COLORADO

A G WASSENAAR, INC / WRIGHT-McLAUGHLIN ENGINEERS
2420 ALCOTT ST — DENVER, COLO

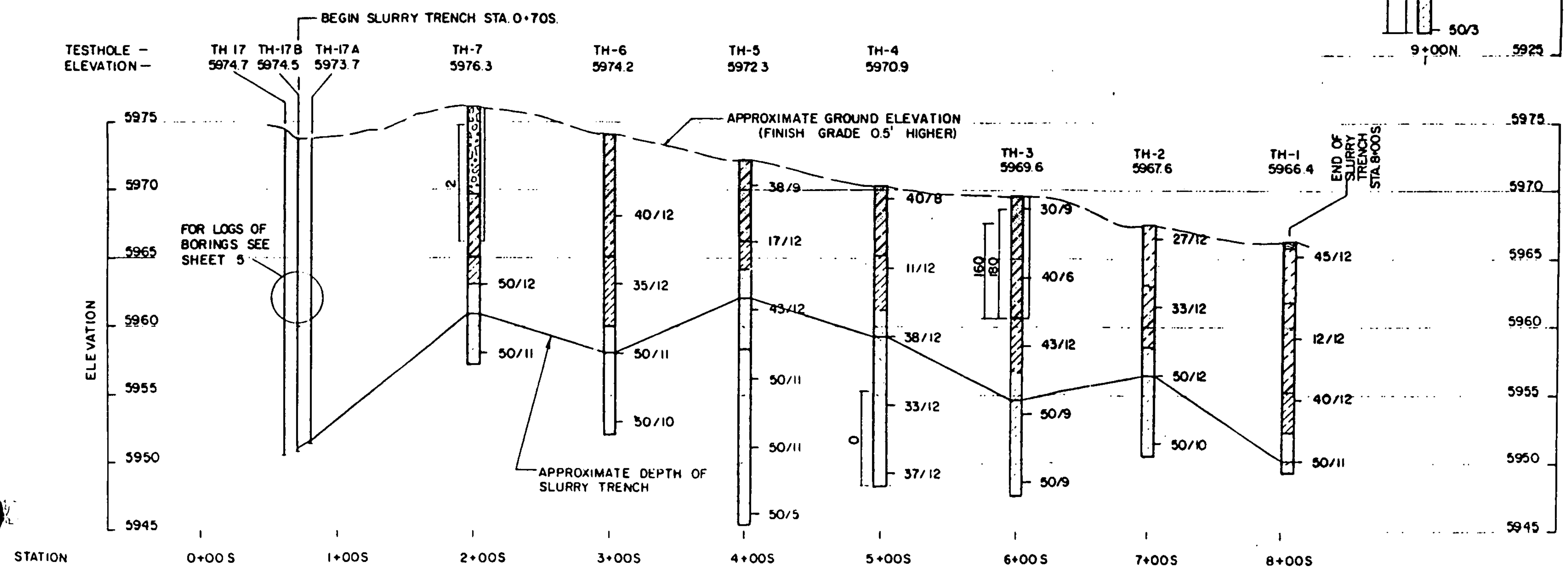
SANITARY LANDFILL EXTENSION

SITE PLAN

SIZE	DRAWING NUMBER	ISSUE	SHEET
D	27915-003	0	3 of



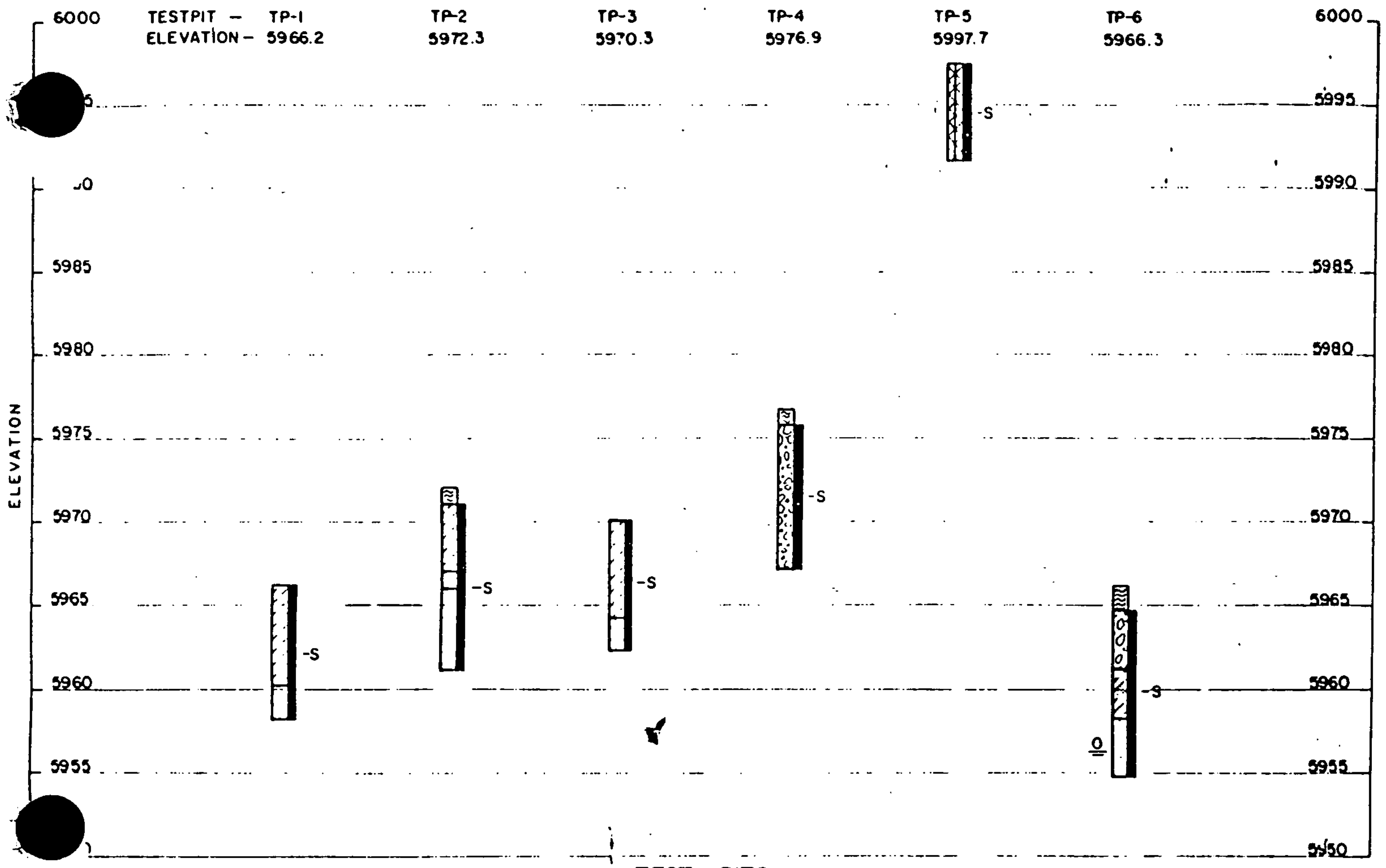
NORTH LINE OF SLURRY TRENCH



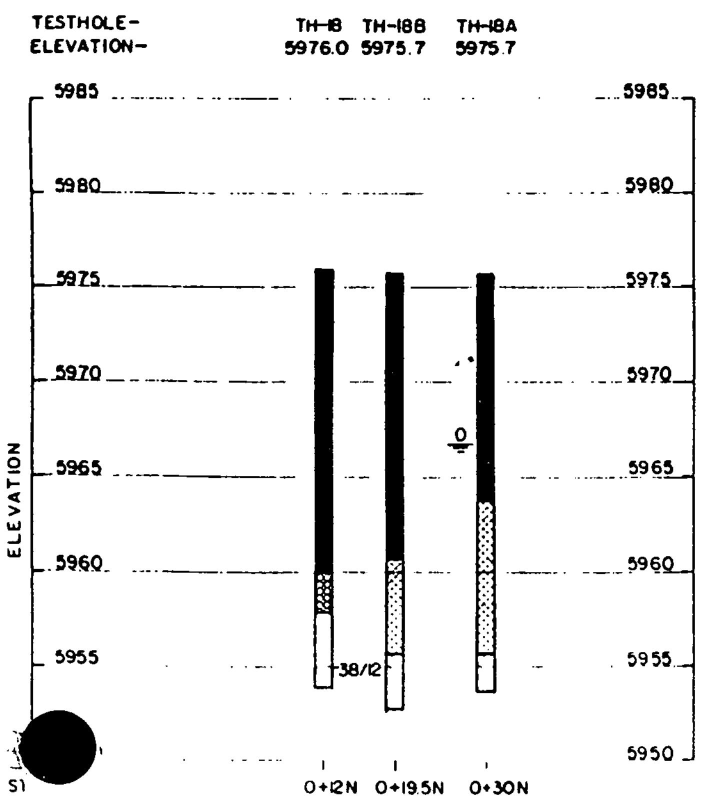
SOUTH LINE OF SLURRY TRENCH

NOTE:
LEGEND ON SHEET 5

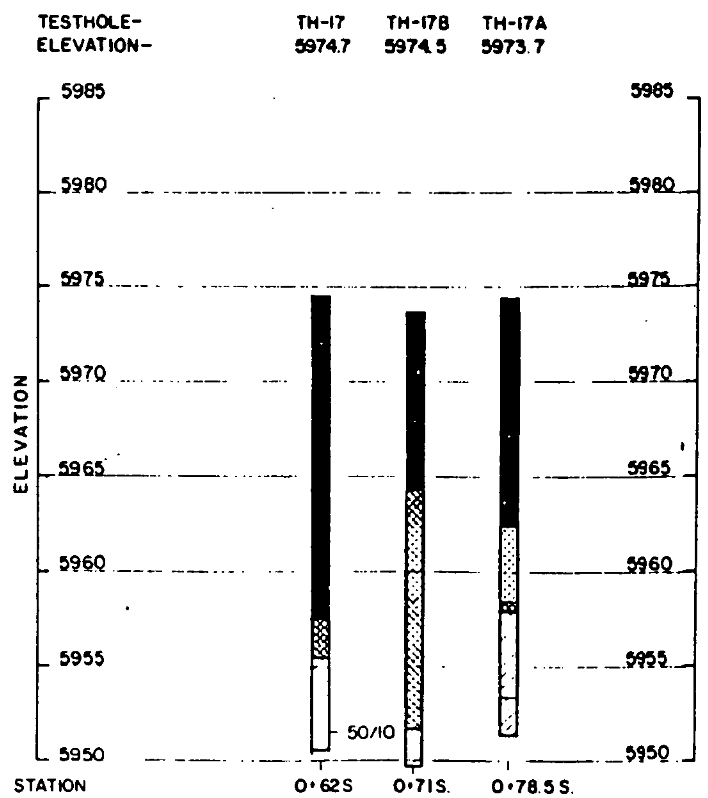
0	ORIGINAL ISSUE		[illegible]	325011
DESIGNED	CESARE	6-82	U.S. DEPARTMENT OF ENERGY, ROCKY FLATS AREA OFFICE	
DRAWN	FRAGUA	6-82	A. G. WASSENAAR, INC / WRIGHT-McLAUGHLIN ENGINEERS, 2420 ALCOTT ST, DENVER, COLO	
CHECKED	[illegible]	7/28/82	SANITARY LANDFILL EXTENSION	
APPROVED	[illegible]	8-3-82	BORING LOGS	
SCALE N/A			D 27915-004	ISSUE 0, SHEET 4



TEST PITS



NORTH TIE IN LINE



SOUTH TIE IN LINE

LEGEND:

- TOPSOIL — ORGANIC, SANDY TO VERY SANDY, SILTY TO VERY SILTY, SOME GRAVELLS AND COBBLES, DRY TO MOIST, BROWN TO DARK BROWN (OL, CL, GC).
- FILL — CLAY, SANDY TO VERY SANDY, GRAVELLY, SLIGHTLY SILTY, OCCASIONAL COBBLES AND BOULDERS, MOIST, RED-BROWN (CL, CL-CH, ZONE A BORROW AREA)
- LANDFILL DEBRIS — SANDY, CLAYEY, SILTY, WITH WOOD, BRICK, GLASS, METAL AND GENERAL CONSTRUCTION DEBRIS, GENERALLY UNCONSOLIDATED (AF).
- FILL — CLAYEY, SLIGHTLY SILTY, SLIGHTLY SANDY, SOFT TO MEDIUM STIFF, MOIST TO WET, BROWN TO GRAY (CL) (PROBABLE LINER MATERIAL FOR EXISTING LANDFILL TRENCH SECTION).
- CLAY — ARKOSIC, VERY STIFF, SILTY, SANDY TO VERY SANDY WITH SAND LENSES, GRAVELLY WITH OCCASIONAL GRAVEL LENSES, OCCASIONAL COBBLES AND BOULDERS, CALCAREOUS, DRY TO MOIST, REDDISH BROWN TO DARK BROWN (CL, CL-SC, GC) (ROCKY FLATS ALLUVIUM, HIGHLY WEATHERED)
- SAND — ARKOSIC, MEDIUM DENSE TO VERY DENSE, SILTY TO VERY SILTY, SLIGHTLY TO VERY CLAYEY WITH SANDY CLAY LENSES, GRAVELLY WITH GRAVEL LENSES, OCCASIONAL COBBLES AND BOULDERS, CALCAREOUS, MOIST TO WET, TAN TO BROWN TO OLIVE (SP, SM-SC, SC) (ROCKY FLATS ALLUVIUM, HIGHLY WEATHERED)
- GRAVEL — VERY DENSE, SANDY TO VERY SANDY, CLAYEY, DRY TO MOIST, GRAY TO BROWN (GC, GC-GP) (ROCKY FLATS ALLUVIUM, HIGHLY WEATHERED)
- GRAVEL — DENSE, SANDY, CLAYEY, GRAY, APPROXIMATELY 1/2" TO 1" DIAMETER (GM-GP) (PROBABLE LINER MATERIAL FOR LANDFILL TRENCH SECTION)
- CLAY — ARKOSIC, VERY STIFF, SANDY WITH CLAYEY SAND LENSES, SILTY TO VERY SILTY, MOIST TO WET, GRAY TO GOLD TO OLIVE (CH, CL, SC-SM) (ARAPAHOE FORMATION, WEATHERED)
- CLAYSTONE — HARD TO VERY HARD, WITH OCCASIONAL SANDSTONE AND SILTSTONE LENSES, SOME MINOR LIGNITE, MOIST TO WET, GRAY TO BROWN (ARAPAHOE FORMATION)
- CLAYSTONE — MEDIUM HARD, SANDY WITH OCCASIONAL SANDSTONE AND SILTSTONE LENSES, MOIST, OLIVE TO BROWN TO GOLD, ARKOSIC IN UPPER PORTION (ARAPAHOE FORMATION)
- 50/9 — INDICATES THAT 50 BLOWS OF A 140 LB. WEIGHT IS NEEDED TO DRIVE A 2 INCH SAMPLER 9 INCHES
- — INDICATES A GRADUAL CHANGE IN MATERIALS
- 8 — INDICATES LARGE BULK SAMPLE OF MATERIAL TAKEN FROM DESIGNATED INTERVAL
- 2 — INDICATES AVERAGE COEFFICIENT OF PERMEABILITY OF 2 FEET PER YEAR FOR DESIGNATED INTERVAL AS DETERMINED BY A FALLING HEAD OR CONSTANT HEAD PERMEABILITY TEST. DETAILS OF TEST RESULTS ARE PRESENTED IN THE CONTRACT DOCUMENTS.
- -S — DEPTH AND EXTENT OF BULK SAMPLE
- — DEPTH AND EXTENT OF 2-INCH DIAMETER PVC PIEZOMETER

ISSUE	DESCRIPTION	DATE		DOE	CLASS	JOB NO
0	ORIGINAL ISSUE	9 Aug '82		WN PCB		325011

TOLERANCES		BY	DATE
FRACT. ±	DESIGNED	CESARE	6-82
ANGLE ±	DRAWN	FRAGUA	6-82
DEC. ±	CHECKED		7/20/82
UNLESS NOTED OTHERWISE	APPROVED		8.3.82
REMOVE BURRS AND SHARP EDGES			
NEXT ASSEMBLY			
DOE CONT. NO	SUBMITTED		
	APPROVED RFP		
SCALE N/A	APPROVED DOE		

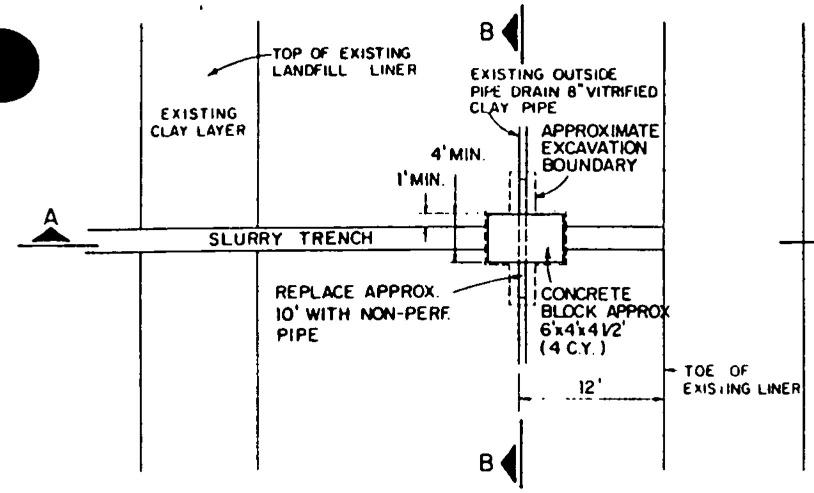
U.S. DEPARTMENT OF ENERGY
ROCKY FLATS AREA OFFICE GOLDEN COLORADO

A G WASSENAAR, INC /
WRIGHT - McLAUGHLIN ENGINEERS
2420 ALCOTT ST DENVER, COLO

SANITARY LANDFILL EXTENSION

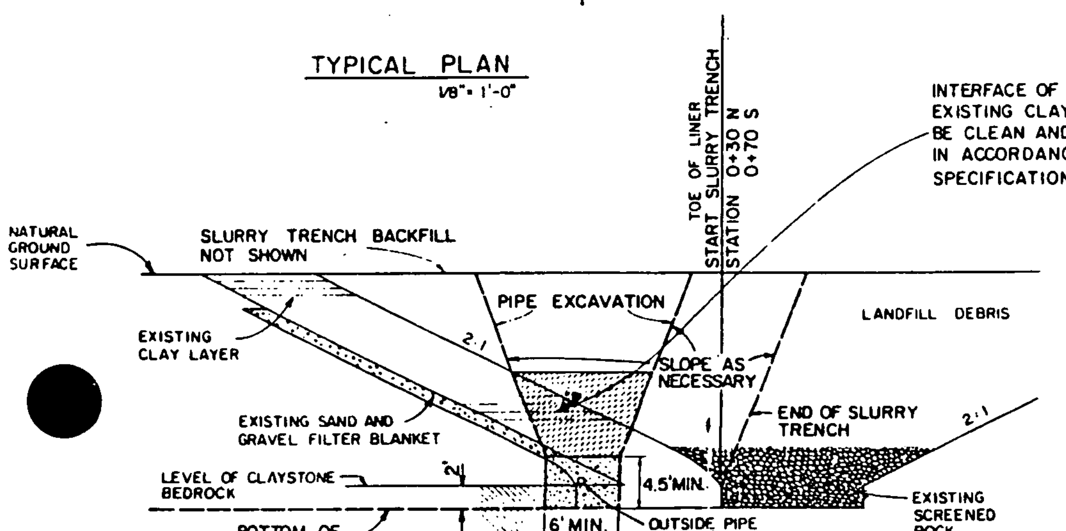
BORING LOGS

SIZE	DRAWING NUMBER	ISSUE	SHEET
D	27915-005	0	5 of



TYPICAL PLAN

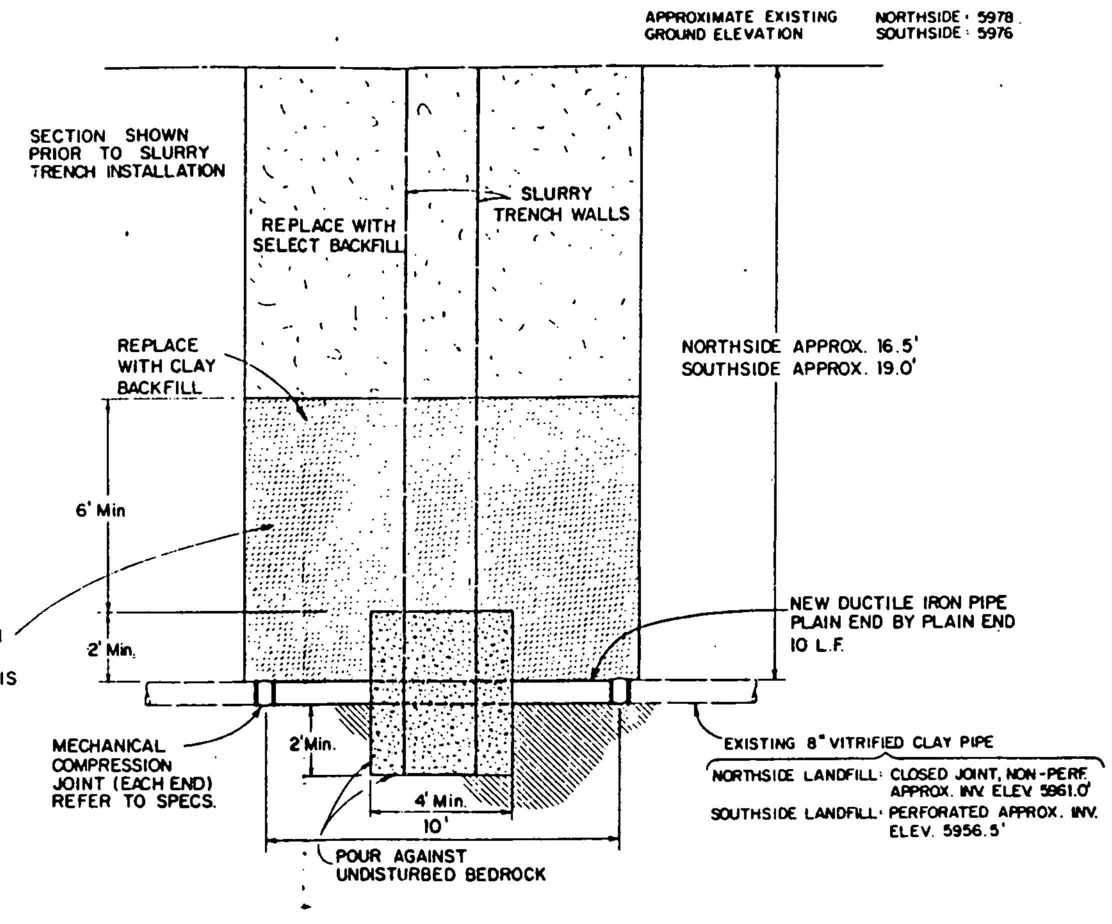
1/8" = 1'-0"



SECTION A-A

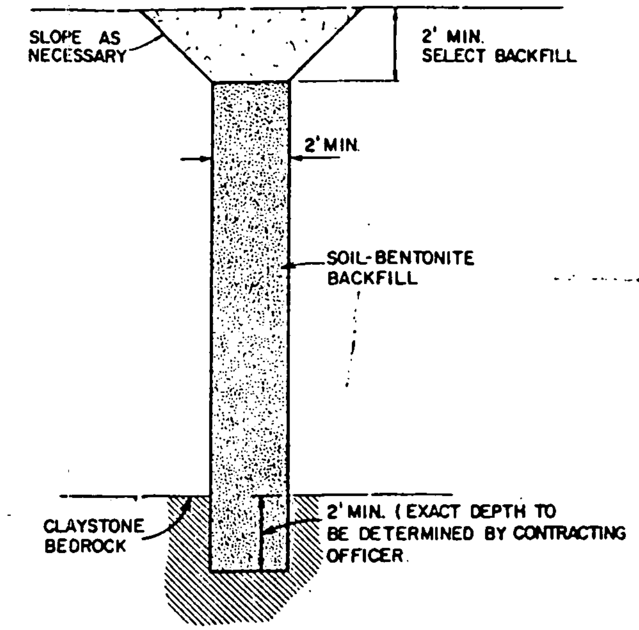
DRAIN PIPE - SLURRY TRENCH INTERSECTION

1/8" = 1'-0" (TYPICAL DETAIL TWO LOCATIONS)



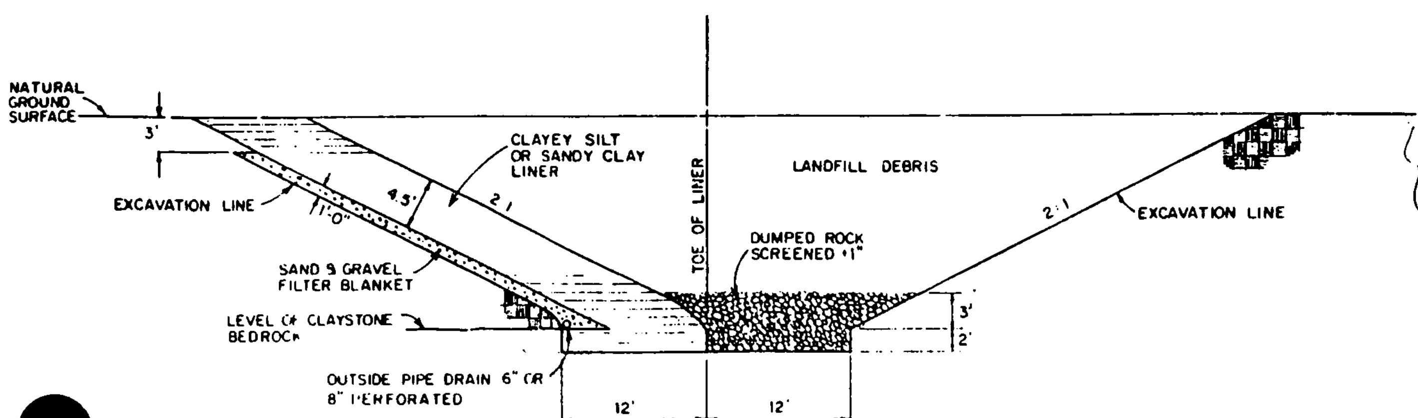
DRAIN PIPE REPLACEMENT SECTION B-B

3/8" = 1'-0"



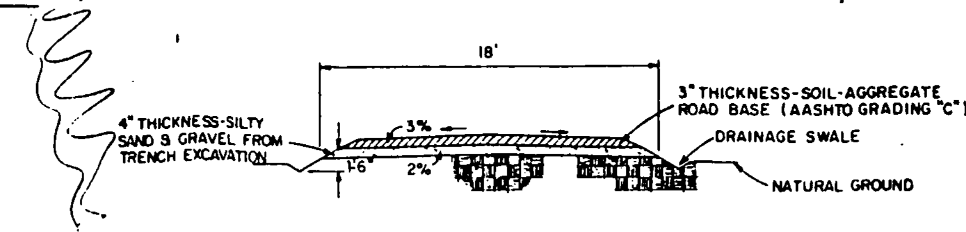
TYPICAL SLURRY TRENCH DETAIL

NOT TO SCALE



TYPICAL EXISTING LANDFILL LINER SECTION

1/8" = 1'-0"



TYPICAL SECTION ACCESS ROAD REPAIR

1" = 5'

NOTE:
—— PEN SIZE INDICATES EXISTING
—— PEN SIZE INDICATES NEW

PART	QUAN.	DESCRIPTION	MATERIAL

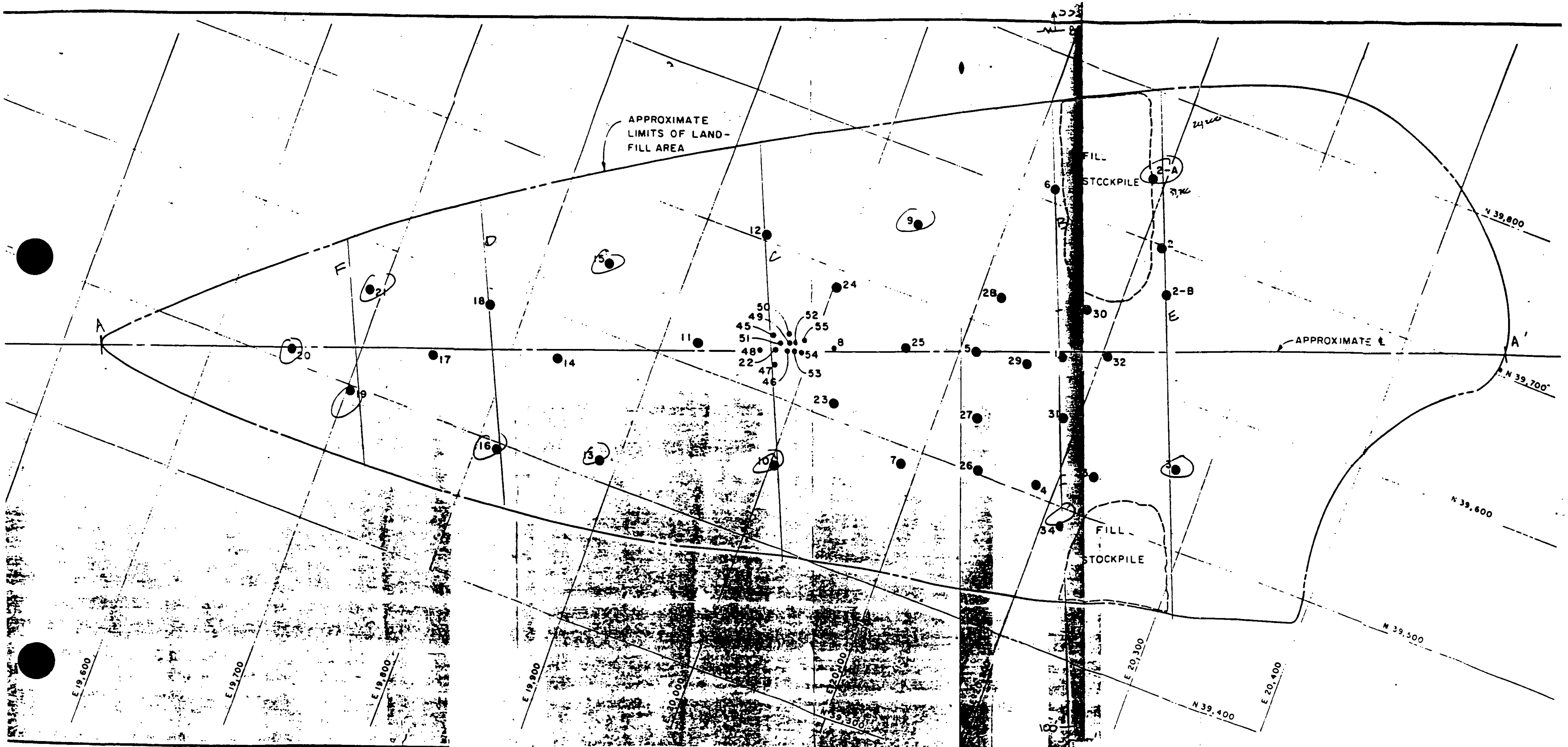
ISSUE	DESCRIPTION	DATE			DOE	CLASS.	JOB NO.
0	ORIGINAL ISSUE	9 Aug 82			RCB		325011

		BY	DATE
TOLERANCES FRACT. ANGLE DEC. UNLESS NOTED OTHERWISE	DESIGNED	CRANDELL	6-82
	DRAWN	FRAGUA	6-82
	CHECKED		7/28/82
	APPROVED		8-3-82

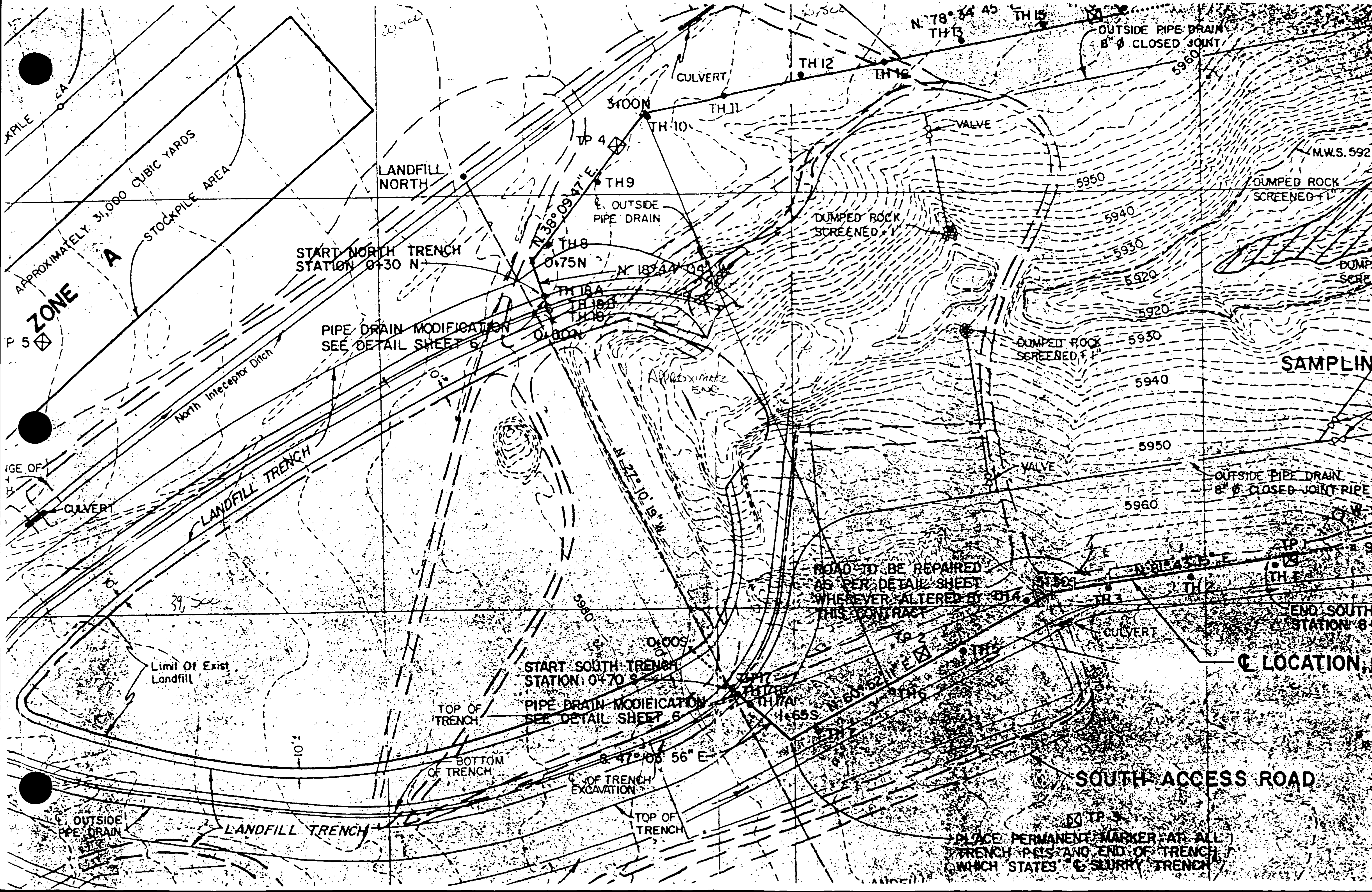
U.S. DEPARTMENT OF ENERGY
ROCKY FLATS AREA OFFICE GOLDEN, COLORADO
A G WASSENAAR, INC / WRIGHT - McLAUGHLIN ENGINEERS
2420 ALCOTT ST DENVER, COLO
SANITARY LANDFILL EXTENSION
DETAIL SHEET

REMOVE BURRS AND SHARP EDGES
NEXT ASSEMBLY
DOE CONT. NO.
SCALE SEE DETAIL
SUBMITTED / APPROVED / APPROVED DOE

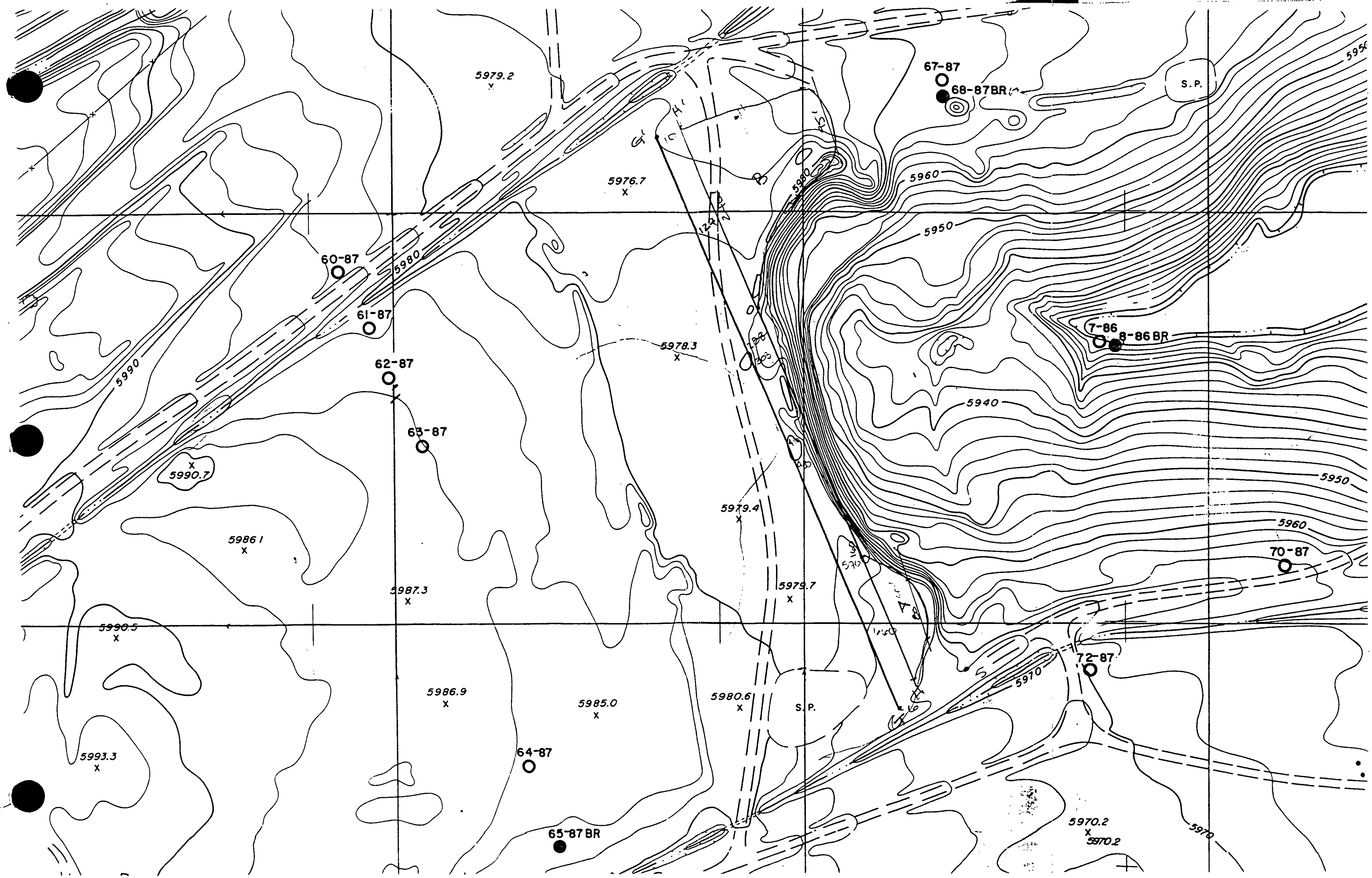
SIZE	DRAWING NUMBER	ISSUE	SHEET
D	27915-006	0	6 of

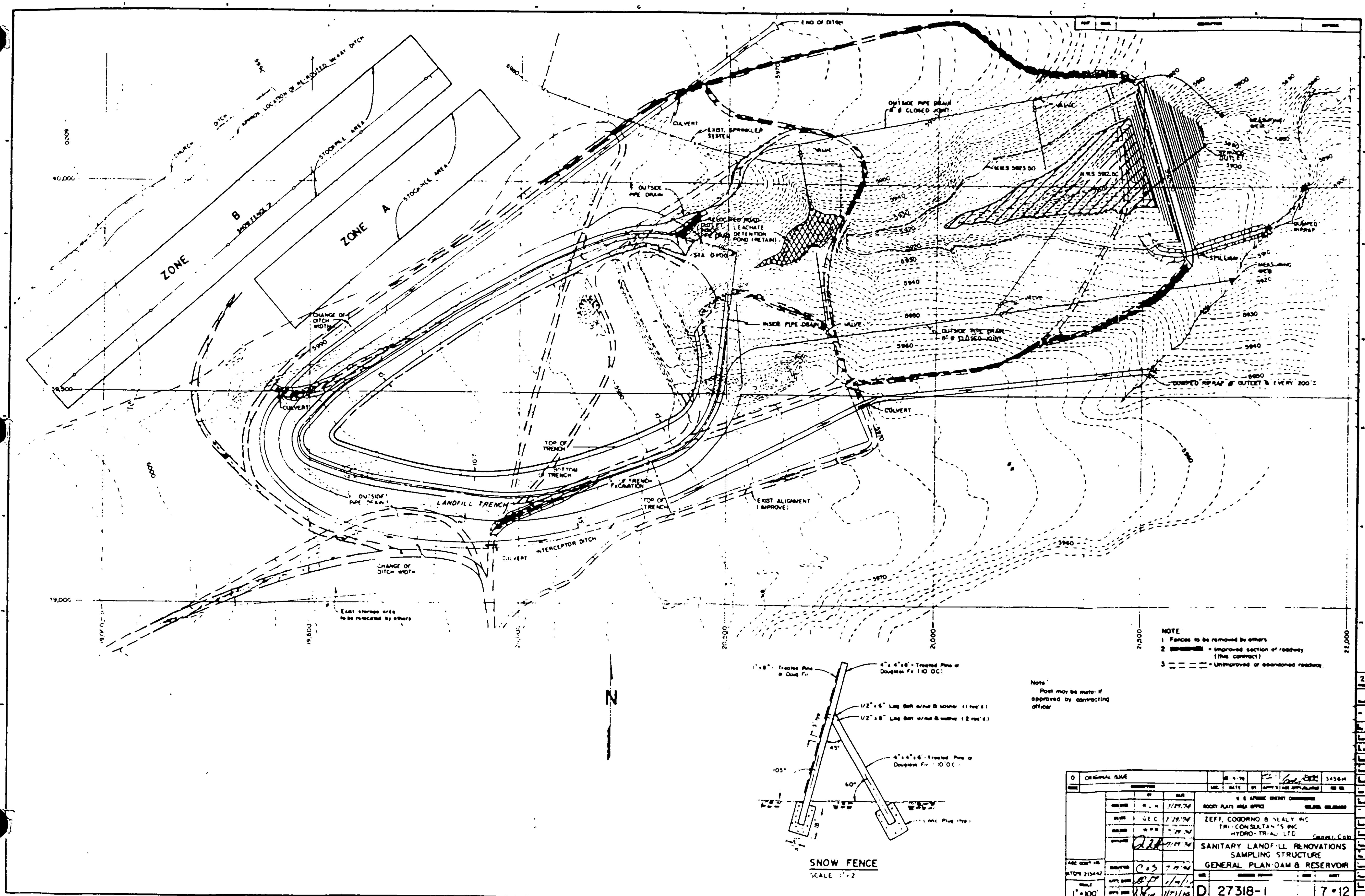


APPROXIMATE LIMITS OF LAND-FILL AREA
FILL STOCKPILE
FILL STOCKPILE
APPROXIMATE ℄
A
A'
N 39,800
N 39,700
N 39,600
N 39,500
N 39,400
N 39,300
E 19,600
E 19,700
E 19,800
E 19,900
E 20,300
E 20,400

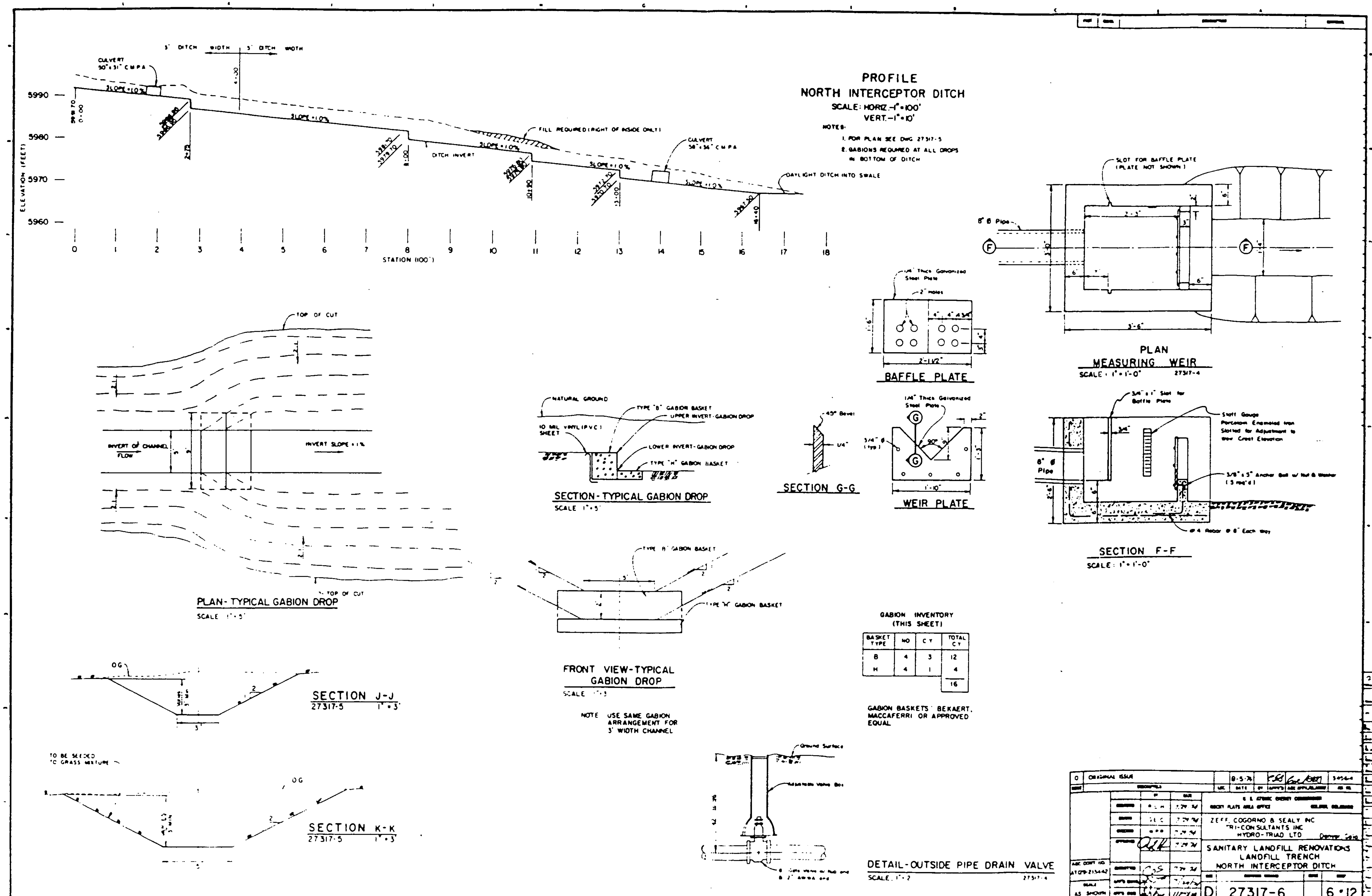


ZONE A
APPROXIMATELY 31,000 CUBIC YARDS
STOCKPILE AREA
TP 5
TP 4
LANDFILL NORTH
N 38° 09' 47" E.
TH9
℄ OUTSIDE PIPE DRAIN
TH 8
0+75N
START NORTH TRENCH STATION 0+30 N
TH 18A
TH 18B
TH 18
0+00N
PIPE DRAIN MODIFICATION SEE DETAIL SHEET 6
North Inteceptor Ditch
LANDFILL TRENCH
CULVERT
3+00N
TH 10
TH 11
TH 12
TH 13
TH 15
TH 16
N 78° 34' 45"
OUTSIDE PIPE DRAIN 8" Ø CLOSED JOINT
VALVE
M.W.S. 5923.
DUMPED ROCK SCREENED 1"
5960
5950
5940
5930
5920
SAMPLING
N 27° 10' 19" W
N 18° 44' 04"
Approximate End
OUTSIDE PIPE DRAIN 8" Ø CLOSED JOINT PIPE
ROAD TO BE REPAIRED AS PER DETAIL SHEET WHEREVER ALTERED BY THIS CONTRACT
N 81° 43' 15" E
TH 2
TH 3
TH 1
TP 1
END SOUTH STATION 8+
CULVERT
℄ LOCATION
0+00S
START SOUTH TRENCH STATION 0+70 S
PIPE DRAIN MODIFICATION SEE DETAIL SHEET 6
TH 17
TH 17B
TH 17A
1+65S
N 60° 52'
TH 6
TH 5
TH 7
TP 2
Limit Of Exist Landfill
TOP OF TRENCH
BOTTOM OF TRENCH
S 47° 05' 56" E
℄ OF TRENCH EXCAVATION
TOP OF TRENCH
℄ OUTSIDE PIPE DRAIN
LANDFILL TRENCH
SOUTH ACCESS ROAD
TP 3
PLACE PERMANENT MARKER AT ALL TRENCH PI'S AND END OF TRENCH WHICH STATES ℄ SLURRY TRENCH


5979.2
5976.7
60-87
5980
61-87
62-87
63-87
5990
5990.7
5986.1
5987.3
5990.5
5993.3
5986.9
5985.0
64-87
65-87 BR
5978.3
5979.4
5979.7
5980.6
S.P.
67-87
68-87 BR
S.P.
5960
5950
7-86
8-86 BR
5940
5950
5960
70-87
72-87
5970
5970.2
5970



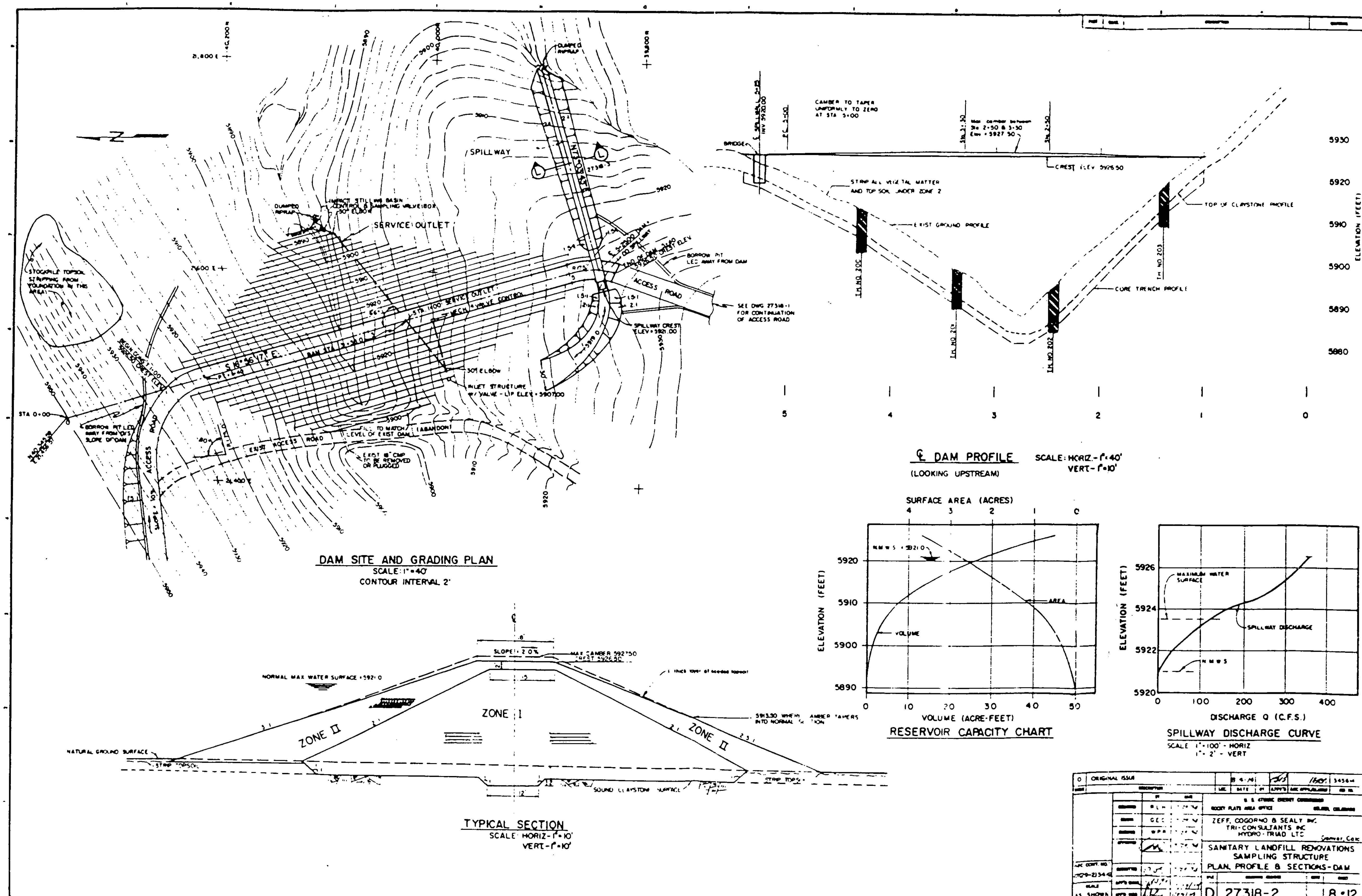
ZONE B
ZONE A
STOCKPILE AREA
LANDFILL TRENCH
INTERCEPTOR DITCH
CULVERT
END OF DITCH
EXIST. SPRINKLER SYSTEM
OUTSIDE PIPE DRAIN 8" Ø CLOSED JOINT
INSIDE PIPE DRAIN
VALVE
SPILLWAY
OUTLET
MEASURING WEIR
DUMPED RIPRAP
DUMPED RIPRAP @ OUTLET & EVERY 200'±
TOP OF TRENCH
BOTTOM OF TRENCH
EXIST ALIGNMENT (IMPROVE)
CHANGE OF DITCH WIDTH
Exist. storage area to be relocated by others
NOTE
1. Fences to be removed by others
2. = Improved section of roadway (this contract)
3. = Unimproved or abandoned roadway
Note: Post may be metal if approved by contracting officer
SNOW FENCE
SCALE 1"=2'
ZEFF, COGORNO & SEALY INC
TRI-CONSULTANTS INC
HYDRO-TRIAD LTD
SANITARY LANDFILL RENOVATIONS
SAMPLING STRUCTURE
GENERAL PLAN-DAM & RESERVOIR
U.S. ATOMIC ENERGY COMMISSION
ROCKY FLATS AREA OFFICE
1"=100'
D 27318-1
7-12
219



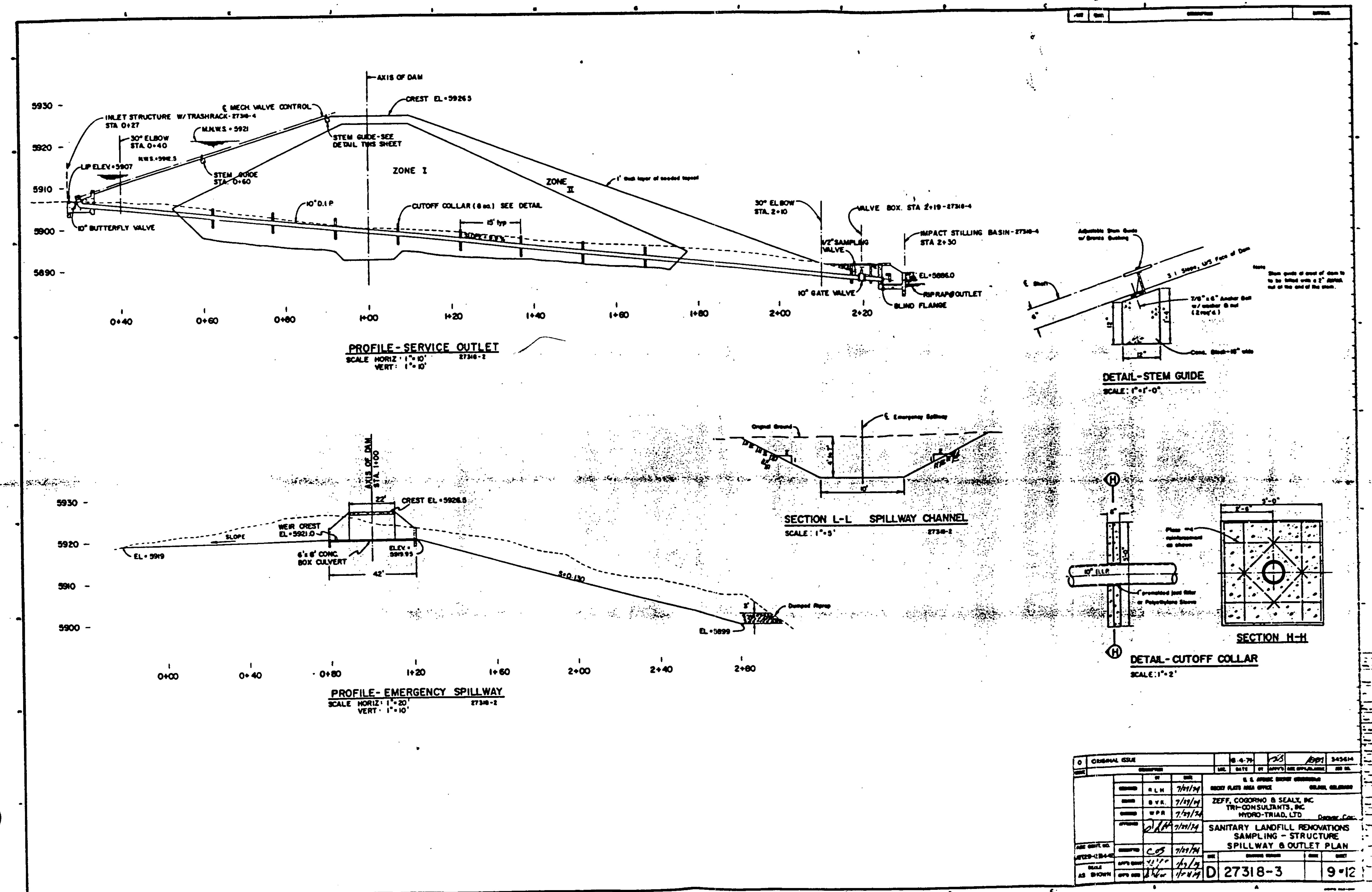
GABION INVENTORY (THIS SHEET)

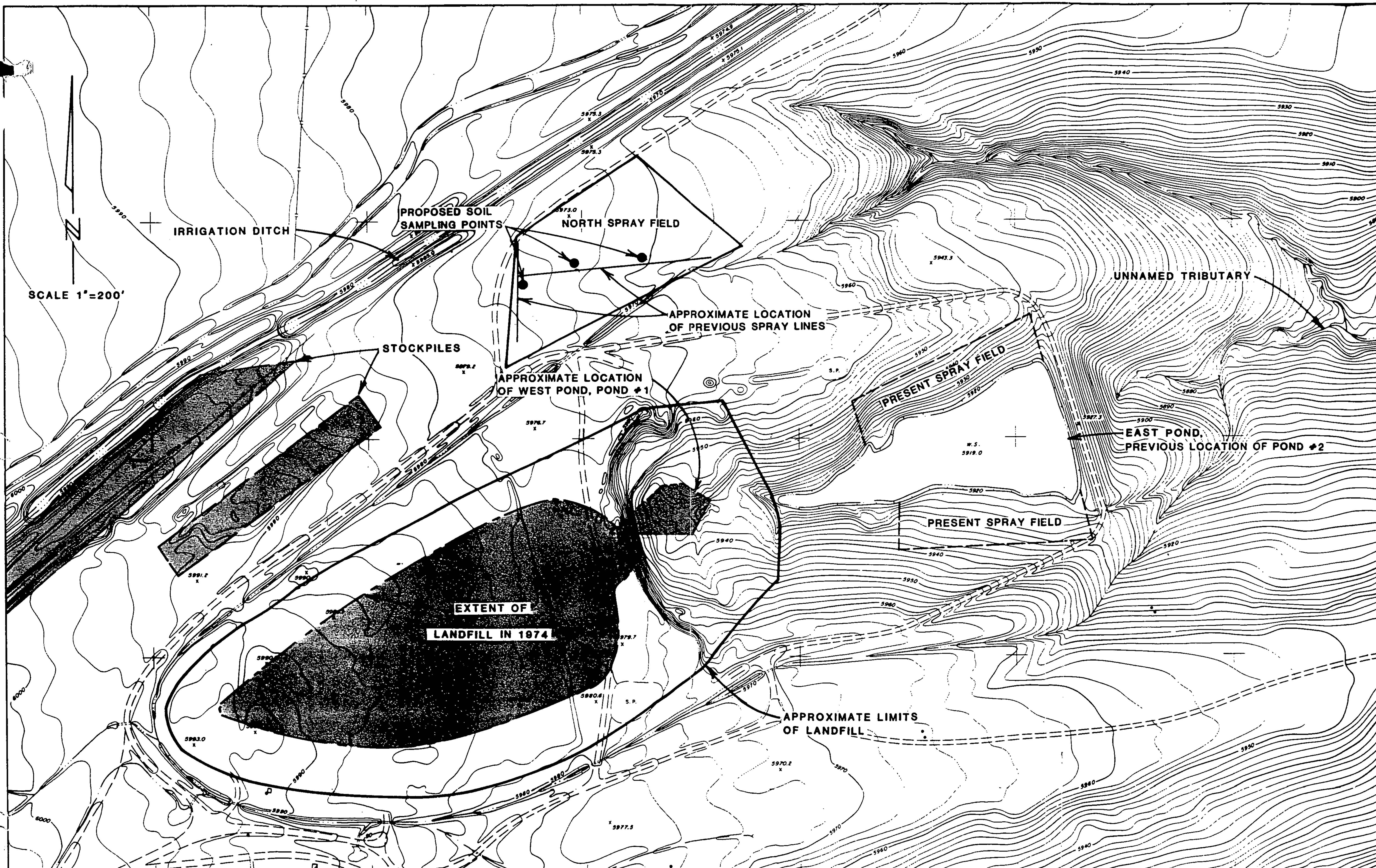
BASKET TYPE	NO	C.Y.	TOTAL C.Y.
B	4	3	12
H	4	1	4
			16

GABION BASKETS: BEKAERT, MACCAFERRI OR APPROVED EQUAL



DAM SITE AND GRADING PLAN
SCALE: 1" = 40'
CONTOUR INTERVAL 2'
SPILLWAY
SERVICE OUTLET
STOCKPILE TOPSOIL STRIPPING FROM FOUNDATION IN THIS AREA
ACCESS ROAD
EXIST ACCESS ROAD
BORROW PIT LED AWAY FROM DAM
INLET STRUCTURE W/ VALVE - LIP ELEV = 5907.00
SPILLWAY CREST ELEV = 5921.00
SEE DWG 27318-1 FOR CONTINUATION OF ACCESS ROAD
STA 0+00
℄ DAM PROFILE
SCALE: HORIZ - 1" = 40'
VERT - 1" = 10'
(LOOKING UPSTREAM)
CREST ELEV 5926.50
STRIP ALL VEGETAL MATTER AND TOP SOIL UNDER ZONE 2
EXIST GROUND PROFILE
TOP OF CLAYSTONE PROFILE
CORE TRENCH PROFILE
ELEVATION (FEET)
RESERVOIR CAPACITY CHART
SURFACE AREA (ACRES)
VOLUME (ACRE-FEET)
VOLUME
AREA
N.M.W.S. = 5921.0
SPILLWAY DISCHARGE CURVE
SCALE 1" = 100' - HORIZ
1" = 2' - VERT
DISCHARGE Q (C.F.S.)
MAXIMUM WATER SURFACE
SPILLWAY DISCHARGE
N.M.W.S.
TYPICAL SECTION
SCALE: HORIZ - 1" = 10'
VERT - 1" = 10'
NORMAL MAX WATER SURFACE = 5921.0
NATURAL GROUND SURFACE
STRIP TOPSOIL
SOUND CLAYSTONE SURFACE
ZONE I
ZONE II
MAX CAMBER 5927.50
CREST 5926.50
0 ORIGINAL ISSUE
ZEFF, COGORNO & SEALY INC.
TRI-CONSULTANTS INC.
HYDRO-TRIAD LTD.
Denver, Colo.
SANITARY LANDFILL RENOVATIONS
SAMPLING STRUCTURE
PLAN, PROFILE & SECTIONS - DAM
AS SHOWN
D 27318-2
8-12

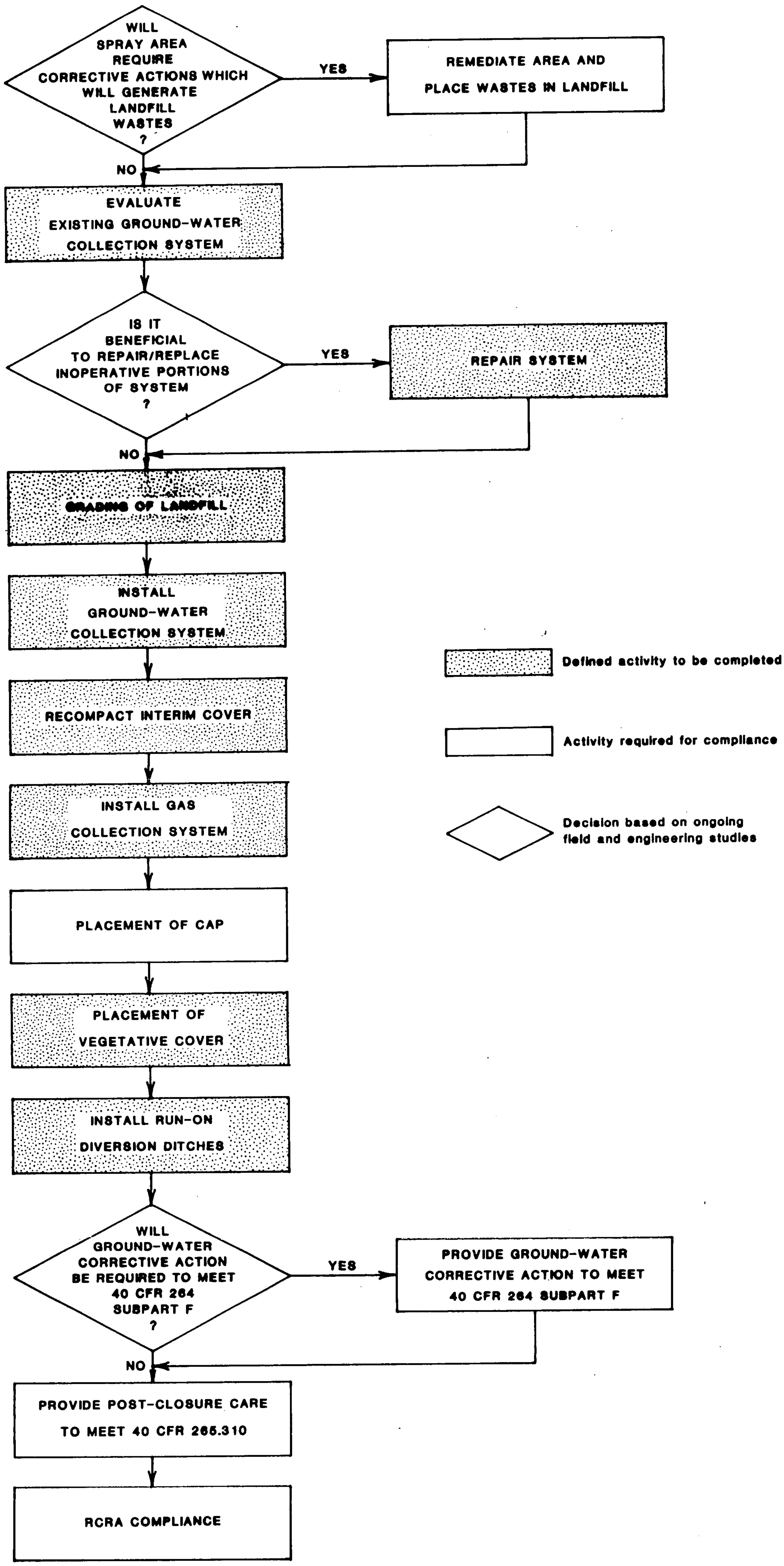

AXIS OF DAM
CREST EL = 5926.5
℄ MECH. VALVE CONTROL
INLET STRUCTURE W/ TRASHRACK - 27318-4
STA 0+27
M.N.W.S. = 5921
30° ELBOW
STA. 0+40
STEM GUIDE - SEE DETAIL THIS SHEET
LIP ELEV. = 5907
STEM GUIDE
STA. 0+60
ZONE I
ZONE II
10" D.I.P.
CUTOFF COLLAR (6 ea.) SEE DETAIL
15' typ
10" BUTTERFLY VALVE
30° ELBOW
STA. 2+10
VALVE BOX. STA 2+19 - 27318-4
1/2" SAMPLING VALVE
IMPACT STILLING BASIN - 27318-4
STA 2+30
EL = 5886.0
10" GATE VALVE
RIPRAP @ OUTLET
BLIND FLANGE
5930
5920
5910
5900
5890
0+40
0+60
0+80
1+00
1+20
1+40
1+60
1+80
2+00
2+20
PROFILE - SERVICE OUTLET
SCALE HORIZ: 1" = 10'
VERT: 1" = 10'
27318-2
DETAIL - STEM GUIDE
SCALE: 1" = 1'-0"
Original Ground
℄ Emergency Spillway
SECTION L-L SPILLWAY CHANNEL
SCALE: 1" = 5'
27318-2
AXIS OF DAM
STA. 1+00
CREST EL = 5926.5
22'
WEIR CREST
EL = 5921.0
SLOPE
EL = 5919
6' x 8' CONC. BOX CULVERT
ELEV = 5919.93
42'
S = 0.130
Dumped Riprap
EL = 5899
0+00
0+40
0+80
1+20
1+60
2+00
2+40
2+80
PROFILE - EMERGENCY SPILLWAY
SCALE HORIZ: 1" = 20'
VERT: 1" = 10'
27318-2
10" D.I.P.
SECTION H-H
DETAIL - CUTOFF COLLAR
SCALE: 1" = 2'
0 ORIGINAL ISSUE
ZEFF, COGORNO & SEALY, INC
TRI-CONSULTANTS, INC
HYDRO-TRIAD, LTD
Denver, Colo.
SANITARY LANDFILL RENOVATIONS
SAMPLING - STRUCTURE
SPILLWAY & OUTLET PLAN
AS SHOWN
D 27318-3
9 - 12



6 032 88	Chen & Associates	PRESENT LANDFILL SITE MAP	Fig. 2

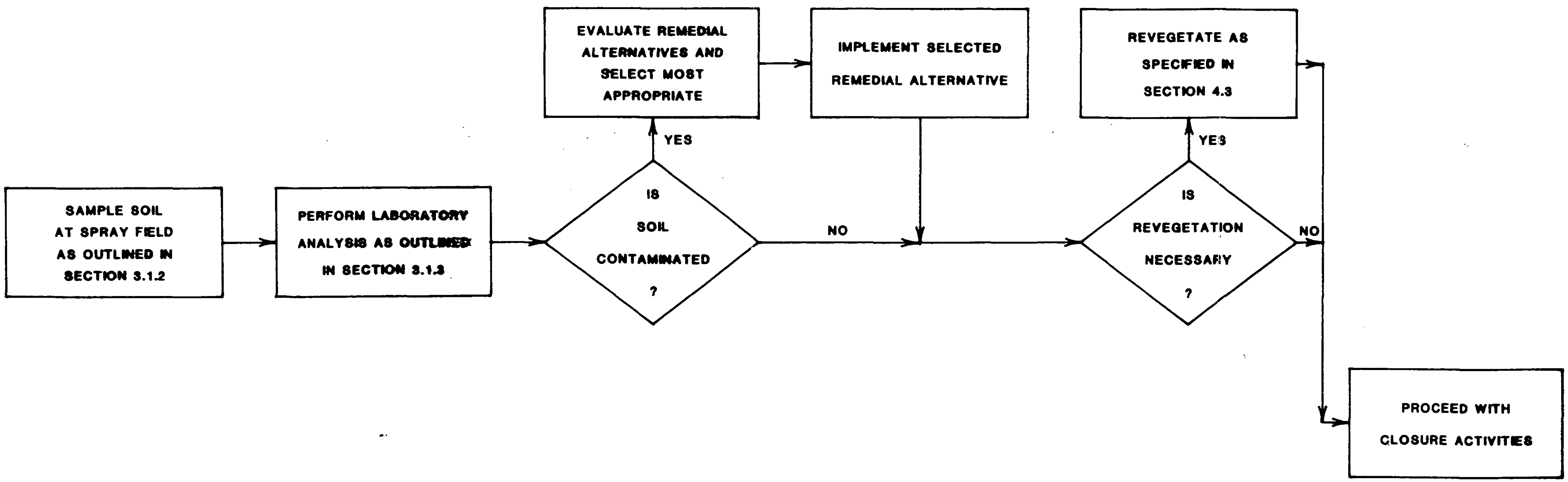
6 032 88

Chen & Associates

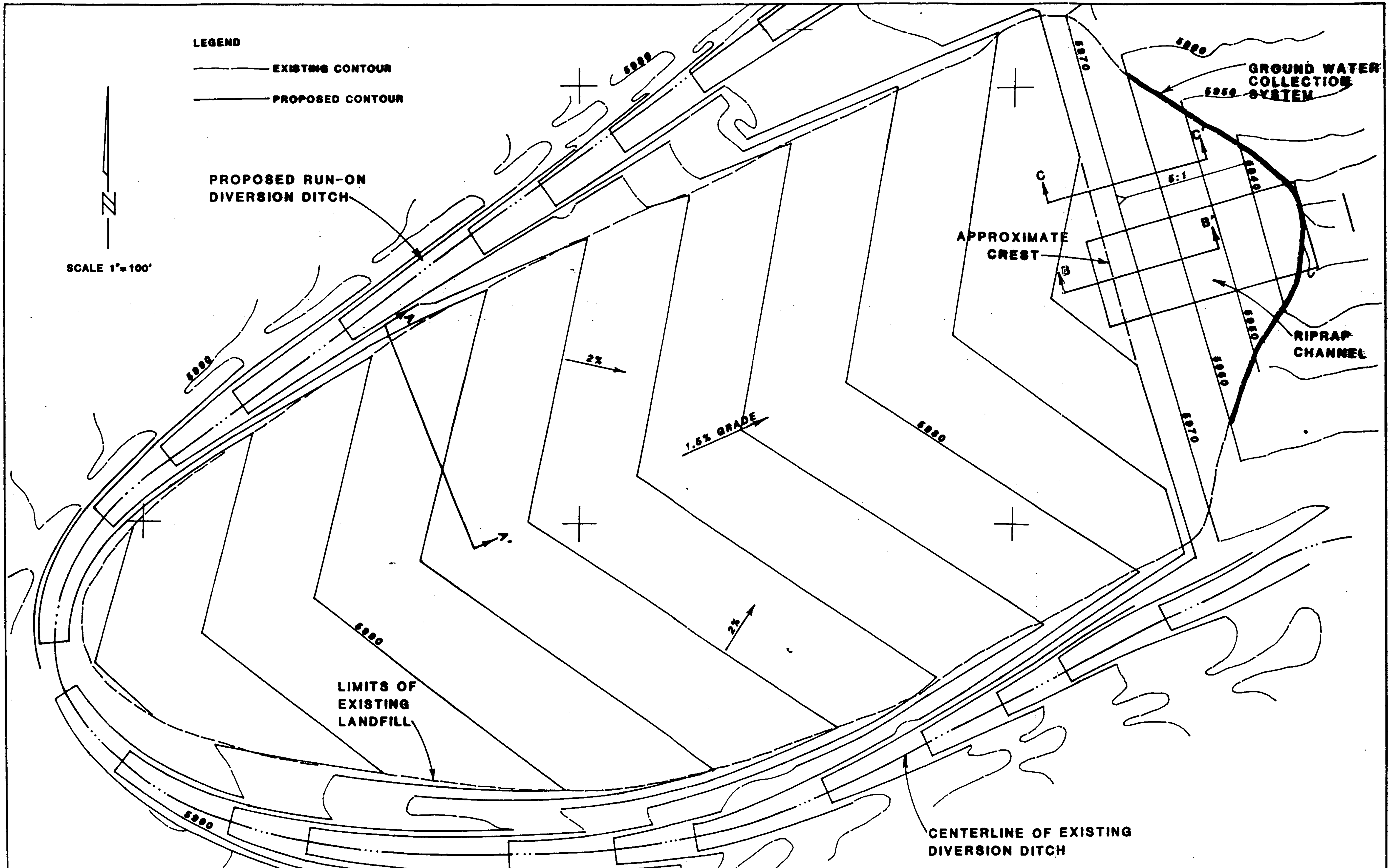


CLOSURE PLAN ACTIVITY FLOW DIAGRAM

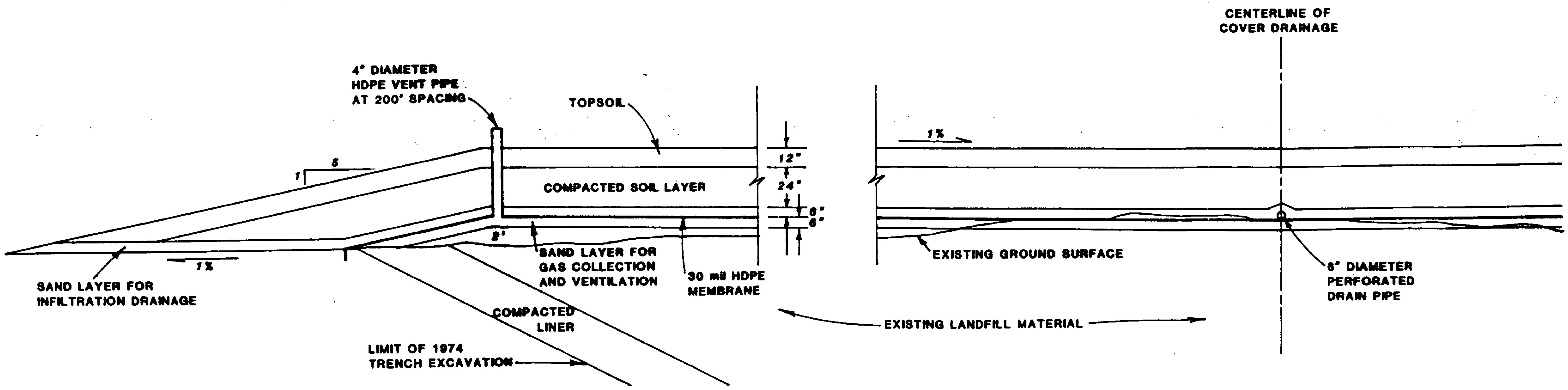
Fig. 5



6 032 88	Chen & Associates	SPRAY FIELD ACTIVITIES FLOW DIAGRAM	Fig. 8

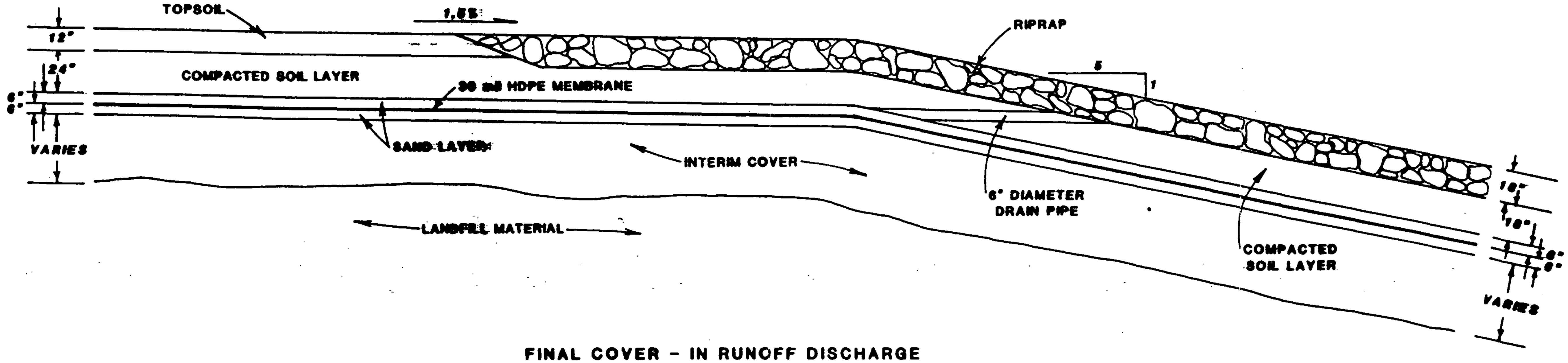


6 032 88	Chen & Associates		PROPOSED LANDFILL REGRADING PRIOR TO FINAL COVER	Fig. 10

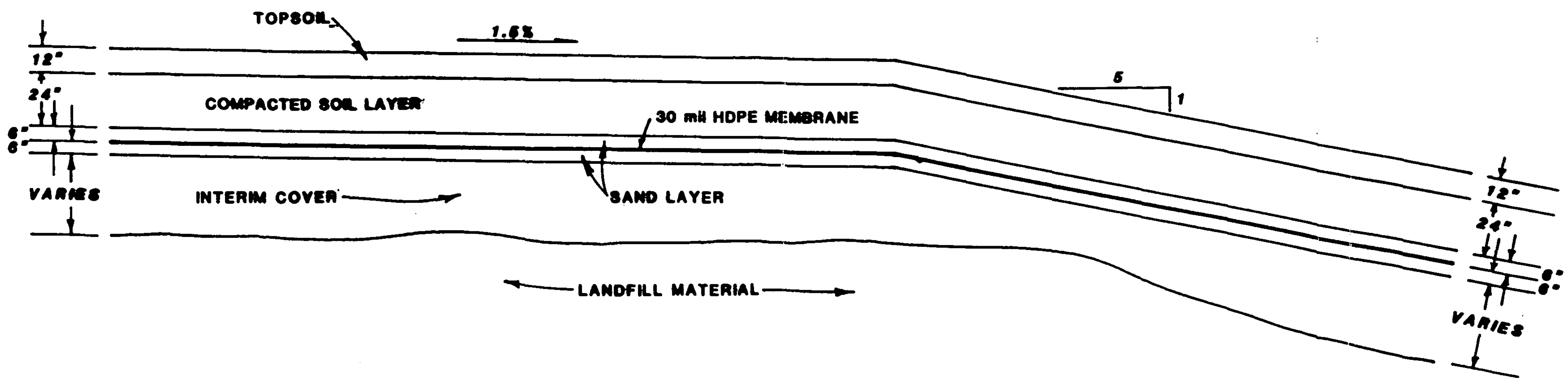


FINAL COVER - LANDFILL TOP
SECTION A-A'

6 032 88	Chen & Associates	PROPOSED FINAL COVER	Fig. 11

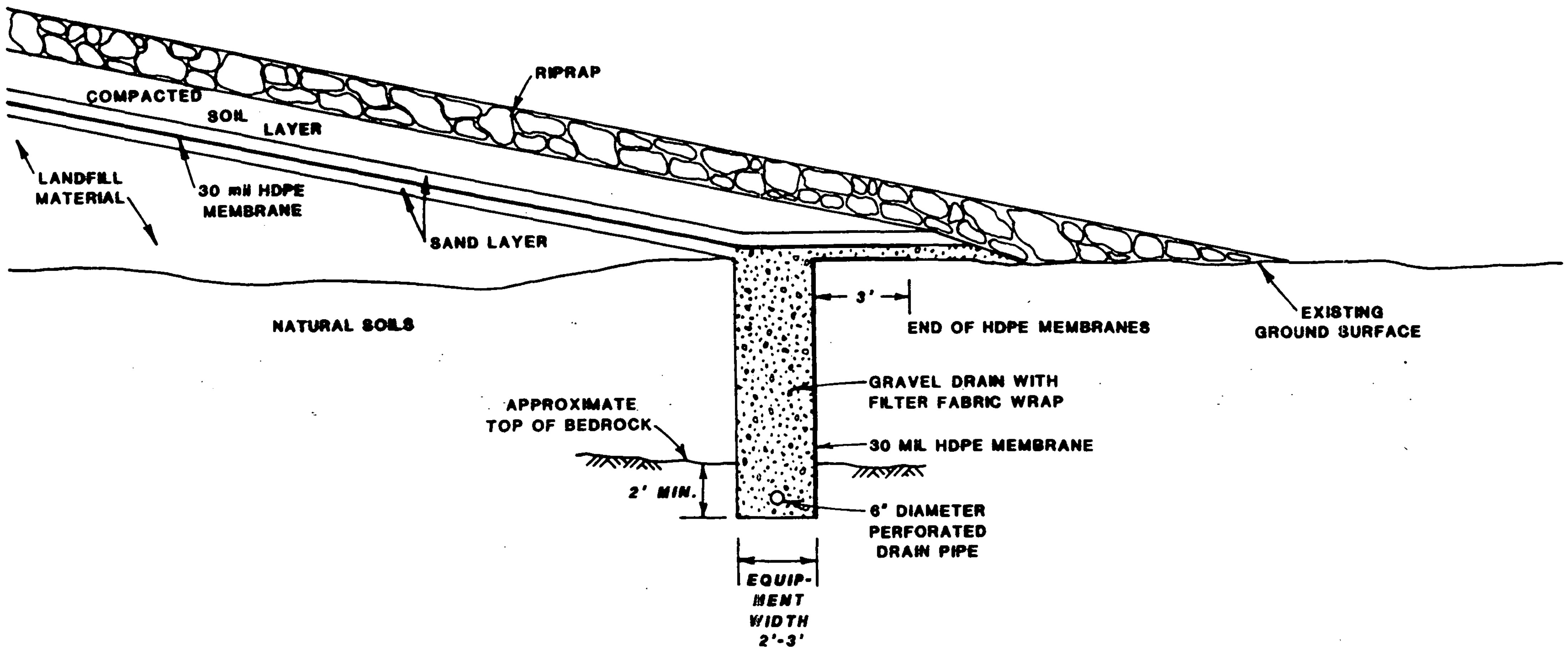


FINAL COVER - IN RUNOFF DISCHARGE
SECTION B-B'

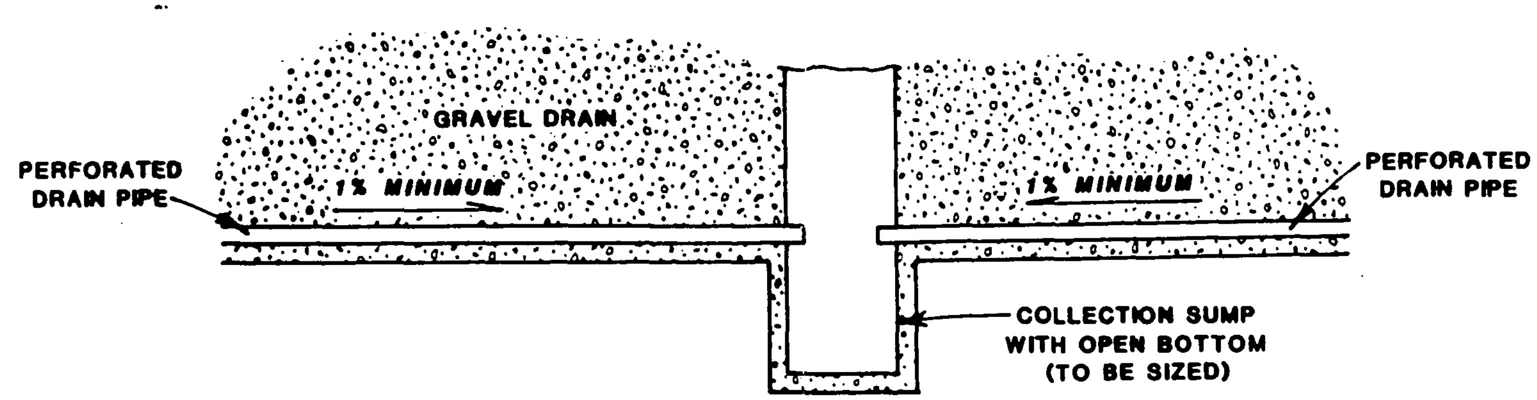


FINAL COVER - VEGETATIVE AREAS
SECTION C-C'

6 032 88	Chen & Associates		PROPOSED FINAL COVER SECTIONS	Fig. 12



GROUND WATER
COLLECTION DRAIN



COLLECTION SUMP

6 032 88	Chen & Associates		PROPOSED GROUND WATER COLLECTION SYSTEM	Fig. 13

UNITED STATES ATOMIC ENERGY COMMISSION

ALBUQUERQUE OPERATIONS OFFICE
ROCKY FLATS AREA OFFICE
GOLDEN, COLORADO

DESIGN CRITERIA

SANITARY LANDFILL RENOVATIONS

DOW CHEMICAL U.S.A.
ROCKY FLATS DIVISION
BOX 888, GOLDEN, COLORADO

DOW AUTH. - 440555

INDEX OF DRAWINGS

SHEET NO.	DRAWING TITLE	DWG. NO.	REV.
1	COVER SHEET	D-27296-1	A
2	AREA PLOT	" -2	A
3	SAMPLING STRUCTURE & WATER DIVERSION DETAILS	" -3	A
4	LANDFILL RING & WATER DIVERSION DETAILS	" -4	B

CRITERIA
NOT FOR CONSTRUCTION

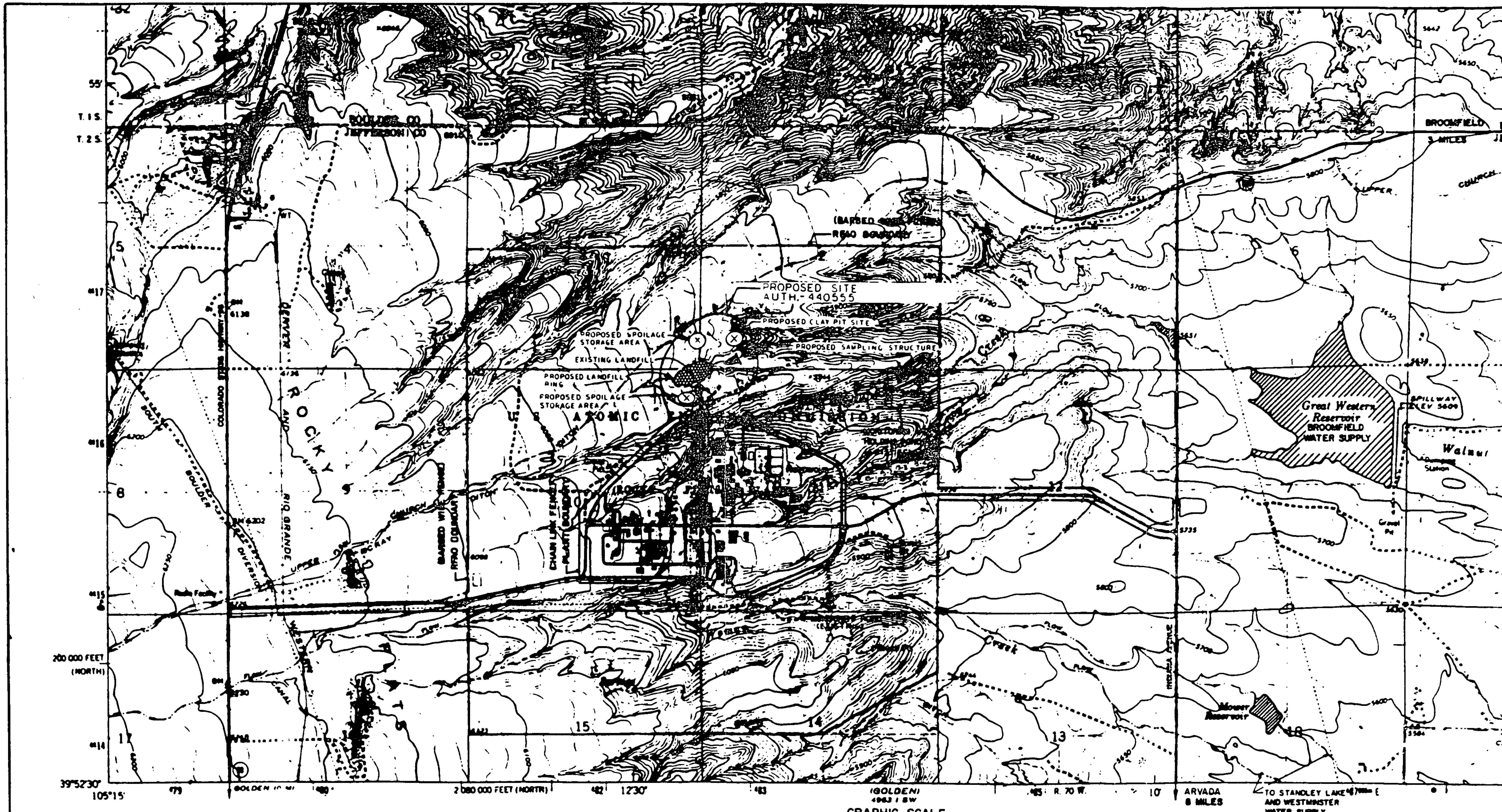
A	ORIGINAL ISSUE DESIGN CRITERIA	~		CM		440555

	BY	DATE
	RICHTER	4-17-74
	[illegible]	4-17-74
	~	~

DOW CHEMICAL U.S.A.

SANITARY LANDFILL RENOVATIONS COVER SHEET

D 27296-1 A 1 OF 4



1 POLYCONIC PROJECTION- 1927 NORTH AMERICAN DATUM 10,000 FT. GRIDS BASED ON COLORADO COORDINATE SYSTEM, NORTH AND CENTRAL ZONES. 1000-METER UNIVERSAL TRANSVERSE MERCATOR GRID TICKS ALSO NOTED ON MAP EDGE.

2. TOPOGRAPHY BY PHOTOGRAMMETRIC METHODS FROM AERIAL PHOTOGRAPHS TAKEN 1964 AND FIELD CHECKED 1965

3 THIS MAP IS A PHOTOGRAPHIC ENLARGEMENT OF THE USGA AND USC AND GS LOUISVILLE, COLORADO QUADRANGLE, 7.5 MINUTE SERIES

GRAPHIC SCALE

1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

CONTOUR INTERVAL 10 FEET
DATUM IS MEAN SEA LEVEL

CRITERIA-
NOT FOR CONSTRUCTION

A | ORIGINAL ISSUE - DESIGN CRITERIA

RICHTER 4-17-70
MAJORS 4-17-70
F.K. 4-17-70

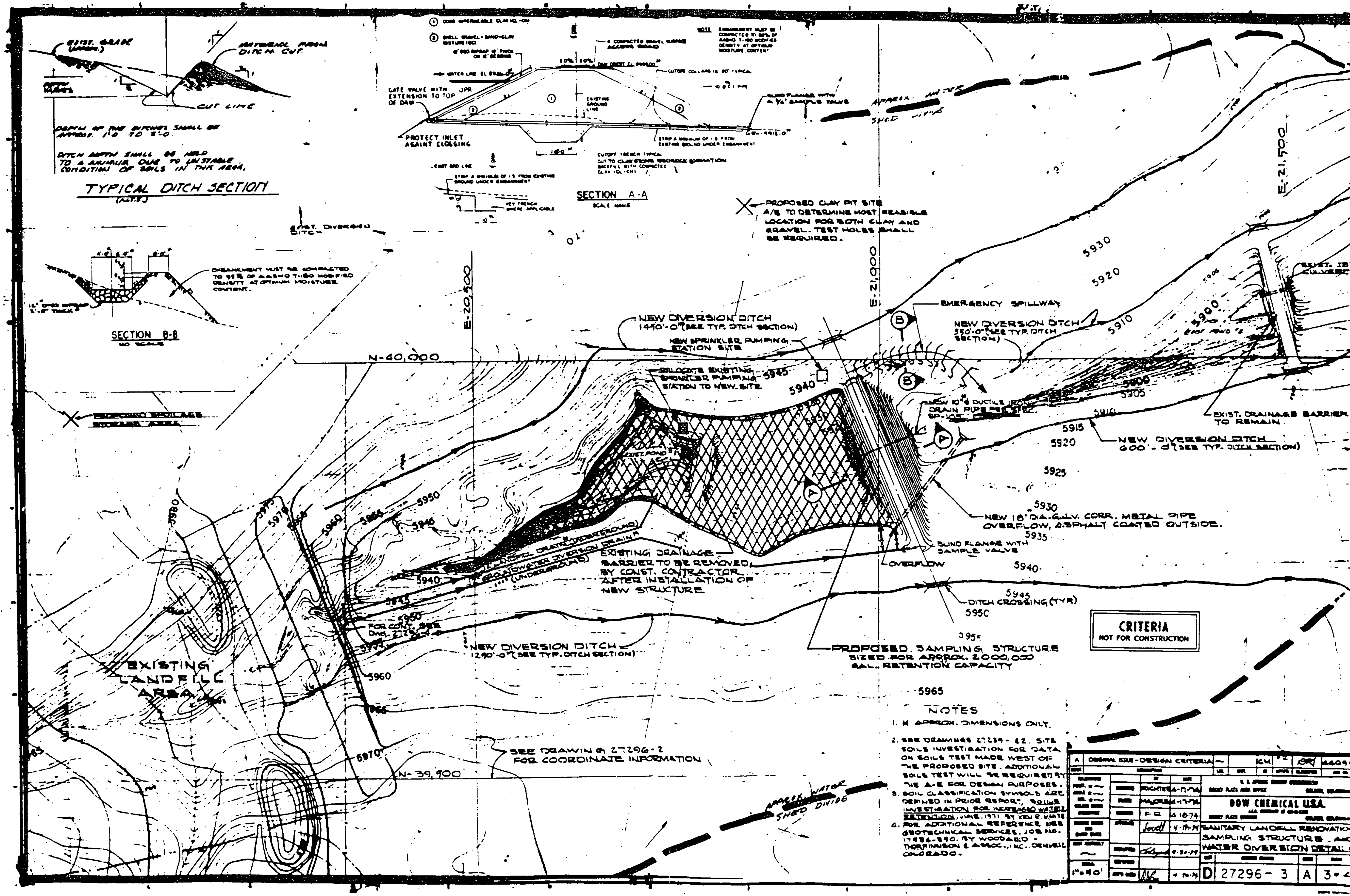
U.S. ATOMIC ENERGY COMMISSION

DOW CHEMICAL USA

SANITARY LANDFILL
RENOVATIONS
AREA PLOT PLAN

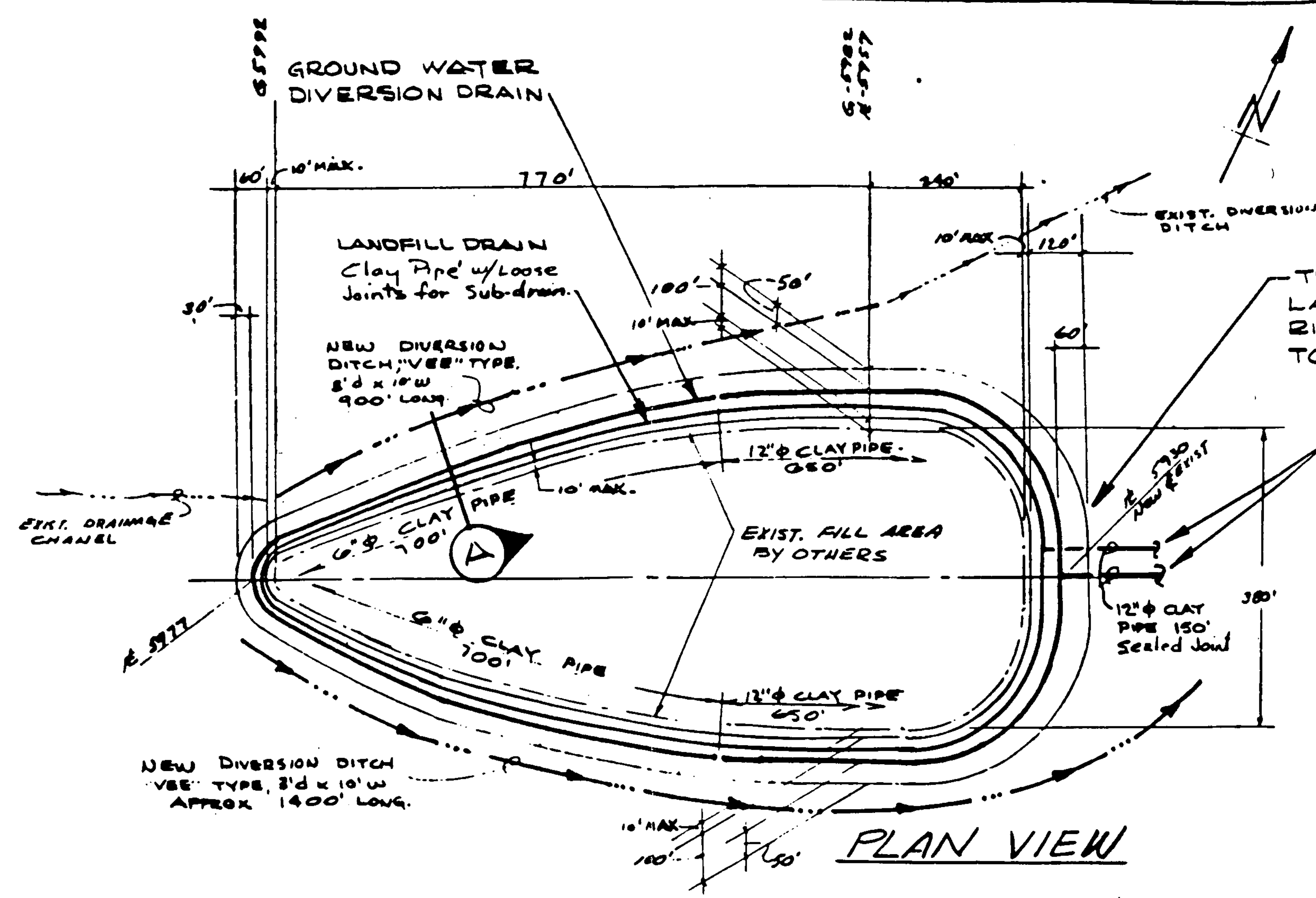
SCALE GRAPHIC

D | 27296-2 | A | 2



TYPICAL DITCH SECTION
CUT LINE
MATERIAL FROM DITCH CUT
SECTION A-A
SECTION B-B
PROTECT INLET AGAINST CLOGGING
GATE VALVE WITH JPR EXTENSION TO TOP OF DAM
PROPOSED CLAY PIT SITE A/E TO DETERMINE MOST FEASIBLE LOCATION FOR BOTH CLAY AND GRAVEL. TEST HOLES SHALL BE REQUIRED.
E-20,500
E-21,000
E-21,500
N-40,000
N-39,900
EMERGENCY SPILLWAY
NEW DIVERSION DITCH 1450'-0" (SEE TYP. DITCH SECTION)
NEW DIVERSION DITCH 350'-0" (SEE TYP. DITCH SECTION)
NEW SPRINKLER PUMPING STATION SITE
RELOCATE EXISTING SPRINKLER PUMPING STATION TO NEW SITE
EXIST. DRAINAGE BARRIER TO REMAIN
NEW DIVERSION DITCH 600'-0" (SEE TYP. DITCH SECTION)
NEW 18" DIA. GALV. CORR. METAL PIPE OVERFLOW, ASPHALT COATED OUTSIDE.
BLIND FLANGE WITH SAMPLE VALVE
OVERFLOW
EXISTING DRAINAGE BARRIER TO BE REMOVED BY CONST. CONTRACTOR AFTER INSTALLATION OF NEW STRUCTURE
DITCH CROSSING (TYP)
CRITERIA
NOT FOR CONSTRUCTION
PROPOSED SAMPLING STRUCTURE SIZED FOR APPROX. 2,000,000 GAL. RETENTION CAPACITY
NEW DIVERSION DITCH 1290'-0" (SEE TYP. DITCH SECTION)
EXISTING LANDFILL AREA
SEE DRAWING 27296-2 FOR COORDINATE INFORMATION
APPROX. WATER SHED DIVIDE
NOTES
1. ✱ APPROX. DIMENSIONS ONLY.
2. SEE DRAWINGS 27239-62. SITE SOILS INVESTIGATION FOR DATA ON SOILS TEST MADE WEST OF THE PROPOSED SITE. ADDITIONAL SOILS TEST WILL BE REQUIRED BY THE A-E FOR DESIGN PURPOSES.
3. SOIL CLASSIFICATION SYMBOLS ARE DEFINED IN PRIOR REPORT, SOILS INVESTIGATION FOR INCREASED WATER RETENTION, JUNE, 1971 BY KEN R. WHITE.
4. FOR ADDITIONAL REFERENCE SEE GEOTECHNICAL SERVICES, JOB NO. 17436-330, BY WOODARD-THORFINNSON & ASSOC., INC. DENVER, COLORADO.
A ORIGINAL ISSUE-DESIGN CRITERIA
DOW CHEMICAL U.S.A.
SANITARY LANDFILL RENOVATION SAMPLING STRUCTURE AND WATER DIVERSION DETAILS
1"=50'
D 27296-3 A

PART	QUAN.	DESCRIPTION	MATERIAL



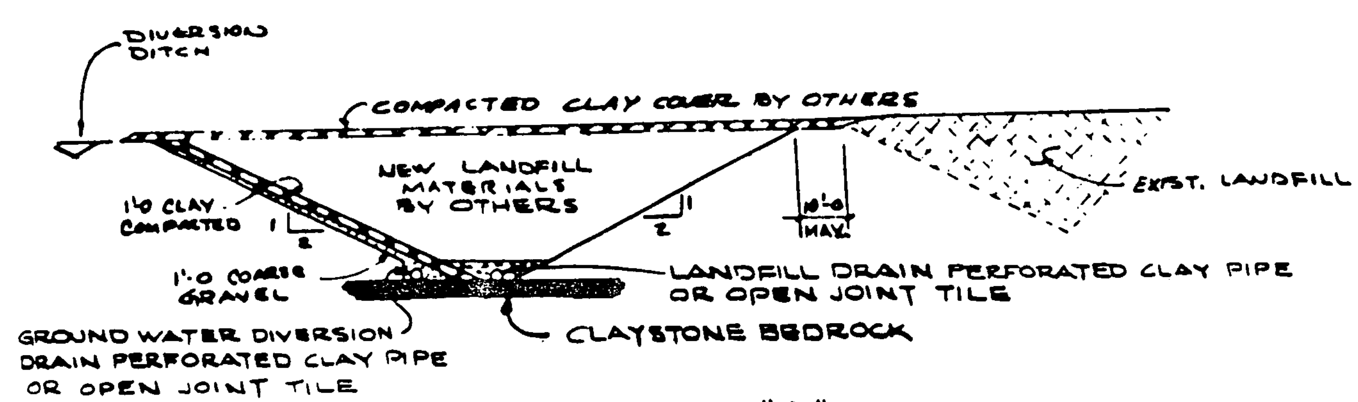
PLAN VIEW

CRITERIA
NOT FOR CONSTRUCTION

LEGEND

G xxx = EXIST. GRADE ELEV.

℄ xxx = FLOW LINE ELEV.



SECTION "A"

ISSUE	DESCRIPTION	LOC.	DATE	BY	APP'D	CLASSIFIER	JOB NO.
B	ISSUED FOR DESIGN CRITERIA	~	4-30-74	CM	F.R.	[signature]	440555
A	ORIGINAL ISSUE-DESIGN CRITERIA	~	4-19-74	CM	F.R.	[signature]	440555

		BY	DATE
TOLERANCES FRACT. ± ~ ANGLE ± ~ DEC. ± ~ UNLESS NOTED OTHERWISE		RICHTER	4-17-74
	DRAWN	MAJORS	4-17-74
	CHECKED	F.R.	4-17-74
REMOVE BURRS AND SHARP EDGES	APPROVED	[signature]	4-17-74
NEXT ASSEMBLY ~	SUBMITTED	[signature]	4-30-74
	REC'M'DED		
SCALE: NO SCALE	APP'D (AEC)	[signature]	4-30-74

U. S. ATOMIC ENERGY COMMISSION
ROCKY FLATS AREA OFFICE — GOLDEN, COLORADO

DOW CHEMICAL U.S.A.
A.E.C. CONTRACT AT (29-1)-1106
ROCKY FLATS DIVISION — GOLDEN, COLORADO

SANITARY LANDFILL RENOVATIONS
LANDFILL RING & WATER DIVERSION DETAILS

SIZE	DRAWING NUMBER	ISSUE	SHEET
B	27296 - 4	B	4 of 4

UNITED STATES ATOMIC ENERGY COMMISSION

ALBUQUERQUE OPERATIONS OFFICE
ROCKY FLATS OFFICE
GOLDEN, COLORADO

I hereby certify that these plans for the SANITARY LANDFILL RENOVATIONS, ROCKY FLATS, were prepared under my direct supervision for the owners thereof.

(Seal: RONALD E. HALL, JR. — REGISTERED PROFESSIONAL ENGINEER — 5235 — STATE OF COLORADO)

Registered Professional Engineer Colorado 5235

I hereby certify that on behalf of the UNITED STATES ATOMIC ENERGY COMMISSION, OWNER, whose Post Office address is:
Rocky Flats Area Office
P. O. Box 928
Golden, Colorado 80401
Do hereby approve & accept these plans for the SANITARY LANDFILL RENOVATIONS, ROCKY FLATS.

Assistant Manager For Construction

Approved on the 22 day of July, 1974.

SANITARY LANDFILL RENOVATIONS
ROCKY FLATS

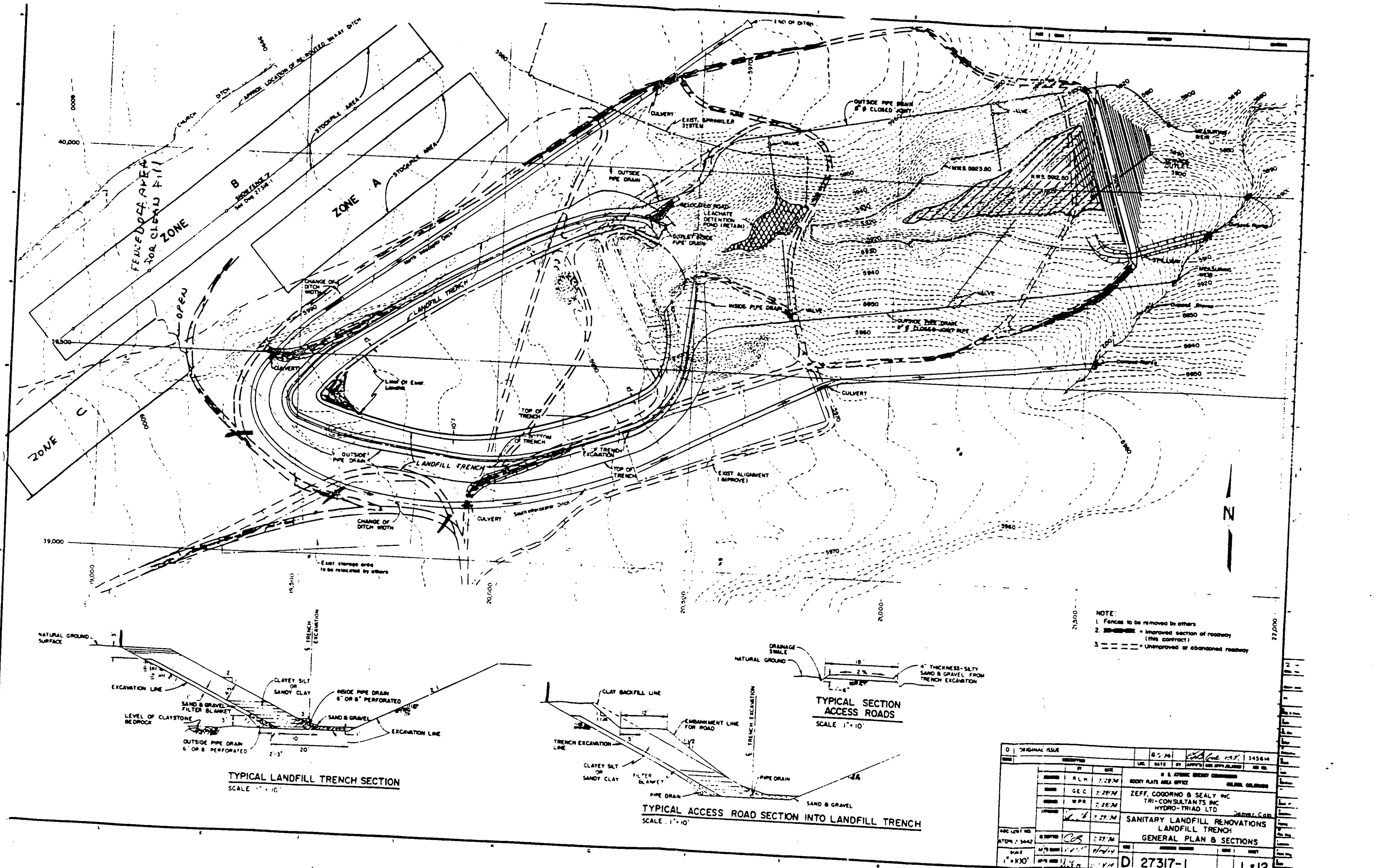
ZEFF, COGORNO & SEALY INC., DENVER, COLORADO
TRI-CONSULTANTS INC., DENVER, COLORADO
HYDRO-TRIAD LTD., DENVER, COLORADO

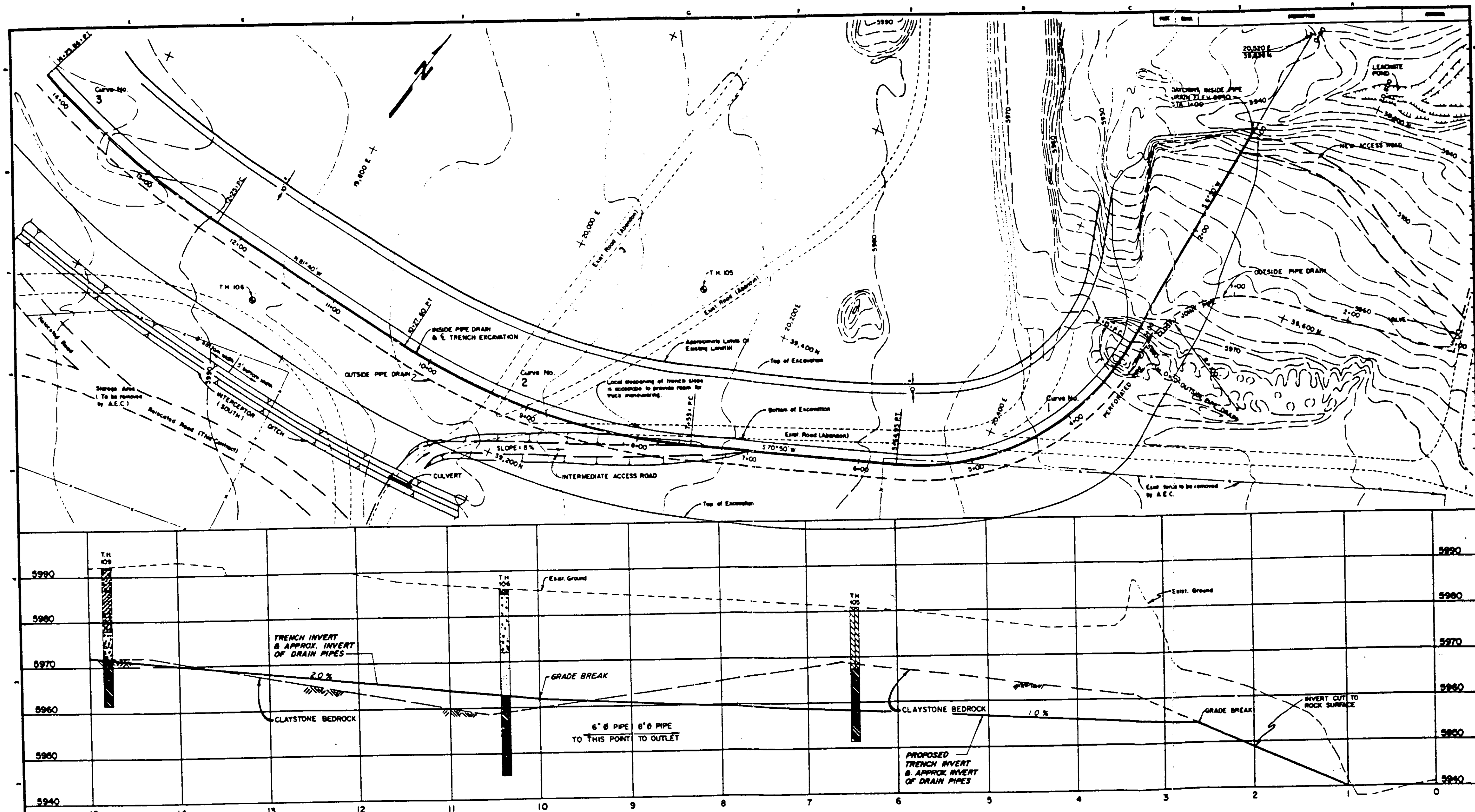
INVITATION NO
292-75-3

INDEX OF SHEETS

0	ORIGINAL ISSUE		8-5-74			343614

	By	Date	
	RLH	7 29 74	U. S. ATOMIC ENERGY COMMISSION, ROCKY FLATS AREA OFFICE, GOLDEN, COLORADO
	GEC	7.29.74	ZEFF, COGORNO & SEALY INC. / TRI-CONSULTANTS INC. / HYDRO-TRIAD LTD — Denver, Colo.
	WPR		
			SANITARY LANDFILL RENOVATIONS / FACILITY NO. 219 / TITLE SHEET
AEC CONT. NO. AT(29-1)-2344?		7.29.74	
SCALE NONE			D 27317-0


ZONE A
STOCKPILE AREA
ZONE B
ZONE C
FENCED OFF AREA FOR CLEAN FILL
APPROX. LOCATION OF RE-ROUTED McKAY DITCH
CHURCH DITCH
END OF DITCH
CULVERT
EXIST. SPRINKLER SYSTEM
OUTSIDE PIPE DRAIN
RELOCATED ROAD
LEACHATE DETENTION POND (RETAIN)
OUTLET INSIDE PIPE DRAIN
CHANGE OF DITCH WIDTH
LANDFILL TRENCH
Limit Of Exist. Landfill
TOP OF TRENCH
BOTTOM OF TRENCH
TRENCH EXCAVATION
EXIST ALIGNMENT (IMPROVE)
INSIDE PIPE DRAIN
VALVE
OUTSIDE PIPE DRAIN 8" Ø CLOSED JOINT PIPE
MEASURING WEIR
SPILLWAY
Exist. storage area to be relocated by others
N
NOTE:
1. Fences to be removed by others
2. = Improved section of roadway (this contract)
3. = Unimproved or abandoned roadway
NATURAL GROUND SURFACE
EXCAVATION LINE
CLAYEY SILT OR SANDY CLAY
INSIDE PIPE DRAIN 6" OR 8" PERFORATED
SAND & GRAVEL FILTER BLANKET
LEVEL OF CLAYSTONE BEDROCK
SAND & GRAVEL
OUTSIDE PIPE DRAIN 6" OR 8" PERFORATED
TYPICAL LANDFILL TRENCH SECTION
SCALE 1" = 10'
CLAY BACKFILL LINE
EMBANKMENT LINE FOR ROAD
TRENCH EXCAVATION LINE
CLAYEY SILT OR SANDY CLAY
FILTER BLANKET
PIPE DRAIN
SAND & GRAVEL
TYPICAL ACCESS ROAD SECTION INTO LANDFILL TRENCH
SCALE 1" = 10'
DRAINAGE SWALE
NATURAL GROUND
4" THICKNESS-SILTY SAND & GRAVEL FROM TRENCH EXCAVATION
TYPICAL SECTION ACCESS ROADS
SCALE 1" = 10'
0 ORIGINAL ISSUE
ROCKY FLATS AREA OFFICE
ZEFF, COGORNO & SEALY INC
TRI-CONSULTANTS INC
HYDRO-TRIAD LTD
Denver, Colo
SANITARY LANDFILL RENOVATIONS
LANDFILL TRENCH
GENERAL PLAN & SECTIONS
D 27317-1
1 of 12



℄ CURVE DATA

1.	2.	3.
Δ = 64°20'	Δ = 27°30'	Δ = 15°00'
R = 222.6'	R = 572.13'	R = 759.58'
T = 140'	T = 140'	T = 100'
P.C = 3+15.00	P.C. = 7+53.00	P.C. = 12+25.00
P.T = 5+64.95	P.T = 10+27.60	P.T = 14+23.86

SCALES:
PLAN - 1" = 40'
PROFILE - 1" = 50' HORIZ.
1" = 10' VERT.

NOTES:
1. PROFILE SHOWS INVERT OF TRENCH & INSIDE PIPE DRAIN ONLY. OUTSIDE PIPE DRAIN NOT SHOWN.
2. SECTION OF COMPLETED TRENCH WITH CLAY BARRIER SHOWN ON DWG 27317-1
3. NORTH SIDE OF TRENCH SHOWN ON DWG 27317-3
4. OUTSIDE PIPE DRAIN PROFILE SHOWN ON DWG 27317-4
5. INTERCEPTOR DITCH PROFILE SHOWN ON DWG 27317-5 & 27317-6

0	ORIGINAL ISSUE	8-5-74		1345614

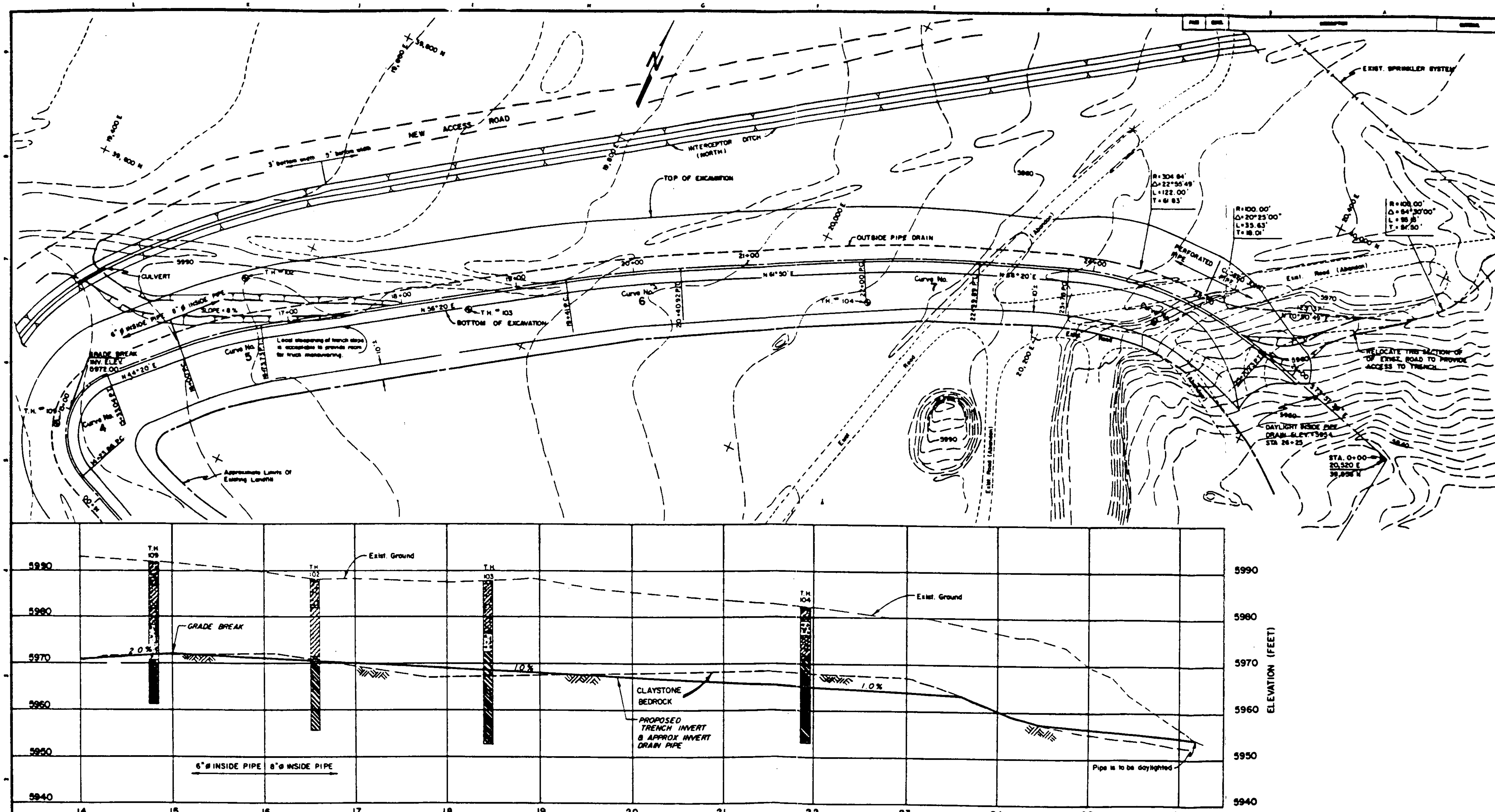
R L H	7/29/74	ROCKY FLATS AREA OFFICE
G E C	7/29/74	ZEFF, COGORNO & SEALY INC
W P R	7/29/74	TRI-CONSULTANTS INC.
	7/29/74	HYDRO-TRIAD LTD Denver, Colo
C O S	7/29/74	

AT(29-2)1344

AS SHOWN

SANITARY LANDFILL RENOVATIONS
LANDFILL TRENCH
PLAN & PROFILE 0 TO 15+00

D 27317-2 2 = 12



℄ CURVE DATA

4.	5.	6.	7.	8.
Δ=111°00'	Δ= 12°00'	Δ= 5°30'	Δ= 6°30'	Δ= 37°42'30"
R= 56.36'	R= 352.03'	R= 1040.94'	R= 880.53'	R= 292.84'
T= 82.00'	T= 37.00	T= 50.00'	T= 50.00'	T= 100.00'
PC= 14+23.86	PC= 16+00.00	PC= 19+41	P.C= 22+00	P.C= 23+78
PT= 15+33.04	PT= 16+73.73	PT= 20+40.92	P.T= 22+99.89	P.T= 25+70.73

SCALES:
PLAN - 1" = 40'
PROFILE - 1" = 50' HORIZ.
1" = 10' VERT.

NOTES:
1. PROFILE SHOWS ONLY INVERT OF TRENCH AND INSIDE PIPE DRAIN ONLY, OUTSIDE PIPE DRAIN NOT SHOWN.
2. SECTION OF COMPLETED TRENCH WITH CLAY BARRIER SHOWN ON DWG 27317-1
3. SOUTH SIDE OF TRENCH SHOWN ON DWG. 27317-2
4. OUTSIDE PIPE DRAIN PROFILE SHOWN ON DWG 27317-4
5. INTERCEPTOR DITCH PROFILE SHOWN ON DWG 27317-5 & 27317-6

0	ORIGINAL ISSUE	8-5-74			345614

	RLH	7/29/74
	GEC	7/29/74
	WPR	7/29/74
		7/29/74
	CB	7/29/74
		7/29/74
		7/29/74

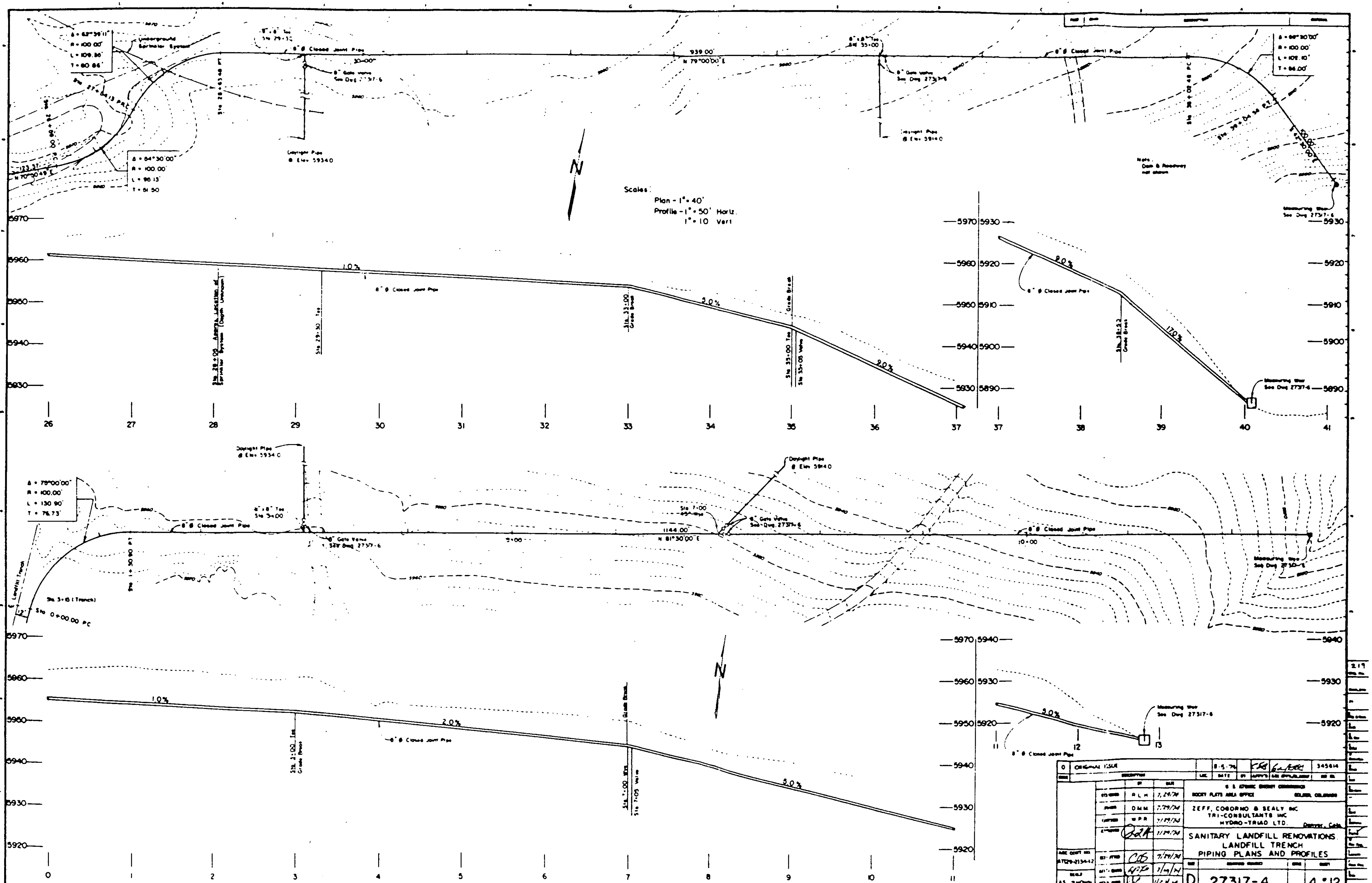
AEC CONT. NO. AT(29-2)-3446
SCALE AS SHOWN

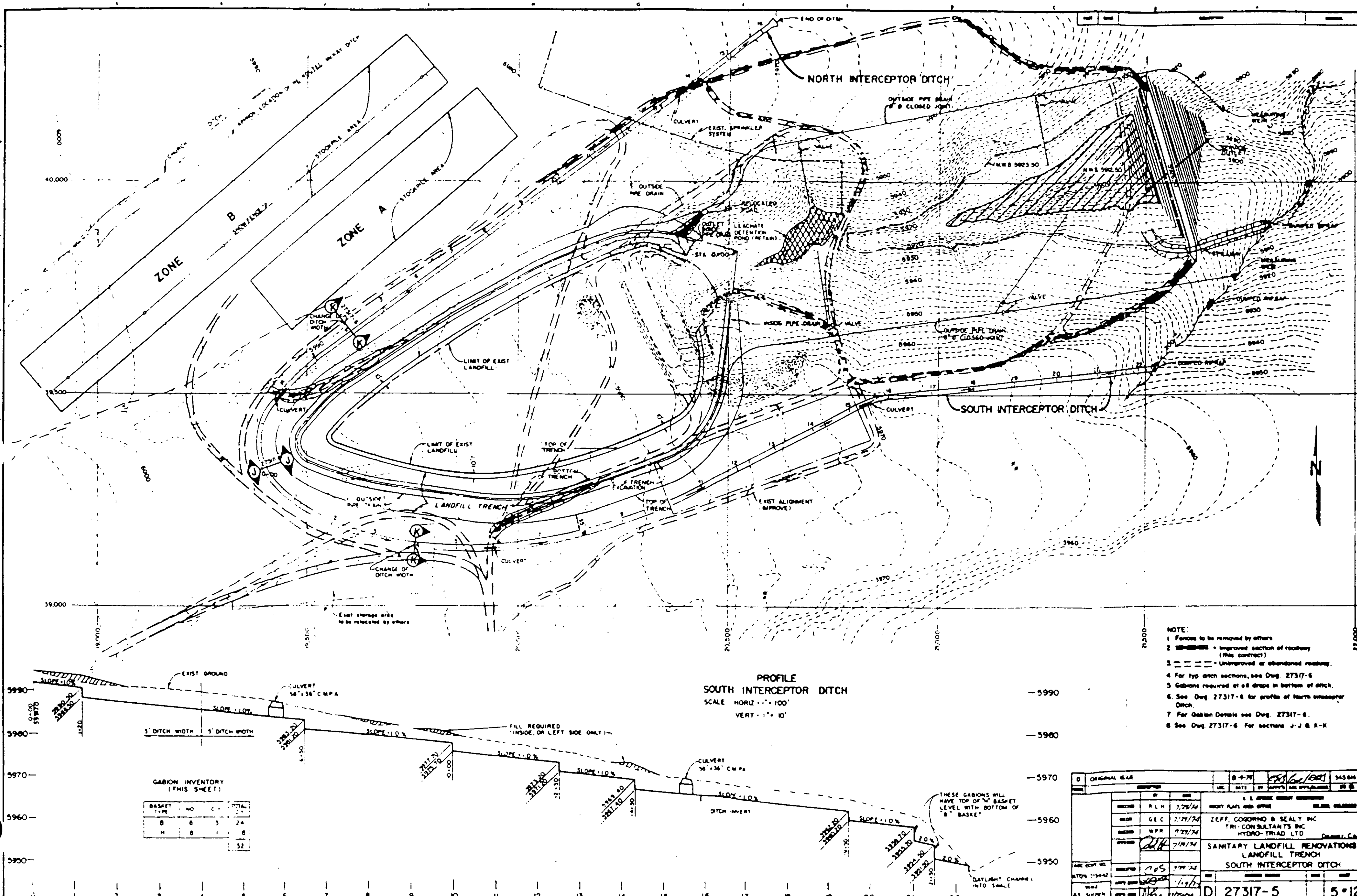
U.S. ATOMIC ENERGY COMMISSION
ROCKY FLATS AREA OFFICE

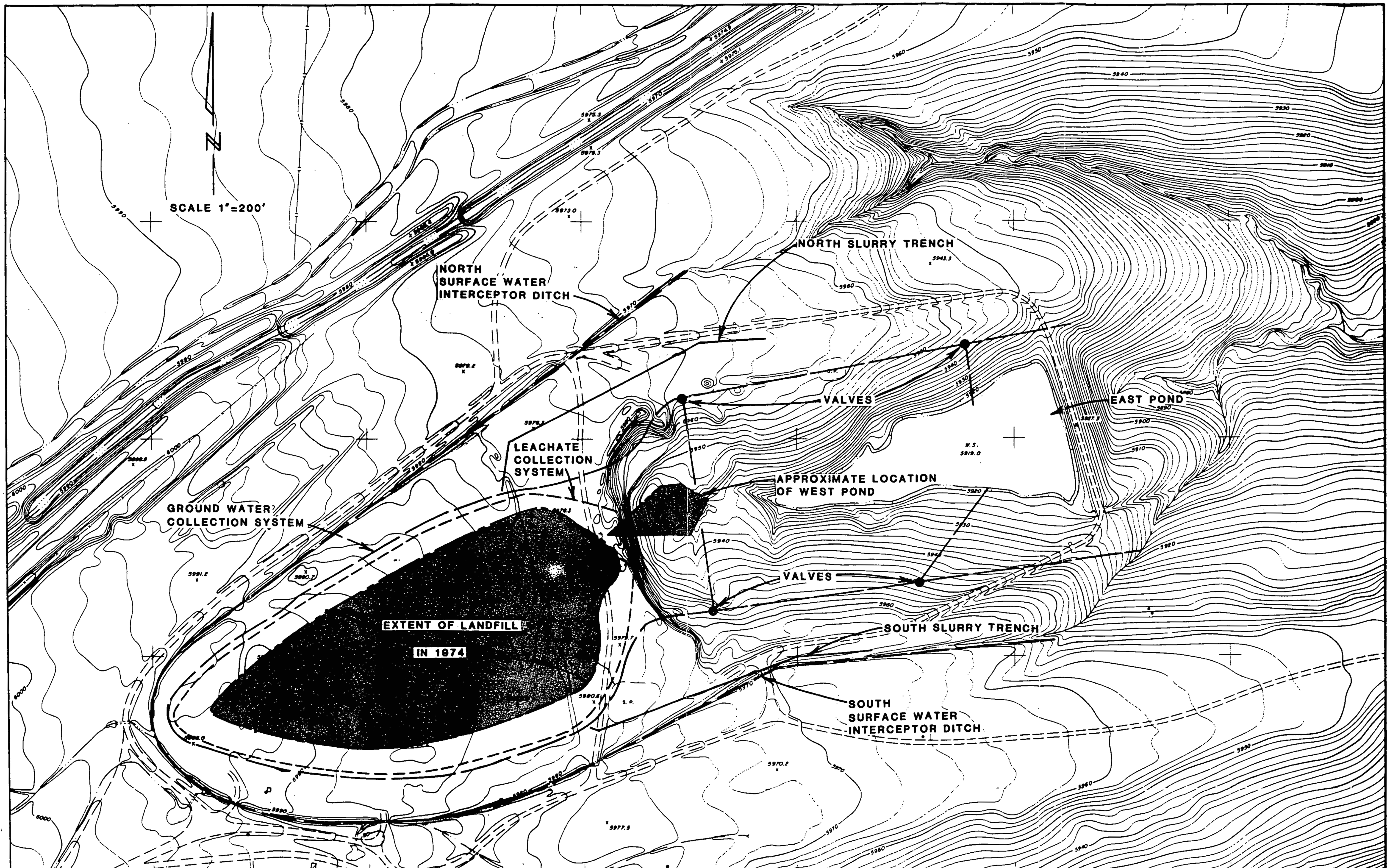
ZEFF, COGORNO & SEALY INC.
TRI-CONSULTANTS INC.
HYDRO-TRIAD LTD
Denver, Colo.

SANITARY LANDFILL RENOVATIONS
LANDFILL TRENCH
PLAN PROFILE 15+00 TO 25+75

D 27317-3 3 of 12


Scales:
Plan - 1" = 40'
Profile - 1" = 50' Horiz.
1" = 10' Vert.
8" Ø Closed Joint Pipe
939.00'
N 79°00'00" E
1144.00'
N 81°30'00" E
Daylight Pipe @ Elev 5934.0
Daylight Pipe @ Elev 5914.0
8" Gate Valve See Dwg 27317-6
Measuring Weir See Dwg 27317-6
Note: Dam & Roadway not shown
Δ = 79°00'00"
R = 100.00'
L = 130.90'
T = 76.73'
Δ = 64°30'00"
R = 100.00'
L = 90.13'
T = 61.50
Δ = 60°30'00"
R = 100.00'
L = 109.10'
T = 64.00'
Sta 0+00.00 PC
Sta 3+15 (Trench)
Landfill Trench
Sta 33+00 Grade Break
Sta 35+00 Tee
Sta 35+05 Valve
Sta 29+50 Tee
Sta 3+00 Tee
Sta 7+00 Wye
Sta 7+05 Valve
Sta 28+00 Approx. Location of Sprinkler System (Depth Unknown)
1.0%
2.0%
5.0%
9.0%
17.0%
0 ORIGINAL ISSUE 8-5-74 345614
ZEFF, COGORNO & SEALY INC
TRI-CONSULTANTS INC
HYDRO-TRIAD LTD.
Denver, Colo.
SANITARY LANDFILL RENOVATIONS
LANDFILL TRENCH
PIPING PLANS AND PROFILES
AT(29-2)3442
AS SHOWN
D 27317-4 4 of 12


NORTH INTERCEPTOR DITCH
SOUTH INTERCEPTOR DITCH
ZONE B
ZONE A
STOCKPILE AREA
LANDFILL TRENCH
LIMIT OF EXIST LANDFILL
TOP OF TRENCH
BOTTOM TRENCH
TRENCH EXCAVATION
CULVERT
CHANGE OF DITCH WIDTH
END OF DITCH
EXIST. SPRINKLER SYSTEM
OUTSIDE PIPE DRAIN
INSIDE PIPE DRAIN
VALVE
LEACHATE DETENTION POND (RETAIN)
EXIST ALIGNMENT (IMPROVE)
Exist storage area to be relocated by others
40,000
39,500
39,000
PROFILE
SOUTH INTERCEPTOR DITCH
SCALE HORIZ 1" = 100'
VERT 1" = 10'
EXIST GROUND
CULVERT 36" x 36" C M P A
SLOPE = 1.0%
3' DITCH WIDTH
5' DITCH WIDTH
FILL REQUIRED INSIDE, OR LEFT SIDE ONLY
DITCH INVERT
THESE GABIONS WILL HAVE TOP OF "M" BASKET LEVEL WITH BOTTOM OF "B" BASKET
DAYLIGHT CHANNEL INTO SWALE
GABION INVENTORY (THIS SHEET)
5990
5980
5970
5960
5950
NOTE:
1 Fences to be removed by others
2 = Improved section of roadway (this contract)
3 = Unimproved or abandoned roadway.
4 For typ ditch sections, see Dwg. 27317-6
5 Gabions required at all drops in bottom of ditch.
6. See Dwg. 27317-6 for profile of North Interceptor Ditch.
7 For Gabion Details see Dwg. 27317-6.
8 See Dwg. 27317-6 For sections J-J & K-K
ORIGINAL ISSUE
R L H 7/29/74
G E C 7/29/74
W P R 7/29/74
ZEFF, COGORNO & SEALY INC
TRI-CONSULTANTS INC
HYDRO-TRIAD LTD
SANITARY LANDFILL RENOVATIONS
LANDFILL TRENCH
SOUTH INTERCEPTOR DITCH
AS SHOWN
D 27317-5
5-12



6 032 88	Chen & Associates	PRESENT LANDFILL COLLECTION SYSTEMS	Fig. 3