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13. ABSTRACT *(Maximum 200 words)*

THE OBJECTIVES OF THE NORTH BOUNDARY CONTAINMENT SYSTEM COMPREHENSIVE OPERATIONAL MONITORING PROGRAM ARE TO MONITOR THE FOLLOWING:

1. CARBON ADSORBERS TO ENSURE EFFECTIVE REMOVAL OF ORGANIC CONTAMINANTS
2. GROUND WATER QUALITY TO ASSESS CHANGES IN THE LEVELS AND DISTRIBUTION OF CONTAMINANTS
3. GROUND WATER LEVELS TO ASSESS HOW THE SYSTEM IS AFFECTING LOCAL HYDROLOGY
4. PLANT INFLUENT AND EFFLUENT FOR NEW CONTAMINANTS AT LEVELS THAT WOULD CAUSE CONCERN FOR PUBLIC HEALTH.

SECTIONS OF THE PLAN DISCUSS THESE TASKS IN DETAIL.

14. SUBJECT TERMS GROUNDWATER HYDROLOGY, GEOLOGY, GC/MS ANALYSIS, QA, ANALYTICAL DATA	15. NUMBER OF PAGES 16. PRICE CODE

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UNCLASSIFIED			

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FINAL COMPREHENSIVE OPERATIONAL MONITORING PROGRAM PLAN
FOR THE
NORTH BOUNDARY CONTAINMENT/TREATMENT SYSTEM
AT
ROCKY MOUNTAIN ARSENAL

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VERSION 3.2
OCTOBER 1990

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Office of the Program Manager
for Rocky Mountain Arsenal

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Rocky Mountain Arsenal
Information Center
Commerce City, Colorado

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SECTION I - INTRODUCTION

1.0 Site History

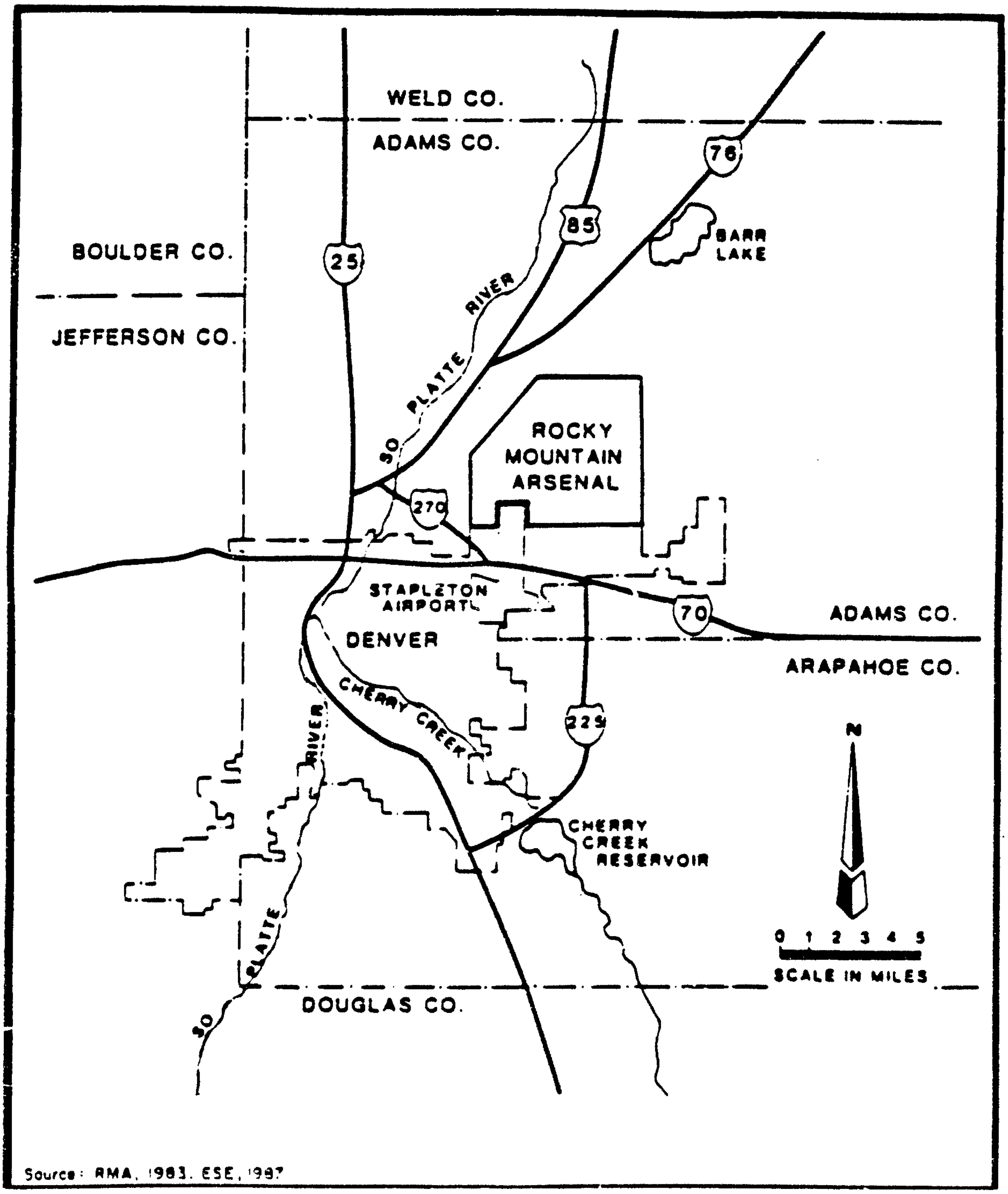
The Rocky Mountain Arsenal (RMA) occupies over 17,000 acres in Adams County, Colorado. Figure 1 shows the Arsenal location in proximity to Denver, Colorado. The property occupied by RMA was purchased by the U.S. Government in 1942. Throughout World War II, RMA manufactured and assembled chemical intermediate and toxic end-item products and incendiary munitions. After the war, many types of obsolete ordnance were destroyed at RMA by detonation or burning. During the 1950's, RMA produced GB nerve agent and filled munitions with the agent until late 1969. After 1970, RMA was primarily involved with the demilitarization of chemical warfare materials by caustic neutralization and incineration. The last military operation at RMA ended in the early 1980's. In addition to these military operations, portions of the Arsenal were leased to private industries from 1946 to 1982 for the manufacture of chemicals including various pesticides and herbicides (Thompson, et. al., 1985).

Industrial wastes generated from both Army and lessee activities were routinely discharged into several unlined evaporation basins located on the Arsenal. This practice continued until 1956 when Basin F was constructed with an asphalt liner. Solid wastes have been buried at various locations throughout the Arsenal. Unintentional spills of chemicals have occurred in and around the manufacturing complexes at RMA. These actions have resulted in the migration of contaminants into the environment and, in particular, the contamination of portions of the shallow alluvial aquifer at RMA (Thompson, et. al., 1985).

Contaminants were found to be migrating across the Arsenal boundaries in the early 1970's. The major contaminants identified at that time included inorganic chloride, diisopropylmethylphosphonate (DIMP), and dicyclopentadiene (DCPD). In 1975 the Army established a contamination control program. The goals of this program were to define the nature and extent of the contamination problem and to develop response actions to control the contaminant migration. Numerous monitoring wells were placed across the Arsenal and a sample collection and

Figure 1

RMA General Location Map



analysis program was initiated. The resulting data were used to develop an overall picture of ground water movement and of the types and distribution of contaminants in the ground water at RMA. The major contaminants found included organo-phosphorous compounds, organo-sulfur compounds, and chlorinated pesticides (Thompson, et. al., 1985).

Based on the data collected from the monitoring program, a plan was developed which included near-term control of contaminant migration through use of ground water control systems located along the Arsenal boundaries and long-term control through removal or control of the sources of contaminants. Under the plan, the boundary control systems would eliminate the migration of contaminated ground water off the Arsenal (Thompson, et. al., 1985).

During the Fourth Quarter of 1977, construction of a pilot containment/treatment system was started at the north boundary of RMA in Section 23, 250 feet south of the RMA property line. The pilot system consisted of six ground water collection wells, a 1500-ft bentonite clay barrier, granular activated carbon treatment and twelve recharge water wells. Monitoring wells were installed in Sections 23 and 24 on-post and in Sections 13 and 14 off-post north of RMA. The purpose of the pilot system was to establish the feasibility of barrier containment in dealing with alluvial ground water contamination and to collect data required for the development of a full-scale containment system. In terms of the design and operational philosophy the following elements were incorporated into the containment system:

a. Hydrologic control, and therefore the containment of ground water, is achieved via the alignment of dewatering and recharge wells.

b. Due to the geohydrologic character of the north boundary alluvium, the design choice made was one line of dewatering wells placed in close proximity to one line of recharge wells.

c. The overall system alignment was placed as close as possible to the installation property line to accelerate the off-post flow of clean, treated water.

d. The close proximity of dewatering and recharge wells to one another dictated that a physical barrier be placed between the alignments to prevent the recirculation of clean water from the artificial mound of ground water near the recharge wells to the dewatering wells. An added advantage of a physical barrier was the "damming" effect that would be created if the dewatering wells shut down.

The RMA demonstration system was the first of its type built to address a major ground water contamination problem. The pilot system started operations in June 1978 (Thompson, et. al., 1985).

After technical discussions, in May 1979 it was agreed by all parties that the pilot containment/treatment system would be expanded 3840 feet to the east (crossing First Creek) and 1400 feet to the west for a total proposed barrier length of 6740 feet. The major elements of the final expanded system design (Figure 2) were as follows:

a. Extend the bentonite barrier to a total length of 6740 feet.

b. Install 29 additional alluvial dewatering wells upgradient and 26 additional recharge wells downgradient.

c. Install 19 Denver sand unit dewatering wells upgradient.

d. Expand the treatment building 25 feet in length.

e. Install a First Creek crossing.

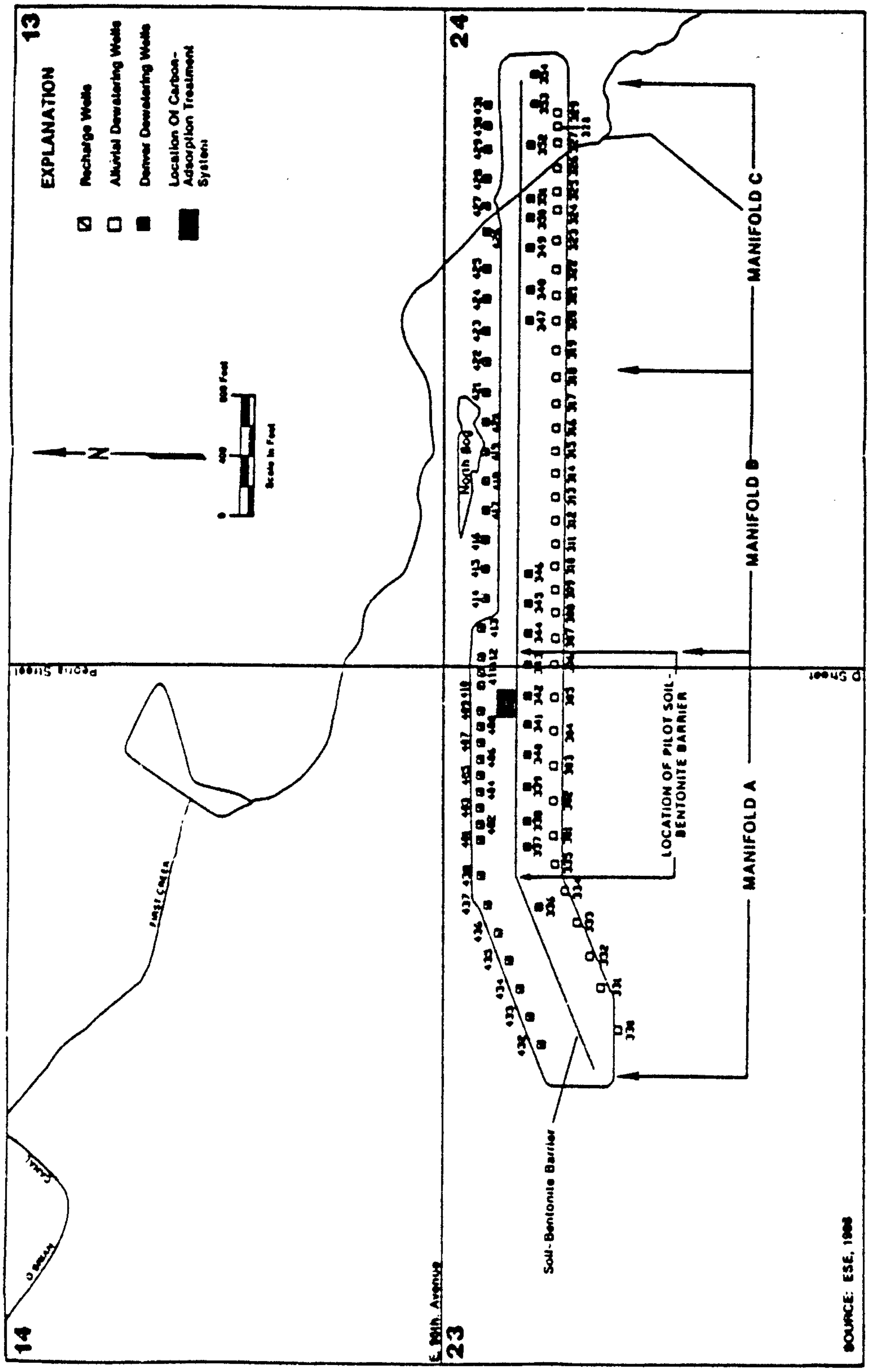


Figure 2
Expanded NBCS System (1982)

f. Install three government-owned carbon adsorbers to replace the leased units.

g. Determine the need for installation of a fluoride treatment system and design and install, if necessary.

The expanded system was constructed and began operations in [illegible]ry 1982 (Thompson, et. al., 1985). The fluoride treatment system was deemed not necessary by the RMA Technical Review Committee in April 1981.

In order to reduce the frequency of recharge well cleaning, bag filters to remove carbon fines from the system effluent were added in May 1987. Ten recharge trenches were installed during the fall of 1988 on the western portion of the system, supplanting eighteen recharge wells. See Section 4.0 for details of system improvements under the NBCS Improvements Interim Response Action (IRA).

2.0 Purpose of the NBCS Comprehensive Operational Monitoring Program

The purpose of the operational monitoring elements of the NBCS COMP is to collect information necessary to operate the system, allow verification of system effectiveness, and assess contaminant trends and hydraulic conditions in and around the NBCS. The objectives of this program are to:

* Monitor to ensure the carbon adsorbers at the NBCS are effectively removing organic contaminants from ground water being treated;

* Monitor ground water quality to assess changes in the levels of contamination and distribution of contaminants within the area of the dewatering system of the NBCS;

* Monitor ground water levels to assess how the system is affecting local hydrology; and

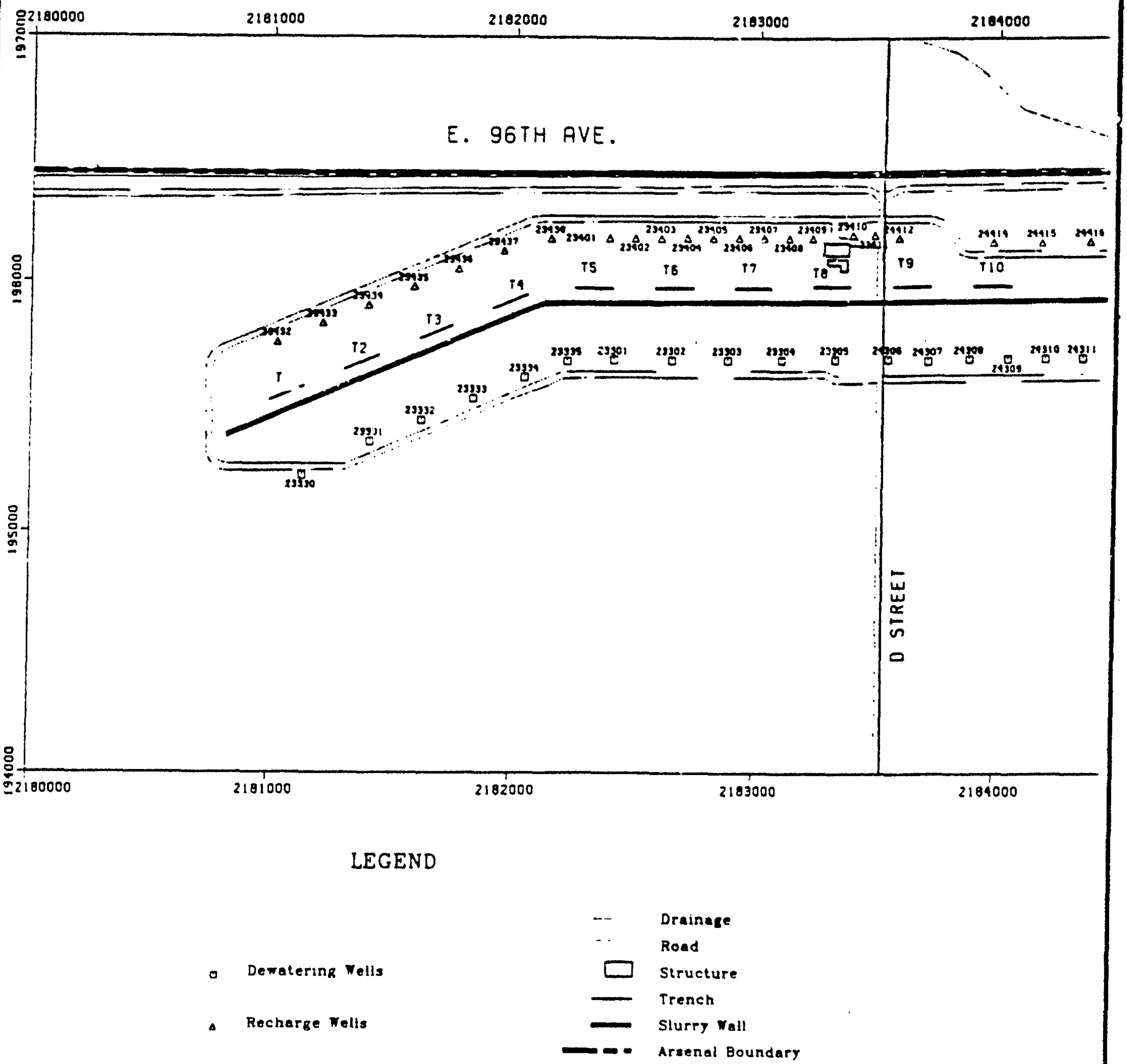
* Monitor plant influents and effluent for new contaminants at levels as to cause concern regarding public health.

These tasks are discussed in detail in separate sections of this plan.

3.0 System Description

The North Boundary Containment/Treatment System (NBCS) (Figure 3) incorporates 35 dewatering wells upgradient (south) of a bentonite slurry wall to intercept the natural flow of ground water approaching the boundary. The thirty-five dewatering wells are screened in the alluvium aquifer. The bentonite barrier is 6740 feet long and approximately three feet wide, with a permeability of 1×10^{-7} cm/sec or less. The barrier depth varies from 20 feet at the pilot system to over 40 feet along the eastern extension. The barrier is anchored in the Denver Formation. The system was designed to remove, treat, and reinject clean, treated ground water flowing through the NBCS area in both the alluvium and upper Denver sands (Thompson, et. al., 1985). Later it was postulated that the nineteen Denver sands dewatering wells may have been acting as a conduit for contamination from the alluvium to the upper Denver sands. These wells were closed under the Abandoned Well IRA to prevent the possible spread of contamination to the upper Denver sands.

The dewatering wells are divided into three collection manifolds that intercept and dewater separate segments of the aquifer. Figure 3 shows the manifold alignment. Manifold A is the westernmost section of the system and contains 12 alluvial dewatering wells. The numbers of these wells are 301 through 306 and 330 through 335. Within Manifold A the primary contaminant of concern is DIMP. Manifold B begins east of D Street and includes 12 alluvial wells, numbered 307 through 318. The primary contaminants of concern in Manifold B are DBCP, DCPD and DIMP. Manifold C includes the easternmost section of the system alignment and is made up of 11 alluvial wells, numbered 319 through 329. Manifold C intercepts trace concentrations of DBCP and DIMP. Ground water from each manifold is fed to a combined influent sump prior to entering the granular activated carbon adsorption treatment system.



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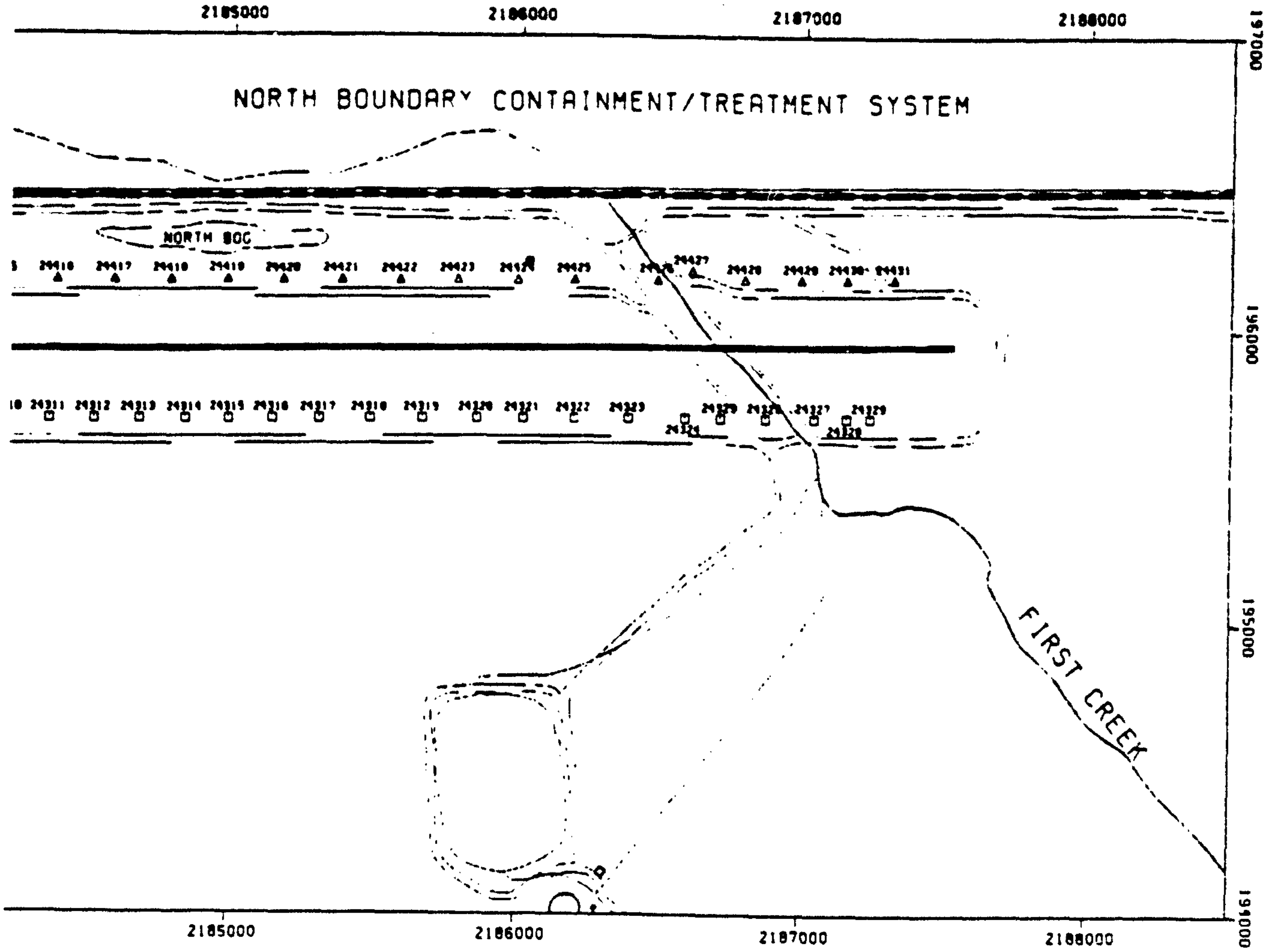
T9
T10
LEGEND
Dewatering Wells
Recharge Wells
Drainage
Road
Structure
Trench
Slurry Wall
Arsenal Boundary



SYM	DESCRIPTION	DATE	APPROVED

REVISIONS

DEPARTMENT OF THE ARMY
ROCKY MOUNTAIN ARSENAL - DENVER, COLO.

DRAWN BY JLS - TT	North Boundary Containment/Treatment System
DATE MAY, 1990	
CHECKED BY	Figure 3
REVIEWED	NBCS System, Spring 1990
FILENAME	

CONTRACTOR	SUB CONTRACTOR	ENGINEERING OFFICE
[illegible] ASSOCIATES, HUNTSVILLE AL	[illegible], DENVER, COLORADO	

ROCKY MOUNTAIN ARSENAL, DATABASE MANAGEMENT CONTRACT	SH		SCALE	DATE
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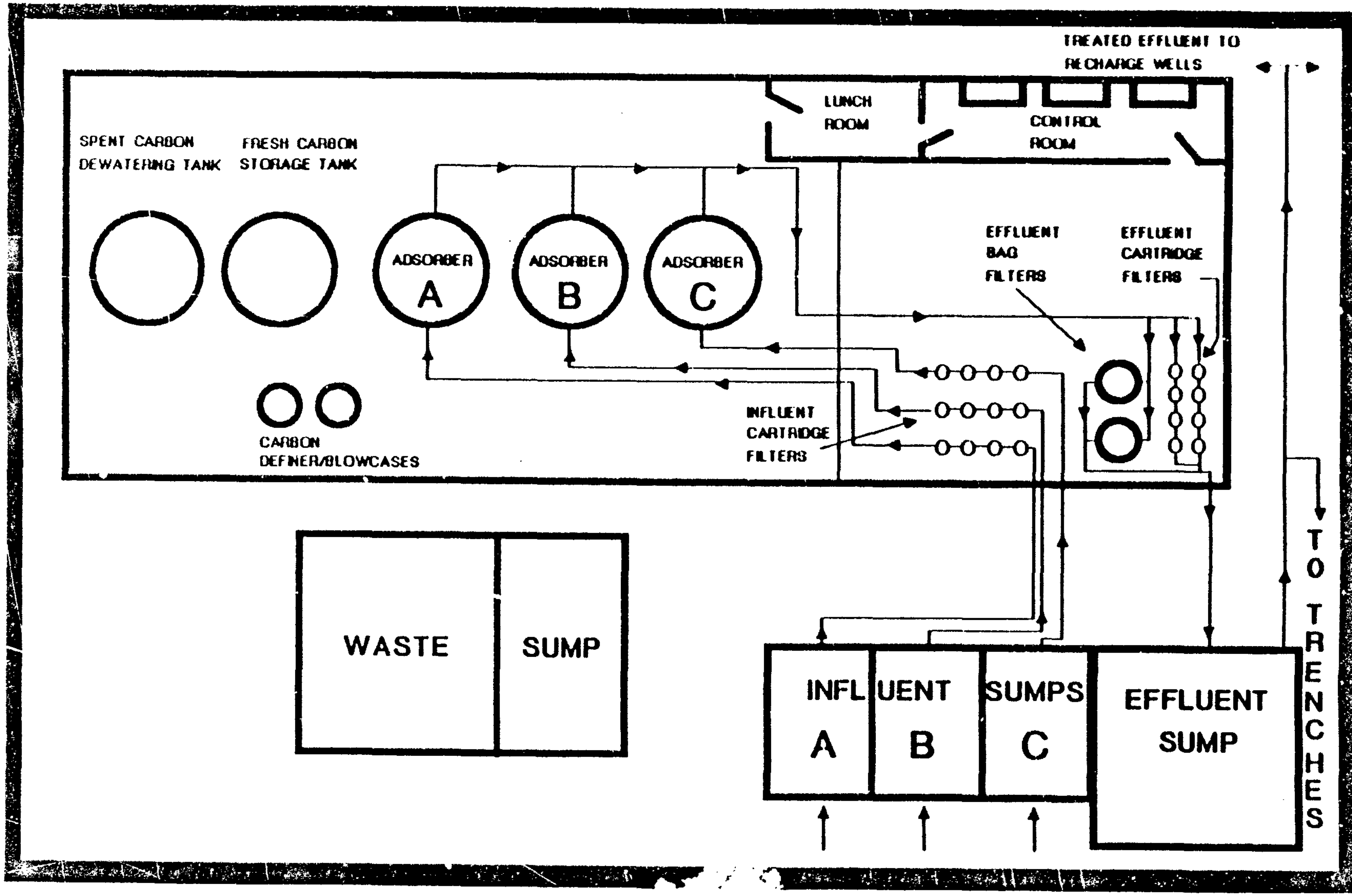
The treatment system is made up of bag-type prefilters to remove suspended solids from the water, three 30,000 pound (carbon capacity) upflow pulsed-bed carbon adsorbers, two carbon transfer vessels, a fresh carbon storage vessel, a spent carbon dewatering vessel, and bag-type postfilters (See Figures 4 and 6). The adsorbers are pulsed-bed type; that is, an amount of spent carbon is removed from the bottom of the adsorber and an equal amount of fresh carbon is added to the top. About 1500 pounds of carbon are changed in a "pulse." Treated ground water is discharged to a common sump prior to recharge. Recharge to the alluvium is accomplished through 15 recharge trenches (original full-size system employed 38 injection wells) located downgradient (north) of the slurry wall. The treated water is pumped to the trenches, but gravity is used to recharge the water to the alluvial aquifer. The trenches are spaced to allow a continued diffusion and dispersion in a manner similar to that which occurred prior to system implementation (Thompson, et. al., 1985).

4.0 NBCS Improvements Interim Response Action

Implementation of an Interim Response Action (IRA) that consists of a series of improvements to the NBCS was started in 1989 with the installation of ten recharge trenches in the westernmost section of the system. Additional work in 1990 included installing five additional recharge trenches on the remaining (eastern) portion of the system. Other improvements completed in 1990 include revising the dewatering manifold system so that all dewatering wells pump to one combined influent sump, repiping the system so that normally two of three adsorbers will be used in parallel with the third on standby, and changing the pre- and post-filtering scheme. The improvements are scheduled to be completed by December 11, 1990. A diagram of the system showing how the dewatering/ recharge system will look after the IRA is completed is at Figure 5. Figure 6 is a diagram of the treatment plant with IRA improvements.



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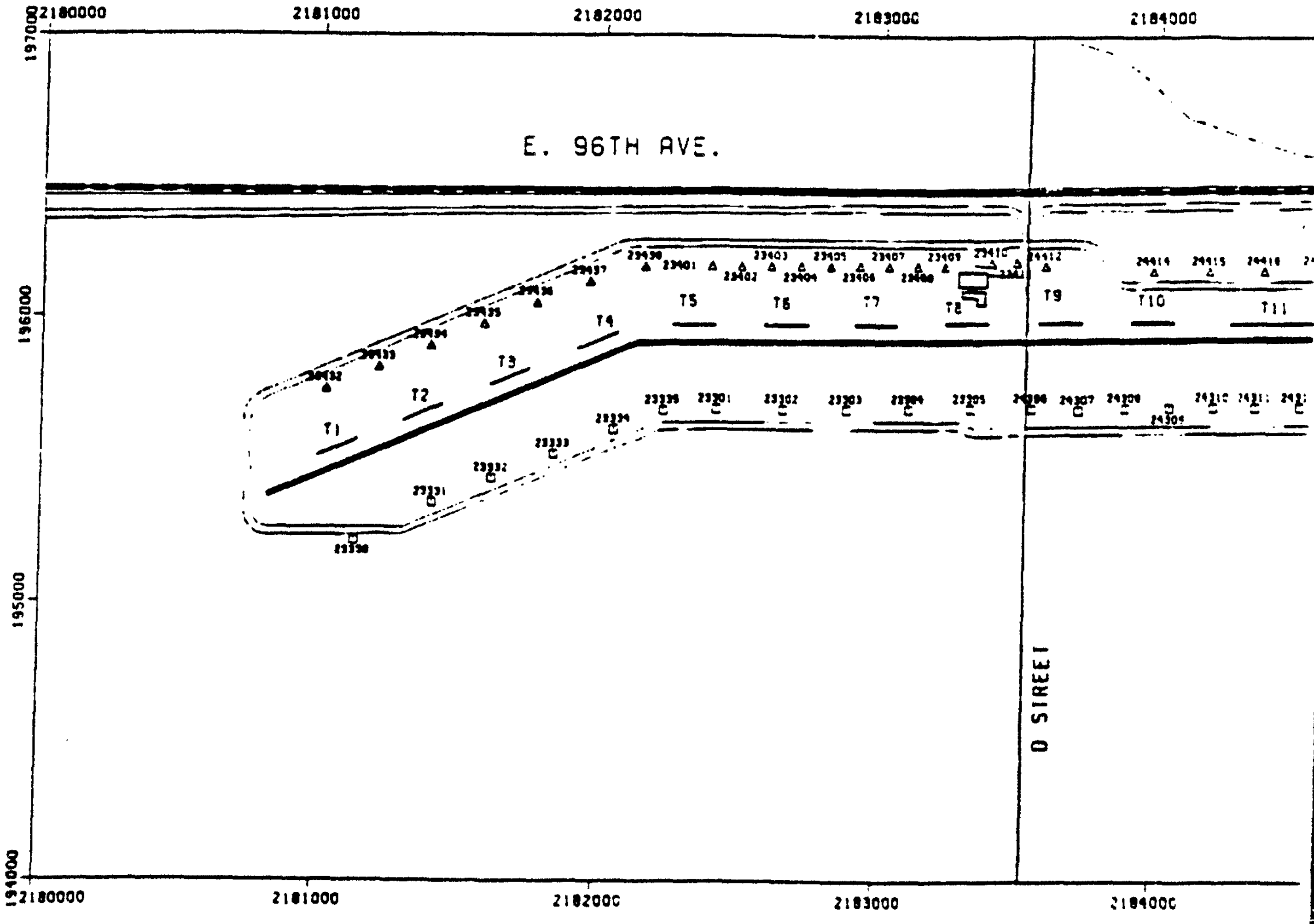
NBCS Treatment [illegible] IRA



LEGEND

- Dewatering Wells
- Recharge Wells
- Drainage
- Road
- Structure
- Trench
- Slurry Wall
- Arsenal Boundary

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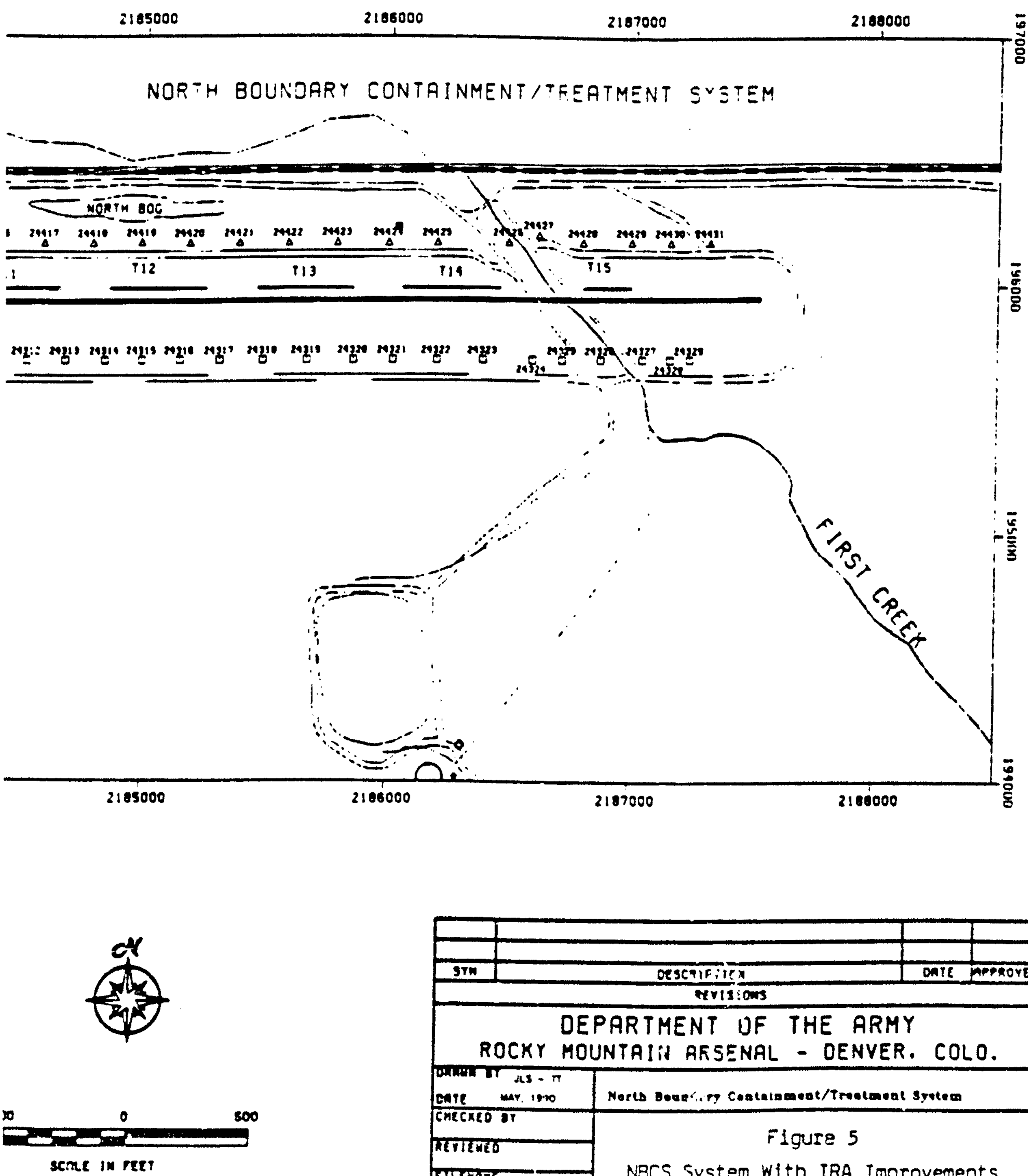
A



SYM	DESCRIPTION	DATE	APPROVED

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DEPARTMENT OF THE ARMY
ROCKY MOUNTAIN ARSENAL - DENVER, COLO.

DRAWN BY JLS - TT
DATE MAY, 1990

North Boundary Containment/Treatment System

CHECKED BY
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Figure 5
NBCS System With IRA Improvements

DP ASSOCIATES, HUNTSVILLE AL	TENTINE, DENVER, COLORADO	
CONTRACTOR	SUB CONTRACTOR	ENGINEERING OFFICE

ROCKY MOUNTAIN ARSENAL
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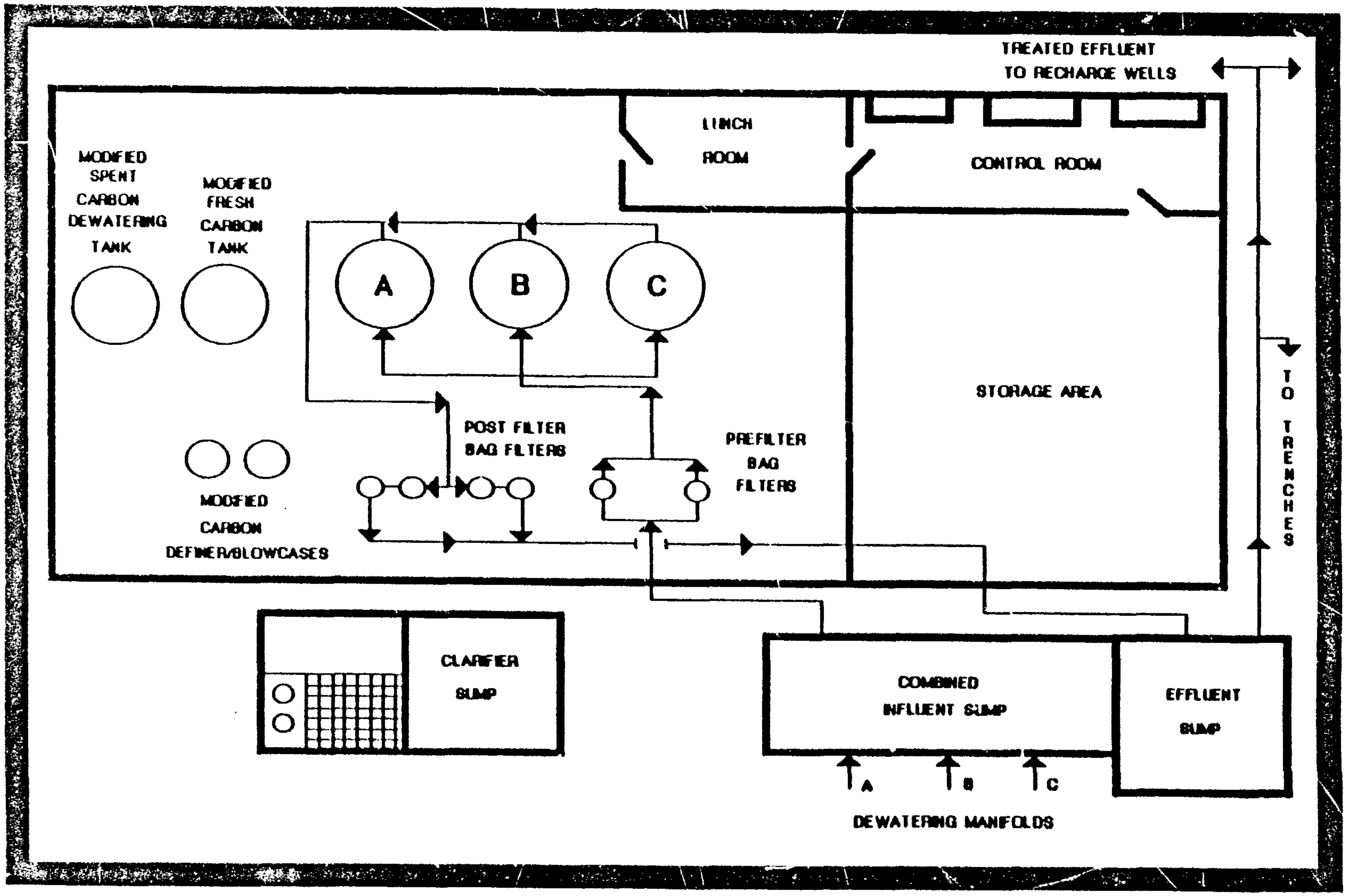


Figure 6

NBCS Treatment Plant With IRA Improvements

5.0 Site Conditions.

5.1 Geology

The topography at RMA consists of rolling hills, expansive areas of plains, and small, shallow, enclosed basins. The maximum topographic relief is approximately 220 feet. The elevation above mean sea level (msl) ranges from 5,340 feet atthe south boundary to 5,120 feet at the north boundary. The topographic surface at RMA slopes gently northwest toward the South Platte River at approximately 0.35 degrees (Stollar, 1989).

Along the north boundary of RMA, the two stratigraphic units of concern are the alluvium and the underlying Denver formation. The alluvium is approximately 20 to 30 feet thick in the vicinity of the containment system. The alluvium has an approximate 10 to 20 feet saturated thickness at the north boundary at a depth 5 to 15 feet below ground surface. Within the Denver Formation, which underlies the alluvium, there are localized saturated sand units with artesian conditions (Thompson, et. al., 1985).

5.2 Ground Water Hydrology

The relative complexity of the ground water regime in the area is due to intricate geologic, stratigraphic, and topographic relationships between and within the Denver Formation and the overlying surficial deposits. The alluvial and Denver aquifers are locally isolated from each other by semipermeable confining layers that restrict flow between the more permeable strata. Flow between the more permeable strata occurs where confining beds are absent, creating interconnections between aquifers (Stollar, 1989).

In the vicinity of the NBCS, the ground water flow is northward between two bedrock highs. The ground water flow in recent years has ranged from 200 to 250 gpm, averaging about 230 gpm (TOD, PMRMA, 1989). Permeability of the coarse-grained alluvium is about three orders of magnitude greater than that of Denver sandstone (Thompson 1985).

The flow path of alluvial ground water is strongly influenced by the buried topography on the underlying Denver formation. A contour map of the Denver surface is at Figure 7. Contours on this map define an apparent broad, buried stream valley or paleochannel feature entering the NBCS area from the southwest and crossing the slurry-wall barrier east of D Street. The buried valley has a maximum width of 4,000 feet in Section 23 between paralleling Denver highs on the east and west. The base of the aquifer is relatively flat and slopes from about 5,148 feet above msl in the northeast portion of Section 26 to 5,130 feet above msl near the north boundary, i.e., 18 feet in a distance of about 6,000 feet. A deeper channel was incised approximately 15 feet lower in the Denver formation. This incised channel is narrow near its origination in Section 26 but gradually widens northward to a confluence with other paleochannels at First Creek (TOD, PMRMA, 1989).

Essentially all alluvial ground water from the northeast portion of Section 26 to east of First Creek follows the paleochannel across the north boundary of RMA. Although subsequent erosion has largely obscured the present surface expression of the buried valley, surface drainage is somewhat similar in flow direction. The flow lines of alluvial ground water (Figure 8) generally parallel the buried valley between two Denver formation highs. Water collecting in the alluvium overlying the Denver highs drains at locally high gradients into the thicker alluvium of the buried valley. The water table is relatively flat within the valley so that alluvial ground water flows at relatively low gradients toward the barrier. The channel-filling coarse alluvium provides the main conduit for contaminants which migrate from the northeast portion of Section 26 to the north boundary of RMA. The major chemical plumes are largely confined within the buried valley limits (TOD, PMRMA, 1989).

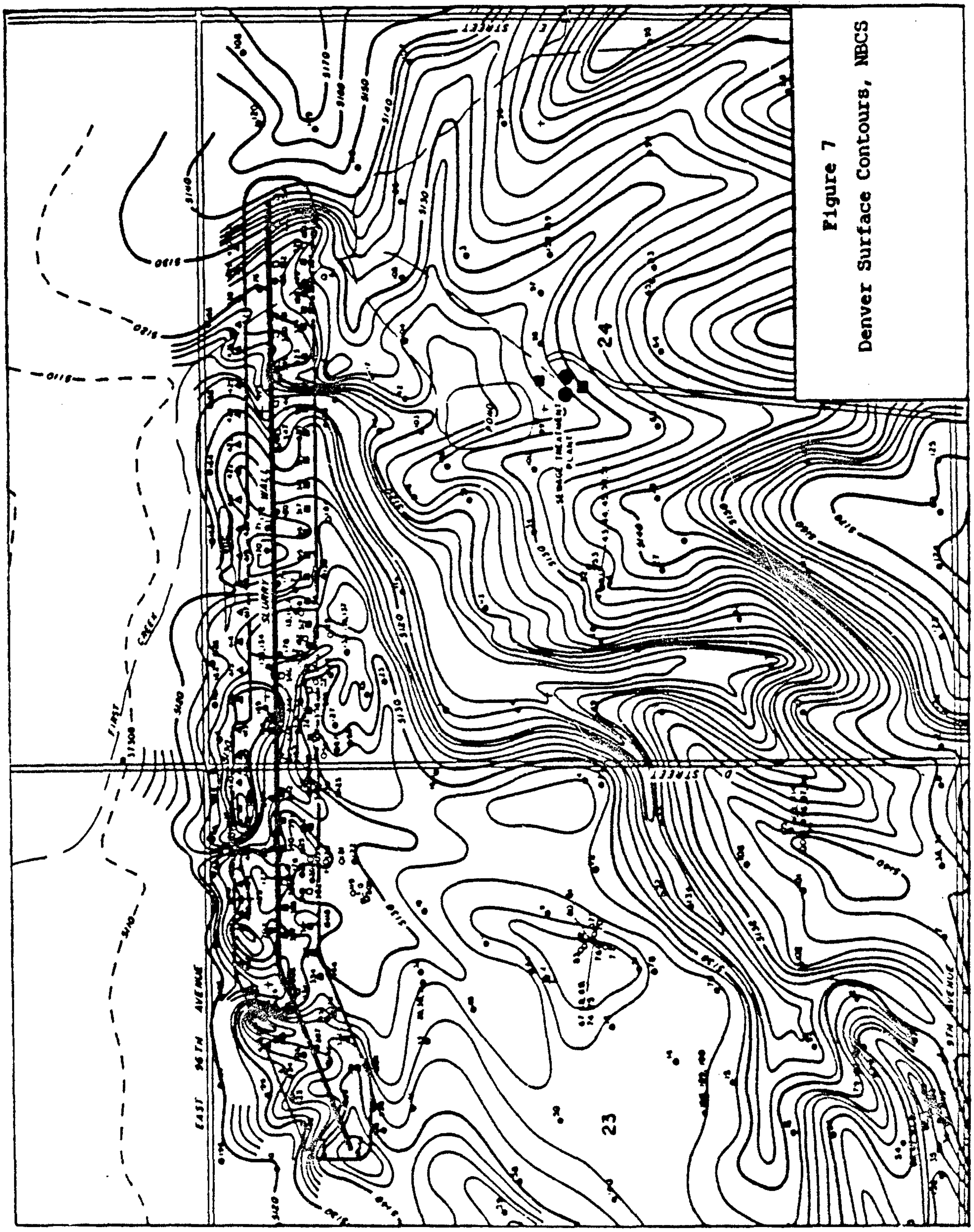


Figure 7
Denver Surface Contours, NBCS

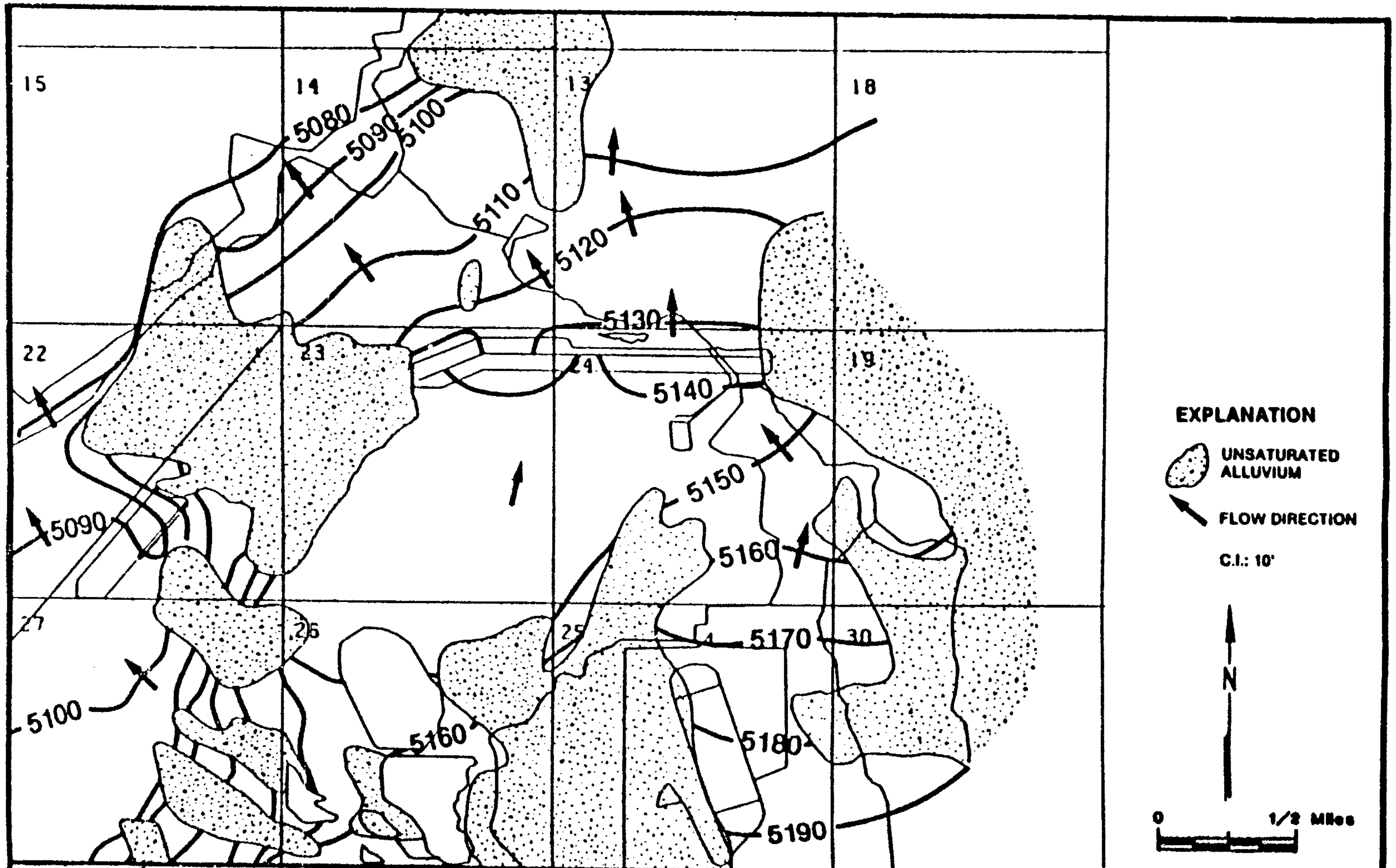


Figure 8

Generalized Alluvial Flow Directions, NBCS

SOURCE: ESE, 1986

Prepared for:
U.S. Army Program Manager's Office
For Rocky Mountain Arsenal

SECTION II - OPERATIONAL MONITORING PROGRAM

6.0 Treatment Plant Operational Monitoring

Operational monitoring of the treatment plant is performed to ensure that the granular activated carbon adsorbers are effectively and efficiently removing organic contaminants from the water, that performance standards (ARARs) are not exceeded, and that adequate data exists to document the performance of the plant.

6.1 Treatment Plant Process Control Monitoring

Process control monitoring at the NBCS water treatment plant is performed on a weekly basis. Grab samples are taken at the middle sample port of each adsorber as well as from the combined effluent line. The samples are analyzed for the following:

* diisopropylmethylphosphonate (DIMP),
* dibromochloropropane (DBCP),
* chloroform, and
* inorganic fluoride.

The analysis of process control samples is done with a quick laboratory turn-around time of one week. DBCP, DIMP, and Chloroform are monitored because they have been found to be the first chemicals to "break through" the activated carbon. This data is used to aid in determining how often and what quantity of carbon is changed in the pulsed-bed adsorbers. Fluoride is monitored in order to ensure compliance with the ARAR standard for fluoride of 4.0 milligrams per liter. In addition to the chemical monitoring, cumulative volumetric (flow meter) readings of water flow through the plant are taken at each adsorber on a daily basis.

6.2 Treatment Plant Performance Monitoring

Performance monitoring is performed at the treatment plant to ensure that it is treating water within performance standards (Table 1), and to ensure that no new

Table 1

NBCS Applicable, Relevant, and Appropriate Requirements (ARARs)

Substance	Abbreviation	* Standard	Source
Arsenic	AS	50 ug/l	40 CFR 141.11(b) and 40 CFR 264.94(a)(2)
Carbon Tetrachloride	CCL4	5 ug/l	40 CFR 141.61(a) and 52 Fed Reg 25716 (1987)
Chloroform	CHCL3	100 ug/l	40 CFR 141.12 (Total Trihalomethanes)
Dibromochloropropane	DBCP	0.20 ug/l	
1,2-Dichloroethane	12DCLE	5 ug/l	40 CFR 141.61(a) and 52 Fed Reg 25716 (1987)
Dichlorodiphenyl-trichloroethane	DDT	10 ug/l	40 CFR 129/101(a)(3)
Dieldrin	DLDRN	0.12 ug/l	40 CFR 129.100(a)(3)
Diisopropylmethyl-phosphonate	DIMP	600 ug/l	EPA Health Advisory, 12/88
Endrin	ENDRN	0.2 ug/l	40 CFR 141.12
Ethylbenzene	ETC6H5	1,400 ug/l	45 Fed Reg 79334 (1980)
Fluoride	F	4,000 ug/l	40 CFR 141.11(c), 141.62(b)
Hexachlorocyclopentadiene	CL6CP	206 ug/l	45 Fed Reg 79336 (1980)
Tetrachloroethylene	TCLEE	8 ug/l	45 Fed Reg 79341 (1980)
Toluene	MEC6H5	14,300 ug/l	45 Fed Reg 79340 (1980)
Trichloroethylene	TRCLE/TCE	5 ug/l	40 CFR 141.61(a) and 52 Fed Reg 25716 (1987)

Note: The following are target analytes for which promulgated standards were not found: Benzothiazole, Chloride, p-Chorophenylmethyl Sulfur Compounds, 1,2-Dichloroethylene, Dicyclopentadiene, Dithiane, Isodrin, and Sulfate.

* Source: Final Decision Document for the North Boundary System Improvements Interim Response Action at the Rocky Mountain Arsenal, April 1989.

contaminant reaches a level as to require closer monitoring and/or treatment.

The principal performance monitoring for the treatment plant is the chemical analysis performed on grab samples from the influent and effluent from each adsorber, and on the combined effluent stream of the water treatment plant. Samples for primary target analytes are monitored on a monthly basis, and secondary target analyte samples plus a gas chromatograph/mass spectrometry (GC/MS) assay are taken on a quarterly basis. Primary target analytes (Table 2) are those that have been periodically found at the NBCS in measurable concentrations. Secondary target analytes (Table 3) are those compounds on the RMA Comprehensive Monitoring Program (CMP) analyte list (compounds that have been determined to be present in ground water at RMA), not routinely found at the NBCS. Chemical analytical sampling locations, location codes, and sampling frequencies are at Table 4.

Maintenance actions, subsystem downtime, and plant downtime are recorded in the operations log. This information is used in the assessment of the overall performance of the plant.

7.0 Dewatering/Recharge Operational Monitoring

Ground water level data from operational monitoring of the dewatering and recharge systems is used to evaluate hydrological conditions at the NBCS, relative to achieving the objective of maintaining a reverse gradient across the barrier. The recharge data collected is used to adjust plant effluent flow to the recharge trenches and wells in order to maintain stable hydrological conditions and achieve a reverse gradient across the barrier, with the highest priority toward those areas where the upgradient ground water is contaminated. A map, showing approximate locations of dewatering wells, recharge wells, recharge trenches, monitoring wells, and piezometers at the NBCS, is at Figure 9.

Table 2

NBCS Primary Target Analytes

Organochlorine Pesticides

- Aldrin
- Dieldrin
- Endrin
- Isodrin
- DDT
- Hexachlorocyclopentadiene

Volatile Organohalogens

- 1,1-Dichloroethylene
- 1,1-Dichloroethane
- 1,2-Dichloroethylene
- 1,2-Dichloroethane
- 1,1,1-Trichloroethane
- 1,1,2-Trichloroethane
- Chlorobenzene
- Chloroform
- Carbon Tetrachloride
- Methylene Chloride
- Tetrachloroethylene
- Trichloroethylene

Volatile Aromatics

- Toluene
- Ethylbenzene

Volatile/Semivolatile Organics

- Dicyclopentadiene
- Dibromochloropropane
- Diisopropylmethylphosphonate

Anions

- Chloride
- Fluoride
- Sulfate

Organosulfur Compounds

- 1,4-Dithiane
- 1,4-Oxathiane
- p-Chlorophenylmethylsulfide
- p-Chlorophenylmethylsulfone
- p-Chlorophenylmethylsulfoxide
- Benzothiazole

Metals

- Arsenic

NOTE: Samples are tested monthly for these compounds.

Table 3

NBCS Secondary Target Analytes

Organochlorine Pesticides	Volatile/Semivolatile Organics
p,p-DDE	Dimethylmethylphosphonate
	Methylisobutyl Ketone
Organosulfur Compounds	**Anions**
Dimethyldisulfide	Cyanide
	Nitrate + Nitrite
	Alkalinity (as $CaCO_3$)
Organophosphorous Compounds	
Parathion	**Cations**
	Potassium
	Calcium
Volatile Aromatics	Magnesium
Benzene	Sodium
m-Xylene	
o-,p-Xylene	
Phenols	**Metals**
	Mercury
	Cadmium
	Chromium
	Copper
	Lead
	Zinc

NOTE: Samples are tested quarterly for these compounds.

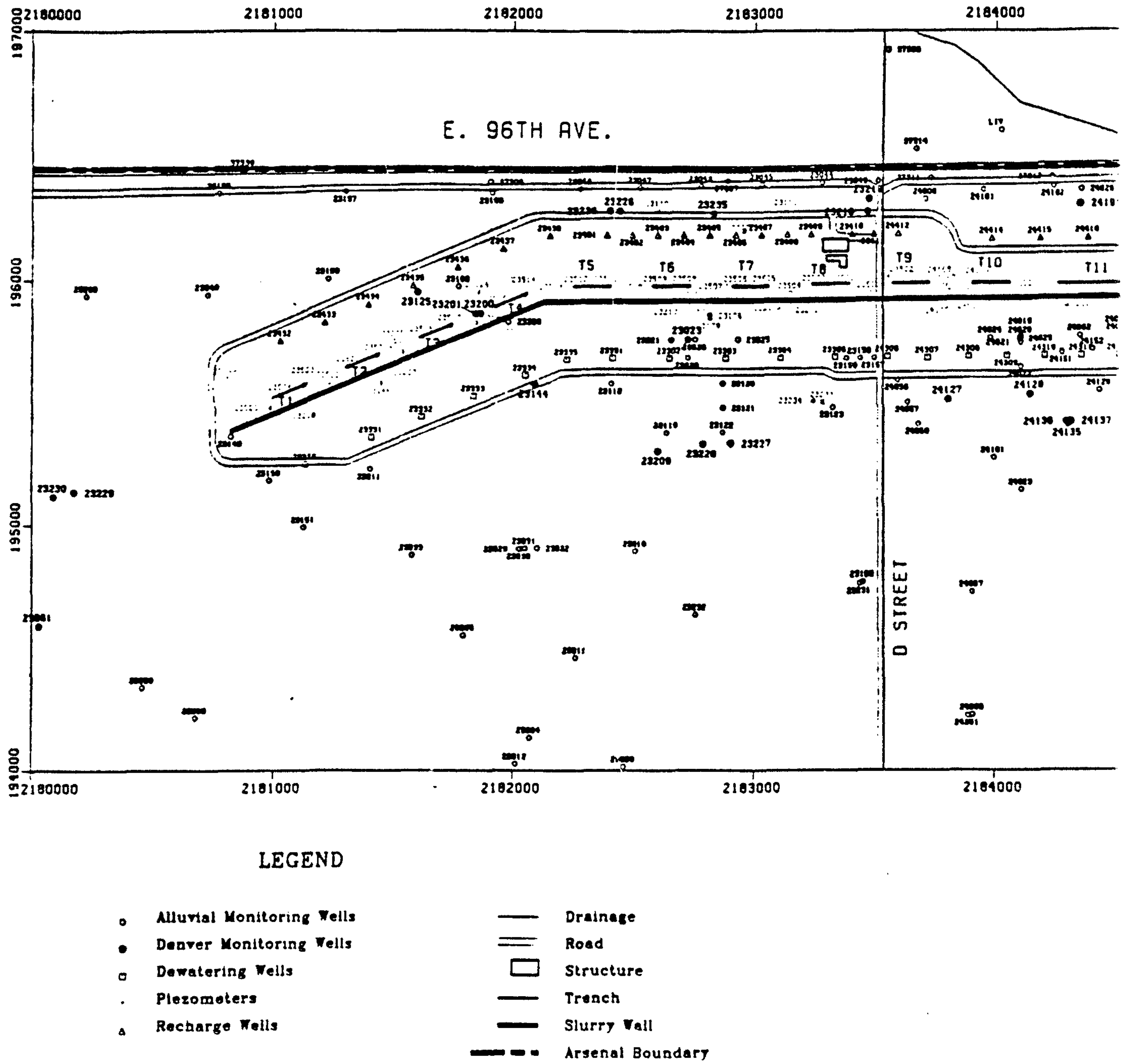
Table 4

Sample Locations, Codes, and Sampling Frequency

Sample Location	Code	Frequency
Adsorber A Influent	PNAAIN	M Q
Adsorber A Sampling Port, Lower	PNAASL	AR
Adsorber A Sampling Port, Middle	PNAASM	W
Adsorber A Sampling Port, Upper	PNAASU	AR
Adsorber A Effluent	PNAAEF	W M Q
Adsorber B Influent	PNABIN	M Q
Adsorber B Sampling Port, Lower	PNABSL	AR
Adsorber B Sampling Port, Middle	PNABSM	W
Adsorber B Sampling Port, Upper	PNABSU	AR
Adsorber B Effluent	PNABEF	W M Q
Adsorber C Influent	PNACIN	M Q
Adsorber C Sampling Port, Lower	PNACSL	AR
Adsorber C Sampling Port, Middle	PNACSM	W
Adsorber C Sampling Port, Upper	PNACSU	AR
Adsorber C Effluent	PNACEF	W M Q
System Combined Effluent	PNEFIN	W M Q
Dewatering Wells (XX = well no.)	PNDWXX	S

KEY TO FREQUENCY CODES:

W = Weekly
M = Monthly
Q = Quarterly
S = Semiannually
AR = As Required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23209
24127
24128
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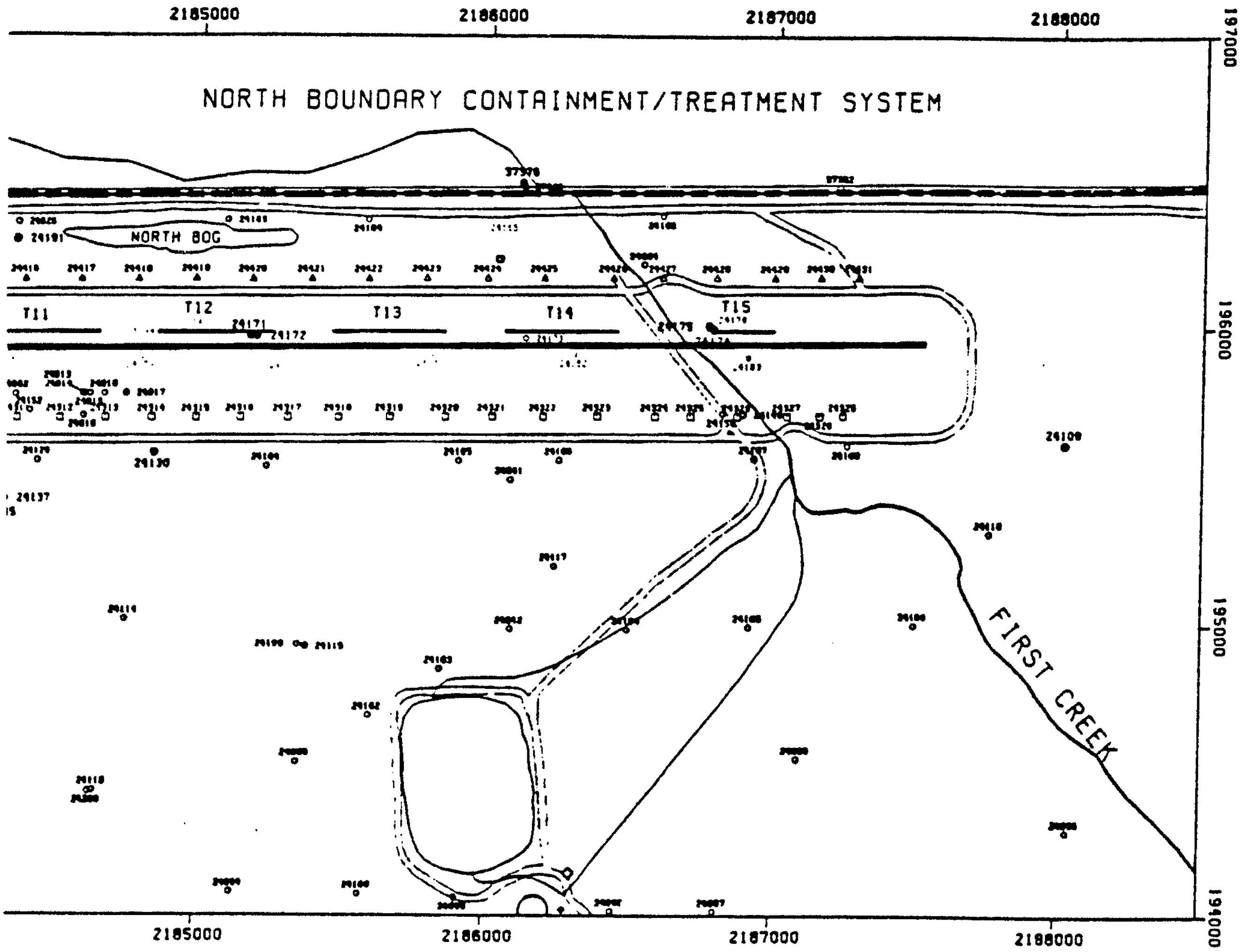
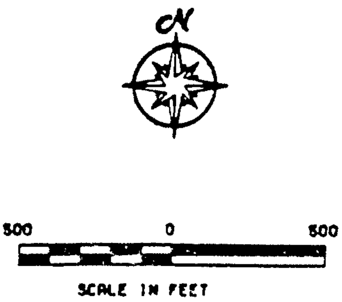
24137
24135
LEGEND
Alluvial Monitoring Wells
Denver Monitoring Wells
Dewatering Wells
Piezometers
Recharge Wells
Drainage
Road
Structure
Trench
Slurry Wall
Arsenal Boundary





SYM	DESCRIPTION	DATE	APPROVED

REVISIONS

DEPARTMENT OF THE ARMY
ROCKY MOUNTAIN ARSENAL - DENVER, COLO.

DRAWN BY DATE	North Boundary Containment/Treatment System
CHECKED BY REVIEWED REVIEWED	Figure 9 Wells, Piezometers, and Trenches Map

ENGINEER	ENGINEER	ENGINEERING OFFICE
APPROVED FOR THE COMMANDING OFFICER	SH / OF	SCALE / DATE

8

7.1 Dewatering Operational Monitoring

Operational monitoring of the dewatering wells is accomplished by measuring the ground water levels in monitoring wells (Table 4) near the dewatering wells on a weekly basis, by weekly recording the volumetric flow from each dewatering well, and by chemical analysis of a semiannual grab sample from each of the wells. These water samples are tested for the RMA CMP analytes listed previously in Table 1 and Table 2. (See Section 6.2.) The resulting chemical analytical data is examined for long-term trends.

Ground water level data obtained from monitoring wells is used for long-term trend analysis of hydrological conditions. Flow data is used to:

* determine when to clean the wells,
* evaluate hydrological control, and
* troubleshoot mechanical problems in the wells.

7.2 Recharge Operational Monitoring

Operational monitoring of the recharge trenches is accomplished by recording weekly the cumulative volumetric flow of water into each trench. The water levels in and around the trenches are monitored by means of weekly observations of alluvial monitoring wells and piezometers. The wells and piezometers used are listed in Table 4. The ground water characteristics determined from these water level readings are used to establish the elevation of the water table and to track any changes as they occur. An example plot of typical readings across the barrier is shown in Figure 10. These profiles along the trenches are constructed as needed, i.e. to illustrate changes. Other east-west profiles can be generated away from the trenches for monitoring more distant effects (Figure 11). Flow into the trenches, recorded by a Halliburton electronic flow measurement system, is reported daily. The forms for reporting this data are shown in Figure 12.

Table 5

NBCS Monitoring Wells

Dewatering Monitoring Wells

23118	24109
23120	24120
23144	24129
23145	24130
23149	24150
23150	24184
23158	24185
23211	24186
24022	24187
24056	24188

Recharge Monitoring Wells

23043	23198
23044	24006
23045	24026
23046	24161
23047	24162
23048	24163
23196	24164
23197	24166

Recharge Piezometers

23110	23208	23508	23522	24181
23111	23212	23509	23523	24182
23124	23213	23510	23524	24183
23146	23214	23511	23525	24192
23148	23215	23512	24165	24193
23161	23216	23513	24157	24194
23176	23217	23514	24168	24195
23177	23501	23515	24169	23233
23178	23502	23516	24170	23234
23202	23503	23517	24176	24501
23203	23504	23518	24177	24502
23204	23505	23519	24178	24503
23205	23506	23520	24179	24504
23207	23507	23521	24180	24505

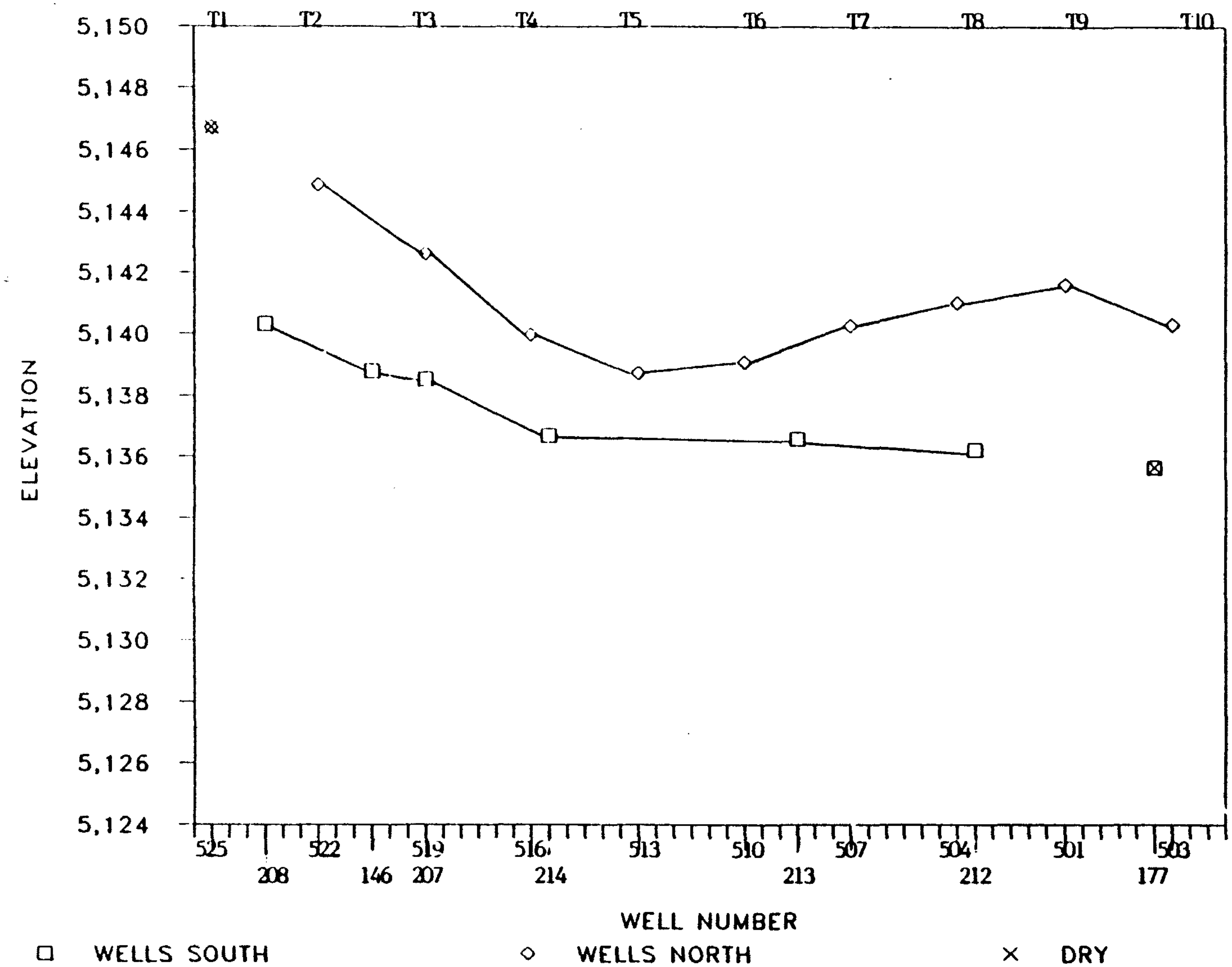


Figure 10

Water Table Profile Across Barrier at Trenches (Typical)

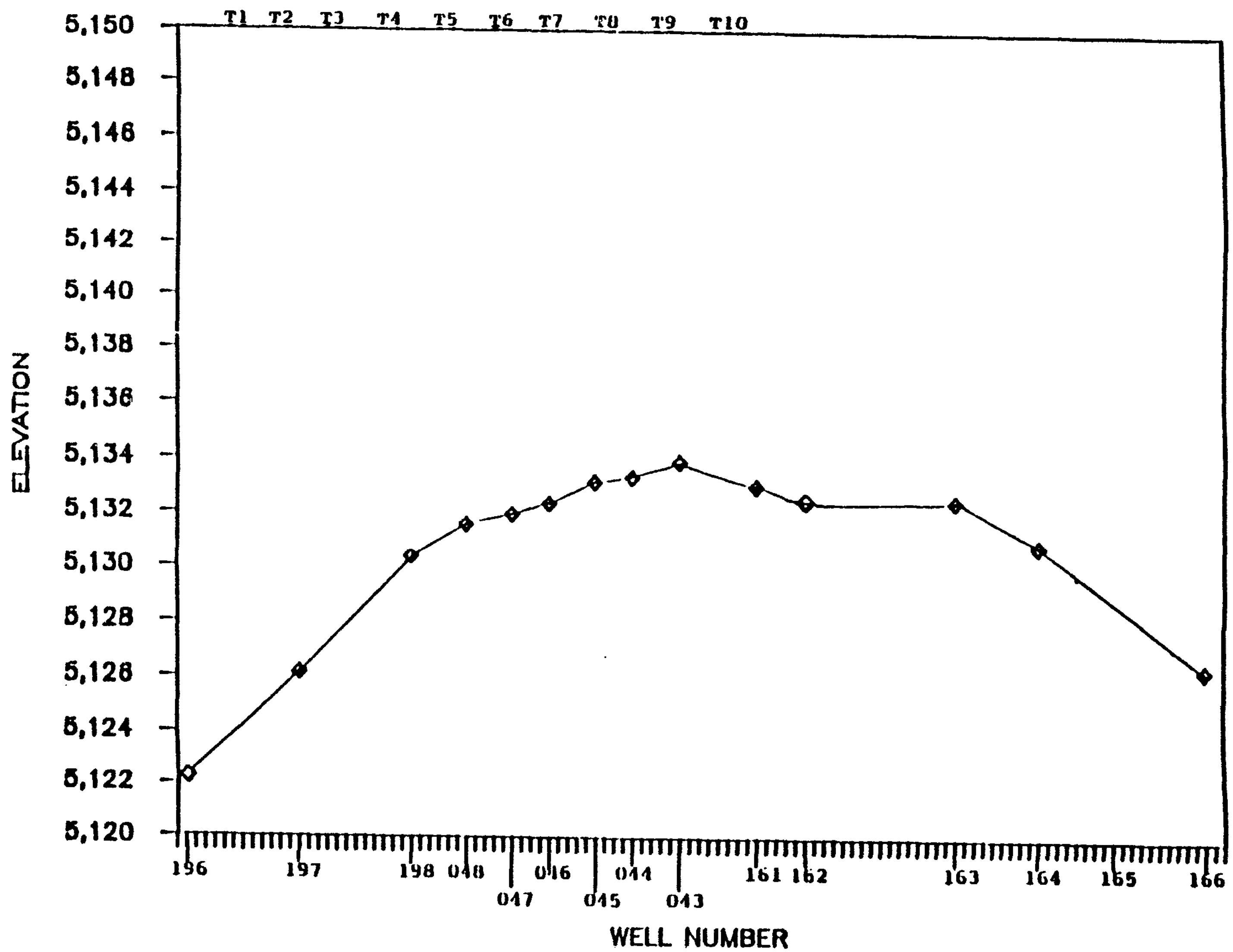


Figure 11
Water Table Profile Near RMA North Boundary (Typical)

Figure 12

Recharge Trench Data Reporting Forms

NORTH BOUNDARY

Recharge Trench Flow Data

Weekly

DATE (mm/dd/yy) ______________ JULIAN ______________ RESET (y or n) ________ TIME ______________

PREPARED BY ______________________

TRENCH NO.	FLOW TOTAL (GALS)	COMMENTS
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		

Additional Comments

____

____

____

____

D.P. ASSOCIATES, INC.

FORM: NB RC TRENCH REPORT [illegible]
REVISED 19 OCT 1990

Figure 12, Continued

NORTH BOUNDARY

Trench Report (Water Levels)

Weekly

PREPARED BY ______________________

WELL NO.	DEPTH (FEET)	MAN HOLE ACTION WATER LEVELS (FROM TOC)		COMMENTS
		HIGH LIMIT <Dec. Flow>	LOW LIMIT <Inc. Flow>	
23148				
23525				
T1 23524				
23208				
T1 23523		8.77	16.38	
23522				
T2 23521				
23146				
T2 23520		9.67	14.21	
23205				
23519				
23207				
T3 23518		8.73	13.11	
23124				
23516				
T3 23517				
23215				
23214				
T4 23515		9.23	12.37	
T4 23514				
23513				
T5 23512				
T5 23511		7.16	10.65	
23202				
23510				
T6 23509		6.75	12.67	
23216				
23213				
23177				
23176				

FORM: NB TRENCH WATER LEVELS REPORT #7

D.P. ASSOCIATES, INC. PAGE 1 OF 2 REVISED 19 OCT 1988

Figure 12, Continued

NORTH BOUNDARY

Trench Report (Water Levels)

Weekly

PREPARED BY ______________

WELL NO.	DEPTH (FEET)	MAN HOLE ACTION WATER LEVELS (FROM TOC)		COMMENTS
		HIGH LIMIT <Dec. Flow>	LOW LIMIT <Inc. Flow>	
23178				
T6 23508				
23507				
T7 23506				
23203				
T7 23505		7.52	15.89	
23504				
23212				
23217				
T8 23503				
23204				
T8 23502		7.32	16.08	
23501				
23111				
23161				
23110				
T9 24501				
T9 24502		8.12	18.07	
24177				
24192				
24503				
24168				
24167				
24169				
T10 24504		7.81	16.46	
T10 24505				
T11 24507				
21493				
24178				
T11 24508		6.53		

Figure 12, Concluded

NORTH BOUNDARY

Trench Report (Water Levels)
Weekly

PREPARED BY ______________

WELL NO.	DEPTH (FEET)	MAN HOLE ACTION WATER LEVELS (FROM TOC)		COMMENTS
		HIGH LIMIT <Dec. Flow>	LOW LIMIT <Inc. Flow>	
24194				
24179				
T12 24610		6.19		
24170				
T12 24611		4.71		
24180				
24195				
T13 24613		4.50		
24181				
T13 24614		4.98		
T14 24616		4.02		
24182				
T14 24617		5.09		
T15 24619		6.39		
24176				
24183				
T15 24620		7.59		
23233				
23234				
24165				

NOTE: T1 designates Trench #1, Trench 2, etc., etc.,
NOTE 2: At High Limit water comes into manhole: at Low Limit water is below the level of the corresponding dewatering well.

D.P. ASSOCIATES, INC. PAGE 3 OF 3 FORM: NB TRENCH WATER LEVELS REPORT #7 REVISED 19 OCT 1990

8.0 Laboratory Analysis Program

The objective of the laboratory analysis program is to provide the PM RMA with reliable ground water quality data for the NBCS. The analytical program requires that collected water samples be analyzed for a selected list of chemical parameters to achieve a quantitative determination of water quality as described in Section 3.1. The analytical program also includes semi-quantitative analysis of selected samples as discussed in Section 8.2.

8.1 Analytical Parameters

The water samples, collected during the sampling events outlined in this plan, are analyzed for parameters listed previously in Tables 1, 2, and 3. The list of analytical parameters used is consistent with the RMA CMP, and may be changed to reflect changes in the CMP. The methodologies and certified reporting limits for analysis of the target analytes are as specified by PM RMA. Specific quality assurance (QA) methods are discussed in detail in the Rocky Mountain Arsenal Chemical Quality Assurance Plan (RMA CQAP), July 1989. The technical quality of data generated in this program is assured by documenting all of the analytical procedures and requiring all data to exceed minimum analysis method requirements with respect to instrument calibration. Sample preparation, materials shipping, handling, and chain-of-custody procedures follow the protocol outlined in the RMA CQAP referenced above. All analytical methods must be certified by PMRMA for use in this program.

8.2 GC/MS Analysis

The laboratory analysis program includes a semi-quantitative analysis of selected water samples (see Section 6.2 and Table 3) by gas chromatography/ mass spectrometry (GC/MS). In addition, the GC/MS analysis is used to indicate the presence of nontarget analytes. Where nontarget analytes are repeatedly detected at elevated levels, action will be coordinated with the RMA CMP Technical Manager to identify the compounds and evaluate them for incorporation into the target analyte parameters. GC/MS analysis is performed on system influent and effluent samples on a quarterly basis.

9.0 Geotechnical Operations

The geotechnical program for the NBCS COMP consists of maintenance of existing dewatering, recharge and monitoring wells and recharge trenches, replacement of existing wells and trenches that prove inadequate, and installation of new wells and trenches, if required.

9.1 Maintenance of Existing Wells and Trenches

The need for maintenance activities is evaluated on a periodic basis. Maintenance of wells common to other programs will be closely coordinated with those programs. Maintenance activities include the following:

* repair or replacement of well pumps;
* repair of casing stickups;
* installation of protector casings;
* installation of steel marker posts;
* installation of surface seals;
* resurvey of repaired well sites;
* installation of permanent identification tags;
* installation of replacement well caps;
* clearance of weeds from area around wells;
* installation of weed barrier mats;
* repair of soil grading around wells;
* redevelopment of wells; and
* removal of accumulated sediment in well casing.

9.2 Limited System Modifications

It may be necessary to occasionally effect limited modifications or additions to the treatment plant, dewatering system, recharge system, or monitoring well network. Should this need arise, the installation will be planned and implemented expeditiously.

10.0 Quality Assurance

The Quality Assurance (QA) program for water quality monitoring, sampling, and analysis will be consistent with the PM Rocky Mountain Arsenal Chemical Quality Assurance Plan, Version 1.0, dated July 1989.

11.0 Interface with the RMA CMP

The Comprehensive Monitoring Program (CMP) maintains a ground water monitoring program up-gradient and down-gradient of the NBCS. The CMP also monitors the Denver sands via monitoring wells in and around the NBCS, and annually provides an assessment of the data gathered. The design of the monitoring network, including ground water level measurement locations and frequencies, and the water quality monitoring sites and frequencies is accomplished through the existing CMP. This monitoring program is developed and coordinated with the operations group. The NBCS COMP is designed to interface with the CMP in sampling times, frequencies and analytes. Data and assessment reports acquired or prepared by the CMP are provided to the NBCS COMP technical manager for evaluation. This information includes:

* ground water level data;
* ground water level contour maps for each aquifer (alluvial and upper Denver sands);
* contaminant distribution or plume maps;
* assessment of any changes in water quantity or quality from monitoring conducted previously in both the alluvium and Denver sands (trend analyses);
* an evaluation of the levels of contamination in both the Denver and alluvial aquifers;
* assessment of any changes in contaminant plumes and contaminant migration pathways, both upgradient and downgradient of the system; and
* recommended changes in sampling locations, frequency, analytical parameters, equipment, or methodology.

Information received from the RMA CMP may be utilized along with other data in the annual system operational assessment report (Section 15). The trend analyses of upgradient and downgradient alluvial and Denver sands conditions, provided by the RMA CMP, are also used to adjust operations at the NBCS.

12.0 Data Management

This section deals with the procedures specific to the management of data generated pursuant to the program's objectives.

12.1 Analytical Data

Water-quality samples requiring laboratory analysis are shipped under chain-of-custody to either the Rocky Mountain Arsenal Laboratory or to a contract laboratory. The laboratories log the samples in a logbook specific to RMA work and review the sample tags and accompanying field chain-of-custody record for agreement. Any discrepancies are noted in the logbook and rectified by contacting the QA Coordinator upon receipt of the samples. The laboratories are responsible for assigning the samples to the various analyses as stated on the field chain-of-custody and ensuring that they are conducted within the guidelines of PM RMA certified methods.

Laboratory personnel are responsible for the coding of the results of analyses into format prescribed for use in the Installation Restoration Data Management System (IRDMS). Data entry and initial data verification are conducted by laboratory personnel utilizing the PC-based IRDMS programs provided by PM RMA. Files are transferred to the RMA database by computer disk. These files are then run through the final data acceptance checks, and acceptable files are uploaded by the Army's Data Management group into the files serving as the final repository for the data generated under the RMA cleanup programs.

12.2 Plant Operations and Maintenance Data

Operational data is maintained by PM RMA. This data includes plant flow information, dewatering and recharge rates, and ground water levels. Maintenance and other operational data, including plant downtime and carbon usage rates, is maintained by the RMA Technical Operations Division.

13.0 Internal Operations Reports

Technical Operations Division of Rocky Mountain Arsenal routinely summarizes operational data in periodic reports for internal use. Reports commonly include volume of water treated, carbon usage, significant downtime, and maintenance required of each treatment system. Internal operations reports cover periods of a day, month, quarter, and year. Information covered by these operational reports are included in the annual assessment report (Section 15).

13.1 Daily Internal Operations Reports

Daily operations reports are used to record operations data. Copies are circulated internally for various uses, including ordering carbon and assessing maintenance actions. Data included on the form are recorded and used for operational assessments. The reports include the following information:

* preset flow for each adsorber, gallons per minute (gpm);
* flowmeter readings for each adsorber and system total;
* daily total volumetric flow for each adsorber and system total;
* average daily flow rate (gpm) for each adsorber and system total;
* daily total volumetric flow to trenches;
* daily average flow rate (gpm) to trenches;
* daily carbon transfers, if any;
* plant or equipment downtime and reason(s);
* dewatering wells not operating, if any;
* recharge wells not operating, if any;

* maintenance requirements log, including type, date repairs were requested, date completed, time required for repairs, and parts required; and

* additional or clarifying comments.

13.2 Monthly Internal Operations Reports

Monthly internal operations reports summarize information contained in the daily reports. A typical monthly report includes:

* total volumetric flow for the month for recharge wells, recharge trenches, total water recharged, individual adsorbers, total adsorbers, and dewatering wells;

* average flow rate (gpm) for the month for recharge wells, recharge trenches, total water recharged, individual adsorbers, total adsorbers, and dewatering wells;

* itemized list of adsorber downtime for the month, including date, adsorber down, time loss, and reason for downtime;

* summarized list of adsorber downtime for the month, and total system downtime; and

* carbon use for the month, by adsorber and plant total.

Information contained within the monthly reports is also summarized on a quarterly and annual basis.

14.0 Quarterly Fluoride Report

A quarterly report, containing results of laboratory chemical analytical tests of the levels of fluoride in the influents and effluent of the NBCS, the volume of water treated on each sample date is prepared by the Technical Operations Division of PMRMA. This report provides information relative to the ARAR standard for fluoride (4.0 milligrams per liter), and is routinely sent to the Environmental Protection Agency.

15.0 Annual System Operational Assessment Report

A formal assessment of the system and its major components is performed each fiscal year. Information collected during the year by the NBCS COMP and provided by the RMA CMP is compiled and evaluated. Results of this evaluation of data is presented in an annual year-end technical report entitled "Rocky Mountain Arsenal North Boundary Containment/Treatment Assessment Report." The report includes:

* a summary of background information;
* discussions of work performed during the year;
* compilation of data gathered under the program;
* compilation of RMA CMP data related to the NBCS;
* the results of interpretive efforts;
* conclusions drawn during the assessment;
* recommendations for program changes, if any;
* recommendations for system improvements, if any; and
* recommendations for operational changes, if any.

Criteria for evaluation of the system and each of its components (treatment plant, dewatering wells, and recharge wells and trenches) are described below.

15.1 Treatment Plant Operational Evaluation

Operations of the treatment plant will be described for the year. Individual adsorber and combined flow data will be presented. Downtime will be presented and discussed. Influent and effluent water quality data will be presented, by analyte, and discussed. Carbon usage will be segregated by adsorber, and summed. Much of this data presented is in tabular or graphical format. Parameters used in evaluation of the treatment plant are:

* effectiveness of the removal of organic contaminants present in the ground water;
* volume of ground water treated;
* carbon usage rates; and
* amount of downtime of the treatment plant.

Data for the year will be compared to previous years' data. Annual and seasonal trends, if any, will be discussed.

15.2 Dewatering Wells Evaluation

Data for each analyte will be presented and discussed. A comparison of contaminant concentration along the line of dewatering wells will be displayed and discussed. Annual and seasonal trends, if any, will be examined. Parameters used in evaluation of the dewatering wells are:

* trends in contaminant concentrations in each well;
* trends in contaminant concentrations along the system;
* volume of water pumped and rate of flow of each well; and
* downtime of the wells.

15.3 Recharge Trenches Evaluation

Ground water behavior around the trenches will be described for the year. Periodic readings will be used to quantify the changes. Flow to individual trenches will be summarized. Evidence of long-term degradation in performance of the western section and the eastern section of trenches will be assessed. The permeability established at startup (see Section 16) will be used initially as a baseline for comparison. It will also be possible to track deterioration year to year for defining a continuing trend. The parameters used for this analysis are the head gradient and flow rate which are measured directly, or calculated from ground water level readings.

15.4 NBCS Operational Evaluation

The overall performance of the system will be evaluated regarding the following parameters:

* control of ground water approaching the system;
* maintenance of a reverse gradient across the barrier;
* containment of contamination within the Arsenal boundaries;
* effect on quality and quantity of ground water downgradient of the system.

Information regarding the type, quality, and methods of data collected during the year will be presented. An operational summary of the past year, a summary of system downtime and significant maintenance actions, and system flow quantities are to be included, as well as a discussion of any alterations to the facility during the past year.

An examination and discussion of ground water levels and flow in the vicinity of the NBCS is also included in this section of the annual report. This section includes:

* a description of the local geology and hydrogeology;
* a discussion of trends in local flow patterns;
* water table maps;
* water table profiles;
* analysis of long-term contaminant trends; and
* discussions and examination of overall system performance.

16.0 Special Reports

Special reports are anticipated occasionally. For example, a startup report may be useful at the introduction of a new or significantly modified component of the NBCS. One such report is the Eastern Recharge Trenches Startup Report. This performance report will be prepared for the startup of the eastern section of recharge trenches, installed as part of the NBCS Improvements IRA. Items discussed will include:

* design and construction of the trenches;
* startup operations;
* alluvial aquifer response;
* response in bedrock (Denver); and
* initial capacity of trenches.

The initial capacity of trenches, established in the startup report, will be used to define the baseline recharge capacity of the trenches for evaluation of long-term degradation of capacity in the annual assessment report.

REFERENCES

Environmental Science & Engineering, Inc. (ESE). Nov. 1989. "Boundary Control Systems Assessment Remedial Investigation Draft Final Report (Version 2.2)."

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