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MAJOR MODIFICATION Application Volumes III & IV

June 11, 2009

STATE OF NEW MEXICO
DIRECTOR OF OIL CONSERVATION DIVISION

IN THE MATTER OF THE APPLICATION OF BASIN DISPOSAL, INC. FOR A SURFACE WASTE MANAGEMENT FACILITY PERMIT

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Oil Conservation Division

APPLICATION FOR MODIFICATION
BASIN DISPOSAL, INC.
OCD Permit # NM-01-0005

DECEMBER 2008
(Updated June 2009)

VOLUME III: ENGINEERING DESIGN AND CALCULATIONS

VOLUME IV: SITING AND HYDROGEOLOGY

Prepared For:

Basin Disposal, Inc.
200 Montana Street
Bloomfield, NM 87413
(505) 632-8936

Submitted To:

New Mexico Energy, Minerals, and Natural Resources Department
Oil Conservation Division
1220 South St. Francis Drive
Santa Fe, NM 87505
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Prepared By:

Gordon Environmental, Inc.
213 South Camino del Pueblo
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(505) 867-6990

APPLICATION FOR MODIFICATION
BASIN DISPOSAL, INC.
OIL FIELD WASTE EVAPORATION PONDS

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STATE OF NEW MEXICO
DIRECTOR OF OIL CONSERVATION DIVISION

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BASIN DISPOSAL, INC.
OIL FIELD WASTE EVAPORATION PONDS

VOLUME III: ENGINEERING DESIGN AND CALCULATIONS
SECTION 1: ENGINEERING DESIGN

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SECTION 1: ENGINEERING DESIGN

1.0 INTRODUCTION

The primary purpose of this Application for Permit Modification is to obtain OCD approval for the installation, operation, and closure of two new evaporation ponds (Ponds 2 and 3), as well as 6 new receiving tanks and 2 additional oil sales tanks. The issuance of the new Permit will also establish a timeline for the 10-year Permit Renewal, and any mid-term reviews by OCD pursuant to §19.15.36.

This Application is an "Engineering Design Plan" as referenced in §19.15.36.17.A: *"Specific requirements applicable to evaporation, storage, treatment and skimmer ponds"*. This Volume addresses the engineering requirements of Subpart A; and the construction Standards of Subpart B of that Section. Compliance with the design standards is demonstrated on the Permit Plans (**Table III.1.1**), which are sealed by a New Mexico Professional Engineer with extensive experience in geotechnical engineering and waste containment design employing geosynthetics. The Permit Plans are engineering drawings provided for reference in **Attachment III.1.A** as 11" x 17" prints; and also submitted to OCD as "D" size sealed plots (i.e., 24" x 36").

Table III.1.1
List of Permit Plans

Sheet No.	Title
1.	Site Location and Drawing Index
2.	Existing Site Conditions
3.	Grading Plan
4.	Cross Sections
5.	Drainage Plan
6.	Drainage Channel Profiles
7.	Engineering Details
8.	Liner Details

The engineering design also addresses the requirements of §19.15.36.13.M. pertaining to the control of run-on and run-off from the 25-year, 24 hour design storm (**Volume III, Section 4** and **Permit Plan Sheets 5** and **6**; **Attachment III.1.A**).

2.0 POND DESIGN STANDARDS

The designs for Ponds 2 and 3 are identical, except that all of the Pond 2 elements are exactly 10' higher than the same components in Pond 3 (**Permit Plan Sheets 3** and **4; Attachment III.1.A**). Each pond is approximately 425' (E-W) by 210' (N-S) as measured at the centerline of the surrounding berms, for a footprint of 4.1 acres ±. The floor of the ponds is designed with a 2% slope to facilitate drainage in the leak detection system to the two sumps in each basin situated on the south sidewall.

Because the berms have a uniform top elevation, the 2% floor slope creates a pond depth that ranges from a maximum of 11' to a minimum of just less than 8'. Maintaining a high water elevation of 5727.5 in Pond 2; and 5717.5 in Pond 3; will provide a freeboard of 3.5' in each pond. This is more than adequate to meet the 3' minimum freeboard standard; while also accommodating the minimal impact potential of rainfall or wave action (**Volume III, Section 5**). The resultant capacity of each pond is approximately 9.5' acre-feet, not including freeboard, below the maximum 10 acre feet volume prescribed by §19.15.36.17.B.(12).

Section 5.0 (Pond Construction) and **Volume III, Section 2** (CQA Plan) provide documentation on the installation of berms, soil subgrade, and geosynthetics. Exceeding the standards specified in §19.15.36.17.B.(4), both the exterior and interior sidewalls of Ponds 2 and 3 have design slopes of 3:1. The top platform of the berms surrounding the Ponds has a design width of 10', which more than adequate for the 2' anchor trench shown on the Permit Plans (**Attachment III.1.A; Sheet 7**).

3.0 LINER SYSTEM

The double liner and leak detection system design planned for BDI Ponds 2 and 3 consists of proven technology with a demonstrated track record of long-term waste containment performance. The secondary liner consists of a smooth 60 mil HDPE geomembrane placed in direct contact with a prepared and compacted soil subgrade [§19.15.36.17.B.(3); B.(8)].

The same material will be used for the primary liner, and the geonet for the leak detection layer is comprised of HDPE as well. HDPE has proven to be the preferred material for waste containment facilities due to its durability and resistance to attack by waste constituents. **Volume III, Section 3** provides documentation regarding liner and leak detection material compatibility in compliance with §19.15.36.17.B.(3). An additional layer of 60 mil HDPE (22.5' x 60' ±) welded at the seams, will be added above the primary liner, where active wastewater discharge will occur (**Permit Plan Sheet 3**). This will protect the liner from excessive hydrostatic force or mechanical damage, and external discharge lines shall not penetrate the liner.

The CQA Plan (**Volume III, Section 2**) provides the most current technical specifications for the geosynthetics. The leak detection system layer design for BDI Ponds 2 and 3 consists of a 200 mil geonet specifically prescribed for these applications (**Permit Plan Sheet 8**). With a design transmissivity of 1×10^{-3} m^2/sec, it will provide fluid flow potential superior to the prescriptive leak detection layer of 2' of pervious soils [§19.15.36.17.B.(9)].

Both the underlaying 60 mil HDPE secondary liner, and the overlaying 60 mil HDPE primary liner, slope at 2% to the 2 leak detection sumps located in each pond (**Permit Plan Sheet 3**). Fluids collected in the leak detection layer, which encompasses the entire 4 ± acre footprint for each pond, are directed with the 2% slope to one of the two leak detection sumps located on the south sidewall (**Permit Plan Sheet 3**). Each of the sumps is approximately 2' deep, as measured from the secondary liner to the primary liner. The sumps consist of ¾" to 2" dia. pre-qualified select aggregate installed on a geotextile cushion placed over the secondary liner. Classification criteria for the aggregate are specified in the CQA Plan (**Volume III, Section 2**), which state that it not be angular (i.e., sharp edges which could damage the liners) or calcareous (which could degrade over time). In addition, each sump will be equipped with a secondary liner consisting of a geosynthetic clay liner (GCL), beneath the secondary liner as shown on **Permit Plan Sheets 3** and **7**. The purpose of the GCL is to provide a composite liner for temporary storage in the leak detection system, and GCL installation/CQA specifications are included in the CQA Plan (**Volume III, Section 2**).

The fluids collected in the leak detection sumps will be monitored and collected by sidewall riser pipes that do not penetrate the secondary liner in compliance with §19.15.36.17.B.(9). The piping is demonstrated to resist degradation by the waste constituents as documented in **Volume III, Section 3**.

Piping will consist of min. 4" diameter SDR 11 HDPE; and will be perforated or slotted for the bottom 2' depth within the sump (i.e., 6' length at 3:1 slope). HDPE piping has shown superior characteristics for waste containment applications vs. the SCH 80 PVC specified in the OCD standards; and has a greater wall thickness as shown on **Table III.1.2**.

Table III.1.2
Comparison of PVC and HDPE Pipe

	4" Diameter Leak Detection Riser Pipes	
Characteristic	**Schedule 80**	**SDR 11 HDPE**
Dimension Ratio	13.4	11.0
Method of Joining	Gasketed	Welded
Manning's Number (n)	0.009	0.010
Outside Diameter (in)	4.500[1]	4.500[2]
Min. Wall Thickness (in)	0.337[1]	0.409[2]
Tensile Strength (psi)	5,000	5,000
Modulus of Elasticity (psi)	400,000	130,000
Flexural Strength (psi)	14,450	135,000

Notes:
[1] Handbook of PVC Pipe, pg. 340 (**Attachment III.1.G**)
[2] PolyPipe, A-4 (**Attachment III.1.G**)

The details in the Permit Plans (**Sheet 7, Details 1, 2, 3, 5** and **6**) have been updated to reflect the deployment of SDR 11 HDPE piping for the leak detection sump riser pipes.

HDPE or geonet layers will be placed beneath the beveled edge of the perforated riser in the sump profile to a minimum thickness of 200 mil to prevent potential liner damage (**Permit Plan Sheet 7**). Solid HDPE piping will extend from the riser pipe above the sumps to the permanent wellheads shown on **Permit Plan Sheet 7**. Clean select sand will be placed in the sidewall riser trench between the primary and secondary liners to provide structural stability of the solid riser pipe system and support for the primary liner (**Permit Plan Sheet 7**).

Fluid in the Ponds will protect the floor and lower sidewall liner by providing ballast and deflecting sunlight (i.e., UV rays). The upper sections of sidewall liner are secured by the anchor trench (Section 5.0). Although the freeboard zone of the sidewall liner will be exposed to the elements, recent research indicates that exposed HDPE in similar environments has a functional longevity in excess of 25 years (**Attachment III.1.B**). GEI has inspected several water storage ponds in New Mexico and has found exposed geomembrane liners to be functionally intact after over 20 years.

4.0 DRAINAGE DESIGN

The Permit Plans, **Attachment III.1.A, Sheets 5** and **6**, show the stormwater management systems that will be employed to manage both run-on and run-off for the BDI Facility. The design event, pursuant to §19.15.36.13.M (i.e., 25-year, 24 hour storm) will be managed by a series of drainageways that surround the proposed Ponds 2 and 3 improvements; and capture stormwater from other on-site areas.

A new Stormwater Detention Basin is planned for installation as shown on **Permit Plan Sheet 5**; and the Stormwater Management Plan is included in **Volume III, Section 4** that demonstrates the efficacy of the proposed system.

The surrounding berms have a maximum exterior slope of 3:1, and an average height of less than 10', minimizing the potential for soil erosion. The drainageways and Detention Basin and will be regularly inspected and cleaned out as necessary.

5.0 POND CONSTRUCTION

Detailed Construction Plans and Technical Specifications have been prepared for BDI Ponds 2 and 3, and submitted to pre-qualified Liner Installation Contractor(s) for quotes. The berm construction, floor grading/compaction, and geosynthetics installation will be subject to the rigorous CQA standards specified in **Volume III, Section 2**.

OCD has been provided a major milestone schedule in advance of construction; and notified via e-mail or phone at least 3 working days prior to the installation of the primary liner in compliance with §19.15.36.17.B.(10). An Engineering Certification Report, sealed by a Professional Engineer with expertise in geotechnical engineering, shall be submitted to OCD documenting compliance of completed construction with the Permit, regulatory requirements, industry standards, and plans and specification.

The Engineering Design (**Attachment III.3.A**) deliberately provides a "sustainable" configuration that does not require import of off-site soils. The materials equation provides a balance between soils excavation (i.e., pond floors) and fill for the sidewalls. The in-situ and on-site fills soil will be pre-qualified in accordance with the CQA Plan (**Volume III, Section 2**). At least one Standard Proctor Density test will be conducted in the laboratory for each pond footprint or change in subgrade material. These tests will be the basis for field density measurements during construction (i.e., 90% Standard Proctor Density) conducted at a minimum frequency of 4 tests/acre/lift.

Fill for the berms will be placed in horizontal compacted lifts that do not exceed 12" in thickness. The subgrade surface will be inspected to confirm the absence of any deleterious materials, abrupt changes in slope, evidence of erosion, etc. The compliance of the completed subgrade construction shall be confirmed prior to secondary liner installation, and documented in the Engineering Certification Report.

The 60 mil HDPE secondary liner shall be installed for Ponds 2 and 3 in direct contact with the prepared and certified subgrade in accordance with the CQA Plan (**Volume III, Section 2**). Installation of the geonet; and construction of the geotextile, aggregate and riser pipes in the sumps will follow. The installation of all soil and geosynthetic components will meet or exceed the requirements of 19.15.36.17.B.(5), as detailed in the CQA Plan. Finally, the primary liner will be constructed, and all three liner/leak detection system elements (i.e., secondary, geonet, primary) will be secured in the common anchor trench (**Permit Plans Sheet 7).** The anchor trench will be carefully backfilled with select on-site soils compacted to 90% of Standard Proctor Density by mechanical and/or hand-tamping devices (CQA Plan). Documentation will be provided in the Engineering Certification Report submitted to

OCD upon completion of construction.

6.0 POND OPERATION

Detailed plans for the operation of Ponds 2 and 3 are prescribed in **Volume II, Section 1**, "Operations, Maintenance, and Inspection Plan". Essentially, it is anticipated that some fluids will accumulate in the leak detection sumps as a result of condensation, construction water, etc. As described in **Volume II, Section 1**, the leak detection sumps will be monitored at least monthly for the presence of fluids, which may be extracted and tested when the level in the sump(s) exceeds 24". The design of Ponds 2 and 3 allows for isolation of potential leaks into 4 drainage basins, facilitating necessary evaluation or repair.

7.0 TANK SECONDARY CONTAINMENT

As proposed in this Application, two (2) additional oil sales tanks and six (6) receiving tanks will be installed. Currently, Tanks 9, 10, 11 will be moved over two tank lengths and rotated so as to be oriented east to west instead of the current north to south. The six new tanks will be repositioned in between the new skimmer tanks and the existing water receiving tanks. Detailed operations of the tanks are prescribed in **Volume II, Section 1,** "Operations, Maintenance, and Inspection Plan". The new tanks will be constructed with underlying continuous 30-mil polyester bermed liner systems, extended from the existing system and designed to capture any fluids within the watershed of Pond 1 (**Attachment III.1.C**).

The current secondary containment liner in the tank area is a 30-mil polyester liner (XR-5 8130 Reinforced Geomembrane). In the extension of the secondary containment within the tank area, a 30-mil polyester liner has been specified to allow welding between compatible materials (i.e., between the existing liner and the additional liner). The use of the XR-5 8130 Reinforced Geomembrane in the tank area is primarily based on the chemical compatibility and puncture resistance of the material compared to either PVC or HDPE material. The chemical resistance of the XR-5 material exceeds the chemical compatibility of either PVC or HDPE to hydrocarbon products (see Chemical Resistance Chart, Page 13, "Technical Data and Specifications for XR Geomembranes", **Attachment III.1.H**). Since PVC material has marginal chemical resistance in a hydrocarbon environment, physical properties of the XR-5 geomembrane (**Attachment III.1.H**) are compared to 60-mil HDPE geomembrane (**Attachment III.1.I**) as shown in **Table III.1.3**:

Table III.1.3
Physical Properties
XR-5 8130 Reinforced Geomembrane and 60-mil HDPE Geomembrane

PROPERTY	XR-5 8130	60-MIL HDPE
THICKNESS	30-MIL	60-MIL
TEAR STRENGTH	40 LBS	42 LBS
PUNCTURE RESISTANCE	275 LBS	108 LBS
BREAK STRENGTH	400 LBS/IN	228 LBS/IN
BREAK ELONGATION	25%	700%
HYDROSTATIC RESISTANCE	800 PSI	> 450 PSI
HYDRAULIC CONDUCTIVITY	1 X 10^{-12} CM/SEC	2 X 10^{-13} CM/SEC
SEAM PROPERTIES		
SHEAR STRENGTH	500 LBS	120 LBS/IN
PEEL STRENGTH	40 LBS/2 IN	91 LBS/IN

The necessary storage capacity for the interconnected tank/containment system is sufficiently managed by the existing lined volume of Pond 1. In the unlikely event of a total catastrophic failure of all affected storage units, the contents of the tanks will flow into Pond 1, which has a lined storage capacity of 100,000 ± bbl (excluding freeboard). When the freeboard is included, the storage capacity of Pond 1 is over 135,000 bbl, which results in a net surplus of over 25,000 bbl. The entire volume of the receiving tanks, after installation of the six additional tank's surplus will be 8900 bbl, such that the net excess capacity is over 16,000 bbls. Thus, **Pond 1 will hold the entire volume of the receiving tanks within the required permanent freeboard of 3'.**

Attachment III.1.D provides details for the containment area construction planned for completion prior to installing the additional six receiving tanks into operation. The seven (7) 440 bbl existing oil sales tanks are currently surrounded by a 30 mil polyester lined bermed area with dimensions of 140 feet long x 22 feet wide x 2.5 feet depth resulting in a capacity of 1370 bbl. With the addition of two oil sales tanks requested in this Application, the berm will be expanded to 180 feet long x 22 feet wide x 2.5 feet depth (**Attachment III.1.E**) resulting in a capacity of 1763 bbl.

The oil sales tanks are not interconnected at the base. Therefore, the berm is conservatively sized to surround the entire oil sales tank unit, which results in a holding capacity of 1763 bbl, which is 1.3 (533 bbl) greater than the capacity of the largest tank within the bermed containment area. **Therefore the containment berm surrounding the oil receiving tanks is more than sufficient.** Also included in this Section is a similar analysis presented in a spreadsheet format as **Attachment III.3.E** for the remaining existing tanks that are not impacted as part of this Application.

APPLICATION FOR MODIFICATION
BASIN DISPOSAL, INC.
OIL FIELD WASTE EVAPORATION PONDS

VOLUME III: ENGINEERING DESIGN AND CALCULATIONS
SECTION 1: ENGINEERING DESIGN

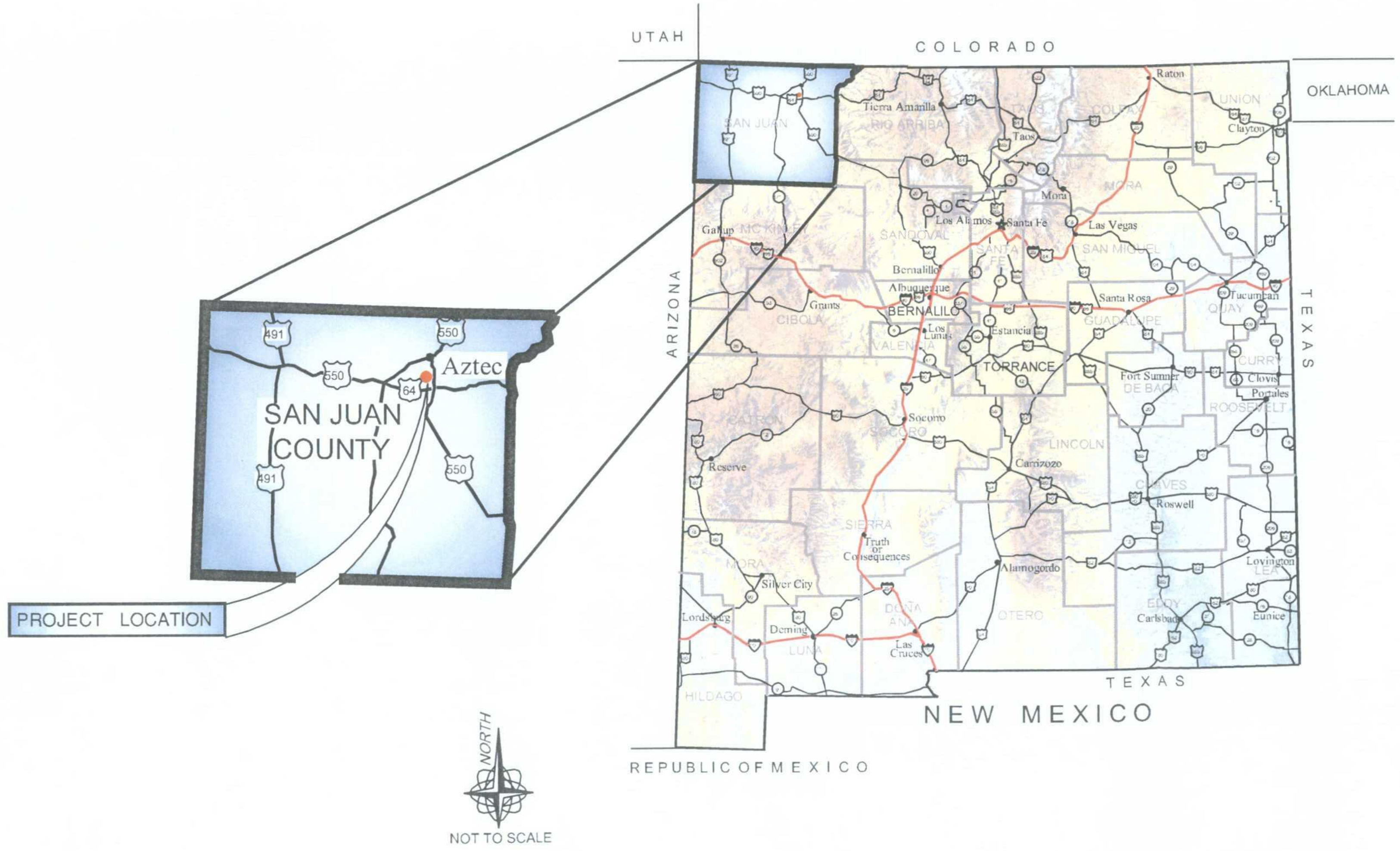
ATTACHMENT III.1.A

PERMIT PLANS

SHEET 1	SITE LOCATION AND DRAWING INDEX
SHEET 2	EXISTING SITE CONDITIONS
SHEET 3	GRADING PLAN
SHEET 4	CROSS SECTIONS
SHEET 5	DRAINAGE PLAN
SHEET 6	DRAINAGE CHANNEL PROFILES
SHEET 7	ENGINEERING DETAILS
SHEET 8	LINER DETAILS

PERMIT PLANS
FOR
EVAPORATION PONDS

BASIN DISPOSAL, INC.
BLOOMFIELD, NEW MEXICO



SITE LOCATION MAP

SHEET	TITLE
01 COVER.DWG	1 SITE LOCATION AND DRAWING INDEX
02 EXISTING.DWG	2 EXISTING SITE CONDITIONS
03 GRADING.DWG	3 GRADING PLAN
04 XSECS.DWG	4 CROSS SECTIONS
05 DRAINAGE.DWG	5 DRAINAGE PLAN
06 DRAIN DETAILS.DWG	6 DRAINAGE CHANNEL DETAILS
07 DETAILS.DWG	7 ENGINEERING DETAILS
08 LINER DETS.DWG	8 LINER DETAILS

I. KEITH GORDON, P.E.
N.M. PROFESSIONAL ENGINEER NO. 10984

NOT FOR CONSTRUCTION
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SITE LOCATION
AND DRAWING INDEX

BASIN DISPOSAL, INC.
BLOOMFIELD, NEW MEXICO

Gordon Environmental, Inc.
Consulting Engineers
213 S. Camino del Pueblo
Bernalillo, New Mexico, USA
Phone: 505-867-6990
Fax: 505-867-6991

DATE: 11/19/08	CAD: B 01 SHEET.dwg	PROJECT #: 520.01.01
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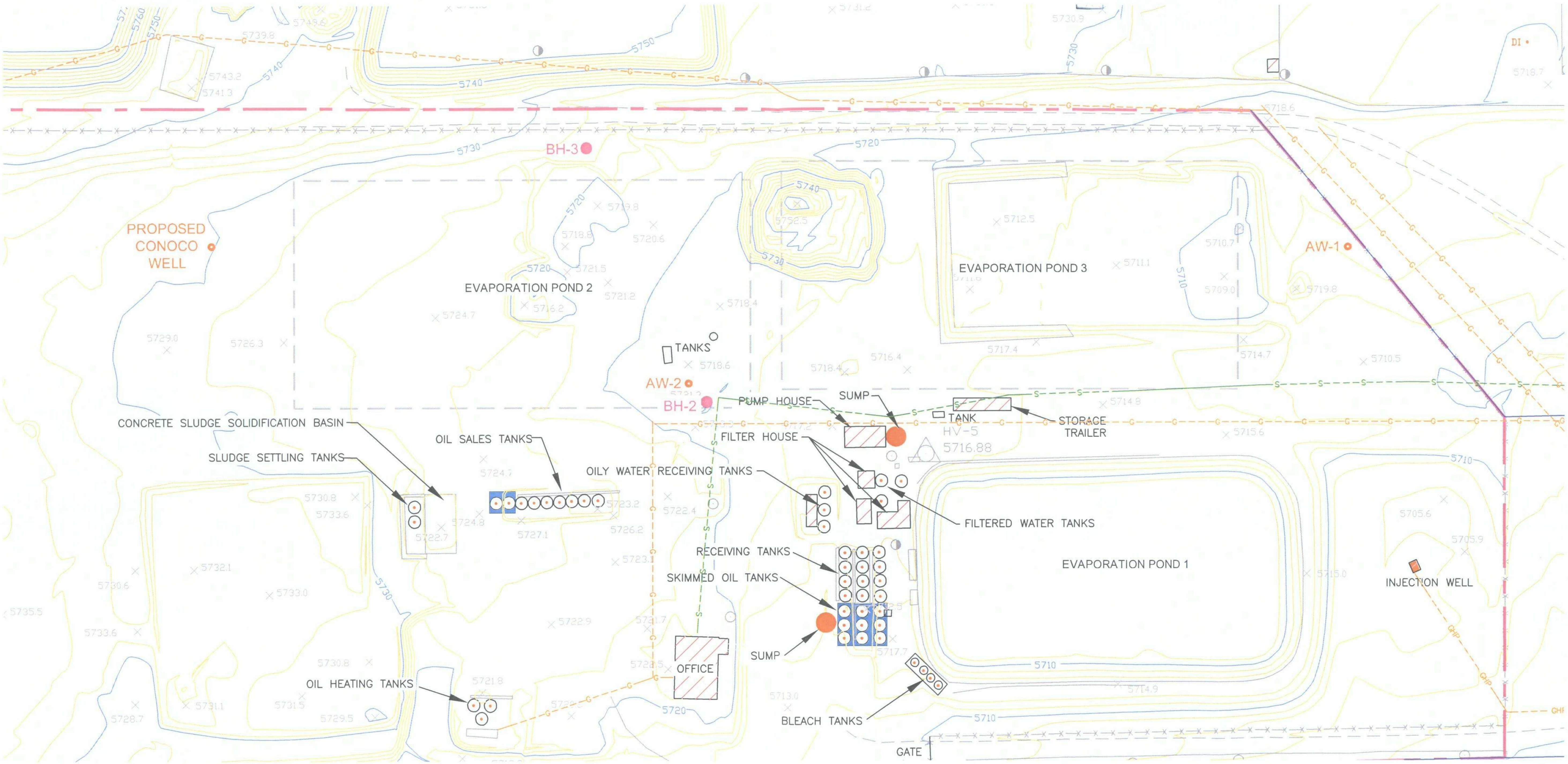
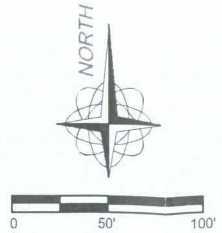
APPROVED BY: IKG	gei@gordonenvironmental.com	





NOTES:

1. LOCATION OF SITE UTILITIES IS APPROXIMATE. LOCATIONS OF SITE UTILITIES WILL BE FIELD VERIFIED PRIOR TO CONSTRUCTION.
2. NOT FOR CONSTRUCTION

BOREHOLE LOCATIONS	
BH-2	LAT 36°45'20.54269"N (NAD 83) LONG 107°59'02.70950"W (NAD83) ELEV: 5717.98 (GROUND)
BH-3	LAT 36°45'22.92950"N (NAD 83) LONG 107°59'04.21563"W (NAD83) ELEV: 5727.46 (GROUND)
AW-1	LAT 36°45'22.01797"N (NAD 83) LONG 107°58'55.15402"W (NAD83) ELEV: 5717.85 (TOP OF CAP)
AW-2	LAT 36°45'20.58589"N (NAD 83) LONG 107°59'02.96163"W (NAD83) ELEV: 5722.20 (TOP OF CAP)

LEGEND

— - —	SITE BOUNDARY
———	2' CONTOUR (EXISTING)
—5700—	10 CONTOUR (EXISTING)
———	2' DEPRESSION CONTOUR (EXISTING)
—5700—	10' DEPRESSION CONTOUR (EXISTING)
= = =	UNPAVED ROADWAY (EXISTING)
—x—x—x—	FENCE (EXISTING)
— — CHP —	3" GAS LINE (EXISTING)
—S— — —	SEWER LINE (EXISTING)
— — —G—	GAS LINE (EXISTING)
— — — —	UTILITY EASEMENT
▨	STRUCTURE
┌ ─ ┐	PROPOSED POND LOCATION
🟦	PROPOSED NEW TANKS
AW-1 ⊙	ASSESSMENT WELL
BH-3 ●	BOREHOLE LOCATION
⊙	TANKS
◐	LIGHT POLE
○	POWER POLE
HV-5 5716.88 △	SURVEY CONTROL POINT AND ELEVATION
5705.6 ×	SPOT ELEVATIONS

EXISTING
SITE CONDITIONS

BASIN DISPOSAL, INC.
BLOOMFIELD, NEW MEXICO

Gordon Environmental, Inc.
Consulting Engineers

213 S. Camino del Pueblo
Bernalillo, New Mexico, USA
Phone: 505-867-6990
Fax: 505-867-6991

DATE: 06/05/09	CAD: B 02 EXISTING.dwg	PROJECT #: 520.01.01
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APPROVED BY: IKG	gei@gordonenvironmental.com	

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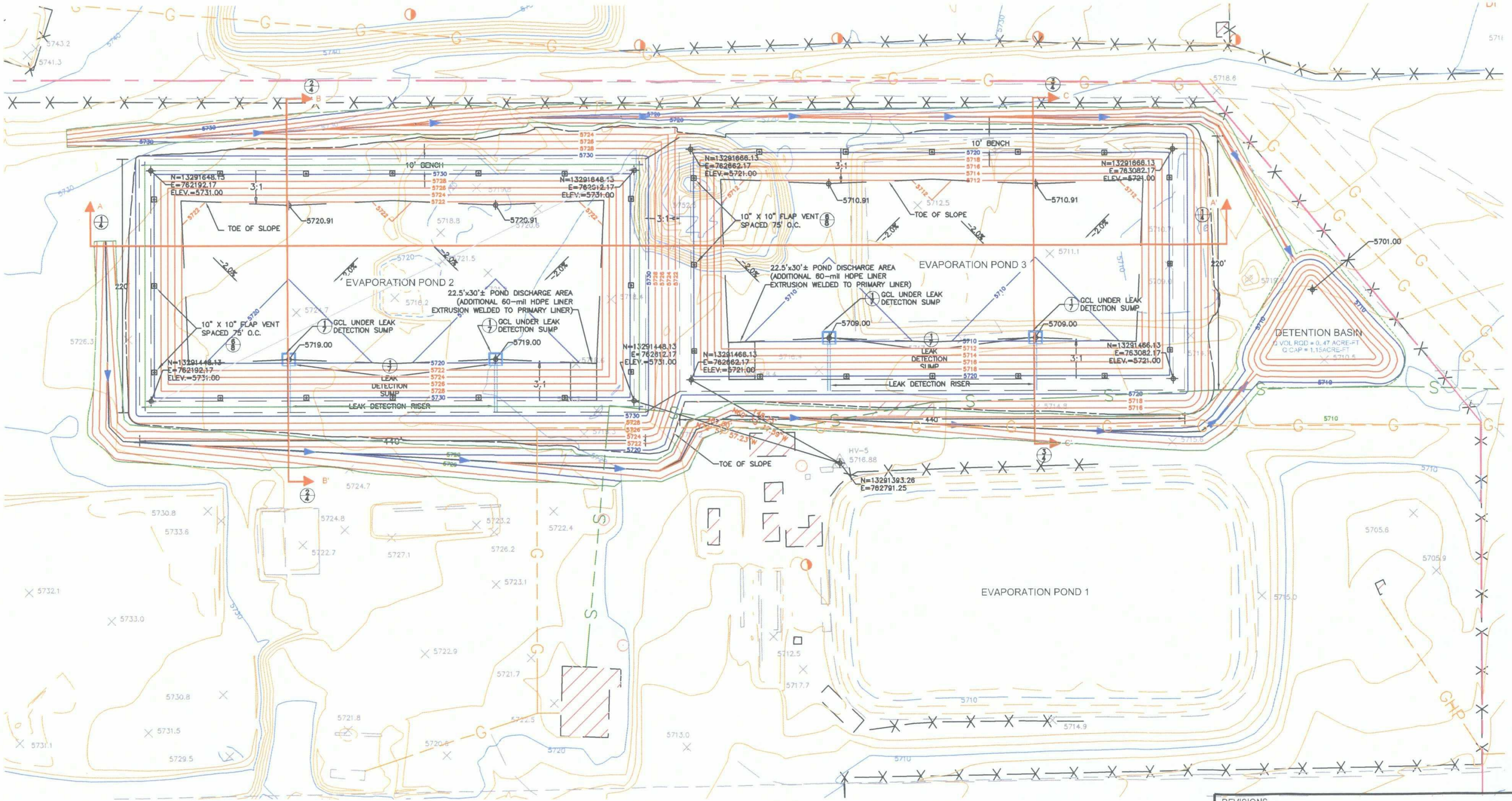

NOTES:

1. LOCATION OF SITE UTILITIES IS APPROXIMATE. LOCATIONS OF SITE UTILITIES WILL BE FIELD VERIFIED PRIOR TO CONSTRUCTION.
2. NOT FOR CONSTRUCTION

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LEGEND

— - —	SITE BOUNDARY
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—5700—	10' CONTOUR (EXISTING)
— —	2' DEPRESSION CONTOUR (EXISTING)
- - -5700- - -	10' DEPRESSION CONTOUR (EXISTING)
—5720—	DESIGN 10' CONTOUR
—5716—	DESIGN 2' CONTOUR
═ ═	UNPAVED ROADWAY (EXISTING)
—x—x—x—x—	FENCE (EXISTING)
→	CHANNEL FLOW LINE
- - - - GHP —	3" GAS LINE (EXISTING)
—S—	SEWER LINE (EXISTING)
- - - -G—	GAS LINE (EXISTING)
- - - -	UTILITY EASEMENT
- - - -	CUT LIMIT
- - - -	FILL LIMIT
○═	LEAK DETECTION SUMP AND RISER PIPE
⊡	FLAP VENT
▨	STRUCTURE
5705.6 ×	SPOT ELEVATION (EXISTING)
HV-5 5716.88 △	SURVEY CONTROL POINT AND ELEVATION
⌖ 5711.04	SPOT ELEVATION (DESIGN)

NORTH

0 50' 100'

REVISIONS

NO.	DATE	DESCRIPTION
1	05/13/09	ADD GCL UNDER LEAK DETECTION SUMP
2	05/13/09	ADD 60-mil HDPE LINER AT POND DISCHARGE AREA

GRADING PLAN

BASIN DISPOSAL, INC.
BLOOMFIELD, NEW MEXICO

Gordon Environmental, Inc.
Consulting Engineers

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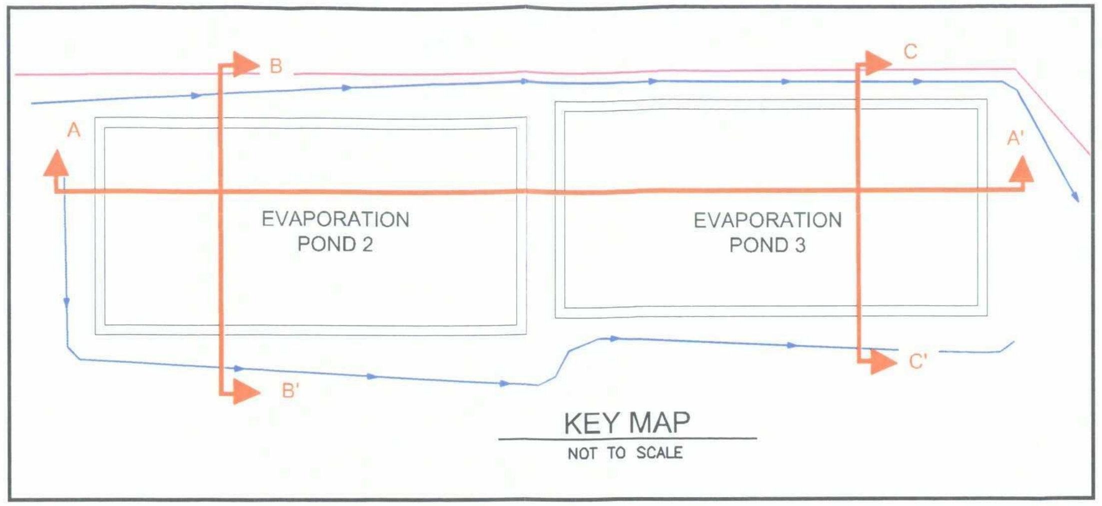
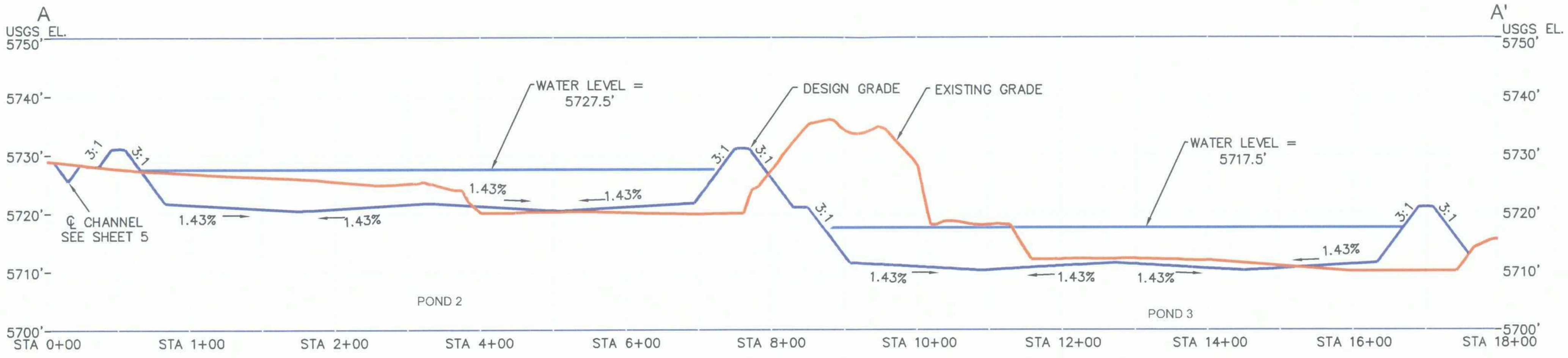
Bernalillo, New Mexico, USA
Phone: 505-867-6990
Fax: 505-867-6991

DATE: 11/19/08	CAD: 03 GRADING.dwg	PROJECT #: 520.01.01
DRAWN BY: JFP	REVIEWED BY: MRH	SHEET 3 of 8
APPROVED BY: IKG	gei@gordonenvironmental.com	

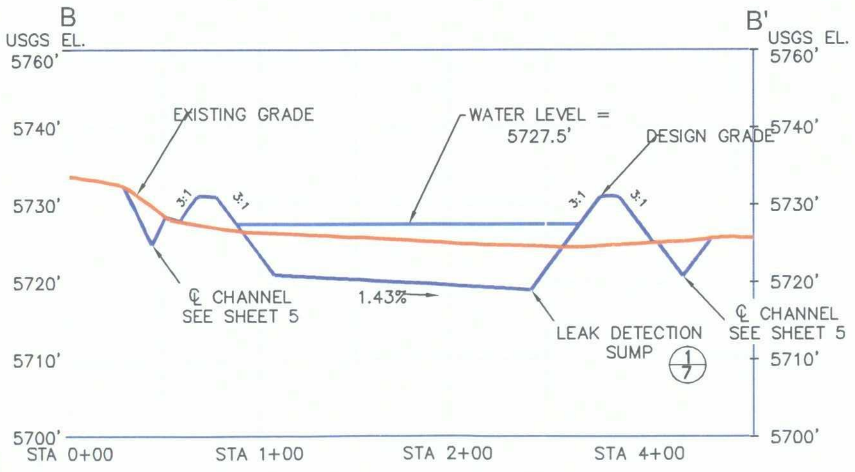


KEY MAP

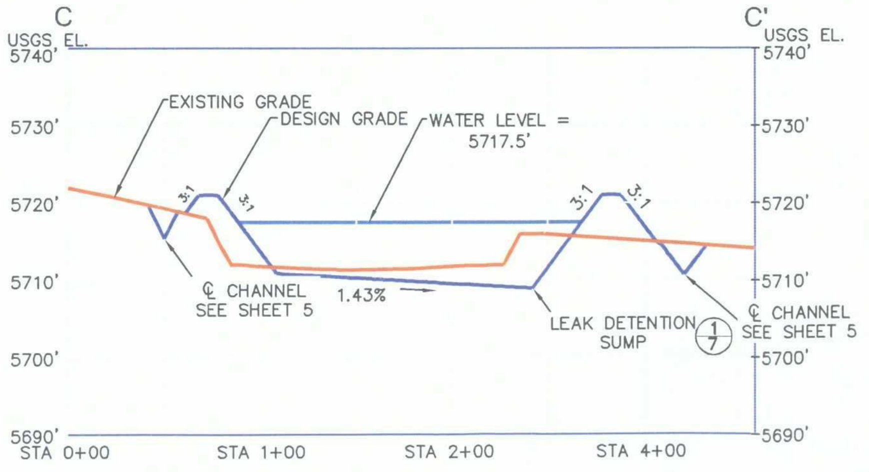
NOT TO SCALE



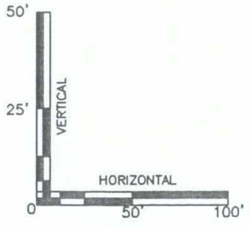
1/4 EVAPORATION PONDS 2 & 3



2/4 EVAPORATION POND 2



3/4 EVAPORATION POND 3



CROSS SECTION
SCALE

LEGEND

━	EXISTING GRADE
━	DESIGN GRADE
— —	WATER LEVEL

NOT FOR CONSTRUCTION
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CROSS SECTIONS

BASIN DISPOSAL, INC.
BLOOMFIELD, NEW MEXICO

Gordon Environmental, Inc.
Consulting Engineers

213 S. Camino del Pueblo
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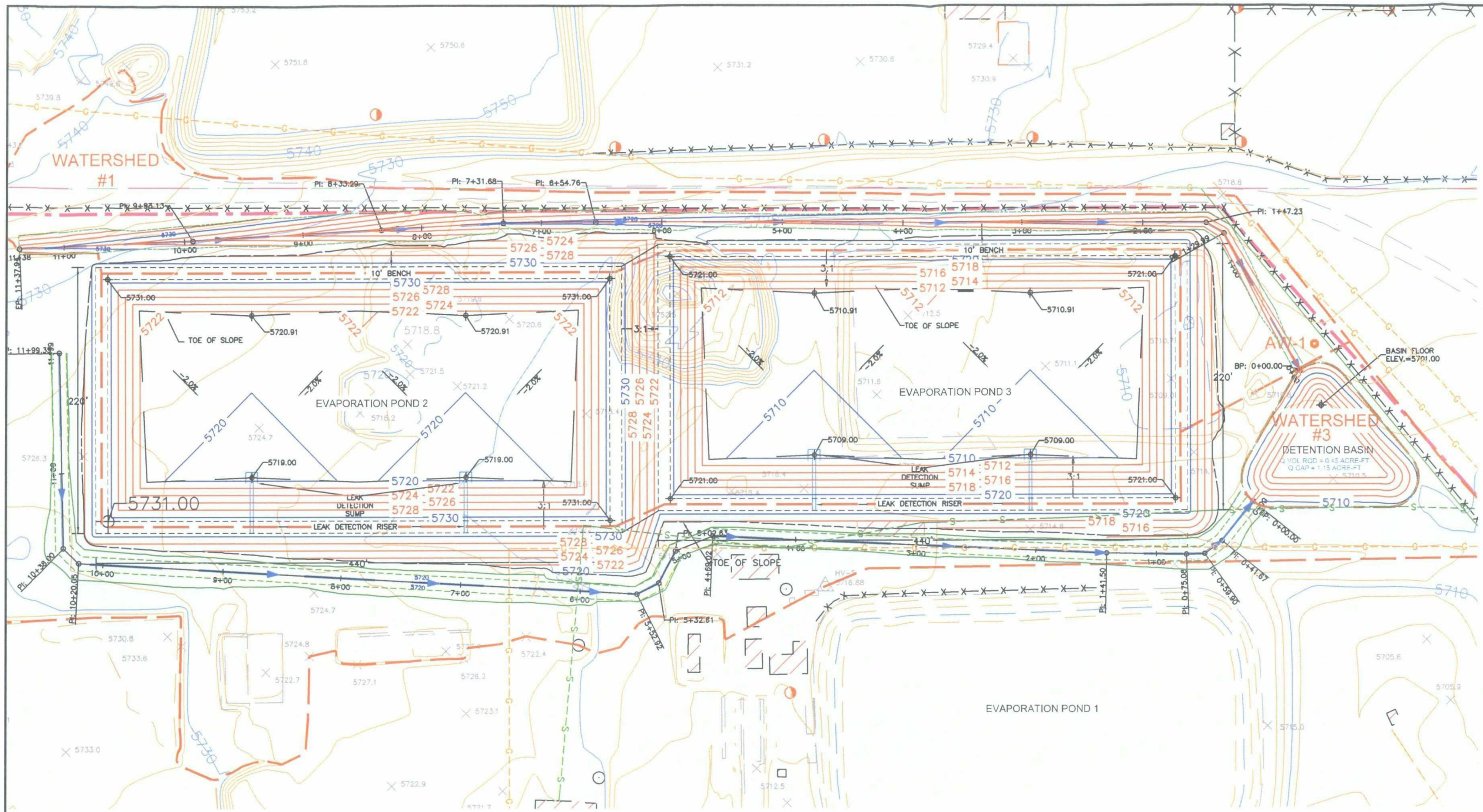
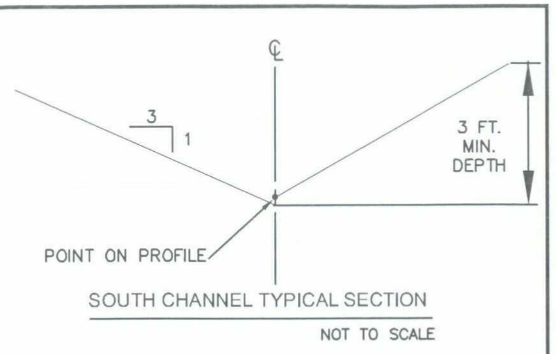
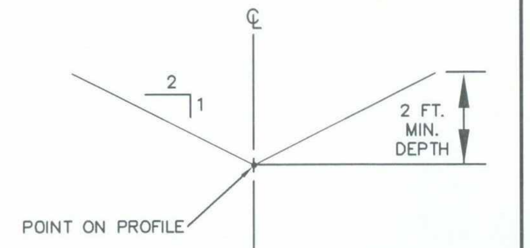
DATE: 11/24/08	CAD: B 04 XSECS.dwg	PROJECT #: 520.01.01
DRAWN BY: JFP	REVIEWED BY: MRH	SHEET 4 of 8
APPROVED BY: IKG	gei@gordonenvironmental.com	





SOUTH CHANNEL TYPICAL SECTION

NOT TO SCALE



NORTH CHANNEL TYPICAL SECTION

NOT TO SCALE

LEGEND

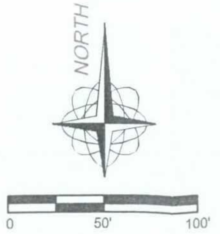
▬ ▬	SITE BOUNDARY
▬ ▬	DRAINAGE DIVIDE
──	2' CONTOUR (EXISTING)
—5700—	10' CONTOUR (EXISTING)
- - -	2' DEPRESSION CONTOUR (EXISTING)
—5700—	10' DEPRESSION CONTOUR (EXISTING)
—5720—	10' MAJOR CONTOUR
—5716—	2' MINOR CONTOUR
⌖5711.04	SPOT ELEVATION (DESIGN)
---GHP---	3" GAS LINE (EXISTING)
—S—	SEWER LINE (EXISTING)
---G---	GAS LINE (EXISTING)
- - -	UTILITY EASEMENT
═══	UNPAVED ROADWAY (EXISTING)
—X—X—X—	FENCE (EXISTING)
AW-1 ●	ASSESSMENT WELL
◑	LIGHT POLE (EXISTING)
▨	STRUCTURE
HV-5 5716.88 △	SURVEY CONTROL POINT AND ELEVATION

NOTES:

1. LOCATION OF SITE UTILITIES IS APPROXIMATE. LOCATIONS OF SITE UTILITIES WILL BE FIELD VERIFIED PRIOR TO CONSTRUCTION.
2. NOT FOR CONSTRUCTION

WATERSHED	AREA (ACRES)	CURVE NUMBER	$P_{25\text{-YR } 24\text{-HR}}$ (INCHES)	Q_{25} (CFS)	Q_{25} VOLUME (ACRE–FT)
#1	1.93	77	2.1	1.93	0.08
#2	7.52	77	2.1	6.62	0.32
#3	0.28	—	—	—	0.05
				TOTAL VOLUME	0.45

25 YEAR 24 HOUR POINT PRECIPITATION FREQUENCY ESTIMATED FROM NOAA ATLAS



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DRAINAGE PLAN

BASIN DISPOSAL, INC.
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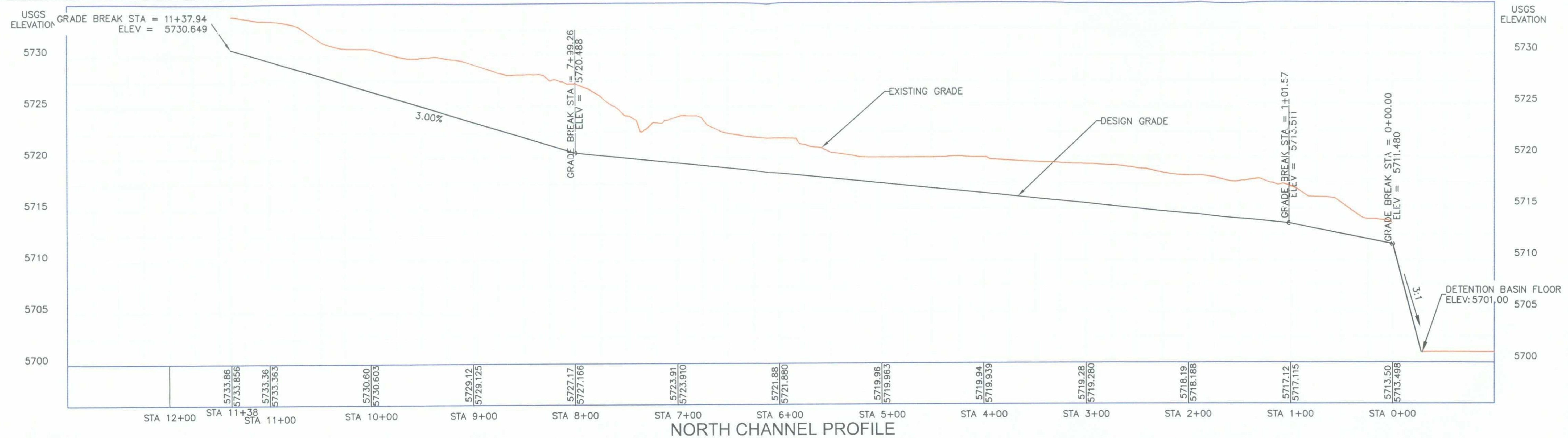
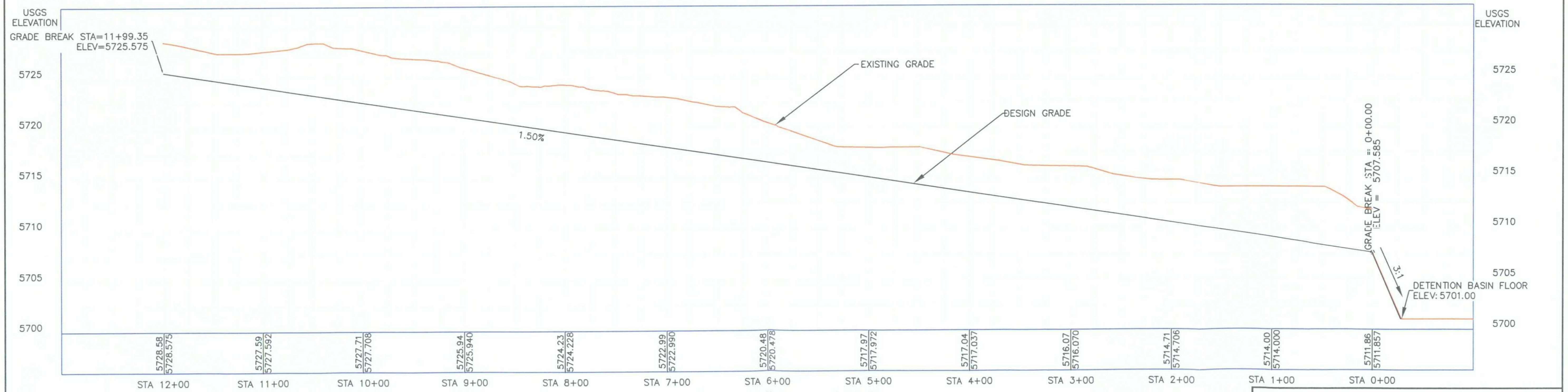
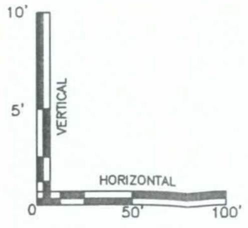
DRAWN BY: JFP	REVIEWED BY: MRH	SHEET 5 of 8
APPROVED BY: IKG	gei@gordonenvironmental.com	



NORTH CHANNEL PROFILE



SOUTH CHANNEL PROFILE



CROSS SECTION
SCALE

NOT FOR CONSTRUCTION

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DRAINAGE CHANNEL DETAILS

BASIN DISPOSAL, INC.
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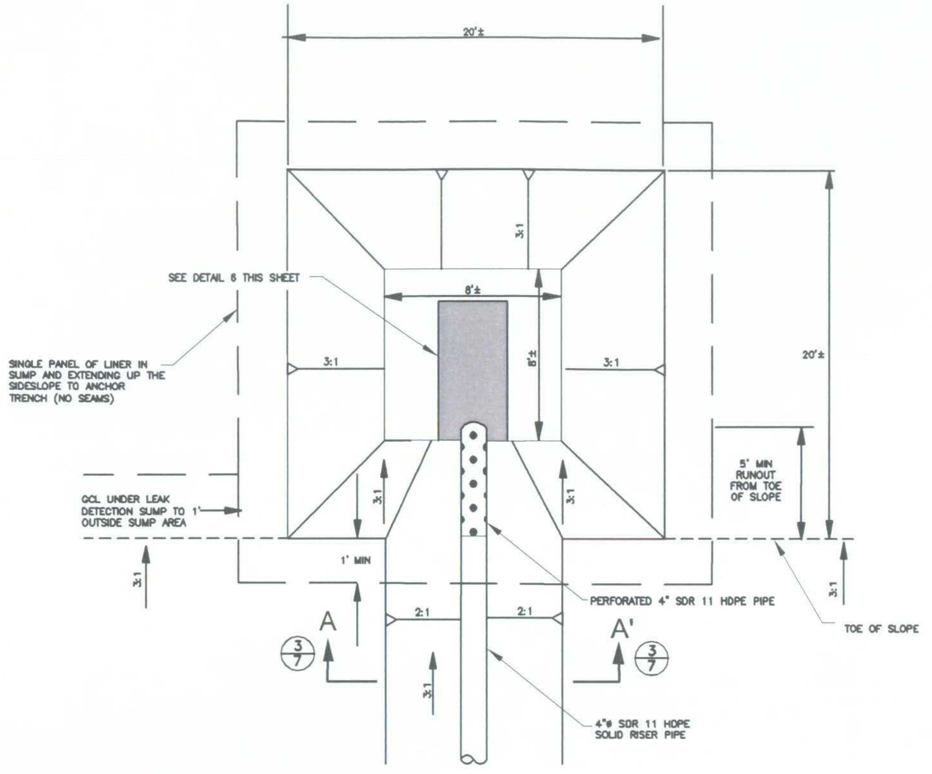
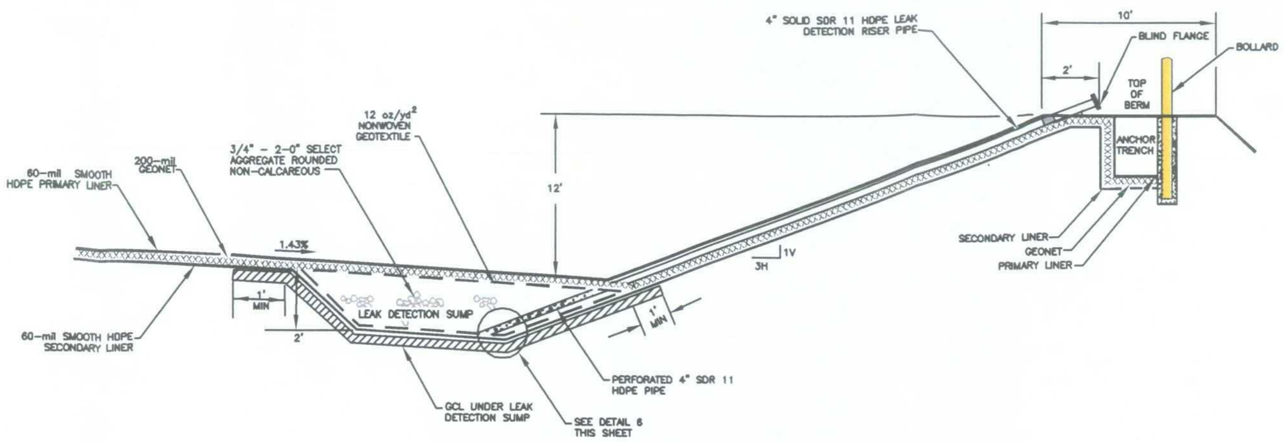
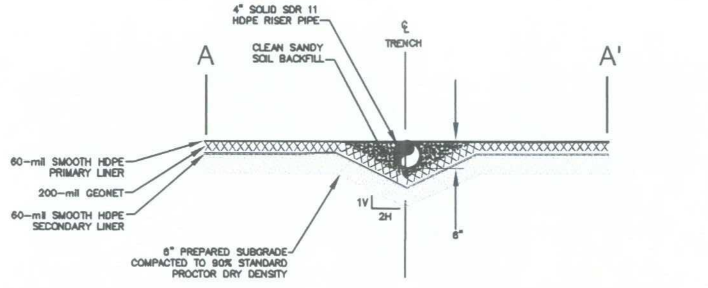
DATE: 11/24/08	CAD: B 06 DRAIN DETAILS.dwg	PROJECT #: 520.01.01
DRAWN BY: JFP	REVIEWED BY: MRH	SHEET 6 of 8
APPROVED BY: IKG	gei@gordonenvironmental.com	



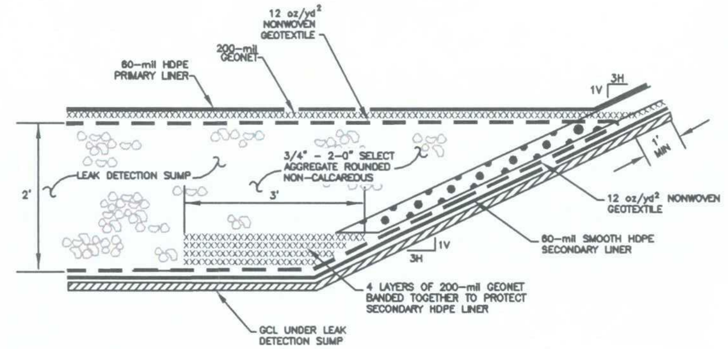
1/7 LEAK DETECTION SUMP
NOT TO SCALE



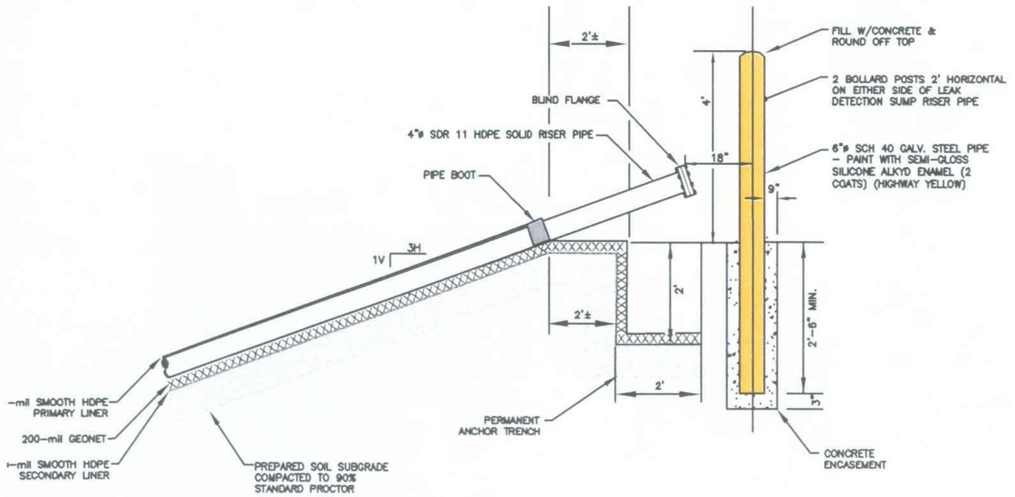
5/7 CROSS-SECTION AT LEAK DETECTION SUMP
NOT TO SCALE



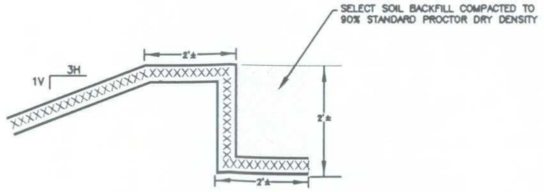
3/7 LEAK DETECTION SUMP RISER PIPE CROSS SECTION A-A'
NOT TO SCALE



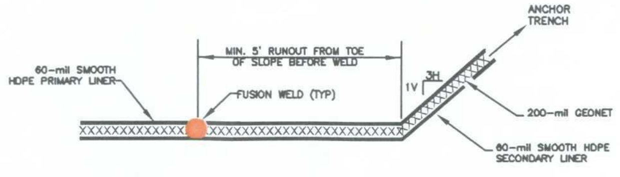
6/7 SUMP FLOOR DETAIL
NOT TO SCALE



2/7 LEACHATE COLLECTION SUMP RISER PIPE
SECTION VIEW
NOT TO SCALE



4/7 ANCHOR TRENCH DETAIL
NOT TO SCALE



7/7 LINER RUNOUT ON POND FLOOR
NOT TO SCALE

NOT FOR CONSTRUCTION

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REVISIONS

NO.	DATE	DESCRIPTION
1	05/13/09	ADD GCL UNDER LEAK DETECTION SUMP
2	05/13/09	ADD CLEAN SANDY SOIL BACKFILL IN LEAK DETECTION SUMP RISER PIPE TRENCH
3	05/13/09	SPECIFY SDR 11 HDPE PIPE

ENGINEERING DETAILS

BASIN DISPOSAL, INC.
BLOOMFIELD, NEW MEXICO

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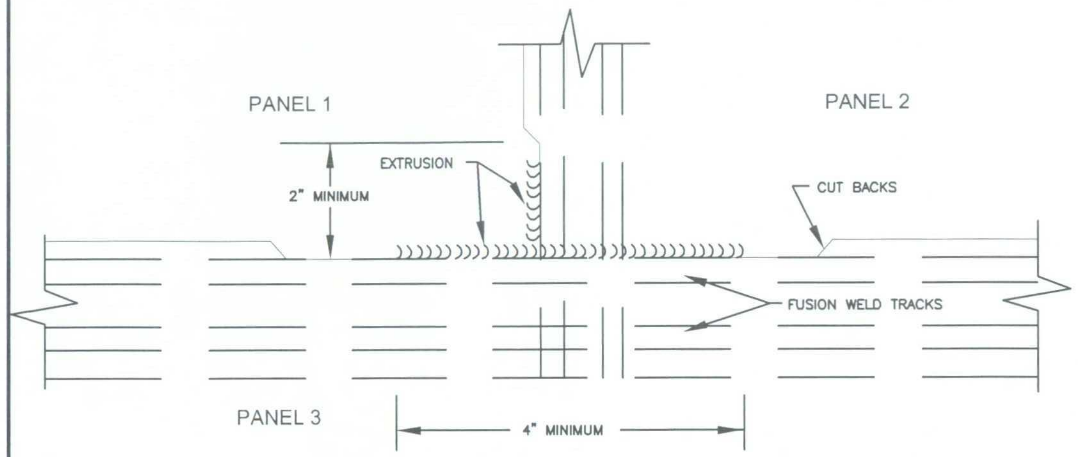
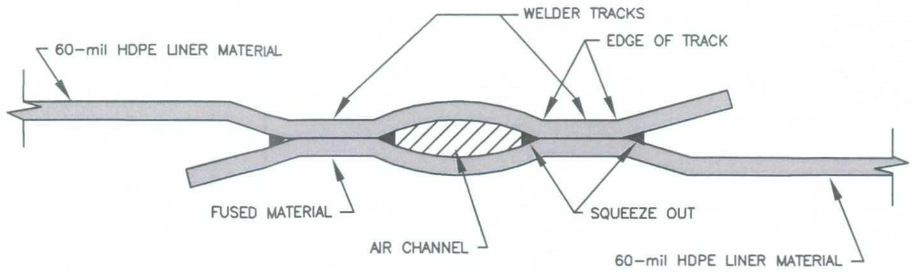
DATE: 11/20/08	CAD: B 07 ENGR DET.dwg	PROJECT #: 520.01.01
DRAWN BY: JFP	REVIEWED BY: MRH	SHEET 7 of 8
APPROVED BY: IKG	gei@gordonenvironmental.com	

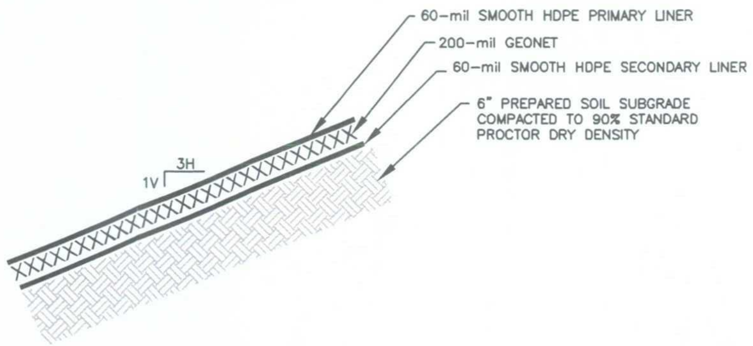


① TYPICAL "T" AT BUTT SEAM
8 PLAN VIEW NOT TO SCALE

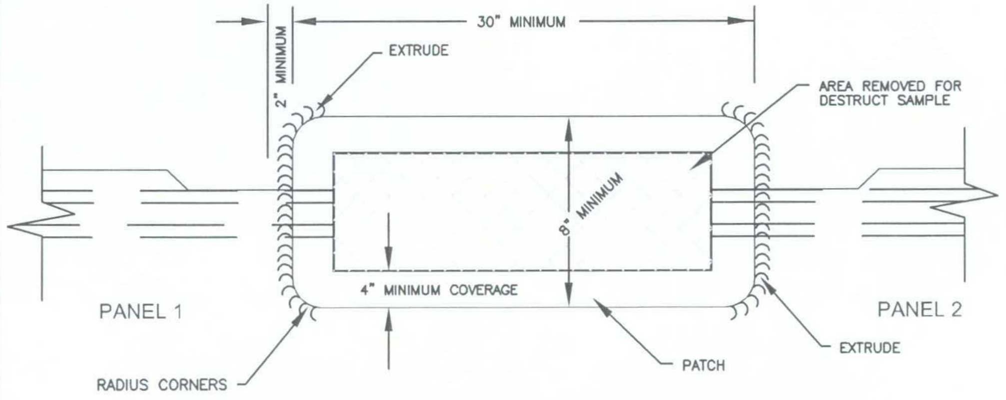


NOTES:
1. BOTH AREAS OF FUSED MATERIAL SHOULD BE VOID OF ANY SEAM LINES.
2. EDGE OF TRACKS NOT TO CUT THE LINER.
3. AIR CHANNEL SHOULD BE CLEAR.
4. BOTH WELDER TRACKS SHALL BE EQUAL WIDTHS.
5. SQUEEZE OUT SHOULD BE JUST BARELY VISIBLE IN ALL 4 LOCATIONS WHEN VIEWED IN THE TEST CROSS-SECTION.

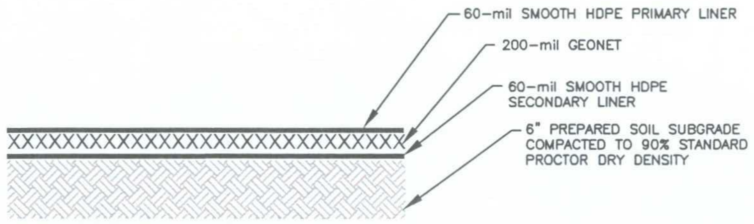
③ TYPICAL FUSION WELD
8 SECTION VIEW NOT TO SCALE



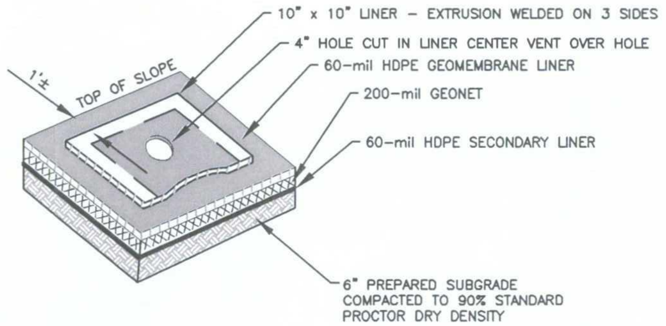
⑤ SIDEWALL LINER SYSTEM
8 NOT TO SCALE



TYPICAL DESTRUCT SAMPLE PATCH
60-mil LINER
② PLAN VIEW NOT TO SCALE
8



④ FLOOR LINER SYSTEM
8 NOT TO SCALE



NOTE: WELD TOP AND SIDES OF VENT; DOWN-SIDE OF FLAP TO REMAIN OPEN

⑥ FLAP-TYPE VENT DETAIL
8 NOT TO SCALE

NOT FOR CONSTRUCTION

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LINER DETAILS

BASIN DISPOSAL, INC.
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DATE: 11/20/08	CAD: B 08 LINER DET.dwg	PROJECT #: 520.01.01
DRAWN BY: JFP	REVIEWED BY: MRH	SHEET 8 of 8
APPROVED BY: IKG	gei@gordonenvironmental.com	

APPLICATION FOR MODIFICATION
BASIN DISPOSAL, INC.
OIL FIELD WASTE EVAPORATION PONDS

VOLUME III: ENGINEERING DESIGN AND CALCULATIONS
SECTION 1: ENGINEERING DESIGN

ATTACHMENT III.1.B

LINER LONGEVITY ARTICLE:

GEOSYNTHETICS MAGAZINE, OCT/NOV 2008

How long will my liner last?

| What is the remaining service life of my HDPE geomembrane?

By Ian D. Peggs, P.E., P.Eng., Ph.D.

Introduction

In his keynote lecture at the GeoAmericas-2008 conference last March, Dr. Robert Koerner (et al., 2008) of the Geosynthetic Institute (GSI) reported the ongoing Geosynthetic Research Institute (GRI) work to make the first real stab at assessing the service lives of high-density polyethylene (HDPE), linear low-density polyethylene (LLDPE), reinforced PE, ethylene propylene diene terpolymer (EPDM), and flexible polypropylene (fPP) exposed geomembranes.

The selected environment simulated that of Texas, USA, in sunny ambient temperatures between ~7°C (45°F) and 35°C (95°F). Of course, an exposed black HDPE geomembrane in the sun will achieve much higher temperatures, probably in excess of 80°C (176°F).

I do not know what the temperature would be at 150-300mm above the liner (for those still specifying this parameter), but it is quite immaterial. The only temperature of concern is the actual geomembrane temperature.

The lifetimes are shown in **Table 1**, but it must be recognized that these data are for specific manufactured products with specific formulations. The "greater than" notation indicates that laboratory exposures (incubations) are still on-going, not that some samples have failed after the indicated time period. The PE-R-1 material is a thin LLDPE, so it might be expected to be the first to reach the defined end of life; the half-life—the time to loss of 50% of uniaxial tensile properties.

It is interesting to note that HDPE-1 and LLDPE-1 are proceeding apace, but it would be expected that the LLDPE-1 would reach its half-life earlier than HDPE-1. However, this does not automatically follow. With adequate additive formulations, perhaps LLDPE could be left exposed and demonstrate more weathering resistance than some HDPEs. This demonstrates the fact that all PEs, whether HD or LLD, are not identical—they can have different long-term performances dependent on the PE resin used and the formulation of the stabilizer package. However, such differences are not evident in the conventional mechanical properties such as tensile strength/elongation, puncture and tear resistances, and so on.

The two fPPs are performing well. However, there had also been an fPP-1, one of the first PP geomembranes that did not perform well. This was due to a totally inappropriate stabilizer formulation. That particular product lasted 1.5 years in service. In

Final Inspection continued on page 44

Type	Specification	Predicted Lifetime in Texas, USA
HDPE-1	GRI-GM13	>28 years (Incubation ongoing)
LLDPEE-1	GRI-GM17	>28 years (Incubation ongoing)
EPDM-1	GRI-GM21	>20 years (Incubation ongoing)
PE-R-1	GRI-GM22	≈17 years (reached halflife)
fPP-2	GRI-GM18 (temp. susp.)	>27 years (Incubation ongoing)
fPP-3	GRI-GM18 (temp. susp.)	>17 years (Incubation ongoing)

Table 1 | Estimated exposed geomembrane lifetimes

| Ian Peggs is president of I-CORP International Inc. and is a member of *Geosynthetics* magazine's Editorial Advisory Committee.

Final Inspection continued from page 56

the QUV weatherometer, it lasted 1,800 light hours at 70°C (158°F). Therefore, the lab/field correlation is that 1,000 QUV light hours is equivalent to a 0.83yr service life under those specific environmental conditions.

At another location in Texas, Koerner/GRI found 1,000hr of QUV exposure was equivalent to 1.1 year actual field exposure. Consequently, for Texas exposures GRI is using a correlation of 1000hr QUV exposure as equivalent to 1yr of in-service exposure. Clearly, the correlation would be different in less sunny and colder environments.

The failed fPP-1 liner was replaced with a correctly stabilized fPP that, subsequently, performed well.

... it should be possible to monitor the condition of the liner to obtain a few years of notice for impending expiration.

While estimated correlations might be made for other locations using historical weather station sunshine and temperature data, there is no question that the best remaining lifetime assessments will be obtained using samples removed from the field installation of interest.

A lifetime in excess of 28yr, demonstrated for a recently-made HDPE geomembrane, is comparable to the present actual service periods of as long as 30-35yr. However, actual lifetimes of as low as ~15yr have also been experienced.

Do service lifetimes now exceeding 30yr mean that we might expect to see another round of stress cracking failures as exposed liners finally oxidize sufficiently on the surface to initiate stress cracking?

This would be frustrating after resolving the early 1980s problems with stress cracking failures at welds and stone protrusions when the liners contracted at low temperatures, but it is the way end-of-life will become apparent. And will that be soon or in another 5-20 years? It would be useful to know.

So how can we evaluate the condition of our exposed liners in a simple and practical manner to ensure they will continue to provide adequate service lifetimes and to get sufficient warning of impending expiration?

For each installation, a baseline needs to be established, and changes from that baseline need to be monitored.

A liner lifetime evaluation program

Rather than be taken by surprise when a liner fails or simply expires, it should be possible to monitor the condition of the liner to obtain a few years of notice for impending expiration. One can then plan for a timely replacement without the potential for accidental environmental damage and undesirable publicity. A program of periodic liner-condition assessment is proposed.

For baseline data, it would be useful to have some archive material to test, but that is not usually available. Manufacturers often discard retained samples after about 5 years. Perhaps facility owners should be encouraged to keep retained samples at room temperature and out of sunlight. The next best thing is to use material from the anchor trench or elsewhere that has not experienced extremes in temperature and that has not been exposed to UV radiation or to expansion/contraction stresses.

Less satisfactory options are to use the original NSF 54 specifications, the manufacturer's specifications, or the GRI-GM13 specifications at the appropriate time of liner manufacturing. The concern with using these specifications is that while aged material may meet them, there is no indication of whether the measured values have significantly decreased from the actual as-manufactured values that generally significantly exceed the specification.

A final option for the baseline would be to use the values at the time of the first liner assessment.

The first liner condition assessment would consist of a site visit during which a general visual examination would be done together with a mechanical probing of the edges of welds. A visual examination would include the black/gray shades of different panels that might indicate low carbon contents.

A closer examination should be done using a loupe (small magnifier) on suspect areas such as wrinkle peaks, the tops and edges of multiple extrusion weld beads, and the apex-down creases of round die-manufactured sheet.

The last detail is significant because the combination of oxidizing surface and exposed surface tension when the liner contracts at low temperatures and the crease is pulled flat can be one of the first locations to crack. The apex-up creases do not fail at the same time because the oxidized exposed surface is under compression (or less tension) when the crease is flattened out.

Appropriate samples for detailed laboratory testing will be removed.

It may be appropriate to do a water lance electrical integrity survey on the exposed sideslopes, but this would only be effective on single liners, and on double liners with a composite primary liner, a conductive geomembrane, or a geocomposite with a conductive geotextile on top.

A sampling and testing regime

A liner lifetime evaluation program should be simple, meaningful, and cost-effective.

While it will initially require expert polymer materials science/engineering input to analyze the test data and to define the critical parameters, it should ultimately be possible to use an expert system to automatically make predictions using the input test data.

Small samples will be taken from deep in the anchor trench and from appropriate

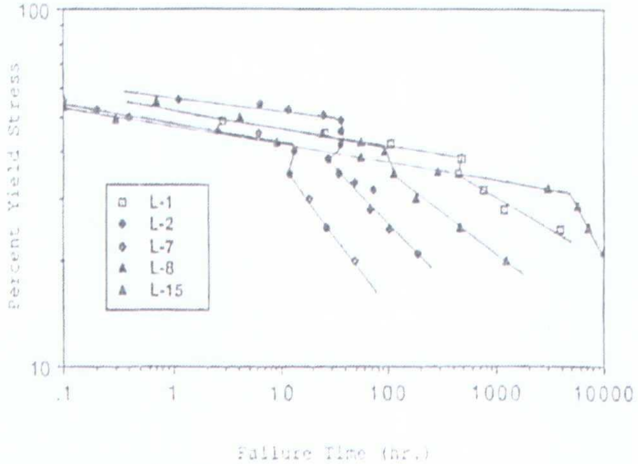

Figure 1 | Standard stress rupture curves for five HDPE geomembranes (Hsuan, et al. 1992)

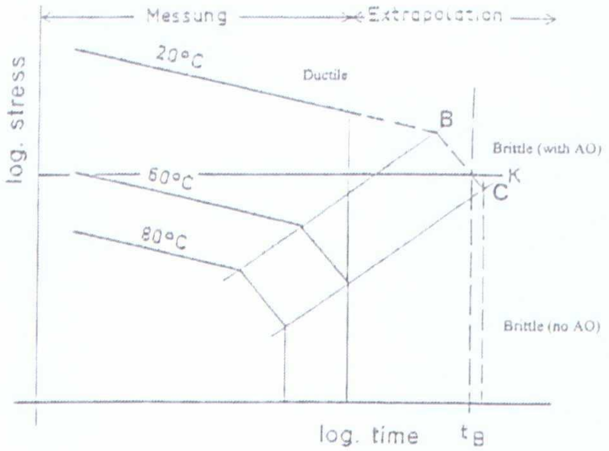

Figure 2 | Stress rupture curves showing third stage (Brittle no AO) oxidized limit. (Gaube, et al. 1985)

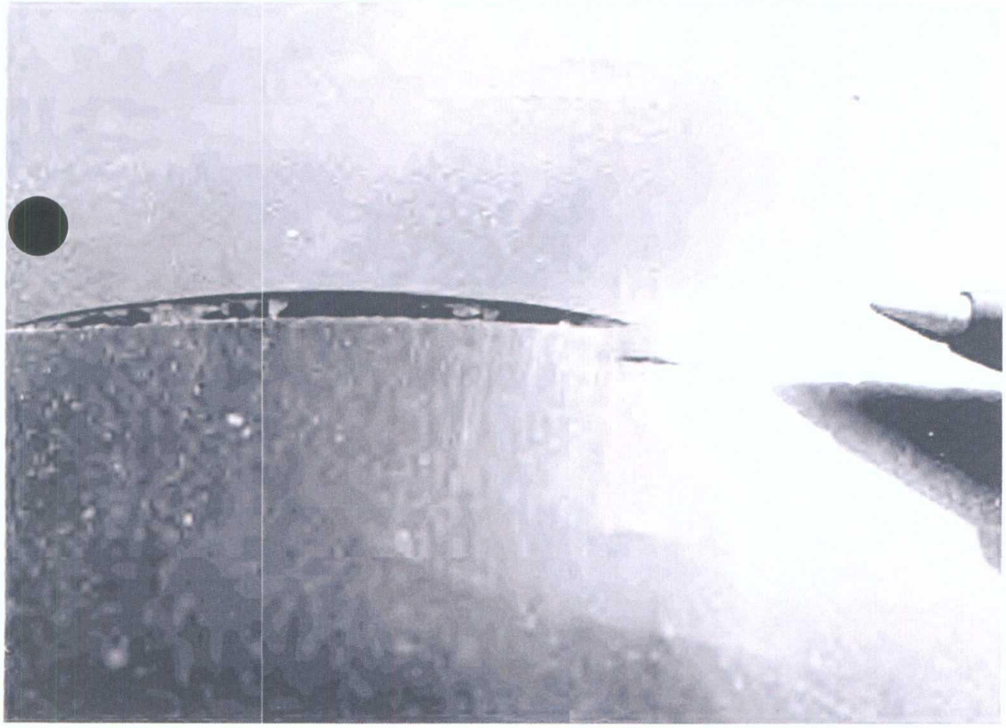

Figure 3 | Stress crack initiated by extruder die line at stone protrusion

exposed locations. Potential sites for future sample removal by the facility owner for future testing will be identified and marked by the expert during the first site visit.

The baseline sample(s) will be tested as follows:

- Single-point stress cracking resistance (SCR) on a molded plaque by ASTM D5397
- High-pressure oxidative induction time (HP-OIT) by ASTM D5885
- Fourier transform infrared spectroscopy (FTIR-ATR) on upper surface to determine carbonyl index (CI) on nonarchive samples only
- Oven aging/HP-OIT (GRI-GM13)
- UV resistance/HP-OIT (GRI-GM13)

The exposed samples will be tested as follows:

- Carbon content (ASTM D1603)
- Carbon dispersion (ASTM D5596)
- Single-point SCR on molded plaque (ASTM D5397)
- Light microscopy of exposed surface, through-thickness cross sections, and thin microsections (~15 µm thick) as necessary
- HP-OIT on 0.5-mm-thick exposed surface layers from basic sheet and from sheet at edge of extruded weld bead (ASTM D5885), preferably at a double-weld bead
- FTIR-ATR on exposed surface to determine CI
- Oven aging/HP-OIT on 0.5mm surface layer (GRI-GM13)
- UV resistance/HP-OIT on 0.5 mm surface layer (GRI-GM13)

Carbon content is done to ensure adequate basic UV protection. Carbon dispersion is done to ensure uniform surface UV protection and to evaluate agglomerates that might act as initiation sites for stress cracking.

HP-OIT is used to assess the remaining amount of stabilizer additives, both in the liner panels and in the sheet adjacent to an extrusion weld. Most stress cracking is observed at the edges of extrusion weld beads in the lower sheet, so it is important to monitor this location.

While standard OIT (ASTM D3895 at 200°C) better assesses the relevant stabilizers effective at processing (melting) and welding temperatures, the relevant changes in effective stabilizer content during continued service, including in the weld zone, will be provided by measurement of HP-OIT. There will be no future high temperature transient where knowledge of S-OIT will be useful. It is expected that the liner adjacent to the weld bead will be more deficient in stabilizer than the panel itself. Therefore, S-OIT is not considered in this program.

Note that HP-OIT is measured on a thin surface layer because the surface layer may be oxidized while the body of the geomembrane may not. If material from the full thickness of the geomembrane is used it could show a significant value of OIT, implying that there is still stabilizer present and that oxidation is far from occurring. However, the surface layer could be fully oxidized with stress cracks already initiated and propagating. A crack will then propagate more easily through unoxidized material than would initiation and propagation occur in unoxidized material.

The fact that the HP-OIT meets a certain specification value in the as-manufactured condition provides no guarantee that thermo- and photo-oxidation protection will be provided for a long time. Stabilizers might be consumed quickly or slowly while providing protection. They may also be consumed quickly to begin with, then more slowly, or vice versa.

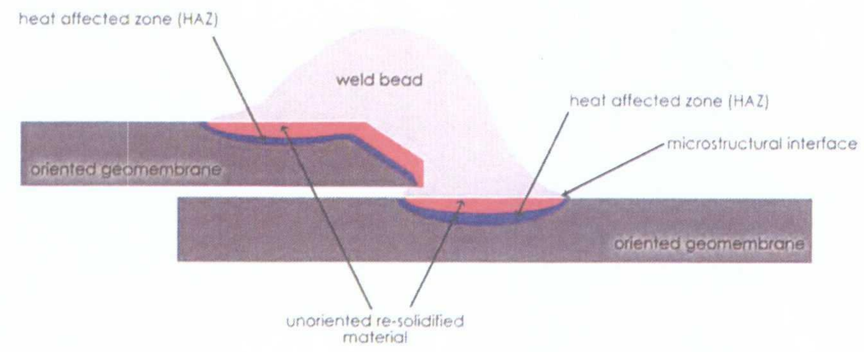

Figure 4 | Schematic of microstructure at extrusion weld

Hence, the need for continuing oven (thermal) aging and UV resistance tests. These two parameters, assessed by measuring retained HP- OIT, are critical to the assessment of remaining service life.

Oven (thermal) aging and UV resistance tests performed in this program will provide an extremely valuable data base that relates laboratory testing to in-service performance and that will further aid in more accurately projecting in-service performance from laboratory testing results.

Special considerations

Because we do not know, by OIT measurements alone, whether the surface layer is or is not oxidized (unless OIT is zero), and since we do not yet know at what level of OIT loss there might be an oxidized surface layer (the database has not yet been generated), FTIR directly on the surface of the geomembrane is performed using the attenuated total reflectance (ATR) technique to deny or confirm the presence of oxidation products (carbonyl groups).

Following the practice of Broutman, et al. (1989) and Duvall (2002) on HDPE pipes, if the ratio of the carbonyl peak at wave number 1760 cm-1 and the C-H stretching (PE) peak at wave number 1410 cm -1 is more than 0.10, there is a sufficiently oxidized surface layer that stress cracking might be initiated. For those familiar with the two slope stress rupture curve (**Figure 1**) where the brittle stress cracking region is the steeper segment below the knee, there is a third vertical part of the curve (**Figure 2**) where the material is fully oxidized and fracture occurs at the slightest stress. This is what will happen at the end of service life. But first note the times to initiation of stress cracking (the knees in the curves) in **Figure 1**—they range from ~10/hr to ~5,000/hr—clearly confirming that all HDPEs are not the same. Some are far more durable than others.

At the end of service life, at some level of OIT, there will be a critically oxidized surface layer that when stressed, such as at low temperatures by an upwards protruding stone, or by flexing due to wind uplift, will initiate a stress crack on the surface that will propagate downward through the geomembrane, as shown by the crack in **Figure 3**.

This crack, initiated at a stress concentrating surface die mark, occurred when the liner contracted at low temperatures, and tightened over an upwardly protruding stone. The straight morphology of the crack, and the ductile break at the bottom surface as the stress in the remaining ligament rose above the knee in the stress rupture curve, are typical of a stress crack. Note the shorter stress cracks initiated along other nearby die marks.

Stress cracks are preferentially initiated along the edges of welds because the adjacent geomembrane has been more depleted of stabilizers during the high temperature welding process. Thus, under further oxidizing service conditions, it will become the first location to

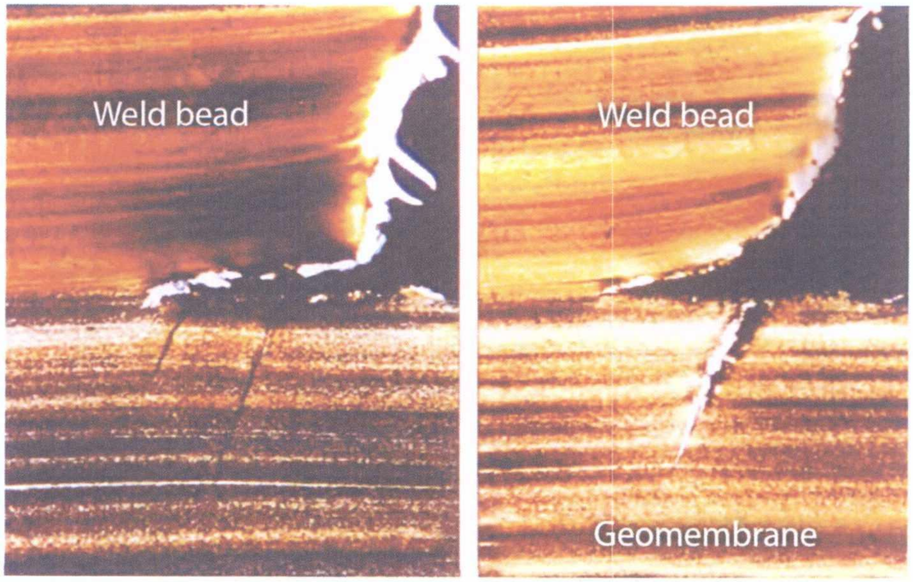

Figure 5 | Typical off-normal angle of precursor crazes (left) and stress crack (right) at edge of extrusion weld.

Type	Specification	Predicted Lifetime in Texas, USA
Side wall exposed	54	5
Side wall concrete side	81	71
Lower launder exposed	16	3
Lower launder concrete side	145	1

Table 2 | S-OIT values on solution and concrete liner surfaces (Peggs, 2008).

be oxidized to the critical level at which stress cracks will be initiated under any applied stress. In addition, the geometrical notches at grinding gouges and at the edges of the bead increase local stresses to critical levels for SC to occur.

I also believe that an internal microstructural flaw exists between the originally oriented geomembrane structure and the pool of more isotropic melted and resolidified material at the edge of the weld zone, as shown schematically in **Figure 4**. Most stress cracks occur at an off-normal angle at the edge of the weld bead that may be related to the angle of this molten-pool to oriented-structure interface (**Figure 5**). It is also known that stress increases the extraction of stabilizers from polyolefin materials.

With all of these agencies acting synergistically, it is not surprising that stress cracking often first occurs adjacent to extrusion welds.

Looking ahead

With the first field assessment test results available to us, and the extent of changes from the baseline sample known, removal of a second set of samples by the facility owner (at locations previously identified and marked by the initial surveyor), will be planned for a future time, probably in 2 or 3 years.

Why 2 or 3 years? In an extreme chemical environment, extensive reductions in S-OIT of studded HDPE concrete protection liners in mine solvent extraction facilities using kerosene/aromatic hydrocarbon/sulfuric acid process solutions at 55°C (131°F) have been observed on the solution and concrete sides of the liner (**Table 2**) within 1 year (Peggs 2008). But it is unlikely that such rapid decreases will be observed in air-exposed material.

With this second set of field samples, and with three sets of data points, practically reliable extrapolations of remaining lifetime can start to be made.

It is expected that a few years of notice for impending failures will be possible.

The key point to note in making these condition assessments is that, while all HDPE geomembranes have very similar conventional index properties, they can have widely variable photo-oxidation, thermal-oxidation, and stress-cracking resistances. Therefore, some HDPEs are more durable than others.

Thus, while one HDPE geomembrane manufactured in 1990 failed after 15 years in 2005, another HDPE geomembrane made in 1990 from a different HDPE resin (or more correctly a medium-density polyethylene [MDPE] resin), and with a better stabilizer additive package, could still have a remaining lifetime of 5, 20, or 30 years.

So, keep a close eye on those exposed liners and we'll learn a great deal more about liner performance and get notice of the end of service lifetime. And if owners can retain some archive material from new installations, so much the better.

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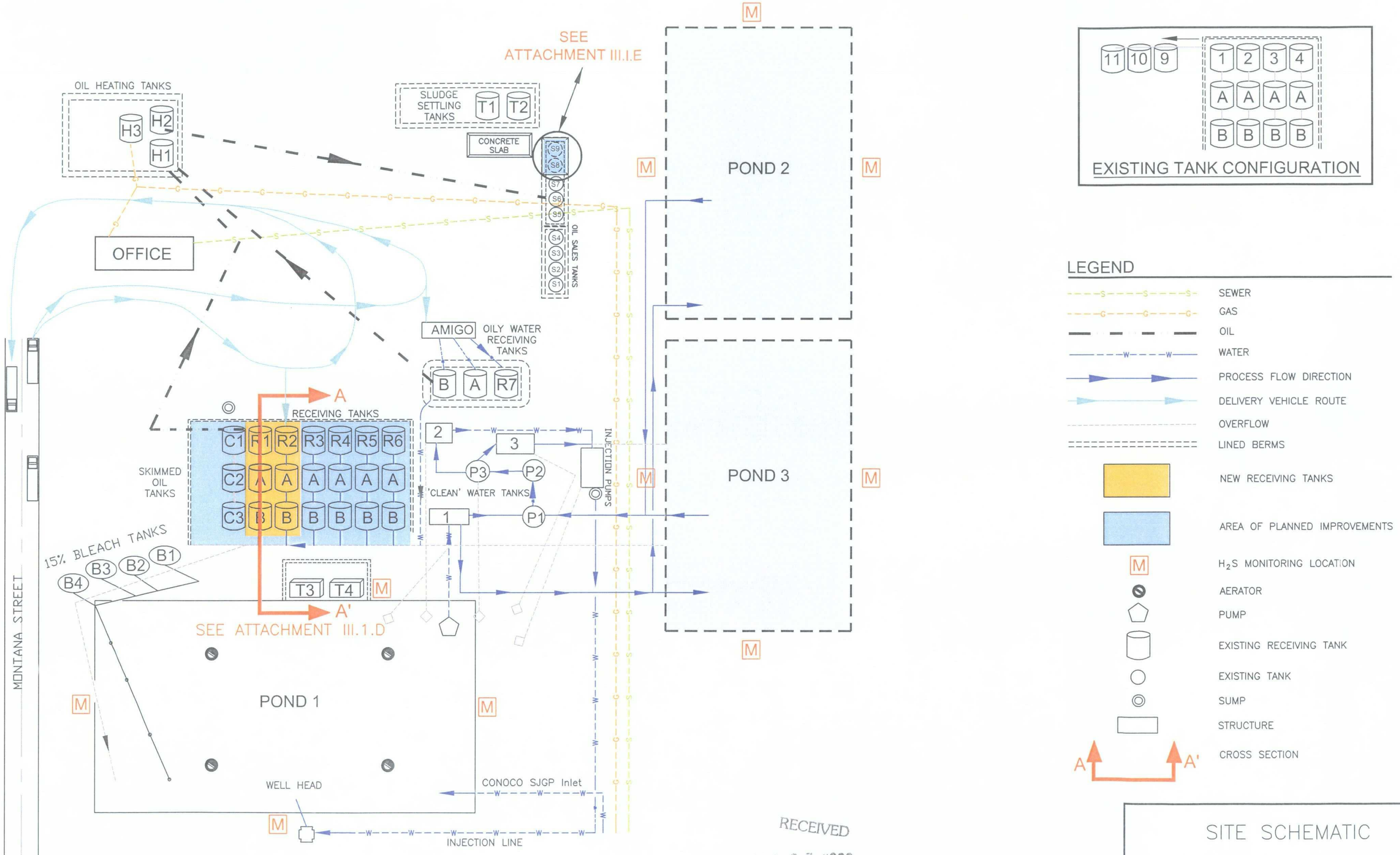
APPLICATION FOR MODIFICATION
BASIN DISPOSAL, INC.
OIL FIELD WASTE EVAPORATION PONDS

VOLUME III: ENGINEERING DESIGN AND CALCULATIONS
SECTION 1: ENGINEERING DESIGN

ATTACHMENT III.1.C

SITE SCHEMATIC



NOTE: ELEMENTS ARE LABELED IN ACCORDANCE WITH THE UPDATED NOMENCLATURE (11/08, ATTACHMENT III.1.F)

SITE SCHEMATIC

BASIN DISPOSAL, INC.
BLOOMFIELD, NEW MEXICO

Gordon Environmental, Inc.
Consulting Engineers
213 S. Camino del Pueblo
Bernalillo, New Mexico, USA
Phone: 505-867-6990
Fax: 505-867-6991

DATE: 08/20/09
CAD: SCHEMATIC A.dwg
PROJECT #: 520.01.01
DRAWN BY: GEI
REVIEWED BY: MRH
APPROVED BY: IKG
gei@gordonenvironmental.com
ATTACHMENT III.I C

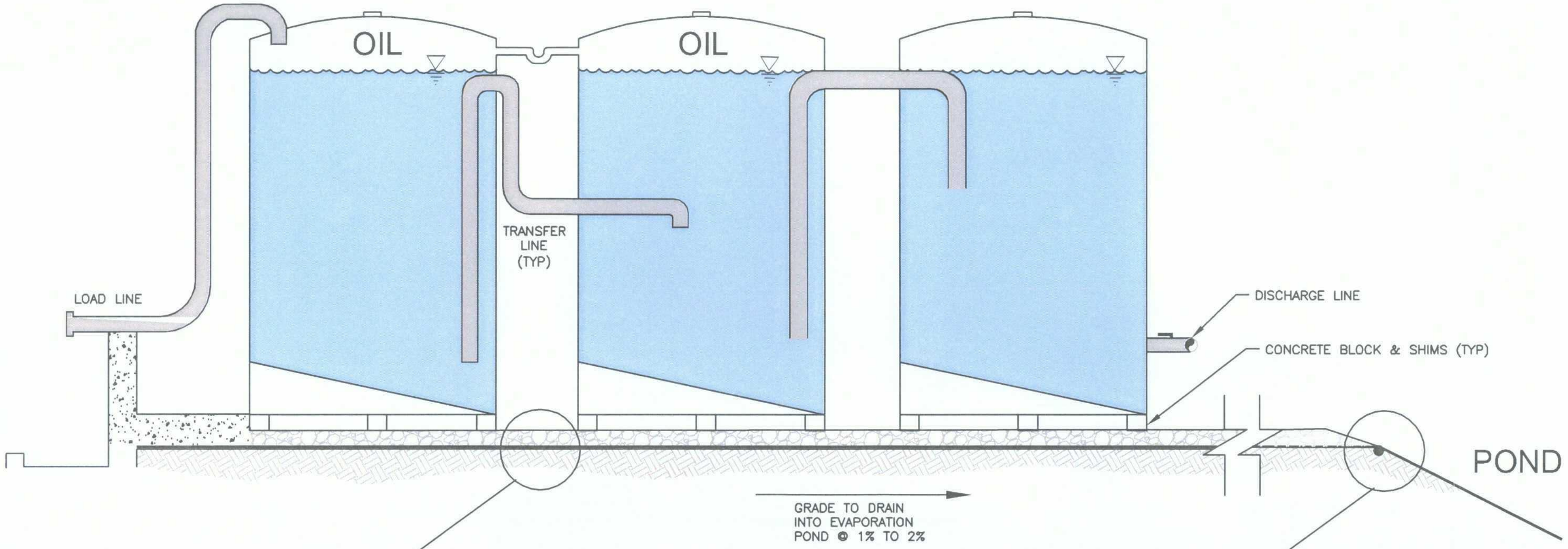
Drawing:P:\acad 2003\520.01.01\FIGURES\SCHEMATIC A.dwg
Date/Time:Aug. 20, 2009-13:17:36

APPLICATION FOR MODIFICATION
BASIN DISPOSAL, INC.
OIL FIELD WASTE EVAPORATION PONDS

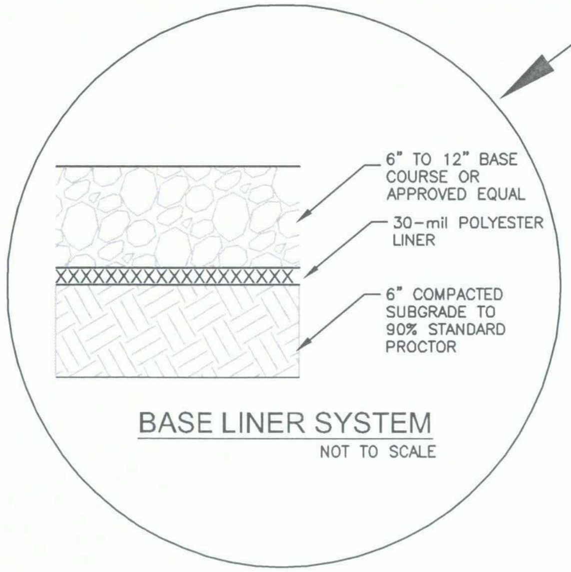
VOLUME III: ENGINEERING DESIGN AND CALCULATIONS
SECTION 1: ENGINEERING DESIGN

ATTACHMENT III.1.D

TYPICAL RECEIVING TANK INSTALLATION DETAILS



ELEVATION - SECTION A-A'
NOT TO SCALE



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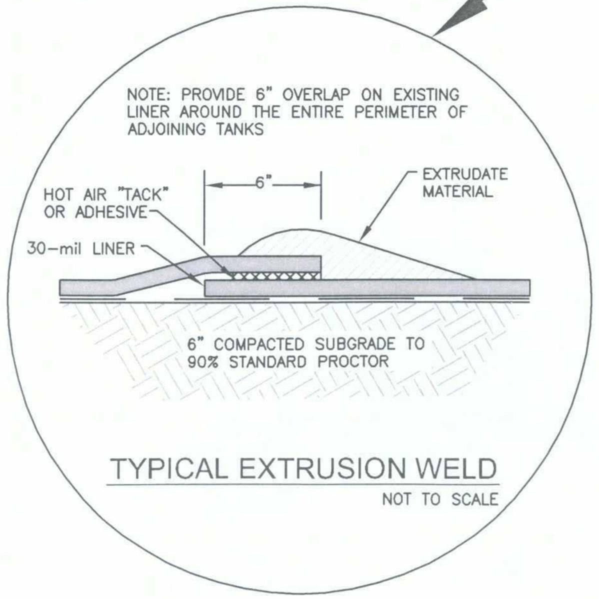

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TYPICAL RECEIVING TANK
INSTALLATION DETAILS

BASIN DISPOSAL, INC.
BLOOMFIELD, NEW MEXICO

Gordon Environmental, Inc.
Consulting Engineers
213 S. Camino del Pueblo
Bernalillo, New Mexico, USA
Phone: 505-867-6990
Fax: 505-867-6991

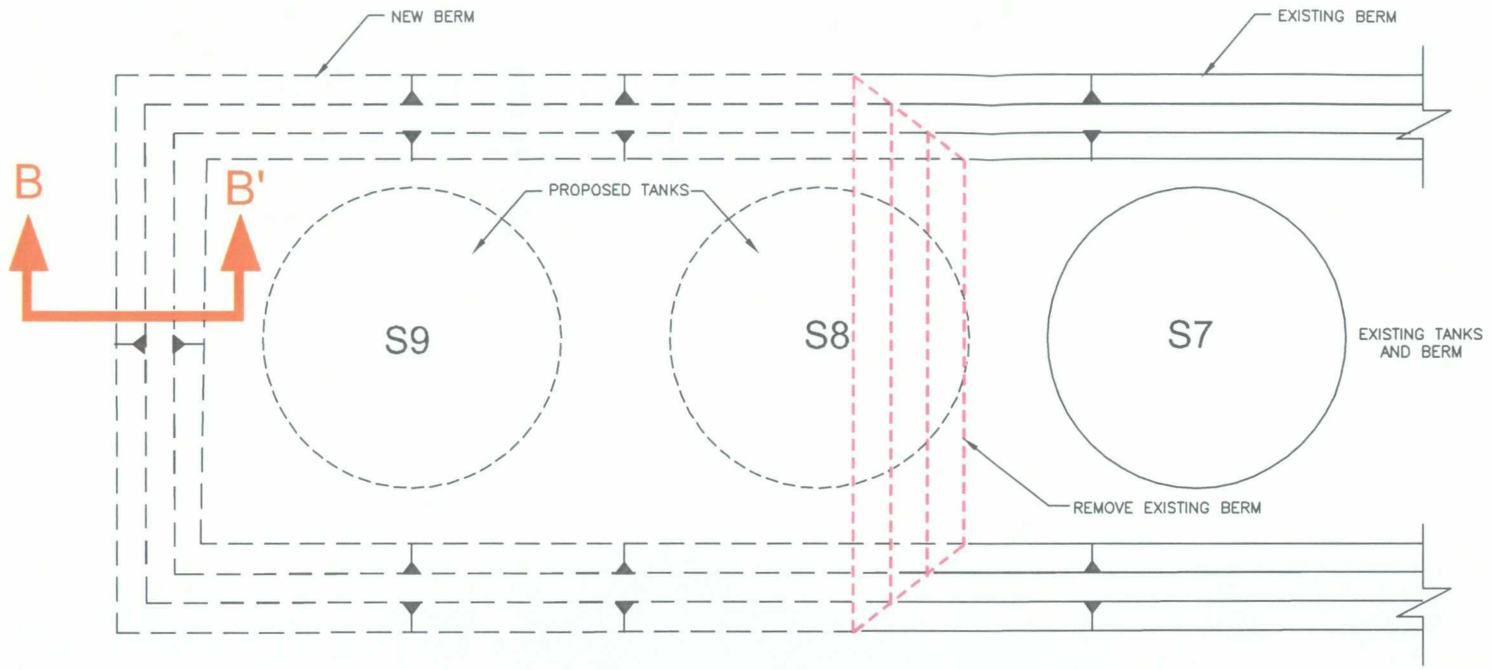
DATE: 06/05/09
CAD: TANK ELEV.dwg
PROJECT #: 520.01.01
DRAWN BY: JFP
REVIEWED BY: MRH
APPROVED BY: IKG
gei@gordonenvironmental.com
ATTACHMENT III.I.D

APPLICATION FOR MODIFICATION
BASIN DISPOSAL, INC.
OIL FIELD WASTE EVAPORATION PONDS

VOLUME III: ENGINEERING DESIGN AND CALCULATIONS
SECTION 1: ENGINEERING DESIGN

ATTACHMENT III.1.E

TYPICAL SALES TANK INSTALLATION DETAILS



PLAN VIEW

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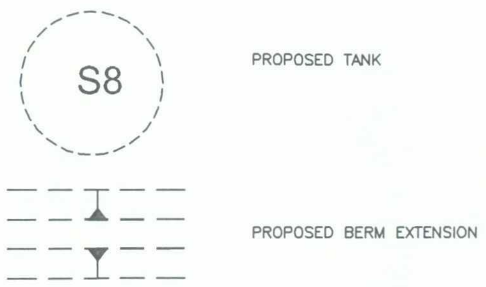
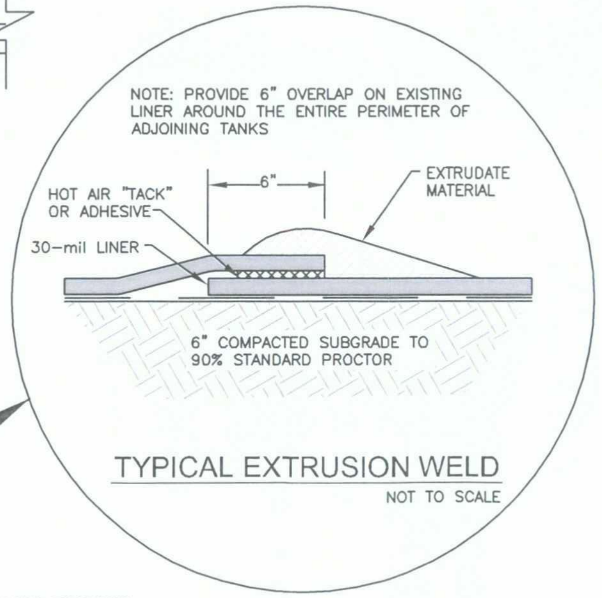
LEGEND





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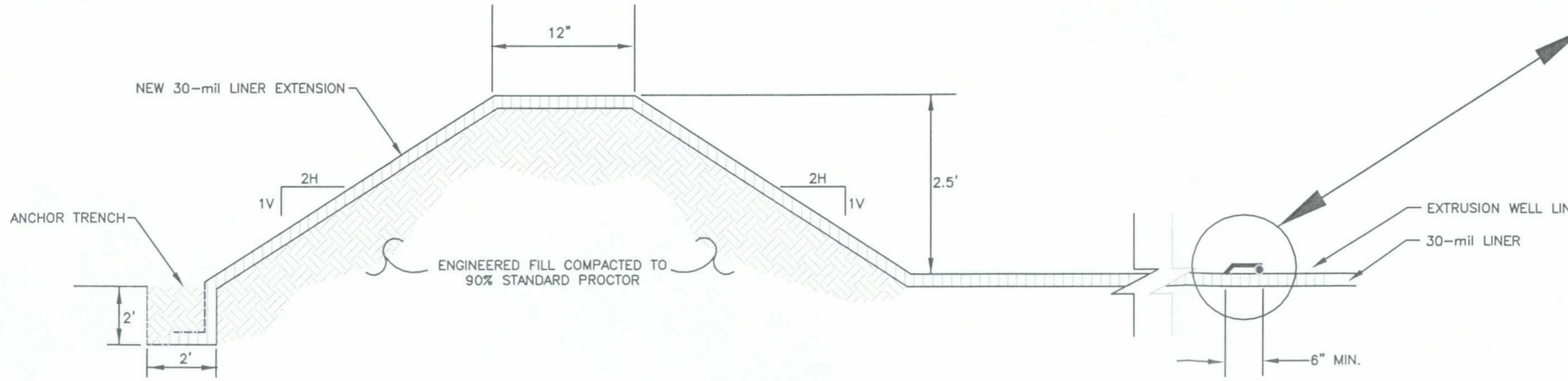

CROSS SECTION B-B'

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TYPICAL SALES TANK INSTALLATION DETAILS

BASIN DISPOSAL, INC.
BLOOMFIELD, NEW MEXICO

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213 S. Camino del Pueblo
Bernalillo, New Mexico, USA
Phone: 505-867-6990
Fax: 505-867-6991

DATE: 11/19/08	CAD: TYP TANK.dwg	PROJECT #: 520.01.01
DRAWN BY: JFP	REVIEWED BY: MRH	ATTACHMENT III.I.E
APPROVED BY: IKG	gei@gordonenvironmental.com	

APPLICATION FOR MODIFICATION
BASIN DISPOSAL, INC.
OIL FIELD WASTE EVAPORATION PONDS

VOLUME III: ENGINEERING DESIGN AND CALCULATIONS
SECTION 1: ENGINEERING DESIGN

ATTACHMENT III.1.F

TANK CAPACITY CALCULATIONS

Attachment III.1.F
Basin Disposal, Inc.
Tank Capacity Calculations

Basin Disposal is an oil and gas produced water disposal facility. The facility is manned 24 hours per day 7 days per week.

A. Water is delivered by trucking companies into one of five sets of currently permitted Receiving Tanks:

Current Number	Proposed Number	Volume	Permitted
1	**R3**	400 bbls	Approved 10/11/1985
A	A	400 bbls	Approved 12/28/2000
B	B	400 bbls	Approved 12/28/2000
2	**R4**	400 bbls	Approved 10/11/1985
A	A	400 bbls	Approved 12/28/2000
B	B	400 bbls	Approved 12/28/2000
3	**R5**	400 bbls	Approved 10/11/1985
A	A	400 bbls	Approved 12/28/2000
B	B	400 bbls	Approved 12/28/2000
4	**R6**	400 bbls	Approved 10/11/1985
A	A	400 bbls	Approved 12/28/2000
B	B	400 bbls	Approved 12/28/2000
Additions under Major Modification Application	**R1**	400 bbls	Premitted under this Application
	A	400 bbls	Premitted under this Application
	B	400 bbls	Premitted under this Application
	R2	400 bbls	Premitted under this Application
	A	400 bbls	Premitted under this Application
	B	400 bbls	Premitted under this Application
12	**R7**	400 bbls	Approved 12/28/2000
A	A	400 bbls	Approved 12/28/2000
B	B	400 bbls	Approved 12/28/2000
Amigo	Amigo	500 bbls	Approved 10/11/1985

i. The Receiving tanks serve to gravity separate solids and oil from the water. Solids collect in the bottoms and oil floats to the tops of the receiving tanks.

ii. The Receiving Tanks bottoms are taken to the OCD permitted IEI (i.e. JFJ) Landfarm.

iii. The Receiving Tanks are set on concrete blocks on top of a lined bermed impermeable pad that drains into the pond.

B. The separated oil flows into the currently permitted Crude Oil Receiving Tanks:

Current Number	Proposed Number	Volume	Permitted
9	**C1**	400 bbls	Approved 10/11/1985
10	**C2**	400 bbls	Approved 10/11/1985
11	**C3**	400 bbls	Approved 10/11/1985

i. The Crude Oil Receiving Tanks are set inside a lined berm of dimensions 44 ft long by 21 ft wide by 2.5 ft tall.

ii. The Crude Oil Tanks are interconnected at the top of the tanks. This design prevents a leak in one tank causing the other tanks to empty. The volume of the lined berm is 576 bbls which exceeds the requirement for 1 1/3 times the capacity of a 400 bbl

C. The water flows into the currently permitted triple lined pond equipped with a leak detection system

Current Number	Proposed Number	Storage Volume	Permitted
	1	109860 bbls	New Liner Approved 6/14/2004

i. Surface aeration and bleach are used to maintain water chemistry parameters:
:O_2 at or above 0.5 ppm one foot off the bottom of the pond.
:pH above 8
ii. Four H2S monitors are placed around the pond covering the four major points on the compass.
iii. The H2S monitors continually monitor the ambient air.
iv. Two chlorine monitors are placed around the ponds covering the East and South borders.
v. 2 Foot Freeboard per current permit, storage volume does not include freeboard
vi. Volume including freeboard is 135,179 bbls

Current Number	Proposed Number	Storage Volume	Permitted
Additions under Major Modification Application	**2**	73,932 bbls	Permitted under this Application
	3	73,932 bbls	Permitted under this Application

i. 3.5 Foot Freeboard
ii. Storage volume does not include freeboard
iii. Volume including freeboard is 122,264 bbls (15.76 acre-feet)
iv. Inside grade shall be no steeper than 3H:1V
v. Levees shall have an outside grade no steeper than 3H:1V
vi. Levees' tops shall be wide enough to install an anchor trench and provide adequate room for inspection/maintenance.
vii. Liner seams shall be minimized and oriented up and down, not across a slope
viii. Each pond shall have a:
:primary liner (30-mil flexible PVC or 60-mil HDPE liner, UV resistant)
:secondary liner (30-mil flexible PVC or 60-mil HDPE liner, UV resistant)
ix. Slope shall be 2% (2 ft V for 100 ft H)
x. Wind fences shall be erected around pond
xi A spray evaporation system shall be installed.
xii Water shall be filtered through 50 um filters from Pond 1 prior to being placed in either Pond 2 or 3 to prevent solids and oils from entering Pond 2 or 3
xiii Approximate size of each pond is 200 x 420 feet x 7.6 feet deep

D. Bleach is stored in the currently permitted Chemical Tanks:

Current Number	Proposed Number	Volume	Permitted
1	**B1**	80 bbls	Approved Between 05/27/2003 & 04/03/2002
A	**B2**	60 bbls	Approved Between 05/27/2003 & 04/03/2002
B	**B3**	80 bbls	Approved Between 05/27/2003 & 04/03/2002
C	**B4**	80 bbls	Approved Between 05/27/2003 & 04/03/2002

i. The Chemical Tanks are set on a bermed concrete pad that drains into the pond.

E. Water from Pond I is:
i. Pumped through one set of currently permitted 20 um filters in Bldg 1
and then
ii. Pumped into currently permitted Positive Head Tanks

Current Number	Proposed Number	Volume	Permitted
15	**P1**	400 bbls	Approved 7/5/2005
16	**P2**	400 bbls	Approved 7/5/2005
13	**P3**	400 bbls	Approved 10/11/1985

F. Water from Tank 13 (P3) is:
i. Filtered though one of two sets of currently permitted 5 um filters in Bldg 2 and Bldg 3

or

ii. Returned to Pond I, if more water is in Tank 13 (P3) than being pulled through the 5 um filters

G. Sumps/hoses from the filter assemblies in Bldg 1, Bldg 2, and Bldg 3 discharge back to pond

H. Water from the 5 um filters is injected into the disposal well through one of the four currently permitted injection pumps (only two operate at any one time) at a rate of approximately barrels 11,300 per day at 1575 psi (permitted limit is 1600 psi)

I. Skimmed oil from Tanks 9, 10, 11 (O1-O3) is transferred to the Oil Heating Tanks 23, 24, 25 (H1-H3) via an underground pipeline. In the Heating Tanks the water and oil mixture is heated so as to allow gravity seperation. The water is discharged into the Amigo tank.

Current Number	Proposed Number	Volume	Permitted
17	**H1**	500 bbls	Approved 3/12/1998
18	**H2**	500 bbls	Approved 7/6/1999
19	**H3**	400 bbls	Approved 1/10/2008

i. The Oil Heating Tanks are set inside a lined berm of dimensions 62 ft long by 46 ft wide by 2.3 ft tall.

ii. The Oil Heating Tanks are not interconnected. The volume of the lined berm is 1168 bbls which exceeds the requirement for 1 1/3 times the capacity of a 500 bbl tank (667 bbls).

I. Dewatered crude oil from Tanks 17,18,19 (H1-H3) is transferred to the Oil Sales Tanks via an underground pipeline for sale to Western (formerly Giant) or Petrosource.

Current Number	Proposed Number	Volume	Permitted
8	**S1**	400 bbls	Approved 10/11/1985
7	**S2**	400 bbls	Approved 10/11/1985
6	**S3**	400 bbls	Approved 10/11/1985
5	**S4**	400 bbls	Approved 10/10/2006
20	**S5**	400 bbls	Approved 10/10/2006
21	**S6**	400 bbls	Approved 10/10/2006
22	**S7**	400 bbls	Approved 10/10/2006
Additions under Major Modification Application	**S8**	400 bbls	Permitted under this Application
	S9	400 bbls	Permitted under this Application

i. The current Oil Sales Tanks are set inside a lined berm of dimensions 140 ft long by 22 ft wide by 2.5 ft tall. The Oil Sales Tanks are not interconnected.

ii. The volume of the lined berm is 1370 bbls which exceeds the requirement for 1 1/3 times the capacity of a 400 bbl tank (533 bbls).

iii. When the additional tanks are added the lined bermed area will be expanded to 180 ft long by 22 ft wide by 2.5 ft tall with a capacity of 1763 bbls. The tanks will not be interconnected.

J. The Separation Tanks are used to separate water from solids from high solid content loads. The separated water is discharged into the Amigo system. The solids are mixed with dirt in the concrete slab and taken to the OCD permitted landfarm.

Current Number	Proposed Number	Volume	Permitted
14	**T1**	210 bbls	Approved 09/03/1992
14.5	**T2**	210 bbls	Approved 09/03/1992

i. The Separation Tanks are not interconnected and are set inside a lined berm that drains to the concrete slab. The concrete slab has a volume of 500 bbls which exceeds the requirement for 1 1/3 times the capacity of a 210 bbl tank (280 bbls).

ii. *The Concrete Slab is emptied daily*

D. The Settling Tanks are used to allow water and solids to separate after cleaning the Receiving Tanks to minimize the volume of waste taken to the landfarm.

Number	Proposed Number	Volume
15	**T3**	80 bbls
16	**T4**	240 bbls

i. The water will be discharged into the pond.
ii. The solids taken to the OCD permitted IEI (i.e. JFJ) Landfarm.
iii. The Settling Tanks are set on concrete blocks on top of a lined bermed impermeable pad that drains into the pond.

APPLICATION FOR MODIFICATION
BASIN DISPOSAL, INC.
OIL FIELD WASTE EVAPORATION PONDS

VOLUME III: ENGINEERING DESIGN AND CALCULATIONS
SECTION 1: ENGINEERING DESIGN

ATTACHMENT III.1.G

PIPE WALL THICKNESS INFORMATION

PVC PIPE DIMENSIONS

	Wall Thickness		Outside Diameters		
				Tolerance	
Nominal Pipe Size	Minimum	Tolerance	Average OD	Average	Out-of-Roundness
ASTM D 1785, PVC PIPE, SCHEDULE 40					
1	0.133	+0.020	1.315	±0.005	±0.010
1¼	0.140	+0.020	1.660	±0.005	±0.012
1½	0.145	+0.020	1.900	±0.006	±0.012
2	0.154	+0.020	2.375	±0.006	±0.012
2½	0.203	+0.024	2.875	±0.007	±0.015
3	0.216	+0.026	3.500	±0.008	±0.015
3½	0.226	+0.027	4.000	±0.008	±0.050
4	0.237	+0.028	4.500	±0.009	±0.050
5	0.258	+0.031	5.563	±0.010	±0.050
6	0.280	+0.034	6.625	±0.011	±0.050
8	0.322	+0.039	8.625	±0.015	±0.075
10	0.365	+0.044	10.750	±0.015	±0.075
12	0.406	+0.049	12.750	±0.015	±0.075
ASTM D 1785, PVC PIPE, SCHEDULE 80					
1	0.179	+0.021	1.315	±0.005	±0.010
1¼	0.191	+0.023	1.660	±0.005	±0.012
1½	0.200	+0.024	1.900	±0.006	±0.012
2	0.218	+0.026	2.375	±0.006	±0.012
2½	0.276	+0.033	2.875	±0.007	±0.015
3	0.300	+0.036	3.500	±0.008	±0.015
3½	0.318	+0.038	4.000	±0.008	±0.015
4	0.337	+0.040	4.500	±0.009	±0.015
5	0.375	+0.045	5.563	±0.010	±0.030
6	0.432	+0.052	6.625	±0.011	±0.035
8	0.500	+0.060	8.625	±0.015	±0.075
10	0.593	+0.071	10.750	±0.015	±0.075
12	0.687	+0.082	12.750	±0.015	±0.075
ASTM D 2241, PVC PIPE (SDR-PR), SDR 21 (200)					
1	0.063	+0.020	1.315	±0.005	±0.015
1¼	0.079	+0.020	1.660	±0.005	±0.015
1½	0.090	+0.020	1.900	±0.006	±0.030
2	0.113	+0.020	2.375	±0.006	±0.030
2½	0.137	+0.020	2.875	±0.007	±0.030
3	0.167	+0.020	3.500	±0.008	±0.030
3½	0.190	+0.023	4.000	±0.008	±0.050
4	0.214	+0.026	4.500	±0.009	±0.050
5	0.265	+0.032	5.563	±0.010	±0.050

Table A-2 (cont'd)
PIPE WEIGHTS AND DIMENSIONS *(IPS)*
PE3608 *(BLACK)*

OD			SDR	Nominal ID		Minimum Wall		Weight	
Nominal	Actual							lb. per	kg. per
in.	in.	mm.		in.	mm.	in.	mm.	foot	meter
			7	2.44	61.98	0.500	12.70	2.047	3.047
			7.3	2.48	63.08	0.479	12.18	1.978	2.943
			9	2.68	67.96	0.389	9.88	1.656	2.464
			9.3	2.70	68.63	0.376	9.56	1.609	2.395
			11	2.83	71.77	0.318	8.08	1.387	2.065
3	3.500	88.90	11.5	2.85	72.51	0.304	7.73	1.333	1.984
			13.5	2.95	74.94	0.259	6.59	1.153	1.716
			15.5	3.02	76.74	0.226	5.74	1.015	1.511
			17	3.06	77.81	0.206	5.23	0.932	1.386
			21	3.15	79.93	0.167	4.23	0.764	1.136
			26	3.21	81.65	0.135	3.42	0.623	0.927
			7	3.14	79.68	0.643	16.33	3.384	5.037
			7.3	3.19	81.11	0.616	15.66	3.269	4.865
			9	3.44	87.38	0.500	12.70	2.737	4.073
			9.3	3.47	88.24	0.484	12.29	2.660	3.958
			11	3.63	92.27	0.409	10.39	2.294	3.413
4	4.500	114.30	11.5	3.67	93.23	0.391	9.94	2.204	3.280
			13.5	3.79	96.35	0.333	8.47	1.906	2.836
			15.5	3.88	98.67	0.290	7.37	1.678	2.497
			17	3.94	100.05	0.265	6.72	1.540	2.292
			21	4.05	102.76	0.214	5.44	1.262	1.879
			26	4.13	104.98	0.173	4.40	1.030	1.533
			32.5	4.21	106.84	0.138	3.52	0.831	1.237
			7	3.88	98.51	0.795	20.19	5.172	7.697
			7.3	3.95	100.27	0.762	19.36	4.996	7.435
			9	4.25	108.02	0.618	15.70	4.182	6.224
			9.3	4.29	109.09	0.598	15.19	4.065	6.049
			11	4.49	114.07	0.506	12.85	3.505	5.216
5	5.563	141.30	11.5	4.54	115.25	0.484	12.29	3.368	5.012
			13.5	4.69	119.11	0.412	10.47	2.912	4.334
			15.5	4.80	121.97	0.359	9.12	2.564	3.816
			17	4.87	123.68	0.327	8.31	2.353	3.502
			21	5.00	127.04	0.265	6.73	1.929	2.871
			26	5.11	129.78	0.214	5.43	1.574	2.343
			32.5	5.20	132.08	0.171	4.35	1.270	1.890
			7	4.62	117.31	0.946	24.04	7.336	10.917
			7.3	4.70	119.41	0.908	23.05	7.086	10.545
			9	5.06	128.64	0.736	18.70	5.932	8.827
			9.3	5.11	129.92	0.712	18.09	5.765	8.579
			11	5.35	135.84	0.602	15.30	4.971	7.398
6	6.625	168.28	11.5	5.40	137.25	0.576	14.63	4.777	7.109
			13.5	5.58	141.85	0.491	12.46	4.130	6.147
			15.5	5.72	145.26	0.427	10.86	3.637	5.413
			17	5.80	147.29	0.390	9.90	3.338	4.967
			21	5.96	151.29	0.315	8.01	2.736	4.072
			26	6.08	154.55	0.255	6.47	2.233	3.322
			32.5	6.19	157.30	0.204	5.18	1.801	2.680

See ASTM D3035, F714 and AWWA C-901/906 for OD and wall thickness tolerances.
Weights are calculated in accordance with PPI TR-7.

APPLICATION FOR MODIFICATION
BASIN DISPOSAL, INC.
OIL FIELD WASTE EVAPORATION PONDS

VOLUME III: ENGINEERING DESIGN AND CALCULATIONS
SECTION 1: ENGINEERING DESIGN

ATTACHMENT III.1.H

TECHNICAL DATA AND SPECIFICATIONS FOR XR GEOMEMBRANES

Technical Data and Specifications for

XR® Geomembranes

XR-3®
XR-5®
XR-3® PW

Industrial, Municipal and Potable Water Grade Geomembranes

Seaman Corporation
1000 Venture Blvd.
Wooster, Ohio 44691
(330) 262-1111
www.xr-5.com

Seaman Corp. XR Geomembranes

Section 1 - Product Overview/Applications

- All XR Geomembrane products are classified as an Ethylene Interpolymer Alloy (EIA)
- XR-5 grade is high strength and chemically resistant for maximum resistance to high temperature, and broad chemical resistance, including acids, oils and methane
- XR-3 grade for moderate chemical resistant requirement applications such as stormwater and domestic wastewater
- NSF 61 approved XR-3 PW grade for potable water contact
- Heat weldable-thermal weldable for seams as strong as the membrane. Factory panels over 15,000 square feet (1400 sq meters) for less field seaming
- Stability is excellent, with low thermal expansion-contraction properties
- 30+ year application history

Product Application Chart

	XR-5			XR-3	XR-3 PW
	8130	**8138**	**6730**	**8228**	**8130**
High Puncture Resistance	X	X	X		X
UV Resistance	X	X	X	X	X
High Strength Applications	X	X	X		X
Floating Covers (Nonpotable)	X	X	X	X	
Diesel/Jet Fuel Containment	X	X	X		
Industrial Wastewater	X	X	X		
Stormwater	X	X	X	X	
Municipal/Domestic Wastewater	X	X	X	X	
Floating Diversion Baffles/Curtains	X		X		X
Potable Water					X
<-65 Deg F Applications	Contact Seaman Corp.				
Chemically Resistant Applications	X	X	X		

XR-5® is a registered trademark of Seaman Corporation
XR-3® is a registered trademark of Seaman Corporation
XR® is a registered trademark of Seaman Corporation

Section 2 - Physical Properties

Part 1- Material Specifications

Property	Test Method	8130 XR-5	8138 XR-5	6730 XR-5
Base Fabric Type Base Fabric Weight	ASTM D 751	Polyester 6.5 oz/yd^2 nominal (220 g/m^2 nominal)	Polyester 6.5 oz/yd^2 nominal (220 g/m^2 nominal)	Polyester 7 oz/yd^2 nominal (235 g/m^2 nominal)
Thickness	ASTM D 751	30 mils min. (0.76 mm min.)	40 mils nom. (1.0 mm nom.)	30 mils min. (0.76 mm min.)
Weight	ASTM D 751	30.0 +- 2 oz/sq yd (1017 +- 2 g/m^2)	38.0 +- 2 oz/sq yd (1288 +- 70 g/m^2)	30.0 +- 2 oz/sq yd (1017 +- 70 g/m^2)
Tear Strength	ASTM D 751 Trap Tear	40/55 lbs. min. (175/245 N min.)	40/55 lbs. min. (175/245 N min.)	
Breaking Yield Strength	ASTM D 751 Grab Tensile	550/550 lbs. min. (2,447/2,447 N min.)	550/550 lbs. min. (2,447/2,447 N min.)	600/550 lbs. min. (2,670/2,447 N min.)
Low Temperature Resistance	ASTM D 2136 4 hrs-1/8" Mandrel	Pass @ -30° F Pass @ -35° C	Pass @ -30° F Pass @ -35° C	Pass @ -30° F Pass @ -35° C
Dimensional Stability	ASTM D 1204 100° C-1 Hr.	0.5% max. each direction	0.5% max. each direction	0.5% max. each direction
Hydrostatic Resistance	ASTM D 751 Procedure A	800 psi min. (5.51 MPa min.)	800 psi min. (5.51 MPa min.)	800 psi min. (5.51 MPa min.)
Blocking Resistance	ASTM D 751 180° F	#2 Rating max.	#2 Rating max.	#2 Rating max.
Adhesion-Ply	ASTM D 413 Type A	15 lbs./in. min. or film tearing bond (13 daN/5 cm min. or FTB)	15 lbs./in. min. or film tearing bond (13 daN/5 cm min. or FTB)	15 lbs./in. min. or film tearing bond (13 daN/5 cm min. or FTB)
Adhesion (minimum) Heat Welded Seam	ASTM D 751 Dielectric Weld	40 lbs./2in. RF weld min. (17.5 daN/5 cm min.)	40 lbs./2in. RF weld min. (17.5 daN/5 cm min.)	15 lbs./in. RF weld min. (15 daN/5 cm min.)
Dead Load Seam Strength	ASTM D 751, 4-Hour Test	Pass 220 lbs/in @ 70° F (Pass 980 N/2.54 cm @ 21° C) Pass 120 lbs/in @ 160° F (Pass 534 N/2.54 cm @ 70° C)	Pass 220 lbs/in @ 70° F (Pass 980 N/2.54 cm @ 21° C) Pass 120 lbs/in @ 160° F (Pass 534 N/2.54 cm @ 70° C)	
Bonded Seam Strength	ASTM D 751 Procedure A, Grab Test Method	550 lbs. min. (2,450 N min.)	550 lbs. min. (2,450 N min.)	550 lbs. min. (2,560 N min.)

Abrasion Resistance	ASTM D 3389 H-18 Wheel 1 kg Load	2,000 cycles min. before fabric exposure, 50 mg/100 cycles max. weight loss	2,000 cycles min. before fabric exposure, 50 mg/100 cycles max. weight loss	2,000 cycles min. before fabric exposure, 50 mg/100 cycles max. weight loss
Weathering Resistance	Carbon-Arc ASTM G 153	8,000 hours min. with no appreciable changes or stiffening or cracking of coating	8000 hours min. with no appreciable change or stiffening or cracking of coating	8000 hours min. with no appreciable change or stiffening or cracking of coating
Water Absorption	ASTM D 471, Section 12 7 Days	0.025 kg/m² max. @70° F/21° C 0.14 kg/m² max at 212° F/100° C	0.025 kg/m² max. @70° F/21° C 0.14 kg/m² max at 212° F/100° C	0.025 kg/m² max. @70° F/21° C 0.14 kg/m² max at 212° F/100° C
Wicking	ASTM D 751	1/8" max (0.3 cm max)	1/8" max. (0.3 cm max.)	1/8" max. (0.3 cm max.)
Bursting Strength	ASTM D 751 Ball Tip	750 lbs. min. (3,330 N min.)	750 lbs. min. (3,330 N min.)	750 lbs. min. (3,330 N min.)
Puncture Resistance	ASTM D 4833	275 lbs. min. 1,200 N min.	275 lbs. min. 1,200 N min.	275 lbs. min. 1,200 N min.
Coefficient of Thermal Expansion/ Contraction	ASTM D 696	8 x 10^{-6} in/in/° F max. (1.4 x 10^{-5} cm/cm/° C max.)	8 x 10^{-6} in/in/° F max. (1.4 x 10^{-5} cm/cm/° C max.)	8 x 10^{-6} in/in/° F max. (1.4 x 10^{-5} cm/cm/° C max.)
Environmental/Chemical Resistant Properties		See Chemical Resistance Table, Page 8	See Chemical Resistance Table, Page 8	See Chemical Resistance Table, Page 8
Puncture Resistance	FED-STD-101C Method 2031	350 lbs. (approx.)	350 lbs. (approx.)	
Cold Crack	ASTM D 2136 4 Hrs, 1/8" Mandrel	Pass at -30° F/-34° C	Pass @ -30° F/-34° C	Pass @ -30° F/-34° C

Section 2 - Physical Properties

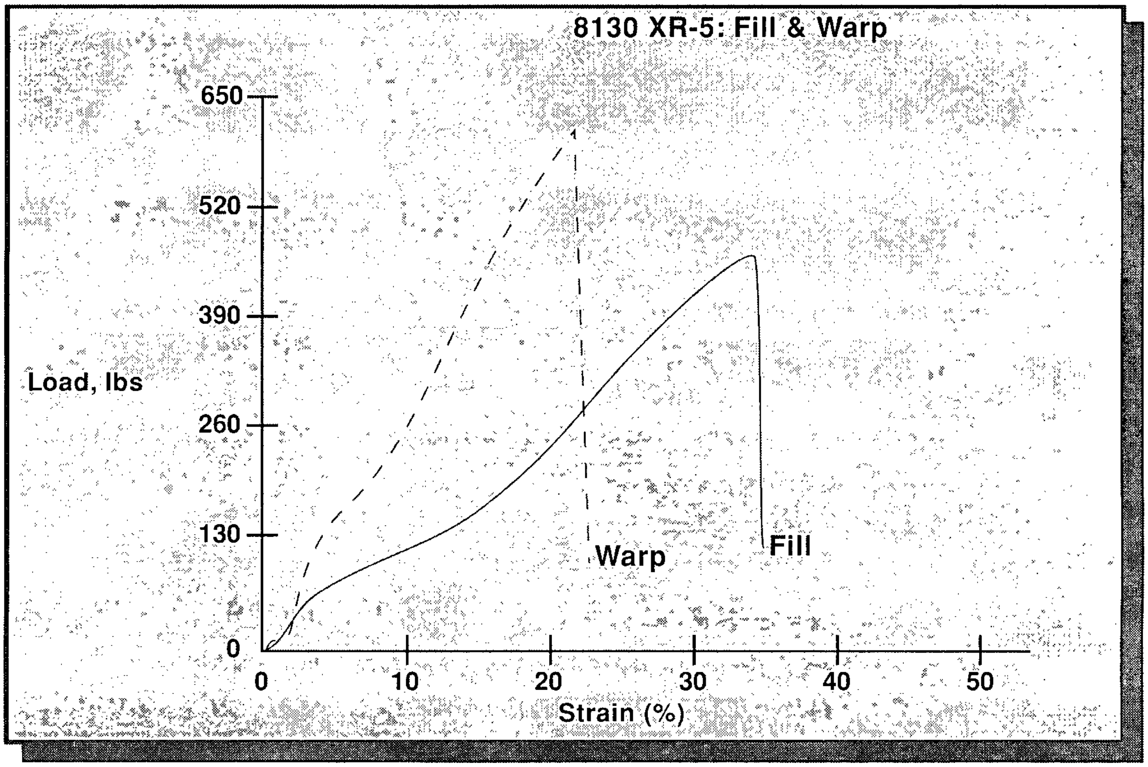
Part 1- Material Specifications (cont.)

Property	Test Method	8130 XR-3 PW	8228 XR-3
Base Fabric Type Base Fabric Weight	ASTM D 751	Polyester 6.5 oz/yd^2 nominal (220 g/m^2 nominal)	Polyester 3.0 oz/yd^2 nominal (100 g/m^2 nominal)
Thickness	ASTM D 751	30 mils min. (0.76 mm min.)	30 mils min. (0.76 mm min.)
Weight	ASTM D 751	30.0 +- 2 oz./sq. yd. (1017 +- 70 g/sq. m)	28.0 +- 2 oz./sq. yd. (950 +- 70 g/sq. m)
Tear Strength	ASTM D 751 Trap Tear	40/55 lbs. min. (175/245 N min.)	30/30 lbs. nom. (133/133 N nom.)
Breaking Yield Strength	ASTM D 751 Grab Tensile	550/550 lbs. min. (2,447/2447 N min.)	250/200 lbs. min. (1,110/890 N min.)
Low Temperature Resistance	ASTM D 2136 4hrs-1/8" Mandrel	Pass @ -30° F (Pass @ -35° C)	Pass @ -25° F (Pass @ -32° C)
Dimensional Stability	ASTM D 1204 100° C-1 hr.	0.5% max. each direction	5% max. each direction
Hydrostatic Resistance	ASTM D 751 Method A	800 psi min. (5.51 MPa min.)	300 psi min. (2.07 MPa min.)
Blocking Resistance	ASTM D 751 180° F	#2 Rating max.	#2 Rating max.
Adhesion-Ply	ASTM D 413 Type A	15 lbs./in. min. or film tearing bond (13 daN/5 cm min. or FTB)	12 lbs./in. (approx.) (10 daN/5 cm approx.)
Adhesion-Heat Welded Seam	ASTM D 751 Dielectrc Weld	40 lbs./2in. min. (17.5 daN/5 cm min.)	10 lbs./in min. (9 daN/5 cm min.)
Dead Load Seam Strength	ASTM D 751, 4-Hour Test	Pass 220 lbs/in. @ 70° F (Pass 980 N/2.54 cm @ 21° C) Pass 120 lbs/in. @ 160° F (Pass 534 N/2.54 cm @ 70° C)	Pass 100 lbs/in @ 70° F (Pass 445 N @ 21° C) Pass 50 lb @ 160° F (Pass 220 N @ 70° C)
Bonded Seam Strength	ASTM D 751 Procedure A, Grab Test Method	550 lbs. min. (2,450 N min.)	250 lbs. (approx.) (1,112 N min.)

Abrasion Resistance	ASTM D 3389 H-18 Wheel 1 kg Load	2000 cycles min. before fabric exposure, 50 mg/100 cycles max. weight loss	2000 cycles min.
Weathering Resistance	ASTM G 153	8000 hours min. with no appreciable change or stiffening or cracking of coating	8000 hours min.
Water Absorption	ASTM D 471, Section 12 7 Days	0.025 kg/m² max. @ 70° F/21° C 0.14 kg/m² max @ 212° F/100° C	0.05 kg/m² max. @ 70° F/21° C (approx.) 0.28 kg/m² max. @ 212° F/100° C (approx.)
Wicking	ASTM D 751	1/8" max. (0.3 cm max.)	1/8" max (0.3 cm max.)
Bursting Strength	ASTM D 751 Ball Tip	750 lbs. min. (3330 N min.)	350 lbs. (approx.) (1557 N min.)
Puncture Resistance	ASTM D 4833	275 lbs. min. 1200 N min.	50 lb typ. (225 N typ.)
Coefficient of Thermal Expansion/ Contraction	ASTM D 696	8×10^{-6} in/in/° F max. (1.4×10^{-5} cm/cm/° C max.)	8×10^{-6} in/in/° F max. (approx.) (1.4×10^{-5} cm/cm/° C max. approx.)
Environmental/Chemical Resistant Properties	ASTM D 741 7-Day Total Immersion With Exposed Edges	NSF 61 approved for potable water	Crude oil 5% max. weight gain Diesel fuel 5% max. weight gain
Puncture Resistance	FTMS 101C Method 2031	350 lbs. (approx.)	205 lbs. (approx.)
Tongue Tear	ASTM D 751		50 lbs. (approx.)

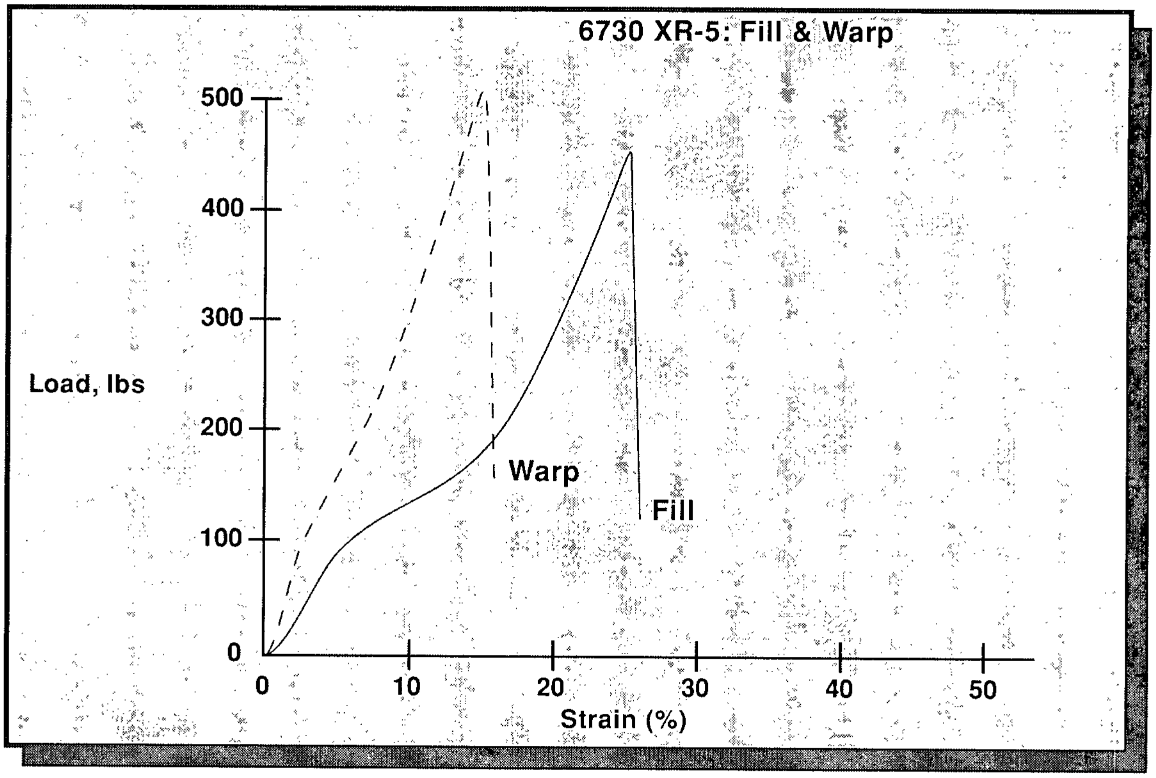
Part 2 - Elongation Properties Test

8130 XR-5

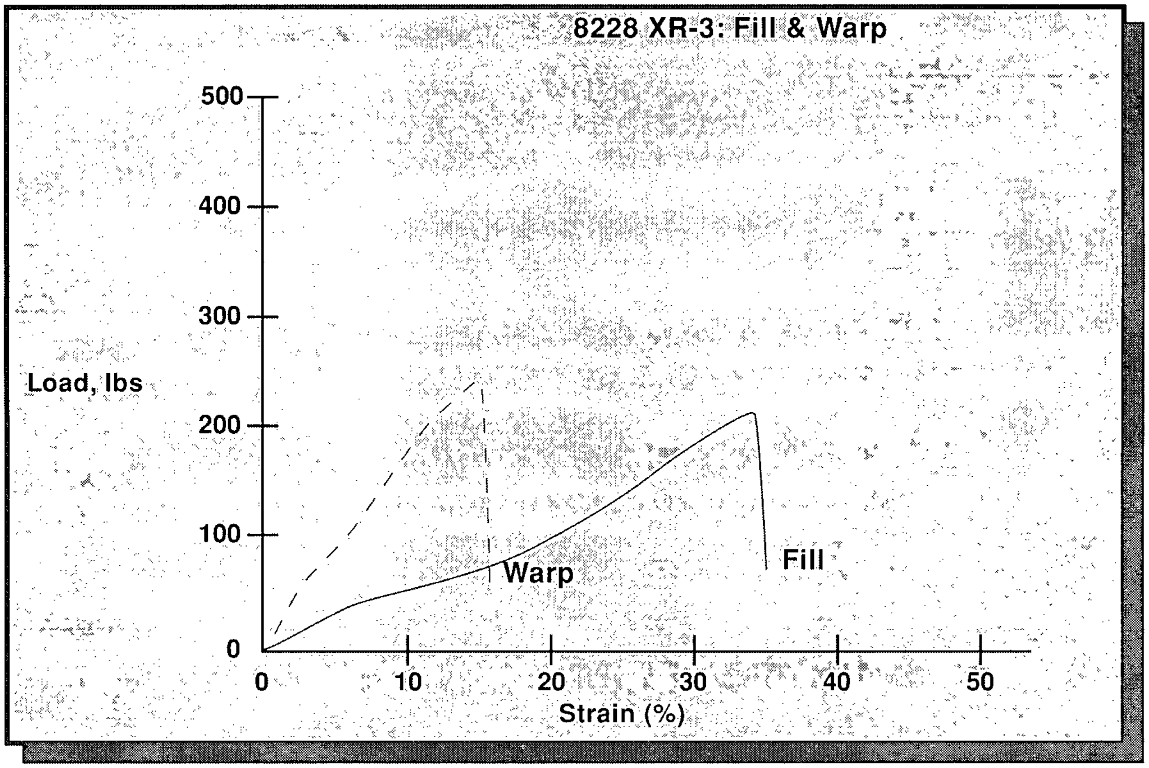


Part 2 - Elongation Properties Test

6730 XR-5



8228 XR-3


8228 XR-3: Fill & Warp
Load, lbs
500
400
300
200
100
0
0
10
20
30
40
50
Strain (%)
Warp
Fill

Section 3 - Chemical/Environmental Resistance

Part 1 - XR-5® Fluid Resistance Guidelines

The data below is the result of laboratory tests and is intended to serve only as a guide. No performance warranty is intended or implied. The degree of chemical attack on any material is governed by the conditions under which it is exposed. Exposure time, temperature, and size of the area of exposure usually varies considerably in application, therefore, this table is given and accepted at the user's risk. Confirmation of the validity and suitability in specific cases should be obtained. Contact a Seaman Corporation Representative for recommendation on specific applications.

When considering XR-5 for specific applications, it is suggested that a sample be tested in actual service before specification. Where impractical, tests should be devised which simulate actual service conditions as closely as possible.

EXPOSURE	RATING
AFFF	A
Acetic Acid (5%)	B
Acetic Acid (50%)	C
Ammonium Phosphate	T
Ammonium Sulfate	T
Antifreeze (Ethylene Glycol)	A
Animal Oil	A
Aqua Regia	X
ASTM Fuel A (100% Iso-Octane)	A
ASTM Oil #2 (Flash Pt. 240° C)	A
ASTM Oil #3	A
Benzene	X
Calcium Chloride Solutions	T
Calcium Hydroxide	T
20% Chlorine Solution	A
Clorox	A
Conc. Ammonium Hydroxide	A
Corn Oil	A
Crude Oil	A
Diesel Fuel	A
Ethanol	A
Ethyl Acetate	C
Ethyl Alcohol	A
Fertilizer Solution	A
#2 Fuel Oil	A
#6 Fuel Oil	A
Furfural	X
Gasoline	B
Glycerin	A
Hydraulic Fluid- Petroleum Based	A
Hydraulic Fluid- Phosphate Ester Based	C
Hydrocarbon Type II (40% Aromatic)	C
Hydrochloric Acid (50%)	A
Hydrofluoric Acid (5%)	A
Hydrofluoric Acid (50%)	A
Hydrofluosilicic Acid (30%)	A
Isopropyl Alcohol	T
Ivory Soap	A
Jet A	A
JP-4 Jet Fuel	A
JP-5 Jet Fuel	A
JP-8 Jet Fuel	A
Kerosene	A
Magnesium Chloride	T
Magnesium Hydroxide	T
Methanol	A
Methyl Alcohol	A
Methyl Ethyl Ketone	X
Mineral Spirits	A
Naphtha	A
Nitric Acid (5%)	B
Nitric Acid (50%)	C
Perchloroethylene	C
Phenol	X
Phenol Formaldehyde	B
Phosphoric Acid (50%)	A
Phosphoric Acid (100%)	C
Phthalate Plasticizer	C
Potassium Chloride	T
Potassium Sulphate	T
Raw Linseed Oil	A
SAE-30 Oil	A
Salt Water (25%)	B
Sea Water	A
Sodium Acetate Solution	T
Sodium Bisulfite Solution	T
Sodium Hydroxide (60%)	A
Sodium Phosphate	T
Sulphuric Acid (50%)	A
Tanic Acid (50%)	A
Toluene	C
Transformer Oil	A
Turpentine	A
Urea Formaldehyde	A
UAN	A
Vegetable Oil	A
Water (200°F)	A
Xylene	X
Zinc Chloride	T

Ratings are based on visual and physical examination of samples after removal from the test chemical after the samples of Black XR-5 were immersed for 28 days at room temperature. Results represent ability of material to retain its performance properties when in contact with the indicated chemical.

Rating Key:
A – Fluid has little or no effect
B – Fluid has minor to moderate effect
C – Fluid has severe effect
T – No data - likely to be acceptable
X – No data - not likely to be acceptable

Vapor Transmission Data

Tested according to ASTM D814-55 Inverted Cup Method

Perhaps a more meaningful test is determination of the diffusion rate of the liquid through the membrane. The vapor transmission rate of Style 8130 XR-5® to various chemicals was determined by the ASTM D814-55 inverted cup method. All tests were run at room temperature and results are shown in the table.

Chemical	8130 XR-5 Black g/hr/m2
Water	0.11
#2 Diesel Fuel	0.03
Jet A	0.11
Kerosene	0.15
Hi-Test Gas	1.78
Ohio Crude Oil	0.03
Low-Test Gas	5.25
Raw Linseed Oil	0.01
Ethyl Alcohol	0.23
Naphtha	0.33
Perchlorethylene	38.58
Hydraulic Fluid	0.006
100% Phosphoric Acid	7.78
50% Phosphoric Acid	0.43
Ethanol (E-96)	0.65
Transformer Oil	0.005
Isopropyl Alcohol	0.44
JP4 (E-96)	0.81
JP8 (E-96)	0.42
Fuel B (E-96)	6.28
Fuel C (E-96)	7.87

Note: The tabulated values are measured Vapor Transmission Rates (VTR). Normal soil testing methods to determine permeability are impractical for synthetic membranes. An "equivalent hydraulic" permeability coefficient can be calculated but is not a direct units conversion. Contact Seaman Corporation for additional technical information.

Seam Strength

Style 8130 XR-5 Black Seam Strength After Immersion

Two pieces of Style 8130 were heat sealed together (seam width 1 inch overlap) and formed into a bag. Various oils and chemicals were placed in the bags so that the seam area was entirely covered. After 28 days at room temperature, the chemicals were removed and one inch strips were cut across the seam and the breaking strength immediately determined. Results are listed below.

Chemical	Seam Strength
None	340 Lbs. Fabric Break- No Seam Failure
Kerosene	355 Lbs. Fabric Break- No Seam Failure
Ohio Crude Oil	320 Lbs. Fabric Break- No Seam Failure
Hydraulic Fluid- Petroleum Based	385 Lbs. Fabric Break- No Seam Failure
Toluene	0 Lbs. Adhesion Failure
Naphtha	380 Lbs. Fabric Break- No Seam Failure
Perchloroethylene	390 Lbs. Fabric Break- No Seam Failure

Even though 1-inch overlap seams are used in the tests to study the accelerated effects, it is recommended that XR-5 be used with a 2-inch nominal overlap seam in actual application. In some cases where temperatures exceed 160°F and the application demands extremely high seam load, it may be necessary to use a wider width seam.

Long Term Seam Adhesion

11 Years Immersion
ASTM D 751
Lbs./In.

Seam samples of 8130 XR-5® were dielectrically welded together and totally immersed in the liquids for 11 years. The samples were taken out, dried for 24 hours and visually observed for any signs of swelling, cracking, stiffening or degradation of the coating. The coating showed no appreciable degradation and no stiffening, swelling, cracking or peeling.

The adhesion, or resistance to separation of the coating from the base cloth, was then measured by ASTM D 751. Results show 8130 XR-5 maintains seam strength over this long period (11 years).

	Control	**Crude Oil**	**JP-4 Jet Fuel**	**Diesel Fuel**	**Kerosene**	**Naphtha**
8130 XR-5	20+	18	33	25	40	33*

Values in lbs./in.

*The naphtha sample was sticky.

We believe this information is the best currently available on the subject. We offer it as a suggestion in any appropriate experimentation you may care to undertake. It is subject to revision as additional knowledge and experience are gained. We make no guarantee of results and assume no obligation or liability whatsoever in connection with this information.

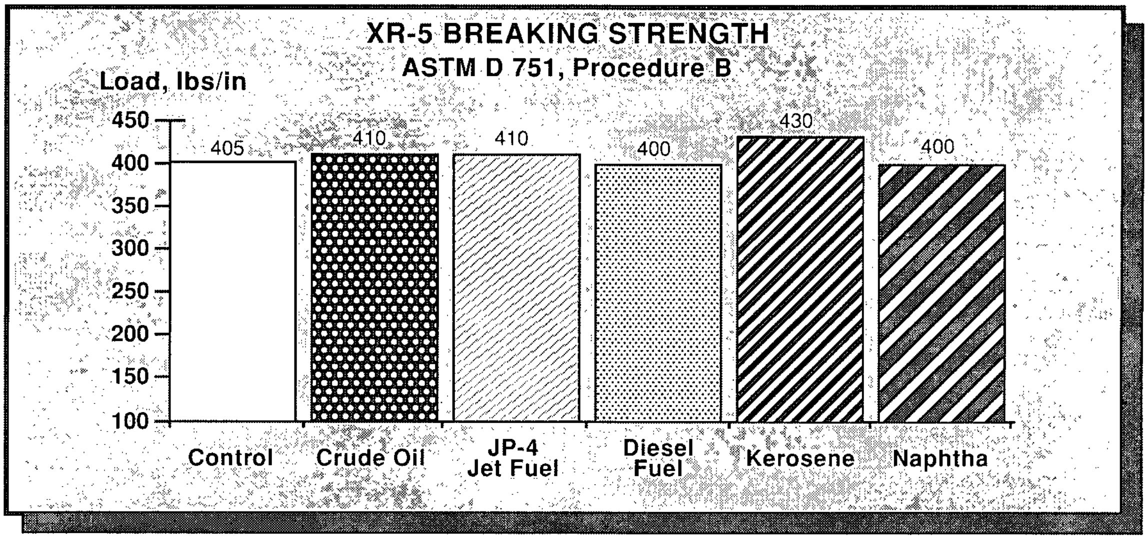
Fuel Compatibility - Long Term Immersion

Test: Samples of 8130 XR-5® Black were immersed in Diesel Fuel, JP-4 Jet Fuel, Crude Oil, Kerosene, and Naphtha for 6 1/2 years.

The samples were then taken out of the test chemicals, blotted and dried for 24 hours. The samples were observed for blistering, swelling, stiffening, cracking or delamination of the coating from the fiber.

Results: It was found in all cases that the 8130 XR-5, after immersion for six years, maintained its strength and there was no evidence of blistering, swelling, stiffening, cracking or delamination.

The strip tensile strength, or breaking strength, of the samples was measured after six years of immersion and the following are the results.



XR-3 Chemical Resistance Statement (Summary)

XR-3® is recommended for moderate chemical resistant applications such as stormwater and municipal wastewater and is not recommended for prolonged contact with pure solutions. XR-3 PW® membranes are recommended only for contact with drinking water and are resistant to low levels of chlorine found in drinking water. XR-5 has a broad range of chemical resistance which is detailed in this section.

Part 2: XR-5® Comparative Chemical Resistance

Chemical Resistance Chart

Comparative Chemical Resistance

	XR-5	HDPE	PVC	Hypalon	Polypropylene
Kerosene	A	B	C	C	C
Diesel Fuel	A	A	C	C	C
Acids (General)	A	A	A	B	A
Naphtha	A	A	C	B	C
Jet Fuels	A	A	C	B	C
Saltwater, 160° F	A	A	C	B	A
Crude Oil	A	B	C	B	C
Gasoline	B	B	C	C	C

A= Excellent **B= Moderate** **C= Poor**

Source: Manufacturer's Literature

XR-5 data based on conditions detailed in Section 3, Part 1.

Part 3: Weathering Resistance

Accelerated Weathering Test

XR-5 has been tested in the carbon arc weatherometer for over 10,000 hours of exposure and in the Xenon weatherometer for over 12,000 hours of exposure. The sample showed no loss in flexibility and no significant color change. Based on field experience of Seaman Corporation products and similar weatherometer exposure tests, XR-5 should have an outdoor weathering life significantly longer than competitive geomembranes, particularly in tropical or subtropical applications.

EMMAQUA Testing: ASTM E-838-81 was performed on a modified form of XR-5, FiberTite, used in the single-ply roofing industry. After 3 million Langleys in Arizona, no signs of degradation were noted with no evidence of cracking, blistering, swelling or adhesion delamination failure of the coating.

Natural Exposure

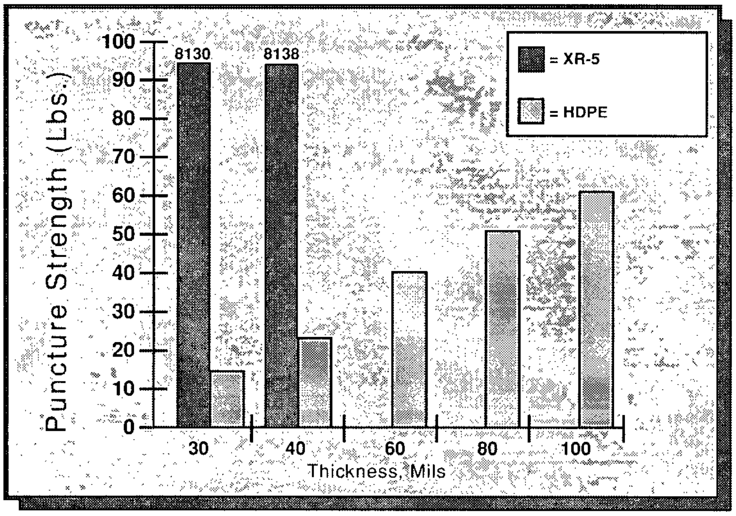
After over 17 years as a holding basin at a large oil company in the Texas desert, XR-5 showed no signs of environmental stress cracking, thermal expansion/contraction, or low yield strength problems. Temperature ranges from near zero to over 100° F.

In service approximately 17 years in a solar pond application at a research facility in Ohio, UV exposed samples, as well as immersed samples, retained over 90% of the tensile strength. Examination of the material determined there was little effect on the coating compound. The solar pond was exposed to temperatures from below zero to over 100° F.

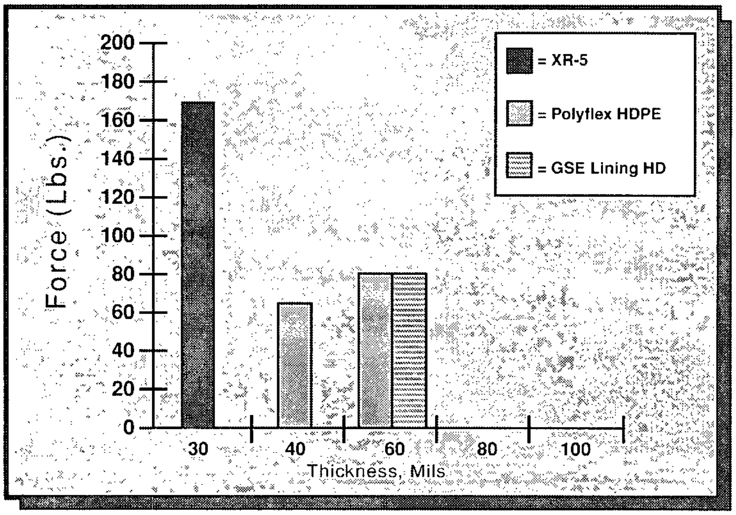
XR5 was exposed for 12½ years in Sarasota, Florida, on a weathering rack, facing the southern direction at 45°. No significant color loss, cracking, crazing, blistering, or adhesion delamination failure of the coating was noted.

XR-5/HDPE Comparative Properties

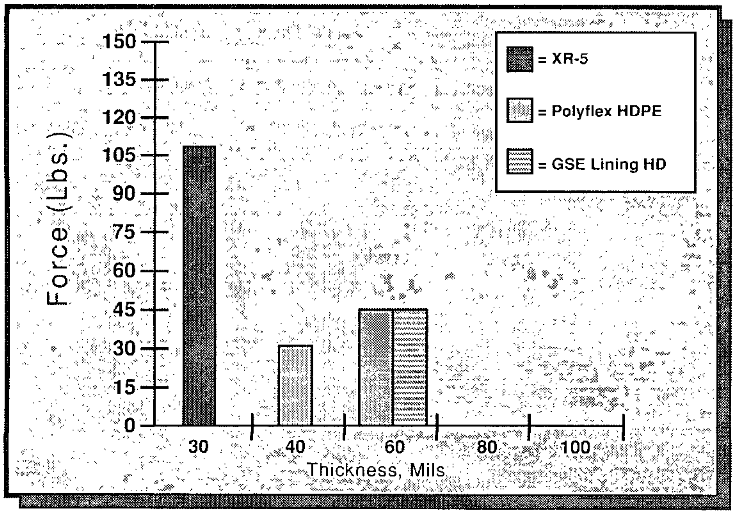
Puncture Resistance



1. ASTM D 751, Screwdriver Tip, 45° Angle (Room Temperature) Puncture Resistance, XR5 vs. HDPE



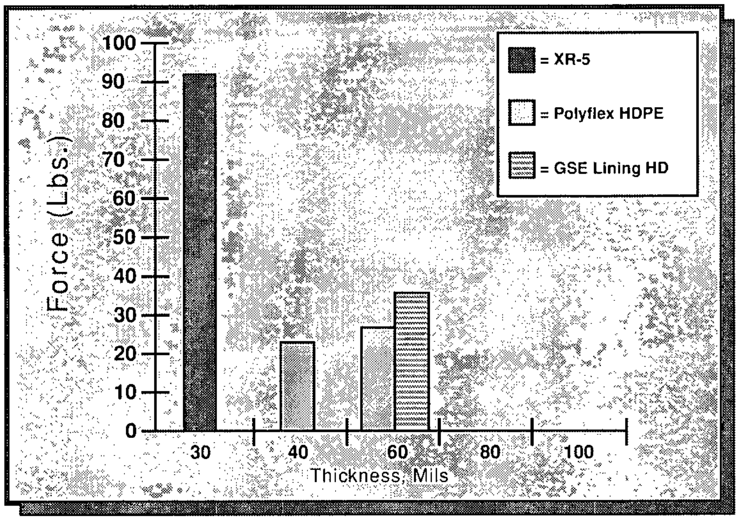
2. FED-STD-101C Method 2065 (Room Temperature)*



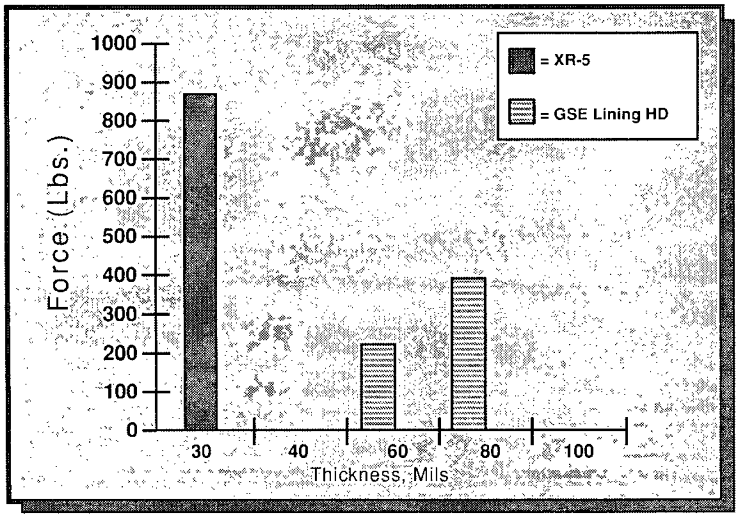
3. FED-STD-101C Method 2065 (70°C)*

* Data provided by E.I. DuPont de Nemours & Co. Wilmington, Delaware

GSE is a registered trademark of GSE Lining Technology, Inc.

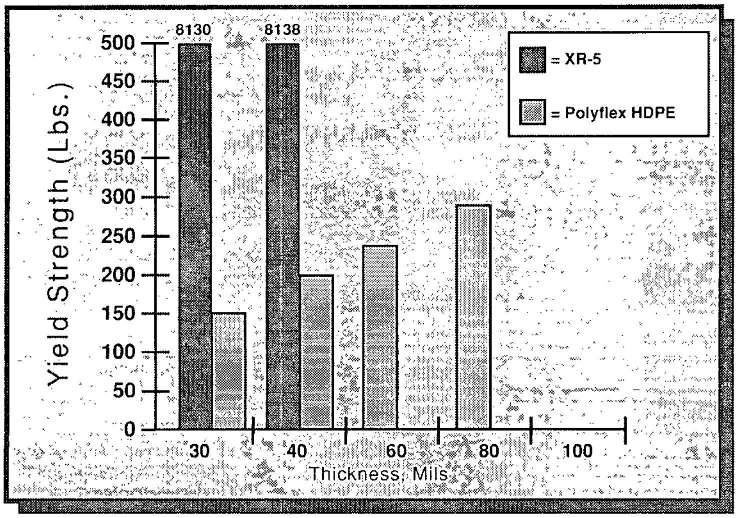


4. FED-STD-101C Method 2065 (100°C)*



5. ASTM D 751 Ball Burst Puncture

Yield Strength

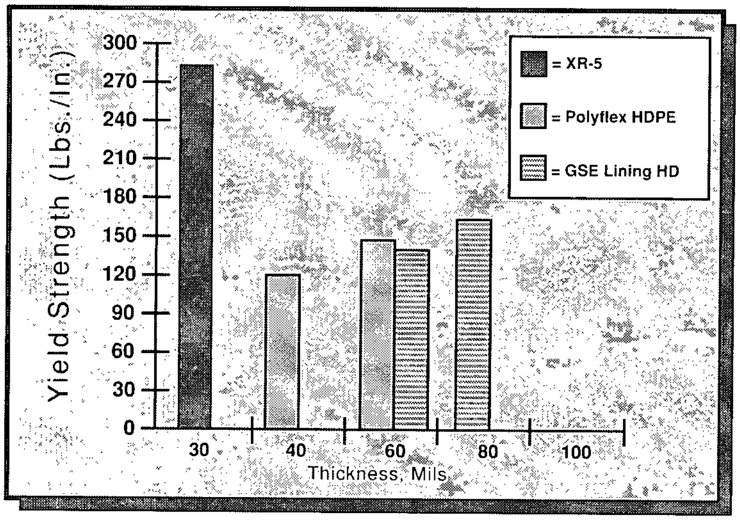


1. Yield Strength, XR-5 vs. HDPE

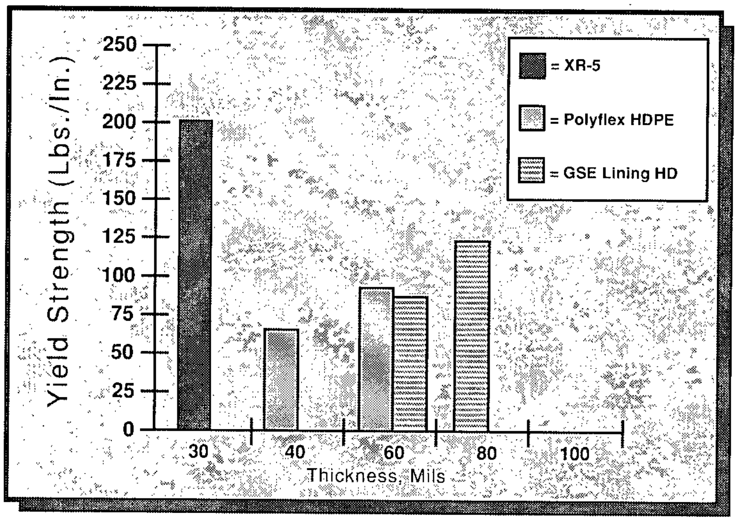
Test Method: Grab Tensile, ASTM D 751, 70° C

* Data provided by E.I. DuPont de Nemours & Co. Wilmington, Delaware

GSE is a registered trademark of GSE Lining Technology, Inc.

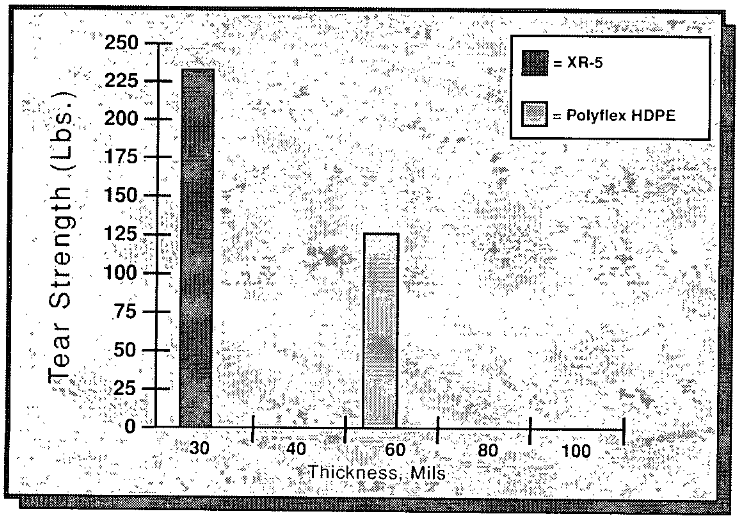


2. Strip Tensile, ASTM D 751, Room Temperature*



3. Strip tensile, ASTM D 751, 70°C*

Tear Strength



1. Tongue Tear (8" x 10" Specimens), ASTM D 751, Room Temperature*

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* Data provided by E.I. DuPont de Nemours & Co. Wilmington, Delaware

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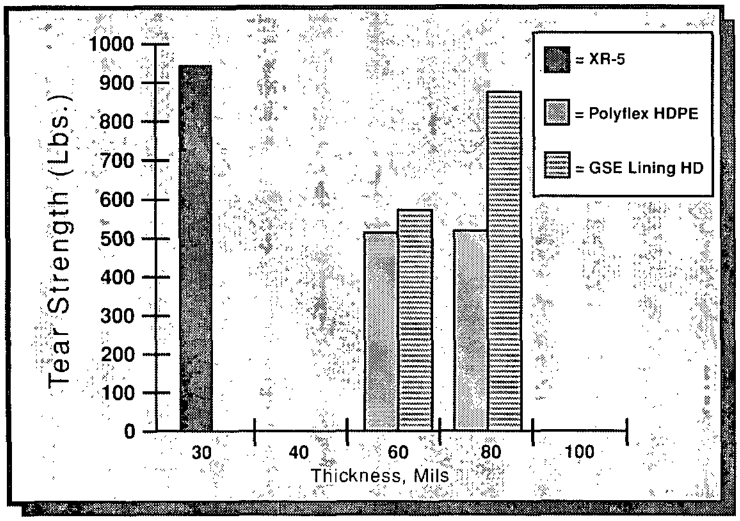
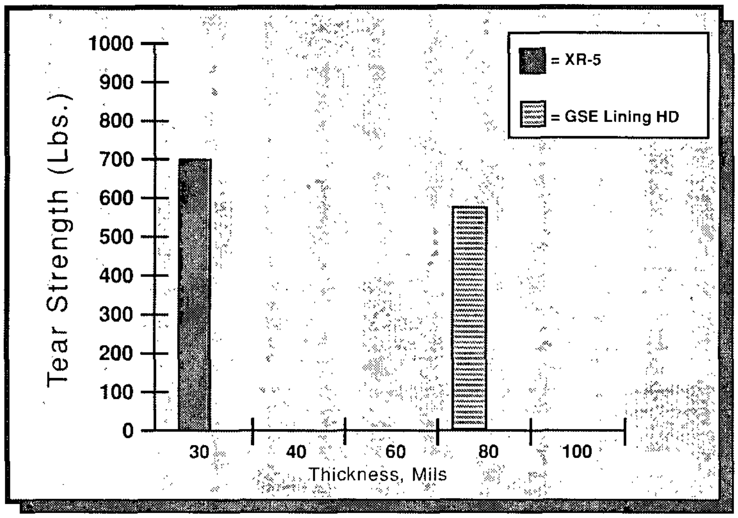


1. Graves Tear, ASTM D 624, Die C, Room Temperature*



2. Graves Tear, ASTM D 624, Die C, 70°C*

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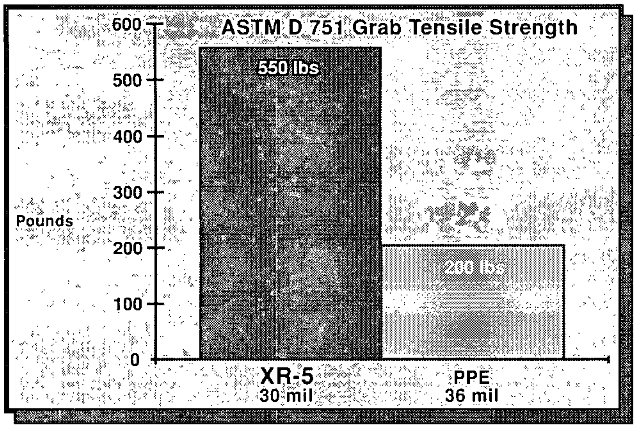
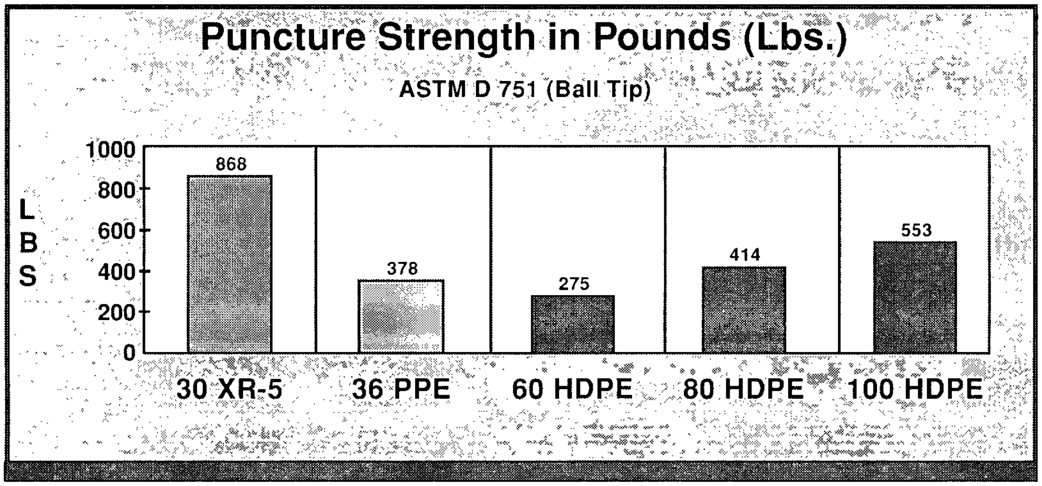
* Data provided by E.I. DuPont de Nemours & Co. Wilmington, Delaware

GSE is a registered trademark of GSE Lining Technology, Inc.

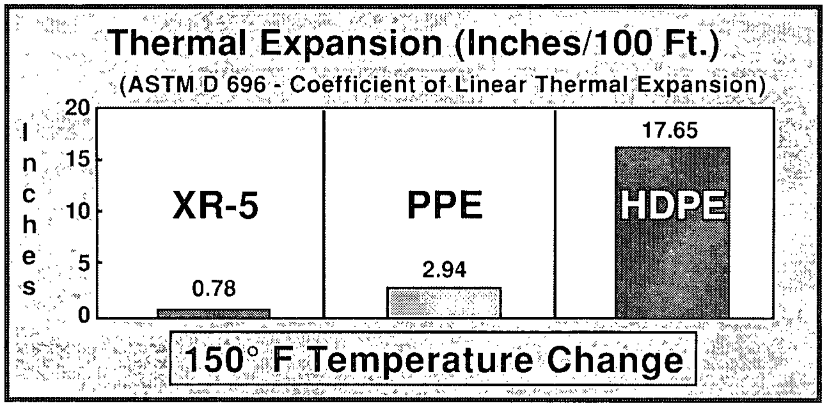
Grab Strength – XR-5® vs. Polypropylene Tensile



Puncture Strength Comparison



Coated Fabric Thermal Stability



Specification For Geomembrane Liner

(Sample specification: 8130 XR-5®. For other product specifications, go to www.xr-5.com)

General

1.01 Scope Of Work

Furnish and install flexible membrane lining in the areas shown on the drawings. All work shall be done in strict accordance with the project drawings, these specifications and membrane lining fabricator's approved shop drawings.

Geomembrane panels will be supplied sufficient to cover all areas, including appurtenances, as required in the project, and shown on the drawings. The fabricator/installer of the liner shall allow for shrinkage and wrinkling of the field panels.

1.02 Products

The lining material shall be 8130 XR-5 as manufactured by Seaman Corporation (1000 Venture Boulevard, Wooster, OH 44691; 330-262-1111), with the following physical specifications:

Base- (Type)	Polyester
Fabric Weight (ASTM D 751)	6.5 oz./sq. yd.
Finished Coated Weight (ASTM D 751)	30 ± 2 oz./sq. yd.
Trapezoid Tear (ASTM D 751)	40/55 lbs. min.
Grab Yield Tensile (ASTM D 751, Grab Method Procedure A)	550/550 lbs. min.
Elongation @ Yield (%)	20% min.
Adhesion- Heat Seam (ASTM D 751, Dielectric Weld)	40 lbs./2in. weld min.
Adhesion- Ply (ASTM D 413, Type A)	15 lbs./in. or film tearing bond
Hydrostatic Resistance (ASTM D 751, Method A)	800 psi min.
Puncture Resistance (ASTM D 4833)	275 lbs. min.
Bursting Strength (ASTM D 751 Ball Tip)	750 lbs. min.
Dead Load (ASTM D 751) Room Temperature	220 lbs. min.
(2" overlap seam, 4 hours) 160°F	120 lbs. min.
Bonded Seam Strength (ASTM D 751 Grab Test Method, Procedure A)	575 lbs. min.
Low Temperature (ASTM D 2136, 4 hours- 1/8" Mandrel)	Pass @ -30°F
Weathering Resistance ASTM G 153 Carbon Arc	8,000 hours min. With no appreciable changes or stiffening or cracking of coating
Dimensional Stability (ASTM D 1204, 212°F 1 Hour, Each Direction)	0.5% max.
Water Absorption (ASTM D 471, 7 Days)	0.025 kg/m^2 max. @ 70°F 0.14 kg/m^2 max. @ 212°F
Abrasion Resistance ASTM D 3389,	2000 cycles before fabric exposure;
H-18 Wheel, 1000 g load	50 mg/100 cycles max. wgt. Loss
Coefficient of Thermal Expansion/Contraction (ASTM D 696)	8 x 10^{-6} in/in/° F max.

1.03 Submittals

The fabricator of panels used in this work shall prepare shop drawings with a proposed panel layout to cover the liner area shown in the project plans. Shop drawings shall indicate the direction of factory seams and shall show panel sizes consistent with the material quantity requirements of 1.01.

Details shall be included to show the termination of the panels at the perimeter of lined areas, the methods of sealing around penetrations, and methods of anchoring.

Placement of the lining shall not commence until the shop drawings and details have been approved by the owner, or his representative.

1.04 Factory Fabrication

The individual XR-5® liner widths shall be factory fabricated into large sheets custom designed for this project so as to minimize field seaming. The number of factory seams must exceed the number of field seams by a factor of at least 10.

A two-inch overlap seam done by heat or RF welding is recommended. The surface of the welded areas must be dry and clean. Pressure must be applied to the full width of the seam on the top and bottom surface while the welded area is still in a melt-type condition. The bottom welding surface must be flat to insure that the entire seam is welded properly. Enough heat shall be applied in the welding process that a visible bead is extruded from both edges being welded. The bead insures that the material is in a melt condition and a successful chemical bond between the two surfaces is accomplished.

Two-inch overlapped seams must withstand a minimum of 240 pounds per inch width dead load at 70° F. and 120 pounds per inch width at 160° F. as outlined in ASTM D 751. All seams must exceed 550 lbs. bonded seam strength per ASTM D 751 Bonded Seam Strength Grab Test Method, Procedure A.

1.05 Inspection And Testing Of Factory Seams

The fabricator shall monitor each linear foot of seam as it is produced. Upon discovery of any defective seam, the fabricator shall stop production of panels used in this work and shall repair the seam, and determine and rectify the cause of the defect prior to continuation of the seaming process.

The fabricator must provide a Quality Control procedure to the owner or his representative which details his method of visual inspection and periodic system checks to ensure leak-proof factory fabrication.

1.06 Certification and Test Reports

Prior to installation of the panels, the fabricator shall provide the owner, or his representative, with written certification that the factory seams were inspected in accordance with Section 1.05.

1.07 Panel Packaging and Storage

Factory fabricated panels shall be accordian-folded, or rolled, onto a sturdy wooden pallet designed to be moved by a forklift or similar equipment. Each factory fabricated panel shall be prominently and indelibly marked with the panel size. Panels shall be protected as necessary to prevent damage to the panel during shipment.

Panels which have been delivered to the project site shall be stored in a dry area.

1.08 Qualifications of Suppliers

The fabricator of the lining shall be experienced in the installation of flexible membrane lining, and shall provide the owner or his representative with a list of not less than five (5) projects and not less than 500,000 square feet of successfully installed XR-5 synthetic lining. The project list shall show the name, address, and telephone number of an appropriate party to contact in each case. The manufacturer of the sheet goods shall provide similar documentation with a 10 million square foot minimum, with at least 5 projects demonstrating 10+ years service life.

The installer shall provide similar documentation to that required by the fabricator.

1.09 Subgrade Preparation By Others

Lining installation shall not begin until a proper base has been prepared to accept the membrane lining. Base material shall be free from angular rocks, roots, grass and vegetation. Foreign materials and protrusions shall be removed, and all cracks and voids shall be filled and the surface made level, or uniformly sloping as indicated on the drawings. The prepared surface shall be free from loose earth, rocks, rubble and other foreign matter. Generally, no rock or other object larger than USCS sand (SP) should remain on the subgrade in order to provide an adequate safety factor against puncture. Geotextiles may be used to compensate for irregular subgrades. The subgrade shall be uniformly compacted to ensure against settlement. The surface on which the lining is to be placed shall be maintained in a firm, clean, dry and smooth condition during lining installation.

1.10 Lining Installation

Prior to placement of the liner, the installer will indicate in writing to the owner or his representative that he believes the subgrade to be adequately prepared for the liner placement.

The lining shall be placed over the prepared surface in such a manner as to assure minimum handling. The sheets shall be of such lengths and widths and shall be placed in such a manner as to minimize field seaming.

In areas where wind is prevalent, lining installation should be started at the upwind side of the project and proceed downwind. The leading edge of the liner shall be secured at all times with sandbags or other means sufficient to hold it down during high winds.

Sandbags or rubber tires may be used as required to hold down the lining in position during installation. Materials, equipment or other items shall not be dragged across the surface of the liner, or be allowed to slide down slopes on the lining. All parties walking or working upon the lining material shall wear soft-sole shoes.

Lining sheets shall be closely fit and sealed around inlets, outlets and other projections through the lining. Lining to concrete seals shall be made with a mechanical anchor, or as shown on the drawings. All piping, structures and other projections through the lining shall be sealed with approved sealing methods.

1.11 XR-5 Field Seaming

All requirements of Section 1.04 and 1.05 apply. A visible bead should be extruded from the hot air welding process.

Field fabrication of lining material will not be allowed.

1.12 Inspection

All field seams will be tested using the Air Lance Method. A compressed air source will deliver 55 psi minimum to a 3/16 inch nozzle. The nozzle will be directed to the lip of the field seam in a near perpendicular direction to the length of the field seam. The nozzle will be held 4 inches maximum from the seam and travel at a rate not to exceed 40 feet per minute. Any loose flaps of 1/8" or greater will require a repair.

Alternatively all field seams should also be inspected utilizing the Vacuum Box Technique as described in Standard Practice for Geomembrane Seam Evaluation by Vacuum Chamber (ASTM D 5641-94 (2006)), using a 3 to 5 psi vacuum pressure. All leaks shall be repaired and tested.

All joints, on completion of work, shall be tightly bonded. Any lining surface showing injury due to scuffing, penetration by foreign objects, or distress from rough subgrade, shall as directed by the owner or his representative be replaced or covered, and sealed with an additional layer of lining of the proper size, in accordance with the patching procedure.

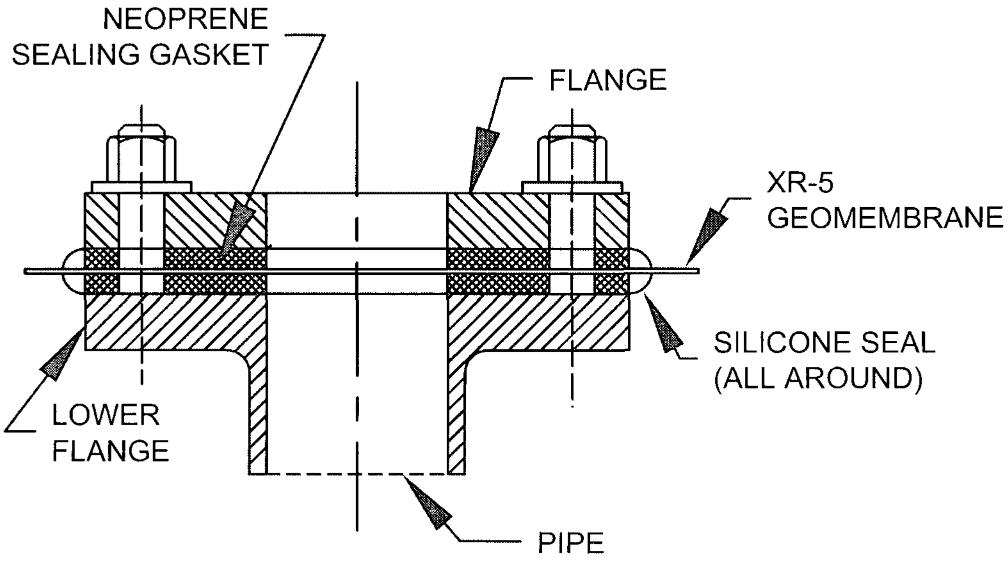
1.13 Patching

Any repairs to the lining shall be patched with the lining material. The patch material shall have rounded corners and shall extend a minimum of four inches (4") in each direction from the damaged area.

Seam repairs or seams which are questionable should be cap stripped with a 1" wide (min.) strip of the liner material. The requirements of Section 1.11 apply to this cap stripping.

1.14 Warranty

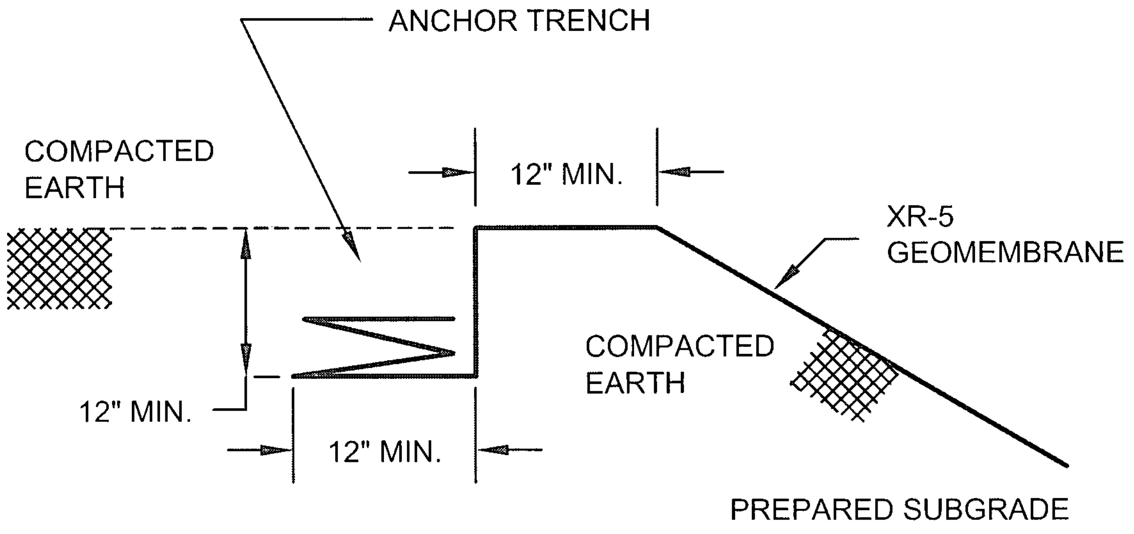
The lining material shall be warranted on a pro-rated basis for 10 years against both weathering and chemical compatibility in accordance with Seaman Corporation warranty for XR-5® Style 8130. A test immersion will be performed by the owner and the samples evaluated by the manufacturer. Workmanship of installation shall be warranted for one year on a 100% basis.



Seaman Corporation
ENGINEERED PRODUCTS GROUP
1000 Venture Blvd.,Wooster, Ohio 44691

FLANGE CONNECTION
TO
PIPE SECTION

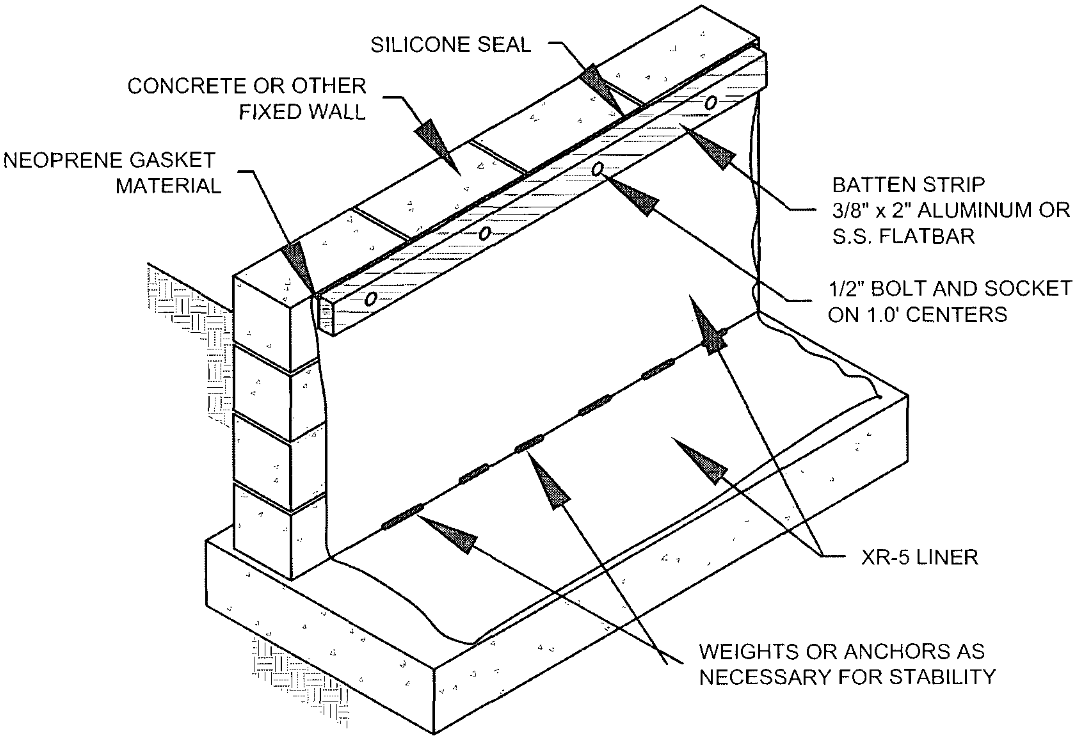
SCALE: NONE
SHEET 1 of 1
DRAW NO. XRD-019



Seaman Corporation
ENGINEERED PRODUCTS GROUP
1000 Venture Blvd.,Wooster, Ohio 44691

ELEVATION VIEW
TYPICAL ANCHOR DETAILS
XR-5 LINER

SCALE: NONE	
SHEET 1 of 1	DRAW NO. XRD-001



Seaman Corporation

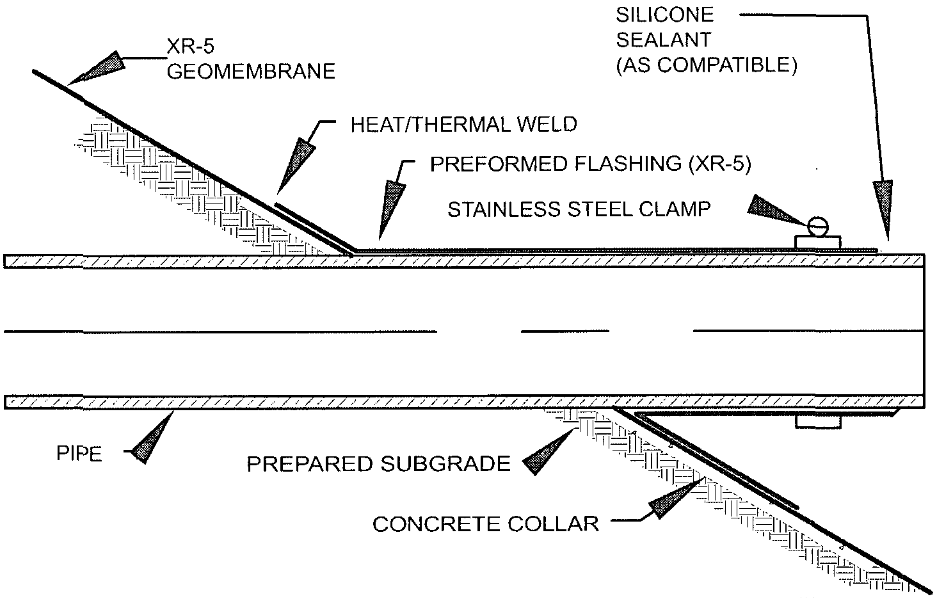
ENGINEERED PRODUCTS GROUP

1000 Venture Blvd.,Wooster, Ohio 44691

ANCHORING DETAIL

XR-5 LINER TO FIXED WALL

SCALE: NONE	
SHEET 1 of 1	DRAW NO. XRD-023



Seaman Corporation

ENGINEERED PRODUCTS GROUP

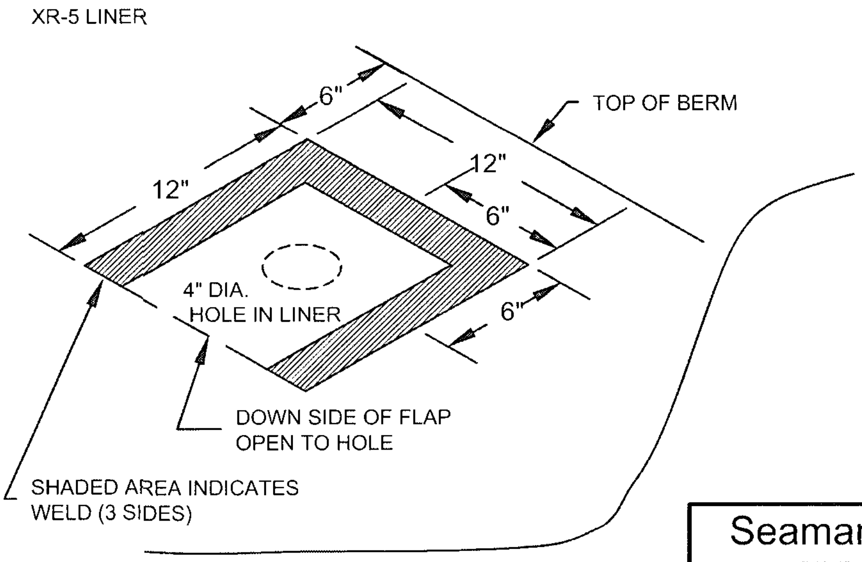
1000 Venture Blvd.,Wooster, Ohio 44691

ELEVATION VIEW
TYPICAL PIPE PUNCTURE
SEAL DETAIL XR-5 LINER

SCALE: NONE

SHEET 1 of 1

DRAW NO. XRD-018



Seaman Corporation

ENGINEERED PRODUCTS GROUP

1000 Venture Blvd.,Wooster, Ohio 44691

PLAN VIEW
FLAP VENT DETAIL
XR-5 LINER

SCALE: NONE

SHEET 1 of 1

DRAW NO. XRD-012

Section 6 - Warranty Information

Warranty

XR-5® is offered with Seaman Corporation standard warranty which addresses weathering and chemical compatibility for a 10-year period. A test immersion is required with subsequent testing and approval by Seaman Corporation.

Instructions for XR-5 Test Immersions and Warranty Requests

1. Completely immerse six Style 8130 XR-5 samples (8-1/2" x 11" size) in the liquid to be contained.
2. At the end of approximately thirty days, retrieve three of the samples. The samples should be rinsed with fresh water and dried.
3. Send the three samples to:

Attn: Geomembrane Department
Seaman Corporation
1000 Venture Blvd.
Wooster, OH 44691

4. Keep the other three samples immersed until further notice in case longer immersion data is required.
5. Complete and return the information form on the liner application.

8228 XR-3® and all PW Geomembranes are offered with a standard 10-year warranty for weathering. The attached information form should be completed.

XR® Membrane Application and Utilization Form

Installation Owner and Address:

Physical Location of Installation:

Expected Date of Installation: ______

Expected Beginning Date of Service: ______

Description of Application:
(Example: impoundment used to contain brine on an emergency basis.)

Physical Features of Application:
(Example: 1.3 million gallon earthen impoundment with overall top dimensions of 160′ x 160′ with 3:1 slopes and 10′ deep.)

Description of Liquid:

(Describe content of liquid including pollutants and expected temperature extremes in basin and at application point. Attach analysis of liquid chemistry, composition taken on a representative basis.)

Operational Characteristics:

(Describe the operation of the facility such as filling schedules, fluctuating liquid levels, operating temperatures, etc.)

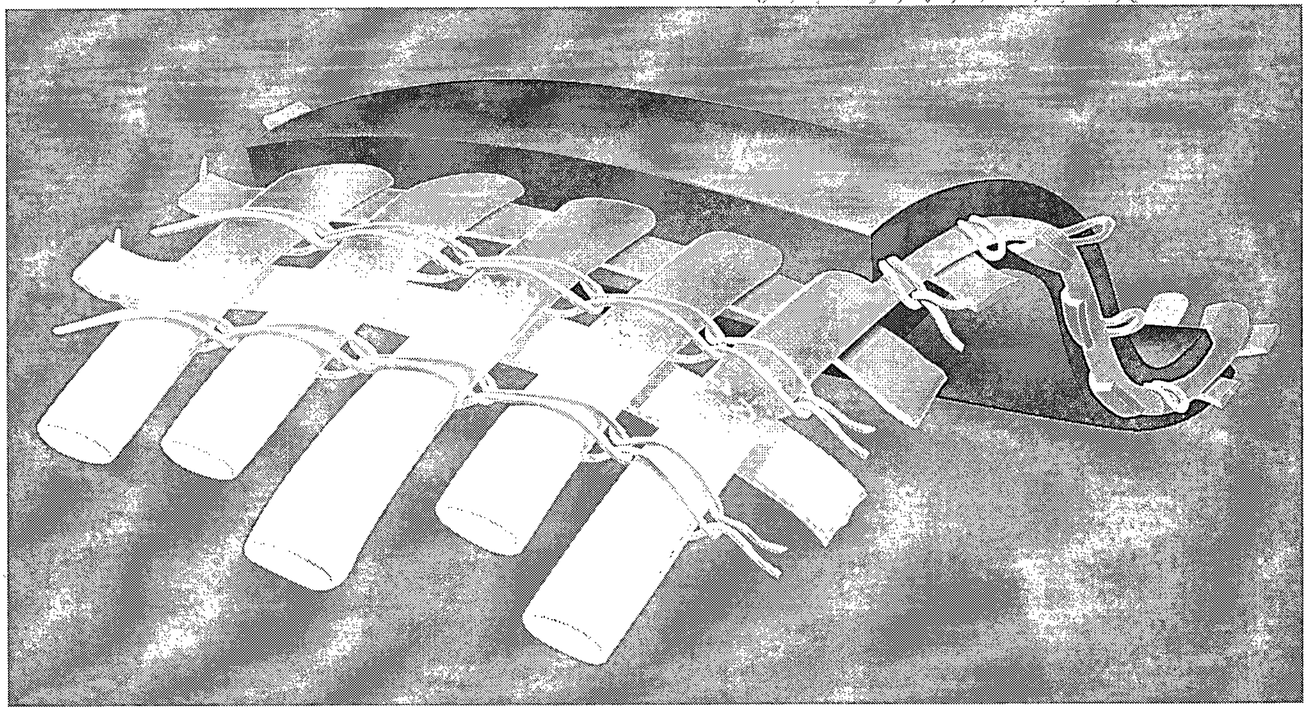
Performance Requirements, Etc:

(State any other requirements, such as rate of permeability required.)

Owner represents the information herein is complete and accurate, and understands and agrees that issuance of Seaman Corporation Warranty for XR products are conditioned upon such completeness and accuracy.

OWNER'S SIGNATURE

Reference Materials:



XR-5®: High Performance Composite Geomembrane

Seaman Corporation
1000 Venture Blvd.
Wooster, Ohio 44691
(330) 262-1111
www.xr-5.com

APPLICATION FOR MODIFICATION
BASIN DISPOSAL, INC.
OIL FIELD WASTE EVAPORATION PONDS

VOLUME III: ENGINEERING DESIGN AND CALCULATIONS
SECTION 1: ENGINEERING DESIGN

ATTACHMENT III.1.I

SMOOTH HDPE GEOMEMBRANE

SMOOTH HDPE GEOMEMBRANE
ENGLISH UNITS

		Minimum Average Values				
Property	**Test Method**	**30 mil**	**40 mil**	**60 mil**	**80 mil**	**100 mil**
Thickness, mils	ASTM D 5199					
minimum average		30	40	60	80	100
lowest individual reading		27	36	54	72	90
Sheet Density, g/cc	ASTM D 1505/D 792	0.940	0.940	0.940	0.940	0.940
Tensile Properties[1]	ASTM D 6693					
1. Yield Strength, lb/in		63	84	126	168	210
2. Break Strength, lb/in		114	152	228	304	380
3. Yield Elongation, %		12	12	12	12	12
4. Break Elongation, %		700	700	700	700	700
Tear Resistance, lb	ASTM D 1004	21	28	42	56	70
Puncture Resistance, lb	ASTM D 4833	54	72	108	144	180
Stress Crack Resistance[2], hrs	ASTM D 5397 (App.)	300	300	300	300	300
Carbon Black Content[3], %	ASTM D 1603	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0
Carbon Black Dispersion	ASTM D 5596			--Note 4--		
Oxidative Induction Time (OIT)						
Standard OIT, minutes	ASTM D 3895	100	100	100	100	100
Oven Aging at 85°C	ASTM D 5721					
High Pressure OIT - % retained after 90 days	ASTM D 5885	60	60	60	60	60
UV Resistance[5]	GRI GM11					
High Pressure OIT[6] - % retained after 1600 hrs	ASTM D 5885	50	50	50	50	50
Seam Properties	ASTM D 6392 (@ 2 in/min)					
1. Shear Strength, lb/in		57	80	120	160	200
2. Peel Strength, lb/in - Hot Wedge		45	60	91	121	151
- Extrusion Fillet		39	52	78	104	130
Roll Dimensions						
1. Width (feet):		23	23	23	23	23
2. Length (feet)		1000	750	500	375	300
3. Area (square feet):		23,000	17,250	11,500	8,625	6,900
4. Gross weight (pounds, approx.)		3,470	3,470	3,470	3,470	3,470

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[1] Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction. Yield elongation is calculated using a gauge length of 1.3 inches; Break elongation is calculated using a gauge length of 2.0 inches.

[2] The yield stress used to calculate the applied load for the SP-NCTL test should be the mean value via MQC testing.

[3] Other methods such as ASTM D 4218 or microwave methods are acceptable if an appropriate correlation can be established.

[4] Carbon black dispersion for 10 different views: Nine in Categories 1 and 2 with one allowed in Category 3.

[5] The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.

[6] UV resistance is based on percent retained value regardless of the original HP-OIT value.

This data is provided for informational purposes only and is not intended as a warranty or guarantee. Poly-Flex, Inc. assumes no responsibility in connection with the use of this data. These values are subject to change without notice. REV. 11/06

APPLICATION FOR MODIFICATION
BASIN DISPOSAL, INC.
OIL FIELD WASTE EVAPORATION PONDS

VOLUME III: ENGINEERING DESIGN AND CALCULATIONS
SECTION 2: LINER CONSTRUCTION QUALITY ASSURANCE (CQA) PLAN

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ATTACHMENTS

SECTION 2: LINER CONSTRUCTION QULITY ASSURANCE (CQA) PLAN

1.0 PROJECT OBJECTIVES

The Liner Construction Quality Assurance (CQA) Plan has been prepared to document the measures that will be used to assure that the environmental control systems will be constructed properly, and in compliance with:

- 19.15.36.17.B NMAC
- The approved Permit Plans
- The permit and any permit conditions
- This CQA Plan
- Industry standards and other applicable technical criteria

This CQA Plan establishes the quantitable criteria that will be used in the field and laboratory to measure the quality of the installed infrastructure. Specific construction elements that are addressed in this plan include:

A) Inspection and compaction of the subgrade and foundation;
B) Installation of a geomembrane;
C) Installation of the leak detection layer and sump;
D) Ancillary installations as needed to complete the above.

This CQA Plan is a quality control plan meeting the specifications of 19.15.36.17.B NMAC. This Plan may be updated to address changes in materials, technologies, test methods, etc. in consultation with the New Mexico Energy, Minerals and Natural Resources Department, Oil Conservation Division.

2.0 PROJECT ORGANIZATION

A. Project Organization

The Project Team shall be identified in advance of construction, and each Team member will be assigned specific responsibilities as discussed in this section.

B. Authority and Responsibilities

1. Owner

The Owner has the responsibility for scheduling and administration, which may include, but not be limited to:

- Contractor procurement
- Some or all of the construction tasks
- Assignments of duties of Project Team and orientation of the Project Staff to the needs and requirements of the project
- Approval of project-specific procedures and internally prepared plans, drawings, and reports
- Serving as the "Collection point" for Project Staff reporting project documents and activities.

2. Site CQA Engineer

The Site CQA Engineer shares responsibilities with the Owner/Operator for addressing technical and administrative issues. The Site CQA Engineer must be present at the outset of major undertakings and at critical times during the construction. The Site CQA Engineer's staff shall be on-site continually for all construction activities. The Site CQA Engineer will also be on-site, as necessary, to perform the following:

- Periodic review of submittals from the Site CQA Manager.
- Approval of any CQA Plan revisions.
- Administrative functions as necessary to staff and maintain personnel for the CQA activities.
- Periodic review and assessment of the CQA Plan as implemented to determine completeness and compliance.
- Spot-checking of field and laboratory methods and results for accuracy.
- Acceptance and approval of materials and workmanship.
- Compilation and submission to OCD of Certification Reports and other project deliverables.
- Design and certification responsibilities mandate that this site CQA Engineer must be a Professional Engineer properly registered in the State of New Mexico; that possesses demonstrated competence and experience in engineering.

3. Site CQA Manager

Responsibilities of the Site CQA Manager will include:

- Review of all documentation from Subcontractors as enumerated in this CQA Plan.
- Review of all CQA activities.
- Notification to all appropriate personnel of nonconformance, or changes in CQA procedures.
- Completion of Project CQA audits.
- Scheduling, at regular intervals, CQA meetings with project staff and Subcontractors.
- Reporting, on a regular basis, to the Site CQA Engineer the results of all reviews, inspections, and audits.
- Identifying for the Site CQA Engineer project issues, which require his direct involvement.

- Maintaining records of all reviews, inspections, audits, and their results.
- Collection of Daily Field Reports from Contractor, which are to be provided no later than 24 hours after each shift has ended.
- Maintenance of calibration records of the instrumentation used on-site in the implementation of this plan.
- Other duties as directed by the Site CQA Engineer.

4. CQA Technicians

The qualifications required for each CQA Technician shall include certification and training on radiation safety and the use of nuclear gauges; and previous experience in the construction of geosynthetic liners. The CQA Technicians will report directly to the Site CQA Manager with the results of his investigations and analysis. The CQA Technicians will, under direct supervision of the Site CQA Manager, perform the following:

A) Moisture-density curves correlated to compaction specifications for the borrow source or in-situ subgrade
B) Field Grain Size Analysis of materials to confirm suitability
C) Nuclear density testing as necessary for in-place compaction confirmations
D) Verification testing for thickness and placement of materials
E) Inspection and documentation of synthetic materials installation
F) Contractor adherence to CQA Plan
G) Additional field testing and documentation as required in these specifications or at the direction of Site CQA Manager or Site CQA Engineer

The CQA Technicians will refer to the Site CQA Manager for any questions regarding implementation of the CQA Plan. The CQA Technicians may not approve any exceptions to the specifications of this plan without prior approval being made by both the Site CQA Engineer and the Site CQA Manager.

5. Contractor

Responsibilities of the Contractor will include:

A) Management of daily field operations (labor and equipment allocation).
B) Submission of Daily Field Progress Reports to the Site CQA Manager.
C) Implementation of all tasks relative to this CQA Plan specific to his assigned construction operations.
D) Submittal of all required shop drawings and certificates to the Site CQA Manager.
E) Submittal of all required work plans to the Site CQA Engineer.

All work performed by the Contractor shall be guaranteed for at least one (l) year from date of completion.

The Contractor/Installer must construct this project in a workmanlike manner, in conformance with the plans and specifications. The purpose of the CQA program is to provide an independent check of compliance with the plans and specifications for the Owner's benefit. The CQA is also required by OCD as means of demonstrating compliance with performance standards, permit conditions, and applicable regulations.

C. Documentation

1. Data will be gathered or developed in accordance with procedures appropriate for the intended use of the data and will be of significant or greater quality to stand up to scientific and regulatory scrutiny.
2. Data will be of known or acceptable precision, accuracy, representatives, completeness, and comparability within the limits of the project.

The quality of the measurement data can be defined in terms of the following elements:

1. Completeness - the adequacy in quantity of valid measurements to reduce the potential for misinterpretation.
2. Representativeness - the extent to which discrete measurements accurately describe the greater picture of which they are intended to represent. Good representativeness is achieved through careful, informed selection of sampling site.
3. Accuracy and Precision - the agreement between a measurement and the true value and the degree of variability in this agreement, respectively. Accuracy and precision of data collected in the investigation will depend upon the measurement standards used and the competent use of them by qualified personnel.
4. Comparability - the extent to which comparisons among different measurements of the same quantity or quality will yield valid conclusions. Comparability among measurements will be achieved through the use of standard procedures and standard field data sheets.
5. Traceability - the extent to which data can be substantiated by hard-copy documentation. Traceability documentation exists in two essential forms: that which links quantitation to authoritative standards, and that which explicitly describes the history of each sample from collection to analysis.

The fundamental mechanisms that will be employed to achieve these quality goals can be categorized as prevention, assessment and correction, as follows:

1. Prevention of defects in the quality through planning and design, documented instructions and procedures, and careful selection and training of skilled, qualified personnel;
2. Quality assessment through a program of regular audits and inspections to supplement continual informal review;
3. Permanent correction of conditions adverse to quality through a closed-loop corrective action system.

The Site CQA Manager shall maintain current records, on appropriate CQA forms, of quality control operations, inspections and tests performed relative to the work of suppliers and contractors. **Table III.2.1** is an index of CQA Forms which are typically used for the Liner CQA program.

Table III.2.1
CQA Forms Index

Form No.	Title
1.	Liner Quality Control Project Specifications (Attachment III.2.A)
2.	Authorization to Proceed Form (Attachment III.2.B)
3.	Daily Summary Report (Attachment III.2.C)
4.	Subgrade/Berm Density Testing Results (Attachment III.2.D)
5.	Geosynthetic Deployment Log (Attachment III.2.E)
6.	Geosynthetic Inventory Control Log (Attachment III.2.F)
7.	Geomembrane Seam Log (Attachment III.2.G)
8.	Geomembrane Trial Seam Field Test Log (Attachment III.2.H)
9.	Geomembrane Seam Pressure Test Log (Attachment III.2.I)
10.	Destructive Field Test Record (Attachment III.2.J)
11.	Geomembrane Seam Vacuum Test/Repair Log (Attachment III.2.K)
12.	Geonet Deployment Log (Attachment III.2.L)
13.	Geonet Inventory Control Log (Attachment III.2.M)
14.	Geotextile Deployment Log (Attachment III.2.N)
15.	Geotextile Inventory Control Log (Attachment III.2.O)
16.	Leak Detection Pipe Inventory Control Log (Attachment III.2.P)

Photographs may also be used to document the progress and acceptability of the work and may be incorporated into the Daily Summary Report; if photographic documentation is used, each photo shall be identified with the following information:

- Date
- Time of Day
- Location

Originals of the photographs will be retained at the offices of the Site CQA Engineer, and photocopies will be submitted with Engineering Certification Reports as applicable.

3.0 CONSTRUCTION QUALITY ASSURANCE OBJECTIVES

A. Allowable Variations

It is the objective of this CQA Plan that all test results must meet the applicable specified values. Should a test result not achieve the specified value for a material, it must be replaced or repaired; or for operation, the operation must be repeated until it is acceptable. However, as stated by Daniel and Koerner, "it is unrealistic to think that 100 percent of all CQA tests will be in compliance with specifications." Variations due to isolated anomalies in material, sample disturbance, human testing errors, or other factors may result in failing tests, yet these tests are not indicative of the general quality of the construction. For this reason, the Site CQA Engineer may accept a small percentage of outliers. The total number of outliers will not exceed the maximum allowable number as defined in Waste Containment Facilities – Guidance for Construction Quality Assurance and Construction Quality Control of Liner and Cover Systems 2nd Edition (Daniel, D.E. and Koerner, R.M.), 2007.

4.0 SITE PREPARATION

A. General

The following is a list of the work to be included in site preparation by the Contractor:

A) Field check utilities locations, as appropriate.
B) Mark all survey hub markers and permanent benchmarks.
C) Strip all topsoil and any other material deemed unsuitable by the Engineer, or his representative, and stockpile at designated location.
D) Strip or remove all brush, and non-mowable vegetation, surface debris, and similar materials from existing surface and relocate to a designated area on the site. Stumps, logs, roots, etc. shall be completely removed.
E) Excavate to design grade at the direction of the Site CQA Engineer.
F) The existing surfaces shall be proof rolled to check stability conditions of existing surface and to provide a trafficable, reasonably smooth, working surface for construction equipment.
G) Contractor shall be responsible for all costs associated with repairing and/or replacement of the ground surface utilities, and appurtenant facilities damaged by the Contractor, to the satisfaction of the Owner. Any damage resulting from unauthorized intrusion upon or use of off-site areas shall be completely and immediately repaired, solely at the expense of the Contractor.

The following is a list of requirements related to site grading:

A) Relocate all exposed debris outside the limits of the construction area to locations as directed by Owner.
B) Remove and dispose of coarse vegetation. Vegetation removal shall be accomplished in such a manner as to minimize the amount of bare soil exposed at any given time.
    1) Stripped vegetation may be stockpiled temporarily at the site, provided that it is stockpiled in a manner, which prevents movement of the material off-site due to wind, water, or other factors.
    2) All residual vegetative matter, such as stumps, shall be transported to the designated on-site area or removed off-site by the Contractor under authorization by the Owner.

B. Survey Coordinate System

The site shall be surveyed and integrated into a grid system so that locations of sample and testing points made during construction can be readily discernible by the CQA personnel. This grid system should consist of equidistant spaced parallel lines, 100-foot on center, projecting north to south and east to west within the limits of the site. In addition, permanent project benchmarks will be placed by the Owner or his representative in the vicinity of the site for correlation of lift thickness, site liner construction, etc. This grid system shall be coincident with the existing and former site coordinate system for future reference. The project limits will be staked out by the Owner or his representative based on record drawings

C. Subgrade Development

Subgrade development will be required prior to pond construction. The existing topography will be contoured to the subgrade elevations shown on the drawings identified by the Site CQA Engineer. The subgrade will be constructed, prepared and protected in accordance with the procedures stated below.

1. Subgrade Preparation

- A) Establish required lines, levels and contours. Place grade stakes as required by Contractor's methods a minimum 100' on center.
- B) Before grading commences, adjust monitoring wells and piezometer heights in the area to be graded in accordance with details shown on the drawings if applicable. All such adjustments shall be made under direct surveillance of the Site CQA Engineer. Any wells adjusted without the Site CQA Engineer being present shall be re-established at the Contractor's expense.
- C) No subgrading shall begin in a given area prior to approval of the area by the Site CQA Engineer.

2. Excavating to Subgrade Elevation

- A) Excavated material will be segregated into the following three designated stockpiles:
  1. Select fill soil exhibiting low permeability shall be retained in this designated stockpile area.
  2. Select sandy soils with a low fines content and high permeability will be stockpiled separately at the direction of the Owner for future use.
  3. Common fill soil/sand mixture to be used on-site shall comprise a third stockpile.
- B) Adequate grade control during subgrading preparation/construction is imperative. Should insufficient grade control during this phase occur, the Site CQA Manager may stop work until the situation has been rectified.

C) If applicable, all excavation shall be cross-sectioned for payment by the Contractor, in the presence of the Site CQA Manager.

3. Filling to Subgrade Elevation and Berm Construction

A) Engineer shall collect samples of proposed in-situ or borrow fill material in advance of construction for determination of soil characteristics (e.g. Standard Proctor)
B) Materials shall be obtained from designated in-situ areas, borrow sources, or stockpiles.
C) No fill shall be used for subgrade or berm construction without approval of the Site CQA Engineer.
D) Place fill material to the required elevations as shown on the drawings.
E) Place all material in maximum 12-inch finished horizontal lifts over the prepared surface. Compact to not less than 90-percent of the maximum dry density, as determined by the Standard Proctor Compaction Test (ASTM D698).
F) The surface of each lift shall be scarified prior to placing the next lift, if applicable.
G) The moisture content of fill material shall be adjusted in the stockpile, borrow area, and/or other approved areas to maintain uniform moisture content of fill. Uniform moisture distribution shall be obtained by mixing with disc, harrow, pulverizers or by otherwise manipulating the soil prior to compaction.
H) The final surface of subgrade and berms shall be rolled smooth, free of protrusions and shall contain no lumps, angular materials or large rocks. Roll the exposed surface transverse to slopes.

4. Final Subgrade Inspection and Protection

The final subgrade lift shall conform to the following specifications:

A) The upper 6-inches shall be scarified and compacted to a minimum 90-percent of the maximum dry density as determined by the Standard Proctor Test (ASTM D698)
B) The surface of the final lift of subgrade shall be free of any angular material or stones greater than one-half inch in diameter.
C) The final lift shall be wetted and smooth rolled. Abrupt changes of grade shall be regraded.
D) Completed subgrade shall be protected from traffic, erosion and damage of any kind.
E) Completed subgrade shall be kept free of all trash and debris.
F) Prior to placement of liner system, any areas of subgrade damaged by traffic, erosion, settlement, or another cause, shall be repaired and the grades shown on the drawings shall be re-established. Any exposed subgrade, which has dried or exhibits desiccation cracking shall be wetted and compacted prior to fill placement. Disturbed areas shall be reshaped, scarified, recompacted and rolled prior to further work.
G) The condition of the subgrade shall be approved by the Site CQA Manager prior to placement of any additional layers or liner system materials immediately in advance of installation.

5. Subgrade and Berm Testing

The following tests will be performed on the subgrade soils prior to compaction:

A) One particle size distribution per 1,000-cubic yards of borrow using ASTM D422.
B) One Standard Proctor moisture density relationship per 5,000 cubic yards of borrow using ASTM D 698
C) One Atterberg Limits per 5,000 cubic yards of borrow using ASTM D423 and D424

The following tests shall be performed during construction:

A) One field compaction test shall be performed at a frequency of a minimum 4 tests per acre per 12-inch lift for any fill material placed, and for confirmation of density of the subgrade and berms.
B) The floors of Ponds 2 and 3 shall be required to meet an elevation tolerance of 0.33' ± (i.e., 4"); and the sidewalls a vertical tolerance of 0.75' (i.e., 9") based on a regular grid established by site survey.

5.0 FLEXIBLE GEOMEMBRANE LINER (FML)

A. Materials

1. The flexible membrane liner (FML) used for liner installation shall be non-textured 60mil thick High Density Polyethylene (HPDE).
2. The geomembrane shall be manufactured of new, prime first-quality products designed and manufactured specifically for the purpose of liquid containment in hydraulic structures and chemically resistant to leachate.
3. The geomembrane material shall be so produced as to be free of holes, blisters, undispersed raw materials, or any sign of contamination by foreign matter.
4. The sheets shall have NSF label of approval and shall be manufactured in a minimum 15-foot seamless width. Labels on the roll shall identify the thickness, length, width and manufacturer's lot number.
5. The geomembrane rolls shall meet the minimum properties listed in **Table III.2.2** for smooth HDPE liner.
6. Extrudate welding rods shall be of the same compound as the geomembrane and supplied by the manufacturer and shall be delivered in the original sealed containers. Each container shall have a label bearing the brand name, manufacturer's lot number and complete directions as to proper storage.

B. Manufacturer Quality Control Documentation

Prior to installation commencement of any geomembrane material, the Contractor shall provide to the Site CQA Manager the following information certified by the manufacturer for the delivered geomembrane.

1. Origin, identification and production of the resin (supplier's name, brand name and production plant).
2. Copies of quality control certificates issued by the resin supplier.
3. Manufacturer's certification verifying that the quality of the resin used to manufacture the geomembrane meets the resin specifications fingerprint properties shown in **Table III.2.2** for 60-mil smooth HDPE liner.
4. Each roll delivered to the project site shall have the following identification information:
    - Manufacturer's name.
    - Product identification.
    - Thickness.
    - Roll number.
    - Roll dimensions.
5. Quality control certificates, signed by the manufacturer's quality assurance manager. Each certificate shall have roll identification number, sampling procedures, frequency, and test results. At a minimum the following test results shall be provided in accordance with test requirements specified in **Table III.2.2**:
    - Thickness (smooth, ASTM D 5199; textured, ASTM D 5994);
    - Density (ASTM D 1505);
    - Tensile properties (ASTM D 638, as modified by annex A);
    - Tear properties (ASTM D 6693);
    - Carbon black content (ASTM D 1603 or ASTM D 4218);
    - Carbon black dispersion (ASTM D 5596);
    - Puncture Resistance (ASTM D 4833);
    - Notched constant tensile load (ASTM D 5397, Appendix); and
    - Interface Friction Angle (Textured Geomembrane) [GRI - GS -7].

C. Conformance Testing

1. Conformance testing shall be performed by an independent Quality Assurance Laboratory. As stated in the contract document, the Site CQA Manager or Installer shall obtain the samples from the roll (at a minimum of 1 per 100,000 ft^2), mark the machine direction and identification number. The number of lots and samples will be determined in accordance with ASTM D4354. The following conformance tests shall be conducted at the laboratory:
    - Thickness (ASTM D 5199, or ASTM D 5994);
    - Density (ASTM D 1505);
    - Tensile properties (ASTM D 6693);
    - Tear resistance (ASTM D 1004);
    - Carbon black content (ASTM D 1603, or ASTM D 4218); and
    - Carbon black dispersion (ASTM D 5996).
2. These conformance tests shall be performed in accordance with **Table III.2.2**.

Table III.2.2
Technical Specifications
60-mil Smooth HDPE Liner

PROPERTY	QUALIFIER	UNIT	VALUE	TEST METHOD
Thickness	Minimum Average Minimum	mils mils	60 54	ASTM D 5199
Density	Minimum	g/cc	0.94	ASTM D 1505
Melt Index	Range	g/10 min	≤1.0	ASTM D 1238
Tensile Properties:				ASTM D 6693
Yield Strength	Minimum	lb/in	126	Type IV Dumbell,
Break Strength	Minimum	lb/in	228	2 ipm
Elongation at Yield	Minimum	%	12	G.L. = 1.3 in
Elongation at Break	Minimum	%	700	G.L. = 2.0 in
Tear Strength	Minimum	lb	42	ASTM D 1004
Puncture Resistance	Minimum	lb	108	ASTM D4833
Carbon Black Content	Range	%	2.0	ASTM D 1603
Carbon Black Dispersion	Rating	N/A	Note 2	ASTM D 5596
Notched Constant Tensile Load	Minimum	hours	300	ASTM D 5397 Appendix

SEAM PROPERTIES				
PROPERTY	QUALIFIER	UNIT	VALUE	TEST METHOD
Thickness	Minimum	mils	60	ASTM D 5199/ D 5994
Bonded Seam Strength	Minimum	lb/in	120	ASTM D 6392
Tensile Properties:				
Fusion Weld	Minimum	lb/in	90	ASTM D 6392
Extrusion Weld	Minimum	lb/in	78	ASTM D 6392

Notes:

(1) Physical properties are representative of GSE HD smooth geomembrane.

(2) Dispersion only applies to near spherical agglomerates. 9 of 10 views shall be Category 1 or 2. No more than 1 view from Category 3.

3. All conformance test results shall be reviewed by the Site CQA Manager, and all lots shall be accepted or rejected prior to the placement of the geomembrane. All test results shall meet, or exceed, the property values listed in **Table III.2.2** for failing sampling results, for any individual lot sample, the lot shall be resampled and retested. This retesting shall be paid for by the Contractor. If all of the test values from the resamples pass the acceptable specification values listed in **Table III.2.2,** the lot shall be accepted.

D. Delivery, Storage and Handling

1. The geomembrane rolls shall be packaged and shipped by appropriate means to prevent damage of the geomembrane rolls. Off-loading and storage of the geomembrane is the responsibility of the Installer. The Installer shall be responsible for replacing any damaged or unacceptable material at no cost to the Owner.
2. No off-loading shall be performed unless the Site CQA Manager is present. Damage during off-loading shall be documented by the Site CQA Manager. All damaged rolls must be separated from the undamaged rolls until the proper disposition of that material has been determined collectively by the Installer and Site CQA officer.
3. The geomembrane rolls shall be stored so as to be protected from puncture, dirt, grease, water, moisture, mud, mechanical abrasions and excessive heat that may damage the geomembrane material. The rolls shall be stored on a prepared surface (not wooden pallets) and shall not be stacked more than two rolls high.

E. Material Warranty

1. The HDPE geomembrane manufacturer shall warrant the membrane, on a prorated basis, against manufacturing defects and material degradation under outdoor exposure for a period of twenty years from the date of installation. The manufacturer shall furnish a written warranty covering the requirements of this paragraph.

F. Guarantee

1. The Contractor shall guarantee the HDPE geomembrane against defects in installation and workmanship for the period of one years commencing with the date of final acceptance by the Owner. The guarantee shall include the services of qualified service technicians and all materials required for the repairs at no expense to the Owner.

G. Quality Assurance

1. In addition to manufacturer and Installer requirements for qualifications and certification specified in submittals, the Quality Assurance consists of conformance testing of the material delivered to the site and field quality control during installation.
2. Conformance testing requirements are listed in this CQA Plan. The purpose of conformance testing is to assure that the supplied material conforms to the specifications and to the manufacturer's quality control certificates.

3. Field quality control requirements are specified in this CQA Plan. The purpose of field quality control procedures is to assure that the geomembrane has been installed in accordance with the specifications and manufacturer's recommendations.
4. Quality Control Forms
   a) Standard forms for geomembrane quality control documentation shall be used for field installation documentation. Alternative forms may be used for documentation as approved by the Site CQA Officer. Sample project forms that will be available on-site throughout the duration of the project are listed on **Tables III.2.3**.

Table III.2.3
Geomembrane Project CQA Forms

Form No.	Title
1.	Liner Quality Control Project Specifications (Attachment III.2.A)
2.	Authorization to Proceed Form (Attachment III.2.B)
3.	Daily Summary Report (Attachment III.2.C)
4.	Geosynthetic Deployment Log (Attachment III.2.E)
5.	Geosynthetic Inventory Control Log (Attachment III.2.F)
6.	Geomembrane Seam Log (Attachment III.2.G)
7.	Geomembrane Trial Seam Field Test Log (Attachment III.2.H)
8.	Geomembrane Seam Pressure Test Log (Attachment III.2.I)
9.	Destructive Field Test Record (Attachment III.2.J)
10.	Geomembrane Seam Vacuum Test/Repair Log (Attachment III.2.K)

Construction photographs will be taken to document, pictorially, the pond construction. Construction photographs shall include Date, Time of Day, and Location.

H. Liner Subgrade and Anchor Trench

1. The geomembrane shall be installed in accordance with this CQA Plan.
2. The anchor trench shall be constructed as shown on the drawings and as specified in the CQA Plan. The same anchor trench shall be used to secure the primary HDPE Geomembrane, geocomposite, and secondary liner. The anchor trench shall be backfilled and compacted by the Contractor to 90% Standard Proctor Density as approved by the Site CQA Manager. Trench backfill material shall be placed in one single lift and compacted by rolling with a rubber-tired wheel or light compaction equipment. Approval of compacting equipment shall be obtained from the Site CQA Manager before any compaction begins.
3. Care shall be taken when backfilling the trenches to prevent any damage to the liner system. At no time shall construction equipment make direct contact with any synthetic materials.

I. Geomembrane Placement

1. Weather Conditions:

Geomembrane placement shall not proceed at an ambient temperature below 40 degrees F or above 104 degrees F unless otherwise authorized, in writing, by the Site CQA Manager. Geomembrane placement shall not be performed during precipitation, excessive moisture, in an area of ponded water, or excessive winds. Observation of temperature, humidity, precipitation, and wind shall be noted on the Daily Summary Report (**Attachment III.2.C**) to ensure that weather conditions are acceptable prior to geomembrane placement.

2. Method of Placement

a) No more material than can be seamed on that same day shall be deployed.
b) Each panel of the geomembrane shall be rolled out and installed in accordance with the approved construction drawings. The layout shall be designed to keep field joining of the HDPE geomembrane to a minimum and consistent with proper methods of HDPE geomembrane installation, seaming, etc.
c) Geomembrane rolls shall be placed using proper spreader and rolling bars with cloth slings.
d) The Site CQA Manager shall inspect each panel, after placement and prior to seaming, for damage and/or defects. Defective or damaged panels shall be replaced or repaired, as approved by the Site CQA Manager.
e) The Installer shall avoid dragging the geomembrane sheets on rough soil subgrades.
f) All geomembrane shall be anchored as shown on the construction drawings and consistent with manufacturer's recommendations.
g) Personnel working on the geomembrane shall not smoke, wear damaging shoes or involve themselves in any activity that may damage the geomembrane.
h) Vehicular traffic across the geomembrane shall not be allowed on the liner material.
i) All damage shall be recorded and located on the as-built drawings.
j) When tying into existing geomembrane, final excavation to previously installed liner segments shall be performed by hand to prevent damage. Damaged sections of previously installed liner at the boundary zone shall be removed and replaced. New liner segments shall be seamed only to competent segments of previously installed liner as approved by the Site CQA Manager.
k) The geomembrane shall be kept free of debris, unnecessary tools and materials. In general, the geomembrane area shall remain neat in appearance.
l) Installed liner will not be left exposed for more than fourteen (14) days to adverse weather conditions.
m) The method used to unroll the panels shall neither score, scratch or crimp the geomembrane, nor damage the underlying GCL or subgrade.
n) Adequate loading (e.g., sand bags or similar items that will not damage the geomembrane) shall be placed to prevent uplift by wind. In cases of high wind, continuous loading is recommended along edges of panels to minimize wind flow

under the panels.

o) Direct contact with the geomembrane shall be minimized; i.e., the geomembrane under traffic areas shall be protected by geotextile, extra geomembrane, or other suitable materials.

p) Sufficient slack shall be placed in the geomembrane to compensate for the coldest temperatures envisioned so that no tensile stresses are generated in the geomembrane or in its seams either during installation or subsequently after the geomembrane is covered.

q) The geomembrane shall have adequate slack such that it does not lift up off of the subgrade or substrate material at any location within the facility, i.e., no "trampolining" of the geomembrane shall be allowed to occur at any time.

r) The geomembrane shall not have excessive slack to the point where creases fold over upon themselves either during placement and seaming, or when the protective soil or drainage materials are placed on the geomembrane.

s) Permanent (fold over type) creases in the covered geomembrane shall not be permitted. Crease shall be repaired in accordance with this CQA Plan and manufacturer's recommendations.

t) The amount of slack to be added to the deployed and seamed geomembrane should be carefully considered and calculated, taking into account the type of geomembrane and the geomembrane's temperature during installation versus its final temperature in the completed facility.

3. Field Seams

a) Individual panels of geomembrane shall be laid out and overlapped by a minimum of 4-inches (or three inches for extrusion fillet welding) but no more than 6-inches prior to welding. The area to be welded shall be cleaned and prepared in accordance with the quality control welding procedures.

b) If the overlap is too wide to contain the hot wedge welding machine, "float" the liner into better position by lifting it high enough to draw air beneath it, guiding it upon the air to an improved position. Avoid dragging the liner, particularly across rough soil subgrades.

c) If overlap between the placed liners is excessive, the excess must be trimmed away. This should be done by trimming the lower sheet. If this is not possible and the upper sheet must be trimmed, use a knife with a shielded or hook blade.

d) All cutting and preparation of odd-shaped sections or small fitted pieces must be completed at least 50 feet ahead of the seaming operation, so that seaming may be conducted with the fewest interruptions.

e) Liner panel overlaps shall be shingled so the upper panel is hydraulically upgradient of lower panel.

f) Sheets which are overlapped and ready for seaming must be clean. If dirty, they must be wiped clean with dry rags.

g) The seam area must be completely free of moisture before the overlapping sheets can be properly seamed. Dry rags should be used to wipe any such moisture up from the seam surface. Air blowers may also be used.

h) Seaming is not to be performed when the soil surface beneath the liners is saturated, because the hot seaming apparatus will draw moisture into the ongoing seam.

Seaming activity on frozen soil is unacceptable for the same reason.

i) Double track hot wedge fusion welder shall be used for straight welds.
j) Extrusion welder shall be used for cross seam tees, patches and repairs and penetration boots.
k) The welding equipment used shall be capable of continuously monitoring and controlling the temperatures in the zone of contact where the machine is actually fusing the geomembrane material so as to ensure that changes in environmental conditions will not affect the integrity of the weld.
l) No "fish mouths" will be allowed within the seam area. Where "fish mouths" occur, the material shall be cut, overlapped and a patch fusion weld shall be applied. All welds upon completion of the work shall be tightly bonded. Any geomembrane area showing injury due to excessive scuffing, puncture, or distress from any cause shall be replaced or repaired with an additional piece of geomembrane. The number of patches per 100- foot length shall not exceed five. If more than five patches per 100-foot length are necessary, then the entire 100- foot length of seam shall be removed. Further welding will cease at this time and the Site CQA Manager shall be notified.
m) All seams shall have a seam number that corresponds with the panel layout numbers. The numbering system shall be used in the development of the as-built drawings. Seam numbers shall be derived from the combination of the two panel numbers that are to be welded together.
n) All fusion welded "T" seams (i.e., the result of the geomembrane panels placed perpendicular to each other) shall be double welded where possible. Extrusion welding shall be used for the second weld.
o) All extrudate shall be free of dirt, dry and protected from damage.
p) If an extrusion welder is stopped for longer than one minute, it shall be purged to remove heat-degraded extrudate. All purged extrudate shall be placed on a sacrificial sheet and disposed of.
q) No horizontal seams shall be constructed on slopes greater than or equal to 5H:IV. If seams are constructed on such slopes, their number must be minimized, and they must be at a minimum angle of 45° with the toe of slope.
r) All vertical panels placed on sloped surfaces shall extend at least 10-foot inward from the toe of slope and 3 feet from the edge of the anchor trench.
s) In the anchor trench, all seams shall extend a minimum 12-inches.
t) All factory seams, field seams and repair welds shall meet seam strength requirements specified in **Table III.2.2**.
u) For geomembrane installation in geometrically unique areas, the number of field seams shall be minimized.
v) No solvent or adhesive may be used unless the product is approved by the Site CQA Officer.

4. Hot Wedge Fusion Welding

The objective of hot wedge seaming is to heat two facing liner surfaces to their melting point before forcing them together and creating a permanent bond. The wedge is situated between the overlap of the two liners; it reduces the surface tension of the viscous polymer sheets and acts as a scraper and mixer, so that the nip rollers can pressure the two liners together. The result is that the two facing surfaces are bonded into one continuous molecular structure. All types of thermoplastic liners can be seamed by the hot wedge method, but temperature settings will vary according to their specific polymer components:

Table III.2.4
Typical Wedge Temperature Ranges for
Hot Wedge Seaming of Thermoplastic Liners

Liner Type	**Fahrenheit (°F)**	**Celsius (°C)**
HDPE		
Minimum[1] Temperature	600	320
Maximum[2] Temperature	750	400

[1] *For dry, warm weather seaming conditions*
[2] *For damp, cold weather seaming conditions*

a) The hot wedge system should be properly positioned for completing the desired single or dual (split) seam.
b) Ambient variables such as temperature, cloud cover, and wind speed may make it necessary to vary the temperatures used successfully in a variety of ambient conditions, so that the hot wedge can be more accurately adjusted if new conditions are met, or if personnel changes are necessary.
c) The drive motor should be off when positioning the welding machine to seam. Place the machine where the sheets overlap. Guide the overlapped material between the idlers and the wedge, and into the drive/nip rollers. When continuing a weld that has been abandoned mid-seam, the liners must be spread where the seam leaves off and loaded into the respective sides of the machine. Raise the machine a few inches, load the bottom sheet first, and then load the top sheet. When the nip rollers engage and the wedge is in position, turn on the drive motor. Immediately engage the sheets when they are between the nip rollers to prevent an imminent melt-through. Move the hot wedge into position and lock it.
d) The Operator must constantly monitor the temperature controls, as well as the completed seam passing out of the machine. Occasional adjustments in temperature or speed will be necessary to maintain a consistent weld. Visual inspection and constant hand testing by the peel method (or other) is also recommended.
e) On some soils, the device tends to "bulldoze" into the ground as it travels, causing soil to enter the weld. A seam with soil trapped in its weld is unacceptable. To keep this from happening, the operator should lift the front of the machine slightly. Alternatively, a moveable base for the machine to travel on can be used. Scrap strips of geotextile or geomembrane have proven to be effective materials upon which the welder can maintain transaction. It may also be necessary to change the size of the rollers in loose soils.
f) A small amount of "squeeze-out" or "flashing" is a reliable indication that proper temperatures have been achieved. The melted polymer will laterally extrude, or

squeeze-out of the seam zone in properly welded seams, but not to excess. An excessive amount of extruded hot melt indicates that excessive heat or pressure, or both, was applied. Reduce the temperature and/or pressure to correct the situation.

g) The hot wedge device has just a few adjustable parts, but it is critical that they be checked after a day of seaming. The machine should be cleaned.

5. Extrusion Welding

a) The upper sheet's leading edge must be ground to a 45° bevel. It is imperative that the sheet be lifted up and away from the lower sheet during the beveling so that no deep gouges are cut in the lower sheet. Grinding should therefore be done before tack welding.

b) After beveling, the upper sheet is lowered and laid flat against the lower sheet. The horizontal surface grinding across the interface of both sheets is completed. All surface sheen in the area to be seamed must be removed. All material dust generated by grinding the liner sheets must be wiped or blown away from the seaming zone.

c) Grinding marks should run perpendicular to the seam. Though this process is slower than grinding parallel to the seam, it does not create the deep, parallel grooves that significantly decrease the thickness of the parent material that can lead to seam failure. Parallel grinding marks can also initiate stress cracking.

d) Grind marks should never be deeper than 10% of the sheet thickness. Optimally, they should be about 5% of the sheet thickness. The only purpose of grinding is the removal of oxide layers and dirt from the liner surfaces, and the roughening of their interface for extrudate.

e) Grinding marks should not extend beyond 1/4 inch of either side of the extrudate after its placement. For example, if the final extrudate bead width is 1 1/2 inches, the width of the grinding trail should not exceed 2 inches.

f) Seaming must take place no more than 10 minutes after grinding, so that surface oxide layers do not reappear where the extrudate must be placed.

g) Never leave the hand grinder running when it is not in use. If it makes contact with the liner while running it will cause serious damage.

h) A hot air gun may be used to "tack" the two sheets together, ahead of the extrusion welder. The hot air gun prepares the seam for the extrusion welder by heating the ground surface and by creating a light bond between the two sheets, securing their position. The hot air gun is not meant to create a primary seam. No heat distortion should be evident on the surface of the upper sheet.

i) The extrusion welder's barrel shall be purged of all heat-degraded extrudate before starting a seam. This must be done every time the extruder is restarted after two or more minutes of inactivity. The purged extrude shall not be discharged onto the surface of previously placed liner, or onto prepared subgrade, where it would eventually form a hard lump under the liner and cause stress concentrations and possibly premature failure.

j) Molten, highly viscous extrudate is deposited along the overlapped seam. The center of the extrudate pass directly along the edge of the upper liner, at sufficient width to completely cover the edge and most of the outlying grind marks, at least to within 1/4 inch of their extremity.

k) The extrudate should be approximately twice the specified sheet thickness, measured from the top of the bottom sheet to the top or "crown" of the extrudate. Excessive "squeeze out" is acceptable, if it is equal on both sides and will not interfere with subsequent vacuum box testing. If however, the extrudate can be pulled by its squeeze-out off the seam, the extrudate is unacceptable. The presence of squeeze-out may indicate that the extrusion die was not riding directly against the liner, that the extrudate temperature was improper for adequate flow, or that the seaming rate was too slow.

l) Where possible, inspect the underside of the lower for heat distortion. This can be done at the end of seams, and wherever samples are cut out of the seam. A slight amount of thermal "puckering" on relatively thin liners (less than 50 mil) is acceptable. It indicates that heat penetrated entirely through the sheet. However, if the underside is greatly distorted, either lower the temperature or increase the rate of seaming.

m) If the seaming process must be interrupted at mid-seam, the extrudate should trail off gradually, not terminate in a large mass of solidified extrudate. Where such welds are abandoned long enough to cool, they must be ground prior to continuing with new extrudate over the remainder of the seam. Grind where the extrudate trail-off begins. This restart procedure must be followed for patches, pipes, fittings, appurtenances and "T" and "Y" shaped items.

n) The extrudate bead should be visually inspected. Look to see that is alignment is straight, its height is appropriate, and its surface texture is uniform. No bubbles or pock marks should appear in the extrudate, which indicate the undesirable presence of air, water or debris within the extrudate rod or palletized polymer.

o) Grind marks should not be visible more than 1/4 inch beyond the extrudate. These should be very light and not contain heavy gouges. As stated previously, grinding is considered excessive when it is deeper than 10% of the liner thickness. It is unacceptable to apply additional extrudate over the original extrusion fillet seam in an area of excessive grinding. A cap strip shall be placed over the entire portion of the seam where excessive grinding is seen.

J. Field Quality Control

1. Start-up Testing

A trial weld, 10 feet long for hot wedge welding and 3 feet long for extrusion welding, from each welder/welding machine shall be run upon the beginning of each shift every four hours thereafter and at the discretion of the Site CQA Manager, under the same conditions as exist for the geomembrane welding. The trial weld shall be marked with date, ambient temperature, welder's name, and welding machine number. A tensiometer provided by the Installer shall be required to be on-site before and during geomembrane installation for the purpose of testing samples. Specimens of weld I-inch wide shall be cut from the trial weld and tested on site for shear and peel strength in accordance with **Table III.2.2.** No welder may start work until the trial weld has been approved by the Site CQA Manager.

2. Nondestructive Seam Testing.

a) The Installer shall perform nondestructive tests on all field seams over their full length. The purpose of this test is to assure continuity and integrity of the seams. Vacuum and air pressure tests shall be used for nondestructive testing. The vacuum test shall be used for extrusion welds and single-track hot wedge welds. The air pressure test shall be used for double track hot wedge welds.

b) Vacuum Testing.
Equipment for testing single wedge fusion seams and extrusion seams shall be comprised of the following:
   (l) A vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft rubber gasket attached to the bottom, port hole or valve assembly and a vacuum gage.
   (2) A vacuum tank and pump assembly equipped with a pressure controller and pipe connections.
   (3) A rubber pressure/vacuum hose with fittings and connections.
   (4) A plastic bucket and wide paintbrush.
   (5) A soapy solution.

The following procedures shall be followed by the Installer:

(1) Excess sheet overlap shall be trimmed away.
(2) Clean the window, gasket surfaces and check for leaks.
(3) Energize the vacuum pump and reduce the tank pressure to approximately 5-psi.
(4) Wet a strip of geomembrane approximately 12-inch by 48-inch (length of box) with the soapy solution.
(5) Place the box over the wetted area and compress.
(6) Close the bleed valve and open the vacuum valve.
(7) Ensure that a leak-tight seal is created.
(8) For a minimum period of ten seconds, examine the geomembrane through the viewing window for the presence of soap bubbles.
(9) If no bubbles appear after ten seconds, close the vacuum valve and open the bleed valve, move the box over the next adjoining area with a minimum of 3-inch overlap and repeat the process.
(10)All areas where soap bubbles appear shall be marked and repaired in accordance with the Repair Procedures contained in this CQA Plan.

If the seam cannot be tested prior to final installation, the seaming operations shall be observed by the Site CQA Manager for uniformity and completeness.

3. Air Pressure Testing (for double track fusion seams only).

The following procedures are applicable to those processes which produce a double seam with an enclosed space. Equipment for testing double fusion seams shall be comprised of the following:

(1) An air pump equipped with pressure gage capable of generating and sustaining a pressure of 30 psi and mounted on a cushion to protect the geomembrane.
(2) A manometer equipped with a sharp hollow needle, or other approved pressure feed device.

The following procedures shall be followed by the Installer:

(1) Seal one end of the seam to be tested.
(2) Insert needle or other approved pressure feed device through the sealed end of the channel created by the double wedge fusion weld.
(3) Energize the air pump to verify the unobstructed passage of air through the channel.
(4) Seal the other end of the channel.
(5) Energize the air pump to a pressure of 30 psi, close valve, and sustain pressure for approximately 5 minutes.
(6) If loss of pressure exceeds 3 psi, or pressure does not stabilize, locate faulty area, repair and retest.
(7) Remove needle or other approved pressure feed device and seal.

K. Destructive Seam Testing

The purpose of the destructive testing is to evaluate seam strength properties. An average minimum of one test sample shall be obtained per 500-foot of performed seam length. The location of samples shall be determined by the Site CQA Site Manager. Selection of such locations may be prompted by suspicion of overheating, contamination, or other potential cause that may adversely impact the welds. This may result in more than one sample per 500 feet of seam length. Sampling shall be performed by the Installer. Testing of field samples shall be performed by the Installer in the presence of the Site CQA Manager as described herein.

1. Sampling Procedures.

a) Samples shall be cut by the Installer at locations chosen by the CQA Site Manager as the seaming progresses.
b) The seams shall not be covered by another layer before they have been tested and accepted by the Site CQA Manager.
c) Upon obtaining each sample, assign a number to the sample and mark it accordingly.
d) Record sample location on layout drawing.
e) Record purpose of the sample, statistical routine or suspicious weld area.
f) Record date, time, location, roll, seam number, master seamer welding apparatus, and ambient temperature.
g) Holes in the geomembrane resulting from destructive seam testing shall be immediately repaired in accordance with the Repair Procedures contained in this CQA Manual.

2. Size and Disposition of Samples.

a) The samples shall be 12 inches wide by 36 inches long with the seam centered lengthwise. The sample shall be cut into three pieces of equal length and distributed as follows:
   (1) One portion to the Installer for field testing; 12-inch by 12-inch.
   (2) One portion for the independent geosynthetic laboratory quality assurance testing; 12-inch by 12-inch.
   (3) One portion to the Owner for archive storage in the Site Operating Record; 12-inch by 12-inch.

b) The portion of the seam samples for geosynthetic laboratory quality assurance testing will be packed and shipped to an independent lab for testing by the Installer.

3. Field Testing.

a) The following shall be performed by the Installer in the presence of the Site CQA Manager for all samples designated for field sampling.
   (1) The Installer shall cut ten 1-inch wide replicate specimens from the sample to be tested for shear and peel strength, in accordance with the criteria set in **Table III.2.2.**
   (2) Any specimen that fails through the weld or by fusion at the weld sheet interface is a non-FTB (Film Tearing Bond) break and shall be considered a failure.
   (3) The Installer shall test five specimens for shear seam strength and five for peel strength. Four out of the five replicate test specimens shall pass for the seam to be acceptable. A specimen must pass both Sections 1 and 2 above to be acceptable.

4. Quality Assurance Laboratory Test.

a) The Installer shall package and ship destructive test samples designated for laboratory testing to the independent Quality Assurance Laboratory. The laboratory must be approved by the Site CQA Manager.

b) Laboratory tests shall include shear and peel strength tests. The minimum acceptable values obtained in these tests shall be in accordance with **Table III.2.2**.

c) At least five specimen shall be tested each for shear and peel strength. A passing test shall meet the minimum required values in at least four of the five specimens tested for each method.

d) Any specimen that fails through the weld or by fusion at the weld sheet interface is a non-FTB (Film Tearing Bond) break and shall be considered a failure.

e) The Laboratory shall provide verbal test results to the Site CQA Manager no more than 24-hours after they receive the samples. The Site CQA Manager shall review the laboratory results as soon as they become available.

5. Procedures for Destructive Test Failure.

a) The following procedures shall apply whenever a sample fails a destructive test, whether that test is conducted in the field or by the laboratory. The Installer has two options:

(1) The Installer can repair the seam between any two passing test locations.
(2) The Installer can retrace the welding path to an intermediate location 10 feet (on both sides) from the location of the failed test and take a sample for an additional field test. If these tests pass, then the seam shall be repaired. If the test fails, then the process is repeated to establish the zone in which the seam should be repaired. This process may only be repeated twice. After the third failed test, the entire seam must be repaired.

b) All acceptable repaired seams shall be bound by two locations from which sample passing destructive tests have been taken. In cases where repaired seam exceeds 150 feet, a sample taken from the zone in which the seam has been repaired must pass destructive testing. Repairs shall be made in accordance with this CQA Plan.

c) The Installer shall document all actions taken in conjunction with destructive test failures.

L. Repair Procedures

1. Any portion of the geomembrane exhibiting signs of defect, failing a destructive or a nondestructive test, shall be repaired. Several procedures exist for the repair of these areas. The final decision as to the appropriate repair procedure shall be made by the Site CQA Manager.
2. The repair procedures available include:
   a. Defective seams shall be restarted/reseamed as described in this CQA Plan.
   b. Small holes shall be repaired by extrusion cap welding. If the hole is larger than 1/4 inch, it shall be patched with a piece of material extending six inches out from the damaged area.
   c. Tears shall be repaired by patching. The sharp end of a tear on a slope, or in an area of particular stress, must be rounded prior to patching.
   d. Blisters, large holes, undispersed raw materials, and contamination by foreign matter shall be repaired by patches.
   e. HDPE surfaces to be patched shall be abraded and cleaned no more than one hour prior to the repair. No more than 10% of the thickness shall be removed.
   f. Patches shall be round or oval in shape, made of the same geomembrane, and extend to a minimum of six inches beyond the edge of defects. All patches shall be of the same compound and thickness as the geomembrane specified. All patches shall have their top edge beveled prior to placement on the geomembrane in accordance with this CQA Plan. Patches shall be applied and the repair made using methods discussed in the CQA Plan.
3. Restart/Reseaming Procedures - Fillet Extrusion Welds
   The Fillet Extrusion Welds process shall restart by grinding the existing seam and rewelding a new seam. Welding shall commence where the grinding started and must overlap the previous seam by at least two inches. Reseaming over an existing seam without regrinding shall not be permitted.
4. Restart/Reseaming Procedures - Hot Wedge Welds
   Over the length of the seam failure, the Installer shall either cut out the old seam, reposition the panel and reseam, or add a cap strip, as required by the Site CQA Manager.

5. For any repair method, the following provisions shall be satisfied:
   a) Surfaces of the geomembrane which are to be repaired using extrusion methods shall be abraded no more than one hour prior to the repair.
   b) All surfaces shall be clean and dry at the time of the repair.
6. Repair Verification.
   a) Each repair shall be numbered and logged by the Installer. Each repair shall be nondestructively tested using the methods described in Section J, Subsection 2 "Non-Destructive Testing" as appropriate. Repairs which pass the nondestructive test shall be taken as an indication of an adequate repair. Repairs more than 150 feet long may be of sufficient length to require destructive test sampling, at the discretion of the Site CQA Manager. Failed test indicate that the repair shall be redone and retested until a passing test results are achieved. The Site CQA Manager shall observe all nondestructive testing of repairs. The Installer shall record the number of each repair, date and test outcome.
7. Disposal of Waste Material
   Upon completion of installation, the Installer shall dispose of all trash, waste material, etc. and shall leave the premises in a neat and acceptable condition.

M. Geomembrane Acceptance

The Installer shall retain all ownership and responsibility for the geomembrane until acceptance by the Owner. The geomembrane liner shall be accepted by the Owner when all of the following conditions are met:

1. Installation is finished.
2. Verification in the form of a certificate of acceptance of the adequacy of all field seams and repairs, including associated testing, is complete.
3. Certification by the Site CQA Engineer that the geomembrane was installed in accordance with the Construction Drawings, CQA Plan and manufacturers recommendations.
4. Certification, including "as built" drawing(s), and installation documentation is provided by the Installer to the Site CQA Manager
5. The High Density Polyethylene Geomembrane liner (HDPE) shall be paid for by the square foot, in place.

Table III.2.5
FML Reference Standards

1. American Society for Testing and Materials (ASTM)
2. ASTM D 638 - Standard Test Method for Tensile Properties of Plastics.
3. ASTM D 746 - Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact.
4. ASTM D 792 - Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
5. ASTM D 1004 - Standard Test Method for Initial Tear Resistance of Plastic Film and Sheeting.
6. ASTM D 1204 - Standard Test Method for Linear Dimensional Changes of Non-rigid Thermoplastic Sheeting or Film at Elevated Temperature.
7. ASTM D 1238 - Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer.
8. ASTM D 1505 - Standard Test Method for Density of Plastics by the Density-Gradient Technique.
9. ASTM D 1603 - Standard Test Method for Carbon Black in Olefin Plastics or ASTM D 4218 Standard Test Method for Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique.
10. ASTM D 5397, Appendix, - Test Method for Evaluation of Stress Crack Resistance of Polyolefin Geomembranes using Notched Constant Tension Load Test.
11. ASTM D 5596 - Standards Practice for Microscopic Examination of Pigment Dispersion in Plastic Compounds.
12. ASTM D 3895 - Standard Test Method for Copper-Induced Oxidative Induction Time of Polyolefin by Thermal Analysis.
13. ASTM D 6392 - Standard Test Method for Determining the Integrity of Non-reinforced Seams Produced Using the Thermo-Fusion Method.
14. ASTM D 4833 - Test Method for Puncture Resistance for Plastics.
15. GRI GM 13 - Test properties, Testing Frequency and Recommended Warrant for High density Polyethylene (HDPE) Geomembranes.
16. Test properties, Testing Frequency, and Recommended Warrant for High Density Polyethylene (HDPE) Geomembranes.

Notes:

1. *Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.*
2. *ASTM = American Society of Testing Materials*
3. *GRI = Geosynthetic Research Institute*

6.0 SELECT AGGREGATE

A. Select Aggregate

Leak Detection System Sump

1. Washed select aggregate, shall be used for bedding material in the leak detection sump. The select aggregate shall be durable, resistant to weathering and shall be free of shale, limestone and organic material.
2. The bedding aggregate shall be rounded and shall have particle sizes that range from $^3/_4$" minimum diameter to 2.0" maximum diameter, with fines (i.e., < #200 Sieve) less than 2% in accordance with ASTM C136, tested at a frequency of 1/500 cy. No crushed aggregate, calcareous or angular material may be used.
3. Gradation analysis shall be performed on samples from each source of the select aggregate to assure compliance with the CQA Plan.

B. Delivery, Storage and Handling

If select aggregate materials are delivered to the site prior to placement approval, materials shall be stockpiled on site in areas as dictated by Owner. Provision shall be implemented to minimize surface water impact on the stockpile. Removal and placement of the materials shall be done in a manner to minimize intrusion of soils adjacent to and beneath the stockpile.

C. Select Aggregate Placement

Select Aggregate Leak Detection System Bedding Layer

1. After primary liner placement has been approved, placement of geocomposite layer in the bottom of the leachate detection system sump will ensure protection of the FML from the overlying select aggregate bedding layer.

2. Placement of the select aggregate should be in gradual 4" to 6" lifts and tamped simultaneously with a blunt tamping tool to ensure the material is well consolidated under the sides of the pipe as well as around it.
3. "Spading" with shovels or any other operations which could jeopardize the underlying liner's integrity will not be allowed.
4. Care shall be taken during backfilling around the riser pipe to assure the pipe will not be crushed or otherwise damaged.

Table III.2.6
Select Aggregate
Reference Standards

1. ASTM D 422 - Standard Test Method for Particle-Size Analysis of Soils.
2. ASTM D 698 - Standard Test Methods for Moisture-Density Relations of Soil and Soil-Aggregate Mixtures Using 5.5-lbm (2.49-kg) Rammer and 12-inch (305-mm) Drop.
3. ASTM D 854 - Standard Test Method for Specific Gravity of Soils.
4. ASTM D 2922 - Density of soil in place by nuclear methods (Shallow Depth).
5. ASTM D 3017 - Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).
6. ASTM D 4254 - Standard Test Methods for Minimum Index Density of Soils and Calculation of Relative Density.
7. ASTM C 40 - Standard Test Method for Organic Impurities in Fine Aggregates for Concrete.
8. ASTM C 136 - Standard Method for Sieve Analysis of Fine and Coarse Aggregates.
9. ASTM C 289 - Standard Test Method for Potential Reactivity of Aggregates (Chemical Method).
10. ASTM D 75 - Standard Practice for Sampling Aggregates.
11. ASTM D 3042 - Standard Test Method for Insoluble Residue in Carbonate Aggregates.
12. ASTM D 4373 - Standard Test Method for Calcium Carbonate Content of Soils.

7.0 GEONET

A. Geonet Properties

1. The geonet shall be manufactured of new, prime first-quality materials designed and manufactured specifically for the purpose of planar drainage of liquid and chemically resistant to leachate.
2. Geonets are unitized sets of parallel ribs positioned in layers to form a three-dimensional structure such that liquid can be transmitted within their open spaces.
3. The geonet material shall meet the minimum properties listed in **Table III.2.7.**

Table III.2.7
HDPE Geonet Standards

PHYSICAL PROPERTIES				
Property	**Qualifier**	**Unit**	**Value**	**Test Method**
Thickness	Minimum	mils	200	ASTM D1777
Density	Minimum	g/cc	0.94	ASTM D1505
Melt Index	Range	g/10 min	0.1 - 1.1	ASTM D1238
Carbon Black Content	Range	%	2.0 - 3.0	ASTM D1603
Tensile Strength	Minimum	lb/in	42	ASTM D1682
Mass Per Unit Area	Minimum	lb/ft^2	0.16	ASTM D3776
Transmissivity (loaded)	Minimum	m^2/sec	$1x10^{-3}$	ASTM D4716

B. Delivery, Storage, and Handling

1. The geonet rolls shall be packaged and shipped by appropriate means to prevent damage to the rolls. Off-loading and storage of the geonet is the responsibility of the Installer. The Installer is responsible for replacing any damaged or unacceptable material at no cost to the Owner.
2. No off-loading shall be performed unless the Site CQA Manager is present. Damage during off-loading shall be documented by the Site CQA Manager. All damaged rolls must be separated from the undamaged rolls until the proper disposition of that material has been determined by the Site CQA Manager.
3. The geonet rolls shall be stored so as to be protected from puncture, dirt, grease, water, moisture, mud, mechanical abrasions, and excessive heat that may damage the geonet material. The rolls shall be stored on a prepared surface (not wooden pallets) and shall not be stacked more than two rolls high.

C. Geonet Installation

1. Geonet Placement

a. As each roll is moved from the storage area by the Installer, the labels shall be removed by the Installer and submitted to the Site CQA Manager. The rolls of geonet shall be brought to the area to be lined with a front-end loader and support pipes set up such that the geonet roll is fully supported across its length. A spreader bar or similar device shall be used to prevent the lifting chains or slings from damaging the edges.

b. Care shall be taken to keep the geonet clean and free from debris prior to installation. If the geonet is not clean, it should be washed using a high-pressured hose prior to installation.

c. Each panel of the geonet shall be rolled out and installed in accordance with the approved shop drawings prepared by the Installer. The layout shall be designed to keep field joining of the geonet to a minimum and consistent with proper methods of geonet installation.

d. On slopes, the geonet shall be secured and rolled down the slope in such a manner as to continually keep the geonet panel in tension. If necessary, the geonet shall be positioned by hand after being unrolled to minimize wrinkles.

e. In areas where wind is prevalent, geonet installation should be started at the upwind side of the project and proceed downwind. The leading edge of the geonet shall be secured at all times with sandbags or other means sufficient to hold it down during windy conditions.

f. The geonet shall not be welded to the geomembrane.

g. The geonet shall only be cut using scissors or other cutting tools approved by the Manufacturer that will not damage the underlying geosynthetics. Care shall be taken not to leave tools on the geonet.

h. Necessary precautions shall be taken to prevent damage to underlying layers during placement of the geonet.

i. During placement of geonet, care shall be taken not to entrap dirt or excessive dust within the geonet that could cause clogging of the drainage system and/or stones that could damage the adjacent geomembrane. If dirt or excessive dust is entrapped in the geonet, it should be hosed clean prior to placement of the next material on top of it. In this regard, care shall be taken in handling the sandbags to prevent rupture or damage of the sandbag.

j. Once the geonet is removed from the storage area by the Installer, it becomes the responsibility of the Installer.

2. Field Seams

The following requirements shall be met during installation of the geonet:

a. Adjacent rolls shall be overlapped by a minimum of 4 inches.
b. Overlaps shall be secured by tying. Tying can be achieved by HDPE fasteners or polymer braids. Tying devices shall be white or yellow for easy inspection. Metallic devices will not be permitted.
c. Tying shall be every 5 feet along the slope and base, every 6 inches in the anchor trench, and every 6 inches along end-to-end seams on the floor of the pond.
d. No horizontal seams shall be allowed on side slopes.
e. In the corners of the side slopes where overlaps between perpendicular geonet panels are required, an extra layer of geonet shall be unrolled along the slope, on top of the previously installed geonet from top to bottom of the slope.
f. When more than one layer of geonet is installed, joints shall be staggered.

D. Field Quality Control

1. The Installer shall provide the Site CQA Manager with Daily Summary Reports addressing the following:
    - Underlying geomembrane approval for areas anticipated to be covered by geonet
    - The total number and location of panels placed
    - Location of repairs
2. The Field Installation Team Manager and the Site CQA Manager shall provide 100% inspection of the installation to ensure compliance with these technical specifications and Manufacturer recommended procedures.
    a. The surface of the geonet shall be clean and free of debris at the time of inspection.
    b. The Field Installation Manager shall record each roll number and lot number as panels are deployed, and a general description of the location of each panel.
    c. The Field Installation Manager and the Site CQA Manager shall inspect the overlap for each panel.
    d. The Field Installation Manager and the Site CQA Manager shall inspect the anchoring of the geonet.
    e. The Field Installation Manager and the Site CQA Manager shall inspect the geonet for any signs of defects or holes. Any areas requiring repair shall be marked and subsequently repaired in accordance with the Repair Procedures listed in these specifications.
    f. The Field Installation Manager and the Site CQA Manager shall reinspect, verify, and approve all repairs and patches.

3. Repair Procedures
   a. All seams and non-seam areas of the geonet shall be inspected for defects, holes, and any sign of contamination by foreign matter in accordance with the Field Quality Control procedures listed in these specifications.
   b. Any defects shall be repaired by the Installer by placing a geonet patch with a minimum 12-inch overlap in all directions.
   c. The patch shall be secured to the original geonet panel by placing HDPE fasteners or polymer braids every 6 inches along the perimeter of the patch.
   d. For any repair method, all surfaces shall be clean and dry at the time of the repair.
   e. Each completed repair shall be inspected and approved in accordance with the Field Quality Control procedures listed in these specifications.

8.0 GEOTEXTILES

A. Geotextile Properties

1. The 12 oz/yd^2 non-woven geotextile must meet the specifications provided in **Table III.2.8**.
2. The minimum roll width shall be 15 feet, and roll length shall be 300 feet.

B. Delivery, Storage and Handling

1. The geotextile shall be packaged in rolls, uniformly wound onto suitable cylindrical forms or cores to aid in handling and unrolling. Each roll shall be packaged to protect the material from damage due to ultraviolet light and moisture during normal storage and handling.
2. Each roll shall be clearly marked with the following:
   - Manufacturer's name
   - Roll width and length
   - Brand name of the product
   - Manufacturer lot or control number
3. Off-loading and storage of the geotextile shall be performed by the Contractor.
4. Storage of the geotextile shall be in accordance with ASTM D-4873. The material shall not be exposed to sunlight for longer than 14 days.
5. The Installer shall be responsible for moving the geotextile from the storage area to the cell area for installation. The Installer shall be responsible for replacing any geotextile material damaged during installation.

Table III.2.8
Technical Specifications
12 oz/yd^2 Non-woven Geotextile[1]

PHYSICAL PROPERTIES				
PROPERTY	**QUALIFIER**	**UNIT**	**VALUE**	**TEST METHOD**
Weight	Typical MARV	12.0 12.5	oz/yd^2 oz/yd^2	ASTM D 5261 ASTM D 5261
Thickness	Typical MARV	135 150	mils mils	ASTM D 5199 ASTM D 5199
Tensile Strength	Typical MARV	340 300	lbs lbs	ASTM D 4632 ASTM D 4632
Elognation	Typical MARV	60 50	% %	ASTM D 4632 ASTM D 4632
Puncture Strength	Typical MARV	200 175	lbs lbs	ASTM D 4833 ASTM D 4833
Mullen Burst Strength	Typical MARV	640 580	psi psi	ASTM D 3786 ASTM D 3786
Tapezoidal Tear Strength	Typical MARV	135 115	lbs lbs	ASTM D 4533 ASTM D 4533
Apparent Opening Size (AOS)	Typical MARV	140 100	US Sieve US Sieve	ASTM D 4751 ASTM D 4751
Coefficient of Permeability	Typical MARV	0.40 0.29	cm/sec cm/sec	ASTM D 4491 ASTM D 4491
Permittivity	Typical MARV	1.30 1.00	sec-^{1} sec-^{1}	ASTM D 4491 ASTM D 4491
Flow Rate	Typical MARV	90 75	gpm/ft^2 gpm/ft^2	ASTM D 4491 ASTM D 4491
UV Resistance	MARV	70	% Retained @ 500 Hours	ASTM D 4355
Roll Width	Measured	15.0	feet	n/a
Roll Length	Measured	300	feet	n/a
Roll Area	Calculated	500	yd^2	n/a

Notes:

1. *Values reported represent Synthetic Industries* 1341 *Non-woven Geotextile*

C. Installation

1. Leak Detection Sump (LDS) Preparation

a. Before the geotextile is placed into position in the Leak Detection Sump (LDS), the following procedures will be completed.
   (1) The subgrade at the bottom and sides of the sump shall be carefully prepared in accordance with this CQA Plan.
   (2) The subgrade will be covered by a Geosynthetic Clay Liner (GCL) and a HDPE geomembrane according to this CQA Plan by the Liner Installer.

2. Geotextile Installation

a. After liner placement has been approved, the Geotextile Installer shall place the non-woven geotextile in the bottom of the sump to ensure protection of the FML from the overlying select aggregate layer.
   (1) Exposure of the geotextiles to the elements between lay down and cover shall be a maximum of 14 days.
   (2) The 12 oz/yd^2 non-woven geotextile shall be placed atop the HDPE FML or GCL in the LDS.
   (3) The 12 oz/yd^2 non-woven geotextile shall be placed atop the HDPE FML or GCL and anchored in temporary and permanent anchor trenches shown on the construction drawings. The geotextile shall be joined by overlapping and sewing. Overlapped seams shall have a minimum overlap of 6 inches.
   (4) The geotextile shall be joined by overlapping the seams 4-inches and sewing the panels together
   (5) The 12 oz/yd^2 geotextile shall terminate in the Liner Anchor Trench discussed in the HDPE Liner Specifications.
   (6) The Installer shall take care not to damage the liner materials. The Installer is responsible for any damage to the geotextile and underlying FML and GCL caused during geotextile installation.

3. Field Quality Control

a. The Site CQA Manager shall inspect the installation for proper placement, sufficient overlap and damaged material. Damaged areas will be repaired in accordance with the Repair Procedures of this CQA Plan.

4. Repair Procedures

a. A geotextile patch shall be placed over the damaged area and extend three feet beyond the perimeter of the tear or damage.
b. The Site CQA Manager shall verify all repairs.

Table III.2.9
Non-woven Geotextile Reference Standards

1. American Society for Testing and Materials (ASTM)
2. ASTM D5261 - Standard Test Method for Mass Per Unit Area (Weight) of Geotextile.
3. ASTM D3786 - Standard Test Method for Hydraulic Bursting Strength of Knitted Goods and Non-woven Fabrics - Diaphragm Bursting Strength Tester Method.
4. ASTM D4491 - Standard Test Methods for Water Permeability of Geotextiles by Permittivity .
5. ASTM D4533 - Standard Test Method for Trapezoid Tearing Strength of Geotextiles.
6. ASTM D4632 - Standard Test Method for Breaking Load and Elongation of Geotextiles (Grab Method).
7. ASTM D4751 - Standard Test Method for Determining Apparent Opening Size of a Geotextile.
8. ASTM D4833 - Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products.
9. ASTM D5199 - Standard Test Method for Measuring Thickness of Textile Materials.
10. Where reference is made to one of the above standards, the revision in effect at the time shall apply.

9.0 LEAK DETECTION PIPE

A. Material Properties

1. High Density Polyethylene (HDPE) Pipe

If high density polyethylene (HDPE) pipe is utilized for the leak detection pipe, the material will be manufactured in accordance with ASTM D714 and have the following physical characteristics:

a) HDPE pipe shall meet the requirements of cell classification PE 345464 or higher cell classification in accordance with ASTM D3350.
b) The pipe shall be as uniform as commercially practical in color, opacity, density, and other physical properties.
c) Slotted or perforated four (4) inch diameter HDPE, with a standard dimension ratio (SDR) of 11 will be used in the leak detection sump.
d) The slots or perforations must conform with the Drawings.

2. HDPE Pipe Fittings and Joints

a) End caps for the clean-out risers will be of low pressure type HDPE, or similar.
b) HDPE fittings shall be manufactured in accordance with the requirements of ASTM E714.
c) Apart from structural voids and hollows associated with some profile wall designs, the pipe fittings shall be homogeneous throughout and free from visible cracks, holes, foreign inclusions or other defects.
d) The pipe shall be joined by the method of thermal butt fusion or electrofusion as outline in ASTM D2657. All joints shall be made in strict compliance with the Manufacturer's recommendations.

e) Mechanical connections of the polyethylene pipe to auxiliary equipment such as valves, pumps and tanks shall be through flanged connections that shall consist of the following:
   (1) A stainless steel back-up, polyethylene flange shall be thermally butt-fused to the stub end of the pipe.
   (2) A 316 stainless steel back up ring on both sides of the connection shall be used as approved by the Owner.

f) Blind Flange connections shall be made in accordance with Manufacturer's recommendations.

3. Polyvinyl Chloride (PVC) Pipe

If Polyvinyl Chloride (PVC) Pipe is utilized for the leak detection pipe, the material shall be manufactured in accordance with ASTM D1784 and have the following physical characteristics:

a) PVC pipe shall be Schedule 80 or as indicated on the Drawings. The pipes shall conform to the requirements of ASTM D1785 and shall have the nominal dimensions shown on the Drawings.
b) Pipe and fitting shall be manufactured from a PVC compound which meets the requirements of Type 1, Grade 1, Polyvinyl chloride (PVC) as outlined in ASTM D1784. A Type1, Grade 1 compound is characterized as having the highest requirements for mechanical properties and chemical resistance.
c) Pipe shall be furnished in standard laying lengths not exceeding twenty (20) feet.
d) Fittings shall conform to the requirements of ASTM D2467 for socket type joints.
e) Slotted or perforated six (6) inch diameter PVC Pipe as shown on the drawings.

4. PVC Joints

The pipe shall be jointed with gasketed, integral bell and spigot or double bell coupling with plain-end spigot-type joints. Gasketed joints shall conform to ASTM D3139. Gaskets shall conform to ASTM F477.

B. Manufacturer Quality Control Documentation

Prior to installation of any (HDPE/PVC) geopipe, the Contractor shall provide the following information certified by the manufacturer for the delivered geopipe:

1. Manufacturer's certification verifying that the quality of the raw materials used to manufacture the geopipe meets the Manufacturer specifications.
2. Each geopipe length delivered to the project site shall have the following identification information:
   - Manufacturer's name
   - Pipe size
   - Ring stiffness constant classification or SDR number
   - Production code designating plant location, machine, and date of manufacture

3. Each length of pipe and each fitting shall be marked with the name of the Manufacturer, size, and class. All gaskets shall be marked with the name of Manufacturer, size, and proper insertion direction.

C. Delivery, Storage and Handling

1. Off-loading and storage of the geopipe shall be performed by the Contractor.
2. Storage of the geopipe shall not exceed 17 rows high, as per Manufacturer's recommendation.
3. The Contractor shall be responsible for moving the pipes and fittings from the storage area to the area of pipe installation. The Contractor shall be responsible for replacing any material damaged during transport or installation.

D. Quality Assurance

1. Finished Product Evaluation

A. Each length of pipe produced shall be checked by production staff for the items listed below. The results of all measurements shall be recorded on production sheets which become part of the Manufacturer's permanent records.
   - a) Pipe in process shall be checked visually, inside and out for cosmetic defects (grooves, pits, hollows, etc.).
   - b) Pipe outside diameter shall be measured using a suitable periphery tape to ensure conformance with ASTM D2160.
   - c) Pipe wall thickness shall be measured at 12 equally spaced locations around the circumference at both ends of the pipe to ensure conformance with the Manufacturer's specifications.
   - d) Pipe length shall be measured.
   - e) Pipe marking shall be examined and checked for accuracy.
   - f) Pipe ends shall be checked to ensure they are cut square and clean.

E. Installation

1. Leak Detection Sump Preparation

A. Before HDPE pipe is placed into position in the sump, the following procedures will be completed:
   - a) The subgrade at the bottom and sides of the sump shall be carefully prepared to project specifications by the Earthwork Contractor.
   - b) The subgrade will be covered by a HDPE geomembrane according to project specifications by the Liner Installer.
   - c) Select Aggregate shall be installed around the geopipe in the leak detection sump in accordance with Section 6.0.

Table III.2.10
HDPE Pipe Reference Standards

1. ASTM D1248 - Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable (Material Classification)
2. ASTM D350 - Standard Test Methods for Flexible Treated Sleeving used for Electrical Insulation (Cell Classification)
3. ASTM D1505 - Standard Test Method for Density of Plastics by the Density – Gradient Technique
4. ASTM D1238 - Standard Test Method for Melt Flow Rates of Thermoplastics by Extrusion Polymer
5. ASTM D790 - Standard Test Methods for Flexural Properties of Unreinforced Plastics and Electrical Insulating Materials
6. ASTM D2990 - Standard Test Methods for Tensile, Compressive, and Flexural Creep and Creep Rupture of Plastics
7. ASTM D2160 - Standard Specification for Solid Wall High Density Polyethylene (HDPE) Condit based on Controlled Outside Diameter (OD)
8. ASTM D638 - Standard Test Method for Tensile Properties of Plastics
9. ASTM D2240 - Standard Test Method for Rubber Property – Durometer Hardness
10. ASTM D695 - Standard Test Method for Compressive Properties of Rigid Plastics
11. ASTM D1693 - Standard Test Method for Environmental Stress – Cracking of Ethylene Plastics
12. ASTM F1248 - Standard Test Method for Determination of Environmental Stress Crack Resistance (ESCR) of Polyethylene Pipe
13. ASTM D256 - Standard Test Method for Determining the IZOD Pendulum Impact Resistance of Plastics
14. ASTM D696 - Standard Test Method for Coefficient of Liner Thermal Expansion of Plastics between -30° C and 30° C with a Vitreous Silica Diletometer
15. ASTM D746 - Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact
16. ASTM D1525 - Standard Test Method for Vicat Softening Temperature of Plastics
17. ASTM F714 - Standard Specification for Polyethylene (PE) Plastic Pipe (SDRPR) Based on Outside Diameter
18. ASTM D3350 - Specification for Polyethylene (PE) Plastic Pipe Fittings Materials

Notes:

1. *Where reference is made to one of the above standards, the revision in effect at the time shall apply.*
2. *ASTM = American Society of Testing Materials*

Table III.2.11
PVC Pipe Reference Standards

1. ASTM D1784 - Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.
2. ASTM D1785 - Standard Specifications for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedule 40, 80 and 120.
3. ASTM D2241 - Standard Specification for Poly (Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series).
4. ASTM D2466 - Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
5. ASTM D2467 - Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
6. ASTM D2564 - Standard Specification for Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Piping Systems.
7. ASTM D2672 - Standard Specification for Joints for IPS PVC Pipe Using Solvent Cement.
8. ASTM D2774 - Standard Practice for Underground Installation of Thermoplastic Pressure Piping.
9. ASTM D2837 - Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials
10. ASTM D3139 - Standard Specification for Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals.
11. ASTM F477 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
12. ASTM F656 - Standard Specification for Primers for Use in Solvent Cement Joints of Poly (Vinyl Chloride) (PVC) Plastic Pipe and Fittings.

Notes:

1. *Where reference is made to one of the above standards, the revision in effect at the time shall apply.*
2. *ASTM = American Society of Testing Materials*

APPLICATION FOR PERMIT
BASIN DISPOSAL, INC.
OIL FIELD WASTE EVAPORATION PONDS

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ATTACHMENT III.2.A

LINER QUALITY CONTROL PROJECT SPECIFICATIONS

BASIN DISPOSAL, INC.

"SPECIALIZING IN DISPOSAL OF PRODUCED WATER AND DRILLING MUD"

P.O. BOX 100 - AZTEC, NEW MEXICO 87410 - PHONE: (505) 334-3013

Liner Quality Control
Project Specifications

1.0 Project Data

Site Name: ______________________ Date Prepared __________

Project/Cell: ______________________

Project Number ______________________ Project Start Date __________

Project Size __________ Acres or ft^2

Location ______________________

____

Client Contact: ______________________

Phone: ______________________

Site Phone: ______________________

		Initials
Project Manager	______________	______
CQA Officer	______________	______
CQA Technicians	______________	______
	______________	______
	______________	______

Project Documentation Available

CQA Plan ______ Construction Drawings ______ Health and Safety Plan ______

Other: ______________

Comments: ______________________

____

____

BASIN DISPOSAL, INC.
"SPECIALIZING IN DISPOSAL OF PRODUCED WATER AND DRILLING MUD"
P.O. BOX 100 - AZTEC, NEW MEXICO 87410 - PHONE: (505) 334-3013

Liner Quality Control
Project Specifications

2.0 Subgrade/Soil Liner

2.1 Grade Control (Survey)

Area: _____ Acres or ft^2

Performed By: ____________________ Date Performed: _______
Tolerance (vert) _______ feet or inches As-Built Drawing(s) Available? Y or N
____
Thickness _______ feet or inches **Standard = 1 per acre**

2.2 Compaction

		Sample ID	Maximum Density	Optimum Moisture
Reference Proctor(s)	_______ lb/ft^3			
Standard (ASTM D698)	_______ lb/ft^3			
Modified (ASTM D1557)	_______ lb/ft^3			

Specifications
Density_______ % of Optimum Moisture _______ lb/ft^3
_______ lb/ft^3

Number of Lifts: _______ Lift Thickness (inches):
Loose: _____ Compacted: _______

Field Test Frequency:_______ per: acre/lift yd^3 other units: _______

Compaction Test Method: Nuclear Density Meter or Other: _______

Total Number of Density Tests Required___________ **Standard = 4/acre/lift**

Field Permeability Tests required? Y or N Perm Test Method ___________

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Liner Quality Control
Project Specifications

2.3 Soil Classification Standards

Acceptable USCS: (circle or box)

GW	SW	ML	MH
GP	SP	CL	CH
GM	SM	OL	OH
GC	SC		

Subgrade/Liner Material Testing:
in situ ________ borrow source: ____________

Grain Size:
#200 Sieve ________________________________ (percent passing)
C_u (D_{60}/D_{10}) ________________________________
Other ________________________________

Atterberg Limits: P.I.
Liquid Limit ____________________
Plastic Limit ____________________
Other ____________________

Laboratory Permeability: ____________________

2.4 Surface Preparation Y or N

______ smooth surface
______ remove angular material
______ remove organic material
______ remove rocks greater than _____ inches

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Liner Quality Control
Project Specifications

3.0 Geosynthetics

Conformance Tests

3.1 FML

Specifications: ________ 60 mil
________ other

HDPE Smooth Area: ________ Acres or ft^2

HDPE Textured Area: ________ Acres or ft^2

Other ________ Area: ________ Acres or ft^2

collected by ________
performed by ________
frequency ________
total number ________

3.2 Geotextile (not including leak detection system)

Specifications: oz
Woven or Nonwoven

Area: ________ Acres or ft^2

collected by ________
performed by ________
frequency ________
total number ________

3.3 Geonet

Area: ________ Acres or ft^2

Specifications: ________ thickness

with Geotextile:
upper ________ lower ________

collected by ________
performed by ________
frequency ________
total number ________

Liner Quality Control
Project Specifications

4.0 Leak Detection System

Conformance Tests

4.1 Piping

Collection System Specifications: ____________
Linear Quantity Material ____________
Diameter ____________
____

Risers Specifications: ____________
Linear Quantity Material ____________
Diameter ____________

4.2 Aggregate

Specifications:
greater than
smaller than

collected by _______
performed by _______
frequency _______
total number _______

4.3 Geotextile

Specifications: oz
Woven or Nonwoven

Area: ________ Acres or ft^2

collected by _______
performed by _______
frequency _______
total number _______

4.4 Sump

Design volume ________ yd^3 or gallons
Double Lined? Y or N
Area of double liner _______ ft^2

APPLICATION FOR PERMIT
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OIL FIELD WASTE EVAPORATION PONDS

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ATTACHMENT III.2.B

AUTHORIZATION TO PROCEED FORM

BASIN DISPOSAL, INC.
"SPECIALIZING IN DISPOSAL OF PRODUCED WATER AND DRILLING MUD"
P.O. BOX 100 - AZTEC, NEW MEXICO 87410 - PHONE: (505) 334-3013

AUTHORIZATION TO PROCEED FORM

THE FOLLOWING LINER SYSTEM SURFACE IS DEEMED ACCEPTABLE ON A VISUAL INSPECTION BY LINER CONTRACTOR REPRESENTATIVE:

PROJECT: ______________________

LAYER: 1. SUBGRADE/BERM ____________
2. HDPE GEOMEMBRANE ____________

LOCATION: ____________ TO ____________
____________ TO ____________

REMARKS: ____
____
____
____
____
____
____

THE ABOVE NOTED LAYER IS NOW ACCEPTABLE FOR COVERING BY THE NEXT LAYER

AUTHORIZATION BY:

______________________ ____________
LINER CONTRACTOR REPRESENTATIVE DATE

SUBMITTED TO:

______________________ ____________
GEI REPRESENTATIVE DATE

APPLICATION FOR PERMIT
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OIL FIELD WASTE EVAPORATION PONDS

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ATTACHMENT III.2.C

DAILY SUMMARY REPORT

BASIN DISPOSAL, INC.
"SPECIALIZING IN DISPOSAL OF PRODUCED WATER AND DRILLING MUD"
P.O. BOX 100 - AZTEC, NEW MEXICO 87410 - PHONE: (505) 334-3013

Daily Summary Report

Owner: ____________ **Report No.:** ____________
Project: ____________ **Page:** ____________
Project No.: ____________ **Date:** ____________
Weather: A.M.: P.M.: ____________ **Day:** ____________
Temp. (°F): ____________ **Precipitation:** ____________

Contractor(s)

Summary of Daily Construction Progress and Inspections:

Summary of Problems and Resolutions:

Equipment:

Summary of Meeting Held and Attendees:

____
CQA Technician

____
CQA Officer

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ATTACHMENT III.2.D

SUBGRADE/BERM DENSITY TESTING RESULTS

BASIN DISPOSAL, INC.

"SPECIALIZING IN DISPOSAL OF PRODUCED WATER AND DRILLING MUD"

P.O. BOX 100 - AZTEC, NEW MEXICO 87410 - PHONE: (505) 334-3013

SUBGRADE/BERM DENSITY TESTING RESULTS

PROJECT INFORMATION	
PROJECT TITLE:	PROJECT NO.:
OWNER:	DATE:
PROJECT LOCATION:	PAGE NO.:
Testing Instrument: Troxler 3440	**Technician:**
Reference Density (pcf):	**Reference Moisture (%):**

Test Number	% Proctor	Dry Density (pcf)	% Moisture

Test Number	% Proctor	Dry Density (pcf)	% Moisture

Reviewed By:___________ **Date:** ___________

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ATTACHMENT III.2.E

GEOSYNTHETIC DEPLOYMENT LOG

BASIN DISPOSAL, INC.
"SPECIALIZING IN DISPOSAL OF PRODUCED WATER AND DRILLING MUD"
P.O. BOX 100 - AZTEC, NEW MEXICO 87410 - PHONE: (505) 334-3013

GEOSYNTHETIC DEPLOYMENT LOG

PROJECT NUMBER: ____________________ PROJECT NAME: ____________________
OWNER: ____________________ CONTRACTOR: ____________________
PROJECT LOCATION: ____________________
SHEET NUMBER: __________
____

MATERIAL TYPE: GCL FML Geonet Geotextile

PANEL NUMBER	ROLL NUMBER	LENGTH	WIDTH	SQUARE FOOTAGE	SHEET TYPE
		TOTAL LINER PLACED:			SQ. FT

REVIEWED BY: ______________ DATE: ______________

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ATTACHMENT III.2.F

GEOSYNTHETIC INVENTORY CONTROL LOG

BASIN DISPOSAL, INC.
"SPECIALIZING IN DISPOSAL OF PRODUCED WATER AND DRILLING MUD"
P.O. BOX 100 - AZTEC, NEW MEXICO 87410 - PHONE: (505) 334-3013

GEOSYNTHETIC INVENTORY CONTROL LOG

PROJECT NUMBER: ____________
OWNER: ____________
PROJECT LOCATION: ____________

PROJECT NAME: ____________
CONTRACTOR: ____________
SHEET NUMBER: ____________

MATERIAL MANUFACTURER: ____________
PRODUCT IDENTIFICATION: ____________
MATERIAL TYPE: ____________

DATE OF INVENTORY: ____________
INVENTORY MONITOR: ____________
UNLOADING METHOD: ____________

	ROLL NUMBER	BATCH OR LOT NO.	MATERIAL DIMENSIONS			MANUF. QC CERT. Y / N	CONF. SAMP. Y / N	OTHER	REMARKS
			LENGTH (FT)	WIDTH (FT)	THICKNESS OR WEIGHT				
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									
22									
23									
24									
25									

REVIEWED BY: ____________ DATE: ____________

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ATTACHMENT III.2.G
GEOMEMBRANE SEAM LOG

BASIN DISPOSAL, INC.
"SPECIALIZING IN DISPOSAL OF PRODUCED WATER AND DRILLING MUD"
P.O. BOX 100 - AZTEC, NEW MEXICO 87410 - PHONE: (505) 334-3013

GEOMEMBRANE SEAMING LOG

PROJECT INFORMATION

PROJECT TITLE:
PROJECT NO.:
PROJECT LOCATION:
OWNER:
CONTRACTOR:
PAGE NO.:
DATE:

	DATE	PANEL NO. / PANEL NO.	START TIME	MACHINE NO.	SEAMER INITIALS	TEMP SETTING	SPEED SETTING	APPROX. LENGTH WELDED	DESTRUCTIVE TEST	MONITORED BY	REMARKS
1											
2											
3											
4											
5											
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											
21											
22											

REVIEWED BY : ____________________

APPLICATION FOR PERMIT
BASIN DISPOSAL, INC.
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ATTACHMENT III.2.H

GEOMEMBRANE TRIAL SEAM FIELD TEST LOG

BASIN DISPOSAL, INC.

"SPECIALIZING IN DISPOSAL OF PRODUCED WATER AND DRILLING MUD"

P.O. BOX 100 - AZTEC, NEW MEXICO 87410 - PHONE: (505) 334-3013

GEOMEMBRANE TRIAL SEAM FIELD TEST LOG

PROJECT INFORMATION		PROJECT SPECIFICATIONS					
PROJECT TITLE:	PROJECT NO.:	**FUSION**	TEXTURED	PEEL	90	SHEAR	120
OWNER:	DATE:		SMOOTH	PEEL	90	SHEAR	120
PROJECT LOCATION:	PAGE NO.:	**EXTRUSION**	TEXTURED	PEEL	78	SHEAR	120
CONTRACTOR:			SMOOTH	PEEL	78	SHEAR	120

DATE AND TIME	WELDER'S INITIALS	QC INITIALS	MACHINE NUMBER	WEDGE WELDS		EXTRUSION WELDS		Pull	FIELD TEST RESULTS					REMARKS
				Temperature	Speed	Barrel Temp	Pre-Heat Temp		Test #1	Test #2	Test #3	Test #4	Test #5	
								P						
								P						
								S						
	NEAREST DT#				AMBIENT TEMP.									
								P						
								P						
								S						
	NEAREST DT#				AMBIENT TEMP.									
								P						
								P						
								S						
	NEAREST DT#				AMBIENT TEMP.									
								P						
								P						
								S						
	NEAREST DT#				AMBIENT TEMP.									
								P						
								P						
								S						
	NEAREST DT#				AMBIENT TEMP.									
								P						
								P						
								S						
	NEAREST DT#				AMBIENT TEMP.									
								P						
								P						
								S						
	NEAREST DT#				AMBIENT TEMP.									

REVIEWED BY: ____________ DATE: ____________

APPLICATION FOR PERMIT
BASIN DISPOSAL, INC.
OIL FIELD WASTE EVAPORATION PONDS

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ATTACHMENT III.2.I

GEOMEMBRANE SEAM PRESSURE TEST LOG

BASIN DISPOSAL, INC.

"SPECIALIZING IN DISPOSAL OF PRODUCED WATER AND DRILLING MUD"

P.O. BOX 100 - AZTEC, NEW MEXICO 87410 - PHONE: (505) 334-3013

GEOMEMBRANE SEAM PRESSURE TEST LOG

PROJECT INFORMATION		
PROJECT NO.:	PROJECT TITLE:	PROJECT LOCATION:
OWNER:	CONTRACTOR:	PAGE NO.:
TEST DURATION:	MIN START PRESSURE:	MAX PRESSURE DROP:

	DATE	PANEL NO. / PANEL NO.	TIME		PRESSURE		TESTER	OBSTRUCTION TEST	PASS/ FAIL	REMARKS
			START	FINISH	INITIAL	FINAL				
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
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27										
28										
29										

REVIEWED BY: ________________ DATE: __________

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BASIN DISPOSAL, INC.
OIL FIELD WASTE EVAPORATION PONDS

VOLUME III: ENGINEERING DESIGN AND CALCULATIONS
SECTION 2: LINER CONSTRUCTION QUALITY ASSURANCE (CQA) PLAN

ATTACHMENT III.2.J

DESTRUCTIVE FIELD TEST RECORD

BASIN DISPOSAL, INC.

"SPECIALIZING IN DISPOSAL OF PRODUCED WATER AND DRILLING MUD"

P.O. BOX 100 - AZTEC, NEW MEXICO 87410 - PHONE: (505) 334-3013

DESTRUCTIVE FIELD TEST RECORD

PROJECT INFORMATION		PROJECT SPECIFICATIONS					
PROJECT TITLE:	PROJECT NO.:	FUSION	TEXTURED	PEEL	90	SHEAR	120
OWNER:	DATE:		SMOOTH	PEEL	90	SHEAR	120
PROJECT LOCATION:	PAGE NO.:	EXTRUSION	TEXTURED	PEEL	78	SHEAR	120
CONTRACTOR:			SMOOTH	PEEL	78	SHEAR	120

DATE AND TIME	WELDER'S INITIALS	QC INITIALS	MACHINE NUMBER	WEDGE WELDS		EXTRUSION WELDS		Pull	FIELD TEST RESULTS					REMARKS
				Temperature	Speed	Barrel Temp	Pre-Heat Temp		Test #1	Test #2	Test #3	Test #4	Test #5	
								P						
								P						
								S						
	NEAREST DT#				AMBIENT TEMP.									
								P						
								P						
								S						
	NEAREST DT#				AMBIENT TEMP.									
								P						
								P						
								S						
	NEAREST DT#				AMBIENT TEMP.									
								P						
								P						
								S						
	NEAREST DT#				AMBIENT TEMP.									
								P						
								P						
								S						
	NEAREST DT#				AMBIENT TEMP.									
								P						
								P						
								S						
	NEAREST DT#				AMBIENT TEMP.									
								P						
								P						
								S						
	NEAREST DT#				AMBIENT TEMP.									

REVIEWED BY: ____________ DATE: ____________

APPLICATION FOR PERMIT
BASIN DISPOSAL, INC.
OIL FIELD WASTE EVAPORATION PONDS

VOLUME III: ENGINEERING DESIGN AND CALCULATIONS
SECTION 2: LINER CONSTRUCTION QUALITY ASSURANCE (CQA) PLAN

ATTACHMENT III.2.K

GEOMEMBRANE SEAM VACUUM TEST/REPAIR LOG

BASIN DISPOSAL, INC.

"SPECIALIZING IN DISPOSAL OF PRODUCED WATER AND DRILLING MUD"

P.O. BOX 100 - AZTEC, NEW MEXICO 87410 - PHONE: (505) 334-3013

GEOMEMBRANE SEAM VACUUM TEST/REPAIR LOG

PROJECT INFORMATION	
PROJECT TITLE:	PROJECT NO.:
OWNER:	DATE:
PROJECT LOCATION:	PAGE NO.:
CONTRACTOR:	

	SEAMS						RETEST		
	PANEL	REPAIR DATE	REPAIR TECH	TYPE OF REPAIR	NUMBER OF LEAKS	TECH ID	DATE ACCEPTED	TESTER	REMARKS
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
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29									
30									

REVIEWED BY: ________________ DATE: ________

APPLICATION FOR PERMIT
BASIN DISPOSAL, INC.
OIL FIELD WASTE EVAPORATION PONDS

VOLUME III: ENGINEERING DESIGN AND CALCULATIONS
SECTION 2: LINER CONSTRUCTION QUALITY ASSURANCE (CQA) PLAN

ATTACHMENT III.2.L

GEONET DEPLOYMENT LOG

BASIN DISPOSAL, INC.

"SPECIALIZING IN DISPOSAL OF PRODUCED WATER AND DRILLING MUD"

P.O. BOX 100 - AZTEC, NEW MEXICO 87410 - PHONE: (505) 334-3013

GEONET DEPLOYMENT LOG

PROJECT NUMBER: ____________________ PROJECT NAME: ____________________

OWNER: ____________________ CONTRACTOR: ____________________

PROJECT LOCATION: ____________________

SHEET NUMBER: __________

____

MATERIAL TYPE: GCL FML Geonet Geotextile

PANEL NUMBER	ROLL NUMBER	LENGTH	WIDTH	SQUARE FOOTAGE	SHEET TYPE
TOTAL LINER PLACED:					SQ. FT

REVIEWED BY: ____________________ DATE: ____________________

APPLICATION FOR PERMIT
BASIN DISPOSAL, INC.
OIL FIELD WASTE EVAPORATION PONDS

VOLUME III: ENGINEERING DESIGN AND CALCULATIONS
SECTION 2: LINER CONSTRUCTION QUALITY ASSURANCE (CQA) PLAN

ATTACHMENT III.2.M

GEONET INVENTORY CONTROL LOG

BASIN DISPOSAL, INC.
"SPECIALIZING IN DISPOSAL OF PRODUCED WATER AND DRILLING MUD"
P.O. BOX 100 - AZTEC, NEW MEXICO 87410 - PHONE: (505) 334-3013

GEONET INVENTORY CONTROL LOG

PROJECT NUMBER: ____________
OWNER: ____________
PROJECT LOCATION: ____________
PROJECT NAME: ____________
CONTRACTOR: ____________
SHEET NUMBER: ____________

MATERIAL MANUFACTURER: ____________
PRODUCT IDENTIFICATION: ____________
MATERIAL TYPE: ____________
DATE OF INVENTORY: ____________
INVENTORY MONITOR: ____________
UNLOADING METHOD: ____________

	ROLL NUMBER	BATCH OR LOT NO.	MATERIAL DIMENSIONS			MANUF. QC CERT. Y / N	CONF. SAMP. Y / N	OTHER	REMARKS
			LENGTH (FT)	WIDTH (FT)	THICKNESS OR WEIGHT				
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
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REVIEWED BY: ____________ DATE: ____________

APPLICATION FOR PERMIT
BASIN DISPOSAL, INC.
OIL FIELD WASTE EVAPORATION PONDS

VOLUME III: ENGINEERING DESIGN AND CALCULATIONS
SECTION 2: LINER CONSTRUCTION QUALITY ASSURANCE (CQA) PLAN

ATTACHMENT III.2.N

GEOTEXTILE DEPLOYMENT LOG

BASIN DISPOSAL, INC.
"SPECIALIZING IN DISPOSAL OF PRODUCED WATER AND DRILLING MUD"
P.O. BOX 100 - AZTEC, NEW MEXICO 87410 - PHONE: (505) 334-3013

GEOTEXTILE DEPLOYMENT LOG

PROJECT NUMBER: ____________________ **PROJECT NAME:** ____________________
OWNER: ____________________ **CONTRACTOR:** ____________________
PROJECT LOCATION: ____________________
SHEET NUMBER: __________
____
MATERIAL TYPE: **GCL** **FML** **Geonet** **Geotextile**

PANEL NUMBER	ROLL NUMBER	LENGTH	WIDTH	SQUARE FOOTAGE	SHEET TYPE
		TOTAL LINER PLACED:			SQ. FT

REVIEWED BY: ____________________ **DATE:** ____________________

APPLICATION FOR PERMIT
BASIN DISPOSAL, INC.
OIL FIELD WASTE EVAPORATION PONDS

VOLUME III: ENGINEERING DESIGN AND CALCULATIONS
SECTION 2: LINER CONSTRUCTION QUALITY ASSURANCE (CQA) PLAN

ATTACHMENT III.2.O

GEOTEXTILE INVENTORY CONTROL LOG

BASIN DISPOSAL, INC.

"SPECIALIZING IN DISPOSAL OF PRODUCED WATER AND DRILLING MUD"

P.O. BOX 100 - AZTEC, NEW MEXICO 87410 - PHONE: (505) 334-3013

GEOTEXTILE INVENTORY CONTROL LOG

PROJECT NUMBER: ____________________
PROJECT NAME: ____________________
OWNER: ____________________
CONTRACTOR: ____________________
PROJECT LOCATION: ____________________
SHEET NUMBER: ____________________

MATERIAL MANUFACTURER: ____________________
DATE OF INVENTORY: ____________________
PRODUCT IDENTIFICATION: ____________________
INVENTORY MONITOR: ____________________
MATERIAL TYPE: ____________________
UNLOADING METHOD: ____________________

	ROLL NUMBER	BATCH OR LOT NO.	MATERIAL DIMENSIONS			MANUF. QC CERT. Y / N	CONF. SAMP. Y / N	OTHER	REMARKS
			LENGTH (FT)	WIDTH (FT)	THICKNESS OR WEIGHT				
1									
2									
3									
4									
5									
6									
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REVIEWED BY: ____________________
DATE: ____________________

APPLICATION FOR PERMIT
BASIN DISPOSAL, INC.
OIL FIELD WASTE EVAPORATION PONDS

VOLUME III: ENGINEERING DESIGN AND CALCULATIONS
SECTION 2: LINER CONSTRUCTION QUALITY ASSURANCE (CQA) PLAN

ATTACHMENT III.2.P

LEAK DETECTION PIPE INVENTORY CONTROL LOG

BASIN DISPOSAL, INC.
"SPECIALIZING IN DISPOSAL OF PRODUCED WATER AND DRILLING MUD"
P.O. BOX 100 - AZTEC, NEW MEXICO 87410 - PHONE: (505) 334-3013

LEAK DETECTION PIPE INVENTORY CONTROL LOG

PROJECT NAME: ____________________ PROJECT NUMBER: __________
CLIENT: ____________________ CONTRACTOR: __________
PROJECT LOCATION: ____________________ SHEET NUMBER: __________

MATERIAL TYPE: ____________________ DATE OF INVENTORY: __________
MATERIAL IDENTIFICATION: ____________________ INVENTORY MONITOR: __________
MATERIAL MANUFACTURER: ____________________ UNLOADING METHOD: __________

	TYPE	QUANTITY	MATERIAL DIMENSIONS			MANUF. QC CERT. (Y/N)	TOTAL LENGTH	DATE INVENTORIED
			LENGTH (FT)	DIAM. (IN)	PIPE SDR			
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
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REVIEWED BY: __________

APPLICATION FOR MODIFICATION
BASIN DISPOSAL, INC.
OIL FIELD WASTE EVAPORATION PONDS

VOLUME III: ENGINEERING DESIGN AND CALCULATIONS
SECTION 3: GEOSYNTHETICS APPLICATION AND COMPATIBILITY DOCUMENTATION

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SECTION 3: GEOSYNTHETICS APPLICATION AND COMPATIBILITY DOCUMENTATION

1.0 SUMMARY

19.15.36.17 Specific requirements applicable to evaporation, storage, treatment, and skimmer ponds:

B. Construction, standards.

> *(3) Liner specifications. Liners shall consist of a 30-mil flexible PVC or 60-mil HDPE liner, or an equivalent liner approved by the division. Synthetic (geomembrane) liners shall have a hydraulic conductivity no greater than 1 x* 10^{-9} *cm/sec. Geomembrane liners shall be composed of an impervious, synthetic material that is resistant to petroleum hydrocarbons, salts and acidic and alkaline solutions. Liner materials shall be resistant to ultraviolet light, or the operator shall make provisions to protect the material from sunlight. Liner compatibility shall comply with EPA SW-846 method 9090A.*

Geosynthetics have a proven track record in a variety of civil engineering applications. Fluid containment construction provides a unique opportunity to incorporate a range of engineered materials that exceed the equivalent performance of soils. The design of the Basin Disposal Evaporation Ponds includes several examples of geosynthetics used for their superior characteristics, usually applied in conjunction with soil layers:

- Geomembranes (flexible membrane liners) provided as barrier layers in the primary and secondary liner.
- Geonets used as drainage layer in the leak detection system.
- Geotextiles serving as cushioning layers and as filters to maintain flow.
- The use of PVC (Polyvinyl Chloride) and HDPE (High Density Polyethylene) piping systems.

Geosynthetics are selected in the design process for their performance characteristics in the project's site-specific environmental setting. Laboratory analysis was completed on the oil field wastewater. The results of this analysis are presented in **Attachment III.3.F**. Extractable Hexane is the only constituent detected which could have a negative impact on the properties of the HDPE liner. However, at the low concentration of 48 mg/l in the wastewater, there should be no impact to the performance of the HDPE liner.

This section provides demonstrations, as required by 19.15.36.17.B, that the geosynthetic components are compatible with the fluids to be contained within the basins. The attached compatibility documentation includes published reports and test results; and is further endorsed by industry experience and proven installations by the design engineer. For the performance criteria of both soil and geosynthetic components to be achieved, they must be constructed in strict accordance with the Permit Plans (**Section 1** of this **Volume**) and the Liner Construction Quality Assurance (CQA) Plan, (**Section 2** of this **Volume**) of this Application for Modification. **Table III.3.1** is an index of compatibility data provided for each of the geosynthetic materials and its function in the engineering design.

TABLE III.3.1
GEOSYNTHETIC APPLICATIONS AND COMPATIBILITY DOCUMENTATION

MATERIAL	FUNCTION	ATTACHED REFERENCE DOCUMENTATION	
EPA	Guidance	**III.3.A**	*EPA SW-846 Method 9090A*
HDPE Geomembrane	Primary and secondary barrier layer for liner.	**III.3.B**	*Chemical Compatibility of Poly-Flex Liners*
			Chemical Resistance Table Low Density and High Density Polyethylene
			NSC, Contaminant Solutions for Industrial Waste; HDPE Geomembrane
			Poly-Flex, Inc. – Chemical Resistance
			Agru America - Geonet
Geonets	Drainage layer in LDS.	**III.3.B**	The chemical compositions of HDPE Geomembranes and Geonets are essentially identical; therefore they refer to the same compatibility document.
Geotextile	Cushion layer above geomembrane.	**III.3.C**	*Amoco Technical Note No. 7, Chemical Resistance of Amoco Polypropylene Geotextiles*
			Amoco Technical Note No. 14, Geotextile Polymers for Waste Applications
HDPE Pipe	Solid and slotted piping (LDS).	**III.5.D**	*Chemical Resistance of Plastics and Elastomers Used in Pipeline Construction*
			Driscopipe Engineering Characteristics
			Plexco Chemical Resistance Information
PVC Pipe	Solid and slotted piping (LDS).	**III.5.E**	*Certainteed - PVC Chemical Resistance*
Wastewater	Laboratory Results	**III.5.F**	*Basin Disposal Wastewater Laboratory Results*

Acronyms used:

FML: Flexible Membrane Liner
PVC: Polyvinyl Chloride
HDPE: High Density Polyethylene
LDS: Leak Detection System

APPLICATION FOR MODIFICATION
BASIN DISPOSAL, INC.
OIL FIELD WASTE EVAPORATION PONDS

VOLUME III: ENGINEERING DESIGN AND CALCULATIONS
SECTION 3: GEOSYNTHETICS APPLICATIONS AND COMPATIBILITY DOCUMENTATION

ATTACHMENT III.3.A

EPA SW-846 METHOD 9090A

METHOD 9090A

COMPATIBILITY TEST FOR WASTES AND MEMBRANE LINERS

1.0 SCOPE AND APPLICATION

1.1 Method 9090 is intended for use in determining the effects of chemicals in a surface impoundment, waste pile, or landfill on the physical properties of flexible membrane liner (FML) materials intended to contain them. Data from these tests will assist in deciding whether a given liner material is acceptable for the intended application.

2.0 SUMMARY OF METHOD

2.1 In order to estimate waste/liner compatibility, the liner material is immersed in the chemical environment for minimum periods of 120 days at room temperature (23 ± 2°C) and at 50 ± 2°C. In cases where the FML will be used in a chemical environment at elevated temperatures, the immersion testing shall be run at the elevated temperatures if they are expected to be higher than 50°C. Whenever possible, the use of longer exposure times is recommended. Comparison of measurements of the membrane's physical properties, taken periodically before and after contact with the waste fluid, is used to estimate the compatibility of the liner with the waste over time.

3.0 INTERFERENCES (Not Applicable)

4.0 APPARATUS AND MATERIALS

NOTE: In general, the following definitions will be used in this method:

1. Sample - a representative piece of the liner material proposed for use that is of sufficient size to allow for the removal of all necessary specimens.
2. Specimen - a piece of material, cut from a sample, appropriately shaped and prepared so that it is ready to use for a test.

4.1 Exposure tank - Of a size sufficient to contain the samples, with provisions for supporting the samples so that they do not touch the bottom or sides of the tank or each other, and for stirring the liquid in the tank. The tank should be compatible with the waste fluid and impermeable to any of the constituents they are intended to contain. The tank shall be equipped with a means for maintaining the solution at room temperature (23 ± 2°C) and 50 ± 2°C and for preventing evaporation of the solution (e.g., use a cover equipped with a reflux condenser, or seal the tank with a Teflon gasket and use an airtight cover). Both sides of the liner material shall be exposed to the chemical environment. The pressure inside the tank must be the same as that outside the tank. If the liner has a side that (1) is not exposed to the waste in actual use and (2) is not designed to withstand exposure to the chemical environment, then such a liner may be treated with only the barrier surface exposed.

4.2 Stress-strain machine suitable for measuring elongation, tensile strength, tear resistance, puncture resistance, modulus of elasticity, and ply adhesion.

4.3 Jig for testing puncture resistance for use with FTMS 101C, Method 2065.

4.4 Liner sample labels and holders made of materials known to be resistant to the specific wastes.

4.5 Oven at 105 ± 2°C.

4.6 Dial micrometer.

4.7 Analytical balance.

4.8 Apparatus for determining extractable content of liner materials.

NOTE: A minimum quantity of representative waste fluid necessary to conduct this test has not been specified in this method because the amount will vary depending upon the waste composition and the type of liner material. For example, certain organic waste constituents, if present in the representative waste fluid, can be absorbed by the liner material, thereby changing the concentration of the chemicals in the waste. This change in waste composition may require the waste fluid to be replaced at least monthly in order to maintain representative conditions in the waste fluid. The amount of waste fluid necessary to maintain representative waste conditions will depend on factors such as the volume of constituents absorbed by the specific liner material and the concentration of the chemical constituents in the waste.

5.0 REAGENTS (Not Applicable)

6.0 SAMPLE COLLECTION, PRESERVATION, AND HANDLING

6.1 For information on what constitutes a representative sample of the waste fluid, refer to the following guidance document:

Permit Applicants' Guidance Manual for Hazardous Waste Land Treatment,
Storage, and Disposal Facilities; Final Draft; Chap. 5, pp. 15-17;
Chap. 6, pp. 18-21; and Chap. 8, pp. 13-16, May 1984.

7.0 PROCEDURE

7.1 Obtain a representative sample of the waste fluid. If a waste sample is received in more than one container, blend thoroughly. Note any signs of stratification. If stratification exists, liner samples must be placed in each of the phases. In cases where the waste fluid is expected to stratify and the phases cannot be separated, the number of immersed samples per exposure period can be increased (e.g., if the waste fluid has two phases, then 2 samples per exposure period are needed) so that test samples exposed at each level of the waste can be tested. If the waste to be contained in the land disposal unit is in solid form, generate a synthetic leachate (see Step 7.9.1).

7.2 Perform the following tests on unexposed samples of the polymeric membrane liner material at 23 ± 2°C (see Steps 7.9.2 and 7.9.3 below for additional tests suggested for specific circumstances). Tests for tear resistance and tensile properties are to be performed according to the protocols referenced in Table 1. See Figure 1 for cutting patterns for nonreinforced liners, Figure 2 for cutting patterns for reinforced liners, and Figure 3 for cutting patterns for semicrystalline liners. (Table 2, at the end of this method, gives characteristics of various polymeric liner materials.)

1. Tear resistance, machine and transverse directions, three specimens each direction for nonreinforced liner materials only. See Table 1 for appropriate test method, the recommended test speed, and the values to be reported.

2. Puncture resistance, two specimens, FTMS 101C, Method 2065. See Figure 1, 2, or 3, as applicable, for sample cutting patterns.

3. Tensile properties, machine and transverse directions, three tensile specimens in each direction. See Table 1 for appropriate test method, the recommended test speed, and the values to be reported. See Figure 4 for tensile dumbbell cutting pattern dimensions for nonreinforced liner samples.

4. Hardness, three specimens, Duro A (Duro D if Duro A reading is greater than 80), ASTM D2240. The hardness specimen thickness for Duro A is 1/4 in., and for Duro D it is 1/8 in. The specimen dimensions are 1 in. by 1 in.

5. Elongation at break. This test is to be performed only on membrane materials that do not have a fabric or other nonelastomeric support as part of the liner.

6. Modulus of elasticity, machine and transverse directions, two specimens each direction for semicrystalline liner materials only, ASTM D882 modified Method A (see Table 1).

7. Volatiles content, SW 870, Appendix III-D.

8. Extractables content, SW 870, Appendix III-E.

9. Specific gravity, three specimens, ASTM D792 Method A.

10. Ply adhesion, machine and transverse directions, two specimens each direction for fabric reinforced liner materials only, ASTM D413 Machine Method, Type A -- 180 degree peel.

11. Hydrostatic resistance test, ASTM D751 Method A, Procedure 1.

7.3 For each test condition, cut five pieces of the lining material of a size to fit the sample holder, or at least 8 in. by 10 in. The fifth sample is an extra sample. Inspect all samples for flaws and discard unsatisfactory ones. Liner materials with fabric reinforcement require close inspection to ensure that threads of the samples are evenly spaced and straight at 90°.

Samples containing a fiber scrim support may be flood-coated along the exposed edges with a solution recommended by the liner manufacturer, or another procedure should be used to prevent the scrim from being directly exposed. The flood-coating solution will typically contain 5-15% solids dissolved in a solvent. The solids content can be the liner formula or the base polymer.

Measure the following:

1. Gauge thickness, in. -- average of the four corners.
2. Mass, lb. -- to one-hundredth of a lb.
3. Length, in. -- average of the lengths of the two sides plus the length measured through the liner center.
4. Width, in. -- average of the widths of the two ends plus the width measured through the liner center.

<u>NOTE</u>: Do not cut these liner samples into the test specimen shapes shown in Figure 1, 2, or 3 at this time. Test specimens will be cut as specified in Step 7.7, <u>after</u> exposure to the waste fluid.

7.4 Label the liner samples (<u>e.g.</u>, notch or use metal staples to identify the sample) and hang in the waste fluid by a wire hanger or a weight. Different liner materials should be immersed in separate tanks to avoid exchange of plasticizers and soluble constituents when plasticized membranes are being tested. Expose the liner samples to the stirred waste fluid held at room temperature and at 50 ± 2°C.

7.5 At the end of 30, 60, 90, and 120 days of exposure, remove one liner sample from each test condition to determine the membrane's physical properties (see Steps 7.6 and 7.7). Allow the liner sample to cool in the waste fluid until the waste fluid has a stable room temperature. Wipe off as much waste as possible and rinse briefly with water. Place wet sample in a labeled polyethylene bag or aluminum foil to prevent the sample from drying out. The liner sample should be tested as soon as possible after removal from the waste fluid at room temperature, but in no case later than 24 hours after removal.

7.6 To test the immersed sample, wipe off any remaining waste and rinse with deionized water. Blot sample dry and measure the following as in Step 7.3:

1. Gauge thickness, in.
2. Mass, lb.
3. Length, in.
4. Width, in.

7.7 Perform the following tests on the exposed samples (see Steps 7.9.2 and 7.9.3 below for additional tests suggested for specific circumstances). Tests for tear resistance and tensile properties are to be performed according to the protocols referenced in Table 1. Die-cut test specimens following suggested cutting patterns. See Figure 1 for cutting patterns for nonreinforced liners, Figure 2 for cutting patterns for reinforced liners, and Figure 3 for semicrystalline liners.

1. Tear resistance, machine and transverse directions, three specimens each direction for materials without fabric reinforcement. See Table 1 for appropriate test method, the recommended test specimen and speed of test, and the values to be reported.

2. Puncture resistance, two specimens, FTMS 101C, Method 2065. See Figure 1, 2, or 3, as applicable, for sample cutting patterns.

3. Tensile properties, machine and transverse directions, three specimens each direction. See Table 1 for appropriate test method, the recommended test specimen and speed of test, and the values to be reported. See Figure 4 for tensile dumbbell cutting pattern dimensions for nonreinforced liner samples.

4. Hardness, three specimens, Duro A (Duro D if Duro A reading is greater than 80), ASTM 2240. The hardness specimen thickness for Duro A is 1/4 in., and for Duro D is 1/8 in. The specimen dimensions are 1 in. by 1 in.

5. Elongation at break. This test is to be performed only on membrane materials that do not have a fabric or other nonelastomeric support as part of the liner.

6. Modulus of elasticity, machine and transverse directions, two specimens each direction for semicrystalline liner materials only, ASTM D882 modified Method A (see Table 1).

7. Volatiles content, SW 870, Appendix III-D.

8. Extractables content, SW 870, Appendix III-E.

9. Ply adhesion, machine and transverse directions, two specimens each direction for fabric reinforced liner materials only, ASTM D413 Machine Method, Type A -- 180 degree peel.

10. Hydrostatic resistance test, ASTM D751 Method A, Procedure 1.

7.8 Results and reporting

7.8.1 Plot the curve for each property over the time period 0 to 120 days and display the spread in data points.

7.8.2 Report all raw, tabulated, and plotted data. Recommended methods for collecting and presenting information are described in the documents listed under Step 6.1 and in related agency guidance manuals.

7.8.3 Summarize the raw test results as follows:

1. Percent change in thickness.

2. Percent change in mass.

3. Percent change in area (provide length and width dimensions).

4. Percent retention of physical properties.

5. Change, in points, of hardness reading.

6. The modulus of elasticity calculated in pounds-force per square inch.

7. Percent volatiles of unexposed and exposed liner material.

8. Percent extractables of unexposed and exposed liner material.

9. The adhesion value, determined in accordance with ASTM D413, Step 12.2.

10. The pressure and time elapsed at the first appearance of water through the flexible membrane liner for the hydrostatic resistance test.

7.9 The following additional procedures are suggested in specific situations:

7.9.1 For the generation of a synthetic leachate, the Agency suggests the use of the Toxicity Characteristic Leaching Procedure (TCLP) that was finalized in the Federal Register on June 29, 1990, Vol. 55, No. 126, p. 26986.

7.9.2 For semicrystalline membrane liners, the Agency suggests the determination of the potential for environmental stress cracking. The test that can be used to make this determination is either ASTM D1693 or the National Institute of Standards and Technology Constant Tensile Load. The evaluation of the results should be provided by an expert in this field.

7.9.3 For field seams, the Agency suggests the determination of seam strength in shear and peel modes. To determine seam strength in peel mode, the test ASTM D413 can be used. To determine seam strength in shear mode for nonreinforced FMLs, the test ASTM D3083 can be used, and for reinforced FMLs, the test ASTM D751, Grab Method, can be used at a speed of 12 in. per minute. The evaluation of the results should be provided by an expert in this field.

8.0 QUALITY CONTROL

8.1 Determine the mechanical properties of identical nonimmersed and immersed liner samples in accordance with the standard methods for the specific physical property test. Conduct mechanical property tests on nonimmersed and immersed liner samples prepared from the same sample or lot of material in the same manner and run under identical conditions. Test liner samples immediately after they are removed from the room temperature test solution.

9.0 METHOD PERFORMANCE

9.1 No data provided.

10.0 REFERENCES

1. None required.

Table 1. Physical testing of exposed membranes in liner-waste liquid compatibility test

Type of compound and construction	Crosslinked or vulcanized	Thermoplastic	Semicrystalline	Fabric-reinforced[a]
Tensile properties method	ASTM D412	ASTM D638	ASTM D638	ASTM D751, Method B
Type of specimen	Dumbbell[b]	Dumbbell[b]	Dumbbell[b]	1-in. wide strip and 2-in. jaw separation
Number of specimens	3 in each direction	3 in each direction	3 in each direction	3 in each direction
Speed of test	20 ipm	20 ipm	2 ipm	12 ipm
Values to be reported	Tensile strength, psi Elongation at break, % Tensile set after break, % Stress at 100 and 200% elongation, psi	Tensile strength, psi Elongation at break, % Tensile set after break, % Stress at 100 and 200% elongation, psi	Tensile strength at yield, psi Elongation at yield, % Tensile set at break, psi Elongation at break, psi Tensile set after break, % Stress at 100 and 200% elongation, psi	Tensile at fabric break, ppi Elongation at fabric break, % Tensile at ultimate break, ppi Elongation at ultimate break, ppi Tensile set after break, % Stress at 100 and 200% elongation, psi
Modulus of elasticity method	c	c	ASTM D882, Method A	c
Type of specimen	—	—	Strip: 0.5 in. wide and 6. in long at a 2 in. jaw separation	—
Number of specimens	—	—	2 in each direction	—
Speed of test	—	—	0.2 ipm	—
Values reported	—	—	Greatest slope of initial stress - strain curve, psi	—
Tear resistance method	ASTM D624	ASTM 1004	ASTM D1004	d
Type of specimen	Die C	e	e	—
Number of specimens	3 in each direction	3 in each direction	2 in each direction	—
Speed of test	20 ipm	20 ipm	2 ipm	—
Values reported	Stress, ppi	Stress, ppi	Maximum stress, ppi	—
Puncture resistance method	FTMS 101C, Method 2065	FTMS 101C, Method 2065	FTMS 101C, Method 2065	FTMS 101C, Method 2065
Type of specimen	2 in. square	2 in. square	2 in. square	2 in. square
Number of specimens	2	2	2	2
Speed of test	20 ipm	20 ipm	20 ipm	20 ipm
Values reported	Gage, mil Stress, 1[b] Elongation, in.	Gage, mil Stress, 1[b] Elongation, in.	Gage, mil Stress, 1[b] Elongation, in.	Gage, mil Stress, 1[b] Elongation, in.

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[a] Can be thermoplastic, crosslinked, or vulcanized membrane.

[b] See Figure 4.

[c] Not performed on this material.

[d] No tear resistance test is recommended for fabric-reinforced sheetings in the immersion study.

[e] Same as ASTM D624, Die C.

TABLE 2.
POLYMERS USED IN FLEXIBLE MEMBRANE LINERS

Thermoplastic Materials (TP)

CPE (Chlorinated polyethylene)[a]

A family of polymers produced by a chemical reaction of chlorine on polyethylene. The resulting thermoplastic elastomers contain 25 to 45% chlorine by weight and 0 to 25% crystallinity.

CSPE (Chlorosulfonated polyethylene)[a]

A family of polymers that are produced by the reaction of polyethylene with chlorine and sulfur dioxide, usually containing 25 to 43% chlorine and 1.0 to 1.4% sulfur. Chlorosulfonated polyethylene is also known as hypalon.

EIA (Ethylene interpolymer alloy)[a]

A blend of EVA and polyvinyl chloride resulting in a thermoplastic elastomer.

PVC (Polyvinyl chloride)[a]

A synthetic thermoplastic polymer made by polymerizing vinyl chloride monomer or vinyl chloride/vinyl acetate monomers. Normally rigid and containing 50% of plasticizers.

PVC-CPE (Polyvinyl chloride - chlorinated polyethylene alloy)[a]

A blend of polyvinyl chloride and chlorinated polyethylene.

TN-PVC (Thermoplastic nitrile-polyvinyl chloride)[a]

An alloy of thermoplastic unvulcanized nitrile rubber and polyvinyl chloride.

Vulcanized Materials (XL)

Butyl rubber[a]

A synthetic rubber based on isobutylene and a small amount of isoprene to provide sites for vulcanization.

---

[a] Also supplied reinforced with fabric.

TABLE 2. (Continued)

EPDM (Ethylene propylene diene monomer)[a,b]

A synthetic elastomer based on ethylene, propylene, and a small amount of nonconjugated diene to provide sites for vulcanization.

CM (Cross-linked chlorinated polyethylene)

No definition available by EPA.

CO, ECO (Epichlorohydrin polymers)[a]

Synthetic rubber, including two epichlorohydrin-based elastomers that are saturated, high-molecular-weight aliphatic polyethers with chloromethyl side chains. The two types include homopolymer (CO) and a copolymer of epichlorohydrin and ethylene oxide (ECO).

CR (Polychloroprene)[a]

Generic name for a synthetic rubber based primarily on chlorobutadiene. Polychloroprene is also known as neoprene.

Semicrystalline Materials (CX)

HDPE - (High-density polyethylene)

A polymer prepared by the low-pressure polymerization of ethylene as the principal monomer.

HDPE - A (High-density polyethylene/rubber alloy)

A blend of high-density polyethylene and rubber.

LLDPE (Liner low-density polyethylene)

A low-density polyethylene produced by the copolymerization of ethylene with various alpha olefins in the presence of suitable catalysts.

PEL (Polyester elastomer)

A segmented thermoplastic copolyester elastomer containing recurring long-chain ester units derived from dicarboxylic acids and long-chain glycols and short-chain ester units derived from dicarboxylic acids and low-molecular-weight diols.

---

[a] Also supplied reinforced with fabric.
[b] Also supplied as a thermoplastic.

TABLE 2. (Continued)

PE-EP-A (Polyethylene ethylene/propylene alloy)

A blend of polyethylene and ethylene and propylene polymer resulting in a thermoplastic elastomer.

T-EPDM (Thermoplastic EPDM)

An ethylene-propylene diene monomer blend resulting in a thermoplastic elastomer.

FIGURE 1. SUGGESTED PATTERN FOR CUTTING TEST SPECIMENS FROM NONREINFORCED CROSSLINKED OR THERMOPLASTIC IMMERSED LINER SAMPLES.

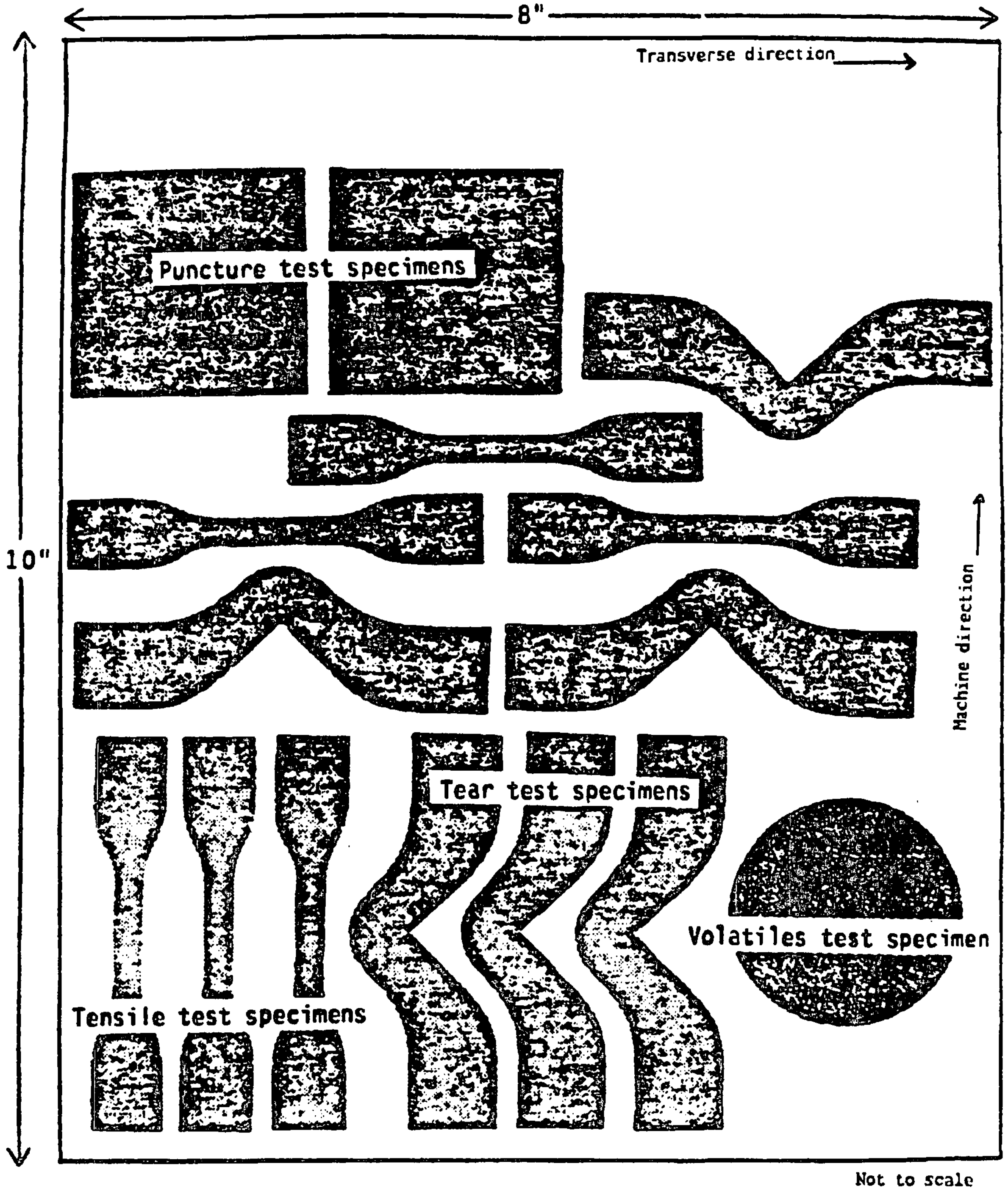


FIGURE 2. SUGGESTED PATTERN FOR CUTTING TEST SPECIMENS FROM FABRIC REINFORCED IMMERSED LINER SAMPLES.

NOTE: TO AVOID EDGE EFFECTS, CUT SPECIMENS
1/8 - 1/4 INCH IN FROM EDGE OF IMMERSED SAMPLE.

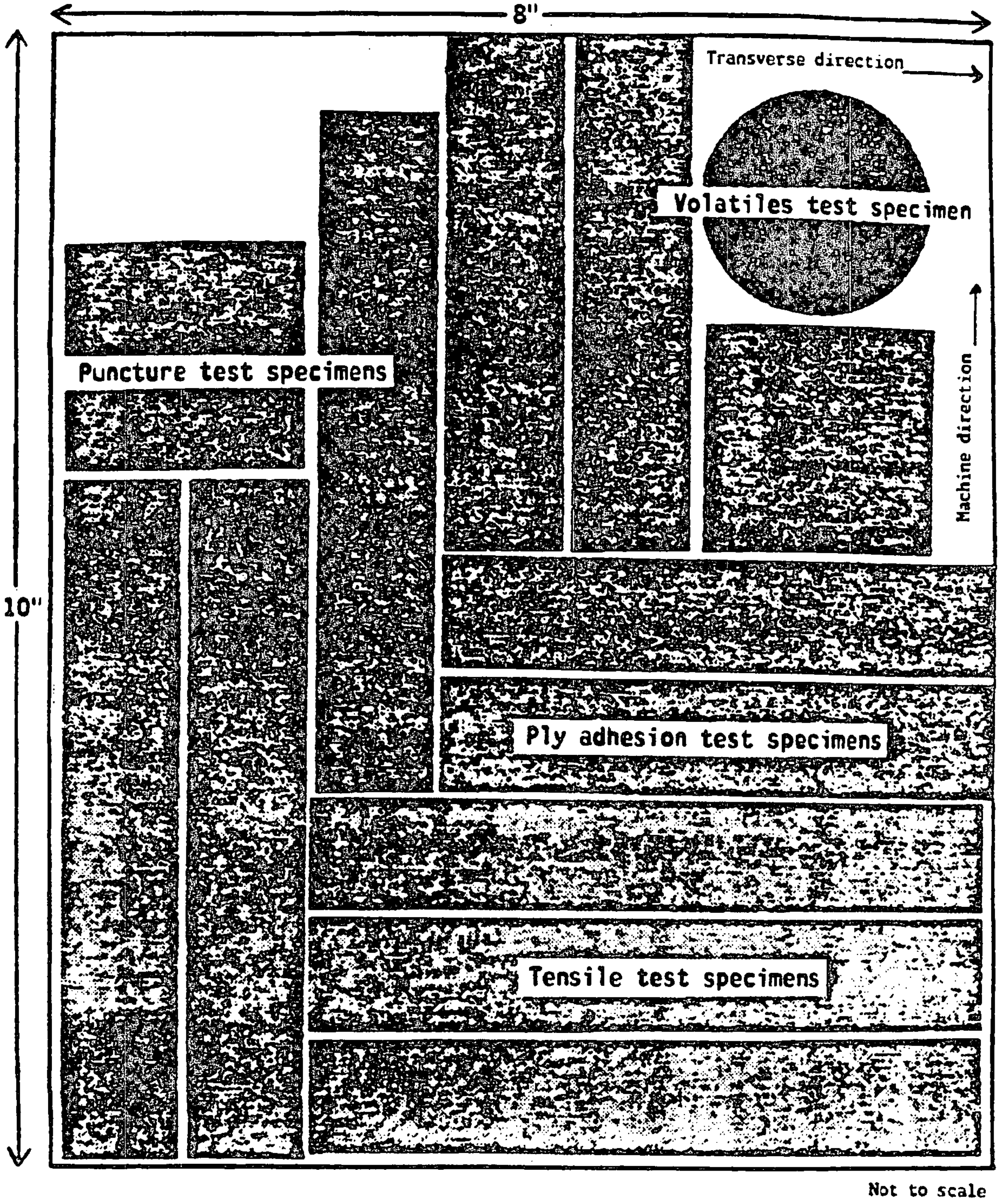


FIGURE 3. SUGGESTED PATTERN FOR CUTTING TEST SPECIMENS FROM SEMICRYSTALLINE IMMERSED LINER SAMPLES.

NOTE: TO AVOID EDGE EFFECTS, CUT SPECIMENS 1/8 TO 1/4 INCH IN FROM EDGE OF IMMERSED SAMPLE.

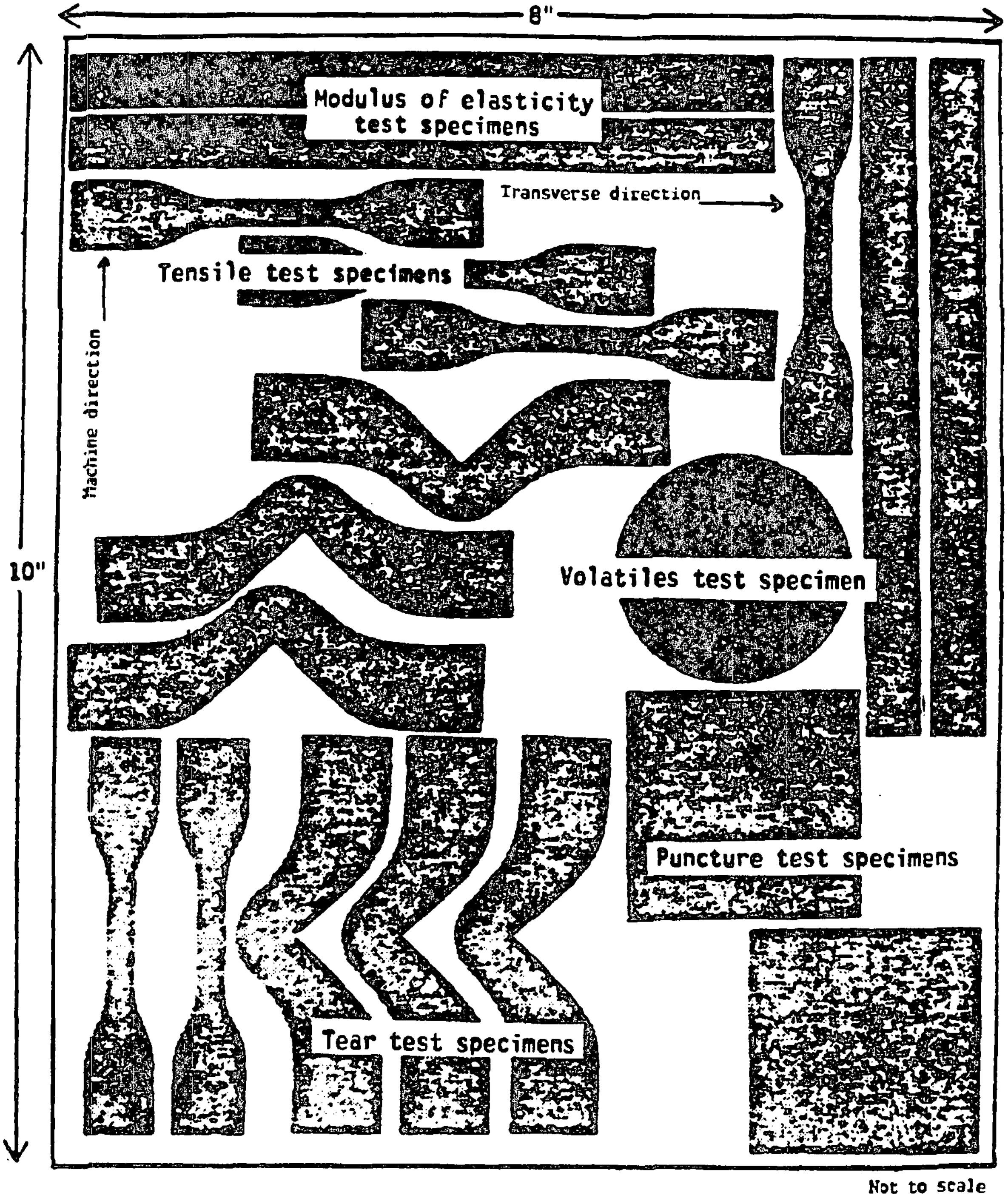
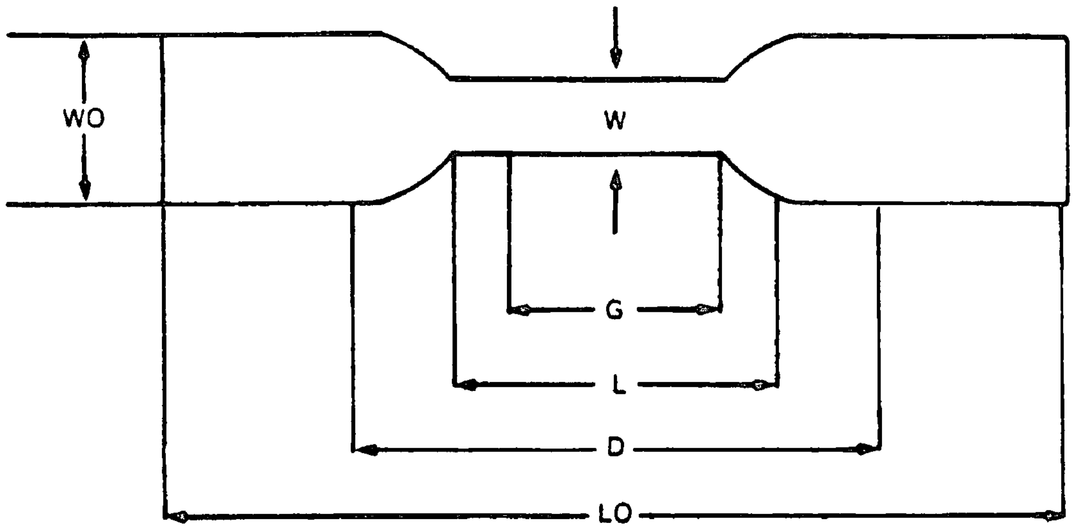
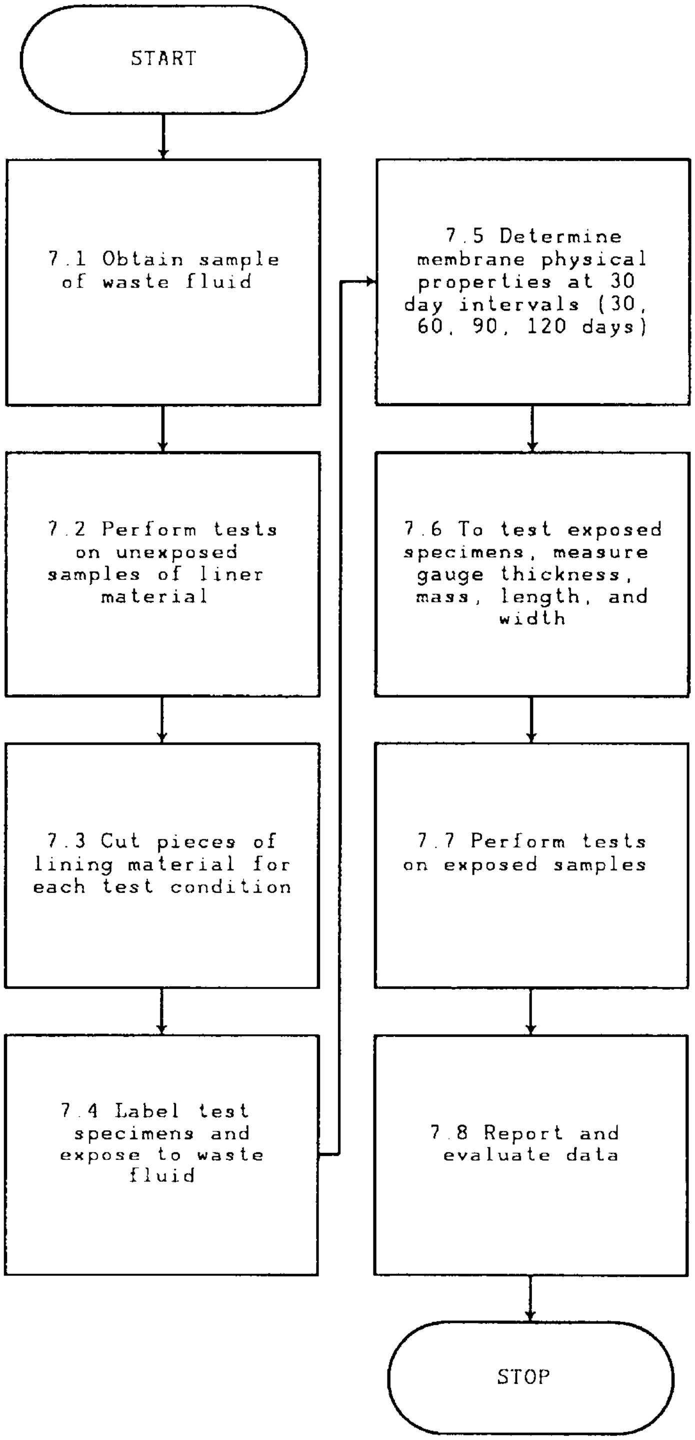


FIGURE 4. DIE FOR TENSILE DUMBBELL (NONREINFORCED LINERS) HAVING THE FOLLOWING DIMENSIONS:



W	- Width of narrow section	0.25	inches
L	- Length of narrow section	1.25	inches
WO	- Width overall	0.625	inches
LO	- Length overall	3.50	inches
G	- Gage length	1.00	inches
D	- Distance between gaps	2.00	inches

METHOD 9090
COMPATIBILITY TEST FOR WASTES AND MEMBRANE LINERS



APPLICATION FOR MODIFICATION
BASIN DISPOSAL, INC.
OIL FIELD WASTE EVAPORATION PONDS

VOLUME III: ENGINEERING DESIGN AND CALCULATIONS
SECTION 3: GEOSYNTHETICS APPLICATIONS AND COMPATIBILITY DOCUMENTATION

ATTACHMENT III.3.B

HDPE GEOMEMBRANES AND GEONETS REFERENCE DOCUMENTATION

CHEMICAL COMPATIBILITY OF POLY-FLEX LINERS

Chemical compatibility or resistance as applied to geomembranes is a relative term. Actually compatibility would mean that one material will dissolve in the other such as alcohol in water or grease in gasoline. An example of incompatibility would be oil and water. In liners it is undesirable to have the chemicals dissolve in the liner hence the term compatibility is the reverse of what is normally meant in the chemical industry. In the strictest sense and from a laboratory prospective, chemical compatibility, as the term applies to this industry, would imply that the chemical has no effect on the liner. On the other hand, from an engineering prospective, chemical compatibility means that a liner will survive the exposure to a given chemical even though the chemical could have some effect on the performance of the liner, but not enough to cause failure. Therefore, one must understand and define chemical compatibility for a specific project.

Generally polyethylene will be effected by chemicals in one of three ways.

1. No effect—This means that the chemical in question and the polyethylene do not interact. The polyethylene does not gain (lose) weight, swell, and the physical properties are not significantly altered.
2. Oxidizes (cross linking)—Chemicals classed as oxidizing agents will cause the polyethylene molecules to cross link and cause irreversible changes to the physical properties of the liner. Basically it makes the liner brittle.
3. Plasticizes—Chemicals in this classification are soluble in the polyethylene structure. They do not change the structure of the polyethylene itself but will act as a plasticizer. In doing so, the liner will experience weight gain of 3-15%, may swell by up to 10%, and will have measurable changes in physical properties (i.e. the tensile strength at yield may decrease by up to 20%). Even under these conditions the liner will maintain its integrity and will not be breached by liquids, provided the liner has not been subjected to any stress. These effects are reversible once the chemicals are removed and the liner has time to dry out.

Aside from the effect that chemicals have on a liner is the issue of vapor permeation through the liner. Vapor permeation is molecular diffusion of chemicals through the liner. Vapor transmission for a given chemical is dependent primarily on liner type, contact time, chemical solubility, temperature, thickness, and concentration gradient, but not on hydraulic head or pressure. Transmission through the liner can occur in as little as 1-2 days. Normally, a small amount of chemical is transmitted. Generally HDPE has the lowest permeation rate of the liners that are commercially available.

As stated above chemical compatibility is a relative term. For example, the use of HDPE as a primary containment of chlorinated hydrocarbons at a concentration of 100% may not be recommended, but it may be acceptable at 0.1% concentration for a limited time period or may be acceptable for secondary containment. Factors that go into assessment of chemical compatibility are type of chemical(s), concentration, temperature and the type of application. No hard and fast rules are available to make decisions on chemical compatibility. Even the EPA 9090 test is just a method to generate data so that an opinion on chemical compatibility can be more reliably reached.

A simplified table on chemical resistance is provided to act as a screening process for chemical containment applications.

CHEMICAL RESISTANCE INFORMATION

CHEMICAL CLASS	CHEMICAL EFFECT	PRIMARY CONTAINMENT (LONG TERM CONTACT) HDPE	PRIMARY CONTAINMENT (LONG TERM CONTACT) LLDPE	SECONDARY CONTAINMENT (SHORT TERM CONTACT) HDPE	SECONDARY CONTAINMENT (SHORT TERM CONTACT) LLDPE
CARBOXYLIC ACID	1				
- Unsubstituted (e.g. Acetic acid)		B	C	A	C
- Substituted (e.g. Lactic acid)		A	B	A	A
- Aromatic (e.g. Benzoic acid)		A	B	A	A
ALDEHYDES	3				
- Aliphatic (e.g. Acetaldehyde)		B	C	B	C
- Hetrocyclic (e.g. Furfural)		C	C	B	C
AMINE	3				
- Primary (e.g. Ethylamine)		B	C	B	C
- Secondary (e.g. Diethylamine)		C	C	B	C
- Aromatic (e.g. Aniline)		B	C	B	C
CYANIDES (e.g. Sodium Cyanide)	1	A	A	A	A
ESTER (e.g. Ethyl acetate)	3	B	C	B	C
ETHER (e.g. Ethyl ether)		C	C	B	C
HYDROCARBONS	3				
- Aliphatic (e.g. Hexane)		C	C	B	C
- Aromatic (e.g. Benzene)		C	C	B	C
- Mixed (e.g. Crude oil)		C	C	B	C
HALOGENATED HYDROCARBONS	3				
- Aliphatic (e.g. Dichloroethane) +A4		C	C	B	C
- Aromatic (e.g. Chlorobenzene)		C	C	B	C
ALCOHOLS	1				
- Aliphatic (e.g. Ethyl alcohol)		A	A	A	A
- Aromatic (e.g. Phenol)		A	C	A	B
INORGANIC ACID					
- Non-Oxidizers (e.g. Hydrocloric acid)	1	A	A	A	A
- Oxidizers (e.g. Nitric Acid)	2	C	C	B	C
INORGANIC BASES (e.g. Sodium hydroxide)	1	A	A	A	A
SALTS (e.g. Calcium chloride)	1	A	A	A	A
METALS (e.g. Cadmium)	1	A	A	A	A
KETONES (e.g. Methyl ethyl ketone)	3	C	C	B	C
OXIDIZERS (e.g. Hydrogen Peroxide)	2	C	C	C	C

Chemical effect (see discussion on Chemical Resistance)

1. No Effect--Most chemicals of this class have no or minor effect.
2. Oxidizer--Chemicals of this class will cause irreversible degradaton.

3. Plasticizer--Chemicals of this class will cause a reversible change in physical properties.

Chart Rating

A. Most chemicals of this class have little or no effect on the liner.
Recommended regardless of concentration or temperature (below 150° F).

B. Chemicals of this class will effect the liner to various degrees.
Recommendations are based on the specific chemical, concentration and temperature.
Consult with Poly-Flex, Inc.

C. Chemicals of this class at high concentrations will have significant effect on the physical properties of the liner.
Generally not recommended but may be acceptable at low concentrations and with special design considerations.
Consult with Poly-Flex, Inc.

This data is provided for informational purposes only and is not intended as a warranty or guarantee. Poly-Flex, Inc. assumes no responsibility in connection with the use of this data. Consult with Poly-Flex, Inc. for specific chemical resistance information and liner selection.

CHEMICAL COMPATIBILITY OF POLY-FLEX LINERS

Chemical compatibility or resistance, as applied to geomembranes, is a relative term. Actual compatibility would mean that one material dissolves in the other such as alcohol in water or grease in gasoline. An example of incompatibility would be oil and water. In liners it is undesirable to have the chemicals dissolve in the liner, hence the term compatibility is the reverse of what is normally meant in the chemical industry. In the strictest sense and from a laboratory perspective, chemical compatibility, as the term applies to this industry, would imply that the chemical has no effect on the liner. On the other hand, from an engineering perspective, chemical compatibility means that a liner survives the exposure to a given chemical even though the chemical could have some effect on the performance of the liner, but not enough to cause failure. Therefore, one must understand and define chemical compatibility for a specific project.

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A simplified table on chemical resistance is provided to act as a screening process for chemical containment applications.

CHEMICAL RESISTANCE INFORMATION

CHEMICAL CLASS	CHEMICAL EFFECT	PRIMARY CONTAINMENT (LONG TERM CONTACT)		SECONDARY CONTAINMENT (SHORT TERM CONTACT)	
		HDPE	LLDPE	HDPE	LLDPE
CARBOXYLIC ACID	1				
- Unsubstituted (e.g. Acetic acid)		B	C	A	C
- Substituted (e.g. Lactic acid)		A	B	A	A
- Aromatic (e.g. Benzoic Acid)		A	B	A	A
ALDEHYDES	3				
- Aliphatic (e.g. Acetaldehyde)		B	C	B	C
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- Primary (e.g. Ethylamine)		B	C	B	C
- Secondary (e.g. Diethylamine)		C	C	B	C
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ESTER (e.g. Ethyl acetate)	3	B	C	B	C
ETHER (e.g. Ethyl ether)		C	C	B	C
HYDROCARBONS	3				
- Aliphatic (e.g. Hexane)		C	C	B	C
- Aromatic (e.g. Benzene)		C	C	B	C
- Mixed (e.g. Crude oil)		C	C	B	C
HALOGENATED HYDROCARBONS	3				
- Aliphatic (e.g. Dichloroethane) +A4		C	C	B	C
- Aromatic (e.g. Chlorobenzene)		C	C	B	C
ALCOHOLS	1				
- Aliphatic (e.g. Ethyl alcohol)		A	A	A	A
- Aromatic (e.g. Phenol)		A	C	A	B
INORGANIC ACID					
- Non-oxidizers (e.g. Hydrochloric acid)	1	A	A	A	A
- Oxidizers (e.g. Nitric Acid)	2	C	C	B	C
INORGANIC BASES (e.g. Sodium hydroxide)	1	A	A	A	A
SALTS (e.g. Calcium chloride)	1	A	A	A	A
METALS (e.g. Cadmium)	1	A	A	A	A
KETONES (e.g. Methyl ethyl ketone)	3	C	C	B	C
OXIDIZERS (e.g. Hydrogen peroxide)	2	C	C	C	C

Chemical Effect (see discussion on Chemical Resistance)

1. No Effect—Most chemicals of this class have no or minor effect.
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Recommended regardless of concentration or temperature (below 150° F).

B. Chemicals of this class will affect the liner to various degrees.
Recommendations are based on the specific chemical, concentration and temperature.
Consult with Poly-Flex, Inc.

C. Chemicals of this class at high concentrations will have significant effect on the physical properties of the liner.
Generally not recommended but may be acceptable at low concentrations and with special design considerations.
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Chemicals Resistance Table
Low Density and High Density Polyethylene

INTRODUCTION

The table in this document summarises the data given in a number of chemical resistance tables at present in use in various countries, derived from both practical experience and test results.

Source: ISO/TR 7472, 7474; Carlowitz: "Kunststofftabellen-3. Auflage".

The table contains an evaluation of the chemical resistance of a number of fluids judged to be either aggressive or not towards low and high density polyethylene. This evaluation is based on values obtained by immersion of low and high density polyethylene test specimens in the fluid concerned at 20 and 60°C and atmospheric pressure, followed in certain cases by the determination of tensile characteristics.

A subsequent classification will be established with respect to a restricted number of fluids deemed to be technically or commercially more important, using equipment which permits testing under pressure and the determination of the ìcoefficient of chemical resistanceî for each fluid. These tests will thus furnish more complete indications on the use of low and high density polyethylene products for the transport of stated fluids, including their use under pressure.

SCOPE AND FIELD APPLICATION

This document establishes a provisional classification of the chemical resistance of low and high density polyethylene with respect to about 300 fluids. It is intended to provide general guidelines on the possible utilisation of low and high density polyethylene:

- at temperatures up to 20 och 60°C
- in the absence of internal pressure and external mechanical stress (for example flexural stresses, stresses due to thrust, rolling loads etc).

DEFINITIONS, SYMBOLS AND ABBREVIATIONS

The criteria of classification, definitions, symbols and abbreviations adopted in this document are as follows:

S = Satisfactory

The chemical resistance of low or high density polyethylene exposed to the action of a fluid is classified as "satisfactory" when the results of test are acknowledged to be ìsatisfactoryî by the majority of the countries participating in the evaluation.

L = Limited

The chemical resistance of low or high density polyethylene exposed to the action of a fluid is classified as "limited" when the results of tests are acknowledged to be "limited" by the majority of the countries participating in the evaluation.

Also classified as "limited" are the resistance to the action of chemical fluids for which judgements "S" and "NS" or "L" are pronounced to an equal extent.

NS = Not satisfactory

The chemical resistance of low or high density polyethylene exposed to the action of a fluid is classified as "not satisfactory" when the results of tests are acknowledged to be "not satisfactory" by the majority of the countries participating in the evaluation.

Also classified as "not satisfactory" are materials for which judgements "L" and "NS" are pronounced to an equal extent.

Sat.sol	Saturated aqueous solution, prepared at 20°C
Sol	Aqueous solution at a concentration higher than 10 %, but not saturated
Dil.sol	Dilute aqueous solution at a concentration equel to or lower than 10 %
Work.sol	Aqueous solution having the usual concentration for industrial use

Solution concentrations reported in the text are expressed as a percentage by mass.
The aqueous solutions of sparingly soluble chemicals are considered, as far as chemical action towards low or high density polyethylene is concerned, as saturated solutions.

In general, common chemical names are used in this document.

The table is made as a first guideline for user of polyethylene. If a chemical compound is not to be found or if there is an uncertainty on the chemical resistance in an application, please contact Borealis for advise and proposal on testing.

Chemical resistance of low density and high density polyethylene, not subjected to mechanical stress, to various fluids at 20 and 60°C

Chemical or product	Concentration	LD	°C	HD	°C
		20	60	20	60
Acetaldehyde	100 %	L	NS	S	L
Acetanilide	–			S	S
Acetic acid	10 %	S	S	S	S
Acetic acid	60 %	S	L	S	S
Acetic acid, glacial	Greater than 96 %	L	NS	S	L
Acetic anhydride	100 %	L	NS	S	L
Acetone	100 %	L	NS	L	L
Acrylnitrile	–	S	S	S	S
Acetylsilicacid	–	S	S	S	S
Adipic acid	Sat.sol	S	S	S	S
After shave	–	NS	NS	NS	NS
Aliphatic hydocarbons	–	L	NS	L	L
Allyl acetate	–	S	L	S	L
Allyl alcohol	100 %	L	NS	–	–
Allyl alcohol	96 %	–	–	S	S
Allyl chloride	–	L	NS	L	NS
Aluminium chloride	Sat.sol	S	S	S	S
Aluminium fluoride	Sat.sol	S	S	S	S
Aluminium hydroxide	Sat.sol	S	S	S	S
Aluminium nitrate	Sat.sol	S	S	S	S
Aluminium oxychloride	Sat.sol	S	S	S	S
Al/potassium sulphate	Sat.sol	S	S	S	S
Aluminium sulphate	Sat.sol	S	S	S	S
Alums	Sol	S	S	S	S
Aminobenzoic acid	–	S	S	S	S
Ammonia, dry gas	100 %	S	S	S	S
Ammonia, liquid	100 %	L	L	S	S
Ammonia, aqueous	Dil.sol	S	S	S	S
Ammonium acetate	–	S	S	S	S
Ammonium carbonate	Sat.sol	S	S	S	S
Ammonium chloride	Sat.sol	S	S	S	S
Ammonium fluoride	Sol	S	–	S	S
Ammonium hexafluorosilicate	Sat.sol	S	S	S	S
Ammonium hydrogen carbonate	Sat.sol	S	S	S	S
Ammonium hydroxide	10 %	S	S	S	S
Ammonium hydroxide	30 %	S	S	S	S

Chemical or product	Concentration	LD	°C	HD	°C
		20	60	20	60
Ammonium metaphosphate	Sat.sol	S	S	S	S
Ammonium nitrate	Sat.sol	S	S	S	S
Ammonium oxalate	Sat.sol	S	S	S	S
Ammonium phosphate	Sat.sol	S	S	S	S
Ammonium persulphate	Sat.sol	S	S	S	S
Ammonium sulphate	Sat.sol	S	S	S	S
Ammonium sulphide	Sol	S	S	S	S
Ammonium thiocyanate	Sat.sol	S	S	S	S
Amyl acetate	100 %	NS	NS	L	L
Amyl alcohol	100 %	L	L	S	L
Amyl chloride	100 %	NS	NS	–	–
Amyl phthalate	–	L	L	S	L
Aniline	100 %	NS	NS	S	L
Anilinchlorohydrate	–	L	–	–	–
Antimony (III) chloride	90 %	–	–	S	S
Antimony (III) chloride	Sat.sol	S	S	S	S
Antimony trichloride	Sol	S	S	S	S
Apple juice	Sol	–	–	S	L
Aqua regia	$HCl/HNO_3 = 3/1$	NS	NS	NS	NS
Aromaitic hydrocarbons	–	NS	NS	NS	NS
Arsenic acid	Sat.sol	S	S	S	S
Asorbic acid	10 %	S	S	S	S
Barium bromide	Sat.sol	S	S	S	S
Barium carbonate	Sat.sol	S	S	S	S
Barium chloride	Sat.sol	S	S	S	S
Barium hydroxide	Sat.sol	S	S	S	S
Barium sulphate	Sat.sol	S	S	S	S
Barium sulphide	Sat.sol	S	S	S	S
Beer	–	S	S	S	S
Benzaldehyde	100 %	L	NS	S	L
Benzene	100 %	NS	NS	L	L
Benzoic acid	Sat.sol	S	S	S	S
Benzoylchloride	–	S	L	S	L
Benzyl alcohol	–	S	L	S	S
Benzylsulphonic acid	10 %	S	S	S	S
Bismuth carbonate	Sat.sol	S	S	S	S
Bitumen	–	S	L	S	S
Bleach lye	10 %	S	S	S	S

Chemical or product	Concentration	LD	°C	HD	°C
		20	60	20	60
Borax	Sat.sol	S	S	S	S
Boric acid	Sat.sol	S	S	S	S
Boron trifluoride	–	L	NS	L	NS
Brake fluid	–	L	NS	L	NS
Brine	–	S	S	S	S
Bromine, dry gas	100 %	NS	NS	NS	NS
Bromine, liquid	100 %	NS	NS	NS	NS
Bromoform	100 %	NS	NS	NS	NS
Butandiol	10 %	S	S	S	S
Butandiol	60 %	S	S	S	S
Butandiol	100 %	S	S	S	S
Butane, gas	100 %	–	–	S	S
Butanol	100 %	S	L	S	S
Butter	–	S	S	S	S
Butyl acetate	100 %	S	L	S	L
Butyl alcohol	100 %	S	S	S	S
Butyl chloride	–	S	–	S	–
Butylene glycol	10 %	S	S	S	S
Butylene glycol	60 %	S	S	S	S
Butylene glycol	100 %	S	S	S	S
Butyraldehyde	–	–	–	S	L
Butyric acid	100 %	L	L	S	L
Calcium arsenate	–	S	S	S	S
Calcium benzoate	–	S	S	S	S
Calcium bisulphide	–	S	S	S	S
Calcium bromate	10 %	S	S	S	S
Calcium bromide	Sat.sol	S	S	S	S
Calcium carbonate	Sat.sol	S	S	S	S
Calcium chlorate	Sat.sol	S	S	S	S
Calcium chloride	Sat.sol	S	S	S	S
Calcium chromate	40 %	S	S	S	S
Calcium cyanide	–	S	S	S	S
Calcium hydrosulphide	Sol	S	S	S	S
Calcium hydroxide	Sat.sol	S	S	S	S
Calcium hypochlorite	Sol	S	S	S	S
Calcium nitrate	Sat.sol	S	S	S	S
Calcium oxide	Sat.sol	S	S	S	S
Calcium perchlorate	1 %	S	–	S	S

Chemical or product	Concentration	LD	°C	HD	°C
		20	60	20	60
Calcium permanganate	20 %	S	S	S	S
Calcium persulphate	Sol	S	S	S	S
Calcium sulphate	Sat.sol	S	S	S	S
Calcium sulphide	Dil.sol	–	–	L	L
Camphor oil	–	NS	NS	L	L
Carbon dioxide, dry gas	100 %	–	–	S	S
Carbon dioxide, wet	–	S	S	S	S
Carbon disulphide	100 %	NS	NS	L	NS
Carbon monoxide	100 %	S	S	S	S
Carbon tetrachloride	100 %	NS	NS	L	NS
Carbonic acid		S	S	S	S
Castor oil	Sol	S	S	S	S
Chlorine, water	2 % Sat.sol	L	L	S	S
Chlorine, aqueous	Sat.sol	NS	NS	L	NS
Chlorine, dry gas	100 %	NS	NS	L	NS
Chloroacetic acid	Sol	–	–	S	S
Chlorobenzene	100 %	NS	NS	NS	NS
Chloroethanol	100 %	S	S	S	S
Chloroform	100 %	NS	NS	NS	NS
Chloromethane, gas	100 %	L	–	L	–
Chlorosulphonic acid	100 %	NS	NS	NS	NS
Chloropropene	–	NS	–	L	–
Chrome alum	Sol	S	S	S	S
Chromic acid	Sat.sol	S	S	–	–
Chromic acid	20 %	–	–	S	L
Chromic acid	50 %	–	–	S	L
Chromium VI oxide	Sat.sol	S	S	S	S
Cider	–	S	S	S	S
Citric acid	Sat.sol	S	S	S	S
Citric acid	10 %	S	S	S	S
Citric acid	25 %	S	S	S	S
Coconut oil alcoholic	–	S	S	S	S
Coffee	–	S	S	S	S
Copper (II) chloride	Sat.sol	S	S	S	S
Copper cyanide	Sat.sol	S	S	S	S
Copper (II) fluoride	Sat.sol	S	S	S	S
Copper (II) fluoride	2 %	S	S	S	S
Copper (II) nitrate	Sat.sol	S	S	S	S
Copper (II) sulphate	Sat.sol	S	S	S	S

Chemical or product	Concentration	LD	°C	HD	°C
		20	60	20	60
Corn oil	–	S	S	S	S
Cottonseed oil	–	S	S	S	S
Cresylic acid	Sat.sol	–	–	L	–
Crotonaldehyde	Sat.sol	L	–	–	–
Cyclanone	–	S	S	S	S
Cyclohexane	–	NS	NS	NS	NS
Cyclohexanol	Sat.sol	L	NS	–	–
Cyclohexanol	100 %	–	–	S	S
Cyclohexanone	100 %	NS	NS	S	L
Decahydronaphthalene	100 %	L	NS	S	L
Decane	–	NS	NS	L	NS
Decalin	100 %	–	–	S	L
Detergents, synthetic	–	S	S	S	S
Developers (photographic)	Work.conc	–	–	S	S
Dextrin	Sol	S	S	S	S
Dextrose	Sol	S	S	S	S
Diacetone alcohol	–	L	L	L	L
Diazo salts	–	S	S	S	S
Dibutyl amine	–	NS	NS	L	NS
Dibuthyl ether	–	NS	NS	L	–
Dibutylphthalate	–	L	L	S	L
Dichlorobenzene	–	NS	NS	NS	NS
Dichloroethylene	–	NS	NS	NS	NS
Dichloropropylene	–	NS	NS	NS	NS
Diesel oil	–	S	NS	S	L
Diethyl ether	100 %	NS	NS	L	–
Diethyl ketone	–	L	NS	L	L
Diethylene glycol	–	S	S	S	S
Diglycolic acid	–	S	S	S	S
Diisobutylketone	100 %	S	L	S	L
Dimethyl amine	100 %	NS	NS	–	–
Dimethyl formamid	–	S	L	S	S
Dioctyl phthalate	100 %	L	NS	S	L
Dioxan	100 %	–	–	S	S
Dipentene	–	NS	NS	NS	NS
Disodium phosphate	–	S	S	S	S
Drano, plumbing cleaner	–	S	S	S	S

Chemical or product	**Concentration**	**LD**	**°C**	**HD**	**°C**
		20	**60**	**20**	**60**
Emulsions, photographic	–	S	S	S	S
Ethandiol	100 %	S	S	S	S
Ethanol	40 %	S	L	S	L
Ethanol	96 %	L	L	–	–
Ethyl acetate	100 %	L	NS	S	NS
Ethyl acrylate	100 %	NS	NS	L	NS
Ethyl alcohol	35 %	S	S	S	S
Ethyl alcohol	100 %	S	S	S	S
Ethyl benzene	–	NS	NS	NS	NS
Ethyl chloride	100 %	NS	NS	NS	NS
Ethylene chloride	100 %	NS	NS	NS	NS
Ethylene diamine	100 %	S	L	S	S
Ethyl ether	–	NS	NS	NS	NS
Ethylene glycol	100 %	S	S	S	S
Ethyl mercaptan	–	NS	NS	NS	NS
Ferric chloride	Sat.sol	S	S	S	S
Ferric nitrate	Sat.sol	S	S	S	S
Ferric sulphate	Sat.sol	S	S	S	S
Ferrous chloride	Sat.sol	S	S	S	S
Ferrous sulphate	Sat.sol	S	S	S	S
Fish solubles	Sol	S	S	S	S
Fluoboric acid	–	S	S	S	S
Fluorine gas	100 %	L	NS	NS	NS
Fluorine gas, dry	100 %	NS	NS	NS	NS
Fluorine gas, wet	100 %	NS	NS	NS	NS
Fluorosilic acid	Conc	S	L	S	L
Fluorosilic acid	40 %	S	S	S	S
Formaldehyde	40 %	S	S	S	S
Formic acid	40 %	S	S	S	S
Formic acid	98 to 100 %	S	S	S	S
Fructose	Sat.sol	S	S	S	S
Fruit pulps	Sol	S	S	S	S
Furfural	100 %	NS	NS	NS	NS
Furfuryl alcohol	100 %	L	NS	S	L
Gallic acid	Sat.sol	S	S	S	S
Gasoline, petrol	–	L	NS	L	L
Gelatine	–	S	S	S	S

Chemical or product	Concentration	LD	°C	HD	°C
		20	60	20	60
Glucose	Sat.sol	S	S	S	S
Glycerine	100 %	S	S	S	S
Glycerol	100 %	S	S	S	S
Glycolic acid	30 %	S	L	–	–
Glycolic acid	Sol	–	–	S	S
n-Heptane	100 %	NS	NS	L	NS
Hexachlorobenzene	–	S	S	S	L
Hexachlorophene	–	NS	NS	L	L
Hexamethylenetriamine	40 %	S	–	S	–
Hexane	–	S	L	S	L
Hexanol, tertiary	–	S	S	S	S
Hydrobromic acid	50 %	S	S	S	S
Hydrobromic acid	Up to 100 %	S	S	S	S
Hydrochloric acid	Up to 36 %	S	S	S	S
Hydrochloric acid	Conc	S	S	S	S
Hydrochlorous acid	Conc	S	S	S	S
Hydrocyanic acid	10 %	S	S	S	S
Hydrocyanic acid	Sat.sol	S	S	S	S
Hydrofluoric acid	40 %	S	S	S	S
Hydrofluoric acid	60 %	S	L	S	L
Hydrogen	100 %	S	S	S	S
Hydrogen chloride	Dry gas	S	S	S	S
Hydrogen peroxide	30 %	S	L	S	S
Hydrogen peroxide	90 %	S	NS	S	NS
Hydrogen sulphide gas	100 %	S	S	S	S
Hydroquinone	Sat.sol	S	S	–	–
Hydroxylamine	up to 12 %	S	S	S	S
Inks	–	S	S	S	S
Iodine (in potassium sol)	–	L	NS	NS	NS
Iodine (in alcohol)	–	NS	NS	NS	NS
Iron (II) chloride	Sat.sol	S	S	S	S
Iron (II) sulphate	Sat.sol	S	S	S	S
Iron (III) chloride	Sat.sol	S	S	S	S
Iron (III) nitrate	Sol	S	S	S	S
Iron (III) sulphate	Sat.sol	S	S	S	S
Iso octane	100 %	S	NS	S	L
Iso pentane	–	NS	NS	NS	NS

Chemical or product	Concentration	LD °C 20	LD °C 60	HD °C 20	HD °C 60
Isopropanol	–	S	S	S	S
Isopropyl amine	–	NS	NS	NS	NS
Isopropyl ether	100 %	L	NS	S	NS
Kerosene	–	NS	NS	NS	NS
Lactic acid	10 %	S	S	S	S
Lactic acid	28 %	S	S	S	S
Lactic acid	up to 100 %	S	S	S	S
Latex	–	S	S	S	S
Lead acetate	Dil.sol	S	S	S	S
Lead acetate	Sat.sol	S	S	S	S
Lead arsenate	–	S	S	S	S
Lubricating oil	–	S	S	S	S
Lysol	–	NS	NS	L	NS
Magnesium carbonate	Sat.sol	S	S	S	S
Magnesium chloride	Sat.sol	S	S	S	S
Magnesium hydroxide	Sat.sol	S	S	S	S
Magnesium nitrate	Sat.sol	S	S	S	S
Magnesium sulphate	Sat.sol	S	S	S	S
Maleic acid	Sat.sol	S	S	S	S
Mercury	–	S	S	S	S
Mercury (I) nitrate	Sol	S	S	S	S
Mercury (II) chloride	Sat.sol	S	S	S	S
Mecury (II) cyanide	Sat.sol	S	S	S	S
Mercury	100 %	S	S	S	S
Methanol	100 %	S	L	S	S
Methyl alcohol	100 %	S	L	S	S
Methyl benzoic acid	Sat.sol	NS	NS	L	–
Methyl bromide	100 %	NS	NS	NS	NS
Methyl chloride	100 %	NS	NS	NS	NS
Methylcyclohexane	–	L	NS	L	NS
Methyl ethyl ketone	100 %	–	–	S	L
Methylene chloride	–	NS	NS	NS	NS
Methoxybutanol	100 %	S	L	S	L
Milk	–	S	S	S	S
Milk of Magnesia	–	S	L	S	L
Mineral oils	–	L	NS	S	L

Chemical or product	Concentration	LD	°C	HD	°C
		20	60	20	60
Molasses	Work.conc	S	S	S	S
Motor oil	–	S	L	S	S
Naphtha	–	L	NS	L	NS
Naphtahalene	–	NS	NS	L	–
Nickel chloride	Sat.sol	S	S	S	S
Nickel nitrate	Sat.sol	S	S	S	S
Nickel sulphate	Sat.sol	S	S	S	–
Nicotine	Dil.sol	S	S	S	S
Nicotinic acid	Dil.sol	L	L	S	–
Nitric acid	25 %	S	S	S	S
Nitric acid	50 %	S	L	S	L
Nitric acid	70 %	S	L	S	L
Nitric acid	95 %	NS	NS	NS	NS
Nitric acid	100 %	NS	NS	NS	NS
Nitrobenzene	100 %	NS	NS	NS	NS
Nitroethane	100 %	S	NS	S	NS
Nitromethane	100 %	S	–	S	–
Nitrotoluene	–	NS	NS	NS	NS
n-Octane	–	S	S	S	S
Octyl alcohol	–	S	NS	S	NS
Oil and fats		L	NS	S	L
Oleic acid	100 %	L	NS	S	S
Oleum (H2SO4 + 10 % SO3)		NS	NS	NS	NS
Oleum (H2SO4 + 50 % SO3)		NS	NS	NS	NS
Olive oil	–	S	NS	S	NS
Orthophosphoric acid	50 %	S	S	S	S
Orthophosphoric acid	95 %	S	L	S	L
Oxalic acid	Sat.sol	S	S	S	S
Oxygen	100 %	S	–	S	L
Ozone	100 %	NS	NS	L	NS
Paraffin oil	–	S	L	S	S
n-Pentane	–	NS	NS	NS	NS
Pentane-2	–	NS	NS	NS	NS
Perchloric acid	20 %	S	S	S	S
Perchloric acid	50 %	S	L	S	L
Perchloric acid	70 %	S	NS	S	NS

Chemical or product	**Concentration**	**LD**	**°C**	**HD**	**°C**
		20	60	20	60
Perchloroethylene	–	NS	NS	NS	NS
Phenol	Sol	L	NS	S	S
Phosphine	100 %	S	S	S	S
Phosphoric acid	up to 25 %	S	S	S	S
Phosphoric acid	25 to 50 %	S	S	S	S
Phosphoric (III) chloride	100 %	S	L	S	L
Phosphorous (II) chloride	100 %	–	–	S	L
Phosphorous pentoxide	100 %	S	S	S	S
Phosphorous trichloride	100 %	S	L	S	L
Photographic solutions	–	S	S	S	S
Phtalic acid	50 %	S	S	S	S
Picric acid	Sat.sol	S	L	S	–
Plating solutions	–	S	S	S	S
Potassium acetate	–	S	S	S	S
Potassium aluminium sulphate	Sat.sol	S	S	S	S
Potassium benzoate	–	S	S	S	S
Potassium bicarbonate	Sat.sol	S	S	S	S
Potassium borate	Sat.sol	S	S	S	S
Potassium bromate	Sat.sol	S	S	S	S
Potassium bromide	Sat.sol	S	S	S	S
Potassium carbonate	Sat.sol	S	S	S	S
Potassium chlorate	Sat.sol	S	S	S	S
Potassium chloride	Sat.sol	S	S	S	S
Potassium chromate	Sat.sol	S	S	S	S
Potassium cyanide	Sol	S	S	S	S
Potassium dichromate	Sat.sol	S	S	S	S
Potassium fluoride	Sat.sol	S	S	S	S
Potassium hexacyanoferrate (III)	Sat.sol	S	S	S	S
Potassium hexacyanoferrate (II)	Sat.sol	S	S	S	S
Potassium hexafluorosilicate	Sat.sol	S	S	S	S
Potassium hydrogen carbonate	Sat.sol	S	S	S	S
Potassium hydrogen sulphate	Sat.sol	S	S	S	S
Potassium hydrogen sulphide	Sol	–	–	S	S
Potassium hydroxide	10 %	S	S	S	S
Potassium hydroxide	Sol	S	S	S	S
Potassium hypochlorite	Sol	S	L	S	L
Potassium iodate	10 %	S	S	S	S
Potassium iodide	Sat.sol	S	S	S	S
Potassium nitrate	Sat.sol	S	S	S	S

Chemical or product	Concentration	LD	°C	HD	°C
		20	60	20	60
Potassium orthophosphate	Sat.sol	S	S	S	S
Potassium oxalate	Sat.sol	S	S	S	S
Potassium perchlorate	Sat.sol	S	S	S	S
Potassium permanganate	20 %	S	S	S	S
Potassium persulphate	Sat.sol	S	S	S	S
Potassium phosphate	Sat.sol	S	S	S	S
Potassium sulphate	Sat.sol	S	S	S	S
Potassium sulphide	Sol	S	S	S	S
Potassium sulphite	Sat.sol	S	S	–	–
Potassium thiocyanate	Sat.sol	S	S	S	S
Potassium thiosulphate	Sat.sol	S	S	S	S
Propargul alcohol	–	S	S	S	S
n-Propyl alcohol	–	S	S	S	S
Propionic acid	50 %	–	–	S	S
Propionic acid	100 %	–	–	S	L
Propylene dichloride	100 %	NS	NS	NS	NS
Propylene glycol	–	S	S	S	S
Pyridine	100 %	–	–	S	L
Quinol (hydroquinone)	Sat.sol	S	S	S	S
Resorcinol	Sat.sol	S	S	S	S
Salicylic acid	Sat.sol	S	S	S	S
Sea water	–	S	S	S	S
Selenic acid	–	S	S	S	S
Silicon oil	–	S	S	S	S
Silver acetate	Sat.sol	S	S	S	S
Silver cyanide	Sat.sol	S	S	S	S
Silver nitrate	Sat.sol	S	S	–	–
Soap solution	100 %	S	S	S	S
Sodium acetate	Sat.sol	S	S	–	–
Sodium antimonate	Sat.sol	S	S	S	S
Sodium arsenite	Sat.sol	S	S	S	S
Sodium benzoate	Sat.sol	S	S	S	S
Sodium bicarbonate	Sat.sol	S	S	S	S
Sodium bisulphate	Sat.sol	S	S	S	S
Sodium bisulphite	Sat.sol	S	S	S	S
Sodium borate	–	S	S	S	S
Sodium bromide	Sat.sol	S	S	S	S
Sodium carbonate	Sat.sol	S	S	S	S

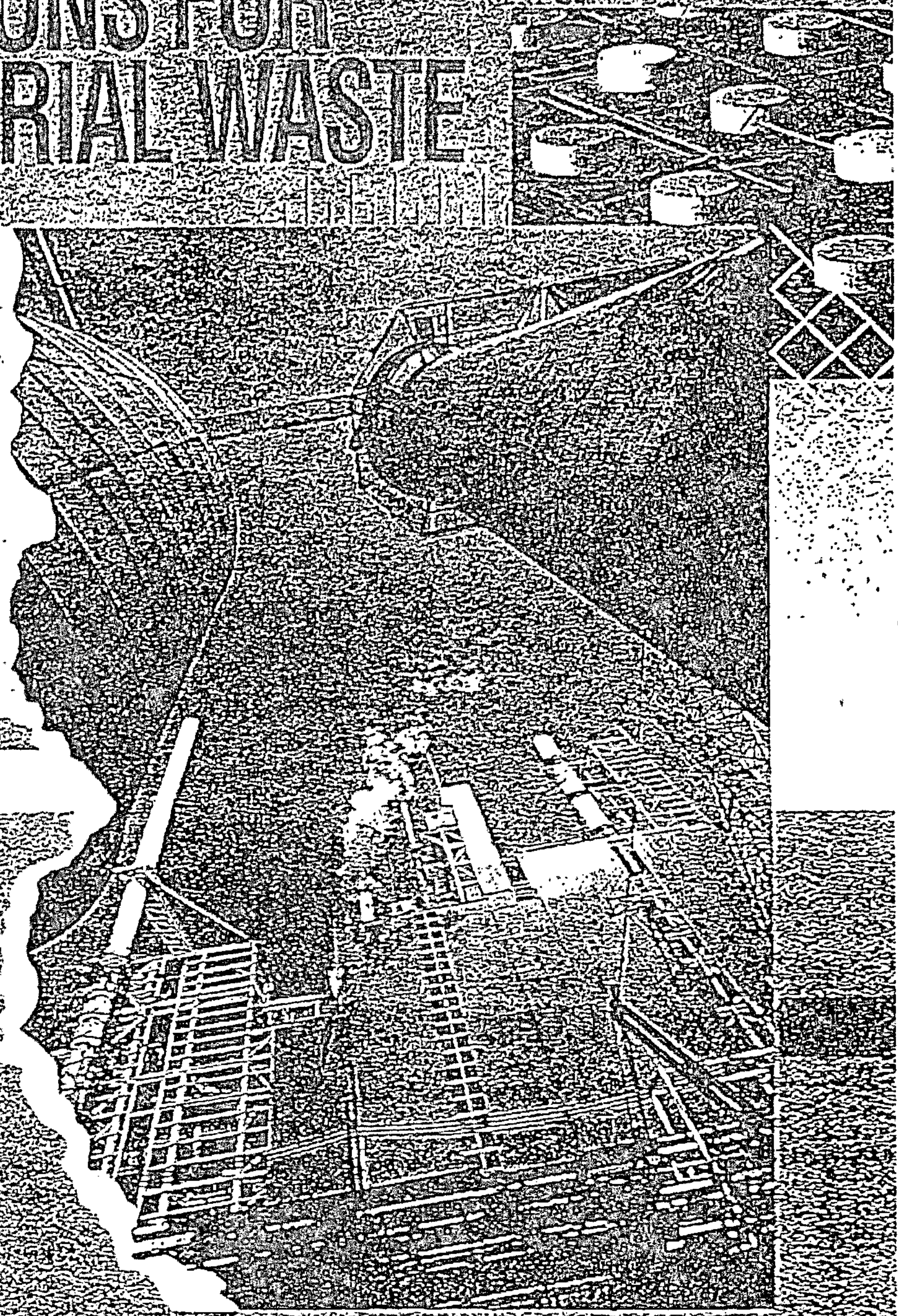
Chemical or product	Concentration	LD	°C	HD	°C
		20	60	20	60
Sodium chlorate	Sat.sol	S	S	S	S
Sodium chloride	Sat.sol	S	S	S	S
Sodium chlorite	Sat.sol	L	–	–	–
Sodium cyanide	Sat.sol	S	S	S	S
Sodium dichromate	Sat.sol	S	S	S	S
Sodium fluoride	Sat.sol	S	S	S	S
Sodium hexacyanoferrate (III)	Sat.sol	–	–	S	S
Sodium hexacyanoferrate (II)	Sat.sol	–	–	S	S
Sodium hexafluorosilicate	Sat.sol	S	S	S	S
Sodium hydrogen carbonate	Sat.sol	S	S	S	S
Sodium hydrogen sulphate	Sat.sol	S	S	S	S
Sodium hydrogen sulphite	Sol	S	S	S	S
Sodium hydroxide	40 %	S	S	S	S
Sodium hydroxide	Sol	–	–	S	S
Sodium hypochloride	–	L	NS	S	S
Sodium hypochlorite	15 %	–	–	S	S
	available Cl	–	–	S	S
Sodium iodate	10 %	S	S	S	S
Sodium iodide	Sat.sol	S	S	S	S
Sodium nitrate	Sat.sol	S	S	S	S
Sodium nitrite	Sat.sol	S	S	S	S
Sodium ortophosphate	Sat.sol	S	S	S	S
Sodium oxalate	Sat.sol	S	S	S	S
Sodium phosphate	Sat.sol	S	S	S	S
Sodium silicate	Sol	S	S	S	S
Sodium sulphate	Sat.sol	S	S	S	S
Sodium sulphide	Sat.sol	S	S	S	S
Sodium sulphite	Sat.sol	S	S	S	S
Sodium thiocyanate	Sat.sol	S	S	S	S
Stannic chloride	Sat.sol	S	S	S	S
Stannous chloride	Sat.sol	S	S	S	S
Starch solution	Sat.sol	S	S	S	S
Stearic acid	Sat.sol	S	L	S	–
Styrene	Sol	L	NS	L	NS
Sulphur dioxide, dry	100 %	S	S	S	S
Sulphur trioxide	100 %	NS	NS	NS	NS
Sulphur acid	10 to 50 %	S	S	S	S
Sulphuric acid	10 %	S	S	S	S
Sulphuric acid	50 %	S	S	S	S

Chemical or product	**Concentration**	**LD**	**°C**	**HD**	**°C**
		20	60	20	60
Sulphuric acid	70 %	S	L	S	L
Sulphuric acid	80 %	S	NS	S	NS
Sulphuric acid	98 %	L	NS	S	NS
Sulphuric acid	Fuming	NS	NS	NS	NS
Sulphurous acid	30 %	S	S	S	S
Sulphurous acid	Sol	S	S	S	S
Tallow	–	S	L	S	L
Tannic acid	Sol	S	S	S	S
Tartaric acid	Sat.sol	S	S	S	S
Tartaric acid	Sol	–	–	S	S
Tetrachloroethylene	100 %	NS	NS	NS	NS
Tetrachloromethane	100 %	NS	NS	L	NS
Tetradecane		NS	NS	NS	NS
Tetrahydrofuran	–	NS	NS	NS	NS
Tetrahydronaphthalene	100 %	L	NS	S	L
Thionyl chloride	100 %	NS	NS	NS	NS
Tin (II) chloride	Sat.sol	S	S	S	S
Tin (IV) chloride	Sol	S	S	S	S
Tin (IV) chloride	Sat.sol	–	–	S	S
Titanium tetrachloride	Sat.sol	NS	NS	NS	NS
Toluene	100 %	NS	NS	L	NS
Tribromomethane	–	NS	NS	NS	NS
Trichloroacetaldehyde	–	S	–	S	–
Trichlorobenzene	–	NS	NS	–	–
Trichloroethylene	100 %	NS	NS	NS	NS
Triethanolamine	100 %	S	–	S	–
Triethanolamine	Sol	–	–	S	L
Triethylene glycol	–	S	S	S	S
Trisodium phosphate	Sat.sol	S	S	–	–
Turpentine	–	NS	NS	NS	NS
Urea	up to 30 %	S	S	S	S
Urea	Sol	S	S	S	S
Urine	-	S	S	S	S
Vanilla extract	–	S	S	S	S
Vaseline	–	S	L	S	S
Vegetables oils		S	L	S	S
Vinegar		S	S	S	S
Water		S	S	S	S
Wetting agents	–	S	S	S	S
Wines and spirits		S	S	S	S
Chemical or product	**Concentration**	**LD**	**°C**	**HD**	**°C**
		20	60	20	60

Xylene	100 %	NS	NS	L	NS
Yeast	Sol	S	S	S	S
Zinc bromide	Sat.sol	S	S	S	S
Zinc carbonate	Sat.sol	–	–	S	S
Zinc chloride	Sat.sol	S	S	S	S
Zinc oxide	Sat.sol	S	S	S	S
Zinc stearate	–	S	S	S	S
Zinc sulphate	Sat.sol	S	S	S	S
o-Zylene		NS	NS	NS	NS
p-Zylene	–	NS	NS	NS	NS

CONTAINMENT SOLUTIONS FOR INDUSTRIAL WASTE

Dike raising
Sludge caps
Sludge ponds
Secondary containment
Landfill linings
Landfill caps
Floating covers



NSC

NSC

HIGH DENSITY POLYETHYLENE (HDPE) GEOMEMBRANE

Over the past five years, the geomembrane industry has experienced numerous changes. Factors such as the increased concern for the environment; new products in the marketplace; and the push for tighter governmental control over the environment have all played a significant role in revolutionizing the geosynthetic industry.

Today, the most widely used geomembrane in the waste management industry is High Density Polyethylene (HDPE). HDPE offers superior performance by maintaining the highest standards of durability.

FEATURES AND BENEFITS

National Seal Company's HDPE geomembrane is manufactured on a computer controlled, flat sheet extruder using virgin, first quality, high molecular weight polyethylene. This process guarantees a material thickness of ±5% from target, the most stringent quality control available in the industry. NSC also guarantees the minimum average thickness of our liner will be greater than or equal to the nominal thickness. HDPE is available in 40 (1.0mm), 50 (1.25mm), 60 (1.5mm), 80 (2.0mm), and 100 (2.5mm) mil thicknesses.

Chemical Resistance - Often the chemical resistance of the liner is the most critical aspect of the design process. HDPE is the most chemically resistant of all geomembranes. Typical landfill leachates pose no threat to a liner made of HDPE.

Low Permeability - The low permeability of HDPE provides assurance that groundwater will not penetrate the liner; rainwater will not infiltrate a cap; and methane gas will not migrate away from the gas venting system.

Ultraviolet Resistance - HDPE has excellent resistance to ultraviolet degradation. NSC adds carbon black which provides UV protection. Plasticizers are never used in NSC's geomembranes so there is never a concern about volatilization of the plasticizer which can be caused by UV exposure.

APPLICATIONS:

Landfill (primary and secondary containment)
Landfill caps
Lagoon liners
Pond liners
Floating covers
Secondary containment for above ground storage tanks

Retention ponds for mining applications
Wastewater treatment facilities
Potable water reservoirs
Tank linings
Canal linings
Heap leach pads

HDPE GEOMEMBRANE
PHYSICAL PROPERTIES
60 mil

The properties on this page are not part of NSC's Manufacturing Quality Control program and are not included on the material certifications. Seam testing is the responsibility of the installer and/or CQA personnel.

PROPERTIES	METHOD	UNITS	MINIMUM[1]	TYPICAL
Multi-Axial Tensile Elongation	GRI, GM-4	percent	20.0	28.0
Critical Cone Height	GRI, GM-3, NSC mod.	cm	1.0	1.5
Wide Width Tensile	ASTM D 4885			
Stress at Yield		psi	2000	2110
Strain at Yield		%	15.0	20.0
Brittleness Temp. by Impact[2]	ASTM D 746	°C	-75	<-90
Coef. of Linear Thermal Exp.[2]	ASTM D 696	$°C^{-1}$	1.5×10^{-4}	1.2×10^{-4}
ESCR, Bent Strip	ASTM D 1693	hours	1500	>10,000
Hydrostatic Resistance	ASTM D 751	psi	450	510
Modulus of Elasticity	ASTM D 638	psi	80,000	135,000
Ozone Resistance	ASTM D 1149, 168 hrs	P/F	P	P
Permeability[2]	ASTM E 96	cm/sec · Pa	2.3×10^{-14}	8.1×10^{-15}
Puncture Resistance	FTMS 101, method 2065	ppi	1300	1700
		lbs	78	105
Soil Burial Resistance[2]	ASTM D 3083, NSF mod.	% change	10	0
Tensile Impact	ASTM D 1822	ft lbs/in²	250	420
Volatile Loss[2]	ASTM D 1203, A	percent	0.10	0.06
Water Absorption[2]	ASTM D 570, 23°C	percent	0.10	0.04
Water Vapor Transmission[2]	ASTM E 96	g/day · m²	0.024	0.009

SEAM PROPERTIES	METHOD	UNITS	MINIMUM[1]	TYPICAL
Shear Strength	ASTM D 4437, NSF mod.	psi	2000	2700
		ppi	120	166
Peel Strength (hot wedge fusion)	ASTM D 4437, NSF mod.	psi	1500	1870
		ppi	90	115
Peel Strength (fillet extrusion)	ASTM D 4437, NSF mod.	psi	1300	1590
		ppi	76	98

STANDARD ROLL DIMENSIONS

Length	1110 feet	Area	16,650 ft²
Width	15 feet	Weight	5,000 lbs

This information contained herein has been compiled by National Seal Company and is, to the best of our knowledge, true and accurate. All suggestions and recommendations are offered without guarantee. Final determination of suitability for use based on any information provided, is the sole responsibility of the user. There is no implied or expressed warranty of merchantability of fitness of the product for the contemplated use.

NSC reserves the right to update the information contained herein in accordance with technological advances in the material properties.

6H-0893

HDPE GEOMEMBRANE
QUALITY CONTROL SPECIFICATIONS

60 mil

National Seal Company's High Density Polyethylene (HDPE) Geomembranes are produced from virgin, first quality, high molecular weight resins and are manufactured specifically for containment in hydraulic structures. NSC HDPE geomembranes have been formulated to be chemically resistant, free of leachable additives and resistant to ultraviolet degradation.

The following properties are tested as a part of NSC's quality control program. Certified test results for properties on this page are available upon request. Refer to NSC's Quality Control Manual for exact test methods and frequencies.

All properties meet or exceed NSF Standard Number 54.

RESIN PROPERTIES	METHOD	UNITS	MINIMUM[1]	TYPICAL
Melt Flow Index[2]	ASTM D 1238	g/10 min	0.50	0.25
Oxidative Induction Time	ASTM D 3895, Al pan, 200°C, 1 atm O_2	minutes	100	120

SHEET PROPERTIES	METHOD	UNITS	MINIMUM[1]	TYPICAL
Thickness	ASTM D 751, NSF mod.			
Average		mils	60.0	61.5
Individual		mils	57.0	59.7
Density	ASTM D 1505	g/cm^3	0.940	0.948
Carbon Black Content	ASTM D 1603	percent	2.0-3.0	2.35
Carbon Black Dispersion	ASTM D 3015, NSF mod.	rating	A1, A2, B1	A1
Tensile Properties	ASTM D 638			
Stress at Yield		psi	2200	2550
		ppi	132	157
Stress at Break		psi	3800	4850
		ppi	228	293
Strain at Yield	1.3" gage length (NSF)	percent	13.0	16.9
Strain at Break	2.0" gage or extensometer	percent	700	890
	2.5" gage length (NSF)	percent	560	710
Dimensional Stability[2]	ASTM D 1204, NSF mod.	percent	1.5	0.4
Tear Resistance	ASTM D 1004	ppi	750	860
		lbs	45	53
Puncture Resistance	ASTM D 4833	ppi	1800	2130
		lbs	108	131
Constant Load ESCR, Single Point	GRI, GM-5a	hours	200	> 400

[1] This value represents the minimum acceptable test value for a roll as tested according to NSC's Manufacturing Quality Control Manual. Individual test specimen values are not addressed in this specification except thickness.

[2] Indicates Maximum Value

NSC

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POLY-FLEX, INC.
Geomembrane Lining Systems

PRODUCTS

Product Listing
- **HDPE Liner**
- **LLDPE Liner**
- **Textured Liner**
- **Drainage Net**
- **Geocomposite**
- **Embed Channel**

Quote Request Form

DRAINAGE NET

Poly-Flex drainage nets are composed of two bonded, overlapping HDPE strands that form diamond shaped openings. The drainage nets are manufactured to allow planar flow of fluids along the plane of the net. This is accomplished by creating open channels along the net that allow flow. Poly-Flex drainage nets exhibit excellent chemical resistance and can replace one or more feet of conventional drainage aggregate. As with all Poly-Flex products, the Poly-Flex Manufacturing Quality Control and Quality Assurance Program ensures that only the highest quality products represent the Poly-Flex name. (Please refer to the QA/QC Manual located under the Technical section of this web site.) For more information, call our technical support staff at 888-765-9359. Or, request a quote by clicking here.

Features:

Cost Effective - Poly-Flex drainage nets can replace one or more feet of conventional aggregate drainage, increasing space within the landfill, allowing for additional revenue generation.

Versatility - Poly-Flex drainage nets can be installed on steep slopes or against vertical walls where conventional drainage aggregates cannot be used.

Chemical Resistance - Poly-Flex drainage nets exhibit the same chemical and biological resistance as the Poly-Flex HDPE geomembrane.

Applications:

- Landfill leachate collection
- Landfill leak detection
- Landfill caps / closures
- Landfill methane gas collection
- Pond leak detection
- Foundation wall drainage
- Athletic field and landscape drainage
- Erosion control

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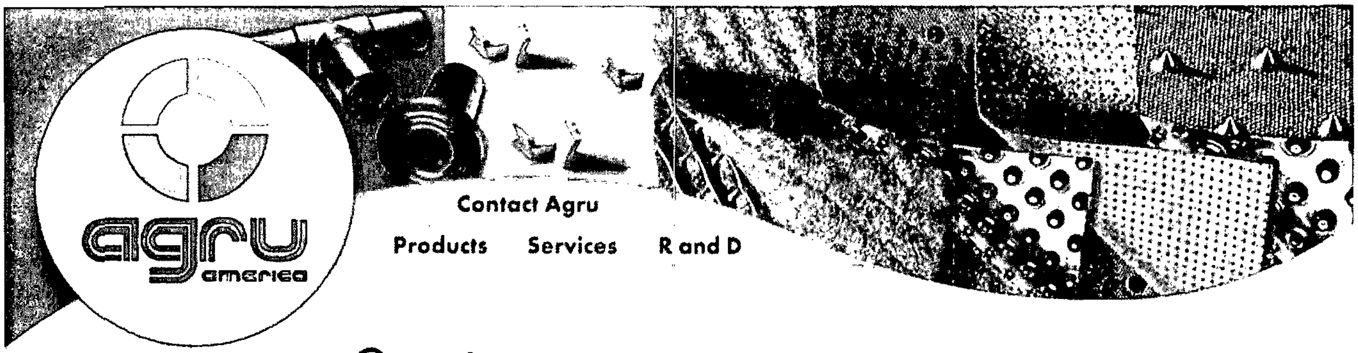

Geonet

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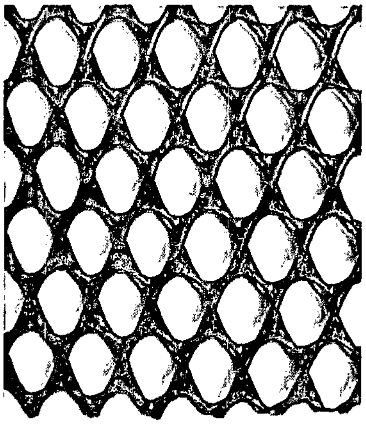
Agru's Geonet is a bixial/biplanar geonet manufactured from high quality high density polyethylene resin. The rib formation of Agru Geonet allows for high flow in both machine and cross machine directions. With thicknesses ranging from 200 mil to 300 mil Agru geonet is designed to meet all the needs of transmitting fluids in high load applications such as landfill cells and low load transmission of fluid for drainage and methane gasses in landfill closure applications.

Manufactured with high density polyethylene resin the material exhibits chemical resistance equal to our HDPE Geomembrane materials. Agru's geonets are UV stabilized.

Applications include: Landfill cells, leak location in double lined systems, landfill caps for both drainage and methane gas collection and landscape drainage systems.



FEATURES AND BENEFITS OF GEONET:

- Cost effective, saves air space in landfill cells
- Chemical resistant
- Consistently reliable
- Easy installation

APPLICATION FOR MODIFICATION
BASIN DISPOSAL, INC.
OIL FIELD WASTE EVAPORATION PONDS

VOLUME III: ENGINEERING DESIGN AND CALCULATIONS
SECTION 3: GEOSYNTHETICS APPLICATIONS AND COMPATIBILITY DOCUMENTATION

ATTACHMENT III.3.C

GEOTEXTILES REFERENCE DOCUMENTATION

Technical
Note No. 7

Chemical Resistance of Amoco Polypropylene Geotextiles

Amoco woven and nonwoven geotextiles are manufactured from polypropylene with ultra violet stabilizing additives. The excellent chemical resistance of Amoco polypropylene geotextiles is one of the qualities which has established Amoco as a leading producer of geotextiles for use in the waste containment industry. This technical note addresses the chemical resistance of polypropylene with a focus on recent testing programs which have clearly demonstrated the durability of Amoco fabrics in a variety of chemical environments.

Are polypropylene geotextiles durable in the chemical environment of landfill leachates?

Yes. Of the polymers used to manufacture geotextiles, polypropylene exhibits the greatest resistance to chemical attack. In fact, polypropylene is the polymer of choice for such commonly used products as landfill liners, synthetic grass for athletic fields, outdoor carpeting, battery cases, bleach bottles, antifreeze jugs, washing machine agitators, and thousands of other commonly used items that are routinely exposed to chemical environments. Polypropylene is stable within a pH range of 2 to 13, making one of the most stable polymers.

Polypropylene geotextiles have been found to be durable in a wide range of chemical environments (Bell, et. al., 1980; Haxo, 1978, 1983; Pucetas, et.al., 1991; Tisinger, et. al., 1989). Research has found both woven and nonwoven polypropylene geotextiles to be non-biodegradable and resistant to commonly encountered soil-bound chemicals, landfill achates, mildew, and insects.

How is the chemical resistance of polypropylene geotextiles determined?

Numerous laboratory test programs have subjected polypropylene to severe chemical environments such as solutions of organic solvents, oils, organic acids, and inorganic acids. The laboratory tests are generally performed in accordance with ASTM D 543, "Standard Test Method for Resistance of Plastics to Chemical Reagents." These test programs have found polypropylene to exhibit superb chemical resistance.

In the ASTM D 543 procedure, the specimens are immersed in a concentrated chemical solution at a specified temperature for a specified exposure period. This test method exposes the polypropylene to etremely harsh conditions which are considerably more severe than those encountered in most civil engineering applications.

The chemical compatibility of geotextiles with leachates is determined by EPA Test Method 9090 (EPA 9090), *"Compatibility Test for Wastes and Membrane Liners."* This was the laboratory method used in the Amoco geotextile test programs reported in this technical note. Geotextile samples are immersed in a constant temperature leachate bath for four months. At the end of each month samples of the fabric are removed and subjected to physical testing. Changes in properties may indicate chemically imposed degradation.

Have Amoco geotextiles been proven to be chemically resistant?

Four laboratory testing programs have been performed to evaluate the chemical compatibility of Amoco geotextiles with landfill leachates. The tests exposed both Amoco woven and nonwoven products to hazardous and municipal waste leachates.

In all testing programs there was no indication of geotextile degradation due to exposure to landfill leachates. The test results are summarized in the remainder of this technical note.

Hazardous waste leachate

A laboratory testing program was performed in 1989 to evaluate the chemical compatibility of Amoco geotextiles with a hazardous waste leachate. The program included EPA 9090 testing of 4 oz/yd² and 8 oz/yd² nonwoven specimens. The testing exposed the geotextiles to leachate in both the laboratory and in a leachate collection sump at a hazardous waste landfill.
Test evaluation incorporated detailed microstructural analyses which are not typically incorporated into chemical resistance testing programs. Methods included differential scanning calorimetry, thermal gravimetric analysis, and infrared spectrophotometry. These analyses were performed to identify any changes in the microstructure of the geotextile due to immersion in the leachate.
The results of this testing program found the geotextile microstructure remained intact, stable, and unchanged (Tisinger, et. al., 1989).

Municipal waste leachate

The chemical resistance of Amoco geotextiles to municipal solid waste leachate was evaluated in three laboratory testing programs. The first program, completed in 1990, included EPA 9090 testing of 16 oz/yd² nonwoven geotextile specimens. The second test program, performed in 1992, tested specimens of 8 oz/yd² nonwoven geotextile. The third program, completed in 1993, evaluated the chemical resistance of a high strength woven geotextile. The testing programs evaluated changes in physical properties of the specimens, including specimen dimensions, thickness, grab tensile strength and elongation, puncture resistance, burst strength, and tear strength. In all cases there were no measurable changes in physical properties of the specimens after exposure to the leachate.

Are the results of these tests applicable to Amoco geotextiles which have not been similarly tested?

Yes. All Amoco geotextiles are equally resistant to chemical degradation because they are all manufactured using the same polymer and additives. This conclusion is supported by the test results, which demonstrated no difference in chemical resistance for different types of Amoco geotextiles. The information in this technical note, therefore, is considered to be applicable to all Amoco geotextiles regardless of weight, thickness, or strength.

References

Bell, J.R., et. al., "*Evaluation of Test Methods and Use Criteria for Geotechnical Fabrics in Highway Applications,*" Federal Highway Administration, FHWA/RD-80-021, 1980, 202 p.

EPA Method 9090, "Compatibility Test for Wastes and Membrane Liners,"
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Haxo, R.S., "Interaction of Selected Lining Materials with Various Hazardous Wastes," *Proceedings of the Fourth Annual Research Symposium on Land Disposal of Hazardous Wastes,* EPA-600/9-78-016, Southwest Research Institute, US Environmental Protection Agency, Solid and Hazardous Waste Research Division, San Antonio, TX, 1978, pp. 256-273.

Pucetas, R.C., Verschoor, K.L., Allen, S.R., and Sprague, C.J., "The Chemical Resistance of Geotextiles to be Used in Secondary Containment Systems for Underground Storage Tanks," *Geosynthetics '91 Conference Proceedings,* Atlanta, GA, published by the Industrial Fabrics Association International,
St. Paul, MN, 1991, pp. 311-314.

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Technical Note No. 14

Amoco Fabrics and Fibers Company

Geotextile Polymers for Waste Applications

What types of polymers are used to manufacture geotextiles?

Virtually all geotextile fibers are made from either polypropylene or polyester polymers.

Are these polymers used in a 100% pure form?

The manufacture of geosynthetics usually includes the addition of stabilizers and other additives that are blended with the base polymer. The additives constitute a minor fraction of the polymer mixture.

Additives are used primarily to counteract the effects of oxidation, to which many synthetic polymers are sensitive. Oxidation can cause a reduction in material properties such as strength and elasticity. The main sources of oxidation are heat/temperature (thermal oxidation) and ultra violet (UV) radiation from sunlight (photo-oxidation). Manufacturers of geosynthetics add a variety of proprietary additives during production to make the polymers more stable against thermal and UV degradation (see Amoco Technical Note No. 9).

Should the designer specify polypropylene or polyester for geotextiles to be used in waste applications?

The type of polymer used in the fabrication of the geotextile is not a relevant design parameter. The specifications should be developed to focus on the required physical properties of the geotextile relative to strength, hydraulic performance, and chemical compatibility and durability. These elements are addressed in detail in the Amoco Waste-Related Geotextile Guide Specifications.

Does the type of base polymer affect the chemical resistance of geotextiles used in landfills?

Geotextiles in landfills are exposed to leachates, which are generally dilute solutions of chemicals. The geotextile must be resistant to degrading in this chemical environment. Chemical resistance of geotextiles to leachates is evaluated in the laboratory using EPA Test Method 9090 (EPA 9090). The results of such testing on polypropylene and polyester have proved both polymers to be relatively inert and durable in various chemical environments of hazardous and nonhazardous waste landfills (refer to Amoco Technical Note No. 7).

Of the polymers used to manufacture geotextiles, polypropylene exhibits the greatest resistance to chemical attack. Polypropylene is inert to most chemicals except for some highly concentrated solvents. Geotextiles are not expected to be exposed to such solvents in waste applications, where the associated leachates typically contain only trace to very low concentrations of solvent constituents.

Polyester exhibits comparable chemical compatibility. However, unlike polypropylene, polyester is subject to hydrolysis in aqueous environments such as landfill leachates. Hydrolysis is a process in which water-based solvents or water alone causes the polymer chains to break. This can result in a reduction in the mechanical properties of the polymer. Despite this characteristic, the results of EPA 9090 testing on polyester do not show an impact from hydrolysis.

What effect does polymer type have on the UV resistance of geotextiles used in landfills?

There are only slight differences in the UV stability of various geotextile polymers. From a construction perspective, these differences have no impact on the selection of geotextiles for landfill applications. Regardless of the polymer type, it is important to limit exposure of the geotextile to potentially damaging UV radiation.

In landfill applications, geotextiles are usually covered by soil layers and waste soon after construction. Their exposure to UV radiation therefore generally occurs only during construction. Regardless of polymer type, exposure of the fabrics to sunlight during installation should be limited in accordance with the project specifications (see Amoco Waste-Related Geotextile Guide Specifications).

On some landfill side slopes, the geotextile might be left exposed for an extended time before being covered with soil. In these cases, the geotextile must be protected from UV radiation by alternative methods, regardless of whether the fabric is manufactured of polypropylene or polyester. Alternatives include covering the geotextile with a sacrificial geotextile layer or opaque plastic sheet. The sacrificial layer would be removed prior to placing soil cover.

Has the performance of Amoco geotextiles in landfill applications been verified?

Yes. In fact, the excellent chemical resistance of Amoco polypropylene geotextiles is one of the qualities that has established Amoco as a leading supplier of fabrics to the waste containment industry.

Laboratory testing programs have been performed specifically to evaluate the chemical compatibility of Amoco polypropylene geotextiles with landfill leachates. In all test cases there were no measurable changes in the physical properties of the Amoco geotextiles after exposure to leachates. Also, unlike polyester, polypropylene does not undergo hydrolysis. Amoco Technical Note No. 7 provides detailed information regarding the chemical compatibility test conditions, procedures, and results.

References

Amoco Fabrics and Fibers Company, *Technical Note No. 7, Chemical Resistance of Amoco Polypropylene Geotextiles.*

Amoco Fabrics and Fibers Company, *Technical Note No. 9, Ultra Violet Light Degradation.*

Amoco Fabrics and Fibers Company, *Technical Note No. 12, Staple Fiber and Continuous Filament Polypropylene Geotextiles: A Comparison.*

Amoco Fabrics and Fibers Company, *Waste-Related Geotextile Guide Specifications.*

EPA Method 9090, "Compatibility Test for Wastes and Membrane Liners," *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, Environmental Protection Agency,* EPA 530/SW-846, 1988.

GeoSyntec Consultants, Correspondence to Amoco Fabrics and Fibers Company, Atlanta, GA, July 1993.

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APPLICATION FOR MODIFICATION
BASIN DISPOSAL, INC.
OIL FIELD WASTE EVAPORATION PONDS

VOLUME III: ENGINEERING DESIGN AND CALCULATIONS
SECTION 3: GEOSYNTHETICS APPLICATIONS AND COMPATIBILITY DOCUMENTATION

ATTACHMENT III.3.D

HDPE PIPE REFERENCE DOCUMENTATION

Chemical Resistance of Plastics and Elastomers Used in Pipeline Construction

1. Introduction

It is now inconceivable to construct pipelines without the use of plastics. Pipes made from plastics are used not only for drinking water, water for general use and waste water, but also for the conveyance of aggressive liquids and gases. Expensive pipe materials such as lined metal, ceramic or glass, have been largely superseded by plastic pipes. It is, however, important that the most suitable plastic material is selected for each application. This "Chemical Resistance List" serves as a useful guide in this respect. The list is periodically revised to include the latest findings. It contains all plastics and elastomers in the George Fischer product range which can come into direct contact with the media.

The information is based on experiments, immersion and, when available, on data from tests which include temperature and pressure as stress factors. The results achieved in immersion experiments cannot be applied without reservation to pipes under stress, i.e. internal pressure, as the factor "stress corrosion cracking" is not taken into consideration. In certain cases it can be of advantage to test the suitability under the planned working conditions. The tests referred to have been carried out partly by George Fischer and partly by the International Standardization Organization (ISO) or national standards organizations.

Pure chemicals were used for the tests. If a mixture of chemicals is to be conveyed in practice this may affect the chemical resistance of the plastic. It is possible in special cases to carry out appropriate tests with the specific mixture. Suitable test equipment is available at George Fischer for this purpose, which we regard as part of our service to the customer. It goes without saying that we are willing to give individual advice at any time. In this connection it is worth mentioning that George Fischer already possesses information concerning the behavior towards plastics of a number of chemicals or mixtures of chemicals which are not yet included in this list. The "Chemical Resistance List" gives valuable assistance in the planning of plastic pipelines. Please refer to the following instructions, which are important for the application and evaluation of this list.

2. Instructions for the Use of the Chemical Resistance List

2.1 General

As stated in the introduction, the "Chemical Resistance List" is only intended as a guide. Changes in the composition of the medium or special working conditions could lead to deviations. If there is any doubt, it is advisable to test the behavior of the material under the specific working conditions, by means of a pilot installation. No guarantees can be given in respect of the information contained in this booklet. The data shown is based upon information available at the time of printing, but it may, however, be revised from time to time in the light of subsequent research and experience.

2.2 Classification

The customary classifications: **resistant, conditionally resistant** and **not recommended** are depicted by the signs: +, O, and –, which allow simple presentation and application. These classifications are defined as:

Resistant: +
Within the acceptable limits of pressure and temperature the material is unaffected or only insignificantly affected.

Conditionally Resistant: O
The medium can attack the material or cause swelling. Restrictions must be made in regard to pressure and/or temperature, taking the expected service life into account. The service life of the installation can be noticeably shortened. Further consultation with George Fischer is recommended.

Not recommended: –
The material cannot be used with the medium at all, or only under special conditions.

(Courtesy George Fischer Engineering Handbook)

2.3 Pipe Joints

2.3.1 Solvent Cement Joints (PVC)

Solvent cement joints made with standard PVC cement and primer systems are generally as resistant as the PVC material itself. The following chemicals are, however, an exception:

- Sulphuric acid H_2SO_4 in concentrations above 70 percent
- Hydrochloric acid HCl in concentrations above 25 percent
- Nitric acid HNO_3 in concentrations above 20 percent

Hydrofluoric acid in any concentration In conjunction with the above media the solvent cement joining is classified as "conditionally resistant". Previously *recommended solvent cement* (Dytex, by Henkel, Germany) used for pipe and fittings to carry concentrated acids, can no longer be brought into the United States because of its methylene chloride solvent system being classified as a carcinogen. There is no known domestically available substitute. Special consideration should be given to the possible attack of the cemented joints by these concentrated acids.

2.3.2 Fusion Joints

In the case of PE, PP, and PVDF (SYGEF®) heat fusion joints have practically the same chemical resistance as the respective material. In conjunction with media which could cause stress cracking, the fused joints can be subjected to an increased risk due to residual stress from the joining process.

2.4 Sealing Materials

Depending upon the working conditions and the stress involved, the life span of the sealing materials can differ from that of the pipeline material. Seals in PTFE, which are not included in this list, are resistant to all the chemicals indicated. The greater permeability of PTFE should, however, be considered. Under certain working conditions, for example when conveying highly aggressive media such as hydrochloric acid, this material characteristic must be taken into account.

2.5 General Summary and Limits of Application

The following table includes all the materials contained in the George Fischer product range, and their abbreviations. The summary gives preliminary information regarding the general behavior of the materials and the temperature limits.

2.6 Standards

This list has been compiled with reference to the following ISO standards:

ISO/TR 7473
Unplasticized polyvinyl chloride pipes and fittings – Chemical resistance with respect to fluids.
ISO/TR 7474
High density polyethylene pipes and fittings – Chemical resistance with respect to fluids to be conveyed.
ISO/TR 7471
Polypropylene (PP) pipes and fittings – Chemical resistance with respect to fluids.
ISO TR 10358
Plastic pipes and fittings – Combined chemical resistance classification table.
DVS 2205 Part I
Calculations for thermoplastic containers and appliances.
DIN 8080 Supplement 1 «Pipes of chlorinated polyvinyl chloride (PVC-C), PVC-C 250 – Chemical Resistance».

(Courtesy George Fischer Engineering Handbook)

Material	Abbreviation	Remarks	Maximum Permissible Temperature (Water) °C	
			Constant	Short Term
Polyvinyl Chloride	PVC	Resistant to most solutions of acids, alkalis and salts and to organic compounds miscible with water. Not resistant to aromatic and chlorinated hydrocarbons	60°	60°
Chlorinated Polyvinyl Chloride	CPVC	Can be used similarly to PVC but at higher temperatures. Consult factory for specific applications.	90°	110°
High-density Polyethylene	PE 50	Resistant to hydrous solutions of acids, alkalis and salts as well as to a large number of organic solvents. Unsuitable for concentrated oxidizing acids.	60°	80°
Polypropylene, heat stabilized	PP	Chemical resistance similar to that of PE but suitable for higher temperatures	90°	110°
Polyvinylidene Fluoride	PVDF (SYGEF®)	Resistant to acids, solutions of salts, aliphatic, aromatic and chlorinated hydrocarbons, alcohols and halogens. Conditionally suitable for ketones, esters, organic bases and alkaline solutions	140°	150°
Polybutylene-1	PB	Similar to PE 50, but can be used up to 90°C	90°	100°
Polyoxymethylene	POM	Resistant to most solvents and hydrous alkalis. Unsuitable for acids	60°	80°
Polytetrafluoroethylene (e.g. Teflon®)	PTFE	Resistant to all chemicals in this list	250°	300°
Nitrile Rubber	NBR	Good resistance to oil and petrol. Unsuitable for oxidizing media	90°	120°
Butyl Rubber Ethylene Propylene Rubber	IIR EPDM	Good resistance to ozone and weather. Especially suitable for aggressive chemicals. Unsuitable for oils and fats	90°	120°
Chloroprene Rubber (e.g. Neoprene®)	CR	Chemical resistance very similar to that of PVC-U and between that of Nitrile and Butyl Rubber	80°	110°
Fluorine Rubber (e.g. Viton®)	FPM	Has best chemical resistance to solvents of all elastomers	150°	200°
Chlorine Sulphonyl Polyethylene (e.g. Hypalon®)	CSM	Chemical resistance similar to that of EPDM	100°	140°

®Registered trade name

The abbreviations listed below are found throughout the listings and have the following definition:

Q/E (Quellung/Erweichung) = swelling/softening
D/P (Diffusion/Permeation) = diffusion/permeation
SpRB (Spannungsrissbildung) = environmental stress cracking

(Courtesy George Fischer Engineering Handbook)

Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Acetaldehyde	CH_3-CHO (C_2H_4O)	21	technically pure	20	-	-	-	+	O	-		+	O	-	-	O
				40				O	-			O	-			-
				60								-				
				80												
				100												
				120												
				140												
Acetaldehyde			40%, aqueous solution	20	O	-	-	+	+	-		+	+	-	+	+
				40	-			+	+			+	+		+	+
				60				O	+			+	O		O	+
				80					O			+	-		-	+
				100					-							
				120												
				140												
Acetic acid (SpRB)	CH_3COOH	118	technically pure, glacial	20	O	-	-	+	+	+		O	-	-	O	O
				40	-			+	+	O						
				60				O	O	-						
				80					-							
				100												
				120												
				140												
Acetic acid (SpRB)	CH_3COOH		10%, aqueous	20	+	+	+	+	+	+		+	O	+	+	O
				40	+	+	+	+	+	+		+	-	O	+	-
				60	O	+	O	+	+	+		O			O	
				80		+			+	+						
				100					+	+						
				120						+						
				140												
Acetic acid (SpRB)			50%, aqueous	20	+	+	-	+	+	+		+	O	-	O	O
				40	+			+	+	+						
				60	O			+	+	+						
				80						O						
				100						O						
				120												
				140												
Acetic acid (SpRB)	CH_3COOH		60%	20	+	-	-	+	+	+		+				
				40												
				60												
				80												
				100												
				120												
				140												
Acetic acid (SpRB)		118	98%	20	-	-	-	+	+	+		O	-			
				40												
				60												
				80												
				100												
				120												
				140												
Acetic acid anhydride (SpRB)	$(CH_3\text{-}CO)_2O$	139	technically pure	20	-	-	-	+	+	-		O	-	-	-	+
				40				O	O							
				60												
				80												
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Acetic acid isobutyl ester	$(CH_2)_2-CH-(CH_2)_2-CO_2H$		technically pure	20						-						
				40												
				60												
				80												
				100												
				120												
				140												
Acetone	$CH_3-CO-CH_3$	56	technically pure	20	-	-	-	+	+	-		+	-	-	-	O
				40				+	+			+				O
				60				+	+			+				O
				80												
				100												
				120												
				140												
Acetone			up to 10%, aqueous	20	-	-	O	+	+	O		+	O	-	+	O
				40				+	+	O		+	O		O	O
				60				+	+	O		+	-		-	O
				80												
				100												
				120												
				140												
Acetonitrile	CH_3CN	81.6	100%	20	-	-	-			-						
				40												
				60												
				80												
				100												
				120												
				140												
Acetophenone	$CH_3-CO-C_6H_5$		100%	20	-	-	-			-		+	-	-	-	
				40												
				60												
				80												
				100												
				120												
				140												
Acrylic acid methyl ester	$CH_2=CHCOOCH_3$	80.3	technically pure	20	-	-	-			+		O				
				40												
				60												
				80												
				100												
				120												
				140												
Acrylic ester	$CH_2=CH-COO\ CH_2CH_3$	100	technically pure	20	-	-	-		-	-		O	-	-	O	+
				40												
				60												
				80												
				100												
				120												
				140												
Acrylonitrile	$CH_2=CH-CN$	77	technically pure	20	-	-	-	+	+	-		+	O	-	+	O
				40				+	O			+	O		+	O
				60				+				O	-		+	-
				80												
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Adipic acid	$HOOC\text{-}(CH_2)_4\text{-}COOH$	Fp 153	saturated, aqueous	20	+	+	-	+	+	+		+	+	+	+	+
				40	+	+		+	+			+	+	+	+	+
				60	-	+		+	+			+	+	+	+	+
				80		+			+							
				100												
				120												
				140												
Alum	see Potassium/ aluminium sulphate															
Alcoholic spirits (Gin, Whisky, etc.)			approx. 40% ethyl alcohol	20	+	O	-	+	+	+		+	+	+	+	+
				40												
				60												
				80												
				100												
				120												
				140												
Allyl alcohol	$H_2C{=}CH\text{-}CH_2\text{-}OH$	97	96%	20	O	O	-	+	+			O	O	+	O	+
				40	-			+	+			O	-	+	-	+
				60				+	+			O		+		+
				80								-		+		-
				100												
				120												
				140												
Aluminium chloride	$AlCl_3$		10%, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	+	+	+	+	+	+		+	+	O	+	+
				80		+				+		+	+			+
				100						+		+	+			
				120						+						
				140												
Aluminium chloride	$AlCl_3$	115	saturated	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	+	+	+	+	+	+		+	+	+	+	+
				80		+			+	+			+	O	+	+
				100					O	+			+	-		+
				120						+						
				140												
Aluminium fluoride	AlF_3		saturated	20		+				+						
				40		+				+						
				60		+				+						
				80						+						
				100												
				120												
				140												
Aluminium hydroxide	$Al(OH)_3$		Suspension	20		+						+				
				40		+						+				
				60		+						+				
				80		+										
				100												
				120												
				140												
Aluminium nitrate	$Al(NO_3)_3$		saturated	20		+				+		+				
				40		+				+		+				
				60		+				+		+				
				80		+										
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Aluminium sulphate	$Al_2(SO_4)_3$		10%, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	O	+	+	+	+	+		+	+	+	+	+
				80		+			+	+			+			O
				100					+	+						
				120						+						
				140												
Aluminium sulphate			cold saturated, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	+	+	+	+	+	+		+	+	+	+	O
				80		+			+	+			+			O
				100						+						
				120						+						
				140												
Ammonia (SpRB)	NH_3	-33	gaseous, technically pure	20	+	-	-	+	+	+		+	+	+	+	+
				40	+			+	+	+			O			
				60	+			+	+	O						
				80						O						
				100						O						
				120												
				140												
Ammonium acetate	CH_3COONH_4		aqueous, all	20	+	+	O	+	+	+		+	+	+	+	+
				40	+	+		+	+	+		+	+	O	+	+
				60	O	+		+	+	+		+	+		O	
				80		+			+	+		O				
				100					+	+						
				120												
				140												
Ammonium aluminium sulfate				20						+						
				40						+						
				60						+						
				80						+						
				100						+						
				120												
				140												
Ammonium bromide				20						+						
				40						+						
				60						+						
				80												
				100												
				120												
				140												
Ammonium carbonate	$(NH_4)_2CO_3$		50%, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	O	+	+	+	+	+		+	+	+	+	+
				80		+			+	+		+	+			+
				100					+	+						
				120						+						
				140												
Ammonium chloride	NH_4Cl	115	aqueous, cold saturated	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	O	+	+	+	+	+		+	+	+	+	+
				80		+			+	+		+	+		+	+
				100					+	+		+	+			+
				120						+			+			
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Ammonium citrate				20	+					+						
				40	+					+						
				60	+					+						
				80						+						
				100						+						
				120												
				140												
Ammonium dicromate	$(NH_4)_2 Cr_2 O_7$		saturated	20		+										
				40		+										
				60		+										
				80		+										
				100												
				120												
				140												
Ammonium dihydrogenphosphate				20	+			+	+							
				40	+			+	+							
				60	+			+	+							
				80					+							
				100												
				120												
				140												
Ammonium fluoride	NH_4F			20	+	+		+	+	+						
				40	+			+	+	+						
				60	+			+	+	+						
				80					+	+						
				100						+						
				120												
				140												
Ammonium formiate				20						+						
				40						+						
				60						+						
				80						+						
				100						+						
				120												
				140												
Ammonium hexafluorosilicate				20						+						
				40						+						
				60						+						
				80						+						
				100						+						
				120												
				140												
Ammonium hydrogen fluoride	NH_4HF_2		50%, aqueous	20	+	+	-	+	+	+		+	+			
				40	+	+		+	+	+						
				60	O	+		+	+	+						
				80												
				100												
				120												
				140												
Ammonium hydrogencarbonate				20	+			+	+							
				40	+			+	+							
				60	+			+	+							
				80					+							
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Ammonium hydrogenphosphate				20	+			+	+							
				40	+			+	+							
				60	+			+	+							
				80					+							
				100												
				120												
				140												
Ammonium hydrogensulfite				20						+						
				40						+						
				60						+						
				80						+						
				100						+						
				120												
				140												
Ammonium hydroxide	NH_4OH		aqueous, cold saturated	20	+	-	+		+	-		+	-	+	+	+
				40	+		+		+			+		O	+	+
				60	O		O		+			O		O	+	O
				80											O	-
				100												
				120												
				140												
Ammonium nitrate	NH_4NO_3	112	aqueous, saturated	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	+	+	+	O	+	+		+	+	O		O
				80		+			O	+			+			
				100						+						
				120						+						
				140												
Ammonium oxalate	$H_4NOOC\text{-}COONH_4$			20						+		+				
				40						+						
				60						+						
				80						+						
				100						+						
				120												
				140												
Ammonium persulphate	$(NH_4)_2S_2O_8$			20		+				+						
				40		+				+						
				60		+				+						
				80		+				+						
				100						+						
				120												
				140												
Ammonium phosphate	$(NH_4)_3PO_4$		saturated	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	+	+	+	+	+	+			+	O	+	O
				80					+	+			+			
				100						+			+			
				120												
				140												
Ammonium sulphate	$(NH_4)_2SO_4$		aqueous, saturated	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	+	+	+	+	+	+		+	+	O	+	O
				80		+			+	+		+	+			
				100					+	+			+			
				120						+						
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Ammonium sulphide	$(NH_4)_2S$		aqueous, all	20	+	O	+	+	+	+		+	+	+	+	+
				40	+	O	+	+	+	+		+	O	+	+	+
				60	O	O	+	+	+	+		+	-	+	+	+
				80		-			+							
				100												
				120												
				140												
Ammonium tetrafluoroborate				20						+						
				40						+						
				60						+						
				80						+						
				100						+						
				120												
				140												
Ammonium thiocyanate	NH_4SCN		saturated	20		+				+						
				40		+				+						
				60		+				+						
				80		+										
				100												
				120												
				140												
Amyl acetate	$CH_3(CH_2)_4\text{-}COOCH_3$	141	technically pure	20	-	-	-	+	O	+		O	-	-	-	-
				40				+	O	O						
				60				+	-	O						
				80												
				100												
				120												
				140												
Amyl alcohol (SpRB)	$CH_3(CH_2)_3\text{-}CH_2\text{-}OH$	137	technically pure	20	+	+	-	+	+	+		+	O	+	+	O
				40	+	+		+	+	+		+		+	+	
				60	O	+		+	+	+		+		+	+	
				80					+	+						
				100						+						
				120						O						
				140												
Aniline	$C_6H_5NH_2$	182	technically pure	20	-	-	-	O	O	+		-	O	-	-	-
				40						O			O			
				60						-			O			
				80												
				100												
				120												
				140												
Aniline hydrochloride	$C_6H_7N{+}HCl$	245	aqueous, saturated	20	+	+	-	+	+	+		+	O	O	-	+
				40	O	+		+	+			+	-	-		+
				60				O	O			+				+
				80												O
				100												
				120												
				140												
Antimony thiocyanate				20						+						
				40						+						
				60						+						
				80						+						
				100						+						
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Antimony trichloride (SpRB)	$SbCl_3$		90%, aqueous	20	+	+	-	+	+	+		+	+	-	+	+
				40	+			+	+	+						
				60				+	+	+						
				80												
				100												
				120												
				140												
Aqua regia (SpRB)	HNO_3+HCl			20	+	+	-	-	-	O		-	O	-	-	O
				40	O											
				60												
				80												
				100												
				120												
				140												
Arsenic acid	H_3AsO_4		80%, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	O	+	+	+	+	+		+	+	+	+	+
				80		+			+	+		+	+	O	+	+
				100						+			+			
				120						+						
				140												
Barium carbonate	$BaCO_3$			20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+		+	+	+		+	+	+		
				60	+	+		+	+	+		+				
				80		+			+							
				100												
				120												
				140												
Barium chloride	$BaCl_2$		saturated	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+		+	+	+		+	+	+		
				60	+	+		+	+	+		+	+			
				80		+			+	+			+			
				100						+						
				120												
				140												
Barium hydroxide	$Ba(OH)_2$	102	aqueous, saturated	20	+	+	+	+	+	-		+	+	+	+	+
				40	+	+	+	+	+			+		+	+	O
				60	O	+	+	+	+			+		+	+	
				80		+			+			+				
				100												
				120												
				140												
Barium salts			aqueous, all	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	+	+	+	+	+	+		+	+	+	+	+
				80		+			+	+		+	+			
				100						+						
				120												
				140												
Barium sulfate	$BaSO_4$			20	+			+	+	+		+				
				40	+			+	+	+		+				
				60	+			+	+	+		+				
				80					+	+						
				100						+						
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Barium sulfide	BaS		suspension	20	+	+		+	+	+		+				
				40	+	+		+	+	+		+				
				60	+	+		+	+	+		+				
				80		+			+	+						
				100						+						
				120												
				140												
Battery acid	see Sulphuric acid 40%															
Beef tallow emulsion, sulphonated (SpRB)			usual commercial	20	+	o	+	+	+	+		-	+	+	+	+
				40						+						
				60						+						
				80												
				100												
				120												
				140												
Beer			usual commercial	20	+	+	+	+	+	+			+	+	+	+
				40	+	+	+	+	+	+						
				60	+	+	+	+	+	+						
				80		+				+						
				100												
				120												
				140												
Benzaldehyde	C_6H_5-CHO	180	saturated, aqueous	20	-	-	-	+	+	+		+	+	O	-	-
				40				+		O		+	+			
				60				+		-		+	+			
				80												
				100												
				120												
				140												
Benzene	C_6H_6	80	technically pure	20	-	-	-	O	O	+		-	+	O	-	-
				40				O	-	O						
				60						-						
				80												
				100												
				120												
				140												
Benzenesulfonic acid	$C_6H_5SO_3H$		technically pure	20						+			+			
				40						+			+			
				60						+						
				80						+						
				100						+						
				120												
				140												
Benzoic acid	C_6H_5-COOH	Fp.*, 122	aqueous, all	20	+	+	+	+	+	+		+	+	-	-	-
				40	+	+	+	+	+	+		+	+			
				60	O	+		+	+	+			+			
				80		O			+	+			+			
				100					+	+			O			
				120						+						
				140												
Benzoyl chloride	$C_6H_5CHCl_2$		technically pure	20						+						
				40						+						
				60						+						
				80						O						
				100						-						
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Benzyl alcohol (SpRB)	C_6H_5-CH_2-OH	206	technically pure	20	O	-	-	+	+	+		-	+	-	+	O
				40				+	+	+					+	
				60				O	O	O					+	
				80						-						
				100												
				120												
				140												
Beryllium chloride				20						+						
				40						+						
				60						+						
				80												
				100												
				120												
				140												
Beryllium sulfate				20						+			+			
				40						+			+			
				60						+			+			
				80						+						
				100						+						
				120												
				140												
Borax	$Na_2B_4O_7$		aqueous, all	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	O	+		+	+	+		+	+	+	+	O
				80		+			+	+		+	+			
				100					+	+						
				120												
				140												
Boric acid	H_3BO_3		all, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	O	+	+	+	+	+		+	+	+	+	+
				80		+			+	+		+	+			
				100					+	+			+			
				120						+						
				140												
Brine, containing chlorine				20	+	+	-	+	O	+		O	+	O	O	O
				40	+	+				+						
				60	+	+				O						
				80												
				100												
				120												
				140												
Brombenzene	C_6H_5Br			20	-	-				+			+			
				40												
				60												
				80												
				100												
				120												
				140												
Bromine, liquid	Br_2	59	technically pure	20	-	-	-	-	-	+		-	+	-	-	-
				40						+						
				60						+						
				80						+						
				100						O						
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Bromine, vapours	Br_2		high	20	-	-	-	-	-	+		-	+	-	-	-
				40						+						
				60						+						
				80						+						
				100						O						
				120												
				140												
Bromine water	$Br.H_2O$		saturated, aqueous	20	+	o	-	-	-	+		-	+	-	-	-
				40						+						
				60						+						
				80						+						
				100												
				120												
				140												
Butadiene (Q/E)	$H_2C=CH-CH=CH_2$	-4	technically pure	20	+	+	-	+	+	+		-	O	-	+	+
				40					+	+					+	O
				60					+	+					O	-
				80						+						
				100						+						
				120												
				140												
Butane	C_4H_{10}	0	technically pure	20	+	+	+	+	+	+		-	+	+	+	+
				40												
				60												
				80												
				100												
				120												
				140												
Butanediol (SpRB)	$HO-(CH_2)_4-OH$	230	aqueous, 10%	20	+	+	-	+	+			+	+	+	O	+
				40	O	+		+	+			+	+	+	-	+
				60				+	+			+	+	+		+
				80												
				100												
				120												
				140												
Butanol (SpRB)	C_4H_9OH	117	technically pure	20	+	+	-	+	+	+		+	+	+	+	+
				40	+	+		+	+	+		+	O	+	+	+
				60	O	+		+	O	+		+	-	+	O	+
				80		O			-	+						
				100						O						
				120												
				140												
Butyl acetate	$CH_3COOCH_2CH_2CH_2CH_3$	126	technically pure	20	-	-	-	+	O	+		+	O	-	O	O
				40						O		-	-		-	-
				60						-						
				80												
				100												
				120												
				140												
Butyl phenol, p-tertiary	$(CH_3)_3C-C_6H_4-OH$	237	technically pure	20	O	O	-	O	+	+		-	O	-	-	-
				40	-	-				+						
				60						+						
				80						+						
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Butylene glycol (SpRB)	HO-CH$_2$-CH=CH-CH$_2$-OH	235	technically pure	20	+	+	+	+	+	+		+	+	-	+	O
				40	+	+	+	+	+	+		+	+		+	
				60	O	+	+	+	+	+		+	O		+	
				80						+						
				100												
				120												
				140												
Butylene liquid	C_4H_8	51	technically pure	20	+			-	-	+		O	+	+	+	O
				40												
				60												
				80												
				100												
				120												
				140												
Butyric acid (SpRB)	CH$_3$-CH$_2$-CH$_2$-COOH	163	technically pure	20	+	+	-	+	+	+		O	O	-	O	O
				40				+		+						
				60				O		+						
				80						+						
				100						O						
				120												
				140												
Cadmium bromide	$CdBr_2$			20	+	+		+	+			+	+			
				40	+	+		+	+			+	+			
				60	+	+		+	+			+	+			
				80		+							+			
				100												
				120												
				140												
Cadmium chloride	$CdCl_2$			20	+	+		+	+			+	+			
				40	+	+		+	+			+	+			
				60	+	+		+	+			+	+			
				80					+							
				100												
				120												
				140												
Cadmium cyanide	Cd(CN)2			20	+			+	+							
				40	+			+	+							
				60	+			+	+							
				80					+							
				100												
				120												
				140												
Cadmium sulfate	$CdSO_4$			20	+	+		+	+			+	+			
				40	+	+		+	+			+	+			
				60	+	+		+	+			+	+			
				80		+			+				+			
				100												
				120												
				140												
Calcium acetate	$(CH_3COO)_2Ca$		saturated	20	+	+	+	+	+	+		+	+			
				40	+	+		+	+	+		+				
				60		+		+	+	+		+				
				80		+										
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Calcium bisulphite	$Ca(HSO_3)_2$		cold saturated, aqueous	20	+	+	+			+		+	+	-	O	+
				40		+	+			+			+			
				60		+				+			+			
				80		+				+			+			
				100						+			+			
				120						+						
				140												
Calcium carbonate	$CaCO_3$			20	+	+		+	+	+		+	+			
				40	+	+		+	+	+		+	+			
				60	+	+		+	+	+		+	+			
				80		+			+	+		+	+			
				100						+						
				120												
				140												
Calcium chlorate	$Ca(ClO_3)_2$			20	+	+		+	+	+						
				40	+	+		+	+	+						
				60	+	+		+	+	+						
				80		+										
				100												
				120												
				140												
Calcium chloride	$CaCl_2$	125	saturated, aqueous, all	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	O	+		+	+	+		+	+	+	+	+
				80		+			+	+		+	+	O	O	+
				100					+	+		O	+			+
				120						+						
				140												
Calcium fluoride	CaF_2			20	+			+	+				+			
				40	+			+	+				+			
				60	+			+	+				+			
				80					+							
				100												
				120												
				140												
Calcium hydrogencarbonate				20						+		+	+			
				40						+		+	+			
				60						+		+	+			
				80						+		+	+			
				100						+			+			
				120												
				140												
Calcium hydrogensulfide	$Ca(SH)_2$			20		+				+		+				
				40		+				+		+				
				60		+				+		+				
				80		+				+						
				100						+						
				120												
				140												
Calcium hydrosulfite	$Ca(HSO_3)_2$		saturated	20						+						
				40						+						
				60						+						
				80						+						
				100						+						
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Calcium hydroxide	$Ca(OH)_2$	100	saturated, aqueous	20	+	+	+	+	+	O		+	+	+	+	+
				40	+	+	+	+	+	-		+	+	+	+	+
				60	+	+	+	+	+			+	+	O	+	+
				80		+			+			+	+			+
				100									+			+
				120												
				140												
Calcium nitrate	$Ca(NO_3)_2$	115	50%, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60		+		+	+	+		+	+			+
				80		+				+			+			
				100						+						
				120												
				140												
Calcium phosphate	$Ca(H_2PO_4)_2$ $CaHPO_4$ $Ca_3(PO_4)_2$			20						+						
				40						+						
				60						+						
				80						+						
				100						+						
				120												
				140												
Calcium sulfide	Ca_5			20	+				+			+				
				40	+				+							
				60	+				+							
				80					+							
				100												
				120												
				140												
Calcium sulphate	$CaSO_4$		suspensions	20	+	+				+		+				
				40	+	+				+		+				
				60	+	+				+		+				
				80		+				+						
				100						+						
				120												
				140												
Calcium sulphite	$Ca(HSO_3)_2$		aqueous, cold saturated	20	+			+	+			+				
				40	+			+	+							
				60	+			+	+							
				80					+							
				100												
				120												
				140												
Calcium tungstate				20						+						
				40						+						
				60						+						
				80												
				100												
				120												
				140												
Calciumbromide	$CaBr_2$			20	+	+		+	+			+	+			
				40	+	+		+	+			+	+			
				60	+	+		+	+			+	+			
				80		+			+							
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Calciumlactate	$(CH_3COO)_2Ca$		saturated	20				+	+	+		+				
				40				+	+	+		+				
				60				+	+	+		+				
				80					+	+						
				100						+						
				120												
				140												
Caprolactam	$C_6H_{11}NO$			20		-										
				40												
				60												
				80												
				100												
				120												
				140												
Caprolactone	$C_6H_{10}O_2$			20		-										
				40												
				60												
				80												
				100												
				120												
				140												
Carbon dioxide -carbonic acid	CO_2		technically pure, anhydrous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	+	+	+	+	+	+			+	+	+	+
				80		+			+	+			+			+
				100						+						
				120												
				140												
Carbon disulphide	CS_2	46	technically pure	20	-	-	-	O	O	+			+	-	-	-
				40												
				60												
				80												
				100												
				120												
				140												
Carbon tetrachloride	CCl_4	77	technically pure	20	-	-	-	-	-	+		-	+	-	-	-
				40												
				60												
				80												
				100												
				120												
				140												
Carbonic acid				20	+	+		+	+	+		+	+			
				40	+	+		+	+	+		+	+			
				60	+	+		+	+	+		+	+			
				80		+			+	+		+	+			
				100						+			+			
				120												
				140												
Caro's acid	see Peroxomonosulfuric acid															
Casein				20						+						
				40						+						
				60						+						
				80												
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Cäsium chloride	ClCs			20						+						
				40						+						
				60						+						
				80												
				100												
				120												
				140												
Cäsiumhydroxide	CsOH			20						+						
				40						+						
				60						+						
				80												
				100												
				120												
				140												
Caustic potash solution (potassium hydroxide)	KOH	131	50%, aqueous	20	+	+	+	+	+	-		+	-	O	-	+
				40	+	+	+	+	+			+		-		O
				60	O	+	+	+	+			+				O
				80		+			+			O				-
				100					+							
				120												
				140												
Caustic soda solution	NaOH		50%, aqueous	20	+	+	+	+	+	O		+	-	O	-	+
				40	+	+		+	+			+		-		O
				60		+		+	+			+				-
				80					+							
				100												
				120												
				140												
Cerium (III) -chloride	$CeCl_3$			20						+						
				40						+						
				60						+						
				80												
				100												
				120												
				140												
Chloral hydrate	$CCl_3\text{-}CH(OH)_2$	98	technically pure	20	-		-	+	O	-		O	O	-	O	+
				40				+								
				60				+	-							
				80												
				100												
				120												
				140												
Chloric acid (SpRB)	$HClO_3$		10%, aqueous	20	+	+	-	+	-	+		+	-	-	-	+
				40	+	+		+		+		+				+
				60	O	+						+				+
				80												
				100												
				120												
				140												
Chloric acid (SpRB)	$HClO_3$		20%, aqueous	20	+	+	-	O	-	+		+	-	-	-	+
				40	+	+						+				+
				60	O	+										
				80												
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Chlorosulphonic acid	$ClSO_3H$	158	technically pure	20	O	-	-	-	-	O		-	-	-	-	-
				40						-						
				60												
				80												
				100												
				120												
				140												
Chrome alum (chromium potassium sulphate)	$KCr(SO_4)2$		cold saturated, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	+	+		+	+			+	+	+	+	+
				80								+	+			
				100									+			
				120												
				140												
Chromic acid (SpRB)	CrO_3+H_2O		up to 50%, aqueous	20	O	+	-	O	O	+		O	+	-	-	O
				40	O	O		-	-	+		O	+			O
				60	-	O				+		O	+			O
				80		-				+						
				100						O						
				120						O						
				140												
Chromic acid (SpRB)			all, aqueous	20	O	O	-	O	O	+			+	-	-	O
				40						+			+			O
				60						+			O			O
				80						O						
				100						O						
				120												
				140												
Chromic acid + sulphuric acid + water (SpRB)	CrO_3 H_2SO_4 H_2O		50 g 15 g 35 g	20	+	+	-	-	-	+		O	+	-	-	O
				40	+	+				+		O	+			O
				60	O	+				+			+			
				80		O				O						
				100												
				120												
				140												
Chromium (II) -chloride				20	+					+						
				40	+					+						
				60	+					+						
				80						+						
				100						+						
				120												
				140												
Chromium (III) -fluoride	CrF_3			20						+						
				40						+						
				60						+						
				80												
				100												
				120												
				140												
Chromium (III) -chloride	$CrCl_3$			20	+					+						
				40	+					+						
				60	+					+						
				80						+						
				100						+						
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Chlorine	Cl_2		moist, 97%, gaseous	20	-	-	-	-	-	-		-	+	-	-	O
				40												
				60												
				80												
				100												
				120												
				140												
Chlorine	Cl_2		anhydrous, technically pure	20	-	-	-	O	-	+		O	+	-	-	O
				40				O		+						
				60				-		+						
				80						+						
				100						O						
				120												
				140												
Chlorine	Cl_2		liquid, technically pure	20	-	-	-	-	-	+		-	O	-	-	-
				40												
				60												
				80												
				100												
				120												
				140												
Chlorine water (SpRB)	Cl_2 H_2O		saturated	20	+	+	O	O	O	O		O	O	-	O	-
				40	+	+		O								
				60	O	O										
				80		-										
				100												
				120												
				140												
Chloroacetic acid, mono (SpRB)	$ClCH_2COOH$		50%, aqueous	20	+	-	-	+	+	+		O	-	-	-	O
				40	+			+	+	O						
				60				+	+	-						
				80												
				100												
				120												
				140												
Chloroacetic acid, mono (SpRB)	$ClCH_2COOH$	188	technically pure	20	+	-	-	+	+	-		O	-	-	-	O
				40	+			+	+							
				60	O			+	+							
				80												
				100												
				120												
				140												
Chlorobenzene	C_6H_5Cl	132	technically pure	20	-	-	-	O	+	+		-	-	-	-	O
				40						+						
				60						O						
				80						-						
				100												
				120												
				140												
Chloroethanol	$ClCH_2$-CH_2OH	129	technically pure	20	-		-	+	+	+		O	-	+	-	O
				40				+	+	O						
				60				+	+	O						
				80						-						
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Chromium (III) -nitrate	$Cr(NO_3)_3$			20	+					+						
				40	+					+						
				60	+					+						
				80						+						
				100						+						
				120												
				140												
Chromium (III) -sulfate	$Cr_2(SO_4)_3$			20	+					+						
				40	+					+						
				60	+					+						
				80						+						
				100						+						
				120												
				140												
Cider				20	+	+	+	+	+	+		+	+	+	+	+
				40			+			+						
				60						+						
				80												
				100												
				120												
				140												
Citric acid		Fp. *153	10%, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	O	+	+	+	+	+		+	+	O	+	+
				80					+	+						
				100					+	+						
				120												
				140												
Citric acid				20	+			+	+							
				40	+			+	+							
				60				+	+							
				80					+							
				100												
				120												
				140												
Citric acid up to 10 %				20						+						
				40						+						
				60						+						
				80												
				100												
				120												
				140												
Coal gas, benzene free				20	+	+	+	+	+	+			+	+	O	+
				40												
				60												
				80												
				100												
				120												
				140												
Coconut fat alcohol (SpR8)			technically pure	20	+	-	-	+	+	+			+	+	+	+
				40	+			O	+	+			+	+	O	O
				60	O				O	+			+	+		
				80												
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance										
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)	EPDM	FPM	NBR	CR	CSM
Compressedair, containing oil (SpRB)				20	-	-	-	+	O	+	-	+	+	+	+
				40				+		+					
				60						+					
				80											
				100											
				120											
				140											
Copper salts	$CuCl$, $CuCl_2$, CuF_2, $Cu(NO_3)_2$, $CuSO_4$, $Cu(CN)_2$		all, aqueous	20	+	+	+	+	+	+	+	+	+	+	+
				40	+	+	+	+	+	+	+	+	+	+	+
				60	O	+	+	+	+	+		+	O	+	O
				80		+			+	+		+			
				100						+					
				120											
				140											
Corn oil (SpRB)			technically pure	20	O	O	O	+	+	+		+	+	O	+
				40		O		+	+	+		+	+	-	+
				60				O	O	+		+	+		O
				80						+					
				100											
				120											
				140											
Cresol	$HO-C_6H_4-CH_3$		cold saturated, aqueous	20	O	-	-	+	+	+		+	O	-	O
				40				+	+	+		+	O		
				60						+					
				80						O					
				100											
				120											
				140											
Crotonic aldehyde	$CH_3-CH=CH-CHO$	102	technically pure	20	-	-	-	+	+	+	+	+	+	+	+
				40						O					
				60						-					
				80											
				100											
				120											
				140											
Cyclohexane (Q/E)	C_6H_{12}	81	technically pure	20	-	-	-	+	+	+	-	+	+	-	-
				40				+		+					
				60				+		+					
				80						+					
				100											
				120											
				140											
Cyclohexanol (SpRB)	$C_6H_{12}O$	161	technically pure	20	+	+	-	+	+	+	-	+	O	+	+
				40	+	+		+	+	+					
				60	+	+		+	O	O					
				80		O				O					
				100						-					
				120											
				140											
Cyclohexanone	$C_6H_{10}O$	155	technically pure	20	-	-	-	+	+	+	O	-	-	-	-
				40				O	O	O					
				60				O	O	-					
				80											
				100											
				120											
				140											

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Densodrine W				20	+	+	O			+			+	+	+	
				40	+	+										
				60	+	+										
				80												
				100												
				120												
				140												
Detergents (SpRB)	see washing powder		for usual washing lathers													
Dextrine	$(C_6H_{10}O_5)_n$		usual commercial	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+		+		+	+	+	+	+
				60	+	+	+	+		+		+	+	+	+	+
				80		+				+						
				100						+						
				120						+						
				140												
Dextrose	siehe Glucose			20	+	+	+	+	+	+		+	+			
				40	+	+		+	+	+		+	+			
				60	+	+		+	+	+		+	+			
				80		+			+	+		+	+			
				100						+			+			
				120												
				140												
Dibutyl ether	$C_4H_9OC_4H_9$	142	technically pure	20	-	-	-	O	O			-	+	+	-	O
				40									+	O		O
				60				-	-				O	-		O
				80												
				100												
				120												
				140												
Dibutyl phthalate	$C_6H_4(COOC_4H_9)_2$	340	technically pure	20	-	-	-	+	+	+		O	O	-	-	-
				40				O	O	+						
				60				O	O	O						
				80												
				100												
				120												
				140												
Dibutyl sebacate	$C_8H_{16}(COOC_4H_9)_2$	344	technically pure	20	-	-	-	+	+	+		+	+	-	-	-
				40												
				60												
				80												
				100												
				120												
				140												
Dichlorbenzol	$C_6H_4Cl_2$	180	technically pure	20	-	-	-									
				40												
				60												
				80												
				100												
				120												
				140												
Dichloroacetic acid	$Cl_2CHCOOH$	194	technically pure	20	+	-	-	+	+	+		+	O	-	O	+
				40	+			+	+	+		+	-		-	O
				60	O			O	O	O		+				-
				80						-						
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Dichloroacetic acid (SpRB)	$Cl_2CHCOOH$		50%, aqueous	20	+	-	-	+	+	+		+	O	-	+	+
				40	+			+	+	+		+	O		O	+
				60	O			+	+	+		+	-		-	O
				80						O						
				100						-						
				120												
				140												
Dichloroacetic acid methyl ester	$Cl_2CHCOOCH_3$	143	technically pure	20	-	-	-	+	+	O		+	-	-	-	+
				40				+	+			+				+
				60				+	+			O				O
				80												
				100												
				120												
				140												
Dichloroethan	Ethylene chloride															
Dichloroethylene	ClCH=CHCl	60	technically pure	20	-	-	-	-	O	+		-	O	-	-	-
				40						+						
				60												
				80												
				100												
				120												
				140												
Dichloromethane				20	-	-	-									
				40												
				60												
				80												
				100												
				120												
				140												
Diesel oil (SpRB, Q/E)				20	+	+	O	+	O	+		-	+	+	O	O
				40	+	+				+			+	+		-
				60				O		+						
				80						+						
				100						+						
				120						+						
				140												
Diethyl ether				20	-	-	-									
				40												
				60												
				80												
				100												
				120												
				140												
Diethylamine	$(C_2H_5)_2NH$	56	technically pure	20	O	-	-	+	+	+		O	-	-	-	-
				40						O						
				60						-						
				80												
				100												
				120												
				140												
Diethylene glycol butyl ether				20	-	-	-									
				40												
				60												
				80												
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Diglycolic acid (SpRB)	$HOOC-CH_2-O-CH_2-COOH$	Fp*.,	30%, aqueous	20	+	+	+	+	+	+		+	O	+	+	O
		148		40	+	+		+	+							
				60	O	+		+	+							
				80												
				100												
				120												
				140												
Di-isobutyl ketone	$[(CH_3)2CHCH_2]_2CO$	124	technically pure	20	-	-	-	+	+	+		O	-	-	-	-
				40						+						
				60				-	-	O						
				80												
				100												
				120												
				140												
Dimethyl formamide	$(CH_3)_2CHNO$	153	technically pure	20	-	-	-	+	+	-		O	-	O	+	+
				40				+	+							
				60				O	+							
				80												
				100												
				120												
				140												
Dimethylamine	$(CH_3)_2NH$	7	technically pure	20	O	-	-	+	+	O		O	-	-	-	-
				40						-						
				60				O								
				80												
				100												
				120												
				140												
Dimethylphthalate (DMP)	$C_6H_4(CH_3)_2$			20	-	-	-									
				40												
				60												
				80												
				100												
				120												
				140												
Dinonylphthalate (DNP)			technically pure	20	-	-	-	O	+			O	+	-	-	-
				40												
				60												
				80												
				100												
				120												
				140												
Dioctylephthalate (SpRB) (DOP)			technically pure	20	-	-	-	O	+			O	+	-	-	-
				40												
				60					-							
				80												
				100												
				120												
				140												
Dioxane	$C_4H_8O_2$	101	technically pure	20	-	-	-	+	O	-			-	O	-	-
				40				+	O							
				60				+	O							
				80					-							
				100												
				120												
				140												
Drinking water	see water															

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Ethanolamine	see Amino ethanol															
Ethyl acetate	CH_3COOCH_2-CH_3	77	technically pure	20	-	-	-	+	+	O		+	-	-	-	-
				40				O	O							
				60				O	O							
				80												
				100												
				120												
				140												
Ethyl alcohol + acetic acid (fermentation mixture)			technically pure	20	+	O	-	+	+	+		O	O	O	+	+
				40	+			+		+		O	O	O	+	+
				60	O			+		+			O		+	+
				80						O						
				100												
				120												
				140												
Ethyl alcohol (Ethanol) (SpRB)	CH_3-CH_2-OH	78	technically pure, 96%	20	+	O	-	+	+	+		+	O	O	+	+
				40	+			+	+	O		+	O			
				60	O			+	+	-		+	O			
				80					+							
				100												
				120												
				140												
Ethyl benzene	C_6H_5-CH_2CH_3	136	technically pure	20	-	-	-	O	O	O		-	+	-	-	-
				40												
				60					-							
				80												
				100												
				120												
				140												
Ethyl chloride	CH_3-CH_2Cl	12	technically pure	20	-	-	-	O	O	O		-	O	-	-	-
				40												
				60												
				80												
				100												
				120												
				140												
Ethyl ether	CH_3CH_2-O-CH_2CH_3	35	technically pure	20	-	-	-	+	O	+		-	-	-	-	-
				40												
				60												
				80												
				100												
				120												
				140												
Ethylenchloride (1,2-Dichloroethane)				20	-	-	-									
				40												
				60												
				80												
				100												
				120												
				140												
Ethylene chloride	$ClCH_2$-CH_2Cl	83	technically pure	20	-	-	-	O	O	+		-	+	O	O	-
				40						+			+	-	-	
				60						+			O			
				80						O						
				100						-						
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Ethylene diamine	H_2N-CH_2-CH_2-NH_2	117	technically pure	20	O	-	-	+	+	O		+	O	+	+	O
				40				+	+	O			O	O	O	O
				60				+	+	-			-	-	-	-
				80												
				100												
				120												
				140												
Ethylene glycol (SpRB)	HO-CH_2-CH_2-OH	198	technically pure	20	+	O	-	+	+	+		+	+	+	+	+
				40	+			+	+	+		+	+	+	+	+
				60	+			+	+	+		+	+	O	O	+
				80					+	+		+	O			O
				100					+	+						
				120						+						
				140												
Ethylene glycol	CH_2OHCH_2OH	198	technically pure	20	+		-	+	+	+		+	+	+	+	+
				40	+			+	+	+		+	+	+	+	+
				60	+			+	+	+		+	+	O	O	+
				80					+	+			O			O
				100						+						
				120												
				140												
Ethylene oxide	CH_2-CH_2	10	technically pure, moist	20	-	-	-	-	O	+		O	-	-	-	-
				40												
				60												
				80												
				100												
				120												
				140												
Ethylenediaminetetraacetic acid (EDTA)				20				+	+	+		+				
				40												
				60												
				80												
				100												
				120												
				140												
Fatty acids $>C_6$ (SpRB)	R-COOH		technically pure	20	+	+	-	+	+	+		+	+	O	O	-
				40	+	+		+	+	+						
				60	+	+		O	+	+						
				80						+						
				100												
				120												
				140												
Fatty alcohol sulphonates (SpRB)			aqueous	20	+	+		+	+	+		+	+	+	+	+
				40	+	+		+	+	+		+	+	+	+	+
				60	O	O		+	O	+		+	+	+	+	+
				80						+						
				100						+						
				120												
				140												
Fertilizers			aqueous	20	+	+	O	+	+	+		+	+	+	+	+
				40	+	+		+	+	+		+	+	+	+	+
				60	O	+		+	+	+		+	+	+	+	+
				80		+				+			+			+
				100									+			
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Fluorine	F_2		technically pure	20	-	-	-	-	-	-		-	-	-	-	-
				40												
				60												
				80												
				100												
				120												
				140												
Fluorosilicic acid (Q/E)	H_2SiF_6		32%, aqueous	20	+	+	+	+	+	+		+	O	O	O	+
				40	+	+	+	+		+				-	-	O
				60	+	+	+	+		+						-
				80						+						
				100						+						
				120												
				140												
Formaldehyde (SpRB)	HCHO		40%, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60			+	+		+		+	+	O	O	O
				80						+						
				100												
				120												
				140												
Formamide	$HCONH_2$	210	technically pure	20	-	-	-	+	+			+	O	+	+	
				40				+	+							
				60				+	+							
				80												
				100												
				120												
				140												
Formic acid (SpRB)	HCOOH		up to 50%, aqueous	20	+	-	O	+	+	+		+	+	-	+	+
				40	+			+	+	+		+	+		+	+
				60	O			+	O	+		O	O		O	+
				80						+			-			O
				100						+						
				120												
				140												
Formic acid (SpRB)	HCOOH	101	technically pure	20	+	-	-	+	+	+		+	+	-	+	+
				40	O			+	O	+		+			O	+
				60	-			+	-	+		+			-	+
				80						+		O				O
				100						+						
				120												
				140												
Formic acid (SpRB)			25%	20	+	+		+	+	+		+				
				40	+	+		+	+	+		+				
				60	+	+		+	+	+		+				
				80					+	+						
				100												
				120												
				140												
Freon 113	see trifluoro, trichlorethane	48														
Frigen 12 (D/P)	see Freon 12	-30	technically pure													

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Fruit juices (SpRB)				20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	+	+	+	+	+	+		+	+	+	+	+
				80		+			+	+		+	+	+	+	+
				100						+		+	+	+		+
				120						+			+			
				140												
Fruit pulp				20	+	+	+	+	+			+	+	+	+	+
				40			+	+	+							
				60				+	+							
				80												
				100												
				120												
				140												
Fuel oil				20	+	+		O	O	+		-	+	+	+	-
				40	O	+		-	-	+			+	+	+	
				60						+			+	+	O	
				80						+						
				100						+						
				120												
				140												
Furfuryl alcohol (SpRB)	$C_5H_6O_2$	171	technically pure	20	-	-	-	+	+	+		O	-	-	O	O
				40				+		+						
				60				+	O	O						
				80						-						
				100												
				120												
				140												
Gasoline (SpRB)	C_5H_{12} to $C_{12}H_{26}$	80-130	free of lead and aromatic compounds	20	+	+	-	+	O	+		-	+	+	-	O
				40	+	+		+		+			+	+		-
				60	+	+		O	-	+			+	+		
				80						+						
				100						+						
				120						+						
				140												
Gelatin			all, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60		+	+	+	+	+						
				80						+						
				100												
				120												
				140												
Glucose	$C_6H_{12}O_6$	Fp*., 148	all, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	O	+	+	+	+	+		+	+	+	+	+
				80		+			+	+		+	+	+	+	+
				100						+			+			
				120												
				140												
Glycerol	HO-CH_2-CH(OH)-CH_2OH	290	technically pure	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		O	+	+	+	+
				60	+	+		+	+	+		O	O	+	+	+
				80		+			+	+			-	O	+	+
				100					+	+					O	O
				120						+						
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Glycocoll (SpRB)	NH_2-CH_2-COOH	Fp.* 233	10%, aqueous	20	+	+	+	+	+	+			+	+	+	+
				40	+	+	+	+	+	+			+	O	+	O
				60		+				+						
				80						+						
				100												
				120												
				140												
Glycol	see Ethylene glycol															
Glycolic acid	HO-CH_2-COOH	Fp.*, 80	37%, aqueous	20	+	-	+	+	+	+			+	+	+	+
				40			+	+		+						
				60				+		+						
				80						+						
				100						+						
				120												
				140												
Heptane (SpRB)	C_7H_{16}	98	technically pure	20	+	O	-	+	+	+		-	+	+	+	+
				40						+			+	+	+	O
				60				O	O	+			+	+	+	-
				80						+						
				100						+						
				120												
				140												
Hexane (SpRB)	C_6H_{14}	69	technically pure	20	+	O	-	+	+	+		-	+	+	+	+
				40						+			+	+	+	O
				60				O	O	+			+	+	+	-
				80						+						
				100						+						
				120												
				140												
Hydrazine hydrate (SpRB)	H_2N-$NH_2 . H_2O$	113	aqueous	20	+	-	-	+	+	-		+	O	-	-	+
				40				+	+							
				60				+	+							
				80												
				100												
				120												
				140												
Hydrobromic acid (SpRB)	HBr	124	aqueous, 50%	20	+	+	+	+	+	+		+	+	O	+	+
				40	+	+	+	+	+	+		+	+	-	+	+
				60	+	+		+	+	+		O	+		O	+
				80		O				+		-	O		-	O
				100						+			-			-
				120												
				140												
Hydrochloric acid (Q/E, D/P)	HCl		up to 38%	20	+	+	-	+	O	+		+	+	-	O	+
				40	+	+		+		+			+			
				60	+	+				+						
				80						+						
				100						+						
				120												
				140												
Hydrochloric acid (Q/E, D/P)	HCl		5%, aqueous	20	+		+	+	+	+		+	+	O	O	+
				40	+		+	+	+	+		+	+	-	-	O
				60	O			+	+	+		+	+			-
				80					O	+			+			
				100						+						
				120						+						
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Hydrochloric acid (Q/E, D/P)	HCl		10%, aqueous	20	+	+	+	+	+	+		+	+	O	O	+
				40	+	+	+	+	+	+		+	+	-	-	O
				60	O	+		+	O	+		+	+			-
				80		+			O	+			+			
				100						+						
				120						+						
				140												
Hydrochloric acid (Q/E, D/P)	HCl		up to 30%, aqueous	20	+	+	O	+	+	+		+	+	-	-	+
				40	+	+	-	+	O	+		+	+			O
				60	O	+		+	O	+		O	O			-
				80		+			-	+						
				100						+						
				120												
				140												
Hydrochloric acid (Q/E, D/P)	HCl		36%, aqueous	20	+	+	-	+	+	+		O	+	-	-	O
				40	+	+		+	O	+		O	O			-
				60	O	O		+	-	+		-	-			
				80		O				+						
				100						+						
				120												
				140												
Hydrocyanic acid	HCN	26	technically pure	20	+	+	-	+	+	+		+	+	O	O	+
				40	+	+		+	+	+		O	O	-	-	O
				60	O	+		+	+	+						
				80						+						
				100												
				120												
				140												
Hydrofluoric acid	HF			20	+	-	-	+	+	+		-	+	-	-	+
				40	O			+	+	+			+			+
				60	O			O	+	+			O			O
				80						+						
				100						+						
				120												
				140												
Hydrogen	H_2	-253	technically pure	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	+	+	+	+	+	+		+	+	+	+	+
				80		+				+		+	+	+	+	+
				100					-	+		+	+	+		
				120												
				140												
Hydrogen chloride (Q/E)	HCl	-85	technically pure, gaseous	20	+	+	-	+	+	+		+	+	O	O	O
				40	+	+		+	+	+		+	+	-	-	O
				60	O	+		+	+	+		+	+			-
				80		O				+						
				100						+						
				120												
				140												
Hydrogen peroxide			70%	20	+	+	-	+	+	O		O	+			
				40						O						
				60												
				80												
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Hydrogen peroxide (SpRB)	H_2O_2		50%, aqueous	20	+	+	-	+	+	O		O	+			
				40												
				60												
				80												
				100												
				120												
				140												
Hydrogen peroxide (SpRB)	H_2O_2		10%, aqueous	20	+	+	-	+	+	O		O	+	O	-	+
				40	+			+	+	O		O	O	-		+
				60	O			+	+	-		-	-			O
				80												-
				100												
				120												
				140												
Hydrogen peroxide (SpRB)	H_2O_2	139	90%, aqueous	20	+		-	+	-	O			O	-	-	O
				40												-
				60				-								
				80												
				100												
				120												
				140												
Hydrogen peroxide (SpRB)	H_2O_2	105	30%, aqueous	20	+	+	-	+	+	O		O	+	-	-	+
				40												O
				60												-
				80												
				100												
				120												
				140												
Hydrogen sulphide	H_2S		technically pure	20	+	+	+	+	+	+		+	+	+	O	+
				40	+	+	+	+	+	+		-	+	O	-	O
				60	+	+		O	+	+			O	-		O
				80						+			-			-
				100						+						
				120						+						
				140												
Hydrogen sulphide	H_2S		saturated, aqueous	20	+	+	+	+	+	+		+	+	-	+	+
				40	+	+	+	+	+	+		-	+	-	-	+
				60	O	+		+	+	+			+			O
				80						+			O			-
				100						+						
				120						+						
				140												
Hydroquinone	$C_6H_4(OH)_2$		saturated	20	+	+		+	+			+				
				40	+	+		+	+							
				60				+	+							
				80					+							
				100												
				120												
				140												
Hydrosulphite	see Sodium dithione															
Hydroxylamine sulfate				20	+			+				+				
				40	+			+								
				60	+			+								
				80												
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Hydroxylamine sulphate	$(NH_3OH)_2SO_4$		all, aqueous	20	+	+	-	+	+			+	+	+	O	+
				40	+	+		+	+				+	O		+
				60				+	+							
				80												
				100												
				120												
				140												
Iodine-potassium iodide solution (lugol's solution)				20	+	-	-			+			+			
				40												
				60												
				80												
				100												
				120												
				140												
Iodium	I_2	185	100%	20	-	-	-			+			+			
				40												
				60												
				80												
				100												
				120												
				140												
Iron (II) -chloride			saturated	20	+	+	+	+	+	+		+	+			
				40	+	+		+	+	+		+	+			
				60	+	+		+	+	+		+	+			
				80		+			+	+			+			
				100						+			+			
				120												
				140												
Iron (II) -chloride	$FeCl_2$		saturated	20	+	+	+	+	+	+		+	+			
				40	+	+		+	+	+		+	+			
				60	+	+		+	+	+		+	+			
				80		+			+	+		+	+			
				100						+			+			
				120												
				140												
Iron (II) -nitrate	$Fe(NO_3)_2$		saturated	20	+	+	+	+	+	+		+	+			
				40	+	+		+	+	+		+	+			
				60	+	+		+	+	+		+	+			
				80		+			+	+			+			
				100						+			+			
				120												
				140												
Iron (III) -chloride	$FeCl_3$		saturated	20	+	+	+	+	+	+		+	+			
				40	+	+		+	+	+		+	+			
				60	+	+		+	+	+		+	+			
				80		+			+	+		+	+			
				100						+			+			
				120												
				140												
Iron (III) -chloride			saturated	20	+	+	+	+	+	+		+	+			
				40	+	+		+	+	+		+	+			
				60	+	+		+	+	+		+	+			
				80		+			+	+		+	+			
				100						+			+			
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Iron (III) -chloridsulfate			saturated	20	+	+	+	+	+	+		+	+			
				40	+	+		+	+	+		+	+			
				60	+	+		+	+	+		+	+			
				80		+			+	+		+	+			
				100						+			+			
				120												
				140												
Iron (III) -nitrate			saturated	20	+	+	+	+	+	+		+	+			
				40	+	+		+	+	+		+	+			
				60	+	+		+	+	+		+	+			
				80		+			+	+		+	+			
				100						+			+			
				120												
				140												
Iron (III) -nitrate	$Fe(NO_3)_3$		saturated	20	+	+	+	+	+	+		+	+			
				40	+	+		+	+	+		+	+			
				60	+	+		+	+	+		+	+			
				80		+			+	+		+	+			
				100						+			+			
				120												
				140												
Iron (III) -sulfate	$Fe_2(SO_4)_3$		saturated	20	+	+	+	+	+	+		+	+			
				40	+	+		+	+	+		+	+			
				60	+	+		+	+	+		+	+			
				80		+			+	+		+	+			
				100						+			+			
				120												
				140												
Iron (III) -sulfate			saturated	20	+	+	+	+	+	+		+	+			
				40	+	+		+	+	+		+	+			
				60	+	+		+	+	+		+	+			
				80		+			+	+		+	+			
				100						+			+			
				120												
				140												
Iron (III) -nitrate	$FE(NO_3)3$		saturated	20	+					+		+	+			
				40	+					+		+	+			
				60	+					+		+	+			
				80						+		+	+			
				100						+			+			
				120												
				140												
Iron (II) -sulfate	$FeSO_4$		saturated	20	+	+	+	+	+	+		+	+			
				40	+	+		+	+	+		+	+			
				60	+	+		+	+	+		+	+			
				80		+			+	+		+	+			
				100						+			+			
				120												
				140												
Iron (III) -sulfate			saturated	20						+						
				40						+						
				60						+						
				80						+						
				100						+						
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Iron salts			all, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	O	+		+	+	+		+	+	+	+	+
				80		+			+	+		+	+			+
				100						+			+			
				120						+						
				140												
Isooctane (SpRB)	$(CH_3)_3$-C-CH_2-CH-$(CH_3)_2$	99	technically pure	20	+		-	+	+	+			+	+	+	O
				40						+						
				60				O	O	+						
				80						+						
				100						+						
				120												
				140												
Isophorone (SpRB)	$C_9H_{14}O$		technically pure	20						-						
				40												
				60												
				80												
				100												
				120												
				140												
Isopropyl alcohol (SpRB)	$(CH_3)_2$-CH-OH	82	technically pure	20				+	+	+		+				
				40						+						
				60						+						
				80						O						
				100												
				120												
				140												
Isopropyl ether	$(CH_3)_2$-CH-O-CH-$(CH_3)_2$	68	technically pure	20	-	-	-	O	O	+		O	-	-	-	-
				40						+						
				60				-	-	+						
				80												
				100												
				120												
				140												
Isopropylbenzene				20	-	-	-									
				40												
				60												
				80												
				100												
				120												
				140												
Jam, Marmalade				20	+	+	+	+	+	+		+	+	+	+	+
				40	O	+	+	+	+	+		+	+	+	+	+
				60	O	+		+	+	+		+	+	+	+	+
				80					+	+		+	+			
				100					+	+						
				120						+						
				140												
Lactic acid (SpRB)	$CH_3CHOHCOOH$		10%, aqueous	20	+	+	+	+	+	+		O	+	-	-	O
				40	O	+	O	+	+	+		O	O			O
				60	-	+	-	+	+	O		O	O			O
				80		+			+	O		-	O			
				100					+	-						
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Lanolin (SpRB)			technically pure	20	+	o	+	+	+	+			+	+	+	O
				40	O		+	+	+	+			+	+	O	-
				60			+	+	+	+			+	+	-	
				80						+						
				100						+						
				120						+						
				140												
Lead acetate	$Pb(CH_3COO)_2$		aqueous, saturated	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	+	+	+	+	+	+		+	+	+	+	+
				80		+				+						
				100						+						
				120												
				140												
Lead salts	$PbCl_2$, $Pb(NO_3)_2$, $PbSO_4$		saturated	20		+										
				40		+										
				60		+										
				80		+										
				100												
				120												
				140												
Leadcarbonate				20	+	+		+	+	+		+				
				40						+						
				60						+						
				80												
				100												
				120												
				140												
Leadnitrate	$Pb(NO_3)2$			20		+										
				40		+										
				60		+										
				80		+										
				100												
				120												
				140												
Leadnitrate				20	+					+						
				40	+					+						
				60	+					+						
				80						+						
				100						+						
				120												
				140												
Leadtetrafluoroborate				20						+						
				40						+						
				60						+						
				80						+						
				100						+						
				120												
				140												
Linoleic acid				20						+						
				40						+						
				60						+						
				80						+						
				100						+						
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Linseed oil (SpRB)			technically pure	20	+	+	+	+	+	+			+	+	O	+
				40	+	+	-	+	+	+			+	+	-	O
				60	O			+	+	+			+	+		-
				80					+	+						
				100					+	+						
				120						+						
				140												
Liqueurs				20	+			+	+	+		+	+	+	+	+
				40	+			+		+						
				60						+						
				80						+						
				100												
				120												
				140												
Liquid fertilizers				20				+	+			+				
				40				+	+			+				
				60				+	+			+				
				80					+							
				100												
				120												
				140												
Lithiumbromide	LiBr			20	+	+		+	+	+		+	+			
				40						+						
				60						+						
				80						+						
				100						+						
				120												
				140												
Lithiumsulfate				20	+	+		+	+	+		+	+			
				40						+						
				60						+						
				80												
				100												
				120												
				140												
Lubricating oils				20	+	O	-	+	O	+		-	+	+	+	+
				40	+			+		+			+	+	O	O
				60	+			O		+			+	O	-	-
				80						+			O			
				100						+			-			
				120						+						
				140												
Magnesium salts	$MgCl_2$, $MgCO_3$, $Mg(No3)_2$, $Mg(OH)_2$, $MgSO_4$		all, aqueous,saturated	20	+	+	+	+	+	+			+	+	+	+
				40	+	+	+	+	+	+			+	+	+	+
				60	O	+		+	+	+		+	+	+	+	+
				80		+			+	+		+	+			+
				100					+	+			+			
				120						+						
				140												
Magnesiumhydrogencarbonate				20	+			+	+			+				
				40	+			+	+			+				
				60	+			+	+			+				
				80												
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Maleic acid (SpRB)	$(CH\text{-}COOH)_2$	Fp. *131	cold saturated, aqueous	20	+	+	+	+	+	+			+	-	-	-
				40	+	+		+	+	+			+			
				60	O			+	+	+			+			
				80						+			-			
				100						+						
				120						+						
				140												
Media water or similar media				20	+	+	+	+	+	+						
				40	+	+	+	+	+	+						
				60	+	+	+	+	+	+						
				80		+			+	+						
				100					+	+						
				120						+						
				140						+						
Mercury	Hg	357	pure	20	+	+	+	+	+	+		+	+	+	+	+
				40	+			+	+	+		+	+	+	+	+
				60	+			+	+	+		+	+	+	+	+
				80						+			+			
				100						+						
				120						+						
				140												
Mercury (II) -chloride	$HgCl_2$			20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+		+	+	+		+	+	+	+	+
				60	+	+		+	+	+		+	+	+	+	+
				80		+			+	+						
				100						+						
				120												
				140												
Mercury (II) -cyanide	$Hg(CN)2$			20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+		+	+	+		+	+	+	+	+
				60	+	+		+	+	+		+	+	+	+	+
				80		+				+						
				100						+						
				120												
				140												
Mercury (II) -cyanide	$Hg(NO_3)_2$			20	+	+		+	+	+		+	+	+	+	+
				40	+	+		+	+	+		+	+	+	+	+
				60	+	+		+	+	+		+	+	+	+	+
				80		+			+	+			+			
				100						+						
				120												
				140												
Mercury (II) -sulfate				20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+		+	+	+		+	+	+	+	+
				60	+	+		+	+	+		+	+	+	+	+
				80		+			+	+			+			
				100						+						
				120												
				140												
Mercury salts	$HgNO_3$, $Hg\ Cl_2$, $Hg(CN)_2$		cold saturated, aqueous	20	+	+	+	+	+	+		+	+	O	O	O
				40	+	+		+	+	+		+	+	O	O	O
				60	O	+		+	+	+			+	-	-	-
				80						+						
				100						+						
				120						+						
				140												
Methane	see natural gas	-161	technically pure													

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Methanol (SpRB)	CH_3OH	65	all	20	+	-	-	+	+	+		+	O	+	+	+
				40	+			+	+	O		+	O	+	+	+
				60	O			+	+	-		+	O	+	O	+
				80												
				100												
				120												
				140												
Methyl acetate	CH_3COOCH_3	56	technically pure	20	-	-	-	+	+	+			-	-	-	-
				40					+	O						
				60					O							
				80												
				100												
				120												
				140												
Methyl amine	CH_3NH_2	-6	32%, aqueous	20	O	-	-	+	+	O			+	-	+	+
				40												
				60												
				80												
				100												
				120												
				140												
Methyl bromide	CH_3Br	4	technically pure	20	-	-	-	O	-	+			O	-	-	O
				40						+						
				60						+						
				80												
				100												
				120												
				140												
Methyl chloride	CH_3Cl	-24	technically pure	20	-	-	-	O	-	+			-	-	-	-
				40						+						
				60						+						
				80												
				100												
				120												
				140												
Methyl ethyl ketone	$CH_3COC_2H_5$	80	technically pure	20	-	-	-	+	+	-			-	-	-	-
				40				O	O							
				60				-	O							
				80												
				100												
				120												
				140												
Methylene chloride	CH_2Cl_2	40	technically pure	20	-	-	-	O	O	+			O	-	-	-
				40						O						
				60						O						
				80												
				100												
				120												
				140												
Methylisobutylketone	$C_6H_{12}O$			20	-	-	-									
				40												
				60												
				80												
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Methylmethacrylate	$C_5H_8O_2$			20	-	-	-									
				40												
				60												
				80												
				100												
				120												
				140												
Methylphenylketone	C_8H_8O			20	-	-	-									
(Acetophenon)				40												
				60												
				80												
				100												
				120												
				140												
Milk (SpR8)				20	+	+	+	+	+	+			+	+	+	+
				40	+	+	+	+	+	+						
				60	+	+	+	+	+	+						
				80		+			+	+						
				100					+	+						
				120						+						
				140												
Mineral oils, free of aromatics				20	+	+	-	+	+	+			+	+	O	O
				40	+			+	+	+			+	+	-	-
				60	+			O	O	+			+	+		
				80						+						
				100						+						
				120						+						
				140												
Mineral water				20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	+	+	+	+	+	+		+	+	+	+	+
				80		+			+	+		+	+	+		+
				100					+	+		+	+			+
				120						+			+			
				140												
Mixed acids	15% HNO_3		3 parts	20	O	O	-	O	-	+			+	-	-	+
- nitric	15% HF		1 part	40						+			O			O
- hydrofluoric	18% H_2SO_4		2 parts	60						+						
- sulphuric				80												
				100												
				120												
				140												
Mixed acids	H_2SO_4		48%	20	+	+	-	-	-	+			-	-	-	-
- sulphuric	HNO_3		49%	40	O											
- nitric	H_2O		43%	60	-											
- water				80												
				100												
				120												
				140												
Mixed acids	H_2SO_4		50%	20	O	O	-	-	-	+			-	-	-	-
- sulphuric	HNO_3		50%	40	-											
- nitric	H_2O		40%	60												
- water				80												
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Mixed acids	H_2SO_4		10%	20	O	O	-	-	-	O			-	-	-	-
- sulphuric	HNO_3		87%	40												
- nitric	H_2O		43%	60												
- water				80												
				100												
				120												
				140												
Mixed acids	H_2SO_4		50%	20	+	+	-	-	-	+			+	-	-	O
- sulphuric	HNO_3		33%	40	O											
- nitric	H_2O		17%	60												
- water				80												
				100												
				120												
				140												
Mixed acids	H_2SO_4		10%	20	+	+	-	O	-	+			+	-	O	+
- sulphuric	HNO_3		20%	40	+					+			+			O
- nitric	H_2O		70%	60						+			+			
- water				80						+						
				100												
				120												
				140												
Mixed acids	H_2SO_4		50%	20	+		-	-	-	+			+	-	O	O
- sulphuric	HNO_3		31%	40												
- nitric	H_2O		19%	60												
- water				80												
				100												
				120												
				140												
Mixed acids	H_2SO_4		30%	20	+	+	-	+	+	+			+	-	+	+
- sulphuric	H_3PO_4		60%	40	+	+		O	O	+			+		O	O
- phosphoric	H_2O		10%	60		+				+			+			
- phosphoric				80						+						
				100												
				120												
				140												
Molasses				20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	O	+	+	+	+	+		+	+	+	+	+
				80		+				+		+	+	+	O	+
				100												
				120												
				140												
Molasses wort				20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	+	+	+	+	+	+		+	+	+	+	+
				80		+				+						
				100												
				120												
				140												
Monochloroacetic acid ethyl ester	$ClCH_2COOC_2H_5$	144	technically pure	20	-	-	-	+	+	O			O	-	-	-
				40				+	+	-						
				60				+	+							
				80												
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Morpholin	C_4H_9NO	129	technically pure	20	-	-	-	+	+	+			+	-	O	O
				40				+	+	+						
				60				+	+	O						
				80												
				100												
				120												
				140												
Mowilith D			usual commercial	20	+	+		+	+	+			+	+	+	+
				40												
				60												
				80												
				100												
				120												
				140												
Naphthalene		218	technically pure	20	-	-	-	+	+	+		-	+	+	-	O
				40						+			+	+		
				60				O		O			+	+		
				80												
				100												
				120												
				140												
Natriumhydrogensulfite	$NaHSO_3$			20	+	+		+	+	+		+	+			
				40	+	+		+	+	+		+				
				60	+	+		+	+	+		+				
				80		+			+	+						
				100						+						
				120												
				140												
Natriumsulfate				20	+	+	+	+	+	+		+	+			
				40	+	+		+	+	+		+	+			
				60	+	+		+	+	+		+	+			
				80		+			+	+		+	+			
				100						+			+			
				120												
				140												
Natriumtetraborate (Borax)				20	+	+	+	+	+	+		+	+			
				40	+	+		+	+	+		+				
				60	+	+		+	+	+		+				
				80		+			+							
				100												
				120												
				140												
Nickel salts	$(CH_3COO)2Ni$, $NiCl_2$, $Ni(NO_3)2$, $Ni SO_4$		cold saturated, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	O	+	+	+	+	+			+	+	+	+
				80						+			+			
				100						+			+			
				120						+						
				140												
Nitrating acid	H_2SO_4		65% 20%	20						+						
	HNO_3		15%	40												
	H_2O			60												
				80												
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Nitric acid (SpRB)	HNO_3			20	+	+	-	+	O	+		+	+			
				40	+	+				+			+			
				60	+	+				+			+			
				80						+						
				100						+						
				120												
				140												
Nitric acid (SpRB)	HNO_3			20	+	+	-	+	+	+		+	+			
				40	+	+		+	O	+			+			
				60	+	+		+		+						
				80		+				+						
				100						+						
				120												
				140												
Nitric acid up to 55% (SpRB)				20	+	+	-	+	-	+			+			
				40	+	+				+						
				60						+						
				80												
				100												
				120												
				140												
Nitric acid (see note 2.3.1 on jointing) (SpRB)	see Salpetre		6,3%, aqueous													
Nitric acid (see note 2.3.1 on jointing) (SpRB)	see Salpetre		up to 40%, aqueous													
Nitric acid (see note 2.3.1 on jointing) (SpRB)	see Salpetre		65%, aqueous													
Nitric acid (see note 2.3.1 on jointing) (SpRB)	see Salpetre		100%													
Nitric acid (see note 2.3.1 on jointing) (SpRB)	see Salpetre		85%													
Nitric oxide	see Nitrous gases															
Nitrilotriacetic acid	$N(CH_2\text{-}COOH)_3$			20				+	+			+				
				40												
				60												
				80												
				100												
				120												
				140												
Nitrobenzene	$C_6H_5\text{-}NO_2$	209	technically pure	20	-	-	-	+	+	+		-	O	-	-	-
				40				O	+	O						
				60				O		-						
				80												
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Nitrotoluene (o-, m-, p-)		222-238	technically pure	20	-	-	-	+	+	+		-	O	O	-	-
				40				O	O	+			-	-		
				60						+						
				80						+						
				100						O						
				120												
				140												
Nitrous acid	HNO_2			20	+	+	-	+	-	+		+	+			
				40	+	+				+						
				60						+						
				80												
				100												
				120												
				140												
Nitrous gases	see Nitric oxide		diluted, moist, anhydrous													
N-Methylpyrrolidon				20	-	-	-									
				40												
				60												
				80												
				100												
				120												
				140												
N,N-Dimethylaniline	$C_6H_5N(CH_3)_2$		technically pure	20	-	-	-	+	+			+				
				40												
				60												
				80												
				100												
				120												
				140												
n-Pentylacetate				20	-	-	-									
				40												
				60												
				80												
				100												
				120												
				140												
Oleic acid (SpRB)	$C_{17}H_{33}COOH$		technically pure	20	+	O	-	+	+	+		-	+	O	-	-
				40	+			+	+	+			O	-		
				60	+			O	O	+			-			
				80						+						
				100						+						
				120						+						
				140												
Oleum (SpRB)	$H_2SO_4+SO_3$		10% SO_3	20	-	-	-	-	-	-		-	-	-	-	-
				40												
				60												
				80												
				100												
				120												
				140												
Oleum vapours (SpRB)			traces	20	+	-	-	-	-	-		-	+	-	-	O
				40												
				60												
				80												
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Olive oil (SpRB)				20	+	-	-	+	+	+		-	+	+	+	+
				40	+			+	+	+			+	+	+	+
				60	+			O	+	+			+	+	+	O
				80					+	+			+			-
				100												
				120												
				140												
Oxalic acid (SpRB)	$(COOH)_2$		cold saturated, aqueous	20	+	+	+	+	+	+		+	+	O	O	O
				40	+	+	+	+	+	+			+	-	-	O
				60	+	+		+	+	+			O			-
				80		O				+			-			
				100						+						
				120												
				140												
Oxygen	O_2		technically pure	20	+	+	+	+	+	+		+	+	+	+	+
				40	+		+	+	+	+		+	+		+	+
				60	+		+	O	O	+		+	+		+	+
				80						+			+		+	+
				100						O			+			+
				120						O			+			
				140												
Ozone (SpRB)	O_3		up to 2%, in air	20	+	+	-	O	O	O		O	+	-	O	+
				40				-	-							
				60												
				80												
				100												
				120												
				140												
Ozone (SpRB)	O_3		cold saturated, aqueous	20	+	+	-	O	O	O		-	+	-	O	+
				40	+			-	-				O		-	+
				60									-			O
				80												
				100												
				120												
				140												
Palm oil, palm nut oil (SpRB)				20	+	O	+	+	+	+		-	+	+	+	O
				40	-			+	+	+			+	+	O	-
				60				O	O	+			+	O	-	
				80						+						
				100						+						
				120												
				140												
Palmitic acid (SpRB)	$C_{15}H_{31}COOH$	390	technically pure	20	+	-	+	O	O	+		O	+	O	+	O
				40						+			O	-	-	-
				60					-	+			-			
				80						+						
				100						+						
				120						+						
				140												
Paraffin emulsions			usual commercial, aqueous	20	+	+	O	+	+	+		-	+	+	+	+
				40	+	+		+	+	+			+	+	O	-
				60				O	O	+			+	O	-	
				80						+			+			
				100						+						
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Paraffin oil				20	+	+	O	+	+	+		-	+	+	+	O
				40	+			+	+	+			+	O	O	-
				60	O			+	O	+			+	O	-	
				80						+			O			
				100						+						
				120						+						
				140												
p-Dibromo benzene	$C_6H_5Br_2$		technically pure	20	-	-	-	O	O	+		-	+	-	-	-
				40						+						
				60						+						
				80						+						
				100						+						
				120												
				140												
Perchlorethylene (tetrachlorethylene)	$Cl_2C=CCl_2$	121	technically pure	20	-	-		O	O	+			+	O	-	-
				40						+			+	-		
				60						+			+			
				80						O						
				100						-						
				120												
				140												
Perchlorid acid (SpRB)	$HClO_4$		10%, aqueous	20	+	+	O	+	+	+		+	+	-	-	+
				40	+	+		+	+	+		O	+			+
				60	O	+		+	+	+			+			O
				80						+			O			-
				100						+						
				120												
				140												
Perchlorid acid (SpRB)			70%, aqueous	20	O	O	-	+	O	+		-	+	-	-	+
				40				O	-	+			+			+
				60				-		+			+			O
				80						+			O			
				100						+						
				120												
				140												
Petroleum			technically pure	20	+	-	-	+	+	+		-	+	+	O	-
				40				+	O	+			+	+	-	
				60				O	O	+			O	+		
				80						+						
				100						+						
				120						+						
				140												
Petroleum ether (SpRB)		40-70	technically pure	20	+	-	-	+	+	+		-	+	+	-	-
				40	+			O	O	+			+	O		
				60	+			O	O	+			O	-		
				80						+						
				100						+						
				120												
				140												
Phenol (SpRB)	C_6H_5-OH	182	up to 10%, aqueous	20	+	+	-	+	+	+			+	-	-	-
				40	O	+		+	+	+			+			
				60				O	+	+		+	+			
				80						+		O	O			
				100						+						
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Phenol (SpRB)			up to 5%	20	+	+	-	+	+	+		+	+	-	-	
				40		+		+	+	+		O	+			
				60				+	+	+			+			
				80						+			O			
				100						O						
				120												
				140												
Phenol (SpRB)	C_6H_5-OH		up to 90%, aqueous	20	O	-	-	+	+	+		-	+	-	-	-
				40				+	+	+			O		O	
				60				O	+	O			-			
				80												
				100												
				120												
				140												
Phenylhydrazine	C_6H_5-NH-NH_2	243	technically pure	20	-	-	-	O	O	O		-	+	-	-	-
				40						-			+			
				60									O			
				80												
				100												
				120												
				140												
Phenylhydrazine hydrochloride	C_6H_5-NH-NH_2.HCl		aqueous	20	O	O	-		+	+			+	O	O	+
				40					O	+			+	-	-	+
				60					O	+		O	O			O
				80									-			-
				100												
				120												
				140												
Phosgene (SpRB)	$COCl_2$	8	liquid, technically pure	20	-	-	-	-	-	-		-	+	O	+	+
				40												
				60												
				80												
				100												
				120												
				140												
Phosgene (SpRB)			gaseous, technically pure	20	+	-	-	O	O	+		+	+	+	+	+
				40	O					+			+	+	O	O
				60	O								O	+	-	
				80												
				100												
				120												
				140												
Phosphate disodique	see d'isodiumphosphate		saturated													
Phosphoric acid	H_3PO_4		up to 30%, aqueous	20	+	+	+	+	+	+		+	+	O	+	+
				40	+	+	+	+	+	+		+	+	O	+	+
				60	O	+	O	+	+	+		O	+	-	+	+
				80		+			+	+			+		O	O
				100						+			+			
				120						+						
				140												
Phosphoric acid			50%, aqueous	20	+	+	+	+	+	+		+	+	O	+	+
				40	+	+	+	+	+	+		O	+	-	+	+
				60	+	+	O	+	+	+			+		O	+
				80		+			+	+			+			+
				100						+			O			O
				120						+						
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Phosphoric acid			85%, aqueous	20	+	+	+	+	+	+		+	+	-	+	+
				40	+	+	+	+	+	+		+	+		+	O
				60	+	+	O	O	+	+		O	+		O	-
				80		+			+	+			+			
				100						+			O			
				120						+						
				140												
Phosphoric acid	H_3PO_4			20	+	+	-	+	+	+		O	+	-	-	-
				40	+	+		+	+	+			+			
				60		+				+			O			
				80						+						
				100												
				120												
				140												
Phosphoric acid	H_3PO_4			20	+	+	-	+	+	+			+			
				40	+	+		+	+	+			+			
				60	+	+			+	+			+			
				80		+			+	+			+			
				100						+			O			
				120												
				140												
Phosphoric acid tributyl ester	$(H_9C_4O)_3P{=}O$			20	-	-	-	+	+	-		+	-			
				40												
				60												
				80												
				100												
				120												
				140												
Phosphorous chlorides: - Phosphorous trichloride - Phosphorous pentachloride - Phosphorous oxichloride (SpRB)	 PCl_3 PCl5 $POCl_3$	175 162 105	technically pure	20	-	-	-	+	O	-			+	-	-	+
				40												
				60				O	O							
				80												
				100												
				120												
				140												
Photographic developer (SpRB)			usual commercial	20	+	+	+	+	+	+		+	+	O	+	+
				40	+	+	+	+	+	+		+	+	O	+	+
				60	O	+	O	O		+						
				80		O										
				100												
				120												
				140												
Photographic emulsions (SpRB)				20	+	+	+	+	+	+		+	+	O	+	+
				40	+	+	+	+	+	+		+	+		+	+
				60		O				+						
				80												
				100												
				120												
				140												
Photographic fixer (SpRB)			usual commercial	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	O	+	O			+						
				80												
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Phthalic acid (SpRB)	$C_6H_5(COOH)_2$	Fp.*, 208	saturated, aqueous	20	+	-	-	+	+	+		+	-	-	+	+
				40	O			+	+	+		O			+	+
				60	-			+	+	+					O	
				80						+						
				100						+						
				120												
				140												
Phthalic acid dioctayl ester	$C_{24}H_{38}O_4$			20	-	-	-	+	+	-		+	-	-		
				40												
				60												
				80												
				100												
				120												
				140												
Picric acid (SpRB)	$C_6H_3N_3O_7$	FP. 122	1%, aqueous	20	+	-	-	+	+	+		+	+	O	O	+
				40						+		+	+	-	-	O
				60						+		+	+			-
				80						+		+	+			
				100						+		+	+			
				120												
				140												
Potash	see potassium carbonate		cold saturated, aqueous													
Potash lye	KOH		50%	20	+	+		+	+	-		+				
				40	+	+		+	+			+				
				60	+	+		+	+			+				
				80												
				100												
				120												
				140												
Potassium (SpRB)	$KMnO_4$		cold saturated, aqueous	20	+	+		+	+	+		+	+	O	O	+
				40	+	+		+	+	+			+	-	-	+
				60	O			O		+			+			+
				80						+			+			
				100						+						
				120												
				140												
Potassium acetate (SpRB)	CH_3COOK		saturated	20	+	+	+	+	+	+		+	-			
				40	+	+		+	+	+		+				
				60	+	+		+	+	+		+				
				80		+			+	+		+				
				100						+						
				120												
				140												
Potassium bichromate (SpRB)	$K_2Cr_2O_7$	107	saturated, aqueous	20	+	+	+	+	+	+		+	+	+	O	+
				40	+	+	+	+	+	+			+	O	-	+
				60	O	+	+	+	+	+			+			+
				80					+	+						
				100					+	+						
				120						+						
				140												
Potassium borate	K_3BO_3		10%, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+			+	+	+	+
				60	O	+	+	+	+	+			+	+	+	+
				80		+										
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Potassium bromate	$KBrO_3$		cold saturated, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	O	+	+	O	+	+		+	+	+	+	+
				80		+			+	+			+	+	O	+
				100					+	+				+	O	+
				120						+						
				140												
Potassium bromide	KBr		all, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	O	+	+	+	+	+		+	+	+	+	+
				80		+				+			+	O	+	+
				100						+			+	O	O	+
				120						+						
				140												
Potassium carbonate (potash)				20	+	+	+	+	+	O		+				
				40	+	+		+	+			+				
				60	+	+		+	+			+				
				80		+			+							
				100												
				120												
				140												
Potassium chlorate (SpRB)	$KClO_3$		cold saturated, aqueous	20	+	+	+	+	+	O		+	+	+	+	+
				40	+	+	+	+	+	·		+	+	O	O	+
				60	+	+	+	+	+				+			+
				80		+							+			O
				100									+			
				120												
				140												
Potassium chloride	KCl		all, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	+	+	+	+	+	+		+	+	+	+	+
				80		+			+	+			+			+
				100					+	+			+			
				120						+						
				140												
Potassium chromate (SpRB)	K_2CrO_4		cold saturated, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+		+	+			+	O	+	+
				60	+	+	+		+	+			+	-	O	O
				80						+						
				100						+						
				120												
				140												
Potassium cyanide	KCN		cold saturated, aqueous	20	+	+	+	+	+	+			+	+	+	+
				40	+	+	+	+	+	+			O	+	+	+
				60	+	+	+	+	+	O		+	-	+	O	+
				80		+			+			+		+	-	+
				100												
				120												
				140												
Potassium dichromate	$K_2Cr_2O_7$		saturated	20		+		+	+	+		+	+			
				40		+		+	+	+						
				60		+		+	+	+						
				80		+				+						
				100						+						
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Potassium fluoride	KF		saturated	20	+	+		+	+	+			+			
				40	+	+		+	+	+						
				60	+	+		+	+	+						
				80		+			+	+						
				100						+						
				120												
				140												
Potassium Hexacyanoferrate -(II)	$K_4[Fe(CN)_6].3H_2O$			20	+	+		+	+	+		+	+			
				40	+	+		+	+	+						
				60	+	+		+	+	+						
				80		+			+	+						
				100						+						
				120												
				140												
Potassium hydrogen carbonate	$KHCO_3$		saturated	20	+	+		+	+	+		+	+			
				40	+	+		+	+	+		+				
				60	+	+		+	+	+		+				
				80		+			+							
				100												
				120												
				140												
Potassium hydrogen sulphate	$KHSO_4$		saturated	20	+	+		+	+			+				
				40	+	+		+	+			+				
				60	+	+		+	+			+				
				80		+			+			+				
				100												
				120												
				140												
Potassium iodide	KJ		cold saturated, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+			+	O	O	+
				60	+	+	+	+	+	+			+	-	-	+
				80		+				+			+			
				100						+						
				120												
				140												
Potassium nitrate	KNO_3		50%, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+			+	+	+	+
				60	+	+	+	+	+	+			+	+	+	+
				80		+				+						
				100						+						
				120												
				140												
Potassium perchlorate (SpRB)	$KClO_4$		cold saturated, aqueous	20	+	+		+		+		+	+	+	+	+
				40	+	+				+			+	O	O	+
				60	O	+				+			+			+
				80		+				+			+			O
				100												
				120												
				140												
Potassium persulphate (SpRB)	$K_2S_2O_8$		all, aqueous	20	+	+	+	+	+	+		+	+	-	+	+
				40	+	+	+	+	+	+		+	+		+	+
				60	O	+	+	+	+	+			+		+	+
				80						+			+		O	O
				100									+			
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Potassium sulphate	K_2SO_4		all, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	O	+	+	+	+	+			+	+	+	+
				80		+				+			+			
				100						+			+			
				120												
				140												
Potassium sulphide	K_2S		saturated	20	+	+		+	+	O		+				
				40	+	+		+	+	O		+				
				60	+	+		+	+	O		+				
				80		+			+			+				
				100												
				120												
				140												
Potassium sulphite	K_2SO_3		saturated	20	+	+		+	+			+				
				40	+	+		+	+							
				60	+	+		+	+							
				80		+										
				100												
				120												
				140												
Potassium-aluminiumsulfate (alum)			50%	20	+	+		+	+	+		+				
				40	+	+		+	+	+		+				
				60	+	+		+	+	+		+				
				80		+			+	+		+				
				100						+						
				120												
				140												
Pottasium hexacyanoferrate -(III)	$K_3[Fe(CN)_6]$.			20	+	+		+	+	+		+	+			
				40	+	+		+	+	+						
				60	+	+		+	+	+						
				80		+			+	+						
				100						+						
				120												
				140												
Pottasium tartrat				20	+			+	+	+		+				
				40	+			+	+	+		+				
				60				+	+	+		+				
				80					+	+						
				100						+						
				120												
				140												
Pottasiumhydrogensulfite				20	+					+		+				
				40	+					+		+				
				60						+						
				80						+						
				100						+						
				120												
				140												
Pottasiumhypochlorite	KOCl			20	+	O		+	+	O		+	O			
				40												
				60												
				80												
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Pottasiumperoxodisulfate	$K_2S_2O_8$		saturated	20	+	+										
				40	+	+										
				60	+	+										
				80		+										
				100												
				120												
				140												
Pottasiumphosphate	KH_2PO_4 und $K_2H\ PO_4$		all, aqueous	20	+	+	O	+	+	+		+	+	+	+	+
				40	+	+		+	+	+		+	+	O	O	+
				60	O	+		+	+	+			+	-	-	+
				80		+			+	+			+			O
				100									+			
				120												
				140												
Pottasiumphosphate				20	+				+							
				40	+				+							
				60	+				+							
				80					+							
				100												
				120												
				140												
Propane	C_3H_8	-42	technically pure, liquid	20	+	-	-	+	+	+		-	+	+	-	-
				40						+						
				60						+						
				80												
				100												
				120												
				140												
Propane			technically pure, gaseous	20	+	+	-	+	+	+		-	+	+	+	O
				40						+						
				60						+						
				80												
				100												
				120												
				140												
Propanol, n- and iso- (SpRB)	C_3H_7OH	97 bzw. 82	technically pure	20	+	-	-	+	+	+		+	+	+	+	+
				40	O			+	+	+		+	+	O	+	O
				60	O			+	+	+			+	-	+	O
				80						O						
				100												
				120												
				140												
Propargyl alcohol (SpRB)	CHčC-CH_2-OH	114	7%, aqueous	20	+	-	-	+	+	+		+	+	+	+	+
				40	+			+	+	O		+	+	+	+	+
				60	+			+	+	O			+	+	O	O
				80												
				100												
				120												
				140												
Propionic acid (SpRB)	CH_3CH_2COOH	141	50%, aqueous	20	+	O	-	+	+	+		+	+	-	O	O
				40	+			+	+	+		+	+		-	-
				60	O			+	+	+			O			
				80												
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Propionic acid (SpRB)		141	technically pure	20	+	O	-	+	+	+		+	+	-	-	-
				40	O			O	O	+		O	+			
				60				O	O	+			+			
				80									O			
				100												
				120												
				140												
Propylene glycol (SpRB)	$C_3H_8O_2$	188	technically pure	20	+	-	O	+	+	+		+	+	+	+	+
				40	+			+	+	+		+	+	O	+	+
				60	+			+	+	+			O	-		+
				80												
				100												
				120												
				140												
Propylene oxide	C_3H_6O	35	technically pure	20	O		-	+	+	+		O	-	-	-	-
				40						O						
				60												
				80												
				100												
				120												
				140												
Pyridine	C_5H_5N	115	technically pure	20	-	-	-	+	O	+		O	-	-	-	-
				40				O	O	-						
				60				O	O							
				80												
				100												
				120												
				140												
Pyrogallol	$C_6H_3(OH)_3$		100%	20						+			+			
				40						+						
				60												
				80												
				100												
				120												
				140												
Ramsit fabric waterproofing agents			usual commercial	20	+			+	+	+		+	+	+	+	+
				40	+					+						
				60	+					+						
				80												
				100												
				120												
				140												
Salicylic acid	$C_6H_4(OH)COOH$		saturated	20	+	+	O	+	+	+		+	+	+	+	+
				40	+			+	+	+		+				
				60				+	+	+		+				
				80						+						
				100												
				120												
				140												
Sea water	see Brine															
Silicic acid	$Si(OH)_4$			20	+	+	+	+	+			+				
				40	+	+		+	+			+				
				60	+	+		+	+			+				
				80					+							
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Silicone oil				20	+	+	+	+	+	+		+	+	+	+	+
				40	O	+		+	+	+		+	+	+	+	+
				60	-			+	+	+		+	+	+	O	
				80					+	+						
				100						+						
				120												
				140												
Silver	AgCn		saturated	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+		+	+	+		+	+			
				60	+	+		+	+	+		+	+			
				80												
				100												
				120												
				140												
Silver salts	$AgNO_3$, AgCN, AgCl		cold saturated, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	O	+	+	+	+	+		+	+	+	+	+
				80		+			+	+						
				100						+						
				120												
				140												
Silvercyanide				20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+		+	+	+		+	+			
				60	+	+		+	+	+		+	+			
				80												
				100												
				120												
				140												
Soap solution (SpRB)			all, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	O	+		+	+	+		+	+	+	+	+
				80						+						
				100						+						
				120												
				140												
Soda	see Sodium carbonate															
Sodium acetate	CH_3COONa		all, aqueous	20	+	+	+	+	+	+		+	-	+	+	O
				40	+	+		+	+	+		+		+	+	
				60	+	+		+	+	+		+				
				80		+			+	+						
				100					+	O						
				120												
				140												
Sodium aluminium sulfate				20	+			+	+							
				40	+			+	+							
				60	+			+	+							
				80					+							
				100												
				120												
				140												
Sodium arsenite	$Na_3 AsO_3$		saturated	20	+	+		+	+			+				
				40	+	+		+	+			+				
				60	+	+		+	+			+				
				80		+			+							
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Sodium benzoate	$C_6H_5{\cdot}COONa$		cold saturated, aqueous	20	+	+	-	+	+	+		+	+	+	+	+
				40	+	+		+	+	+		O	+	+	+	+
				60	O	+		+	+	+			+			O
				80		+				+			O			
				100						O						
				120												
				140												
Sodium bicarbonate	$NaHCO_3$		cold saturated, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	+	+	+	+	+	+		+	+	+	+	+
				80					+	+		+	+			
				100						+						
				120												
				140												
Sodium bisulphate	$NaHSO_4$		10%, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		O	+	O	+	+
				60	O	+	+	+	+	+			+	-	O	
				80						+			+			
				100						+			+			
				120						+						
				140												
Sodium bisulphite	$NaHSO_3$		all, aqueous	20	+	+		+	+	+		+	O	O	+	+
				40	O	+		+	+	+		O	-	-	+	+
				60	-	+		+	+	+		-			O	+
				80						+					-	O
				100						+						
				120												
				140												
Sodium borate	Na_3BO_3		saturated	20	+	+		+	+			+	+			
				40	+	+		+	+			+	+			
				60	+	+		+	+			+	+			
				80		+			+							
				100												
				120												
				140												
Sodium bromate	$NaBrO_3$		all, aqueous	20	+	+		+	+	+		+	+	+	+	+
				40	O	+		O	O	+			+	O	+	+
				60						+			+	-	O	+
				80						+						
				100						+						
				120												
				140												
Sodium bromide	NaBr		all, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+			+	O	+	+
				60	O	+	+	+	+	+			+		O	O
				80		+			+	+			+			
				100						+						
				120						+						
				140												
Sodium carbonate	see soda		cold saturated, aqueous													
Sodium chlorate (SpRB)	$NaClO_3$		all, aqueous	20	+	+	+	+	+	O		+	+	+	+	+
				40	+	+	+	+	+			+	+	O	+	+
				60	O	+	+	+	+			+	+	-	O	+
				80		+						O	+		-	O
				100								-				
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Sodium chlorite (SpRB)	$NaClO_2$		diluted, aqueous	20	O	+		+	+	+		+	+	-	O	+
				40		+		O	O	O		+	+		-	+
				60		+				O		+	+			+
				80		+										
				100												
				120												
				140												
Sodium chromate (SpRB)	Na_2CrO_4		diluted, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+		+	+		+	+	O	+	+
				60	O		+			+		+	+	-	O	O
				80						+						
				100						+						
				120												
				140												
Sodium disulphite	$Na_2S_2O_5$		all, aqueous	20	+	+		+	+	+		+	+	O	+	+
				40	+	+				+		+	+	-	+	+
				60	O	+				+		+	+		+	O
				80						+						
				100						+						
				120												
				140												
Sodium dithionite	see hyposulphite		up to 10%, aqueous													
Sodium fluoride	NaF		cold saturated, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+			+		+	+	+	+	+
				60	+	+	+			+		+	+	O	+	+
Sodium hydroxide (see Caustic soda)				80						+						
				100						+						
				120												
				140												
Sodium hypochlorite (SpRB)	NaOCl		12,5% active chlorine, aqueous	20	+			O	O	O		+	+	-	-	+
				40	+			-	-							
				60	O											
Sodium iodide	NaI		all, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+			+			+	+	+	+
				60	O	+	+			+			+	O	+	O
				80		+				+						
				100						+						
				120												
				140												
Sodium nitrate	$NaNO_3$		cold saturated, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	O	+		+	+	+		+	+	+	+	+
				80					+	+						
				100						+						
				120						+						
				140												
Sodium nitrite	$NaNO_2$		cold saturated, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+			+	O	+	+
				60	+	+		+	+	+			+	-	+	+
				80		+			+	+						
				100						+						
				120						+						
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Sodium oxalate	$Na_2C_2O_4$		cold saturated, aqueous	20	+	+	+	+	+	+			+	+	+	+
				40	+	+				+						
				60	O	+				O						
				80												
				100												
				120												
				140												
Sodium perborate	$NaBO_3\,4H_2O$		saturated	20	+	+		+	+	+		+	+			
				40	+	+				+						
				60	+	+				+						
				80		+										
				100												
				120												
				140												
Sodium perchlorate	$NaClO_4$		saturated	20	+	+		+	+			+	+			
				40	+	+										
				60	+	+										
				80		+										
				100												
				120												
				140												
Sodium persulphate (SpRB)	$Na_2S_2O_8$		cold saturated, aqueous	20	+			+	+	+		+	+	-	+	+
				40	+			+	+	+		+	+		+	+
				60	O			+	+	+			+		+	+
				80									+		O	O
				100									+			
				120												
				140												
Sodium phosphate	Na_3PO_4		cold saturated, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+		+	+	+		+	+	+	+	+
				60	O	+		+	+	+		+	+	+	+	+
				80		+			+	O						
				100					+	-						
				120												
				140												
Sodium silicate	Na_2SiO_3		all, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	O	+		+	+	O		+	+	+	+	+
				80					+	-						
				100												
				120												
				140												
Sodium Sulfide	Natriumsulfid															
Sodium sulphate	Na_2SO_4, $NaHSO_4$		cold saturated, aqueous	20	+	+	+	+	+	+		O	+	+	+	+
				40	+	+	+	+	+	+		O	+	+	+	+
				60	O	+	+	+	+	+		O	+	+	+	+
				80					+	+			+			
				100						+						
				120						+						
				140												
Sodium sulphide	Na_2S		cold saturated, aqueous	20	+	+	+	+	+	O		+	+	+	-	+
				40	+	+	+	+	+	O		+		+		+
				60	O	+	+	+	+	O		+		+		+
				80		+			+							
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Sodium sulphite	Na_2SO_3		cold saturated, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+		+	+	+		+	+	O	+	+
				60	O	+		+	+	+		+	+	-	O	+
				80		+			+	+						
				100						+						
				120												
				140												
Sodium thiosulphate	$Na_2S_2O_3$		cold saturated, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40										O	+	+
				60										-	O	O
				80												
				100												
				120												
				140												
Sodiumchloride	$NaCl$		each, aqueous	20	+	+	+	+	+	+		+	+			
				40	+	+	+	+	+	+		+	+			
				60	+	+		+	+	+		+	+			
				80		+			+	+		+	+			
				100						+			+			
				120												
				140												
Sodiumcyanide	$NaCN$			20	+	+		+	+	+		+	+			
				40	+	+		+	+	+		+	+			
				60	+	+		+	+	+		+	+			
				80		+			+							
				100												
				120												
				140												
Sodiumdichromate	Na_2Cs2O_7			20	O	+		+	+			+	+			
				40		+		+				+	+			
				60		+							+			
				80		+										
				100												
				120												
				140												
Sodiumhydrogen-carbonate	$NaHCO_3$			20	+	+	+	+	+	+		+	+			
				40	+	+		+	+	+		+				
				60	+	+		+	+	+		+				
				80		+			+							
				100												
				120												
				140												
Sodiumhydrogensulfate	$NaHSO_4$			20	+	+	+	+	+	+		+	+			
				40	+	+		+	+	+		+	+			
				60	+	+		+	+	+		+	+			
				80		+			+	+						
				100						+						
				120												
				140												
Spindle oil				20	O	O	-	O	+	+		-	+	+	O	-
				40					O	+			O	+	-	O
				60				O	-	+			-	O		-
				80						+				-		
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Spinning bath acids containing carbon disulphide (SpRB)			100 mg CS_2/l	20	+			+	+	+			+	-	-	O
				40	+					+						
				60												
				80												
				100												
				120												
				140												
Spinning bath acids containing carbon disulphide (SpRB)			200 mg CS_2/l	20	O			+	+	+		-	+	-	-	-
				40						+						
				60												
				80												
				100												
				120												
				140												
Spinning bath acids containing carbon disulphide (SpRB)			700 mg CS_2/l	20	-			+	+	+		-	+	-	-	-
				40						+						
				60												
				80												
				100												
				120												
				140												
Stannous chloride	see Tin II chloride		cold saturated, aqueous													
Stannous chloride - Tin IV chloride	$SnCl_4$		cold saturated, aqueous	20				+	+							
				40				+	+							
				60				+	+							
				80					+							
				100												
				120												
				140												
Starch solution	$(C_6H_{10}O_5)n$		all, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	+	+		+	+	+		+	+	+	+	+
				80		+				+						
				100						+						
				120												
				140												
Starch syrup			usual commercial	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	+	+		+	+	+		+	+	+	+	+
				80		+			+	+		+	+	+	+	+
				100						+		+	+	+	+	+
				120												
				140												
Stearic acid (SpRB)	$C_{17}H_{35}COOH$	Fp. 69	technically pure	20	+	O	+	+	+	+		+	+	+	+	O
				40	+		+			+		+	+	+	+	O
				60	+			O	O	+		O	O	O	O	-
				80						+						
				100						+						
				120						+						
				140												
Styrol				20	-	-	-			+			+			
				40												
				60												
				80												
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Succinic acid	$HOOC\text{-}CH_2\text{-}CH_2\text{-}COOH$	Fp*., 185	aqueous, all	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+		+	+	+		+	+	+	+	+
				60	+	+		+	+	+		+	+	+	+	+
				80									+			
				100												
				120												
				140												
Sugar syrup			usual commercial	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	O	+	+	+		+	+	+	+	+
				60	O	+		+	+	+		+	+	+	+	+
				80					+	+		+	+			+
				100					+	+						
				120						+						
				140												
Sulfur	S	Fp.*, 119	technically pure	20	O	O	-	+	+	+		+	+	-	+	+
				40	-			+	+	+			+			+
				60				+	+	+			+			+
				80					+	+			+			+
				100						+						
				120						+						
				140												
Sulfur dioxide	SO_2	-10	technically pure, anhydrous	20	+	+	-	+	+	O		+	+	-	-	O
				40	+	+		+	+	O		O	O			-
				60	+	+		+	+	-		-				
				80												
				100												
				120												
				140												
Sulfur dioxide	SO_2		technically pure, moist	20	-	-	-	-	-	-		-	O	-	-	O
				40												
				60												
				80												
				100												
				120												
				140												
Sulfur dioxide	SO_2		oil, moist	20	+	+	-	+	+	+		+	+	-	-	O
				40	+	+		+	+	O		O	O			-
				60	O			+	+	-		-	-			
				80												
				100												
				120												
				140												
Sulfur trioxide	SO_3			20	-	-	-	-	-	-		-	-	-	-	-
				40												
				60												
				80												
				100												
				120												
				140												
Sulfuric acid saturated by Chlorine	$H_2SO_4+Cl_2$		60%	20						+						
				40						+						
				60						+						
				80						+						
				100						+						
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Sulfuric acid (see note 2.3.1 on jointing)	H_2SO_4	120	up to 40%, aqueous	20	+	+	+	+	+	+		+	+	O	+	+
				40	+	+	O	+	+	+		+	+	-	O	+
				60	O	+		+	+	+		+	+			O
				80		+				+		O	O			O
				100						+		-	-			-
				120						+						
				140												
Sulfuric acid (see note 2.3.1 on jointing) (SpRB)	H_2SO_4	140	up to 60%, aqueous	20	+	+	-	+	+	+		+	+	-	-	+
				40	+	+		+	O	+		+	+			O
				60	+	+		+	-	+		O	+			O
				80		+				+		-	O			-
				100						+						
				120						+						
				140												
Sulfuric acid (see note 2.3.1 on jointing) (SpRB)	H_2SO_4	195	up to 80%, aqueous	20	+	+	-	+	+	+		O	+	-	-	+
				40	+	+		+	+	+		O	+			O
				60	+	+		O	O	+		-	O			-
				80		+				+			-			
				100						+						
				120						O						
				140												
Sulfuric acid (see note 2.3.1 on jointing) (SpRB)	H_2SO_4	250	90%, aqueous	20	+	+	-	O	O	+		-	+	-	-	-
				40	+	+				+			+			
				60		+				+						
				80						+						
				100						O						
				120						O						
				140												
Sulfuric acid (see note 2.3.1 on jointing) (SpRB)	H_2SO_4		96%, aqueous	20	+	+	-	-	-	+		-	+	-	-	-
				40	+	+				+			+			
				60	O	+				-						
				80												
				100												
				120												
				140												
Sulfuric acid (see note 2.3.1 on jointing) (SpRB)	H_2SO_4		97%	20	+	+	-	-	-	O		-	+	-	-	-
				40		+										
				60												
				80												
				100												
				120												
				140												
Sulfuric acid (see note 2.3.1 on jointing) (SpRB)	H_2SO_4	340	98%	20	+	+	-	-	-	-		-	O	-	-	-
				40	O	+										
				60		O										
				80												
				100												
				120												
				140												
Sulfurous acid	H_2SO_3		saturated, aqueous	20	+	+	O	+	+	+		+	+	-	-	O
				40	+	+	+	+	+	+		-	+			O
				60	O			+	+	+			O			-
				80						+			-			
				100						+						
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Sulfuryl chloride	SO_2Cl_2	69	technically pure	20	-	-	-	-	-	O			+	-	O	+
				40												
				60												
				80												
				100												
				120												
				140												
Surfactants (SpRB)			up to 5%, aqueous	20	O	-	-	+	+	+		+	+	+	+	+
				40	O				O	O						
				60	O				O	O						
				80						O						
				100												
				120												
				140												
Surfactants (ESC)				20	O	O	O	O	O	O		O	O	O	O	
				40												
				60												
				80												
				100												
				120												
				140												
Tallow (SpRB)			technically pure	20	+	-	-	+	+	+		+	+	+	+	+
				40	+			+	+	+		+	+	+	+	+
				60	+			+	+	+		+	+	+	+	+
				80						+						
				100						+						
				120												
				140												
Tannic acid (SpRB)			all, aqueous	20	+	+	+	+	+				+	+	+	+
				40		+	+	+	+							
				60		+		+	+							
				80												
				100												
				120												
				140												
Tanning extracts form plants (SpRB)			usual commercial	20	+	+	+	+	+	+		+	+	+	+	+
				40		+	+									
				60												
				80												
				100												
				120												
				140												
Tartaric acid				20						+						
				40						+						
				60												
				80												
				100												
				120												
				140												
Tartaric acid	$HO_2C-CH(OH)-CH(OH)-CO_2H$		all, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+		+	+	+	+		+	+	+	+	+
				60	O			+	+	+		+	+	O	+	+
				80						+						
				100						+						
				120						+						
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Tartaric acid up to 10%				20						+						
				40						+						
				60						+						
				80												
				100												
				120												
				140												
Tetrachlorethylene				20	-	-	-	-	-	+		-	+			
				40												
				60												
				80												
				100												
				120												
				140												
Tetrachloroethane	$Cl_2CH\text{-}CHCl_2$	146	technically pure	20	-	-	-	O	O	+		-	O	-	-	-
				40						+						
				60						O						
				80												
				100												
				120												
				140												
Tetrachloroethylene	see Perchloroethylene	121														
Tetraetylene lead (SpRB)	$(C_2H_5)_4Pb$		technically pure	20	+	+	-	+	+	+		O	+	+	O	+
				40						+						
				60						+						
				80						+						
				100						+						
				120						+						
				140												
Tetrahydrofurane	C_4H_8O	66	technically pure	20	-	-	-	O	O	-		O	-	-	-	-
				40												
				60												
				80												
				100												
				120												
				140												
Tetrahydronaphthalene	Teralin	207	technically pure													
Thionyl chloride	$SOCl_2$	79	technically pure	20	-	-	-	-	-	-		O	+	-	-	-
				40												
				60												
				80												
				100												
				120												
				140												
Tin (IV) -chloride				20	+	+				+		+	+			
				40	+	+				+		+	+			
				60	+	+				+		+	+			
				80		+				+			+			
				100						+						
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Tin-(II)-chloride	$SnCl_2$			20				+	+							
				40				+	+							
				60				+	+							
				80					+							
				100												
				120												
				140												
Toluene	C_6H_5-CH_3	111	technically pure	20	-	-	-	O	O	+		-	+	-	-	-
				40												
				60												
				80												
				100												
				120												
				140												
Triacetin (Glycerintriacetat)	$C_9H_{14}O_6$			20	-	-	-	+	+	+		+				
				40						+						
				60												
				80												
				100												
				120												
				140												
Tributylphosphate	$(C_4H_9)_3PO_4$	289	technically pure	20	-	-	-	+	+	+		+	-	-	-	-
				40				+	+							
				60				+	+							
				80												
				100												
				120												
				140												
Trichloroacetic acid	Cl_3C-COOH	196	technically pure	20	O	-	-	+	+	O		O	-	-	-	-
				40				O	+							
				60				-	O							
				80												
				100												
				120												
				140												
Trichloroacetic acid	Cl_3-C-COOH		50%, aqueous	20	+	-	-	+	+	+		O	-	-	-	-
				40	O			+	+	+						
				60				+	O	O						
				80						-						
				100												
				120												
				140												
Trichloroethane	Methylchloroform	74	technically pure													
Trichloroethylene	$Cl_2C{=}CHCl$	87	technically pure	20	-	-	-	-	O	+		-	+	-	-	-
				40						+						
				60						+						
				80						O						
				100												
				120												
				140												
Trichloromethane	Chloroform	61														

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Tricresyl phosphate (SpRB)	$H_3C-C_6H_5-O)_3PO_4$		technically pure	20	-	-	-	+	+			+	-	O	-	-
				40				+						-		
				60				+	O							
				80												
				100												
				120												
				140												
Triethanolamine (SpRB)	$N(CH_2-CH_2-OH)_3$	Fp. *21	technically pure	20	O	-	-	+	+	+		O	-	O	-	-
				40						+						
				60												
				80												
				100												
				120												
				140												
Triethylamine (SpRB)	$N(CH_2-CH_3)3$	89	technically pure	20	-	-	-	+	+	O		-	-	-	-	-
				40						-						
				60												
				80												
				100												
				120												
				140												
Trifluoro acetic acid (SpRB)	$F_3C-COOH$		up to 50%	20	-	-	-	+	+	+		O	-	-	-	-
				40						O						
				60												
				80												
				100												
				120												
				140												
Trioctyl phosphate (SpRB)	$(C_8H_{17})_3 PO_4$		technically pure	20	-	-	-	+	+	O		+	-	O	-	-
				40				+	O							
				60												
				80												
				100												
				120												
				140												
Turpentine oil (SpRB)			technically pure	20	+	-	-	O	-	+		-	+	O	-	-
				40	O			O					+			
				60									+			
				80												
				100												
				120												
				140												
Urea (SpRB)	$H_2N-CO-NH_2$	Fp.*, 133	up to 30%, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	O	+		+	+	+		+	+	+	+	+
				80		O				+						
				100						O						
				120												
				140												
Urine				20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	O	+		+	+	+		+	+	+	+	+
				80						+						
				100						+						
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Vaseline			technically pure	20	O	O	-	+	O	+		-	+	+	-	-
				40	-					+			+	+		
				60				-	-	+			+	+		
				80						+			+	+		
				100						+			+	+		
				120						+			+			
				140												
Vegetable oils				20	O	-	-	+	+	+		-	+	+	O	O
				40						+						
				60						+						
				80												
				100												
				120												
				140												
Vegetable oils and fats (SpRB)				20	+	O	-	+	+	+		-	+	+	O	O
				40	O			O	+	+			+	+	O	O
				60					O	+			+	+	-	-
				80						+						
				100						+						
				120												
				140												
Vinegar	see wine vinegar															
Vinyl acetate	$CH_2{=}CHOOCCH_3$	73	technically pure	20	-	-	-	+	+	+		+	-	-	-	-
				40				+		-						
				60					O							
				80												
				100												
				120												
				140												
Vinyl chloride	$CH_2{=}CHCl$	-14	technically pure	20	-	-	-	-	-	+		-	+	-	-	
				40						+						
				60												
				80												
				100												
				120												
				140												
Viscose spinning solution				20	+	-	-	+	+	+			+	-	O	+
				40	+			+	+	+		+	+		O	+
				60	+			+	+	+		+	+		-	+
				80												
				100												
				120												
				140												
Waste gases containing - Alkaline				20	+	+		+	+	+		+	+	+	+	+
				40	+	+		+	+	O		+	+	+	+	+
				60	+	+		+	+	-		+	+	+	+	O
				80		+			+			+	O			-
				100									-			
				120												
				140												
Waste gases containing - Carbon oxides			all	20	+	+		+	+	+		+	+	+	+	+
				40	+	+		+	+	+		+	+	+	+	+
				60	+	+		+	+	+		+	+	+	+	+
				80		+			+	+		+	+			+
				100						+			+			
				120						+						
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Waste gases containing - Hydrochloric acid			all	20	+	+		+	+	+		+	+	O	+	+
				40	+	+		+	+	+		+	+	-	+	+
				60	+	+		+	O	+		+	+		+	+
				80		+				+		O	+			+
				100						+			+			
				120						+						
				140												
Waste gases containing - Hydrogen fluoride (SpRB)			traces	20	+	+		+	+	+		+	+	+	+	+
				40	+	+		+	+	+		+	+	O	+	+
				60	+	+		+	+	+		O	+	-	O	+
				80		+				+			+			
				100						+						
				120												
				140												
Waste gases containing - Nitrous gases			traces	20	+	+		+	+	+		+	+	O	+	+
				40	+	+		+	+	+		+	+	-	+	+
				60	+	+		+	O	+		+	+		O	+
				80		+				+		O	+			O
				100						+			O			
				120												
				140												
Waste gases containing - Sulphur dioxide			traces	20	+	+		+	+	+		+	+	O	+	+
				40	+	+		+	+	+		+	+	-	+	+
				60	+	+		+	+	+		+	+		+	+
				80		+			+	+		+	+			+
				100						+			+			
				120						+						
				140												
Waste gases containing - Sulphur trioxide (SpRB)			traces	20	+	+		+	+	+		+	+	O	+	+
				40	+	+		+	+	+		+	+	-	+	+
				60	+	+		+	O	+		+	+		+	+
				80		+				+		O	+			
				100						+						
				120												
				140												
Waste gases containing - Sulphuric acid			all	20	+	+		+	+	+		+	+	O	+	+
				40	+	+		+	+	+		+	+	-	+	+
				60	+	+		+	+	+		+	+		+	+
				80		+			O	+		O	+			+
				100						+			+			
				120						+						
				140												
Water - distilled - deionised	H_2O	100		20	+	+	+	+	+	+			+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	+	+	+	+	+	+		O	+	+	+	+
				80		+			+	+		-	+	+		+
				100					+	+			+	+		
				120						+			+			
				140												
Water, condensed				20	+	+	+	+	+	+			+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	O	+	+	+	+	+		O	+	+	+	+
				80		+			+	+			+	O		+
				100						+						
				120						+						
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Water, drinking, chlorinated				20	+	+	+	+	+	+			+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60	+	+	+	+	+	+		O	+	+	+	+
				80					+	+			+	O		+
				100					+	+			+			
				120						+						
				140												
Water, waste water without organic solvent and surfactants				20	+	+	+	+	+	+			+	+	+	+
				40	+	+	+	+	+	+		+	+	+	+	+
				60		+	+	+	+	+		O	+	+	+	+
				80		+			+	+			+	+		+
				100						+				O		
				120						+						
				140												
Wax alcohol (SpRB)	$C_{31}H_{63}OH$		technically pure	20	+	O	-	O	O	+		+	+	+	+	-
				40	+			-	-	+		+	+	+	+	
				60	+					+		+	+	+	+	
				80												
				100												
				120												
				140												
Wine vinegar (SpRB)			usual commercial	20	+	o	O	+	+	+		+	O	-	O	+
				40	+			+	+	+			-		-	O
				60	+			+	+	+						-
				80					+	+						
				100						+						
				120												
				140												
Wines, red and white			usual commercial	20	+	O	+	+	+	+		+	+	+	+	+
				40			+	+	+	+						
				60				+	+	+						
				80						+						
				100						+						
				120												
				140												
Xylene	$C_6H_4(CH_3)_2$	138? 144	technically pure	20	-	-	-	-	-	+		-	+	-	-	-
				40						+			O			
				60						O			-			
				80						-						
				100												
				120												
				140												
yeasts			all, aqueous	20	+	+	+	+	+	+		+	+	+	+	+
				40	+	+		+	+	+		+	+	+	+	+
				60		+		+	+	+						
				80		+				+						
				100												
				120												
				140												
Zinc salts	$ZnCl_2$, $ZnCO_3$, $Zn(NO_3)_2$, $ZnSO_4$		all, aqueous	20	+	+	+	+	+	+			+	+	+	+
				40	+	+	+	+	+	+		+	+	O	+	+
				60	O	+		+	+	+		+	+	-	+	+
				80						+						
				100						+						
				120						+						
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
Zinccarbonate				20	+	+	+	+	+	+		+	+			
				40	+	+		+	+	+		+	+			
				60	+	+		+	+	+		+	+			
				80		+			+	+		+	+			
				100						+						
				120												
				140												
Zincchloride			saturated	20	+	+	+	+	+	+		+	+			
				40	+	+		+	+	+		+	+			
				60	+	+		+	+	+		+	+			
				80		+			+	+			+			
				100						+						
				120												
				140												
Zincnitrate	$Zn(NO_3)_2$		saturated	20	+	+	+	+	+	+		+	+			
				40	+	+		+	+	+		+	+			
				60	+	+		+	+	+		+	+			
				80		+			+	+			+			
				100						+						
				120												
				140												
Zincoxide			Suspension	20						+						
				40						+						
				60						+						
				80						+						
				100						+						
				120												
				140												
Zincphosphate			saturated	20	+	+	O	+	+	+		+	+			
				40	+	+		+	+	+		+	+			
				60	+	+		+	+	+		+	+			
				80		+			+	+			+			
				100						+						
				120												
				140												
Zincstearate			Suspension	20	-	-	-	+	+	+		+	O			
				40				+	+	+		+				
				60				+	+	+		+				
				80					+	+						
				100						+						
				120												
				140												
Zincsulfate	$ZnSO_4$			20	+	+		+	+	+		+	+			
				40	+	+		+	+	+		+	+			
				60	+	+		+	+	+		+	+			
				80		+			+	+		+	+			
				100						+			+			
				120												
				140												
1-Chloropentan	$C_5H_{11}Cl$			20	-	-	-									
				40												
				60												
				80												
				100												
				120												
				140												

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Aggressive Media					Chemical Resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PVC	CPVC	ABS	PE	PP-H	PVDF (SYGEF)		EPDM	FPM	NBR	CR	CSM
1,1,2-Trifluoro, 1,2,2-Trichloroethane (Freon 113) (SpRB)	$FCl_2C\text{-}CClF_2$	47	technically pure	20	+		-			+			+	+	+	+
				40	+											
				60												
				80												
				100												
				120												
				140												

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DRISCOPIPE

Engineering Characteristics

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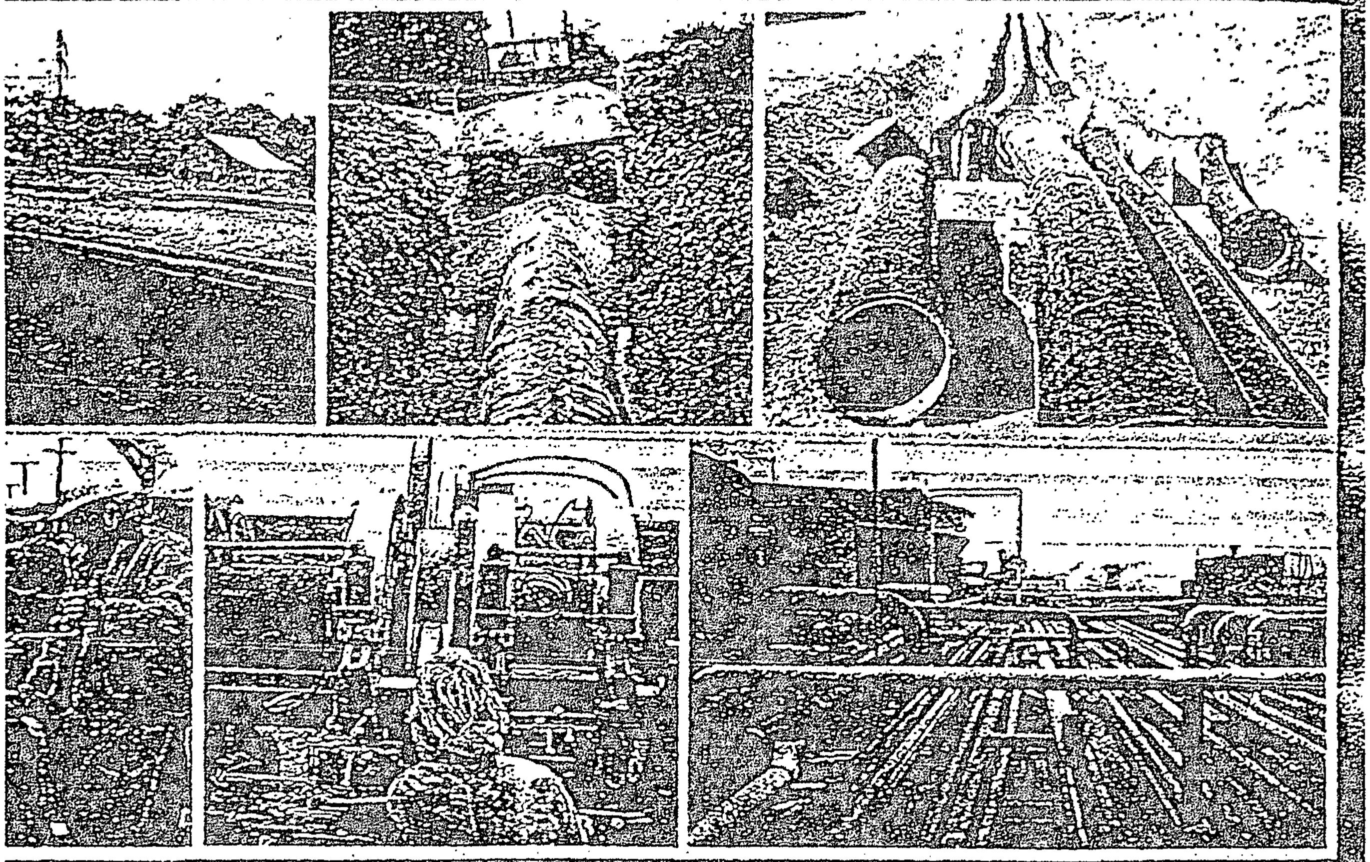
Contents

Photographs shown are typical Driscopipe installations.



Driscopipe® Engineering Characteristics

Introduction

Driscopipe high density polyethylene piping systems offer the modern engineer the opportunity to take advantage of the unusual characteristics of these materials and use them to solve many old problems and to design systems for applications where traditional materials are either unsuitable or too expensive. When compared to the older traditional piping materials, Driscopipe polyethylene piping systems offer a new freedom in environmental design, extended service life, significant savings for installation labor and equipment costs, and reduced maintenance for pipeline systems where operating conditions are within the pressure and temperature capabilities of the material.

This brochure outlines the Engineering Characteristics of Driscopipe high density polyethylene pipe and fittings and points out many of the advantages and benefits to be realized through the use of these systems. The discussion is directed primarily toward the large diameter (3" through 54") Driscopipe 8600 and Driscopipe 1000 Industrial and Municipal product lines. However, these engineering characteristics are also typical of other Driscopipe polyethylene product lines.

Physical Properties

Driscopipe 8600 is manufactured from Marlex M-8000 very high molecular weight high density PE 3408 resin. Pipe and fittings made from Marlex M-8000 are extremely tough and durable, and possess exceptional long term strength. Marlex M-8000 is a proprietary product and is extruded only by Phillips Driscopipe, Inc.

Driscopipe 1000 is manufactured from Marlex TR-480, a PE 3408 polyethylene pipe resin in a molecular weight range which permits the pipe to be extruded by conventional methods. In this respect, Driscopipe 1000 is comparable to other extra high molecular weight, high density, PE 3408 polyethylene pipes commercially available in North America.

Sheets detailing typical physical properties for Driscopipe 1000 and Driscopipe 8600 are available upon request.

Long Term Hydrostatic Strength

One of the outstanding engineering characteristics of Driscopipe high density polyethylene pipe is its long term hydrostatic strength under various thermal and environmental conditions. Life expectancy is conservatively estimated to be in excess of 50 years using the standard design basis. This strength is determined by standardized methods and procedures which the plastic pipe industry has used for many years to evaluate the long term strength of all types of plastic pipe.

Pipe hoop stress versus time to failure plots of long term hydrostatic pressure data for thermoplastic pipe have been studied and analyzed for many years. The mathematical equations used to evaluate the test data and extrapolate values to longer periods of time were chosen after careful evaluation of more than 1,000 sets of long term test data representing more than 400 plastic pipe compounds. Continued testing on new compounds and extended testing of older compounds have proven the validity of these test methods. Actual data from more than 11½ years (100,000 hours) of continuous testing shows the industry methods to be slightly conservative in that actual values are slightly higher than those calculated by the industry-accepted ASTM method.

The reduction in strength which occurs with time, as indicated by the stress-life curves, does not represent a strength degradation of the material but is more in the nature of a relaxation effect. Plastic pipe samples which have been on test for periods up to 70,000 hours have been de-pressurized and checked for permanent reduction of strength by using the quick-burst test. No loss has been found when compared to samples previously quick-burst from the same test lot.

All evidence confirms that the methods used to predict the long term strength of plastic pipe are sound methods. Through the years, these policies and procedures, used to develop recommended hydrostatic design strengths, have influenced manufacturers to research and develop improved piping products such as Driscopipe 8600 and Driscopipe 1000.

Typical calculated long term strengths are shown below:

Long Term Strength @ 73.4°F(23°C)

Time	Hoop Stress, psi
100,000 hrs. (11.43 yrs.)	1635
438,000 hrs. (50 yrs.)	1604
500,000 hrs. (57 yrs.)	1601
1,000,000 hrs. (114 yrs.)	1586

The 114-year long term strength has been included to show more about the nature of the method used by the industry to evaluate the long term strength of plastic pipe and to illustrate the very slow reduction in strength as time progresses.

Long term hoop stresses for design purposes are normally selected at a level which is much lower than the long term strength of the materials. This ensures that the pipe is operating in a hoop stress range where creep (relaxation) of the materials is nil and assures service life in excess of 50 years. Design stress levels are discussed further in the next section.

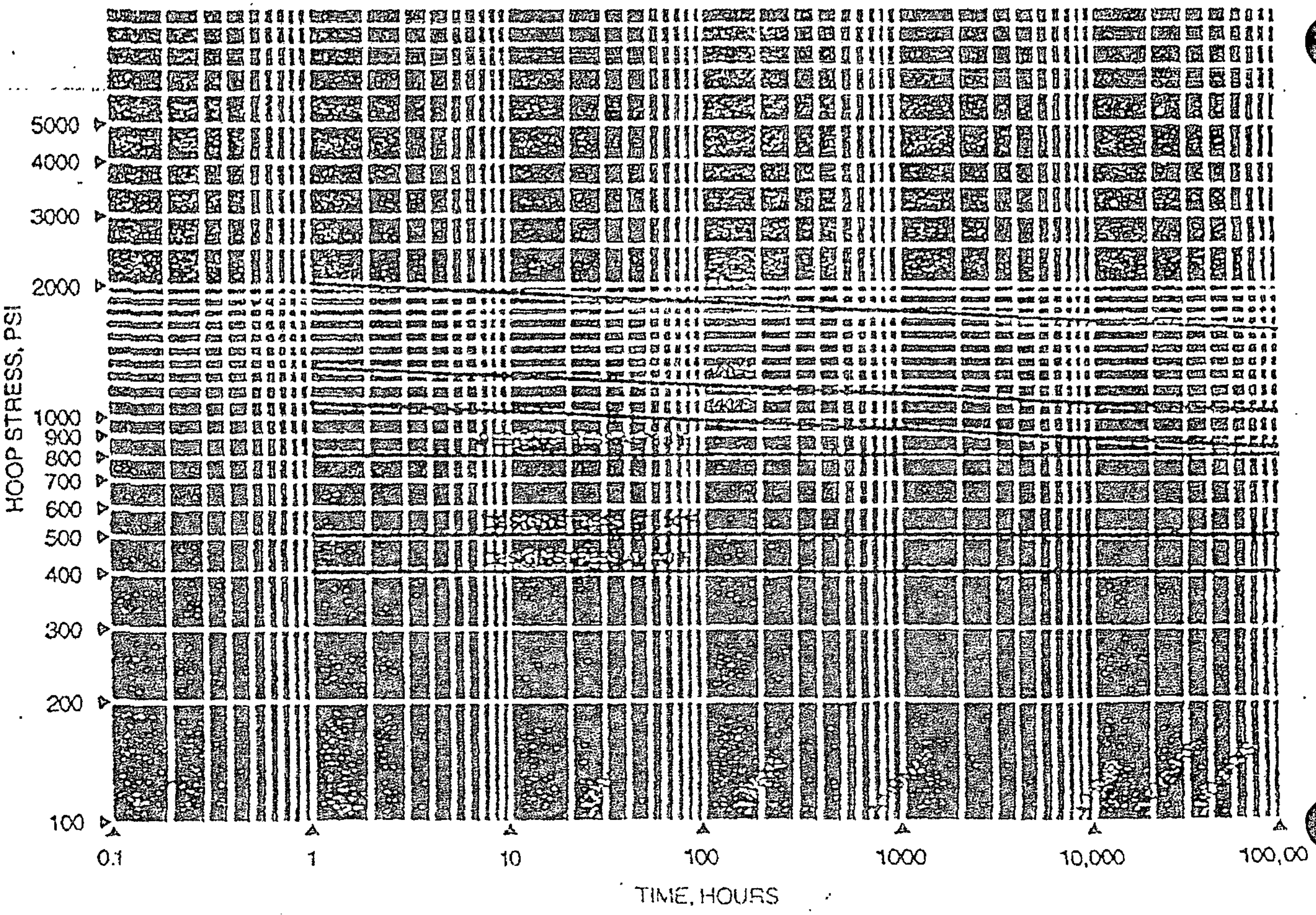
The long term hydrostatic tests are conducted by using ASTM standard test procedures which may be applied to all types of plastic pipe (ASTM D 1598 Test for Time-to-Failure of Plastic Pipe Under Constant Internal Pressure). Stress-life tests are conducted by using numerous pipe samples which are filled with water (or other environmental fluids) and subjected to a controlled pressure at a controlled temperature.

Samples are held on test until they fail. The pressure, temperature and time-to-failure data from all samples are used to calculate and plot stress-life curves for the particular type pipe being tested (ASTM D 2837 Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials). This data is then used to predict the probable safe life of the pipe at various stress levels (working pressures) and various temperatures. Because it is not practical to test at all temperature levels, these tests are generally conducted at temperatures of 73.4°F and one or more higher temperatures such as 100°F, 120°F and 140°F.

These stress-life curves give a relationship of the expected life span of the pipe when subjected to various internal stress levels (working pressures) at various temperatures. By comparing stress-life curves, one can compare relative long term performance ability of different plastic pipes. Stress-life curves for Driscopipe 8600 and Driscopipe 1000 are shown in Figure 1.

Figure 1

Stress-Life of Driscopipe® 8600 and Driscopipe® 1000



These stress-life curves were obtained using water as [illegible] st medium. However, years of laboratory testing [illegible] field experience have shown that these same curves may be used to design Driscopipe systems for natural gas, salt water, sewage and hundreds of other industrial and municipal fluids, mixtures and effluents. The long term strength of Driscopipe indicated by these curves must be de-rated in some environmental circumstances, such as in the presence of liquid hydrocarbons or abrasive fluids, although the pipe is very suitable for use in these environments. An outstanding engineering advantage of Driscopipe is its exceptionally long term service life in the presence of internal and external corrosive service conditions.

Design Pressure Ratings

Since plastic pipe was introduced in the late 50s, the safety factor for design of water systems at standard temperature has been 2 to 1. The 2:1 design factor which was officially adopted by the plastic pipe industry in 1963, was based on allowances for many sources of variation. The guiding principle has always been to make the selection on a conservative basis but not to be unreasonably conservative.

The sources of variation for which allowances are made include ... variation in test methods and [illegible]cedures among laboratories ... variation among [illegible] of the same compound ... variation of lots of pipe from the compound in different plants and from different extruders ... variation in compounds of the same general class ... variations in handling and installation techniques ... variation in operating pressures (water hammer and surge) ... a strength-time allowance to give service life well beyond 50 years ... and, finally, the great unknown. Each of the factors was judged to reduce the 100,000 hour design strength by 5%-10% or 20% ... for a total of 100% ... or a design factor of 2:1. This is why polyethylene pipe, with a designated 100,000 hour strength of 1600 psi at 73.4°F, has a hydrostatic design strength of 800 psi hoop stress.

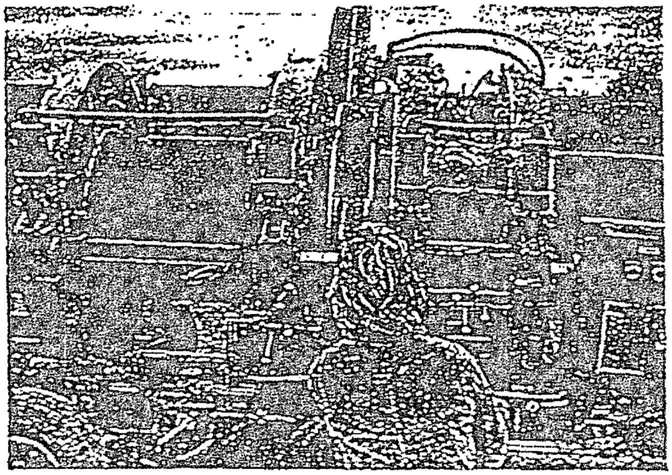
The design pressures for Driscopipe are determined by the following equation, adopted internationally by the industry for this purpose:

$$P = \frac{2S}{SDR-1} \times F \quad \text{or} \quad P = 2S\frac{t}{D-t} \times F$$

Where:
D = Specified Outside Diameter, Inches
P = Design Pressure, psi
S = Long Term Hydrostatic Strength, psi, at the design temperature
t = Minimum Wall Thickness, Inches
F = Service Design Factor
SDR = Standard Dimension Ratio of D/t

The traditional Service Design Factor for water at standard temperature (73.4°F) is one-half (.5). The Service Design Factor for oil or liquid hydrocarbons is 0.25 @ 73°F. The service design factor may be adjusted by the design engineer to reflect the particular conditions anticipated for the application. The temperature selected for design should consider both internal and external conditions. The design temperature should be based on the temperature of the pipe itself. For practical purposes, it is safer to design to the highest temperature.

The design service factor for water may also be used for solutions of inorganic salts, alkaline fluids, non-oxidizing acids, low concentrations of oxidizing acids and many other solutions. See the discussion on chemical resistance for more information.



All standard design pressure ratings shown in Driscopipe literature are based on water at 73.4°F temperature; ie, a safety factor of 2:1 based on the long term hydrostatic strength of the material. Driscopipe is applicable at pressures from 0 to 265 psi and temperatures from below 32°F up to 180°F. Standard Dimension Ratios (SDR) are available from SDR 32.5 to SDR 7.0

Flow Characteristics

Driscopipe polyethylene has excellent flow characteristics as compared to traditional materials. An extremely smooth interior surface offers low resistance to flow. It maintains these excellent flow properties throughout its service life in most applications due to the inherent chemical and abrasion resistance of the material. Because of smooth walls and the non-wetting characteristic of polyethylene, higher flow capacity and less friction loss is possible with Driscopipe. In many cases this higher flow capacity may permit the use of smaller pipe at a lower cost.

A "C" factor of 155 is commonly used in the Hazen-Williams formula for calculating flow in pressure applications. For gravity flow, an "n" factor of .009 is used in Manning's formula.

Experimental test data regarding pumping and pressure drop through Driscopipe is available upon request. This study compares the flow through 8" Driscopipe with and without internal fusion beads using clear water. It also includes flow data for some clay-water slurries and clay-water-sand slurries. Velocities up to 20 fps are studied. Data includes determination of Hazen-Williams "C" factor, Reynolds number, boundry drag, relative roughness, sand grain roughness and friction loss at various velocities.

Lightweight – Flexible

The inherent light weight and flexibility of Driscopipe provides many cost saving benefits related to handling, storage, hauling, unloading, stringing, joining and installation. Because of its light weight, Driscopipe can be moved, handled and placed in the ditch with smaller and less expensive construction equipment. Usually, manpower requirements are also reduced.

Driscopipe weighs less than water; it has a specific gravity of .955-.957. Because it will float, it can be joined in long strings and easily towed into position on job sites where water is encountered. The combination of light weight and flexibility provides opportunity to fusion join the pipe in a convenient work area and pull it into position in difficult work areas where terrain or other obstacles present installation problems. The pipe can be joined above ground and rolled or lowered into the trench thus allowing the use of smaller trench widths and eliminating the necessity of placing men and equipment inside the trench. Such installation methods can dramatically reduce the time required for installation in many instances.

The flexibility of Driscopipe allows it to be curved over, under and around obstacles and to make elevation and directional changes, thus eliminating fittings and reducing installation costs. The pipe can be cold bent as it is installed to a radius of 20-40 times the pipe diameter. This flexibility and the butt fusion joining method make Driscopipe ideally suited for inserting it inside older piping systems to renew and renovate such systems at a much lower cost than would be possible otherwise.

Pipe flexibility and toughness also allow small diameter Driscopipe to be plowed-in or pulled-in with suitable equipment.

Toughness – "Ductile PE Pipe"

[illegible]verall "toughness" of Driscopipe is an important [illegible]acteristic of the pipe which is derived from many of the chemical and physical properties of the material as well as the extrusion method. The pipe is ductile. It flexes, bends and absorbs impact loads over a wide temperature range of – 180°F up to + 180°F. This inherent resiliency and flexibility allow the pipe to absorb surge pressures, vibration and stresses caused by soil movement. Driscopipe can be deformed without permanent damage and with no adverse effect on long term service life. It is flexible for contouring to installation conditions. The toughness of Driscopipe is one of its outstanding engineering characteristics leading to innovative piping design.

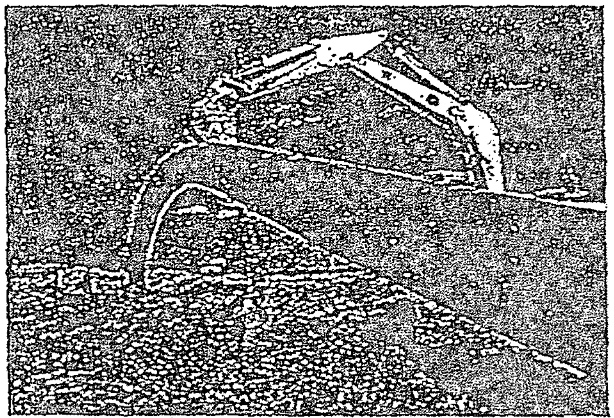
Even though "toughness" has become generally recognized by the industry as a highly desirable characteristic ... there is no standard test which can be used to directly compare the "toughness" among polyethylenes ... as well as among the different plastic materials which are considered suitable for piping.

A "toughness" test has not been devised is simply because it is influenced by so many of the physical and chemical properties of the material. The extreme toughness of Driscopipe has been noted as one of its [illegible]standing features since its introduction to the [illegible]stry ... yet to explain "toughness", many properties are discussed and demonstrated. To obtain a complete evaluation of the toughness of a plastic material, it is necessary to see demonstrations of tests and to conduct some tests in person in order to compare it with materials which are more familiar, such as cast iron, steel, cement, copper, etc.

Toughness is related to ... Environmental Stress Crack Resistance (ESCR) ... Notch sensitivity ... Resistance to secondary stresses from external loading ... Impact strength ... Tear strength ... Flexibility ... Kink resistance ... Abrasion and scratch resistance ... Flexural strength ... Elongation ... Chemical resistance ... Tensile strength ... Ductility ... Creep resistance ... Temperature resistance ... Density ... Molecular weight ... and the thermoplastic nature of the material. Part of the toughness of any polyethylene material can be attributed to its flexibility, flexural strength and impact resistance as compared to the more rigid thermoplastic materials such as PVC. Polyethylene is ductile and will elongate many times more than PVC. Consequently, it will absorb more impact without damage or failure. PE will flex or elongate and stress relieve itself rather than rupture. Generally, impact strength is greater for the higher molecular weight PE resins. Impact resistance is also important from the standpoint of a piping system being able to absorb energy imposed on it by external forces.

The expansive force of water freezing inside Driscopipe will not damage it.

ESCR is one of the properties closely related to "toughness" and has been studied as a possible means to define and measure toughness. The exceptional resistance of Driscopipe 8600 to environmental stress cracking as compared to other PE materials is discussed further in the next section.



Driscopipe 8600 is unique and differs from Driscopipe 1000 and from all other polyethylene pipes. Driscopipe 8600 exhibits a superior toughness which gives the pipe the highest impact strength, highest tear strength and lowest notch sensitivity of any polyethylene pipe currently available. Driscopipe 8600 offers the highest resistance to cuts, scratches and abrasions which occur when handling and installing the pipe.

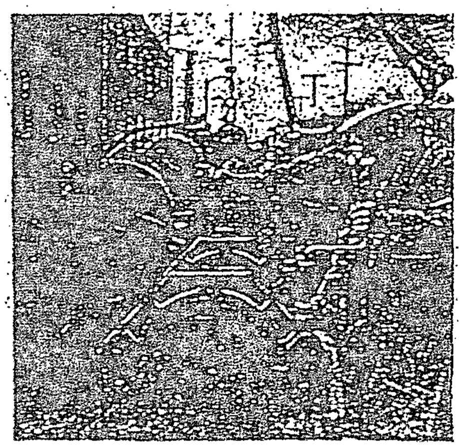
These properties are maintained throughout its temperature range without a loss of ductility or reduced resistance to notch sensitivity. Driscopipe has been successfully installed in numerous arctic applications. Some of these applications have included direct burial in the unstable arctic permafrost.

To learn more of the relative toughness of Driscopipe 8600, we encourage you to take a piece of pipe with a butt fusion joint and try to tear it up without using sharp tools. Pound it flat with a sledge hammer ... slam it against a corner of angle iron ... run over it with a truck ... then do the same with steel, copper, PVC, cast iron and the less rugged PEs. It's not very scientific ... but we believe you'll be convinced that Driscopipe 8600 has extremely high toughness. We have evaluated Driscopipe many times in laboratory and field test experiments to demonstrate and prove this toughness.

- One excellent indicator of the relative toughness of Driscopipe 8600, as compared to other polyethylene pipe materials, can be observed in the ASTM Standard Test for determination of flow rate of the thermoplastic materials.

  When Driscopipe 8600 is heated to 190°C (374°F) to measure the flow rate, it requires 432.5 pounds/sq. in. force, applied for 10 minutes, to flow 1½ grams of 8600 material through the orifice of the test unit! Other commercially available polyethylene pipe materials will flow 10 to 20 times this amount under the same conditions.

- When Driscopipe 8600 is heated to 475-500°F to melt it for fusion joining, it requires 150 pounds pressure per square inch of material to make the melted surfaces flow together. This is another indicator of toughness. Other commercially available polyethylene pipe materials require about one-half that amount of pressure and some competitive pipes require less than 25 psi!
- Driscopipe 8600 has been pressure tested for long periods at temperatures up to 140°F and performance requirements at these high temperatures can be used in purchase specifications to assure that the user is getting the highest performing polyethylene pipe.



Environmental Stress Crack Resistance

The most recent ASTM specification written to identify polyethylene plastic pipe and fittings materials is ASTM D 3350, "Polyethylene Plastics Pipe and Fittings Materials", adopted in 1974. This specification uses six (6) properties to classify PE material ... one of these is ESCR.

ASTM D 3350 lists three cell limits for ESCR classification which use the ESCR test outlined in ASTM D 1693, Test Method for Environmental Stress Cracking of Ethylene Plastics. The cell limits are:

Cell Classification Limit	Test Condition ASTM D 1693	Test Duration Hours	Percent of Failures Allowed	Test Temp. °C
1	A	48	50	50°
2	B	24	50	50°
3	C	192	20	100°

Minimum Notch for A is .020"; for B and C is .012".
Minimum Thickness for A is .120"; for B and C is .070".
A and B use a diluted aqueous solution reagent, C uses full strength reagent.

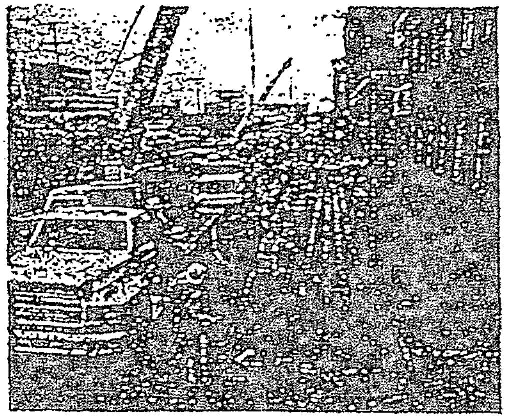
This method of testing for ESCR was first written in 1959 and was developed primarily to evaluate polyethylene as a jacketing material for power and communications cable. Although the method requires the use of laboratory compression molded specimens rather than pipe, it became the generally accepted method for evaluating ESCR of PE materials used for piping. Its wide use was responsible for its inclusion in ASTM D 3550 to describe one of the six primary properties of a PE pipe material.

The test method, ASTM D-1693, is an accelerated test method to determine the resistance of a polyethylene material to environmental stress cracking. It is a measure of the ability of the polyethylene to withstand secondary stress loadings. These loadings are typically thought of as low-level, long-term, external stresses which may act upon the polyethylene pipe in field installations.

Under conditions of the test, high local multiaxial stresses are developed through the introduction of a controlled imperfection (notch). The notched sample is subjected to an elevated temperature bath of a surface active agent. Environmental stress cracking has been found to occur most readily under such conditions.

A note in the test specifications states that, generally, low density (Type I) polyethylenes are tested under Condition A, medium and high density (Type II and Type III) polyethylenes are generally tested under Condition B and high density resins with high melt viscosity, such as pipe grade P34, are tested under Condition C.

As pipe grade polyethylenes have improved, the testing requirements of ASTM D-1693 have become less stringent for P34 pipe grade polyethylenes such as Driscopipe 8600 and Driscopipe 1000. As a result, a more severe stress crack resistance test has been developed to evaluate high density polyethylene pipe. The ASTM F-1248 stress crack resistance test method was developed by a gas distribution company for quality control purposes and is often referred to as Ring ESCR since it tests actual produced pipe ring samples rather than molded specimens.



ASTM F-1248 utilizes rings cut from a pipe sample. The rings are notched on one side and compressed between parallel plates until the distance between the plates is three times the specified pipe minimum wall thickness. The compressed ring samples are subjected to an elevated temperature bath of a surface active agent and visibly inspected for crack formation or propagation.

The Ring ESCR test provides useful information regarding the different polyethylene pipe grade materials. Driscopipe 8600 shows no tendency for sample failures when tested in excess of 10,000 hours. This further reinforces the unique ability of Driscopipe 8600 to provide the highest degree of resistance to the external stresses inherent to a pipeline installation.

Driscopipe 1000, an extra high molecular weight HDPE pipe, will exhibit a ring ESCR of $F_{50} > 1000$ hours. Other lower molecular weight pipes may exhibit lower F_{50} values.

Chemical Corrosion Resistance

The outstanding resistance of Driscopipe to attack by most chemicals makes it suitable to transport these chemicals or to be installed in an environment where these chemicals are present. Factors which determine the suitability and service life of each particular application include the specific chemical and its concentration, pressure, temperature, period of contact and service conditions which may introduce stress concentrations in the pipe or fittings.

Driscopipe is, for all practical purposes, chemically inert within its temperature use range. This advantageous engineering characteristic is one of the primary reasons for the wide use of Driscopipe in industrial applications. It does not rot, rust, pit, corrode or lose wall thickness through chemical or electrical reaction with the surrounding soil, whether acid, alkaline, wet or dry. It neither supports the growth of, nor is affected by, algae, bacteria or fungi and is resistant to marine biological attack. It contains no ingredients which make it attractive to rodents, gophers, etc.

Information relative to the resistance of Driscopipe to a wide range of chemicals is shown in the following tables. This information is based on results of immersion tests (usually 3 months) at various temperatures. Changes in tensile strength and elongation are evaluated at a rapid strain rate to emphasize any strength decay in the material.

Most acids, bases and other chemicals can be transported by Driscopipe using the same design parameters as would apply to water, natural or manufactured gas and water solutions of inorganic salts. Strong oxidizing agents such as fuming sulfuric acid may adversely affect the pipe, depending upon concentration, temperature and period of contact. In many cases, such as gravity flow waste lines, these chemicals can be handled because of dilution and intermittent flow.

Some chemicals, such as all types of liquid hydrocarbons, will mechanically absorb into the wall of the pipe and cause a reduction in hoop stress but this does not degrade the material. This effect is temporary if exposure is intermittent. Where exposure is continuous, it is necessary to derate the pressure capability of the pipe for long term service. This includes such products as gasoline, ethyl alcohol, benzene, carbon tetrachloride, crude and refined oils, etc. Where 5-100% hydrocarbon liquids are continuously present in a pressure system, a service design factor of .25 should be used to calculate design pressures instead of the service design factor of .5 used with water.

$$P = \frac{2S}{SDR-1} \times F \quad \text{or} \quad P = 2S\frac{t}{D-t} \times F$$

Where: D = Outside Diameter, Inches
P = Design Pressure, psi
S = Long Term Hydrostatic Strength, psi, at the design temperature
t = Minimum Wall Thickness, Inches
F = Service Design Factor
SDR = Standard Dimension Ratio of D/t

CHEMICAL RESISTANCE OF DRISCOPIPE

S – Satisfactory
U – Unsatisfactory
M – Marginal
N – Not known

All concentrations are 100% unless noted otherwise.

On reagents marked marginal, chemical attack will be recognized by a loss of physical properties of the pipe which may require a change in design factors.

Reagent	70°F (21°C)	140°F (60°C)
Acetic Acid 1-10%	S	S
Acetic Acid 10-60%	S	M
Acetic Acid 60-100%	S	M
Acetone	M	U
Acrylic Emulsions	S	S
Aluminum Chloride-Dilute	S	S
Aluminum Chloride Conc.	S	S
Aluminum Fluoride Conc.	S	S
Aluminum Sulfate Conc.	S	S
[illegible]ums (All Types) Conc.	S	S
Ammonia 100% Dry Gas	S	S
Ammonium Carbonate	S	S
Ammonium Chloride Sat'd	S	S
Ammonium Fluoride 20%	S	S
Ammonium Hydroxide 0.88 S.G.	S	S
Ammonium Metaphosphate Sat'd	S	S
Ammonium Nitrate Sat'd	S	S
Ammonium Persulfate Sat'd	S	S
Ammonium Sulfate Sat'd	S	S
Ammonium Sulfide Sat'd	S	S
Ammonium Thiocyanate Sat'd	S	S
Amyl Acetate	M	U
Amyl Alcohol 100%	S	S
Amyl Chloride 100%	N	U
Aniline 100%	S	N
Antimony Chloride	S	S
Aqua Regia	U	U
Barium Carbonate Sat'd	S	S
Barium Chloride	S	S
Barium Hydroxide	S	S
Barium Sulfate Sat'd	S	S
Barium Sulfide Sat'd	S	S
Beer	S	S
Benzene	M	U
Benzene Sulfonic Acid	S	S
Bismuth Carbonate Sat'd	S	S
[illegible]each Lye 10%	S	S
[illegible]lack Liquor	S	S
Borax Cold Sat'd	S	S
Boric Acid Dilute	S	S

Reagent	70°F (21°C)	140°F (60°C)
Boric Acid Conc.	S	S
Bromic Acid 10%	S	S
Bromine Liquid 100%	M	U
Butanediol 10%	S	S
Butanediol 60%	S	S
Butanediol 100%	S	S
Butyl Alcohol 100%	S	S
Calcium Bisulfide	S	S
Calcium Carbonate Sat'd	S	S
Calcium Chlorate Sat'd	S	S
Calcium Chloride Sat'd	S	S
Calcium Hydroxide	S	S
Calcium Hypochlorite BL'GH Sol.	S	S
Calcium Nitrate 50%	S	S
Calcium Sulfate	S	S
Camphor Oil	N	U
Carbon Dioxide 100% Dry	S	S
Carbon Dioxide 100% Wet	S	S
Carbon Dioxide Cold Sat'd	S	S
Carbon Disulfide	N	U
Carbon Monoxide	S	S
Carbon Tetrachloride	M	U
Carbonic Acid	S	S
Castor Oil Conc.	S	S
Chlorine Dry Gas 100%	S	M
Chlorine Moist Gas	M	U
Chlorine Liquid	M	U
Chlorobenzene	M	U
Chloroform	M	U
Chlorosulfonic Acid 100%	M	U
Chrome Alum Sat'd	S	S
Chromic Acid 20%	S	S
Chromic Acid Up to 50%	S	S
Chromic Acid and Sulfuric Acid	S	M
Cider	S	S
Citric Acid Sat'd	S	S
Coconut Oil Alcohols	S	S
Cola Concentrates	S	S
Copper Chloride Sat'd	S	S
Copper Cyanide Sat'd	S	S
Copper Fluoride 2%	S	S
Copper Nitrate Sat'd	S	S
Copper Sulfate Dilute	S	S
Copper Sulfate Sat'd	S	S
Cottonseed Oil	S	S
Crude Oil*	S	M
Cuprous Chloride Sat'd	S	S
Cyclohexanol	S	S
Cyclohexanone	M	U
Detergents Synthetic	S	S
Developers, Photographic	S	S
Dextrin Sat'd	S	S
Dextrose Sat'd	S	S
Dibutylphthalate	S	M
Disodium Phosphate	S	S

Reagent	70°F (21°C)	140°F (60°C)
Diazo Salts	S	S
Diethylene Glycol	S	S
Diglycolic Acid	S	S
Dimethylamine	M	U
Emulsions, Photographic	S	S
Ethyl Acetate 100%	M	U
Ethyl Alcohol 100%	S	S
Ethyl Alcohol 35%	S	S
Ethyl Butyrate	M	U
Ethyl Chloride	M	U
Ethyl Ether	U	U
Ethylene Chloride	U	U
Ethylene Chlorohydrin	U	U
Ethylene Dichloride	M	U
Ethylene Glycol	S	S
Ferric Chloride Sat'd	S	S
Ferric Nitrate Sat'd	S	S
Ferrous Chloride Sat'd	S	S
Ferrous Sulfate	S	S
Fish Solubles	S	S
Fluoboric Acid	S	S
Fluorine	S	U
Fluosilicic Acid 32%	S	S
Fluosilicic Acid Conc.	S	S
Formaldehyde 40%	S	N
Formic Acid 0-20%	S	S
Formic Acid 20-50%	S	S
Formic Acid 100%	S	S
Fructose Sat'd	S	S
Fruit Pulp	S	S
Fuel Oil	S	U
Furfural 100%	M	U
Furfuryl Alcohol	M	U
Gallic Acid Sat'd	S	S
Gas Liquids*	S	M
Gasoline*	M	U
Gin	S	U
Glucose	S	S
Glycerine	S	S
Glycol	S	S
Glycolic Acid 30%	S	S
Grape Sugar Sat'd Aq.	S	S
Hexanol, Tert.	S	S
Hydrobromic Acid 50%	S	S
Hydrocyanic Acid Sat'd	S	S
Hydrochloric Acid 10%	S	S
Hydrochloric Acid 30%	S	S
Hydrochloric Acid 35%	S	S
Hydrochloric Acid Conc.	S	S
Hydrofluoric Acid 40%	S	S
Hydrofluoric Acid 60%	S	S
Hydrofluoric Acid 75%	S	-S
Hydrogen 100%	S	S
Hydrogen Bromide 10%	S	S
Hydrogen Chloride Gas Dry	S	S

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*HDPE Resin Service Design Factor for hydrocarbons per the formula on page 3 and 8 is F = 0.25 to compensate for hydrocarbon saturation effects on long term hydrostatic strength.

continued on page 10

continued from page 9

CHEMICAL RESISTANCE OF DRISCOPIPE

Reagent	70°F (21°C)	140°F (60°C)
Hydrogen Peroxide 30%	S	S
Hydrogen Peroxide 90%	S	M
Hydrogen Phosphide 100%	S	S
Hydroquinone	S	S
Hydrogen Sulfide	S	S
Hypochlorus Acid Conc.	S	S
Inks	S	S
Iodine (Alc. Sol.) Conc.	S	U
Lactic Acid 10%	S	S
Lactic Acid 90%	S	S
Latex	S	S
Lead Acetate Sat'd	S	S
Lube Oil*	S	M
Magnesium Carbonate Sat'd	S	S
Magnesium Chloride Sat'd	S	S
Magnesium Hydroxide Sat'd	S	S
Magnesium Nitrate Sat'd	S	S
Magnesium Sulfate Sat'd	S	S
Mercuric Chloride Sat'd	S	S
Mercuric Cyanide Sat'd	S	S
Mercurous Nitrate Sat'd	S	S
Mercury	S	S
Methyl Alcohol 100%	S	S
Methyl Bromide	M	U
Methyl Chloride	M	U
Methyl Ethyl Ketone 100%	M	U
Methylsulfuric Acid	S	S
Methylene Chloride 100%	M	U
Milk	S	S
Mineral Oils	S	U
Molasses Comm.	S	S
Nickel Chloride Sat'd	S	S
Nickel Nitrate Conc.	S	S
Nickel Sulfate Sat'd	S	S
Nicotine Dilute	S	S
Nicotinic Acid	S	S
Nitric Acid 0-30%	S	S
Nitric Acid 30-50%	S	M
Nitric Acid 70%	S	M
Nitric Acid 85-93%	U	U
Nitrobenzene 100%	U	U
Octyl Cresol	S	U
Oils and Fats*	S	M
Oleic Acid Conc.	S	U
Oleum Conc.	U	U
Orange Extract	S	S
Oxalic Acid Dilute	S	S
Oxalic Acid Sat'd	S	S
Ozone 100%	S	U
Perchloric Acid 10%	S	S
Petroleum Ether	U	U
Phenol 90%	U	U
Phosphoric Acid Up to 30%	S	S
Phosphoric Acid Over 30%	S	S
Phosphoric Acid 90%	S	S
Phosphorous (Yellow) 100%	S	N
Phosphorus Pentoxide 100%	S	N
Photographic Solutions	S	S
Pickling Baths		
Sulfuric Acid	S	S
Hydrochloric Acid	S	S
Sulfuric-Nitric	S	U
Plating Solutions		
Brass	S	S
Cadmium	S	S
Chromium	N	N
Copper	S	S
Gold	S	S
Indium	S	S
Lead	S	S
Nickel	S	S
Rhodium	S	S
Silver	S	S
Tin	S	S
Zinc	S	S
Potassium Bicarbonate Sat'd	S	S
Potassium Borate 1%	S	S
Potassium Bromate 10%	S	S
Potassium Bromide Sat'd	S	S
Potassium Carbonate	S	S
Potassium Chlorate Sat'd	S	S
Potassium Chloride Sat'd	S	S
Potassium Chromate 40%	S	S
Potassium Cyanide Sat'd	S	S
Potassium Dichromate 40%	S	S
Potassium Ferri/ Ferro Cyanide Sat'd	S	S
Potassium Fluoride	S	S
Potassium Hydroxide 20%	S	S
Potassium Hydroxide Conc.	S	S
Potassium Nitrate Sat'd	S	S
Potassium Perborate Sat'd	S	S
Potassium Perchlorate 10%	S	S
Potassium Sulfate Conc.	S	S
Potassium Sulfide Conc.	S	S
Potassium Sulfite Conc.	S	S
Potassium Persulfate Sat'd	S	S
Propargyl Alcohol	S	S
Propyl Alcohol	S	S
Propylene Dichloride 100%	U	U
Propylene Glycol	S	S
Rayon Coagulating Bath	S	S
Sea Water	S	S
Selenic Acid	S	S
Shortening	S	S
Silicic Acid	S	S
Silver Nitrate Sol.	S	S
Soap Solution Any Conc'n	S	S
Sodium Acetate Sat'd	S	S
Sodium Benzoate 35%	S	S
Sodium Bicarbonate Sat'd	S	S
Sodium Bisulfate Sat'd	S	S
Sodium Bisulfite Sat'd	S	S
Sodium Borate	S	S
Sodium Bromide Dilute Sol.	S	S
Sodium Carbonate Con.	S	S
Sodium Carbonate	S	S
Sodium Chlorate Sat'd.	S	S
Sodium Chloride Sat'd	S	S
Sodium Cyanide	S	S
Sodium Dichromate Sat'd	S	S
Sodium Ferricyanide	S	S
Sodium Ferrocyanide Sat'd	S	S
Sodium Fluoride Sat'd	S	S
Sodium Hydroxide Conc.	S	S
Sodium Hypochlorite	S	S
Sodium Nitrate	S	S
Sodium Sulfate	S	S
Sodium Sulfide 25%	S	S
Sodium Sulfide Sat'd Sol.	S	S
Sodium Sulfite Sat'd	S	S
Stannous Chloride Sat'd	S	S
Stannic Chloride Sat'd	S	S
Starch Solution Sat'd	S	S
Stearic Acid 100%	S	S
Sulfuric Acid 0-50%	S	S
Sulfuric Acid 70%	S	M
Sulfuric Acid 80%	S	U
Sulfuric Acid 96%	M	U
Sulfuric Acid 98%	M	U
Sulfuric Acid, Fuming	U	U
Sulfurous Acid	S	S
Tallow*	S	M
Tannic Acid 10%	S	S
Tanning Extracts Comm.	S	S
Tartaric Acid Sat'd	N	N
Tetrahydrofurane	N	U
Titanium Tetrachloride Sat'd	N	U
Toluene	M	U
Transformer Oil	S	M
Trisodium Phosphate Sat'd	S	S
Trichloroethylene	U	U
Urea Up to 30%	S	S
Urine	S	S
Vinegar Comm.	S	S
Vanilla Extract	S	S
Wetting Agents	S	S
Whiskey	S	N
Wines	S	S
Xylene	M	U
Yeast	S	S
Zinc Chloride Sat'd	S	S
Zinc Sulfate Sat'd	S	S

For additional chemical resistance listings, consult the P.P.I. technical report #TR 19/10-84, Table I and the ISO technical report #ISO/Data 8-1979, Tables I, II, III.

Temperature Characteristics

Since polyethylene is a thermoplastic material, many of its physical and chemical properties are dependent on temperature and will change as the temperature of the material is increased or decreased. However, the exposure of Driscopipe to temperature variations within the recommended operating range does not result in degradation of the material. As these temperature changes are reversed, the material properties also reverse to their original values.

You will note from the information on physical properties that Driscopipe has a brittleness temperature below −180°F and a softening temperature of +257°F. The recommended operating temperature is limited only on the higher temperature side to a range of 140-180°F, dependent upon the pressure of the application and other operating and installation considerations. On the lower temperature side, Driscopipe gains strength without becoming brittle and is ideal for use at sub-zero temperatures.

Driscopipe becomes molten at 400-500°F and temperatures in this range are used to fusion join the piping system. Pipe is extruded at about the same temperature. To protect the material against degradation at the higher temperature, it is chemically stabilized. This stabilizer protects the material against thermal degradation which might otherwise occur during manufacture, outside storage and installation.

Driscopipe has been tested for thousands of hours at elevated temperatures of 140°F and 180°F without thermal degradation. These long term pressure tests at the higher temperatures are used to obtain recommended design strengths for the pipe at these temperatures.

Since all thermoplastic piping materials are affected by temperature, it is a general practice to characterize these materials at ambient temperature of 23°C (73.4°F). Nearly all ASTM tests relating to physical, mechanical and chemical properties of thermoplastic materials are conducted at this temperature. If a test is conducted, or a property defined, at other than 73.4°F, it is always noted.

One example of the effect of temperature on Driscopipe is the change in long term strength of the material as shown on the stress-life curves. This type behavior is true for all thermoplastics but there are large differences between the performance of specific materials at the higher temperatures.

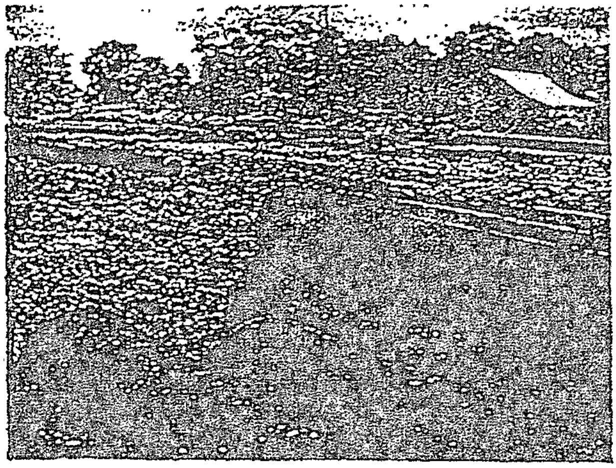
Knowledge of the long term strength of Driscopipe at the various temperatures allows selective design of a system. Accurate interpolations can be made for other temperatures between those which are known when data at three or more temperature levels is available.

Other properties of thermoplastic pipe which change with temperature and can affect system design and installation procedures include the following.

Burst strength – Short term (1 minute) burst tests on Driscopipe at various temperatures show these typical hoop stress values:

Temperature, °F	Hoop Stress, psi
73.4°	3250
32°	4300
0°	5290
−20°	5670
−40°	6385

Driscopipe will quick-burst at a pressure approximately four times greater than the rated operating pressure.



Chemical Resistance – The ability of most thermoplastics to resist degradation in the presence of corrosive chemicals is reduced as temperature increases. This is also true for Driscopipe but to a lesser extent because of its high density and high molecular weight. The effect of temperature on Driscopipe in the presence of various chemicals is shown in the chemical resistance tables.

Flexibility – As temperature is decreased, the flexibility of Driscopipe is also decreased. This has very little effect on installation except that at the lower winter temperatures, coiled pipe becomes more difficult, mechanically, to uncoil and stretch out in the ditch. Although Driscopipe becomes stiffer at low temperature, it can be bent, uncoiled or plowed in with sufficient mechanical power and no damage will occur to the pipe because of bending it at cold temperatures.

Other Physical Properties – There is a slight change with temperature of impact strength, notch sensitivity, flexural modulus, hardness and elongation ... but none are of such extent as to affect design parameters or installation procedures over the normal range of temperatures.

Modulus of Elasticity – Typical values for the variance in modulus of elasticity with temperature change is shown below.

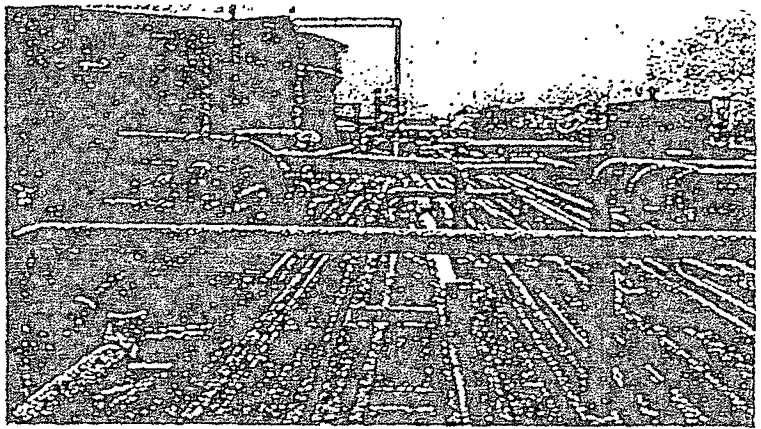
Temperature °F	Modulus of Elasticity, psi
−20°	300,000
0°	260,000
32°	200,000
75°	130,000
100°	105,000
140°	60,000

Thermal Expansion and Contraction – Polyethylene, like other thermoplastics, has a coefficient of expansion higher than metals. This coefficient is usually determined by a standard test method which employs the use of molded specimens. Measurements are made with a quartz dilatometer while the test specimen is held at elevated temperature. Typical coefficient values by this method range from $.75 \times 10^{-4}$ for Driscopipe 8600 to $.83 \times 10^{-4}$ for Driscopipe 1000.

The coefficient of linear expansion may also be determined by measuring the change in length of unrestrained pipe samples at different temperatures. The calculated coefficient is somewhat higher on extruded pipe than on molded test specimens. This appears to be true for all polyethylene pipe. The average coefficient calculated from measurements made on Driscopipe in the temperature range 0°F to 140°F, is 1.2×10^{-4} in/in/°F.

The circumferential coefficient of expansion and contraction for Driscopipe is approximately $.6 \times 10^{-4}$ in/in/°F in the range of 0° to 140°F ... or about ½ the linear coefficient. This circumferential change with temperature rarely presents any problems in system design. There may be need to consider this factor if compression fittings are used.

The expansion or contraction for Driscopipe can be stated in an easy rule of thumb ... the pipe will expand or contract approximately 1.4" per 100 feet for each 10°F change in temperature. Thus a 1000 foot unrestrained line which undergoes a 20°F increase in temperature change will increase in length 28 inches. The relatively large amount of expansion and contraction of plastic pipe generally presents no real problems in installation. The pipe has a relatively low elastic modulus and consequently there is less stress build-up. These stresses, caused by temperature change, are easily dissipated due to the thermoplastic nature of the material which relaxes and adjusts with time.



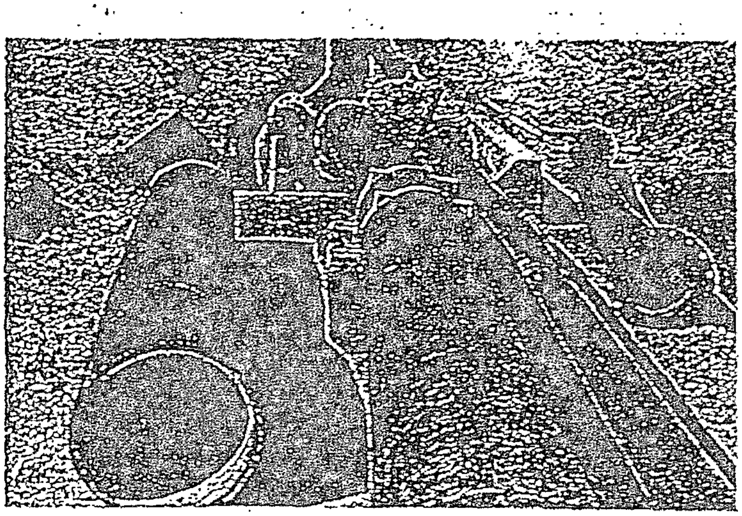
Tests have been conducted wherein the temperature [illegible]re than 100 feet of unrestrained pipe was [illegible]nged 130°F in a period of a few minutes. The total force created by contraction was measured and proved to be about (½) one-half the theoretical calculated value. Thermoplastic materials are unique in their ability to stress-relieve themselves. Actual changes in temperature in most applications take place slowly over an extended period of time. The total stresses imposed will vary but are generally much lower than the calculated values.

Direct buried pipe will generally have ample soil friction and interference to restrain movement of the pipe under normal application temperature changes. It is a good idea to make the final tie-ins on a system at a temperature which is as close to operating temperature as possible. This is particularly true for insert liner systems where there is no soil restraint.

Normal good direct burial installation practices which include snaking the pipe in the ditch, proper backfill and compaction, making the tie-in at the proper temperature, etc. should be used at all times and will substantially reduce the possibility of pull out at tie-in connections on such installations. However, planning the transition tie-in becomes more important when Driscopipe is used for insert renewal inside another pipe because there is no restraint from earth loading. [illegible] contraction of the pipe due to reduction in [illegible]perature is freely transmitted to the transition [illegible]nection and may result in pull-out if proper design precautions are not taken. In those cases, it may be necessary to provide additional anchoring at the terminations of the insert liner. Concrete anchors poured into undisturbed soil and cast around anchor projections in the Driscopipe line will restrict movement at the end of the line. Anchor projections on the Driscopipe liner can be made by fusing a blind tee into the line or by the use of two reducers, to the next larger size of pipe, fused together in the line.

Thermal Conductivity – This property of Driscopipe is lower than that for metals and can sometimes be exploited in the design of the system. It may eliminate or reduce the need for insulating pipe which carries water or other fluids through freezing temperatures. Thermal Conductivity of Driscopipe is 2.7 BTU per hour per sq. ft. per °F per inch of thickness. The slow heat transfer inhibits freezing and, if normal burial precautions are used, accidental freezing is usually eliminated. If the pipe does freeze, it does not fracture but fluid flow will be stopped. It will resume its function upon thawing. Direct application of intense heat should not be used to thaw a line. Antifreeze compounds such as methanol, isoproponol and ethylene glycol can be used without detrimental effect on the pipe.

Ignition Temperatures – The flash point for high density polyethylene using the Cleveland open cup method (ASTM D92) is 430°F. The flash ignition and self ignition temperatures using ASTM D1929 are 645°F and 660°F.



Weatherability

Two principal factors influence the weathering of plastic pipe in outside above ground applications ... temperature changes caused by seasonal variations and solar heating and solar radiation of ultraviolet rays. Effects of temperature variations on Driscopipe were discussed in the preceding section. Expansion and contraction of a line above ground, due to differential heating, will cause the line to move laterally, particularly if it is empty. This movement can easily be controlled within desired limits through the use of restraints.

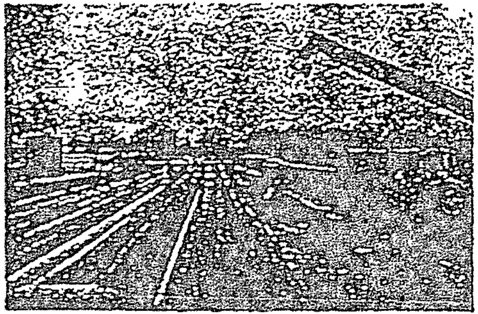
Driscopipe is also protected against degradation caused by ultraviolet rays when exposed to direct sunlight. The material contains 2½% of finely divided carbon black which also accounts for the black color of Driscopipe. Carbon black is the most effective single additive capable of enhancing the weathering characteristic of plastic materials. The protection even relatively low levels of carbon black impart to the plastic is so great that it is not necessary to use other light stabilizers or UV absorbers.

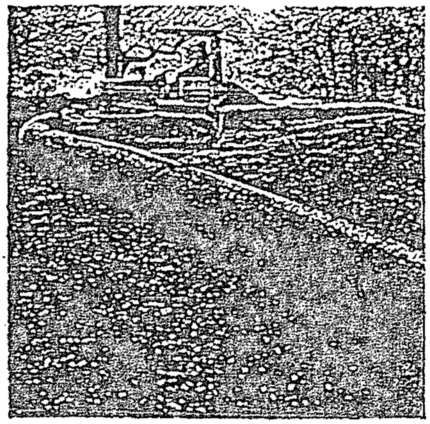
Weatherability tests indicate that Driscopipe can be safely used outside in most climates for periods of many years without danger of loss of physical properties due to UV exposure. Phillips has done extensive testing of polyethylene compounds containing 2 to 3% carbon black and compared these to other UV stabilizers to determine their effectiveness for protection against UV degradation in outdoor exposure. Samples were aged in outdoor exposure in three geographical locations: Phoenix, Arizona, Bartlesville, Oklahoma (Phillips 66 headquarters) and Akron, Ohio. From these actual tests, it was determined that one year exposure in Arizona was equivalent to at least two years in Bartlesville and greater than three and one-half years in Akron.

Weather-Ometer tests were run under standard conditions as set out in ASTM D 1499-64 and compared with the actual test samples in the three locations described above. From this test work, it was determined, conservatively, that 5000 hours (approximately 7 months) in the Weather-Ometer compares to greater than 42 months exposure in Arizona. Samples containing 2 to 3% carbon black and thermal stabilizers as used in Driscopipe have been tested for greater than 25,000 hours (2.85 years) in the Weather-Ometer without any brittleness or loss of physical properties. This is equivalent to over 17 years in Arizona and over 60 years in Akron, Ohio.

Permeability

The permeability of gases, vapors or liquids through a plastic membrane is generally considered to be an activated diffusion process. That is, the gas, vapor or liquid dissolves in the membrane and then diffuses to a position of lower concentration. The permeation rate is determined by the functional groups of the permeating molecules and by the density of the plastic ... the higher the density, the lower the permeability. Listed below are typical permeability rates for HDPE.





	Permeability Rate*
[illegible]n Dioxide	345
Hydrogen	321
Oxygen	111
Helium	247
Ethane	236
Natural Gas	113
Freon 12	95
Nitrogen	53

*Cubic centimeters per day per 100 sq. inches per mil thickness at atmospheric pressure differential.

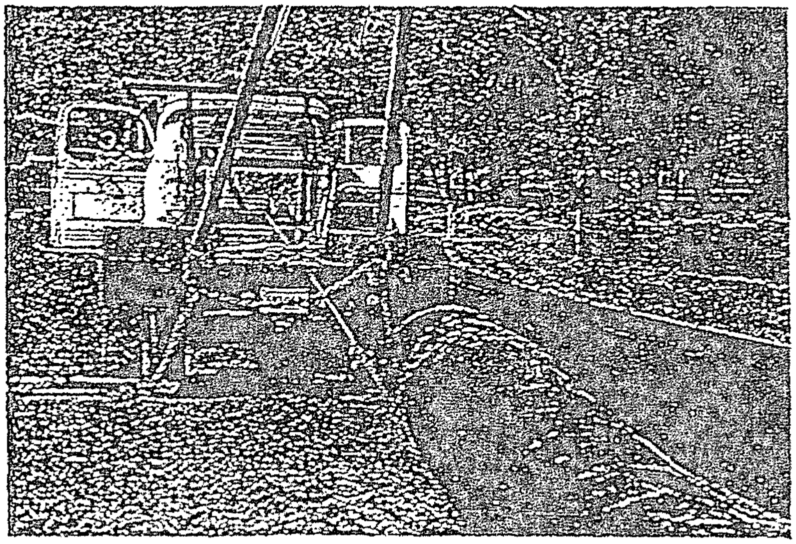
These permeation rates are considered very low. They result in negligible loss of product and create no hazard. For example, polyethylene piping systems are the predominant material used to construct new gas distribution systems and to renew old deteriorated systems. The permeation rate will vary in direct proportion to the differential pressure applied.

If the internal operating pressure is 60 psi, for example, the permeability rate would be approximately 4 times that shown above but volume losses would still be extremely low. Calculated volume loss in one mile of SDR 11 pipe (any size) in one day, for natural gas, would be ¼ of one cubic foot. At 120 psi, it would be ½ cubic foot per day.

Abrasion Resistance

One of the many outstanding characteristics of Driscopipe polyethylene is its resistance to abrasion. The inherent resilience and toughness of Driscopipe allows the mining industry to use this pipe in numerous surface applications where more conventional materials would be unsatisfactory, either because of the terrain encountered or the abrasiveness of the slurry to be moved. Quite often, a Driscopipe system offers substantial economic advantage as a means of transport over more conventional transportation methods used in the mining industry. Some of the more common applications include tailings lines and the transport of gypsum, limestone, sand, slimes and coal.

Due to its unique toughness, as indicated by low melt flow values, Driscopipe 8600 provides improved abrasion resistance over all other polyethylene piping materials. Controlled pipe loop pumping tests have demonstrated that Driscopipe can outlast steel pipe by as much as 4 to 1. One such test, performed by Williams Brothers Engineering, Tulsa, Oklahoma, compared Driscopipe to steel in pumping a coarse particle size magnetite iron ore slurry. At 13½ ft/sec velocity, Driscopipe was better by a factor of 4:1 and at 17 ft/sec by a factor of 3:1.



Heat Fusion Joining

The heat fusion joining technique has a long history of use for joining polyethylene pipe materials. The heat fusion method of joining PE pipe began shortly after the first commercial production of high density polyethylene in the early 1950s ... both developed by Phillips 66.

The integrity and superiority of heat fusion are now recognized universally. The modern day heat fusion joint is the same joint made in 1956 ... only the fusion equipment has evolved to gain efficiency, reliability and convenience. The principles learned on early equipment for making a successful joint are still in use today. Phillips designed, developed and built many models of heat fusion equipment from 1956 until the early 1970s. Since that time, Phillips has guided this development by others. The extensive line of high quality, efficient fusion equipment offered by McElroy Manufacturing, Inc., Tulsa, Oklahoma is one of the results of this long history of development. Phillips pioneered the idea and development of heat fusion and has used it exclusively in every high density polyethylene piping system sold by Phillips since 1956. There are millions of these joints in service today. In fact, 92% of all natural gas distribution pipe to homes, farms and factories is installed with polyethylene pipe and fittings. Heat fusion joints are industry accepted and field proven.

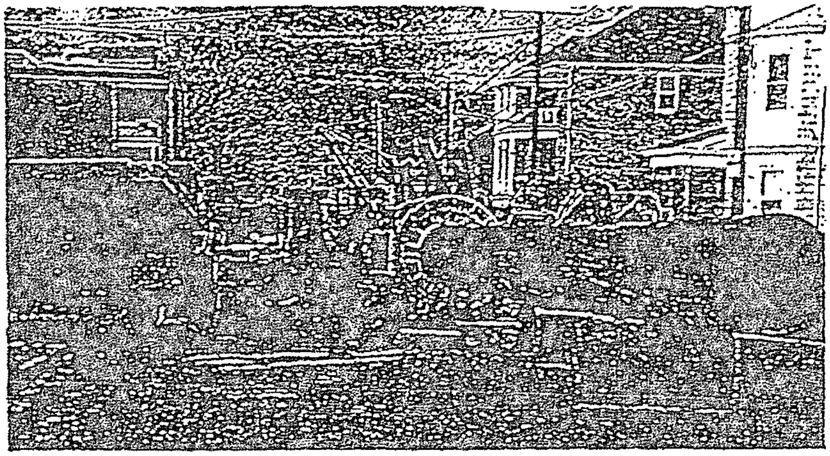
The heat fusion joining system has been so successful that it is the "standard" joining system for polyethylene. There are many reasons ... here are some.

Heat fusion joining ideally meets the requirements for a fast joining method to facilitate all phases of construction work in a safe and reliable manner.

The heat fusion joint is structurally superior to the socket fusion joint by configuration and, therefore, better meets the requirements of service. The heat joint configuration allows it to better disperse stresses initiated by pipe deflection and external loading. Stress concentration is minimized when the joint is placed in a strain and the joint is more "forgiving" when ground settlement occurs. In a socket joint, there is an extremely high ratio of "joint wall" to "pipe wall", resulting in stress intensification from external loading.

The Driscopipe heat fusion joining system is a simple, visual procedure with straight forward instructions. No "timing cycles" are necessary. The visual procedure allows the operator to concentrate on his work rather than a clock. Visually, he knows when the pipe ends have melted to the degree required to fuse them together. Visually, he observes and controls fusion pressure by observing the amount and configuration of the fusion bead as it is formed.

In the course of this work, the fusion operator is faced with a wide variety of job conditions. Changes in air temperature, material temperature, wind velocity, sun exposure, humidity, as well as condition of the terrain and the equipment all influence the joining requirements. Quality work under field conditions is more consistent with a simple, straight-forward, visual procedure.

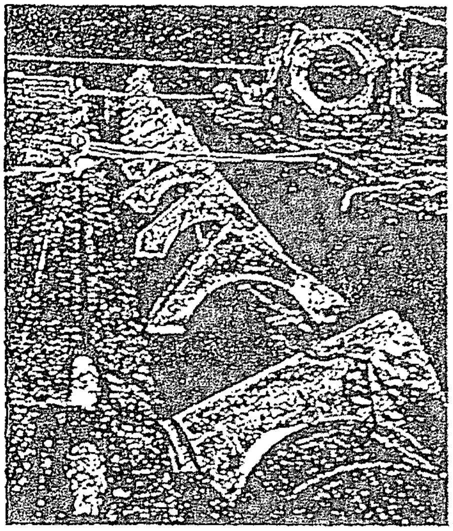


One heat fusion operator, with equipment, typically [illegible] the whole operation himself, sometimes using a [illegible]nd person as a helper. Pipe tolerances, ovality and curvature are no problem and "melt" is easily controlled by the visual procedure.

Heat fusion joints offer a large advantage over socket coupled joints for plow-in installation and for insert renewal applications. Socket coupled pipe requires larger size plow chutes and bore holes. Heat fused pipe one size larger can usually be handled and installed through bore holes and plow chutes selected for socket coupled pipe. Larger sizes of heat fused pipe can be used inside old mains for insert renewal because it does not require the extra space for the coupling.

Heat fusion joints may easily be cut out and re-done. This fact has a bearing on the quantity and quality of training necessary and favorably affects operator attitude toward quality in the field. These joints can be easily cut out and destructively tested in the field to check joining proficiency and equipment condition and it's inexpensive. There is no coupling to destroy and throw away.

The heat fusion joining system is especially effective with Driscopipe 8600. The melt of this material is very viscous and tough. The operator can apply ample pressure to form the heat fusion joint with little danger [illegible]rcing the molten material from between the two [illegible]s of the joint, as can be done with the softer, less viscous, high density materials.



Driscopipe 8600 can be fusion joined to other polyethylene piping materials when necessary. Special joining techniques are required to achieve good joints. Phillips Driscopipe technical personnel are available to instruct and demonstrate the fusion joining procedure for joining Driscopipe to other polyethylene materials.

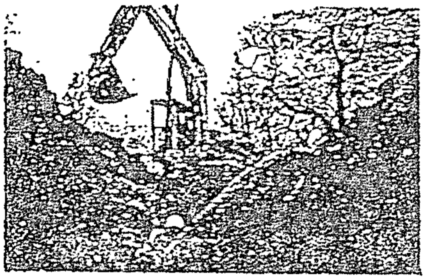
Fatigue Resistance

Driscopipe 8600 very high molecular weight, high density polyethylene has superior resistance to fatigue failure caused by cyclic loading. Independent laboratory tests were conducted to determine the suitability of Driscopipe 8600 for use as the cold water supply pipe and the barge mooring leg of the Mini-OTEC Project (Hawaii, 1979). In that application, 2150' of 24" 60 psi Driscopipe 8600 was deployed vertically in a deep ocean trench just offshore Keahole Point and was subject to cyclic distortion caused by wave action, current, and barge motion.

Cyclic tests showed that Driscopipe 8600 very high molecular weight PE could endure more than 100,000 cycles at a stress of 1800 psi without failure. Copies of this test report are avialable upon request.

Driscopipe 1000 offers good fatigue service life also, but not equal to 8600. Neither requires de-rating like PVC AWWA C-900 pipe. In fact, per AWWA C-906 for 4" to 63" HDPE pipe, no water hammer or fatigue de-rating factor need be applied to Driscopipe 8600 or Driscopipe 1000 ductile PE pipe.

The Driscopipe performance team offers you innovative solutions to your piping requirements. Contact your nearest Driscopipe Sales Representative. He'll give you personalized technical service, installation assistance and all the cost-saving advantages of a Driscopipe Piping System. Engineered for Performance!



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butane may condense and liquefy in the pipe. Such liquefied fuel gasses are known to permeate polyethylene pipe, and result in unreliable heat fusion or electrofusion joints.

In potable water applications, permeating chemicals could affect the pipe or water in the pipe. ANSI/AWWA standards provide the following guidance for potable water applications:

> "The selection of materials is critical for water service and distribution piping where there is likelihood the pipe will be exposed to significant concentrations of pollutants comprised of low molecular weight petroleum products or organic solvents or their vapors. Research has documented that pipe materials such as polyethylene, polybutylene, polyvinyl chloride, and asbestos cement, and elastomers, such as used in jointing gaskets and packing glands, may be subject to permeation by lower molecular weight organic solvents or petroleum products. If water pipe must pass through such a contaminated area or an area subject to contamination, consult with the manufacturer regarding permeation of pipe walls, jointing materials, and so forth, *before* selecting materials for use in that area."[1]

Chemical Attack

A direct chemical attack on the polymer will result in permanent, irreversible polymer damage or chemical change by chain scission, cross-linking, oxidation, or substitution reactions. Such damage or change cannot be reversed by removing the chemical.

Chemical Resistance Information

The following chemical resistance guide, Table 5-1 (next page), presents immersion test chemical resistance data for a wide variety of chemicals.

- ☐ This data may be applicable to gravity flow and low stress applications.
- ☐ It may not be applicable when there is applied stress such as internal pressure, or applied stress at elevated temperature.

Unless stated otherwise, polyethylene was tested in the relatively pure, or concentrated chemical.

It is generally expected that dilute chemical solutions, lower temperatures, and the absence of stress have less potential to affect the material. At higher temperature, or where there is applied stress, resistance may be reduced, or polyethylene may be unsuitable for the application. Further, combinations of chemicals may have effects where individual chemicals may not.

Testing is recommended where information about suitability for use with chemicals or chemical combinations in a particular environment is not available. PLEXCO cannot provide chemical testing services.

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[1] *ANSI/AWWA C906-90, Section 1.2; ANSI/AWWA C901-96, Section 4.1.*

Table 5-1 Chemical Resistance

Because the particular conditions of each application may vary, Table 5-1 information should be used only as a preliminary guide for PLEXCO and SPIROLITE polyethylene pipe materials. This information is offered in good faith, and is believed to be accurate at the time of publication, but it is offered without any warranty, expressed or implied. Additional information may be required, particularly in regard to unusual or special applications. Determinations of suitability for use in particular chemical or environmental conditions may require specialized laboratory testing.

Additional information on chemical compatibility may be found in PPI TR-19, *Thermoplastic Piping for the Transport of Chemicals.*

Chemical Resistance Key

Key†	*Meaning*
X	resistant (swelling <3% or weight loss <0.5%; elongation at break not substantially changed)
/	limited resistance (swelling 3 - 8% or weight loss 0.5 - 5%; elongation at break reduced by <50%)
—	not resistant (swelling > 8% or weight loss >5%; elongation at break reduced by >50%)
D	discoloration
*	aqueous solutions in all concentrations
**	only under low mechanical stress

† Where a key is not printed in the table, data is not available.

Medium	*73°F*	*140°F*
Acetaldehyde, gaseous	X	/
Acetic acid (10%)	X	X
Acetic acid (100%) (Glacial acetic acid)	X	/D
Acetic anhydride	X	/D
Acetone	X	X
Acetylene tetrabromide	**/ to —	—
Acids, aromatic	X	X
Acrylonitrile	X	X
Adipic acid	X	X
Allyl alcohol	X	X
Aluminum chloride, anhydrous	X	X
Aluminum sulphate	*X	X
Alums	X	X
Ammonia, liquid (100%)	X	X
Ammonium chloride	*X	X
Ammonium flouride, aqueous (up to 20%)	X	X
Ammonium nitrate	*X	X
Ammonium sulphate	*X	X
Ammonium sulfide	*X	X
Amyl acetate	X	X
Aniline, pure	X	X
Anisole	/	—
Antimony trichloride	X	X
Aqua regia	—	—
Barium chloride	*X	X
Barium hydroxide	*X	X

Medium	73°F	140°F	Medium	73°F	140°F
Beeswax	X	**/ to —	Cyclohexanone	X	X
Benzene	/	/	Decahydronaphthalene	X	/
Benezenesulphonic acid	X	X	Desiccator grease	X	/
Benzoic acid	*X	X	Detergents, synthetic	X	X
Benzyl alcohol	X	X to /	Dextrin, aqueous (18% saturated)	X	X
Borax, all concentrations	X	X	Dibutyl ether	X to /	—
Boric acid	*X	X	Dibutyl phthalate	X	/
Brine, saturated	X	X	Dichloroacetic acid (100%)	X	/D
Bromine	—	—	Dichloroacetic acid (50%)	X	X
Bromine vapor	—		Dicliloroacetic acid methyl ester	X	X
Butanetriol	X	X	Dichlorbenzene	/	—
Butanol	X	X	Diclolorethane	/	/
Butoxyl	*X	/	Dicloroethylene	—	—
Butyl acetate	X	/	Diesel oil	X	/
Butyl glycol	X	X	Diethyl ether	X to /	/
Butyric acid	X	/	Diisobutyl ketone	X	/ to —
Calcium chloride	*X	X	Dimethyl formamide (100%)	X	X to /
Calcium hypochlorite	*X	X	Dioxane	X	X
Camphor	X	/	Emulsifiers	X	X
Carbon dioxide	X	X	Esters, aliphatic	X	X to /
Carbon disulphide	/		Ether	X to /	/
Carbon tetrachloride	**/ to —	—	Ethyl acetate	/	—
Caustic potash	X	X	Ethyl alcohol	X	X
Caustic soda	X	X	Ethyl glycol	X	X
Chlorine, liquid	—	—	Ethyl hexanol	X	X
Chlorine bleaching solution (12% active chlorine)	/	—	Ethylene chloride (dichlorothene)	/	/
Chlorine gas, dry	/	—	Ethylene diamine	X	X
Chlorine gas, moist	/	—	Fatty acids ($>C^6$)	X	/
Clorine water (disinfection of mains)	X		Feric chloride*	X	X
Chloroacetic acid (mono)	X	X	Fluorine	—	—
Chlorobenzene	/	—	Fluorocarbons	/	—
Chloroethanol	X	XD	Fluorosilic acid, aqueous (up to 32%)	X	X
Chloroform	**/ to —	—	Formaldehyde (40%)	X	X
Chlorosulphonic acid	—	—	Formamide	X	X
Chromic acid (80%)	X	—D	Formic acid	X	
Citric acid	X	X	Fruit juices	X	X
Coconut oil	X	/	Fruit pulp	X	X
Copper salts	*X	X	Furfuryl alcohol	X	XD
Corn oil	X	/	Gelatine	X	X
Creosote	X	XD	Glucose	*X	X
Creosol	X	XD	Glycerol	X	X
Cyclohexane	X	X	Glycerol chlorohydrin	X	X
Cyclohexanol	X	X	Glycol (conc.)	X	X

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Medium	*73°F*	*140°F*
Glycolic acid (50%)	X	X
Glycolic acid (70%)	X	X
Halothane	/	/
Hydrazine hydrate	X	X
Hydrobromic acid (50%)	X	X
Hydrochloric acid (all concentrations)	X	X
Hydrocyanic acid	X	X
Hydrofluoric acid (40%)	X	/
Hydrofluoric acid (70%)	X	/
Hydrogen	X	X
Hydrogen chloride gas, moist and dry	X	X
Hydrogen peroxide (30%)	X	X
Hydrogen peroxide (100%)	X	
Hydrogen sulfide	X	X
Iodine, tincture of, DAB 7 (German Pharmacopoeia)	X	/D
Isooctane	X	/
Isopropanol	X	X
Isopropyl ether	X to /	—
Jam	X	X
Keotones	X	X to /
Lactic acid	X	X
Lead acetate	*X	X
Linseed oil	X	X
Magnesium chloride	*X	X
Magnesium sulphate	*X	X
Maleic acid	X	X
Malic acid	X	X
Menthol	X	/
Mercuric chloride (sublimate)	X	X
Mercury	X	X
Methanol	X	X
Methyl butanol	X	X
Methyl ethyl ketone	X	/ to —
Methyl glycol	X	X
Methylene chloride	/	/
Mineral oils	X	X to /
Molasses	X	X
Monochloroacetic acid	X	X
Monochloroacetic ethyl ester	X	X
Monochloroacetic methyl ester	X	X
Morpholine	X	X
Naptha	X	/
Naphthalene	X	/
Nickel salts	*X	X
Nitric acid (25%)	X	X
Nitric acid (50%)	/	—
Nitrobenzene	X	/
o-Nitrotoluene	X	/
Octyl cresol	/	—
Oils, ethereal	/	/
Oils, vegetable & animal	X	X to /
Oleic acid (conc.)	X	/
Oxalic acid (50%)	X	X
Ozone	/	—
Ozone, aqueous solution (Drinking water purification)	X	
Paraffin oil	X	X
Perchloric acid (20%)	X	X
Perchloric acid (50%)	X	/
Perchloric acid (70%)	X	—D
Petrol	X	X to /
Petroleum	X	/
Petroleum ether	X	/
Petroleum jelly	**X to /	/
Phenol	X	XD
Phosphates	*X	X
Phosphoric acid (25%)	X	X
Phosphoric acid (50%)	X	X
Phosphoric acid (95%)	X	/D
Phosphorus oxychloride	X	/D
Phosphorus pentoxide	X	X
Phosphorus trichloride	X	/
Photographic developers, commecial	X	X
Phthalic acid (50%)	X	X
Polyglycols	X	X
Potassium bichromate (40%)	X	X
Potassium borate, aqueous (1%)	X	X
Potassium bromate, aqueous (up to 10%)	X	X
Potassium bromide	*X	X
Potassium chloride	*X	X
Potassium chromate, aqueous (40%)	X	
Potassium cyanide	*X	X
Potassium hydroxide (30% solution)	X	X
Potassium nitrate	*X	X
Potassium permanganate	X	XD
Propanol	X	X
Propionic acid (50%)	X	X
Propionic acid (100%)	X	/

Medium	73°F	140°F
Propylene glycol	X	X
Pseudocumene	/	/
Pyridine	X	/
Seawater	X	X
Silicic acid	X	X
Silicone oil	X	X
Silver nitrate	X	X
Soduim benzoate	X	X
Sodium bisulphite, weak aqueous solutions	X	X
Sodium carbonate	*X	X
Sodium chloride	*X	X
Sodium chlorite (50%)	X	/
Sodium hydroxide (30% solution)	X	X
Sodium hypochlorite (12% active chlorine)	/	—
Sodium nitrate	*X	X
Sodium silicate	*X	X
Sodium sulfide	*X	X
Sodium thiosulphate	X	X
Spermaceti	X	/
Spindle oil	X to /	/
Starch	X	X
Steric acid	X	/
Succinc acid (50%)	X	X
Sugar syrup	X	X
Sulfates	*X	X
Sulfur	X	X
Sulfur dioxide, dry	X	X
Sulfur dioxide, moist	X	X
Sulfur trioxide	—	—
Sulfuric acid (10%)	X	X
Sulfuric acid (50%)	X	X
Sulfuric acid (98%)	/	—
Sulfuric acid, fuming	—	—
Sulfurous acid	X	X
Sulfuryl chloride	—	
Tallow	X	X
Tannic acid (10%)	X	X
Tartaric acid	X	X
Tetrachloroethane	**X to /	—
Tetrahydrofurane	**X to /	
Tetetrahydronapthalene	X	/
Thionyl chloride	—	—
Thiophene	/	/
Toluene	/	—
Transformer oil	X	/
Tributyl phosphate	X	X
Trichloroacetic acid (50%)	X	X
Trichloroacetic acid (100%)	X	/ to —
Trichloroethylene	**X to /	—
Triethanolamine	X	X
Turpentine, oil of	x to /	/
Tween 20 and 90 (Atlas Chemicals)	X	X
Urea	*X	X
Vinegar (commecial conc.)	X	X
Viscose spinning solutions	X	X
Waste gases containing		
carbon dioxide	X	X
carbon monoxide	X	X
hydrocloric acid (all conc.)	X	X
hydrogen fluoride (traces)	X	X
nitrous vitriol (traces)	X	X
sulfur dioxide (low conc.)	X	X
sulphuric acid, moist (all conc.)	X	X
Water gas	X	X
Xylene	—	—
Yeast, aqueous preparations	X	X
Zinc chloride	*X	X

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APPLICATION FOR MODIFICATION
BASIN DISPOSAL, INC.
OIL FIELD WASTE EVAPORATION PONDS

VOLUME III: ENGINEERING DESIGN AND CALCULATIONS
SECTION 3: GEOSYNTHETICS APPLICATIONS AND COMPATIBILITY DOCUMENTATION

ATTACHMENT III.3.E

PVC PIPE REFERENCE DOCUMENTATION

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PVC Chemical Resistance

KEY — E = Excellent G = Good L = Limited U = Unsuitable O = No test

Chemical	PVC I		PVC II	
	72 °F.	140 °F.	72 °F.	140 °F.
Acetaldehyde	U	U	U	U
Acetamide	O	O	U	U
Acetate Solvents - Crude	U	U	U	U
Acetate Solvents - Pure	U	U	U	U
Acetic Acid 0-10%	E	E	G	L
Acetic Acid 10-20%	E	E	G	L
Acetic Acid 20-30%	E	G	G	L
Acetic Acid 30-60%	E	E	G	L
Acetic Acid 80%	G	L	L	L
Acetic Acid - Glacial	G	U	L	U
Acetic Acid - Vapors	E	E	G	G
Acetic Anhydride	U	U	U	U
Acetone	U	U	U	U
Acetylene	L	L	E	E
Adipic Acid	E	E	E	E
Alcohol - Allyl - 96%	G	L	U	U
Alcohol - Amyl	E	L	L	U
Alcohol - Buty	E	G	L	U
Alcohol - Ethyl	E	E	E	G
Alcohol - Methyl	E	E	E	E
Alcohol - Propargyl	E	E	E	E
Alcohol - Propyl	E	E	E	G
Allyl - Chloride	U	U	U	U
Alum	E	E	E	E
Alum, Ammonium	E	E	E	E
Alum, Chrome	E	E	E	E
Alum, Potassium	E	E	E	E
Aluminum Chloride	E	E	E	E
Aluminum Fluoride	E	E	E	E
Aluminum Hydroxide	E	E	E	E
Aluminum Oxychloride	E	E	E	E
Aluminum Nitrate	E	E	E	E
Aluminum Sulfate	E	E	E	E
Ammonia - Dry Gas	E	E	E	E
Ammonia, Aqua (10%)	E	E	E	E
Ammonia - Liquid	L	U	O	O
Ammonium Acetate	E	E	E	E
Ammonium BiFluoride	E	E	E	E
Ammonium Carbonate	E	E	E	E
Ammonium Chloride	E	E	E	E
Ammonium Fluoride - 25%	E	L	U	U
Ammonium Hydroxide - 28%	E	E	E	E
Ammonium Metaphosphate	E	E	E	E
Ammonium Monophosphate	E	E	E	E
Ammonium Nitrate	E	E	E	E
Ammonium Persulfate	E	E	E	E
Ammonium Phosphatel (Ammoniacal)	E	E	O	O
Ammonium Phosphate - Neutral	E	E	E	E
Ammonium Sulfate	E	E	E	E
Ammonium Sulfide	E	E	E	E
Ammonium Thiocyanate	E	E	E	E
Amyl Acetate	U	U	U	U
Amyl Chloride	U	U	U	U
Aniline	U	U	U	U
Aniline Chlorohydrate	U	U	U	U
Aniline Dyes	U	U	U	U
Aniline Hydrochloride	U	U	U	U
Anthraquinone	E	E	E	L
Anthraquinonesulfonic Acid	E	E	E	E
Anitimony Trichloride	E	E	E	E
Aqua Regia	E	L	U	U
Arsenic Acid - 80%	E	G	E	G
Arylsulfonic Acid	E	E	L	U
Asphalt	E	E	E	E
Barium Carbonate	E	E	E	E
Barium Chloride	E	E	E	E
Barium Hydroxide	E	E	E	E
Barium Sulfate	E	E	E	E
Barium Sulfide	E	E	E	E
Beer	E	E	E	E
Beet - Sugar Liquor	E	E	E	E
Benzaldehyde	U	U	U	U
Benzene	U	U	U	U
Benzenesulfonic Acid - 10%	E	E	E	E
Benzenesulfonic Acid	U	U	U	U
Benzoic Acid	E	E	E	E
Benzol	U	U	U	U
Bismouth Carbonate	E	E	E	E
Black Liquor (Paper Industry)	E	E	E	E
Bleach - 12.5% Active CL_2	E	G	G	L
Borax	E	E	E	E
Borax Liquors	E	E	E	E
Boric Acid	E	E	E	E
Boron, TriFluoride	E	E	E	E
Breeder Pellets - Fish Deriv.	E	E	E	E
Brine	E	E	E	E
Bromic Acid	E	E	E	E
Bromine - Liquid	U	U	U	U
Bromine (Gas) - 25%	E	E	U	U
Bromine - Water	E	E	L	U
Butadiene	E	E	L	U
Butane	E	E	E	E
Butane, Buthylene	E	E	E	U
Butane, Diol	E	E	U	U
Butanol	E	U	U	U
Butanol - Primary	E	E	U	U
Butanol - Secondary	E	L	U	U
Buttermilk	E	E	E	E
Butyl Acetate	U	U	U	U
Butyl Phenol	E	U	L	U.
Butylene	E	O	E	O
Butynediol (Erthritol)	E	U	U	U
Butyric Acid 20%	G	U	L	U
Butyric Acid	E	U	U	U
Calcium Bisulfide	E	E	E	E
Calcium Bisulfite	E	E	E	E
Calcium Carbonate	E	E	E	E
Calcium Chlorate	E	E	E	E
Calcium Chloride	E	E	E	E
Calcium Hydroxide	E	E	E	E
Calcium Hyposhlorite	E	E	E	E
Calcium Nitrate	E	E	E	E
Calcium Oxide	E	E	E	U
Calcium Sulfate	E	E	E	E
Cane Sugar Liquors	E	E	E	E
Carblic Acid	E	E	E	E
Carbon Bisulfide	U	U	U	U
Carbon Dioxide (Aqueous S.L.)	E	E	E	E
Carbon Dioxide Gas (Wet)	E	E	E	E
Carbon Monoxide	E	E	E	E
Carbon Tetrachloride	L	U	U	U
Carbonated Water	E	E	E	E
Carbonic Acid	E	E	E	E
Casein	E	E	E	E
Castor Oil	E	E	E	E
Caustic Potash	E	E	E	E
Caustic Soda	E	E	E	E
Cellosolve	G	L	L	U
Chloracetic Acid	E	L	E	U
Chloral Hydrate	E	E	E	E
Chloric Acid 20%	E	E	E	E
Chlorinated Solvents	U	U	U	U
Chlorine (Dry)	E	L	L	L
Chlorine Gas (Moist)	G	L	L	L
Chlorine Water	E	E	E	E
Chloroacetic Acid	E	E	E	U
Chlorobenzene	U	U	U	U
Chlorobenzyl Chloride	U	U	U	U
Chloro Form	U	U	U	U
Chlorosulfonic Acid (100%)	E	U	O	O
Chrome Alum	E.	E	E	E

Chemical	PVC I		PVC II	
	72 °F.	140 °F.	72 °F.	140 °F.
Chromic Acid 10%	E	E	E	E
Chromic Acid 25%	E	L	G	L
Chromic Acid 30%	E	L	G	U
Chromic Acid 40%	E	L	L	U
Chromic Acid 50%	E	L	L	U
Citric Acid	E	E	E	E
Coconut Oil	E	E	E	E
Coke Oven Gas	E	E	E	E
Copper Carbonate	E	E	E	E
Copper Chloride	E	E	E	E
Copper Cyanide	E	E	E	E
Copper Fluoride	E	E	E	E
Copper Nitrate	E	E	E	E
Copper Sulfate	E	E	E	E
Core Oils	E	E	E	E
Corn Oil	E	E	E	E
Corn Syrup	E	E	E	E
Cottonseed Oil	E	E	E	E
Cresol	U	U	U	U
Cresylic Acid 50%	E	E	L	U
Croton Aldehyde	U	U	U	U
Crude Oil - Sour	E	E	E	E
Crude Oil - Sweet	E	E	E	E
Cuprous Chloride	E	E	E	E
Cyclohexane	U	U	U	U
Cyclohexanol	U	U	U	U
Cyclohexanon	U	U	U	U
Demineralized Water	E	E	E	E
Dextrin	E	E	E	E
Dextrose	E	E	E	E
Diazo Salts	E	E	E	E
Diesel Fuels	E	E	E	U
Diethye Amine	U	U	U	U
Dioctylphthalate	U	U	U	U
Disodium Phosphate	E	E	E	E
Diethyl Ether	U	U	U	U
Diglycolic Acid	E	G	E	G
Dioxane - 1,4	O	O	O	O
Divinyl Benzene	O	O	O	O
Drying Oil	O	O	O	O
Ethers	U	U	U	U
Ethyl Acetate	U	U	U	U
Ethyl Acrylate	U	U	U	U
Ethyl Chloride	U	U	U	U
Ethyl Ether	U	U	U	U
Ethylene Bromide	U	U	U	U
Ethylene Chlorohydrin	U	U	U	U
Ethylene Dichloride	U	U	U	U
Ethylene Glycol	E	E	E	E
Ethylene Oxide	U	U	U	U
Fatty Acide	E	E	E	E
Ferric Chloride	E	E	E	E
Ferric Nitrate	E	E	E	E
Ferric Sulfate	E	E	E	E
Ferrous Nitrate	E	E	E	E
Fish Solubles	E	E	E	E
Fluorine Gas - Dry	L	U	U	U
Flourine Gas - Wet	L	U	U	U
Fluoroboric Acid - 25%	E	E	E	E
Fluorosilicic Acid	E	E	E	E
Formaldehyde	E	G	G	L
Food Products such.as Milk, Buttermilk, Molasses, Salad Oils, Fruit	E	E	E	E
Formic Acid	E	U	E	U
Freon - 12	E	G	E	G
Fructone	E	E	E	E
Fruit Pulps and Juices	E	E	E	E
Fuel Oil (containing H_2SO_4)	E	E	E	E
Furfural	U	U	U	U
Gallic Acid	E	E	E	E
Gas - Coke Oven	E	E	G	G
Gas - Manufactured	U	U	U	U
Gas - Natural (Dry)	E	E	E	E
Gas - Natural (Wet)	E	E	E	E
Gasoline (Leaded)	E	E	E	U
Gasoline (unleaded)	E	E	E	U
Gasoline - Refined	E		L	
Gasoline - Sour	E	E	E	E
Gelatine	E	E	E	E
Glucose	E	E	E	E
Glycerine (Glycerol)	E	E	E	E
Glycol	E	E	E	E
Glue	E	E	E	E
Glycolic Acid 30%	E	E	E	E
Green Liquor (Paper Industry)	E	E	E	E
Heptane	E	G	L	U
Hexane	E	L	U	U
Hexanol Tertiary	E	E	L	U
Hydrobromic Acid - 20%	E	E	E	G
Hydrochloric Acid - 0-25%	E	G	E	G
Hydrochloric Acid - 25-40%	E	E	E	G
Hydrocyanic Acid or Hydrogen Cyanide	E	E	E	E
Hydrofluoric Acid 4%	E	L	G	G
Hydrofluoric Acid 10%	E	L	E	G
Hydrofluoric Acid 48%	E	L	G	U
Hydrofluoric Acid 60%	E	L	G	U
Hydrofluoric Acid 100%	G	L	O	L
Hydrogen	E	E	E	G
Hydrogen Peroxide - 30%	E	E	E	G
Hydrogen Peroxide - 50%	E	E	E	L
Hydrogen Peroxide - 90%	E	E	U	U
Hydrogen Slurfide - Agueous Solution	E	E	E	E
Hydrogen Sulfide - Dry	E	E	E	E
Hydroquinone	E	E	E	E
Hydroxylamine Sulfate	E	E	E	E
Hypochlorous Acid	E	E	E	E
Hypo-(Sodium Thiosulfate)	E	E	E	E
Iodine	U	U	U	U
Iodine (in Alcohol)	U	U	U	U
Iodine Solution (10%)	U	U	U	U
Iodoform	O	O	O	O
Isopropylalcohol	E	E	E	G
Jet Fuels, JP4 & JP5	E	E	E	E
Kerosene	E	E	E	E
Ketones	U	U	U	U
Kraft Liquor (Paper Industry)	E	E	E	E
Lacquer Thinners	L	U	L	U
Lactic Acid 28%	E	E	E	E
Lard Oil	E	E	E	G
Lauric Acid	E	E	E	E
Lauryl Chloride	E	E	E	E
Lauryl Sulfate	E	E	E	E
Lead Acetate	E	E	E	E
Lime Sulfur	E	E	E	E
Linoleic Acid	E	E	E	E
Linseed Oil	E	E	E	E
Liquers	E	E	E	E
Liquors	E	E	E	E
Lithium Bromide	E	E	E	E
Lubricating Oil	E	E	E	E
Machine Oil	E	E	E	E
Magnesium Carbonate	E	E	E	E
Magnesium Chloride	E	E	E	E
Magnesium Citrate	E	E	E	E
Magnesium Hydroxide	E	E	E	E
Magnesium Nitrate	E	E	E	E
Magnesium Sulfate	E	E	E	E
Maleic Acid	E	E	E	E
Malic Acid	E	E	E	E
Mercuric Chloride	E	E	G	G
Mercuric Cyanide	E	E	G	G
Mercurous Nitrate	E	E	G	G
Mercury	E	E	G	G

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Chemical	PVC I 72 °F.	PVC I 140 °F.	PVC II 72 °F.	PVC II 140 °F.
Methane	E	E	E	E
Methyl Bromide	U	U	U	U
Methyl Cellosolve	U	U	U	U
Methyl Chloride	U	U	U	U
Methyl Chloroform	U	U	U	U
Methyl Ethyl Ketone	U	U	U	U
Methyl Iso-Butyl Ketone	U	U	U	U
Methyl Salicylate	E	E	E	E
Methyl Sulfate	E	L	E	L
Methyl Sulfonic Acid	E	E	E	E
Methyl Sulfuric Acid	E	E	E	E
Methylene Chloride	U	U	U	U
Milk	E	E	E	E
Mineral Oils	E	E	E	G
*Mixed Acids (H_2SO_4 & HNO_3)	E	E	E	L
Molasses	E	E	E	E
Monoethanolamine	U	U	U	U
Muriatic Acid	E	E	E.	E
Naptha	E	E	E	U
Napthalene	U	U	U	U
Natural Gas, Dry & Wet	E	E	E	E
Nickel Acetate	E	E	E	E
Nickel Chloride	E	E	E	E
Nickel Nitrate.	E	E	E	E
Nickel Sulfate	E	E	E	E
Nickel Sulphate	E	E	E	E
Nicotine	E	E	E	E
Nicotine Acid	E	E	E	G
Nitric Acid Anhydrous	U	U	U	U
Nitric Acid 10%	E	E	E	E
Nitric Acid 20%	E	L	G	L
Nitric Acid 35%	E	G	G	L
Nitric Acid 40%	E	G	G	L
Nitric Acid 60%	E	L	G	U
Nitric Acid 68%	G	U	L	U
Nitric Acid 70%	E	E	U	U
Nitric Acid 100%	E	U	U	U
Nitric Acid, Red Fuming	U	U	U	U
Nitrobenzene	U	U	U	U
Nitropropane	O	O	O	O
Nitrous Acid (10%)	E	E	E	E
Nitrous Oxide	E	E	E	E
Ocenol (Unsaturated Alcohol)	E	E	G	G
Oil and Fats	E	E	E	G
Oleic Acid	E	E	E	E
Oleum	U	U	U	U
Oxalic Acid	E	E	E	G
Oxygen	E	E	E	E
Ozone	G	L	U	U
Palmitic Acid 10%	E	E	E	E
Palmitic Acid 70%	E	U	L	U
Paraffin	E	E	E	E
Pentane	O	O	O	O
Paracetic Acid 40%	E	U	U	U
Perchloric Acid 10%	E	L	G	L
Perchloric Acid 15%	E	U	G	U
Perchloric Acid 70%	E	U	U	U
Perchloroethylene	O	O	O	O
Petrolatum	E	E	E	E
Phenol	L	U	U	U
Phenol (90%)	U	U	U	U
Phenylhydrazine	U	U	U	U
Phenylhydrazine Hydrochloride	E	U	L	U
Phosgene (Gas)	E	G	E	G
Phosgene (Liquid)	U	U	U	U
Phosphoric Acid 0-25%	E	G	E	G
Phosphoric Acid 25-50%	E	E	E	G
Phosphoric Acid 50-75%	E	E	E	G
Phosphoric Acid - 85%	E	E	E	G
Phosphorous (Yellow)	E	G	G	L
Phosphorous (Red)	E	E	E	U
Phosphorous Pentoxide	E	L	G	U
Phosphorous Trichloride	U	U	U	U
Photographic Chemicals	E	E	E	E

*Use PVC 1120

Chemical	PVC I 72 °F.	PVC I 140 °F.	PVC II 72 °F.	PVC II 140 °F.
Photographic Solutions	E	E	E	E
Phthalic Acid	O	O	O	O
Picric Acid	U	U	U	U
Plating Solutions:				
Brass	E	E	E	E
Cadium	E	E	E	E
Chromium	E	G	G	G
Copper	E	E	E	E
Gold	E	E	E	E
Iron	E	E	O	O
Judium	E	E	E	E
Lead	E	E	E	E
Nickel	E	E	E	E
Rhodium	E	E	E	E
Silver	E	E	E	E
Tin	E	E	E	E
Zinc	E	E	E	G
Potassium Acid Sulfate	E	E	E	E
Potassium Aluminum Sulfate	E	E	O	O
Potassium Alum	E	E	E	E
Potassium Antimonate	E	E	E	E
Potassium Bicarbonate	E	E	E	E
Potassium Bichromate	E	E	E	E
Potassium Bisulfite	E	E	E	E
Potassium Borate 1%	E	E	E	E
Potassium Borate	E	E	E	E
Potassium Bromate 10%	E	E	E	E
Potassium Bromate	E	E	E	E
Potassium Bromide	E	E	E	E
Potassium Carbonate	E	E	E	E
Potassium Chlorate (ag)	E	E	E	E
Potassium Chlorate	E	E	E	E
Potassium Chloride	E	E	E	E
Potassium Chromate (Aln)	E	E	E	E
Potassium Chromate (Neut.)	E	E	E	E
Potassium Chromate 40%	E	E	E	E
Potassium Cuprocyanide	E	E	E	E
Potassium Cyanide	E	E	E	E
Potassium Dichromate 40%	E	E	E	E
Potassium Dichromate	E	E	E	E
Potassium Dichrom (Alkaline)	E	E	E	E
Potassium Dichron (Neutral)	E	E	E	E
Potassium Diphosphate	E	E	E	E
Potassium Ferricyanide	E	E	E	E
Potassium Ferrocyanide	E	E	E	E
Potassium Fluoride	E	E	E	E
Potassium Hydroxide	E	E	E	E
Potassium Hypochlorite	E	G	G	L
Potassium Iodide	E	E	E	E
Potassium Nitrate	E	E	E	E
Potassium Perborate	E	E	E	E
Potassium Perchlorate	E	E	U	U
Potassium Perchlorite	E	E	E	E
Potassium Permanganate 10%	E	E	E	E
Potassium Permanganate 25%	G	L	G	L
Potassium Persulfate	E	E	E	E
Potassium Sulfate	E	E	E	E
Potassium Sulfide	E	E	E	E
Potassium Thiosulfate	E	E	E	E
Propane	E	E	E	E
Proplylene Dichloride	U	U	U	U
Proplylene Glycol	E	E	E	E
Pyrogallic Acid	O	O	O	O
Rayon Coagulating Bath	E	E	E	G
Rachelle Salts	E	E	E	E
Sea Water	E	E	E	E
Salenis Acid (Aqueous)	O	O	O	O
Salicylaldehyde	O	O	O	O
Salt Water	E	E	E	E
Selenic Acid	E	E	E	E
Sewage	E	E	E	G
Silicic Acid	E	E	E	E
Silver Cyanide	E	E	E	E
Silver Nitrate	E	E	E	E
Silver Sulfate	E	E	E	E
Soap Solution	E	E	E	E

CertainTeed

Chemical	PVC I 72°F.	PVC I 140°F.	PVC II 72°F.	PVC II 140°F.
Soaps	E	E	E	E
Sodium Acetate	E	E	E	E
Sodium Alum	E	E	E	E
Sodium Acid Sulfate	E	E	E	E
Sodium Aluminate	E	E	E	E
Sodium Antinonate	E	E	E	E
Sodium Arsenite	E	E	E	E
Sodium Benzoate	E	E	E	E
Sodium Bicarbonate	E	E	E	E
Sodium Bisulfate	E	E	E	E
Sodium Bisulfite	E	E	E	E
Sodium Borate	E	E	E	E
Sodium Bromide	E	E	E	E
Sodium Carbonate (Soda Ash)	E	E	E	E
Sodium Chlorate	E	G	G	L
Sodium Chloride	E	E	E	E
Sodium Chlorite	E	E	O	O
Sodium Cyanide	E	E	E	E
Sodium Dichromate	E	E	E	G
Sodium Dichromate (Neutral)	E	E	E	E
Sodium Ferricyanide	E	E	E	E
Sodium Ferrocyanide	E	E	E	E
Sodium Fluoride	E	E	E	E
Sodium Hydroxide 10%	E	E	E	E
Sodium Hydroxide 15%	E	E	E	E
Sodium Hydroxide 35%	E	E	E	E
Sodium Hydroxide 70%	E	E	O	O
Sodium Hydroxide (Satr)	E	E	E	E
Sodium Hypochlorite	E	E	E	E
Sodium Iodide	E	E	E	E
Sodium Nitrate	E	E	E	E
Sodium Nitrite	E	E	E	E
Sodium Perborate	E	E	O	O
Sodium Peroxide	E	E	E	E
Sodium Phosphate	E	E	E	E
Sodium Phosphate - Acid	E	E	G	G
Sodium Silicate	E	E	E	E
Sodium Sulfate	E	E	E	E
Sodium Sulfide	E	E	E	E
Sodium Sulfite	E	E	E	E
Sodium Thiosulfate (Hypo)	E	E	E	E
Sour Crude Oil	E	E	E	E
Stannic Chloride	E	E	E	E
Stannous Chloride (50%)	E	E	E	E
Stannous Chloride	E	G	E	G
Starch	E	E	E	E
Stearic Acid	E	E	E	E
Stoddards Solvent	E	E	U	U
Sulfated Detergents	E	E	E	E
Sulfur	E	E	E	E
Sulfur Dioxide Gas - Dry	E	E	E	E
*Sulfur Dioxide Gas - Wet	E	L	U	U
Sulfur Trioxide	E	E	E	G
Sulphur Dioxide - Liquid	G	U	L	U
Sulphuric Acid 0-10%	E	E	E	G
Sulphuric Acid 10-30%	E	E	E	G
Sulphuric Acid 30-50%	E	E	E	G

*Use PVC 1120

Chemical	PVC I 72°F.	PVC I 140°F.	PVC II 72°F.	PVC II 140°F.
Sulphuric Acid 50-75%	E	E	E	G
Sulphuric Acid 75-90%	E	E	L	L
Sulphuric Acid 95%	E	G	U	U
Sulphurous Acid	G	U	L	U
Tan Oil	E	E	E	E
Tannic Acid	E	E	E	E
Tanning Liquors	E	E	E	E
Tartaric Acid	E	E	E	E
Tetrachloroethane	O	O	O	O
Tetraethyl Lead	E	G	G	L
Tetrahydra Furane	U	U	U	U
Thionyl Chloride	U	U	U	U
Tepineol	G	L	G	L
Tin Chloride	E	E	E	E
Titanium Tetrachloride	E	U	E	U
Toluol or Toluene	U	U	U	U
Toxaphene (90%)	O	O	O	O
Tributyl Phosphate	U	U	U	U
Trichloroacetic Acid	E	E	E	E
Trichloroethylene	U	U	U	U
Tricresylphosphate	U	U	U	U
Triethanolamine	E	G	G	U
Triethylamine	E	E	G	L
Trimethyl Propane	E	G	L	U
Trisodium Phosphate	E	E	E	E
Turpentine	E	E	L	U
Urea	E	E	E	E
Urine	E	E	E	E
Vegetable Oil	E	E	E	E
Vinegar	E	E	E	U
Vinyl Acetate	U	U	U	U
Water - Acid Mine	E	E	E	E
Water - Distilled	E	E	E	E
Water - Fresh	E	E	E	E
Water - Salt	E	E	E	E
Water - Sewage	E	E	E	E
Whiskey	E	E	E	E
White Gasoline	E	E	E	E
White Liquor (Paper Industry)	E	E	E	E
Wines	E	E	E	E
Xylene or Xylol	U	U	U	U
Zinc Chloride	E	E	E	E
Zinc Chromate	E	E	E	E
Zinc Cyanide	E	E	E	E
Zinc Nitrate	E	E	E	E
Zinc Sulfate	E	E	E	E
Mixtures of Acids:				
Nitric 15% - Hydrofluoric 4%	E	E	E	G
Sodium Dichromate 13% - Nitric Acid 16 Water 71%	E	E	E	G

This information has been obtained from reliable sources and can be used as a guide to assist in the proper application of PVC pipe. CertainTeed, however, cannot warrant its accuracy. It is suggested that you run your own tests for critical applications.

Pipe & Plastics Group

CertainTeed Corporation
P.O. Box 860
Valley Forge, PA 19482
(610) 341-6820
(610) 341-6837 Fax

Code No. 40-10-29

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APPLICATION FOR MODIFICATION
BASIN DISPOSAL, INC.
OIL FIELD WASTE EVAPORATION PONDS

VOLUME III: ENGINEERING DESIGN AND CALCULATIONS
SECTION 3: GEOSYNTHETICS APPLICATIONS AND COMPATIBILITY DOCUMENTATION

ATTACHMENT III.3.F

BASIN DISPOSAL WASTEWATER LABORATORY RESULTS

GE Infrastructure
Water & Process Technologies

WATER ANALYSIS REPORT

BASIN DISPOSAL
Aztec, NM

Sampled: 04-AUG-2006
Reported: 16-AUG-2006
Field Rep: Lambert, John W
91000497

	POST FILT PROD. WTR Q0808025
Particle Size Distribution	A
Ammonia, Free And Fixed, as N, ppm	35
pH	6.9
Specific Conductance, at 25°C, µmhos	22400
Alkalinity, "P" as $CaCO_3$, ppm	0
Alkalinity, "M" as $CaCO_3$, ppm	1370
Sulfur, Total, as SO_4, ppm	978
Chloride, as Cl, ppm	7600
Hardness, Total, as $CaCO_3$, ppm	497
Calcium Hardness, Total, as $CaCO_3$, ppm	347
Magnesium Hardness, Total, as $CaCO_3$, ppm	129
Barium, Total, as Ba, ppm	3.1
Strontium, Total, as Sr, ppm	16.5
Copper, Total, as Cu, ppm	< 0.05
Iron, Total, as Fe, ppm	6.9
Sodium, as Na, ppm	4970

GE Infrastructure
Water & Process Technologies

WATER ANALYSIS REPORT

BASIN DISPOSAL
Aztec, NM

Sampled: 04-AUG-2006
Reported: 16-AUG-2006
Field Rep: Lambert, John W
91000497

	POST FILT PROD. WTR Q0808025
Potassium, as K, ppm	571
Aluminum, Total, as Al, ppm	0.1
Manganese, Total, as Mn, ppm	0.47
Nitrate, as NO_3, ppm	< 1
Phosphate, Total, as PO_4, ppm	5.3
Silica, Total, as SiO_2, ppm	22
Fluoride, as F, ppm	< 0.1
Lead, Total, as Pb, ppm	0.019
Mercury, Total, as Hg, ppb	1.0
Carbon, Total Organic, as C, ppm	549
Turbidity, NTU	47
Hexane Extractable Material, mg/l	48

WATER ANALYSIS REPORT

BASIN DISPOSAL
Aztec, NM

Sampled:	04-AUG-2006
Reported:	16-AUG-2006
Field Rep:	Lambert, John W 91000497

Result Legend

A - This test was aborted for cause. More detail is provided below.

Comments

Sample Name: POST FILT PROD. WTR   Lab ID: Q0808025

The Particle Size Distribution report will be sent at a later date under separate cover. For any questions or concerns, please contact Roberto Dominguez at 281-681-5270.

GE Infrastructure
Water & Process Technologies

Customer Services Analytical Laboratories *9 669 Grogans Mill Road* *The Woodlands, TX 77380* *(281) 681-5270*

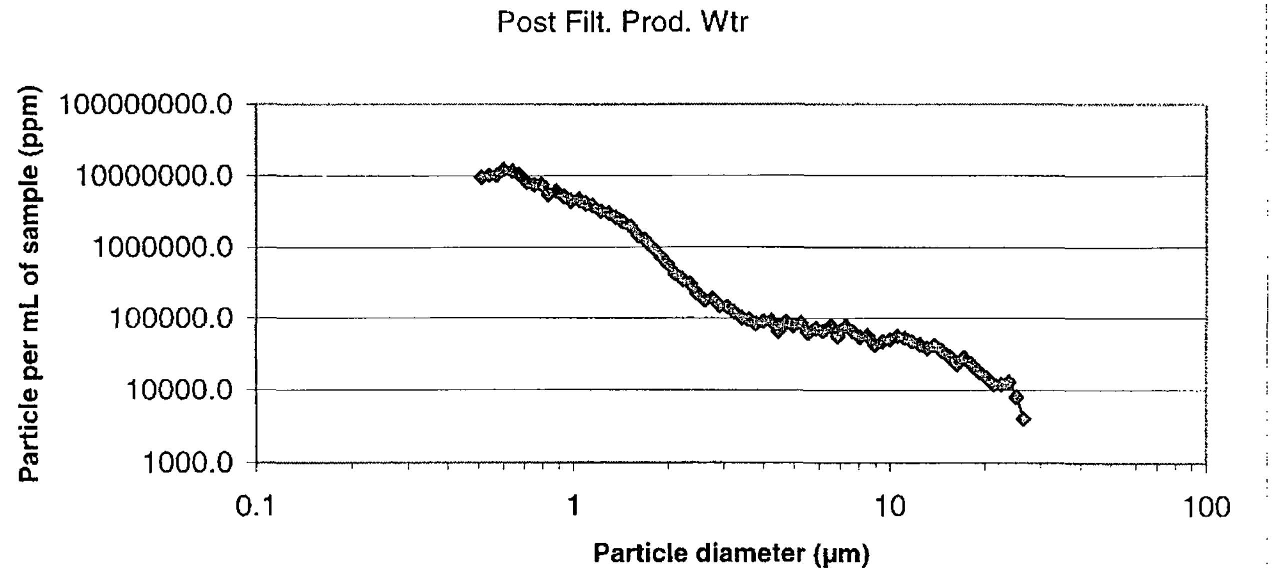
Date: August 22, 2006

Customer Name **Basin Disposal**
Address

Aztec, NM

Ship To#
Field Rep: **John W Lambert**
PE # **91000497**
Sample Date: April 8, 2006
Sample Point: **Post Filt. Prod. Wtr**

Particle Size (microns)	Particles per mL	% of Total Particles	Volume ppm	% of Total Volume	Particle Volume
0.5-1.0	107361999.1	75.6%	20.2208	0.72%	2.02E+08
1.0-2.0	30551000.0	21.5%	39.3963	1.39%	3.94E+08
2.0-4.0	2446000.0	1.7%	27.2570	0.96%	2.73E+08
4.0-6.0	541000.0	0.4%	35.5571	1.26%	3.56E+08
6.0-8.0	343000.0	0.2%	59.1686	2.09%	5.92E+08
8.0-10.0	250000.0	0.2%	95.9334	3.39%	9.6E+08
10.-15.0	314000.0	0.2%	314.9535	11.14%	3.15E+09
15.0-20.0	121000.0	0.1%	317.7735	11.24%	3.18E+09
20.0-30.0	70000.0	0.0%	470.5920	16.64%	4.71E+09
30.0-40.0	14000.0	0.0%	297.2424	10.51%	2.97E+09
40.0-50.0	4000.0	0.0%	173.8154	6.15%	1.74E+09
50-100	1000.0	0.0%	79.0452	2.80%	7.91E+08
100-200	1000.0	0.0%	896.4909	31.71%	8.97E+09
Total	142017999.0	100%	2827.4463	100%	



APPLICATION FOR MODIFICATION
BASIN DISPOSAL, INC.
OIL FIELD WASTE EVAPORATION PONDS

VOLUME III: ENGINEERING DESIGN AND CALCULATIONS
SECTION 4: STORMWATER MANAGEMENT PLAN

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LIST OF TABLES

LIST OF ATTACHMENTS

SECTION 4: STORMWATER MANAGEMENT PLAN

1.0 DESIGN CRITERIA

The stormwater management systems for the Basin Disposal, Inc. Evaporation Ponds are designed to meet the requirements of the regulatory standards identified in the Oil Conservation Division 19.15.36 NMAC (Regulations), New Mexico Energy, Minerals, and Natural Resources Department. More specifically, §19.15.36.8.C.(11) requires:

> *a plan to control run-on water onto the site and run-off water from the site that complies with the requirements of Subsection M of 19.15.36.13 NMAC;*

and further §19.15.36.13.M specifics that:

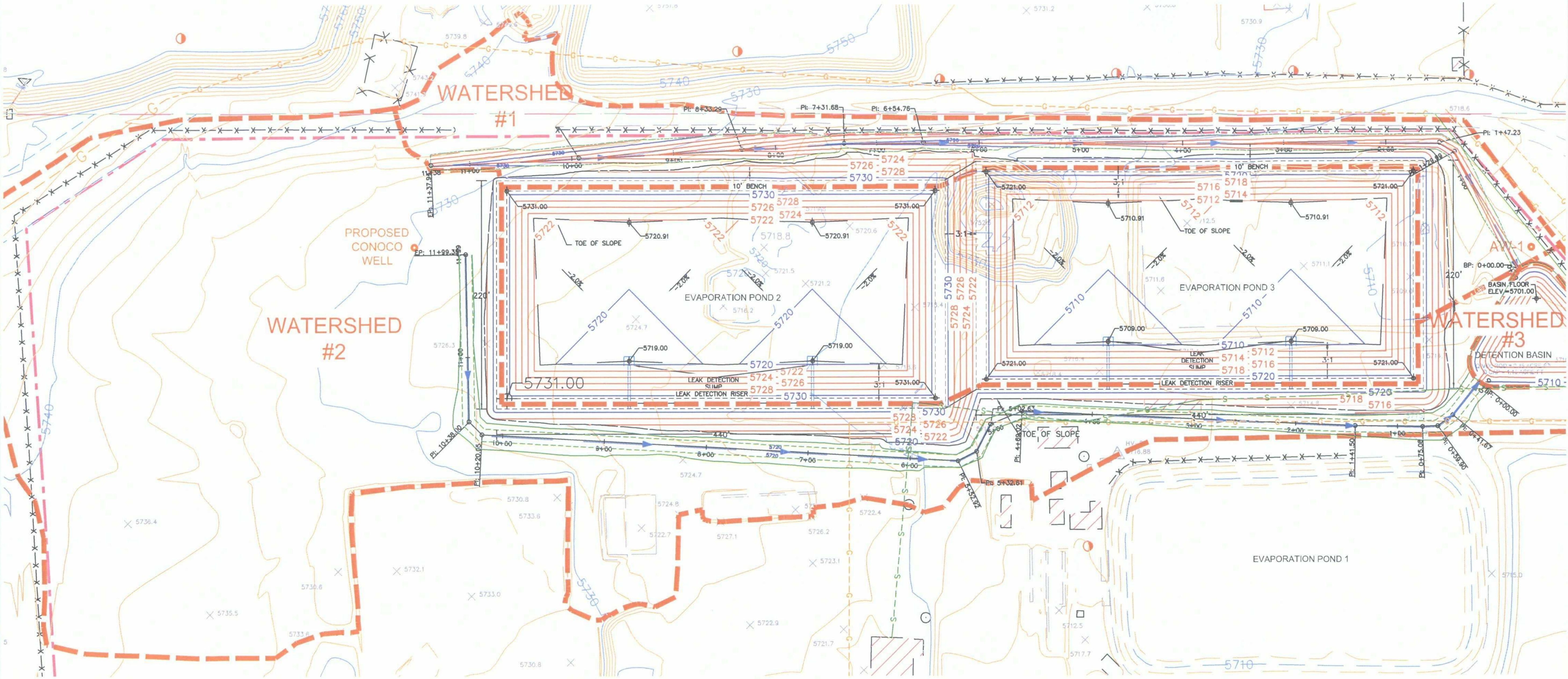
> *Each operator shall have a plan to control run-on water onto the site and run-off water from the site, such that:*
>
> *(1) the run-on and run-off control system shall prevent flow onto the surface waste management facility's active portion during the peak discharge from a 25-year storm; and*
>
> *(2) run-off from the surface waste management facility's active portion shall not be allowed to discharge a pollutant to the waters of the state or United States that violates state water quality standards.*

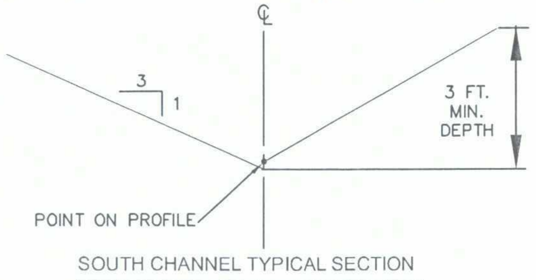
2.0 SITE CONDITIONS

The Basin Disposal, Inc. site is comprised of 28 acres± located in S3; T29N; R11W NMPM, 3 miles north of the intersection of U.S. Highway 550 and U.S. Highway 64. Existing topography for the site generally drains to the east/southeast at 2% to 5% slopes. The northern boundary of the site is contiguous with commercial properties, portions of which contribute run-on to the stormwater management footprint (Watershed #1, **Figure III.4.1**). On-site run-off (Watersheds #2 and #3) will be controlled, along with run-on, by the installation of a new Stormwater Detection Basin located east of Evaporation Pond 3. Site drainage will be conveyed by two new perimeter channels; one to the north of Evaporation Ponds 2 and 3, and one to the south of the Ponds (**Figure III.4.1**).

3.0 METHODOLOGY

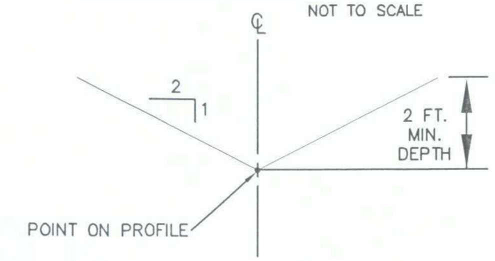
The approach for the calculation of run-on and run-off stormwater flows was based on the Drainage Manual (New Mexico State Highway and Transportation Department, "Drainage Manual, Volume 1, Hydrology). The Drainage Manual specifies that the Simplified Peak Flow method should be used to compute run-off from watersheds less than 5 square miles. The total drainage basin acreage for the project area is determined to be approximately 10 acres (**Table III.4.6**), when the two new Ponds (2 and 3) are subtracted out.





SOUTH CHANNEL TYPICAL SECTION

NOT TO SCALE



NORTH CHANNEL TYPICAL SECTION

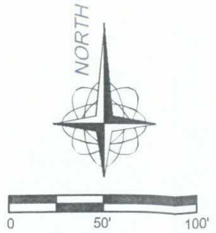
NOT TO SCALE

WATERSHED	AREA (ACRES)	CURVE NUMBER	$P_{25\text{-YR } 24\text{-HR}}$ (INCHES)	Q_{25} (CFS)	Q_{25} VOLUME (ACRE–FT)
#1	1.93	77	2.1	1.93	0.08
#2	7.52	77	2.1	6.62	0.32
#3	0.28	–	–	–	0.05
				TOTAL VOLUME	0.45

25 YEAR 24 HOUR POINT PRECIPITATION FREQUENCY ESTIMATED FROM NOAA ATLAS

LEGEND

	SITE BOUNDARY
	DRAINAGE DIVIDE
	2' CONTOUR (EXISTING)
5700	10' CONTOUR (EXISTING)
	2' DEPRESSION CONTOUR (EXISTING)
5700	10' DEPRESSION CONTOUR (EXISTING)
5720	10' MAJOR CONTOUR
5716	2' MINOR CONTOUR
5711.04	SPOT ELEVATION (DESIGN)
OHP	3" GAS LINE (EXISTING)
S	SEWER LINE (EXISTING)
G	GAS LINE (EXISTING)
	UTILITY EASEMENT
	UNPAVED ROADWAY (EXISTING)
—X—X—X—	FENCE (EXISTING)
AW-1 ●	ASSESSMENT WELL
◐	LIGHT POLE (EXISTING)
▨	STRUCTURE
HV-5 5716.88 △	SURVEY CONTROL POINT AND ELEVATION



NOTES:

1. LOCATION OF SITE UTILITIES IS APPROXIMATE. LOCATIONS OF SITE UTILITIES WILL BE FIELD VERIFIED PRIOR TO CONSTRUCTION.
2. NOT FOR CONSTRUCTION

DRAINAGE PLAN

BASIN DISPOSAL, INC.
BLOOMFIELD, NEW MEXICO

Gordon Environmental, Inc.
Consulting Engineers

213 S. Camino del Pueblo
Bernalillo, New Mexico, USA
Phone: 505-867-6990
Fax: 505-867-6991

DATE: 12/02/08	CAD: DRAINAGE FIG.dwg	PROJECT #: 520.01.01
DRAWN BY: JMC	REVIEWED BY: MRH	Figure III.4.1
APPROVED BY: IKG	gei@gordonenvironmental.com	

Drawing:\\server01\public\acad 2003\520.01.01\FIGURES\DRAINAGE FIG.dwg
Date/Time:Dec. 02, 2008-09:08:00

4.0 SURFACE WATER CALCULATIONS

The Simplified Peak Flow method was used to determine run-on surface water flow rates. The Simplified Peak Flow method estimates the peak rate of run-on and run-off volume from small to medium watersheds. This method was developed by the Soil Conservation Service (SCS) and revised for use in New Mexico. Infiltration and other losses are estimated using the SCS Curve Number (*CN*) methodology. Input parameters are consistent with those used in the SCS Unit Hydrograph Method. The Simplified Peak Flow method is used for New Mexico to basins less than 5 square miles in area, and is used when the time of concentration is expected not to exceed 8.0 hours. The Simplified Peak Flow method is described as follows:

Table III.4.1
Drainage Calculations

1. Establish the appropriate Design Frequency for analysis: Per Regulations the Design Storm is the 25-year, 24-hour event=2.10 inches (Obtained from **Figure E-10** located in **Attachment III.4.A**).
2. Estimate the drainage area, A, in Acres:
    a. Run-on Watershed #1 = 1.93 acres
    b. Run-off Watershed #2 = 7.52 acres
    c. Detention Basin Watershed #3 = 0.28 acres
3. Compute the Time of Concentration, T_c, in hours.
4. Determine Curve Number: From **Table 3-4** "Run-off curve Numbers for Urban Areas" in **Attachment III.4.A**; Developing urban areas; newly graded; Soil type A; CN=77.
5. Because the watershed is less than 1.0 square miles, transmission losses were considered.
6. The average run-off depth, Q_d, is obtained from **Equation 3-23, Attachment III.4.A pg. 3-50**. $Q_d = \frac{[P_{24} - (200/CN) + 2]^2}{P_{24} + (800/CN) - 8}$ Where: P_{24} = 24-hour rainfall depth (in) and CN= curve number.
7. Compute the design frequency peak flow by the following (**Equation 3-24, Attachment III.4.A pg. 3-50**): $Q_p = (\text{Acres})(Q_d)(q_u)$ cfs
8. Compute the stormwater volume (**Equation 3-25, Attachment III.4.A pg. 3-50**): $Q_v = \frac{Q_d \bullet A}{12}$.
9. Stormwater that falls within the footprint of the two new Evaporation Ponds (10 ac ±) is accommodated within the freeboard calculation (**Volume III, Section 5**).

The Simplified Peak Flow methods used to determine stormwater flow at the Basin Disposal, Inc. site are identified as follows:

Table III.4.2
Watershed #1 Calculations

Watershed #1: Discharge point at north side of detention pond (25-year, 24-hour storm event; conservatively estimated at 2.1 inches).

1. Area = 1.93 acres
2. Longest travel distance = 156’ (overland flow) + 1039’ (channel flow).
3. Average slope = 0.128 ft/ft (overland flow) and 0.016 ft/ft (channel flow).
4. Velocity = 3.5 ft/s (**Figure 3-10, Attachment III.4.A pg. 3-33**; overland flow).
5. $T_{c1} = \left[\frac{156 ft}{3.5 ft/s}\right]\left(\frac{1}{60}\right) = 0.74$ min (**Equation 3-17, Attachment III.4.A pg. 3-30;** overland flow).
6. $T_{c2} = 0.0078(1039^{0.77})(0.016^{-0.385}) = 8$ min (**Equation 3-18, Attachment III.4.A pg. 3-34;**channel flow).
7. $T_c = T_{c1} + T_{c2} = 0.74 + 8 = 8.74$ min. = 0.15 hours.
8. Curve Number = 77 (**Table 3-4, Attachment III.4.A pg. 3-26**) for soil group A, newly graded areas.
9. Unit peak discharge (**Equation 3-22, Attachment III.4.A pg. 3-50**) $q_u = 0.543(T_c^{-0.812})10^{-\frac{(|\log(T_c)+0.3|-\log(T_c)-0.3)^{1.5}}{10}}$ cfs/ac-in = 1.98 cfs/ac-in.
10. Average Run-off Depth = $Qd = \frac{[2.1-(200/77)+2]^2}{2.1+(800/77)-8} = 0.503$ inches (**Equation 3-23, Attachment III.4.A pg. 3-50**).
11. Design Frequency Peak Flow (**Equation 3-24, Attachment III.4.A pg. 3-50**) Q_p = (1.93 acres)(0.503in.)(1.98 cfs/ac-in.) = 1.93 cfs (This flow volume is used in sizing the channel north of Evaporation Ponds 2 and 3 which will convey the run-off from Watershed #1).
12. Stormwater volume (**Equation 3-25, Attachment III.4.A pg. 3-50**) $Q_v = [(Q_d)(\text{Acres})]/12 = 0.08$ acre-ft (This volume is used in sizing the detention basin located east of Evaporation Pond 3 (see **Figure III.4.1**)).

Table III.4.3
Watershed #2 Calculations

Watershed #2: Discharge point at southwestern side of detention pond (25-year, 24-hour storm event; conservatively estimated at 2.1 inches).

1. Area = 7.52 acres
2. Longest travel distance = 555' (overland flow) + 1123' (channel flow).
3. Average slope = 0.0468 ft/ft (overland flow) and 0.015 ft/ft (channel flow).
4. Velocity = 3.2 ft/s (**Figure 3-10, Attachment III.4.A pg. 3-33**; overland flow).
5. $T_{c1} = \left[\frac{555 ft}{3.2 ft/s}\right]\left(\frac{1}{60}\right) = 2.89$ min (**Equation 3-17, Attachment III.4.A pg. 3-30;** overland flow).
6. $T_{c2} = 0.0078(1123^{0.77})(0.015^{-0.385}) = 8.77$ min (**Equation 3-18, Attachment III.4.A pg. 3-34;** channel flow).
7. $T_c = T_{c1} + T_{c2} = 2.89 + 8.77 = 11.66$ min. = 0.19 hours.
8. Curve Number = 77 (**Table 3-4, Attachment III.4.A pg. 3-26**) for soil group A, newly graded areas.
9. Unit peak discharge (**Equation 3-22, Attachment III.4.A pg. 3-50**) $q_u = 0.543(T_c^{-0.812})10^{-\frac{(|\log(T_c)+0.3|-\log(T_c)-0.3)^{1.5}}{10}}$ cfs/ac-in = 1.75 cfs/ac-in.
10. Average Run-off Depth = $Qd = \frac{[2.1-(200/77)+2]^2}{2.1+(800/77)-8} = 0.503$ inches (**Equation 3-23, Attachment III.4.A pg. 3-50**).
11. Design Frequency Peak Flow (**Equation 3-24, Attachment III.4.A pg. 3-50**) Q_p = (7.52 acres)(0.503in.)(1.75 cfs/ac-in.) = 6.62 cfs (This flow volume is used in sizing the channel south of Evaporation Ponds 2 and 3 which will convey run-off from Watershed #2).
12. Stormwater volume (**Equation 3-25, Attachment III.4.A pg. 3-50**) $Q_v = [(Q_d)(\text{Acres})]/12 = 0.32$ acre-ft (This volume is used in sizing the detention basin located east of Evaporation Pond 3 (see **Figure III.4.1**)).

Table III.4.4
Watershed #3 Calculations (Detention Basin)

Watershed #3 (Pond): Assume all rainfall is contained within the Basin area and losses are negligible (25-year, 24-hour storm event; conservative estimated at 2.1 inches).

1. Area = 0.28 acres
2. Q_v = [(2.1 in.)(0.28 acres)]/12 = 0.05 acre-ft.

5.0 DRAINAGE CHANNEL DESIGN

The design frequency peak flow (Q_p) is used to size perimeter drainage channels. Drainage channels are sized to convey the volume of runoff from Watersheds #1 and #2, and sizing is based on Hydraflow Express Extension for AutoCAD Civil 3D. Hydraflow Express Extension software computes the velocity, depth based on the input values of flowrate, slope, and channel dimensions.

Table III.4.5
Channel Calculations

Channel	Q_{25} (cfs)	Slope (ft/ft)	Velocity (ft/s)	Water Depth (ft)	Freeboard (ft)
North	1.93	0.016	2.97	0.57	1.43
South	6.62	0.015	3.63	0.78	2.22

6.0 DETENTION BASIN DESIGN

The Stormwater Detention Basin is designed to store the volume of runoff from Watershed #1 (**Table III.4.2**), Watershed #2 (**Table III.4.3**), and Watershed #3 (**Table III.4.4**) as calculated in Section 4.0. The Detention Basin controls the flow from the North Channel and the South Channel, as well as rainfall within the Basin area. To determine the volume required of the basin the Simplified Peak Flow method is used from the NMSHTD Drainage Manual. The Simplified Peak Flow method calculates volume in acre-ft as follows:

Table III.4.6
Detention Basin Summary

Watershed	Area (acres)	Curve No.	$P_{25\text{-yr }24\text{-hr}}$ (inches)*	Q_{25} Volume (acre-ft)
#1	1.93	77	2.1	0.08
#2	7.52	77	2.1	0.32
#3	0.28	NA	2.1	0.05
Total	**9.73**	**-**	**2.1**	**0.45**

Notes:
*Conservative Estimate
NA = Not Applicable

Based on the available volume in the basin compared to the incoming flow, peak storage in the Detention Basin is assumed to be at elevation 5709.5. At this elevation, available volume = 1.15 acre-ft and the peak inflow from the 25-year 24-hour storm event is 0.45 acre-ft., therefore the basin size is more than sufficient to detain the stormwater runoff as a result of the design storm event.

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VOLUME III: ENGINEERING DESIGN AND CALCULATIONS
SECTION 4: STORMWATER MANAGEMENT PLAN

ATTACHMENT III.4.A
NEW MEXICO STATE HIGHWAY AND TRANSPORATION DEPARTMENT
DRAINAGE MANUAL

DRAINAGE MANUAL

VOLUME 1, HYDROLOGY

DECEMBER, 1995

NEW MEXICO STATE HIGHWAY
AND TRANSPORTATION DEPARTMENT
PRELIMINARY DESIGN BUREAU/DRAINAGE SECTION
P. O. BOX 1149
SANTA FE, NEW MEXICO 87504-1149

Table 3–4 — Runoff Curve Numbers Urban Areas[1]

Source: USDA SCS, TR–55, 1986

Cover Description		Curve Numbers for Hydrologic Soil Group –			
Cover Type and Hydrologic Condition	Average Percent Impervious Area[2]	A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.)[3]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right–of–way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right–of–way)		98	98	98	98
Paved; open ditches (including right–of–way)		83	89	92	93
Gravel (including right–of–way)		76	85	89	91
Dirt (including right–of–way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only)[4]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1– to 2–inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation)[5]		77	86	91	94
Vacant lands (CN's are determined using cover types similar to those in **Table 3–3**).					

---

[1] Average runoff condition.

[2] The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using Figure 3.9.

[3] CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.

[4] Composite CN's for natural desert landscaping should be computed using Figure 3.9 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.

[5] Composite CN's to use for the design of temporary measures during grading and construction should be computed using Figure 3.9, based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

3.3.1.4 TIME OF CONCENTRATION

Time of Concentration is defined as the time required for runoff to travel from the hydraulically most distant part of the watershed to the point of interest. Time of concentration is one of the most important drainage basin characteristics needed to calculate the peak rate of runoff. An accurate estimate of a watershed's time of concentration is crucial to every type of hydrologic modeling.

The method used to calculate time of concentration must be consistent with the method of hydrologic analysis selected for design. Designers working on NMSHTD projects must use the time of concentration methods specified in this section for each hydrologic method. Mixing of methods is not allowed on NMSHTD projects. **Table 3–6** defines the correct time of concentration method to be used for each hydrologic method.

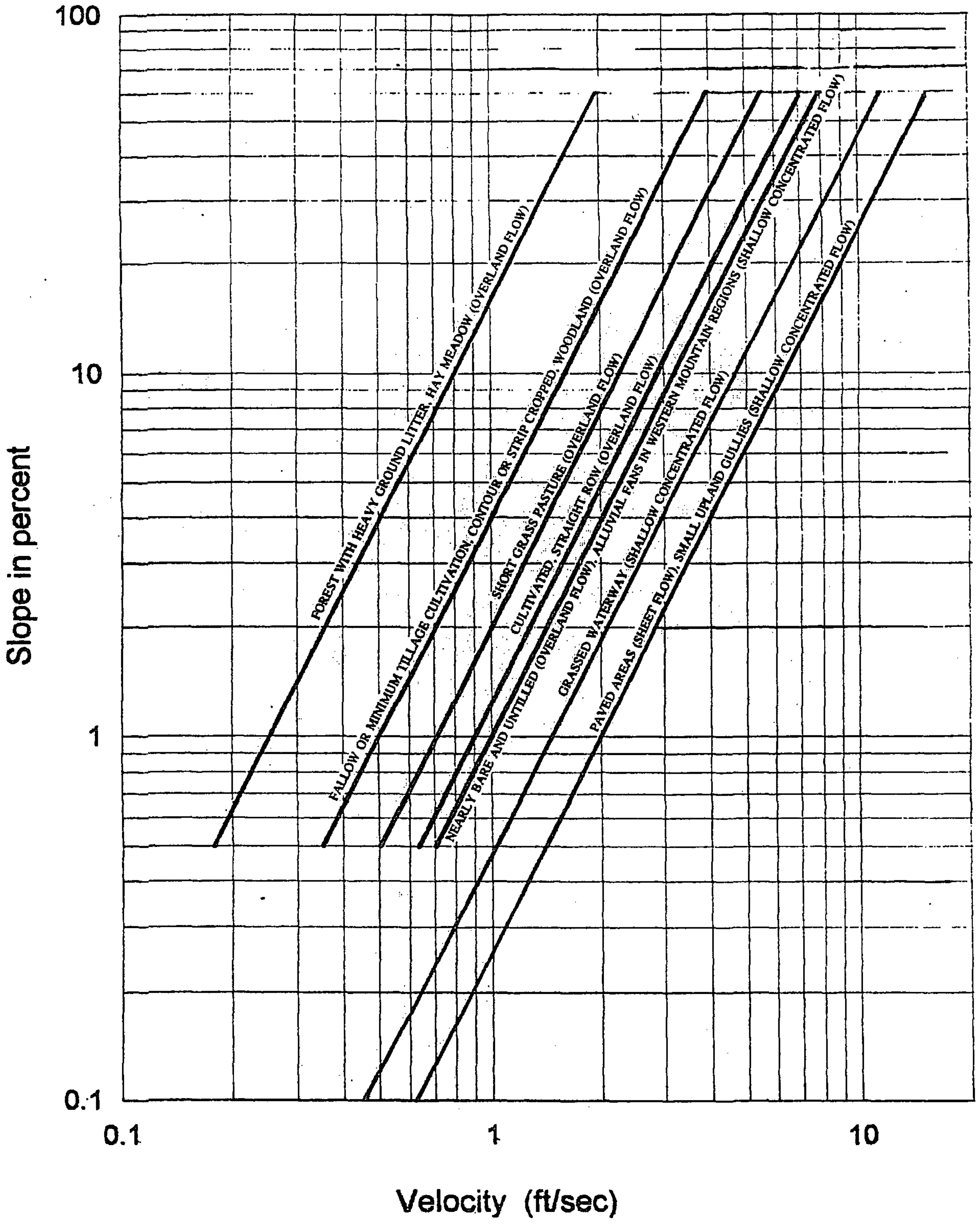
Within each watershed the designer must locate the primary watercourse. This is the watercourse that extends from the bottom of the watershed or drainage structure to the most hydraulically remote point in the watershed. Most designers begin at the bottom of the watershed and work their way upstream until the longest watercourse has been found. At the top of the watershed a defined watercourse may not exist. In these areas overland flow will be the dominant flow type. As the runoff proceeds downstream, overland flows will naturally begin to coalesce, gradually concentrating together. Shallow concentrated flow often has enough force to shape small gullies in erosive soils. Gullies eventually gather together until a defined stream channel is formed. The water course is now large enough to be identified on a quadrangle topographic map.

Sections along the primary watercourse should be identified which are hydraulically similar. Time of concentration is estimated for each section of the watercourse. Time of concentration in any given watershed is simply the sum of flow travel times within hydraulically similar reaches along the longest watercourse. Time of concentration is determined from measured reach lengths and estimated average reach velocities. The basic equation for time of concentration is:

$$T_c = \left(\frac{L_1}{V_1} + \frac{L_2}{V_2} + \frac{L_3}{V_3} + \dots \frac{L_n}{V_n} \right) \frac{1}{60} \qquad \textbf{(3–17)}$$

where

T_c = Time of concentration, minutes
V_1 = Average flow velocity in the uppermost reach of the watercourse, ft./sec.
L_1 = Length of the uppermost reach of the watercourse, ft.
V_2, V_3, ... = Average flow velocities in subsequent reaches progressing downstream, ft./sec.
L_2, L_3, ... = Lengths of subsequent reaches progressing downstream, ft.



Note: For watercourses with slopes less than 0.5 percent, use the overland flow velocity given for 0.5 percent, except for shallow concentrated flow where a flatter slope may be considered.

Figure 3-10
Flow Velocities for
Overland and Shallow
Concentrated Flows

Modified from SCS, NEH-4, 1972

3.3.1.4.2 TIME OF CONCENTRATION BY THE KIRPICH FORMULA

This method is used to calculate time of concentration in gullied watersheds when using the Rational Method or the Simplified Peak Flow Method. The Kirpich Formula should be used when gullying is evident in more than 10% of the primary watercourse. Gullying can be assumed if a blue line appears on the watercourse shown on the USGS quadrangle topographic map. The Kirpich Formula is given as:

$$T_c = 0.0078 \; L^{0.77} \; S^{-0.385} \tag{3–18}$$

where

T_c = time of concentration, in minutes
L = length from drainage to outlet along the primary drainage path, in feet
S = average slope of the primary drainage path, in ft./ft.

The Kirpich Formula should generally be used for the entire drainage basin. The exception to this rule occurs when the Simplified Peak Flow Method is being used on NMSHTD projects and the watercourse has a mixture of gullied and un–gullied sections. In these situations, mixing of time of concentration methods is allowed. The Upland Method is used for the ungullied portion of the primary watercourse, and the Kirpich Formula is used for the gullied portion of the watercourse. The two times of concentration are added together to obtain the total time of concentration of the watershed. Typically the Kirpich Formula is only used for that portion of the watercourse shown in blue on the quadrangle topo map. **Mixing of time of concentration methods is only allowed with the Simplified Peak Flow Method for NMSHTD projects.**

3.3.1.4.3 THE STREAM HYDRAULIC METHOD

The stream hydraulic method is used when calculating peak flows by the Unit Hydrograph Method in a watercourse where a defined stream channel is evident (blue line, solid or broken, on a quadrangle topo map). The designer must measure or estimate the hydraulic properties of the stream channel, and must divide the total watercourse into channel reaches which are hydraulically similar. Field reconnaissance measurements of the stream channel are best, however sometimes direct measurements are not possible. The designer must determine the slope, channel cross section and an appropriate hydraulic roughness coefficient for each channel reach. Average slope is often determined from the topographic mapping of the watershed. Channel cross section should be measured in the field whenever possible. Roughness coefficients of the waterway should be based on actual observations of the watercourse or of nearby watercourses which are believed to be similar and which are more accessible.

Time of Concentration by the stream hydraulic method is simply the travel time in the stream channel. Channel flow velocities can be estimated from normal depth calculations for the watercourse. In addition to the average flow velocity, designers should compute the Froude Number of the flow. If the Froude number of the flow exceeds a value of 1.3, then the designer should verify that supercritical flow conditions can actually be sustained. For most earth lined channels the velocity calculation should be recomputed using a larger effective

<u>Step 2</u> Determine the unit peak discharge, q_u, for the watershed. The unit peak discharge can be read from **Figure 3–18**, given the time of concentration, or calculated directly by the following equation:

$$q_u = 0.543 \; T_c^{-0.812} \; 10^{-\frac{[\,|\log(T_c) + 0.3| - \log(T_c) - 0.3]^{1.5}}{10}} \tag{3–22}$$

where

q_u = unit peak discharge from the watershed, in cfs/ac–in
T_c = time of concentration, in hours

<u>Note</u>: for $T_c > 0.5$ hours, the last term of the equation, $10^{-\frac{[\,|\log(T_c) + 0.3| - \log(T_c) - 0.3]^{1.5}}{10}}$, is equal to 1.0

Step 3

Calculate the direct runoff from the watershed. The direct runoff is expressed as an average depth of water over the entire watershed, in inches. The direct runoff may be read from **Figure 3–17** using the 24–hour rainfall depth P_{24} in inches, and the runoff curve number, CN. The runoff depth may also be calculated from the following equation:

$$Q_d = \frac{[P_{24} - (200/CN) + 2]^2}{P_{24} + (800/CN) - 8} \tag{3–23}$$

where

Q_d = average runoff depth for the entire watershed, in inches

Step 4

Compute the peak discharge from the watershed by the following equation:

$$Q_p = A \circ Q_d \circ q_u \tag{3–24}$$

where

Q_p = peak discharge, in cfs
A = drainage area, in acres

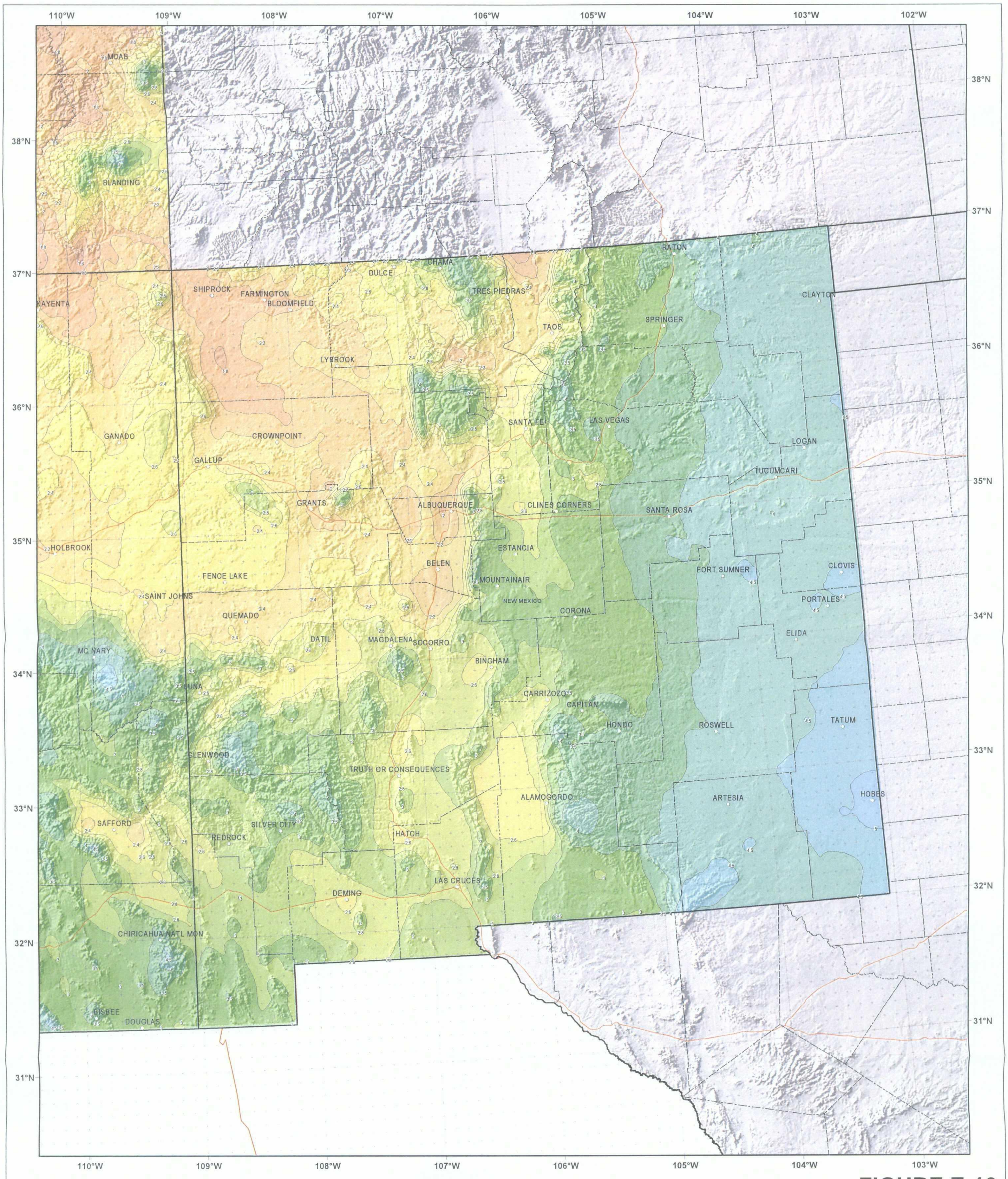
Step 5

Compute the runoff volume, if required. The runoff volume is obtained by the equation:

$$Q_v = \frac{Q_d \circ A}{12} \tag{3–25}$$

where

Q_v = runoff volume from the watershed, in ac–ft



NEW MEXICO

FIGURE E-10

NOAA Atlas 14, Volume 1, Version 4
Semiarid Southwestern United States

Prepared by U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL WEATHER SERVICE
OFFICE OF HYDROLOGIC DEVELOPMENT
HYDROMETEOROLOGICAL DESIGN STUDIES CENTER
June 2006

SCALE 1:2,000,000
(when printed/viewed at ANSI C size)
0 10 20 30 40 50 Miles
0 5 10 20 30 40 50 60 70 Kilometers

Isopluvials of 24 hour precipitation (inches) with Average Recurrence Interval of 25 years

See NOAA Atlas 14 documentation for factors to convert to Annual Exceedance Probabilities for all estimates below 25 years

N

Inches

☐ 1.25 - 1.40	☐ 2.21 - 2.40	☐ 3.51 - 4.00	☐ 7.01 - 8.00	☐ 12.01 - 13.00
☐ 1.41 - 1.60	☐ 2.41 - 2.60	☐ 4.01 - 4.50	☐ 8.01 - 9.00	☐ 13.01 - 14.00
☐ 1.61 - 1.80	☐ 2.61 - 2.80	☐ 4.51 - 5.00	☐ 9.01 - 10.00	☐ 14.01 - 15.00
☐ 1.81 - 2.00	☐ 2.81 - 3.00	☐ 5.01 - 6.00	☐ 10.01 - 11.00	
☐ 2.01 - 2.20	☐ 3.01 - 3.50	☐ 6.01 - 7.00	☐ 11.01 - 12.00	

Projection: Lambert Conformal Conic; Datum NAD83; Standard Parallels: 38° and 45°; Central Meridian 112°.

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LIST OF ATTACHMENTS

Attachment No.	Title
III.1.A	LOW COST SHORE PROTECTION...A GUIDE FOR ENGINEERS AND CONTRACTORS
III.1.B	WATER-RESOURCES ENGINEERING

SECTION 5: WAVE ACTION CALCULATIONS

1.0 OBJECTIVE

Calculate wave height and run-up in the proposed evaporation ponds at Basin Disposal, Inc. assuming a pond length of 440 feet and a wind speed of 75 miles per hour (Fastest Mile Wind Speed: 25-Year Return Period). Wave height and run-up must be less than the 3 ½ foot of freeboard provided in the pond design.

2.0 METHODOLOGY

The methodology used in this calculation is presented in "Water Resources Engineering", Third Edition (**Attachment III.5.B)** for determining wave height and run-up in reservoirs and "Low Cost Shore Protection…a Guide for Engineers and Contractors", U.S. Army Corps of Engineers (**Attachment III.5.A**).

3.0 CALCULATION

The fastest mile wind speed for a 25-year return period was obtained from Figure 16, **Attachment III.5.A**. The fastest mile wind speed is approximately 75 mph.

Wave height in a reservoir can be estimated using the following equation:

$Z_w = 0.034\,(V_w)^{1.06}\,F^{0.47}$ Equation 7-4, Page 166, **Attachment III.5.B**

Where:
Z_w = height of wave (feet)
V_w = wind speed (mph) = 75 mph
F = fetch length (miles) = 440 feet/5,280 feet/mile = 0.083 miles

Therefore: $Z_w = 0.034\,(75\text{ mph})^{1.06}\,(0.083\text{ miles})^{0.47}$

$Z_w = 0.034\,(97.2)\,(0.31)$

$Z_w = 1.02$ feet = height of wave in pond due to a 75 mph wind

Height of wave run-for a smooth (i.e., HDPE liner) surface can be obtained from Table 11, **Attachment III.5.A**. On Table 11, R = 1.75H for a 2.5H:1V smooth slope and R = 1.50H for a 4.0H:1V smooth slope. Interpolating between these two values a value of R = 1.68H is obtained for a 3.0H:1V smooth slope. Therefore:

Wave Run-up = 1.68H = 1.68(1.02 feet) = 1.71 feet for a 3H:1V smooth sideslope.

Total: Wave height + Wave run-up = 1.02 feet + 1.71 feet = 2.73 feet

4.0 SUMMARY

When considering a 75 mph wind across the length of the pond, a wave height of 1.02 feet is obtained. This wave will run-up approximately 1.71 feet up the sideslope of the pond. The ponds have been design with a minimum freeboard of 3.5 feet which will provide adequate protection against the combined potential impact of waves, wave run-up, and simultaneous rainfall event (i.e., 25 year, 24 hour rainfall = <2.1").

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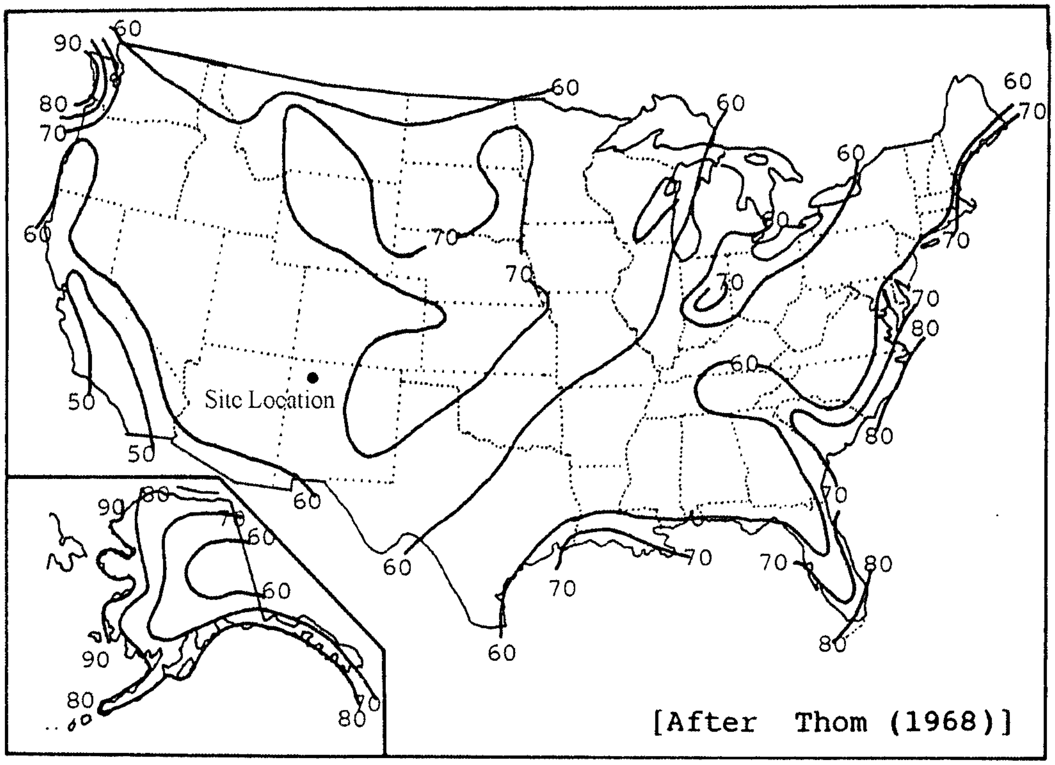
ATTACHMENT III.5.A

LOW COST SHORE PROTECTION…A GUIDE FOR ENGINEERS AND CONTRACTORS

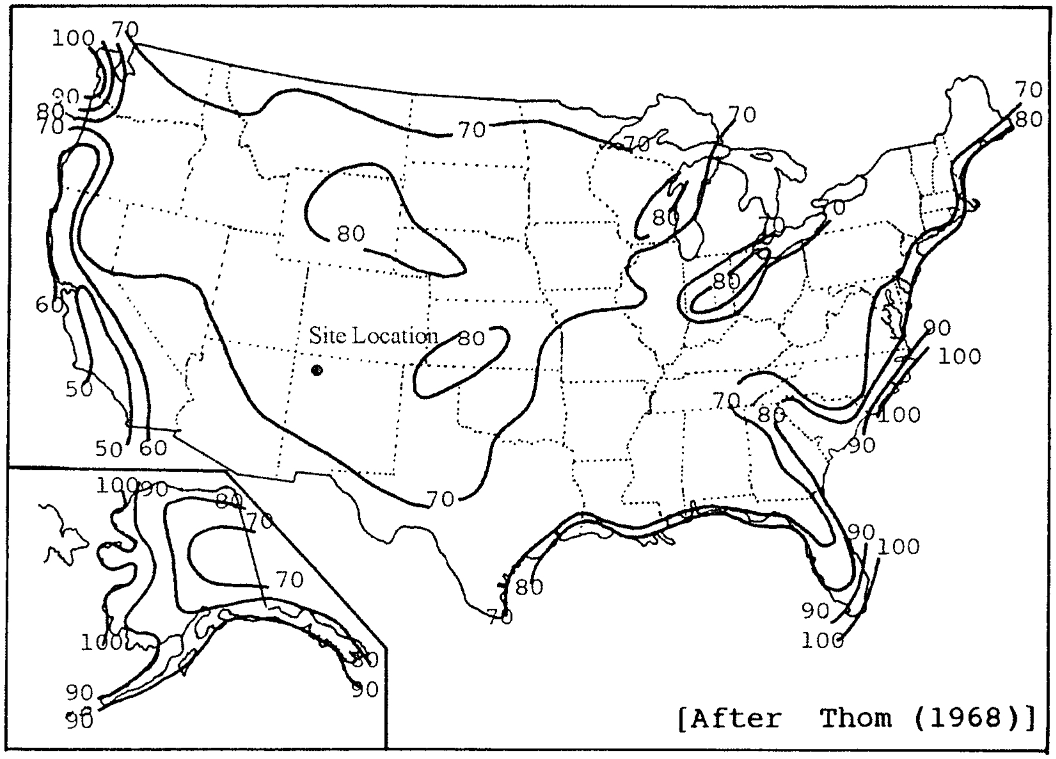
LOW COST SHORE PROTECTION

... a Guide for Engineers and Contractors



[After Thom (1968)]

Figure 15 Fastest-Mile Wind Speeds: 10-year Return Period



[After Thom (1968)]

Figure 16 Fastest-Mile Wind Speeds: 25-year Return Period

Structure Height

Waves breaking against an inclined structure will run up to an elevation higher than the Stillwater level depending on the roughness of the structure. Smooth concrete surfaces experience higher runup than rough stone slopes. Vertical structures also cause splashing and can experience overtopping. If possible, the structure should be built high enough to preclude severe overtopping. White spray does little damage, but solid jets of "green" water should be avoided. The required height of the structure will depend on the computed runup height based on the wave and structure characteristics. Detailed guidance is presented in Stoa (1978) and (1979). The runup height, R, can be found by a more approximate method as given below.

First, find the wavelength at the structure by using either Figure 26 or Equation (3) with the known depth at the structure and the design wave period. The definition sketch for runup is shown on Figure 27. For SMOOTH impermeable slopes, the runup, R, is given in Seelig (1980) by,

$$R=HC_1 (0.12L/H){}^\wedge(C_2 (H/d_s)^{0.5} + C_3)$$

where: L = the local wavelength from Figure 26 or Eq. (3),
d_s = the depth at the structure (feet),
the approaching wave height (feet), and
C_1, C_2, C_3 = coefficients given below.

Structure Slope *	C_1	C_2	C_3
Vertical	0.96	0.23	+0.06
1 on 1.0	1.47	0.35	-0.11
1 on 1.5	1.99	0.50	-0.19
1 on 2.25	1.81	0.47	-0.08
1 on 3.0	1.37	0.51	+0.04

*Interpolate linearly between these values for other slopes.

For ROUGH slopes, Seelig (1980) gives the runup as,

$$R = (0.69\xi/1+0.5\xi)H \qquad (14)$$

$$\xi = \tan\theta/(H/L_o)^{0.5} \qquad (15)$$

$$L_o = 5.12\ T^2 \qquad (16)$$

θ = structure of the slope (e. g., $\tan\theta = 0.25$ for a slope of 1V on 4H

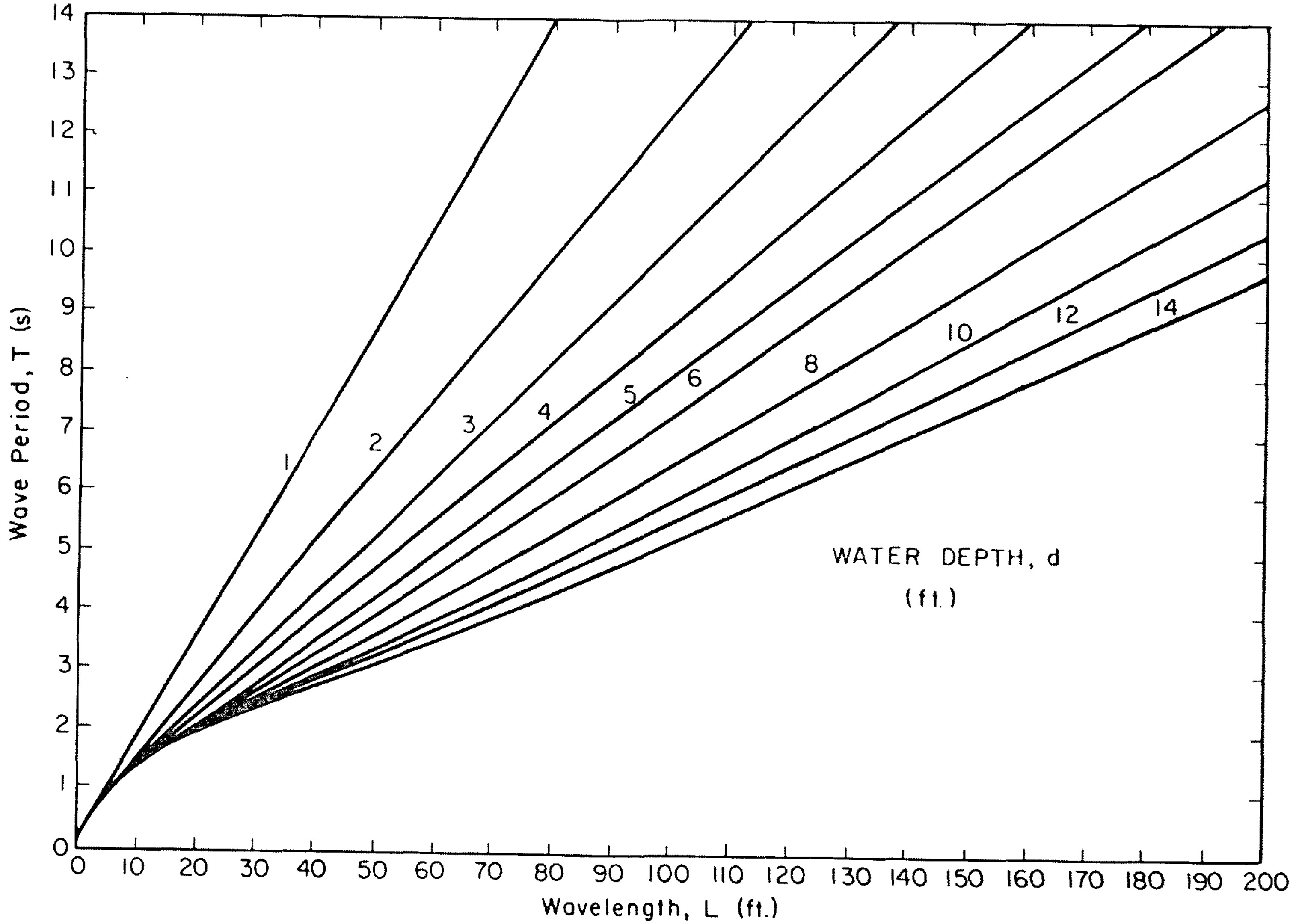


Figure 26 Local Wavelength Given Depth and Period [After Giles and Eckert (1979)]

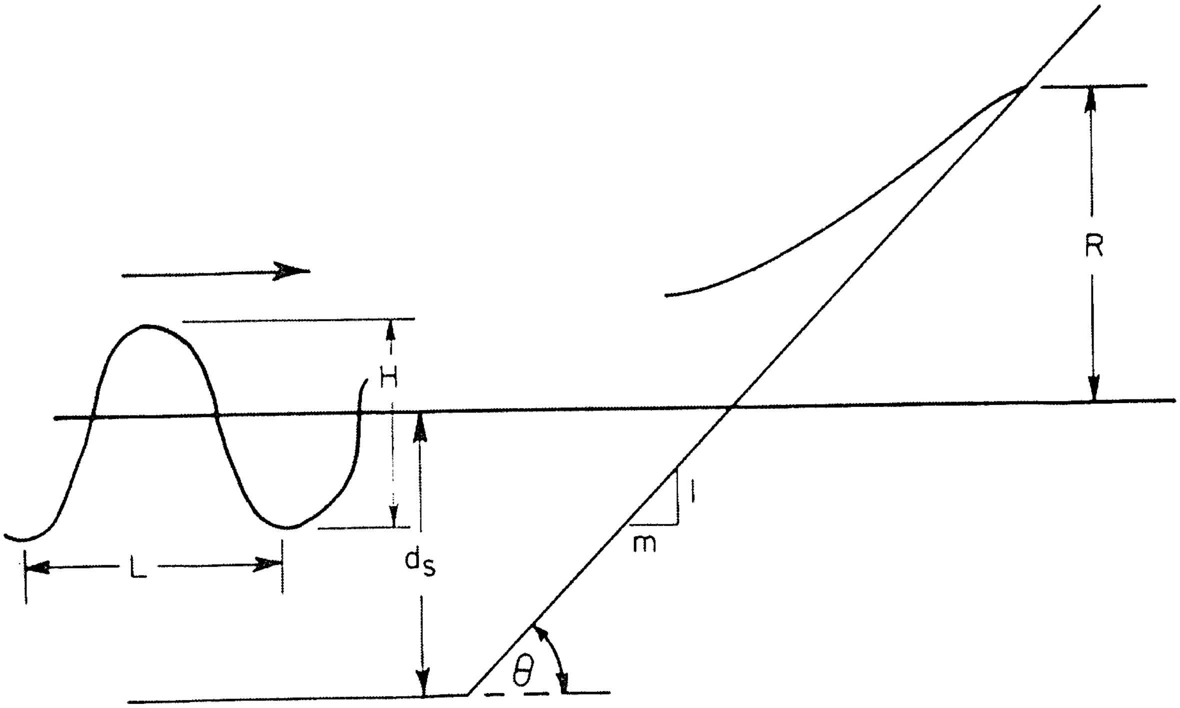


Figure 27 Wave Runup Definition Sketch

For STEPPED slopes, Stoa (1979) recommends using 70 to 75 percent of the smooth slope runup if the risers are vertical, and 86 percent if the edges are rounded.

A rough approximation of the runup height can be obtained from Table 11. However, the values in the table tend to represent the upper bound of the available data and may result in over design. Equations (13) and (14) or the methods given in Stoa (1978) and (1979) are recommended.

If it is impossible or undesirable to build a structure to the recommended height, a splash apron should be provided at the top of the structure. These are generally constructed of rock and they prevent the ground at the top from being eroded and undermining that portion of the structure.

Environmental Factors

Many different materials can be used to construct shore protection structures, including rock, concrete, timber, metal and plastics. The choice often depends on the desired permanence of the protection. Durable materials usually cost considerably more than shorter-lived materials used for temporary protection. The choice of materials is important because the coastal environment is a harsh testing ground for all man-made structures. Aside from wave forces, which are formidable in and of themselves, a host of chemical, biological and other factors can degrade structural materials. A brief review of these follows.

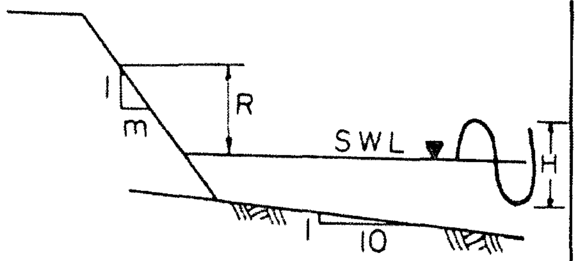
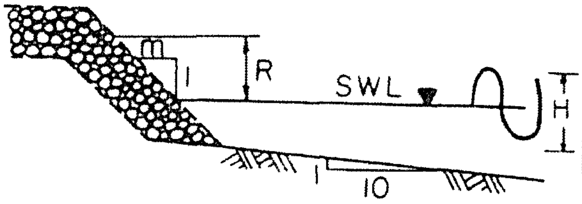
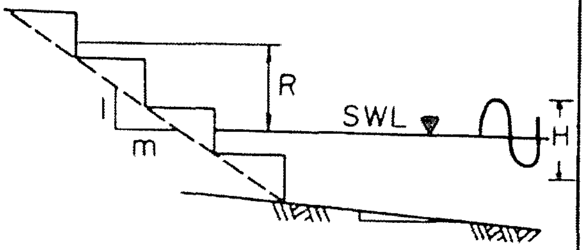
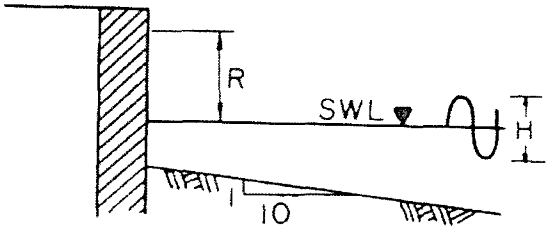
	m	R
 SMOOTH FACE	1.5 2.5 4.0	2.25H 1.75H 1.50H
 ROUGH FACE	1.5 2.5 4.0	1.25H 1.00H 0.75H
 STEPPED FACE	1.5	2.00H
 VERTICAL FACE	—	2.00H

Table 11 Wave Runup Heights

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ATTACHMENT III.5.B

WATER-RESOURCES ENGINEERING

WATER-RESOURCES ENGINEERING

THIRD EDITION

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Paris São Paulo Singapore Sydney Tokyo Toronto

by ordinary earth-moving methods would be expensive unless the excavated sediment has some sales value.

7-9 Wind setup and waves in reservoirs Earth dams must have sufficient freeboard above maximum pool level so that waves cannot wash over the top of the dam. Waves in reservoirs may also damage shoreline structures and embankments adjacent to the water and interfere with navigation. Part of the design of any reservoir is an estimate of wind setup and wave height.

Wind setup is the tilting of the reservoir water surface caused by the movement of the surface water toward the leeward shore under the action of the wind. This current of surface water is a result of tangential stresses between the wind and the water and of differences in atmospheric pressure over the reservoir. The latter, however, is, typically, a smaller effect. As a consequence of wind setup, the reservoir water surface is above normal still-water level on the leeward side and below the still-water level on the windward side. This results in hydrostatic unbalance, and a return flow at some depth must occur. The water-surface slope which results is that necessary to sustain the return flow under conditions of bottom roughness and cross-sectional area of flow which exist. Wind setup is generally larger in shallow reservoirs with rough bottoms.

Wind setup may be estimated from

$$Z_s = \frac{V_w^2 F}{1400d} \tag{7-3}$$

where Z_s is the rise in feet (meters) above still-water level, V_w is the wind speed in miles (kilometers) per hour, F is the *fetch* or length of water surface over which the wind blows in miles (kilometers), and d is the average depth of the lake along the fetch in feet (meters). In SI metric units, the constant in the denominator becomes 63,200.

Equation (7-3) is modified[1] from the original equation developed by Dutch engineers on the Zuider Zee. Additional information and techniques are given in other references.[2] Wind-setup effects may be transferred around bends in a reservoir and the value of F used may be somewhat longer than the straight-line fetch.

When wind begins to blow over a smooth surface, small waves, called capillary waves, appear in response to the turbulent eddies in the wind stream. These waves grow in size and length as a result of the continuing push of the wind on the back of the waves and of the shearing or tangential force between the wind and the water. As the waves grow in size and length, their speed increases until they move at speeds approaching the speed of the wind. Because growth of a wave depends in part upon the difference between wind speed and wave speed, the growth rate approaches zero as the wave speed approaches the wind speed.

---

[1] T. Saville, Jr., E. W. McClendon, and A. L. Cochran, Freeboard Allowances for Waves in Inland Reservoirs, *J. Waterways and Harbors Div., ASCE*, pp. 93–124, May, 1962.

[2] Shore Protection, Planning and Design, *Tech. Rept.* 3, 3d ed., U.S. Army Coastal Engineering Research Center, June, 1966.

The duration of the wind and the time and direction from which it blows are important factors in the ultimate height of a wave. The variability of the wind and the amazingly complex and yet to be fully understood response of the water surface to the wind lead to a wave pattern that is a superposition of many waves. The pattern is often described by its energy distribution or spectrum. The growth of wind waves as a function of fetch, wind speed, and duration can be calculated from knowledge of the mechanism of wave generation and use of collected empirical results.[1] The duration of the wind and the fetch play an important role because a wave may not reach its ultimate height if the wave passes out of the region of high wind or strikes a shore during the growth process. The depth of water also plays a key role, tending to yield smaller and shorter waves in deep water.

Wave-height data gathered at two major reservoirs[2] confirm the theoretical and experimental data for ocean waves if a modified value of fetch is used. The derived equation is

$$z_w = 0.034 V_w^{1.06} F^{0.47} \tag{7-4}$$

---

[1] W. J. Pierson, Jr., and R. W. James, Practical Methods for Observing and Forecasting Ocean Waves, *U.S. Navy Hydrographic Office Pub.* 603, 1955 (reprinted 1960).

[2] T. Saville, Jr., E. W. McClendon, and A. L. Cochran, Freeboard Allowances for Waves in Inland Reservoirs, *J. Waterways and Harbors Div., ASCE*, pp. 93–124, May, 1962.

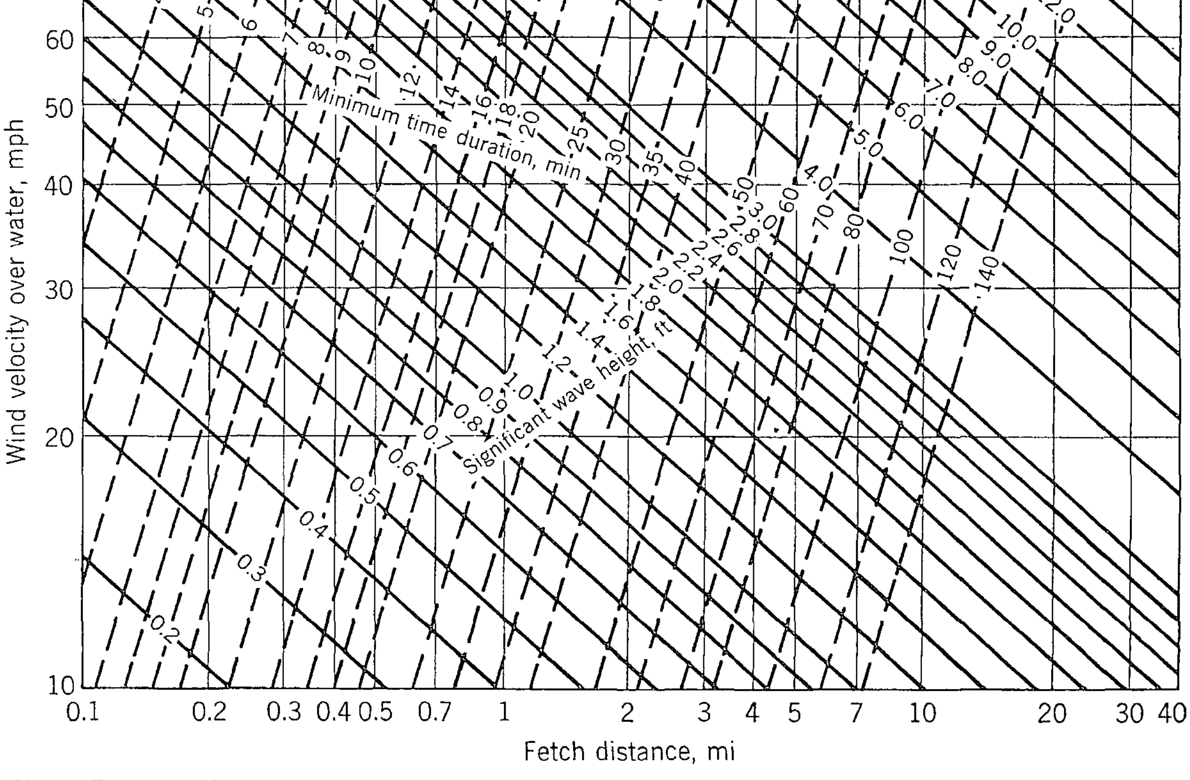
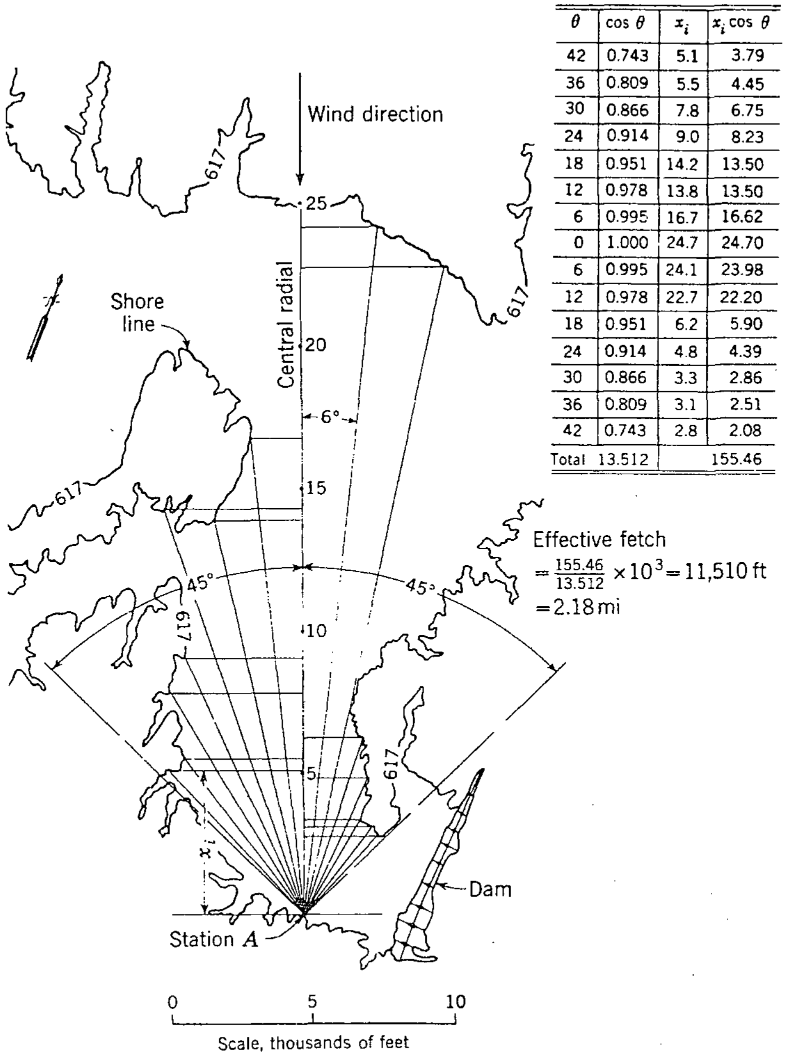


Figure 7-14 Significant wave heights and minimum wind durations (*from Saville, McClendon, and Cochran*). For metric version see Appendix B.



θ	$\cos\theta$	x_i	$x_i \cos\theta$
42	0.743	5.1	3.79
36	0.809	5.5	4.45
30	0.866	7.8	6.75
24	0.914	9.0	8.23
18	0.951	14.2	13.50
12	0.978	13.8	13.50
6	0.995	16.7	16.62
0	1.000	24.7	24.70
6	0.995	24.1	23.98
12	0.978	22.7	22.20
18	0.951	6.2	5.90
24	0.914	4.8	4.39
30	0.866	3.3	2.86
36	0.809	3.1	2.51
42	0.743	2.8	2.08
Total	13.512		155.46

Effective fetch
$=\frac{155.46}{13.512}\times 10^3 = 11{,}510$ ft
$=2.18$ mi

igure 7-15 Computation of effective fetch. (*Modified from Saville, McClendon, and Cochran*)

vhere z_w is the average height in feet (meters) of the highest one-third of the waves nd is called the *significant wave height*, V_w is the wind velocity in miles (kilmeters) per hour about 25 ft (7.6 m) above the water surface, and F is the fetch in niles (kilometers). In SI metric units the coefficient becomes 0.005. The equation s shown graphically in Fig. 7-14[1] together with lines showing the minimum duraion of wind required to develop the indicated wave height. Figure 7-15 shows the nethod of computing the effective fetch for a narrow reservoir.

Since the design must be made before the reservoir is complete, wind data ver land must generally be used. Table 7-2 gives ratios of wind speed over land to hose over water and may be used to correct observed wind to reservoir conditions. Waves are critical only when the reservoir is near maximum levels. Thus in electing the critical wind speed for reservoirs subject to seasonal fluctuations,

---

[1] A graph for the solution of Eq. (7-4) in SI metric units is given in Appendix B-1.

Table 7-2 Relationship between wind over land and that over water. (After Saville, McClendon, and Cochran)

Fetch, mi (km)	0.5 (0.8)	1 (1.6)	2 (3.2)	4 (6.5)	6 (9.7)	8 (12.9)
$V_{\text{water}}/V_{\text{land}}$	1.08	1.13	1.21	1.28	1.31	1.31

only winds which can occur during the season of maximum pool levels should be considered. The direction of the wind and the adopted fetch must also be the same.

The height of the significant wave is exceeded about 13 percent of the time. If a more conservative design is indicated, a higher wave height may be chosen. Table 7-3 gives ratios of z'/z_w for waves of lower exceedance.

When a wave strikes a land slope, it will *run up* the slope to a height above its open-water height. The amount of run-up depends on the surface. Figure 7-16 shows the results of small-scale experiments[1] on smooth slopes and rubble mounds. Height of run-up z_r is shown as a ratio z_r/z_w and is dependent on the ratio of wave height to wavelength (wave steepness). Wavelength λ for deep-water waves may be computed from

$$\lambda = 5.12 t_w^2 \text{ ft} \qquad \text{or} \qquad \lambda = 1.56 t_w^2 \text{ m} \tag{7-5}$$

where the wave period t_w is given by

$$t_w = 0.46 V_w^{0.44} F^{0.28} \tag{7-6}$$

For shallow-water waves other length relations are appropriate.[2] In metric units the coefficient of Eq. (7-6) becomes 0.32. The curves for rubble mounds represent extremely permeable construction, and for more typical riprap on earth embankments the run-up may be somewhat higher, depending on both the permeability and the relative smoothness of the surface.

---

[1] T. Saville, Jr., Wave Run-up on Shore Structures, *Trans., ASCE*, Vol. 123, pp. 139–158, 1958; R. Y. Hudson, Laboratory Investigation of Rubble-mound Breakwaters, *Trans. ASCE*, Vol. 126, Part IV, pp. 492–541, 1962.

[2] Shore Protection, Planning and Design, *Tech. Rept.* 3, 3d ed., U.S. Army Coastal Engineering Research Center, June, 1966.

Table 7-3 Percentage of waves exceeding various wave heights greater than z_w. (After Saville, McClendon, and Cochran)

z'/z_w	1.67	1.40	1.27	1.12	1.07	1.02	1.00
Percentage of waves > z'	0.4	2	4	8	10	12	13

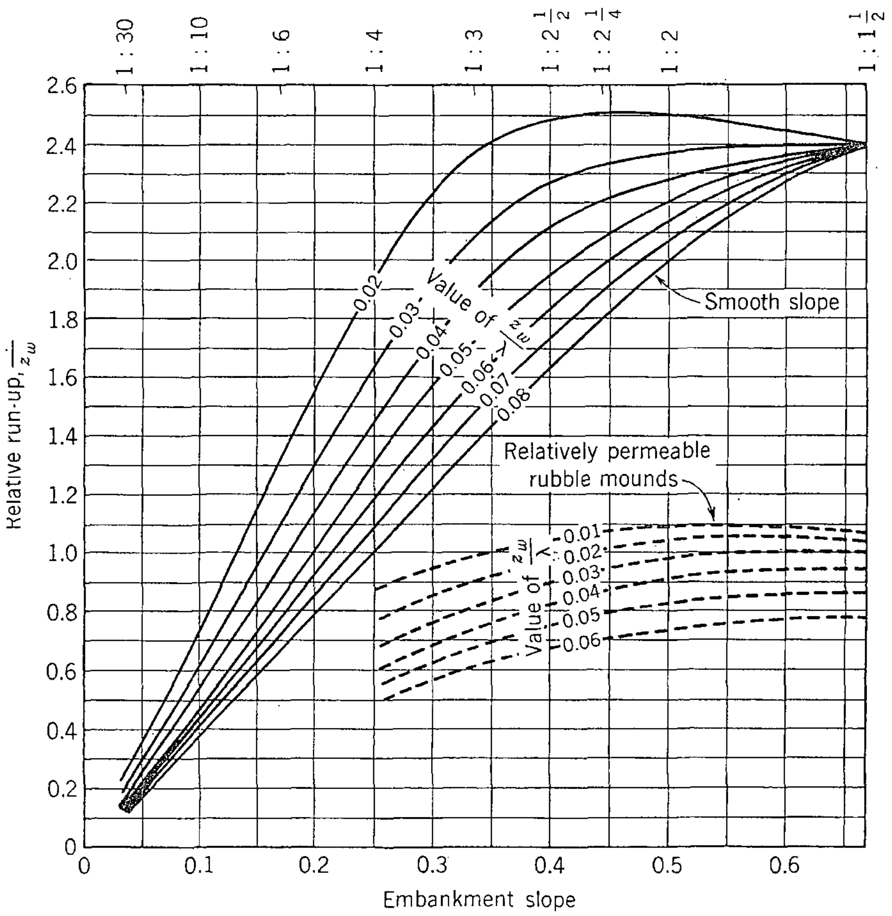


Figure 7-16 Wave run-up ratios versus wave steepness and embankment slopes. (*From Saville, McClendon, and Cochran*)

STATE OF NEW MEXICO
DIRECTOR OF OIL CONSERVATION DIVISION

IN THE MATTER OF THE APPLICATION OF BASIN DISPOSAL, INC. FOR A SURFACE WASTE MANAGEMENT FACILITY PERMIT

APPLICATION FOR MODIFICATION
BASIN DISPOSAL, INC.
OCD Permit # NM-01-0005

DECEMBER 2008
(Updated June 2009)

VOLUME IV:
SITING AND HYDROGEOLOGY

Prepared For:

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Submitted To:

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Oil Conservation Division
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Prepared By:

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APPLICATION FOR MODIFICATION
BASIN DISPOSAL, INC.
OIL FIELD WASTE EVAPORATION PONDS

VOLUME IV: SITING AND HYDROGEOLOGY
SECTION 1: SITING CRITERIA

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LIST OF ATTACHMENTS

Attachment No.	Title
IV.1.A	MONTHLY AVERAGE PAN EVAPORATION (INCHES)
IV.1.B	PERIOD OF RECORD MONTHLY CLIMATE SUMMARY (FARMINGTON AG SCIENCE CENTER, NM)
IV.1.C	PERIOD OF RECORD GENERAL CLIMATE SUMMARY – TEMPERATURE (FARMINGTON AG SCIENCE CENTER, NM)
IV.1.D	PERIOD OF RECORD GENERAL CLIMATE SUMMARY – TEMPERATURE (AZTEC RUINS NATIONAL MONUMENT, NM)

SECTION 1: SITING CRITERIA

1.0 INTRODUCTION

The Basin Disposal Facility is located on approximately 28 acres in unincorporated San Juan County adjacent to the Bloomfield City Limits (**Figure IV.1.1**). The site has been used for the management of oil field waste fluids since 1985; and consists of receiving facilities, storage tanks, processing units, an evaporation pond, injection well, etc. Current installations are shown on the Site Plan (**Figure IV.1.2**), which also shows site access, topography, fencelines, etc. Proposed improvements, primarily related to the construction of two new Evaporation Ponds (4 ± acres each) are shown on the Permit Plans (**Volume III, Section 1, Attachment III.1.A**).

Basin Disposal meets of the OCD 19.15.36.13 siting requirements applicable to this type of permitted surface waste management facility. The following sections provide the regulatory citation for each criterion, followed by a narrative response. In most cases, a figure is referenced to demonstrate compliance with applicable standard(s).

2.0 DEPTH-TO-GROUNDWATER

19.15.36.13 Siting and operational requirements applicable to all permitted surface waste management facilities: Except as otherwise provided in 19.15.36 NMAC.

A Depth to ground water.

> *(5) No other surface waste management facility shall be located where ground water is less than 50 feet below the lowest elevation at which the operator will place oil field waste.*

A comprehensive subsurface investigation completed by John Shomaker & Associates in 2008 concludes that any shallow groundwater has excessive TDS concentrations; and that **the first regulated water-bearing zone is more than 100' below the deepest oil field waste management units (Volume IV, Section 2)**. The upper water-bearing zone will be protected from additional impacts by Basin Disposal's liner systems, surface water controls, operating procedures, etc.

3.0 WATERCOURSE, LAKEBED, SINKHOLE, OR PLAYA LAKE

19.15.36.13.B. No surface waste management facility shall be located:
(1) within 200 feet of a watercourse, lakebed, sinkhole or playa lake;

BDI waste disposal facilities are not located within 200 feet of a watercourse, lakebed, sinkhole or playa lake. **Figure IV.1.3**, USGS Quadrangle Map (11" x 17"), shows surface features on and adjacent to the Basin Disposal site, and **Figure IV.1.2** provides detailed topographic information for the footprint of the facility. These figures, accompanied by focused site reconnaissance, document that there are no regulated surface water features on or adjacent to the site. The intermittent drainage feature, shown on the USGS Quadrangle Map (**Figure IV.1.3**) is limited to the extreme southwest corner of the property over 750' from any waste management installations. The "Karst Terrain Map" (**Figure IV.1.9**) also shows that the potential for subsidence features that might create sinkhole or playa conditions are absent from the region.

4.0 WELLHEAD PROTECTION AREA; 100-YEAR FLOODPLAIN

19.15.36.13.B. No surface waste management facility shall be located:
(2) within an existing wellhead protection area or 100-year floodplain

BDI is **not located within an existing wellhead protection area or 100-year floodplain**. The Wellhead Protection Area Map (**Figure IV.1.4**) provides the locations, with 200' setbacks, for water supply wells in the area based on data provided by the Office of the State Engineers (OSE). The closest water wells are more than 1,000 feet from the facility in accordance with the definition of wellhead protection area in 19.15.2.7.W.(8) NMAC. The closest municipal water supply well belongs to the city of Bloomfield and is located over 3 miles south-southeast of the BDI site.

Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM FM3500640550B, August 1988) was reviewed for 100-year floodplain delineations near the facility (**Figure IV.1.5**). A Letter of Correction (LOMA) from December 2001 was issued for this map for an area 2.86 miles southeast of the BDI property line. A review of these maps, in addition to site inspections, did not indicate watercourses or surface features characteristic of a regulated floodplain within or adjacent to the site; or any "waters of the

U.S." regulated by ACOE 404. The nearest regulated floodplain is over 1000' from the site to the east.

5.0 WETLANDS

19.15.36.13.B. No surface waste management facility shall be located:
(3) within, or within 500 feet of, a wetland

The Facility is **not located within 500 feet of a wetland**. There are no areas meeting the definition of a regulated wetland on or adjacent to the facility property as defined by the National Wetland Inventory Mapping Convention. The applicable National Wetlands Inventory Map published by the U.S. Department of the Interior is provided as **Figure IV.1.6**, which demonstrates that the nearest regulated wetland is over 2.5 miles south-southeast of the BDI site.

6.0 SUBSURFACE MINES

19.15.36.13.B. No surface waste management facility shall be located:
(4) within the area overlying a subsurface mine

There are no known records of subsurface mines in the immediate vicinity of the facility location. The "Mines, Mills and Quarries in New Mexico" map generated by New Mexico Energy, Minerals, and Natural Resources Department confirms the absence of these sites in the vicinity of BDI (**Figure IV.1.7**). The nearest subsurface mine is shown to be over 8 miles from the BDI facility.

7.0 LAND USE SETBACKS

19.15.36.13.B. No surface waste management facility shall be located:
(5) within 500 feet from the nearest permanent residence, school, hospital, institution or church in existence at the time of initial application

The Facility site **is in excess of 500 feet from the nearest permanent residence, school, hospital, institution, or church.** The examination of land use setbacks for the BDI facility includes a site reconnaissance, aerial photo review and evaluation of adjacent San Juan County parcel (zoning) map (**Figure IV.1.8**).

The results of this analysis conclude that:

- The surrounding land uses are primarily industrial/commercial in nature, highly compatible with BDI established and proposed activities.
- Access to BDI and nearby facilities is adequate and compatible with current traffic patterns.
- The nearest residential land use is over 1000' directly south of the site; and other protected land uses are even more remote.
- There is no trend for development of residential, institutional, or educational facilities in the vicinity of the BDI site.

8.0 UNSTABLE AREAS

19.15.36.13.B. *No surface waste management facility shall be located:*

(6) within an unstable area, unless the operator demonstrates that engineering measures have been incorporated into the surface waste management facility design to ensure that the surface waste management facility's integrity will not be compromised.

An unstable area is defined as *". . . susceptible to natural or human-induced events or forces capable of impairing the integrity of some or all of a division-approved facility's structural components. Examples of unstable areas are areas of poor foundation conditions, areas susceptible to mass movements, and Karst terrain areas . . ."*
(19.15.2.7.U.(6) NMAC).

Figure IV.1.9 shows that the nearest areas with potential Karst subsidence are over 61 miles from the BDI site. The location was also evaluated for geologic faults (**Figure IV.1.10**) and potential seismic impacts (**Figure IV.1.11**).

There are no active faults known within 200 feet of the site, and earthquake risk is low. The site topography is characterized by relatively gently sloping surfaces underlain by shale, sandstone, and alluvium. No limestone or other carbonate rock is exposed near the property, and no sinkholes or slumps have been reported within the region (Ward, 1990).

Select textural and hydrologic properties of the stratigraphic units encountered in boreholes and in the regional geology are described in the Shomaker report. These properties and the inferred geotechnical characteristics of the units, together with the low seismic risk, document that foundation conditions are suitable for the surface ponds at this site. In summary, the topography of the site, and the nature of the sediments beneath the facility, indicate that the site is stable and suitable for the installation of existing and proposed waste processing and containment facilities.

9.0 MAXIMUM SIZE

19.15.36.13.C. No surface waste management facility shall exceed 500 acres.

The BDI occupies approximately 28 acres, in northwest quarter of Section 3, Township 29 North, Range 11 West of the New Mexico Principal Meridian. The Site Location Map, included as **Figure IV.1.1**, identifies the limits of the BDI facility; and the detailed Plat Survey Map is provided as **Figure IV.1.12**. The facility's permitted footprint includes 13.18 acres (Tract 2: Remainder Tract) and 14.59 acres as shown on **Figure IV.1.12**.

10.0 CLIMATOLOGY

The Basin Disposal site is located in a region of low precipitation and high evaporation, which optimizes the performance of the evaporation ponds. Although pan evaporation rates are low from November to March, the annual evaporation rate is over 66' per year (**Attachment IV.1.A**).

The precipitation is low, at 8.5" ± per year (**Attachment IV.1.B**), with most of the rainfall occurring during the high evaporation season. The net difference of evaporation vs. precipitation (i.e., 66.8" – 8.5") provides a net treatment rate of over 58" annually (i.e., potential evaporation rate of 6 million gallons/yr for Ponds 2 and 3). **Attachments IV.1.C** and **IV.1.D** provide additional detail regarding temperature and precipitation trends.

APPLICATION FOR MODIFICATION
BASIN DISPOSAL, INC.
OIL FIELD WASTE EVAPORATION PONDS

VOLUME IV: SITING AND HYDROGEOLOGY
SECTION 1: SITING CRITERIA

FIGURES

Based on:
FLORA VISTA, NM (1963, PHOTOREVISED 1979),
HORN CANYON, NM (1965 PHOTOREVISED 1979),
AZTEC, NM (1985 PROVISIONAL EDITION), AND
BLOOMFIELD (1985 PROVISIONAL EDITION),
USGS 7.5' SERIES (1:24,000 SCALE TOPOGRAPHIC) QUADRANGLES.

Drawing:P:\acad 2003\520.01.01\02\FIGURES\SITE LOCATION 24K.dwg
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SITE LOCATION MAP

SURFACE WASTE MANAGEMENT FACILITY
BASIN DISPOSAL, INC.
SAN JUAN COUNTY, NEW MEXICO

Gordon Environmental, Inc.
Consulting Engineers

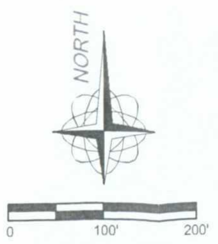
213 S. Camino del Pueblo
Bernalillo, New Mexico, USA
Phone: 505-867-6990
Fax: 505-867-6991

DATE: 10/27/08	CAD: SITE LOCATION 24K.dwg	PROJECT #: 520.01.01
DRAWN BY: MLH	REVIEWED BY: IKG	FIGURE IV.1.1
APPROVED BY: IKG	gei@gordonenvironmental.com	

BOREHOLE LOCATIONS	
BH–2	LAT 36°45'20.54269"N (NAD 83) LONG 107°59'02.70950"W (NAD83) ELEV: 5717.98 (GROUND)
BH–3	LAT 36°45'22.92950"N (NAD 83) LONG 107°59'04.21563"W (NAD83) ELEV: 5727.46 (GROUND)
AW–1	LAT 36°45'22.01797"N (NAD 83) LONG 107°58'55.15402"W (NAD83) ELEV: 5717.85 (TOP OF CAP)
AW–2	LAT 36°45'20.58589"N (NAD 83) LONG 107°59'02.96163"W (NAD83) ELEV: 5722.20 (TOP OF CAP)

LEGEND

—·—·—	PROPERTY BOUNDARY
——	2' CONTOUR (EXISTING)
— 5700 —	10 CONTOUR (EXISTING)
— —	2' DEPRESSION CONTOUR (EXISTING)
— 5700 —	10' DEPRESSION CONTOUR (EXISTING)
= = = =	ROADWAY (EXISTING)
—×—×—	FENCE (EXISTING)
🟦	PROPOSED NEW TANKS
—	CULVERT
▨	STRUCTURE
⌐ ¬	CONCRETE SLAB
AW-1 ●	ASSESSMENT WELL
BH-3 ●	BOREHOLE LOCATION
⊙	TANKS
◐	LIGHT POLE (EXISTING)
○	POWER POLE (EXISTING)
5705.6 ×	SPOT ELEVATIONS



SITE PLAN

BASIN DISPOSAL, INC.
BLOOMFIELD, NEW MEXICO

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Consulting Engineers

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Bernalillo, New Mexico, USA
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APPROVED BY: IKG	gei@gordonenvironmental.com	

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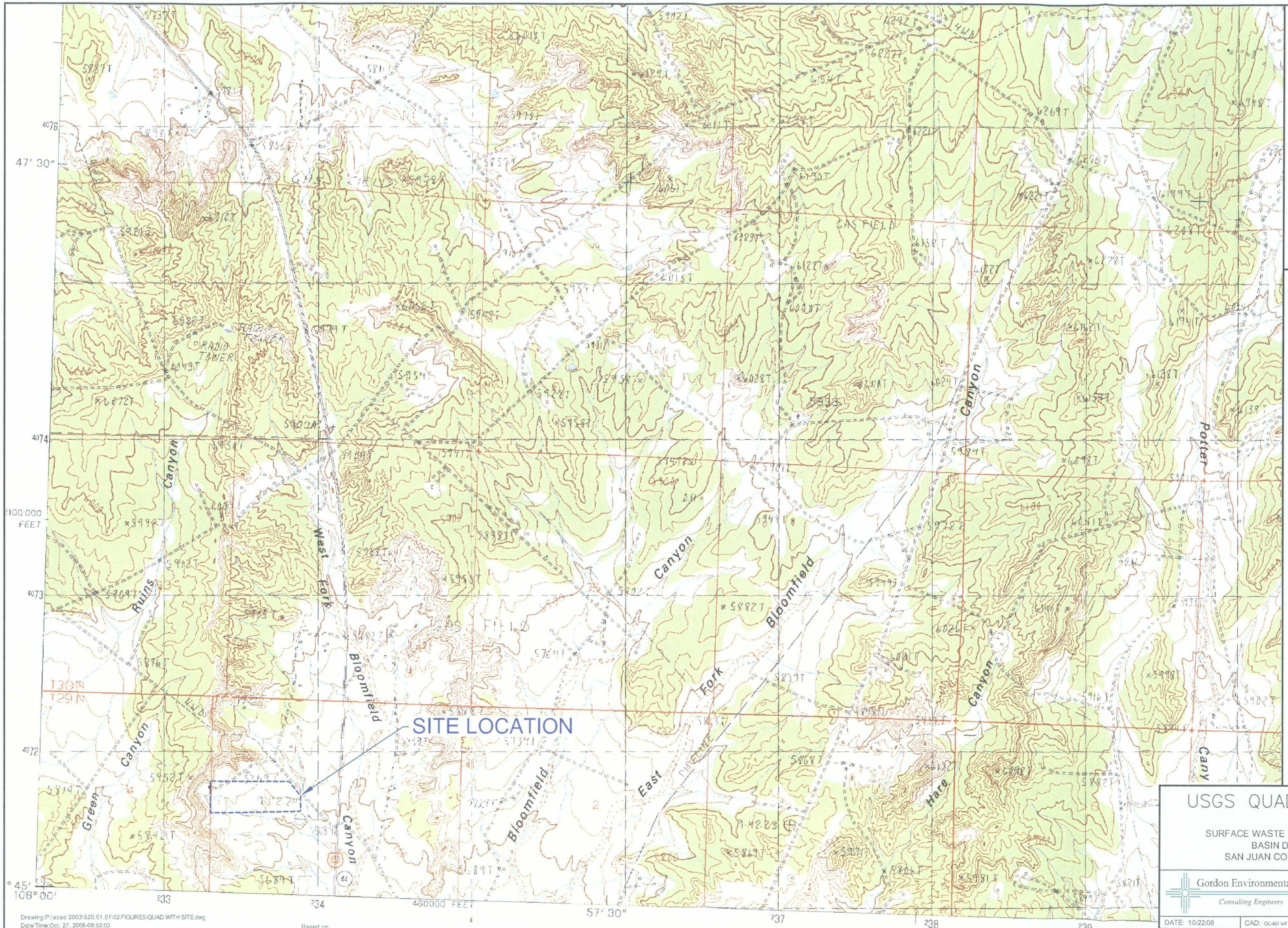

LEGEND

SITE BOUNDARY

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Based on:
AZTEC, NM (1985 PROVISIONAL EDITION), AND
USGS 7.5' SERIES (1:24,000 SCALE TOPOGRAPHIC) QUADRANGLE.

USGS QUADRANGLE MAP

SURFACE WASTE MANAGEMENT FACILITY
BASIN DISPOSAL, INC.
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DATE: 10/22/08	CAD: QUAD WITH SITE.dwg	PROJECT #: 520.01.01
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APPROVED BY: IKG	gei@gordonenvironmental.com	

Based on: FLORA VISTA, NM (1963, PHOTOREVISED 1979); HORN CANYON, NM (1965 PHOTOREVISED 1979); AZTEC, NM (1985 PROVISIONAL EDITION), AND BLOOMFIELD (1985 PROVISIONAL EDITION); USGS 7.5' SERIES (1:24,000 SCALE TOPOGRAPHIC) QUADRANGLES.

LEGEND

○ DOMESTIC WATER WELL SHOWING 200' RADIUS

WATER WELL DATA FROM NMOSE 2008 GIS DATABASE

NORTH

0' 1000' 2000'

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WELLHEAD PROTECTION AREA MAP

SURFACE WASTE MANAGEMENT FACILITY
BASIN DISPOSAL, INC.
SAN JUAN COUNTY, NEW MEXICO

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Consulting Engineers

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Bernalillo, New Mexico, USA
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Fax: 505-867-6991

DATE: 10/27/08	CAD: WH PROT AREA.dwg	PROJECT #: 520.01.01
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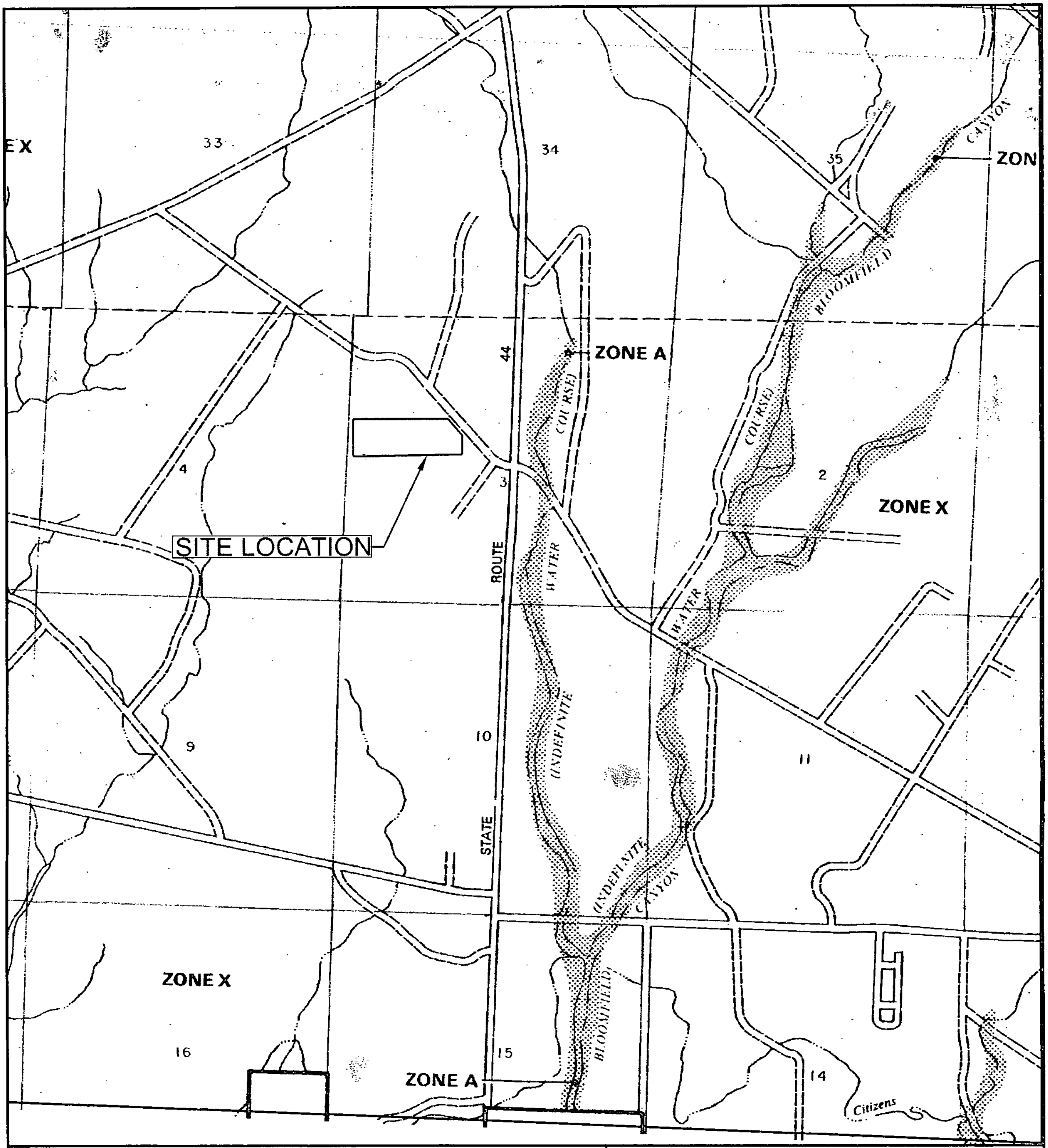
APPROVED BY: IKG	gei@gordonenvironmental.com	



FEMA DATA FROM:
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AUGUST 4, 1988.

Drawing:P:\acad 2003\520.01.01\02\FIGURES\FEMA.dwg
Date/Time:Oct. 27, 2008-09:04:56

FEMA FLOODPLAIN MAP

SURFACE WASTE MANAGEMENT FACILITY
BASIN DISPOSAL, INC.
SAN JUAN COUNTY, NEW MEXICO

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Consulting Engineers

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Bernalillo, New Mexico, USA
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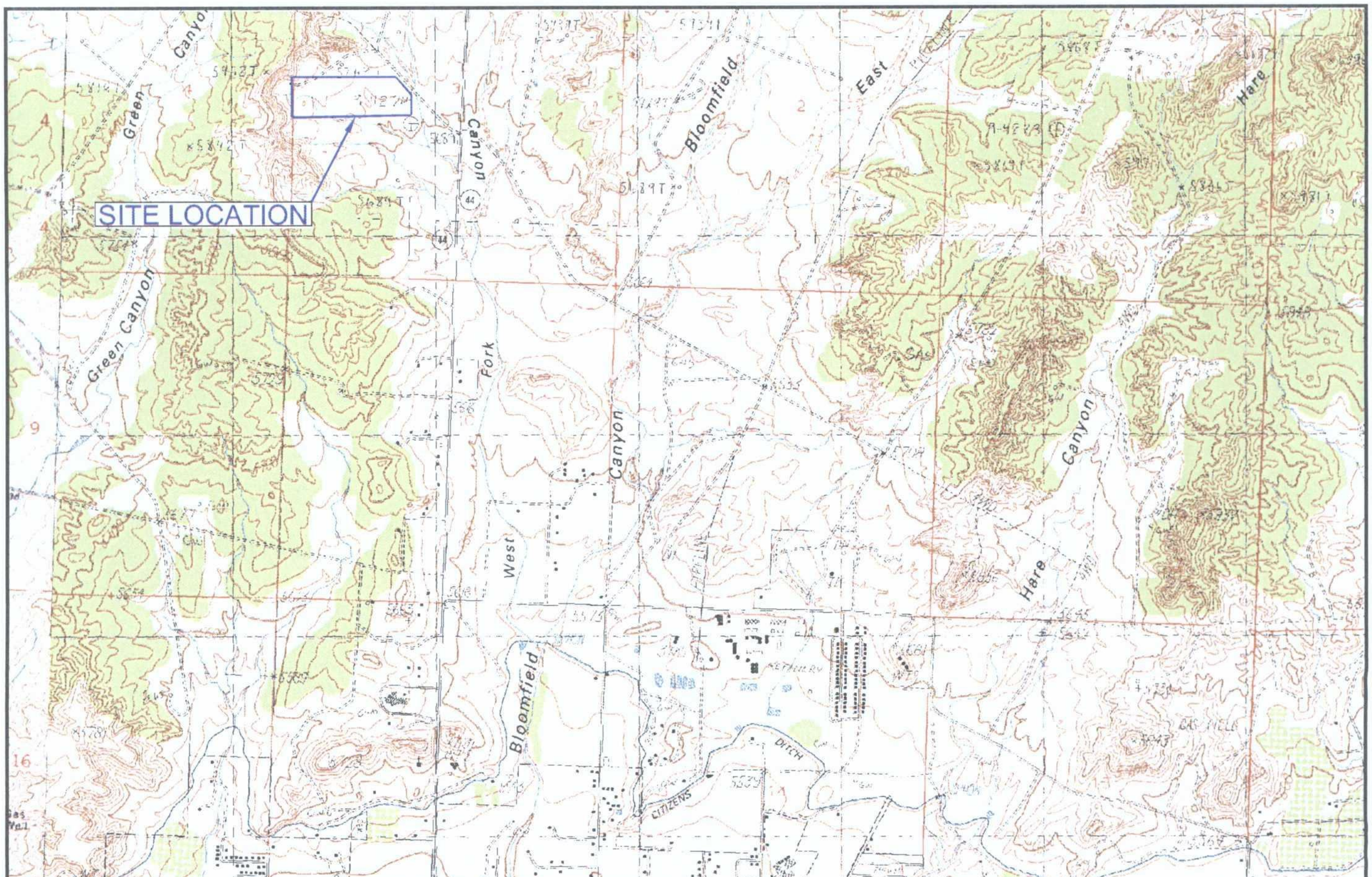
Fax: 505-867-6991

DATE: 10/27/08	CAD: FEMA.dwg	PROJECT #: 520.01.01
DRAWN BY: MLH	REVIEWED BY: IKG	FIGURE IV.1.5
APPROVED BY: IKG	gei@gordonenvironmental.com	



LEGEND

▨ WETLANDS UNDIVIDED

NORTH

0' 1500' 3000'

WETLANDS DATA FROM: US FISH AND WILDLIFE SERVICE
CLASSIFICATION OF WETLANDS AND DEEPWATER HABITATS
OF THE UNITED STATES, PUBLISHED MAY 22, 2008

Drawing:P:\acad 2003\520.01.01\02\FIGURES\WETLANDS.dwg
Date/Time:Oct. 27, 2008-09:08:47

NATIONAL WETLANDS INVENTORY MAP

SURFACE WASTE MANAGEMENT FACILITY
BASIN DISPOSAL, INC.
SAN JUAN COUNTY, NEW MEXICO

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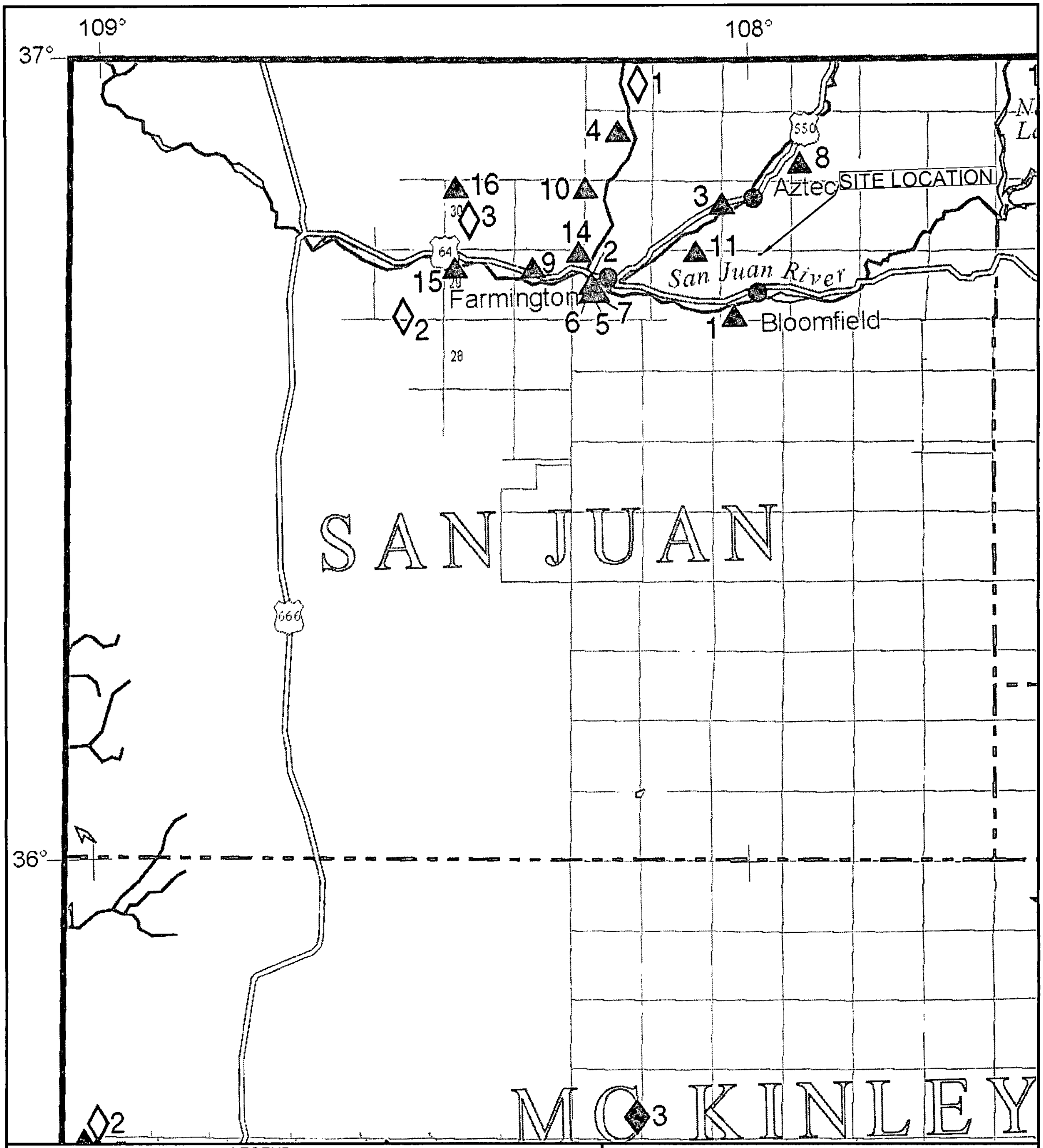
Phone: 505-867-6990
Fax: 505-867-6991

DATE: 10/27/08	CAD: WETLANDS.dwg	PROJECT #: 520.01.01
DRAWN BY: MLH	REVIEWED BY: IKG	FIGURE IV.1.6
APPROVED BY: IKG	gei@gordonenvironmental.com	



LEGEND

- ● Town or City
- ▲ Aggregate and stone mining
- ◇ Coal mining
- ★ Industrial minerals, mining, and milling
- ◩ Metals
- ■ Potash mining and milling
- ☐ Smelters, converters, and refineries
- ◆ Uranium mining and milling

NORTH

0 6 12 MILES

Drawing:P:\acad 2003\520.01.01\02\FIGURES\MINES.dwg
Date/Time:Oct. 22, 2008-13:45:30

MINES, MILLS AND QUARRIES MAP

SURFACE WASTE MANAGEMENT FACILITY
BASIN DISPOSAL, INC.
SAN JUAN COUNTY, NEW MEXICO

Gordon Environmental, Inc.
Consulting Engineers
213 S. Camino del Pueblo
Bernalillo, New Mexico, USA
Phone: 505-867-6990
Fax: 505-867-6991

DATE: 10/22/08	CAD: LAND USE.dwg	PROJECT #: 520.01.01
DRAWN BY: MLH	REVIEWED BY: IKG	FIGURE IV.1.7
APPROVED BY: IKG	gei@gordonenvironmental.com	

LEGEND

▬ ▬ SITE BOUNDARY

▬ · ▬ BLOOMFIELD CITY LIMITS

▨ RESIDENTIAL

▨ COMMERCIAL / INDUSTRIAL

SOURCE:
San Juan County, New Mexico Parcel Data CD
Created on September 3, 2008.

Jason Brady
Geographic Information Systems DBA

San Juan County
Assessor's Office

Phone: (505) 334-4269
jbrady@sjcounty.net

ADDITIONAL ON-SITE INSPECTION:
J. JORDAN, P.E., 2008

AERIAL PHOTO / LAND USE MAP

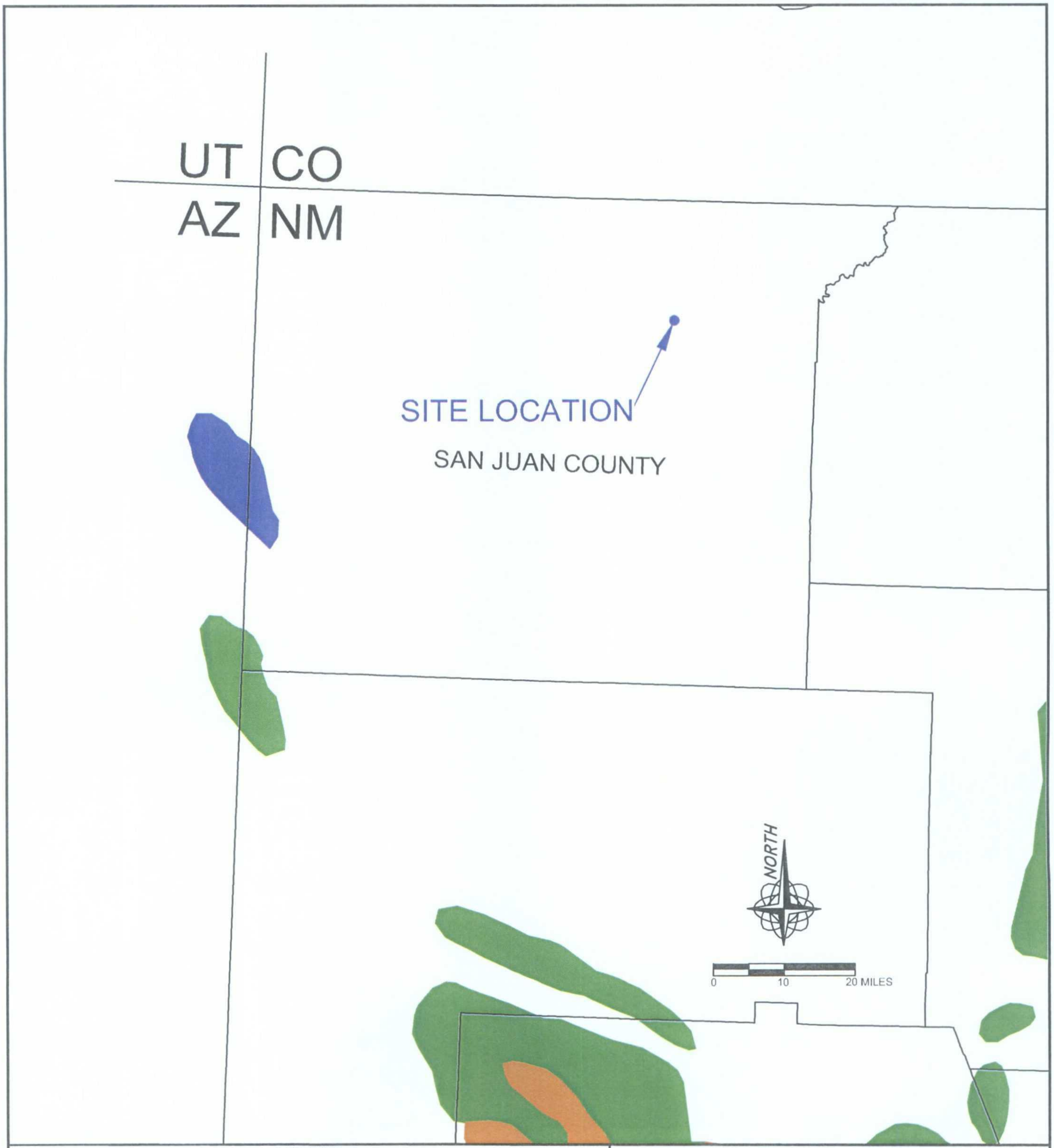
SURFACE WASTE MANAGEMENT FACILITY
BASIN DISPOSAL, INC.
SAN JUAN COUNTY, NEW MEXICO

Gordon Environmental, Inc.
Consulting Engineers

213 S. Camino del Pueblo
Bernalillo, New Mexico, USA
Phone: 505-867-6990
Fax: 505-867-6991

DATE: 10/24/08	CAD: LAND USE ZONING BY CODE.dwg	PROJECT #: 520.01.01
DRAWN BY: MLH	REVIEWED BY: IKG	FIGURE IV.1.8
APPROVED BY: IKG	gei@gordonenvironmental.com	

Drawing:P:\acad 2003\520.01.01\02\FIGURES\LAND USE ZONING BY CODE.dwg
Date/Time:Oct. 27, 2008-08:30:50



LEGEND

🟩 KARST
Fissures, tubes and caves generally less than 1,000 ft (300 m) long; 50 ft (15 m) or less vertical extent; in gently dipping to flat-lying beds of carbonate rock

🟦 PSEUDOKARST
Fissures and voids present to a depth of 250 ft (75 m) or more in areas of subsidence from piping in thick, unconsolidated material

🟧 PSEUDOKARST 2
Fissures, tubes, and tunnels present to a depth of 50 ft. (15 m) in lava

KARST DATA FROM:digital version of U.S. Geological Survey *Open FileReport 2004-1352, Engineering Aspects of Karst.* NATIONAL ATLAS GIS DATA.

Drawing:P:\acad 2003\520.01.01\02\FIGURES\KARST.dwg
Date/Time:Oct. 22, 2008-08:01:02

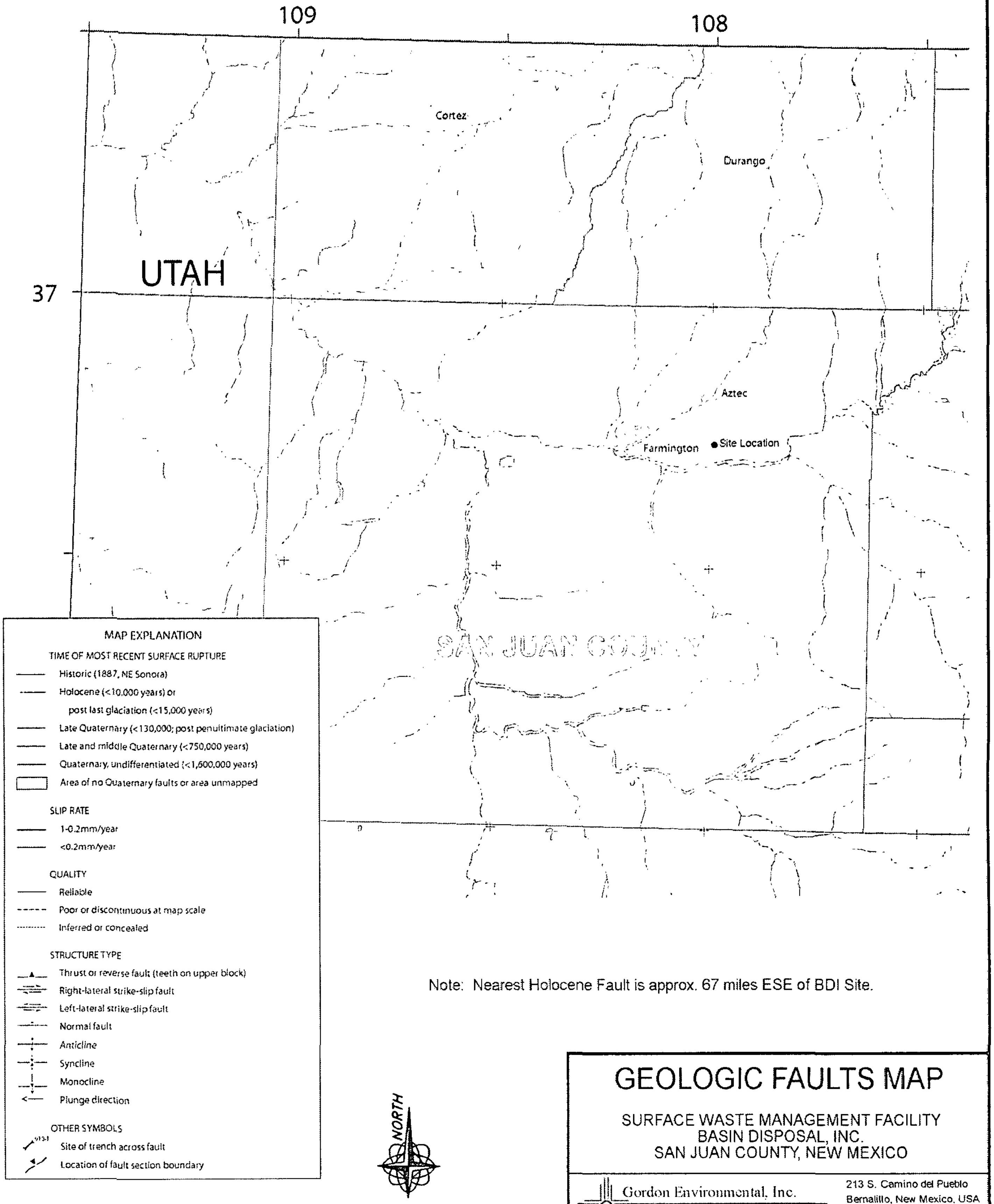
KARST TERRAINS MAP

SURFACE WASTE MANAGEMENT FACILITY
BASIN DISPOSAL, INC.
SAN JUAN COUNTY, NEW MEXICO

Gordon Environmental, Inc.
Consulting Engineers

213 S. Camino del Pueblo
Bernalillo, New Mexico, USA
Phone: 505-867-6990
Fax: 505-867-6991

DATE: 10/16/08	CAD: KARST.dwg	PROJECT #: 520.01.01
DRAWN BY: MLH	REVIEWED BY: IKG	FIGURE IV.1.9
APPROVED BY: IKG	gei@gordonenvironmental.com	



Note: Nearest Holocene Fault is approx. 67 miles ESE of BDI Site.

0 50 km

Scale is Approximate

Adapted from USGS Map OFR 98-521B

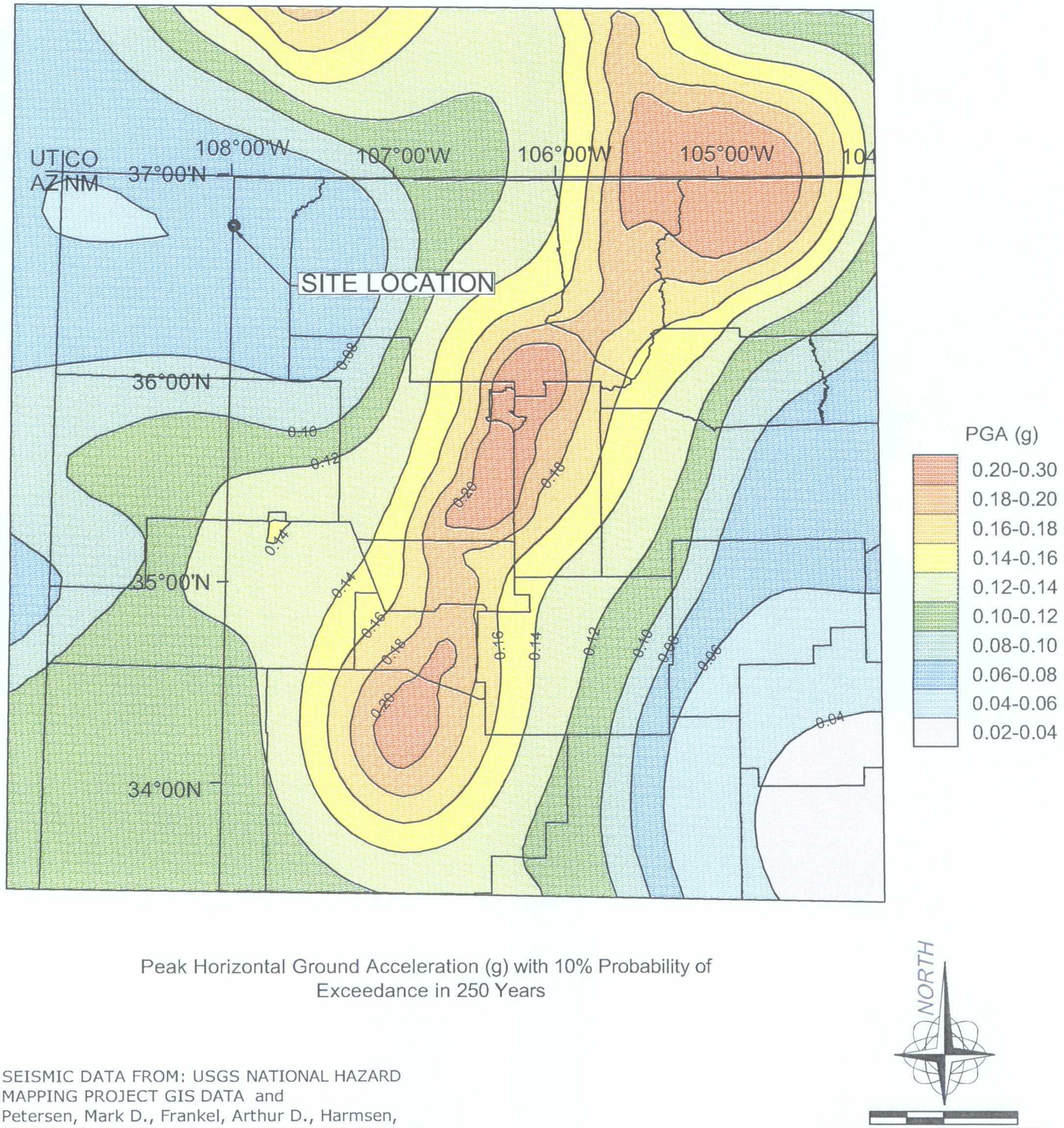
GEOLOGIC FAULTS MAP

SURFACE WASTE MANAGEMENT FACILITY
BASIN DISPOSAL, INC.
SAN JUAN COUNTY, NEW MEXICO

Gordon Environmental, Inc.
Consulting Engineers

213 S. Camino del Pueblo
Bernalillo, New Mexico, USA
Phone: 505-867-6990
Fax: 505-867-6991

DATE: 10/09/08	CAD: Basin-Faults.doc	PROJECT #: 520.01.01
DRAWN BY: PG	REVIEWED BY: DRT	FIGURE IV.1.10
APPROVED BY: IKG	gei@gordonenvironmental.com	



Peak Horizontal Ground Acceleration (g) with 10% Probability of Exceedance in 250 Years

SEISMIC DATA FROM: USGS NATIONAL HAZARD MAPPING PROJECT GIS DATA and Petersen, Mark D., Frankel, Arthur D., Harmsen, Stephen C., Mueller, Charles S., Haller, Kathleen M., Wheeler, Russell L., Wesson, Robert L., Zeng, Yuehua, Boyd, Oliver S., Perkins, David M., Luco, Nicolas, Field, Edward H., Wills, Chris J., and Rukstales, Kenneth S., 2008, Documentation for the 2008 Update of the United States National Seismic Hazard Maps: U.S. Geological Survey Open-File Report 2008-1128, 61

SEISMIC IMPACT ZONES MAP

SURFACE WASTE MANAGEMENT FACILITY
BASIN DISPOSAL, INC.
SAN JUAN COUNTY, NEW MEXICO

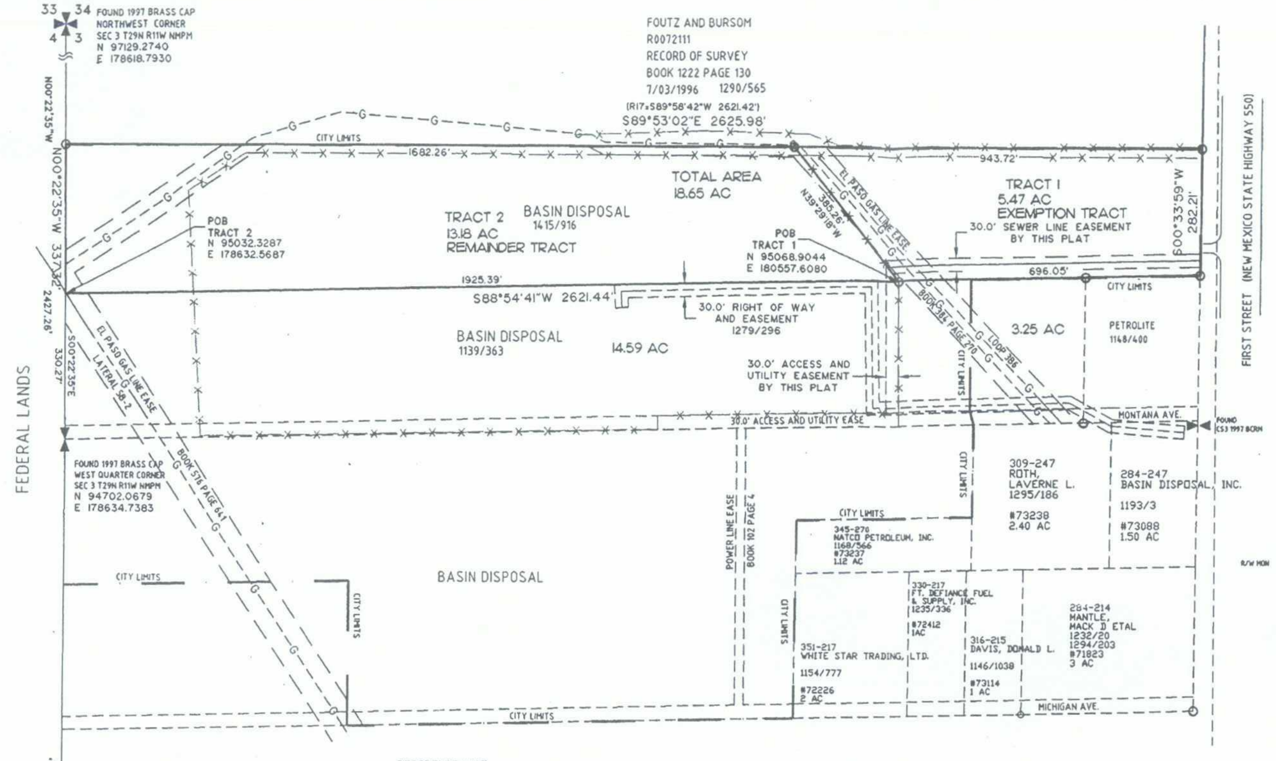
Gordon Environmental, Inc.
Consulting Engineers

213 S. Camino del Pueblo
Bernalillo, New Mexico, USA
Phone: 505-867-6990
Fax: 505-867-6991

DATE: 10/16/08	CAD: SEISMIC 2008 DATA.dwg	PROJECT #: 520.01.01
DRAWN BY: MLH	REVIEWED BY: IKG	FIGURE IV.1.11
APPROVED BY: IKG	gei@gordonenvironmental.com	

Drawing:P:\acad 2003\520.01.01\02\FIGURES\Seismic 2008 DATA.dwg
Date/Time:Oct. 22, 2008-08:03:20

EXEMPTION SURVEY
LYIN IN THE
NW1/4 SECTION 3, T29N, R11W, N.M.P.M.
SAN JUAN COUNTY, NEW MEXICO
FOR
BASIN DISPOSAL, INC., A NEW MEXICO CORPORATION



BASIS OF BEARING
S00°07'38"W 2629.47'

✜ = SECTION CORNER AS NOTED
⧓ = QUARTER CORNER AS NOTED
○ = SET 1/2" REBAR W/CAP LS 6159
⊕ = SET 1/2" REBAR W/ALUM CAP LS 6159
○ = FOUND REBAR AS NOTED
× = X MARK IN CONCRETE
◇ = SET PK NAIL W/WASHER
■ = HWY DEPT BRASS CAP R/W MON

4 3 FOUND 1997 BRASS CAP
SOUTHWEST CORNER
SEC 3 T29N R11W NMPM
9 10 N 92072.6080
E 178628.8970

REFERENCE LIST

R1. Date of field work was March 9, 2007.
R2. Basis of bearing is Bloomfield GPS control network.
R3. San Juan County Assessor's map of Section 3, T29N, R11W.
R4. Record of survey in Book 1222, page 130 on July 3, 1996.
R5. Warranty Deed in Book 1139, page 363.
R6. Warranty Deed in Book 1193, page 782.
R7. Warranty Deed in Book 1148, page 400.
R8. Dependent re-survey of Section 3, T29N, R11W by United States Department of the Interior, Bureau of Land Management dated June 8, 2000.
R9. Right of Way Easement in favor of The City of Farmington Electric Utility System and the Mountain States Telephone & Telegraph Company in Book 902, page 606.
R10. Right of Way and Easement in favor of Conoco Inc. in Book 1279, page 296.
R11. Right of Way and Easement in favor of El Paso Natural Gas Company in Book 214, page 295.
R12. Right of Way and Easement in favor of El Paso Natural Gas Company in Book 384, page 270.
R13. Annexation to the City of Bloomfield in Book 1297, page 716.
R14. Notice of Real Estate Contract in favor of Basin Disposal, Inc. in Book 1193, page 782.
R15. Warranty Deed in favor of Basin Disposal, Inc. in Book 1415, page 916.
R16. Warranty Deed in favor of Basin Disposal, Inc. in Book 1139, page 363.
R17. Record of Survey for Robert Martin, Wayne Hare, Byron Martin and Marilyn Ann White in Book 1222, page 130.

TRACT 1 - EXEMPTION TRACT

A tract of land situated in the Northwest Quarter (NW1/4) of Section 3, T29N, R11W, N.M.P.M., San Juan County, New Mexico, being more particularly described as follows:

BEGINNING at a point on the south line of a tract of land described in Book 1415, page 916 from whence the West Quarter Corner of said Section 3 bears S88°54'41"W for a distance of 1925.39 feet and S00°22'35"E for a distance of 330.27 feet;

THENCE: N39°29'18"W for a distance of 385.26 feet to a point on the south line of the record of survey in Book 1222, page 130;
THENCE: S89°53'02"E for a distance of 943.72 feet along the south line of record of survey to a point on the westerly right-of-way line of New Mexico State Highway 550;
THENCE: S00°33'59"W for a distance of 282.21 feet along said right-of-way;
THENCE: S88°54'41"W for a distance of 696.05 feet to the point of beginning, containing 5.47 acres, more or less.

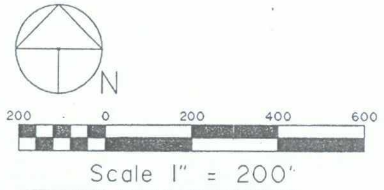
TRACT 2 - REMAINDER TRACT

A tract of land situated in the Northwest Quarter (NW1/4) of Section 3, T29N, R11W, N.M.P.M., San Juan County, New Mexico, being more particularly described as follows:

BEGINNING at the Southwest Corner of a tract of land described in Book 1415, page 916 from whence the West Quarter Corner of said Section 3 bears S00°22'35"E for a distance of 330.27 feet;

THENCE: N00°22'35"W for a distance of 337.32 feet to the Southwest Corner of the record of survey in Book 1222, page 130;
THENCE: S89°53'02"E for a distance of 1682.26 feet along the south line of record of survey;
THENCE: S39°29'18"E for a distance of 385.26 feet;
THENCE: S88°54'41"W for a distance of 1925.39 feet to the point of beginning, containing 13.18 acres, more or less.

The land which is the subject of this plat may lie within an area which is subject to the extra-territorial planning and platting jurisdiction of a municipality as [illegible] as the jurisdiction of San Juan County. [illegible] should therefore contact the [illegible]ate city authority to assure com[illegible].



Scale 1" = 200'

CHENEY-WALTERS-ECHOLS INC.
ENGINEERS · SURVEYORS
909 W. APACHE · FARMINGTON, NEW MEXICO 87401 · (505)327-3303

ISSUE DATE: 04/13/2007 - GTW
PRINTED: April 30, 2007
FILE: \\Gtw\d\2007GTW\07423EXE1.dwg

200707711 05/10/2007 03:06P K-5
1of1 B1454 P1048 R 11.00
San Juan County, NM Clerk FRAN HANHARDT

OWNERS CERTIFICATE OF INTENT

WE, BASIN DISPOSAL, INC., A NEW MEXICO CORPORATION, CLAIM AN EXEMPTION FROM THE REQUIREMENTS OF THE NEW MEXICO SUBDIVISION ACT AND THE SAN JUAN COUNTY SUBDIVISION REGULATIONS FOR THE FOLLOWING REASON(S). WE CERTIFY THAT THIS TRANSACTION INVOLVES:

> THE SALE, LEASE OR OTHER CONVEYANCE OF A SINGLE PARCEL FROM A TRACT OF LAND, EXCEPT FROM A TRACT WITHIN A PREVIOUSLY APPROVED SUBDIVISION, WITHIN ANY FIVE (5) YEAR PERIOD; PROVIDED THAT A SECOND OR SUBSEQUENT SALE, LEASE OR OTHER CONVEYANCE FROM THE SAME TRACT OF LAND WITHIN FIVE (5) YEARS OF THE FIRST SALE, LEASE OR OTHER CONVEYANCE SHALL BE SUBJECT TO THE PROVISIONS OF THE NEW MEXICO SUBDIVISION ACT AND THESE REGULATIONS; PROVIDED FURTHER THAT A SURVEY SHALL BE FILED WITH THE COUNTY CLERK INDICATING THE FIVE (5) YEAR HOLDING PERIOD FOR BOTH THE ORIGINAL TRACT AND THE NEWLY CREATED TRACT.

WE FURTHER CERTIFY THAT THE INFORMATION PROVIDED IN THIS CLAIM OF EXEMPTION PLAT IS TRUE AND ACCURATE AND THAT ALL DOCUMENTS PRESENTED IN SUPPORT OF MY APPLICATION FOR AN EXEMPTION ARE ORIGINALS OR ARE TRUE, COMPLETE AND CORRECT COPIES OF THE ORIGINALS.

Jerry Sandel
Jerry Sandel, President
Basin Disposal, Inc.

State of New Mexico)
) ss:
County of San Juan)

The foregoing was acknowledged before me by Jerry Sandel, President of Basin Disposal, Inc., the 1st day of May 2007.

My Commission Expires:
11/22/09
Notary Public

ANNE T. AMOS
11-22-09

ACCEPTANCE - SAN JUAN COUNTY

The Claim of Exemption shown hereon was duly submitted to the San Juan County Subdivision Review Officer/Real Estate Specialist and is hereby approved and accepted for recording, this 10th day of May, 2007.
Approval of this plat does not restrict any regulatory official from thereafter requiring a correction of errors.

Signed: Allison R. Kroeger
Subdivision Review Officer/
Real Estate Specialist

The land which is the subject of this plat may lie within an area which is subject to the extra-territorial planning and platting jurisdiction of a municipality as well as the jurisdiction of San Juan County. You should therefore contact the appropriate city authority to assure compliance.

ACCEPTANCE BY THE CITY OF BLOOMFIELD

This re-plat/lot-split/land-split, shown hereon was duly submitted to the City of Bloomfield, New Mexico, Planning/Zoning Administrator and is hereby approved and accepted for recording this 2 day of May, 2007.

Planning and Zoning Administrator
City of Bloomfield, New Mexico

Seal:

OFFICIAL SEAL
City of Bloomfield
STATE OF NEW MEXICO

CERTIFICATION

I, George T. Walters, a New Mexico Professional Surveyor certify that I conducted and am responsible for this Survey Plat, that this Survey is true and correct to the best of my knowledge and belief, and that this Survey Plat meets the Minimum Standards for Surveying in New Mexico.
I further certify that this is not a subdivision as defined in the New Mexico Subdivision Act and that this is an exempt division of land.

5-1-07
Date

George T. Walters
George T. Walters
Professional Land Surveyor No. 6159
State of New Mexico

6159

APPLICATION FOR MODIFICATION
BASIN DISPOSAL, INC.
OIL FIELD WASTE EVAPORATION PONDS

VOLUME IV: SITING AND HYDROGEOLOGY
SECTION 1: SITING CRITERIA

ATTACHMENT IV.1.A

MONTHLY AVERAGE PAN EVAPORATION (INCHES)

ATTACHMENT IV.1.A

NEW MEXICO
MONTHLY AVERAGE PAN EVAPORATION (INCHES)

	PERIOD OF RECORD	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
ABIQUIU DAM	1957-2005	0.00	0.00	6.06	7.43	9.95	11.39	10.52	8.90	7.23	5.30	3.13	2.22	72.13
AGRICULTURAL COLLEGE	1892-1959	3.01	4.00	7.89	10.20	8.65	13.99	12.33	11.16	8.31	6.28	4.35	2.89	93.06
ALAMOGORDO DAM	1939-1975	3.73	4.35	8.21	11.30	12.88	14.43	13.66	11.59	9.17	7.19	4.89	3.46	104.86
ANIMAS	1923-2005	3.87	4.91	8.29	10.78	12.36	14.25	11.60	11.07	8.54	6.71	4.69	3.61	100.68
ARTESIA 6 S	1914-2005	4.38	3.03	7.25	7.66	12.11	13.13	10.86	10.44	9.36	6.34	3.12	0.00	87.68
BITTER LAKES WL REFUGE	1950-2005	2.67	3.93	6.82	9.60	11.31	12.62	11.88	10.16	8.02	5.85	3.53	2.50	88.89
BOSQUE DEL APACHE	1914-2005	3.21	4.20	7.76	10.20	11.61	13.13	11.56	10.36	8.03	6.25	3.66	2.54	92.51
BRANTLEY DAM	1987-2005	4.65	0.00	8.62	11.77	14.61	15.46	14.19	12.22	9.88	7.97	5.77	4.34	109.48
CABALLO DAM	1938-2005	4.42	5.10	8.56	11.37	13.59	14.80	13.08	11.35	9.26	7.27	4.78	3.48	107.06
CAPULIN NATL MONUMENT	1966-1979	0.00	0.00	0.00	0.00	9.08	10.57	9.71	9.18	7.65	0.00	0.00	0.00	46.19
CLOVIS 13 N	1929-2005	3.83	4.12	6.63	8.72	10.15	11.45	11.65	9.55	7.64	5.78	3.95	3.21	86.68
COCHITI DAM	1975-2005	0.00	4.14	6.44	8.48	11.07	12.95	12.38	10.62	8.91	6.29	3.94	2.79	88.01
CONCHAS DAM	1938-2005	0.00	0.00	7.35	8.88	10.29	11.69	11.37	10.06	8.24	6.18	4.04	2.79	80.89
EAGLE NEST	1937-2005	0.00	0.00	0.00	4.91	7.67	7.83	7.07	5.87	5.30	4.31	0.00	0.00	42.96
EL VADO DAM	1923-2005	0.00	0.00	3.61	5.43	7.46	8.84	8.52	6.91	5.66	3.84	1.72	0.00	51.99
ELEPHANT BUTTE DAM	1917-2005	3.47	4.87	8.61	12.22	14.94	16.37	14.15	12.05	9.78	7.70	4.91	3.34	112.41
ESTANCIA	1914-2005	0.00	0.00	3.26	6.79	8.56	9.27	8.61	7.10	5.60	3.82	2.62	0.00	55.63
FARMINGTON AG SCIENCE C	1978-2005	0.00	0.00	0.00	7.97	10.06	12.00	12.52	10.70	8.15	5.41	0.00	0.00	66.81
FLORIDA	1939-1992	3.54	4.81	8.10	10.94	13.03	14.80	11.84	10.10	8.51	6.58	4.57	3.11	99.93
GALLUP RANGER STN	1966-1975	0.00	0.00	0.00	6.61	9.31	12.12	10.50	8.70	7.95	5.07	2.20	0.00	62.46
JEMEZ DAM	1953-2005	0.00	0.00	0.00	9.91	12.27	13.95	14.29	11.45	9.80	6.72	3.65	0.00	82.04
JORNADA EXP RANGE	1925-2005	2.50	4.18	7.24	10.06	11.94	12.85	10.88	9.53	7.82	5.71	3.61	2.50	88.82
LAGUNA	1914-2005	0.00	0.00	0.00	8.47	9.33	11.98	10.76	8.88	6.83	5.00	1.98	0.00	63.23
LAKE AVALON	1914-1979	4.49	5.33	9.42	12.36	14.31	15.16	14.14	12.33	9.25	7.26	4.68	4.20	112.93
LAKE MC MILLAN	1941-1949	0.00	0.00	0.00	13.78	8.14	14.26	13.38	13.45	10.35	6.15	0.00	0.00	79.51
LOS LUNAS 3 SSW	1923-2005	1.87	2.81	5.27	7.77	9.74	10.49	10.06	8.67	6.58	4.64	2.75	2.45	73.10
NARROWS	1948-1964	3.09	5.67	7.62	11.07	13.37	15.44	13.07	11.42	9.97	7.20	4.32	2.64	104.88
NAVAJO DAM	1963-2005	0.00	0.00	0.00	6.58	9.10	11.07	11.24	9.66	7.22	4.74	0.00	0.00	59.61
PORTALES 7 WNW	1934-1960	3.26	4.57	8.24	8.85	10.72	12.16	10.44	9.28	7.95	5.98	4.15	3.53	89.13
HOOD RANGER STN	1954-2005	0.00	0.00	0.00	7.84	9.02	10.81	8.25	6.87	6.12	5.14	2.65	0.00	56.70
ROSWELL WSO AIRPORT	1893-1972	0.00	0.00	0.00	11.29	0.00	15.87	12.11	12.63	7.92	6.97	4.66	4.51	75.96
SANTA FE	1867-1972	0.00	0.00	3.00	7.28	8.73	10.93	9.95	8.26	7.15	5.10	2.50	0.00	62.90
SANTA FE 2	1972-2005	0.00	0.00	0.00	7.10	9.76	11.31	10.36	9.20	7.41	5.08	0.00	0.00	60.22
SHIPROCK	1926-2005	0.00	0.00	0.00	7.84	10.57	14.44	13.17	10.80	9.80	6.54	0.00	0.00	73.16
SOCORRO	1914-2005	0.00	0.00	4.83	7.09	9.17	9.35	8.56	7.57	5.73	4.14	0.00	0.00	56.44
STATE UNIVERSITY	1959-2005	3.00	4.33	7.40	9.90	12.03	12.91	12.05	10.34	8.14	6.17	3.85	2.79	92.91
SUMNER LAKE	1921-2005	0.00	0.00	7.33	10.22	12.35	13.54	13.36	11.16	9.02	6.97	4.92	3.17	92.04
TUCUMCARI 4 NE	1904-2005	0.00	0.00	0.00	9.83	11.53	13.11	13.00	11.13	8.96	6.74	0.00	0.00	74.30
UTE DAM	1965-2005	4.38	4.91	7.53	8.78	10.75	10.49	10.92	9.42	7.56	6.68	4.98	3.04	89.44

Western Regional Climate Center, wrcc@dri.edu

APPLICATION FOR MODIFICATION
BASIN DISPOSAL, INC.
OIL FIELD WASTE EVAPORATION PONDS

VOLUME IV: SITING AND HYDROGEOLOGY
SECTION 1: SITING CRITERIA

ATTACHMENT IV.1.B

PERIOD OF RECORD MONTHLY CLIMATE SUMMARY

(Farmington AG Science Center, NM)

Attachment IV.1.B

FARMINGTON AG SCIENCE C, NEW MEXICO (293142)

Period of Record Monthly Climate Summary

Period of Record : 5/ 1/1978 to 12/31/2008

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	41.9	48.2	57.4	66.1	75.8	86.7	91.0	87.6	80.5	68.0	53.4	42.6	66.6
Average Min. Temperature (F)	19.3	24.2	29.9	36.1	44.8	53.3	60.0	58.5	51.0	39.4	28.2	19.9	38.7
Average Total Precipitation (in.)	0.52	0.57	0.75	0.67	0.58	0.21	0.90	1.10	1.06	0.91	0.76	0.48	8.51
Average Total SnowFall (in.)	2.8	3.7	1.0	0.2	0.0	0.0	0.0	0.0	0.0	0.2	0.5	2.9	11.3
Average Snow Depth (in.)	0	0	0	0	0	0	0	0	0	0	0	0	0

Percent of possible observations for period of record.
Max. Temp.: 99.2% Min. Temp.: 99.2% Precipitation: 99.2% Snowfall: 96.8% Snow Depth: 93.2%
Check Station Metadata or Metadata graphics for more detail about data completeness.

Western Regional Climate Center, wrcc@dri.edu

APPLICATION FOR MODIFICATION
BASIN DISPOSAL, INC.
OIL FIELD WASTE EVAPORATION PONDS

VOLUME IV: SITING AND HYDROGEOLOGY
SECTION 1: SITING CRITERIA

ATTACHMENT IV.1.C
PERIOD OF RECORD GENERAL CLIMATE SUMMARY – TEMPERATURE
(Farmington AG Science Center, NM)

Attachment IV.1.C
FARMINGTON AG SCIENCE C, NEW MEXICO
Period of Record General Climate Summary - Temperature

Station:(293142) FARMINGTON AG SCIENCE C

From Year=1978 To Year=2008

	Monthly Averages			Daily Extremes				Monthly Extremes				Max. Temp.		Min. Temp.	
	Max.	Min.	Mean	High	Date	Low	Date	Highest Mean	Year	Lowest Mean	Year	>= 90 F	<= 32 F	<= 32 F	<= 0 F
	F	F	F	F	dd/yyyy or yyyymmdd	F	dd/yyyy or yyyymmdd	F	-	F	-	# Days	# Days	# Days	# Days
January	41.9	19.3	30.6	66	17/2000	-8	30/1979	37.9	2003	23.9	2008	0.0	4.2	29.7	0.5
February	48.2	24.2	36.2	70	27/1986	-14	07/1989	43.3	1995	31.0	1982	0.0	1.0	24.2	0.2
March	57.4	29.9	43.6	82	21/2004	3	03/2002	49.9	2004	38.8	1987	0.0	0.1	19.7	0.0
April	66.1	36.1	51.1	86	30/1992	16	02/1979	56.6	2002	44.9	1983	0.0	0.0	9.2	0.0
May	75.8	44.8	60.3	97	30/2000	23	03/2008	65.2	2006	55.9	1983	0.9	0.0	1.5	0.0
June	86.7	53.3	70.0	100	26/1981	32	05/1999	75.1	2002	66.3	1983	12.1	0.0	0.0	0.0
July	91.0	60.0	75.5	103	07/1989	44	25/1981	80.3	2003	71.6	1992	20.6	0.0	0.0	0.0
August	87.6	58.5	73.1	99	06/1983	27	08/1984	76.4	2003	63.5	1984	12.0	0.0	0.0	0.0
September	80.5	51.0	65.7	97	02/1995	28	29/1999	69.8	1998	61.0	2006	2.2	0.0	0.2	0.0
October	68.0	39.4	53.7	87	02/2003	15	30/1989	58.5	2003	47.0	1984	0.0	0.0	5.6	0.0
November	53.4	28.2	40.8	75	07/1999	4	30/2006	45.4	1999	34.8	1992	0.0	0.2	20.9	0.0
December	42.6	19.9	31.2	64	02/1995	-16	24/1990	37.1	1980	22.9	1990	0.0	3.2	29.6	0.5
Annual	**66.6**	**38.7**	**52.7**	**103**	**19890707**	**-16**	**19901224**	**54.7**	**2003**	**50.6**	**1982**	**47.8**	**8.7**	**140.8**	**1.1**
Winter	44.2	21.1	32.7	70	19860227	-16	19901224	37.0	1995	26.9	1979	0.0	8.4	83.5	1.1
Spring	66.4	36.9	51.7	97	20000530	3	20020303	55.9	1989	47.5	1983	0.9	0.1	30.4	0.0
Summer	88.5	57.3	72.9	103	19890707	27	19840808	75.7	2003	69.4	1984	44.6	0.0	0.1	0.0
Fall	67.3	39.5	53.4	97	19950902	4	20061130	57.2	2001	51.0	1993	2.2	0.2	26.8	0.0

Table updated on Apr 28, 2009

For monthly and annual means, thresholds, and sums:

Months with 5 or more missing days are not considered

Years with 1 or more missing months are not considered

Seasons are climatological not calendar seasons

Winter = Dec., Jan., and Feb. Spring = Mar., Apr., and May

Summer = Jun., Jul., and Aug. Fall = Sep., Oct., and Nov.

APPLICATION FOR MODIFICATION
BASIN DISPOSAL, INC.
OIL FIELD WASTE EVAPORATION PONDS

VOLUME IV: SITING AND HYDROGEOLOGY
SECTION 1: SITING CRITERIA

ATTACHMENT IV.1.D
PERIOD OF RECORD GENERAL CLIMATE SUMMARY – TEMPERATURE
(Aztec Ruins National Monument, NM)

Attachment IV.1.D
AZTEC RUINS NATL MONUME, NEW MEXICO
Period of Record General Climate Summary - Temperature

Station:(290692) AZTEC RUINS NATL MONUME

From Year=1895 To Year=2008

	Monthly Averages			Daily Extremes				Monthly Extremes				Max. Temp.		Min. Temp.	
	Max.	Min.	Mean	High	Date	Low	Date	Highest Mean	Year	Lowest Mean	Year	>= 90 F	<= 32 F	**<= 32 F**	<= 0 F
	F	F	F	F	dd/yyyy or yyyymmdd	F	dd/yyyy or yyyymmdd	F	-	F	-	# Days	# Days	**# Days**	# Days
January	43.2	15.3	29.3	69	01/1981	-23	07/1971	38.1	1956	14.8	1937	0.0	3.1	**30.1**	2.6
February	49.5	20.4	35.0	78	21/1958	-27	08/1933	42.6	1995	21.2	1933	0.0	0.9	**26.3**	0.7
March	58.2	25.5	41.8	82	10/1989	-3	03/2002	49.1	2004	35.5	1897	0.0	0.1	**25.7**	0.0
April	67.8	32.1	50.0	89	30/1943	10	04/1955	55.6	1946	44.4	1975	0.0	0.0	**15.4**	0.0
May	77.1	40.5	58.8	98	31/2002	12	07/1975	64.4	1934	53.4	1930	0.9	0.0	**3.7**	0.0
June	86.9	48.6	67.8	103	22/1954	24	09/1974	72.9	1959	61.6	1945	11.5	0.0	**0.2**	0.0
July	91.2	56.9	74.1	105	13/1971	39	19/1897	77.0	1966	69.5	1897	21.1	0.0	**0.0**	0.0
August	88.6	55.7	72.2	105	04/1960	36	28/1920	75.5	1970	68.2	1989	14.1	0.0	**0.0**	0.0
September	81.7	47.2	64.5	100	13/2008	22	20/1978	70.0	1960	60.5	2006	2.7	0.0	**0.7**	0.0
October	70.1	36.0	53.1	92	12/1928	10	31/1900	59.3	1963	47.8	1984	0.0	0.0	**9.5**	0.0
November	55.1	24.2	39.7	80	09/1947	-7	23/1931	45.2	1999	33.0	1938	0.0	0.2	**25.7**	0.1
December	43.9	16.3	30.1	67	02/1926	-24	25/1924	36.2	1946	17.1	1898	0.0	3.1	**29.9**	2.1
Annual	**67.8**	**34.9**	**51.4**	**105**	**19600804**	**-27**	**19330208**	**53.9**	**1954**	**48.2**	**1897**	**50.4**	**7.4**	**167.1**	**5.6**
Winter	45.5	17.3	31.4	78	19580221	-27	19330208	36.9	1995	21.0	1899	0.0	7.1	**86.3**	5.4
Spring	67.7	32.7	50.2	98	20020531	-3	20020303	55.1	1934	46.0	1975	0.9	0.1	**44.8**	0.0
Summer	88.9	53.7	71.3	105	19600804	24	19740609	74.1	1981	68.0	1949	46.7	0.0	**0.2**	0.0
Fall	69.0	35.8	52.4	100	20080913	-7	19311123	57.0	1963	49.8	1930	2.7	0.2	**35.9**	0.1

Table updated on Apr 28, 2009
For monthly and annual means, thresholds, and sums:
Months with 5 or more missing days are not considered
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Seasons are climatological not calendar seasons

Winter = Dec., Jan., and Feb. Spring = Mar., Apr., and May
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Western Regional Climate Center, wrcc@dri.edu

APPLICATION FOR MODIFICATION
BASIN DISPOSAL, INC.
OIL FIELD WASTE EVAPORATION BASINS

VOLUME IV: SITING AND HYDROGEOLOGY
SECTION 2: HYDROGEOLOGY

- JOHN SHOMAKER & ASSOCIATES, INC., SEPTEMBER 2008, SUBSURFACE AND GROUNDWATER INVESTIGATION IN SUPPORT OF THE MODIFICATION OF A SURFACE WASTE MANAGEMENT FACILITY, BASIN DISPOSAL, INC., BLOOMFIELD, NM

- JOHN SHOMAKER & ASSOCIATES, INC., NOVEMBER 2008, RESULTS FROM WATER-QUALITY TESTING OF ASSESSMENT WELL NO. 2 AT BASIN DISPOSAL, INC., BLOOMFIELD, SAN JUAN COUNTY, NM

- JOHN SHOMAKER & ASSOCIATES, INC., MAY 2009, GROUNDWATER AND POND WATER COMPARISON AT BASIN DISPOSAL, INC., BLOOMFIELD, NM

SUBSURFACE AND GROUND-WATER INVESTIGATION IN SUPPORT OF THE MODIFICATION OF A SURFACE WASTE MANAGEMENT FACILITY
BASIN DISPOSAL, INC.
BLOOMFIELD, NEW MEXICO

by

Erwin Melis, PhD

Roger Peery, CPG

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2611 Broadbent Parkway NE
Albuquerque, New Mexico 87107

prepared for

Basin Disposal, Inc.
Aztec, New Mexico

September 2008

SUBSURFACE AND GROUND-WATER INVESTIGATION IN SUPPORT OF THE MODIFICATION OF A SURFACE WASTE MANAGEMENT FACILITY
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SUBSURFACE AND GROUND-WATER INVESTIGATION IN SUPPORT OF THE MODIFICATION OF A SURFACE WASTE MANAGEMENT FACILITY, BASIN DISPOSAL, INC., BLOOMFIELD, NEW MEXICO

1.0 INTRODUCTION

John Shomaker & Associates, Inc. (JSAI) was contracted by Basin Disposal, Inc. to perform a hydrogeologic investigation of the northern part of the Basin Disposal 30-acre property at 500 Montana, Bloomfield, New Mexico. The subject property is located within the city limits of Bloomfield, about 4 miles north of center of Bloomfield, and west of New Mexico Highway 544 connecting Bloomfield and Aztec (Fig. 1). Basin Disposal collects produced water from oil and gas wells in the area, processes it, and conveys it into an evaporation pond, before the saline water is filtered and then injected into a deep aquifer using an injection well. Basin Disposal would like to expand its current storage capacity and construct one or two new evaporation ponds, and hydrogeologic and pedologic data pertaining to the Site are required by New Mexico Administrative Code (NMAC 19.15.36.13), enforced by the New Mexico Energy, Minerals and Natural Resources Department, Oil Conservation Division (NMOCD).

JSAI has completed a hydrogeologic and pedologic investigation of the Basin Disposal Site. The investigation was conducted in accordance with the NMOCD approved workplan of May 13, 2008 (JSAI, 2008) between May 19 and May 26, 2008. NMOCD Environmental Engineer Brad A. Jones was present on-site during the investigation from May 19, 2008 through May 23, 2008.

1.1 Background

The Basin Disposal facility was constructed in 1985 and operates as a "Commercial Surface Waste Management Facility" with permit number NM-1-005 (order date of October 16, 1987). JSAI performed an initial site visit of the Basin Disposal Site during February 2008. Based on this visit, JSAI submitted a workplan to the NMOCD detailing drilling and coring operations at the Site to gather hydrogeologic data. The workplan was approved on May 13, 2008 (JSAI, 2008). Drilling and coring commenced on May 19, 2008.

This hydrogeologic report uses the results of the on-site investigation, other site-based information from Basin Disposal, preliminary engineering drawings provided by C-W-E, Inc., and published and unpublished regional hydrogeologic data.

1.2 Objective

The primary objectives of the investigation at Basin Disposal were as follows: 1) to determine whether a 50-ft separation exists between the lowest ground elevation of the proposed evaporation pond and the ground-water table, pursuant to Regulation 19.15.36.13 NMAC, 2) to characterize the alluvium and bedrock at the Site and obtain samples for laboratory geotechnical analysis, and 3) to determine the quality of shallow ground water, if it is present.

2.0 METHODS

This hydrogeologic investigation at the Basin Disposal Site began on May 19, 2008 and is summarized below:

1. A total of four (4) boreholes (BH-1 through BH-4) were drilled by Hydrogeological Services of Albuquerque, New Mexico, with a single rig using a combination of hollow-stem auger drilling and direct-air rotary coring at approved locations with clean equipment. Boreholes BH-1 and BH-4 were completed as ground-water initial assessment wells AW-1 and AW-2, respectively (Fig. 2).
2. Continuous soil samples (alluvium) were collected using split-spoon sampling methods at BH-1 (AW-1), BH-2, and BH-3. Continuous core samples were collected from bedrock below the alluvium. Alluvium samples, drill cuttings, and core samples were described by JSAI personnel in the field (Appendix A). NMOCD's Brad Jones collected samples at selected intervals; these intervals are marked in Appendix A. BH-4 (AW-2) is 20 ft west of BH-2 and was not sampled.
3. Several split-spoon samples were collected at the AW-1 location from the 6 to 8.5 feet below ground level (ft bgl) interval. Two of these samples were submitted to Vinyard & Associates Engineering Consultants of Albuquerque, New Mexico for hydraulic conductivity, plasticity, moisture content, and pore volume analysis.

4. Initial assessment wells AW-1 and AW-2 were completed at the two sites where either shallow ground water in the alluvium or moisture in clay lenses was present. Wells were completed with 2-inch schedule 40 PVC, flush-threaded casing, and 10 ft of 0.010-inch wide manufactured screen. The screened interval was set to span the water table as measured at the time of construction. The annulus from the bottom of the screen to about 10 ft above the screen was filled with 10-20 gradation silica sand, above which about 10 ft of bentonite was emplaced in order to prevent surface-water infiltration and contamination. Wellheads were completed using above ground completion, and both well casings were secured with locking caps. Well completion diagrams are presented as Figure 8 and 9.
5. Initial assessment wells were developed using dedicated, disposable bailers on May 27 and May 29, 2008. Field measurements consisting of pH, specific conductance, and temperature of produced water were periodically measured throughout well development and purging.
6. After the water level in the wells recovered, depth to water was measured to the nearest 0.01 ft. Water-quality samples were collected after purging three well volumes and submitted to Hall Environmental Analysis Laboratory for analysis.

3.0 GEOGRAPHY

The Basin Disposal Site is located within the northwest quarter of Section 3, Township 29 North, Range 11 West (Fig. 1). The Site lies about 4 miles north of the San Juan River, and about 6 miles south of the Animas River on Crouch Mesa, about 500 ft and 400 ft above the respective river plains. The Site occupies the West Fork of Bloomfield Canyon, an ephemeral drainage that drains south to the San Juan River; the Site slopes gently to the east and southeast, from a maximum elevation of 5,750 ft to less than 5,700 ft. Based on our review of preliminary engineering drawings, the elevation of the base of the lowest evaporation pond is located approximately 5,709 ft above mean sea level (amsl), with a sump at approximately 5,704 ft amsl. The final design may have the base of the sump as low as 5,700 ft amsl (personal communication, John Volkerding).

4.0 HYDROGEOLOGY

The Basin Disposal Site is located within the San Juan Basin, a large Late Cretaceous to Early Tertiary-aged elliptical-shaped basin related to sedimentary deposition outboard of continental convergence along the Pacific margin. The San Juan Basin consists of about 12,000 ft of Early Tertiary- and Mesozoic-age sedimentary rocks, on top of about 2,500 ft of Paleozoic-age sedimentary rocks all tilted in toward a point more than 40 miles east-southeast of Bloomfield (Stone et al., 1983). Figure 3 presents a geologic map showing the Basin Disposal Site and the surrounding area. Figure 4 presents a general west to east geologic cross-section, whereas Figure 5 is a detailed geologic cross-section through the Site. At the Site, a relatively thin layer of alluvium overlies the Paleocene-aged Nacimiento Formation. The alluvium regionally consists of clay, silt, sand, and gravel (Brown and Stone, 1979). The Nacimiento Formation consists of white, medium- to coarse-grained, arkosic sandstones, alternating with grey to black mudstones. The total thickness of the Nacimiento Formation regionally ranges from 418 to 2,232 ft, but at the Conoco-Phillips Martin 3 No. 1 gas well, about 500 ft northwest of the Site (Fig. 2), the Tertiary section, including the Nacimiento Formation is noted to be less than 845 ft (NMOCD, 2008). Beds within the Nacimiento Formation dip very slightly to the basin center, or to the southeast (Brown and Stone, 1979). Immediately below the Nacimiento Formation lie 81 to 96 ft of Tertiary-aged Ojo Alamo Sandstone (NMOCD, 2008), followed by at least 1,100 ft of the Cretaceous-aged Fruitland Formation-Kirtland Shale (Stone et al., 1983).

Records of wells within a 6- to 10-mile radius show few completed wells away from the immediate confines of the Animas River and the San Juan River valleys and near the Basin Disposal Site. Stone et al. (1983) lists 15 bedrock wells completed into the Nacimiento Formation and 36 alluvial wells in the area. Only six of the bedrock wells and two alluvial wells are more than 2 miles from either river. The New Mexico Office of the State Engineer (NMOSE) WATERS database (WATERS) lists ten additional wells with completion dates and/or well completion information recorded within a 2-mile radius of the Site (see Appendix B for NMOSE wells). An additional six wells are recorded in WATERS that have expired permits or no completion dates. These wells may or may not have been completed. Four of the WATERS-listed well permit applications are within a 1-mile radius of the Site. Permit number SJ-01887 is expired and conceivably was never drilled. Permit numbers SJ-01995, SJ-02086, and SJ-03658 are applications to appropriate ground water with no further known information. It is possible that these wells were never drilled and completed.

Wells completed in the Nacimiento Formation range in depth from 10 to 975 ft, and average 306 ft. Reported water levels in these wells range between 2 and 280 ft bgl and average 60 ft bgl (Stone et al., 1983). Away from the rivers, water levels in bedrock wells average 127 ft bgl. Riverside alluvial wells have depths between 6 and 70 ft and average 37 ft, whereas alluvial thicknesses near the river axes average about 60 ft (Brown and Stone, 1979). Reported water levels in alluvial wells range between 3 and 45 ft bgl and average 19.6 ft bgl (Stone et al., 1983). Away from the rivers, lithologic logs in WATERS indicate between 6 and 73 ft (average 37 ft) of alluvium, whereas these wells average 143 ft in depth, suggesting that most of these wells are completed into bedrock (Appendix B). Water levels in these wells have a bimodal distribution. NMOSE-listed wells with little alluvial thickness have deeper water levels (245 ft bgl), whereas wells with larger alluvial thickness have shallower water levels (56 ft bgl). Brown and Stone (1979) reported that perched water is common in the alluvium. The closest well, NMOSE file number SJ-01851, 8,500 ft to the southeast (Fig. 3), was completed to a depth of 125 ft bgl (73 ft of alluvium); it has a water depth of 48 ft bgl and most likely produces water from both the alluvium and bedrock. Alluvial thickness at the Basin Disposal Site ranged from 10.5 ft (borehole No. 3) to 42.9 ft (AW-1), and averaged 24.8 ft (Fig. 5).

Regional ground-water elevation at the Basin Disposal Site is based on a combination of water wells listed in Stone et al. (1983) and WATERS-listed wells, and is estimated as less than 5,600 ft amsl (Fig. 6). This indicates that the regional ground-water table at the Site is deeper than 100 ft bgl and suggests that the ground-water present in AW-1 and AW-2 at the Site is perched. Other evidence of perched ground water includes dry sandstone below wet 'bridging and swelling' clays and mudstones, present in BH-2 and BH-3, and deeper water levels in bedrock wells in the area (SJ-01302, SJ-03668), and well 29.10.16.2143 (Stone et al., 1983). The potentiometric surface elevation map (Fig. 6) shows that bedrock wells and alluvial wells mostly have similar water levels where they are in close proximity to each other. These wells likely have water levels representative of the shallow aquifer because these wells draw water from both aquifers. Ground water flows to the south-southeast at the Basin Disposal Site, as is shown on the water-level elevation contour map (Fig. 6). The hydraulic gradient in the area is about 0.01 ft/ft.

4.1 Regional Water Quality

All ground water in the area has been found to have a relatively high specific conductance and a corresponding elevated total dissolved solids (TDS) concentration except where the shallow “infiltration of irrigation and river water decreases the specific conductance of [ground] water” (Stone et al., 1983). Ground-water quality in wells completed in the alluvium within a 6- to 12-mile radius of the Basin Disposal Site varies compared to wells completed in the underlying Nacimiento Formation. The average specific conductance of 23 wells completed in the Nacimiento Formation is 5,660 micromhos per centimeter (μmhos/cm), whereas the average specific conductance of 54 wells completed in the alluvium is 1,690 μmhos/cm. Chloride concentrations are as high as 4,100 milligrams per liter (mg/L) and sulfate concentrations as high as 4,300 mg/L have been noted within the Nacimiento Formation (Stone et al., 1983, table 6). Brown and Stone (1979) report that well drillers in the area avoid drilling into the Nacimiento Formation due to the presence of “salty” waters at the alluvial/bedrock contact, and poor-quality sodium-, calcium-, sulfate-rich waters within the Nacimiento Formation. Near Aztec, shallow alluvial ground water was also found to be high in TDS, sulfate, and manganese (JSAI, 2003).

4.2 Springs and Watercourses

The nearest listed spring, Peach Spring, is more than 5 miles to the north and Thurston Spring is more than 8 miles to the northeast (White and Kues, 1992). Both springs have their use listed as “stock watering” and “domestic,” and no yield is provided for either spring. Thurston Spring is sourced from the Nacimiento Formation and drains to the Animas River, away from the Basin Disposal Site (Stone et al., 1983). The source for the Peach Spring is not listed. The nearest river is the San Juan, about 4 miles south of the Basin Disposal Site. A map showing the river, springs, and the NMOSE WATERS database wells and the wells listed in table 1 of Stone et al. (1983) is included as Figure 1.

5.0 RESULTS

5.1 Borehole Depth and Lithology

Four boreholes were drilled between May 19, 2008 and May 27, 2008 on the Basin Disposal Site. Two boreholes were drilled to about 100 ft bgl to characterize the subsurface sediments and lithology and the relative moisture content. After shallow ground water was found two of the four boreholes were completed as ground-water initial assessment wells to a total depth of about 43 and 31 ft, respectively (Table 1). Locations are shown on Figure 2, and well completion details are shown on Figures 8 and 9. The lithology of each borehole was described from continuous core samples collected from three of the four boreholes. AW-2 (BH-4) was drilled and completed about 20 ft west of BH-2 after BH-2 was found to have shallow ground water. BH-2 was logged and plugged and abandoned; BH-4 was not logged.

Perched ground water was present in the alluvium at BH-1 (AW-1) 41.25 ft bgl and above the Nacimiento Formation sandstone contact at 42.90 ft bgl. Moist zones within the Nacimiento Formation siltstone and sandstone members were present in BH-2 at 25 to 30 ft bgl, at 57 ft bgl, and at 94 ft bgl. Moist zones within the Nacimiento Formation siltstone and sandstone members were present in BH-3 at 40.5 to 43.5 ft bgl, at 56.5 ft bgl, and at 80.5 ft bgl. Moist zones within the Nacimiento Formation were characterized by slightly damp horizons of less consolidated sandstone, and locally, of shale/siltstone that stuck to the inside of the core barrel. Locally, the siltstone horizons were unconsolidated, and clay coated the inside of the core barrel and the outside of the core (Figure 7). Moist zones occurred near visible fractures in the bedrock, or above lithology changes, where presumably a less permeable member of the Nacimiento Formation retards vertical ground-water flow. The alluvium in general consists of sandy loam to well graded sand with few (about 5 percent) clay members that were documented to be less than 1 ft thick. The Nacimiento Formation consists of interbedded mudstones, siltstones, and sandstones, with small amounts of coal, and arkose/conglomerate. Detailed lithologic logs are presented in Appendix A.

Table 1. Depth of borehole, lithologic thickness, and measured depth to ground water at Basin Disposal Site, Bloomfield, San Juan County, New Mexico

well name	depth of borehole, ft bgl	alluvium type	alluvial interval, ft bgl	interpreted Nacimiento Formation interval, ft	measured depth to ground water, ft bgl
BH-1/ AW-1	45.0	loamy sand	0 – 42.9	42.9 – 845	42.22
BH-2	101.0	sand and loamy sand	0 – 23.5	23.5 – 845	-
BH-3	100.0	sand fill and silt	0 – 10.5	10.5 – 845	-
BH-4/ AW-2	30.5	mostly sand	-	~25 - 845	29.25

ft bgl - feet below ground level

The unconsolidated alluvium at the Site ranges from about 10 to 43 ft bgl, and is thicker at the eastern edge of the Site, closer to the West Fork of Bloomfield Canyon drainage. The alluvium thins to the west, toward the lower slopes of Crouch Mesa rising to 5,920 ft amsl, a quarter of a mile west of the Site. Individual siltstone and sandstone members of the Nacimiento Formation, between about 3 to 37 ft thick, occur below the alluvium and are covered by an approximately 10 ft thick friable, weathered bedrock horizon.

5.2 Geotechnical Characterization of Soil Samples

Selected samples of the unconsolidated alluvium were collected during drilling using a split-spoon sampler and preserved in capped 6-inch brass sleeves. On May 19, 2008, five samples were collected at BH-1 from the interval between 6 to 8.5 ft bgl, the approximate lower elevation of the proposed evaporation pond, and stored in sealed plastic bags. Of all the samples collected from BH-1, two samples, the 6.5 to 7.0 ft bgl sample (Sample 1) and the 7.5 to 8.0 ft bgl sample (Sample 2) were selected for detailed geotechnical analysis. Sample 1 is loamy sand; Sample 2 is coarse sand. The samples were submitted to Vinyard & Associates to be analyzed for porosity, permeability, and conductivity in the laboratory according to ASTM standards D5856-95, and D4318-05 (Atterberg Limits). Testing for porosity according to ASTM standard D4044-84 (2004) was not commercially available due to the "hazardous material involved," instead laboratory density, unit weight, and moisture content were determined by standard methods, giving an estimate on the pore volume. The results are summarized in Table 2, whereas the laboratory report is attached as Appendix C.

Table 2. Summary of laboratory analyses of alluvium from borehole No. 1, Basin Disposal Site, Bloomfield, New Mexico

depth, ft bgl	BH-1/ AW-1							
	hydraulic conductivity, cm/sec	Atterberg limit tests			laboratory density[1], g/cm^3	unit weight (dry), lb/ft^3	moisture content, percent	pore volume, percent
		liquid limit	plastic limit	plasticity index[2]				
6.5 – 7.0	2.83E-3	-	non-plastic	NA	2.5	89.9	8.3	43.6
7.5 – 8.0	2.80E-3	-	non-plastic	NA	2.5	89.5	8.2	45.0

[1] – assumed specific gravity
ft bgl - feet below ground level
g/cm^3 - grams per cubic centimeter
N/A - not applicable

[2] plasticity index - range between liquid and plastic limit
cm/sec - centimeters per second
lb/ft^3 - pound per cubic foot

The two soil samples from BH-1 (AW-1) were classified in the field as loamy sand and coarse sand, or well-graded sands, with little or no fines. The obtained porosity or pore volume (n) corresponds to a void ratio (e), or the ratio of the void volume to solids volume (total volume minus void volume) of between 0.77 and 0.82. This indicates the volume of all air and water-filled voids as a percentage of the total volume of the core sample. The dry unit weight (γ_d) is equal to the weight of the solids in the sample over the total volume of the sample, and the three parameters, porosity, void ratio, and dry unit weight of the two samples, are typical for loose, uniform sand (Peck et al., 1974), confirming our field classification. Strength and compressibility were not calculated from these parameters. The average hydraulic conductivity (per ASTM D5856-95) of the samples compares with an approximate coefficient of permeability of 10^{-2} centimeters per second (cm/s) for sand (table 2-2; Scott and Schoustra, 1968). Atterberg limit tests for the two samples detected no plastic limit, or no appreciable clay content to the samples. Correspondingly, there is no liquid limit for the sample.

5.3 Well Development

The ground-water initial assessment wells were developed using dedicated, disposable bailers on May 27 and May 29, 2008. The depth to water, pH, specific conductance, and temperature of produced water were measured before development and periodically throughout development. Water levels in the two initial assessment wells were fairly constant, although AW-2 was bailed dry after about 4 well volumes on May 29, 2008; however, water was present in the well after 5 minutes. AW-1 had a pre-development water level of 42.37 ft bgl on May 27, 2008, and a water level of 41.88 ft bgl on May 29, 2008; AW-2 had a pre-development water level of 29.25 ft bgl on May 29, 2008, and a water level of 29.60 ft bgl 100 minutes after development. Specific conductance in AW-1 slowly increased during bailing, whereas pH, specific conductance and temperature in AW-2 stabilized quickly.

5.4 Depth to Water of the Shallow Ground Water

Depths to water were measured on May 27 and 29, 2008 prior to development and again prior to sampling. Sampling occurred on 2 days. AW-1 was sampled for inorganics on May 27, 2008, and for organics on May 29, 2008. On May 29, 2008 water was present in AW-2 and it was sampled for some selected inorganics. Well completion depths, screen intervals, ground surface elevations, and water elevations are reported in Table 3. Initial assessment well elevations were determined on a U.S. Geological Survey topographic map from locations that were plotted using a handheld Garmin® GPS unit. Depth to water for the two initial assessment wells shows shallower water levels to the west and deeper water levels at the eastern end of the Basin Disposal Site (Table 1; Fig. 5). Regional ground-water-flow direction is presumed to be to the southeast with an unknown local ground-water gradient due to the apparent disconnectedness of the perched ground-water lenses.

Table 3. Total depth, ground-surface elevation, top of casing, depth to water, and water-level elevations of completed initial assessment wells, Basin Disposal Site, Bloomfield, New Mexico

	UTM coordinates, m easterly[1]	UTM coordinates, m northerly[1]	total depth of well, ft bgl	screen interval, ft bgl	ground-surface elevation, ft amsl	top of casing, ft agl	water level on 5/29/08, ft bgl	ground-water elevation, ft amsl
AW-1	233,845	4,071,760	45.0	33.0 – 43.1	~5,715.0	2.5	42.22	5,669.8
AW-2	233,652	4,071,721	30.0	20.0 – 30.0	~5,719.0	2.9	29.60	5,689.8

[1] reference is NAD 1927
m - meters
ft bgl - feet below ground level
ft agl - feet above ground level
ft amsl - feet above mean sea level

5.5 Site Ground-Water Quality

Field water-quality data for initial assessment wells AW-1 and AW-2 (Table 4) indicate extremely elevated values of specific conductance when compared to the background water-quality data obtained from Stone et al. (1983; table 1 and table 6). AW-1 shows slightly higher specific conductance values than AW-2, in addition to increasing specific conductance values during bailing. Water from AW-2 had consistently high, but precise specific conductance values. A lacquer-like odor was detected during drilling of the nearby BH-2, but was not detected in AW-2 (BH-4).

Table 4. Summary of field analyses of specific conductance, pH, and temperature on May 29, 2008 in Basin Disposal AW-1 and AW-2, Bloomfield, New Mexico

	specific conductance, µS/cm	pH	temperature, °C
AW-1	31,900 ± 30	7.31	16.8
AW-2	26,600 ± 30	7.80	19.1

°C - degrees Celsius µS/cm - microSiemens per centimeter

A laboratory analysis of water from AW-2 indicated no significant differences in metals concentrations compared to water produced from AW-1, indicating that the ground water at both initial assessment wells, one within the alluvium, the other a bedrock well, is similar. Only water from AW-1 was analyzed according to U.S. Environmental Protection Agency (EPA) method 8021B, EPA method 8015B-GRO, and EPA method 8015B-DRO. Water from AW-2 was not analyzed for organic compounds. Ground water collected from AW-1 yielded concentrations of these organics below the laboratory detection limit (see Table 5).

Water produced from AW-1 had elevated concentrations of TDS, chloride, fluoride, nitrate, sulfate, and lead (EPA method 6010 measures total recoverable metals) when compared to the New Mexico Water Quality Control Commission (NMWQCC) standards (see Table 6). The high TDS concentration resulted in elevated detection limits for some parameters, and as a result, detection limits for arsenic, cadmium, and chromium concentrations are above the applicable NMWQCC standards (Table 6). The laboratory report and chain-of-custody documentation are attached as Appendix D.

Table 5. Summary of laboratory analyses of selected organic compounds in ground-water samples from AW-1, Basin Disposal Site, Bloomfield, New Mexico

constituent	unit	AW-1	NMWQCC standards
date sampled		5/29/2008	
diesel range organics	mg/L	<1.0	no standard
motor range organics	mg/L	<5.0	no standard
gasoline range organics	mg/L	<0.050	no standard
MTBE	µg/L	<2.5	no standard
benzene	µg/L	<1.0	10 µg/L
toluene	µg/L	<1.0	750 µg/L
ethylbenzene	µg/L	<1.0	750 µg/L
total xylenes	µg/L	<2.0	620 µg/L
1, 2, 4-trimethylbenzene	µg/L	<1.0	no standard
1, 3, 5-trimethylbenzene	µg/L	<1.0	no standard

NMWQCC - New Mexico Water Quality Control Commission
mg/L - milligrams per liter
µg/L - micrograms per liter
MTBE - methyl tertiary butyl ether

Table 6. Summary of water-quality analysis results from AW-1 and AW-2, sampled at the Basin Disposal Site, Bloomfield, San Juan County, New Mexico

constituent	unit	AW-1	AW-2	NMWQCC discharge standards
date sampled		5/27/2008	5/29/2007	
TDS	mg/L	**38,000**	**24,000**	1,000
bromide	mg/L	6.3	NA	no standards
chloride	mg/L	**2,300**	NA	250
fluoride	mg/L	**1.7**	NA	1.6
nitrate	mg/L	**11**	NA	10 (total)
phosphorus	mg/L	<5.0	NA	no standards
sulfate	mg/L	**18,000**	NA	600
arsenic (total)	mg/L	<0.20	<0.20	0.10
barium	mg/L	<0.20	<0.20	1.0
cadmium	mg/L	<0.020	<0.020	0.01
calcium	mg/L	480	490	no standard
chromium	mg/L	<0.060	<0.060	0.05
lead	mg/L	**0.098**	<0.050	0.05
magnesium	mg/L	300	170	no standard
mercury	mg/L	<0.00020	NA	0.002
potassium	mg/L	15	39	no standard
selenium	mg/L	<0.50	<0.50	0.05
silver	mg/L	<0.050	<0.050	0.05
sodium	mg/L	10,000	7,800	no standard

[1] - action level for public water supply systems

NMWQCC - New Mexico Water Quality Control Commission

bold - result exceeds standard

TDS - total dissolved solids

mg/L - milligrams per liter

NA - not analyzed

6.0 CONCLUSIONS

The following conclusions are based on the findings from the ground-water investigation at the Basin Disposal Site.

1. Initial assessment wells AW-1 and AW-2 produced ground water with TDS concentrations of 38,000 mg/L and 24,000 mg/L, respectively. These are above the TDS concentration of 10,000 mg/L for fresh water (to be protected), per NMAC 19.15.36.8 C. (15) (b), as defined in NMAC 19.15.1.7 F. (3). Therefore, the shallow ground-water system is not within the jurisdiction of the NMOCD.
2. Initial assessment well AW-1 produced ground water with elevated concentrations of TDS, chloride, fluoride, nitrate, sulfate, and lead. Concentrations of total arsenic, cadmium, and chromium were below laboratory detection limits; however, the detection limit was above NMWQCC standards. Benzene, toluene, ethylbenzene, and xylenes (BTEX), gasoline range organics, and diesel range organics concentrations were below the laboratory detection limits, which are below NMWQCC standards.
3. At three of the four boreholes, there is less than 50 ft separation between the shallow ground water and the base of the proposed evaporation pond. However, the shallow ground water is perched. The estimated depth to the regional ground water is greater than 100 ft bgl, with a corresponding elevation of below 5,600 ft amsl. There is a 50 ft separation between the regional water table and the lowest proposed elevation of the new evaporation pond. The regional ground-water flow direction is to the south-southeast.
4. The Site is underlain by 10 to 43 ft of loamy sand alluvium, 10 to 16 ft of weathered (friable) Nacimiento Formation, and more than 82.5 ft of dry Nacimiento Formation consisting of alternating siltstone and sandstone, that are locally fractured, and are moist at or above lithologic and structural contacts. At the Basin Disposal Site, the Nacimiento Formation is less than 845 ft thick.
5. No known ground-water supply wells are within a 1-mile radius of the Site. The NMOSE WATERS database has records of three "applications to appropriate ground water" and one expired drilling permit in a 1-mile radius of the Basin Disposal Site. It is possible that these wells were never drilled and completed.
6. Laboratory results for the well-sorted sandy alluvium at the Basin Disposal Site indicate that the hydraulic conductivity is about 8.0 ft/day.

7.0 REFERENCES

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ILLUSTRATIONS

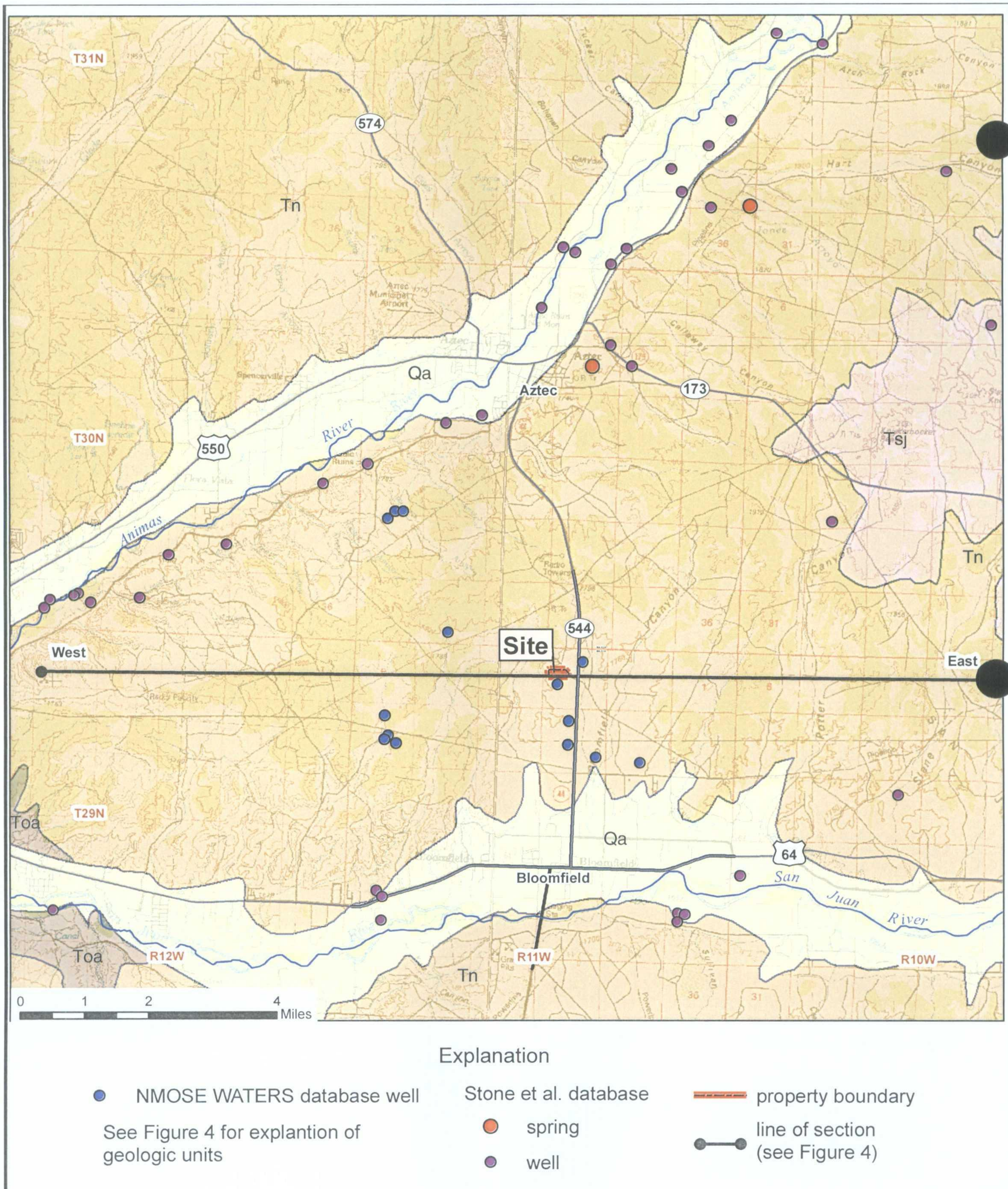


Figure 1. Geologic map showing geographic features, including streams, springs, and water wells from the NM[illegible] WATERS database and Stone et al. (1983), and the line of section of the general cross-section near the Basin Disposal Site, Bloomfield, New Mexico.

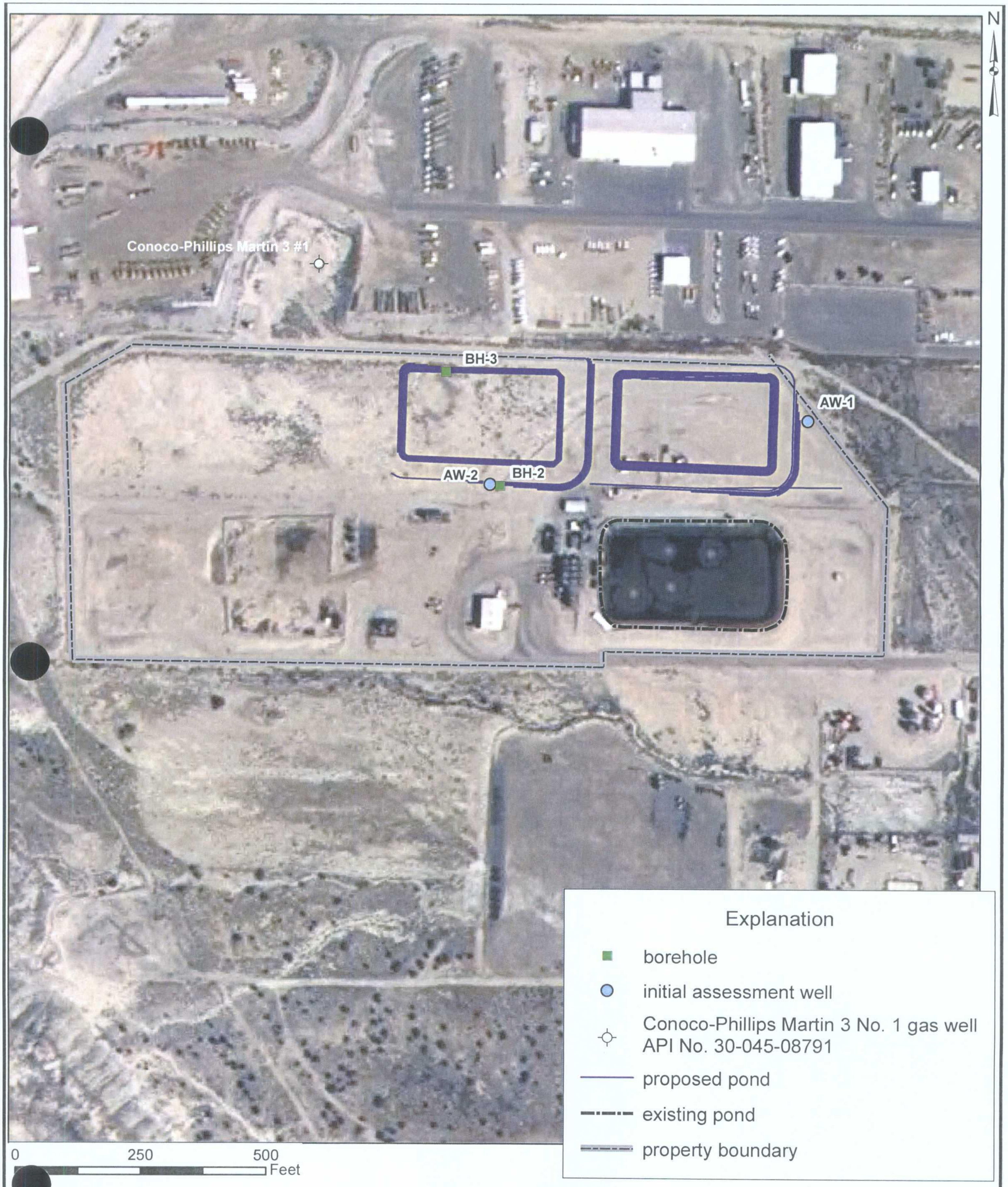


Figure 2. Aerial photograph showing the locations of the existing pond, the drilled boreholes, initial assessment wells proposed evaporation ponds, and well site of the Conoco-Phillips Martin 3 No. 1, Basin Disposal Site, Bloomfield, New Mexico.

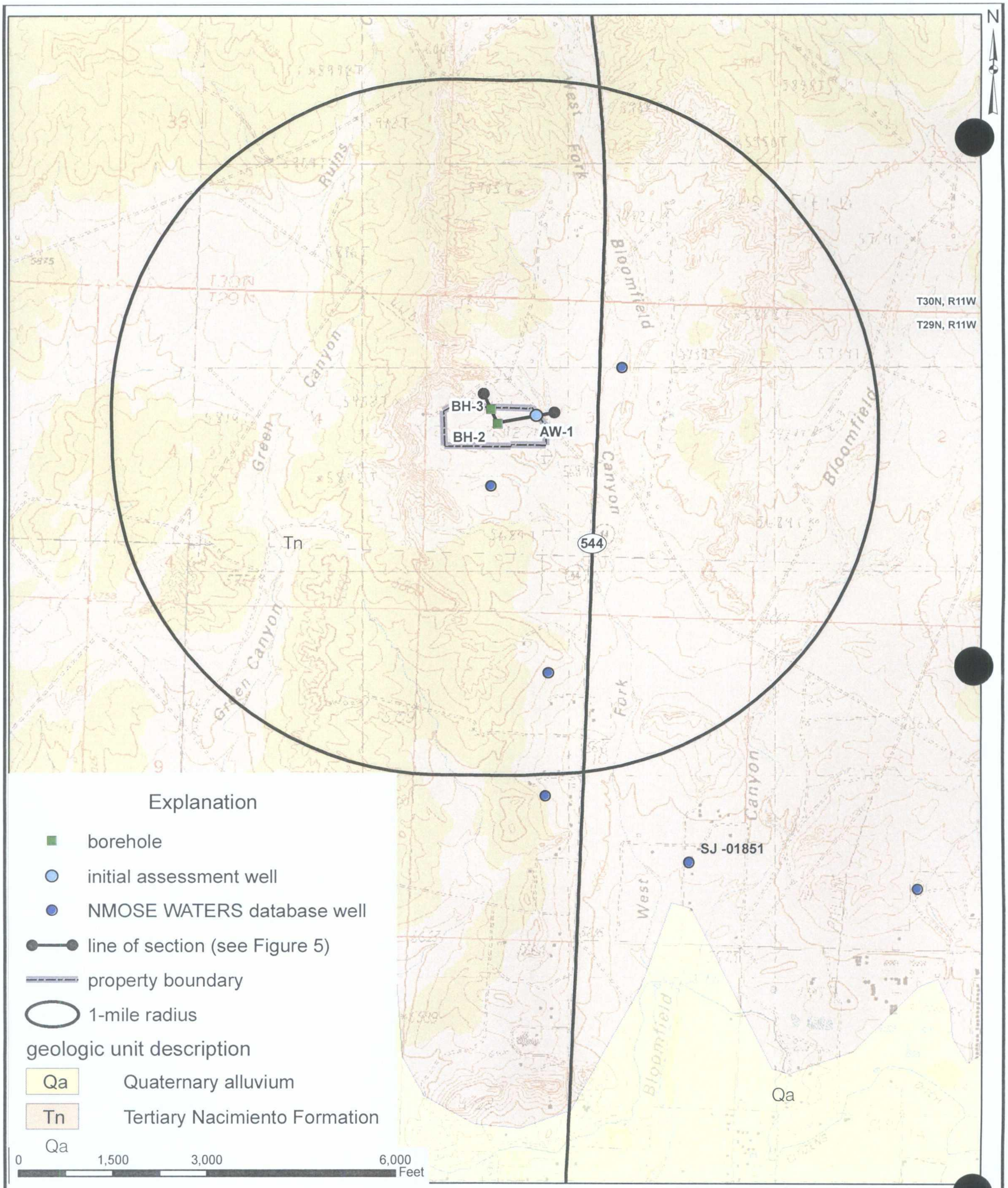
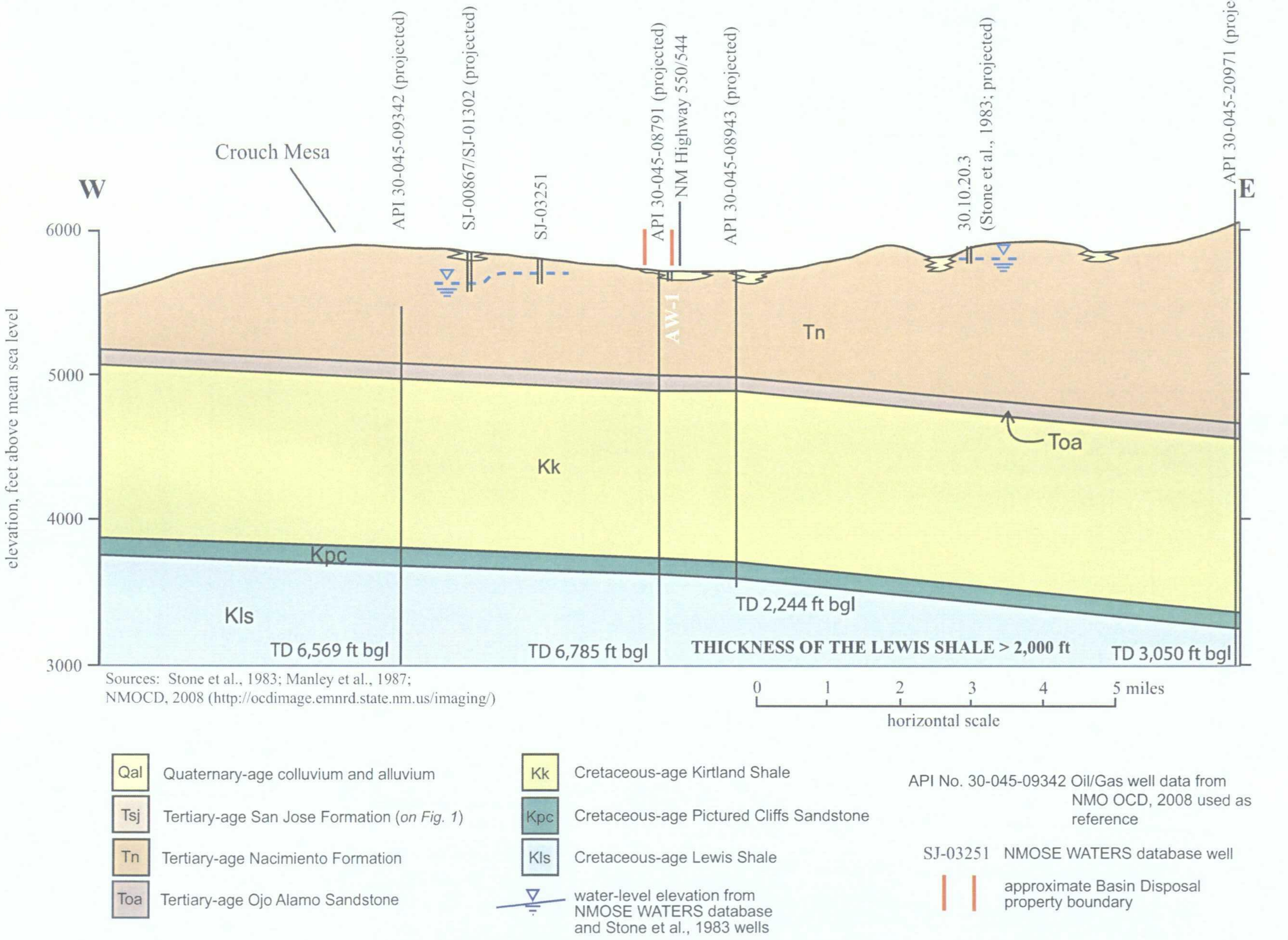


Figure 3. Geologic map of the area north of Bloomfield, New Mexico showing line of section and NMOSE database wells within a 1-mile radius of the Basin Disposal Site.



Sources: Stone et al., 1983; Manley et al., 1987; NMOCD, 2008 (http://ocdimage.emnrd.state.nm.us/imaging/)

Figure 4. General west-east geologic cross-section across Crouch Mesa, and the Basin Disposal site, Bloomfield, San Juan County, New Mexico (see Figure 1 for line of section).

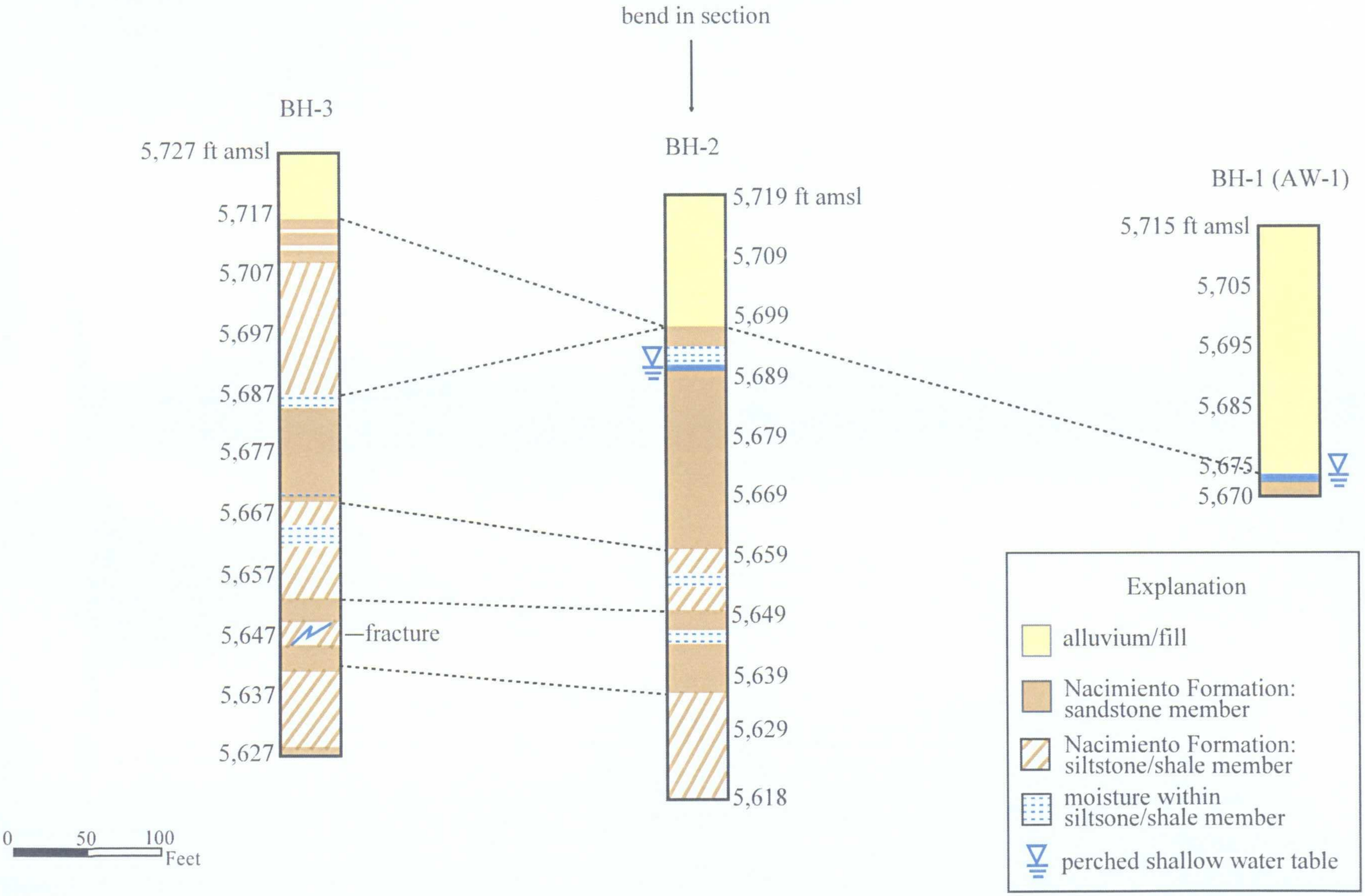


Figure 5. Detailed west to east geologic cross-section including lithologic data from BH-3, BH-2, and BH-1 (AW-1) at the Basin Disposal Site, Bloomfield, New Mexico (see Figure 3 for line of section).

Figure 6. Topographic map showing water wells from the NMOSE WATERS database and Stone et al. (1983), Basin Disposal Site initial assessment wells, and water-level elevation contours of the alluvial and Nacimiento Formation bedrock aquifers, Basin Disposal Site, Bloomfield, New Mexico.

Slightly moist, less consolidated sandstone horizon within the Nacimiento Formation adhering to the core barrel in borehole No. 2 (BH-2).

Moist, clay-rich zones, 'missing' from the core and smeared on the core and the inside of the core barrel in borehole No. 2 (BH-2).

Figure 7. Photographs of continuous core samples from borehole No. 2 (BH-2), Basin Disposal Site, Bloomfield, New Mexico.

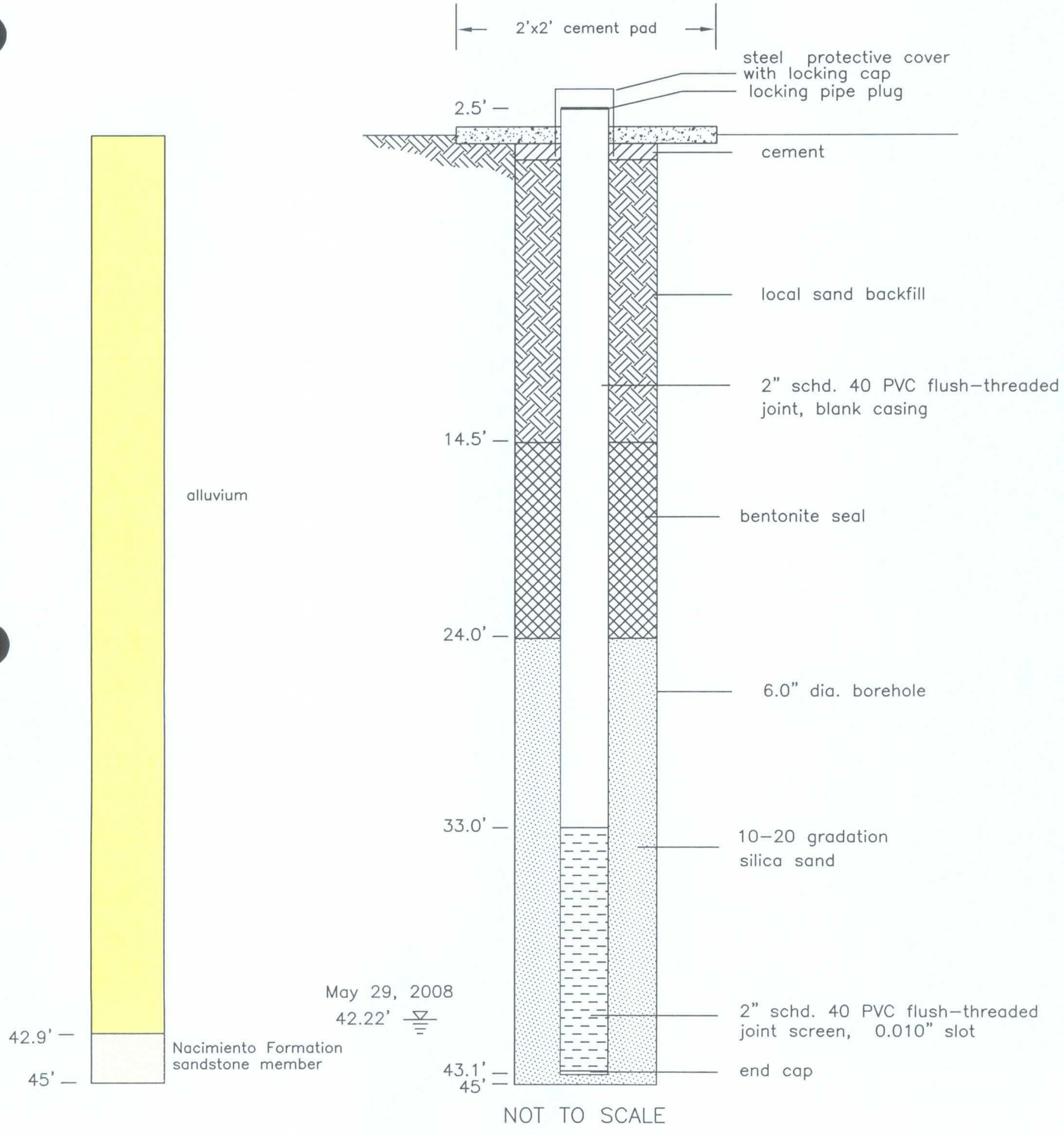


Figure 8. Ground-water initial assessment well AW-1 completion diagram, borehole lithology, and ground-water elevation, Basin Disposal Site, Bloomfield, New Mexico.

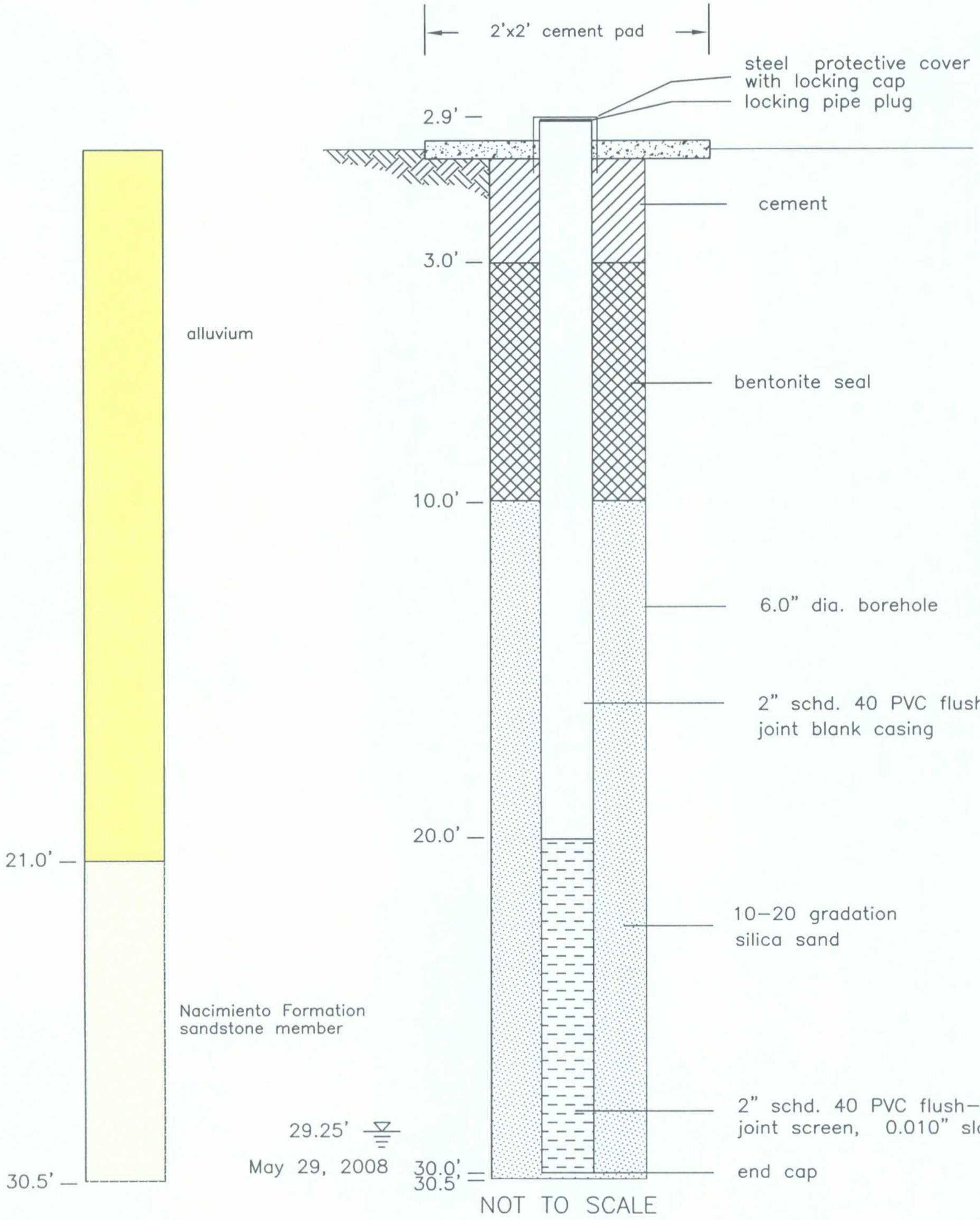


Figure 9. Ground-water initial assessment well AW-2 completion diagram, borehole lithology (from nearby borehole No. 2), and ground-water elevation, Basin Disposal Site, Bloomfield, New Mexico.

APPENDICES

Appendix A

Lithologic logs

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Water-Resource and Environmental Consultants
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Borehole Logging Form

Client: Basin Disposal, Inc.	Project: borehole No. 1/AW-1	Hole: 1	1 of 1
Site: Bloomfield, NM		Date: 5/19/2008	
Geologist: EM	Contractor: Hydrogeologic Services	Map:	
Drill Method: auger and split spoon	Rig: Failings-International		
Notes: operation attended by Brad Jones, Env. Engineer with NMEMNR/OCD	Bit size:		
Elevation, ft:	Land Surface:	TOC:	

Sample Depth, ft	Lithology	% Rec.	Moisture Encountered, ft bgl	Description
0 - 2	fill ?	72		sandy loam
2 - 4	fill ?	72		same as 0 – 1.5 ft interval
4 - 6	fill ? alluvium	83		sandy loam changing gradually to a clayey sand; at 58" abrupt contact to a coarse sand
6 - 6.5	alluvium	100		coarse sand (**full core in sleeve**)
6.5 - 7	alluvium	100		loamy sand (**full core in sleeve**)
7 - 7.5	alluvium	100		coarse sand (**full core in sleeve**)
7.5 - 8	alluvium	100		coarse sand (**full core in sleeve**)
8 - 8.5	alluvium	100		silty sand/loamy sand (full core in sleeve)
8.5 - 10.5	alluvium	100		well-sorted (dry) sand
10.5 - 12.5	alluvium	100		well-sorted (dry) sand; contact at 12 ft bgl to clay with Stage I caliche
12.5 - 14.5	alluvium	100		predominantly clay with caliche, layered with sandy loam, layered with silty sand in 6" intervals
14.5 - 16.5	alluvium	100		coarse sand – bottom tagged ~17 ft bgl, salt xstals grow on wet glued sample 15 ft & down
17 - 19	alluvium	100		coarse sand; contact at 17.5 ft bgl with a dry silty fine sand
19 - 21	alluvium	100		loamy sand grading (over a few inches at 19.5 ft bgl) to a white, loamy silt
21 - 23	alluvium	50		white, silty sand, including some caliche
24 - 26	alluvium	80		silty sand grading to a sandy silt, grading to a (more consolidated) loamy sand at the base
26 - 28	alluvium	100		predominantly yellow-white sand – loamy sand, with 2" of sandy loam
28 - 30	alluvium	92		sandy loam; contact at 28.5 ft bgl with well graded (sorted) sand
30 - 32	alluvium	100		10" sand; 4" of semi-consolidated sandy loam; with 10" of reddish, fine sand
32 - 34	alluvium	100		12" fine sand; 12" fine, yellow-white sandy loam
34 - 36	alluvium	100		6" fine, sandy loam; 12" fine sand; 6" sandy loam with a trace of clay
36 - 38	alluvium	100		12" gray sand; 6" sandy loam; 6" sand
38 - 40	alluvium	100		14" medium (slightly cool – moist?) yellow-gray sand; 10" clayey sand (first real clay layer)
40 - 42	alluvium	100	41.25	15" medium, gray-yellow sand; 9" sand (with feldspar, quartz)
42 - 43	alluvium sandstone	100		moist, coarse sand; sandstone contact at 42.90 ft bgl; sandstone with green alteration (predominantly quartz, minor feldspar), consolidated, no fizz with HCl; fractured/weathered with horizontal fractures

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Borehole Logging Form

Client: Basin Disposal, Inc.	Project: Coring to 100 ft bgl	Hole: 2	1 of 1
Site: Bloomfield, NM		Date: 5/20/2008	
Geologist: EM	Contractor: Hydrogeologic Services	Map:	
Drill Method: auger and split spoon / direct air with 10-ft core barrel	Rig: Failings-International		
Notes: operation attended by Brad Jones, Env. Engineer of the NMEMNR/OCD	Bit size:		
Elevation, ft:	Land Surface:	TOC:	

Sample Depth, ft	Lithology	% Rec.	Moisture Encountered, ft bgl	Description
0 - 2	alluvium			loamy sand
2 - 4	alluvium	good		sandy loam; grading to loamy sand; grading to sandy clay
4 - 6	alluvium	50		loamy sand; grading to sandy, unsaturated clay; bottom few in. stage I caliche
6 - 8	alluvium	100		fine sand (with gypsum flakes); grading to medium sand with 10% rounded gravel, salt crystals grow on wet glued samples from 6 ft & down in alluvium
8 - 10	alluvium	100		medium - coarse sand with 2" gravel layer @ 8.35 ft bgl; gravel is subangular, has weathering rinds; provenance is a mudstone
10 - 12	alluvium	100		medium - coarse sand; sharp contact @9.5 ft bgl to loam with stage I/II caliche
12 - 14	alluvium	100		very friable dark-gray, silt(stone) (no-fizz w HCl);almost-consolidated.
14 - 16	alluvium	75		dark-gray, friable silt(stone), dry; non-lithified but consolidated, with small bits of gravel locally
16 - 18	alluvium	88		v. consolidated silt(stone); @ 15.8 ft bgl caliche layer
18 - 20	alluvium	63		consolidated silt(stone), @ 19.8 ft bgl 1/4 in. gravel
20 - 21	alluvium	?		consolidated (but friable) silt(stone), fract with FeO
				(split-spoon sampling above)
				(coring with direct air below)
21 - 31	siltstone sandstone	**25**	25 – 30	greenish, siltstone (0.8 ft). Greenish sandstone (0.5 ft); followed by 0.3 ft of loose yellow well-graded. Bottom (?) of the core has a total of 0.9 ft of sandstone. Missing section. Lacquer-like smell. Moist section above sandstone contact
31 – 41	sandstone	85		sandstone, (quartz, feldspar) with 5% mudstone; in places arkosic
41 – 51	sandstone	100		same as 31 – 41; with platelets of eroded mudstone
51 - 61	sandstone siltstone	90	57	sandstone grading to arkose – conglomerate with coal horizons green-gray siltstone contact at 59.3 ft bgl
61 - 71	siltstone sandstone	85		gray siltstone with fine sandstone (contact @ 69.5 ft bgl)
71 - 81	siltstone	95		siltstone with coal-horizons; clay-coating on the inside of the core barrel, from local clay lenses (?); no moisture within core when fresh
81 - 91	siltstone	100		greenish-gray siltstone with coal-horizons, blacker marbling, no minerals seen unaided
91 - 101	siltstone	100	94	green siltstone with clay horizon approximately 2 in. thick; approx. 1.5 ft of core left in the hole

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2611 Broadbent Parkway NE, Albuq., NM 87107

Borehole Logging Form

Client: Basin Disposal, Inc.	Project: Coring to 100 ft bgl	Hole: 3	1 of 1
Site: Bloomfield, NM		Date: 5/22/2008	
Geologist: EM	Contractor: Hydrogeologic Services	Map:	
Drill Method: auger and split spoon / direct air with 10 ft core barrel	Rig: Failings-International		
Notes: operation attended by Brad Jones, Env. Engineer of the NMEMNR/OCD	Bit size:		
Elevation, ft:	Land Surface:	TOC:	

Sample Depth, ft	Lithology	Rec. %	Moisture Encountered, ft bgl	Description
0 - 2	fill	-		medium sand – middle 6" is silty sand; more loamy sand toward the bottom
2 - 4	fill	80		well-sorted sand; grading to loamy sand; grading to silty sand; grading to well sorted sand
4 - 6	fill	100		well-sorted sand; clay lens; grading to loamy sand; grading to coarse sand; grading to loamy (yellow) sand
6 - 8	alluvium	100		loamy (yellow) sand; abrupt contact with loamy(gray) compacted; grading to well-sorted sand
8 - 10	alluvium	100		well-sorted (dry) sand
10 - 12	sandstone	60		0.2 ft well-sorted sand; 1 ft weathered sandstone bedrock, non-lithified,white and dry sand
12 - 14	sandstone	GRAB		yellow, weathered, friable sandstone (dry)
14 - 16	sandstone	GRAB		yellow, weathered, friable sandstone (dry)
16 - 18	sandstone	GRAB		yellow, weathered, friable sandstone (dry)
18 - 20	siltstone	95		17.5 ft bgl brown – gray siltstone (bottom 2" is very friable and calcified, with caliche (non-linked))
				(split-spoon sampling above)
				(coring with direct air below)
20 - 30	siltstone	50		greenish, brown, friable, dry, siltstone. Smells of sulfur. Fracture surface coated by calcite (?) xstals.
30 - 40	siltstone	100		greenish siltstone, grading to gray siltstone with faint paint thinner smell (33 – 38 ft bgl),grading to green siltstone with FeO on fractures. 3 (6" thick) ss lenses from 33 to 38 ft bgl. At 38 ft bgl a 4" soft (no moisture) clay lens.
40 - 50	sandstone	100	40.5 - 43.5	sandstone (dolomite, quartz, rare fldspr, mica) with micaceous cross beds (dry), @ 43 ft bgl fract. siltstone lens – to the base sandstone is coal-bearing
50 - 60	sandstone, siltstone	90	56.5	sandstone with green-gray siltstone contact at 58.5 ft bgl
60 - 70	siltstone	85		siltstone with friable organic horizons (64 & 65 ft bgl) – no fractures, no moisture, but slippery, talc-like feel, org. are greasy luster, botryoidal in habit
70 - 80	siltstone	97		same as 60 – 70 ft bgl
80 - 90	siltstone	100	80.5	siltstone with gypsum-filled fractures, fracture at 80 ft bgl is moist
90 - 100	siltstone, sandstone	100		same as 60 – 70 ft bgl; sandstone contact @ 99.8 ft bgl

Appendix B.

Summary of sample horizons where small samples were shared with the NMOCD during coring operations at borehole No. 2 and borehole No. 3, at the Basin Disposal Site, Bloomfield, San Juan County, New Mexico

APPENDIX B.

Table B1. Summary of sample horizons where small samples were shared with the NMOCD during coring operations at borehole No. 2 and borehole No. 3, at the Basin Disposal Site, Bloomfield, San Juan County, New Mexico

number	unit	borehole No. 2 sample depth, ft bgl	borehole No. 3 sample depth, ft bgl
sampling date		5/22/2008	5/23/2007
1	Tn	~20	31.1
2	Tn	~21	33.5
3	Tn	35.4	34.3
4	Tn	49.8	38.6
5	Tn	57.2	39.8
6	Tn	61.1	41.6
7	Tn	62.4	42.6
8	Tn	66.8	45.4
9	Tn	~70.5	47.8
10	Tn	80.6	55.8
11	Tn	~81.2	59.7
12	Tn	89.7	63.1
13	Tn	94.5	67.7
14	Tn	98.5	69.2
15	Tn	-	74.6
16	Tn	-	76.7
17	Tn	-	79.8
18	Tn	-	84.7
19	Tn	-	89.6
20	Tn	-	95.2
21	Tn	-	99.7

Tn - Nacimiento Formation
ft bgl - feet below ground level

Appendix C

NMOSE wells (from WATERS) within a 2-mile radius of the Basin Disposal Site, Bloomfield, New Mexico

Appendix C. NMOSE wells (from WATERS) within a 2-mile radius of the Basin Disposal Site, Bloomfield, New Mexico

JSAI No.	DB File Nbr	Use	Diver-sion	Owner	POD Number	Source	Tws	Rng	Sec q q q	UTM Zone	Easting	Northing	Completion Date	Well depth	Water depth	Yield, gpm	Alluvial depth, ft	Notes
1	SJ 00867	DOM	3	S. L. Brannin	SJ 867	shallow	29N	11W	07 4	13	229570	4069949	1/31/1979	77	55	5	65	
2	SJ 01302	DOM	3	R. W. Brannin	SJ 1302	shallow	29N	11W	07 4 1	13	229381	4070147	1/30/1981	250	210	2.5	6	
3	SJ 01851	DOM	3	J. Bosse'	SJ 1851	shallow	29N	11W	10 4 4	13	234586	4069572	6/20/1984	125	48	10	73	closest
4	SJ 01887	DOM	0	P. Hargis	SJ 1887		29N	11W	03 3	13	233625	4071417	presumably not drilled - expired permit					
5	SJ 01891	DOM	3	E. Walker	SJ 1891		29N	11W	07 4 1 3	13	229280	4070046	8/23/1984	157		?	33	no casing - dry?
6	SJ 01995	DOM	3	R. Detterrera	SJ 1995		29N	11W	03 2 3	13	234260	4071994	application to appropriate ground water only					
7	SJ 02086	DOM	3	R. Doerr	SJ 2086		29N	11W	10 3 2 4	13	233890	4069898	application to appropriate ground water only					
8	SJ 02466	POL	0.84	El Paso Nat. Gas Co.	SJ 2466	shallow	29N	11W	11 4 3 3	13	235694	4069436		66	recovery well			
9					SJ 2466 S	shallow	29N	11W	11 4 3 3	13	235694	4069436		65				
10	SJ 03658	DOM	3	M. Maurer	SJ 3658		29N	11W	10 1 4 2	13	233903	4070499	application to appropriate ground water only					
11	SJ 03749	DOM	3	M. J. Baird	SJ 3749 POD1		29N	11W	07 2 3 1	13	229292	4070646	application to appropriate ground water only					
12	SJ 02854	DOM	3	C. D. & M. J. Atwood	SJ 2854		30N	11W	30 2 1 1	13	229565	4075823	application to appropriate ground water only					
13	SJ 03077	DOM	3	L. McGaha	SJ 3077	shallow	30N	11W	30 2 1 1	13	229565	4075823	4/6/2001	75	70	2	15	
14	SJ 03224	DOM	3	D. Dufur	SJ 3224	shallow	30N	11W	30 1 2 4	13	229376	4075638	4/24/2003	80	30	3	30	
15	SJ 03251	DOM	3	E. Urie	SJ 3251	shallow	30N	11W	32 3 4 4	13	230879	4072752	4/11/2003	150	77	6	14	
16	SJ 03668	DOM	3	C. Colson	SJ 3668	shallow	30N	11W	30 2 1 2	13	229765	4075823	8/12/2005	380	280	5	60	"Fill"
		SUM	**39.84**										AVERAGE	142.5	110	4.8	37	

Appendix D

Copy of laboratory measurement of hydraulic conductivity and plasticity index (Atterberg test) for AW-1 alluvial soil samples

V

Vinyard & Associates, Inc.

8916-A Adams Street NE
Albuquerque, New Mexico 87113
505/797-9743 505/797-9749 FAX

A

Geotechnical Engineering * Materials Testing * Environmental Engineering

June 25, 2008

Note: Revised to show atterberg test results.

John Shomaker & Associates, Inc.
2611 Broadbent Parkway
Albuquerque, NM 87107

Attn: Mr. Erwin A Melis, Ph.D

Project: Basin Disposal
V & A Project No. 08-2-282

Gentlemen:

Attached are copies of the Laboratory Test results for the subject project.

Should you have any questions regarding this data, please do not hesitate to call.

Sincerely,

Martie Neves

Vinyard & Associates, Inc.

Robert K. Abeyta, S.E.T.

Attachment: Figure No.: 4

cc: Addressee: (1)
Basin Disposal, Inc. - Attn: Mr. John Volkerding

mn

Falling Head Permeability Test
ASTM D5856-95

Project : Basin Disposal **Date:** 7/12/2008

Project No.: 08-2-282

Sample Number 926 @ 5.5' to 6.0'

Permeameter No.: b

MDD (pcf):	d	110	**Diameter of Specimen, cm:**	D	6.172
γ=d/62.4:	γ	1.763	**Area of Specimen, cm^2:**	A	29.92
% Compaction:	%	80%	**Initial Height of Specimen,cm :**	L	7.96
Dry Soil= % * V * γ :	Ws	335.9	**Volume, ml, V=A*L**	V	238.16
Specific Gravity:	g	2.5	**Void Ratio (V-Vs)/Vs :**	e	0.77
Vol of Solids,Vs=Ws/g:	Vs	134.3	**Constant 2.303 *(a/A)*L :**	c	0.194225
Area of Standpipe, cm^2:	a	0.317			

Initial Time	t_0	8:00 AM	8:02 AM	8:04 AM	8:06 AM	8:08 AM	8:10 AM
Final Time	t_f	8:01 AM	8:03 AM	8:05 AM	8:07 AM	8:09 AM	8:11 AM
Time Interval, min		1	1	1	1	1	1
Elapsed Time, sec:	t	69	71	73	74	74	75
Initial Head, cm	h_0	182.0	182.0	182.0	182.0	182.0	182.0
Final Head, cm	h_f	15.3	15.3	15.3	15.3	15.3	15.3
Log h_0/h_f	l	1.08	1.08	1.08	1.08	1.08	1.08
Water Temp, C	T	22.5	22.5	22.5	22.5	22.5	22.5
Viscosity Corr. Factor	R_t	0.9433	0.9433	0.9433	0.9433	0.9433	0.9433
Coefficient of Permeability, cm/sec	K	3.03E-03	2.95E-03	2.86E-03	2.83E-03	2.83E-03	2.79E-03
Coefficient of Permeability Corrected,	K_{20}	2.86E-03	2.78E-03	2.70E-03	2.67E-03	2.67E-03	2.63E-03

Average - Coefficient of Permeability, cm/sec	K	2.83E-03
Permeability Corr.,	K_{20}	2.67E-03

Note : MDD and Specific Gravity are assumed

Moisture content - 8.3

In place dry density 89.9 ll ft^3

Atterberg Limit - Liquid Limit NV - Plastic Limit NV - Plasticity Index NP

Falling Head Permeability Test
ASTM D5856-95

Project : Basin Disposal **Date:** 7/12/2008

Project No.: 08-2-282

Sample Number 927 @ 6.5' to 7.0'

Permeameter No.: b

MDD (pcf):	d	110	**Diameter of Specimen, cm:**	D	6.172
γ=d/62.4:	γ	1.763	**Area of Specimen, cm^2:**	A	29.92
% Compaction:	%	78%	**Initial Height of Specimen,cm :**	L	7.89
Dry Soil= % * V * γ :	Ws	324.6	**Volume, ml, V=A*L**	V	236.07
Specific Gravity:	g	2.5	**Void Ratio (V-Vs)/Vs :**	e	0.82
Vol of Solids,Vs=Ws/g:	Vs	129.8	**Constant 2.303 *(a/A)*L :**	c	0.192517
Area of Standpipe, cm^2:	a	0.317			

Initial Time	t_0	8:00 AM	8:02 AM	8:04 AM	8:06 AM	8:08 AM	8:10 AM
Final Time	t_f	8:01 AM	8:03 AM	8:05 AM	8:07 AM	8:09 AM	8:11 AM
Time Interval, min		1	1	1	1	1	1
Elapsed Time, sec:	t	71	71	72	73	75	76
Initial Head, cm	h_0	182.0	182.0	182.0	182.0	182.0	182.0
Final Head, cm	h_f	15.3	15.3	15.3	15.3	15.3	15.3
Log h_0/h_f	l	1.08	1.08	1.08	1.08	1.08	1.08
Water Temp, C	T	22.5	22.5	22.5	22.5	22.5	22.5
Viscosity Corr. Factor	R_t	0.9433	0.9433	0.9433	0.9433	0.9433	0.9433
Coefficient of Permeability, cm/sec	K	2.92E-03	2.92E-03	2.88E-03	2.84E-03	2.76E-03	2.73E-03
Coefficient of Permeability Corrected,	K_{20}	2.75E-03	2.75E-03	2.72E-03	2.68E-03	2.61E-03	2.57E-03

Average - Coefficient of Permeability, cm/sec	K	2.80E-03
Permeability Corr.,	K_{20}	2.64E-03

Note : MDD and Specific Gravity are assumed

Moisture content - 8.2

In place dru density - 89.5 lbs / ft^3

Atterburg Limits Liquid Limit NV - Plastic Limit NV - Plasticity Index NP

Appendix E

Copy of laboratory reports and chain-of-custody documentation for ground-water samples

HALL
ENVIRONMENTAL
ANALYSIS
LABORATORY

COVER LETTER

Thursday, June 12, 2008

Erwin Melis
John Shomaker & Assoc.
2611 Broadbent Parkway NE
Albuquerque, NM 87107

TEL: (505) 250-1607
FAX (505) 345-9920

RE: BDI/Bloomfield, NM

Order No.: 0805373

Dear Erwin Melis:

Hall Environmental Analysis Laboratory, Inc. received 1 sample(s) on 5/28/2008 for the analyses presented in the following report.

These were analyzed according to EPA procedures or equivalent.

Reporting limits are determined by EPA methodology. No determination of compounds below these (denoted by the ND or < sign) has been made.

Please don't hesitate to contact HEAL for any additional information or clarifications.

Sincerely,

Andy Freeman, Business Manager
Nancy McDuffie, Laboratory Manager

NM Lab # NM9425
AZ license # AZ0682
ORELAP Lab # NM100001

ACCREDITED IN ACCORDANCE WITH nelac

4901 Hawkins NE ▪ Suite D ▪ Albuquerque, NM 87109
505.345.3975 ▪ Fax 505.345.4107
www.hallenvironmental.com

Hall Environmental Analysis Laboratory, Inc. **Date:** *12-Jun-08*

CLIENT:	John Shomaker & Assoc.	**Client Sample ID:**	MW-1
Lab Order:	0805373	**Collection Date:**	5/27/2008 4:45:00 PM
Project:	BDI/Bloomfield, NM	**Date Received:**	5/28/2008
Lab ID:	0805373-01	**Matrix:**	AQUEOUS

Analyses	Result	PQL	Qual	Units	DF	Date Analyzed
EPA METHOD 300.0: ANIONS						Analyst: **SLB**
Fluoride	1.7	1.0		mg/L	10	5/28/2008 11:27:10 PM
Chloride	2300	20		mg/L	200	5/29/2008 9:53:54 AM
Nitrogen, Nitrite (As N)	ND	1.0		mg/L	10	5/28/2008 11:27:10 PM
Bromide	6.3	1.0		mg/L	10	5/28/2008 11:27:10 PM
Nitrogen, Nitrate (As N)	11	1.0		mg/L	10	5/28/2008 11:27:10 PM
Phosphorus, Orthophosphate (As P)	ND	5.0		mg/L	10	5/28/2008 11:27:10 PM
Sulfate	18000	250		mg/L	500	6/3/2008 8:03:20 PM
EPA METHOD 7470: MERCURY						Analyst: **SNV**
Mercury	ND	0.00020		mg/L	1	6/4/2008 4:10:28 PM
EPA 6010B: TOTAL RECOVERABLE METALS						Analyst: **NMO**
Arsenic	ND	0.20		mg/L	10	6/2/2008 10:04:06 AM
Barium	ND	0.20		mg/L	10	6/2/2008 9:03:05 AM
Cadmium	ND	0.020		mg/L	10	6/2/2008 9:03:05 AM
Calcium	480	10		mg/L	10	6/2/2008 9:03:05 AM
Chromium	ND	0.060		mg/L	10	6/2/2008 9:03:05 AM
Lead	0.098	0.050		mg/L	10	6/2/2008 9:03:05 AM
Magnesium	300	10		mg/L	10	6/2/2008 9:03:05 AM
Potassium	15	10		mg/L	10	6/2/2008 9:03:05 AM
Selenium	ND	0.50		mg/L	10	6/2/2008 9:03:05 AM
Silver	ND	0.050		mg/L	10	6/2/2008 9:03:05 AM
Sodium	10000	100		mg/L	100	6/2/2008 8:59:59 AM
SM 2540C TOTAL DISSOLVED SOLIDS						Analyst: **KMS**
Total Dissolved Solids	38000	2000		mg/L	1	5/29/2008

Qualifiers:				
	*	Value exceeds Maximum Contaminant Level	B	Analyte detected in the associated Method Blank
	E	Value above quantitation range	H	Holding times for preparation or analysis exceeded
	J	Analyte detected below quantitation limits	MCL	Maximum Contaminant Level
	ND	Not Detected at the Reporting Limit	RL	Reporting Limit
	S	Spike recovery outside accepted recovery limits		

QA/QC SUMMARY REPORT

Client: John Shomaker & Assoc.
Project: BDI/Bloomfield, NM **Work Order:** 0805373

Method: **EPA Method 300.0: Anions**

Analyte	Result	Units	PQL	%Rec	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Sample ID: MB		*MBLK*			Batch ID:	**R28701**	Analysis Date:	5/28/2008 8:39:22 AM	
Fluoride	ND	mg/L	0.10						
Chloride	ND	mg/L	0.10						
Nitrogen, Nitrite (As N)	ND	mg/L	0.10						
Bromide	ND	mg/L	0.10						
Nitrogen, Nitrate (As N)	ND	mg/L	0.10						
Phosphorus, Orthophosphate (As P)	ND	mg/L	0.50						
Sulfate	ND	mg/L	0.50						
Sample ID: MB		*MBLK*			Batch ID:	**R28726**	Analysis Date:	5/29/2008 8:44:16 AM	
Fluoride	ND	mg/L	0.10						
Chloride	ND	mg/L	0.10						
Nitrogen, Nitrite (As N)	ND	mg/L	0.10						
Bromide	ND	mg/L	0.10						
Nitrogen, Nitrate (As N)	ND	mg/L	0.10						
Phosphorus, Orthophosphate (As P)	ND	mg/L	0.50						
Sulfate	ND	mg/L	0.50						
Sample ID: MB		*MBLK*			Batch ID:	**R28779**	Analysis Date:	6/3/2008 9:01:46 AM	
F[illegible]e	ND	mg/L	0.10						
C[illegible]ide	ND	mg/L	0.10						
Nitrogen, Nitrite (As N)	ND	mg/L	0.10						
Bromide	ND	mg/L	0.10						
Nitrogen, Nitrate (As N)	ND	mg/L	0.10						
Phosphorus, Orthophosphate (As P)	ND	mg/L	0.50						
Sulfate	ND	mg/L	0.50						
Sample ID: LCS		*LCS*			Batch ID:	**R28701**	Analysis Date:	5/28/2008 8:56:47 AM	
Fluoride	0.5351	mg/L	0.10	107	90	110			
Chloride	4.865	mg/L	0.10	97.3	90	110			
Nitrogen, Nitrite (As N)	0.9089	mg/L	0.10	90.9	90	110			
Bromide	2.542	mg/L	0.10	102	90	110			
Nitrogen, Nitrate (As N)	2.497	mg/L	0.10	99.9	90	110			
Phosphorus, Orthophosphate (As P)	5.036	mg/L	0.50	101	90	110			
Sulfate	10.03	mg/L	0.50	100	90	110			
Sample ID: LCS		*LCS*			Batch ID:	**R28726**	Analysis Date:	5/29/2008 9:01:41 AM	
Fluoride	0.5169	mg/L	0.10	103	90	110			
Chloride	4.860	mg/L	0.10	97.2	90	110			
Nitrogen, Nitrite (As N)	0.9198	mg/L	0.10	92.0	90	110			
Bromide	2.567	mg/L	0.10	103	90	110			
Nitrogen, Nitrate (As N)	2.499	mg/L	0.10	100	90	110			
Phosphorus, Orthophosphate (As P)	5.070	mg/L	0.50	101	90	110			
Sulfate	10.11	mg/L	0.50	101	90	110			
Sample ID: LCS		*LCS*			Batch ID:	**R28779**	Analysis Date:	6/3/2008 9:19:11 AM	
Flu[illegible]e	0.5075	mg/L	0.10	101	90	110			
C[illegible]	4.796	mg/L	0.10	95.9	90	110			
Nitrogen, Nitrite (As N)	0.9539	mg/L	0.10	95.4	90	110			

Qualifiers:

E	Value above quantitation range	H	Holding times for preparation or analysis exceeded
J	Analyte detected below quantitation limits	ND	Not Detected at the Reporting Limit
R	RPD outside accepted recovery limits	S	Spike recovery outside accepted recovery limits

QA/QC SUMMARY REPORT

Client: John Shomaker & Assoc.
Project: BDI/Bloomfield, NM
Work Order: 0805373

Analyte	Result	Units	PQL	%Rec	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Method: EPA Method 300.0: Anions									
Sample ID: LCS		*LCS*			**Batch ID: R28779**		**Analysis Date: 6/3/2008 9:19:11 AM**		
Bromide	2.540	mg/L	0.10	102	90	110			
Nitrogen, Nitrate (As N)	2.417	mg/L	0.10	96.7	90	110			
Phosphorus, Orthophosphate (As P)	4.926	mg/L	0.50	98.5	90	110			
Sulfate	9.953	mg/L	0.50	99.5	90	110			
Method: EPA Method 7470: Mercury									
Sample ID: MB-16112		*MBLK*			**Batch ID: 16112**		**Analysis Date: 6/4/2008 3:59:53 PM**		
Mercury	ND	mg/L	0.00020						
Sample ID: LCS-16112		*LCS*			**Batch ID: 16112**		**Analysis Date: 6/4/2008 4:01:38 PM**		
Mercury	0.004938	mg/L	0.00020	98.0	80	120			
Method: EPA 6010B: Total Recoverable Metals									
Sample ID: MB-16071		*MBLK*			**Batch ID: 16071**		**Analysis Date: 6/2/2008 7:57:03 AM**		
Arsenic	ND	mg/L	0.020						
Barium	ND	mg/L	0.010						
Cadmium	ND	mg/L	0.0020						
Calcium	ND	mg/L	0.50						
Chromium	ND	mg/L	0.0060						
Lead	ND	mg/L	0.0050						
Magnesium	ND	mg/L	0.50						
Potassium	ND	mg/L	1.0						
Selenium	ND	mg/L	0.050						
Silver	ND	mg/L	0.0050						
Sodium	ND	mg/L	0.50						
Sample ID: LCS-16071		*LCS*			**Batch ID: 16071**		**Analysis Date: 6/2/2008 8:00:07 AM**		
Arsenic	0.4967	mg/L	0.020	99.3	80	120			
Barium	0.4886	mg/L	0.010	97.7	80	120			
Cadmium	0.4980	mg/L	0.0020	99.6	80	120			
Calcium	48.11	mg/L	0.50	96.2	80	120			
Chromium	0.4996	mg/L	0.0060	99.9	80	120			
Lead	0.4908	mg/L	0.0050	98.2	80	120			
Magnesium	48.62	mg/L	0.50	97.2	80	120			
Potassium	51.29	mg/L	1.0	103	80	120			
Selenium	0.5031	mg/L	0.050	101	80	120			
Silver	0.4943	mg/L	0.0050	98.9	80	120			
Sodium	50.71	mg/L	0.50	101	80	120			
Method: SM 2540C Total Dissolved Solids									
Sample ID: MB-16060		*MBLK*			**Batch ID: 16060**		**Analysis Date: 5/29/2008**		
Total Dissolved Solids	ND	mg/L	20						
Sample ID: LCS-16060		*LCS*			**Batch ID: 16060**		**Analysis Date: 5/29/2008**		
Total Dissolved Solids	1021	mg/L	20	102	80	120			

Qualifiers:

E	Value above quantitation range	H	Holding times for preparation or analysis exceeded
J	Analyte detected below quantitation limits	ND	Not Detected at the Reporting Limit
R	RPD outside accepted recovery limits	S	Spike recovery outside accepted recovery limits

Hall Environmental Analysis Laboratory, Inc.

Sample Receipt Checklist

Client Name SHO

Date Received: 5/28/2008

Work Order Number 0805373

Received by: TLS

Sample ID labels checked by: TS
Initials

Checklist completed by: Signature 5/28/08 Date

Matrix:

Carrier name Client drop-off

Shipping container/cooler in good condition?	Yes ☑	No ☐	Not Present ☐	
Custody seals intact on shipping container/cooler?	Yes ☐	No ☐	Not Present ☐	Not Shipped ☑
Custody seals intact on sample bottles?	Yes ☐	No ☐	N/A ☑	
Chain of custody present?	Yes ☑	No ☐		
Chain of custody signed when relinquished and received?	Yes ☑	No ☐		
Chain of custody agrees with sample labels?	Yes ☑	No ☐		
Samples in proper container/bottle?	Yes ☑	No ☐		
Sample containers intact?	Yes ☑	No ☐		
Sufficient sample volume for indicated test?	Yes ☑	No ☐		
[illegible]mples received within holding time?	Yes ☑	No ☐		
Water - VOA vials have zero headspace?	No VOA vials submitted ☑	Yes ☐	No ☐	
Water - Preservation labels on bottle and cap match?	Yes ☑	No ☐	N/A ☐	
Water - pH acceptable upon receipt?	Yes ☑	No ☐	N/A ☐	
Container/Temp Blank temperature?	5°	<6° C *Acceptable* If given sufficient time to cool.		

COMMENTS:

Client contacted

Date contacted:

Person contacted

Contacted by:

Regarding:

Comments:

Corrective Action

Chain-of-Custody Record

Client: JSAI / Erwin Melis

Address: 2611 Broadbent Pkwy NE
Alb., NM 87107

Phone #: 345 - 3407

email or Fax#: emelis@shomaker.com

QA/QC Package:
☐ Standard ☐ Level 4 (Full Validation)
☐ Other ____________
☐ EDD (Type) ____________

Turn-Around Time:
☐ Standard ☐ Rush ____________

Project Name: BDI / Bloomfield, NM

Project #:

Project Manager: Edwin Melis

Sampler: EM

On Ice ☒ Yes ☐ No

Sample Temperature 5

HALL ENVIRONMENTAL ANALYSIS LABORATORY

www.hallenvironmental.com
4901 Hawkins NE - Albuquerque, NM 87109
Tel. 505-345-3975 Fax 505-345-4107

Analysis Request

Date	Time	Sample Request ID	Container Type and #	Preservative Type	HEAL No. 0805373	BTEX + MTBE + TMB's (8021)	BTEX + MTBE + TPH (Gas only)	TPH Method 8015B (Gas/Diesel)	TPH (Method 418.1)	EDB (Method 504.1)	EDC (Method 8260)	8310 (PNA or PAH)	Anions (F,Cl,NO_3,NO_2,PO_4,SO_4)	8081 Pesticides / 8082 PCB's	8260B (VOA)	8270 (Semi-VOA)					Air Bubbles (Y or N)
5/27	10:45	MW-1			-1	see attached															

Date: 5/28 Time: 14:00 Relinquished by: Ed Melis
Received by: 5/28/08 1400

Date: Time: Relinquished by:
Received by:

Remarks: Cancel 8021/GRO/DRO analysis per EM
AT 5/28/08

If necess[illegible]nples submitted to Hall Environmental may be subcontracted to other accredited laboratories. [illegible]rves as notice of this possibility. Any sub-contracted data will be clearly notated on the analytica[illegible]port.

HALL
ENVIRONMENTAL
ANALYSIS
LABORATORY

COVER LETTER

Wednesday, June 11, 2008

Erwin Melis
John Shomaker & Assoc.
2611 Broadbent Parkway NE
Albuquerque, NM 87107

TEL: (505) 250-1607
FAX (505) 345-9920

RE: BDI

Order No.: 0805406

Dear Erwin Melis:

Hall Environmental Analysis Laboratory, Inc. received 3 sample(s) on 5/30/2008 for the analyses presented in the following report.

These were analyzed according to EPA procedures or equivalent.

Reporting limits are determined by EPA methodology. No determination of compounds below these (denoted by the ND or < sign) has been made.

Please don't hesitate to contact HEAL for any additional information or clarifications.

Sincerely,

Andy Freeman, Business Manager
Nancy McDuffie, Laboratory Manager

NM Lab # NM9425
AZ license # AZ0682
ORELAP Lab # NM100001

ACCREDITED IN ACCORDANCE WITH nelac

4901 Hawkins NE ▪ Suite D ▪ Albuquerque, NM 87109
505.345.3975 ▪ Fax 505.345.4107
www.hallenvironmental.com

Hall Environmental Analysis Laboratory, Inc.

Date: *11-Jun-08*

CLIENT:	John Shomaker & Assoc.	**Client Sample ID:**	BDI-MW1-2
Lab Order:	0805406	**Collection Date:**	5/29/2008 12:45:00 PM
Project:	BDI	**Date Received:**	5/30/2008
Lab ID:	0805406-01	**Matrix:**	AQUEOUS

Analyses	Result	PQL	Qual	Units	DF	Date Analyzed
EPA METHOD 8015B: DIESEL RANGE						Analyst: **SCC**
Diesel Range Organics (DRO)	ND	1.0		mg/L	1	6/3/2008 10:06:43 AM
Motor Oil Range Organics (MRO)	ND	5.0		mg/L	1	6/3/2008 10:06:43 AM
Surr: DNOP	120	58-140		%REC	1	6/3/2008 10:06:43 AM
EPA METHOD 8015B: GASOLINE RANGE						Analyst: **NSB**
Gasoline Range Organics (GRO)	ND	0.050		mg/L	1	6/2/2008 4:33:33 PM
Surr: BFB	94.1	79.2-121		%REC	1	6/2/2008 4:33:33 PM
EPA METHOD 8021B: VOLATILES						Analyst: **NSB**
Methyl tert-butyl ether (MTBE)	ND	2.5		µg/L	1	6/2/2008 4:33:33 PM
Benzene	ND	1.0		µg/L	1	6/2/2008 4:33:33 PM
Toluene	ND	1.0		µg/L	1	6/2/2008 4:33:33 PM
Ethylbenzene	ND	1.0		µg/L	1	6/2/2008 4:33:33 PM
Xylenes, Total	ND	2.0		µg/L	1	6/2/2008 4:33:33 PM
1,2,4-Trimethylbenzene	ND	1.0		µg/L	1	6/2/2008 4:33:33 PM
1,3,5-Trimethylbenzene	ND	1.0		µg/L	1	6/2/2008 4:33:33 PM
Surr: 4-Bromofluorobenzene	86.2	68.9-122		%REC	1	6/2/2008 4:33:33 PM

Qualifiers:				
*	Value exceeds Maximum Contaminant Level	B	Analyte detected in the associated Method Blank
E	Value above quantitation range	H	Holding times for preparation or analysis exceeded
J	Analyte detected below quantitation limits	MCL	Maximum Contaminant Level
ND	Not Detected at the Reporting Limit	RL	Reporting Limit
S	Spike recovery outside accepted recovery limits		

Hall Environmental Analysis Laboratory, Inc.

Date: *11-Jun-08*

CLIENT:	John Shomaker & Assoc.	**Client Sample ID:**	BDI-MW2
Lab Order:	0805406	**Collection Date:**	5/29/2008 1:15:00 PM
Project:	BDI	**Date Received:**	5/30/2008
Lab ID:	0805406-02	**Matrix:**	AQUEOUS

Analyses	Result	PQL	Qual	Units	DF	Date Analyzed
EPA 6010B: TOTAL RECOVERABLE METALS						Analyst: TES
Arsenic	ND	0.20		mg/L	5	6/6/2008 11:10:05 AM
Barium	ND	0.20		mg/L	5	6/6/2008 11:10:05 AM
Cadmium	ND	0.020		mg/L	5	6/6/2008 11:10:05 AM
Calcium	490	10		mg/L	5	6/6/2008 11:10:05 AM
Chromium	ND	0.060		mg/L	5	6/6/2008 11:10:05 AM
Lead	ND	0.050		mg/L	5	6/6/2008 11:10:05 AM
Magnesium	170	10		mg/L	5	6/6/2008 11:10:05 AM
Potassium	39	10		mg/L	5	6/6/2008 11:10:05 AM
Selenium	ND	0.50		mg/L	5	6/6/2008 11:10:05 AM
Silver	ND	0.050		mg/L	5	6/6/2008 11:10:05 AM
Sodium	7800	100		mg/L	50	6/10/2008 4:53:37 PM
SM 2540C TOTAL DISSOLVED SOLIDS						Analyst: KMS
Total Dissolved Solids	24000	100		mg/L	1	6/2/2008

Qualifiers:

*	Value exceeds Maximum Contaminant Level	B	Analyte detected in the associated Method Blank
E	Value above quantitation range	H	Holding times for preparation or analysis exceeded
J	Analyte detected below quantitation limits	MCL	Maximum Contaminant Level
ND	Not Detected at the Reporting Limit	RL	Reporting Limit
S	Spike recovery outside accepted recovery limits		

Hall Environmental Analysis Laboratory, Inc.

Date: *11-Jun-08*

CLIENT:	John Shomaker & Assoc.	**Client Sample ID:**	TRIP BLANK
Lab Order:	0805406	**Collection Date:**	
Project:	BDI	**Date Received:**	5/30/2008
Lab ID:	0805406-03	**Matrix:**	TRIP BLANK

Analyses	Result	PQL	Qual	Units	DF	Date Analyzed
EPA METHOD 8015B: GASOLINE RANGE						Analyst: **NSB**
Gasoline Range Organics (GRO)	ND	0.050		mg/L	1	6/2/2008 5:33:52 PM
Surr: BFB	89.9	79.2-121		%REC	1	6/2/2008 5:33:52 PM
EPA METHOD 8021B: VOLATILES						Analyst: **NSB**
Methyl tert-butyl ether (MTBE)	ND	2.5		µg/L	1	6/2/2008 5:33:52 PM
Benzene	ND	1.0		µg/L	1	6/2/2008 5:33:52 PM
Toluene	ND	1.0		µg/L	1	6/2/2008 5:33:52 PM
Ethylbenzene	ND	1.0		µg/L	1	6/2/2008 5:33:52 PM
Xylenes, Total	ND	2.0		µg/L	1	6/2/2008 5:33:52 PM
1,2,4-Trimethylbenzene	ND	1.0		µg/L	1	6/2/2008 5:33:52 PM
1,3,5-Trimethylbenzene	ND	1.0		µg/L	1	6/2/2008 5:33:52 PM
Surr: 4-Bromofluorobenzene	82.9	68.9-122		%REC	1	6/2/2008 5:33:52 PM

Qualifiers:

*	Value exceeds Maximum Contaminant Level	B	Analyte detected in the associated Method Blank
E	Value above quantitation range	H	Holding times for preparation or analysis exceeded
J	Analyte detected below quantitation limits	MCL	Maximum Contaminant Level
ND	Not Detected at the Reporting Limit	RL	Reporting Limit
S	Spike recovery outside accepted recovery limits		

Hall Environmental Analysis Laboratory, Inc. **Date:** *11-Jun-08*

QA/QC SUMMARY REPORT

Client: John Shomaker & Assoc.
Project: BDI **Work Order:** 0805406

Analyte	Result	Units	PQL	%Rec	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Method: EPA Method 8015B: Diesel Range									
Sample ID: MB-16080		*MBLK*			Batch ID:	**16080**	Analysis Date:	6/3/2008 3:57:00 AM	
Diesel Range Organics (DRO)	ND	mg/L	1.0						
Motor Oil Range Organics (MRO)	ND	mg/L	5.0						
Sample ID: LCS-16080		*LCS*			Batch ID:	**16080**	Analysis Date:	6/3/2008 5:06:20 AM	
Diesel Range Organics (DRO)	5.211	mg/L	1.0	104	74	157			
Sample ID: LCSD-16080		*LCSD*			Batch ID:	**16080**	Analysis Date:	6/3/2008 5:41:42 AM	
Diesel Range Organics (DRO)	5.384	mg/L	1.0	108	74	157	3.26	23	
Method: EPA Method 8015B: Gasoline Range									
Sample ID: 5ML RB		*MBLK*			Batch ID:	**R28760**	Analysis Date:	6/2/2008 9:22:36 AM	
Gasoline Range Organics (GRO)	ND	mg/L	0.050						
Sample ID: 2.5UG GRO LCS		*LCS*			Batch ID:	**R28760**	Analysis Date:	6/2/2008 8:34:38 PM	
Gasoline Range Organics (GRO)	0.5012	mg/L	0.050	100	80	115			
Sample ID: 2.5UG GRO LCSD		*LCSD*			Batch ID:	**R28760**	Analysis Date:	6/2/2008 9:04:46 PM	
Gasoline Range Organics (GRO)	0.5072	mg/L	0.050	101	80	115	1.19	8.39	
Method: EPA Method 8021B: Volatiles									
Sample ID: 5ML RB		*MBLK*			Batch ID:	**R28760**	Analysis Date:	6/2/2008 9:22:36 AM	
Methyl tert-butyl ether (MTBE)	ND	µg/L	2.5						
Benzene	ND	µg/L	1.0						
Toluene	ND	µg/L	1.0						
Ethylbenzene	ND	µg/L	1.0						
Xylenes, Total	ND	µg/L	2.0						
1,2,4-Trimethylbenzene	ND	µg/L	1.0						
1,3,5-Trimethylbenzene	ND	µg/L	1.0						
Sample ID: 100NG BTEX LCS		*LCS*			Batch ID:	**R28760**	Analysis Date:	6/2/2008 7:34:19 PM	
Methyl tert-butyl ether (MTBE)	19.81	µg/L	2.5	99.1	51.2	138			
Benzene	18.29	µg/L	1.0	91.4	85.9	113			
Toluene	18.19	µg/L	1.0	90.9	86.4	113			
Ethylbenzene	18.56	µg/L	1.0	92.8	83.5	118			
Xylenes, Total	55.54	µg/L	2.0	92.6	83.4	122			
1,2,4-Trimethylbenzene	18.33	µg/L	1.0	90.5	83.5	115			
1,3,5-Trimethylbenzene	17.24	µg/L	1.0	86.2	85.2	113			
Sample ID: 100NG BTEX LCSD		*LCSD*			Batch ID:	**R28760**	Analysis Date:	6/2/2008 8:04:29 PM	
Methyl tert-butyl ether (MTBE)	21.06	µg/L	2.5	105	51.2	138	6.10	28	
Benzene	19.16	µg/L	1.0	95.8	85.9	113	4.64	27	
Toluene	19.14	µg/L	1.0	95.7	86.4	113	5.09	19	
Ethylbenzene	19.25	µg/L	1.0	96.2	83.5	118	3.64	10	
Xylenes, Total	57.93	µg/L	2.0	96.6	83.4	122	4.22	13	
1,2,4-Trimethylbenzene	19.27	µg/L	1.0	95.2	83.5	115	5.02	21	
1,3,5-Trimethylbenzene	18.03	µg/L	1.0	90.2	85.2	113	4.50	10	

Qualifiers:

E	Value above quantitation range	H	Holding times for preparation or analysis exceeded
J	Analyte detected below quantitation limits	ND	Not Detected at the Reporting Limit
R	RPD outside accepted recovery limits	S	Spike recovery outside accepted recovery limits

QA/QC SUMMARY REPORT

Client: John Shomaker & Assoc.
Project: BDI **Work Order:** 0805

Analyte	Result	Units	PQL	%Rec	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Method: EPA 6010B: Total Recoverable Metals									
Sample ID: MB-16089		*MBLK*			Batch ID: **16089**		Analysis Date: 6/6/2008 1:12:49 PM		
Arsenic	ND	mg/L	0.020						
Barium	ND	mg/L	0.010						
Cadmium	ND	mg/L	0.0020						
Calcium	ND	mg/L	0.50						
Chromium	ND	mg/L	0.0060						
Lead	ND	mg/L	0.0050						
Magnesium	ND	mg/L	0.50						
Potassium	ND	mg/L	1.0						
Selenium	ND	mg/L	0.050						
Silver	ND	mg/L	0.0050						
Sodium	ND	mg/L	0.50						
Sample ID: LCS-16089		*LCS*			Batch ID: **16089**		Analysis Date: 6/6/2008 10:47:25 AM		
Arsenic	0.5282	mg/L	0.020	106	80	120			
Barium	0.4907	mg/L	0.010	98.1	80	120			
Cadmium	0.5011	mg/L	0.0020	100	80	120			
Calcium	50.71	mg/L	0.50	101	80	120			
Chromium	0.5060	mg/L	0.0060	101	80	120			
Lead	0.4927	mg/L	0.0050	98.5	80	120			
Magnesium	50.86	mg/L	0.50	102	80	120			
Potassium	52.58	mg/L	1.0	105	80	120			
Selenium	0.4768	mg/L	0.050	95.4	80	120			
Silver	0.5005	mg/L	0.0050	100	80	120			
Sodium	53.65	mg/L	0.50	107	80	120			
Method: SM 2540C Total Dissolved Solids									
Sample ID: MB-16086		*MBLK*			Batch ID: **16086**		Analysis Date: 6/2/2008		
Total Dissolved Solids	ND	mg/L	20						
Sample ID: LCS-16086		*LCS*			Batch ID: **16086**		Analysis Date: 6/2/2008		
Total Dissolved Solids	1007	mg/L	20	101	80	120			

Qualifiers:

E	Value above quantitation range	H	Holding times for preparation or analysis exceeded
J	Analyte detected below quantitation limits	ND	Not Detected at the Reporting Limit
R	RPD outside accepted recovery limits	S	Spike recovery outside accepted recovery limits

Hall Environmental Analysis Laboratory, Inc.

Sample Receipt Checklist

lient Name SHO

Date Received: 5/30/2008

Work Order Number 0805406

Received by: TLS

Sample ID labels checked by: TS
Initials

Checklist completed by: 5/30/08
Signature Date

Matrix:

Carrier name Client drop-off

Shipping container/cooler in good condition?	Yes ☑	No ☐	Not Present ☐	
Custody seals intact on shipping container/cooler?	Yes ☐	No ☐	Not Present ☐	Not Shipped ☑
Custody seals intact on sample bottles?	Yes ☐	No ☐	N/A ☑	
Chain of custody present?	Yes ☑	No ☐		
Chain of custody signed when relinquished and received?	Yes ☑	No ☐		
Chain of custody agrees with sample labels?	Yes ☑	No ☐		
Samples in proper container/bottle?	Yes ☑	No ☐		
Sample containers intact?	Yes ☑	No ☐		
Sufficient sample volume for indicated test?	Yes ☐	No ☑		
All samples received within holding time?	Yes ☑	No ☐		
er - VOA vials have zero headspace?	No VOA vials submitted ☐	Yes ☑	No ☐	
Water - Preservation labels on bottle and cap match?	Yes ☑	No ☐	N/A ☐	
Water - pH acceptable upon receipt?	Yes ☑	No ☐	N/A ☐	
Container/Temp Blank temperature?	7°	<6° C *Acceptable* If given sufficient time to cool.		

COMMENTS:

Client contacted

Date contacted:

Person contacted

Contacted by:

Regarding:

Comments: Head #2 has very low volume. Per EM don't run Hg 5/30/08

rrective Action

Chain-of-Custody Record

Client: JSAI

Address: 2611 Broadbent Pkway
Alb. NM 87107

Phone #: 345-3407

email or Fax#: emelis@shomaker.com

QA/QC Package:
☐ Standard ☐ Level 4 (Full Validation)
☐ Other
☐ EDD (Type)

Turn-Around Time:
☒ Standard ☐ Rush

Project Name: BDI

Project #: BDI / Bloomfield

Project Manager: Edwin Melis

Sampler: Edwin Melis

On Ice ☒ Yes ☐ No

Sample Temperature 7

HALL ENVIRONMENTAL ANALYSIS LABORATORY

www.hallenvironmental.com
4901 Hawkins NE - Albuquerque, NM 87109
Tel. 505-345-3975 Fax 505-345-4107

Analysis Request

Date	Time	Sample Request ID	Container Type and #	Preservative Type	HEAL No. 0805406	BTEX + MTBE + TMB's (8021)	BTEX + MTBE + TPH (Gas only)	TPH Method 8015B (Gas/Diesel)	TPH (Method 418.1)	EDB (Method 504.1)	EDC (Method 8260)	8310 (PNA or PAH)	Anions (F,Cl,NO_3,NO_2,PO_4,SO_4)	8081 Pesticides / 8082 PCB's	8260B (VOA)	8270 (Semi-VOA)	cat/anion - total	RCRA 8 minus Hg			Air Bubbles (Y or N)
5/29/08	12:45	BDI-MW1-2			1	X		X									~~X~~	~~X~~	Cw		
5/29/08	13:15	BDI-MW2			2												X	X			
		trip blank			3																
		Ty 5/30/08																			

Date:	Time:	Relinquished by:	Received by:
5/30/08	10:45	Edwin A. Melis	Tanya Shomis 5/30/08 1045
Date:	Time:	Relinquished by:	Received by:

Remarks: On the second sample do TDS please - please try anions & cations if possible.

If necessary, samples submitted to Hall Environmental may be subcontracted to other accredited laboratories. This serves as notice of this possibility. Any sub-contracted data will be clearly notated on the analytical report.

JOHN SHOMAKER & ASSOCIATES, INC.
WATER-RESOURCE AND ENVIRONMENTAL CONSULTANTS
2611 BROADBENT PARKWAY NE
ALBUQUERQUE, NEW MEXICO 87107
(505) 345-3407, FAX (505) 345-9920
www.shomaker.com

MEMORANDUM

To: John Volkerding, PhD, Basin Disposal, Inc.

From: Erwin A. Melis, PhD, Hydrogeologist, JSAI

Date: November 19, 2008

Subject: Results from water-quality testing of assessment well No. 2 at Basin Disposal, Inc., Bloomfield, San Juan County, New Mexico

This memorandum describes the results of water-quality testing at the second assessment well (AW-2) at Basin Disposal, Inc. Locations of the two assessment wells (No. 1 and No. 2) are shown on the map attached as Figure 1. The objective of the assessment wells was to test for the presence of ground water at the site. Our report of September 2008 (JSAI, 2008[1]) described perched ground water at the site with a total dissolved solids concentration of between 24,000 and 38,000 milligrams per liter (mg/L), above the above the total dissolved solids (TDS) concentration of 10,000 mg/L for fresh water (to be protected), per NMAC 19.15.36.8 C. (15) (b), as defined in NMAC 19.15.1.7 F. (3). This memorandum adds the results of a water-quality analysis at AW-2 to the AW-1 results given in our previous report (JSAI, 2008).

Well Development and Field Ground-Water Quality

Prior to sampling, well AW-2 was purged by hand using a dedicated, disposable bailer on October 30, 2008. The depth to water, pH, specific conductance, and temperature of produced water were periodically measured during purging. On October 30, 2008, AW-2 had an initial water level of 17.74 feet below ground level (ft bgl), and a post sampling water level of 20.31 ft bgl. Specific conductance values in AW-2 were within 3 percent before and after bailing, whereas pH and temperature in AW-2 were essentially constant during development.

---

[1] [JSAI] John Shomaker & Associates, Inc., 2008, Subsurface and Ground-Water Investigation in Support of the Modification of a Surface Waste Management Facility, Basin Disposal, Inc., Bloomfield, New Mexico: consultant's report, 16 p.

Field water-quality data for AW-2 (Table 1) indicate elevated values of specific conductance during the October 30, 2008 sampling event. During the October 30, 2008 sampling event, water at AW-2 was clear, without the lacquer-like odor that was detected during drilling of the nearby BH-2 on May 27, 2008. A summary of the field water-quality measurements is provided in Table 1.

Table 1. Summary of field measurement of specific conductance, pH, and temperature in Basin Disposal AW-2, October 30, 2008, Bloomfield, New Mexico

	specific conductance, µS/cm	**pH**	**temperature, °C**
AW-2	31,190 ± 30	7.51	17.2

°C - degrees Celsius

µS/cm - microSiemens per centimeter

Ground-Water Quality Results - Organics

Water from AW-2 was analyzed according to U.S. Environmental Protection Agency (EPA) method 8021B, EPA method 8015B-GRO, EPA method 8015B-DRO, and also EPA method 418.1 (Total Petroleum Hydrocarbons) on October 30, 2008. Concentrations of organic parameters analyzed were below the laboratory detection limits (Table 2). Attached is a copy of the full laboratory results, which contains QA/QC results and the chain-of-custody form for the October 30, 2008 sampling event.

Table 2. Summary of laboratory analyses of selected organic compounds in ground-water samples collected October 30, 2008 from AW-2, Basin Disposal Site, Bloomfield, New Mexico

constituent	**unit**	**AW-2**	**NMWQCC standard**
diesel range organics	mg/L	<1.0	no standard
motor range organics	mg/L	<5.0	no standard
gasoline range organics	mg/L	<0.05	no standard
MTBE	µg/L	<2.5	no standard
benzene	µg/L	<1.0	10
toluene	µg/L	<1.0	750
ethylbenzene	µg/L	<1.0	750
total xylenes	µg/L	<2.0	620
1, 2, 4-trimethylbenzene	µg/L	<1.0	no standard
1, 3, 5-trimethylbenzene	µg/L	<1.0	no standard
total petroleum hydrocarbons	mg/L	<1.0	no standard

NMWQCC - New Mexico Water Quality Control Commission
mg/L - milligrams per liter

µg/L - micrograms per liter
MTBE - methyl tert-butyl ether

Water-Quality Results – Cations, Anions, RCRA Metals

Samples of ground water from AW-2 were also collected for laboratory analysis for major cations, anions, and RCRA metals. Water produced from AW-2 had elevated concentrations of TDS, chloride, and sulfate (EPA method 300.0) when compared to the New Mexico Water Quality Control Commission (NMWQCC) standards (see Table 3). The high TDS concentration resulted in elevated detection limits for some parameters, and as a result, detection limits for arsenic, cadmium, and selenium concentrations are at or above the applicable NMWQCC standards (Table 3). The laboratory report and chain-of-custody documentation are attached.

Table 3. Summary of water-quality analysis results from AW-2, sampled at the Basin Disposal Site, Bloomfield, San Juan County, New Mexico

constituent	unit	AW-2	NMWQCC discharge standard
date sampled		10/30/2008	
TDS	mg/L	**29,000**	1,000
bromide	mg/L	9.5	no standards
chloride	mg/L	**2,600**	250
fluoride	mg/L	<1.0	1.6
nitrite	mg/L	<1.0	no standard
nitrate	mg/L	<1.0	10 (total)
phosphorus	mg/L	<5.0	no standards
sulfate	mg/L	**17,000**	600
arsenic (total)	mg/L	<0.10	0.10
barium	mg/L	<0.10	1.0
cadmium	mg/L	<0.01	0.01
calcium	mg/L	420	no standard
chromium	mg/L	<0.03	0.05
lead	mg/L	<0.025	0.05
magnesium	mg/L	230	no standard
mercury	mg/L	<0.0002	0.002
potassium	mg/L	32	no standard
selenium	mg/L	<0.25	0.05
silver	mg/L	<0.025	0.05
sodium	mg/L	10,000	no standard

NMWQCC - New Mexico Water Quality Control Commission
bold - result exceeds standard
TDS - total dissolved solids
mg/L - milligrams per liter

Em:em

Enc: Figure 1
Copy of full laboratory report

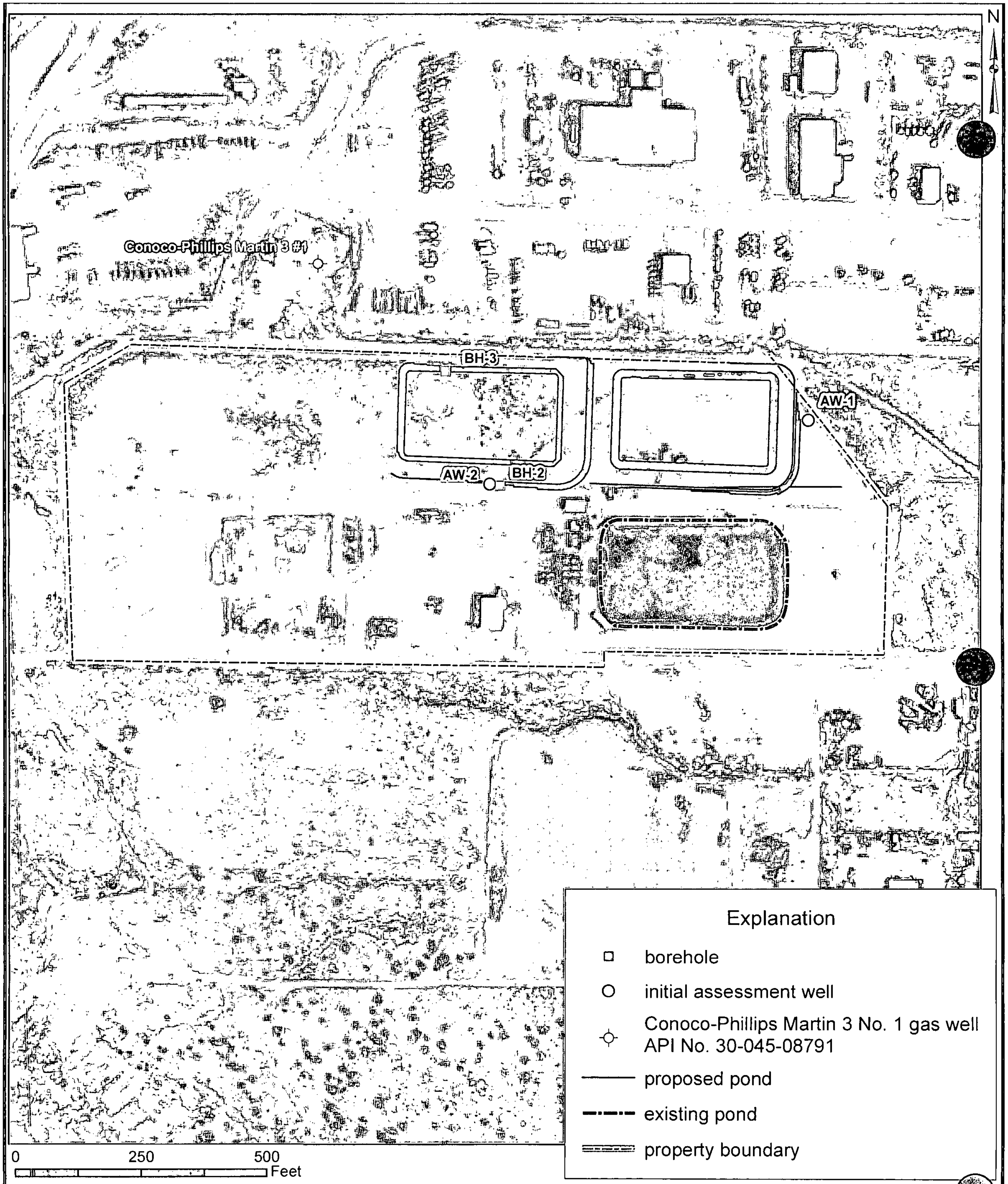

Figure 1. Aerial photograph showing the locations of the existing pond, the drilled boreholes, initial assessment wells, proposed evaporation ponds, and well site of the Conoco-Phillips Martin 3 No. 1, Basin Disposal Site, Bloomfield, New Mexico.

JOHN SHOMAKER & ASSOCIATES, INC.

HALL
ENVIRONMENTAL
ANALYSIS
LABORATORY

COVER LETTER

Friday, November 14, 2008

Erwin Melis
John Shomaker & Assoc.
2611 Broadbent Parkway NE
Albuquerque, NM 87107

TEL: (505) 250-1607
FAX (505) 345-9920

RE: BDI

Order No.: 0810632

Dear Erwin Melis:

Hall Environmental Analysis Laboratory, Inc. received 2 sample(s) on 10/30/2008 for the analyses presented in the following report.

These were analyzed according to EPA procedures or equivalent. Below is a list of our accreditations. To access our accredited tests please go to www.hallenvironmental.com or the state specific web sites.

Reporting limits are determined by EPA methodology. No determination of compounds below these (denoted by the ND or < sign) has been made.

Please don't hesitate to contact HEAL for any additional information or clarifications.

Sincerely,

Andy Freeman, Business Manager
Nancy McDuffie, Laboratory Manager

NM Lab # NM9425
AZ license # AZ0682
ORELAP Lab # NM100001
Texas Lab# T104704424-08-TX

4901 Hawkins NE ▪ Suite D ▪ Albuquerque, NM 87109
505.345.3975 ▪ Fax 505.345.4107
www.hallenvironmental.com

Hall Environmental Analysis Laboratory, Inc.

Date: *14-Nov-08*

CLIENT:	John Shomaker & Assoc.	**Client Sample ID:**	AW-2
Lab Order:	0810632	**Collection Date:**	10/30/2008 12:30:00 PM
Project:	BDI	**Date Received:**	10/30/2008
Lab ID:	0810632-01	**Matrix:**	AQUEOUS

Analyses	Result	PQL	Qual	Units	DF	Date Analyzed
EPA METHOD 8015B: DIESEL RANGE						Analyst: **SCC**
Diesel Range Organics (DRO)	ND	1.0		mg/L	1	11/5/2008
Motor Oil Range Organics (MRO)	ND	5.0		mg/L	1	11/5/2008
Surr: DNOP	135	58-140		%REC	1	11/5/2008
EPA METHOD 8015B: GASOLINE RANGE						Analyst: **DAM**
Gasoline Range Organics (GRO)	ND	0.050		mg/L	1	11/6/2008 11:45:00 PM
Surr: BFB	87.8	59.9-122		%REC	1	11/6/2008 11:45:00 PM
EPA METHOD 8021B: VOLATILES						Analyst: **DAM**
Methyl tert-butyl ether (MTBE)	ND	2.5		µg/L	1	11/6/2008 11:45:00 PM
Benzene	ND	1.0		µg/L	1	11/6/2008 11:45:00 PM
Toluene	ND	1.0		µg/L	1	11/6/2008 11:45:00 PM
Ethylbenzene	ND	1.0		µg/L	1	11/6/2008 11:45:00 PM
Xylenes, Total	ND	2.0		µg/L	1	11/6/2008 11:45:00 PM
1,2,4-Trimethylbenzene	ND	1.0		µg/L	1	11/6/2008 11:45:00 PM
1,3,5-Trimethylbenzene	ND	1.0		µg/L	1	11/6/2008 11:45:00 PM
Surr: 4-Bromofluorobenzene	81.5	65.9-130		%REC	1	11/6/2008 11:45:00 PM
EPA METHOD 300.0: ANIONS						Analyst: **IC**
Fluoride	ND	1.0		mg/L	10	10/31/2008 1:24:47 PM
Chloride	2600	20		mg/L	200	11/11/2008 1:20:17 AM
Nitrogen, Nitrite (As N)	ND	1.0		mg/L	10	10/31/2008 1:24:47 PM
Bromide	9.5	1.0		mg/L	10	10/31/2008 1:24:47 PM
Nitrogen, Nitrate (As N)	ND	1.0		mg/L	10	10/31/2008 1:24:47 PM
Phosphorus, Orthophosphate (As P)	ND	5.0		mg/L	10	10/31/2008 1:24:47 PM
Sulfate	17000	250		mg/L	500	11/14/2008 6:07:21 AM
EPA METHOD 7470: MERCURY						Analyst: **SNV**
Mercury	ND	0.00020		mg/L	1	11/2/2008 8:01:18 PM
EPA METHOD 6010B: DISSOLVED METALS						Analyst: **TES**
Calcium	420	5.0		mg/L	5	11/3/2008 7:32:10 PM
Magnesium	230	5.0		mg/L	5	11/3/2008 7:32:10 PM
Potassium	32	1.0		mg/L	1	11/3/2008 7:26:31 PM
Sodium	10000	500		mg/L	500	11/3/2008 8:12:50 PM
EPA 6010B: TOTAL RECOVERABLE METALS						Analyst: **NMO**
Arsenic	ND	0.10		mg/L	5	11/5/2008 2:48:32 PM
Barium	ND	0.10		mg/L	5	11/5/2008 1:09:02 PM
Cadmium	ND	0.010		mg/L	5	11/5/2008 1:09:02 PM
Chromium	ND	0.030		mg/L	5	11/5/2008 1:09:02 PM
Lead	ND	0.025		mg/L	5	11/5/2008 1:09:02 PM

Qualifiers:

*	Value exceeds Maximum Contaminant Level	B	Analyte detected in the associated Method Blank
E	Estimated value	H	Holding times for preparation or analysis exceeded
J	Analyte detected below quantitation limits	MCL	Maximum Contaminant Level
ND	Not Detected at the Reporting Limit	RL	Reporting Limit
S	Spike recovery outside accepted recovery limits		

CLIENT:	John Shomaker & Assoc.	**Client Sample ID:**	AW-2
Lab Order:	0810632	**Collection Date:**	10/30/2008 12:30:00 PM
Project:	BDI	**Date Received:**	10/30/2008
Lab ID:	0810632-01	**Matrix:**	AQUEOUS

Analyses	Result	PQL	Qual	Units	DF	Date Analyzed
EPA 6010B: TOTAL RECOVERABLE METALS						Analyst: **NMO**
Selenium	ND	0.25		mg/L	5	11/5/2008 2:48:32 PM
Silver	ND	0.025		mg/L	5	11/5/2008 1:09:02 PM
EPA METHOD 418.1: TPH						Analyst: **LRW**
Petroleum Hydrocarbons, TR	ND	1.0		mg/L	1	11/4/2008
SM 2540C: TDS						Analyst: **KMB**
Total Dissolved Solids	29000	20		mg/L	1	11/3/2008

Qualifiers:

*	Value exceeds Maximum Contaminant Level	B	Analyte detected in the associated Method Blank
E	Estimated value	H	Holding times for preparation or analysis exceeded
J	Analyte detected below quantitation limits	MCL	Maximum Contaminant Level
ND	Not Detected at the Reporting Limit	RL	Reporting Limit
S	Spike recovery outside accepted recovery limits		

Hall Environmental Analysis Laboratory, Inc.

Date: *14-Nov-08*

CLIENT:	John Shomaker & Assoc.	**Client Sample ID:**	Trip Blank
Lab Order:	0810632	**Collection Date:**	
Project:	BDI	**Date Received:**	10/30/2008
Lab ID:	0810632-02	**Matrix:**	TRIP BLANK

Analyses	Result	PQL	Qual	Units	DF	Date Analyzed
EPA METHOD 8015B: GASOLINE RANGE						Analyst: **DAM**
Gasoline Range Organics (GRO)	ND	0.050		mg/L	1	11/7/2008 12:15:26 AM
Surr: BFB	92.3	59.9-122		%REC	1	11/7/2008 12:15:26 AM

Qualifiers:				
*	Value exceeds Maximum Contaminant Level	B	Analyte detected in the associated Method Blank
E	Estimated value	H	Holding times for preparation or analysis exceeded
J	Analyte detected below quantitation limits	MCL	Maximum Contaminant Level
ND	Not Detected at the Reporting Limit	RL	Reporting Limit
S	Spike recovery outside accepted recovery limits		

QA/QC SUMMARY REPORT

Client: John Shomaker & Assoc.
P[illegible]t: BDI
Work Order: 0810632

Method: **EPA Method 300.0: Anions**

Sample ID: MB *MBLK* Batch ID: **R30970** Analysis Date: 10/31/2008 9:38:28 AM

Analyte	Result	Units	PQL	%Rec	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Fluoride	ND	mg/L	0.10						
Chloride	ND	mg/L	0.10						
Nitrogen, Nitrite (As N)	ND	mg/L	0.10						
Bromide	ND	mg/L	0.10						
Nitrogen, Nitrate (As N)	ND	mg/L	0.10						
Phosphorus, Orthophosphate (As P)	ND	mg/L	0.50						
Sulfate	ND	mg/L	0.50						

Sample ID: MB *MBLK* Batch ID: **R30970** Analysis Date: 11/1/2008 12:08:58 AM

Analyte	Result	Units	PQL	%Rec	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Fluoride	ND	mg/L	0.10						
Chloride	ND	mg/L	0.10						
Nitrogen, Nitrite (As N)	ND	mg/L	0.10						
Bromide	ND	mg/L	0.10						
Nitrogen, Nitrate (As N)	ND	mg/L	0.10						
Phosphorus, Orthophosphate (As P)	ND	mg/L	0.50						
Sulfate	ND	mg/L	0.50						

Sample ID: MB *MBLK* Batch ID: **R31092** Analysis Date: 11/10/2008 9:22:52 AM

Analyte	Result	Units	PQL	%Rec	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Fluoride	ND	mg/L	0.10						
Chloride	ND	mg/L	0.10						
Ni[illegible]n, Nitrite (As N)	ND	mg/L	0.10						
B[illegible]	ND	mg/L	0.10						
Nitrogen, Nitrate (As N)	ND	mg/L	0.10						
Phosphorus, Orthophosphate (As P)	ND	mg/L	0.50						
Sulfate	ND	mg/L	0.50						

Sample ID: MB *MBLK* Batch ID: **R31170** Analysis Date: 11/13/2008 10:06:06 AM

Analyte	Result	Units	PQL	%Rec	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Fluoride	ND	mg/L	0.10						
Chloride	ND	mg/L	0.10						
Nitrogen, Nitrite (As N)	ND	mg/L	0.10						
Bromide	ND	mg/L	0.10						
Nitrogen, Nitrate (As N)	ND	mg/L	0.10						
Phosphorus, Orthophosphate (As P)	ND	mg/L	0.50						
Sulfate	ND	mg/L	0.50						

Sample ID: LCS *LCS* Batch ID: **R30970** Analysis Date: 10/31/2008 9:55:52 AM

Analyte	Result	Units	PQL	%Rec	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Fluoride	0.5085	mg/L	0.10	102	90	110			
Chloride	5.050	mg/L	0.10	101	90	110			
Nitrogen, Nitrite (As N)	1.014	mg/L	0.10	101	90	110			
Bromide	2.539	mg/L	0.10	102	90	110			
Nitrogen, Nitrate (As N)	2.613	mg/L	0.10	105	90	110			
Phosphorus, Orthophosphate (As P)	5.050	mg/L	0.50	101	90	110			
Sulfate	10.35	mg/L	0.50	103	90	110			

Sample ID: LCS *LCS* Batch ID: **R30970** Analysis Date: 11/1/2008 12:26:23 AM

Analyte	Result	Units	PQL	%Rec	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Fluoride	0.4930	mg/L	0.10	98.6	90	110			
Chloride	4.784	mg/L	0.10	95.7	90	110			
Nitrogen, Nitrite (As N)	0.9554	mg/L	0.10	95.5	90	110			

[illegible]iers:

E	Estimated value	H	Holding times for preparation or analysis exceeded
J	Analyte detected below quantitation limits	ND	Not Detected at the Reporting Limit
R	RPD outside accepted recovery limits	S	Spike recovery outside accepted recovery limits

QA/QC SUMMARY REPORT

Client: John Shomaker & Assoc.
Project: BDI **Work Order:** 081062[illegible]

Method: **EPA Method 300.0: Anions**

Sample ID: LCS *LCS* Batch ID: **R30970** Analysis Date: 11/1/2008 12:26:23 AM

Analyte	Result	Units	PQL	%Rec	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Bromide	2.419	mg/L	0.10	96.8	90	110			
Nitrogen, Nitrate (As N)	2.452	mg/L	0.10	98.1	90	110			
Phosphorus, Orthophosphate (As P)	4.801	mg/L	0.50	96.0	90	110			
Sulfate	9.545	mg/L	0.50	95.5	90	110			

Sample ID: LCS *LCS* Batch ID: **R31092** Analysis Date: 11/10/2008 9:40:16 AM

Analyte	Result	Units	PQL	%Rec	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Fluoride	0.4516	mg/L	0.10	90.3	90	110			
Chloride	4.742	mg/L	0.10	94.8	90	110			
Nitrogen, Nitrite (As N)	0.9015	mg/L	0.10	90.2	90	110			
Bromide	2.458	mg/L	0.10	98.3	90	110			
Nitrogen, Nitrate (As N)	2.390	mg/L	0.10	95.6	90	110			
Phosphorus, Orthophosphate (As P)	4.794	mg/L	0.50	95.9	90	110			
Sulfate	9.767	mg/L	0.50	97.7	90	110			

Sample ID: LCS *LCS* Batch ID: **R31170** Analysis Date: 11/13/2008 10:23:30 AM

Analyte	Result	Units	PQL	%Rec	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Fluoride	0.4985	mg/L	0.10	99.7	90	110			
Chloride	4.677	mg/L	0.10	93.5	90	110			
Nitrogen, Nitrite (As N)	0.9444	mg/L	0.10	94.4	90	110			
Bromide	2.416	mg/L	0.10	96.6	90	110			
Nitrogen, Nitrate (As N)	2.393	mg/L	0.10	95.7	90	110			
Phosphorus, Orthophosphate (As P)	4.153	mg/L	0.50	83.1	90	110			S
Sulfate	10.03	mg/L	0.50	100	90	110			

Method: **EPA Method 418.1: TPH**

Sample ID: MB-17541 *MBLK* Batch ID: **17541** Analysis Date: 11/4/2008

Analyte	Result	Units	PQL	%Rec	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Petroleum Hydrocarbons, TR	ND	mg/L	1.0						

Sample ID: LCS-17541 *LCS* Batch ID: **17541** Analysis Date: 11/4/2008

Analyte	Result	Units	PQL	%Rec	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Petroleum Hydrocarbons, TR	4.660	mg/L	1.0	93.2	78.5	120			

Sample ID: LCSD-17541 *LCSD* Batch ID: **17541** Analysis Date: 11/4/2008

Analyte	Result	Units	PQL	%Rec	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Petroleum Hydrocarbons, TR	4.600	mg/L	1.0	92.0	78.5	120	1.30	20	

Method: **EPA Method 8015B: Diesel Range**

Sample ID: MB-17539 *MBLK* Batch ID: **17539** Analysis Date: 11/5/2008

Analyte	Result	Units	PQL	%Rec	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Diesel Range Organics (DRO)	ND	mg/L	1.0						
Motor Oil Range Organics (MRO)	ND	mg/L	5.0						

Sample ID: LCS-17539 *LCS* Batch ID: **17539** Analysis Date: 11/5/2008

Analyte	Result	Units	PQL	%Rec	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Diesel Range Organics (DRO)	6.243	mg/L	1.0	125	74	157			

Sample ID: LCSD-17539 *LCSD* Batch ID: **17539** Analysis Date: 11/5/2008

Analyte	Result	Units	PQL	%Rec	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Diesel Range Organics (DRO)	6.376	mg/L	1.0	128	74	157	2.10	23	

Qualifiers:

E	Estimated value	H	Holding times for preparation or analysis exceeded
J	Analyte detected below quantitation limits	ND	Not Detected at the Reporting Limit
R	RPD outside accepted recovery limits	S	Spike recovery outside accepted recovery limits

QA/QC SUMMARY REPORT

Client: John Shomaker & Assoc.
P[illegible]t: ..BDI
Work Order: 0810632

Analyte	Result	Units	PQL	%Rec	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Method: EPA Method 8015B: Gasoline Range									
Sample ID: 0810632-01A MSD		*MSD*			Batch ID:	**R31040**	Analysis Date:	11/7/2008 1:33:48 PM	
Gasoline Range Organics (GRO)	0.4292	mg/L	0.050	85.8	80	115	4.42	8.39	
Sample ID: 5ML RB		*MBLK*			Batch ID:	**R31040**	Analysis Date:	11/6/2008 9:30:33 AM	
Gasoline Range Organics (GRO)	ND	mg/L	0.050						
Sample ID: 2.5UG GRO LCS		*LCS*			Batch ID:	**R31040**	Analysis Date:	11/7/2008 4:51:20 AM	
Gasoline Range Organics (GRO)	0.4598	mg/L	0.050	92.0	80	115			
Sample ID: 0810632-01A MS		*MS*			Batch ID:	**R31040**	Analysis Date:	11/7/2008 1:03:14 PM	
Gasoline Range Organics (GRO)	0.4486	mg/L	0.050	89.7	80	115			
Method: EPA Method 8021B: Volatiles									
Sample ID: 100NG BTEX LCS		*LCS*			Batch ID:	**R31040**	Analysis Date:	11/7/2008 5:21:46 AM	
Methyl tert-butyl ether (MTBE)	24.96	µg/L	2.5	125	51.2	138			
Benzene	20.99	µg/L	1.0	105	85.9	113			
Toluene	21.44	µg/L	1.0	107	86.4	113			
Ethylbenzene	21.56	µg/L	1.0	108	83.5	118			
Xylenes, Total	64.46	µg/L	2.0	107	83.4	122			
1,2,4-Trimethylbenzene	21.72	µg/L	1.0	109	83.5	115			
1,3,5-Trimethylbenzene	20.79	µg/L	1.0	104	85.2	113			
Method: EPA Method 7470: Mercury									
Sa[illegible]ID: MBLK-17519		*MBLK*			Batch ID:	**17519**	Analysis Date:	11/2/2008 7:12:41 PM	
Mercury	ND	mg/L	0.00020						
Sample ID: LCS1-17519		*LCS*			Batch ID:	**17519**	Analysis Date:	11/2/2008 7:14:28 PM	
Mercury	0.004835	mg/L	0.00020	96.7	80	120			
Method: EPA Method 6010B: Dissolved Metals									
Sample ID: MB		*MBLK*			Batch ID:	**R30991**	Analysis Date:	11/3/2008 5:48:58 PM	
Calcium	ND	mg/L	1.0						
Magnesium	ND	mg/L	1.0						
Potassium	ND	mg/L	1.0						
Sodium	ND	mg/L	1.0						
Sample ID: LCS		*LCS*			Batch ID:	**R30991**	Analysis Date:	11/3/2008 5:52:02 PM	
Calcium	52.38	mg/L	1.0	104	80	120			
Magnesium	52.25	mg/L	1.0	103	80	120			
Potassium	54.69	mg/L	1.0	99.4	80	120			
Sodium	55.57	mg/L	1.0	110	80	120			

Q[illegible]rs:

E	Estimated value	H	Holding times for preparation or analysis exceeded
J	Analyte detected below quantitation limits	ND	Not Detected at the Reporting Limit
R	RPD outside accepted recovery limits	S	Spike recovery outside accepted recovery limits

QA/QC SUMMARY REPORT

Client: John Shomaker & Assoc.

Project: BDI

Work Order: 081062

Method: **EPA 6010B: Total Recoverable Metals**

Sample ID: **MB-17522** *MBLK* Batch ID: **17522** Analysis Date: 11/5/2008 9:28:24 AM

Analyte	Result	Units	PQL	%Rec	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Barium	ND	mg/L	0.010						
Cadmium	ND	mg/L	0.0020						
Chromium	ND	mg/L	0.0060						
Lead	ND	mg/L	0.0050						
Silver	ND	mg/L	0.0050						

Sample ID: **LCS-17522** *LCS* Batch ID: **17522** Analysis Date: 11/5/2008 9:31:36 AM

Analyte	Result	Units	PQL	%Rec	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Barium	0.4770	mg/L	0.010	95.4	80	120			
Cadmium	0.4839	mg/L	0.0020	96.8	80	120			
Chromium	0.4926	mg/L	0.0060	98.5	80	120			
Lead	0.4753	mg/L	0.0050	95.1	80	120			
Silver	0.4869	mg/L	0.0050	97.0	80	120			

Method: **SM 2540C: TDS**

Sample ID: **MB-17531** *MBLK* Batch ID: **17531** Analysis Date: 11/3/2008

Analyte	Result	Units	PQL	%Rec	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Total Dissolved Solids	ND	mg/L	20						

Sample ID: **LCS-17531** *LCS* Batch ID: **17531** Analysis Date: 11/3/2008

Analyte	Result	Units	PQL	%Rec	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Total Dissolved Solids	987.0	mg/L	20	98.7	80	120			

Qualifiers:

E	Estimated value	H	Holding times for preparation or analysis exceeded
J	Analyte detected below quantitation limits	ND	Not Detected at the Reporting Limit
R	RPD outside accepted recovery limits	S	Spike recovery outside accepted recovery limits

Hall Environmental Analysis Laboratory, Inc.

Sample Receipt Checklist

t Name SHO Date Received: 10/30/2008

Work Order Number 0810632 Received by: ARS

Sample ID labels checked by: ______ Initials

Checklist completed by: ______ Signature 10/30/08 Date

Matrix: Carrier name Client drop-off

Shipping container/cooler in good condition?	Yes ☑	No ☐	Not Present ☐	
Custody seals intact on shipping container/cooler?	Yes ☐	No ☐	Not Present ☐	Not Shipped ☑
Custody seals intact on sample bottles?	Yes ☐	No ☐	N/A ☑	
Chain of custody present?	Yes ☑	No ☐		
Chain of custody signed when relinquished and received?	Yes ☑	No ☐		
Chain of custody agrees with sample labels?	Yes ☑	No ☐		
Samples in proper container/bottle?	Yes ☑	No ☐		
Sample containers intact?	Yes ☑	No ☐		
Sufficient sample volume for indicated test?	Yes ☑	No ☐		
All samples received within holding time?	Yes ☑	No ☐		
r - VOA vials have zero headspace?	No VOA vials submitted ☐	Yes ☑	No ☐	
ater - Preservation labels on bottle and cap match?	Yes ☑	No ☐	N/A ☐	
Water - pH acceptable upon receipt?	Yes ☑	No ☐	N/A ☐	
Container/Temp Blank temperature?	4°	*<6° C Acceptable* If given sufficient time to cool.		

COMMENTS:

Client contacted ______ Date contacted: ______ Person contacted ______

Contacted by: ______ Regarding: ______

Comments: ______

rrective Action ______

Chain-of-Custody Record

HALL ENVIRONMENTAL ANALYSIS LABORATORY
www.hallenvironmental.com
4901 Hawkins NE - Albuquerque, NM 87109
Tel. 505-345-3975 Fax 505-345-4107

Client: JSAI

Mailing Address: 2611 Broadbent Parkway, Abq

Phone #: 345-3407

email or Fax#: emelis@shomaker.com

QA/QC Package:
☐ Standard ☐ Level 4 (Full Validation)
☐ Other
☐ EDD (Type)

Turn-Around Time:
☐ Standard ☐ Rush

Project Name: BDI

Project #: Basin Disposal, Inc AW-2

Project Manager: Erwin A. Melis

Sampler: Erwin A. Melis

On Ice: ☑ Yes ☐ No

Sample Temperature: 1

Analysis Request

Date	Time	Matrix	Sample Request ID	Container Type and #	Preservative Type	HEAL No. 0810632	BTEX + MTBE + TMB's (8021)	BTEX + MTBE + TPH (Gas only)	TPH Method 8015B (Gas/Diesel)	TPH (Method 418.1)	EDB (Method 504.1)	8310 (PNA or PAH)	RCRA 8 Metals	Anions (F,Cl,NO_3,NO_2,PO_4,SO_4)	8081 Pesticides / 8082 PCB's	8260B (VOA)	8270 (Semi-VOA)	see attached list				Air Bubbles (Y or N)
10/30	12:30	-	AW-2			1												X				
			n b by mistake																			
			opened one																			
			blank bottle																			
			Trip Blank			2																

Date:	Time:	Relinquished by:	Received by:	Date	Time
10/30	16:10			16:10	10/30/08

Date:	Time:	Relinquished by:	Received by:	Date	Time

Remarks:

If necessary, samples submitted to Hall Environmental may be subcontracted to other accredited laboratories. This serves as notice of this possibility. Any sub-contracted data will be clearly notated on the analytical report.

JOHN SHOMAKER & ASSOCIATES, INC.
WATER-RESOURCE AND ENVIRONMENTAL CONSULTANTS
2611 BROADBENT PARKWAY NORTHEAST
ALBUQUERQUE, NEW MEXICO 87107
(505) 345-3407, FAX (505) 345-9920
www.shomaker.com

May 22, 2009

John Volkerding, Ph.D.
Basin Disposal, Inc.
P.O. Box 100
Aztec, New Mexico 87410

Re: Ground-water and pond-water comparison at Basin Disposal, Inc., Bloomfield, NM

Dear John:

This letter report is in response to the May 1, 2009 New Mexico Oil Conservation Division (NMOCD) request for additional information, and compares water-quality test results of perched ground water at the Basin Disposal Site to the pond water at the Basin Disposal facility and to regional "fresh" ground water. Water-quality test results of the perched water were obtained from the two assessment wells drilled in May of 2008 and sampled on May 27, and October 30, 2008 at Basin Disposal, Inc. (NMOCD Permit application Volume IV, Section 2; JSAI, 2008; JSAI Memorandum of November 19, 2008). Basin Disposal's pond water was sampled by GE Osmonics on August 4, 2006, with the laboratory report completed by GE Infrastructure, Water and Process Technology Division on August 16, 2006. Locations of the two assessment wells (AW-1 and AW- 2) and the existing pond are shown on the map attached as Figure 1. The five regional wells used as an average to represent the background "fresh" ground-water quality are summarized from Stone et al., 1983 and are shown in Figure 2. Water-quality results are presented in Table 1.

Basin Disposal Assessment Wells

Borehole data strongly suggest that ground water at the Site is present under perched conditions. Physical evidence includes moist fracture zones, moist 'clay-rich' areas prone to dissolution within the Nacimiento Formation cores retrieved during drilling at the Site, and assessment wells that collected ground water at the Site, above a level at which a core in the same borehole was dry. On May 29, 2008, two assessment wells, AW-1 and AW-2 at Basin Disposal, Inc., had respective water elevations of 5,672.83 and 5,690.05 ft above mean sea-level (ft amsl) (figures 7 and 8 in JSAI, 2008 used with Bore Hole Survey dated December 2, 2008 and provided by Basin Disposal, Inc.). In contrast, the regional water-level elevation is between 5,600 ft and 5,500 ft amsl (figure 6 in JSAI, 2008).

Ground water in these assessment wells was submitted for analysis and the total dissolved solids (TDS), anions, mercury, dissolved metals, and the total recoverable metals are summarized from reports by JSAI (2008; JSAI Memorandum dated November 19, 2008). Perched ground water at the Site has TDS concentrations of between 24,000 and 38,000 mg/L, above the TDS concentration of 10,000 mg/L for fresh water (to be protected), per NMAC 19.15.36.8 C. (15) (b), as defined in NMAC 19.15.1.7 F. (3), and outside the jurisdiction of the NMOCD (JSAI, 2008). Water produced from the assessment wells had elevated concentrations of TDS, chloride, fluoride, nitrate, sulfate, and lead (EPA method 6010 measures total recoverable metals) when compared to the New Mexico Water Quality Control Commission (NMWQCC) standards (see Table 1). The ground water in the assessment wells can be classified as Na-SO_4 type water on a Piper diagram (Figure 3). Piper diagrams plot the number of major ions in water, balancing mass and electric charge.

Regional Ground-Water Quality

As mentioned in the ground-water investigation (JSAI, 2008), regional ground water has a relatively high average specific conductance and TDS content, except where shallow recharge decreases these parameters (Stone et al., 1983). Recharge occurs from the Animas River, the San Juan River, and irrigation canals in the floodplain, lowering the average specific conductance of ground water in alluvial wells (1,690 micromhos per centimeter; µmhos/cm) as compared to water from wells completed in the underlying Nacimiento Formation (5,660 µmhos/cm).

Water-quality results for wells completed in the Nacimiento Formation on Crouch Mesa, near the Basin Disposal Site, are unavailable (Stone et al., 1983). Wells in the Nacimiento Formation but south of the San Juan River are characterized as Na-Ca-SO_4 ground water. This same characterization applies to alluvial ground water in an 8-mile radius of the Basin Disposal Site. In these wells, ground water contains high concentrations of calcium, sodium, and sulfate, and is also classified as Na-Ca-SO_4 type water (see Table 1).

The "fresh" ground-water aquifer probably encompasses the Ojo Alamo Sandstone in addition to the Nacimiento Formation, which lies on top of a relatively impermeable Kirtland Shale. For the purposes of this report the Kirtland Shale is considered an aquiclude. The thickness of the Nacimiento Formation and the Ojo Alamo Sandstone under the Basin Disposal Site is considered to be less than 941 ft (NMOCD oil & gas well records). Taking the thickness of these units and subtracting the unsaturated thickness based on water-elevation contours leads to an estimated maximum saturated thickness of at most 869 ft under the Basin Disposal Site and in some areas significantly less.

Disposal Pond Water Quality

Disposal-pond water, sampled on August 4, 2006 and reported by the laboratory on August 16, 2006, can be classified as a Na-Cl (sodium-chloride) type water that plots in different regions of a tri-linear (Piper) diagram (Figure 3).

Table 1. Summary of water-quality analysis results at the Basin Disposal Site and the surrounding area in Bloomfield, San Juan County, New Mexico

constituent	unit	AW-1 water sample	AW-2 water sample	average of 5 wells in a 8-mile radius (Stone et al., 1983)	Basin Disposal surface pond water sample	NMWQCC discharge standards
date sampled		5/27/2008	10/30/2008	ranges from 1933 to 1974	08/04/2006	
water type[1]		Na-SO$_4$	Na-SO$_4$	Na-Ca-SO$_4$	Na-Cl	not applicable
TDS	mg/L	**38,000**	**29,000**	**1,577**	**15,721**[2]	1,000
bromide	mg/L	6.3	9.5	NA	NA	no standards
chloride	mg/L	**2,300**	**2,600**	25	**7,600**	250
fluoride	mg/L	**1.7**	<1.0	0.7	<0.1	1.6
nitrate	mg/L	**11**	<1.0	1.9	<1.0	10 (total)
phosphorus	mg/L	<5.0	<5.0	NR	5.3	no standards
sulfate	mg/L	**18,000**	**17,000**	**1,249**	**978**	600
arsenic (total)	mg/L	<0.20	<0.10	NA	NA	0.10
barium	mg/L	<0.20	<0.10	NA	**3.1**	1.0
cadmium	mg/L	<0.020	<0.010	NA	NA	0.01
calcium	mg/L	480	420	188	139	no standard
chromium	mg/L	<0.060	<0.030	NA	NA	0.05
lead	mg/L	**0.098**	<0.025	NA	0.019	0.05
magnesium	mg/L	300	230	24	31.5	no standard
mercury	mg/L	<0.00020	<0.00020	NA	0.001	0.002
potassium	mg/L	15	32	6	571	no standard
selenium	mg/L	<0.50	<0.25	NR	NA	0.05
silver	mg/L	<0.050	<0.025	NA	NA	0.05
sodium	mg/L	10,000	10,000	650	4,970	no standard

[1] - water type calculated by aqueous geochemistry software AquaChem, version 3.7.42 by Waterloo Hydrogeologic

[2] - calculated total dissolved solids concentration from charge balance

NMWQCC - New Mexico Water Quality Control Commission
TDS - total dissolved solids
bold - result exceeds standard
mg/L - milligrams per liter
NA - not analyzed
ND - not determined

Conclusions

In summary, the water in the disposal ponds, assessment wells, and the regional "fresh" ground water are distinct and different from each other. The pond water has a higher chloride and lower sulfate concentration compared to the perched water in the assessment wells. In turn, assessment well (perched) water has higher concentrations of sulfate, TDS, and sodium compared to the regional "fresh" ground water in either bedrock or alluvial aquifers near the Basin Disposal Site (Stone et al., 1983). The differences in water quality indicate that the perched water is not from the disposal ponds, and that there is little or no hydraulic connection between the perched aquifer and the water in the regional "fresh" ground-water system.

Sincerely,

JOHN SHOMAKER & ASSOCIATES, INC.

Erwin A. Melis, Ph.D.
Hydrogeologist

Em:em

Enc: Figures 1, 2, and 3

References:

[JSAI] John Shomaker & Associates, Inc., 2008, Subsurface and ground-water investigation in support of the modification of a surface waste management facility Basin Disposal, Inc. Bloomfield, New Mexico: consultant's report to Basin Disposal, Inc., 14 p., plus figures and appendices.

[JSAI] John Shomaker & Associates, Inc., Memorandum of November 19, 2008, Results from water-quality testing of assessment well No. 2 at Basin Disposal, Inc., Bloomfield, San Juan County, New Mexico, 3 p.

Stone, W.J., Lyford, F.P., Frenzel, P.F., Mizell, N.H., and Padgett, E.T., 1983, Hydrogeologic Map of the San Juan Basin, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Hydrologic Report 6, scale 1:500,000.

igure 1. Aerial photograph showing the locations of the existing pond, the drilled boreholes, initial assessment wells, proposed evaporation ponds, and well site of the Conoco-Phillips Martin 3 No. 1, Basin Disposal Site, Bloomfield, New Mexico.

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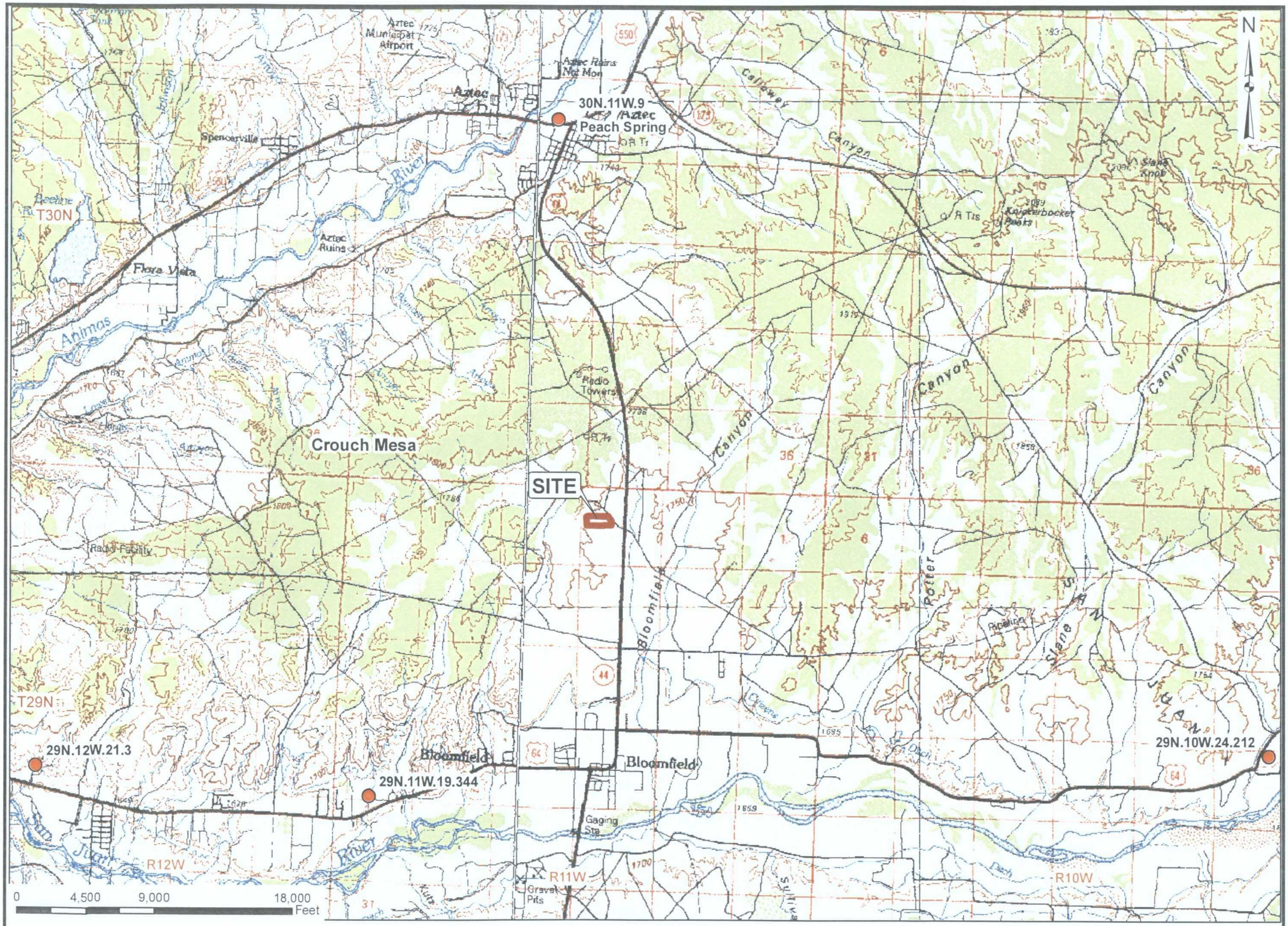

Figure 2. Topographic map of the Crouch Mesa area showing regional wells used to calculated the ground-water quality (Stone et al., 1983) within an 8-mile radius of the Basin Disposal site, Bloomfield, New Mexico.

LEGEND

🔴 Basin Disposal injection pond (surface) water quality

🟡 Basin Disposal AW-1/AW-2 perched ground-water quality

🔵 average water quality of five bedrock/alluvial wells on
Crouch Mesa within a 8-mile radius of the Basin Disposal site
(Stone et al., 1983)

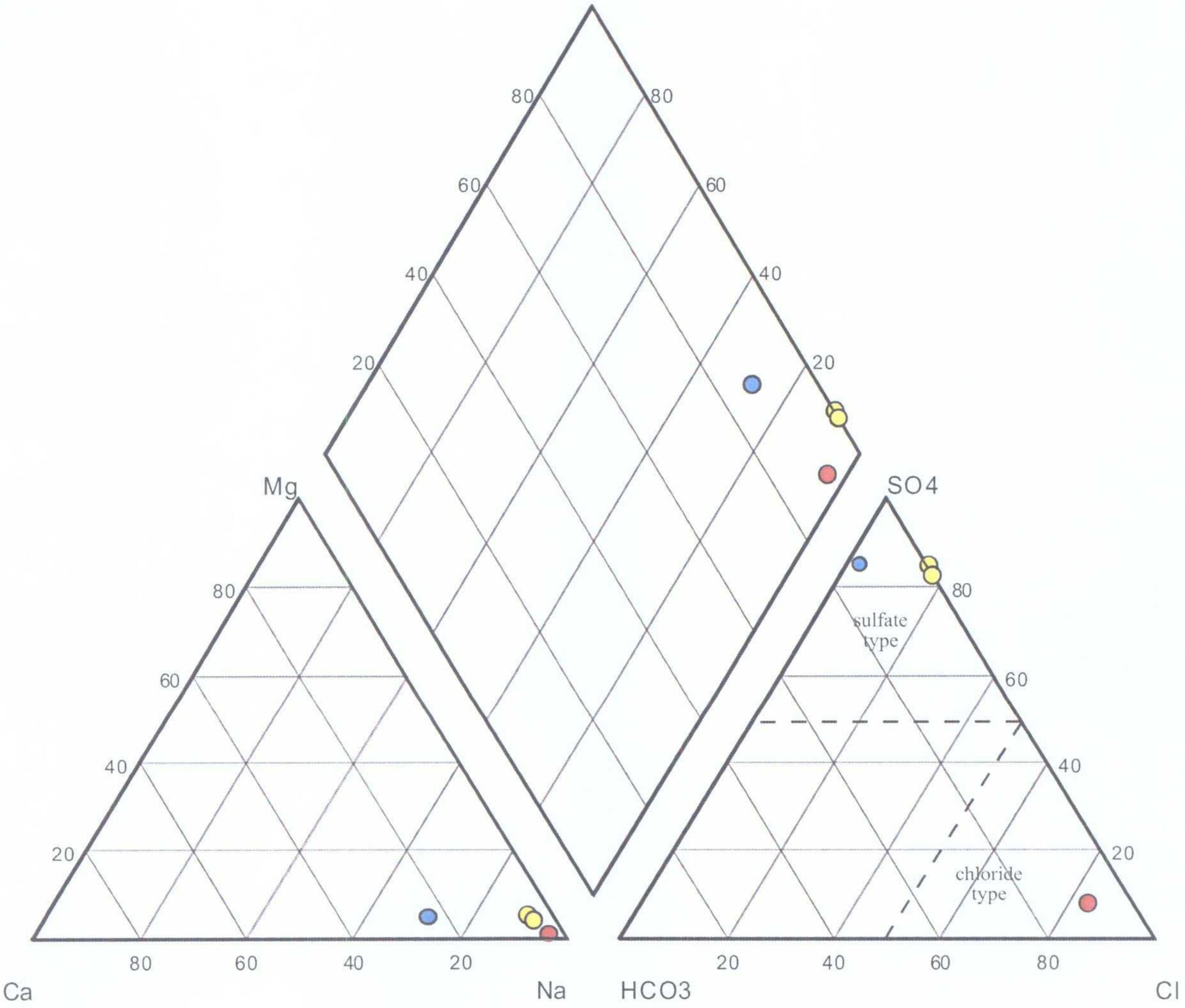

Figure 3. Tri-linear (Piper) diagram of three distinct types of water quality, including injection pond water, at the Basin Disposal site, north of Bloomfield, San Juan County, New Mexico.