Please replace Part III with the following pages

MSW AUTH NO. 2284A

PART III – SITE DEVELOPMENT PLAN

CITY OF EL PASO, TEXAS
GREATER EL PASO LANDFILL VERTICAL EXPANSION
PROJECT NO. 155488

REVISION 1
MAY 16, 2025

Landfill Permit Amendment
Part III – Site Development Plan
MSW Auth No. 2284A

prepared for

City of El Paso, Texas
Greater El Paso Landfill Major Amendment
El Paso County, Texas

Project No. 155488

Revision 0, October 31, 2024
Revision 1, May 16, 2025

STATE OF TEXAS
TONYA L. KOLLER
133943
LICENSED
PROFESSIONAL ENGINEER
5-16-25

prepared by

Burns & McDonnell Engineering Company, Inc.
6200 Bridge Point Pkwy, Building 4, Suite 400, Austin, TX 78730
Texas Firm Registration No. F-845

Waste enters the Facility via the site entrance road and passes through the scale house where the scale house attendant conducts screening, weighing, and documentation of incoming waste loads. The attendant will be familiar with the types of waste that can or cannot be accepted at the GEP Landfill and will direct the hauler to the appropriate disposal area or load inspection. If prohibited loads are discovered, the scale house attendant can reject the load and require the hauler or transporter to remove the load immediately upon discovery. At the working face, trained personnel will observe unloading and will have the authority and responsibility to reject loads that contain any prohibited wastes. Accepted loads will be directed to the working face for disposal.

Ventilation and odor control measures are discussed in greater detail in Section IV.14.0 of Part IV SOP. Landfill gas management design details related to ventilation and odor control measures are discussed in **Appendix III.H**.

Generalized construction details of the leachate evaporation ponds (including freeboard) and cells/sumps showing approximate dimensions and capacities, construction materials, covers, enclosures, etc. are provided in **Appendix III.A** and **Appendix III.C**.

No solid waste processing units are included in this permit.

III.2.2.1 Sequence of Site Development

The GEP Landfill will be developed in two phases with 20 individual cells outlined representing discrete construction limits for extending the landfill floor excavation and lining system as indicated on the drawings in **Appendix III.A**. Sequential fill plans are provided as **Drawings III.A.6 through III.A.9**.

III.2.3 Water Pollution Control [30 TAC §§330.55, 330.63(b)(4)]

In accordance with 30 §TAC 330.55(b), all liquids resulting from the operation of the GEP Landfill will be disposed of in a manner that will not cause surface water or groundwater pollution.

During the development of the landfill, diversion berms will be constructed to prevent stormwater from running onto the working area as well as to control run-off from the landfill. These berms will be constructed to contain the 25-year, 24-hour storm event. For a complete description of the berms refer to **Appendix III.B**.

Any water that comes in contact with the waste will be confined in the working face areas and will be collected in the leachate collection system. There will be no off-site discharge of contaminated water. **Appendix III.C** provides a complete description of contaminated water handling and disposal procedures.

No solid waste processing units are included in this permit.

III.2.4 Endangered Species Protection [30 TAC §330.63(b)(5)]

Neither the Facility nor its operation will result in the destruction or adverse modification of the critical habitat of endangered or threatened species or cause or contribute to the taking of endangered or threatened species. If endangered or threatened species are encountered during site operations, Texas Parks and Wildlife Department and United States Fish and Wildlife Service (USFWS) will be notified within 48-hours.

Prior to Facility development, Dr. Richard D. Worthington, Ph.D. of Floristic Inventories of the Southwest Program, conducted an intensive survey to determine the presence of any threatened and endangered species at the Facility. The survey indicated that no endangered or threatened species were found on the subject site. Two species of concern were encountered: the Texas horned lizard and the sand prickly pear cacti. Dr. Worthington estimated that no more than five lizards were present. Five clumps of sand prickly pear were found on the site; however, the plant vigor was marginal and quite stressed. The landfill site development was considered not likely to impact endangered or threatened species, therefore there is no protection plan for threatened or endangered species required for this Facility.

The generation and review of the USFWS's Information for Planning and Conservation (IPaC) report for the permitted boundary was conducted and compared to the results of the aforementioned survey. No critical habitat of endangered or threatened species was identified within the permitted boundary, as supported by the survey results. The referenced IPaC is presented as Part I/II, Appendix I/II.H – Location Restrictions. Correspondence with the USFWS and Texas Parks and Wildlife Department are also included in Part I/II, Appendix I/II.H.

III.4.0 Waste Management Unit Design [30 TAC §330.63(d)]

The following section describes the waste management unit design for the GEP Landfill, which is in accordance with 30 TAC §330.63(d).

III.4.1 Surface Impoundment Design [30 TAC §330.63(d)(3)]

Construction details for the leachate evaporation ponds, including design freeboard, are provided in **Appendix III.C**. The liner quality control plan (LQCP) is provided in **Appendix III.D**.

III.4.2 Landfill Unit Design Parameters [30 TAC §330.63(d)(4)]

The following subsections describe the landfill unit design parameters, which are in accordance with 30 TAC §330.63(d)(4).

III.4.2.1 All-Weather Operations [30 TAC §330.63(d)(4)(A)]

Wet weather operations will be accommodated through the construction of an all-weather roadway from the on-site entrance roadway to the area being filled. The all-weather roadway will also serve as the access to the working fill area throughout the site. Landfill haul and access roads are shown on Drawing III.A.3 in Part III, Attachment III.A. Perimeter access road and cell access road details are provided on Drawing III.B.6 in Part III, Attachment III.B. Mud tracking control measures are provided in Part IV, Section 16.0

A wet weather unloading area will be constructed of crushed stone or similar as the fill area moves throughout the site.

Should the haul roads into the fill area become unusable, fill operations will continue by depositing the waste from the top of the excavation. For periods when filling occurs above grade, waste will be deposited at the toe of the fill area in the lined areas.

A series of speed bumps/mud removal devices will be installed along the interior access road prior to the site exit.

III.4.2.2 Landfilling Methods [30 TAC §330.63(d)(4)(B)]

Operations at the GEP Landfill utilize the area fill method. Landfilling occurs both below-grade and above-grade (or aerial filling). The disposal operation is accomplished in two phases as shown on the drawings in **Appendix III.A**. Typical cross sections and final contours are also provided in **Appendix III.A**.

Excavations will be performed with appropriate equipment. Waste will be placed in lifts and will be compacted with a compactor or other suitable equipment prior to the application of daily cover.

III.4.2.3 Landfill Design Parameters [30 TAC §330.63(d)(4)(C)]

Constructed cell excavation side slopes are sloped at 3 foot horizontal to 1 foot vertical (3H:1V). The elevation of deepest waste disposal is 3896.1 feet above mean sea level (msl) utilizing North American Vertical Datum of 1988 (NAVD 88). Final cover side slopes will be installed at 4H:1V slopes with a five percent crown. The maximum elevation of waste disposal will be 4126.9 feet above msl (NAVD 88). The maximum elevation of the final cover will be 4128.1 feet above msl (NAVD 88). Details are provided in the drawings in **Appendix III.A**.

It should be noted that the previous permit application for the GEP Landfill (2284) utilized City Datum for listed elevations. A conversation from City Datum to NAVD 88 is provided in Part I/II, Appendix I/II-B.

III.4.2.4 Site Life Projections [30 TAC 330.63(d)(4)(D)]

The GEP Landfill is divided into two phases. Phase 1 encompasses approximately 93.9 acres and Phase 2 approximately 122.5 acres. The total volume for each section was determined by adding the below and above grade airspace together. To determine the available disposal capacity (including daily and intermediate cover), the bottom liner and final cover were subtracted from the total capacity. The total available disposal capacity for the GEP Landfill is presented in **Table III.4-1**, which is 34,864,506 cubic yards. Volumes were calculated by comparing the base and final surfaces created by AutoCAD.

Table III.4-1: Greater El Paso Landfill Disposal Capacity

Item	Phase 1 (North)	Phase 2 (South)	Total
Waste Area (Acres)[1]	93.9	122.5	216.4
Gross Volume Permitted under 2284 (CY)	11,355,647	17,455,872	28,811,519
Expansion Volume for 2284A (CY)	1,883,898	5,681,927	7,565,825
Gross Volume for 2284A (CY)	13,239,545	23,137,799	36,377,344
Less Alternate Final Cover Material (CY)[2]	353,534	461,071	814,605
Less 2-foot Protective Cover Material (CY)	303,029	395,204	698,233
Net Disposal Capacity (CY)	**12,582,982**	**22,281,524**	**34,864,506**

[1] Area within limit of waste placement as shown on the Drawings in **Appendix III.A**.

[2] Alternative final cover profile is 4-inches of rock armoring, 18-inches of infiltration layer, and 6-inches of base layer for a total of 28-inches. Geosynthetic thicknesses are considered negligible for calculations.

The GEP Landfill currently accepts approximately 1,600 tons of solid waste per day (6 days per week). The expected rate of solid waste deposition is anticipated to increase at approximately 2.0 percent based on the average growth rate for the past 5-years. For calculating volumes, a compaction density of 1,300 pounds per cubic yard was used. **Table III.4-2** shows the solid waste deposition projection used for calculating the expected site life of the GEP Landfill with the vertical expansion. Actual quantities accepted at the GEP Landfill will vary depending on the number of cities sending waste to the Facility, changes in population or economic activity, and changes in waste collection and disposal practices by private haulers using the Facility.

Using the remaining disposal capacity as of August 31, 2023 of 20,548,110 cubic yards (with the vertical expansion volume included), a site life of approximately 21.7 years from the August 31, 2023 survey was calculated, or capacity depleted in FY2045. Should waste quantities increase or decrease, the site life will be adjusted accordingly.

Please replace Appendix III.A with the following pages

APPENDIX III.A – PERMIT DRAWINGS

Greater El Paso Landfill

Vertical Expansion Permit Amendment

City of El Paso, TX

MSW Authorization No. 2284A

MAY 2024

BMcD Project No. 155488

ONE OR TWO CHARACTER DISCIPLINE DESIGNATOR (MAY NOT BE PRESENT IF CALLOUT AND TITLE ARE ON DRAWINGS WITHIN THE SAME DISCIPLINE)

LETTER OR NUMBER DESIGNATOR

A
FP001

DRAWING SEQUENCE NUMBER INDICATES WHERE TITLE IS LOCATED (MAY NOT BE PRESENT IF CALLOUT AND TITLE ARE ON THE SAME DRAWING)

SECTION, DETAIL, AND ELEVATION SYMBOL IDENTIFIERS

A FP001 A FP001

SECTION CALLOUT EXAMPLE

7 FP001

DETAIL CALLOUT EXAMPLE

B A001

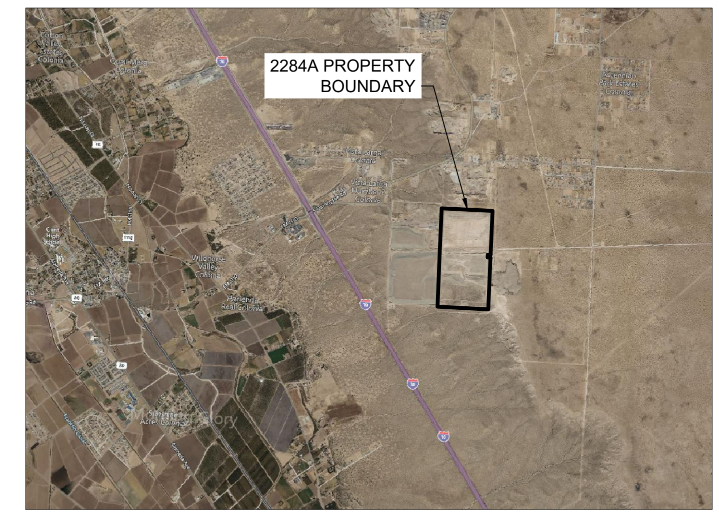
ELEVATION CALLOUT EXAMPLE

THE WORD "SECTION" MAY BE REPLACED WITH "ELEVATION" OR "DETAIL"

SECTION A 001

SECTION, DETAIL, OR ELEVATION TITLE EXAMPLE

SECTION, DETAIL, AND ELEVATION IDENTIFICATION SYSTEM



GENERAL LOCATION MAP

0 10000' 20000'
SCALE IN FEET
N

List of Drawings

SHEET INDEX	
DWG NO.	SHEET TITLE
III.A.0	COVER - INDEX
III.A.1	GENERAL NOTES, LEGEND, AND ABBREVIATIONS
III.A.2	ENTRANCE FACILITIES
III.A.3	EXISTING SITE LAYOUT
III.A.4	LANDFILL BASE GRADING PLAN
III.A.5	LANDFILL GRID SYSTEM
III.A.6	SEQUENCE OF DEVELOPMENT PHASE 2 (CELLS 11-14)
III.A.7	SEQUENCE OF DEVELOPMENT PHASE 2 (CELLS 15-16)
III.A.8	SEQUENCE OF DEVELOPMENT PHASE 2 (CELLS 17-18)
III.A.9	SEQUENCE OF DEVELOPMENT PHASE 2 (CELLS 19-20)
III.A.10	FINAL GRADING PLAN
III.A.11	LARGEST OPEN AREA
III.A.12	LANDFILL SECTION KEY MAP
III.A.13	LANDFILL SECTION A-A', 1 OF 2
III.A.14	LANDFILL SECTION A-A', 2 OF 2
III.A.15	LANDFILL SECTION B-B', 1 OF 2
III.A.16	LANDFILL SECTION B-B', 2 OF 2

SHEET INDEX	
DWG NO.	SHEET TITLE
III.A.17	LANDFILL SECTION C-C'
III.A.18	LANDFILL SECTION D-D'
III.A.19	LANDFILL SECTION E-E'
III.A.20	LANDFILL SECTION F-F'
III.A.21	LANDFILL SECTION G-G'
III.B.1A	HISTORIC OFFSITE DRAINAGE CONDITIONS
III.B.1B	HISTORIC ON-SITE DRAINAGE CONDITIONS
III.B.3	POST-DEVELOPMENT DRAINAGE CONDITIONS
III.B.4	POST-DEVELOPMENT DRAINAGE MAP
III.B.5	DRAINAGE DETAILS, 1 OF 2
III.B.6	DRAINAGE DETAILS, 2 OF 2
III.B.7	DRAINAGE PROFILE KEY MAP
III.B.8	DRAINAGE PROFILES DITCH B1, B2, C1, C2
III.B.9	DRAINAGE PROFILES DITCH D1, D2, D3
III.B.10	DRAINAGE PROFILES DITCH E1, E2
III.B.11	POND BC LAYOUT
III.B.12	POND DE LAYOUT

SHEET INDEX	
DWG NO.	SHEET TITLE
III.B.13	POND BC OUTFALL AND SECTIONS
III.B.14	POND DE OUTFALL AND SECTIONS
III.C.1	LEACHATE COLLECTION SYSTEM LAYOUT
III.C.2	LEACHATE COLLECTION SYSTEM PUMP PLAN AND SECTION
III.C.3	LEACHATE COLLECTION SYSTEM DETAILS, 1 OF 2
III.C.4	LEACHATE COLLECTION SYSTEM DETAILS, 2 OF 2
III.C.5	PHASE 1 LEACHATE EVAPORATION POND LAYOUT
III.C.6	PHASE 1 LEACHATE EVAPORATION POND DETAILS
III.C.7	PHASE 2 LEACHATE EVAPORATION POND LAYOUT
III.C.8	PHASE 2 LEACHATE EVAPORATION POND DETAILS
III.F.1	FINAL ENVIRONMENTAL MONITORING PLAN
III.F.2	FINAL GROUNDWATER MONITORING PLAN
III.H.1	EXISTING LANDFILL GAS MONITORING PROBE PLAN
III.H.2	LANDFILL GAS MANAGEMENT PLAN
III.H.3	LANDFILL GAS MONITORING PROBE DETAIL

STATE OF TEXAS
TONYA L. KOLLER
133943
LICENSED PROFESSIONAL ENGINEER
5-16-25

TONYA L. KOLLER P.E.
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no.	date	by	ckd	description
0	5/1/24	TMC	TLK	2284A PERMIT MOD
1	5/16/25	AAN	TJS	TCEQ NOD 1

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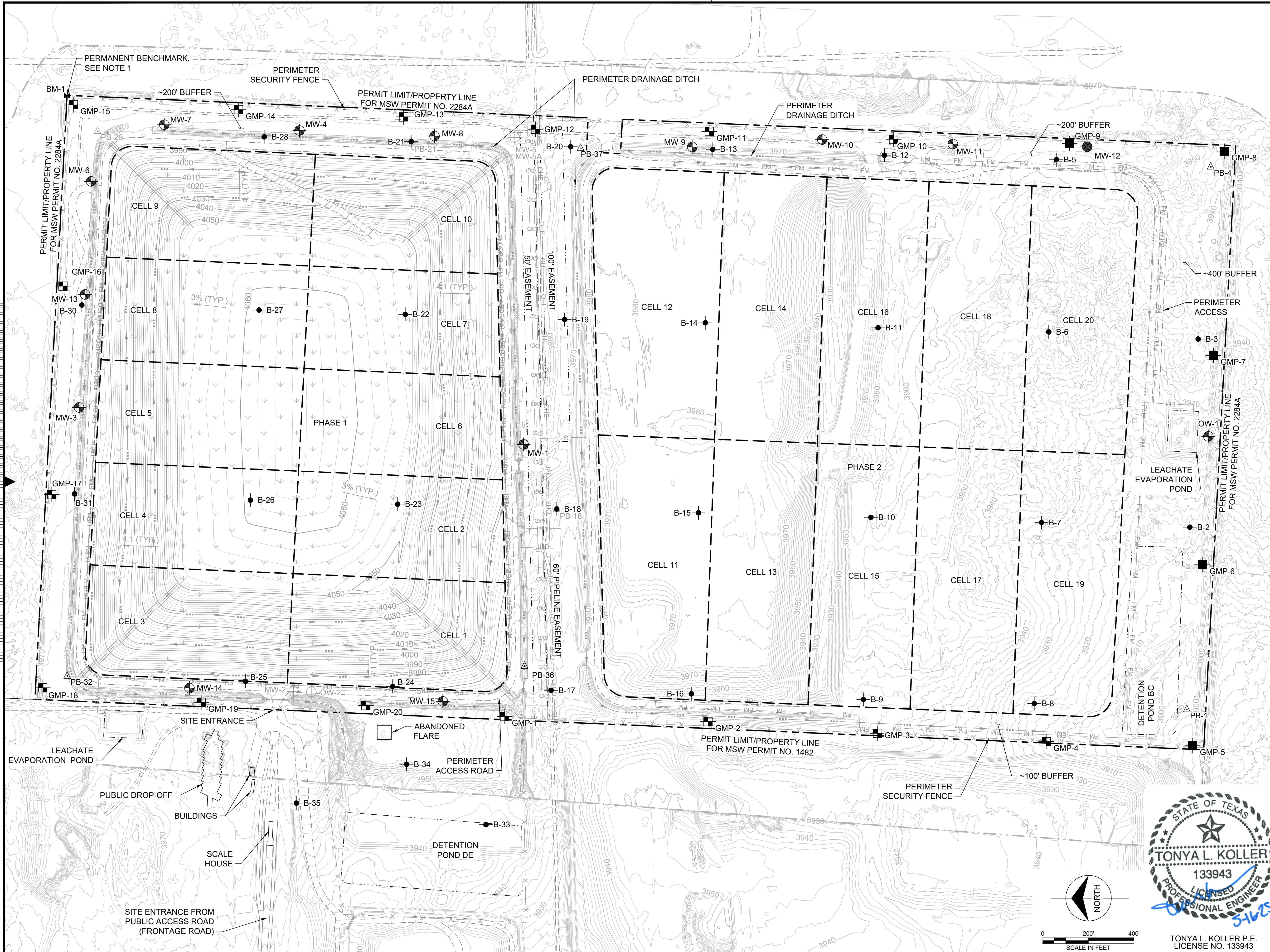
Burns & McDonnell Engineering Co, Inc.
FIRM REG. NO. F-845

COVER - INDEX



TONYA L. KOLLER P.E.
LICENSE NO. 133943

no.	date	by	ckd	description
0	5/1/24	TMC	TLK	2284A PERMIT MOD
1	5/16/25	AAN	TJS	TCEQ NOD 1

NOTES:

1. PERMANENT BENCHMARK 3" Ø BRASS CAP SET IN CONCRETE (NAD83)
   N: 10,594,029.88 FEET
   E: 482,320.00 FEET
   ELEV:3986.67 FEET (NAVD88)
   LATITUDE: 31.602233
   LONGITUDE: -106.163511
2. INDEX CONTOUR INTERVAL, 2 FEET.
3. GREATER EL PASO LANDFILL EXISTING SITE TOPOGRAPHY (2284A PERMIT AREA) DERIVED FROM ORTHO-PHOTOGRAPHY FROM AN UNMANNED AERIAL SURVEY TIED TO GROUND CONTROL PANELS PROVIDED BY PARKHILL, SMITH & COOPER, AUGUST 28, 2019. TOPOGRAPHY WITHIN CELLS 11 THROUGH 14 COMPLETED WITH GROUND CONTROL POINTS PROVIDED BY THE CITY OF EL PASO, AUGUST 2022. TOPOGRAPHY OUTSIDE OF THE SURVEY EXTENTS WAS OBTAINED FROM THE TEXAS NATURAL RESOURCES INFORMATION SYSTEM, DATED APRIL 2008.
4. THE SURVEY COORDINATES ARE ON THE TEXAS COORDINATE SYSTEM, CENTRAL ZONE 4203, NORTH AMERICAN DATUM OF 1983 (NAD83). HORIZONTAL DATUM IS NAD 1983. VERTICAL DATUM IS NAVD 1988.
5. EXISTING TOP OF FINAL COVER SURFACE FOR PHASE 1 PREPARED BY PARKHILL, SMITH AND COOPER, INC. AND REPRESENTS DESIGN FINAL COVER ELEVATIONS. CONTOUR INTERVAL IS 2 FEET. PHASE 1 RECEIVED FINAL COVER IN 2021.
6. AT THE TIME OF DRAWING PREPARATION, WASTE PLACEMENT IS CURRENTLY OCCURRING IN CELLS 11-14, WHICH WERE CONSTRUCTED IN 2018.

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date	detailed
MAY 2024	D. KAMBLE
designed	checked
T. CAMMACK	T. KOLLER

City of El Paso, Texas

2284A PERMIT AMENDMENT

EXISTING SITE LAYOUT

project	contract
155488	-

drawing III.A.3 – rev. 1

file III.A.3 EXISTING SITE LAYOUT.dwg

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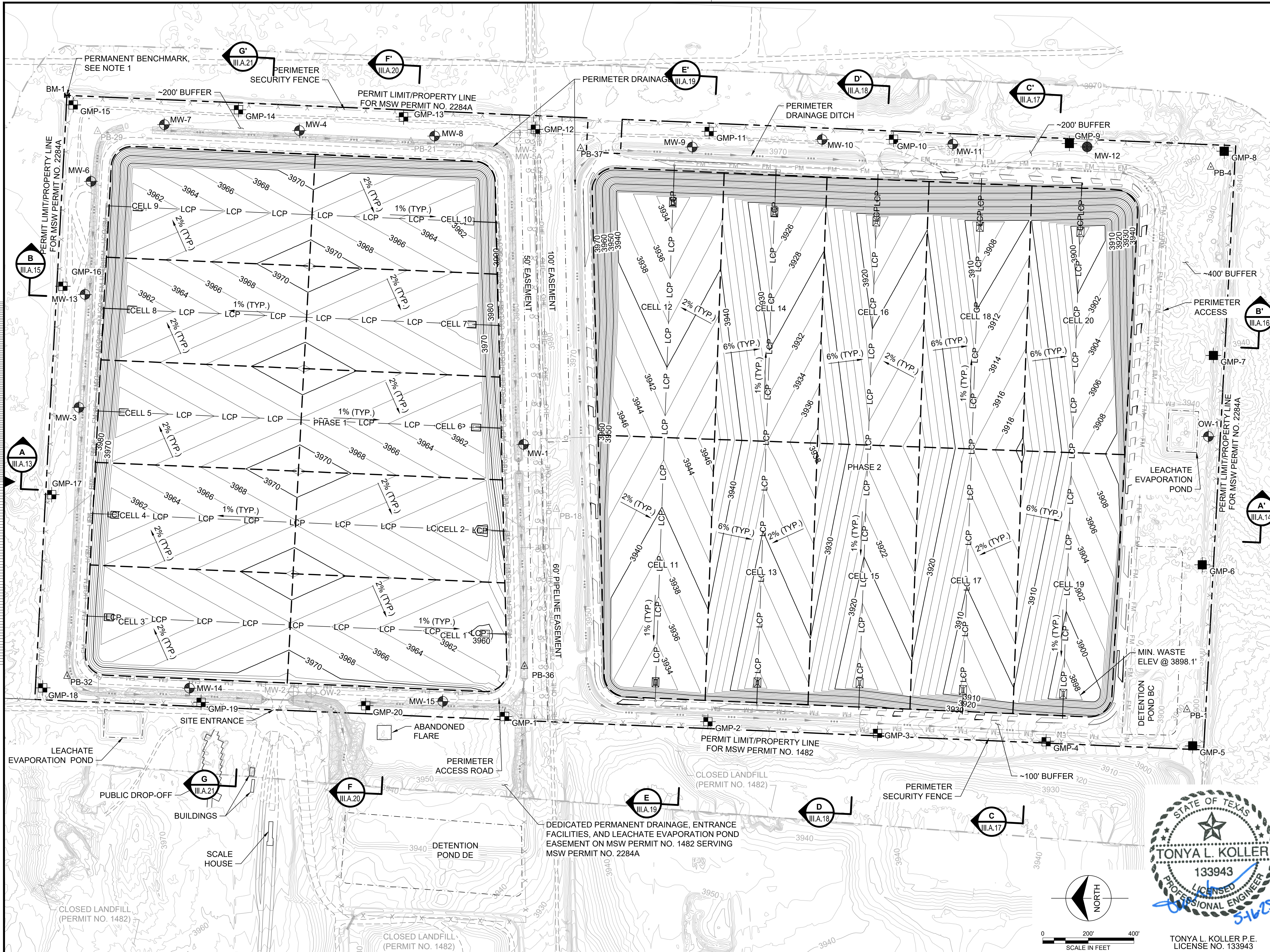

no.	date	by	ckd	description
0	5/1/24	TMC	TLK	2284A PERMIT MOD
1	5/16/25	AAN	TJS	TCEQ NOD 1

NOTES:

1. PERMANENT BENCHMARK 3" Ø BRASS CAP SET IN CONCRETE (NAD83)
   N: 10,594,029.88 FEET
   E: 482,320.00 FEET
   ELEV:3986.67 FEET (NAVD88)
   LATITUDE: 31.602233
   LONGITUDE: -106.163511
2. INDEX CONTOUR INTERVAL, 2 FEET.
3. GREATER EL PASO LANDFILL EXISTING SITE TOPOGRAPHY (2284A PERMIT AREA) DERIVED FROM ORTHO-PHOTOGRAPHY FROM AN UNMANNED AERIAL SURVEY TIED TO GROUND CONTROL PANELS PROVIDED BY PARKHILL, SMITH & COOPER, AUGUST 28, 2019. TOPOGRAPHY WITHIN CELLS 11-14 COMPLETED WITH GROUND CONTROL POINTS PROVIDED BY THE CITY OF EL PASO, AUGUST 2022. TOPOGRAPHY OUTSIDE OF THE SURVEY EXTENTS WAS OBTAINED FROM THE TEXAS NATURAL RESOURCES INFORMATION SYSTEM, DATED APRIL 2008.
4. THE SURVEY COORDINATES ARE ON THE TEXAS COORDINATE SYSTEM, CENTRAL ZONE 4203, NAD83. HORIZONTAL DATUM IS NAD83. VERTICAL DATUM IS NAVD88.
5. DESIGN CONTOURS ARE FROM 2284 PERMIT AND REPRESENT TOP OF PROTECTIVE COVER SURFACE FOR PHASE 1 AND PHASE 2. CONTOUR INTERVAL IS 2 FEET. 2284 PERMITTED DESIGN CONTOURS WERE BASED ON CITY DATUM ELEVATIONS AND WERE ADJUSTED TO NAVD88 BY ADDING 10.39 FEET AS CERTIFIED BY BROCK & BUSTILLOS INC. ON DECEMBER 7, 2023. DATUM CERTIFICATION LETTER INCLUDED IN APPENDIX I/II.B.

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EP TX CITY OF EL PASO
City of El Paso, Texas

2284A PERMIT AMENDMENT

LANDFILL BASE GRADING PLAN

project	contract
155488	-

drawing III.A.4 – rev. 1

file III.A.4 LANDFILL BASE GRADING PLAN.dwg

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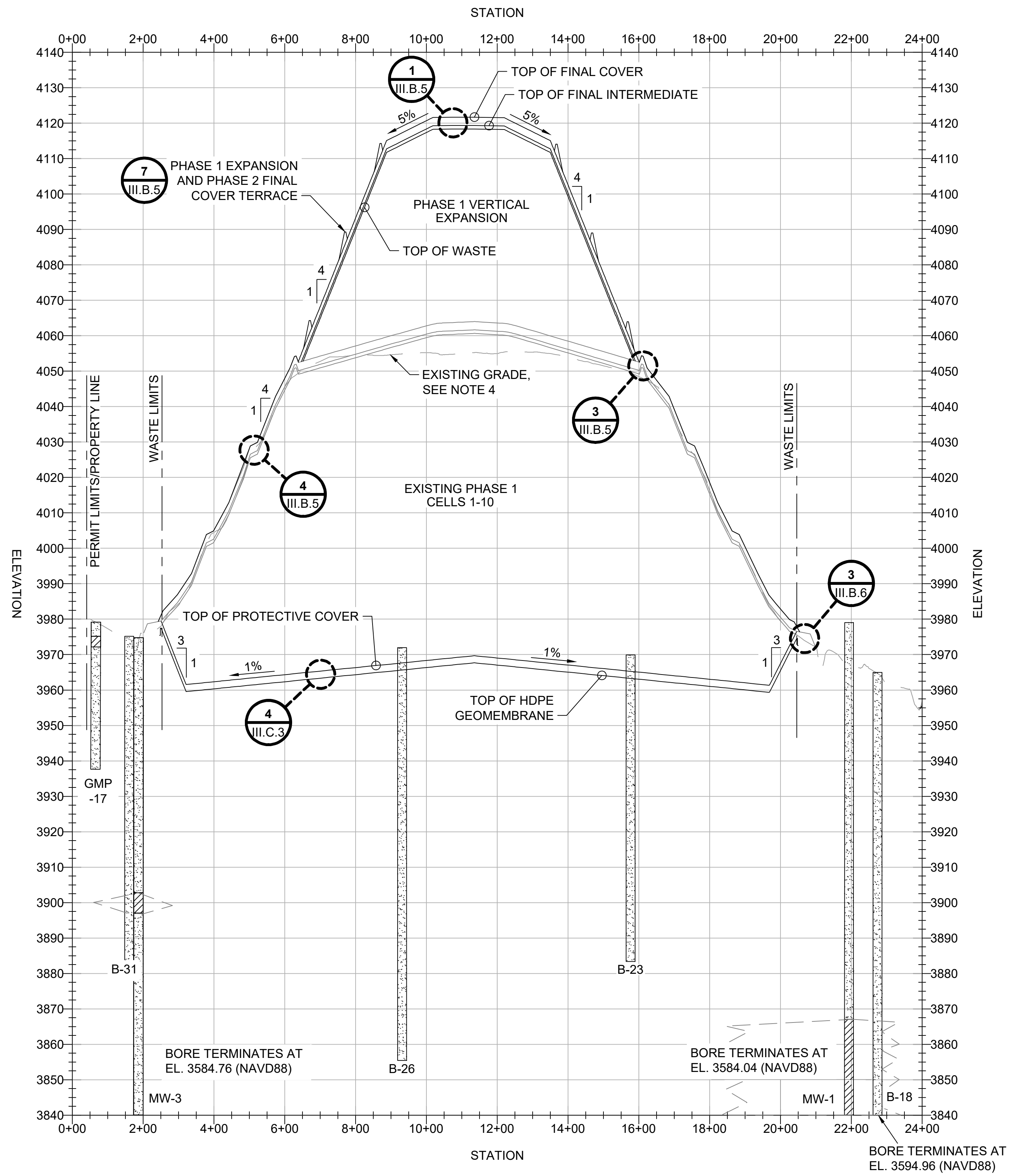


LANDFILL SECTION A-A* A III.A.4 A III.A.12

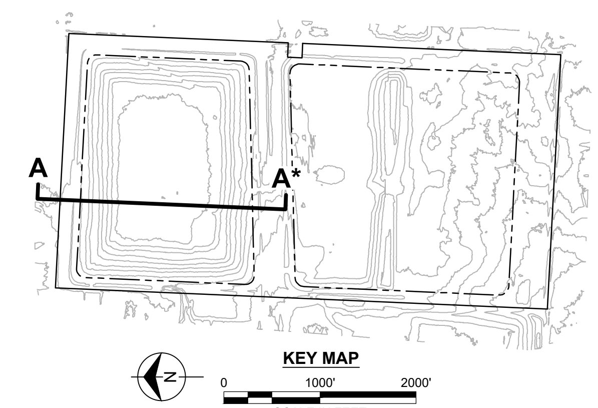
0 10' 20' 40' SCALE IN FEET

0 200' 400' SCALE IN FEET

GAS MONITORING PROBE BORING ELEVATIONS (SEE NOTE 5)				
GMP BORING	SURFACE EL. (CITY DATUM)	BOTTOM EL. (CITY DATUM)	SURFACE EL. (NAVD88)	BOTTOM EL. (NAVD88)
GMP-17	3968.76	3927.26	3979.15	3937.65

MONITORING WELL BORING ELEVATIONS (SEE NOTE 5)				
MW BORING	SURFACE EL. (CITY DATUM)	BOTTOM EL. (CITY DATUM)	SURFACE EL. (NAVD88)	BOTTOM EL. (NAVD88)
MW-1	3968.65	3573.65	3979.04	3584.04
MW-3	3964.37	3575.37	3974.76	3584.76

SOIL BORING ELEVATIONS (SEE NOTE 5)				
SOIL BORING	SURFACE EL. (CITY DATUM)	BOTTOM EL. (CITY DATUM)	SURFACE EL. (NAVD88)	BOTTOM EL. (NAVD88)
B-18	3954.57	3584.57	3964.96	3594.96
B-23	3959.51	3873.01	3969.90	3883.40
B-26	3961.56	3845.06	3971.95	3855.45
B-31	3964.76	3873.26	3975.15	3883.65



KEY MAP

0 1000' 2000' SCALE IN FEET

LEGEND:

- CLAY
- SILT
- SAND
- CLAYEY SAND
- SILTY SAND
- GENERALIZED INFERRED STRATA
- 2284A GRADES
- 2284 GRADES

NOTES:

1. CROSS SECTION TRANSECT LINES DO NOT INTERSECT ALL BORINGS DEPICTED. GENERALIZED, INFERRED STRATA PRESENTED, AS INTERPRETED FROM DEPICTED BORINGS. REFER TO III.A.3 AND III.A.12 FOR BORING LOCATIONS.
2. STATIC WATER ELEVATIONS BASED ON THE MAXIMUM SEASONAL HIGH GROUNDWATER SURFACE AS OF THE DATE OF THE ORIGINAL APPLICATION, SHOWN ON DRAWING III.E.21.
3. LITHOLOGY IS GENERALIZED BY SAND, SILT, AND CLAY. REFER TO BORING LOGS PROVIDED IN APPENDIX III.E FOR EXACT LITHOLOGY DESCRIPTIONS.
4. EXISTING GROUND SOURCES PROVIDED ON DRAWING III.A.3.
5. 2284 PERMITTED DESIGN CONTOURS WERE BASED ON CITY DATUM ELEVATIONS AND WERE ADJUSTED TO NAVD88 BY ADDING 10.39 FEET AS CERTIFIED BY BROCK & BUSTILLOS INC. ON DECEMBER 7, 2023. DATUM CERTIFICATION LETTER INCLUDED IN APPENDIX I/II.B.

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date	detailed
MAY 2024	D. KAMBLE
designed	checked
T. CAMMACK	T. KOLLER

EPTX CITY OF EL PASO

City of El Paso, Texas

2284A PERMIT AMENDMENT

LANDFILL SECTION A-A', 1 OF 2

project 155488 contract -

drawing **III.A.13 – rev. 1**

file III.A.13 LANDFILL SECTION A-A', 1 OF 2.dwg

STATE OF TEXAS NATHAN KILGORE GEOLOGY 15672 LICENSED PROFESSIONAL GEOSCIENTIST

5/16/2025

NATHAN S. KILGORE P.G.
LICENSE NO. 15672

STATE OF TEXAS TONYA L. KOLLER 133943 LICENSED PROFESSIONAL ENGINEER

5-16-25

TONYA L. KOLLER P.E.
LICENSE NO. 133943

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no.	date	by	ckd	description
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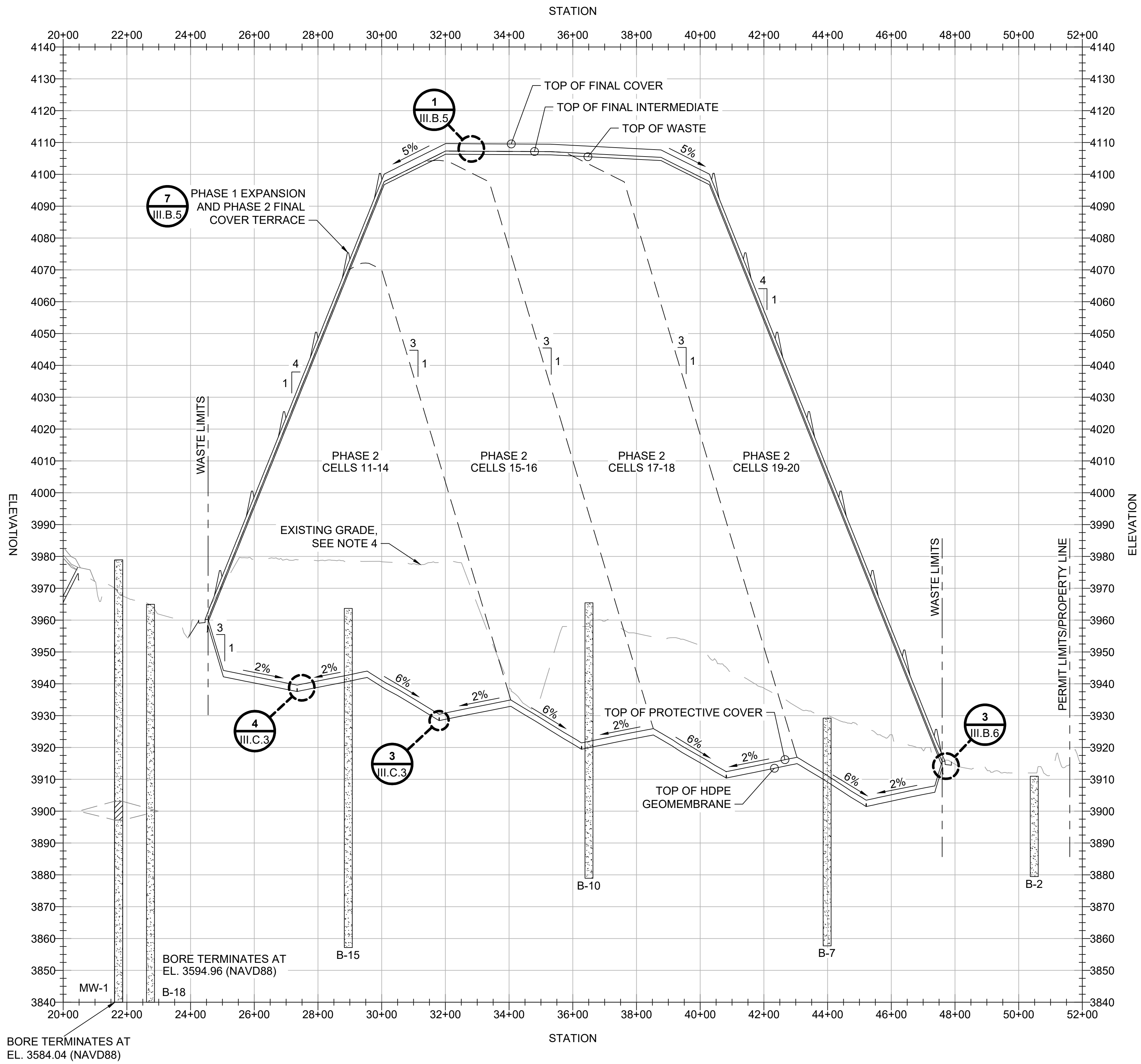
1	5/16/25	AAN	TJS	TCEQ NOD 1



LANDFILL SECTION A*-A' (A III.A.4) (A III.A.12)

0 10' 20' 40' SCALE IN FEET

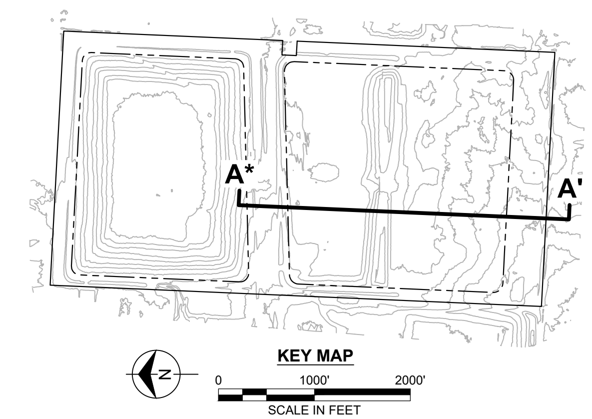
0 200' 400' SCALE IN FEET

MONITORING WELL BORING ELEVATIONS (SEE NOTE 5)

MW BORING	SURFACE EL. (CITY DATUM)	BOTTOM EL. (CITY DATUM)	SURFACE EL. (NAVD88)	BOTTOM EL. (NAVD88)
MW-1	3968.65	3573.65	3979.04	3584.04

SOIL BORING ELEVATIONS (SEE NOTE 5)

SOIL BORING	SURFACE EL. (CITY DATUM)	BOTTOM EL. (CITY DATUM)	SURFACE EL. (NAVD88)	BOTTOM EL. (NAVD88)
B-2	3900.56	3869.06	3910.95	3879.45
B-7	3918.80	3847.30	3929.19	3857.69
B-10	3955.04	3868.54	3965.43	3878.93
B-15	3953.26	3846.76	3963.65	3857.15
B-18	3954.57	3584.57	3964.96	3594.96



KEY MAP

0 1000' 2000' SCALE IN FEET

LEGEND:

- CLAY
- SILT
- SAND
- CLAYEY SAND
- SILTY SAND
- GENERALIZED INFERRED STRATA
- 2284A GRADES

NOTES:

1. CROSS SECTION TRANSECT LINES DO NOT INTERSECT ALL BORINGS DEPICTED. GENERALIZED, INFERRED STRATA PRESENTED, AS INTERPRETED FROM DEPICTED BORINGS. REFER TO III.A.3 AND III.A.12 FOR BORING LOCATIONS.
2. STATIC WATER ELEVATIONS BASED ON THE MAXIMUM SEASONAL HIGH GROUNDWATER SURFACE AS OF THE DATE OF THE ORIGINAL APPLICATION, SHOWN ON DRAWING III.E.21.
3. LITHOLOGY IS GENERALIZED BY SAND, SILT, AND CLAY. REFER TO BORING LOGS PROVIDED IN APPENDIX III.E FOR EXACT LITHOLOGY DESCRIPTIONS.
4. EXISTING GROUND SOURCES PROVIDED ON DRAWING III.A.3.
5. 2284 PERMITTED DESIGN CONTOURS WERE BASED ON CITY DATUM ELEVATIONS AND WERE ADJUSTED TO NAVD88 BY ADDING 10.39 FEET AS CERTIFIED BY BROCK & BUSTILLOS INC. ON DECEMBER 7, 2023. DATUM CERTIFICATION LETTER INCLUDED IN APPENDIX I/II.B.

FOR PERMITTING PURPOSES ONLY

BURNS McDONNELL
9400 WARD PARKWAY
KANSAS CITY, MO 64114
816-333-9400
Burns & McDonnell Engineering Co, Inc.
FIRM REG. NO. F-845

date: MAY 2024 | detailed: D. KAMBLE
designed: T. CAMMACK | checked: T. KOLLER

EP TX CITY OF EL PASO

City of El Paso, Texas

2284A PERMIT AMENDMENT

LANDFILL SECTION A-A', 2 OF 2

project: 155488 | contract: -

drawing: **III.A.14** – rev. **1**

file III.A.14 LANDFILL SECTION A-A', 2 OF 2.dwg

STATE OF TEXAS NATHAN KILGORE GEOLOGY 15672 LICENSED PROFESSIONAL GEOSCIENTIST

5/16/2025

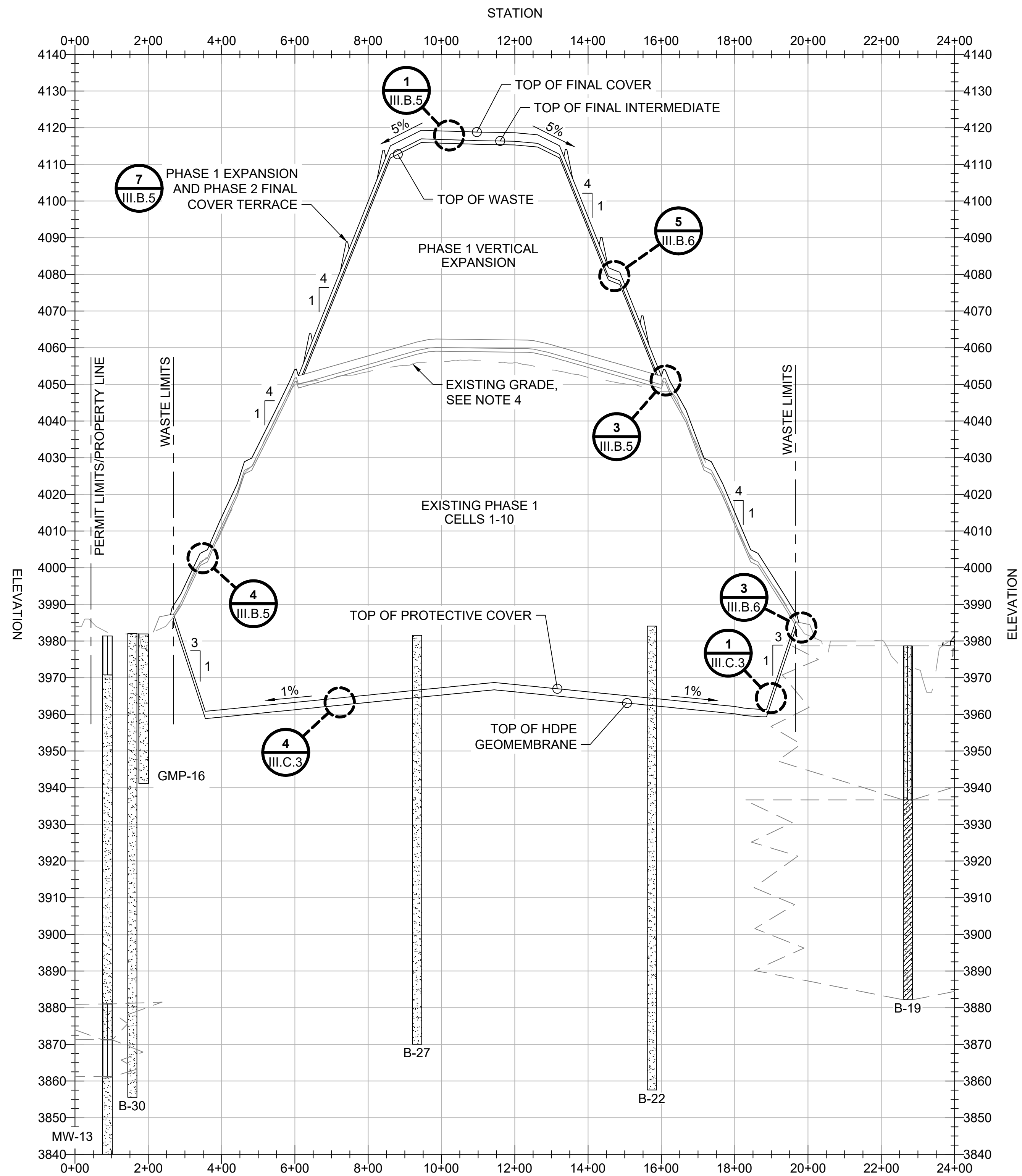
NATHAN S. KILGORE, P.G.
LICENSE NO. 15672

STATE OF TEXAS TONYA L. KOLLER 133943 LICENSED PROFESSIONAL ENGINEER

5-16-25

TONYA L. KOLLER P.E.
LICENSE NO. 133943

no.	date	by	ckd	description
0	5/1/24	TMC	TLK	2284A PERMIT MOD
1	5/16/25	AAN	TJS	TCEQ NOD 1



BORE TERMINATES AT EL. 3584.17 (NAVD88)

LANDFILL SECTION B-B*

B III.A.4 B III.A.12

0 10' 20' 40' SCALE IN FEET

0 200' 400' SCALE IN FEET

GAS MONITORING PROBE BORING ELEVATIONS (SEE NOTE 5)

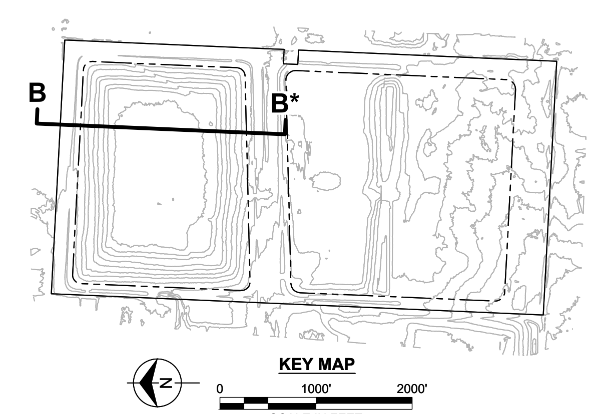
GMP BORING	SURFACE EL. (CITY DATUM)	BOTTOM EL. (CITY DATUM)	SURFACE EL. (NAVD88)	BOTTOM EL. (NAVD88)
GMP-16	3971.98	3931.98	3982.37	3942.37

MONITORING WELL BORING ELEVATIONS (SEE NOTE 5)

MW BORING	SURFACE EL. (NAVD88)	BOTTOM EL. (NAVD88)
MW-13	3981.17	3584.17

SOIL BORING ELEVATIONS (SEE NOTE 5)

SOIL BORING	SURFACE EL. (CITY DATUM)	BOTTOM EL. (CITY DATUM)	SURFACE EL. (NAVD88)	BOTTOM EL. (NAVD88)
B-19	3968.26	3871.76	3978.65	3882.15
B-22	3973.66	3847.16	3984.05	3857.55
B-27	3971.12	3859.62	3981.51	3870.01
B-30	3971.66	3845.16	3982.05	3855.55



LEGEND:

CLAY
SILT
SAND
CLAYEY SAND
SILTY SAND
GENERALIZED INFERRED STRATA
2284A GRADES
2284 GRADES

NOTES:

1. CROSS SECTION TRANSECT LINES DO NOT INTERSECT ALL BORINGS DEPICTED. GENERALIZED, INFERRED STRATA PRESENTED, AS INTERPRETED FROM DEPICTED BORINGS. REFER TO III.A.3 AND III.A.12 FOR BORING LOCATIONS.
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816-333-9400
Burns & McDonnell Engineering Co, Inc.
FIRM REG. NO. F-845

date	detailed
MAY 2024	D. KAMBLE
designed	checked
T. CAMMACK	T. KOLLER

EP TX CITY OF EL PASO
City of El Paso, Texas

2284A PERMIT AMENDMENT

LANDFILL SECTION B-B', 1 OF 2

project	contract
155488	-

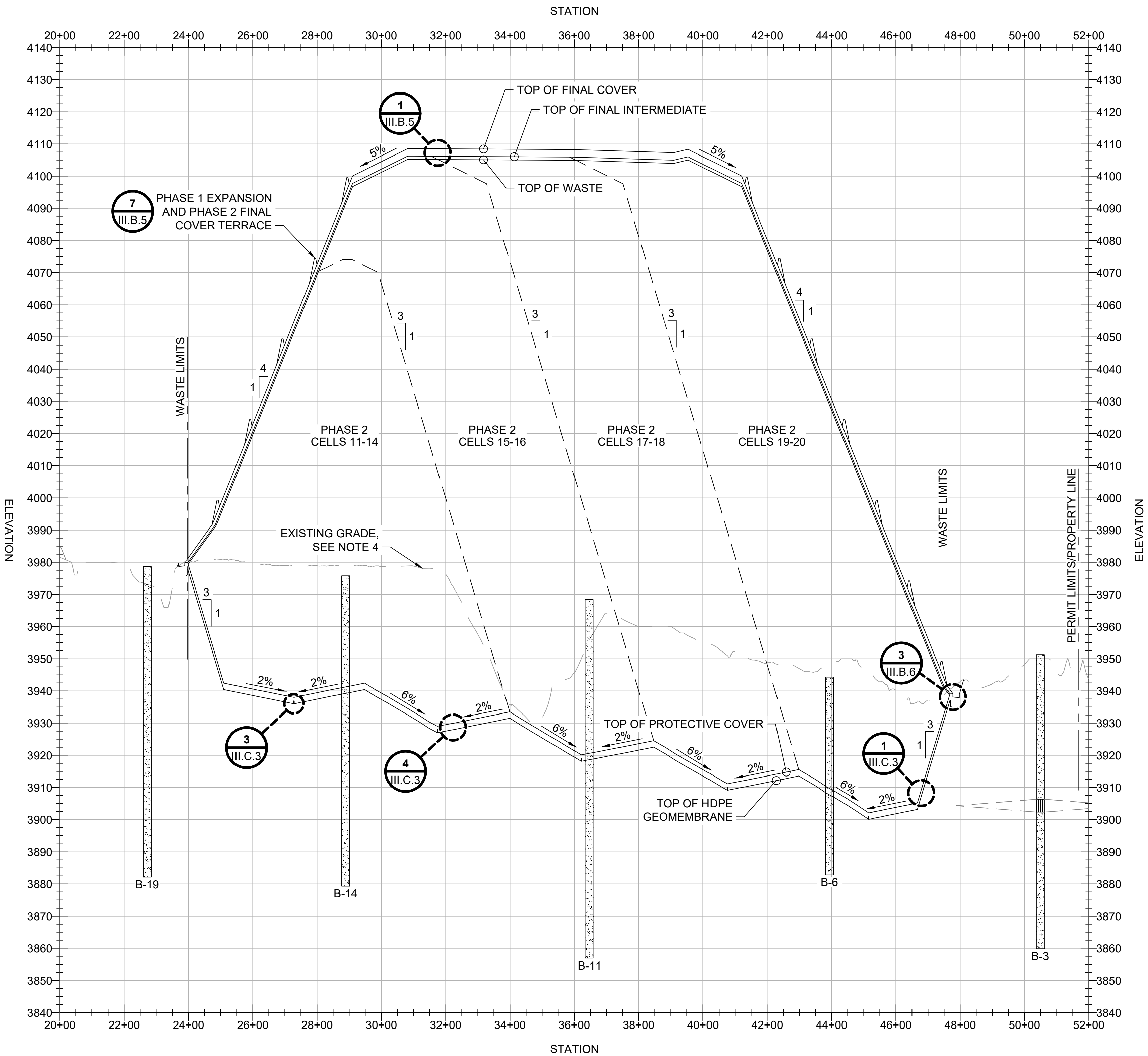
drawing **III.A.15** rev. **1**

file III.A.15 LANDFILL SECTION B-B', 1 OF 2.dwg

STATE OF TEXAS NATHAN KILGORE GEOLOGY 15672 LICENSED PROFESSIONAL GEOSCIENTIST
5/16/2025
NATHAN S. KILGORE P.G.
LICENSE NO. 15672

STATE OF TEXAS TONYA L. KOLLER 133943 LICENSED PROFESSIONAL ENGINEER
5-16-25
TONYA L. KOLLER P.E.
LICENSE NO. 133943

no.	date	by	ckd	description
0	5/1/24	TMC	TLK	2284A PERMIT MOD
1	5/16/25	AAN	TJS	TCEQ NOD 1

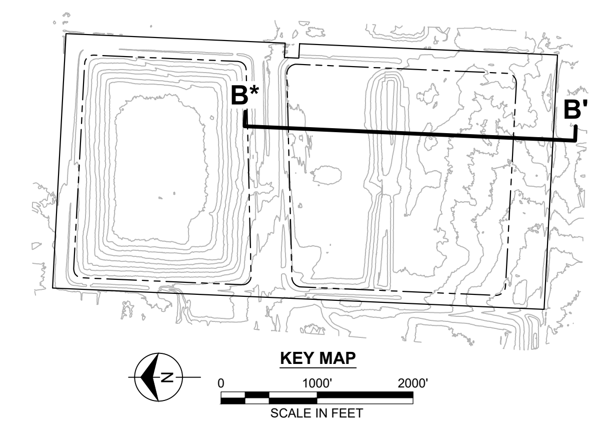


LANDFILL SECTION B*-B'

SCALE IN FEET

SCALE IN FEET

SOIL BORING ELEVATIONS (SEE NOTE 5)				
SOIL BORING	SURFACE EL. (CITY DATUM)	BOTTOM EL. (CITY DATUM)	SURFACE EL. (NAVD88)	BOTTOM EL. (NAVD88)
B-3	3940.93	3849.43	3951.32	3859.82
B-6	3933.91	3872.41	3944.30	3882.80
B-11	3958.04	3846.54	3968.43	3856.93
B-14	3965.40	3868.90	3975.79	3879.29
B-19	3968.26	3871.76	3978.65	3882.15



KEY MAP

SCALE IN FEET

LEGEND:

- CLAY
- SILT
- SAND
- CLAYEY SAND
- SILTY SAND
- GENERALIZED INFERRED STRATA
- 2284A GRADES

NOTES:

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BURNS McDONNELL
9400 WARD PARKWAY
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Burns & McDonnell Engineering Co, Inc.
FIRM REG. NO. F-845

date: MAY 2024 | detailed: D. KAMBLE
designed: T. CAMMACK | checked: T. KOLLER

City of El Paso, Texas

2284A PERMIT AMENDMENT

LANDFILL SECTION B-B', 2 OF 2

project: 155488 | contract: -

drawing: III.A.16 — rev. 1

file III.A.16 LANDFILL SECTION B-B', 2 OF 2.dwg

STATE OF TEXAS
NATHAN KILGORE
GEOLOGY
15672
LICENSED
PROFESSIONAL GEOSCIENTIST
5/16/2025

NATHAN S. KILGORE P.G.
LICENSE NO. 15672

STATE OF TEXAS
TONYA L. KOLLER
133943
LICENSED
PROFESSIONAL ENGINEER
5-16-25

TONYA L. KOLLER P.E.
LICENSE NO. 133943

tkoller May 15, 2025 - 8:06am - \\bmcd.burnsmcd.com\dfs\Clients\ENS\cityelpasotx\155488_geplfexpans\Design\CADD\Dwgs\III.A.16 LANDFILL SECTION B-B', 2 OF 2.dwg

no.	date	by	ckd	description
0	5/1/24	TMC	TLK	2284A PERMIT MOD
1	5/16/25	AAN	TSJ	TCEQ NOD 1

GAS MONITORING PROBE BORING ELEVATIONS (SEE NOTE 5)		
GMP BORING	SURFACE EL. (NAVD88)	BOTTOM EL. (NAVD88)
GMP-17	3914.98	3852.68

SOIL BORING ELEVATIONS (SEE NOTE 5)				
SOIL BORING	SURFACE EL. (CITY DATUM)	BOTTOM EL. (CITY DATUM)	SURFACE EL. (NAVD88)	BOTTOM EL. (NAVD88)
B-5	3946.46	3844.96	3956.85	3855.35
B-6	3933.91	3872.41	3944.30	3882.80
B-7	3918.80	3847.30	3929.19	3857.69
B-8	3913.93	3872.43	3924.32	3882.82

NOTES:

1. CROSS SECTION TRANSECT LINES DO NOT INTERSECT ALL BORINGS DEPICTED. GENERALIZED, INFERRED STRATA PRESENTED, AS INTERPRETED FROM DEPICTED BORINGS. REFER TO III.A.3 AND III.A.12 FOR BORING LOCATIONS.
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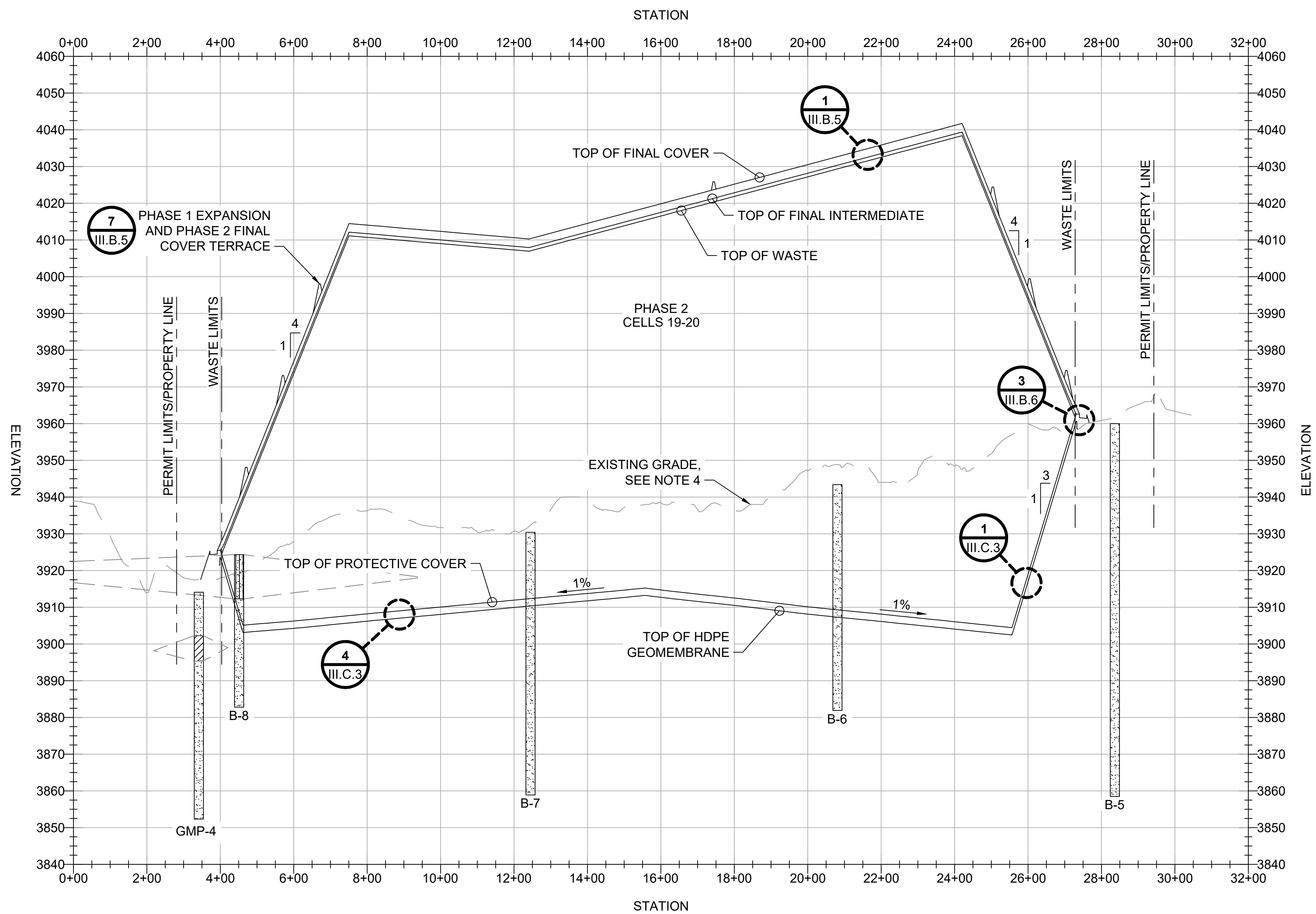
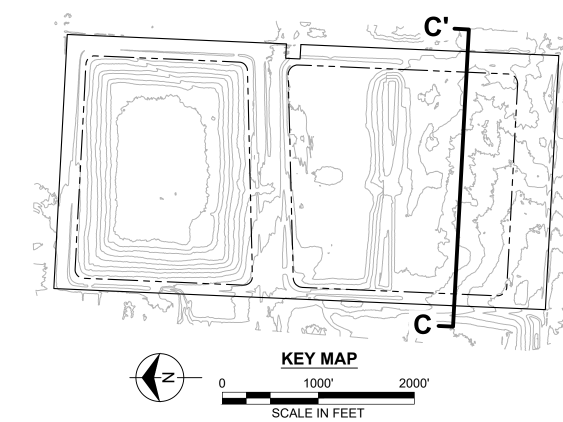


LANDFILL SECTION C-C'

C III.A.4 C III.A.12

SCALE IN FEET 0 10' 20' 40'

SCALE IN FEET 0 200' 400'



KEY MAP

SCALE IN FEET 0 1000' 2000'

LEGEND:

CLAY

SILT

SAND

CLAYEY SAND

SILTY SAND

GENERALIZED INFERRED STRATA

2284A GRADES

STATE OF TEXAS NATHAN KILGORE GEOLOGY 15672 LICENSED PROFESSIONAL GEOSCIENTIST

5/16/2025

NATHAN S. KILGORE, P.G. LICENSE NO. 15672

STATE OF TEXAS TONYA L. KOLLER 133943 LICENSED PROFESSIONAL ENGINEER

5-16-25

TONYA L. KOLLER P.E. LICENSE NO. 133943

FOR PERMITTING PURPOSES ONLY

BURNS McDONNELL

9400 WARD PARKWAY
KANSAS CITY, MO 64114
816-333-9400
Burns & McDonnell Engineering Co, Inc.
FIRM REG. NO. F-845

date	detailed
MAY 2024	D. KAMBLE
designed	checked
T. CAMMACK	T. KOLLER

EP TX CITY OF EL PASO

City of El Paso, Texas

2284A PERMIT AMENDMENT

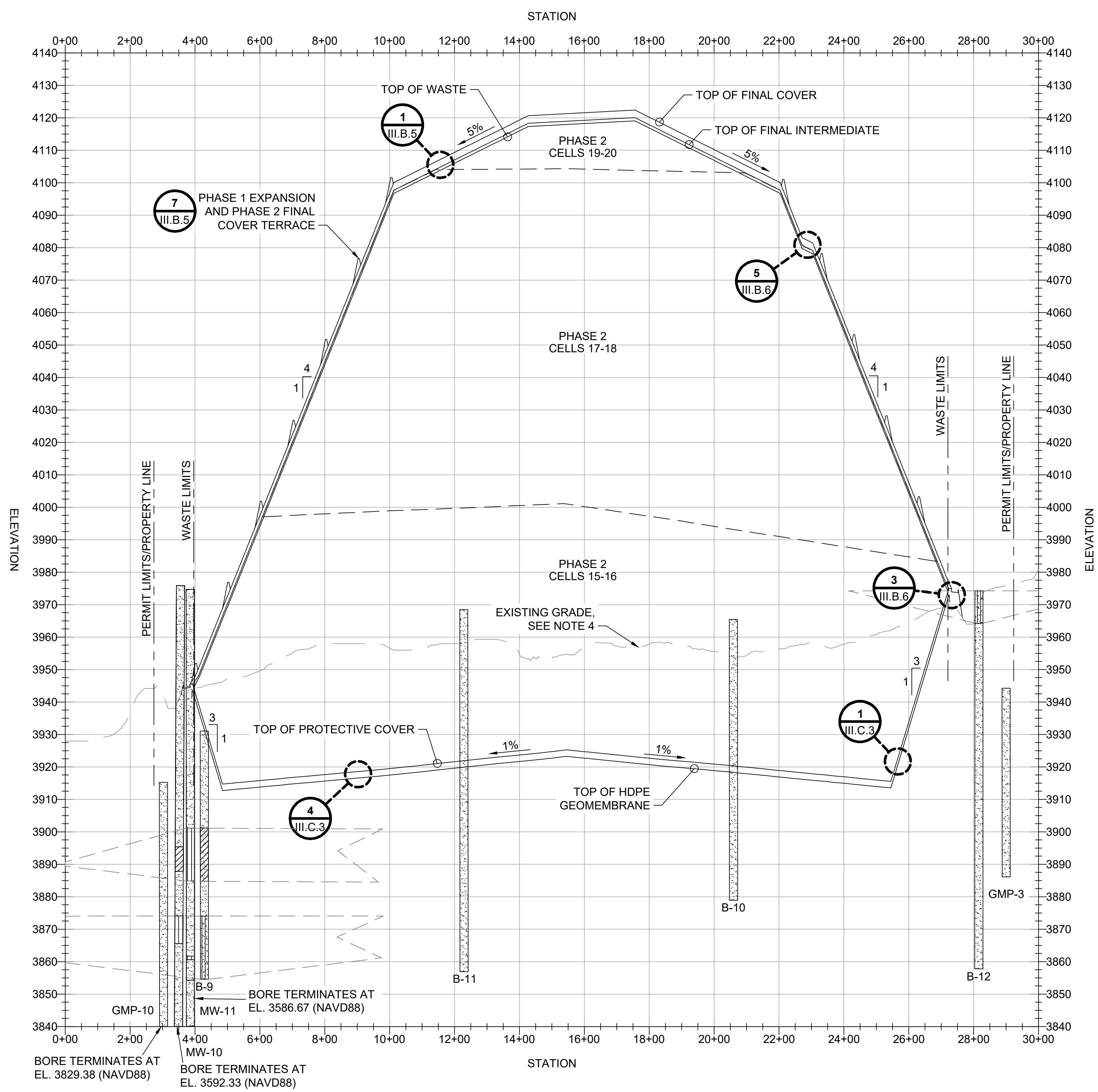
LANDFILL SECTION C-C'

project	contract
155488	-

drawing **III.A.17** rev. **1**

file III.A.17 LANDFILL SECTION C-C'.dwg

no.	date	by	ckd	description
0	5/1/24	TMC	TLK	2284A PERMIT MOD
1	5/16/25	AAN	TJS	TCEQ NOD 1



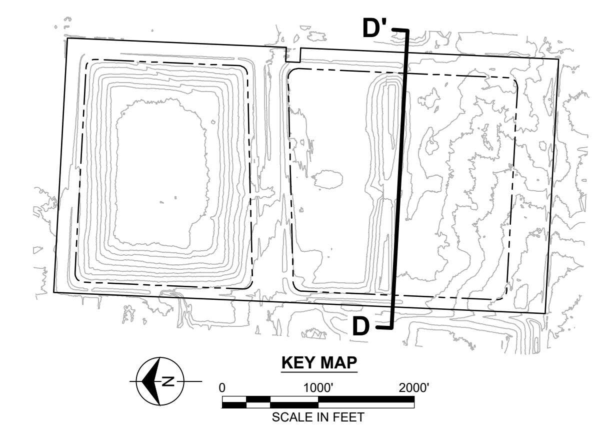
LANDFILL SECTION D-D'

SCALE IN FEET

GAS MONITORING PROBE BORING ELEVATIONS (SEE NOTE 5)		
GMP BORING	SURFACE EL. (NAVD88)	BOTTOM EL. (NAVD88)
GMP-10	3914.98	3829.38
GMP-3	3944.70	3886.00

MONITORING WELL BORING ELEVATIONS (SEE NOTE 5)		
MW BORING	SURFACE EL. (NAVD88)	BOTTOM EL. (NAVD88)
MW-10	3976.33	3592.33
MW-11	3974.67	3586.67

SOIL BORING ELEVATIONS (SEE NOTE 5)				
SOIL BORING	SURFACE EL. (CITY DATUM)	BOTTOM EL. (CITY DATUM)	SURFACE EL. (NAVD88)	BOTTOM EL. (NAVD88)
B-9	3920.66	3844.16	3931.05	3854.55
B-10	3955.04	3868.54	3965.43	3878.93
B-11	3958.04	3846.54	3968.43	3856.93
B-12	3963.88	3847.38	3974.27	3857.77



KEY MAP

SCALE IN FEET

LEGEND:

- CLAY
- SILT
- SAND
- CLAYEY SAND
- SILTY SAND
- GENERALIZED INFERRED STRATA
- 2284A GRADES

NOTES:

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FOR PERMITTING PURPOSES ONLY

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9400 WARD PARKWAY
KANSAS CITY, MO 64114
816-333-9400
Burns & McDonnell Engineering Co, Inc.
FIRM REG. NO. F-845

date	detailed
MAY 2024	D. KAMBLE
designed	checked
T. CAMMACK	T. KOLLER

City of El Paso, Texas

2284A PERMIT AMENDMENT

LANDFILL SECTION D-D'

project	contract
155488	-

drawing III.A.18 — rev. 1

file III.A.18 LANDFILL SECTION D-D'.dwg

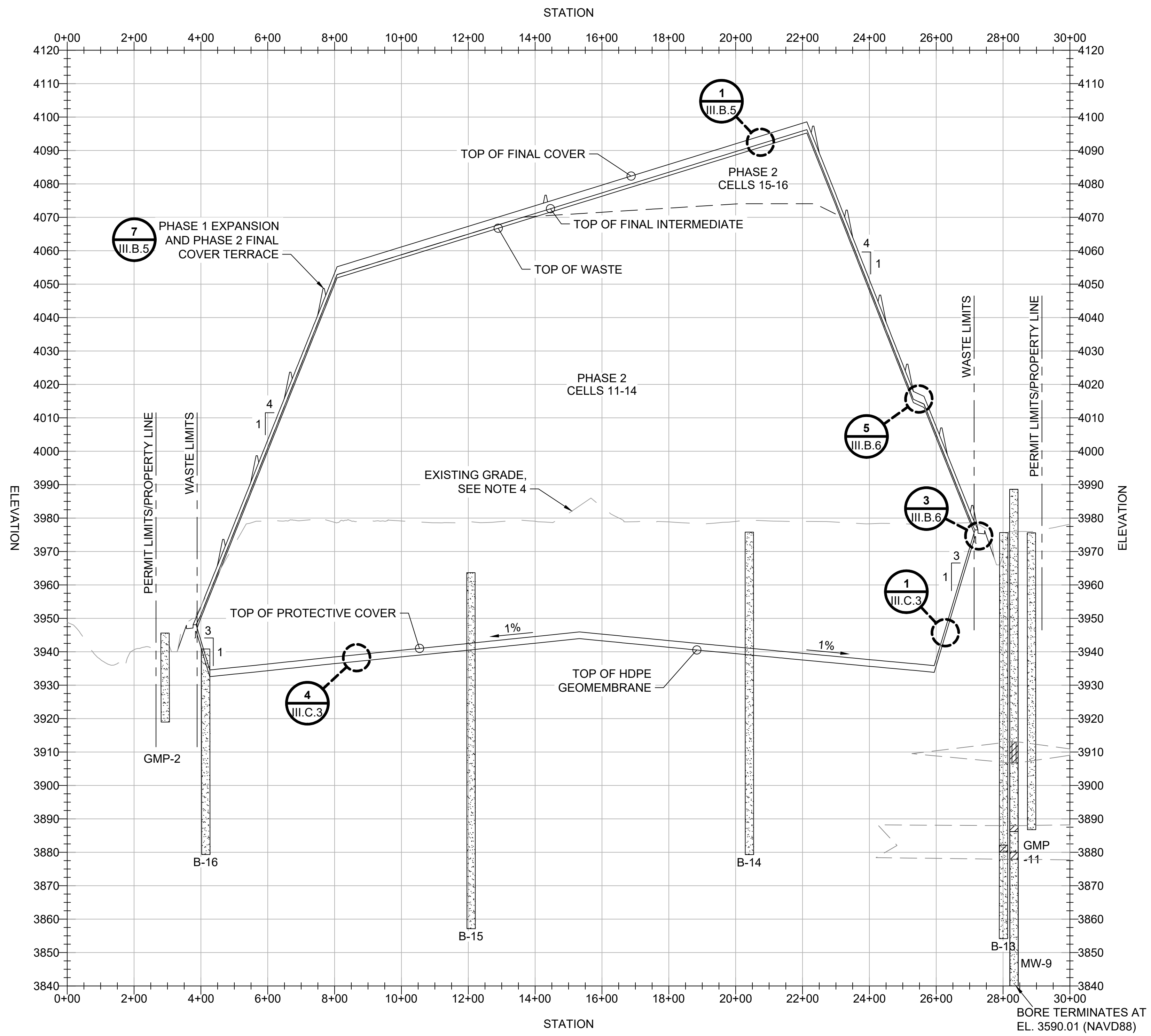
STATE OF TEXAS
NATHAN KILGORE
GEOLOGY
15672
LICENSED
PROFESSIONAL GEOSCIENTIST
5/16/2025

NATHAN S. KILGORE P.G.
LICENSE NO. 15672

STATE OF TEXAS
TONYA L. KOLLER
133943
LICENSED
PROFESSIONAL ENGINEER
5-16-25

TONYA L. KOLLER P.E.
LICENSE NO. 133943

no.	date	by	ckd	description
0	5/1/24	TMC	TLK	2284A PERMIT MOD
1	5/16/25	AAN	TJS	TCEQ NOD 1



LANDFILL SECTION E-E' E III.A.4 E III.A.12

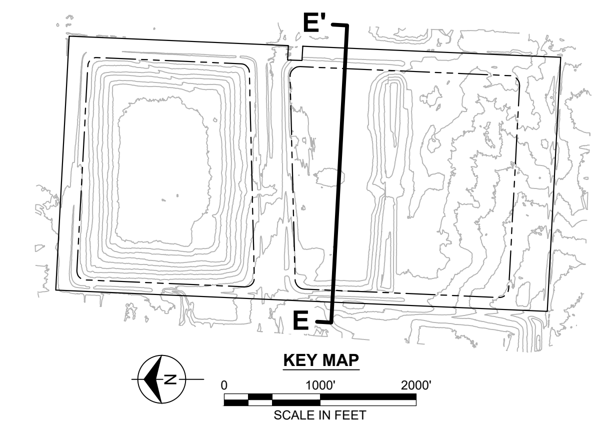
SCALE IN FEET (0, 10', 20', 40')

SCALE IN FEET (0, 200', 400')

GAS MONITORING PROBE BORING ELEVATIONS (SEE NOTE 5)				
GMP BORING	SURFACE EL. (CITY DATUM)	BOTTOM EL. (CITY DATUM)	SURFACE EL. (NAVD88)	BOTTOM EL. (NAVD88)
GMP-2	3935.93	3908.43	3946.32	3918.82
GMP-11	3965.25	3877.25	3975.64	3887.64

MONITORING WELL BORING ELEVATIONS (SEE NOTE 5)				
MW BORING	SURFACE EL. (CITY DATUM)	BOTTOM EL. (CITY DATUM)	SURFACE EL. (NAVD88)	BOTTOM EL. (NAVD88)
MW-9	3976.62	3579.62	3987.01	3590.01

SOIL BORING ELEVATIONS (SEE NOTE 5)				
SOIL BORING	SURFACE EL. (CITY DATUM)	BOTTOM EL. (CITY DATUM)	SURFACE EL. (NAVD88)	BOTTOM EL. (NAVD88)
B-13	3965.28	3843.78	3975.67	3854.17
B-14	3965.40	3868.90	3975.79	3879.29
B-15	3953.26	3846.76	3963.65	3857.15
B-16	3960.45	3868.95	3940.84	3879.34



KEY MAP

SCALE IN FEET (0, 1000', 2000')

LEGEND:

- CLAY
- SILT
- SAND
- CLAYEY SAND
- SILTY SAND
- SILTY CLAY
- GENERALIZED INFERRED STRATA
- 2284A GRADES

NOTES:

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STATE OF TEXAS
NATHAN KILGORE
GEOLOGY
15672
LICENSED
PROFESSIONAL GEOSCIENTIST
5/16/2025

NATHAN S. KILGORE, P.G.
LICENSE NO. 15672

STATE OF TEXAS
TONYA L. KOLLER
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5-16-25

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LICENSE NO. 133943

FOR PERMITTING PURPOSES ONLY

BURNS McDONNELL
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KANSAS CITY, MO 64114
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Burns & McDonnell Engineering Co, Inc.
FIRM REG. NO. F-845

date	detailed
MAY 2024	D. KAMBLE
designed	checked
T. CAMMACK	T. KOLLER

EP TX CITY OF EL PASO

City of El Paso, Texas

2284A PERMIT AMENDMENT

LANDFILL SECTION E-E'

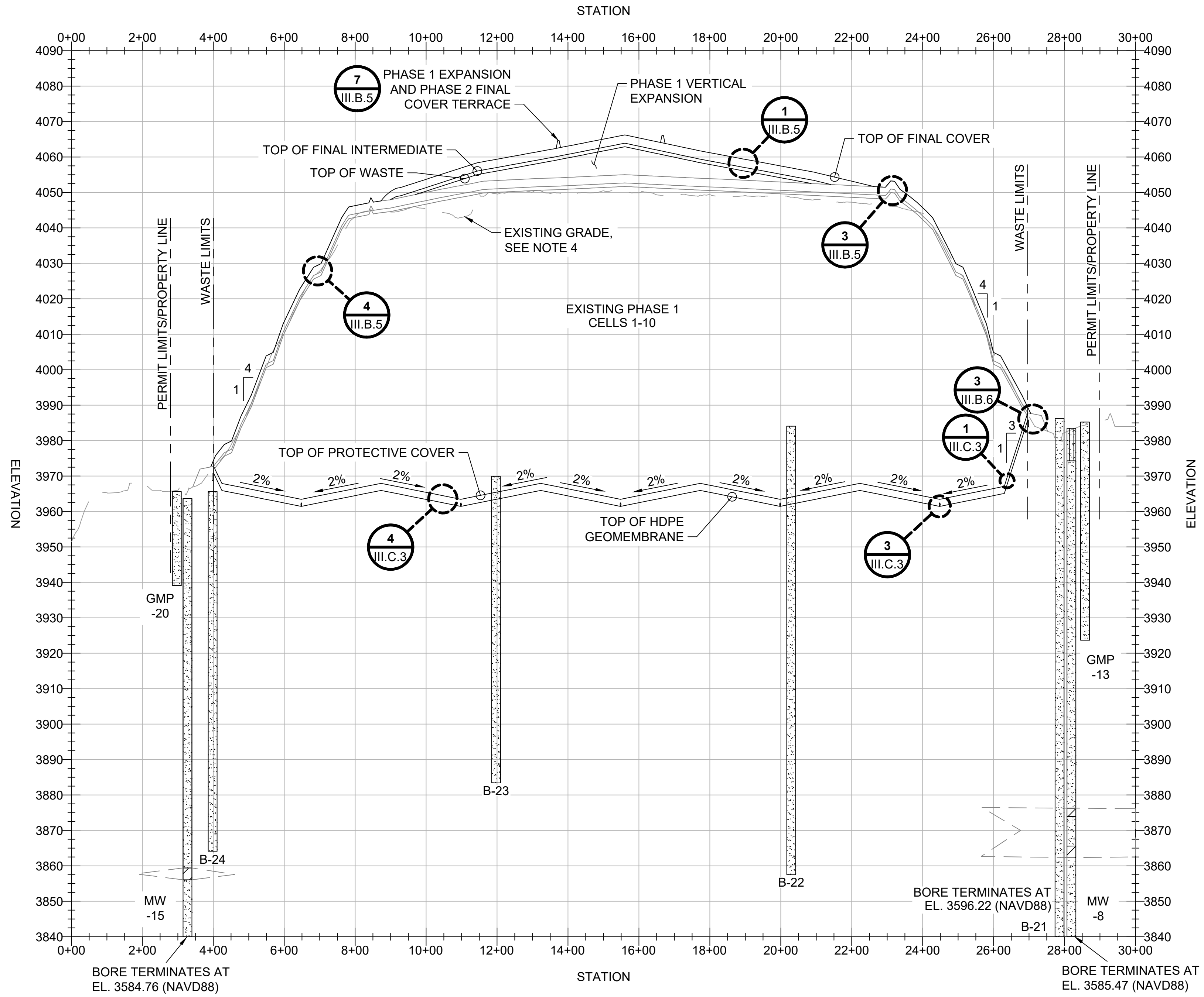
project	contract
155488	-

drawing **III.A.19** rev. **1**

file III.A.19 LANDFILL SECTION E-E'.dwg

tkoller May 15, 2025 - 8:10am - \\bmcd.burnsmcd.com\dfs\Clients\ENS\cityelpasotx\155488_geplfexpans\Design\CADD\Dwgs\III.A.19 LANDFILL SECTION E-E'.dwg

no.	date	by	ckd	description
0	5/1/24	TMC	TLK	2284A PERMIT MOD
1	5/16/25	AAN	TJS	TCEQ NOD 1



LANDFILL SECTION F-F' F III.A.4 F III.A.12

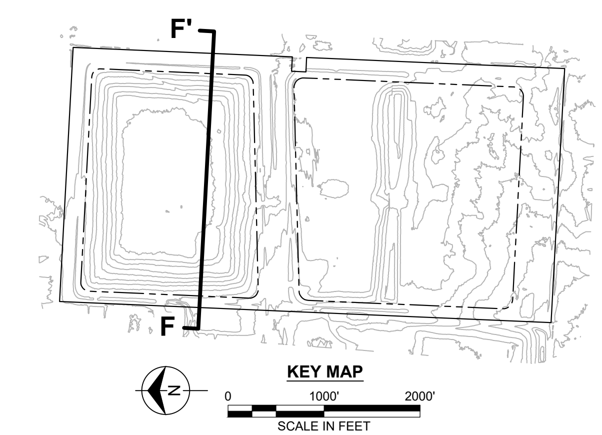
SCALE IN FEET 0 10' 20' 40'

SCALE IN FEET 0 200' 400'

GAS MONITORING PROBE BORING ELEVATIONS (SEE NOTE 5)				
GMP BORING	SURFACE EL. (CITY DATUM)	BOTTOM EL. (CITY DATUM)	SURFACE EL. (NAVD88)	BOTTOM EL. (NAVD88)
GMP-13	3975.08	3912.08	3985.47	3922.47
GMP-20	3954.73	3929.23	3965.12	3939.62

MONITORING WELL BORING ELEVATIONS (SEE NOTE 5)				
MW BORING	SURFACE EL. (CITY DATUM)	BOTTOM EL. (CITY DATUM)	SURFACE EL. (NAVD88)	BOTTOM EL. (NAVD88)
MW-8	3979.08	3575.08	3983.47	3585.47
MW-15	3964.37	3575.37	3963.63	3584.76

SOIL BORING ELEVATIONS (SEE NOTE 5)				
SOIL BORING	SURFACE EL. (CITY DATUM)	BOTTOM EL. (CITY DATUM)	SURFACE EL. (NAVD88)	BOTTOM EL. (NAVD88)
B-21	3975.83	3585.83	3986.22	3596.22
B-22	3973.66	3847.16	3984.05	3857.55
B-23	3959.51	3873.01	3969.90	3883.40
B-24	3955.24	3853.74	3965.63	3864.13



KEY MAP

SCALE IN FEET 0 1000' 2000'

LEGEND:

- CLAY
- SILT
- SAND
- CLAYEY SAND
- SILTY SAND
- GENERALIZED INFERRED STRATA
- 2284A GRADES
- 2284 GRADES

NOTES:

1. CROSS SECTION TRANSECT LINES DO NOT INTERSECT ALL BORINGS DEPICTED. GENERALIZED, INFERRED STRATA PRESENTED, AS INTERPRETED FROM DEPICTED BORINGS. REFER TO III.A.3 AND III.A.12 FOR BORING LOCATIONS.
2. STATIC WATER ELEVATIONS BASED ON THE MAXIMUM SEASONAL HIGH GROUNDWATER SURFACE, AS OF THE DATE OF THE ORIGINAL APPLICATION, SHOWN ON DRAWING III.E.21.
3. LITHOLOGY IS GENERALIZED BY SAND, SILT, AND CLAY. REFER TO BORING LOGS PROVIDED IN APPENDIX III.E FOR EXACT LITHOLOGY DESCRIPTIONS.
4. EXISTING GROUND SOURCES PROVIDED ON DRAWING III.A.3.
5. 2284 PERMITTED DESIGN CONTOURS WERE BASED ON CITY DATUM ELEVATIONS AND WERE ADJUSTED TO NAVD88 BY ADDING 10.39 FEET AS CERTIFIED BY BROCK & BUSTILLOS INC. ON DECEMBER 7, 2023. DATUM CERTIFICATION LETTER INCLUDED IN APPENDIX I/II.B.

FOR PERMITTING PURPOSES ONLY

BURNS McDONNELL
9400 WARD PARKWAY
KANSAS CITY, MO 64114
816-333-9400
Burns & McDonnell Engineering Co, Inc.
FIRM REG. NO. F-845

date MAY 2024 | detailed D. KAMBLE
designed T. CAMMACK | checked T. KOLLER

City of El Paso, Texas

2284A PERMIT AMENDMENT

LANDFILL SECTION F-F'

project 155488 | contract -

drawing **III.A.20** rev. **1**

file III.A.20 LANDFILL SECTION F-F'.dwg

STATE OF TEXAS NATHAN KILGORE GEOLOGY 15672 LICENSED PROFESSIONAL GEOSCIENTIST 5/16/2025

NATHAN S. KILGORE P.G.
LICENSE NO. 15672

STATE OF TEXAS TONYA L. KOLLER 133943 LICENSED PROFESSIONAL ENGINEER 5-16-25

TONYA L. KOLLER P.E.
LICENSE NO. 133943

no.	date	by	ckd	description
0	5/1/24	TMC	TLK	2284A PERMIT MOD
1	5/16/25	AAN	TJS	TCEQ NOD 1

GAS MONITORING PROBE BORING ELEVATIONS (SEE NOTE 5)

GMP BORING	SURFACE EL. (CITY DATUM)	BOTTOM EL. (CITY DATUM)	SURFACE EL. (NAVD88)	BOTTOM EL. (NAVD88)
GMP-14	3974.60	3927.60	3984.99	3937.99
GMP-19	3961.89	3924.98	3972.28	3935.37

MONITORING WELL BORING ELEVATIONS (SEE NOTE 5)

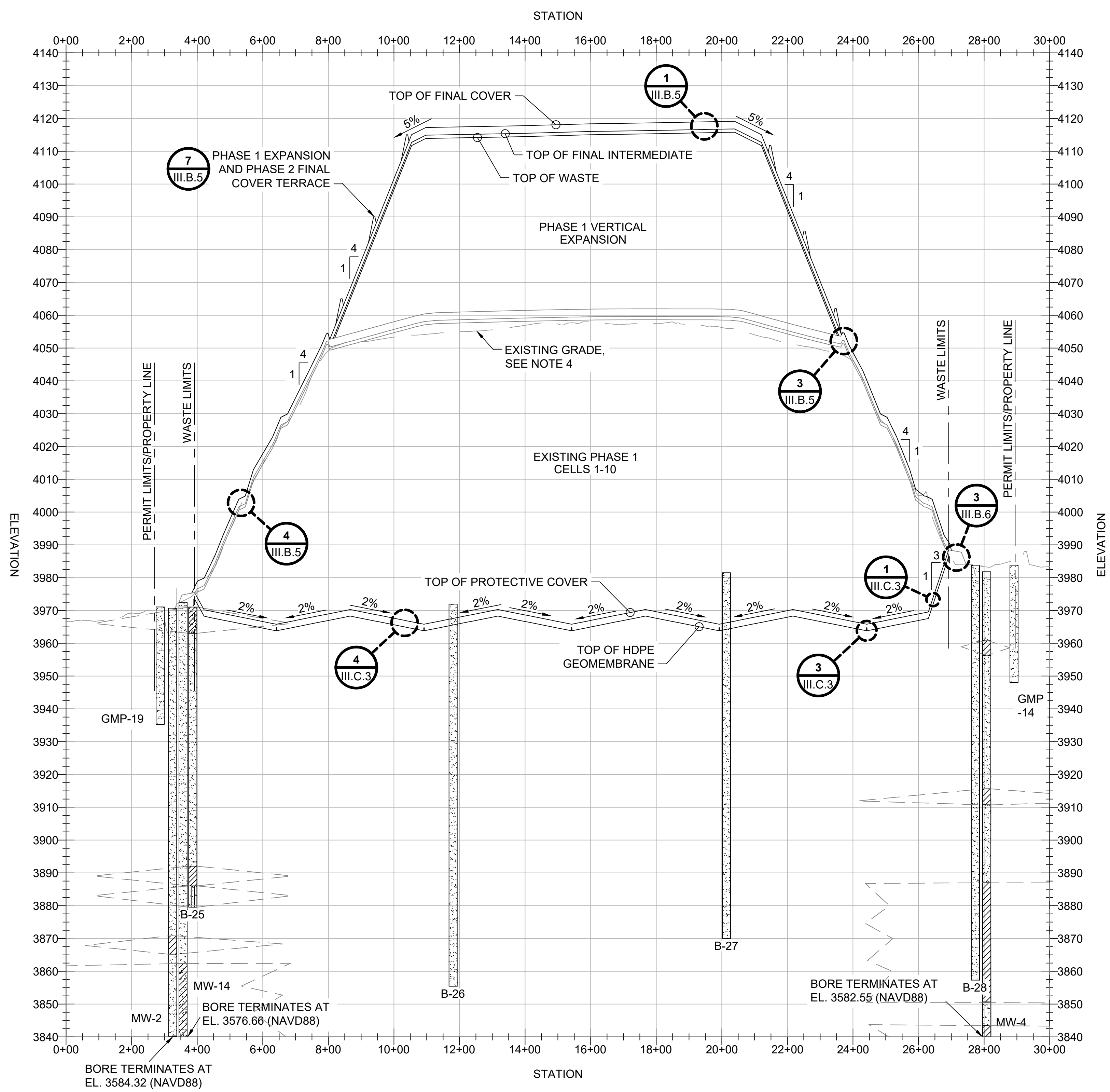
MW BORING	SURFACE EL. (CITY DATUM)	BOTTOM EL. (CITY DATUM)	SURFACE EL. (NAVD88)	BOTTOM EL. (NAVD88)
MW-2	3959.93	3537.93	3970.32	3584.32
MW-3	3964.37	3575.37	3974.76	3584.76
MW-4	3972.16	3572.16	3982.55	3582.55
MW-14	3961.27	3566.27	3971.66	3576.66

SOIL BORING ELEVATIONS (SEE NOTE 5)

SOIL BORING	SURFACE EL. (CITY DATUM)	BOTTOM EL. (CITY DATUM)	SURFACE EL. (NAVD88)	BOTTOM EL. (NAVD88)
B-25	3960.66	3869.16	3971.05	3879.55
B-26	3961.56	3845.06	3971.95	3855.45
B-27	3971.12	3859.62	3981.51	3870.01
B-28	3973.42	3846.92	3983.81	3857.31

NOTES:

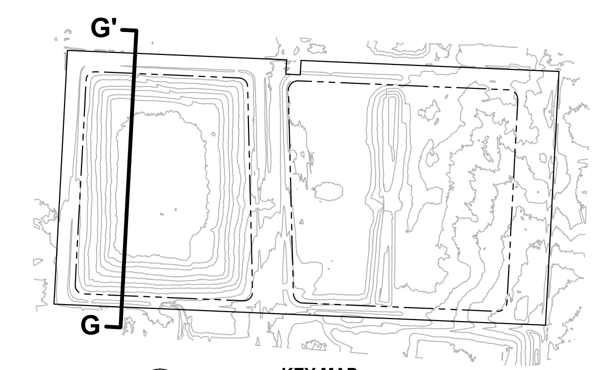
1. CROSS SECTION TRANSECT LINES DO NOT INTERSECT ALL BORINGS DEPICTED. GENERALIZED, INFERRED STRATA PRESENTED, AS INTERPRETED FROM DEPICTED BORINGS. REFER TO III.A.3 AND III.A.12 FOR BORING LOCATIONS.
2. STATIC WATER ELEVATIONS BASED ON THE MAXIMUM SEASONAL HIGH GROUNDWATER SURFACE, AS OF THE DATE OF THE ORIGINAL APPLICATION, SHOWN ON DRAWING III.E.21.
3. LITHOLOGY IS GENERALIZED BY SAND, SILT, AND CLAY. REFER TO BORING LOGS PROVIDED IN APPENDIX III.E FOR EXACT LITHOLOGY DESCRIPTIONS.
4. EXISTING GROUND SOURCES PROVIDED ON DRAWING III.A.3.
5. 2284 PERMITTED DESIGN CONTOURS WERE BASED ON CITY DATUM ELEVATIONS AND WERE ADJUSTED TO NAVD88 BY ADDING 10.39 FEET AS CERTIFIED BY BROCK & BUSTILLOS INC. ON DECEMBER 7, 2023. DATUM CERTIFICATION LETTER INCLUDED IN



LANDFILL SECTION G-G' G III.A.4 G III.A.12

SCALE IN FEET 0 10' 20' 40'

SCALE IN FEET 0 200' 400'



KEY MAP

SCALE IN FEET 0 1000' 2000'

LEGEND:

	CLAY
	SILT
	SAND
	CLAYEY SAND
	SILTY SAND
GENERALIZED INFERRED STRATA	— — — —
2284A GRADES	————
2284 GRADES	————

STATE OF TEXAS NATHAN KILGORE GEOLOGY 15672 LICENSED PROFESSIONAL GEOSCIENTIST

5/16/2025

NATHAN S. KILGORE P.G.
LICENSE NO. 15672

STATE OF TEXAS TONYA L. KOLLER 133943 LICENSED PROFESSIONAL ENGINEER

5-16-25

TONYA L. KOLLER P.E.
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FIRM REG. NO. F-845

date	detailed
MAY 2024	D. KAMBLE
designed	checked
T. CAMMACK	T. KOLLER

EP TX CITY OF EL PASO

City of El Paso, Texas

2284A PERMIT AMENDMENT

LANDFILL SECTION G-G'

project 155488 contract -

drawing **III.A.21** – rev. **1**

file III.A.21 LANDFILL SECTION G-G'.dwg

Please replace Appendix III.B with the following pages

APPENDIX III.B – SURFACE WATER DRAINAGE REPORT

MSW AUTH NO. 2284A

APPENDIX III.B – SURFACE WATER DRAINAGE REPORT

CITY OF EL PASO, TEXAS
GREATER EL PASO LANDFILL MAJOR AMENDMENT
PROJECT NO. 155488

REVISION 1
MAY 16, 2025

Part III, Appendix B
Surface Water Drainage Report
MSW Auth No. 2284A

prepared for

City of El Paso, Texas
Greater El Paso Landfill Major Amendment
El Paso County, Texas

Project No. 155488

Revision 0, October 31 2024
Revision 1, May 16, 2025

prepared by

Burns & McDonnell Engineering Company, Inc.
6200 Bridge Point Pkwy, Building 4, Suite 400, Austin, TX 78730
Texas Firm Registration No. F-845

CONTENTS

TABLES

List of Abbreviations

Abbreviation	Term/Phrase/Name
ac-ft	acre-foot
BMPs	best management practices
cfs	cubic feet per second
CN	curve number
FEMA	Federal Emergency Management Agency
FIRM	Preliminary Flood Insurance Rate Map
fps	feet per second
GEP Landfill	Greater El Paso Landfill, MSW Authorization Number 2284A
HEC-HMS	Hydraulic Engineering Center-Hydrologic Modeling System
hr	hour
in/hr	inches per hour
MSW	Municipal Solid Waste
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
RCP	reinforced concrete pipe
RG-417	TCEQ Regulatory Guidance, “Surface Water Drainage and Erosional Stability Guidelines for a Municipal Solid Waste Landfill”, dated May 2018
SCS	Soil Conservation Service
sq. mi.	square mile
SWDR	Surface Water Drainage Report
TAC	Texas Administrative Code
T_c	Times of Concentration
TCEQ	Texas Commission on Environmental Quality
T_{lag}	Lag Times
TPDES	Texas Pollutant Discharge Elimination System
TR-55	“Urban Hydrology for Small Watersheds”, Technical Release 55 developed by the Natural Resources Conservation Service
TxDOT	Texas Department of Transportation
USGS	United States Geological Survey

III.B.1.0 Introduction

The facility was designed to manage peak flows and erosion potential resulting from a 25-year storm, to comply with Texas Administrative Code 30 (TAC) §330.303. This surface water drainage report (SWDR) has been prepared for the City of El Paso, Greater El Paso Landfill, Municipal Solid Waste (MSW) Authorization Number 2284A (GEP Landfill). Included in this SWDR are the pre- and post-development drainage area maps and designs of temporary and permanent drainage appurtenances including interceptor ditches, down chutes, culverts, channels, and detention ponds.

The existing landfill consists of four permitted outfalls: Southeast (A), Southwest Detention Pond (BC), and West Detention Pond (D, E). Pre-development conditions reflect the previous permitted conditions of 2022 under Texas Commission on Environmental Quality (TCEQ) MSW Authorization Number 2284. In 2284A, Outfall A will remain as planned. Outfall BC, from Pond BC, will include the final cover conditions of Phase 2. Final cover is complete on Phase 1 which includes Pond DE. This permit includes a vertical expansion of Phase 1.

This SWDR has been prepared in general conformance with the requirements of 30 TAC §§330.63(c) and 330.305 and the TCEQ Regulatory Guidance, “Surface Water Drainage and Erosional Stability Guidelines for a Municipal Solid Waste Landfill”, dated May 2018 (RG-417). This SWDR includes the locations, details and supporting design methodology for the site’s stormwater control features, which include erosion and sediment control best management practices (BMPs), interceptor ditches, letdown chutes, drainage channels, perimeter ditches, swales, culverts, and detention/retention ponds. The overall routing of stormwater can be seen in the Drawings in **Attachment III.B.3**. Rainfall data was obtained from the National Oceanic and Atmospheric Administration (NOAA) Atlas 14, Volume 11 (version 2) precipitation frequency tables for the project location in El Paso County, Texas. A 25-year recurrence interval and 24-hour storm duration were selected for both the Pre- and Post-Development Conditions model. The facilities requested permit extents were also designed to provide protection from 100-year frequency flooding to comply with 30 TAC §330.307. Drainage calculations are included in **Attachment III.B.1**. Geotechnical stability calculations are provided in Part III, Appendix III.G.

An erosion and sedimentation control plan is provided in **Attachment III.B.2**. Estimates of soil loss over the 50-year development and 30-year post-closure period are also included.

A Notice of Intent for Stormwater discharge in association with an industrial activity under the Texas Pollutant Discharge Elimination System (TPDES) General Permit has been filed for the GEP Landfill. A copy TPDES General Permit is located in Part I/II, Appendix I/II.I.

Details regarding site geology and groundwater are provided in Part III, Appendix III.E. The site Groundwater Sampling and Analysis Plan is provided in Part III, Appendix III.F. A discussion of the leachate collection system performance, along with calculations for leachate quantity predictions and design adequacy is included as Part III, Appendix III.C.

III.B.2.0 Pre-Development Conditions

The GEP Landfill property occupies approximately 311 acres adjacent to the east boundary of the existing Clint Landfill (MSW Authorization Number 1482). The northern two-thirds of the site is nearly level to gently sloping to the west; surface soils on this portion of the site are brown loamy fine sands of the Hueco-Wink association. The southern third of the site slopes at approximately five percent to the south. The Soil Survey for El Paso County identifies soils on this portion of the site are of the Bluepoint association; these soils are also described as loamy fine sands. Site soils are of a poor quality for vegetation production. Site vegetation consists of sparse desert shrubs. The soils are moderately to very permeable and susceptible to blowing.

III.B.2.1 Pre-Development Conditions Drainage Patterns

Drawing III.B.2 in **Attachment III.B.3** shows the pre-development drainage patterns at the site (reflecting permit 2284). Per RG-417, the existing drainage patterns are the drainage patterns at the currently permitted site closure conditions. Drainage patterns beyond the extent of this topography in area C/Cos were estimated from the 1995 United States Geological Survey (USGS) 1:24000 topo map for Clint, Texas. Historical off-site and on-site drainage areas are shown on Drawing III.B.1 in **Attachment III.B.3**. The existing permitted drainage patterns, drawn by Parkhill, Smith, & Cooper are provided in Drawing III.B.2 in **Attachment III.B.3.**

A series of berms were constructed at some point in the past along the north, east and south sides of the property. A break in the berm along the east boundary just south of the pipeline easement allows runoff from area Cos to enter the property. This is the only location where run-on enters the property.

Stormwater runoff leaves the site at four points, labeled A, BC, D and E. Area A is on-site runoff located outside the reach of perimeter Ditch B. Its outfall is off-site to the south. This area will remain consistent from Permit 2284 to Permit 2284A. Runoff from areas B and C are collected from Phase 2 into boundary channels that are collected into Detention Pond BC. In similar fashion, Detention Pond DE collects runoff from the boundary channels of Phase 1 and discharges through two separate culverts on opposite ends on the basin.

The site does not lie in the 100-year floodplain as shown on Figure I/II.A.11 in Part I/II, Appendix I/II.A, which is based on the Federal Emergency Management Agency (FEMA) Flood Service Map Center, Preliminary Flood Insurance Rate Map (FIRM) Panel 48141C0660F, dated July 08, 2020.

III.B.2.2 Pre-Development Conditions Drainage Area Map

The drainage area for the site totals 464 acres. The pre-development area is divided into 25 sub-areas as shown in Drawing III.B.2 in **Attachment III.B.3**. The figure also contains a table summarizing pre-development flows from the sub-areas and at discharge points A-E.

III.B.2.3 Pre-Development Conditions Modeling

For determining the peak flows at all points, the Hydraulic Engineering Center-Hydrologic Modeling System (HEC-HMS) program was utilized. The Rational method was not used because the cumulative drainage area is greater than 200 acres. Soil Conservation Service (SCS) runoff curve number (CN) methodology as outlined in the SCS National Engineering Handbook, Section 4, Hydrology was used as a guide for developing input data for HEC-HMS in the pre-development calculations.

III.B.2.3.1 Pre-Development Precipitation

Rainfall data was obtained from the NOAA Atlas 14, Volume 11 (version 2) precipitation frequency tables for the project location. A 25-year recurrence interval and 24-hour duration event were selected for a cumulative depth of 3.12-inches at the time of the permit. **Table III.B.2-1** contains the values that were used in the HEC-HMS model for 24-hour rainfall depths for pre-development conditions under the previous permit.

Table III.B.2-1: Pre-Development Rainfall Depth/Duration Data (Inches/Hour)

Duration	Return Period (Years)	
	25	100
5 min	0.44	0.55
10 min	0.81	1.04
15 min	1.08	1.40
30 min	1.47	1.89
60 min	1.87	2.40
2 hr	2.01	2.58
3 hr	2.15	2.75
6 hr	2.50	3.20
12 hr	2.81	3.60
24 hr	3.12	4.00

Rainfall intensity for the rational method calculations was calculated based on the Texas Department of Transportation (TxDOT) Bridge Division Hydraulic Manual. Rainfall intensity (inches per hour [in/hr]) was computed as follows:

$$\boldsymbol{I = \frac{b}{(t+d)^e}}$$

b = TxDOT factor for 25 year event in El Paso County = 60
d = TxDOT factor for 25 year event in El Paso County = 12.0
e = TxDOT factor for 25 year event in El Paso County = 0.843
t = longest time of concentration for basin being considered; minimum of 10 minutes per 30 TAC §330.305(f)(1)

III.B.2.3.2 T_c and T_{lag}

Pre-development Times of Concentration (T_c) and Lag Times (T_{lag}) were developed from USGS topographic maps and the previous permit plans shown in Drawings III.B.1 and III.B.2 in **Attachment III.B.3**. The methods presented in “Urban Hydrology for Small Watersheds” (Technical Release 55 [TR-55]) developed by the Natural Resources Conservation Service (NRCS) (formerly SCS) were used to calculate T_c. The T_{lag} for each subbasin was calculated using the following equation:

$$T_{lag} = T_c \times 0.6 \text{ (Haan, 1994)}$$

Attachment III.B.1 contains calculations for T_c and T_{lag}.

III.B.2.3.3 Loss Rates

According to the NRCS Web Soil Survey, site soils belong to the following hydrologic groups:

Table III.B.2-2: Site Soil Hydrologic Groups

Soil Classification	Hydrologic Soil Group
Hueco- Wink	A
Bluepoint association, rolling	A
Bluepoint gravelly association, rolling	A

CNs for Pre-development Conditions were found by combining hydrologic soil classification with existing land use. Soil classification and land use are combined to select values for each subbasin CN from Tables 2.2a —2.2d in TR-55. A CN of 63 was used for desert shrub (poor condition). The tables from TR-55 are reproduced in **Attachment III.B.1**. Curve numbers used for all subbasins modeled are provided in **Table III.B.2-3**.

III.B.2.3.4 Pre-Development HEC-HMS Model

The output from the HEC-HMS model is included in **Attachment III.B.1**. Pre-development flows calculated by HEC-HMS are summarized in **Table III.B.2-3**.

Table III.B.2-3: Pre-Development: SCS Parameters in HEC-HMS

Discharge	Subbasin	Area (acres)	Area (sq. mi.)	T_{lag} (hr.)	CN	Peak Discharge (cfs)	Peak Runoff (ac-ft)	Peak Velocity (fps)
	A1	5.0	0.008	0.12	63	3	0.2	1.61
Outfall A		**5.0**	0.008			**3**	**0.2**	**1.61**
	B1	17.5	0.027	0.16	96	44	3.9	2.31
	B2	18.1	0.028	0.16	96	46	4.0	2.31
	B3	19.3	0.030	0.16	96	48	4.3	2.31
	B4	15.3	0.024	0.07	96	43	3.4	2.39
	B5	9.9	0.015	0.08	96	28	2.2	2.39
	B6	7.4	0.012	0.07	96	20	1.6	2.39
	B7	19.4	0.030	0.57	75	10	1.7	4.46
	B8	17.9	0.028	0.24	75	13	1.6	4.46
	Cos	151.4	0.237	0.76	63	23	6.1	1.14
	C1	18.5	0.029	0.16	96	46	4.1	2.31
	C2	10.6	0.017	0.07	96	29	2.4	2.39
	C3	10.2	0.016	0.36	96	19	2.3	4.46
Inflow @ Pond BC		**315.5**	**0.493**			**259**	**38.7**	

Discharge	Subbasin	Area (acres)	Area (sq. mi.)	T_{lag} (hr.)	CN	Peak Discharge (cfs)	Peak Runoff (ac-ft)	Peak Velocity (fps)
Outflow @ Pond BC						**48**	**34.5**	**27.32**
	D1	9.7	0.015	0.18	96	33	2.2	19.1
	D2	10.3	0.016	0.21	96	33	2.3	19.1
	D3	12.5	0.020	0.12	96	48	2.8	19.1
	D4	7.7	0.012	0.12	96	29	1.7	19.1
	D5	24.8	0.039	0.14	76	38	2.3	4.23
	D6	12.9	0.020	0.17	88	34	2.1	3.09
	E1	9.9	0.015	0.18	96	34	2.2	19.1
	E2	10.5	0.016	0.13	96	39	2.3	19.1
	E3	12.9	0.020	0.11	96	51	2.9	19.1
	E4	12.5	0.020	0.11	80	25	1.4	4.28
	E5	8.2	0.013	0.12	96	31	1.8	19.1
	E6	11.9	0.019	0.04	80	29	1.3	12.11
Inflow @ Pond DE		**143.8**	**0.225**			**357**	**37**	
Outflow @ Pond DE						**32**	**19**	**9.05**

III.B.3.0 Post-Development Conditions

Post-development condition grading for the GEP Landfill is provided in Drawings III.B.3 and III.B.4 in **Attachment III.B.3**. Side slopes are graded at a 4H:1V and the cap is graded at a five percent slope. Sheet flow on the side slopes is cut off by "side slope interceptors" immediately above and roughly parallel to each 20-foot-wide bench constructed Phase 1 and every 100 horizontal feet for the vertical expansion of Phase 1 and for Phase 2. These interceptors reduce the erosion potential of sheet flows down the side slopes by minimizing the length of sheet flow and diverting it to armored down chutes. High points are located at the center of the north and south sections as indicated in the drawings in **Attachment III.B.3**.

III.B.3.1 Post-Development Conditions Modeling

Twenty-four sub-areas make up the post-development conditions drainage area as shown on Drawing III.B.4 in **Attachment III.B.3**. Sub-area D2, shown in the pre-development drainage map and calculations, is now included in sub-area E2 of the post-development conditions. Proposed grading and drainage controls are included in Drawings III.B.5 and III.B.6 in **Attachment III.B.3**. Post-development conditions T_c and T_{lag} were calculated using the TR-55 method, see **Table III.B.3-1**. Peak flows were calculated for sub-areas and the discharge point. The output from the HEC-HMS model is included in **Attachment III.B.1**. Post-development Conditions flows calculated by HEC-HMS are in **Table III.B.3-2**.

III.B.3.1.1 Post-Development Precipitation

Rainfall data was obtained from the NOAA Atlas 14, Volume 11 (version 2) precipitation frequency tables for the project location. A 25-year recurrence interval and 24-hour duration event were selected for a cumulative depth of 3.37-inches at the time of the permit. **Table III.B.3-1** contains the values that were used in the HEC-HMS model for 24-hour rainfall depths for pre-development conditions under the previous permit.

Table III.B.3-1: Post-Development: T_c and T_{lag} Calculations

Duration	Return Period (Years)	
	25	100
5 min	0.65	0.883
10 min	1.08	1.46
15 min	1.26	1.72
30 min	1.60	2.17
60 min	1.94	2.61
2 hr	2.23	3.02
3 hr	2.40	3.25
6 hr	2.70	3.67
12 hr	3.01	4.15
24 hr	3.37	4.7

Rainfall intensity for the rational method calculations was calculated based on the TxDOT Bridge Division Hydraulic Manual. Rainfall intensity (in/hr) was computed as follows:

$$I = \frac{b}{(t+d)^e} = 6.12$$

b = TxDOT factor for 25 year event in El Paso County = 80.75
d = TxDOT factor for 25 year event in El Paso County = 7.36
e = TxDOT factor for 25 year event in El Paso County = 0.904
t = longest time of concentration for basin being considered; minimum of 10 minutes per 30 TAC §330.305(f)(1)

III.B.3.1.2 Post-Development T_c and T_{lag}

Post-Development T_c and T_{lag} were developed from USGS topographic maps and the previous permit plans shown in Drawings III.B.1 and III.B.2 in **Attachment III.B.3**. The methods presented in TR-55 were used to calculate T_c. The T_{lag} for each subbasin was calculated using the following equation:

$T_{lag} = T_c$ x 0.6 (Haan, 1994)

Attachment III.B.1 contains calculations for T_c and T_{lag}.

III.B.3.1.3 Post-Development Conditions HEC-HMS Model

The output from the HEC-HMS model is included in **Attachment III.B.1.** Post-development condition flows calculated by HEC-HMS are summarized in **Table III.B.3-2.**

Table III.B.3-2: Post-Development Conditions: SCS Parameters in HEC-HMS

Discharge	Subbasin	Area (acres)	Area (sq. mi.)	T_{lag} (hr.)	CN	Peak Discharge (cfs)	Peak Runoff (ac-ft)	Peak Velocity (fps)
	A1	5	0.01	0.12	63	4.7	0.25	1.61
@A		**5**	**0.01**			**4.7**	**0.25**	**1.61**
	B1	17	0.03	0.09	96	102.8	4.3	2.47
	B2	18	0.03	0.1	96	103.0	4.4	2.47
	B3	19	0.03	0.11	96	109.0	4.3	2.47
	B4	13	0.02	0.09	96	92.0	3.7	2.4
	B5	10	0.02	0.14	96	50.3	2.4	2.4
	B6	7	0.01	0.09	96	43.7	1.8	2.4
	B7	19	0.03	0.56	73	16.9	1.9	4.46
	B8	18	0.03	0.23	76	57.9	1.8	4.46
	Cos	151	0.24	0.78	63	42.3	7.4	1.14
	C1	19	0.03	0.1	96	108.7	4.5	2.47
	C2	11	0.02	0.08	96	65.2	2.6	2.4
	C3	10	0.02	0.36	96	16.5	2.5	4.46

Inflow @ Pond BC		**315**	**0.50**			**474.75**	**41.6**	
Outflow @ Pond BC						**45.4**	**26.2**	**25.70**
	D1	10	0.02	0.07	96	62.7	2.4	2.47
	D2	-	-	-	-	-	-	-
	D3	13	0.02	0.12	96	66.9	3.0	19.1
	D4	8	0.01	0.12	96	40.7	1.9	19.1
	D5	25	0.04	0.14	76	56.8	2.6	4.27
	D6	12	0.02	0.17	88	46.3	2.3	3.08
	E1	10	0.02	0.08	96	62.1	2.4	2.47
	E2	11	0.02	0.10	96	59.4	2.6	2.47
	E3	13	0.02	0.11	96	70.8	3.1	19.1
	E4	13	0.02	0.11	80	38.5	1.6	4.27
	E5	8	0.01	0.12	96	43.3	2.0	19.1
	E6	12	0.02	0.04	80	49.1	1.5	12.06
Inflow @ Pond DE		**143**	**0.22**			**383.35**	**25.2**	
Outflow @ Pond DE						**18.4**	**17.0**	**5.21**

III.B.3.2 Post-Development Conditions Drainage Controls

Drainage controls are incorporated into the site in order to reduce flooding and minimize the amount of sediment carried off the site. Drainage controls include berms, interceptor ditches, down chutes, culverts, channels, and detention ponds. Drainage controls are shown in Drawing III. B.3 in **Attachment III.B.3**, with details in Drawings III. B.5 and III.B.6 in **Attachment III.B.3**.

III.B.3.2.1 Runoff from Landfill Slopes

Sheet flows from the landfill cap will be intercepted by stormwater berms designed to channelize flows into stabilized down chutes to minimize erosion of the cap and side slopes. Flows from the down chutes enter the perimeter ditches. Sheet flows from the lowest portions of the 4H:1V side slopes collect in perimeter ditches before being routed to the detention ponds.

In accordance with 30 TAC §330.305(f)(2), calculations for peak runoff (Q) for a 25-year, 24-hour storm event were completed in HEC-HMS and can be found in **Attachment III.B.1**. The TxDOT Drainage Manual and NRCS method was used to calculate the time of concentrations and velocities for the sub-areas. The velocities for the final cover are reflected in **Attachment III.B.1.** Phase 1 sideslope interceptors below the cap were previously sized in accordance with 30 TAC §330.305(f)(1), as a part of the previous permit.

Calculations based on TxDOT Bridge Division Hydraulic Manual and provided in **Attachment III.B.1**, were computed as follows:

$$Q = cIA$$

Where: Q = Peak runoff from 25-year, 24-hour storm event, cubic feet per second (cfs)

C = Runoff coefficient, dimensionless
I = Rainfall intensity, in/hr (calculated above)
A = Area of sub-basin, acres

III.B.3.2.1.1 Top Berms

Top berms for phase 1 and phase 2 are designed in accordance with 30 TAC §330.305(f)(1). All berms are sized based on the largest calculated flow for a cap sub-area during a 24-hour, 25-year storm. Using the Rational Method for the largest runoff area contributing to a top berm, E2, the peak runoff is 18.9 cfs. Solving Manning's Equation yields a flow depth of 0.97-feet. Therefore, berms with a height of 2-feet will have a minimum 1.03-feet freeboard for the 24-hour, 25-year storm. A cross-sectional view and calculations are provided in **Attachment III.B.1.**

III.B.3.2.1.2 Sideslope Interceptors

For a 2:1 berm built on 4:1 sideslopes, Manning's equation is used to determine flow depth. The highest flow contributing to an interceptor is considered for calculating flow depth and available freeboard.

During Phase 1, under the previous permit, the maximum flow of 9.5 cfs results in a flow depth of 1.23 feet. The interceptor berms are designed to a depth of 2 feet, providing 0.77 feet of freeboard during a 24-hour, 25-year storm event.

For Phase 2, the expected flow is 13.1 cfs, yielding a flow depth of 1.39 feet during the 25-year design storm. A 2-foot interceptor berm will maintain a minimum freeboard of 0.61 feet.

III.B.3.2.1.3 Down Chutes/Let Down Structures

Down chutes (or let down structures) convey flows from the cap of the landfill or from the terrace/interceptors down the 4H:1V slopes and discharge into perimeter ditches. All down chutes will be lined with Flexamat Plus or equivalent and include a 3-foot by 3-foot gabion revetment and/or a water energy dissipator at the bottom. A plan view of a typical down chute is provided in Drawing III.B.3 in **Attachment III.B.3.** The typical section is provided in Drawings III.B.5 and III.B.6 in **Attachment III.B.3**. Down chute hydraulic calculations are included in **Attachment III.B.1**.

III.B.3.2.2 Perimeter Ditches

Perimeter ditches collect stormwater runoff from landfill slopes and buffer areas and discharge to the detention ponds. Ditches are trapezoidal with an 8-foot bottom and 3H:1V side slopes. Ditches will be lined with concrete stabilized rock riprap, gabion mattresses, concrete, or other suitable erosion control material. Table III.B.2.4-1 in **Attachment III.B.2** provides a summary of these ditches and Drawing III.B.5 in **Attachment III.B.3** provides a typical perimeter ditch section.

Supporting Manning's Equation calculations for interceptors, top berms, down chutes, and perimeter ditches, performed using Haestead Methods Flowmaster program, as well as Rational Method and HEC-HMS results, are included in **Attachment III.B.1**.

A culvert will be required to provide access across the perimeter ditches for this expansion. Culverts are shown on Drawing III.B.4 in **Attachment III.B.3**. Culvert C2 is the only culvert that has not yet been installed. Culvert C2 was sized using the HEC-HMS and HY-8 computer programs and calculations are provided in **Attachment III.B.1**.

III.B.3.2.3 Detention Ponds

Each phase of the facility will utilize a detention pond to control storm water runoff. Pond BC is located in the southern portion of the site and captures the runoff for Phase 2. Pond DE performs the same function for the northern phase; however, Pond DE is located west of the site on property owned by the City of El Paso within the permit limits of the Clint Landfill (MSW Permit No. 1482). Plan views for Ponds BC and DE are provided in Drawings III.B.11 and III.B.12 in **Attachment III.B.3**, respectively. Outfalls and Sections for Ponds BC and DE are provided on Drawings III.B.13 and III.B.14 in **Attachment III.B.3**. The purpose of the detention ponds is to attenuate post-development peak discharges at points BC and DE so as not to alter natural drainage patterns. Storage of runoff in the pond reduces peak discharge from ditches.

Pond DE has been designed to be drained by two 18-inch reinforced concrete pipe (RCP) riser barrel low-level outlets. The entrance to the low-level outlets are a minimum of 3-feet above the pond sump elevations to provide sediment storage. A concrete overflow spillway is designed to convey any overflow encountered during exceptional storm events. The pond is sized to convey the 25-year frequency storm without overtopping the spillways. Storm routing through the pond is incorporated in the HEC-HMS post-development conditions run. Stage-storage calculations for pond DE is provided in **Attachment III.B.1**.

Pond BC is designed to be drained by an 18-inch RCP riser barrel low level outlet and a concrete overflow spillway. The entrance of the low level outlet is a minimum of 3-feet above the pond sump elevation to provide sediment storage. Pond BC will be expanded upon as a part of the Phase II development. Final conditions storm routing through pond BC is incorporated in the HEC-HMS post-development conditions run included in **Attachment III.B.1**.

III.B.3.3 Sequence of Development for Drainage Appurtenances

Pond DE and the outlets to the existing landfill ditches have been constructed and will remain in place prior to beginning the vertical expansion for Phase 1. For Pond BC, the perimeter ditches adjacent to Cell 11 and 12 have been constructed along with Culverts B1 and C1. When filling operations allow, construction of interceptor ditches and down chutes can begin. Generally, top berms, down chutes, and interceptor ditches will be constructed as soon as practicable after final grades are attained.

III.B.3.4 Maintenance of Drainage Appurtenances

The landfill manager is responsible for maintaining drainage appurtenances. Refer to Table III.B.2.3-5, Structural Control Inspection Parameters in **Attachment III.B.2**, and the Site Operating Plan in Part IV, Table IV.3-3 for inspection and maintenance requirements.

III.B.3.5 Contaminated Water

The handling, storage, treatment, and disposal of contaminated surface or groundwater shall be in accordance with 30 TAC §330.207. Rainfall that shall come in contact and percolate through the working face of the waste unit shall be considered leachate, which is discussed in Appendix III.C ‑ Leachate and Contaminated Water Plan, Section III.C.3.0.

The working face shall be maintained to prevent run on flow and to prevent runoff from leaving the landfill boundary after contacting exposed waste. Furthermore, the working face shall be enclosed within a soil diversion berm and will typically have minimal slopes, as to limit runoff and provide means for rainfall to percolate through the waste. Calculations are provided in **Attachment III.B.1** in the contaminated water containment and diversion berm calculations**.**

The leachate management system shall convey leachate collected from the bottom of each cell to evaporation ponds within the Facility. Drawings III.C.1, 5, and 7 in Attachment III.C.1 provide information on the force main layout and evaporation ponds. Additional discussion is also provided in Appendix III.C - Leachate and Contaminated Water Plan. All leachate transferred to offsite facilities will be handled in compliance with TCEQ requirements in accordance with 30 TAC §330.207(e).

III.B.4.0 Comparison of Pre- and Post-Development Drainage Patterns

Final drainage patterns will not be significantly altered by construction of the landfill. Like existing conditions, stormwater runoff from the site leaves the site at points in the same location, and from direct runoff areas adjacent to the site. Updates to NOAA Atlas 14 design storm depths may enhance the apparent impact of pre- versus post-development conditions. All calculations for the outfalls are included in **Attachment III.B.1. Table III.B.4-1**Error! Reference source not found. provides a summary of the pre- and post-development conditions comparison.

Table III.B.4-1: Pre- vs. Post-Development Conditions Comparison

	Outfall	Discharge	Volume	Velocity
Pre-	A	3	0.202	1.61
	BC	48	34.5	27.32
	DE	32	19	9.05
Post-	A	4.7	0.249	1.61
	BC	45	32.7	45.25
	DE	18	25.2	9.9

III.B.4.1 Point A

Runoff from the far southeastern corner of the site exits at Point A. Development has minimal to no impact on the drainage area and does not significantly alter flow patterns. Alterations are mostly due to the change in design rainfall intensity and depths. The peak discharge for Outfall A increases from 3 cfs pre-development to 4.7 cfs post-development. The post-development runoff volume rises from 0.202 acre-foot to 0.249 acre-foot. Discharge velocity remains relatively unchanged at 1.61 fps, as overland flow characteristics are largely governed by surface conditions rather than direct precipitation inputs in the NRCS method.

III.B.4.2 Point BC

Runoff from the southern half of the tract leaves the site at point BC. The 25-year flow at discharge point BC for pre-development conditions is 48 cfs. The 25-year flows combined at discharge point BC for the post-development conditions is 45 cfs. The geometry of the drainageway, surfacing conditions, and flow-line slope remain unchanged between pre- and post-development conditions. The outlet for basin BC remains the same from pre- to post-development. The velocity through the outlet is reduced from 27 fps to 26 fps and outfall BC has a lower runoff volume in total. Overall, point BC will not be adversely impacted due to development.

III.B.4.3 Point DE

Similar to pre-development conditions, runoff from the detention ponds exits into two pre-existing drainage ditches associated with the adjacent landfill. The combined pre-development flow leaving Pond DE is 32 cfs, with 16 cfs per outlet. Velocity and volume are also reduced in post-development conditions.

ATTACHMENT III.B.1 – DRAINAGE STRUCTURES – DESIGN CALCULATIONS

TIME OF CONCENTRATION CALCULATIONS

El Paso Co. New Landfill
Drainage Calculations
Pre-Developed Conditions TOC

By:______ Date:______
Checked:______ Date:______

Sheet Flow (T_c only)		ID	A1	~~B1~~	~~B2~~	~~B3~~	~~B4~~	~~B5~~	~~B6~~	~~B7~~
Surface description			rock riprap	~~rock riprap~~	~~rock riprap~~	~~rock riprap~~	~~rock riprap~~	~~rock riprap~~	~~rock riprap~~	~~rock riprap~~
Manning's roughness coefficient, n			0.02	~~0.02~~	~~0.02~~	~~0.02~~	~~0.02~~	~~0.02~~	~~0.02~~	~~0.02~~
Flow length, L		ft	300	~~300~~	~~300~~	~~300~~	~~300~~	~~300~~	~~250~~	~~300~~
Two-yr 24-hr rainfall, P		in	1.5	~~1.5~~	~~1.5~~	~~1.5~~	~~1.5~~	~~1.5~~	~~1.5~~	~~1.5~~
Land slope, s		ft / ft	0.06	~~0.02~~	~~0.02~~	~~0.02~~	~~0.25~~	~~0.25~~	~~0.25~~	~~0.02~~
Travel time, $T_t = 0.007\ (nL)^{0.8} / P^{0.5} s^{0.4}$	Compute T_t	hr	0.07	~~0.11~~	~~0.11~~	~~0.11~~	~~0.04~~	~~0.04~~	~~0.04~~	~~0.11~~

Shallow concentrated flow		ID	A1	~~B1~~	~~B2~~	~~B3~~	~~B4~~	~~B5~~	~~B6~~	~~B7~~
Surface description (paved or unpaved)			unpaved	~~unpaved~~	~~unpaved~~	~~unpaved~~	~~unpaved~~	~~unpaved~~	~~unpaved~~	~~unpaved~~
Flow length, L		ft	700	~~1100~~	~~1200~~	~~1250~~	~~1000~~	~~1100~~	~~1100~~	~~500~~
Watercourse slope, s		ft / ft	0.01	~~0.01~~	~~0.01~~	~~0.01~~	~~0.01~~	~~0.01~~	~~0.01~~	~~0.005~~
Average velocity, V		ft / s	1.61	~~1.61~~	~~1.61~~	~~1.61~~	~~1.61~~	~~1.61~~	~~1.61~~	~~1.14~~
Travel time, $T_t = L / 3600\ V$	Compute T_t	hr	0.12	~~0.19~~	~~0.21~~	~~0.22~~	~~0.17~~	~~0.19~~	~~0.19~~	~~0.12~~

Channel flow		ID	A1	B1	B2	B3	B4	B5	B6	B7
Cross sectional flow area, a		ft^2		~~8.5~~	~~8.5~~	~~8.5~~				~~39~~
Wetted perimeter, p_w		ft		~~10~~	~~10~~	~~10~~				~~23~~
Hydraulic radius, $r = a/p_w$		ft		~~0.850~~	~~0.850~~	~~0.850~~				~~1.696~~
Channel slope, s		ft / ft		~~0.25~~	~~0.25~~	~~0.25~~				~~0.006~~
Manning's roughness coefficient, n				~~0.035~~	~~0.035~~	~~0.035~~				~~0.035~~
$V = 1.49\ r^{2/3} s^{1/2} / n$	Compute V	ft / s		~~19.10~~	~~19.10~~	~~19.10~~				~~4.69~~
Flow length, L		ft		~~750~~	~~550~~	~~370~~				~~2900~~
Travel time, $T_t = L / 3600\ V$	Compute T_t	hr		~~0.01~~	~~0.01~~	~~0.01~~				~~0.17~~
Watershed or subarea T_c or T_t	Total	hr	0.19	~~0.31~~	~~0.33~~	~~0.34~~	~~0.21~~	~~0.23~~	~~0.23~~	~~0.41~~
Lag time T_L, $= 0.6T_c$		hr	0.12	~~0.19~~	~~0.20~~	~~0.20~~	~~0.13~~	~~0.14~~	~~0.14~~	~~0.24~~

Time of concetration or Travel time   Page 1

5/25/22
10/6/21
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Sheet Flow (T_c only)			~~B8~~	~~C1~~	~~C2~~	~~C3~~	D1	D2	D3	D4
Surface description		ID	~~rock riprap~~	~~rock riprap~~	~~rock riprap~~	~~rock riprap~~	rock riprap	rock riprap	rock riprap	rock riprap
Manning's roughness coefficient, n			~~0.02~~	~~0.02~~	~~0.02~~	~~0.02~~	0.02	0.02	0.02	0.02
Flow length, L		ft	~~100~~	~~300~~	~~250~~	~~100~~	300	300	220	220
Two-yr 24-hr rainfall, P		in	~~1.5~~	~~1.5~~	~~1.5~~	~~1.5~~	1.5	1.5	1.5	1.5
Land slope, s		ft / ft	~~0.1~~	~~0.02~~	~~0.25~~	~~0.1~~	0.02	0.02	0.25	0.25
Travel time, $T_t = 0.007\ (nL)^{0.8} / P^{0.5}s^{0.4}$	Compute T_t	hr	~~0.02~~	~~0.11~~	~~0.04~~	~~0.02~~	0.11	0.11	0.03	0.03

Shallow concentrated flow		ID	~~B8~~	~~C1~~	~~C2~~	~~C3~~	D1	D2	D3	D4
Surface description (paved or unpaved)			~~unpaved~~	~~unpaved~~	~~unpaved~~	~~unpaved~~	unpaved	unpaved	unpaved	unpaved
Flow length, L		ft		~~1000~~	~~1100~~	~~4300~~	1000	1350	950	1000
Watercourse slope, s		ft / ft		~~0.01~~	~~0.01~~	~~0.005~~	0.01	0.01	0.01	0.01
Average velocity, V		ft / s		~~1.61~~	~~1.61~~	~~1.14~~	1.61	1.61	1.61	1.61
Travel time, $T_t = L / 3600\ V$	Compute T_t	hr		~~0.17~~	~~0.19~~	~~1.05~~	0.17	0.23	0.16	0.17

Channel flow		ID	~~B8~~	~~C1~~	~~C2~~	~~C3~~	D1	D2	D3	D4
Cross sectional flow area, a		ft^2	~~39~~	~~8.5~~		~~39~~	8.5	8.5	8.5	8.5
Wetted perimeter, p_w		ft	~~23~~	~~10~~		~~23~~	10	10	10	10
Hydraulic radius, $r = a/p_w$		ft	~~1.696~~	~~0.850~~		~~1.696~~	0.850	0.850	0.850	0.850
Channel slope, s		ft / ft	~~0.03~~	~~0.25~~		~~0.005~~	0.25	0.25	0.25	0.25
Manning's roughness coefficient, n			~~0.035~~	~~0.035~~		~~0.035~~	0.035	0.035	0.035	0.035
$V=1.49\ r^{2/3}\ s^{1/2} / n$	Compute V	ft / s	~~10.49~~	~~19.10~~		~~4.28~~	19.10	19.10	19.10	19.10
Flow length, L		ft	~~1600~~	~~500~~		~~4300~~	650	420	300	200
Travel time, $T_t = L / 3600\ V$	Compute T_t	hr	~~0.04~~	~~0.01~~		~~0.28~~	0.01	0.01	0.00	0.00

Watershed or subarea T_c or T_t	Total	hr	~~0.07~~	~~0.29~~	~~0.23~~	~~1.35~~	0.30	0.35	0.20	0.21
Lag time $T_L = 0.6T_c$		hr	~~0.04~~	~~0.18~~	~~0.14~~	~~0.81~~	0.18	0.21	0.12	0.12

Sheet Flow (T_c only)			D5	D6	E1	E2	E3	E4	E5	E6
		ID	D5	D6	E1	E2	E3	E4	E5	E6
Surface description			rock riprap	rock riprap	rock riprap	rock riprap	rock riprap	rock riprap	rock riprap	rock riprap
Manning's roughness coefficient, n			0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Flow length, L		ft	300	100	300	300	300	200	220	130
Two-yr 24-hr rainfall, P		in	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Land slope, s		ft / ft	0.01	0.1	0.02	0.25	0.25	0.25	0.25	0.04
Travel time, $T_t = 0.007\ (nL)^{0.8} / P^{0.5} s^{0.4}$	Compute T_t	hr	0.15	0.02	0.11	0.04	0.04	0.03	0.03	0.04

Shallow concentrated flow		ID	D5	D6	E1	E2	E3	E4	E5	E6
Surface description (paved or unpaved)			unpaved	unpaved	unpaved	unpaved	unpaved	unpaved	unpaved	unpaved
Flow length, L		ft			1000	1000	850		1000	
Watercourse slope, s		ft / ft			0.01	0.01	0.01		0.01	
Average velocity, V		ft / s			1.61	1.61	1.61		1.61	
Travel time, $T_t = L / 3600\ V$	Compute T_t	hr			0.17	0.17	0.15		0.17	

Channel flow		ID	D5	D6	E1	E2	E3	E4	E5	E6
Cross sectional flow area, a		ft^2	39	39	8.5	8.5	8.5	39	8.5	39
Wetted perimeter, p_w		ft	23	23	10	10	10	23	10	23
Hydraulic radius, $r = a/p_w$		ft	1.696	1.696	0.850	0.850	0.850	1.696	0.850	1.696
Channel slope, s		ft / ft	0.005	0.0026	0.25	0.25	0.25	0.005	0.25	0.04
Manning's roughness coefficient, n			0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035
$V = 1.49\ r^{2/3}\ s^{1/2} / n$	Compute V	ft / s	4.28	3.09	19.10	19.10	19.10	4.28	19.10	12.11
Flow length, L		ft	1200	2800	600	500	50	2400	200	1100
Travel time, $T_t = L / 3600\ V$	Compute T_t	hr	0.08	0.25	0.01	0.01	0.00	0.16	0.00	0.03

Watershed or subarea T_c or T_t	Total	hr	**0.23**	**0.28**	**0.30**	**0.22**	**0.19**	**0.19**	**0.21**	**0.07**
Lag time T_L, $= 0.6T_c$		hr	0.14	0.17	0.18	0.13	0.11	0.11	0.12	0.04

Time of concetration or Travel time

By:______ Date:______
Checked:______ Date:______

Sheet Flow (T_C only)		ID	Cos
Surface description			dense grass
Manning's roughness coefficient, n			0.24
Flow length, L		ft	300
Two-yr 24-hr rainfall, P		in	1.5
Land slope, s		ft / ft	0.1
Travel time, $T_t = 0.007\ (nL)^{0.8} / P^{0.5} s^{0.4}$	Compute T_t	hr	0.44
Shallow concentrated flow		ID	Cos
Surface description (paved or unpaved)			unpaved
Flow length, L		ft	3600
Watercourse slope, s		ft / ft	0.005
Average velocity, V		ft / s	1.14
Travel time, $T_t = L / 3600\ V$	Compute T_t	hr	0.88
Channel flow		ID	Cos
Cross sectional flow area, a		ft^2	
Wetted perimeter, p_w		ft	
Hydraulic radius, $r = a/p_w$		ft	
Channel slope, s		ft / ft	
Manning's roughness coefficient, n			
$V = 1.49\ r^{2/3}\ s^{1/2} / n$	Compute V	ft / s	
Flow length, L		ft	
Travel time, $T_t = L / 3600\ V$	Compute T_t	hr	
Watershed or subarea T_c or T_t	Total	hr	**1.32**
Lag time T_L, $= 0.6T_c$		hr	0.79

STATE OF TEXAS
MICHAEL K. STACEY
65460
REGISTERED PROFESSIONAL
Michael K. Stacey
11/29/99

for 5 page
DRAINAGE CALCULATIONS

Time of concetration or Travel time

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Pre-Developed Conditions

Sheet Flow	Basin ID/Unit	B1	B2	B3	B4	B5	B6	B7	B8	C1	C2	C3	Notes
Surface Description		Rock Riprap	Rock Riprap	Rock Riprap	Rock Riprap	Rock Riprap	Rock Riprap	Range - Natural	Range - Natural	Rock Riprap	Rock Riprap	Range - Natural	(1)Precipitation values obtained from NOAA Atlas 14, Volume 11, Version 2. Location Info: Latitude: 31.6019 deg, Longitude: -106.1867
Manning's Roughness Coefficient, n	N/A	0.02	0.02	0.02	0.02	0.02	0.02	0.13	0.13	0.02	0.02	0.13	(2)Slopes for Basins B7, B8, and C3 assumed to be 1%. No topography available
Flow Length, L	ft	300	300	300	100	100	100	300	105	300	100	130	
(1)2-yr 24-hr Rainfall, P	in	1.48	1.48	1.48	1.48	1.48	1.48	1.48	1.48	1.48	1.48	1.48	
(2)Slope, s	ft/ft	0.03	0.03	0.03	0.25	0.25	0.25	0.01	0.01	0.03	0.25	0.01	
Travel Time, T_t	hr	0.10	0.10	0.10	0.02	0.02	0.02	0.68	0.29	0.10	0.02	0.35	

$$T_t = \frac{0.007(nL)^{0.8}}{P^{0.5}s^{0.4}}$$

Shallow Concentrated Flow	Basin ID/Unit	B1	B2	B3	B4	B5	B6	B7	B8	C1	C2	C3	Notes
Surface Description	N/A	unpaved	unpaved	unpaved				unpaved		unpaved			
Flow Length, L	ft	785	680	675				675		675			
Watercourse Slope, s	ft/ft	0.03	0.03	0.03				0.01		0.03			
(1)Average Velocity, V, where $V=16.135s^{0.5}$	ft/s	2.79	2.79	2.79				1.61		2.79			(1)Source: TDOT Hydraulic Design Manual Chapter 4, Section 11 - Time of Concentration
Travel Time, T_t	hr	0.08	0.07	0.07				0.12		0.07			

$$T_t = \frac{L}{3600Ks^{0.5}}$$

Channelized Flow	Basin ID/Unit	(1)B1	(1)B2	(1)B3	(2)B4	(2)B5	(2)B6	(3)B7	(3)B8	(1)C1	(2)C2	(3)C3	Notes
Cross-Sectional Area, A	ft^2	36.00	36.00	36.00	6.75	6.75	6.75	18.75	18.75	36.00	6.75	18.75	(1)Triangular channel with 30:1 and 2:1 (H:V) side slopes and a flow depth of 1.5 ft
Wetted Permiter, P_w	ft^2	53.38	53.38	53.38	9.54	9.54	9.54	17.50	17.50	53.38	9.54	17.50	(2)Triangular channel with 4:1 and 2:1 (H:V) side slopes and a flow depth of 1.5 ft
Hydraulic Radius, R, where $R=A/P_w$	ft^2	0.67	0.67	0.67	0.71	0.71	0.71	1.07	1.07	0.67	0.71	1.07	(3)Trapezoidal channel (perimeter ditch) with 3:1 side slopes, 8-ft bottom width and a flow depth of 1.5 ft
(4)Channel Slope, s	ft/ft	0.005	0.005	0.005	0.005	0.005	0.005	0.01	0.01	0.005	0.005	0.01	(4)Slopes for Basins B7, B8, and C3 assumed to be 1%. No topography available
Manning's Roughness Coefficient, n	N/A	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	
Velocity, V, where $V= 1.49R^{2/3}s^{1/2}/n$	ft/s	2.31	2.31	2.31	2.39	2.39	2.39	4.46	4.46	2.31	2.39	4.46	
Flow Length, L	ft	745	810	860	910	980	855	2470	1600	860	880	4100	
Travel Time, T_t	hr	0.09	0.10	0.10	0.11	0.11	0.10	0.15	0.10	0.10	0.10	0.26	

$$T_t = \frac{L}{3600V}$$

Basin Time of Concentration, T_c	hr	0.27	0.26	0.27	0.12	0.13	0.12	0.95	0.39	0.27	0.12	0.60
Lag Time, T_L, where $T_L=0.6T_c$	hr	0.16	0.16	0.16	0.07	0.08	0.07	0.57	0.24	0.16	0.07	0.36
	min	9.56	9.47	9.67	4.44	4.73	4.21	34.22	14.17	9.67	4.31	21.74

Proposed T_c

Sheet Flow (T_c only)		ID	A1	B1	B2	B3	B4	B5	B6	B7	B8	C1	C2	C3
Surface description			rock riprap	rock riprap	rock riprap	rock riprap	rock riprap	rock riprap	rock riprap	Range - Natural	Range - Natural	rock riprap	rock riprap	Range - Natural
Manning's roughness coefficient, n			0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.13	0.13	0.02	0.02	0.13
Flow length, L		ft	300	300	300	300	100	100	100	300	105	300	100	130
Two-yr 24-hr rainfall, P		in	1.58	1.58	1.58	1.58	1.58	1.58	1.58	1.58	1.58	1.58	1.58	1.58
Land slope, s		ft/ft	0.06	0.05	0.05	0.05	0.25	0.25	0.25	0.01	0.01	0.05	0.25	0.01
Travel time, T_t	Compute Tt	hr	0.07	0.08	0.08	0.08	0.02	0.02	0.02	0.66	0.28	0.08	0.02	0.34

Shallow concentrated flow		ID	A1	B1	B2	B3	B4	B5	B6	B7	B8	C1	C2	C3
Surface description (paved or unpaved)			unpaved	unpaved	unpaved	unpaved				unpaved		unpaved		
Flow length, L		ft	700	300	249	309				675		300		
Watercourse slope, s		ft/ft	0.01	0.05	0.05	0.05				0.01		0.05		
Average velocity, V		ft/s	1.61	3.61	3.61	3.61				1.61		3.61		
Travel time, T_t	Compute Tt	hr	0.12	0.02	0.02	0.02				0.12		0.02		

Channel flow		ID	A1	B1[1]	B2[1]	B3[1]	B4[2]	B5[2]	B6[2]	B7[3]	B8[3]	C1[1]	C2[2]	C3[3]
Cross sectional flow area, a		ft^2		24.8	24.8	24.8	6.75	6.75	6.75	18.75	18.75	24.8	6.75	18.75
Wetted perimeter, pw		ft		33.4	33.4	33.4	9.5	9.5	9.5	17.5	17.5	33.4	9.5	17.5
Hydraulic radius, r=a/pw		ft		0.74	0.74	0.74	0.71	0.71	0.71	1.07	1.07	0.74	0.71	1.07
Channel slope, s		ft/ft		0.005	0.005	0.005	0.005	0.005	0.005	0.01	0.01	0.005	0.005	0.01
Manning's roughness coefficient, n				0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035
Velocity	Compute V	ft/s		2.47	2.47	2.47	2.40	2.40	2.40	4.46	4.46	2.47	2.40	4.46
Flow length, L		ft		505	677	660	1118	1800	1205	2470	1600	520	1050	4100
Travel time, T_t	Compute Tt	hr		0.06	0.08	0.07	0.13	0.21	0.14	0.15	0.10	0.06	0.12	0.26

Watershed or subarea T_c or T_t	Total	hr	0.19	0.16	0.17	0.18	0.15	0.23	0.16	0.93	0.38	0.16	0.14	0.59

Lag time T_L		hr	0.12	0.09	0.10	0.11	0.09	0.14	0.09	0.56	0.23	0.10	0.08	0.36
		min	6.9	5.7	6.2	6.3	5.3	8.1	5.6	33.4	13.8	5.7	5.0	21.3

[1]Triangular channel with 20:1 and 2:1 (H:V) side slopes and a flow depth of 1.5 ft

[2]Triangular channel with 4:1 and 2:1 (H:V) side slopes and a flow depth of 1.5 ft

[3]Trapezoidal channel (perimeter ditch) with 3:1 side slopes, 8-ft bottom width and a flow depth of 1.5 ft

Proposed T_c

Sheet Flow (T_c only)		ID	D1	D3	D4	D5	D6	E1	E2	E3	E4	E5	E6	Cos
Surface description			rock riprap	rock riprap	rock riprap	rock riprap	rock riprap	rock riprap	rock riprap	rock riprap	rock riprap	rock riprap	rock riprap	dense grass
Manning's roughness coefficient, n			0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.24
Flow length, L		ft	258	220	220	300	100	250	250	300	200	220	130	300
Two-yr 24-hr rainfall, P		in	1.58	1.58	1.58	1.58	1.58	1.58	1.58	1.58	1.58	1.58	1.58	1.58
Land slope, s		ft/ft	0.05	0.25	0.25	0.01	0.1	0.05	0.05	0.25	0.25	0.25	0.04	0.1
Travel time, T_t	Compute Tt	hr	0.07	0.03	0.03	0.15	0.02	0.07	0.07	0.04	0.03	0.03	0.04	0.43

Shallow concentrated flow		ID	D1	D3	D4	D5	D6	E1	E2	E3	E4	E5	E6	Cos
Surface description (paved or unpaved)				unpaved	unpaved					unpaved		unpaved		unpaved
Flow length, L		ft		950	1000					850		1000		3600
Watercourse slope, s		ft/ft		0.01	0.01					0.01		0.01		0.005
Average velocity, V		ft/s		1.61	1.61					1.61		1.61		1.14
Travel time, T_t	Compute Tt	hr		0.16	0.17					0.15		0.17		0.88

Channel flow		ID	D1[1]	D3	D4	D5	D6	E1[1]	E2[1]	E3	E4	E5	E6	Cos
Cross sectional flow area, a		ft^2	24.8	8.5	8.5	39	39	24.8	24.8	8.5	39	8.5	39	
Wetted perimeter, pw		ft	33.4	10	10	23	23	33.4	33.4	10	23	10	23	
Hydraulic radius, r=a/pw		ft	0.74	0.85	0.85	1.70	1.70	0.74	0.74	0.85	1.70	0.85	1.70	
Channel slope, s		ft/ft	0.005	0.25	0.25	0.005	0.0026	0.005	0.005	0.25	0.005	0.25	0.04	
Manning's roughness coefficient, n			0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	
Velocity	Compute V	ft/s	2.47	19.12	19.12	4.27	3.08	2.47	2.47	19.12	4.27	19.12	12.06	
Flow length, L		ft	420	300	200	1200	2800	560	955	50	2400	200	1100	
Travel time, T_t	Compute Tt	hr	0.05	0.00	0.00	0.08	0.25	0.06	0.11	0.00	0.16	0.00	0.03	

Watershed or subarea T_c or T_t	Total	hr	0.12	0.20	0.21	0.23	0.28	0.13	0.17	0.19	0.19	0.21	0.07	1.30

Lag time T_L		hr	0.07	0.12	0.12	0.14	0.17	0.08	0.10	0.11	0.11	0.12	0.04	0.78
		min	4.17	7.2	7.4	8.1	9.9	4.68	6.28	6.8	6.7	7.4	2.5	47.0

[1]Triangular channel with 20:1 and 2:1 (H:V) side slopes and a flow depth of 1.5 ft

[2]Triangular channel with 4:1 and 2:1 (H:V) side slopes and a flow depth of 1.5 ft

[3]Trapezoidal channel (perimeter ditch) with 3:1 side slopes, 8-ft bottom width and a flow depth of 1.5 ft

HEC-1 Printouts

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1***************************************                    ***************************************
*                                      *                    *                                     *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)  *                    *   U.S. ARMY CORPS OF ENGINEERS      *
*           SEPTEMBER 1990             *                    *   HYDROLOGIC ENGINEERING CENTER     *
*             VERSION 4.0              *                    *        609 SECOND STREET            *
*                                      *                    *     DAVIS, CALIFORNIA 95616         *
* RUN DATE  04/07/1999  TIME  17:24:50 *                    *         (916) 756-1104              *
*                                      *                    *                                     *
****************************************                    ***************************************


                     X     X  XXXXXXX   XXXXX          X
                     X     X  X        X     X        XX
                     X     X  X        X               X
                     XXXXXXX  XXXX     X       XXXXX   X
                     X     X  X        X               X
                     X     X  X        X     X         X
                     X     X  XXXXXXX   XXXXX         XXX


THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL   LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM


1                                        HEC-1 INPUT                                        PAGE  1

 LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

               *DIAGRAM
   1           ID   ****************************************************************
   2           ID   *                                                              *
   3           ID   *          El Paso Clint Landfill  -  Developed Conditions     *
   4           ID   *                                                              *
   5           ID   * ............................................................*
   6           ID   * :                                                          : *
   7           ID   * :          STORM DURATION.............24 HOUR              : *
   8           ID   * :          RETURN PERIOD..............25 YEAR              : *
   9           ID   * :          FILENAME............ clintdev.DAT               : *
  10           ID   * :          DATE..................  APR, 1999               : *
  11           ID   * :          BY..................... DBP & MRD               : *
  12           ID   * :..........................................................: *
  13           ID   ****************************************************************
  14           ID     SOILS:
  15           ID     SOIL CLASSIFICATIONS FOR El Paso COUNTY BY THE SCS WERE
  16           ID     USED AND AREA WEIGHTED CURVE NUMBERS ASSIGNED TO SUBBASINS
  17           ID
  18           ID     RAINFALL DISTRIBUTION: FROM TP40, HYDRO35
  19           ID     HYPOTHETICAL STORM - PH CARD
  20           ID
  21           ID     VELOCITIES FROM (SCS MANUAL, FIGURE 15.2)
  22           ID   ****************************************************************
  23           ID   1 0  0.55 1.40 2.40 2.58 2.75 3.20 3.60 4.00 (100 YEAR)
  24           ID   4 0  0.44 1.08 1.87 2.01 2.15 2.50 2.81 3.12 (25 YEAR)
  25           ID
  26           ID
  27           ID   FOR ROUTING FLOWS IN PROPOSED DITCHES USE TRAPEZOIDAL
  28           ID   CHANNEL, 8' BOTTOM WIDTH, 2:1 BANK SLOPES
  29           ID   DITCH   N=0.035
```

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168       HC        5
          *
          * ********************************************************************
          *

169       KK   PONDBC
170       KM    LOW LEVEL OUTLET IS..........(1)18"RCP
171       KM    DOWNSTREAM FL LOW LEVEL OUTLET 3885.7 FT
172       KM    SPILLWAY OVERFLOW ELEVATION .. 3894.0 FT
173       KM    SPILLWAY WIDTH ................10.0 FT
174       KM    TOP OF DAM ELEVATION.......... 3896.50 FT
175       KM    FOR TAILWATER USE CONST ELEV.  3894.0 FT
176       RS        1    ELEV      -1
177       SV        0    4.59    9.34   14.24   19.31   24.53   29.92
178       SE     3890    3891    3892    3893    3894    3895    3896
179       SL   3886.7   0.785    0.70     0.5
180       SS     3894      10     3.0     1.5
181       ST     3896     300     3.0     1.5
          * ********************************************************************

182       KK   SUB.D2
183       KM    AREA........(AC)....10.3
184       KM    LAG TIME....(HR)... 0.21
185       KM    CN..................96
186       BA   0.0161
187       LS        0      96
188       UD     0.21
          *
          * ********************************************************************

189       KK   SUB.D4
190       KM    AREA........(AC)....7.7
191       KM    LAG TIME....(HR)... 0.12
192       KM    CN..................96
193       BA   0.0120
194       IN       15
195       LS        0      96
196       UD     0.12
          *
          * ********************************************************************

197       KK   PT.D24
198       KM    COMBINE FLOW FROM D2 AND D4
199       HC        2
          * ********************************************************************
1                                 HEC-1 INPUT                                           PAGE  6

LINE      ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

200       KK   THRUD2
201       KM    ROUTE RUNOFF THROUGH DITCH D2 TO COMBINATION PT D246
202       KM    TRAPEZOIDAL CHANNEL
203       RK     1300  0.0026   0.035       0    TRAP       8       5
          * ********************************************************************

204       KK   SUB.D6
205       KM    AREA........(AC)....12.9
206       KM    LAG TIME....(HR)... 0.17
207       KM    CN..................88
208       BA   0.0202
209       IN       15
210       LS        0      88
211       UD     0.17
          *
          * ********************************************************************

212       KK  PT.D246
213       KM    COMBINE FLOW FROM D2,D4,AND D6
214       HC        2
```

```
            * ******************************************************************

215         KK  SUB.D1
216         KM   AREA........(AC)....9.7
217         KM   LAG TIME....(HR)... 0.18
218         KM   CN..................96
219         BA  0.0152
220         IN      15
221         LS       0       96
222         UD    0.18
            *
            * ******************************************************************

223         KK  SUB.D3
224         KM   AREA........(AC)....12.5
225         KM   LAG TIME....(HR)....0.12
226         KM   CN..................96
227         BA  0.0195
228         IN      15
229         LS       0       96
230         UD    0.12
            *
            * ******************************************************************

231         KK  PT.D23
232         KM   COMBINE FLOW FROM D1,D3
233         HC       2
            * ******************************************************************
                                     HEC-1 INPUT                                              PAGE  7
1

LINE        ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

234         KK THRUD22
235         KM   ROUTE RUNOFF THROUGH DITCH D2 TO POND DE COMBINATION PT
236         KM   TRAPEZOIDAL CHANNEL
237         RK     400   0.019   0.035       0    TRAP       8       5
            * ******************************************************************

238         KK  SUB.D5
239         KM   AREA........(AC)....24.8
240         KM   LAG TIME....(HR)....0.14
241         KM   CN..................76
242         BA  0.0388
243         IN      15
244         LS       0       76
245         UD    0.14
            *
            * ******************************************************************

246         KK  SUB.E2
247         KM   AREA........(AC)....10.5
248         KM   LAG TIME....(HR)... 0.13
249         KM   CN..................96
250         BA  0.0164
251         IN      15
252         LS       0       96
253         UD    0.13
            *
            * ******************************************************************

254         KK  SUB.E5
255         KM   AREA........(AC)....8.2
256         KM   LAG TIME....(HR)... 0.12
257         KM   CN..................96
258         BA  0.0128
259         IN      15
260         LS       0       96
261         UD    0.12
            *
```

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          * ********************************************************************

 262      KK  PT.E25
 263      KM   COMBINE FLOW FROM E2 AND E5
 264      HC       2
          * ********************************************************************

 265      KK  THRUE1
 266      KM   ROUTE RUNOFF THROUGH DITCH E1 TO COMBINATION PTE1-5
 267      KM   TRAPEZOIDAL CHANNEL
 268      RK    2425    0.006   0.035       0     TRAP       8        5
          * ********************************************************************
1                                    HEC-1 INPUT                                        PAGE  8

LINE      ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 269      KK  SUB.E1
 270      KM   AREA........(AC)....9.9
 271      KM   LAG TIME....(HR)... 0.18
 272      KM   CN..................96
 273      BA  0.0155
 274      IN      15
 275      LS       0       96
 276      UD    0.18
          *
          * ********************************************************************

 277      KK  SUB.E3
 278      KM   AREA........(AC)....12.9
 279      KM   LAG TIME....(HR)... 0.11
 280      KM   CN..................96
 281      BA  0.0202
 282      IN      15
 283      LS       0       96
 284      UD    0.11
          *
          * ********************************************************************

 285      KK  SUB.E4
 286      KM   AREA........(AC)....12.5
 287      KM   LAG TIME....(HR)... 0.11
 288      KM   CN..................80
 289      BA  0.0195
 290      IN      15
 291      LS       0       80
 292      UD    0.11
          *
          * ********************************************************************

 293      KK PT.E1-5
 294      KM   COMBINE FLOW FROM AREAS E1-E5
 295      HC       4
          *
          * ********************************************************************

 296      KK  CULVE2
 297      KM   LOW LEVEL OUTLET IS..........(2)42"RCP
 298      KM   DOWNSTREAM FL LOW LEVEL OUTLET 3952.23 FT
 299      KM   SPILLWAY OVERFLOW ELEVATION .. 3958.0 FT
 300      KM   SPILLWAY WIDTH ...............40.0 FT
 301      KM   TOP OF DAM ELEVATION.......... 3958.0 FT
 302      KM   FOR TAILWATER USE CONST ELEV.  3955.2 FT
 303      RS       1     ELEV      -1
 304      SV       0     0.09     0.37     0.76     1.27     1.89     2.64
 305      SE  3952.5     3953     3954     3955     3956     3957     3958
 306      SL 3952.23    19.23     0.70      0.5
 307      SS  3957.5       40      3.0      1.5
 308      ST  3958.0       40      3.0      1.5
          * ********************************************************************
```

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 309          KK  THRUE2
 310          KM   ROUTE RUNOFF THROUGH DITCH E2 TO POND DE COMBINATION PT
 311          KM   TRAPEZOIDAL CHANNEL
 312          RK     570    0.05   0.035       0    TRAP       8       5
              * ******************************************************************

 313          KK  SUB.E6
 314          KM   AREA........(AC)....11.9
 315          KM   LAG TIME....(HR)... 0.04
 316          KM   CN..................80
 317          BA  0.0186
 318          IN       15
 319          LS        0      80
 320          UD    0.04
              *
              * ******************************************************************

 321          KK   PT.DE
 322          KM   COMBINE FLOW FROM AREAS D AND E
 323          HC        5
              *
              * ******************************************************************

 324          KK  PONDDE
 325          KM   LOW LEVEL OUTLET IS..........(2)18"RCP
 326          KM   DOWNSTREAM FL LOW LEVEL OUTLET 3921.2 FT
 327          KM   SPILLWAY OVERFLOW ELEVATION .. 3931.5 FT
 328          KM   SPILLWAY WIDTH ................10.0 FT
 329          KM   TOP OF DAM ELEVATION.......... 3933.5 FT
 330          KM   FOR TAILWATER USE CONST ELEV.  3928.0 FT
 331          RS        1     ELEV      -1
 332          SV        0     3.93    8.66   13.54   18.56   26.37   37.29
 333          SE 3926.33     3927    3928    3929    3930  3931.5  3933.5
 334          SL  3921.6    0.884    0.70     0.5
 335          SS 3931.33       10     3.0     1.5
 336          ST 3933.33      800     3.0     1.5
              * ******************************************************************

 337          KK  SUB.A1
 338          KM   AREA........(AC)....5.0
 339          KM   LAG TIME....(HR)... 0.12
 340          KM   CN..................63
 341          BA  0.0078
 342          IN       15
 343          LS        0      63
 344          UD    0.12
              *
              * ******************************************************************
 345          ZZ
```

1

SCHEMATIC DIAGRAM OF STREAM NETWORK

```
 INPUT
  LINE      (V) ROUTING          (--->) DIVERSION OR PUMP FLOW

  NO.       (.) CONNECTOR        (<---) RETURN OF DIVERTED OR PUMPED FLOW

  33    ~~SUB.CO5(~~
                .
  42            .      ~~SUB.B3~~
                .         .
  49            .         .       ~~SUB.B6~~
                .         .          .
                .         .          .
```

```
  57  PT.B36CO.....................
               V
               V
  60   THRUB1
               .
  64           .     SUB.B7
               .           .
  72           .           .     SUB.B2
               .           .           .
  80           .           .           .     SUB.B5
               .           .           .           .
  88  PT.B2356.................................
               V
               V
  91   THRUB2
               .
  95           .     SUB.B8
               .           .
 103  PT.B235...........
               .
 106           .     SUB.C1
               .           .
 114           .           .     SUB.C2
               .           .           .
 122           .     PT.C12............
               .           V
               .           V
 125           .     CULVC2
               .           V
               .           V
 138           .     THRUC2
               .           .
 142           .           .     SUB.C3
               .           .           .
 150           .           .           .     SUB.B1
               .           .           .           .
 158           .           .           .           .     SUB.B4
               .           .           .           .           .
 166    PT.BC...........................................
               V
               V
 169   POHDBC
               .
 182           .     SUB.D2
               .           .
 189           .           .     SUB.D4
               .           .           .
 197           .     PT.D24............
               .           V
               .           V
 200           .     THRUD2
               .           .
 204           .           .     SUB.D6
```

```
              .           .           .
212           .     PT.D246............
              .           .
215           .           .      SUB.D1
              .           .           .
223           .           .           .      SUB.D3
              .           .           .           .
231           .           .      PT.D23............
              .           .           V
              .           .           V
234           .           .     THRUD22
              .           .           .
238           .           .           .      SUB.D5
              .           .           .           .
246           .           .           .           .      SUB.E2
              .           .           .           .           .
254           .           .           .           .           .      SUB.E5
              .           .           .           .           .           .
262           .           .           .           .      PT.E25............
              .           .           .           .           V
              .           .           .           .           V
265           .           .           .           .      THRUE1
              .           .           .           .           .
269           .           .           .           .           .      SUB.E1
              .           .           .           .           .           .
277           .           .           .           .           .           .      SUB.E3
              .           .           .           .           .           .           .
285           .           .           .           .           .           .           .      SUB.E4
              .           .           .           .           .           .           .           .
293           .           .           .           .     PT.E1-5....................................
              .           .           .           .           V
              .           .           .           .           V
296           .           .           .           .      CULVE2
              .           .           .           .           V
              .           .           .           .           V
309           .           .           .           .      THRUE2
              .           .           .           .           .
313           .           .           .           .           .      SUB.E6
              .           .           .           .           .           .
321           .       PT.DE................................................
              .           V
              .           V
324           .      PONDDE
              .           .
337           .           .      SUB.A1
```

```
(***) RUNOFF ALSO COMPUTED AT THIS LOCATION
1*****************************************
 *                                        *
 *   FLOOD HYDROGRAPH PACKAGE   (HEC-1)   *
 *           SEPTEMBER 1990               *
 *             VERSION 4.0                *
 *                                        *
 *  RUN DATE  04/07/1999  TIME  17:24:50  *
 *                                        *
```

```
*****************************************
*                                       *
*   U.S. ARMY CORPS OF ENGINEERS        *
*   HYDROLOGIC ENGINEERING CENTER       *
*        609 SECOND STREET              *
*     DAVIS, CALIFORNIA 95616           *
*          (916) 756-1104               *
*                                       *
```

```
****************************************************************
*                                                              *
*         El Paso Clint Landfill  -  Developed Conditions      *
*                                                              *
* ............................................................ *
* :                                                          : *
* :        STORM DURATION.............24 HOUR                : *
* :        RETURN PERIOD..............25 YEAR                : *
* :        FILENAME............ clintdev.DAT                 : *
* :        DATE.................  APR, 1999                  : *
* :        BY.................... DBP & MRD                  : *
* :..........................................................: *
****************************************************************
  SOILS:
  SOIL CLASSIFICATIONS FOR El Paso COUNTY BY THE SCS WERE
  USED AND AREA WEIGHTED CURVE NUMBERS ASSIGNED TO SUBBASINS

  RAINFALL DISTRIBUTION: FROM TP40, HYDRO35
  HYPOTHETICAL STORM - PH CARD

  VELOCITIES FROM (SCS MANUAL, FIGURE 15.2)
****************************************************************
1 0  0.55 1.40 2.40 2.58 2.75 3.20 3.60 4.00 (100 YEAR)
4 0  0.44 1.08 1.87 2.01 2.15 2.50 2.81 3.12 (25 YEAR)


FOR ROUTING FLOWS IN PROPOSED DITCHES USE TRAPEZOIDAL
CHANNEL, 8' BOTTOM WIDTH, 2:1 BANK SLOPES
DITCH   N=0.035

32 IO         OUTPUT CONTROL VARIABLES
                   IPRNT          5  PRINT CONTROL
                   IPLOT          0  PLOT CONTROL
                   QSCAL          0.  HYDROGRAPH PLOT SCALE

   IT         HYDROGRAPH TIME DATA
                   NMIN           4  MINUTES IN COMPUTATION INTERVAL
                   IDATE      1   0  STARTING DATE
                   ITIME       0000  STARTING TIME
                   NQ           300  NUMBER OF HYDROGRAPH ORDINATES
                  NDDATE      1   0  ENDING DATE
                  NDTIME       1956  ENDING TIME
                  ICENT          19  CENTURY MARK

              COMPUTATION INTERVAL     .07 HOURS
                   TOTAL TIME BASE   19.93 HOURS

    ENGLISH UNITS
         DRAINAGE AREA          SQUARE MILES
         PRECIPITATION DEPTH    INCHES
         LENGTH, ELEVATION      FEET
         FLOW                   CUBIC FEET PER SECOND
         STORAGE VOLUME         ACRE-FEET
         SURFACE AREA           ACRES
         TEMPERATURE            DEGREES FAHRENHEIT
1
                                          RUNOFF SUMMARY
                                    FLOW IN CUBIC FEET PER SECOND
                                  TIME IN HOURS,  AREA IN SQUARE MILES

                               PEAK   TIME OF     AVERAGE FLOW FOR MAXIMUM PERIOD      BASIN   MAXIMUM   TIME OF
  OPERATION        STATION     FLOW     PEAK                                          AREA     STAGE   MAX STAGE
                                                   6-HOUR      2'  'R     72-HOUR
```

+		SUB.D2	33.	10.20	4.	1.	1.	.02		
+	HYDROGRAPH AT	SUB.D4	29.	10.07	3.	1.	1.	.01		
+	2 COMBINED AT	PT.D24	60.	10.13	7.	2.	2.	.03		
+	ROUTED TO	THRUD2	59.	10.20	7.	2.	2.	.03		
+	HYDROGRAPH AT	SUB.D6	34.	10.13	4.	1.	1.	.02		
+	2 COMBINED AT	PT.D246	91.	10.20	10.	4.	4.	.05		
+	HYDROGRAPH AT	SUB.D1	33.	10.13	4.	1.	1.	.02		
+	HYDROGRAPH AT	SUB.D3	48.	10.07	5.	2.	2.	.02		
+	2 COMBINED AT	PT.D23	79.	10.13	8.	3.	3.	.03		
+	ROUTED TO	THRUD22	79.	10.13	8.	3.	3.	.03		
+	HYDROGRAPH AT	SUB.D5	38.	10.13	4.	1.	1.	.04		
+	HYDROGRAPH AT	SUB.E2	39.	10.13	4.	1.	1.	.02		
+	HYDROGRAPH AT	SUB.E5	31.	10.07	3.	1.	1.	.01		
+	2 COMBINED AT	PT.E25	70.	10.07	7.	2.	2.	.03		
+	ROUTED TO	THRUE1	69.	10.20	7.	2.	2.	.03		
+	HYDROGRAPH AT	SUB.E1	34.	10.13	4.	1.	1.	.02		
+	HYDROGRAPH AT	SUB.E3	51.	10.07	5.	2.	2.	.02		
+	HYDROGRAPH AT	SUB.E4	25.	10.13	2.	1.	1.	.02		
+	4 COMBINED AT	PT.E1-5	165.	10.13	18.	6.	6.	.08		
+	ROUTED TO	CULVE2	150.	10.20	38.	27.	27.	.08	3954.16	10.20
+										
+	ROUTED TO	THRUE2	148.	10.20	40.	28.	28.	.08		
+	HYDROGRAPH AT	SUB.E6	29.	10.00	2.	1.	1.	.02		
+	5 COMBINED AT	PT.DE	357.	10.20	65.	37.	37.	.22		
	ROUTED TO									

```
+                    PONDDE       34.   15.07        33.      19.       19.       .22
+                                                                                        3932.04      15.07

       HYDROGRAPH AT
+                    SUB.A1        3.   10.13         0.       0.        0.       .01
1
                               SUMMARY OF KINEMATIC WAVE - MUSKINGUM-CUNGE ROUTING
                                  (FLOW IS DIRECT RUNOFF WITHOUT BASE FLOW)
                                                                       INTERPOLATED TO
                                                                   COMPUTATION INTERVAL
         ISTAQ    ELEMENT     DT      PEAK    TIME TO    VOLUME      DT      PEAK    TIME TO      VOLUME
                                                PEAK                                   PEAK

                             (MIN)    (CFS)    (MIN)      (IN)     (MIN)    (CFS)    (MIN)        (IN)

         THRUB1   MANE        2.46    92.00    612.77      .75      4.00    90.17    612.00        .75

CONTINUITY SUMMARY (AC-FT) - INFLOW= .1125E+02 EXCESS= .0000E+00 OUTFLOW= .1120E+02 BASIN STORAGE= .4885E-01 PERCENT ERROR=    .0

         THRUB2   MANE        1.03   199.39    614.14      .99      4.00   196.16    612.00        .99

CONTINUITY SUMMARY (AC-FT) - INFLOW= .1896E+02 EXCESS= .0000E+00 OUTFLOW= .1894E+02 BASIN STORAGE= .2929E-01 PERCENT ERROR=    .0

         THRUC2   MANE        1.68    87.57    607.53    16.72      4.00    87.37    608.00      17.48

CONTINUITY SUMMARY (AC-FT) - INFLOW= .3282E+02 EXCESS= .0000E+00 OUTFLOW= .3522E+02 BASIN STORAGE= .1952E+00 PERCENT ERROR=  -7.9

         THRUD2   MANE        2.53    59.01    612.18     2.58      4.00    58.82    612.00       2.57

CONTINUITY SUMMARY (AC-FT) - INFLOW= .3866E+01 EXCESS= .0000E+00 OUTFLOW= .3860E+01 BASIN STORAGE= .1320E-01 PERCENT ERROR=   -.2

         THRUD22  MANE         .40    78.94    608.50     2.58      4.00    78.72    608.00       2.58

CONTINUITY SUMMARY (AC-FT) - INFLOW= .4776E+01 EXCESS= .0000E+00 OUTFLOW= .4775E+01 BASIN STORAGE= .2270E-02 PERCENT ERROR=    .0

         THRUE1   MANE        3.21    69.68    612.47     2.58      4.00    69.12    612.00       2.58

CONTINUITY SUMMARY (AC-FT) - INFLOW= .4020E+01 EXCESS= .0000E+00 OUTFLOW= .4018E+01 BASIN STORAGE= .1859E-01 PERCENT ERROR=   -.4

         THRUE2   MANE         .32   149.80    612.81     9.81      4.00   148.34    612.00      10.38

CONTINUITY SUMMARY (AC-FT) - INFLOW= .4386E+02 EXCESS= .0000E+00 OUTFLOW= .4414E+02 BASIN STORAGE= .2053E-01 PERCENT ERROR=   -.7

1                          SUMMARY OF DAM OVERTOPPING/BREACH ANALYSIS FOR STATION   CULVC2
                       (PEAKS SHOWN ARE FOR INTERNAL TIME STEP USED  DURING BREACH FORMATION)

     PLAN  1 ..............          INITIAL VALUE     SPILLWAY CREST      TOP OF DAM
                          ELEVATION      3928.52           3936.50          3937.00
                          STORAGE             0.                1.               1.
                          OUTFLOW             0.              217.             267.

               RATIO     MAXIMUM     MAXIMUM    MAXIMUM    MAXIMUM    DURATION     TIME OF     TIME OF
                OF      RESERVOIR     DEPTH     STORAGE    OUTFLOW    OVER TOP   MAX OUTFLOW   FAILURE
                PMF      W.S.ELEV   OVER DAM     AC-FT       CFS        HOURS       HOURS       HOURS
```

1.00	3930.26	.00	0.	88.	.00	10.07	.00

1 SUMMARY OF DAM OVERTOPPING/BREACH ANALYSIS FOR STATION PONDBC
(PEAKS SHOWN ARE FOR INTERNAL TIME STEP USED DURING BREACH FORMATION)

PLAN 1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	3881.96	3894.00	3896.00
STORAGE	0.	19.	30.
OUTFLOW	0.	7.	93.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	3895.87	.00	29.	85.	.00	11.07	.00

1 SUMMARY OF DAM OVERTOPPING/BREACH ANALYSIS FOR STATION CULVE2
(PEAKS SHOWN ARE FOR INTERNAL TIME STEP USED DURING BREACH FORMATION)

PLAN 1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	3951.77	3957.50	3958.00
STORAGE	0.	2.	3.
OUTFLOW	0.	248.	302.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	3954.16	.00	0.	150.	.00	10.20	.00

1 SUMMARY OF DAM OVERTOPPING/BREACH ANALYSIS FOR STATION PONDDE
(PEAKS SHOWN ARE FOR INTERNAL TIME STEP USED DURING BREACH FORMATION)

PLAN 1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	3916.63	3931.33	3933.33
STORAGE	0.	25.	36.
OUTFLOW	0.	15.	102.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	3932.04	.00	29.	34.	.00	15.07	.00

*** NORMAL END OF HEC-1 ***

HEC-HMS Printouts

Project: GEPL_SS_Berm_Mod
Simulation Run: 24-hr 25-yr
Simulation Start: 30 September 2021, 24:00
Simulation End: 2 October 2021, 24:00

HMS Version: 4.9
Executed: 01 June 2022, 12:25

Global Parameter Summary - Subbasin

Area (MIē)

Element Name	Area (MIē)
B1	0.03
B2	0.03
B3	0.03
B4	0.02
B4.1	0
B5	0.02
B6	0.01
B7	0.03
B8	0.03
C1	0.03
C2	0.02
C3	0.02
Off - Site Contribution	0.24

Downstream

Element Name	Downstream
B1	Junction - 1
B2	Junction - 4
B3	Junction - 3
B4	Junction - 1
B5	Junction - 4
B6	Junction - 3
B7	Junction - 3
B8	Ditch B2
C1	Junction - 2
C2	Junction - 2
C3	Ditch C1
Off - Site Contribution	Junction - 3

Loss Rate: Scs

Element Name	Percent Impervious Area	Curve Number
B1	0	96
B2	0	96
B3	0	96
B4	0	96
B4.1	0	96
B5	0	96
B6	0	96
B7	0	75
B8	0	75
C1	0	96
C2	0	96
C3	0	96
Off - Site Contribution	0	63

Transform: Scs

Element Name	Lag	Unitgraph Type
B1	9.56	Standard
B2	9.47	Standard
B3	9.67	Standard
B4	4.44	Standard
B4.1	8.21	Standard
B5	4.44	Standard
B6	4.21	Standard
B7	34.22	Standard
B8	14.17	Standard
C1	9.67	Standard
C2	4.31	Standard
C3	21.74	Standard
Off - Site Contribution	45.6	Standard

Global Parameter Summary - Reach

Downstream

Element Name	Downstream
Ditch B1	Junction - 4
Ditch B2	Detention Pond BC
Ditch C1	Junction - 2
Ditch C2	Detention Pond BC

Route: Muskingum Cunge

Element Name	Method	Channel	Length (FT)	Energy Slope (FT/FT)	Mannings n	Bottom Width (FT)	Side Slope (FT/FT)	Initial Variable	Space - Time Method	Index Parameter Type	Index Celerity	Index
Ditch B1	Muskingum Cunge	Trapezoid	2465	0.01	0.04	8	3	Combined Inflow	Automatic DX and DT	Index Celerity	5	0
Ditch B2	Muskingum Cunge	Trapezoid	1600	0.01	0.04	8	3	Combined Inflow	Automatic DX and DT	Index Celerity	5	0
Ditch C1	Muskingum Cunge	Trapezoid	1900	0.01	0.04	8	3	Combined Inflow	Automatic DX and DT	Index Celerity	5.5	No Speci
Ditch C2	Muskingum Cunge	Trapezoid	2200	0.01	0.04	8	3	Combined Inflow	Automatic DX and DT	Index Celerity	5	0

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
B1	0.03	44.07	01Oct2021, 12:00	2.72
B2	0.03	45.89	01Oct2021, 12:00	2.72
B3	0.03	48.49	01Oct2021, 12:00	2.72
B4	0.02	42.48	01Oct2021, 12:00	2.72
B4.1	0	6.89	01Oct2021, 12:00	2.72
B5	0.02	27.55	01Oct2021, 12:00	2.72
B6	0.01	20.44	01Oct2021, 12:00	2.72
B7	0.03	10.16	01Oct2021, 12:30	1.07
B8	0.03	13.03	01Oct2021, 12:15	1.07
C1	0.03	46.08	01Oct2021, 12:00	2.72
C2	0.02	29.15	01Oct2021, 12:00	2.72
C3	0.02	19.4	01Oct2021, 12:15	2.72
Off - Site Contribution	0.24	23.01	01Oct2021, 12:45	0.51
Ditch B1	0.31	63.75	01Oct2021, 12:15	0.86
Ditch B2	0.38	118.59	01Oct2021, 12:15	1.09
Ditch C1	0.02	17.13	01Oct2021, 12:15	2.72
Ditch C2	0.06	66.81	01Oct2021, 12:15	2.72
Junction - 1	0.05	86.56	01Oct2021, 12:00	2.72
Junction - 2	0.06	85.25	01Oct2021, 12:00	2.72
Junction - 3	0.31	75.12	01Oct2021, 12:00	0.86
Junction - 4	0.35	123	01Oct2021, 12:00	1.09
Detention Pond BC	0.49	48.28	01Oct2021, 13:30	1.31

Subbasin: B1

Area (MIē) : 0.03
Downstream : Junction - 1

Loss Rate: Scs

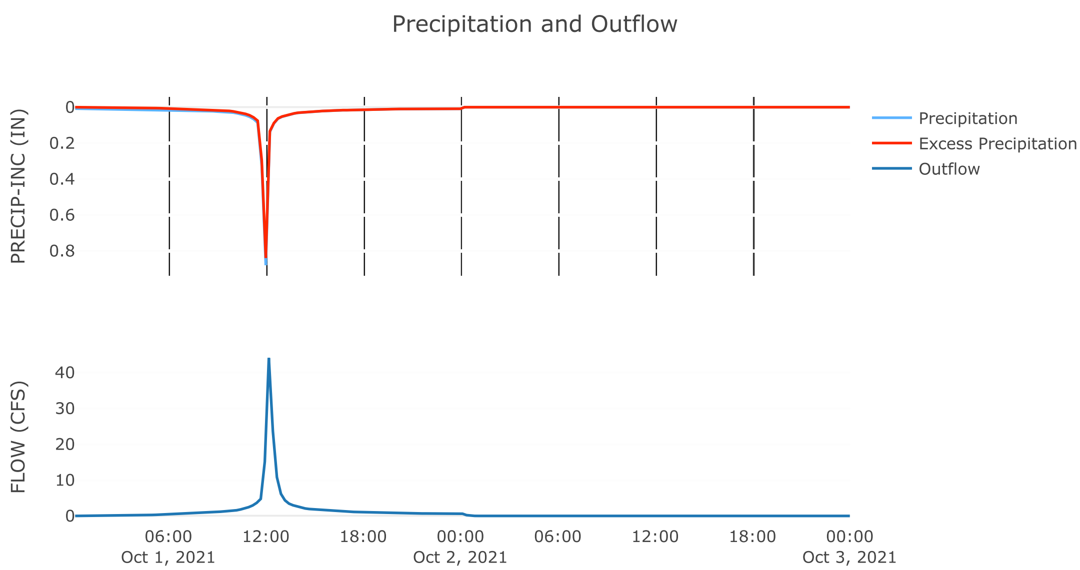
Percent Impervious Area	0
Curve Number	96

Transform: Scs

Lag	9.56
Unitgraph Type	Standard

Results: B1

Peak Discharge (CFS)	44.07
Time of Peak Discharge	01Oct2021, 12:00
Volume (IN)	2.72
Precipitation Volume (AC - FT)	4.62
Loss Volume (AC - FT)	0.66
Excess Volume (AC - FT)	3.96
Direct Runoff Volume (AC - FT)	3.96
Baseflow Volume (AC - FT)	0



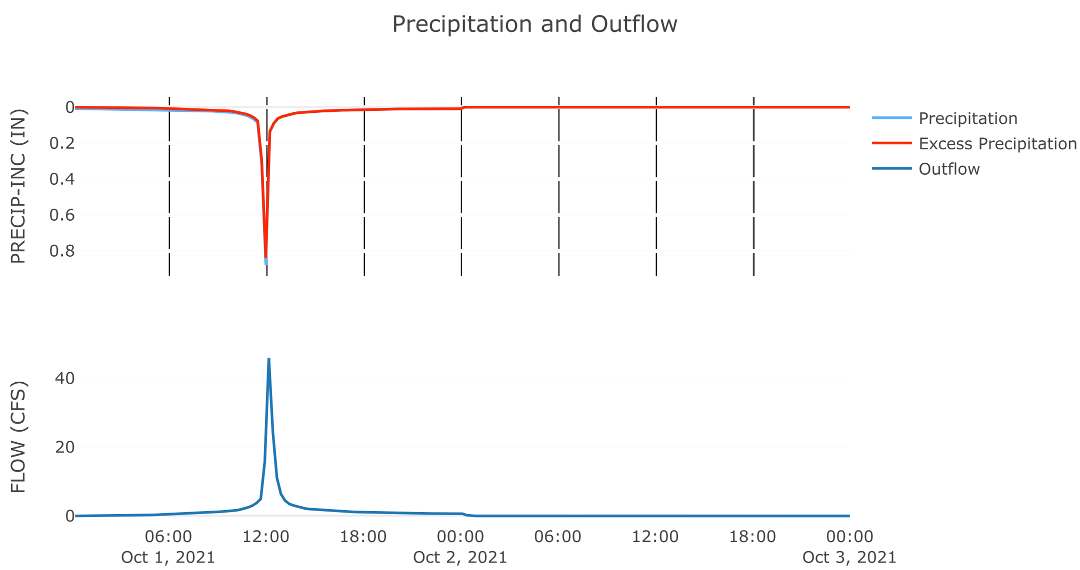
Subbasin: B2

Area (MIē) : 0.03
Downstream : Junction - 4

Loss Rate: Scs	
Percent Impervious Area	0
Curve Number	96

Transform: Scs	
Lag	9.47
Unitgraph Type	Standard

Results: B2	
Peak Discharge (CFS)	45.89
Time of Peak Discharge	01Oct2021, 12:00
Volume (IN)	2.72
Precipitation Volume (AC - FT)	4.78
Loss Volume (AC - FT)	0.68
Excess Volume (AC - FT)	4.1
Direct Runoff Volume (AC - FT)	4.1
Baseflow Volume (AC - FT)	0



Subbasin: B3

Area (MIē) : 0.03
Downstream : Junction - 3

Loss Rate: Scs

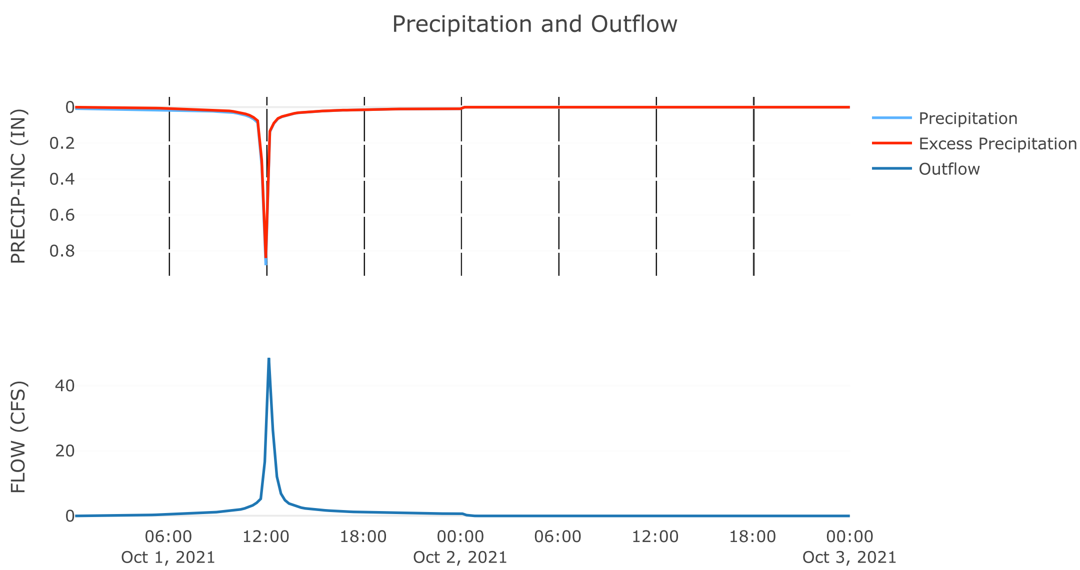
Percent Impervious Area	0
Curve Number	96

Transform: Scs

Lag	9.67
Unitgraph Type	Standard

Results: B3

Peak Discharge (CFS)	48.49
Time of Peak Discharge	01Oct2021, 12:00
Volume (IN)	2.72
Precipitation Volume (AC - FT)	5.11
Loss Volume (AC - FT)	0.73
Excess Volume (AC - FT)	4.38
Direct Runoff Volume (AC - FT)	4.38
Baseflow Volume (AC - FT)	0



Subbasin: B4

Area (MIē) : 0.02
Downstream : Junction - 1

Loss Rate: Scs

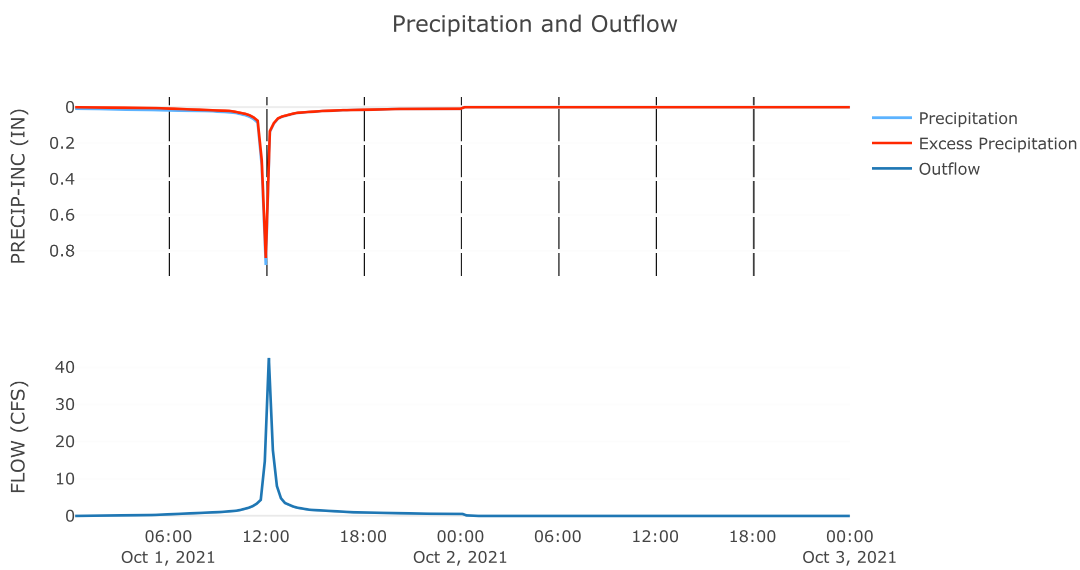
Percent Impervious Area	0
Curve Number	96

Transform: Scs

Lag	4.44
Unitgraph Type	Standard

Results: B4

Peak Discharge (CFS)	42.48
Time of Peak Discharge	01Oct2021, 12:00
Volume (IN)	2.72
Precipitation Volume (AC - FT)	4.04
Loss Volume (AC - FT)	0.57
Excess Volume (AC - FT)	3.47
Direct Runoff Volume (AC - FT)	3.47
Baseflow Volume (AC - FT)	0



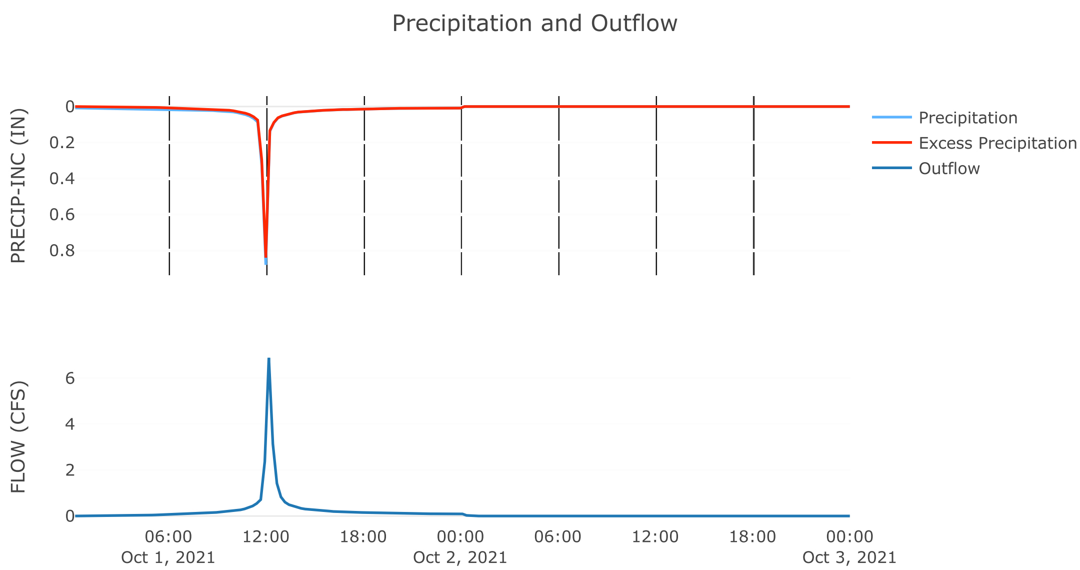
Subbasin: B4.1

Area (MIē) : 0

Loss Rate: Scs	
Percent Impervious Area	0
Curve Number	96

Transform: Scs	
Lag	8.21
Unitgraph Type	Standard

Results: B4.1	
Peak Discharge (CFS)	6.89
Time of Peak Discharge	01Oct2021, 12:00
Volume (IN)	2.72
Precipitation Volume (AC - FT)	0.68
Loss Volume (AC - FT)	0.1
Excess Volume (AC - FT)	0.58
Direct Runoff Volume (AC - FT)	0.58
Baseflow Volume (AC - FT)	0



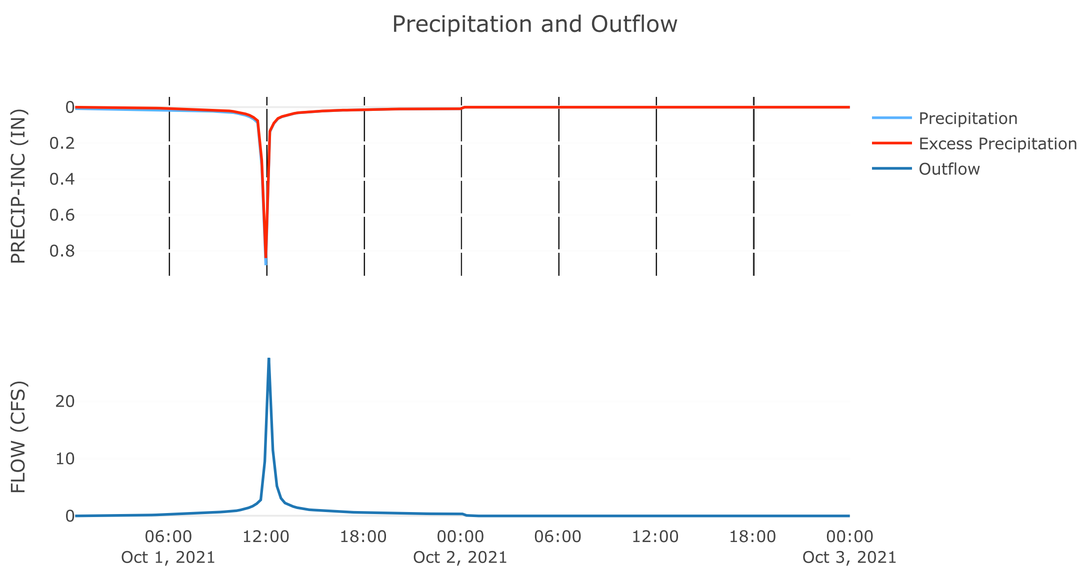
Subbasin: B5

Area (MIē) : 0.02
Downstream : Junction - 4

Loss Rate: Scs	
Percent Impervious Area	0
Curve Number	96

Transform: Scs	
Lag	4.44
Unitgraph Type	Standard

Results: B5	
Peak Discharge (CFS)	27.55
Time of Peak Discharge	01Oct2021, 12:00
Volume (IN)	2.72
Precipitation Volume (AC - FT)	2.62
Loss Volume (AC - FT)	0.37
Excess Volume (AC - FT)	2.25
Direct Runoff Volume (AC - FT)	2.25
Baseflow Volume (AC - FT)	0



Subbasin: B6

Area (MIē) : 0.01
Downstream : Junction - 3

Loss Rate: Scs

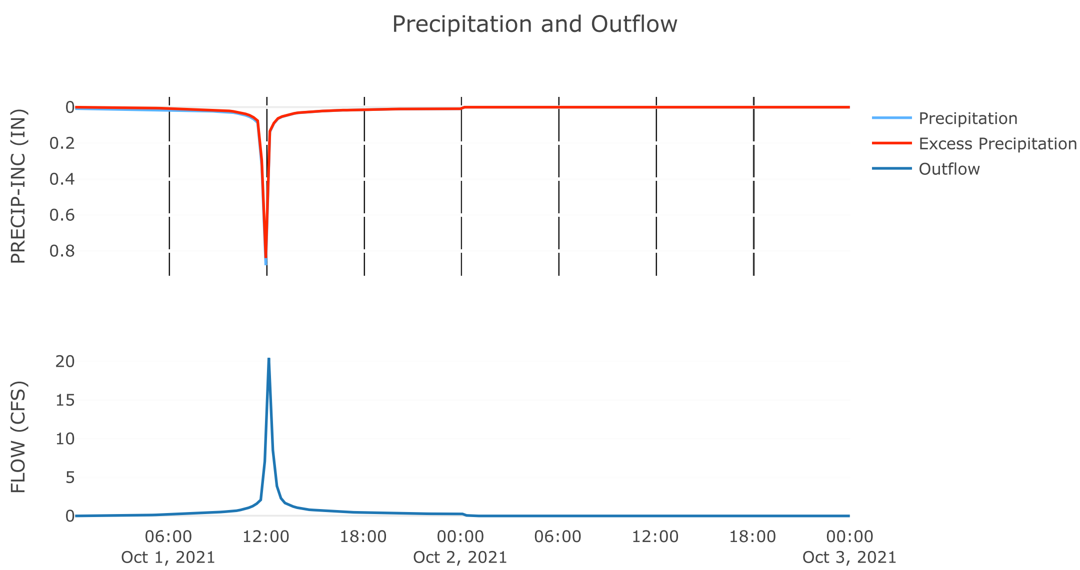
Percent Impervious Area	0
Curve Number	96

Transform: Scs

Lag	4.21
Unitgraph Type	Standard

Results: B6

Peak Discharge (CFS)	20.44
Time of Peak Discharge	01Oct2021, 12:00
Volume (IN)	2.72
Precipitation Volume (AC - FT)	1.94
Loss Volume (AC - FT)	0.28
Excess Volume (AC - FT)	1.67
Direct Runoff Volume (AC - FT)	1.67
Baseflow Volume (AC - FT)	0



Subbasin: B7

Area (MIē) : 0.03
Downstream : Junction - 3

Loss Rate: Scs

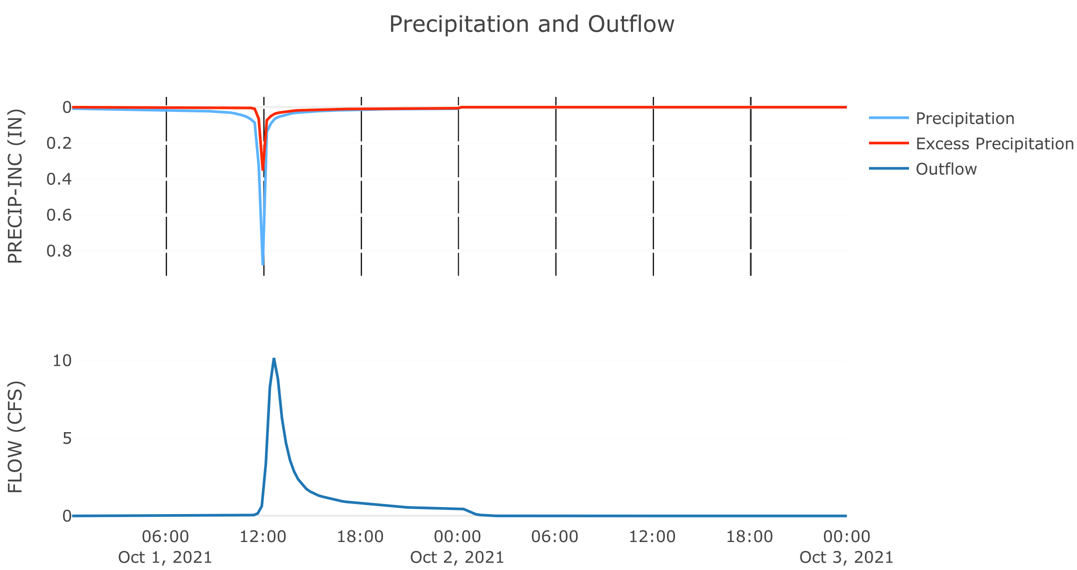
Percent Impervious Area	0
Curve Number	75

Transform: Scs

Lag	34.22
Unitgraph Type	Standard

Results: B7

Peak Discharge (CFS)	10.16
Time of Peak Discharge	01Oct2021, 12:30
Volume (IN)	1.07
Precipitation Volume (AC - FT)	5.19
Loss Volume (AC - FT)	3.43
Excess Volume (AC - FT)	1.76
Direct Runoff Volume (AC - FT)	1.76
Baseflow Volume (AC - FT)	0



Subbasin: B8

Area (MIē) : 0.03
Downstream : Ditch B2

Loss Rate: Scs

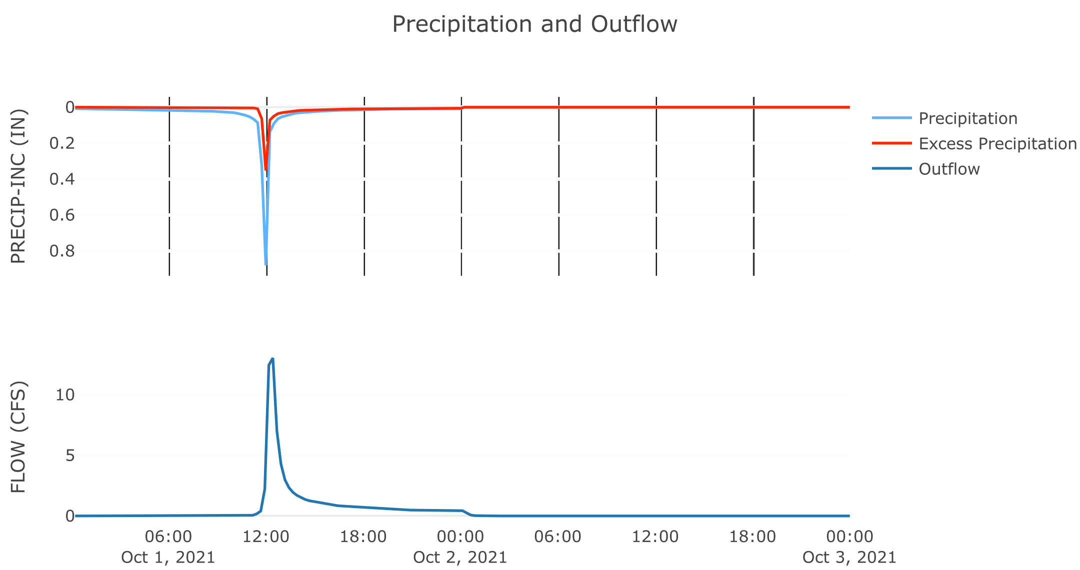
Percent Impervious Area	0
Curve Number	75

Transform: Scs

Lag	14.17
Unitgraph Type	Standard

Results: B8

Peak Discharge (CFS)	13.03
Time of Peak Discharge	01Oct2021, 12:15
Volume (IN)	1.07
Precipitation Volume (AC - FT)	4.73
Loss Volume (AC - FT)	3.13
Excess Volume (AC - FT)	1.6
Direct Runoff Volume (AC - FT)	1.6
Baseflow Volume (AC - FT)	0



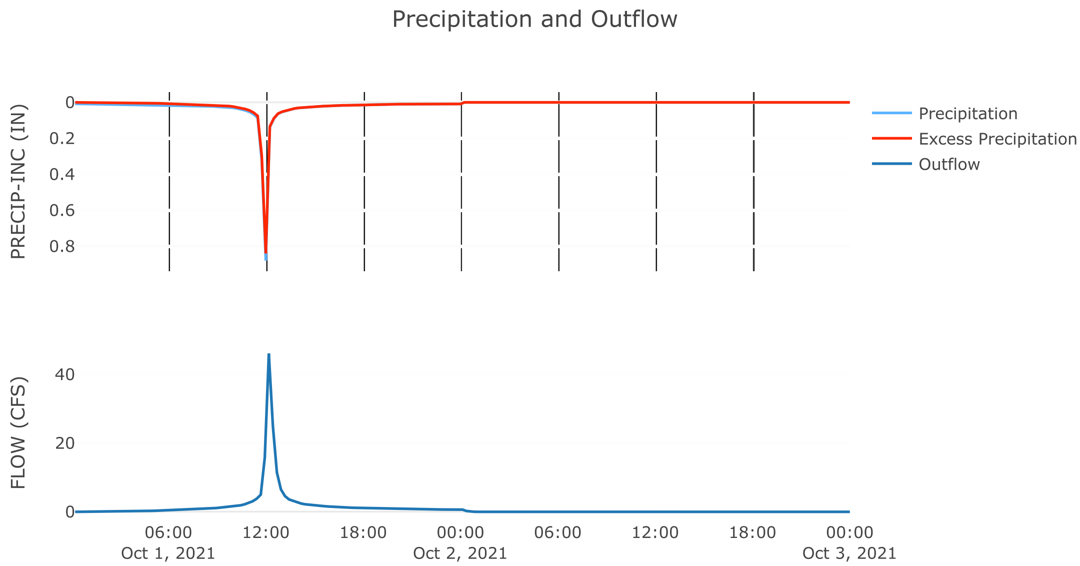
Subbasin: C1

Area (MI²) : 0.03
Downstream : Junction - 2

Loss Rate: Scs	
Percent Impervious Area	0
Curve Number	96

Transform: Scs	
Lag	9.67
Unitgraph Type	Standard

Results: C1	
Peak Discharge (CFS)	46.08
Time of Peak Discharge	01Oct2021, 12:00
Volume (IN)	2.72
Precipitation Volume (AC - FT)	4.85
Loss Volume (AC - FT)	0.69
Excess Volume (AC - FT)	4.16
Direct Runoff Volume (AC - FT)	4.16
Baseflow Volume (AC - FT)	0



Subbasin: C2

Area (MIē) : 0.02
Downstream : Junction - 2

Loss Rate: Scs

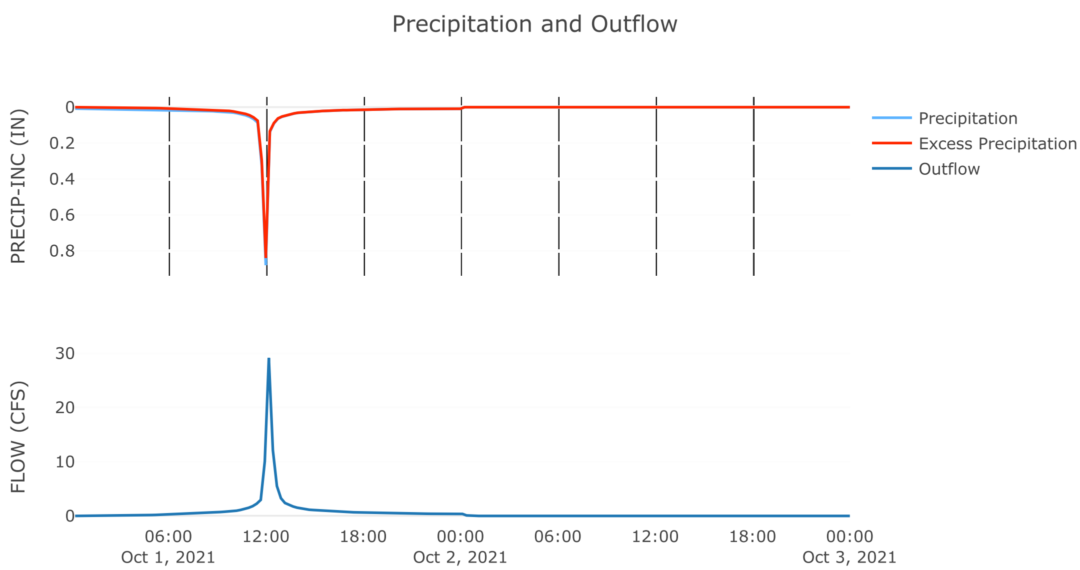
Percent Impervious Area	0
Curve Number	96

Transform: Scs

Lag	4.31
Unitgraph Type	Standard

Results: C2

Peak Discharge (CFS)	29.15
Time of Peak Discharge	01Oct2021, 12:00
Volume (IN)	2.72
Precipitation Volume (AC - FT)	2.77
Loss Volume (AC - FT)	0.39
Excess Volume (AC - FT)	2.38
Direct Runoff Volume (AC - FT)	2.38
Baseflow Volume (AC - FT)	0



Subbasin: C3

Area (MIē) : 0.02
Downstream : Ditch C1

Loss Rate: Scs

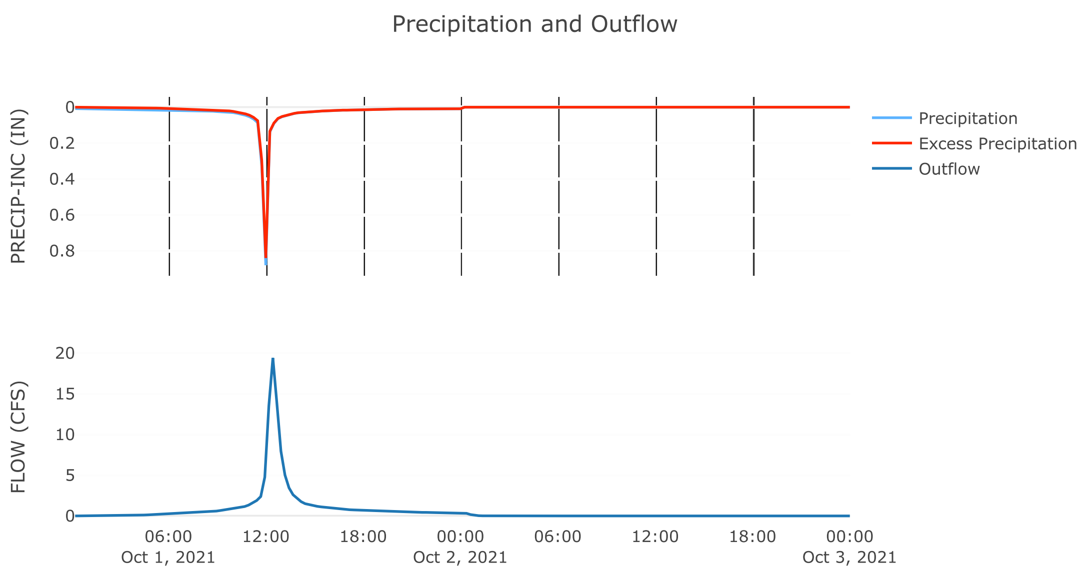
Percent Impervious Area	0
Curve Number	96

Transform: Scs

Lag	21.74
Unitgraph Type	Standard

Results: C3

Peak Discharge (CFS)	19.4
Time of Peak Discharge	01Oct2021, 12:15
Volume (IN)	2.72
Precipitation Volume (AC - FT)	2.92
Loss Volume (AC - FT)	0.42
Excess Volume (AC - FT)	2.51
Direct Runoff Volume (AC - FT)	2.51
Baseflow Volume (AC - FT)	0



Subbasin: Off-Site Contribution

Area (MIē) : 0.24
Downstream : Junction - 3

Loss Rate: Scs

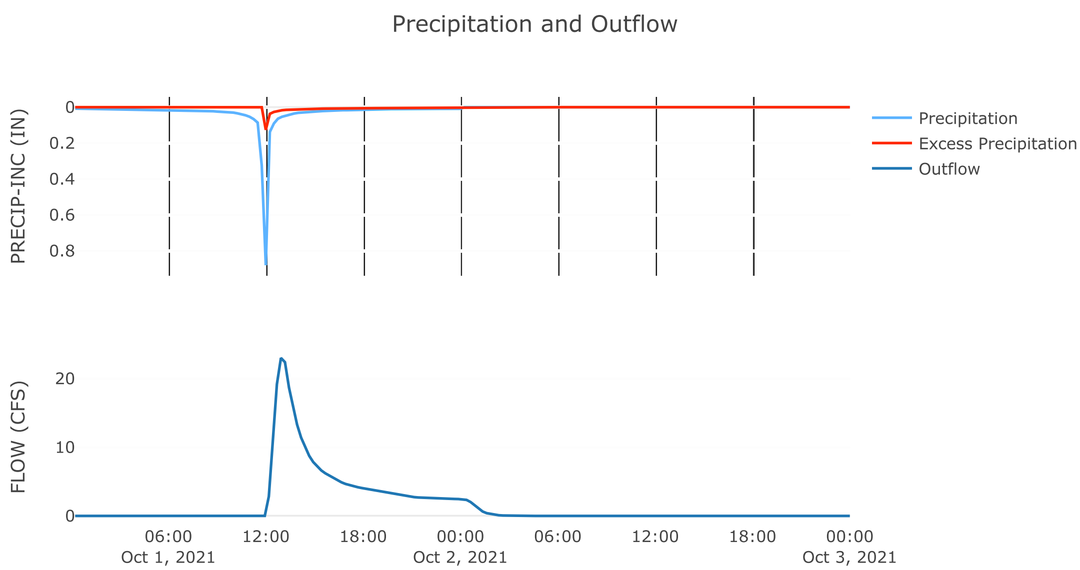
Percent Impervious Area	0
Curve Number	63

Transform: Scs

Lag	45.6
Unitgraph Type	Standard

Results: Off-Site Contribution

Peak Discharge (CFS)	23.01
Time of Peak Discharge	01Oct2021, 12:45
Volume (IN)	0.51
Precipitation Volume (AC - FT)	40
Loss Volume (AC - FT)	33.62
Excess Volume (AC - FT)	6.39
Direct Runoff Volume (AC - FT)	6.39
Baseflow Volume (AC - FT)	0



Reach: Ditch B1

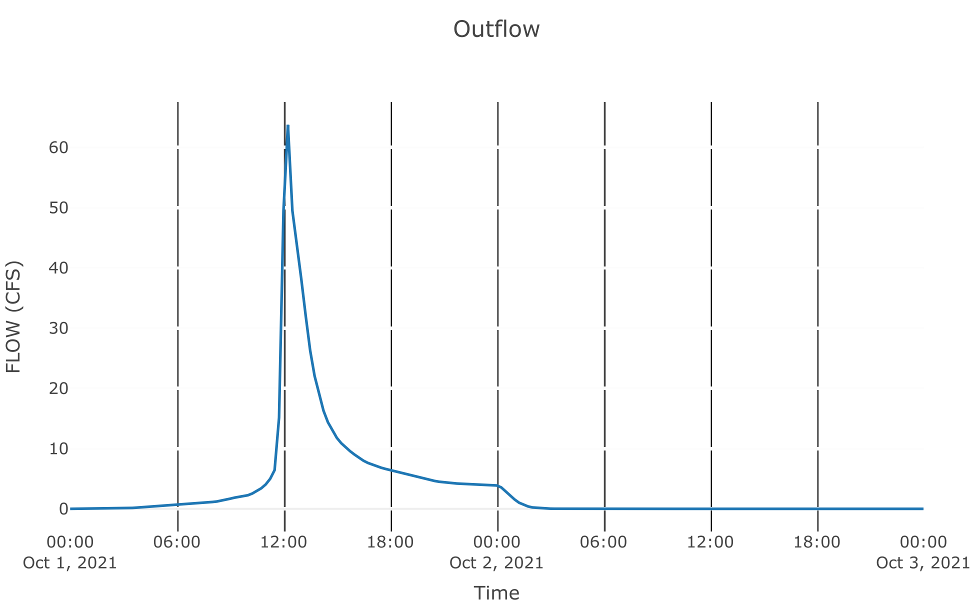
Downstream : Junction - 4

Route: Muskingum Cunge

Method	Muskingum Cunge
Channel	Trapezoid
Length (FT)	2465
Energy Slope (FT/FT)	0.01
Mannings n	0.04
Bottom Width (FT)	8
Side Slope (FT/FT)	3
Initial Variable	Combined Inflow
Space - Time Method	Automatic DX and DT
Index Parameter Type	Index Celerity
Index Celerity	5
Index Flow	0
Maximum Depth Iterations	20
Maximum Route Step Iterations	30

Results: Ditch B1

Peak Discharge (CFS)	63.75
Time of Peak Discharge	01Oct2021, 12:15
Volume (IN)	0.86
Peak Inflow (CFS)	75.12
Inflow Volume (AC - FT)	14.19



Reach: Ditch B2

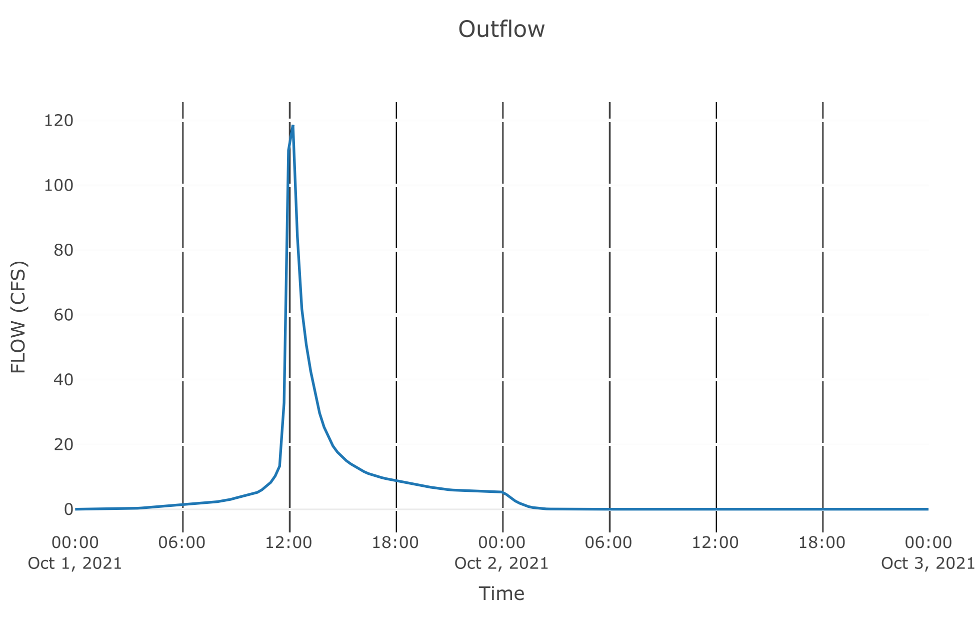
Downstream : Detention Pond BC

Route: Muskingum Cunge

Method	Muskingum Cunge
Channel	Trapezoid
Length (FT)	1600
Energy Slope (FT/FT)	0.01
Mannings n	0.04
Bottom Width (FT)	8
Side Slope (FT/FT)	3
Initial Variable	Combined Inflow
Space - Time Method	Automatic DX and DT
Index Parameter Type	Index Celerity
Index Celerity	5
Index Flow	0
Maximum Depth Iterations	20
Maximum Route Step Iterations	30

Results: Ditch B2

Peak Discharge (CFS)	118.59
Time of Peak Discharge	01Oct2021, 12:15
Volume (IN)	1.09
Peak Inflow (CFS)	135.44
Inflow Volume (AC - FT)	22.14

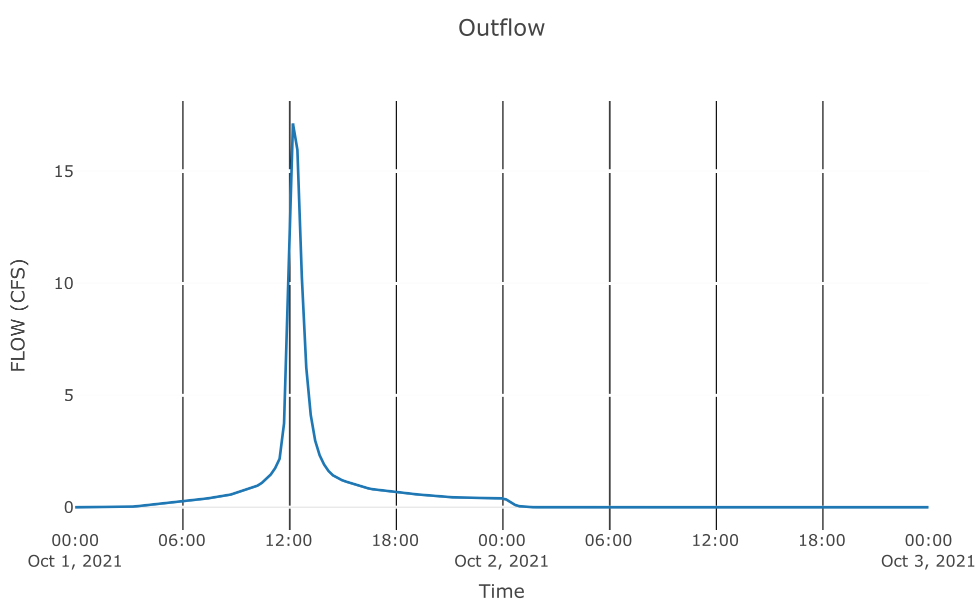


Reach: Ditch C1

Downstream : Junction - 2

Route: Muskingum Cunge	
Method	Muskingum Cunge
Channel	Trapezoid
Length (FT)	1900
Energy Slope (FT/FT)	0.01
Mannings n	0.04
Bottom Width (FT)	8
Side Slope (FT/FT)	3
Initial Variable	Combined Inflow
Space - Time Method	Automatic DX and DT
Index Parameter Type	Index Celerity
Index Celerity	5.5
Maximum Depth Iterations	20
Maximum Route Step Iterations	30

Results: Ditch C1	
Peak Discharge (CFS)	17.13
Time of Peak Discharge	01Oct2021, 12:15
Volume (IN)	2.72
Peak Inflow (CFS)	19.4
Inflow Volume (AC - FT)	2.51



Reach: Ditch C2

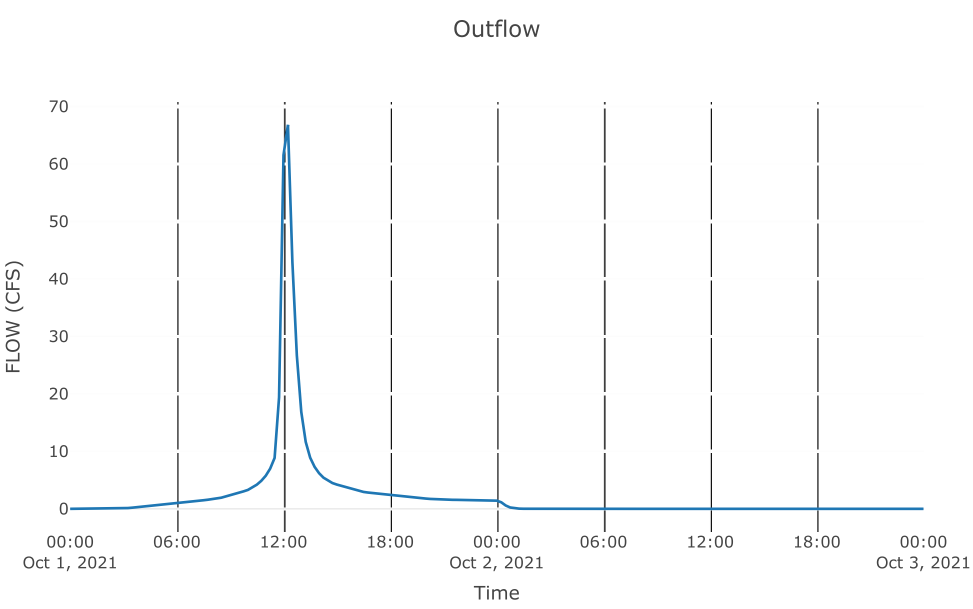
Downstream : Detention Pond BC

Route: Muskingum Cunge

Method	Muskingum Cunge
Channel	Trapezoid
Length (FT)	2200
Energy Slope (FT/FT)	0.01
Mannings n	0.04
Bottom Width (FT)	8
Side Slope (FT/FT)	3
Initial Variable	Combined Inflow
Space - Time Method	Automatic DX and DT
Index Parameter Type	Index Celerity
Index Celerity	5
Index Flow	0
Maximum Depth Iterations	20
Maximum Route Step Iterations	30

Results: Ditch C2

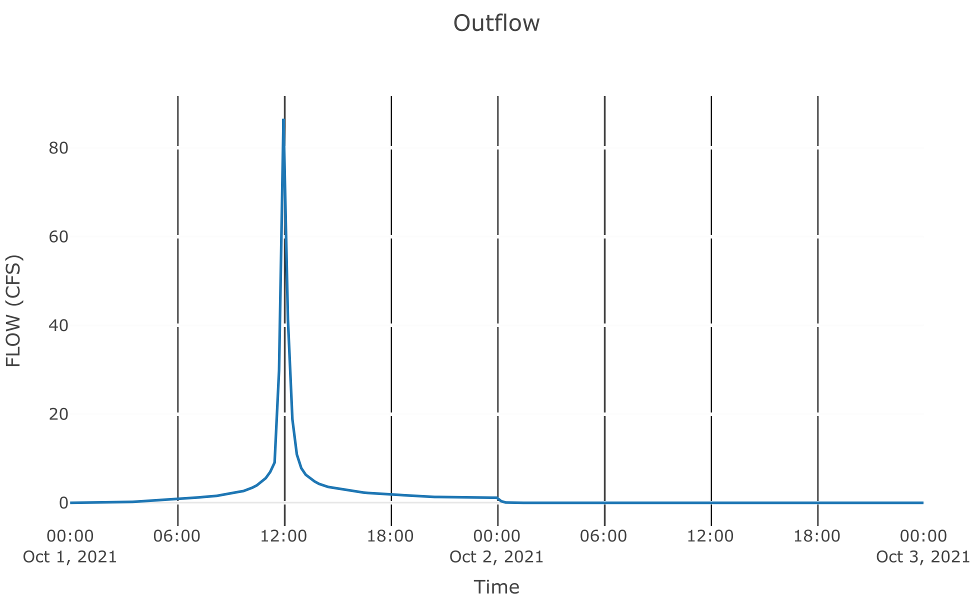
Peak Discharge (CFS)	66.81
Time of Peak Discharge	01Oct2021, 12:15
Volume (IN)	2.72
Peak Inflow (CFS)	85.25
Inflow Volume (AC - FT)	9.05



Junction: Junction-1

Downstream : Detention Pond BC

Results: Junction-1	
Peak Discharge (CFS)	86.56
Time of Peak Discharge	01Oct2021, 12:00
Volume (IN)	2.72

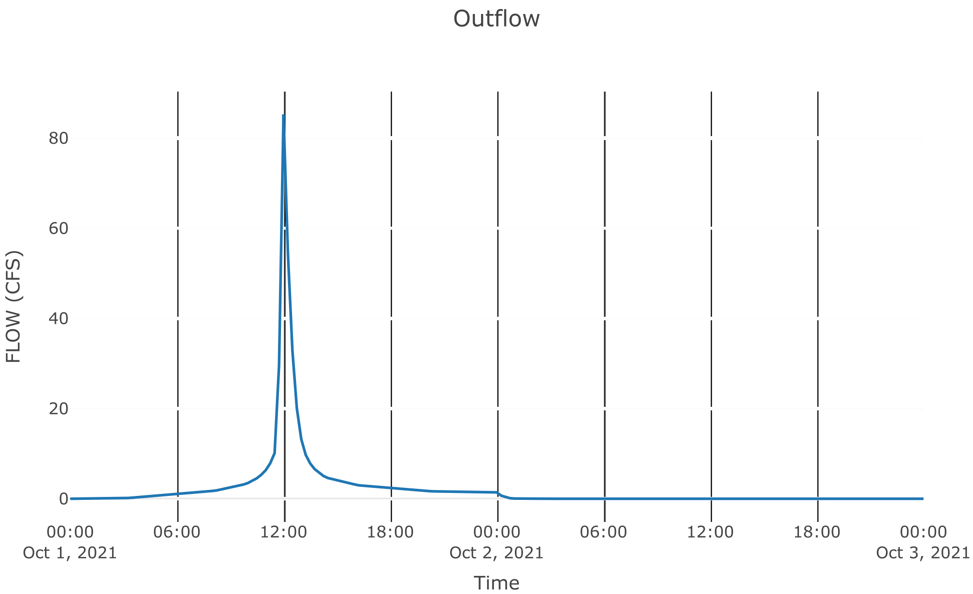


Junction: Junction-2

Downstream : Ditch C2

Results: Junction-2

Peak Discharge (CFS)	85.25
Time of Peak Discharge	01Oct2021, 12:00
Volume (IN)	2.72

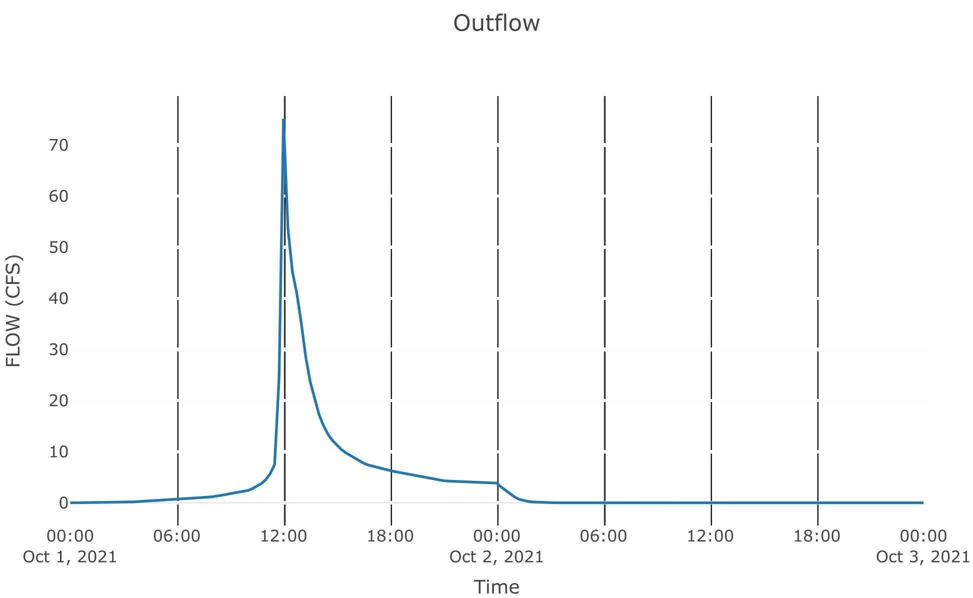


Junction: Junction-3

Downstream : Ditch B1

Results: Junction-3

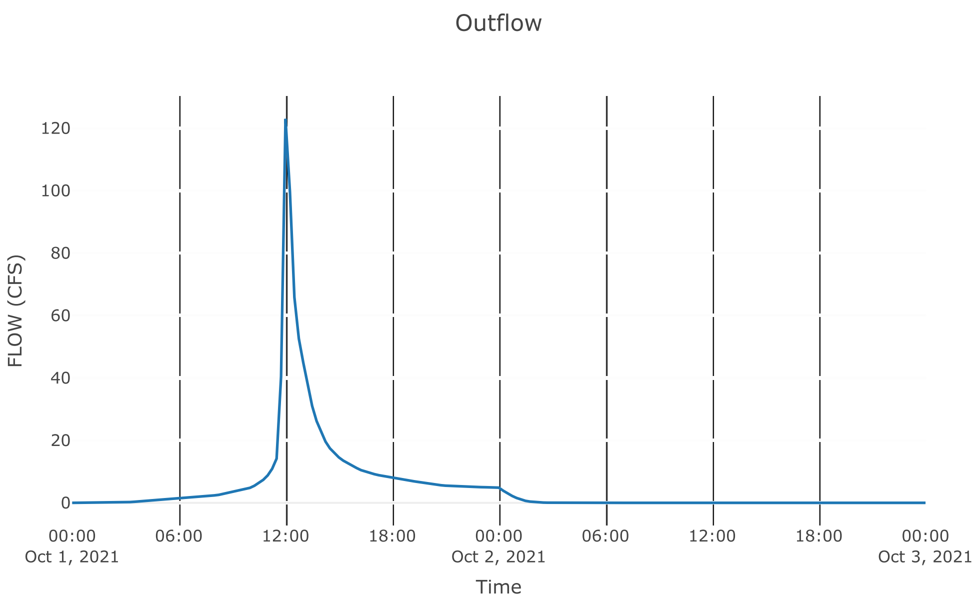
Peak Discharge (CFS)	75.12
Time of Peak Discharge	01Oct2021, 12:00
Volume (IN)	0.86



Junction: Junction-4

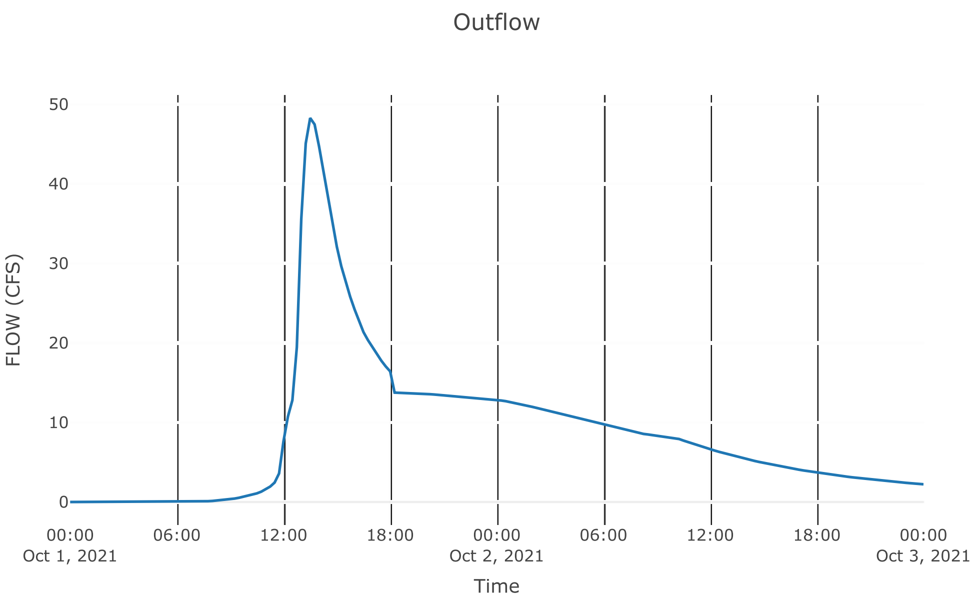
Downstream : Ditch B2

Results: Junction-4	
Peak Discharge (CFS)	123
Time of Peak Discharge	01Oct2021, 12:00
Volume (IN)	1.09



Reservoir: Detention Pond BC

Results: Detention Pond BC	
Peak Discharge (CFS)	48.28
Time of Peak Discharge	01Oct2021, 13:30
Volume (IN)	1.31
Peak Inflow (CFS)	258.89
Time of Peak Inflow	01Oct2021, 12:00
Inflow Volume (AC - FT)	38.69
Maximum Storage (AC - FT)	21.61
Peak Elevation (FT)	3894.44
Discharge Volume (AC - FT)	34.53



DEVELOPED CONDITIONS
HEC-HMS CALCULATIONS

Project: GEPLandfill_Update2025
Simulation Run: ProposedConditions25Year
Simulation Start: 31 December 1999, 24:00
Simulation End: 1 January 2000, 24:00

HMS Version: 4.11
Executed: 02 May 2025, 20:45

Global Parameter Summary - Subbasin

	Area (MI2)
Element Name	Area (MI2)
B1	0.03
B4	0.02
B3	0.03
B6	0.01
Cos	0.24
B2	0.03
B5	0.02
B7	0.03
B8	0.03
C1	0.03
C2	0.02
C3	0.02
A1	0.01
D4	0.01
D6	0.02
D1	0.02
D5	0.04
D3	0.02
E6	0.02
E2	0.02
E5	0.01
E4	0.02
E3	0.02
E1	0.02

Downstream

Element Name	Downstream
B1	B1 Junction
B4	B1 Junction
B3	B3 Junction
B6	B3 Junction
Cos	Ditch B1
B2	B2 Junction
B5	B2 Junction
B7	Ditch B2
B8	Ditch B2
C1	C1 Junction
C2	C1 Junction
C3	Ditch C2
A1	Outfall A
D4	D4 Junction
D6	Ditch D1
D1	D1 Junction
D5	Ditch D2
D3	Ditch D2
E6	Ditch D3
E2	E2 Junction
E5	E2 Junction
E4	Ditch E1
E3	E1 Junction
E1	E1 Junction

Loss Rate: Scs

Element Name	Percent Impervious Area	Curve Number
B1	0	96
B4	0	96
B3	0	96
B6	0	96
Cos	0	63
B2	0	96
B5	0	96
B7	0	75
B8	0	75
C1	0	96
C2	0	96
C3	0	96
A1	0	63
D4	0	96
D6	0	88
D1	0	96
D5	0	76
D3	0	96
E6	0	80
E2	0	96
E5	0	96
E4	0	80
E3	0	96
E1	0	96

Transform: Scs

Element Name	Lag	Unitgraph Type
B1	5.7	Standard
B4	5.3	Standard
B3	6.3	Standard
B6	5.6	Standard
Cos	47	Standard
B2	6.2	Standard
B5	8.1	Standard
B7	33.4	Standard
B8	2.4	Standard
C1	5.7	Standard
C2	5	Standard
C3	48.6	Standard
A1	6.9	Standard
D4	7.4	Standard
D6	9.9	Standard
D1	4.17	Standard
D5	8.1	Standard
D3	7.2	Standard
E6	2.5	Standard
E2	6.28	Standard
E5	7.4	Standard
E4	6.7	Standard
E3	6.8	Standard
E1	4.68	Standard

Global Parameter Summary - Reach

Downstream

Element Name	Downstream
Ditch B1	Ditch B2
Ditch B2	Basin BC
Ditch C1	Culvert C2
Ditch C2	Basin BC
Ditch D1	D1 Junction
Ditch D2	Junction - 2
Ditch D3	Basin DE
Ditch E1	E1 Junction
Ditch E2	Basin DE

Route: Kinematic Wave

Element Name	Method	Channel	Length (FT)	Energy Slope (FT/FT)	Mannings n	Shape	Number of Subreaches	Width (FT)	Side Slope (FT/FT)	Initial Variable	Index Parameter Type	Index Flow
Ditch B1	Kinematic Wave	Kinematic Wave	2769	0.01	0.04	Trapezoid	2	8	5	Combined Inflow	Index Flow	0.05
Ditch B2	Kinematic Wave	Kinematic Wave	1596	0.03	0.04	Trapezoid	2	8	5	Combined Inflow	Index Flow	0.05
Ditch C1	Kinematic Wave	Kinematic Wave	2080	0.02	0.04	Trapezoid	2	8	5	Combined Inflow	Index Flow	0.05
Ditch C2	Kinematic Wave	Kinematic Wave	2335	0.02	0.04	Trapezoid	2	8	5	Combined Inflow	Index Flow	0.05
Ditch D1	Kinematic Wave	Kinematic Wave	1300	0	0.04	Trapezoid	2	8	5	Combined Inflow	Index Flow	0.05
Ditch D2	Kinematic Wave	Kinematic Wave	400	0.02	0.04	Trapezoid	2	8	5	Combined Inflow	Index Flow	0.05
Ditch D3	Kinematic Wave	Kinematic Wave	400	0.02	0.04	Trapezoid	2	8	5	Combined Inflow	Index Flow	0.05
Ditch E1	Kinematic Wave	Kinematic Wave	2425	0.01	0.04	Trapezoid	2	8	5	Combined Inflow	Index Flow	0.05
Ditch E2	Kinematic Wave	Kinematic Wave	570	0.05	0.04	Trapezoid	2	8	5	Combined Inflow	Index Flow	0.05

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
B1	0.03	102.79	01Jan2000, 12:07	2.91
B4	0.02	91.96	01Jan2000, 12:06	2.91
B3	0.03	109	01Jan2000, 12:07	2.91
B6	0.01	43.69	01Jan2000, 12:07	2.91
Cos	0.24	42.33	01Jan2000, 12:58	0.59
B3 Junction	0.04	152.69	01Jan2000, 12:07	2.91
Ditch B1	0.28	153.37	01Jan2000, 12:16	0.93
B2	0.03	102.97	01Jan2000, 12:07	2.91
B5	0.02	50.31	01Jan2000, 12:09	2.91
B2 Junction	0.04	151.58	01Jan2000, 12:08	2.91
B7	0.03	16.94	01Jan2000, 12:39	1.2
B8	0.03	57.85	01Jan2000, 12:04	1.21
Ditch B2	0.38	255.58	01Jan2000, 12:17	1.19
C1	0.03	108.67	01Jan2000, 12:07	2.91
C2	0.02	65.17	01Jan2000, 12:06	2.91
C1 Junction	0.05	172.68	01Jan2000, 12:07	2.91
Ditch C1	0.05	172.63	01Jan2000, 12:11	2.9
Culvert C2	0.05	152.65	01Jan2000, 12:13	2.89
C3	0.02	16.53	01Jan2000, 12:51	2.89
Ditch C2	0.06	157.7	01Jan2000, 12:18	2.88
B1 Junction	0.05	194.34	01Jan2000, 12:07	2.91
Basin BC	0.49	45.42	01Jan2000, 14:02	1
Outfall BC	0.49	45.42	01Jan2000, 14:02	1
A1	0.01	4.7	01Jan2000, 12:10	0.6
D4	0.01	40.66	01Jan2000, 12:08	2.91
D6	0.02	46.3	01Jan2000, 12:11	2.15
D4 Junction	0.01	40.66	01Jan2000, 12:08	2.91
Ditch D1	0.03	84.51	01Jan2000, 12:16	2.42
D1	0.02	62.74	01Jan2000, 12:05	2.91
D1 Junction	0.05	100.95	01Jan2000, 12:15	2.58
D5	0.04	56.82	01Jan2000, 12:10	1.27

D3	0.02	66.92	01Jan2000, 12:08	2.91
Ditch D2	0.11	197.9	01Jan2000, 12:12	2.16
Junction - 2	0.11	197.9	01Jan2000, 12:12	2.16
E6	0.02	49.07	01Jan2000, 12:04	1.53
Ditch D3	0.12	220.53	01Jan2000, 12:08	2.06
E2	0.02	59.39	01Jan2000, 12:07	2.91
E5	0.01	43.3	01Jan2000, 12:08	2.91
E2 Junction	0.03	102.35	01Jan2000, 12:08	2.91
E4	0.02	38.46	01Jan2000, 12:08	1.53
Ditch E1	0.05	140.36	01Jan2000, 12:16	2.34
E3	0.02	70.78	01Jan2000, 12:08	2.91
E1	0.02	62.06	01Jan2000, 12:06	2.91
E1 Junction	0.08	198.7	01Jan2000, 12:14	2.58
Culvert E2	0.08	187.42	01Jan2000, 12:17	2.56
Ditch E2	0.08	186.94	01Jan2000, 12:18	2.56
Basin DE	0.21	18.42	01Jan2000, 13:40	1.53
Outfall DE	0.21	18.42	01Jan2000, 13:40	1.53
Outfall A	0.01	4.7	01Jan2000, 12:10	0.6

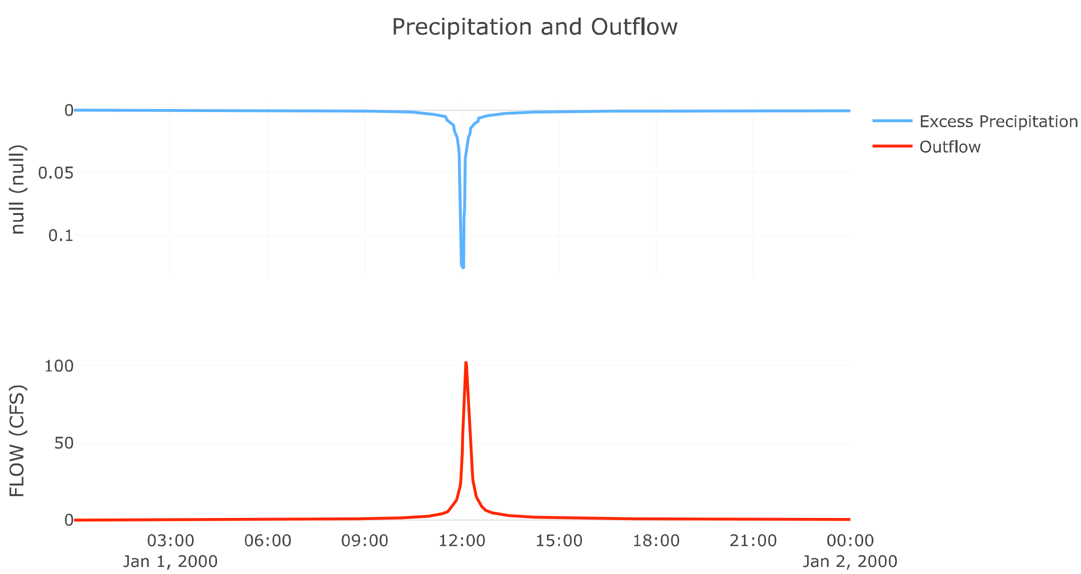
Subbasin: B1

Area (MI2) : 0.03
Downstream : B1 Junction

Loss Rate: Scs	
Percent Impervious Area	0
Curve Number	96

Transform: Scs	
Lag	5.7
Unitgraph Type	Standard

Results: B1	
Peak Discharge (CFS)	102.79
Time of Peak Discharge	01Jan2000, 12:07
Volume (IN)	2.91
Precipitation Volume (AC - FT)	4.91
Loss Volume (AC - FT)	0.66
Excess Volume (AC - FT)	4.25
Direct Runoff Volume (AC - FT)	4.25
Baseflow Volume (AC - FT)	0



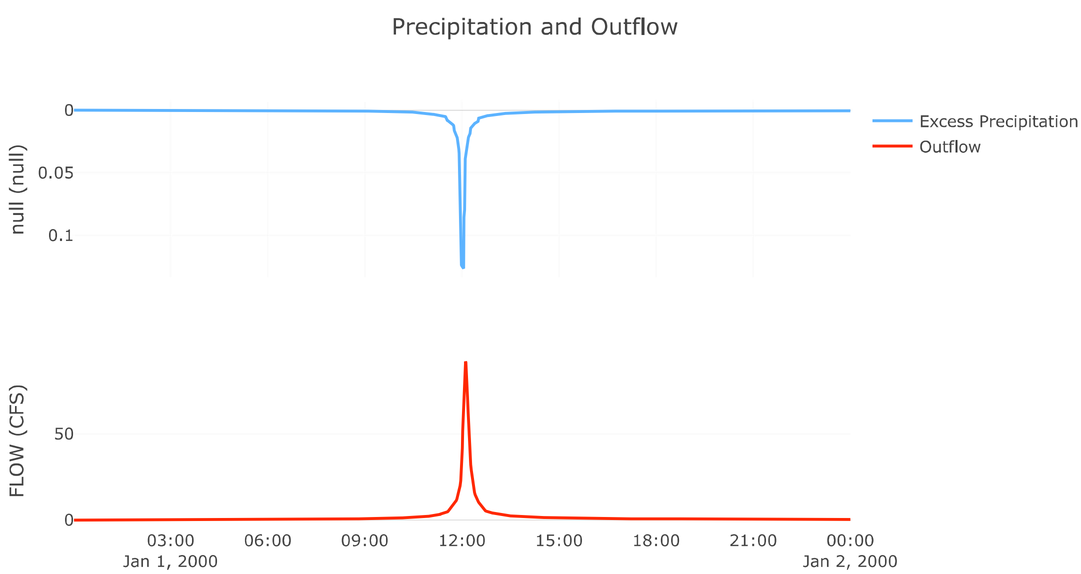
Subbasin: B4

Area (MI2) : 0.02
Downstream : B1 Junction

Loss Rate: Scs	
Percent Impervious Area	0
Curve Number	96

Transform: Scs	
Lag	5.3
Unitgraph Type	Standard

Results: B4	
Peak Discharge (CFS)	91.96
Time of Peak Discharge	01Jan2000, 12:06
Volume (IN)	2.91
Precipitation Volume (AC - FT)	4.3
Loss Volume (AC - FT)	0.58
Excess Volume (AC - FT)	3.72
Direct Runoff Volume (AC - FT)	3.72
Baseflow Volume (AC - FT)	0



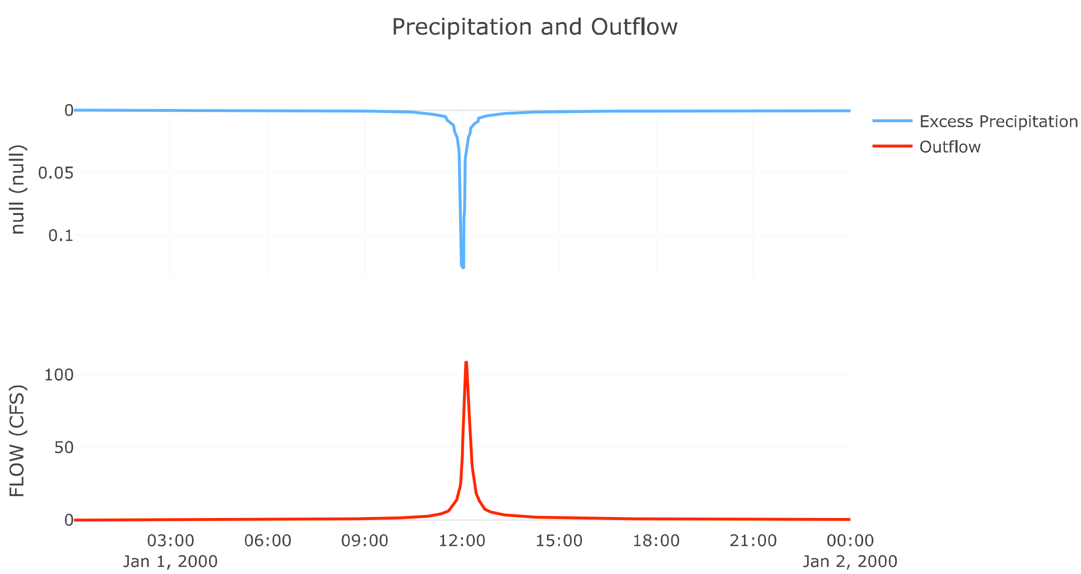
Subbasin: B3

Area (MI2) : 0.03
Downstream : B3 Junction

Loss Rate: Scs	
Percent Impervious Area	0
Curve Number	96

Transform: Scs	
Lag	6.3
Unitgraph Type	Standard

Results: B3	
Peak Discharge (CFS)	109
Time of Peak Discharge	01Jan2000, 12:07
Volume (IN)	2.91
Precipitation Volume (AC - FT)	5.42
Loss Volume (AC - FT)	0.73
Excess Volume (AC - FT)	4.69
Direct Runoff Volume (AC - FT)	4.69
Baseflow Volume (AC - FT)	0



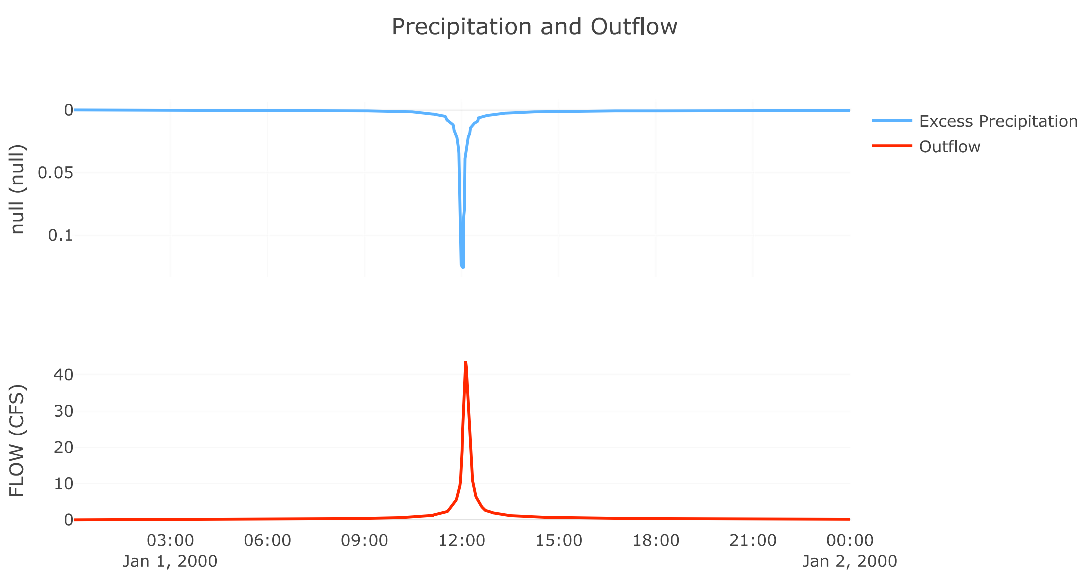
Subbasin: B6

Area (MI2) : 0.01
Downstream : B3 Junction

Loss Rate: Scs	
Percent Impervious Area	0
Curve Number	96

Transform: Scs	
Lag	5.6
Unitgraph Type	Standard

Results: B6	
Peak Discharge (CFS)	43.69
Time of Peak Discharge	01Jan2000, 12:07
Volume (IN)	2.91
Precipitation Volume (AC - FT)	2.08
Loss Volume (AC - FT)	0.28
Excess Volume (AC - FT)	1.8
Direct Runoff Volume (AC - FT)	1.8
Baseflow Volume (AC - FT)	0



Subbasin: COS

Area (MI2) : 0.24
Downstream : Ditch B1

Loss Rate: Scs

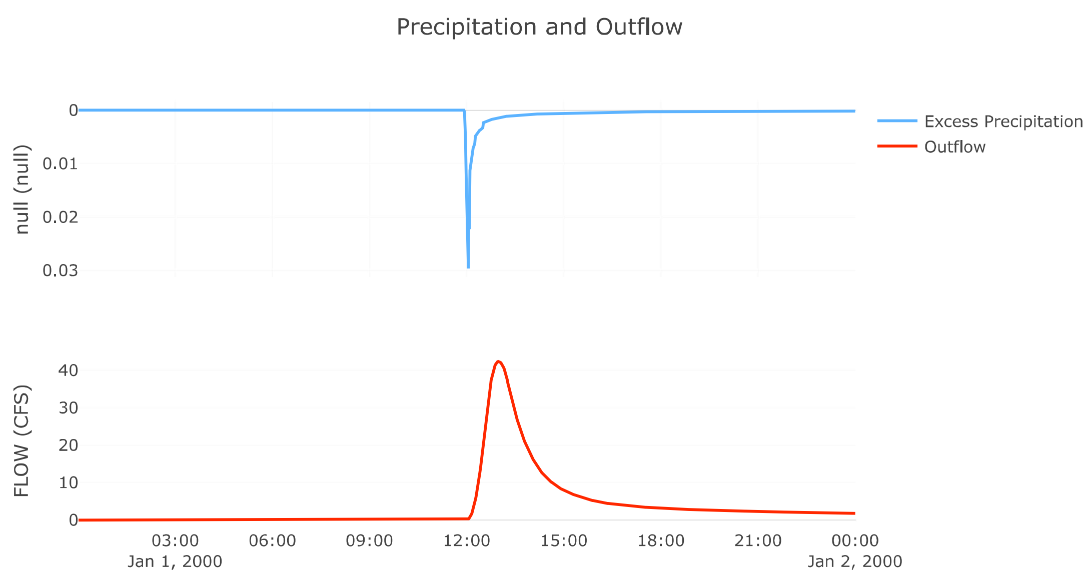
Percent Impervious Area	0
Curve Number	63

Transform: Scs

Lag	47
Unitgraph Type	Standard

Results: COS

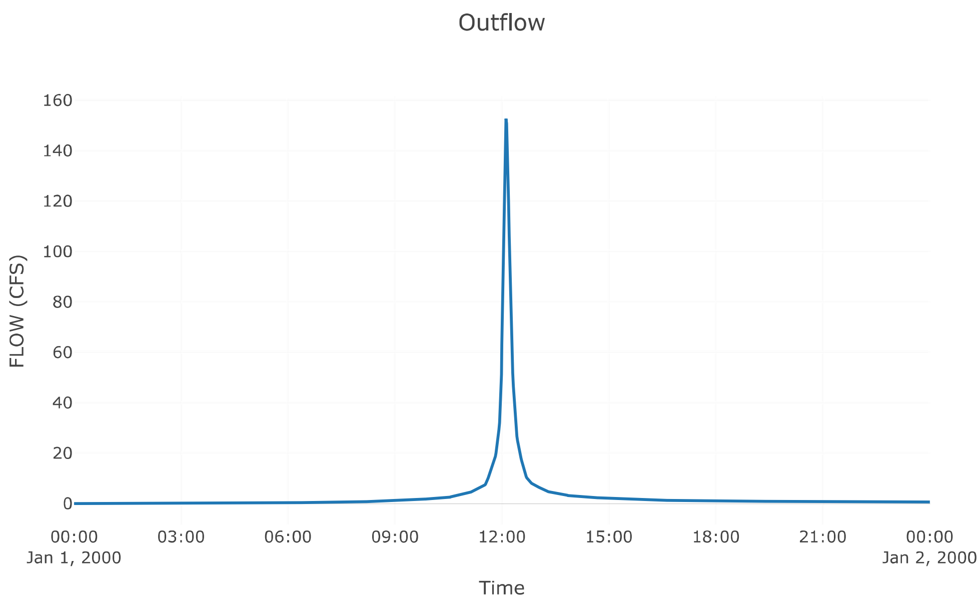
Peak Discharge (CFS)	42.33
Time of Peak Discharge	01Jan2000, 12:58
Volume (IN)	0.59
Precipitation Volume (AC - FT)	42.52
Loss Volume (AC - FT)	34.98
Excess Volume (AC - FT)	7.54
Direct Runoff Volume (AC - FT)	7.39
Baseflow Volume (AC - FT)	0



Junction: B3 Junction

Downstream : Ditch B1

Results: B3 Junction	
Peak Discharge (CFS)	152.69
Time of Peak Discharge	01Jan2000, 12:07
Volume (IN)	2.91

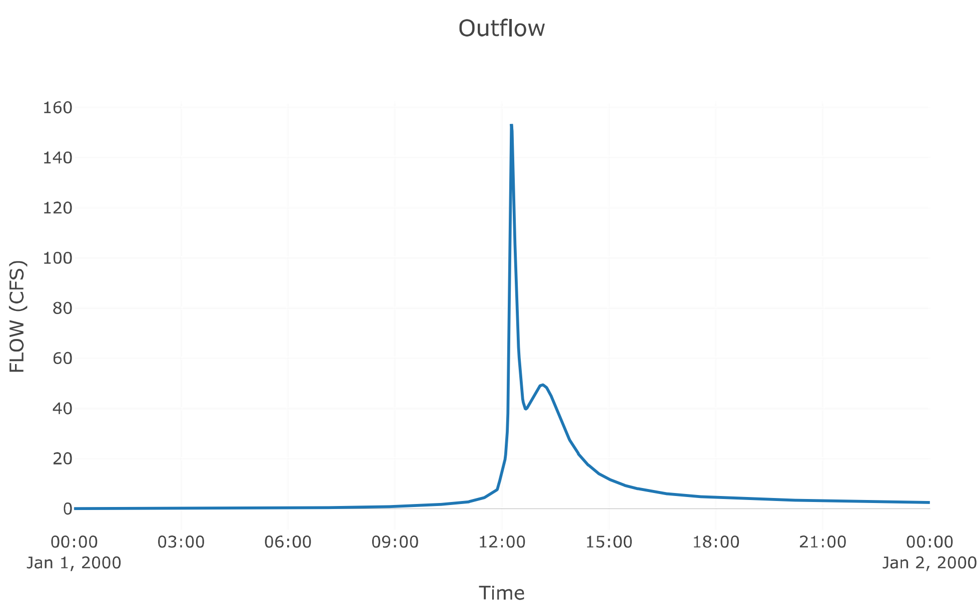


Reach: Ditch B1

Downstream : Ditch B2

Route: Kinematic Wave	
Method	Kinematic Wave
Channel	Kinematic Wave
Length (FT)	2769
Energy Slope (FT/FT)	0.01
Mannings n	0.04
Shape	Trapezoid
Number of Subreaches	2
Width (FT)	8
Side Slope (FT/FT)	5
Initial Variable	Combined Inflow
Index Parameter Type	Index Flow
Index Flow	0.05

Results: Ditch B1	
Peak Discharge (CFS)	153.37
Time of Peak Discharge	01Jan2000, 12:16
Volume (IN)	0.93
Peak Inflow (CFS)	153.79
Inflow Volume (AC - FT)	13.88



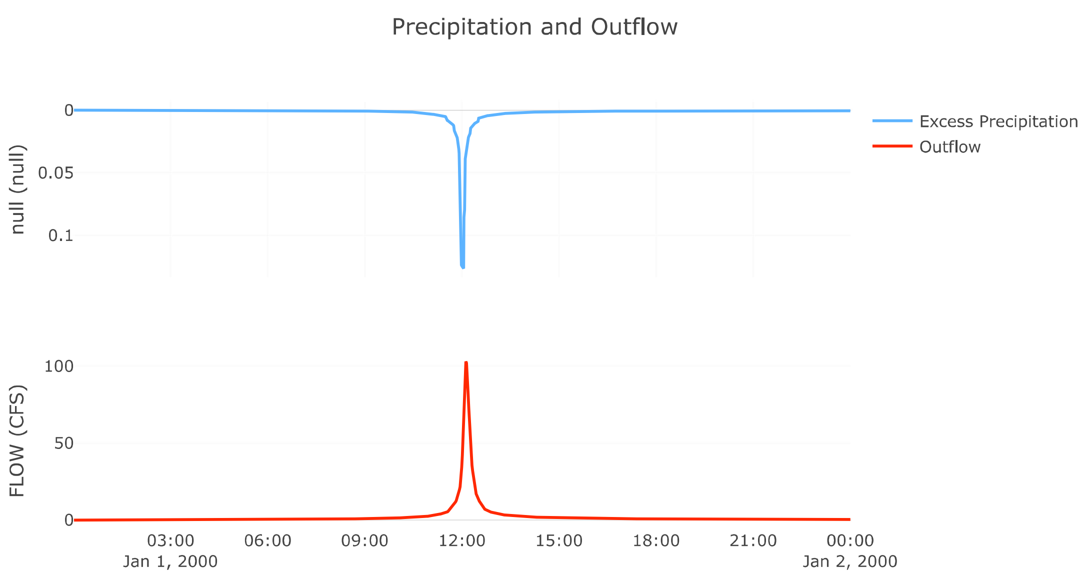
Subbasin: B2

Area (MI2) : 0.03
Downstream : B2 Junction

Loss Rate: Scs	
Percent Impervious Area	0
Curve Number	96

Transform: Scs	
Lag	6.2
Unitgraph Type	Standard

Results: B2	
Peak Discharge (CFS)	102.97
Time of Peak Discharge	01Jan2000, 12:07
Volume (IN)	2.91
Precipitation Volume (AC - FT)	5.08
Loss Volume (AC - FT)	0.68
Excess Volume (AC - FT)	4.4
Direct Runoff Volume (AC - FT)	4.39
Baseflow Volume (AC - FT)	0



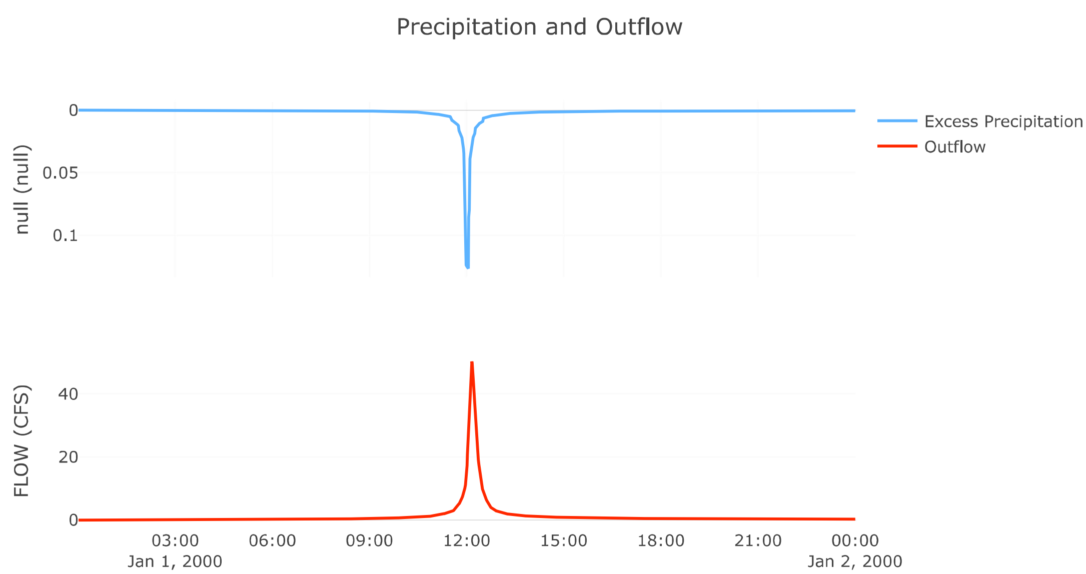
Subbasin: B5

Area (MI2) : 0.02
Downstream : B2 Junction

Loss Rate: Scs	
Percent Impervious Area	0
Curve Number	96

Transform: Scs	
Lag	8.1
Unitgraph Type	Standard

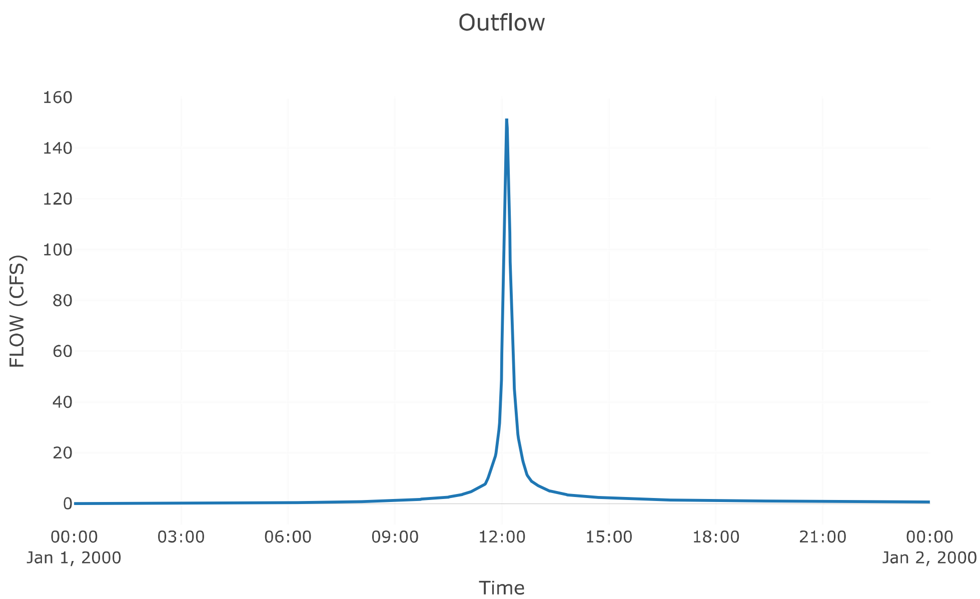
Results: B5	
Peak Discharge (CFS)	50.31
Time of Peak Discharge	01Jan2000, 12:09
Volume (IN)	2.91
Precipitation Volume (AC - FT)	2.78
Loss Volume (AC - FT)	0.37
Excess Volume (AC - FT)	2.41
Direct Runoff Volume (AC - FT)	2.4
Baseflow Volume (AC - FT)	0



Junction: B2 Junction

Downstream : Ditch B2

Results: B2 Junction	
Peak Discharge (CFS)	151.58
Time of Peak Discharge	01Jan2000, 12:08
Volume (IN)	2.91



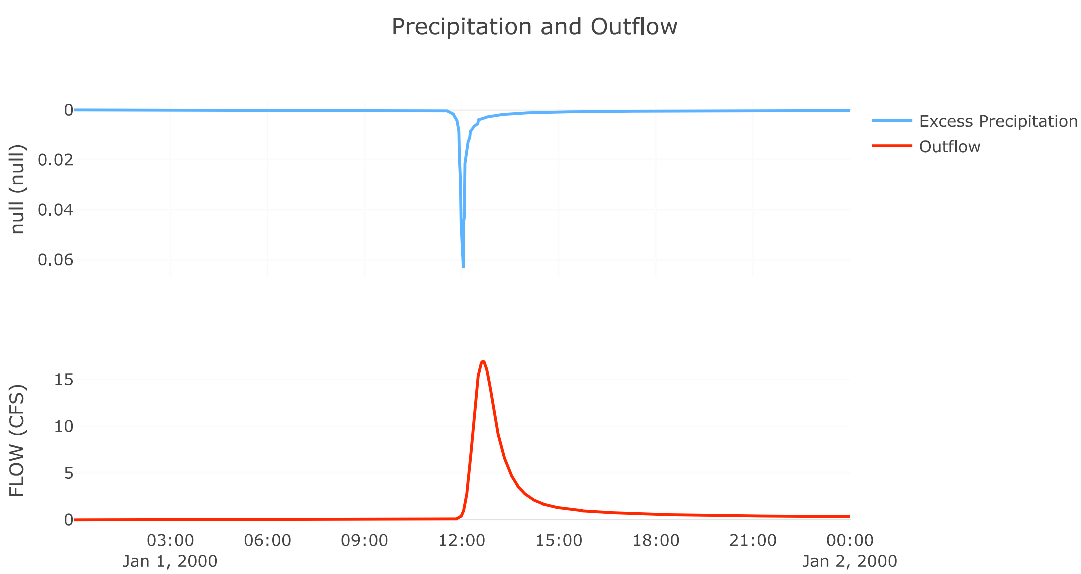
Subbasin: B7

Area (MI2) : 0.03
Downstream : Ditch B2

Loss Rate: Scs	
Percent Impervious Area	0
Curve Number	75

Transform: Scs	
Lag	33.4
Unitgraph Type	Standard

Results: B7	
Peak Discharge (CFS)	16.94
Time of Peak Discharge	01Jan2000, 12:39
Volume (IN)	1.2
Precipitation Volume (AC - FT)	5.45
Loss Volume (AC - FT)	3.49
Excess Volume (AC - FT)	1.96
Direct Runoff Volume (AC - FT)	1.94
Baseflow Volume (AC - FT)	0



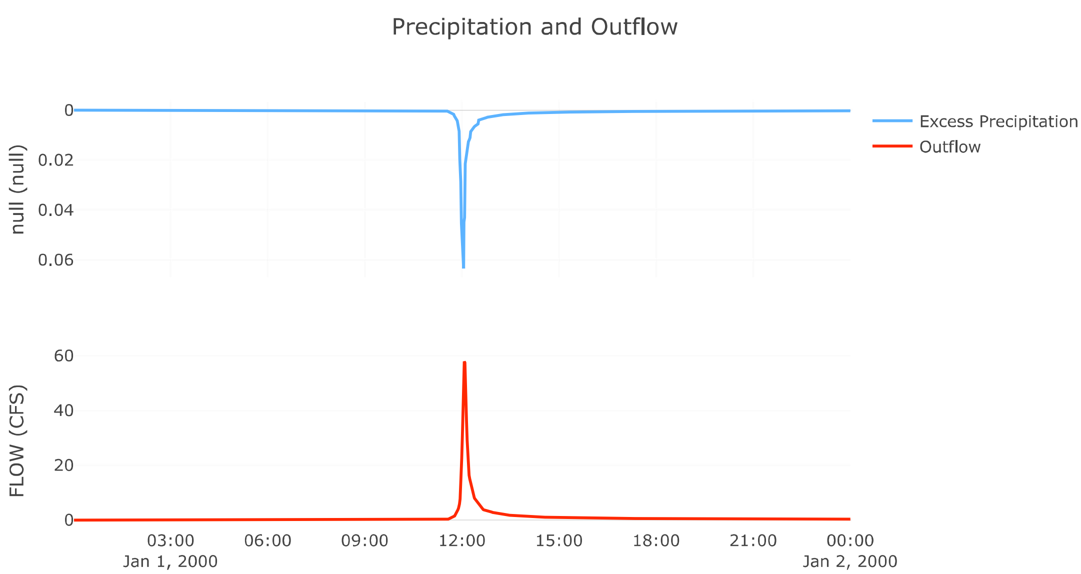
Subbasin: B8

Area (MI2) : 0.03
Downstream : Ditch B2

Loss Rate: Scs	
Percent Impervious Area	0
Curve Number	75

Transform: Scs	
Lag	2.4
Unitgraph Type	Standard

Results: B8	
Peak Discharge (CFS)	57.85
Time of Peak Discharge	01Jan2000, 12:04
Volume (IN)	1.21
Precipitation Volume (AC - FT)	5.03
Loss Volume (AC - FT)	3.22
Excess Volume (AC - FT)	1.81
Direct Runoff Volume (AC - FT)	1.8
Baseflow Volume (AC - FT)	0

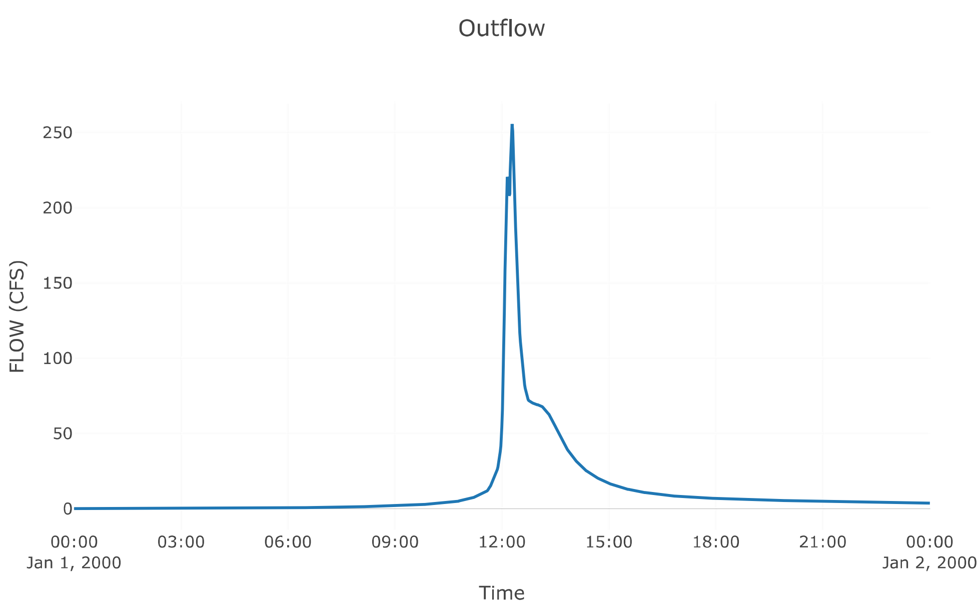


Reach: Ditch B2

Downstream : Basin BC

Route: Kinematic Wave	
Method	Kinematic Wave
Channel	Kinematic Wave
Length (FT)	1596
Energy Slope (FT/FT)	0.03
Mannings n	0.04
Shape	Trapezoid
Number of Subreaches	2
Width (FT)	8
Side Slope (FT/FT)	5
Initial Variable	Combined Inflow
Index Parameter Type	Index Flow
Index Flow	0.05

Results: Ditch B2	
Peak Discharge (CFS)	255.58
Time of Peak Discharge	01Jan2000, 12:17
Volume (IN)	1.19
Peak Inflow (CFS)	255.87
Inflow Volume (AC - FT)	24.29



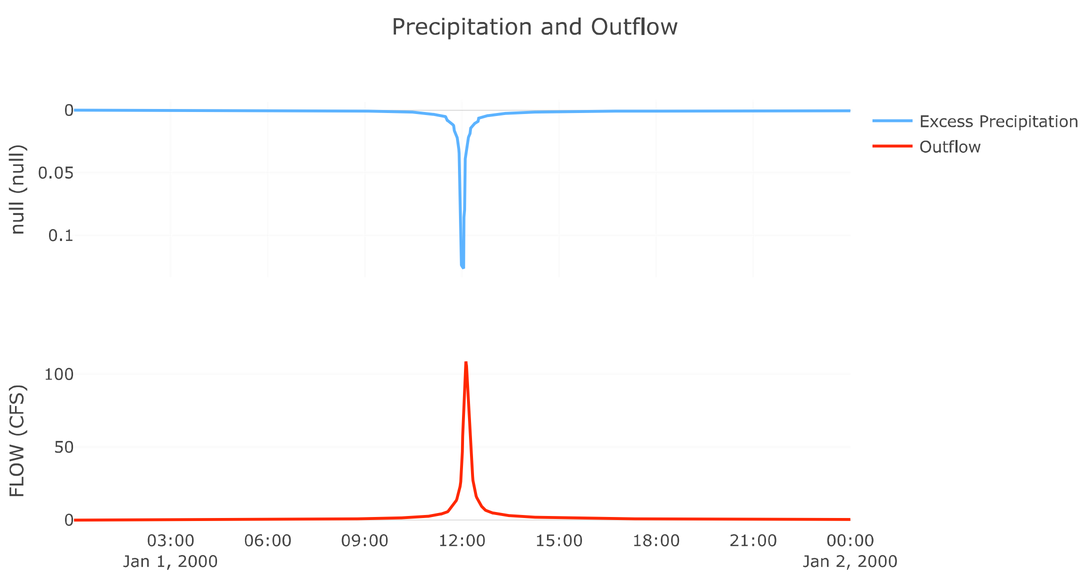
Subbasin: C1

Area (MI2) : 0.03
Downstream : C1 Junction

Loss Rate: Scs	
Percent Impervious Area	0
Curve Number	96

Transform: Scs	
Lag	5.7
Unitgraph Type	Standard

Results: C1	
Peak Discharge (CFS)	108.67
Time of Peak Discharge	01Jan2000, 12:07
Volume (IN)	2.91
Precipitation Volume (AC - FT)	5.2
Loss Volume (AC - FT)	0.7
Excess Volume (AC - FT)	4.5
Direct Runoff Volume (AC - FT)	4.49
Baseflow Volume (AC - FT)	0



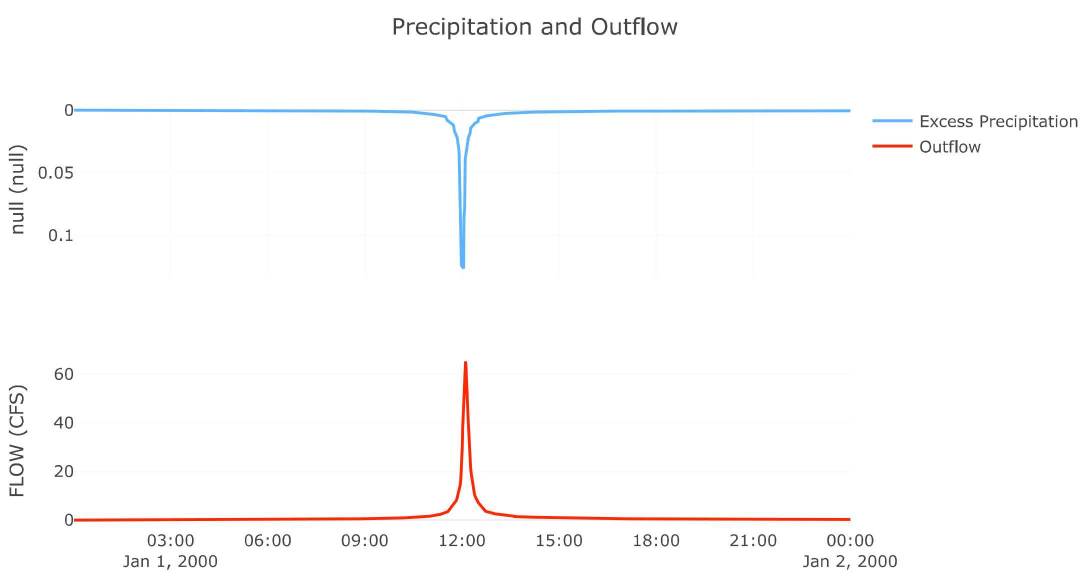
Subbasin: C2

Area (MI2) : 0.02
Downstream : C1 Junction

Loss Rate: Scs	
Percent Impervious Area	0
Curve Number	96

Transform: Scs	
Lag	5
Unitgraph Type	Standard

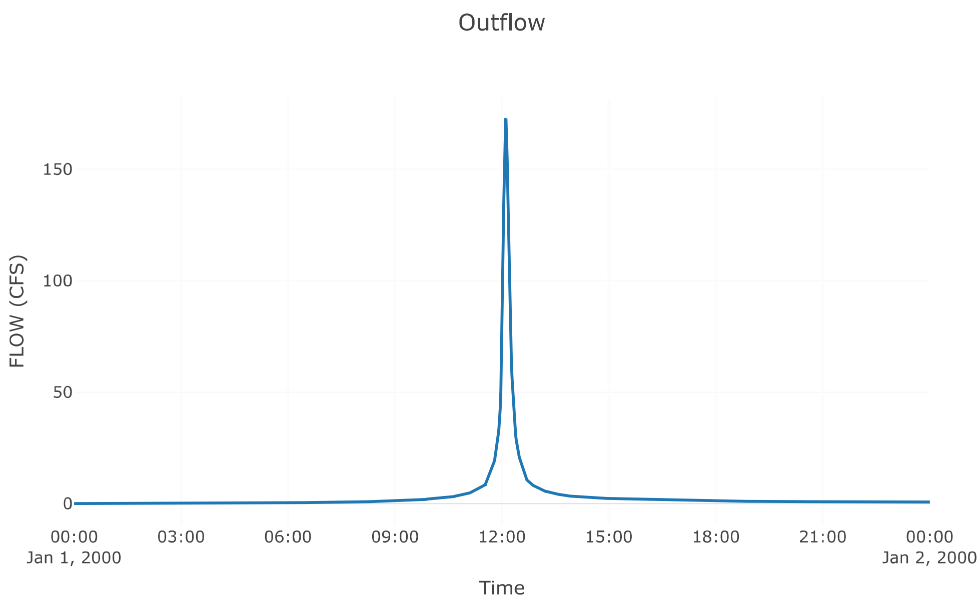
Results: C2	
Peak Discharge (CFS)	65.17
Time of Peak Discharge	01Jan2000, 12:06
Volume (IN)	2.91
Precipitation Volume (AC - FT)	2.98
Loss Volume (AC - FT)	0.4
Excess Volume (AC - FT)	2.58
Direct Runoff Volume (AC - FT)	2.57
Baseflow Volume (AC - FT)	0



Junction: C1 Junction

Downstream : Ditch C1

Results: C1 Junction	
Peak Discharge (CFS)	172.68
Time of Peak Discharge	01Jan2000, 12:07
Volume (IN)	2.91

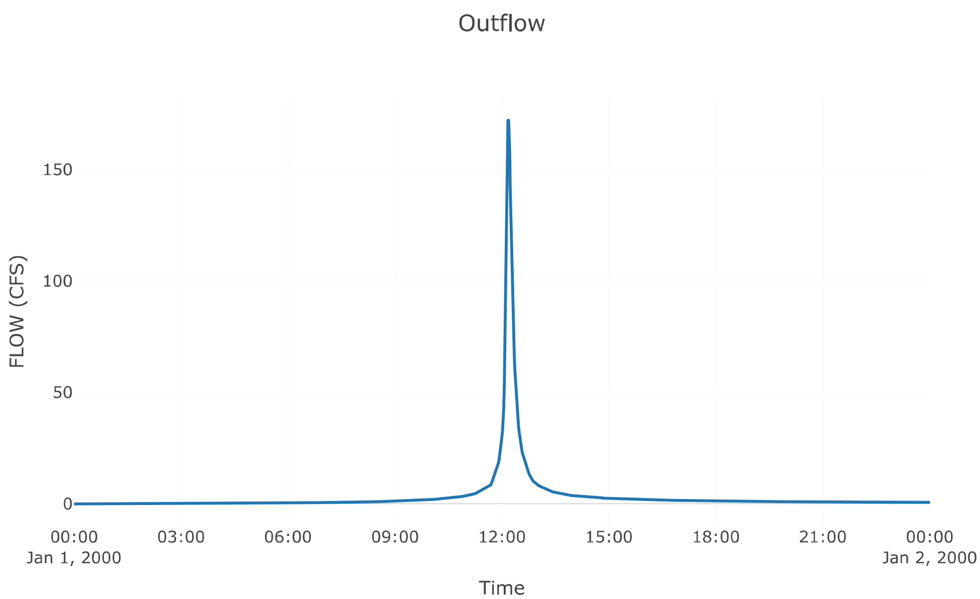


Reach: Ditch C1

Downstream : Culvert C2

Route: Kinematic Wave	
Method	Kinematic Wave
Channel	Kinematic Wave
Length (FT)	2080
Energy Slope (FT/FT)	0.02
Mannings n	0.04
Shape	Trapezoid
Number of Subreaches	2
Width (FT)	8
Side Slope (FT/FT)	5
Initial Variable	Combined Inflow
Index Parameter Type	Index Flow
Index Flow	0.05

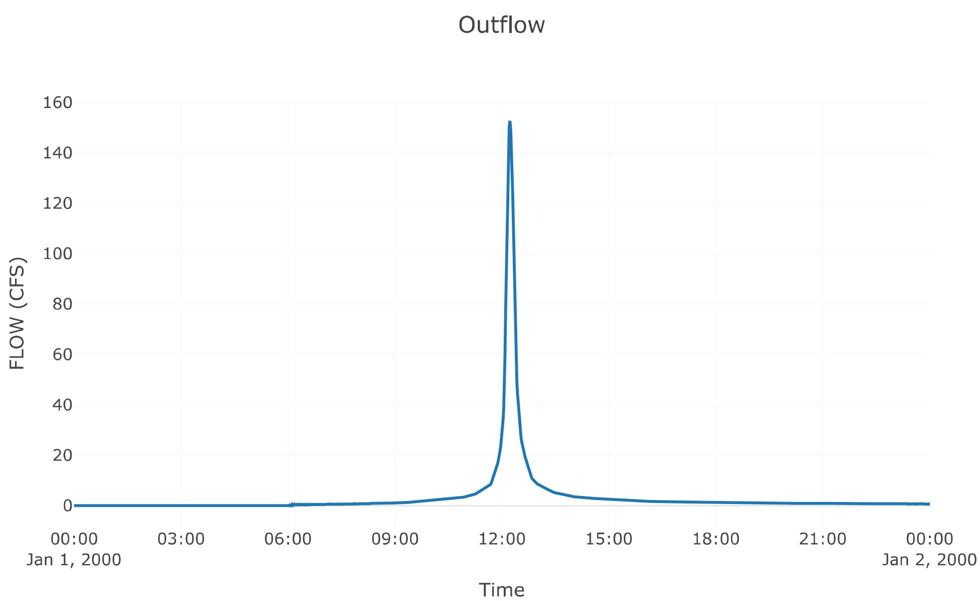
Results: Ditch C1	
Peak Discharge (CFS)	172.63
Time of Peak Discharge	01Jan2000, 12:11
Volume (IN)	2.9
Peak Inflow (CFS)	172.68
Inflow Volume (AC - FT)	7.07



Reservoir: Culvert C2

Downstream : Ditch C2

Results: Culvert C2	
Peak Discharge (CFS)	152.65
Time of Peak Discharge	01Jan2000, 12:13
Volume (IN)	2.89
Peak Inflow (CFS)	172.63
Time of Peak Inflow	01Jan2000, 12:11
Inflow Volume (AC - FT)	7.04
Maximum Storage (AC - FT)	0.39
Peak Elevation (FT)	3934.7
Discharge Volume (AC - FT)	7.01



Subbasin: C3

Area (MI2) : 0.02
Downstream : Ditch C2

Loss Rate: Scs

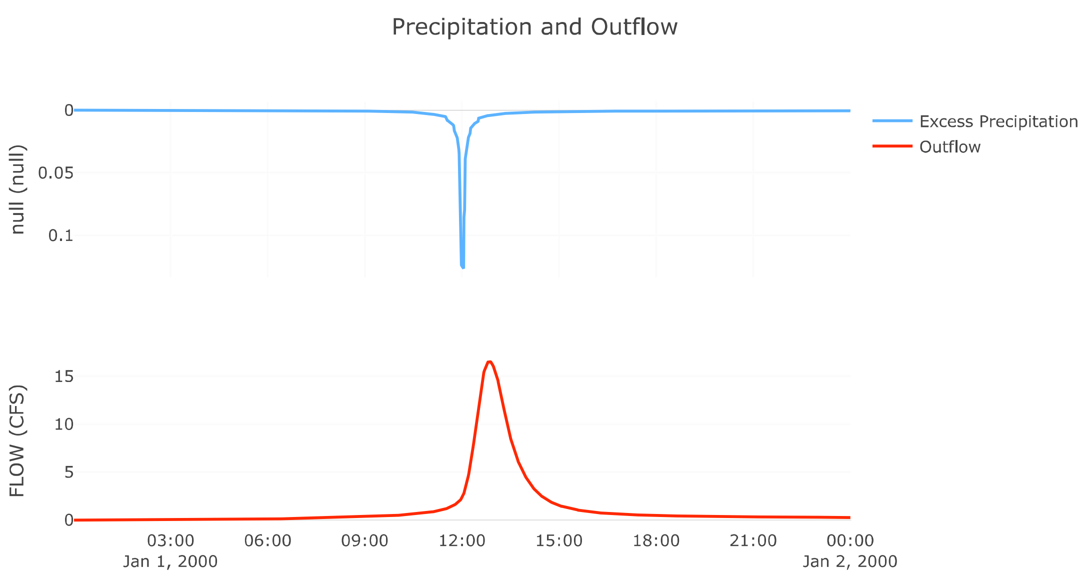
Percent Impervious Area	0
Curve Number	96

Transform: Scs

Lag	48.6
Unitgraph Type	Standard

Results: C3

Peak Discharge (CFS)	16.53
Time of Peak Discharge	01Jan2000, 12:51
Volume (IN)	2.89
Precipitation Volume (AC - FT)	2.86
Loss Volume (AC - FT)	0.39
Excess Volume (AC - FT)	2.48
Direct Runoff Volume (AC - FT)	2.46
Baseflow Volume (AC - FT)	0



Reach: Ditch C2

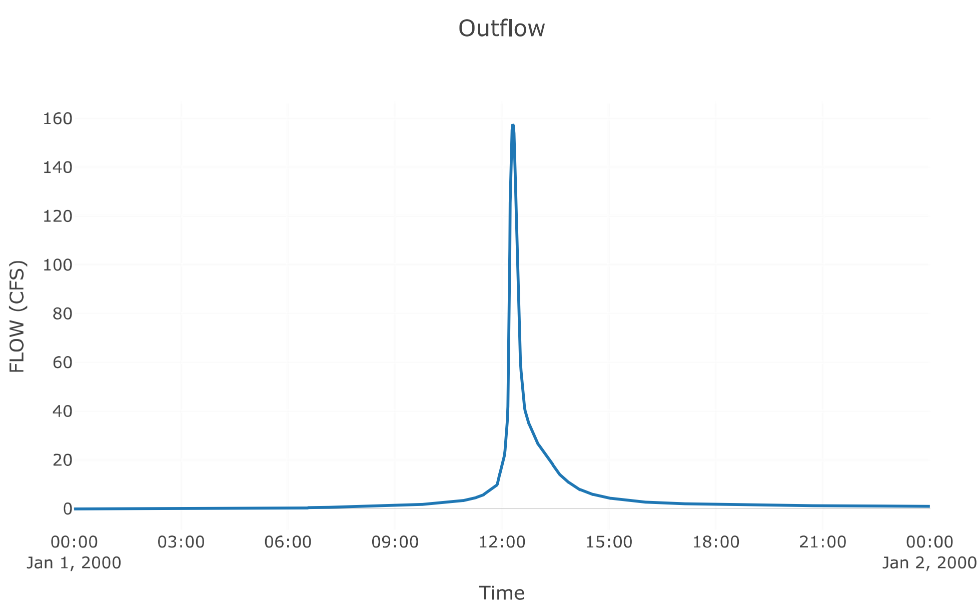
Downstream : Basin BC

Route: Kinematic Wave

Method	Kinematic Wave
Channel	Kinematic Wave
Length (FT)	2335
Energy Slope (FT/FT)	0.02
Mannings n	0.04
Shape	Trapezoid
Number of Subreaches	2
Width (FT)	8
Side Slope (FT/FT)	5
Initial Variable	Combined Inflow
Index Parameter Type	Index Flow
Index Flow	0.05

Results: Ditch C2

Peak Discharge (CFS)	157.7
Time of Peak Discharge	01Jan2000, 12:18
Volume (IN)	2.88
Peak Inflow (CFS)	157.73
Inflow Volume (AC - FT)	9.47

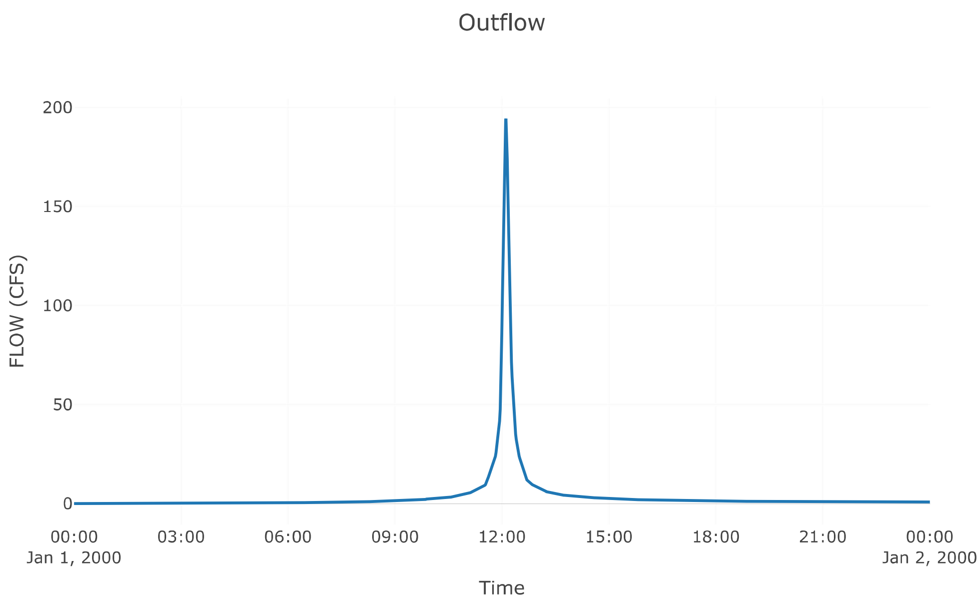


Junction: B1 Junction

Downstream : Basin BC

Results: B1 Junction

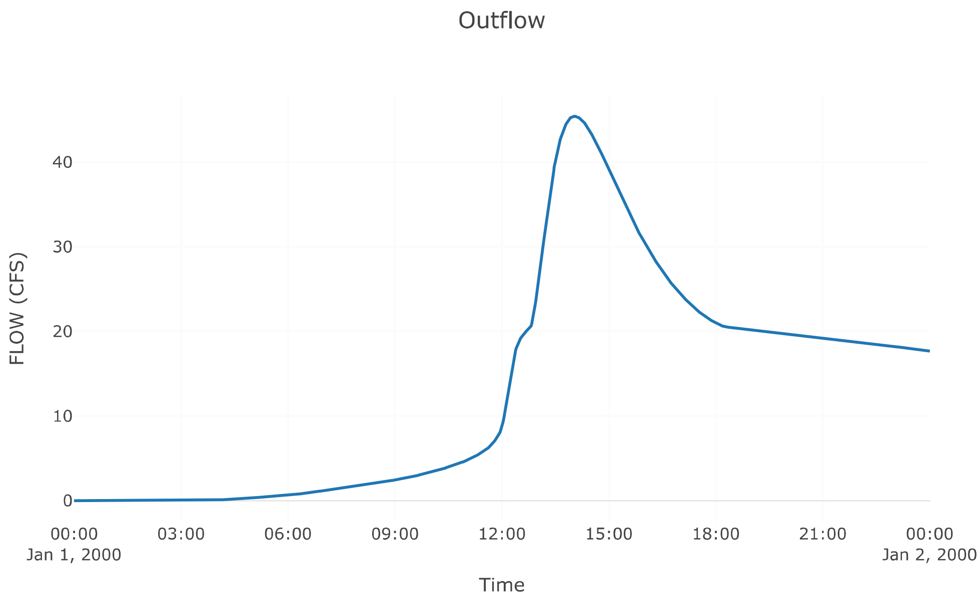
Peak Discharge (CFS)	194.34
Time of Peak Discharge	01Jan2000, 12:07
Volume (IN)	2.91



Reservoir: Basin BC

Downstream : Outfall BC

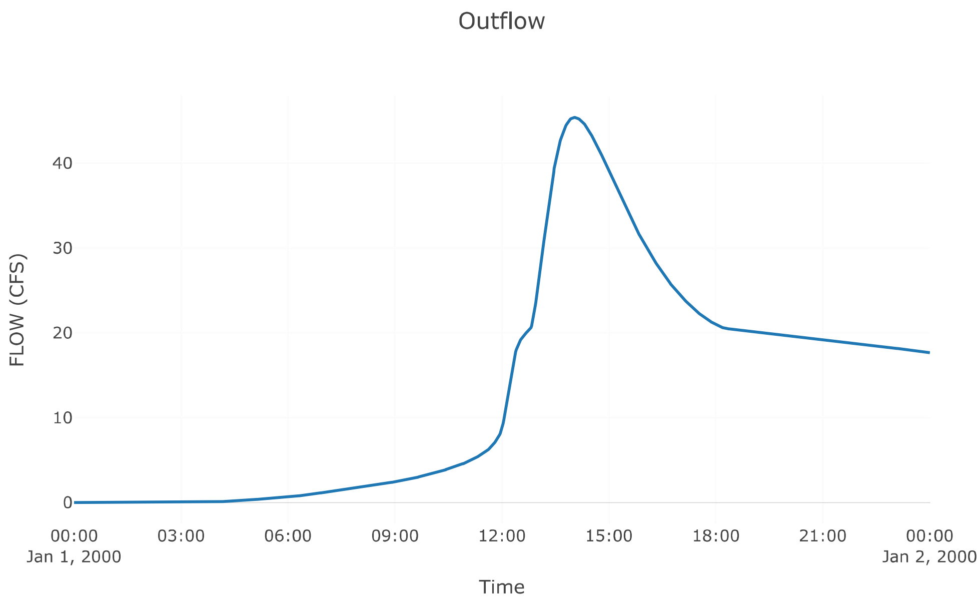
Results: Basin BC	
Peak Discharge (CFS)	45.42
Time of Peak Discharge	01Jan2000, 14:02
Volume (IN)	1
Peak Inflow (CFS)	474.75
Time of Peak Inflow	01Jan2000, 12:17
Inflow Volume (AC - FT)	41.63
Maximum Storage (AC - FT)	29.04
Peak Elevation (FT)	3895.84
Discharge Volume (AC - FT)	26.2



Sink: Outfall BC

Results: Outfall BC

Peak Discharge (CFS)	45.42
Time of Peak Discharge	01Jan2000, 14:02
Volume (IN)	1



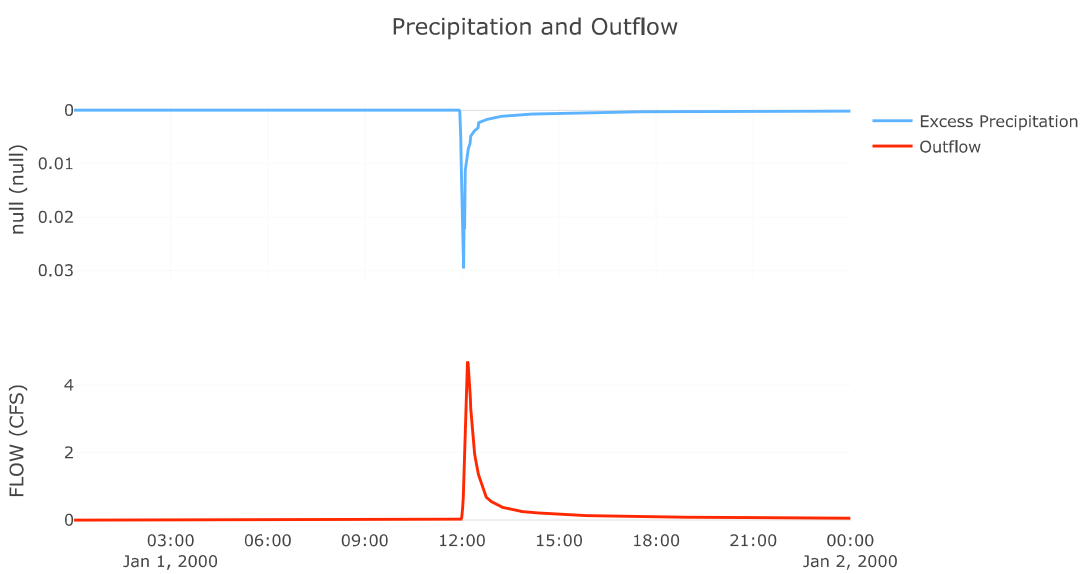
Subbasin: A1

Area (MI2) : 0.01
Downstream : Outfall A

Loss Rate: Scs	
Percent Impervious Area	0
Curve Number	63

Transform: Scs	
Lag	6.9
Unitgraph Type	Standard

Results: A1	
Peak Discharge (CFS)	4.7
Time of Peak Discharge	01Jan2000, 12:10
Volume (IN)	0.6
Precipitation Volume (AC - FT)	1.4
Loss Volume (AC - FT)	1.16
Excess Volume (AC - FT)	0.25
Direct Runoff Volume (AC - FT)	0.25
Baseflow Volume (AC - FT)	0



Subbasin: D4

Area (MI2) : 0.01
Downstream : D4 Junction

Loss Rate: Scs

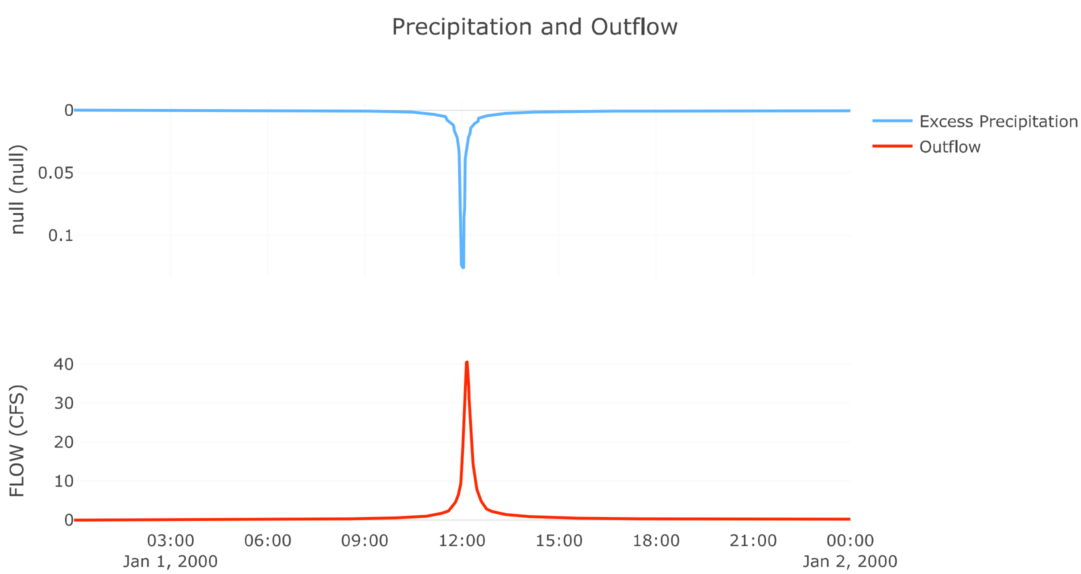
Percent Impervious Area	0
Curve Number	96

Transform: Scs

Lag	7.4
Unitgraph Type	Standard

Results: D4

Peak Discharge (CFS)	40.66
Time of Peak Discharge	01Jan2000, 12:08
Volume (IN)	2.91
Precipitation Volume (AC - FT)	2.16
Loss Volume (AC - FT)	0.29
Excess Volume (AC - FT)	1.87
Direct Runoff Volume (AC - FT)	1.87
Baseflow Volume (AC - FT)	0



Subbasin: D6

Area (MI2) : 0.02
Downstream : Ditch D1

Loss Rate: Scs

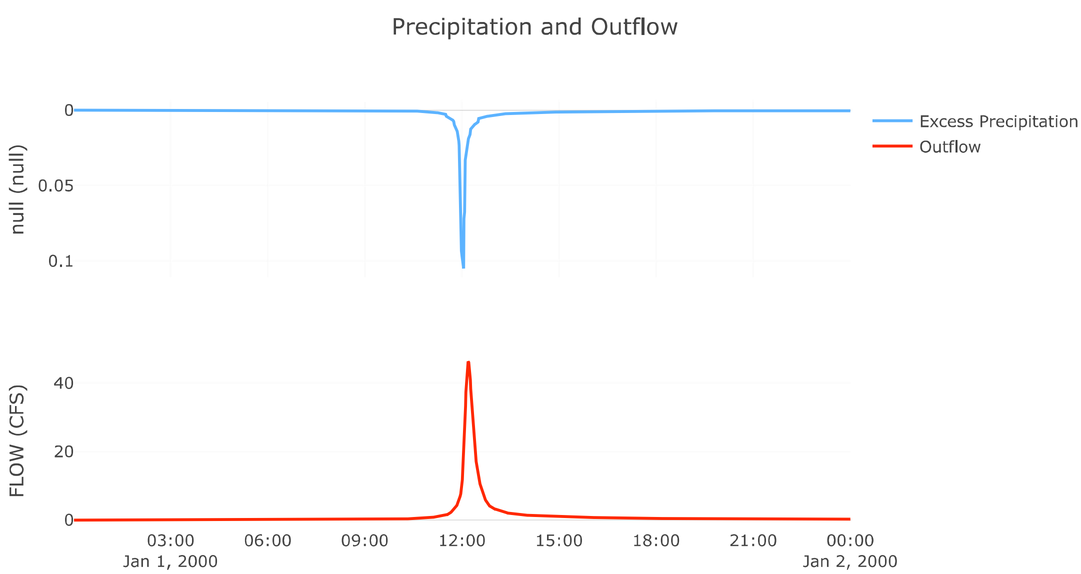
Percent Impervious Area	0
Curve Number	88

Transform: Scs

Lag	9.9
Unitgraph Type	Standard

Results: D6

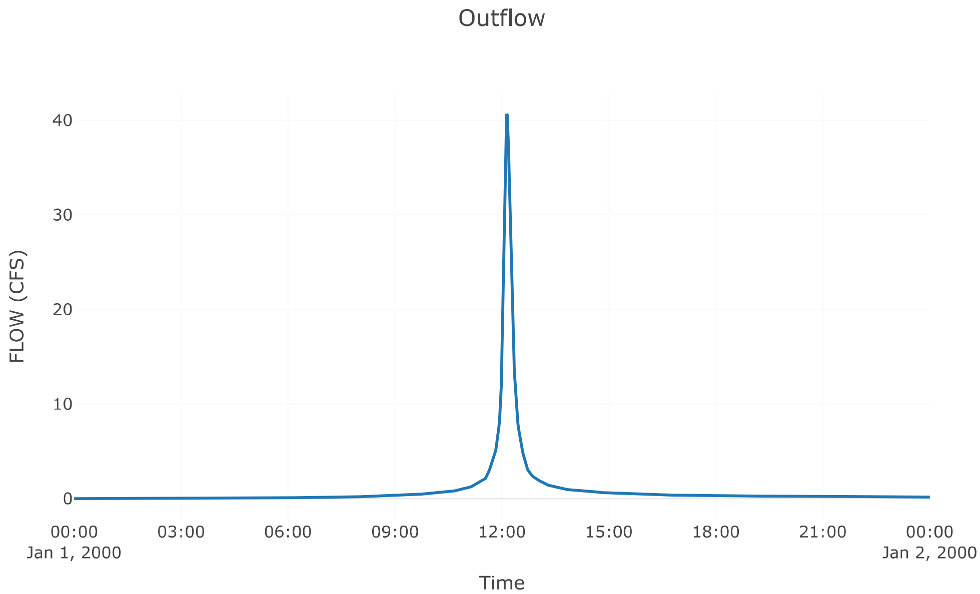
Peak Discharge (CFS)	46.3
Time of Peak Discharge	01Jan2000, 12:11
Volume (IN)	2.15
Precipitation Volume (AC - FT)	3.62
Loss Volume (AC - FT)	1.31
Excess Volume (AC - FT)	2.31
Direct Runoff Volume (AC - FT)	2.31
Baseflow Volume (AC - FT)	0



Junction: D4 Junction

Downstream : Ditch D1

Results: D4 Junction	
Peak Discharge (CFS)	40.66
Time of Peak Discharge	01Jan2000, 12:08
Volume (IN)	2.91



Reach: Ditch D1

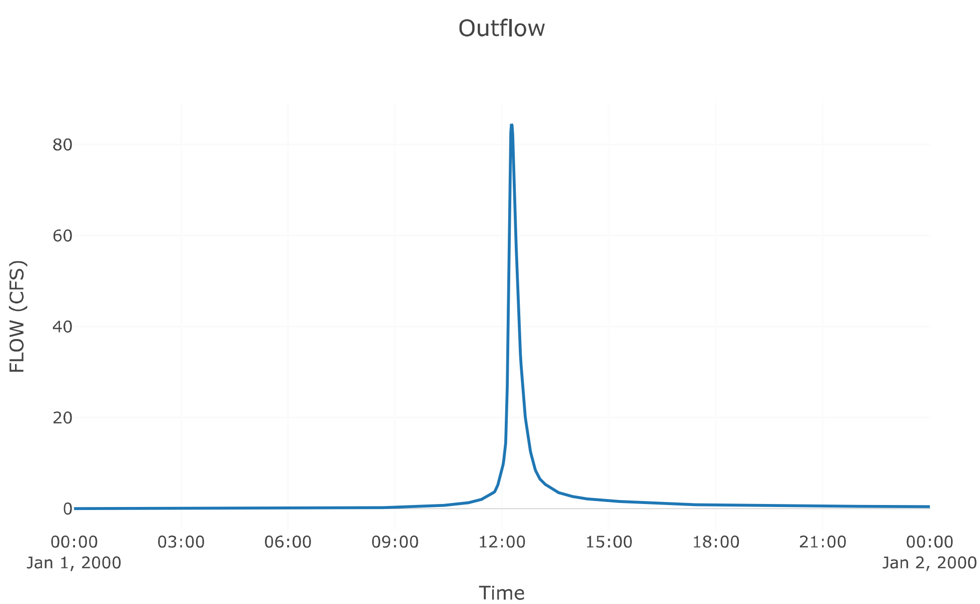
Downstream : D1 Junction

Route: Kinematic Wave

Method	Kinematic Wave
Channel	Kinematic Wave
Length (FT)	1300
Energy Slope (FT/FT)	0
Mannings n	0.04
Shape	Trapezoid
Number of Subreaches	2
Width (FT)	8
Side Slope (FT/FT)	5
Initial Variable	Combined Inflow
Index Parameter Type	Index Flow
Index Flow	0.05

Results: Ditch D1

Peak Discharge (CFS)	84.51
Time of Peak Discharge	01Jan2000, 12:16
Volume (IN)	2.42
Peak Inflow (CFS)	84.8
Inflow Volume (AC - FT)	4.18



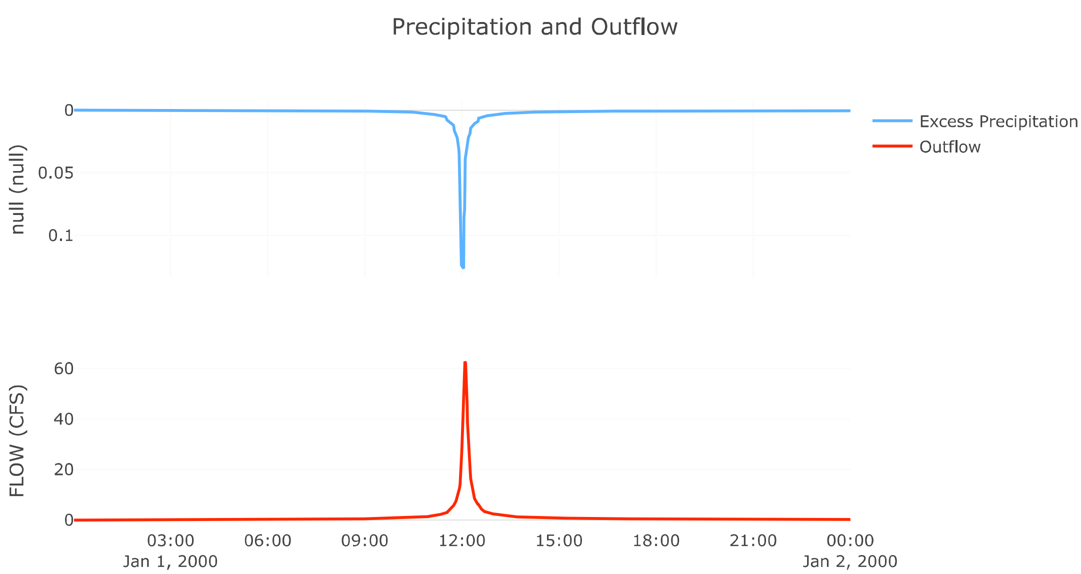
Subbasin: D1

Area (MI2) : 0.02
Downstream : D1 Junction

Loss Rate: Scs	
Percent Impervious Area	0
Curve Number	96

Transform: Scs	
Lag	4.17
Unitgraph Type	Standard

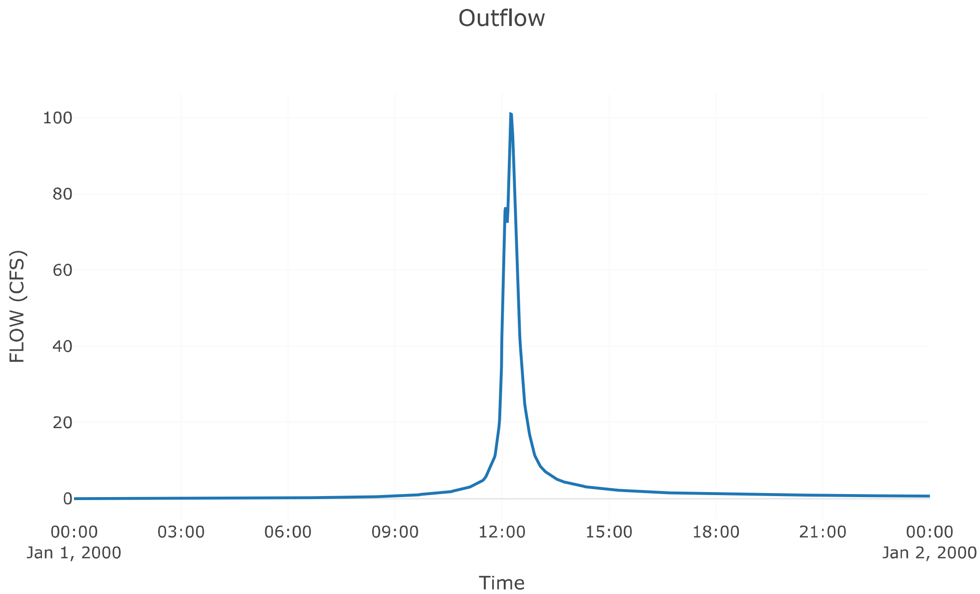
Results: D1	
Peak Discharge (CFS)	62.74
Time of Peak Discharge	01Jan2000, 12:05
Volume (IN)	2.91
Precipitation Volume (AC - FT)	2.72
Loss Volume (AC - FT)	0.37
Excess Volume (AC - FT)	2.36
Direct Runoff Volume (AC - FT)	2.36
Baseflow Volume (AC - FT)	0



Junction: D1 Junction

Downstream : Ditch D2

Results: D1 Junction	
Peak Discharge (CFS)	100.95
Time of Peak Discharge	01Jan2000, 12:15
Volume (IN)	2.58



Subbasin: D5

Area (MI2) : 0.04
Downstream : Ditch D2

Loss Rate: Scs

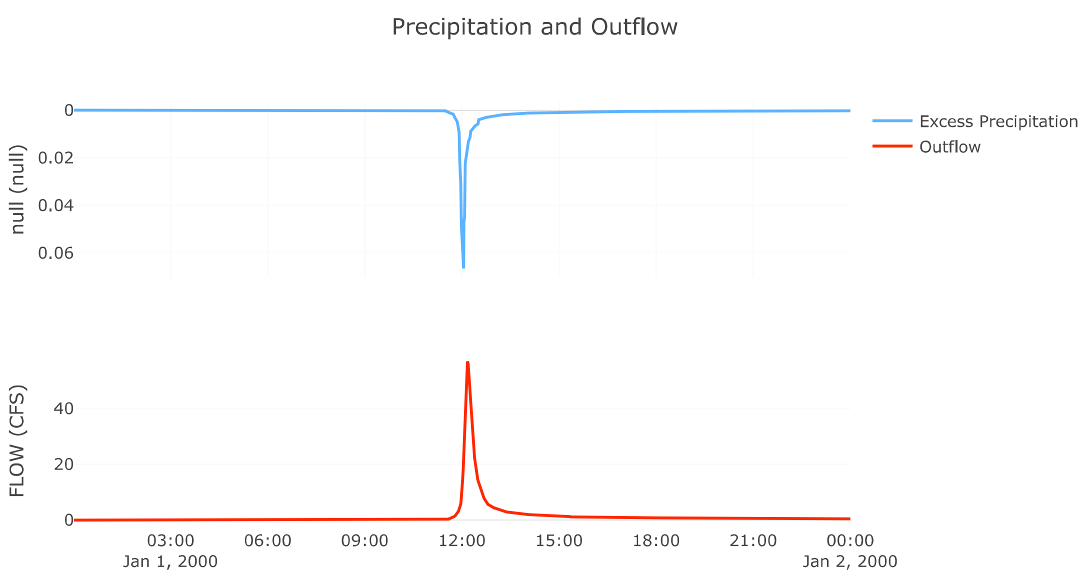
Percent Impervious Area	0
Curve Number	76

Transform: Scs

Lag	8.1
Unitgraph Type	Standard

Results: D5

Peak Discharge (CFS)	56.82
Time of Peak Discharge	01Jan2000, 12:10
Volume (IN)	1.27
Precipitation Volume (AC - FT)	6.96
Loss Volume (AC - FT)	4.34
Excess Volume (AC - FT)	2.63
Direct Runoff Volume (AC - FT)	2.62
Baseflow Volume (AC - FT)	0



Subbasin: D3

Area (MI2) : 0.02
Downstream : Ditch D2

Loss Rate: Scs

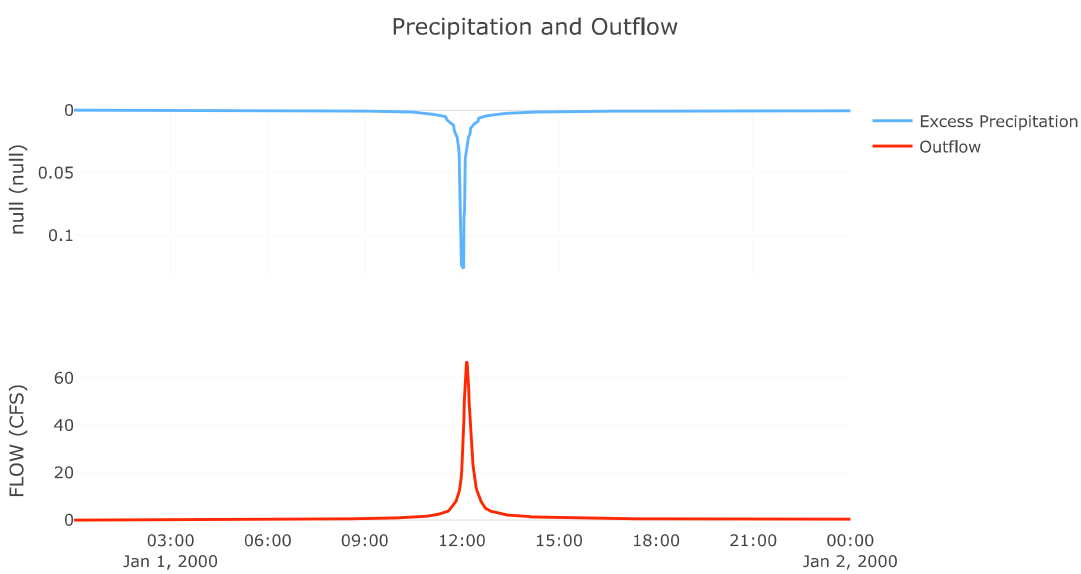
Percent Impervious Area	0
Curve Number	96

Transform: Scs

Lag	7.2
Unitgraph Type	Standard

Results: D3

Peak Discharge (CFS)	66.92
Time of Peak Discharge	01Jan2000, 12:08
Volume (IN)	2.91
Precipitation Volume (AC - FT)	3.51
Loss Volume (AC - FT)	0.47
Excess Volume (AC - FT)	3.04
Direct Runoff Volume (AC - FT)	3.03
Baseflow Volume (AC - FT)	0



Reach: Ditch D2

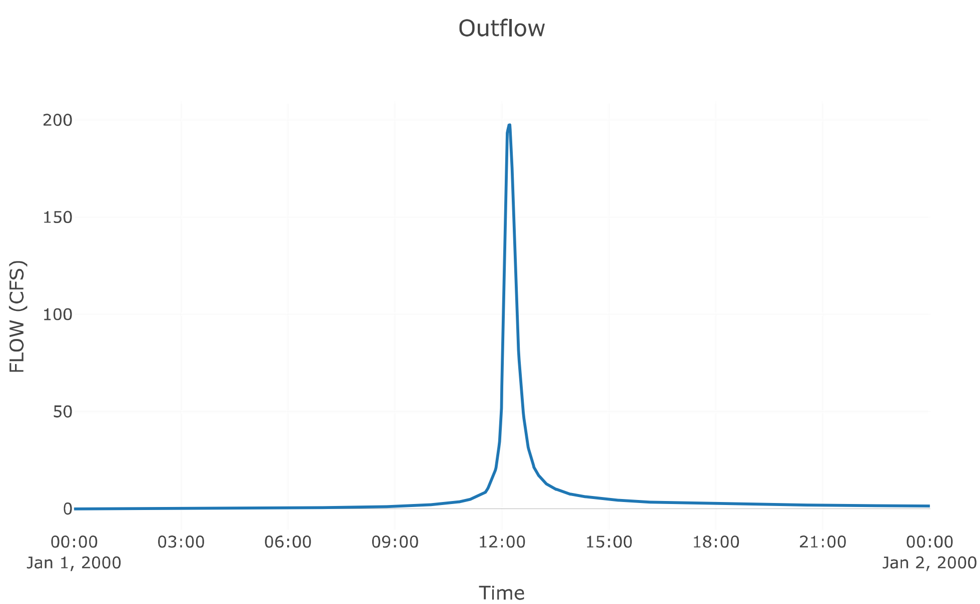
Downstream : Junction - 2

Route: Kinematic Wave

Method	Kinematic Wave
Channel	Kinematic Wave
Length (FT)	400
Energy Slope (FT/FT)	0.02
Mannings n	0.04
Shape	Trapezoid
Number of Subreaches	2
Width (FT)	8
Side Slope (FT/FT)	5
Initial Variable	Combined Inflow
Index Parameter Type	Index Flow
Index Flow	0.05

Results: Ditch D2

Peak Discharge (CFS)	197.9
Time of Peak Discharge	01Jan2000, 12:12
Volume (IN)	2.16
Peak Inflow (CFS)	197.99
Inflow Volume (AC - FT)	12.16

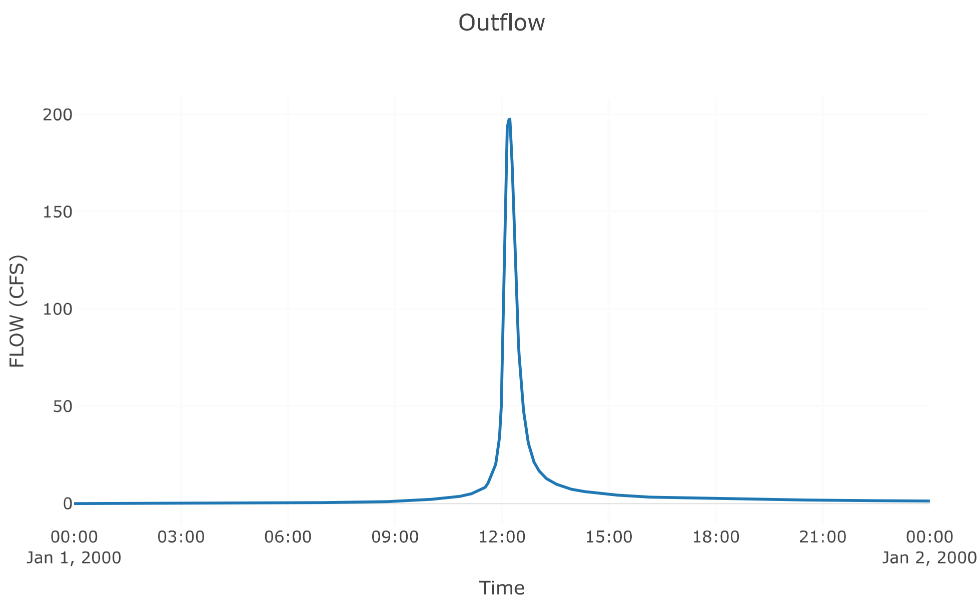


Junction: Junction-2

Downstream : Ditch D3

Results: Junction-2

Peak Discharge (CFS)	197.9
Time of Peak Discharge	01Jan2000, 12:12
Volume (IN)	2.16



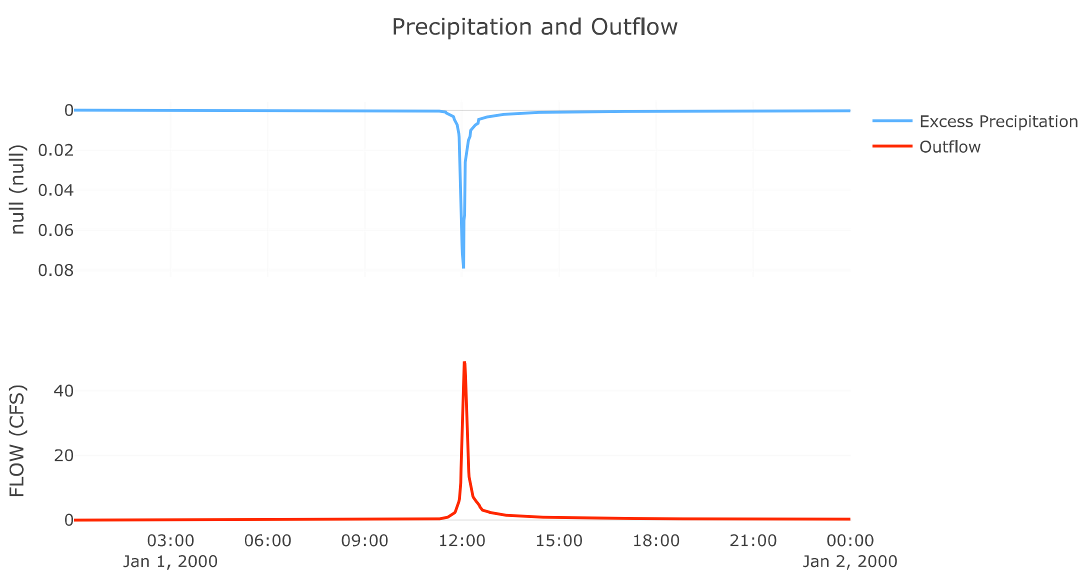
Subbasin: E6

Area (MI2) : 0.02
Downstream : Ditch D3

Loss Rate: Scs	
Percent Impervious Area	0
Curve Number	80

Transform: Scs	
Lag	2.5
Unitgraph Type	Standard

Results: E6	
Peak Discharge (CFS)	49.07
Time of Peak Discharge	01Jan2000, 12:04
Volume (IN)	1.53
Precipitation Volume (AC - FT)	3.34
Loss Volume (AC - FT)	1.82
Excess Volume (AC - FT)	1.52
Direct Runoff Volume (AC - FT)	1.52
Baseflow Volume (AC - FT)	0



Reach: Ditch D3

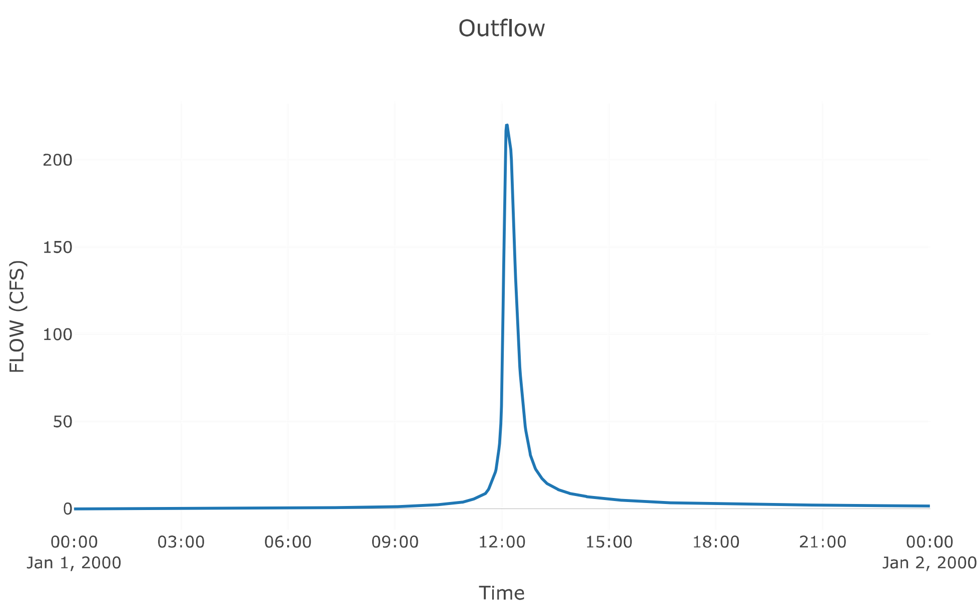
Downstream : Basin DE

Route: Kinematic Wave

Method	Kinematic Wave
Channel	Kinematic Wave
Length (FT)	400
Energy Slope (FT/FT)	0.02
Mannings n	0.04
Shape	Trapezoid
Number of Subreaches	2
Width (FT)	8
Side Slope (FT/FT)	5
Initial Variable	Combined Inflow
Index Parameter Type	Index Flow
Index Flow	0.05

Results: Ditch D3

Peak Discharge (CFS)	220.53
Time of Peak Discharge	01Jan2000, 12:08
Volume (IN)	2.06
Peak Inflow (CFS)	220.55
Inflow Volume (AC - FT)	13.67



Subbasin: E2

Area (MI2) : 0.02
Downstream : E2 Junction

Loss Rate: Scs

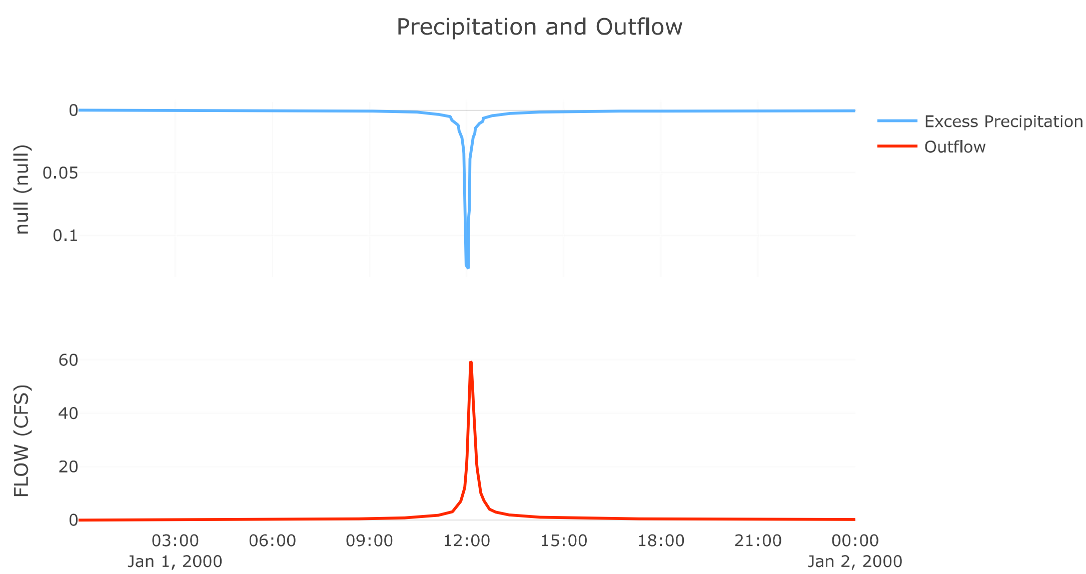
Percent Impervious Area	0
Curve Number	96

Transform: Scs

Lag	6.28
Unitgraph Type	Standard

Results: E2

Peak Discharge (CFS)	59.39
Time of Peak Discharge	01Jan2000, 12:07
Volume (IN)	2.91
Precipitation Volume (AC - FT)	2.95
Loss Volume (AC - FT)	0.4
Excess Volume (AC - FT)	2.55
Direct Runoff Volume (AC - FT)	2.55
Baseflow Volume (AC - FT)	0



Subbasin: E5

Area (MI2) : 0.01
Downstream : E2 Junction

Loss Rate: Scs

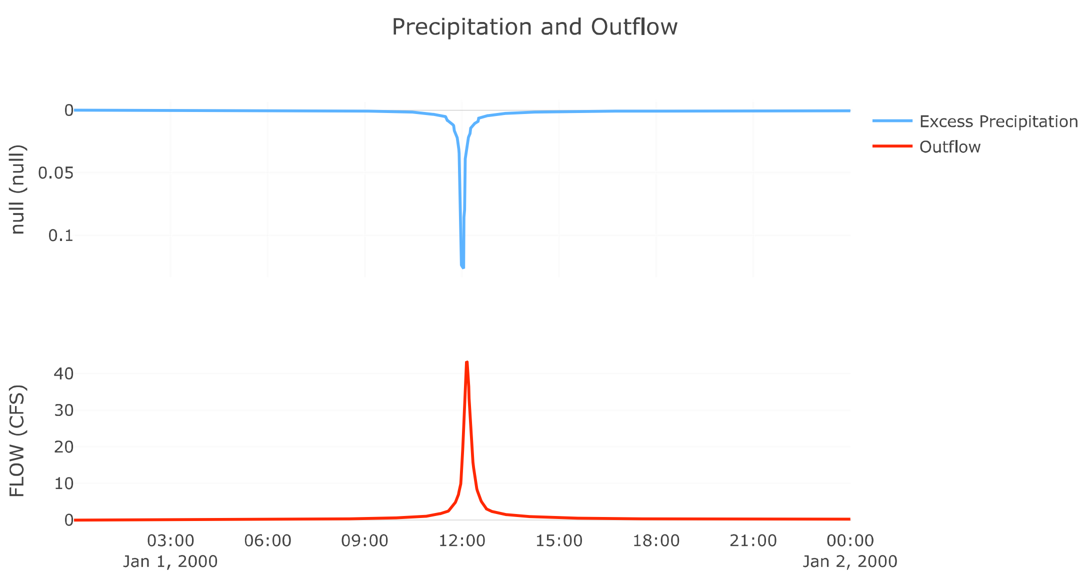
Percent Impervious Area	0
Curve Number	96

Transform: Scs

Lag	7.4
Unitgraph Type	Standard

Results: E5

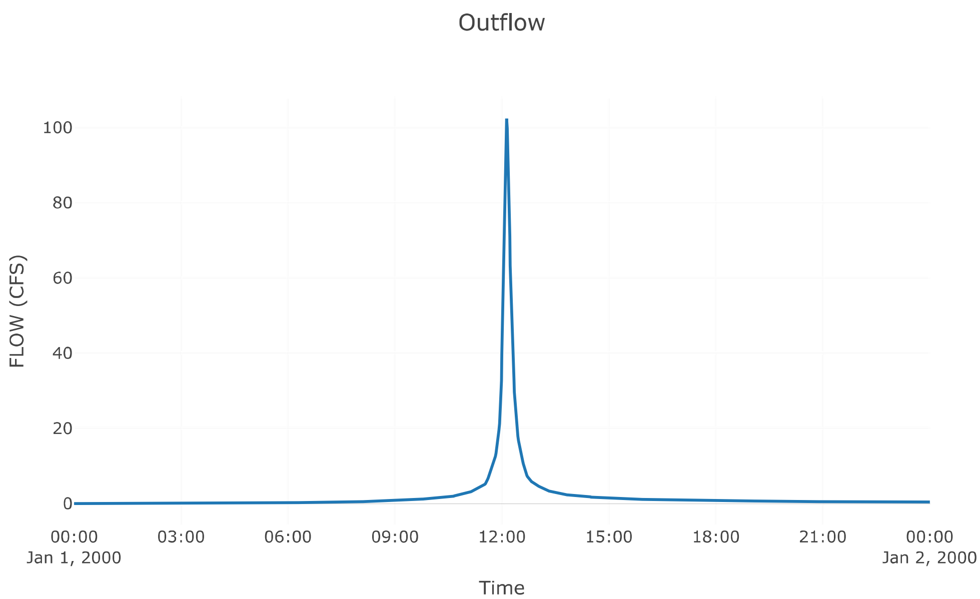
Peak Discharge (CFS)	43.3
Time of Peak Discharge	01Jan2000, 12:08
Volume (IN)	2.91
Precipitation Volume (AC - FT)	2.3
Loss Volume (AC - FT)	0.31
Excess Volume (AC - FT)	1.99
Direct Runoff Volume (AC - FT)	1.99
Baseflow Volume (AC - FT)	0



Junction: E2 Junction

Downstream : Ditch E1

Results: E2 Junction	
Peak Discharge (CFS)	102.35
Time of Peak Discharge	01Jan2000, 12:08
Volume (IN)	2.91



Subbasin: E4

Area (MI2) : 0.02
Downstream : Ditch E1

Loss Rate: Scs

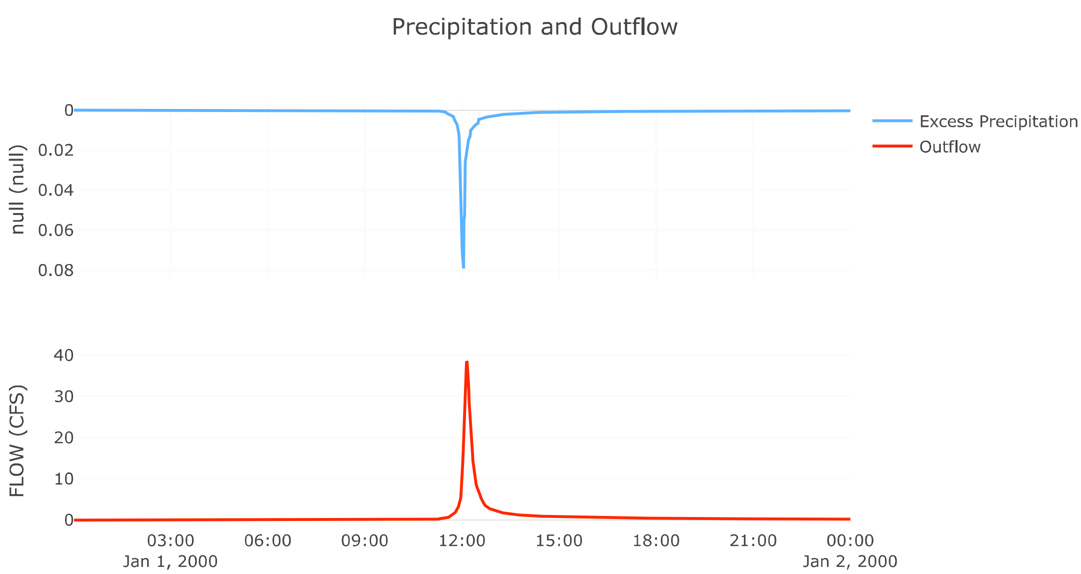
Percent Impervious Area	0
Curve Number	80

Transform: Scs

Lag	6.7
Unitgraph Type	Standard

Results: E4

Peak Discharge (CFS)	38.46
Time of Peak Discharge	01Jan2000, 12:08
Volume (IN)	1.53
Precipitation Volume (AC - FT)	3.51
Loss Volume (AC - FT)	1.91
Excess Volume (AC - FT)	1.6
Direct Runoff Volume (AC - FT)	1.6
Baseflow Volume (AC - FT)	0

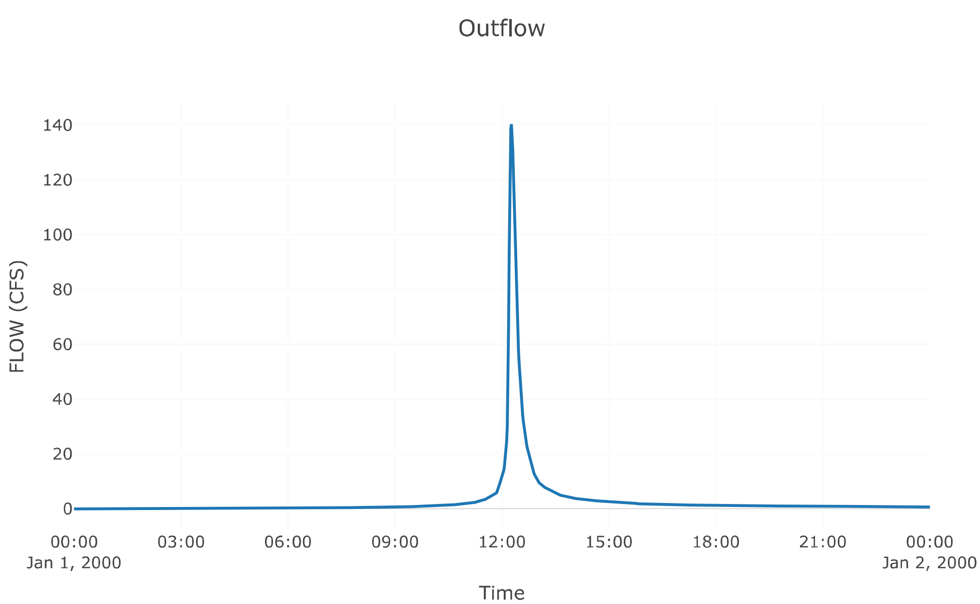


Reach: Ditch E1

Downstream : E1 Junction

Route: Kinematic Wave	
Method	Kinematic Wave
Channel	Kinematic Wave
Length (FT)	2425
Energy Slope (FT/FT)	0.01
Mannings n	0.04
Shape	Trapezoid
Number of Subreaches	2
Width (FT)	8
Side Slope (FT/FT)	5
Initial Variable	Combined Inflow
Index Parameter Type	Index Flow
Index Flow	0.05

Results: Ditch E1	
Peak Discharge (CFS)	140.36
Time of Peak Discharge	01Jan2000, 12:16
Volume (IN)	2.34
Peak Inflow (CFS)	140.81
Inflow Volume (AC - FT)	6.14



Subbasin: E3

Area (MI2) : 0.02
Downstream : E1 Junction

Loss Rate: Scs

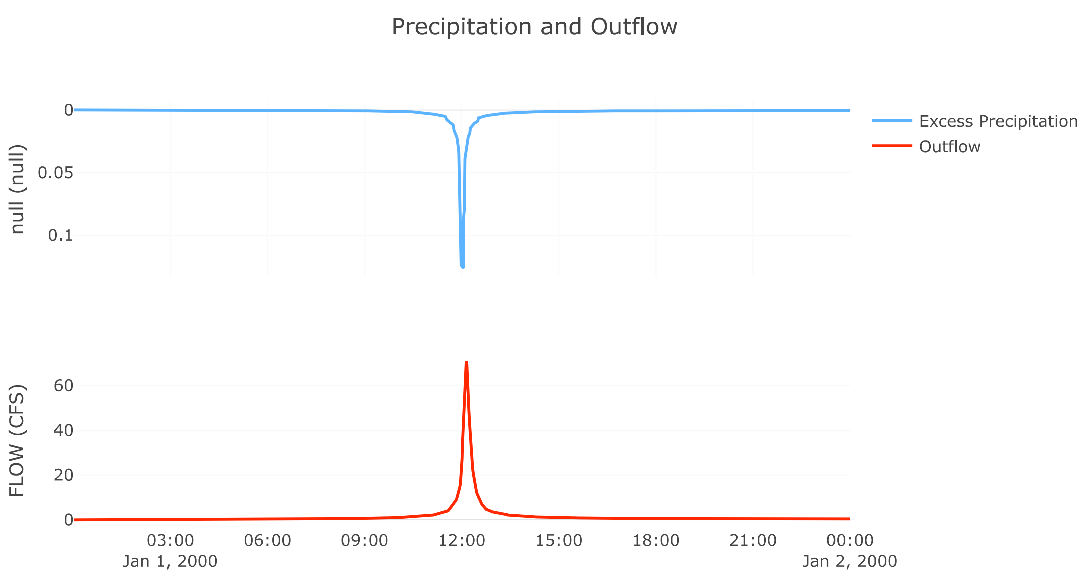
Percent Impervious Area	0
Curve Number	96

Transform: Scs

Lag	6.8
Unitgraph Type	Standard

Results: E3

Peak Discharge (CFS)	70.78
Time of Peak Discharge	01Jan2000, 12:08
Volume (IN)	2.91
Precipitation Volume (AC - FT)	3.62
Loss Volume (AC - FT)	0.49
Excess Volume (AC - FT)	3.14
Direct Runoff Volume (AC - FT)	3.13
Baseflow Volume (AC - FT)	0



Subbasin: E1

Area (MI2) : 0.02
Downstream : E1 Junction

Loss Rate: Scs

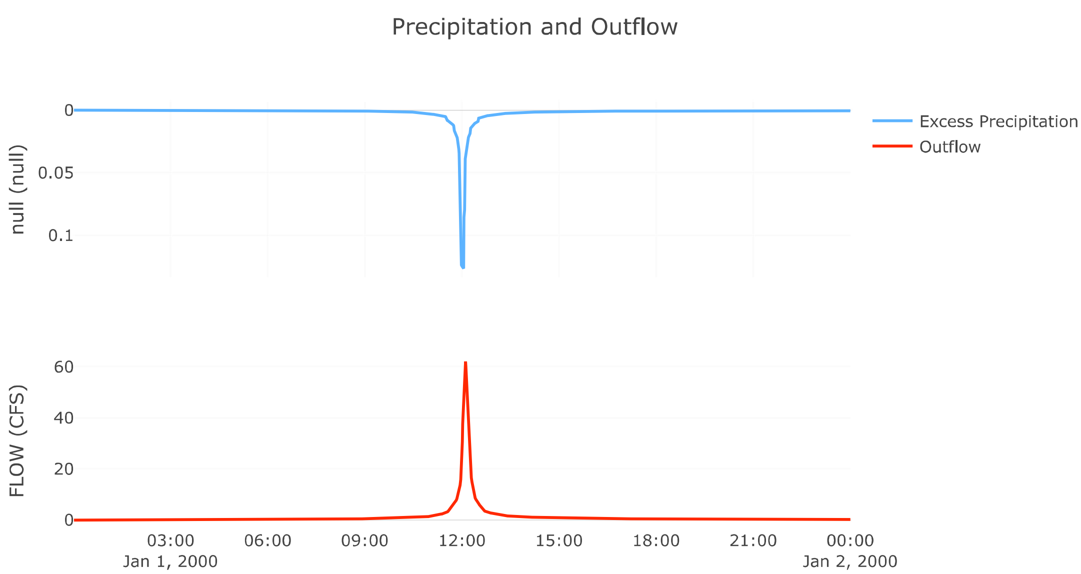
Percent Impervious Area	0
Curve Number	96

Transform: Scs

Lag	4.68
Unitgraph Type	Standard

Results: E1

Peak Discharge (CFS)	62.06
Time of Peak Discharge	01Jan2000, 12:06
Volume (IN)	2.91
Precipitation Volume (AC - FT)	2.78
Loss Volume (AC - FT)	0.37
Excess Volume (AC - FT)	2.41
Direct Runoff Volume (AC - FT)	2.4
Baseflow Volume (AC - FT)	0

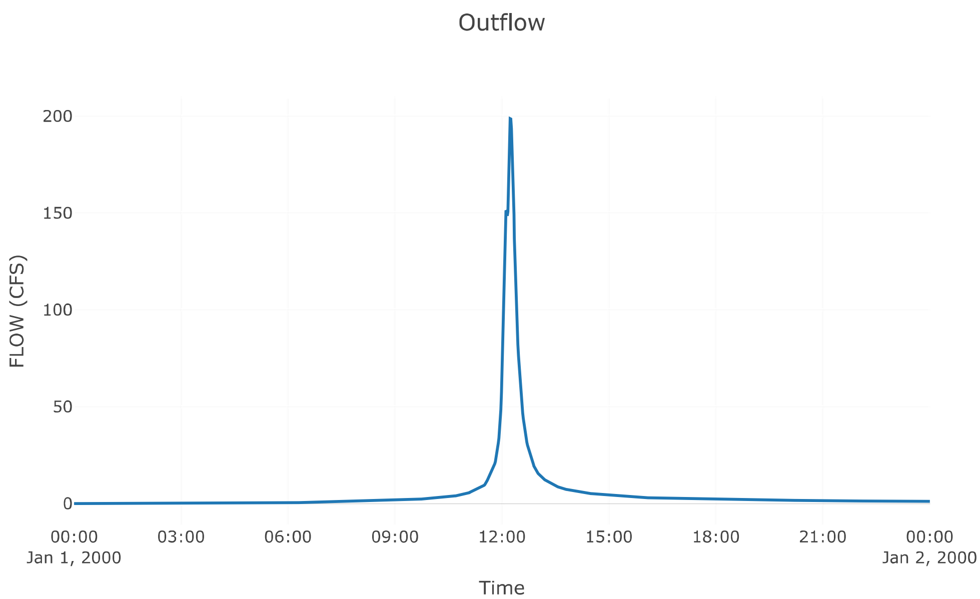


Junction: E1 Junction

Downstream : Culvert E2

Results: E1 Junction

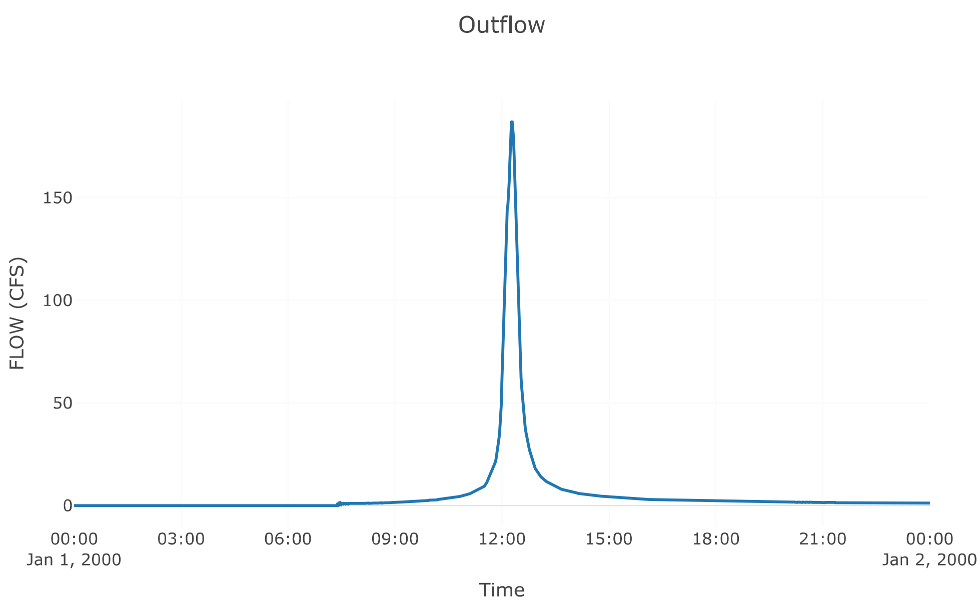
Peak Discharge (CFS)	198.7
Time of Peak Discharge	01Jan2000, 12:14
Volume (IN)	2.58



Reservoir: Culvert E2

Downstream : Ditch E2

Results: Culvert E2	
Peak Discharge (CFS)	187.42
Time of Peak Discharge	01Jan2000, 12:17
Volume (IN)	2.56
Peak Inflow (CFS)	198.7
Time of Peak Inflow	01Jan2000, 12:14
Inflow Volume (AC - FT)	11.62
Maximum Storage (AC - FT)	1.25
Peak Elevation (FT)	3955.95
Discharge Volume (AC - FT)	11.51



Reach: Ditch E2

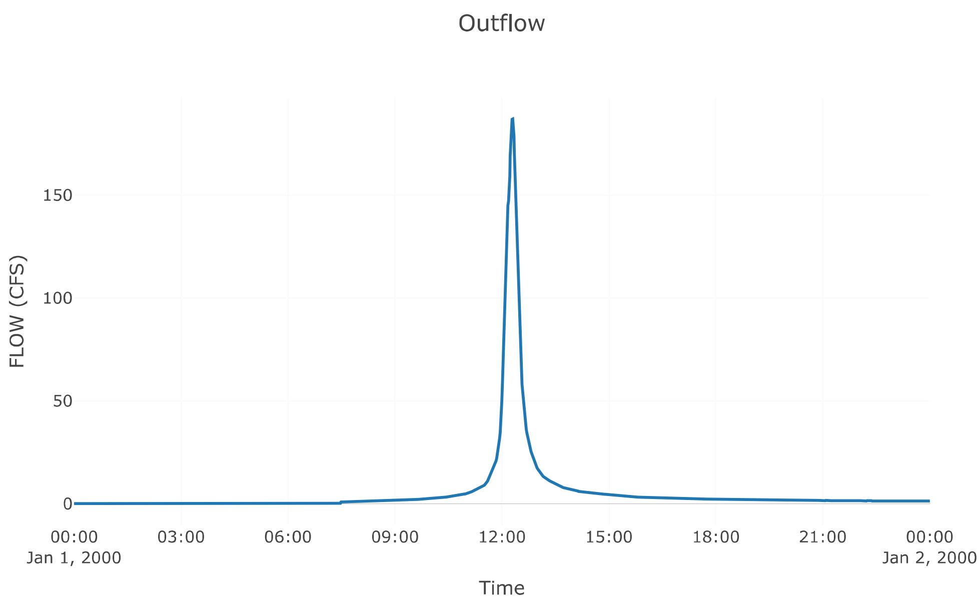
Downstream : Basin DE

Route: Kinematic Wave

Method	Kinematic Wave
Channel	Kinematic Wave
Length (FT)	570
Energy Slope (FT/FT)	0.05
Mannings n	0.04
Shape	Trapezoid
Number of Subreaches	2
Width (FT)	8
Side Slope (FT/FT)	5
Initial Variable	Combined Inflow
Index Parameter Type	Index Flow
Index Flow	0.05

Results: Ditch E2

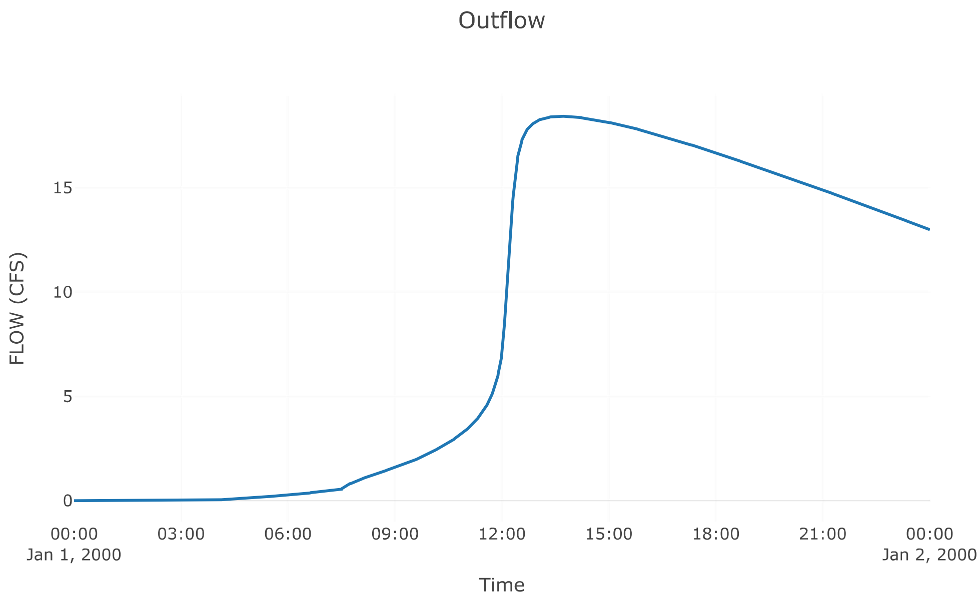
Peak Discharge (CFS)	186.94
Time of Peak Discharge	01Jan2000, 12:18
Volume (IN)	2.56
Peak Inflow (CFS)	187.42
Inflow Volume (AC - FT)	11.51



Reservoir: Basin DE

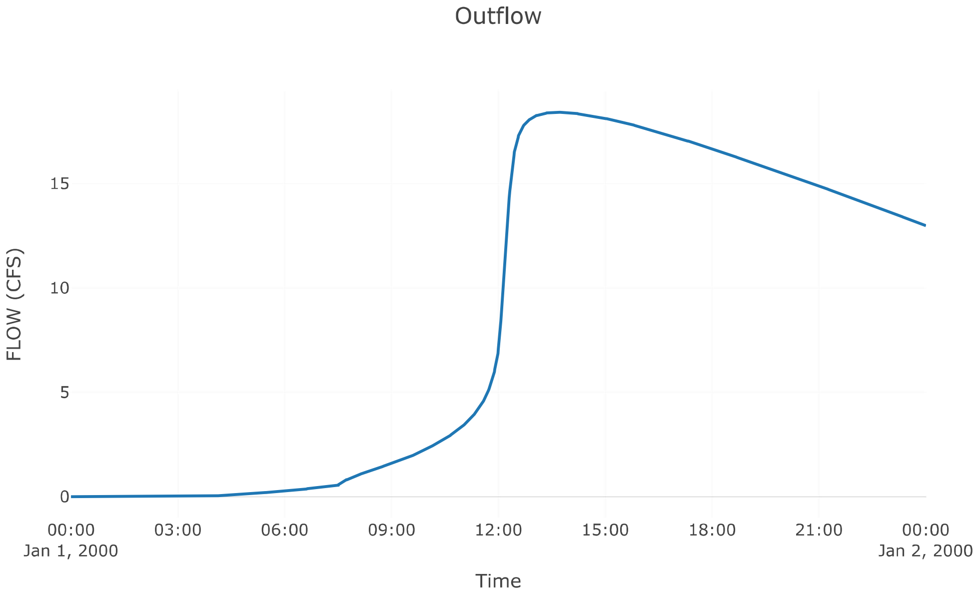
Downstream : Outfall DE

Results: Basin DE	
Peak Discharge (CFS)	18.42
Time of Peak Discharge	01Jan2000, 13:40
Volume (IN)	1.53
Peak Inflow (CFS)	383.35
Time of Peak Inflow	01Jan2000, 12:16
Inflow Volume (AC - FT)	25.16
Maximum Storage (AC - FT)	21.25
Peak Elevation (FT)	3930.52
Discharge Volume (AC - FT)	16.97



Sink: Outfall DE

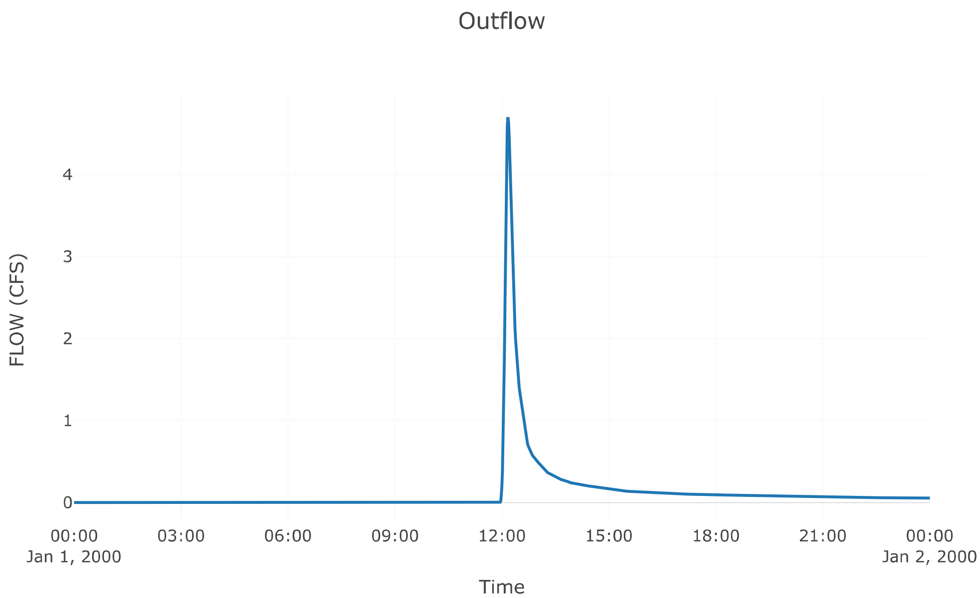
Results: Outfall DE	
Peak Discharge (CFS)	18.42
Time of Peak Discharge	01Jan2000, 13:40
Volume (IN)	1.53



Sink: Outfall A

Results: Outfall A

Peak Discharge (CFS)	4.7
Time of Peak Discharge	01Jan2000, 12:10
Volume (IN)	0.6



EL PASO, TEXAS
RAINFALL DATA

NOAA Atlas 14, Volume 11, Version 2
Location name: El Paso, Texas, USA*
Latitude: 31.5954°, Longitude: -106.1722°
Elevation: 3938 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sandra Pavlovic, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Orlan Wilhite

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.235 (0.178-0.311)	0.300 (0.228-0.387)	0.402 (0.306-0.526)	0.490 (0.368-0.653)	0.615 (0.446-0.843)	0.713 (0.504-1.01)	0.819 (0.565-1.19)	0.939 (0.631-1.40)	1.11 (0.723-1.72)	1.26 (0.795-1.98)
10-min	0.394 (0.298-0.520)	0.502 (0.381-0.647)	0.672 (0.511-0.879)	0.818 (0.614-1.09)	1.03 (0.747-1.41)	1.19 (0.845-1.69)	1.37 (0.944-1.98)	1.56 (1.05-2.32)	1.82 (1.18-2.81)	2.03 (1.29-3.21)
15-min	0.452 (0.342-0.597)	0.576 (0.437-0.744)	0.772 (0.588-1.01)	0.941 (0.706-1.25)	1.18 (0.856-1.62)	1.37 (0.966-1.93)	1.57 (1.08-2.28)	1.80 (1.21-2.69)	2.15 (1.40-3.32)	2.44 (1.54-3.85)
30-min	0.560 (0.424-0.739)	0.714 (0.542-0.922)	0.957 (0.728-1.25)	1.17 (0.875-1.55)	1.46 (1.06-2.01)	1.70 (1.20-2.39)	1.95 (1.34-2.83)	2.24 (1.51-3.34)	2.67 (1.73-4.12)	3.02 (1.91-4.77)
60-min	0.671 (0.508-0.887)	0.856 (0.649-1.10)	1.15 (0.872-1.50)	1.40 (1.05-1.86)	1.75 (1.27-2.40)	2.03 (1.44-2.87)	2.34 (1.61-3.39)	2.68 (1.80-3.98)	3.17 (2.06-4.89)	3.58 (2.26-5.65)
2-hr	0.785 (0.597-1.03)	0.996 (0.760-1.28)	1.33 (1.02-1.73)	1.61 (1.22-2.14)	2.02 (1.47-2.75)	2.34 (1.66-3.27)	2.68 (1.86-3.86)	3.08 (2.08-4.55)	3.66 (2.39-5.61)	4.15 (2.64-6.51)
3-hr	0.853 (0.652-1.12)	1.08 (0.828-1.38)	1.44 (1.10-1.87)	1.74 (1.32-2.30)	2.18 (1.59-2.95)	2.52 (1.79-3.51)	2.89 (2.00-4.14)	3.32 (2.24-4.88)	3.96 (2.59-6.04)	4.50 (2.86-7.02)
6-hr	0.962 (0.739-1.25)	1.22 (0.939-1.55)	1.63 (1.26-2.10)	1.98 (1.50-2.59)	2.47 (1.81-3.33)	2.86 (2.04-3.96)	3.28 (2.29-4.68)	3.78 (2.57-5.54)	4.54 (2.98-6.88)	5.18 (3.31-8.02)
12-hr	1.04 (0.805-1.35)	1.34 (1.03-1.68)	1.80 (1.40-2.30)	2.20 (1.69-2.88)	2.79 (2.06-3.74)	3.26 (2.34-4.49)	3.78 (2.65-5.35)	4.38 (2.99-6.36)	5.29 (3.48-7.95)	6.06 (3.88-9.30)
24-hr	1.13 (0.875-1.45)	1.48 (1.13-1.83)	2.00 (1.55-2.54)	2.47 (1.90-3.20)	3.17 (2.36-4.23)	3.75 (2.72-5.15)	4.39 (3.09-6.17)	5.13 (3.51-7.38)	6.21 (4.10-9.25)	7.11 (4.58-10.8)
2-day	1.25 (0.976-1.60)	1.67 (1.28-2.03)	2.28 (1.78-2.87)	2.85 (2.20-3.67)	3.70 (2.78-4.94)	4.44 (3.24-6.07)	5.25 (3.71-7.32)	6.13 (4.21-8.75)	7.38 (4.90-10.9)	8.41 (5.43-12.7)
3-day	1.34 (1.05-1.71)	1.81 (1.39-2.19)	2.48 (1.94-3.11)	3.10 (2.41-3.99)	4.05 (3.06-5.39)	4.87 (3.57-6.64)	5.77 (4.09-8.02)	6.73 (4.64-9.57)	8.10 (5.38-11.9)	9.19 (5.95-13.8)
4-day	1.42 (1.12-1.81)	1.91 (1.47-2.31)	2.62 (2.06-3.29)	3.28 (2.56-4.21)	4.28 (3.24-5.68)	5.14 (3.78-6.99)	6.09 (4.33-8.44)	7.11 (4.90-10.1)	8.54 (5.68-12.5)	9.71 (6.29-14.6)
7-day	1.61 (1.27-2.04)	2.15 (1.67-2.60)	2.94 (2.32-3.67)	3.66 (2.86-4.67)	4.75 (3.60-6.25)	5.67 (4.17-7.65)	6.68 (4.77-9.20)	7.79 (5.40-11.0)	9.38 (6.26-13.7)	10.7 (6.95-15.9)
10-day	1.77 (1.40-2.24)	2.34 (1.83-2.84)	3.19 (2.53-3.98)	3.96 (3.11-5.04)	5.11 (3.88-6.70)	6.07 (4.47-8.15)	7.12 (5.09-9.77)	8.28 (5.75-11.6)	9.95 (6.66-14.4)	11.3 (7.38-16.8)
20-day	2.27 (1.81-2.85)	2.92 (2.32-3.56)	3.92 (3.13-4.86)	4.79 (3.78-6.05)	6.06 (4.61-7.86)	7.07 (5.23-9.42)	8.17 (5.87-11.1)	9.38 (6.55-13.1)	11.1 (7.47-16.0)	12.5 (8.19-18.4)
30-day	2.67 (2.14-3.34)	3.38 (2.72-4.14)	4.50 (3.62-5.57)	5.46 (4.32-6.87)	6.81 (5.20-8.80)	7.88 (5.84-10.4)	9.01 (6.49-12.2)	10.3 (7.18-14.2)	12.0 (8.10-17.2)	13.4 (8.80-19.7)
45-day	3.20 (2.57-3.98)	4.00 (3.24-4.91)	5.30 (4.28-6.55)	6.40 (5.08-8.02)	7.92 (6.06-10.2)	9.10 (6.76-12.0)	10.3 (7.46-14.0)	11.6 (8.18-16.1)	13.5 (9.12-19.2)	14.9 (9.82-21.8)
60-day	3.65 (2.94-4.54)	4.55 (3.70-5.58)	6.01 (4.87-7.41)	7.22 (5.75-9.04)	8.91 (6.83-11.4)	10.2 (7.60-13.4)	11.5 (8.35-15.5)	12.9 (9.10-17.8)	14.8 (10.1-21.1)	16.3 (10.8-23.8)

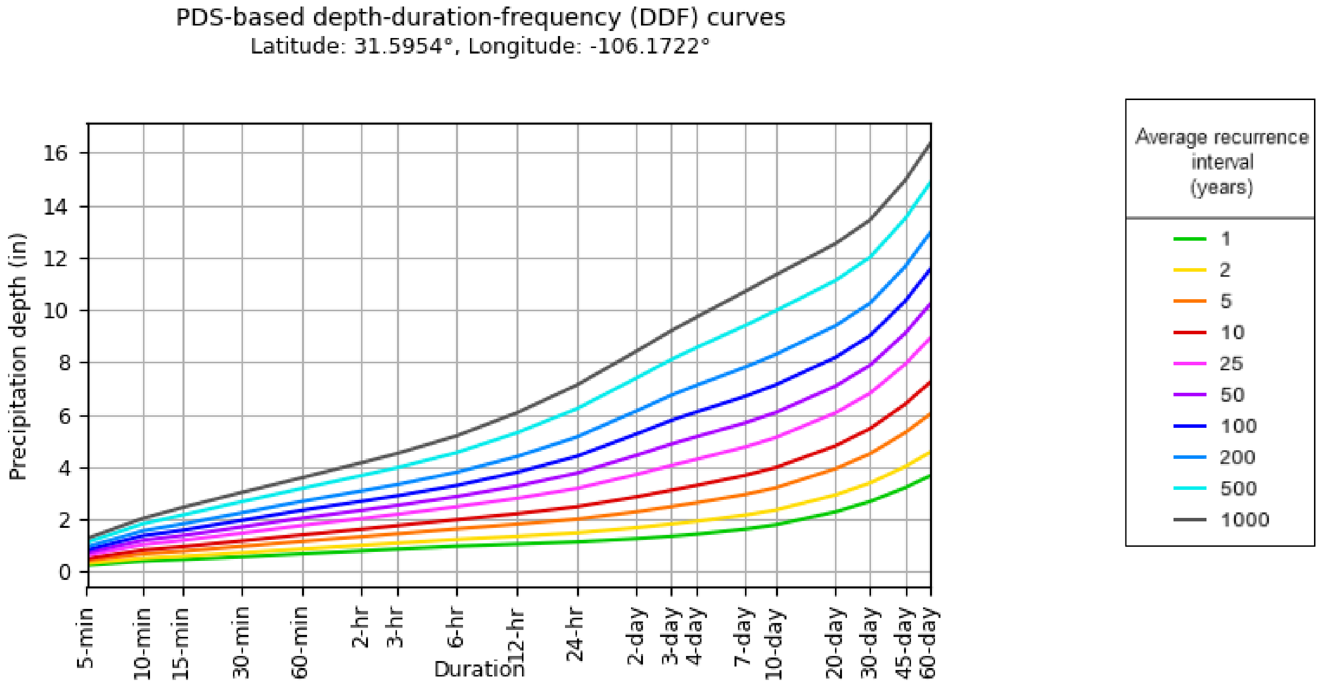
[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

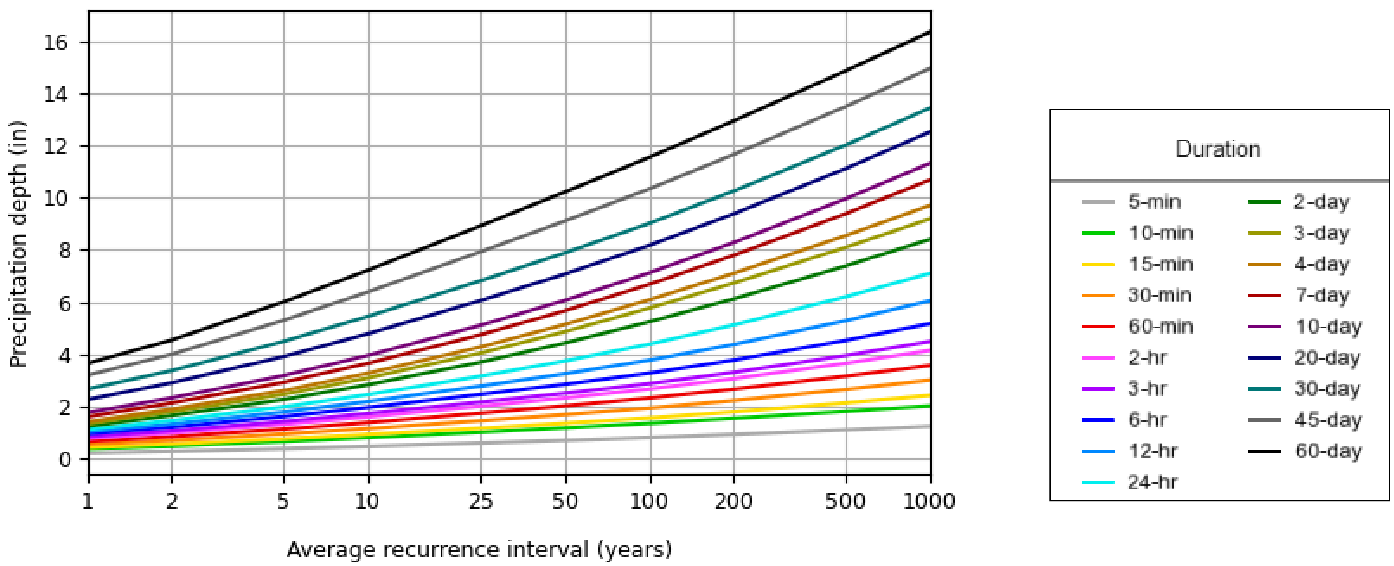
Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

Back to Top

PF graphical



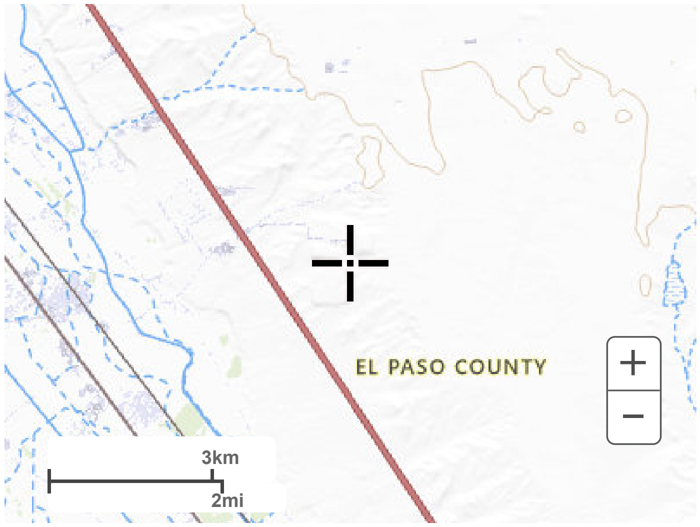


NOAA Atlas 14, Volume 11, Version 2 Created (GMT): Wed Apr 23 17:16:16 2025

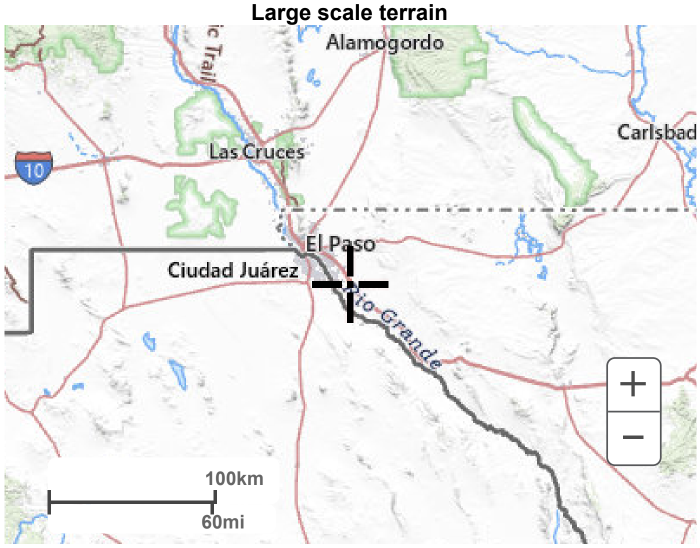
Back to Top

Maps & aerials

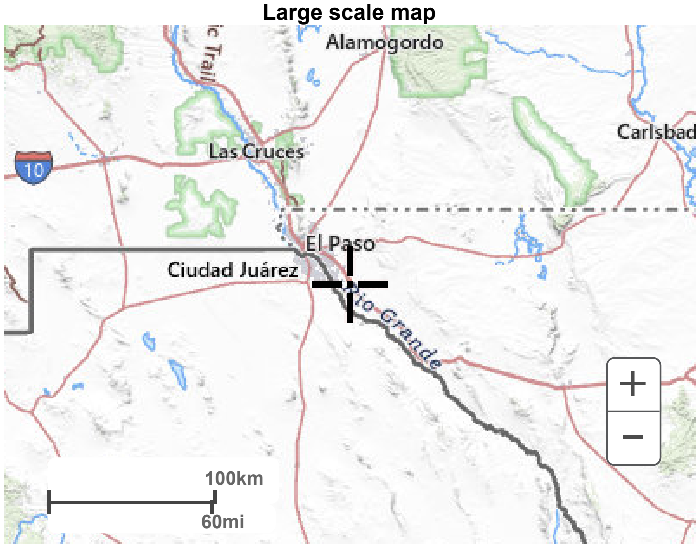
Small scale terrain



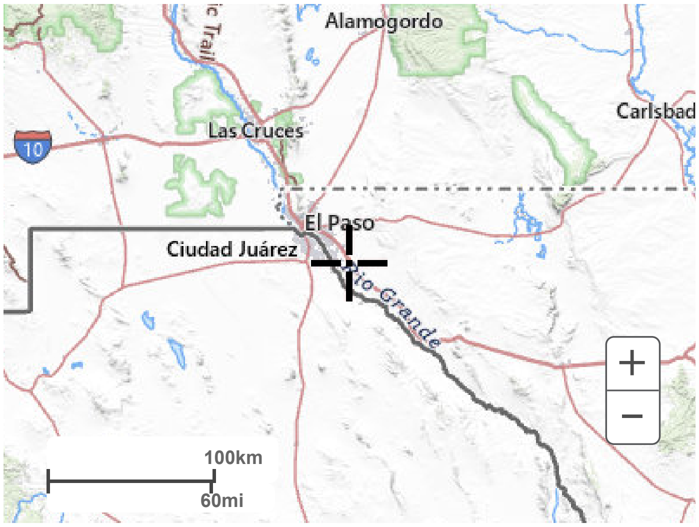
Large scale terrain



Large scale map



Large scale aerial



Back to Top

US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
National Water Center
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

Disclaimer

Rainfall Intensity-Duration-Frequency Coefficients for Texas

Based on United States Geological Survey (USGS) Scientific Investigations Report 2004–5041
"Atlas of Depth-Duration Frequency of Precipitation Annual Maxima for Texas"

1. Select English or SI Units

English

2. Select or Enter a County

El Paso

3. Enter a Time of Conc.
Select Units

10	min

Coefficient	50% (2-year)	20% (5-year)	10% (10-year)	4% (25-year)	2% (50-year)	1% (100-year)
e	0.8722	0.8916	0.9184	0.9037	0.8987	0.8902
b (in.)	30.36	48.03	70.58	80.75	90.38	100.88
d (min)	4.11	5.22	7.20	7.36	7.76	8.56
Intensity (in./hr)	3.02	4.24	5.18	6.12	6.81	7.49

(Spreadsheet Release Date: August 31, 2015; data table reshuffle by Asquith July 14, 2016)

HY-8 CULVERT ANALYSIS

HY-8 Culvert Analysis Report

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 0.00 cfs

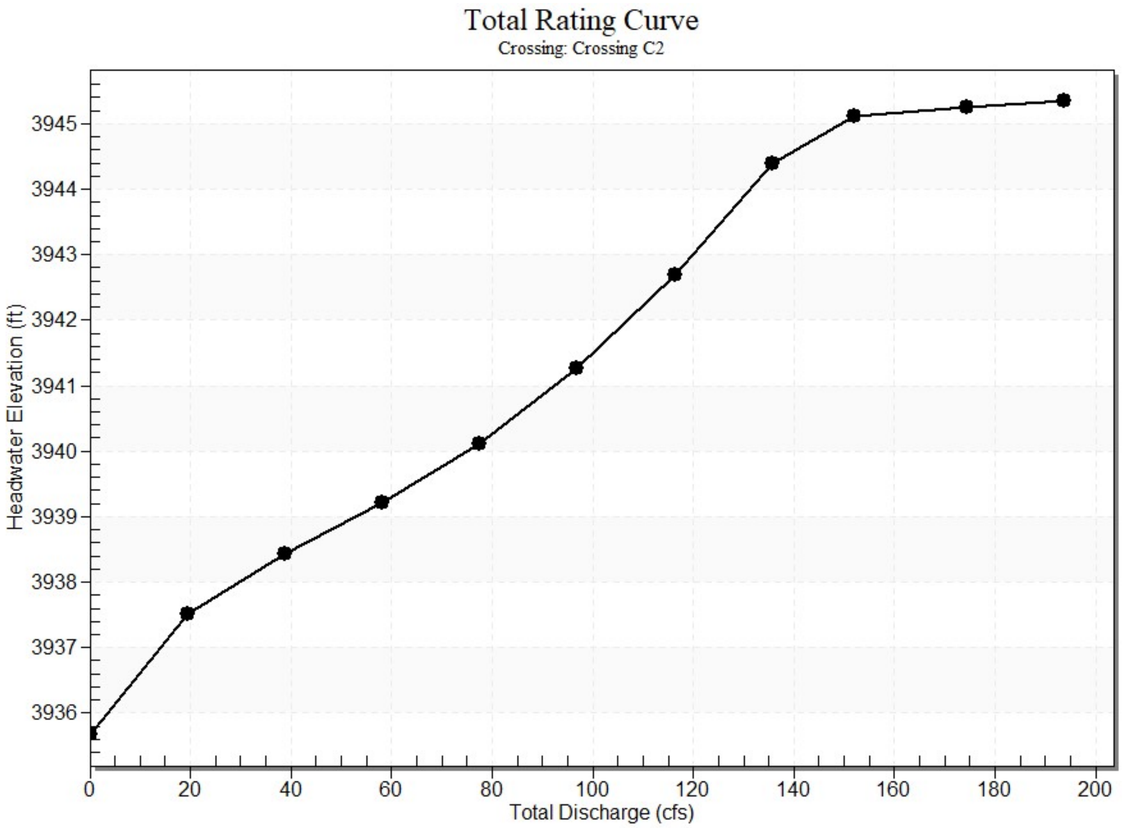
Design Flow: 152.00 cfs

Maximum Flow: 193.82 cfs

Table 1 - Summary of Culvert Flows at Crossing: Crossing C2

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert C2 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
3935.68	0.00	0.00	0.00	1
3937.51	19.38	19.38	0.00	1
3938.44	38.76	38.76	0.00	1
3939.22	58.15	58.15	0.00	1
3940.12	77.53	77.53	0.00	1
3941.26	96.91	96.91	0.00	1
3942.69	116.29	116.29	0.00	1
3944.39	135.67	135.67	0.00	1
3945.11	152.00	143.11	8.78	10
3945.25	174.44	144.51	29.79	6
3945.34	193.82	145.44	48.28	5
3945.00	141.96	141.96	0.00	Overtopping

Rating Curve Plot for Crossing: Crossing C2



Culvert Data: Culvert C2

Table 1 - Culvert Summary Table: Culvert C2

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00 cfs	0.00 cfs	3935.68	0.00	0.000	0-NF	0.00	0.00	0.00	0.00	0.00	0.00
19.38 cfs	19.38 cfs	3937.51	1.83	0.0*	1-S2n	0.84	1.35	0.84	0.56	10.98	3.61
38.76 cfs	38.76 cfs	3938.44	2.76	0.0*	1-S2n	1.19	1.93	1.23	0.82	12.87	4.51
58.15 cfs	58.15 cfs	3939.22	3.54	0.0*	5-S2n	1.49	2.39	1.54	1.03	14.30	5.11
77.53	77.53	3940.1	4.44	1.34	5-	1.75	2.75	1.8	1.20	15.2	5.57

cfs	cfs	2		3	S2n			3		1	
96.91 cfs	96.91 cfs	3941.26	5.58	2.729	5-S2n	2.01	3.03	2.11	1.35	16.00	5.94
116.29 cfs	116.29 cfs	3942.69	7.01	4.348	5-S2n	2.27	3.22	2.38	1.49	16.68	6.27
135.67 cfs	135.67 cfs	3944.39	8.71	6.206	5-S2n	2.54	3.34	2.66	1.61	17.26	6.55
152.00 cfs	143.11 cfs	3945.11	9.43	6.904	5-S2n	2.66	3.20	2.77	1.71	17.50	6.76
174.44 cfs	144.51 cfs	3945.25	9.57	7.040	5-S2n	2.69	3.18	2.79	1.84	17.57	7.02
193.82 cfs	145.44 cfs	3945.34	9.66	7.133	5-S2n	2.70	3.17	2.80	1.94	17.60	7.23

* Full Flow Headwater elevation is below inlet invert.

Culvert Barrel Data

Culvert Barrel Type Straight Culvert

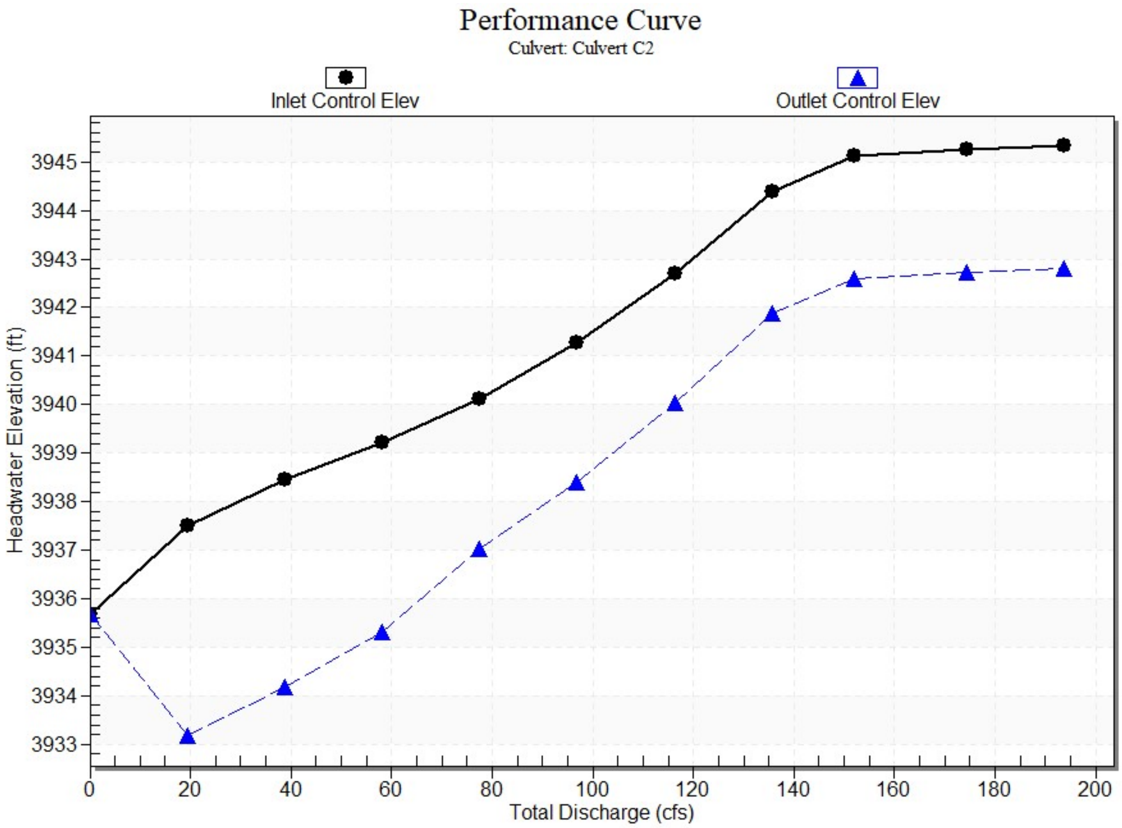
Inlet Elevation (invert): 3935.68 ft,

Outlet Elevation (invert): 3931.68 ft

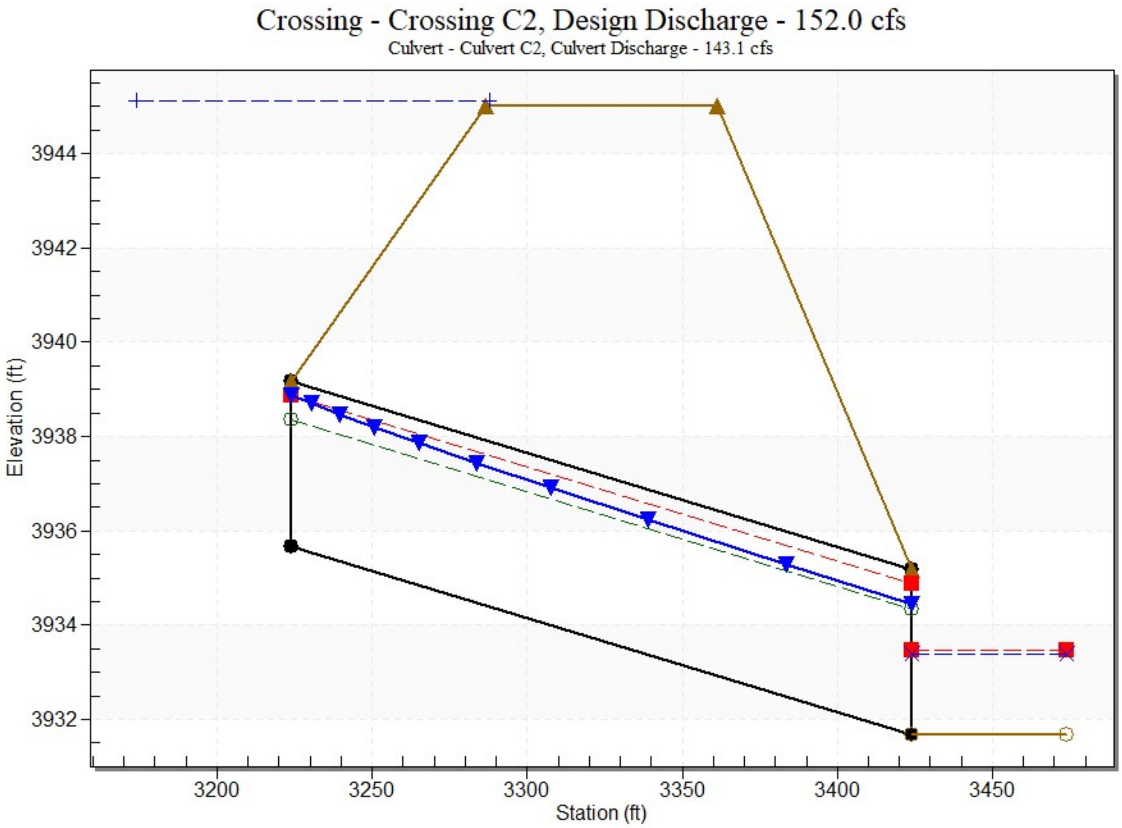
Culvert Length: 200.04 ft,

Culvert Slope: 0.0200

Culvert Performance Curve Plot: Culvert C2



Water Surface Profile Plot for Culvert: Culvert C2



Site Data - Culvert C2

Site Data Option: Culvert Invert Data

Inlet Station: 3224.00 ft

Inlet Elevation: 3935.68 ft

Outlet Station: 3424.00 ft

Outlet Elevation: 3931.68 ft

Number of Barrels: 1

Culvert Data Summary - Culvert C2

Barrel Shape: Circular

Barrel Diameter: 3.50 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Grooved End Projecting (Ke=0.2)

Inlet Depression: None

Tailwater Data for Crossing: Crossing C2

Table 2 - Downstream Channel Rating Curve (Crossing: Crossing C2)

Flow (cfs)	Water Surface Elev (ft)	Velocity (ft/s)	Depth (ft)	Shear (psf)	Froude Number
0.00	3931.68	0.00	0.00	0.00	0.00
19.38	3932.24	0.56	3.61	0.69	0.92
38.76	3932.50	0.82	4.51	1.02	0.98
58.15	3932.71	1.03	5.11	1.28	1.00
77.53	3932.88	1.20	5.57	1.50	1.03
96.91	3933.03	1.35	5.94	1.69	1.04
116.29	3933.17	1.49	6.27	1.86	1.05
135.67	3933.29	1.61	6.55	2.01	1.07
152.00	3933.39	1.71	6.76	2.14	1.07
174.44	3933.52	1.84	7.02	2.29	1.08
193.82	3933.62	1.94	7.23	2.42	1.09

Tailwater Channel Data - Crossing C2

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 8.00 ft

Side Slope (H:V): 3.00 (_:1)

Channel Slope: 0.0200

Channel Manning's n: 0.0350

Channel Invert Elevation: 3931.68 ft

Roadway Data for Crossing: Crossing C2

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 90.00 ft

Crest Elevation: 3945.00 ft

Roadway Surface: Gravel

Roadway Top Width: 75.00 ft

RATIONAL METHOD AND MANNING'S EQUATION CALCULATIONS

RATIONAL METHOD **Q = C I A**

C	=	RUNOFF COEFFICIENT, refer to Table 4-10: Runoff Coefficients for Urban Watersheds Texas Department of Transportation Hydraulic Design Manual (2019)
I	=	Rainfall intensity, per Atlas of Depth-Duration Frequency of Precipitation Annual Maxima for Texas
A	=	Area, largest sub-area contributing to drainage control

Active Face Diversion Berm

Q = (0.58)*(6.12)*(4) = **14.2 cfs**

C = 0.58, calculated in Contaminated Water Containment worksheet
I = 6.12 in/hr
A = 4 acres, calculated in Contaminated Water Containment worksheet

Intermediate Interceptor Ditches

Q = (0.25)*(6.12)*(3.88) = **5.94 cfs**

C = 0.25, Sand or sandy loam soil, 5%
I = 6.12 in/hr
A = 3.88 acres, Drainage Area from B5

Intermediate Top Berms

Q = (0.25)*(6.12)*(7.23) = **11.06 cfs**

C = 0.25, Sand or sandy loam soil, 5%
I = 6.12 in/hr
A = 7.23 acres, Drainage Area from B3

Interceptor Ditches

Q = (0.8)*(6.12)*(3.88) = **19.0 cfs**

C = 0.8, Riprap
I = 6.12 in/hr
A = 3.88 acres, Drainage Area from B5

Top Berms

Q = (0.8)*(6.12)*(7.23) = **35.4 cfs**

C = 0.8, Riprap
I = 6.12 in/hr
A = 7.23 acres, Drainage Area from B3

Letdown Structure

Q = (0.8)*(6.12)*(35.98) = **176.2 cfs**

C = 0.8, Riprap
I = 6.12 in/hr
A = 35.98 acres, Drainage Area from B2 & B5

Ditches - Calculated using HEC-HMS

Rainfall Intensity-Duration-Frequency Coefficients for Texas

Based on United States Geological Survey (USGS) Scientific Investigations Report 2004–5041
"Atlas of Depth-Duration Frequency of Precipitation Annual Maxima for Texas"

1. Select English or SI Units

English

2. Select or Enter a County

El Paso

3. Enter a Time of Conc.
Select Units

10 min

Coefficient	50% (2-year)	20% (5-year)	10% (10-year)	4% (25-year)	2% (50-year)	1% (100-year)
e	0.8722	0.8916	0.9184	0.9037	0.8987	0.8902
b (in.)	30.36	48.03	70.58	80.75	90.38	100.88
d (min)	4.11	5.22	7.20	7.36	7.76	8.56
Intensity (in./hr)	3.02	4.24	5.18	6.12	6.81	7.49

(Spreadsheet Release Date: August 31, 2015; data table reshuffle by Asquith July 14, 2016)

Worksheet for Active Face Diversion Berm

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.018
Channel Slope	0.005 ft/ft
Left Side Slope	3.000 H:V
Right Side Slope	2.000 H:V
Discharge	14.20 cfs

Results

Normal Depth	14.4 in
Flow Area	3.6 ft²
Wetted Perimeter	6.5 ft
Hydraulic Radius	6.7 in
Top Width	6.00 ft
Critical Depth	13.8 in
Critical Slope	0.006 ft/ft
Velocity	3.95 ft/s
Velocity Head	0.24 ft
Specific Energy	1.44 ft
Froude Number	0.898
Flow Type	Subcritical

GVF Input Data

Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

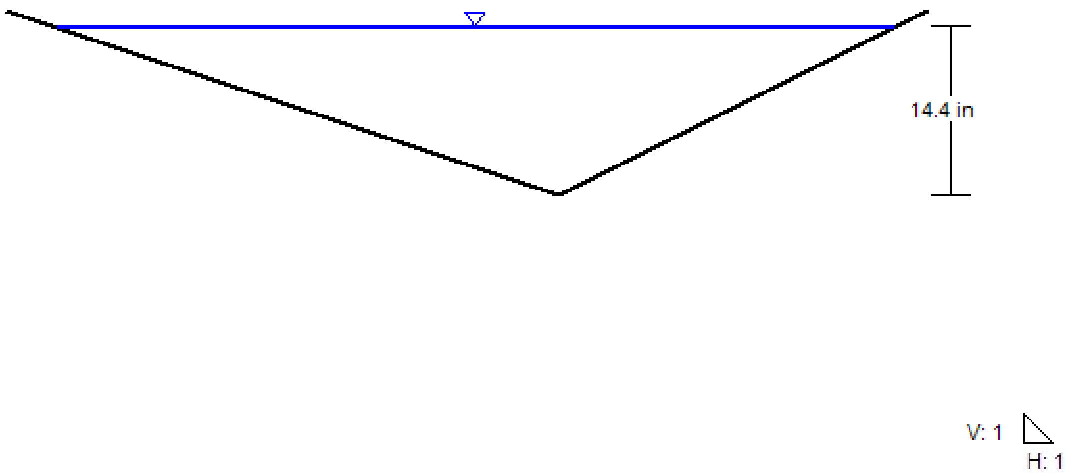
GVF Output Data

Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	14.4 in
Critical Depth	13.8 in
Channel Slope	0.005 ft/ft
Critical Slope	0.006 ft/ft

Cross Section for Active Face Diversion Berm

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Roughness Coefficient	0.018
Channel Slope	0.005 ft/ft
Normal Depth	14.4 in
Left Side Slope	3.000 H:V
Right Side Slope	2.000 H:V
Discharge	14.20 cfs



Worksheet for Intermediate Interceptor Ditches

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Roughness Coefficient	0.020
Channel Slope	0.010 ft/ft
Left Side Slope	4.000 H:V
Right Side Slope	2.000 H:V
Discharge	5.94 cfs

Results	
Normal Depth	8.8 in
Flow Area	1.6 ft²
Wetted Perimeter	4.7 ft
Hydraulic Radius	4.2 in
Top Width	4.41 ft
Critical Depth	9.0 in
Critical Slope	0.009 ft/ft
Velocity	3.67 ft/s
Velocity Head	0.21 ft
Specific Energy	0.94 ft
Froude Number	1.066
Flow Type	Supercritical

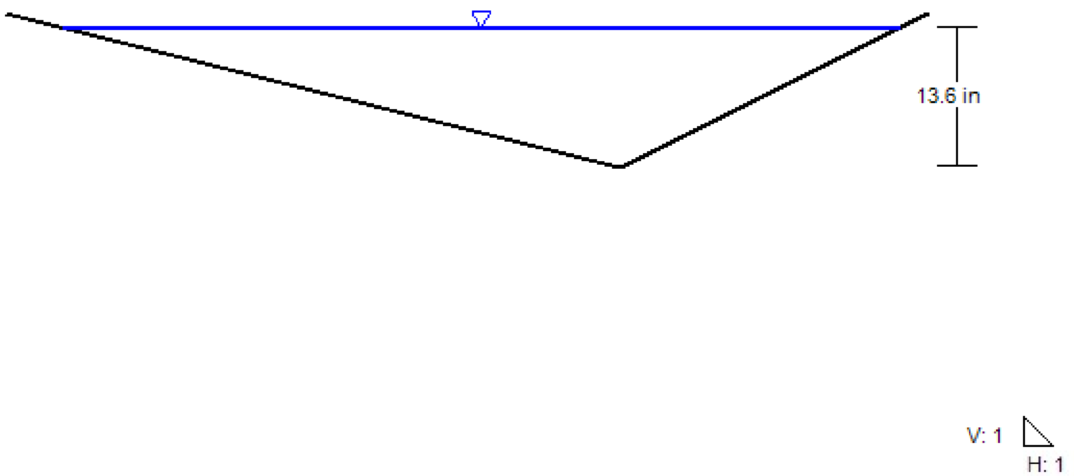
GVF Input Data	
Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data	
Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	8.8 in
Critical Depth	9.0 in
Channel Slope	0.010 ft/ft
Critical Slope	0.009 ft/ft

Cross Section for Intermediate Interceptor Ditches

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Roughness Coefficient	0.020
Channel Slope	0.010 ft/ft
Normal Depth	13.6 in
Left Side Slope	4.000 H:V
Right Side Slope	2.000 H:V
Discharge	19.00 cfs



Worksheet for Intermediate Top Berms

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Roughness Coefficient	0.020
Channel Slope	0.005 ft/ft
Left Side Slope	20.000 H:V
Right Side Slope	2.000 H:V
Discharge	11.06 cfs

Results	
Normal Depth	7.7 in
Flow Area	4.5 ft²
Wetted Perimeter	14.3 ft
Hydraulic Radius	3.8 in
Top Width	14.12 ft
Critical Depth	6.9 in
Critical Slope	0.009 ft/ft
Velocity	2.44 ft/s
Velocity Head	0.09 ft
Specific Energy	0.73 ft
Froude Number	0.760
Flow Type	Subcritical

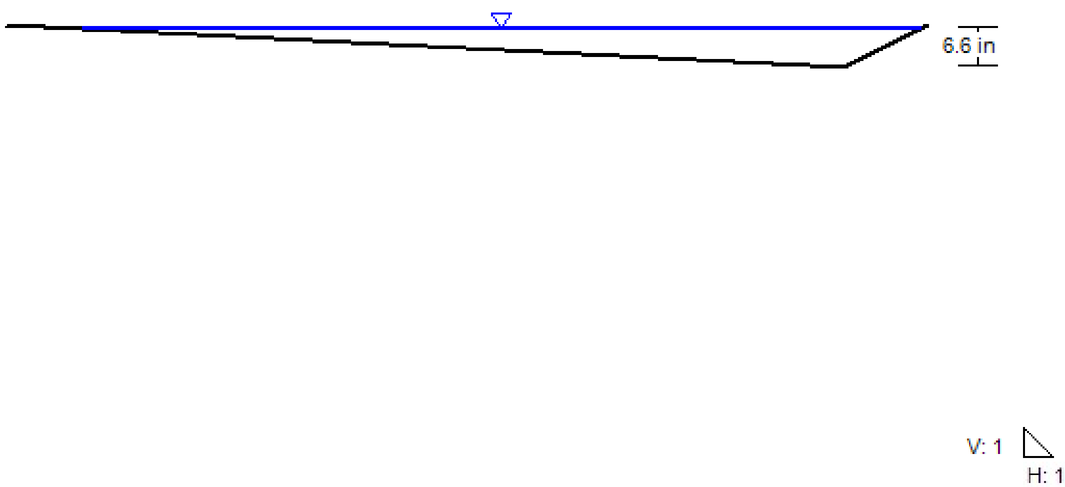
GVF Input Data	
Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data	
Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	7.7 in
Critical Depth	6.9 in
Channel Slope	0.005 ft/ft
Critical Slope	0.009 ft/ft

Cross Section for Intermediate Top Berms

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Roughness Coefficient	0.020
Channel Slope	0.005 ft/ft
Normal Depth	6.6 in
Left Side Slope	20.000 H:V
Right Side Slope	2.000 H:V
Discharge	7.23 cfs



Worksheet for Interceptor Ditches

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035
Channel Slope	0.010 ft/ft
Left Side Slope	4.000 H:V
Right Side Slope	2.000 H:V
Discharge	19.00 cfs

Results

Normal Depth	16.8 in
Flow Area	5.9 ft²
Wetted Perimeter	8.9 ft
Hydraulic Radius	7.9 in
Top Width	8.41 ft
Critical Depth	14.4 in
Critical Slope	0.023 ft/ft
Velocity	3.22 ft/s
Velocity Head	0.16 ft
Specific Energy	1.56 ft
Froude Number	0.679
Flow Type	Subcritical

GVF Input Data

Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

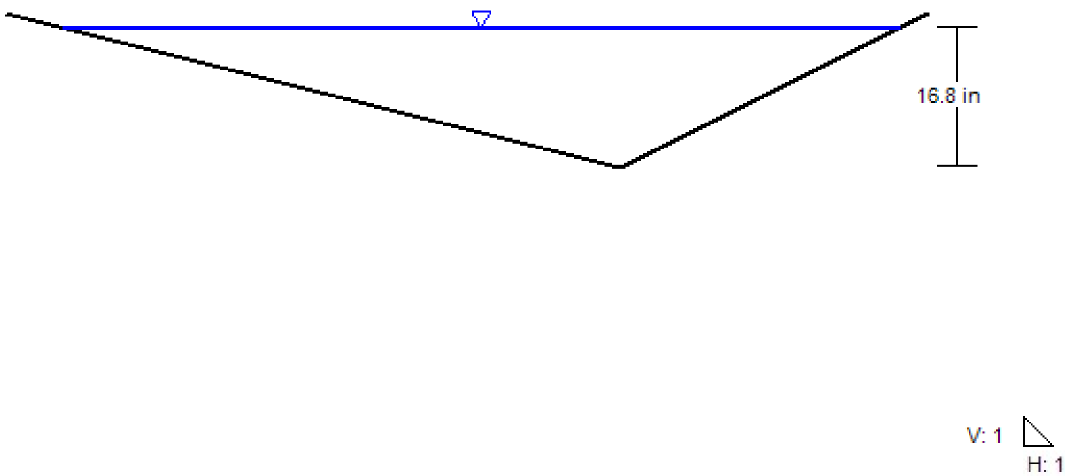
GVF Output Data

Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	16.8 in
Critical Depth	14.4 in
Channel Slope	0.010 ft/ft
Critical Slope	0.023 ft/ft

Cross Section for Interceptor Ditches

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Roughness Coefficient	0.035
Channel Slope	0.010 ft/ft
Normal Depth	16.8 in
Left Side Slope	4.000 H:V
Right Side Slope	2.000 H:V
Discharge	19.00 cfs



Worksheet for Top Berms

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Roughness Coefficient	0.035
Channel Slope	0.005 ft/ft
Left Side Slope	20.000 H:V
Right Side Slope	2.000 H:V
Discharge	35.40 cfs

Results	
Normal Depth	14.7 in
Flow Area	16.5 ft²
Wetted Perimeter	27.3 ft
Hydraulic Radius	7.3 in
Top Width	26.93 ft
Critical Depth	11.0 in
Critical Slope	0.024 ft/ft
Velocity	2.15 ft/s
Velocity Head	0.07 ft
Specific Energy	1.30 ft
Froude Number	0.484
Flow Type	Subcritical

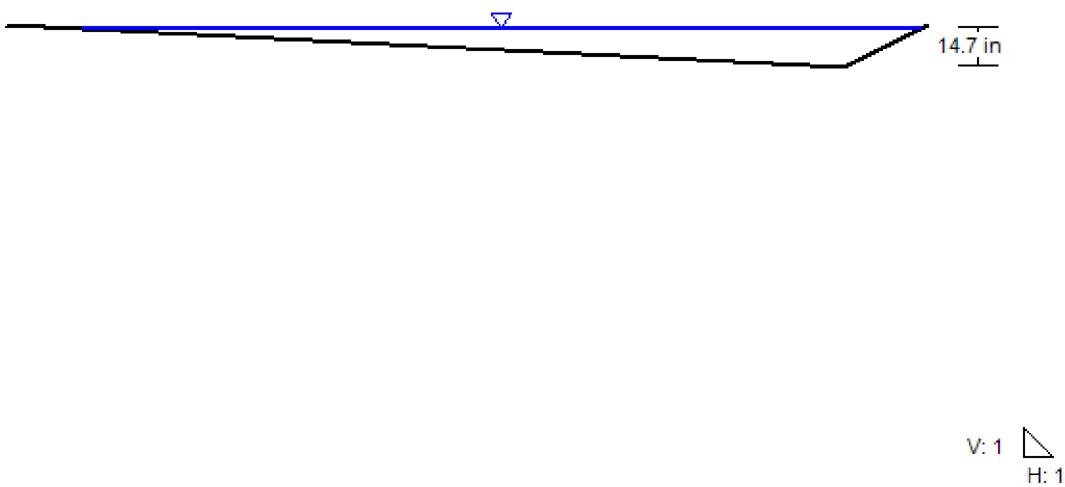
GVF Input Data	
Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data	
Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	14.7 in
Critical Depth	11.0 in
Channel Slope	0.005 ft/ft
Critical Slope	0.024 ft/ft

Cross Section for Top Berms

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Roughness Coefficient	0.035
Channel Slope	0.005 ft/ft
Normal Depth	14.7 in
Left Side Slope	20.000 H:V
Right Side Slope	2.000 H:V
Discharge	35.40 cfs



Worksheet for Letdown Structure

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.041
Channel Slope	0.250 ft/ft
Left Side Slope	2.000 H:V
Right Side Slope	2.000 H:V
Bottom Width	8.00 ft
Discharge	176.20 cfs

Results

Normal Depth	12.8 in
Flow Area	10.9 ft²
Wetted Perimeter	12.8 ft
Hydraulic Radius	10.2 in
Top Width	12.28 ft
Critical Depth	24.8 in
Critical Slope	0.023 ft/ft
Velocity	16.24 ft/s
Velocity Head	4.10 ft
Specific Energy	5.17 ft
Froude Number	3.045
Flow Type	Supercritical

GVF Input Data

Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

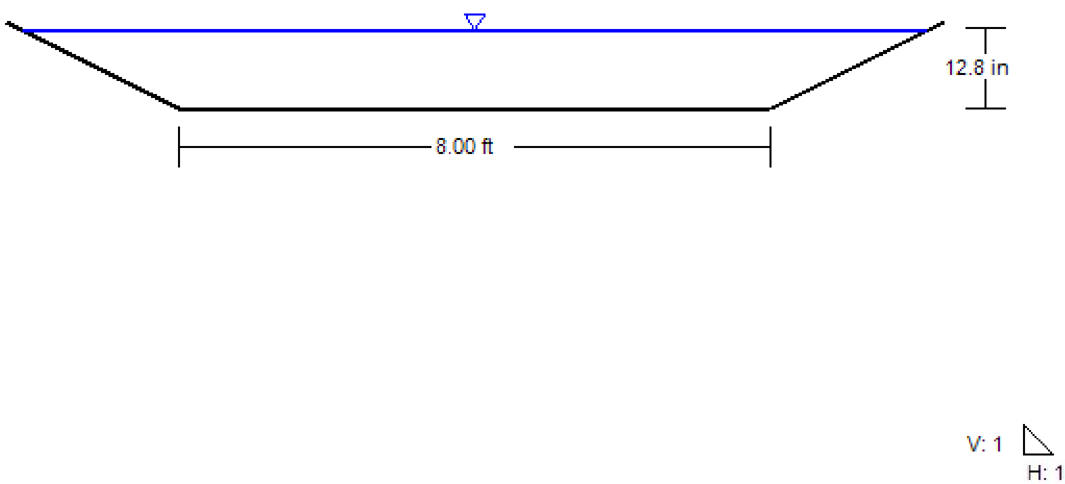
GVF Output Data

Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	12.8 in
Critical Depth	24.8 in
Channel Slope	0.250 ft/ft
Critical Slope	0.023 ft/ft

Cross Section for Letdown Structure

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Roughness Coefficient	0.041
Channel Slope	0.250 ft/ft
Normal Depth	12.8 in
Left Side Slope	2.000 H:V
Right Side Slope	2.000 H:V
Bottom Width	8.00 ft
Discharge	176.20 cfs



Worksheet for Ditch B1 - Flow from B3, B6, B7, & C-Offsite

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035
Channel Slope	0.006 ft/ft
Left Side Slope	3.000 H:V
Right Side Slope	3.000 H:V
Bottom Width	8.00 ft
Discharge	153.80 cfs

Results

Normal Depth	28.0 in
Flow Area	35.1 ft^2
Wetted Perimeter	22.8 ft
Hydraulic Radius	18.5 in
Top Width	22.02 ft
Critical Depth	21.5 in
Critical Slope	0.017 ft/ft
Velocity	4.38 ft/s
Velocity Head	0.30 ft
Specific Energy	2.64 ft
Froude Number	0.612
Flow Type	Subcritical

GVF Input Data

Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

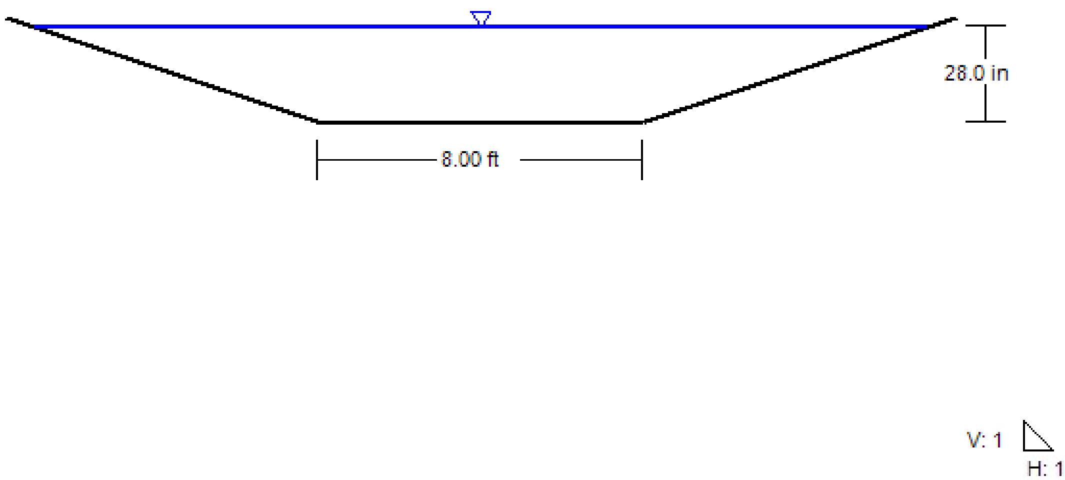
GVF Output Data

Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Downstream Velocity	0.00 ft/s
Upstream Velocity	0.00 ft/s
Normal Depth	28.0 in
Critical Depth	21.5 in
Channel Slope	0.006 ft/ft
Critical Slope	0.017 ft/ft

Cross Section for Ditch B1 - Flow from B3, B6, B7, & C-Offsite

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Roughness Coefficient	0.035
Channel Slope	0.006 ft/ft
Normal Depth	28.0 in
Left Side Slope	3.000 H:V
Right Side Slope	3.000 H:V
Bottom Width	8.00 ft
Discharge	153.80 cfs



Worksheet for Ditch B1 - Flow from B3, B6, B7, & C-Offsite

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035
Channel Slope	0.016 ft/ft
Left Side Slope	3.000 H:V
Right Side Slope	3.000 H:V
Bottom Width	8.00 ft
Discharge	153.80 cfs

Results

Normal Depth	21.9 in
Flow Area	24.6 ft²
Wetted Perimeter	19.5 ft
Hydraulic Radius	15.1 in
Top Width	18.95 ft
Critical Depth	21.5 in
Critical Slope	0.017 ft/ft
Velocity	6.26 ft/s
Velocity Head	0.61 ft
Specific Energy	2.43 ft
Froude Number	0.969
Flow Type	Subcritical

GVF Input Data

Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data

Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Downstream Velocity	0.00 ft/s
Upstream Velocity	0.00 ft/s
Normal Depth	21.9 in
Critical Depth	21.5 in
Channel Slope	0.016 ft/ft
Critical Slope	0.017 ft/ft

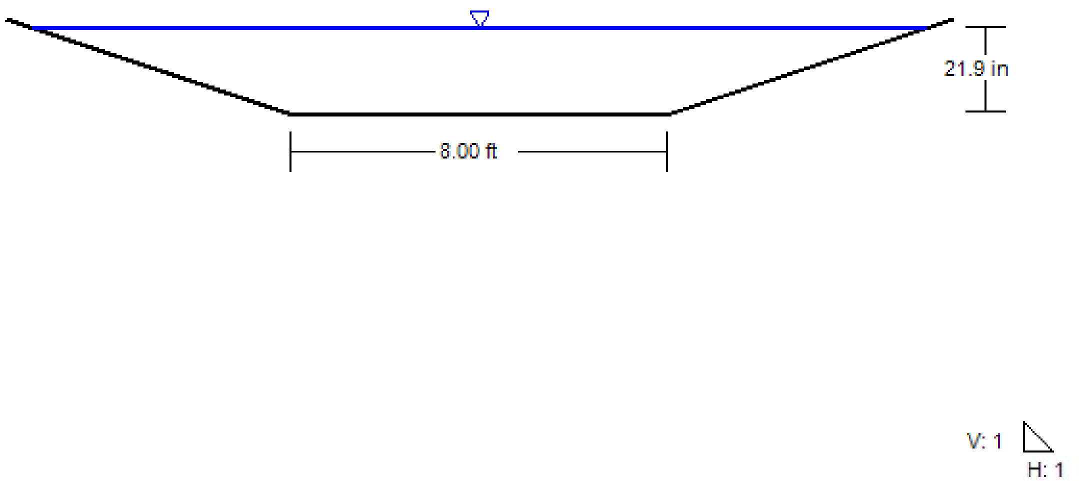
Cross Section for Ditch B1 - Flow from B3, B6, B7, & C-Offsite

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035
Channel Slope	0.016 ft/ft
Normal Depth	21.9 in
Left Side Slope	3.000 H:V
Right Side Slope	3.000 H:V
Bottom Width	8.00 ft
Discharge	153.80 cfs



Worksheet for Ditch B2 - Flow from B2, B5, B8, & Ditch B1

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035
Channel Slope	0.016 ft/ft
Left Side Slope	3.000 H:V
Right Side Slope	3.000 H:V
Bottom Width	8.00 ft
Discharge	255.58 cfs

Results

Normal Depth	28.3 in
Flow Area	35.5 ft²
Wetted Perimeter	22.9 ft
Hydraulic Radius	18.6 in
Top Width	22.14 ft
Critical Depth	28.3 in
Critical Slope	0.016 ft/ft
Velocity	7.19 ft/s
Velocity Head	0.80 ft
Specific Energy	3.16 ft
Froude Number	1.001
Flow Type	Supercritical

GVF Input Data

Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

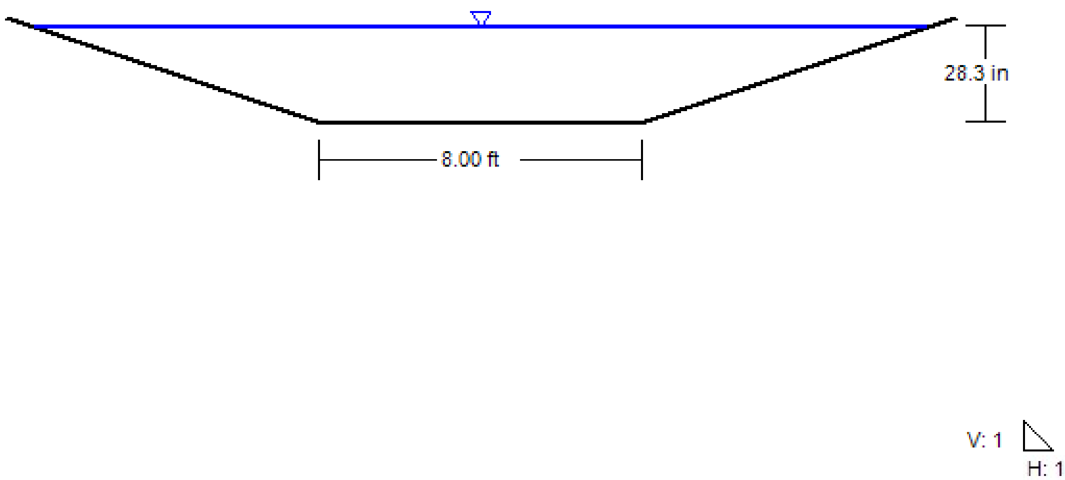
GVF Output Data

Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	28.3 in
Critical Depth	28.3 in
Channel Slope	0.016 ft/ft
Critical Slope	0.016 ft/ft

Cross Section for Ditch B2 - Flow from B2, B5, B8, & Ditch B1

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Roughness Coefficient	0.035
Channel Slope	0.016 ft/ft
Normal Depth	28.3 in
Left Side Slope	3.000 H:V
Right Side Slope	3.000 H:V
Bottom Width	8.00 ft
Discharge	255.58 cfs



Worksheet for Ditch B2 - Flow from B2, B5, B8, & Ditch B1

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035
Channel Slope	0.043 ft/ft
Left Side Slope	3.000 H:V
Right Side Slope	3.000 H:V
Bottom Width	8.00 ft
Discharge	255.58 cfs

Results

Normal Depth	22.0 in
Flow Area	24.8 ft²
Wetted Perimeter	19.6 ft
Hydraulic Radius	15.2 in
Top Width	19.02 ft
Critical Depth	28.3 in
Critical Slope	0.016 ft/ft
Velocity	10.31 ft/s
Velocity Head	1.65 ft
Specific Energy	3.49 ft
Froude Number	1.591
Flow Type	Supercritical

GVF Input Data

Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data

Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	22.0 in
Critical Depth	28.3 in
Channel Slope	0.043 ft/ft
Critical Slope	0.016 ft/ft

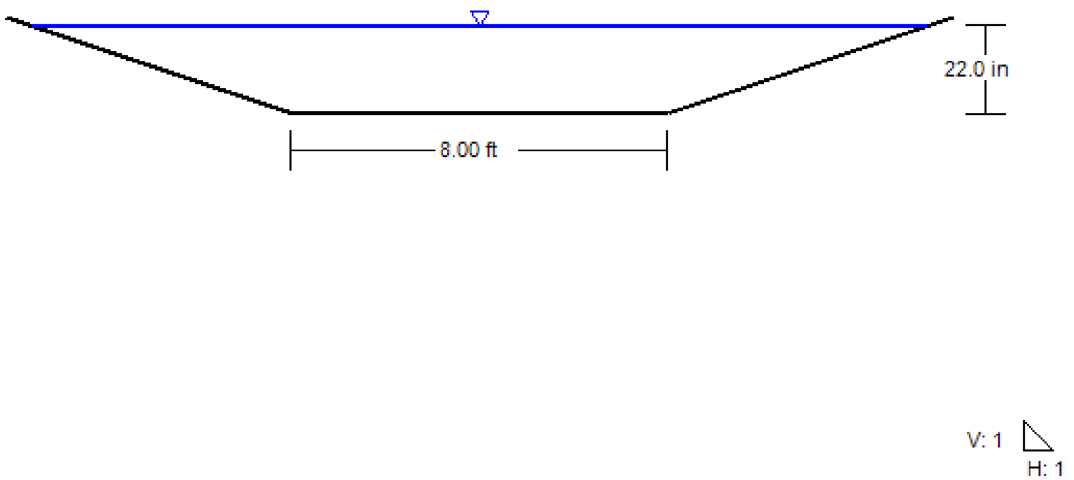
Cross Section for Ditch B2 - Flow from B2, B5, B8, & Ditch B1

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035
Channel Slope	0.043 ft/ft
Normal Depth	22.0 in
Left Side Slope	3.000 H:V
Right Side Slope	3.000 H:V
Bottom Width	8.00 ft
Discharge	255.58 cfs



Worksheet for Ditch B2 - Flow from B2, B5, B8, & Ditch B1-3

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035
Channel Slope	0.021 ft/ft
Left Side Slope	3.000 H:V
Right Side Slope	3.000 H:V
Bottom Width	8.00 ft
Discharge	255.58 cfs

Results

Normal Depth	26.3 in
Flow Area	32.0 ft²
Wetted Perimeter	21.9 ft
Hydraulic Radius	17.5 in
Top Width	21.15 ft
Critical Depth	28.3 in
Critical Slope	0.016 ft/ft
Velocity	8.00 ft/s
Velocity Head	0.99 ft
Specific Energy	3.19 ft
Froude Number	1.147
Flow Type	Supercritical

GVF Input Data

Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

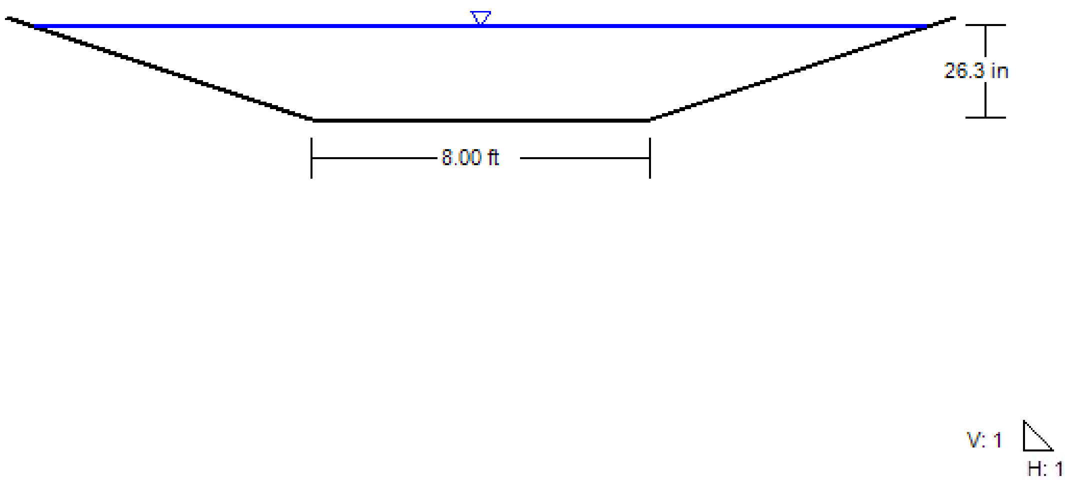
GVF Output Data

Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	26.3 in
Critical Depth	28.3 in
Channel Slope	0.021 ft/ft
Critical Slope	0.016 ft/ft

Cross Section for Ditch B2 - Flow from B2, B5, B8, & Ditch B1-3

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Roughness Coefficient	0.035
Channel Slope	0.021 ft/ft
Normal Depth	26.3 in
Left Side Slope	3.000 H:V
Right Side Slope	3.000 H:V
Bottom Width	8.00 ft
Discharge	255.58 cfs



Worksheet for Ditch C1 - Flow from C3

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035
Channel Slope	0.008 ft/ft
Left Side Slope	3.000 H:V
Right Side Slope	3.000 H:V
Bottom Width	8.00 ft
Discharge	16.50 cfs

Results

Normal Depth	8.0 in
Flow Area	6.7 ft²
Wetted Perimeter	12.2 ft
Hydraulic Radius	6.6 in
Top Width	12.02 ft
Critical Depth	5.7 in
Critical Slope	0.024 ft/ft
Velocity	2.46 ft/s
Velocity Head	0.09 ft
Specific Energy	0.76 ft
Froude Number	0.581
Flow Type	Subcritical

GVF Input Data

Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

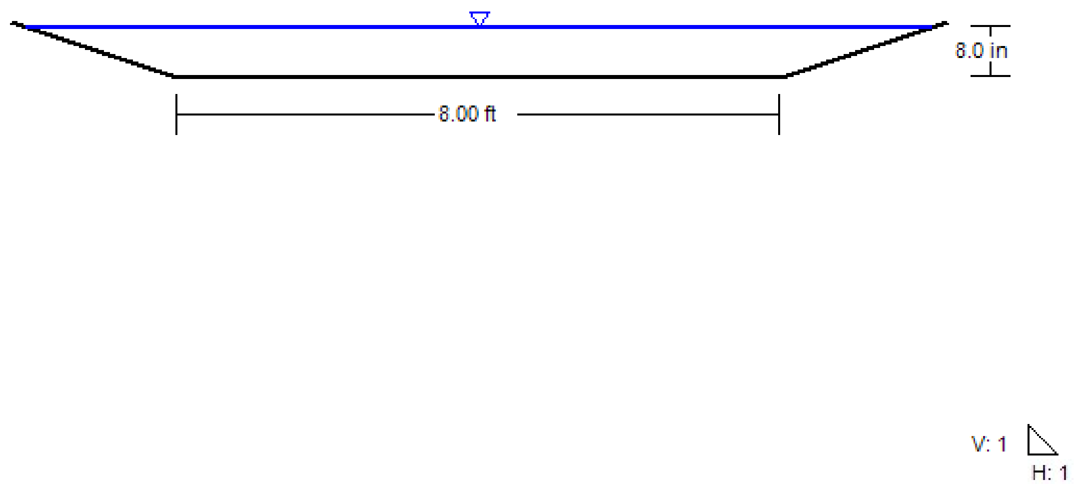
GVF Output Data

Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	8.0 in
Critical Depth	5.7 in
Channel Slope	0.008 ft/ft
Critical Slope	0.024 ft/ft

Cross Section for Ditch C1 - Flow from C3

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Roughness Coefficient	0.035
Channel Slope	0.008 ft/ft
Normal Depth	8.0 in
Left Side Slope	3.000 H:V
Right Side Slope	3.000 H:V
Bottom Width	8.00 ft
Discharge	16.50 cfs



Ditch C1 - Flow from C3-2

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035
Channel Slope	0.027 ft/ft
Left Side Slope	3.000 H:V
Right Side Slope	3.000 H:V
Bottom Width	8.00 ft
Discharge	16.50 cfs

Results

Normal Depth	5.6 in
Flow Area	4.4 ft²
Wetted Perimeter	10.9 ft
Hydraulic Radius	4.8 in
Top Width	10.79 ft
Critical Depth	5.7 in
Critical Slope	0.024 ft/ft
Velocity	3.78 ft/s
Velocity Head	0.22 ft
Specific Energy	0.69 ft
Froude Number	1.046
Flow Type	Supercritical

GVF Input Data

Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data

Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	5.6 in
Critical Depth	5.7 in
Channel Slope	0.027 ft/ft
Critical Slope	0.024 ft/ft

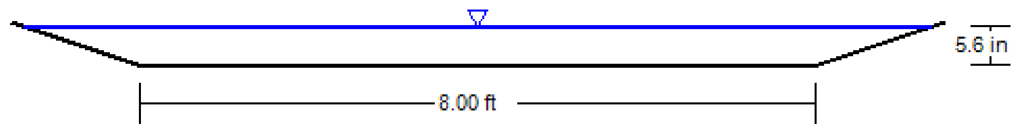
Cross Section for Ditch C1 - Flow from C3-2

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035
Channel Slope	0.027 ft/ft
Normal Depth	5.6 in
Left Side Slope	3.000 H:V
Right Side Slope	3.000 H:V
Bottom Width	8.00 ft
Discharge	16.50 cfs



V: 1
H: 1

Worksheet for Ditch C1 - Flow from C3-3

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035
Channel Slope	0.004 ft/ft
Left Side Slope	3.000 H:V
Right Side Slope	3.000 H:V
Bottom Width	8.00 ft
Discharge	16.50 cfs

Results

Normal Depth	9.6 in
Flow Area	8.3 ft²
Wetted Perimeter	13.1 ft
Hydraulic Radius	7.6 in
Top Width	12.79 ft
Critical Depth	5.7 in
Critical Slope	0.024 ft/ft
Velocity	1.99 ft/s
Velocity Head	0.06 ft
Specific Energy	0.86 ft
Froude Number	0.435
Flow Type	Subcritical

GVF Input Data

Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

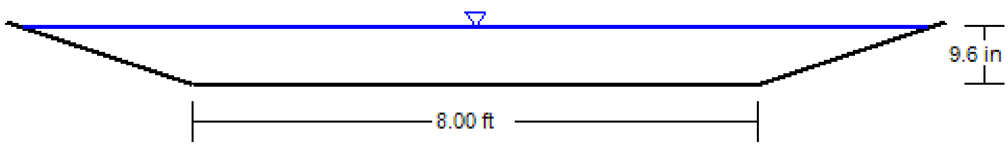
GVF Output Data

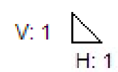
Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	9.6 in
Critical Depth	5.7 in
Channel Slope	0.004 ft/ft
Critical Slope	0.024 ft/ft

Cross Section for Ditch C1 - Flow from C3-3

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Roughness Coefficient	0.035
Channel Slope	0.004 ft/ft
Normal Depth	9.6 in
Left Side Slope	3.000 H:V
Right Side Slope	3.000 H:V
Bottom Width	8.00 ft
Discharge	16.50 cfs





Worksheet for Ditch C2 - Flows from C1, C2, Ditch C1

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035
Channel Slope	0.004 ft/ft
Left Side Slope	3.000 H:V
Right Side Slope	3.000 H:V
Bottom Width	8.00 ft
Discharge	172.63 cfs

Results

Normal Depth	32.8 in
Flow Area	44.3 ft²
Wetted Perimeter	25.3 ft
Hydraulic Radius	21.0 in
Top Width	24.40 ft
Critical Depth	22.9 in
Critical Slope	0.017 ft/ft
Velocity	3.90 ft/s
Velocity Head	0.24 ft
Specific Energy	2.97 ft
Froude Number	0.511
Flow Type	Subcritical

GVF Input Data

Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data

Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	32.8 in
Critical Depth	22.9 in
Channel Slope	0.004 ft/ft
Critical Slope	0.017 ft/ft

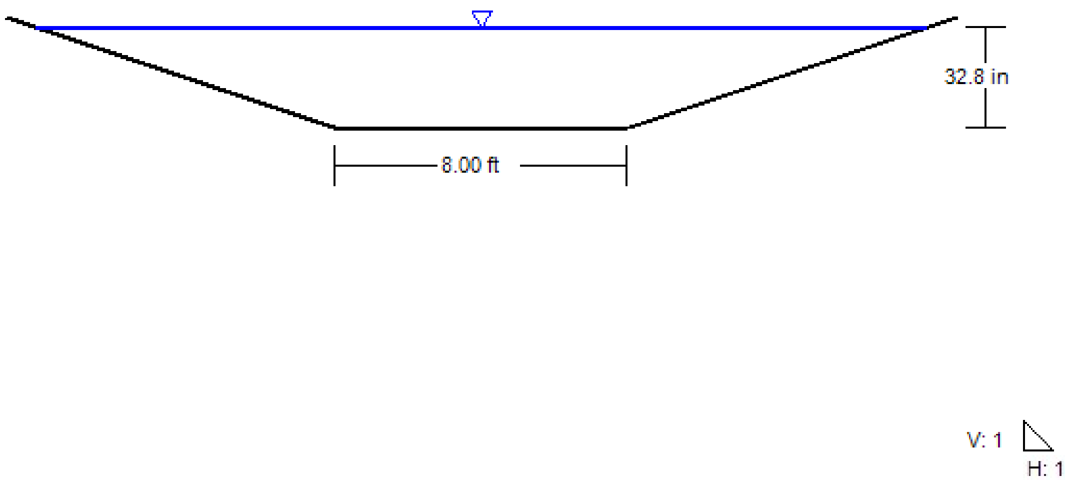
Cross Section for Ditch C2 - Flows from C1, C2, Ditch C1

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035
Channel Slope	0.004 ft/ft
Normal Depth	32.8 in
Left Side Slope	3.000 H:V
Right Side Slope	3.000 H:V
Bottom Width	8.00 ft
Discharge	172.63 cfs



Ditch C2 - Flows from C1, C2, & Ditch C1.2

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035
Channel Slope	0.039 ft/ft
Left Side Slope	3.000 H:V
Right Side Slope	3.000 H:V
Bottom Width	8.00 ft
Discharge	172.63 cfs

Results

Normal Depth	18.4 in
Flow Area	19.3 ft²
Wetted Perimeter	17.7 ft
Hydraulic Radius	13.1 in
Top Width	17.20 ft
Critical Depth	22.9 in
Critical Slope	0.017 ft/ft
Velocity	8.93 ft/s
Velocity Head	1.24 ft
Specific Energy	2.77 ft
Froude Number	1.486
Flow Type	Supercritical

GVF Input Data

Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

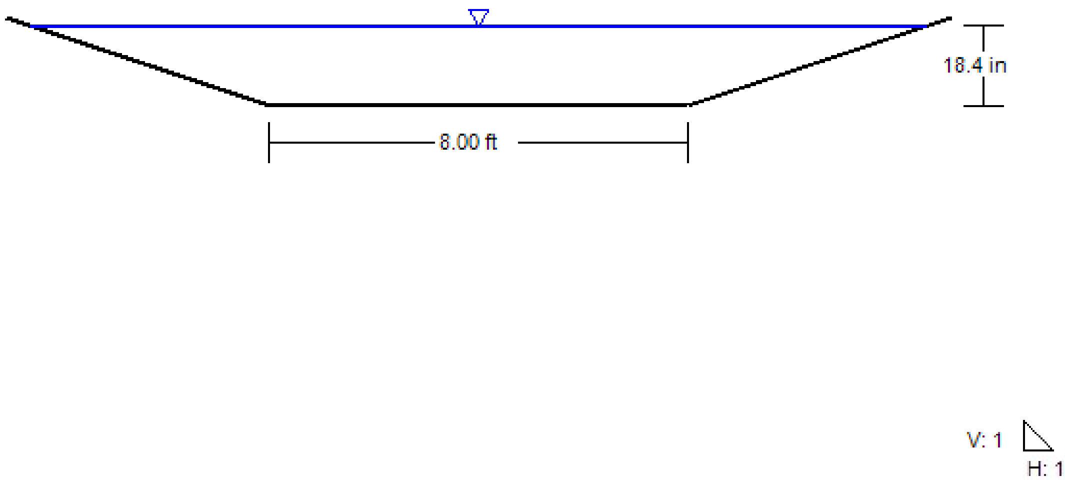
GVF Output Data

Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	18.4 in
Critical Depth	22.9 in
Channel Slope	0.039 ft/ft
Critical Slope	0.017 ft/ft

Cross Section for Ditch C2 - Flows from C1, C2, & Ditch C1.2

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Roughness Coefficient	0.035
Channel Slope	0.039 ft/ft
Normal Depth	18.4 in
Left Side Slope	3.000 H:V
Right Side Slope	3.000 H:V
Bottom Width	8.00 ft
Discharge	172.63 cfs



Worksheet for Ditch C2 - Flows from C1, C2, & Ditch C1.3

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035
Channel Slope	0.076 ft/ft
Left Side Slope	3.000 H:V
Right Side Slope	3.000 H:V
Bottom Width	8.00 ft
Discharge	172.63 cfs

Results

Normal Depth	15.5 in
Flow Area	15.3 ft²
Wetted Perimeter	16.2 ft
Hydraulic Radius	11.4 in
Top Width	15.75 ft
Critical Depth	22.9 in
Critical Slope	0.017 ft/ft
Velocity	11.26 ft/s
Velocity Head	1.97 ft
Specific Energy	3.26 ft
Froude Number	2.012
Flow Type	Supercritical

GVF Input Data

Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

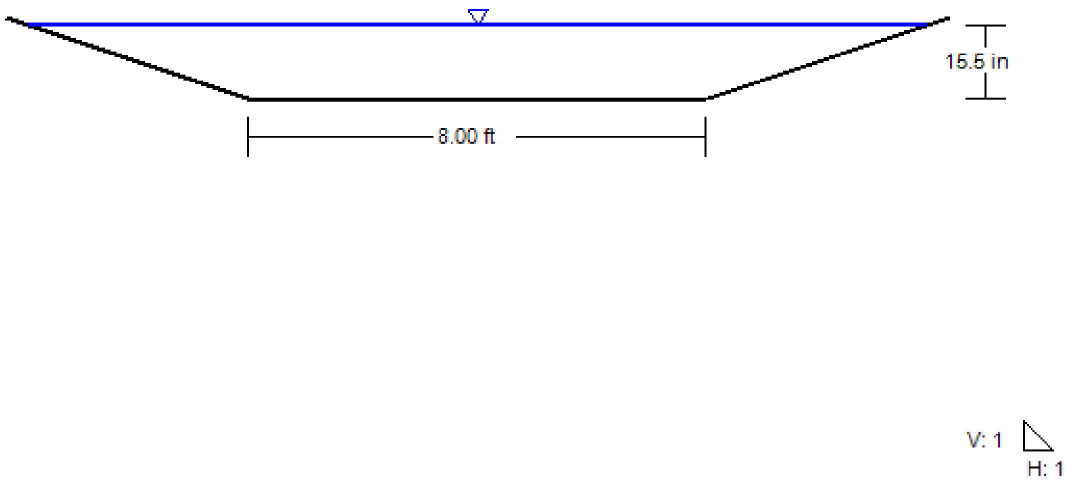
GVF Output Data

Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	15.5 in
Critical Depth	22.9 in
Channel Slope	0.076 ft/ft
Critical Slope	0.017 ft/ft

Cross Section for Ditch C2 - Flows from C1, C2, & Ditch C1.3

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Roughness Coefficient	0.035
Channel Slope	0.076 ft/ft
Normal Depth	15.5 in
Left Side Slope	3.000 H:V
Right Side Slope	3.000 H:V
Bottom Width	8.00 ft
Discharge	172.63 cfs



Ditch D1 - Flow from D4 & D6

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Roughness Coefficient	0.035
Channel Slope	0.003 ft/ft
Left Side Slope	3.000 H:V
Right Side Slope	3.000 H:V
Bottom Width	8.00 ft
Discharge	84.50 cfs

Results	
Normal Depth	24.7 in
Flow Area	29.2 ft²
Wetted Perimeter	21.0 ft
Hydraulic Radius	16.7 in
Top Width	20.36 ft
Critical Depth	15.4 in
Critical Slope	0.019 ft/ft
Velocity	2.89 ft/s
Velocity Head	0.13 ft
Specific Energy	2.19 ft
Froude Number	0.426
Flow Type	Subcritical

GVF Input Data	
Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data	
Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	24.7 in
Critical Depth	15.4 in
Channel Slope	0.003 ft/ft
Critical Slope	0.019 ft/ft

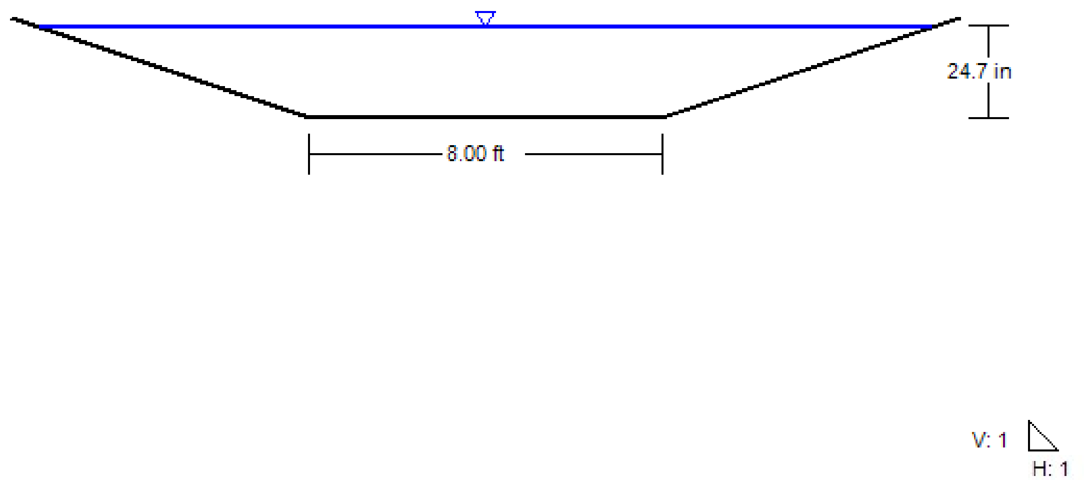
Cross Section for Ditch D1 - Flow from D4, D6

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035
Channel Slope	0.003 ft/ft
Normal Depth	24.7 in
Left Side Slope	3.000 H:V
Right Side Slope	3.000 H:V
Bottom Width	8.00 ft
Discharge	84.50 cfs



Worksheet for Ditch D2 - Flow from D1, D3, D5, & Ditch D1

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035
Channel Slope	0.003 ft/ft
Left Side Slope	3.000 H:V
Right Side Slope	3.000 H:V
Bottom Width	8.00 ft
Discharge	198.00 cfs

Results

Normal Depth	37.5 in
Flow Area	54.4 ft²
Wetted Perimeter	27.8 ft
Hydraulic Radius	23.5 in
Top Width	26.77 ft
Critical Depth	24.7 in
Critical Slope	0.017 ft/ft
Velocity	3.64 ft/s
Velocity Head	0.21 ft
Specific Energy	3.33 ft
Froude Number	0.450
Flow Type	Subcritical

GVF Input Data

Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

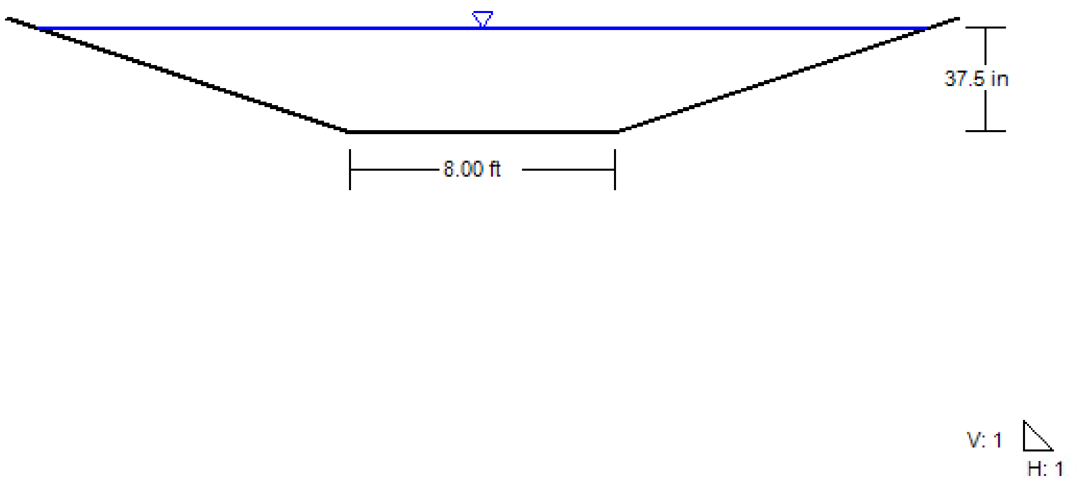
GVF Output Data

Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	37.5 in
Critical Depth	24.7 in
Channel Slope	0.003 ft/ft
Critical Slope	0.017 ft/ft

Cross Section for Ditch D2 - Flow from D1, D3, D5, & Ditch D1

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Roughness Coefficient	0.035
Channel Slope	0.003 ft/ft
Normal Depth	37.5 in
Left Side Slope	3.000 H:V
Right Side Slope	3.000 H:V
Bottom Width	8.00 ft
Discharge	198.00 cfs



Worksheet for Ditch D2 - Flow from D1, D3, D5, & Ditch D1

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035
Channel Slope	0.016 ft/ft
Left Side Slope	3.000 H:V
Right Side Slope	3.000 H:V
Bottom Width	8.00 ft
Discharge	198.00 cfs

Results

Normal Depth	24.7 in
Flow Area	29.2 ft²
Wetted Perimeter	21.0 ft
Hydraulic Radius	16.7 in
Top Width	20.37 ft
Critical Depth	24.7 in
Critical Slope	0.017 ft/ft
Velocity	6.77 ft/s
Velocity Head	0.71 ft
Specific Energy	2.77 ft
Froude Number	0.996
Flow Type	Subcritical

GVF Input Data

Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

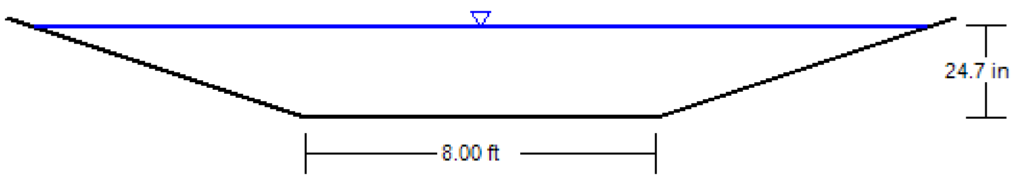
GVF Output Data

Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	24.7 in
Critical Depth	24.7 in
Channel Slope	0.016 ft/ft
Critical Slope	0.017 ft/ft

Cross Section for Ditch D2 - Flow from D1, D3, D5, & Ditch D1

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Roughness Coefficient	0.035
Channel Slope	0.016 ft/ft
Normal Depth	24.7 in
Left Side Slope	3.000 H:V
Right Side Slope	3.000 H:V
Bottom Width	8.00 ft
Discharge	198.00 cfs



V: 1
H: 1

Ditch D2 - Flow from D1, D3, D5, & Ditch D1

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035
Channel Slope	0.026 ft/ft
Left Side Slope	3.000 H:V
Right Side Slope	3.000 H:V
Bottom Width	8.00 ft
Discharge	198.00 cfs

Results

Normal Depth	22.0 in
Flow Area	24.7 ft²
Wetted Perimeter	19.6 ft
Hydraulic Radius	15.1 in
Top Width	18.98 ft
Critical Depth	24.7 in
Critical Slope	0.017 ft/ft
Velocity	8.02 ft/s
Velocity Head	1.00 ft
Specific Energy	2.83 ft
Froude Number	1.240
Flow Type	Supercritical

GVF Input Data

Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

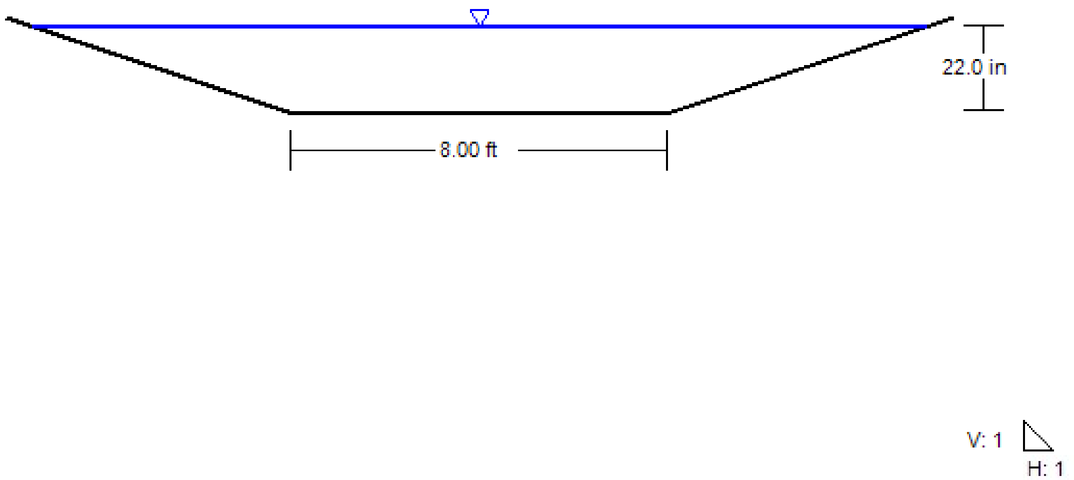
GVF Output Data

Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	22.0 in
Critical Depth	24.7 in
Channel Slope	0.026 ft/ft
Critical Slope	0.017 ft/ft

Cross Section for Ditch D2 - Flow from D1, D3, D5, & Ditch D1

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Roughness Coefficient	0.035
Channel Slope	0.026 ft/ft
Normal Depth	22.0 in
Left Side Slope	3.000 H:V
Right Side Slope	3.000 H:V
Bottom Width	8.00 ft
Discharge	198.00 cfs



Worksheet for Ditch D3 - Flow From E6 & Ditch D2

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035
Channel Slope	0.026 ft/ft
Left Side Slope	3.000 H:V
Right Side Slope	3.000 H:V
Bottom Width	8.00 ft
Discharge	220.53 cfs

Results

Normal Depth	23.2 in
Flow Area	26.8 ft²
Wetted Perimeter	20.3 ft
Hydraulic Radius	15.9 in
Top Width	19.62 ft
Critical Depth	26.2 in
Critical Slope	0.016 ft/ft
Velocity	8.24 ft/s
Velocity Head	1.06 ft
Specific Energy	2.99 ft
Froude Number	1.244
Flow Type	Supercritical

GVF Input Data

Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data

Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	23.2 in
Critical Depth	26.2 in
Channel Slope	0.026 ft/ft
Critical Slope	0.016 ft/ft

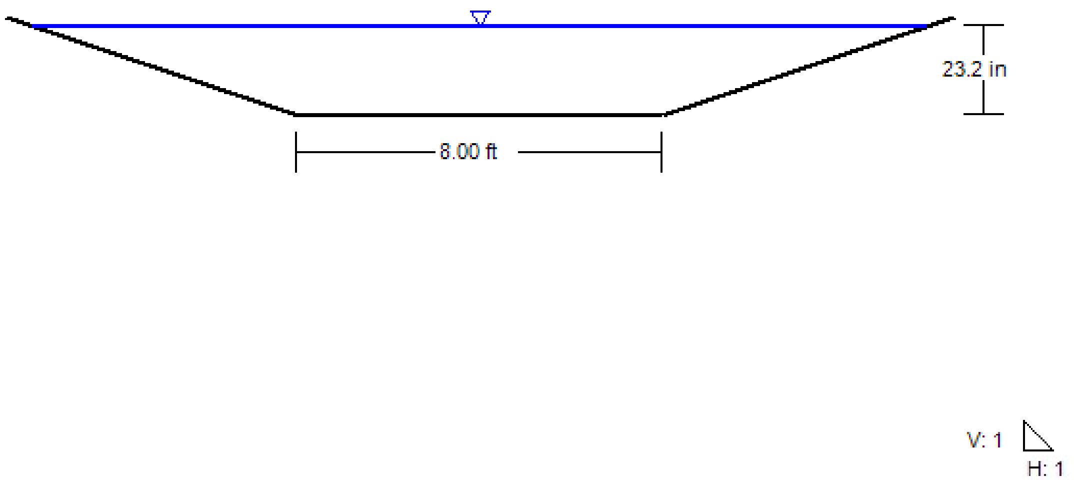
Cross Section for Ditch D3 - Flow From E6 & Ditch D2

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035
Channel Slope	0.026 ft/ft
Normal Depth	23.2 in
Left Side Slope	3.000 H:V
Right Side Slope	3.000 H:V
Bottom Width	8.00 ft
Discharge	220.53 cfs



Ditch D3 - Flow From E6 & Ditch D2

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035
Channel Slope	0.034 ft/ft
Left Side Slope	3.000 H:V
Right Side Slope	3.000 H:V
Bottom Width	8.00 ft
Discharge	220.53 cfs

Results

Normal Depth	21.7 in
Flow Area	24.3 ft²
Wetted Perimeter	19.4 ft
Hydraulic Radius	15.0 in
Top Width	18.85 ft
Critical Depth	26.2 in
Critical Slope	0.016 ft/ft
Velocity	9.08 ft/s
Velocity Head	1.28 ft
Specific Energy	3.09 ft
Froude Number	1.411
Flow Type	Supercritical

GVF Input Data

Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

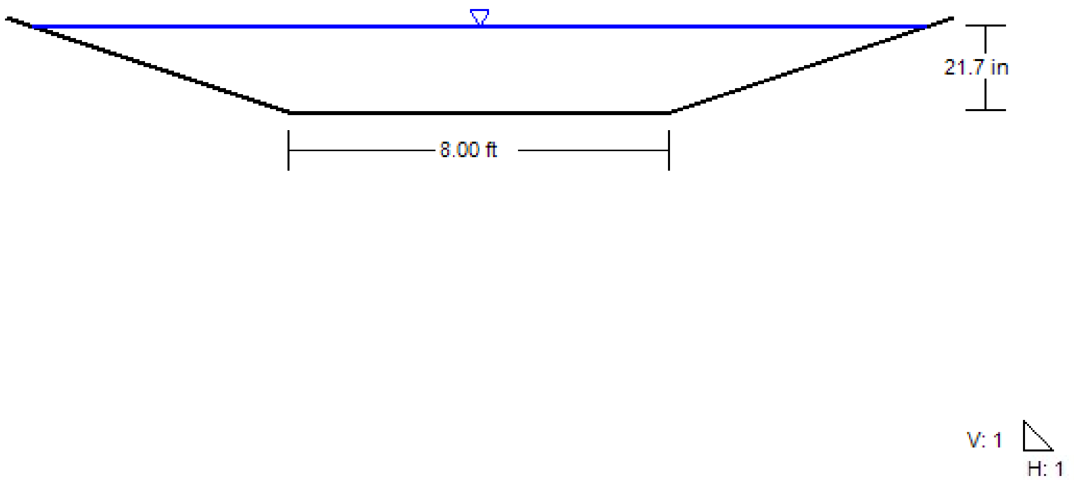
GVF Output Data

Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	21.7 in
Critical Depth	26.2 in
Channel Slope	0.034 ft/ft
Critical Slope	0.016 ft/ft

Cross Section for Ditch D3 - Flow From E6 & Ditch D2

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Roughness Coefficient	0.035
Channel Slope	0.034 ft/ft
Normal Depth	21.7 in
Left Side Slope	3.000 H:V
Right Side Slope	3.000 H:V
Bottom Width	8.00 ft
Discharge	220.53 cfs



Worksheet for Ditch E1 - Flow from E2, E4, & E5

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035
Channel Slope	0.003 ft/ft
Left Side Slope	3.000 H:V
Right Side Slope	3.000 H:V
Bottom Width	8.00 ft
Discharge	140.36 cfs

Results

Normal Depth	33.2 in
Flow Area	45.2 ft²
Wetted Perimeter	25.5 ft
Hydraulic Radius	21.2 in
Top Width	24.62 ft
Critical Depth	20.5 in
Critical Slope	0.017 ft/ft
Velocity	3.11 ft/s
Velocity Head	0.15 ft
Specific Energy	2.92 ft
Froude Number	0.404
Flow Type	Subcritical

GVF Input Data

Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data

Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	33.2 in
Critical Depth	20.5 in
Channel Slope	0.003 ft/ft
Critical Slope	0.017 ft/ft

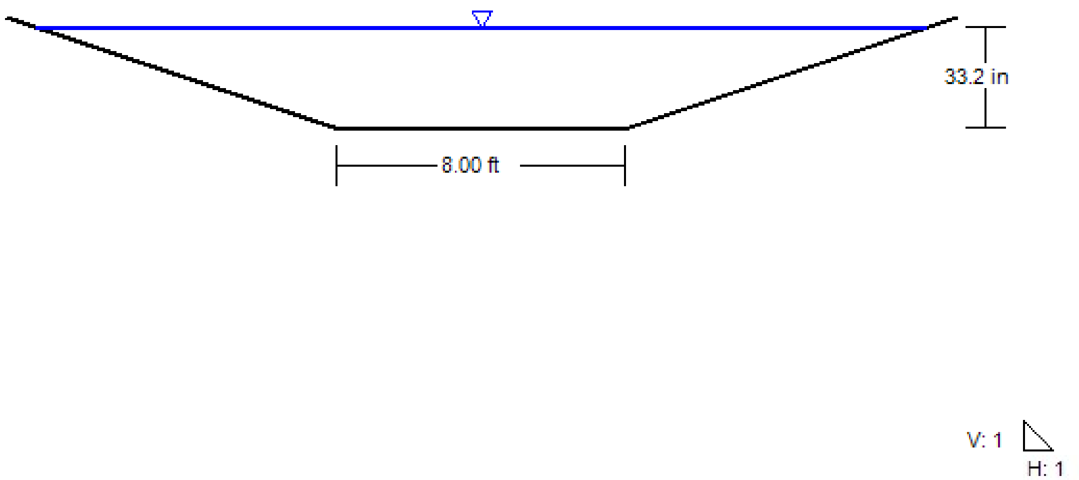
Cross Section for Ditch E1 - Flow from E2, E4, & E5

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035
Channel Slope	0.003 ft/ft
Normal Depth	33.2 in
Left Side Slope	3.000 H:V
Right Side Slope	3.000 H:V
Bottom Width	8.00 ft
Discharge	140.36 cfs



Worksheet for Ditch E1 - Flow from E2, E4, & D5.2

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035
Channel Slope	0.019 ft/ft
Left Side Slope	3.000 H:V
Right Side Slope	3.000 H:V
Bottom Width	8.00 ft
Discharge	140.36 cfs

Results

Normal Depth	20.0 in
Flow Area	21.6 ft²
Wetted Perimeter	18.5 ft
Hydraulic Radius	14.0 in
Top Width	17.99 ft
Critical Depth	20.5 in
Critical Slope	0.017 ft/ft
Velocity	6.49 ft/s
Velocity Head	0.65 ft
Specific Energy	2.32 ft
Froude Number	1.043
Flow Type	Supercritical

GVF Input Data

Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

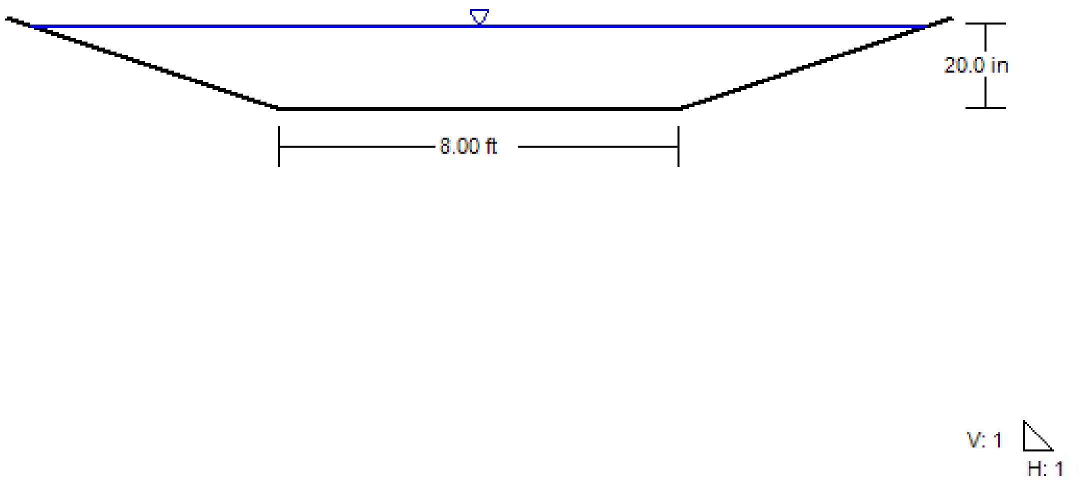
GVF Output Data

Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	20.0 in
Critical Depth	20.5 in
Channel Slope	0.019 ft/ft
Critical Slope	0.017 ft/ft

Cross Section for Ditch E1 - Flow from E2, E4, & D5.2

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Roughness Coefficient	0.035
Channel Slope	0.019 ft/ft
Normal Depth	20.0 in
Left Side Slope	3.000 H:V
Right Side Slope	3.000 H:V
Bottom Width	8.00 ft
Discharge	140.36 cfs



Worksheet for Ditch E1 - Flow from E2, E4, & D5.3

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035
Channel Slope	0.004 ft/ft
Left Side Slope	3.000 H:V
Right Side Slope	3.000 H:V
Bottom Width	8.00 ft
Discharge	140.36 cfs

Results

Normal Depth	29.6 in
Flow Area	38.0 ft²
Wetted Perimeter	23.6 ft
Hydraulic Radius	19.3 in
Top Width	22.82 ft
Critical Depth	20.5 in
Critical Slope	0.017 ft/ft
Velocity	3.69 ft/s
Velocity Head	0.21 ft
Specific Energy	2.68 ft
Froude Number	0.504
Flow Type	Subcritical

GVF Input Data

Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data

Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	29.6 in
Critical Depth	20.5 in
Channel Slope	0.004 ft/ft
Critical Slope	0.017 ft/ft

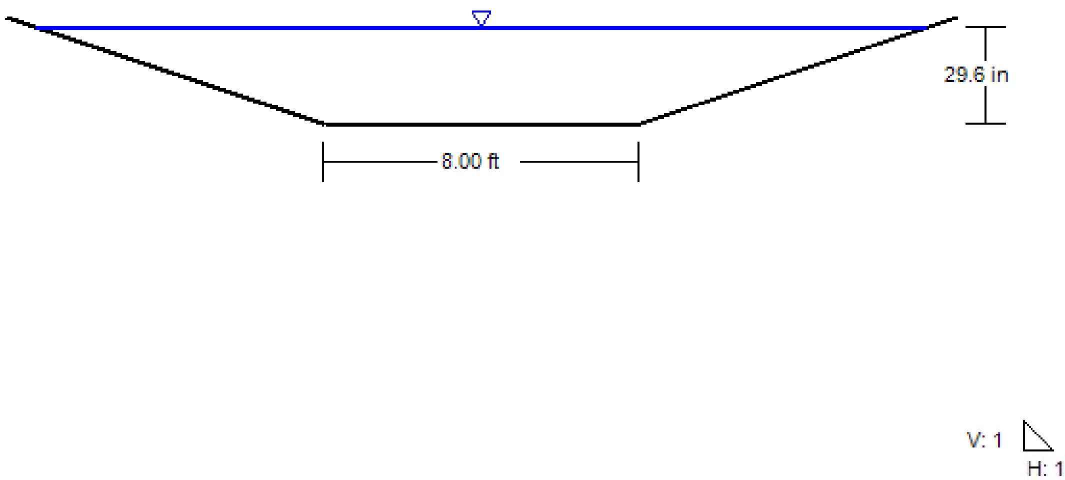
Cross Section for Ditch E1 - Flow from E2, E4, & D5.3

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035
Channel Slope	0.004 ft/ft
Normal Depth	29.6 in
Left Side Slope	3.000 H:V
Right Side Slope	3.000 H:V
Bottom Width	8.00 ft
Discharge	140.36 cfs



Ditch E2 - Flow from E1, E3, & Ditch E1

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035
Channel Slope	0.004 ft/ft
Left Side Slope	3.000 H:V
Right Side Slope	3.000 H:V
Bottom Width	8.00 ft
Discharge	186.94 cfs

Results

Normal Depth	34.5 in
Flow Area	47.8 ft²
Wetted Perimeter	26.2 ft
Hydraulic Radius	21.9 in
Top Width	25.25 ft
Critical Depth	23.9 in
Critical Slope	0.017 ft/ft
Velocity	3.91 ft/s
Velocity Head	0.24 ft
Specific Energy	3.11 ft
Froude Number	0.501
Flow Type	Subcritical

GVF Input Data

Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data

Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	34.5 in
Critical Depth	23.9 in
Channel Slope	0.004 ft/ft
Critical Slope	0.017 ft/ft

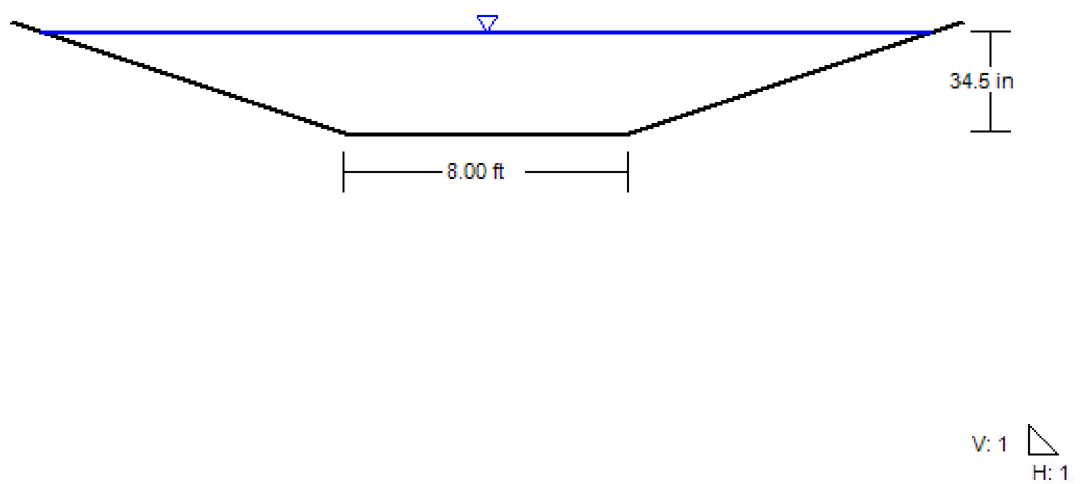
Cross Section for Ditch E2 - Flow from E1, E3, & Ditch E1

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035
Channel Slope	0.004 ft/ft
Normal Depth	34.5 in
Left Side Slope	3.000 H:V
Right Side Slope	3.000 H:V
Bottom Width	8.00 ft
Discharge	186.94 cfs



Worksheet for Ditch E2 - Flow from E1, E3, & Ditch E1

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035
Channel Slope	0.051 ft/ft
Left Side Slope	3.000 H:V
Right Side Slope	3.000 H:V
Bottom Width	8.00 ft
Discharge	186.94 cfs

Results

Normal Depth	17.9 in
Flow Area	18.6 ft²
Wetted Perimeter	17.4 ft
Hydraulic Radius	12.8 in
Top Width	16.96 ft
Critical Depth	23.9 in
Critical Slope	0.017 ft/ft
Velocity	10.03 ft/s
Velocity Head	1.56 ft
Specific Energy	3.06 ft
Froude Number	1.686
Flow Type	Supercritical

GVF Input Data

Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

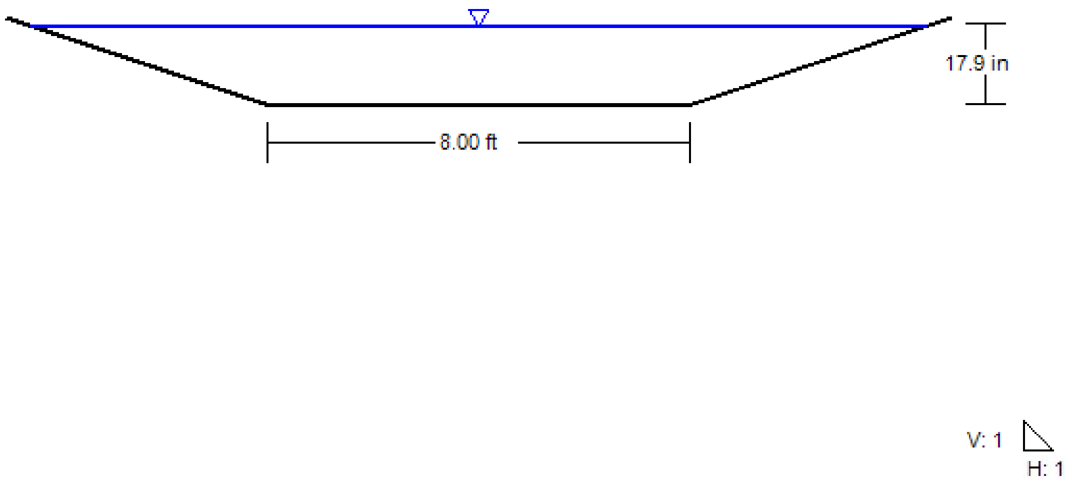
GVF Output Data

Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	17.9 in
Critical Depth	23.9 in
Channel Slope	0.051 ft/ft
Critical Slope	0.017 ft/ft

Cross Section for Ditch E2 - Flow from E1, E3, & Ditch E1

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Roughness Coefficient	0.035
Channel Slope	0.051 ft/ft
Normal Depth	17.9 in
Left Side Slope	3.000 H:V
Right Side Slope	3.000 H:V
Bottom Width	8.00 ft
Discharge	186.94 cfs



CONTAMINATED WATER CONTAINMENT AND DIVERSION BERM CALCULATIONS

Greater El Paso Landfill
CONTAMINATED WATER CONTAINMENT AND DIVERSION BERM CALCULATION

BURNS & McDONNELL

PROJECT	Greater El Paso Landfill Permit 2284A
SUBJECT	Contaminated Water Containment and Diversion Berms
PROJECT NUMBER	155488
DATE	Apr-25 Page 1 of 3

Purpose: The purpose of this calculation is to determine the height of the contaminated water containment berm at the downstream edge of the active face and the height of the diversion berm controlling stormwater run-on to the active face.

Methodology: These calculations are organized into two parts: those pertaining to the containment berm and those pertaining to the diversion berm. First, the containment berm height was calculated by estimating the volume of runoff within the active area, then solving for the required height based on this volume, the length of the berm and the geometry of the v-shaped water cross-section. Second, the diversion berm height was calculated using the Rational Method to estimate the peak flow from a typical run-on drainage basin and Mannings Equation to size the v-shaped swale. Runoff peak flows and volumes were calculated using the 25-year, 24-hour storm event for El Paso, TX.

Assumptions:

1. Runoff coefficient for the active face is determined according to exposed waste at 3% slopes.
2. The average weekly waste placement rate, used to size the active face was determined using the 2019 annual disposal tonnage, a 1,300 lb/cy factor, and a compaction ratio of 2:1 (volume in truck:volume in landfill)
3. The lift thickness, used to size the active face, is 10 feet. This is typical for landfill operations.
4. The active face is square-shaped.
5. The active face has a slope of 3%.
6. The containment/diversion berms shall have 2:1 slopes and no minimum top width.
7. Time of concentration is assumed to be 10 min.
8. Runoff coefficient for the run-on basin is determined according to interim cover material at 3:1 slopes that extend to touch the flowine of the berm.
9. Area of the run-on basin is 4 acres. This is equivalent to approximately 14 former active faces.
10. A 0.5% flowline slope was used to design the run-on berm. Actual slopes at time of installation should be 1.0%. This accounts for settlement.

References:

1. Texas DOT Hydraulic Design Manual, 2019
2. NOAA Atlas 14, Volume 11, Version 2 Estimates for El Paso, TX
3. Rainfall Intensity-Duration-Frequency Coefficients for Texas Version 2.1, 2015
4. Flowmaster Output

7222	= Data Input Cell
7222	= Calculated and/or Referenced

Conclusions: 2-foot containment and diversion berms with 2:1 side slopes shall be installed around the active face. The diversion portion of the berm, along the upstream edge of the active face, shall have a flowline of at least 0.5% for the duration of the active face.

Prepared By:	J. Pistorius	Date:	Apr-25
Checked By:	K. Benjamin	Date:	Apr-25
Approved By:		Date:	

Greater El Paso Landfill
CONTAMINATED WATER CONTAINMENT CALCULATION

Calculation by: JGP Date: Apr-25

1) PEAK VOLUME OF CONTMINATED WATER

MSW Runoff Coefficient, C

				Reference
Watershed Relief Component, Cr	**Cr =**	0.09		Reference 1, Assumption 1
Soil Infiltration Component, Ci	**Ci =**	0.06		Reference 1, Assumption 1
Vegetal Cover Component, Cv	**Cv =**	0.16		Reference 1, Assumption 1
Surface Type Component, Cs	**Cs =**	0.04		Reference 1, Assumption 1
Overall Runoff Coefficient, C = Cr + Ci + Cv + Cs	**C =**	0.35		Reference 1

25-year, 24-hour Rainfall Depth, D

Rainfall Depth	**D =**	3.17	in	Reference 2
		0.26	ft	

Area, A

In-place waste volume per year, Wyear		**W_{year} =**	767,385	CY	Assumption 2
In-place waste volume per week	**$W = W_{year} / 52$**	**W =**	14,757	CY	Assumption 2
			398,450	ft^3	
Lift Thickness, T		**T =**	10	ft	Assumption 3
Contact Water Area	**A = W/T**	**A =**	39,845	ft^2	
			0.91	acres	

Contaminated Water Volume, V

V = Total Contaminated Water = C x D x A	**V =**	3,684	ft^3

2) REQUIRED CONTAINMENT BERM HEIGHT

Downstream Berm Length, L	**$L = A^{0.5}$**	**L =**	199.61	ft	Assumption 4
Required Cross-Sectional Area	**$A_x = V/L$**	**A_x =**	18.46	ft^2	
Slope of Active Area (inside edge of triangular cross-sectional area, A,		**S_1 =**	0.03	ft/ft	Assumption 5
Slope of Berm (outside edge of triangular cross-sectional area, Ax)		**S_2 =**	0.50	ft/ft	Assumption 6
Height of Contaminated Water	**$H_W = (2Ax / [(1/S_2)+(1/S_1)])^{0.5}$**	**H_W =**	1.02	ft	
Height of Containment Berm	**$H_B = H_W$ + 6 inches freeboard**	**H_B =**	1.52	ft	

Use a berm height of 2 feet.

NOTE:
Areas and Lengths calculated using AutoCAD Civil3D

Greater El Paso Landfill
ACTIVE FACE RUN-ON DIVERSION CALCULATION

Calculation by: JGP Date: Apr-25

1) PEAK FLOW OF RUN-ON WATER

Runoff Coefficient, C

				Reference
Watershed Relief Component, Cr	**Cr =**	0.30		Reference 1, Assumption 8
Soil Infiltration Component, Ci	**Ci =**	0.08		Reference 1, Assumption 8
Vegetal Cover Component, Cv	**Cv =**	0.12		Reference 1, Assumption 8
Surface Type Component, Cs	**Cs =**	0.08		Reference 1, Assumption 8
Overall Runoff Coefficient, C = Cr + Ci + Cv + Cs		0.58		

Average Rainfall Intensity, I

Time of Concentration, T	**T_c =**	10.0	min	Assumption 7
25- Year Intensity-Frequency-Duration Coefficient, e	**e =**	0.9037		Reference 3
25- Year Intensity-Frequency-Duration Coefficient, b	**b =**	80.750	in	Reference 3
25- Year Intensity-Frequency-Duration Coefficient, d	**d =**	7.360	min	Reference 3
Average Rainfall Intensity, $I = b/(T_c + d)^e$	**I =**	6.123	in/hr	Reference 3

Drainage Area, A

Drainage Area, A	**A =**	4.00	Ac	Assumption 9

Peak Flow, Q

Q= Total Discharge from Watershed = C x I x A	**Q =**	14.2	**cfs**	

2) REQUIRED DIVERSION BERM HEIGHT

Slope of Run-on Basin (inside edge of triangular cross-sectional area)	**S =**	0.33	ft/ft	Assumption 8
Slope of Berm (outside edge of triangular cross-sectional area)	**S =**	0.50	ft/ft	Assumption 6
Slope of Swale Flowline	**S =**	0.50	%	Assumption 10
Mannings Roughness Coefficient, n	**n =**	0.018		Reference 1
Depth of Flow	**H_W =**	1.117	ft	Reference 4
Height of Diversion Berm **$H_B = H_W$ + 6 inches freeboard**	**H_B =**	1.62	ft	

Use a berm height of 2 feet.

NOTE:
Areas and Lengths calculated using AutoCAD Civil3D

Reference 1
Texas DOT Hydraulic Design Manual, 2019

Hydraulic Design Manual

Revised September 2019

Table 4-11: Runoff Coefficients for Rural Watersheds

Watershed characteristic	Extreme	High	Normal	Low
Relief - C_r	0.28-0.35 Steep, rugged terrain with average slopes above 30%	0.20-0.28 Hilly, with average slopes of 10-30%	0.14-0.20 Rolling, with average slopes of 5-10%	0.08-0.14 Relatively flat land, with average slopes of 0-5%
Soil infiltration - C_i	0.12-0.16 No effective soil cover; either rock or thin soil mantle of negligible infiltration capacity	0.08-0.12 Slow to take up water, clay or shallow loam soils of low infiltration capacity or poorly drained	0.06-0.08 Normal; well drained light or medium textured soils, sandy loams	0.04-0.06 Deep sand or other soil that takes up water readily; very light, well-drained soils
Vegetal cover - C_v	0.12-0.16 No effective plant cover, bare or very sparse cover	0.08-0.12 Poor to fair; clean cultivation, crops or poor natural cover, less than 20% of drainage area has good cover	0.06-0.08 Fair to good; about 50% of area in good grassland or woodland, not more than 50% of area in cultivated crops	0.04-0.06 Good to excellent; about 90% of drainage area in good grassland, woodland, or equivalent cover
Surface Storage - C_s	0.10-0.12 Negligible; surface depressions few and shallow, drainageways steep and small, no marshes	0.08-0.10 Well-defined system of small drainageways, no ponds or marshes	0.06-0.08 Normal; considerable surface depression, e.g., storage lakes and ponds and marshes	0.04-0.06 Much surface storage, drainage system not sharply defined; large floodplain storage, large number of ponds or marshes
Table 4-11 note: The total runoff coefficient based on the 4 runoff components is $C = C_r + C_i + C_v + C_s$				

While this approach was developed for application to rural watersheds, it can be used as a check against mixed-use runoff coefficients computed using other methods. In so doing, the designer would use judgment, primarily in specifying C_s, to account for partially developed conditions within the watershed.

Mixed Land Use

For areas with a mixture of land uses, a composite runoff coefficient should be used. The composite runoff coefficient is weighted based on the area of each respective land use and can be calculated as:

Table 4-10: Runoff Coefficients for Urban Watersheds

Type of drainage area	Runoff coefficient
Heavy soil, steep 7%	0.25-0.35
Streets:	
Asphaltic	0.85-0.95
Concrete	0.90-0.95
Brick	0.70-0.85
Drives and walks	0.75-0.95
Roofs	0.75-0.95

Rural and Mixed-Use Watershed

Table 4-11 shows an alternate, systematic approach for developing the runoff coefficient. This table applies to rural watersheds only, addressing the watershed as a series of aspects. For each of four aspects, the designer makes a systematic assignment of a runoff coefficient "component." Using Equation 4-22, the four assigned components are added to form an overall runoff coefficient for the specific watershed segment.

The runoff coefficient for rural watersheds is given by:

$$C = C_r + C_i + C_v + C_s$$

Equation 4-22.

Where*:*

C = runoff coefficient for rural watershed

C_r = component of coefficient accounting for watershed relief

C_i = component of coefficient accounting for soil infiltration

C_v = component of coefficient accounting for vegetal cover

C_s = component of coefficient accounting for surface type

The designer selects the most appropriate values for C_r, C_i, C_v, and C_s from Table 4-11.

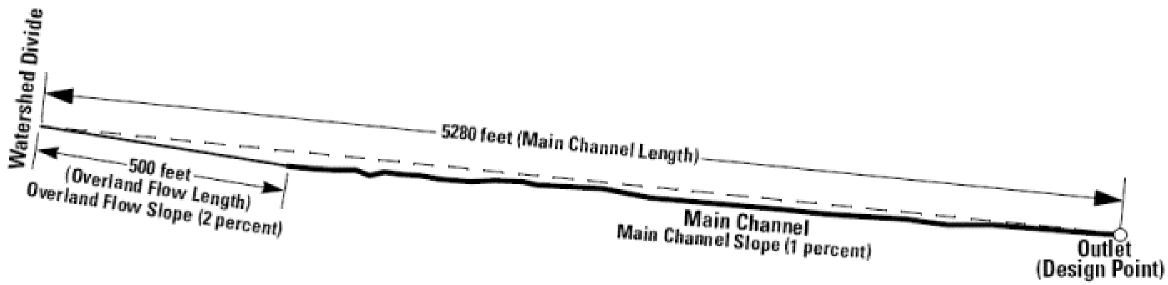


Figure 4-7. Example application of Kerby-Kirpich method

Natural Resources Conservation Service (NRCS) Method for Estimating t_c

The NRCS method for estimating t_c is applicable for small watersheds, in which the majority of flow is overland flow such that timing of the peak flow is not significantly affected by the contribution flow routed through underground storm drain systems. With the NRCS method:

$$t_c = t_{sh} + t_{sc} + t_{ch}$$

Equation 4-16.

Where:

t_{sh} = sheet flow travel time

t_{sc} = shallow concentrated flow travel time

t_{ch} = channel flow travel time

NRCS 1986 provides the following descriptions of these flow components:

Sheet flow is flow over plane surfaces, usually occurring in the headwater of streams. With sheet flow, the friction value is an effective roughness coefficient that includes the effect of raindrop impact; drag over the plane surface; obstacles such as litter, crop ridges, and rocks; and erosion and transportation of sediment.

Sheet flow usually becomes shallow concentrated flow after around 100 feet.

Open channels are assumed to begin where surveyed cross section information has been obtained, where channels are visible on aerial photographs, or where blue lines (indicating streams) appear on USGS quadrangle sheets.

For open channel flow, consider the uniform flow velocity based on bank-full flow conditions. That is, the main channel is flowing full without flow in the overbanks. This assumption avoids the significant iteration associated with rainfall intensity or discharges (because rainfall intensity and discharge are dependent on time of concentration).

For conduit flow, in a proposed storm drain system, compute the velocity at uniform depth based on the computed discharge at the upstream. Otherwise, if the conduit is in existence, determine full capacity flow in the conduit, and determine the velocity at capacity flow. You may need to compare this velocity later with the velocity calculated during conduit analysis. If there is a significant difference and the conduit is a relatively large component of the total travel path, recompute the time of concentration using the latter velocity estimate.

If it is determined that a low slope condition or a transitional slope condition exists, the user should consider using an adjusted slope in calculating the time of concentration. See Time of Concentration.

Sheet Flow Time Calculation

Sheet flow travel time is computed as:

$$t_{sh} = \frac{0.007(n_{ol}L_{sh})^{0.8}}{(P_2)^{0.5}S_{sh}^{0.4}}$$

Equation 4-17.

Where:

t_{sh} = sheet flow travel time (hr.)

n_{ol} = overland flow roughness coefficient (provided in Table 4-6)

L_{sh} = sheet flow length (ft) (100 ft. maximum)

P_2 = 2-year, 24-h rainfall depth (in.) (provided in - [NOAA's Precipitation Frequency Data Server for Atlas 14])

S_{sh} = sheet flow slope (ft/ft)

Table 4-6: Overland Flow Roughness Coefficients for Use in NRCS Method in Calculating Sheet Flow Travel Time (NRCS 1986)

Surface description		**n_{ol}**
Smooth surfaces (concrete, asphalt, gravel, or bare soil)		0.011
Fallow (no residue)		0.05
Cultivated soils:	Residue $cover \leq 20\,\%$	0.06
	Residue cover > 20%	0.17
Grass:	Short grass prairie	0.15
	Dense grasses	0.24
	Bermuda	0.41

Table 4-6: Overland Flow Roughness Coefficients for Use in NRCS Method in Calculating Sheet Flow Travel Time (NRCS 1986)

Surface description		n_{ol}
Range (natural):		0.13
Woods:	Light underbrush	0.40
	Dense underbrush	0.80

NOTE: 'n' values for overland flows (nol) are not to be used in other channel or floodplain applications.

Shallow Concentrated Flow

Shallow concentrated flow travel time is computed as:

$$t_{sc} = \frac{L_{sc}}{3600 K S_{sc}^{0.5}}$$

Equation 4-18.

Where:

t_{sc} = shallow concentrated flow time (hr.)

L_{sc} = shallow concentrated flow length (ft)

K = 16.13 for unpaved surface, 20.32 for paved surface

S_{sc} = shallow concentrated flow slope (ft/ft)

Channel Flow

Channel flow travel time is computed by dividing the channel distance by the flow rate obtained from Manning's equation. This can be written as:

$$t_{ch} = L_{ch} \Big/ \left(\left(3600 \frac{1.49}{n} R^{\frac{2}{3}} S_{ch}^{\frac{1}{2}} \right) \right)$$

Equation 4-19.

Where:

t_{ch} = channel flow time (hr.)

L_{ch} = channel flow length (ft)

S_{ch} = channel flow slope (ft/ft)

n = Manning's roughness coefficient

R = channel hydraulic radius (ft), and is equal to $\frac{a}{p_w}$, where: a = cross sectional area (ft^2) and p_w = wetted perimeter (ft), consider the uniform flow velocity based on bank-full flow conditions. That is, the main channel is flowing full without flow in the overbanks. This assumption avoids the significant iteration associated with other methods that employ rainfall intensity or discharges (because rainfall intensity and discharge are dependent on time of concentration).

Manning's Roughness Coefficient Values

Manning's roughness coefficients are used to calculate flows using Manning's equation. Values from American Society of Civil Engineers (ASCE) 1992, FHWA 2001, and Chow 1959 are reproduced in Table 4-7, Table 4-8, and Table 4-9.

Table 4-7: Manning's Roughness Coefficients for Open Channels

Type of channel	Manning's n
A. Natural streams	
1. Minor streams (top width at flood stage < 100 ft)	
a. Clean, straight, full, no rifts or deep pools	0.025-0.033
b. Same as a, but more stones and weeds	0.030-0.040
c. Clean, winding, some pools and shoals	0.033-0.045
d. Same as c, but some weeds and stones	0.035-0.050
e. Same as d, lower stages, more ineffective	0.040-0.055
f. Same as d, more stones	0.045-0.060
g. Sluggish reaches, weedy, deep pools	0.050-0.080
h. Very weedy, heavy stand of timber and underbrush	0.075-0.150
i. Mountain streams with gravel and cobbles, few boulders on bottom	0.030-0.050
j. Mountain streams with cobbles and large boulders on bottom	0.040-0.070
2. Floodplains	
a. Pasture, no brush, short grass	0.025-0.035
b. Pasture, no brush, high grass	0.030-0.050
c. Cultivated areas, no crop	0.020-0.040
d. Cultivated areas, mature row crops	0.025-0.045
e. Cultivated areas, mature field crops	0.030-0.050
f. Scattered brush, heavy weeds	0.035-0.070
g. Light brush and trees in winter	0.035-0.060
h. Light brush and trees in summer	0.040-0.080

Table 4-7: Manning's Roughness Coefficients for Open Channels

Type of channel	Manning's n
i. Medium to dense brush in winter	0.045-0.110
j. Medium to dense brush in summer	0.070-0.160
k. Trees, dense willows summer, straight	0.110-0.200
l. Trees, cleared land with tree stumps, no sprouts	0.030-0.050
m. Trees, cleared land with tree stumps, with sprouts	0.050-0.080
n. Trees, heavy stand of timber, few down trees, flood stage below branches	0.080-0.120
o. Trees, heavy stand of timber, few down trees, flood stage reaching branches	0.100-0.160
3. Major streams (top width at flood stage > 100 ft)	
a. Regular section with no boulders or brush	0.025-0.060
b. Irregular rough section	0.035-0.100
B. Excavated or dredged channels	
1. Earth, straight and uniform	
a. Clean, recently completed	0.016-0.020
b. Clean, after weathering	0.018-0.025
c. Gravel, uniform section, clean	0.022-0.030
d. With short grass, few weeds	0.022-0.033
2. Earth, winding and sluggish	
a. No vegetation	0.023-0.030
b. Grass, some weeds	0.025-0.033
c. Deep weeds or aquatic plants in deep channels	0.030-0.040
d. Earth bottom and rubble sides	0.028-0.035
e. Stony bottom and weedy banks	0.025-0.040
f. Cobble bottom and clean sides	0.030-0.050
g. Winding, sluggish, stony bottom, weedy banks	0.025-0.040
h. Dense weeds as high as flow depth	0.050-0.120
3. Dragline-excavated or dredged	
a. No vegetation	0.025-0.033
b. Light brush on banks	0.035-0.060
4. Rock cuts	

Procedure for using the Rational Method

The rational formula estimates the peak rate of runoff at a specific location in a watershed as a function of the drainage area, runoff coefficient, and mean rainfall intensity for a duration equal to the time of concentration. The rational formula is:

$$Q = \frac{CIA}{Z}$$

Equation 4-20.

***Where**:*

Q = maximum rate of runoff (cfs or m^3/sec.)

C = runoff coefficient

I = average rainfall intensity (in./hr. or mm/hr.)

A = drainage area (ac or ha)

Z = conversion factor, 1 for English, 360 for metric

Rainfall Intensity

The rainfall intensity (I) is the average rainfall rate in in./hr. for a specific rainfall duration and a selected frequency. The duration is assumed to be equal to the time of concentration. For drainage areas in Texas, you may compute the rainfall intensity using Equation 4-21, which is known as a rainfall intensity-duration-frequency (IDF) relationship (power-law model).

$$I = \frac{b}{(t_c + d)^e}$$

Equation 4-21.

Where:

I = design rainfall intensity (in./hr.)

t_c = time of concentration (min) as discussed in Section 11

e, b, d = coefficients based on rainfall IDF data.

In September 2018, the National Oceanic and Atmospheric Administration (NOAA) released updated precipitation frequency estimates for Texas. These estimates are available through NOAA's Precipitation Frequency Data Server (PFDS) website and the report documenting the approach is also available at the same website - NOAA Atlas 14, Volume 11: Precipitation-Frequency Atlas of the United States. This new rainfall data is considered best available data and should be used for all projects. Tabular IDF data are available from the PFDS, but linear interpolation or curve generation is needed to obtain intensity values between tabular durations. Ongoing TxDOT research will produce future e, b, d coefficients to better automate intensity calculations. However, barring significant project implementation concerns, Atlas 14 IDF data should be used. Exceptions must be approved by the DHE or DES HYD and noted on the plans or drainage report.

Currently, the coefficients in Equation 4-21 can be found in the EBDLKUP-2015v2.1.xlsx spreadsheet lookup tool (developed by Cleveland et al. 2015) for specific frequencies listed by county (See video/tutorial on the use of the EBDLKUP-2015v2.1.xlsx spreadsheet tool). This spreadsheet is based on prior rainfall frequency-duration data contained in the Atlas of Depth-Duration Frequency (DDF) of Precipitation of Annual Maxima for Texas (TxDOT 5-1301-01-1).

If a project is approved to use the older values from the EBDLKUP-2015v2.1.xlsx spreadsheet lookup tool or from existing functionality in design software like GEOPAK, they should still evaluate the new NOAA rainfall changes for their project area and, if there are increases for the design frequency, estimate an appropriate level of freeboard for use. The freeboard amount and a description of how it was generated should be noted in both the plans and the drainage report. Software that facilitates Rational Method calculations often has IDF curves from rainfall data embedded into the software. Location-specific IDF from the new NOAA rainfall data can be imported for each project into the software.

TxDOT is currently working with Texas Transportation Institute (TTI) staff, as part of research project 0-6980, to update the IDF curve relationships for the state of Texas based on the 2018 NOAA rainfall data. This work will include an update of the EBDLKUP-2015v2.1.xlsx file linked above and planned for inclusion in the next HDM update.

The general shape of a rainfall IDF curve is shown in Figure 4-9. As rainfall duration approaches zero, the rainfall intensity tends towards infinity. Because the rainfall intensity/duration relationship is assessed by assuming that the duration is equal to the time of concentration, small areas with exceedingly short times of concentration could result in design rainfall intensities that are unrealistically high. To minimize this likelihood, use a minimum time of concentration of 10 minutes. As the duration tends to infinity, the design rainfall tends towards zero. Usually, the area limitation of 200 acres for Rational Method calculations should result in rainfall intensities that are not unrealistically low. However, if the estimated time of concentration is

Reference 2
NOAA Atlas 14, Volume 11, Version 2 Estimates for El Paso, TX

NOAA Atlas 14, Volume 11, Version 2
Location name: El Paso, Texas, USA*
Latitude: 31.5954°, Longitude: -106.1722°
Elevation: 3938 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sandra Pavlovic, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Orlan Wilhite

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	**2**	**5**	**10**	**25**	**50**	**100**	**200**	**500**	**1000**
5-min	**0.235** (0.178-0.311)	**0.300** (0.228-0.387)	**0.402** (0.306-0.526)	**0.490** (0.368-0.653)	**0.615** (0.446-0.843)	**0.713** (0.504-1.01)	**0.819** (0.565-1.19)	**0.939** (0.631-1.40)	**1.11** (0.723-1.72)	**1.26** (0.795-1.98)
10-min	**0.394** (0.298-0.520)	**0.502** (0.381-0.647)	**0.672** (0.511-0.879)	**0.818** (0.614-1.09)	**1.03** (0.747-1.41)	**1.19** (0.845-1.69)	**1.37** (0.944-1.98)	**1.56** (1.05-2.32)	**1.82** (1.18-2.81)	**2.03** (1.29-3.21)
15-min	**0.452** (0.342-0.597)	**0.576** (0.437-0.744)	**0.772** (0.588-1.01)	**0.941** (0.706-1.25)	**1.18** (0.856-1.62)	**1.37** (0.966-1.93)	**1.57** (1.08-2.28)	**1.80** (1.21-2.69)	**2.15** (1.40-3.32)	**2.44** (1.54-3.85)
30-min	**0.560** (0.424-0.739)	**0.714** (0.542-0.922)	**0.957** (0.728-1.25)	**1.17** (0.875-1.55)	**1.46** (1.06-2.01)	**1.70** (1.20-2.39)	**1.95** (1.34-2.83)	**2.24** (1.51-3.34)	**2.67** (1.73-4.12)	**3.02** (1.91-4.77)
60-min	**0.671** (0.508-0.887)	**0.856** (0.649-1.10)	**1.15** (0.872-1.50)	**1.40** (1.05-1.86)	**1.75** (1.27-2.40)	**2.03** (1.44-2.87)	**2.34** (1.61-3.39)	**2.68** (1.80-3.98)	**3.17** (2.06-4.89)	**3.58** (2.26-5.65)
2-hr	**0.785** (0.597-1.03)	**0.996** (0.760-1.28)	**1.33** (1.02-1.73)	**1.61** (1.22-2.14)	**2.02** (1.47-2.75)	**2.34** (1.66-3.27)	**2.68** (1.86-3.86)	**3.08** (2.08-4.55)	**3.66** (2.39-5.61)	**4.15** (2.64-6.51)
3-hr	**0.853** (0.652-1.12)	**1.08** (0.828-1.38)	**1.44** (1.10-1.87)	**1.74** (1.32-2.30)	**2.18** (1.59-2.95)	**2.52** (1.79-3.51)	**2.89** (2.00-4.14)	**3.32** (2.24-4.88)	**3.96** (2.59-6.04)	**4.50** (2.86-7.02)
6-hr	**0.962** (0.739-1.25)	**1.22** (0.939-1.55)	**1.63** (1.26-2.10)	**1.98** (1.50-2.59)	**2.47** (1.81-3.33)	**2.86** (2.04-3.96)	**3.28** (2.29-4.68)	**3.78** (2.57-5.54)	**4.54** (2.98-6.88)	**5.18** (3.31-8.02)
12-hr	**1.04** (0.805-1.35)	**1.34** (1.03-1.68)	**1.80** (1.40-2.30)	**2.20** (1.69-2.88)	**2.79** (2.06-3.74)	**3.26** (2.34-4.49)	**3.78** (2.65-5.35)	**4.38** (2.99-6.36)	**5.29** (3.48-7.95)	**6.06** (3.88-9.30)
24-hr	**1.13** (0.875-1.45)	**1.48** (1.13-1.83)	**2.00** (1.55-2.54)	**2.47** (1.90-3.20)	**3.17** (2.36-4.23)	**3.75** (2.72-5.15)	**4.39** (3.09-6.17)	**5.13** (3.51-7.38)	**6.21** (4.10-9.25)	**7.11** (4.58-10.8)
2-day	**1.25** (0.976-1.60)	**1.67** (1.28-2.03)	**2.28** (1.78-2.87)	**2.85** (2.20-3.67)	**3.70** (2.78-4.94)	**4.44** (3.24-6.07)	**5.25** (3.71-7.32)	**6.13** (4.21-8.75)	**7.38** (4.90-10.9)	**8.41** (5.43-12.7)
3-day	**1.34** (1.05-1.71)	**1.81** (1.39-2.19)	**2.48** (1.94-3.11)	**3.10** (2.41-3.99)	**4.05** (3.06-5.39)	**4.87** (3.57-6.64)	**5.77** (4.09-8.02)	**6.73** (4.64-9.57)	**8.10** (5.38-11.9)	**9.19** (5.95-13.8)
4-day	**1.42** (1.12-1.81)	**1.91** (1.47-2.31)	**2.62** (2.06-3.29)	**3.28** (2.56-4.21)	**4.28** (3.24-5.68)	**5.14** (3.78-6.99)	**6.09** (4.33-8.44)	**7.11** (4.90-10.1)	**8.54** (5.68-12.5)	**9.71** (6.29-14.6)
7-day	**1.61** (1.27-2.04)	**2.15** (1.67-2.60)	**2.94** (2.32-3.67)	**3.66** (2.86-4.67)	**4.75** (3.60-6.25)	**5.67** (4.17-7.65)	**6.68** (4.77-9.20)	**7.79** (5.40-11.0)	**9.38** (6.26-13.7)	**10.7** (6.95-15.9)
10-day	**1.77** (1.40-2.24)	**2.34** (1.83-2.84)	**3.19** (2.53-3.98)	**3.96** (3.11-5.04)	**5.11** (3.88-6.70)	**6.07** (4.47-8.15)	**7.12** (5.09-9.77)	**8.28** (5.75-11.6)	**9.95** (6.66-14.4)	**11.3** (7.38-16.8)
20-day	**2.27** (1.81-2.85)	**2.92** (2.32-3.56)	**3.92** (3.13-4.86)	**4.79** (3.78-6.05)	**6.06** (4.61-7.86)	**7.07** (5.23-9.42)	**8.17** (5.87-11.1)	**9.38** (6.55-13.1)	**11.1** (7.47-16.0)	**12.5** (8.19-18.4)
30-day	**2.67** (2.14-3.34)	**3.38** (2.72-4.14)	**4.50** (3.62-5.57)	**5.46** (4.32-6.87)	**6.81** (5.20-8.80)	**7.88** (5.84-10.4)	**9.01** (6.49-12.2)	**10.3** (7.18-14.2)	**12.0** (8.10-17.2)	**13.4** (8.80-19.7)
45-day	**3.20** (2.57-3.98)	**4.00** (3.24-4.91)	**5.30** (4.28-6.55)	**6.40** (5.08-8.02)	**7.92** (6.06-10.2)	**9.10** (6.76-12.0)	**10.3** (7.46-14.0)	**11.6** (8.18-16.1)	**13.5** (9.12-19.2)	**14.9** (9.82-21.8)
60-day	**3.65** (2.94-4.54)	**4.55** (3.70-5.58)	**6.01** (4.87-7.41)	**7.22** (5.75-9.04)	**8.91** (6.83-11.4)	**10.2** (7.60-13.4)	**11.5** (8.35-15.5)	**12.9** (9.10-17.8)	**14.8** (10.1-21.1)	**16.3** (10.8-23.8)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

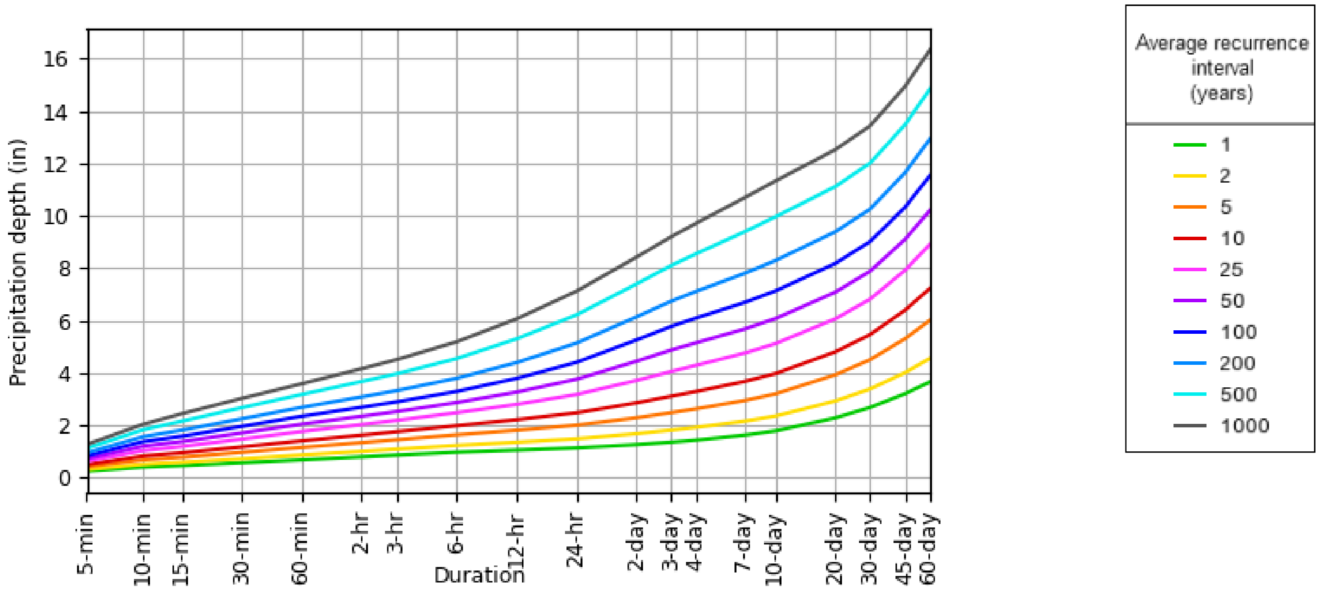
Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

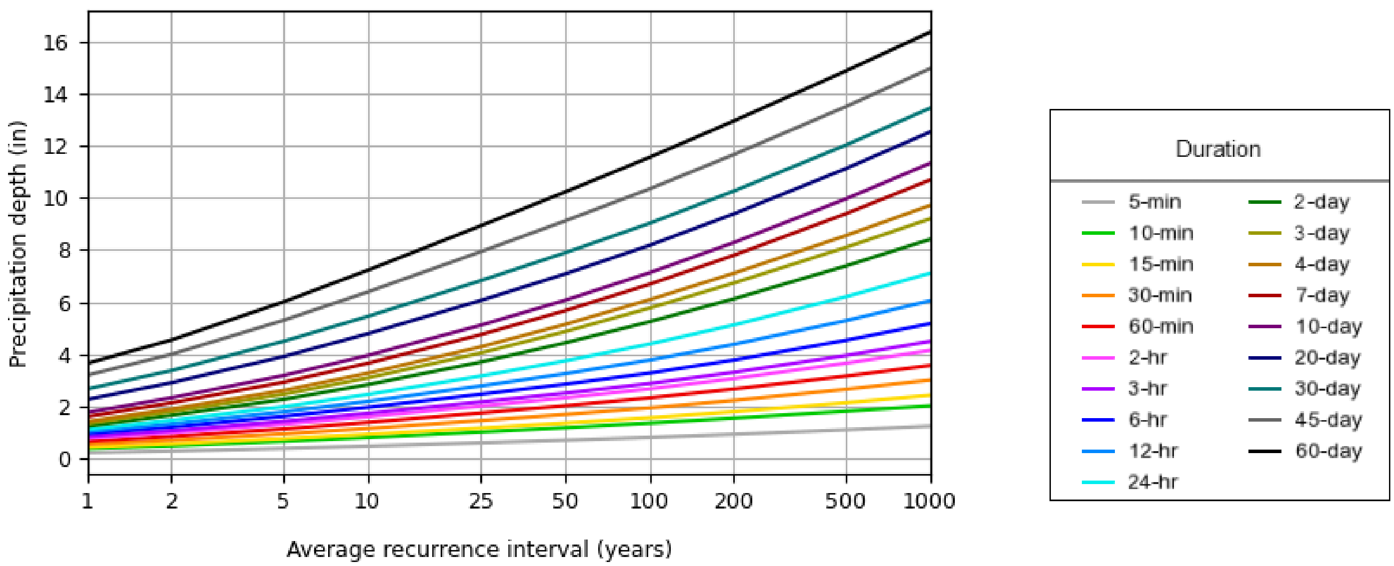
Please refer to NOAA Atlas 14 document for more information.

Back to Top

PF graphical

PDS-based depth-duration-frequency (DDF) curves
Latitude: 31.5954°, Longitude: -106.1722°





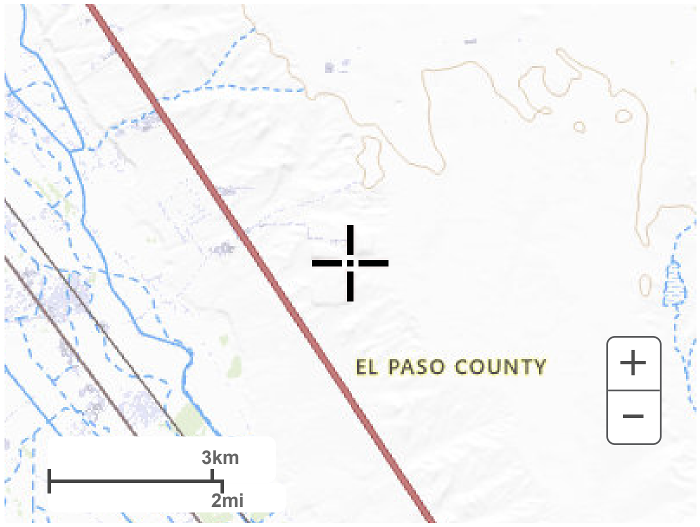
NOAA Atlas 14, Volume 11, Version 2

Created (GMT): Wed Apr 23 17:16:16 2025

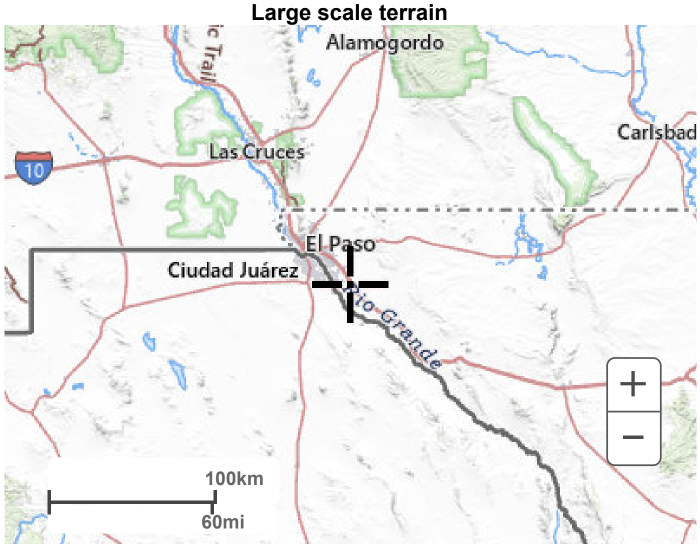
Back to Top

Maps & aerials

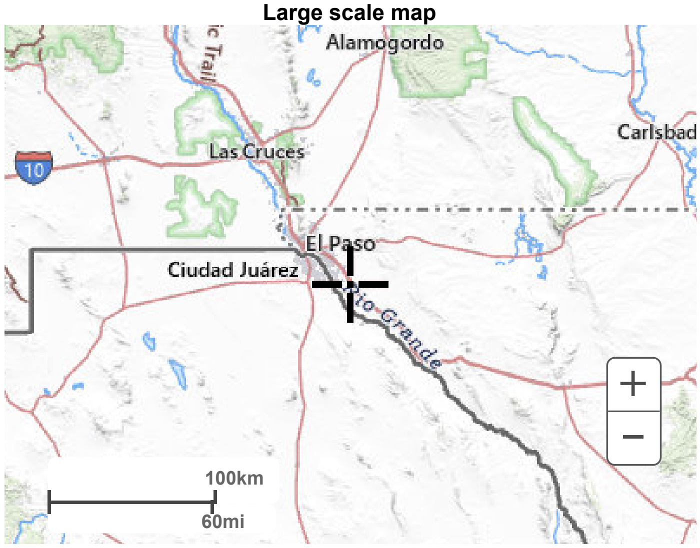
Small scale terrain



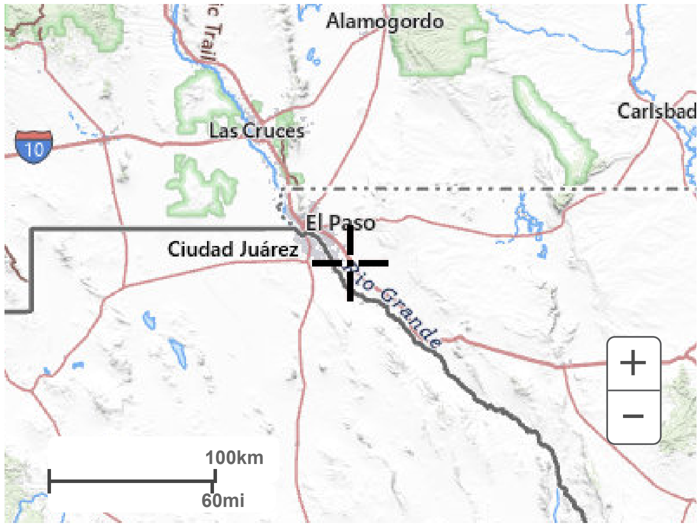
Large scale terrain



Large scale map



Large scale aerial



Back to Top

US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
National Water Center
1325 East West Highway
Silver Spring, MD 20910
Questions? [redacted]

Reference 3
Rainfall Intensity-Duration-Frequency Coefficients for Texas Version 2.1, 2015

Rainfall Intensity-Duration-Frequency Coefficients for Texas

Based on United States Geological Survey (USGS) Scientific Investigations Report 2004–5041
"Atlas of Depth-Duration Frequency of Precipitation Annual Maxima for Texas"

1. Select English or SI Units

English

2. Select or Enter a County

El Paso

3. Enter a Time of Conc.
Select Units

10 min

Coefficient	50% (2-year)	20% (5-year)	10% (10-year)	4% (25-year)	2% (50-year)	1% (100-year)
e	0.8722	0.8916	0.9184	0.9037	0.8987	0.8902
b (in.)	30.36	48.03	70.58	80.75	90.38	100.88
d (min)	4.11	5.22	7.20	7.36	7.76	8.56
Intensity (in./hr)	3.02	4.24	5.18	6.12	6.81	7.49

(Spreadsheet Release Date: August 31, 2015; data table reshuffle by Asquith July 14, 2016)

Reference 4
FlowMaster Output

Worksheet for Active Face Diversion Berm

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Roughness Coefficient	0.018
Channel Slope	0.005 ft/ft
Left Side Slope	3.000 H:V
Right Side Slope	2.000 H:V
Discharge	14.20 cfs

Results	
Normal Depth	14.4 in
Flow Area	3.6 ft²
Wetted Perimeter	6.5 ft
Hydraulic Radius	6.7 in
Top Width	6.00 ft
Critical Depth	13.8 in
Critical Slope	0.006 ft/ft
Velocity	3.95 ft/s
Velocity Head	0.24 ft
Specific Energy	1.44 ft
Froude Number	0.898
Flow Type	Subcritical

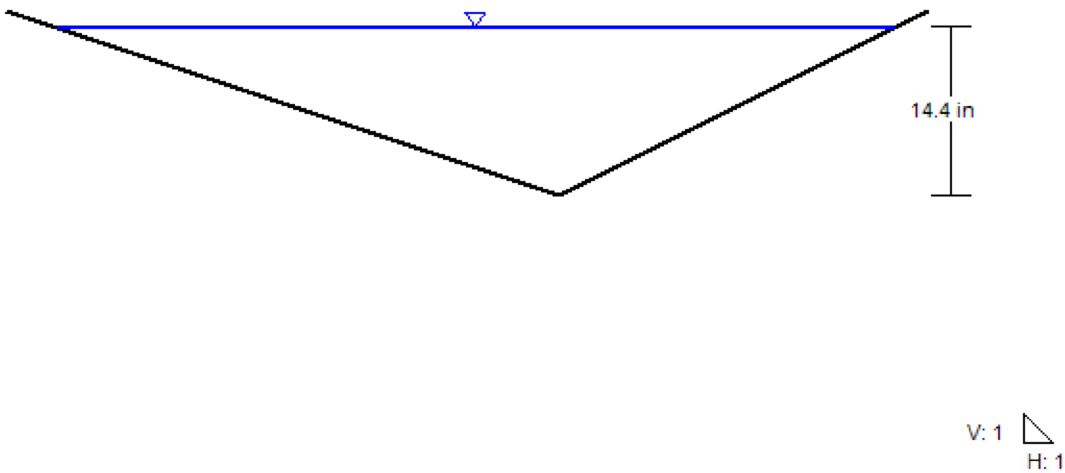
GVF Input Data	
Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data	
Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	14.4 in
Critical Depth	13.8 in
Channel Slope	0.005 ft/ft
Critical Slope	0.006 ft/ft

Cross Section for Active Face Diversion Berm

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Roughness Coefficient	0.018
Channel Slope	0.005 ft/ft
Normal Depth	14.4 in
Left Side Slope	3.000 H:V
Right Side Slope	2.000 H:V
Discharge	14.20 cfs



ATTACHMENT III.B.2 – EROSION AND SEDIMENTATION CONTROL PLAN

MSW AUTH NO. 2284A

ATTACHMENT III.B.2 – EROSION AND SEDIMENTATION CONTROL PLAN

MSW AUTH NO. 2284A
GREATER EL PASO LANDFILL MAJOR AMENDMENT
PROJECT NO. 155488

REVISION 1
MAY 16, 2025

CONTENTS

TABLES

List of Abbreviations

Abbreviation	Term/Phrase/Name
C	cover management factor
c	Rational Method runoff coefficient
Cccc	canopy cover factor
Cplu	prior land use factor
Csc	surface cover factor
Csm	soil moisture factor
Csr	surface roughness factor
EPA	United States Environmental Protection Agency
ESCP	Erosion and Sedimentation Control Plan
fps	feet per second
GEP Landfill	Greater El Paso Landfill, MSW Authorization Number 2284A
I	rainfall intensity
K	soil erodibility factor
L	slope length factor
MSW	Municipal Solid Waste
NRCS	Natural Resources Conservation Service
P	support practices factor
R	rainfall value
RG-17	Texas Commission on Environmental Quality Regulatory Guidance, “Surface Water Drainage and Erosional Stability Guidelines for a Municipal Solid Waste Landfill”, dated May 2018
RUSLE	Revised Universal Soil Loss Equation
S	slope factors
SCS	Soil Conservation Service
TAC	Texas Administrative Code
TCEQ	Texas Commission on Environmental Quality
USDA	United States Department of Agriculture

III.B.2.1.0 Introduction

This Erosion and Sedimentation Control Plan (ESCP) was developed to provide structural and non-structural control measures for the Greater El Paso Landfill, Municipal Solid Waste (MSW) Authorization Number 2284A (GEP Landfill) to provide long term erosional stability during landfill operation, closure, and post-closure care. The ESCP was developed to meet the requirements of Chapter 30 of Texas Administrative Code (TAC) Rule §330.305(d). The soil erodibility calculations for final and interim scenarios are provided in **Appendix III.B.2.A**. These calculations were completed using the Revised Universal Soil Loss Equations (RUSLE) which is developed and maintained by the Natural Resources Conservation Service (NRCS). These calculations show weighted soil loss values of less than 3 tons/acre/year for final cover conditions and less than 50 tons/acre for interim conditions, which complies with the recommendation set forth in the Texas Commission on Environmental Quality (TCEQ) Regulatory Guidance, "Surface Water Drainage and Erosional Stability Guidelines for a Municipal Solid Waste Landfill", dated May 2018 (RG-417).

III.B.2.1.1 Pre-Development Conditions

The GEP Landfill is located in northeast El Paso County and encompasses approximately 311 acres adjacent to the existing Clint Landfill, MSW Authorization Number 1482. Prior to the landfill development, the site and surrounding area were vacant land. The northern two-thirds of the site was nearly level to gently sloping to the west; surface soils on this portion of the site are brown loamy fine sands of the Hueco-Wink association. The southern third of the site sloped at approximately five percent to the south. The Soil Survey for El Paso County, Texas (United States Department of Agriculture (USDA) Soil Conservation Service (SCS), April 1971), identifies that soils on this portion of the site are of the Bluepoint association; these soils are also described as loamy fine sands. Site soils are of a poor quality for vegetation production. Site vegetation consists of sparse desert shrubs. The soils are moderately to very permeable and susceptible to blowing and the hazard of water erosion is moderate to severe.

Pre-development site drainage conditions are shown on Drawing III.B.2 in **Attachment III.B.3**. Surface drainage was toward the south and southwest direction.

III.B.2.1.2 Post-Development Drainage Conditions

During landfill operation, temporary diversion berms and drainage swales will be constructed to protect open fill areas from on-site surface water run-on and run-off. Calculations for temporary berms are provided in Appendix III.C ‐ Leachate and Contaminated Water Plan. Drainage controls for final cover are incorporated into the site in order to reduce flooding and minimize the amount of sediment carried off the site. Drainage controls include berms, interceptor ditches, down chutes, culverts, channels, and detention ponds. Drainage controls are shown in Drawing III. B.3 in **Attachment III.B.3**, with details in Drawings III. B.5 and III.B.6 in **Attachment III.B.3**.

The interim external embankment slopes of the landfill shall be no greater than 3:1. These slopes shall be equipped with semi-permanent swales, as discussed in **Section III.B.2.3.1.4.** These swales shall be installed along the slopes with a minimum spacing of 25 vertical feet (100 horizontal feet on 3:1 slopes) which is consistent with the final cover design. This spacing will limit the runoff type to sheet flow with negligible velocity before being collected in the armored swales. Swale spacing throughout the site is shown in the drawings in **Attachment III.B.3.**

III.B.2.2.0 Soil Loss Calculation

30 TAC §330.305(d)(2) requires the demonstration of interim and long-term erosional stability of the landfill, to include the estimation of soil loss.

Soil loss calculations have been performed using the RUSLE as presented in NRCS Agricultural Handbook #703, “Design Hydrology and Sedimentology for Small Catchments” by Haan and Barfield and the United States Environmental Protection Agency (EPA). These loss calculations have been completed for the external embankment side slopes and top surfaces for both intermediate and final cover conditions.

Based on the RUSLE, it is anticipated that an average of approximately 2.65 tons of soil per acre per year will erode from the final cover, and 46.99 tons of soil per acre per year will erode from the intermediate cover external slopes (4H:1V) and 48.05 tons of soil per acre per year for the intermediate cover internal slopes (3H:1V). Refer to the calculation sheets provided on the following pages. The amount of erosion from the intermediate cover external side slopes when using diversion berms or sediment capture will be below 50 tons per acre per year. The long-term stability of the landfill is demonstrated with estimated losses less than 3 tons/acre/year from the external side slopes.

III.B.2.2.1 RUSLE Calculation

The RUSLE calculation is the product of variables representing rainfall value (R), soil erodibility factor (K), slope length factor (L), slope factors (S), cover management factor (C), and support practices factor (P). The cover management factor is also the product of another calculation involving variables for prior land use (Cplu), canopy cover factor (Ccc), surface cover factor (Csc), surface roughness factor (Csr), and soil moisture factor (Csm). The values for each variable were selected from tables contained in either the NRCS Agricultural Handbook #703 or “Design Hydrology and Sedimentology for Small Catchments” by Haan and Barfield.

- The rainfall value variable, R, is the same for all RUSLE calculations for the site. A value of 20.0 was determined per the NRCS Agricultural Handbook.
- The soil erodibility factor, K, is also the same for all RUSLE calculations for the site. A value of 0.24 was determined per the soil survey report from the NRCS.
- The support practices factor, P, is also the same for all RUSLE calculations for the site. A value of 1.0 was selected as a conservative value which assumes no extra erosion prevention efforts.
- The slope length factor, L, and the slope factor, S, vary depending on whether the calculation is for the top dome surface, an external embankment side slope or rock armored let-down chute. External embankment side slope calculations assume a slope length of 200-feet for external intermediate slopes (4H:1V) and 140-feet for internal intermediate slopes (3H:1V). Top dome surface calculations assume a max slope length of 600-feet at a 5 percent slope. Lastly, a final cover of rock armoring (or equivalent) in the longest chute of 800-feet at 25 percent slope.
- The cover factor calculation uses two different variations for this site: rock cover and no cover. A prior land use factor, Cplu, of 1.0 was selected for these conditions. This value represents the former range and was found in Table 8-10.B of the Haan, Barfield text.
- A canopy cover factor of 1.0 was selected for all conditions. This value was selected conservatively to represent no canopy coverage even if there is vegetation established.
- A surface roughness subfactor; Csr, of 1.0 was selected for all conditions as a conservative estimate assuming zero root development.

- A soil moisture subfactor, Csm, of 1.0 was selected for all conditions, which is a value for rangeland from the Haan, Barfield text.
- The cover factor that does not vary between the conditions is the surface cover subfactor, Csc.
- For the final cover condition, the fraction of ground cover was set at 0.35, which was selected as a conservative estimate for the continuous crushed rock covering. For the no vegetative cover condition, the fraction of the ground cover was set at 0.0 because there will be no groundcover.

Overall, the variables for the RUSLE calculations were selected to be conservative, but to still give a fair comparison between the different conditions.

RUSLE results are discussed in **Section III.B.2.3.2** and calculations are provided in **Appendix III.B.2.A**.

III.B.2.3.0 Erosion and Sediment Controls

The most effective means to reduce the amount of soil loss during construction of the landfill is to prevent erosion. The primary goal of erosion control is to minimize the area of disturbance through the phasing of construction activities, implementation of intermediate erosion control practices, and the timely establishment of permanent controls. The following paragraphs describe the structural and non-structural controls to be employed at this landfill throughout the development of the facility.

III.B.2.3.1 Structural Controls

Structural controls are those items that need to be constructed or installed to limit erosion. Structural controls will be implemented as necessary during the development of the landfill. These include silt fences, ditch checks, sediment logs and straw bales. Additionally, rock filter berms, gabions, interceptor ditches, down chutes, culverts, channels, and detention ponds which are discussed in **Part III, Appendix B, Section III.B.3.0**. Calculations for these structural controls are provided in **Attachment III.B.1.** The interim and permanent structural controls will be constructed in accordance with the Sequence of Development as provided in the Site Development Plan. In general, the following types of erosion controls will be used at the facility.

III.B.2.3.1.1 Slope Erosion Protection

Areas of the landfill that reach final design elevations will be armored with native stone or equivalent as part of the final cover system. Intermediate slopes may remain bare depending on the length of time the area is exposed prior to commencing filling. In intermediate baren conditions, structural controls will be used to control velocity where maximum non-erodible velocities are not maintained. Calculations performed in **Appendix III.B.2.A** demonstrate that for bare soil interim condition, soil loss is not a large concern. However, velocity calculations performed using Manning’s Equation and provided in **Attachment III.B.1** show that velocity above permissible limits may be an issue. Therefore, structural controls such as ditch checks, sediment control logs, etc. are required to reduce interim velocities below permissible limits, see **Section III.B.2.3.1.4**. The site will have excess soil available for operations at the landfill. It is likely that some of the soil will remain stockpiled for extended periods of time; therefore, it will be necessary to install perimeter silt fences to prevent soil loss and erosion.

III.B.2.3.1.2 Sediment Capture and Cover Replenishment

A sediment capture and cover replenishment system may be used to keep soil loss below 50 tons per acre of cover per year. As shown in **Table III.B.2.3-3**, the annual soil loss per acre will not exceed 50 tons. In the event that a surplus of 50 tons per acre is lost, earth-moving equipment on site will be sufficient to replenish the captured surplus of sediment per acre of external side slope. The sediment capture facilities will be monitored monthly, as well as after any rain event. The slopes will be replenished whenever a downstream sediment capture device becomes full or after a major storm event. The sediment capture facilities will be placed at the toe of slope for all intermediate side slopes. Structures must also be placed on the slopes to keep the flow velocity on the slopes below the maximum non-erodible velocity for bare soil of 1.5-feet per second. The suggested capture structures include silt fences, sediment logs, ditch checks and sediment traps. Non-erodible velocities are discussed more in-depth in **III.B.2.4.0** and controls for achieving these velocities on interim conditions are listed in **Table III.B.2.3-1**.

III.B.2.3.1.3 Drainage Channel Erosion Protection

Perimeter channels will be constructed around the landfilled area to divert runoff around the landfill to the detention ponds. The erosion for each channel section is selected based on the flow velocity in the channel from a 25-year storm. Channels with a flow velocity less than 1.5-feet per second may be bare soil without erosion control lining. Channel sections with a flow velocity less than 4.0-feet per second may use vegetative lining as a continuous erosion control lining, or velocity control devices may be used to bring the flow velocity below 1.5-feet per second between the devices to allow for bare soil without continuous lining. Channel sections with a flow velocity greater than 4.0-feet per second must use a more heavy-duty continuous lining, such as gabions, concrete, or Flexamat Plus, riprap or velocity control devices. Drawings III.B.4-6 in **Attachment III.B.3** contain channel locations and details. Non-erodible and design velocities are discussed further in **Section III.B.2.4.0**.

III.B.2.3.1.4 Interim Controls

Interim Controls will be installed around the base of soil stockpile areas, active excavation and construction areas, and other areas as necessary to control siltation of run-off control facilities. Interim controls will be necessary to keep soil losses to an acceptable level as vegetative cover may be difficult to establish. They will be needed to prevent the transmission of silt into detention and drainage structures and eventually off site. These interim controls may include sediment capture and replenishment system, silt fences, straw bales, filter dams, sediment traps, and interceptor berms. Interim controls will not be installed on any sections of daily cover. **Table III.B.2.3-1** includes parameters for the installation of various structural controls.

III.B.2.3.1.4.1 Crown/Top Slope Controls

Before installing the rock armoring, the crown may temporarily be exposed to bare soil conditions. During this interim phase, soil loss, as indicated in **Section III.B.2.3.2,** is not a major concern for the crown. However, high peak velocities could pose a risk to erosion. Structural controls—outlined in **Table III.B.2.3-1,** should be implemented to regulate stormwater velocity on top slopes and within the diversion berm around the edge of the top slope. Per NRCS time of concentration calculations, see Appendix III.B.1, this can be achieved for the top slope by spacing a grade break control (i.e. silt fence, sediment log) every 300 feet to control sheet flow. To regulate velocity within the diversion berm, a check control (such as straw bales, ditch checks, or sediment logs) should be placed as specified in **Table III.B.2.3-1.**

III.B.2.3.1.4.2 Side Slope Controls

During interim conditions, two slope configurations are required for interceptor ditches:

- External embankments: The slope will be 4H:1V.
- Internal intermediate slope construction: The slope will be 3H:1V.

These slope conditions were calculated to account for soil loss and peak velocities. In accordance with RG-417 requirements, two-foot interceptor ditches must be spaced as follows:

- 200 feet apart for 4H:1V slopes.
- 140 feet apart for 3H:1V slopes.

For 4H:1V slopes, a structural control (i.e., silt fence, sediment log, straw bale, etc.) must be placed every 50 feet to slow sheet flow to the allowable velocity. The same is true for 3H:1V slopes on the internal intermediate slope, where the structural control spacing needs to be 35-feet.

For channel flow within the interceptor ditches, check controls—such as straw bales, ditch checks, or sediment logs—should be installed at the spacing and area specified in **Table III.B.2.3-1** to effectively reduce peak flow to manageable rates.

Table III.B.2.3-1: Structural Controls

Control	Typical Placement	Max Spacing/ Max Drainage Area	Slope Restrictions
Silt Fence	Downstream of disturbed area which has not received permanent erosion controls	100 ft 75 ft 50 ft 25 ft	3%-5% 5%-10% 10%-20% 20%-50%
Straw Bales	Perpendicular to slope, downstream of disturbed area which has not received permanent erosion controls	100 ft spacing max	3:1 max
Rock Filter Dam Type 1	Toe of slope, around inlets, in small ditches, and swale outlets	5 acres max	2:1 max
Rock Filter Dam Type 2	In larger ditches and at swale outlets	5 acres max	2:1 max
Rock Filter Dam Type 3	In stream flow, attached to the stream bed	5 acres max	2:1 max
Rock Filter Dam Type 4	In ditches and smaller channels	5 acres max	2:1 max
Ditch Checks	In swales or channels	5 acres max, spaced for desired velocity	3:1 max
Sediment Logs	In swales, channels, or on slopes	25 to 50 ft while slowing flow, 100 ft once at desired velocity	2:1 max

III.B.2.3.2 Effectiveness of Applied Controls

The structural controls applied to the landfill after final cover is installed include terracing with diversion berms and rock armoring. These structural controls are used to keep the soil losses to appropriate amounts for both long- and short-term erosional stability for the facility. A RUSLE analysis was completed to determine the effectiveness of each control.

Table III.B.2.3-2: Effectiveness of Applied Controls: Final Cover

Condition	Results
Final Cover Side Slope with Rock Armoring	2.45 Tons/Acre/Year
Final Cover Crown with Rock Armoring	0.20 Tons/Acre/Year

The total soil loss for final cover conditions with rock armoring, diversion berms, and grade break berms (at the edge of the crown) is 2.65 tons/acre/year. Therefore, it is possible to keep the soil loss below the maximum allowable amount of 3 tons/acre/year using rock armoring.

Table III.B.2.3-3: Effectiveness of Applied Controls: Intermediate Cover

Condition	Results
Intermediate Cover External Side Slopes (4H:1V)	37.82 Tons/Acre/Year
Intermediate Cover Crown (20H:1V)	9.17 Tons/Acre/Year
Internal Intermediate Cover Slope (3H:1V)	38.88 Tons/Acre/Year

The total soil loss for both internal and external intermediate cover conditions with bare soil, diversion berms, and grade break berms (at the edge of the crown) are below 50 tons/acre/year as shown in **Table III.B.2.3-3.** If construction diversion berms cannot be achieved in a timely manner, a sediment capture and cover replenishment system will be used to capture and replace at least the amount of projected loss in excess of the maximum allowable amount on a yearly basis. RUSLE calculations are provided in **Appendix III.B.2.A**.

III.B.2.3.3 Non-Structural Controls

Non-structural controls are used in the design and daily operations of the landfill. These controls include maintenance of the landfill facilities with regard to soil loss and sediment deposition.

Maintenance of erosion and sedimentation controls is an integral part of the daily operation of the landfill. The Site Supervisor is the responsible party for the installation and maintenance of all erosion and sedimentation controls. **Table III.B.2.3-4** describes an appropriate maintenance schedule for erosion damage. The frequency of maintenance can be adjusted if minimal or excessive damage is discovered per event.

The non-structural controls also include plans and designs to minimize disruption of the natural drainage, topography, and vegetative cover features. This has been achieved through the design of the landfill and its drainage controls, which also comply with City of El Paso drainage standards. **Appendix III.B** discusses the changes in natural drainage and topography.

The non-structural controls also include phased development to minimize the area of bare soil exposed at any time and plans to disturb only the smallest area necessary to perform current activities. This will be achieved through the phasing of the landfill development. There will be two phases of development which are made up of ten cells each. These cells will be opened at a rate consistent with the waste acceptance rate, preventing any interruption of waste acceptance. Another non-structural control used will be the scheduling of construction activities during the times of the year with the least erosion potential. The time of the year with the least erosional potential for this site runs from October through June. Extra emphasis will be placed on erosion control during construction activities that occur outside of this period.

The final non-structural control that will be utilized at the facility is the timely stabilization of exposed surfaces. Any exposed surface will have structural controls applied as soon as practicable and within 180 days of placement of intermediate of final cover, as shown in **Table III.B.2.3-4**.

Table III.B.2.3-4: Structural Control Inspection Parameters

Inspection Site	Frequency	Corrective Action
Intermediate Cover	Biweekly or after storm event	Place additional soil in areas of erosion loss, reseed any areas with insufficient vegetative cover, use temporary controls to protect areas of severe erosional damage
Silt Fence	Weekly or after storm event	Repair any damage and remove collected sediment
Hay Bales	Weekly or after storm event	Repair any damage, replace worn bales, and remove excess sediment
Final Cover – Rock Armoring	Monthly or after storm event	Repair any damage with more rock, consider placement of permanent controls to protect areas of reoccurring damage
Drainage Channels and Detention Ponds	Monthly or after storm event	Remove any areas of sediment buildup, reseed areas of insufficient vegetative cover, and repair damage to structural lining
Culverts	Monthly or after storm event	Remove any areas of sediment buildup
Outflow Points	During Storm Event	Note sediment load off-site and adjust on-site controls appropriately
Ditch Creek	Monthly or after storm event	Remove accumulated sediment, remove collected debris, repair any damage
Sediment Collection System	On schedule with type of structure	Remove collected sediment and place on upstream cover; Ensure sediment collection capability is not compromised
Sediment Trap	Monthly or after each rain event	Remove collected sediment where collected to 50% of capacity; Repair trap if needed

III.B.2.3.4 Controls Installation Schedule

As the development of the landfill progresses, the effectiveness of the erosion controls is highly dependent upon the controls being installed at the appropriate time in the development. Timely installation of needed controls will protect against significant erosion damage. **Table III.B.2.3-5** contains the installation time requirements for all controls.

Table III.B.2.3-5: Controls Installation Schedule

Control	Installation Timeframe
Silt Fence or Equivalent	In concurrence with upstream disturbance
Rock Armoring (final cover)	Begin closure activities in accordance with the Closure Plan in Appendix III.I
Diversion Berms	In concurrence with development of final contours
Channel Protection (gabion, riprap, concrete, check dam, or equivalent)	In concurrence with development of drainage channels
Filter Dam	In concurrence with upstream disturbance
Sediment Capture System	Upon placement of intermediate cover upstream.

III.B.2.3.5 Wind Erosion Control

The historical wind speed in the City of El Paso averages 8.8-miles per hour and site soils are classified as having a high potential for erosion. As a result, wind erosion will need to be controlled during all phases of landfill development. This will be achieved with the intermediate phase of landfill development, mainly through non-structural controls. Non-structural controls to be used at the site include limiting the amounts of disturbed ground to the smallest area necessary to perform current activities, prompt stabilization of disturbed ground, and inspection and repair of disturbed ground after a windy day or specific event. One control that will be utilized specifically to limit wind erosion will be the wetting of access roads and disturbed ground by a water truck.

Once the landfill has received final cover, the wind erosion potential will be reduced significantly as a result of permanent stabilization, which includes crushed rock exterior. Permanent stabilization for all other areas on the site includes re-establishment of natural vegetation. This will maximize the long-term wind erosion stability of the facility.

III.B.2.4.0 Non-Erodible Velocities

30 TAC §330.305(d)(1) requires the demonstration that the estimated peak velocities for all external embankment slopes and top surfaces shall be less than the permissible non-erodible velocity under similar conditions.

The permissible non-erodible velocities have been determined by comparing intermediate and final cover conditions to the permissible velocities at certain cover conditions as published by the USDA. The USDA posts these velocities in the Stream Restoration Design National Engineering Handbook, Chapter 8.

Based upon this comparison, the maximum velocity over each surface has been compared to permissible velocity for its cover condition and results are provided in **Table III.B.2.4-1**. For most situations, the minimally acceptable condition is listed. If achieving the minimally acceptable condition is not possible, a condition with a higher non-erodible velocity or a condition which will reduce the velocity of flow will be implemented. For example, the section of Ditch B2 at 4.3 percent slopes could use rock lining, which has a higher non-erodible velocity than bare soil.

The cover condition for each type of slope has been selected to meet both soil-loss and max non-erodible velocity criteria. Note that for intermediate cover, the external side slopes do not meet maximum non-erodible velocity criteria in a non-vegetated condition. Because this situation may only occur during intermediate cover conditions, temporary structural controls, such as ditch checks, or a sediment capture and cover replenishment system will be implemented to keep cover conditions on these slopes on par with all other slopes. Therefore, the side slopes will either require vegetation or velocity control drives to be placed within 180 days of placement of intermediate cover to control side slope erosion.

All berms, ditches, and channels are sized based on the largest peak flow calculated using the Rational Method (Q = cIA) during a 24-hour, 25-year storm. The final cover design is expected to behave hydrologically similar to rock riprap, so a Rational Method runoff coefficient (c) of 0.8 was used to calculate peak storm flows. For the intermediate cover, a runoff coefficient of 0.25 was used, assuming sand or sandy loam soil with a slope of 3-5%. A rainfall intensity (I) of 6.12 inches per hour was calculated for El Paso County, Texas. The largest contributing area to each drainage control was used to calculate the peak flow, which was then used to size the depth of each drainage feature. These calculations are included in **Attachment III.B.1.**

Table III.B.2.4-1: Non-Erodible Velocities

Flow Surface	Condition	Max Velocity[4] (fps)	Max Non-erodible Velocity[1] (fps)	Acceptable
Intermediate Cover				
External Side Slope (4H:1V)	Non-vegetated	1.43	1.5	Yes
External Side Slope Interceptor Ditch	Non-vegetated	3.67	1.5	No[3]
Top Slope (20H:1V)	Non-vegetated	1.08	1.5	Yes
Top Slope Diversion Berm	Non-vegetated	2.44	1.5	No[3]
Internal Side Slope (3H:1V)	Non-vegetated	1.50	1.5	Yes
Internal Side Slope Berm	Non-vegetated	3.80	1.5	No[3]

Flow Surface	Condition	Max Velocity[4] (fps)	Max Non-erodible Velocity[1] (fps)	Acceptable
Final Cover				
External Side Slope (4H:1V)	Rock-armored	1.64	10.0	Yes
Interceptor Ditch	Rock-armored	3.22	10.0	Yes
Top Dome (20H:1V)	Rock-armored	3.61	10.0	Yes
Diversion Berm	Rock-armored	2.15	10.0	Yes
Letdown Structure	Rock Stabilized[2]	16.24	20.0	Yes
Channels				
Ditch B1 – 0.6%	Rock Stabilized[2]	4.38	20.0	Yes
Ditch B1 – 1.6%	Rock Stabilized[2]	6.26	20.0	Yes
Ditch B2 – 1.6%	Rock Stabilized[2]	7.19	20.0	Yes
Ditch B2 – 4.3%	Rock Stabilized[2]	10.31	20.0	Yes
Ditch B2 – 2.1%	Rock Stabilized[2]	8.00	20.0	Yes
Ditch C1 – 0.8%	Rock Stabilized2	2.46	20.0	Yes
Ditch C1 – 2.7%	Rock Stabilized[2]	3.78	20.0	Yes
Ditch C1 – 0.4%	Rock Stabilized[2]	1.99	20.0	Yes
Ditch C2 – 0.4%	Rock Stabilized[2]	3.90	20.0	Yes
Ditch C2 – 3.9%	Rock Stabilized[2]	8.93	20.0	Yes
Ditch C2 – 7.6%	Rock Stabilized[2]	11.26	20.0	Yes
Ditch D1 – 0.3%	Rock Stabilized[2]	2.89	20.0	Yes
Ditch D2 – 0.3%	Rock Stabilized[2]	3.64	20.0	Yes
Ditch D2 – 1.6%	Rock Stabilized[2]	6.77	20.0	Yes
Ditch D2 – 2.6%	Rock Stabilized[2]	8.02	20.0	Yes
Ditch D3 – 2.6%	Rock Stabilized[2]	8.24	20.0	Yes
Ditch D3 – 3.4%	Rock Stabilized[2]	9.08	20.0	Yes
Ditch E1 – 0.3%	Rock Stabilized[2]	3.11	20.0	Yes
Ditch E1 – 1.9%	Rock Stabilized[2]	6.49	20.0	Yes
Ditch E1 – 0.4%	Rock Stabilized[2]	3.69	20.0	Yes
Ditch E2 – 0.4%	Rock Stabilized[2]	3.91	20.0	Yes
Ditch E2 – 5.1%	Rock Stabilized[2]	10.03	20.0	Yes

[1] Max velocities provided by USDA NRCS National Engineering Handbook, Part 654 Stream Restoration Design, Chapter 8.

[2] Rock Stabilized may include gabion-lined, Flexamat Plus, Riprap, or approved equal. See Detail 2 (ditch) and Detail 5 (let down structure), Drawing III.B.5 in Attachment III.B.3.

[3] Maximum non-erodible velocities are exceeded in the non-vegetated berms/ditches. Sediment capture and replenishment or alternative structural controls need to be used as discussed in **Section III.B.2.3.1.4** for compliance with maximum non-erodible velocities.

[4] Max velocities calculated using Rational Method and HEC-HMS for peak flows and Manning's Equation byway of FlowMaster for Normal Depth and Velocity and the NRCS method for estimating T_c, these are included in **Attachment III.B.1**.

APPENDIX III.B.2.A – RUSLE SOIL EROSION CALCULATIONS

Rainfall Value (R)

= 20 — Fig. 2-1, NRCS Agricultural Handbook #703

Soil Erodibility factor (K)

= 0.24 — Per NRCS Web Soil Survey

Topographic Factor (LS)

= 800 feet @ 25% — based on longest downchute, B2, Dwg III.B.4
= 23.24 — Per NRCS Agricultural Handbook #703, Table 4-3

Cover Management Factor (C)

= 0.022 — See C factor calculation sheet

Support Practice Factor (P)

= 1 — Conservative Estimate

Calculated Soil Loss (A)

= RKLSCP
= 2.45 tons/acre/year < 3 tons/acre/year in accordance with RG-417

Rainfall Value (R)

= 20 — Fig. 2-1, NRCS Agricultural Handbook #703

Soil Erodibility factor (K)

= 0.24 — Per NRCS Web Soil Survey

Topographic Factor (LS)

= 600 feet @ 5% — based on longest crown slope, Dwg III.B.4

= 1.91 — Per NRCS Agricultural Handbook #703, Table 4-3

Cover Management Factor (C)

= 0.022 — See C factor calculation sheet

Support Practice Factor (P)

= 1 — Conservative Estimate

Calculated Soil Loss (A)

= RKLSCP

= 0.20 tons/acre/year

5/13/2025

Rainfall Value (R)

= 20 — Fig. 2-1, NRCS Agricultural Handbook #703

Soil Erodibility factor (K)

= 0.24 — Per NRCS Web Soil Survey

Topographic Factor (LS)

= 200 feet @ 25% — based on longest side slope, Dwg III.B.4

= 7.88 — Per NRCS Agricultural Handbook #703, Table 4-3

Cover Management Factor (C)

= 1 bare soil — See C factor calculation sheet

Support Practice Factor (P)

= 1 — Conservative Estimate

Calculated Soil Loss (A)

= RKLSCP

= 37.82 tons/acre/year

Rainfall Value (R)

= 20 — Fig. 2-1, NRCS Agricultural Handbook #703

Soil Erodibility factor (K)

= 0.24 — Per NRCS Web Soil Survey

Topographic Factor (LS)

= 140 feet @ 33.3% — based on active face slope interceptor ditches being spaced @ 55 feet

= 8.10 — Per NRCS Agricultural Handbook #703, Table 4-3

Cover Management Factor (C)

= 1 bare soil — See C factor calculation sheet

Support Practice Factor (P)

= 1 — Conservative Estimate

Calculated Soil Loss (A)

= RKLSCP

= 38.88 tons/acre/year

Rainfall Value (R)

= 20 — Fig. 2-1, NRCS Agricultural Handbook #703

Soil Erodibility factor (K)

= 0.24 — Per NRCS Web Soil Survey

Topographic Factor (LS)

= 600 feet @ 5% — based on longest crown slope, Dwg III.B.4
= 1.91 — Per NRCS Agricultural Handbook #703, Table 4-3

Cover Management Factor (C)

= 1 bare soil — See C factor calculation sheet

Support Practice Factor (P)

= 1 — Conservative Estimate

Calculated Soil Loss (A)

= RKLSCP
= 9.17 tons/acre/year

C_{plu} = prior land us subfactor
= **1.0** for rangeland — table 8-10.B, page 271, Haan , Barfield text

C_{cc} = canopy cover subfactor
= $1 - F_c \exp(-0.1H)$
F_c = fraction of surface covered by canopy
= 0 — conservative estimate
H = average canopy height in feet
= 0 — conservative estimate
= **1.0**

C_{sc} = surface cover subfactor
= $\exp[-bR_c(6/6+R_g))^{0.08}]$ — eq. 8.53, page 270, Haan, Barfield text
b = constant
= 4.5 — table 8-10.B, page 271, Haan , Barfield text
R_c = fraction ground cover
= 0.85 — conservative estimate for 85% rock covering
R_g = surface roughness variable
= $(25.4R_R - 6)(1 - \exp(-0.0015R_S))(\exp(-0.14P_T))$ — eq. 8.55, page 271, Haan, Barfield text
R_R = random roughness
= 0.5 total root and buriend residue — conservative estimate from Ag. Handbook #703

R_S = [lb/acre]
= 0 — conservative estimate assuming limited vegetative cover
P_T = average yearly rainfall
= 8.67 Inches — National Weather Service Data
= 0.00
= **0.022**

C_{sr} = surface roughness subfactor
= $\exp(-0.26*R_G)$ — eq. 8.62, page 273, Haan, Barfield text
R_G = surface roughness variable
= 0
= **1.0**

C_{sm} = soil moisture subfactor
= **1.0** for rangeland — page 273, Haan, Barfield text

C = Cover Management Factor
= $C_{plu}C_{cc}C_{sc}C_{sr}C_{sm}$

= **<u>0.022</u>**

$\mathbf{C_{plu}}$	= prior land us subfactor	
	= **1.0** for rangeland	table 8-10.B, page 271, Haan , Barfield text
$\mathbf{C_{cc}}$	= canopy cover subfactor	
	= $1 - F_c\exp(-0.1H)$	
	F_c = fraction of surface covered by canopy	
	= 0	conservative estimate
	H = average canopy height in feet	
	= 0	conservative estimate
	= **1.0**	
$\mathbf{C_{sc}}$	= surface cover subfactor	
	= $\exp[-bR_c(6/6+R_g))^{0.08}]$	eq. 8.53, page 270, Haan, Barfield text
	b = constant	
	= 4.5	table 8-10.B, page 271, Haan , Barfield text
	R_c = fraction ground cover	
	= 0.0	conservative estimate
	R_g = surface roughness variable	
	= $(25.4R_R - 6)(1 - \exp(-0.0015R_S))(\exp(-0.14P_T))$	eq. 8.55, page 271, Haan, Barfield text
	R_R = random roughness	
	= 0.5 total root and buriend residue	conservative estimate from Ag. Handbook #703
	R_S = [lb/acre]	
	= 0	conservative estimate
	P_T = average yearly rainfall	
	= 8.67 Inches	National Weather Service Data
	= 0.00	
	= **1.0**	
$\mathbf{C_{sr}}$	= surface roughness subfactor	
	= $\exp(-0.26^*R_G)$	eq. 8.62, page 273, Haan, Barfield text
	R_G = surface roughness variable	
	= 0	
	= **1.0**	
$\mathbf{C_{sm}}$	= soil moisture subfactor	
	= **1.0** for rangeland	page 273, Haan, Barfield text
C	= Cover Management Factor	
	= $C_{plu}C_{cc}C_{sc}C_{sr}C_{sm}$	
	= **1.0**	

5/13/2025

TOPOGRAPHIC FACTOR (LS) CALCULATIONS

Table 4-3.
Values for topographic factor, LS, for high ratio of rill to interrill erosion.[1]

Slope (%)	Horizontal slope length (ft)															
	<3	6	9	12	15	25	50	75	100	150	200	250	300	400	600	800	1000
0.2	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.06
0.5	0.07	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.09	0.09	0.10	0.10	0.10	0.11	0.12	0.12	0.13
1.0	0.09	0.09	0.09	0.09	0.09	0.10	0.13	0.14	0.15	0.17	0.18	0.19	0.20	0.22	0.24	0.26	0.27
2.0	0.13	0.13	0.13	0.13	0.13	0.16	0.21	0.25	0.28	0.33	0.37	0.40	0.43	0.48	0.56	0.63	0.69
3.0	0.17	0.17	0.17	0.17	0.17	0.21	0.30	0.36	0.41	0.50	0.57	0.64	0.69	0.80	0.96	1.10	1.23
4.0	0.20	0.20	0.20	0.20	0.20	0.26	0.38	0.47	0.55	0.68	0.79	0.89	0.98	1.14	1.42	1.65	1.86
5.0	0.23	0.23	0.23	0.23	0.23	0.31	0.46	0.58	0.68	0.86	1.02	1.16	1.28	1.51	1.91	2.25	2.55
6.0	0.26	0.26	0.26	0.26	0.26	0.36	0.54	0.69	0.82	1.05	1.25	1.43	1.60	1.90	2.43	2.89	3.30
8.0	0.32	0.32	0.32	0.32	0.32	0.45	0.70	0.91	1.10	1.43	1.72	1.99	2.24	2.70	3.52	4.24	4.91
10.0	0.35	0.37	0.38	0.39	0.40	0.57	0.91	1.20	1.46	1.92	2.34	2.72	3.09	3.75	4.95	6.03	7.02
12.0	0.36	0.41	0.45	0.47	0.49	0.71	1.15	1.54	1.88	2.51	3.07	3.60	4.09	5.01	6.67	8.17	9.57
14.0	0.38	0.45	0.51	0.55	0.58	0.85	1.40	1.87	2.31	3.09	3.81	4.48	5.11	6.30	8.45	10.40	12.23
16.0	0.39	0.49	0.56	0.62	0.67	0.98	1.64	2.21	2.73	3.68	4.56	5.37	6.15	7.60	10.26	12.69	14.96
20.0	0.41	0.56	0.67	0.76	0.84	1.24	2.10	2.86	3.57	4.85	6.04	7.16	8.23	10.24	13.94	17.35	20.57
25.0	0.45	0.64	0.80	0.93	1.04	1.56	2.67	3.67	4.59	6.30	7.88	9.38	10.81	13.53	18.57	23.24	27.66
30.0	0.48	0.72	0.91	1.08	1.24	1.86	3.22	4.44	5.58	7.70	9.67	11.55	13.35	16.77	23.14	29.07	34.71
40.0	0.53	0.85	1.13	1.37	1.59	2.41	4.24	5.89	7.44	10.35	13.07	15.67	18.17	22.95	31.89	40.29	48.29
50.0	0.58	0.97	1.31	1.62	1.91	2.91	5.16	7.20	9.13	12.75	16.16	19.42	22.57	28.60	39.95	50.63	60.84
60.0	0.63	1.07	1.47	1.84	2.19	3.36	5.97	8.37	10.63	14.89	18.92	22.78	26.51	33.67	47.18	59.93	72.15

140 ft
33.3-8.10

[1]Such as for freshly prepared construction and other highly disturbed soil conditions with little or no cover (not applicable to thawing soil)

NRCS SOIL REPORT

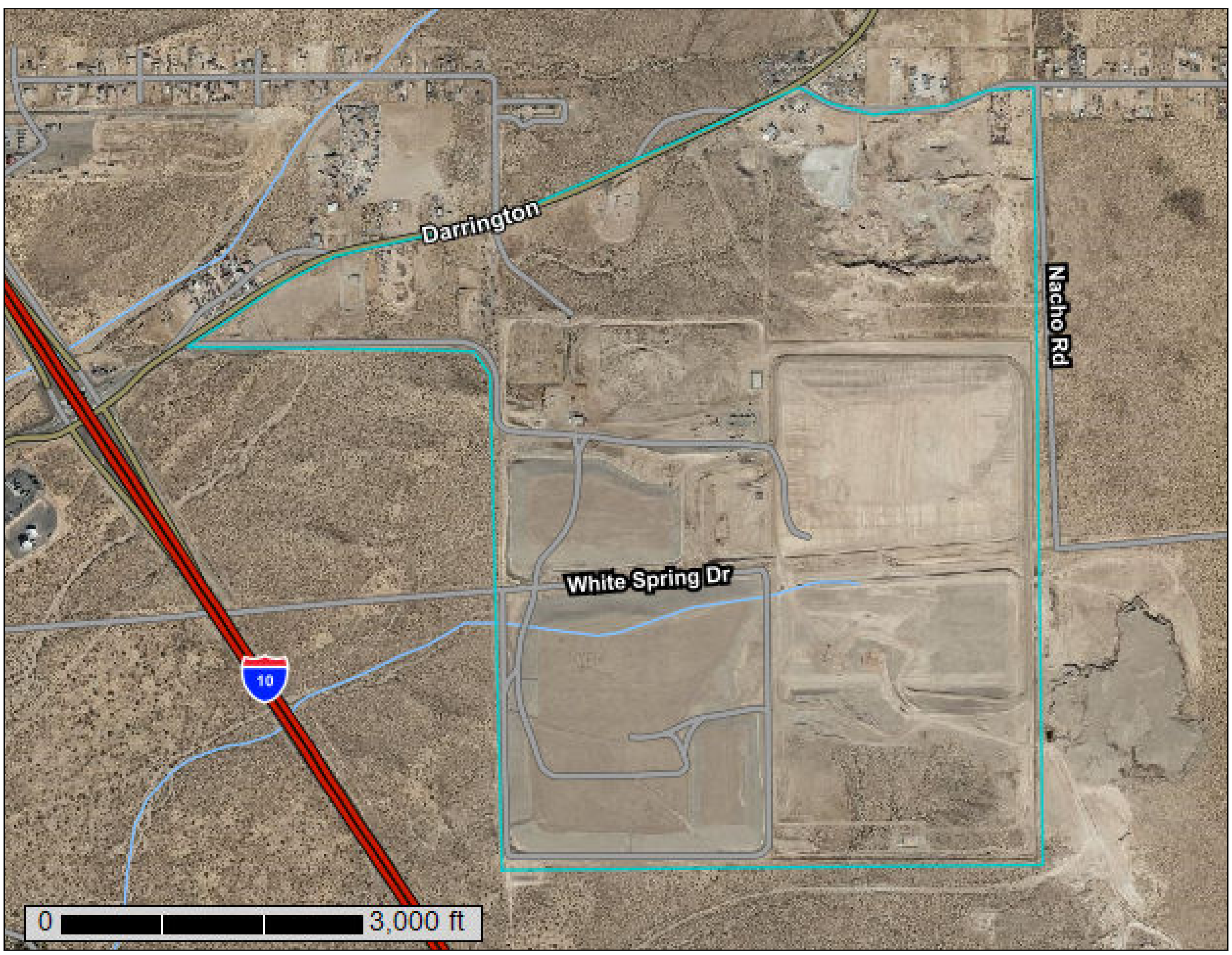
United States Department of Agriculture

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for

El Paso County, Texas (Main Part)



November 7, 2023

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

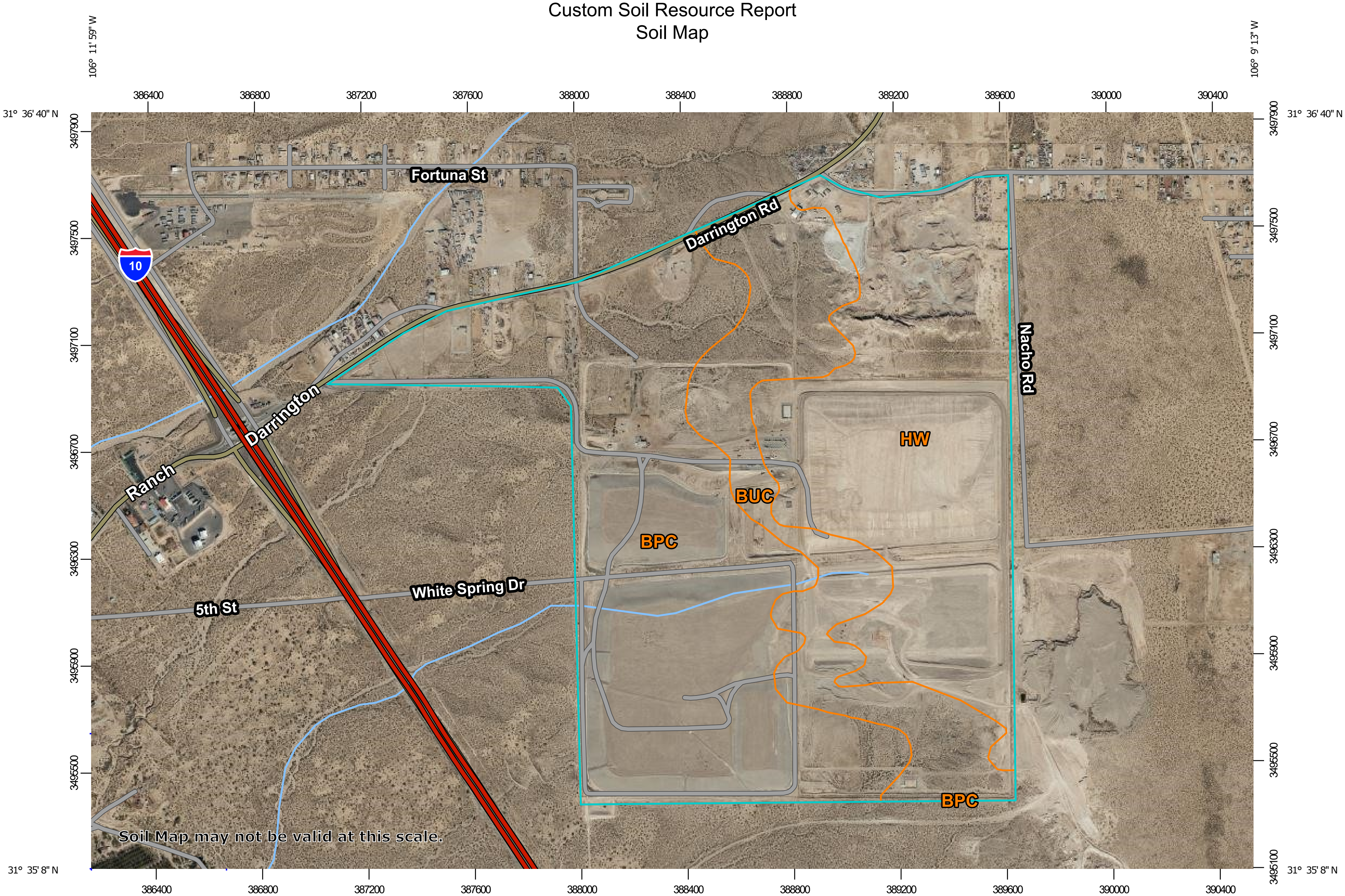
Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Custom Soil Resource Report
Soil Map



Map Scale: 1:20,000 if printed on A landscape (11" x 8.5") sheet.

Meters: 0, 250, 500, 1000, 1500

Feet: 0, 500, 1000, 2000, 3000

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 13N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:31,700.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: El Paso County, Texas (Main Part)
Survey Area Data: Version 22, Sep 5, 2023

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Nov 15, 2020—Nov 17, 2020

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
BPC	Bluepoint association, rolling	434.9	45.4%
BUC	Bluepoint gravelly association, rolling	188.1	19.6%
HW	Hueco-Wink association, hummocky	335.6	35.0%
Totals for Area of Interest		**958.7**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

El Paso County, Texas (Main Part)

BPC—Bluepoint association, rolling

Map Unit Setting

National map unit symbol: rcwg
Elevation: 1,400 to 5,200 feet
Mean annual precipitation: 3 to 10 inches
Mean annual air temperature: 55 to 66 degrees F
Frost-free period: 180 to 300 days
Farmland classification: Not prime farmland

Map Unit Composition

Bluepoint and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Bluepoint

Setting

Landform: Hillsides
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Convex
Parent material: Wind-modified sandy alluvium

Typical profile

H1 - 0 to 6 inches: loamy fine sand
H2 - 6 to 12 inches: fine sand
H3 - 12 to 60 inches: stratified sand to loamy fine sand to very fine sandy loam

Properties and qualities

Slope: 5 to 15 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: Rare
Frequency of ponding: None
Calcium carbonate, maximum content: 5 percent
Gypsum, maximum content: 1 percent
Maximum salinity: Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)
Sodium adsorption ratio, maximum: 12.0
Available water supply, 0 to 60 inches: Low (about 5.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: A
Ecological site: R042BB011NM - Deep Sand, Desert Shrub
Hydric soil rating: No

BUC—Bluepoint gravelly association, rolling

Map Unit Setting

National map unit symbol: rcwj
Elevation: 1,400 to 5,200 feet
Mean annual precipitation: 4 to 10 inches
Mean annual air temperature: 57 to 70 degrees F
Frost-free period: 1 to 80 days
Farmland classification: Not prime farmland

Map Unit Composition

Bluepoint, gravelly, and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Bluepoint, Gravelly

Setting

Landform: Hillsides
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Convex
Parent material: Wind-modified sandy alluvium

Typical profile

H1 - 0 to 12 inches: gravelly fine sand
H2 - 12 to 60 inches: fine sand

Properties and qualities

Slope: 2 to 8 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 3 percent
Maximum salinity: Nonsaline to moderately saline (0.0 to 8.0 mmhos/cm)
Sodium adsorption ratio, maximum: 3.0
Available water supply, 0 to 60 inches: Low (about 5.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: A
Ecological site: R042AC244TX - Gravelly, Desert Grassland
Hydric soil rating: No

HW—Hueco-Wink association, hummocky

Map Unit Setting

National map unit symbol: rcww
Elevation: 2,700 to 4,500 feet
Mean annual precipitation: 5 to 12 inches
Mean annual air temperature: 57 to 70 degrees F
Frost-free period: 210 to 260 days
Farmland classification: Not prime farmland

Map Unit Composition

Hueco and similar soils: 45 percent
Wink and similar soils: 35 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Hueco

Setting

Landform: Sand sheets
Landform position (three-dimensional): Rise
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Pleistocene-age coarse-loamy alluvium

Typical profile

H1 - 0 to 4 inches: loamy fine sand
H2 - 4 to 26 inches: fine sandy loam
H3 - 26 to 58 inches: cemented material
H4 - 58 to 80 inches: variable

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: 20 to 40 inches to petrocalcic
Drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Available water supply, 0 to 60 inches: Very low (about 3.0 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: B
Ecological site: R042BB012NM - Sandy, Desert Shrub
Hydric soil rating: No

Description of Wink

Setting

Landform: Sand sheets
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Pleistocene-age coarse-loamy alluvium

Typical profile

H1 - 0 to 6 inches: fine sandy loam
H2 - 6 to 24 inches: fine sandy loam
H3 - 24 to 73 inches: variable
H4 - 73 to 80 inches: very gravelly loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 40 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Low (about 4.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: A
Ecological site: R042BB012NM - Sandy, Desert Shrub
Hydric soil rating: No

Minor Components

Unnamed

Percent of map unit: 20 percent
Hydric soil rating: No

Soil Information for All Uses

Soil Properties and Qualities

The Soil Properties and Qualities section includes various soil properties and qualities displayed as thematic maps with a summary table for the soil map units in the selected area of interest. A single value or rating for each map unit is generated by aggregating the interpretive ratings of individual map unit components. This aggregation process is defined for each property or quality.

Soil Erosion Factors

Soil Erosion Factors are soil properties and interpretations used in evaluating the soil for potential erosion. Example soil erosion factors can include K factor for the whole soil or on a rock free basis, T factor, wind erodibility group and wind erodibility index.

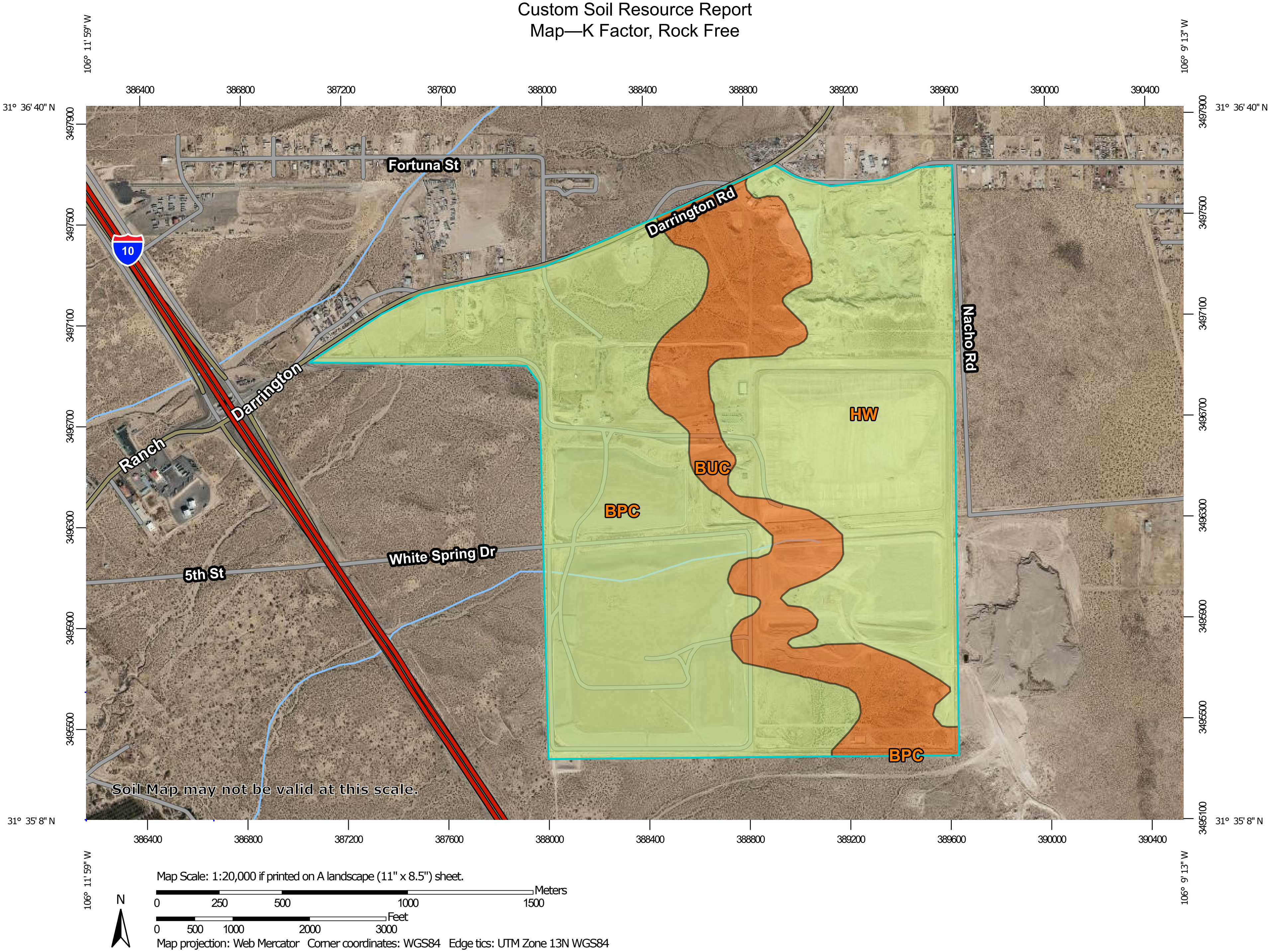
K Factor, Rock Free

Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) and the Revised Universal Soil Loss Equation (RUSLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter and on soil structure and saturated hydraulic conductivity (Ksat). Values of K range from 0.02 to 0.69. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by water.

"Erosion factor Kf (rock free)" indicates the erodibility of the fine-earth fraction, or the material less than 2 millimeters in size.

Factor K does not apply to organic horizons and is not reported for those layers.

Custom Soil Resource Report
Map—K Factor, Rock Free



MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- .02
- .05
- .10
- .15
- .17
- .20
- .24
- .28
- .32
- .37
- .43
- .49
- .55
- .64
- Not rated or not available

Soil Rating Lines
- .02
- .05
- .10
- .15
- .17
- .20
- .24
- .28
- .32
- .37
- .43
- .49
- .55
- .64
- Not rated or not available

Soil Rating Points
- .02
- .05
- .10
- .15
- .17
- .20
- .24
- .28
- .32
- .37
- .43
- .49
- .55
- .64
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:31,700.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: El Paso County, Texas (Main Part)
Survey Area Data: Version 22, Sep 5, 2023

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Nov 15, 2020—Nov 17, 2020

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—K Factor, Rock Free

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
BPC	Bluepoint association, rolling	.24	434.9	45.4%
BUC	Bluepoint gravelly association, rolling	.05	188.1	19.6%
HW	Hueco-Wink association, hummocky	.24	335.6	35.0%
Totals for Area of Interest			**958.7**	**100.0%**

Rating Options—K Factor, Rock Free

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Layer Options (Horizon Aggregation Method): Surface Layer (Not applicable)

Soil Health Properties

Soil health is defined as the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans. This folder contains information on soil properties that are important indicators of soil health.

Soil Health - Bulk Density, One-Third Bar

Bulk density, one-third bar is the oven-dry weight of the soil material less than 2 millimeters in size per unit volume of soil at a water tension of 1/3 bar (33 kPa). It indicates the density of the soil and is expressed in grams per cubic centimeter (g/cc) of soil material.

Significance:

Bulk density is one of several soil properties frequently used as a measure of soil health (Volchko et al., 2014) and as an indicator of soil compaction and root restriction. It reflects the soils capacity to provide structural support, water and solute movement, and soil aeration (Arshad et al., 1996). Even though bulk density varies with soil texture, it is a dynamic soil property that also varies depending on the structural condition of the soil. It can be altered by cultivation, trampling by animals, compaction by agricultural machinery, and raindrop impact (Arshad et al., 1996). Any soil management that alters the soil cover, the amount of organic matter, soil structure, or porosity will affect soil bulk density (USDA-NRCS, 2008). A dense soil will restrict root growth and seedling emergence, reduce the available water capacity, restrict water and air movement, and ultimately reduce productivity.

Management that improves soil bulk density includes reducing soil disturbance when the soil is wet, applying conservation practices that increase or maintain soil organic matter contents, and maintaining soil surface protection (such as a cover crop, especially a multi-species cover that can provide a wide range of root penetration).

Measurement of bulk density is essential for weight to volume or area conversions of other properties, such as soil carbon stocks and nutrient pools. It is also used in the calculation of pore space.

Factors Affecting Bulk Density:

Inherent factors.Bulk density is dependent on soil texture and the densities of soil mineral particles (sand, silt, and clay) and organic matter particles, as well as their packing arrangement. Generally, loose, porous soils and those rich in organic matter have lower bulk densities. Sandy soils have relatively high bulk densities since total pore space in sands is less than that of silty or clayey soils. Finer-textured soils that have good structure, such as silt loams and clay loams, have higher pore space and lower bulk density compared to sandy soils.

There is a general relationship of soil bulk density to root growth based on soil texture. Bulk densities ideal for root growth are less than 1.60 g/cc for sandy textures, less than 1.40 g/cc for loamy textures, and less than 1.10 g/cc for clayey textures. Bulk densities that restrict root growth are greater than 1.80 g/cc for sandy textures, 1.65 g/cc for loamy textures, and 1.47 g/cc for clayey textures.

Dynamic factors.Bulk density is changed by crop and land management practices that affect soil cover, organic matter, soil structure, and/or porosity. Cultivation can result in compacted soil layers with increased bulk density. Livestock as well as the use of agricultural and construction equipment can compact the soil and reduce porosity, especially on wet soils. Freeze-thaw action in the soil can lead to lowered bulk density.

Measurement:

In general, there are two broad groupings of bulk density methods. One group is for soil materials that are cohesive enough that a field sample can be removed, and the other group is for soils that are too fragile for field sampling and require an excavation operation. In methods for the former group, a clod sample is coated with a plastic film and the volume determined by submergence. There are also various core methods for the former group in which a cylinder of known volume is used to obtain a sample. The detailed procedures are outlined in the Kellogg Soil Survey Laboratory Methods Manual (Soil Survey Staff, 2014).

References:

Arshad, M.A., B. Lowery, and R. Grossman. 1996. Physical tests for monitoring soil quality. In: J.W. Doran and A.J. Jones (eds.) Methods for Assessing Soil Quality. Soil Science Society of America Special Publication 49:123-142.

Soil Survey Staff. 2014. Kellogg Soil Survey Laboratory methods manual. Soil Survey Investigations Report No. 42, Version 5.0. R. Burt and Soil Survey Staff (eds.). U.S. Department of Agriculture, Natural Resources Conservation Service.

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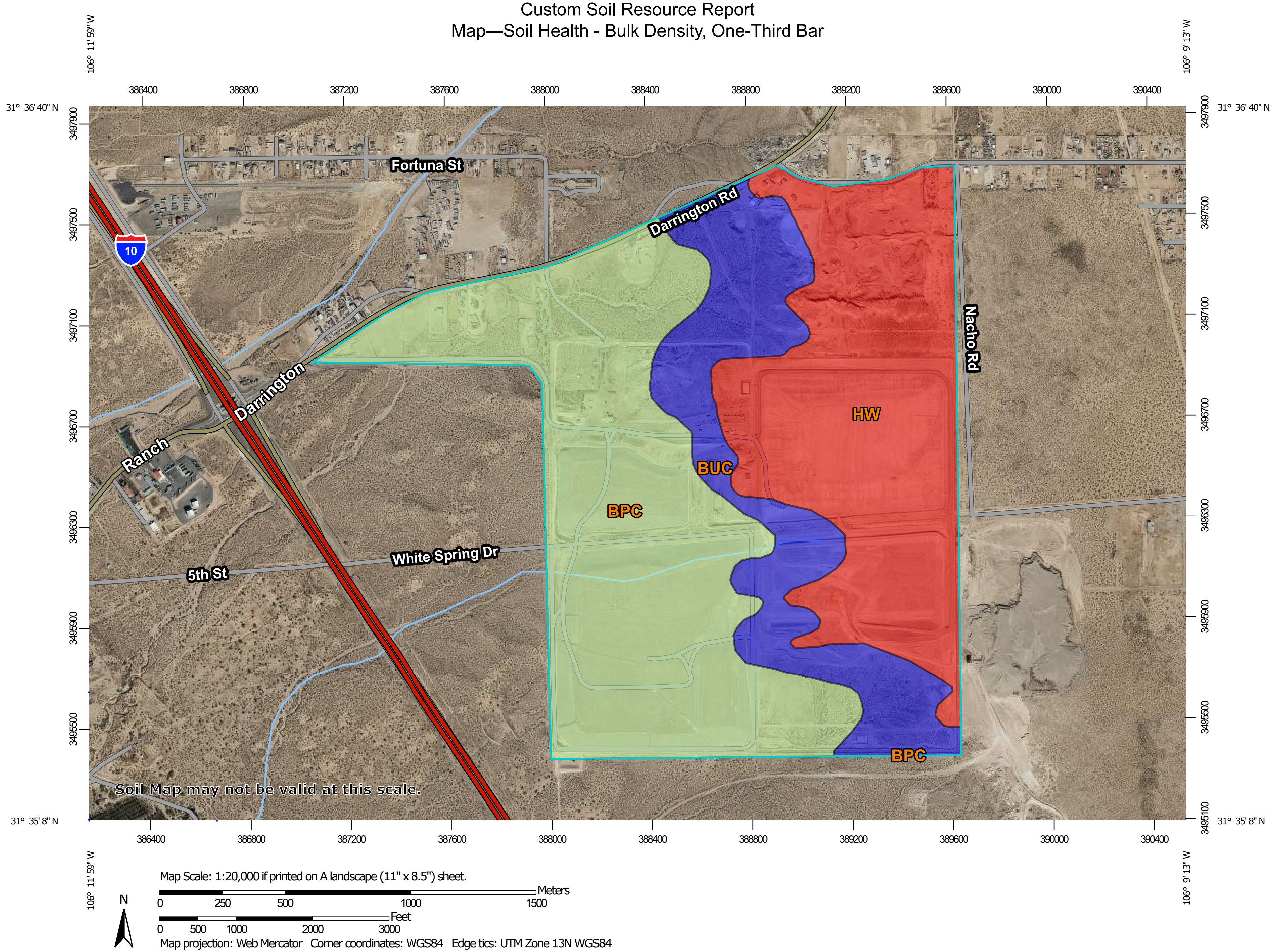
Volchko, Y., J. Norrman, L. Rosen, and T. Norberg. 2014. A minimum data set for evaluating the ecological soil functions in remediation projects. Journal of Soils and Sediments 14:1850-1860.

Custom Soil Resource Report
Map—Soil Health - Bulk Density, One-Third Bar



MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

<= 1.53

> 1.53 and <= 1.55

> 1.55 and <= 1.60

Not rated or not available

Soil Rating Lines

<= 1.53

> 1.53 and <= 1.55

> 1.55 and <= 1.60

Not rated or not available

Soil Rating Points

<= 1.53

> 1.53 and <= 1.55

> 1.55 and <= 1.60

Not rated or not available

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:31,700.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: El Paso County, Texas (Main Part)
Survey Area Data: Version 22, Sep 5, 2023

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Nov 15, 2020—Nov 17, 2020

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—Soil Health - Bulk Density, One-Third Bar

Map unit symbol	Map unit name	Rating (grams per cubic centimeter)	Acres in AOI	Percent of AOI
BPC	Bluepoint association, rolling	1.55	434.9	45.4%
BUC	Bluepoint gravelly association, rolling	1.60	188.1	19.6%
HW	Hueco-Wink association, hummocky	1.53	335.6	35.0%
Totals for Area of Interest			**958.7**	**100.0%**

Rating Options—Soil Health - Bulk Density, One-Third Bar

Units of Measure: grams per cubic centimeter

Aggregation Method: Dominant Component

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Interpret Nulls as Zero: No

Layer Options (Horizon Aggregation Method): Surface Layer (Not applicable)

References

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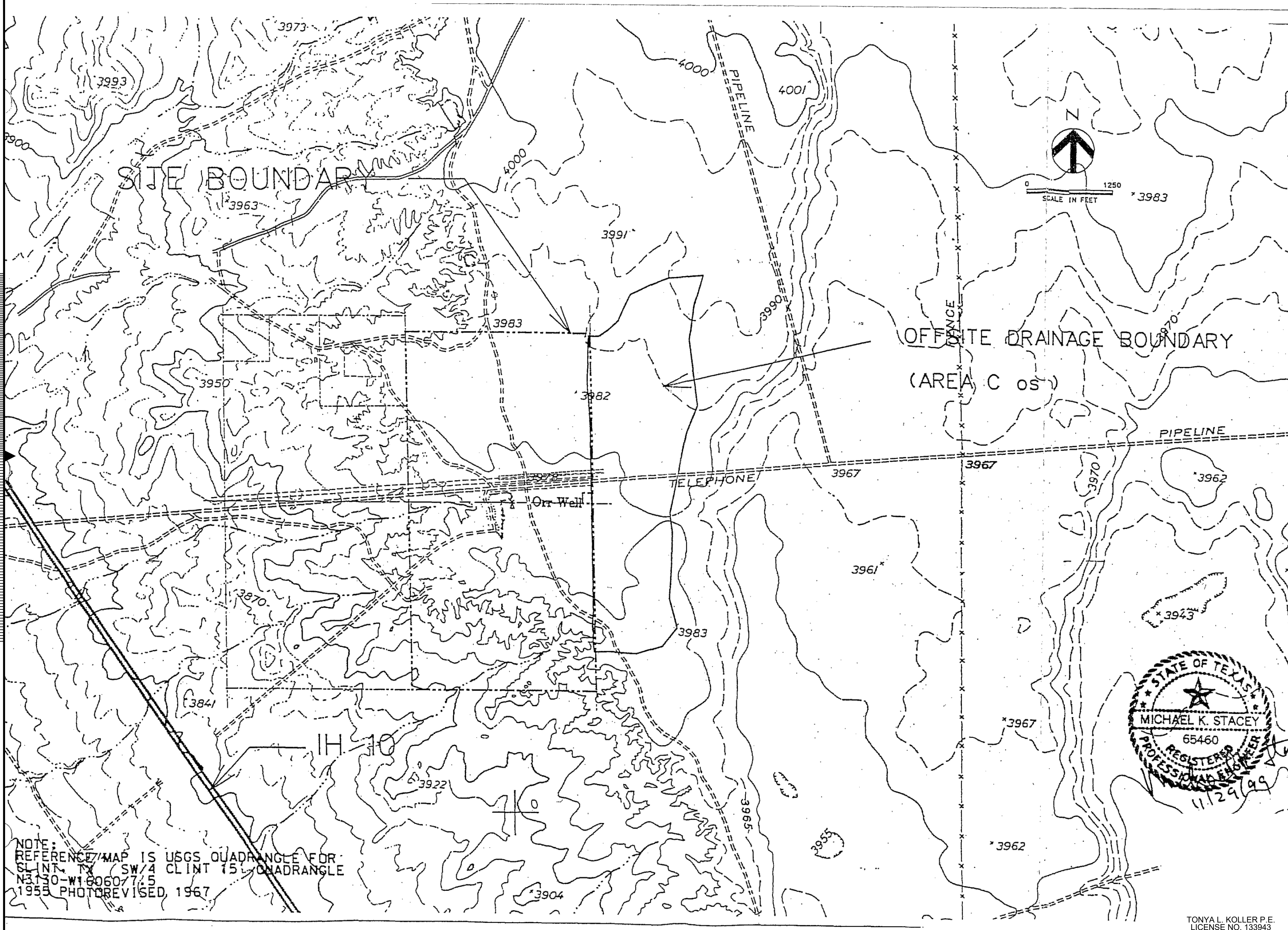
United States Department of Agriculture, Soil Conservation Service. 1961. Land capability classification. U.S. Department of Agriculture Handbook 210. http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_052290.pdf

ATTACHMENT III.B.3 – DRAWINGS



no.	date	by	ckd	description
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1	5/16/25	AAN	TJS	TCEQ NOD 1

NOTES:

1. DRAWING ORIGINALLY FROM THE CLINT LANDFILL NEW PERMIT PREPARED BY HDR ENGINEERING AND SIGNED BY MICHAEL K. STACEY ON NOVEMBER 29, 1999.
2. TOPOGRAPHICAL DATUM ASSUMED TO BE CITY DATUM.

FOR PERMITTING PURPOSES ONLY

BURNS McDONNELL

9400 WARD PARKWAY
KANSAS CITY, MO 64114
816-333-9400
Burns & McDonnell Engineering Co, Inc.
FIRM REG. NO. F-845

date	detailed
MAY 2024	D. KAMBLE
designed	checked
T. CAMMACK	T. KOLLER

EP TX
CITY OF EL PASO

City of El Paso, Texas

2284A PERMIT AMENDMENT

HISTORIC OFFSITE DRAINAGE CONDITIONS

project	contract
155488	-

drawing **III.B.1A** — rev. **1**

file III.B.1A PRE-DEVELOPMENT CONDITIONS.dwg

aanesbitt May 14, 2025 - 7:54am - \\bmcd\Dfs\Clients\ENS\CityElPasoTX\155488_GEPLFExpans\Design\CADD\Dwgs\III.B.1A PRE-DEVELOPMENT CONDITIONS.dwg

no.	date	by	ckd	description
0	5/1/24	TMC	TLK	2284A PERMIT MOD
1	5/16/25	AAN	TJS	TCEQ NOD 1

LEGEND

DRAINAGE BASIN
DRAINAGE SUB-BASIN
PERMIT LIMIT
FLOW DIRECTION
DISCHARGE POINT
DRAINAGE BASIN IDENTIFIER
STREAM OR DITCH

DISCHARGE	SUBBASIN	AREA (AC.)	DISCHARGE (CFS)
	A1	7	5.3
@A		7	5.3
	B1	79	38
	C1	151	34
	C2	82	33
@B		313	81
	D1	42	20
	D2	10	4.8
@D		52	25
	E1	91	26
	E2	8	4.6
@E		99	27.5

NOTE: FOR OFFSITE TOPOGRAPHY SEE DRAWING III.B.1A

TOPOGRAPHY INFORMATION PROVIDED BY ROE ENGINEERS BASED ON AERIAL PHOTOGRAPHY DATED 11-11-97

NO AREAS WITHIN SITE ARE SUBJECT TO 100 YEAR FLOODPLAIN AS SHOWN IN FEMA PANEL NO. 4802120012A

NOTES:

1. DRAWING ORIGINALLY FROM THE CLINT LANDFILL NEW PERMIT PREPARED BY HDR ENGINEERING AND SIGNED BY MICHAEL K. STACEY ON SEPTEMBER 1, 2000. DISCHARGE VELOCITIES AND DRAWING REFERENCES UPDATED FROM ORIGINAL SEALED DRAWING.
2. TOPOGRAPHICAL DATUM ASSUMED TO BE CITY DATUM.
3. DRAINAGE PATTERNS PROVIDED OUTSIDE OF THE SITE BOUNDARY IN AREA C1 ARE APPROXIMATED FROM THE 1995 USGS TOPOGRAPHIC MAP OF EL PASO.

STATE OF TEXAS
MICHAEL K. STACEY
65460
REGISTERED PROFESSIONAL ENGINEER
9/1/00

FOR PERMITTING PURPOSES ONLY

BURNS McDONNELL
9400 WARD PARKWAY
KANSAS CITY, MO 64114
816-333-9400
Burns & McDonnell Engineering Co, Inc.
FIRM REG. NO. F-845

date: MAY 2024
detailed: D. KAMBLE
designed: T. CAMMACK
checked: T. KOLLER

EP TX
CITY OF EL PASO
City of El Paso, Texas

2284A PERMIT AMENDMENT

HISTORIC ON-SITE DRAINAGE CONDITIONS

project: 155488
contract: -
drawing: III.B.1B – rev. 1

TONYA L. KOLLER P.E.
LICENSE NO. 133943

file III.B.1B PRE-DEVELOPMENT DRAINAGE CONDITIONS.dwg

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no.	date	by	ckd	description
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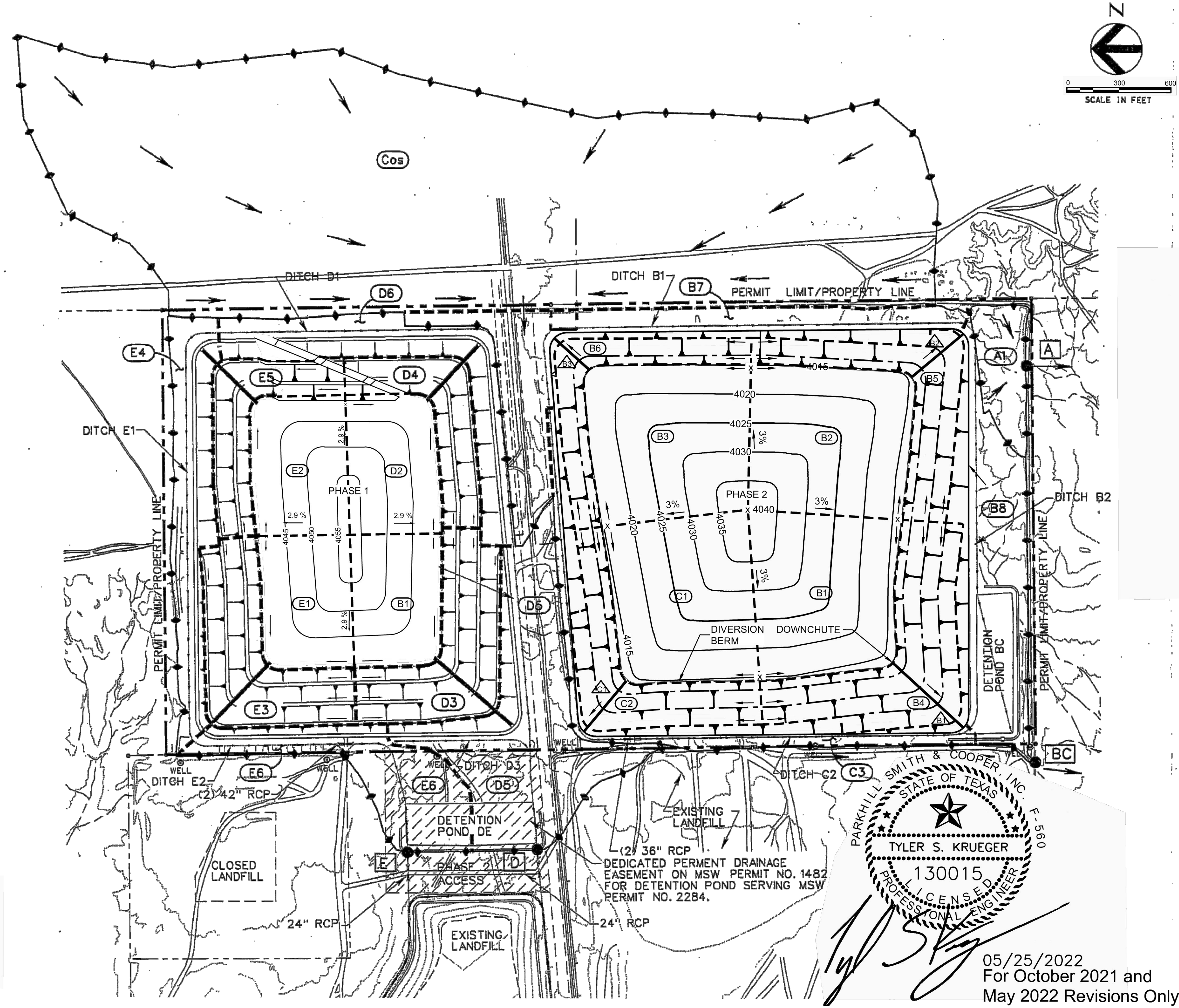
1	5/16/25	AAN	TJS	TCEQ NOD 1



LEGEND

- DRAINAGE BASIN
- DRAINAGE SUB-BASIN
- PERMIT LIMIT
- FLOW DIRECTION
- A DISCHARGE POINT
- 1 DRAINAGE BASIN IDENTIFIER
- STREAM OR DITCH
- CULVERT
- SIDESLOPE INTERCEPTORS

DEVELOPED CONDITIONS SUMMARY

Discharge Point	Subbasin	Area (acres)	Discharge (cfs)
A	A1	5.0	3
			3
Pond BC		17.5	44
	B2	18.1	46
	B3	19.3	48
	B4	15.3	43
	B5	9.9	28
	B6	7.4	20
	B7	19.4	10
	B8	17.9	13
	Cos	151.4	23
	C1	18.5	46
	C2	10.6	29
	C3	10.2	19
Inflow @ Pond BC[1]			259
Outflow @ Pond BC[1]			48
Pond DE	D1	9.7	33
	D2	10.3	33
	D3	12.5	48
	D4	7.7	29
	D5	24.8	38
	D6	12.9	34
	E1	9.9	34
	E2	10.5	39
	E3	12.9	51
	E4	12.5	25
	E5	8.2	31
	E6	11.9	29
Inflow @ Pond DE[2]			357
Outflow @ Pond DE[2]			32

[1]From the HEC HMS Output included in Appendix 1 of this Attachment

[2]From the HEC HMS Output included in Appendix 1 of this Attachment

STATE OF TEXAS
MICHAEL K. STACEY
65460
REGISTERED PROFESSIONAL ENGINEER
9/1/00

NOTES:

1. DRAWING ORIGINALLY FROM THE 2022 PERMIT MODIFICATION (2284) COMPLETED BY PARKHILL, SMITH AND ASSOCIATES AND SIGNED BY TYLER S. KRUEGER ON MAY 25, 2022.
2. TOPOGRAPHICAL DATUM ASSUMED TO BE CITY DATUM.

FOR PERMITTING PURPOSES ONLY

BURNS McDONNELL
9400 WARD PARKWAY
KANSAS CITY, MO 64114
816-333-9400
Burns & McDonnell Engineering Co, Inc.
FIRM REG. NO F-845

date 5/16/2025
detailed A. NESBITT
designed T. SCHMIDT
checked T. KOLLER

City of El Paso, Texas

2284A PERMIT AMENDMENT

PRE-DEVELOPMENT DRAINAGE CONDITIONS

project 155488
contract -
drawing **III.B.2** rev. **1**

TONYA L. KOLLER P.E.
LICENSE NO. 133943

file III.B.2PRE-DEVELOPMENTDRAINAGECONDITIONS.DWG

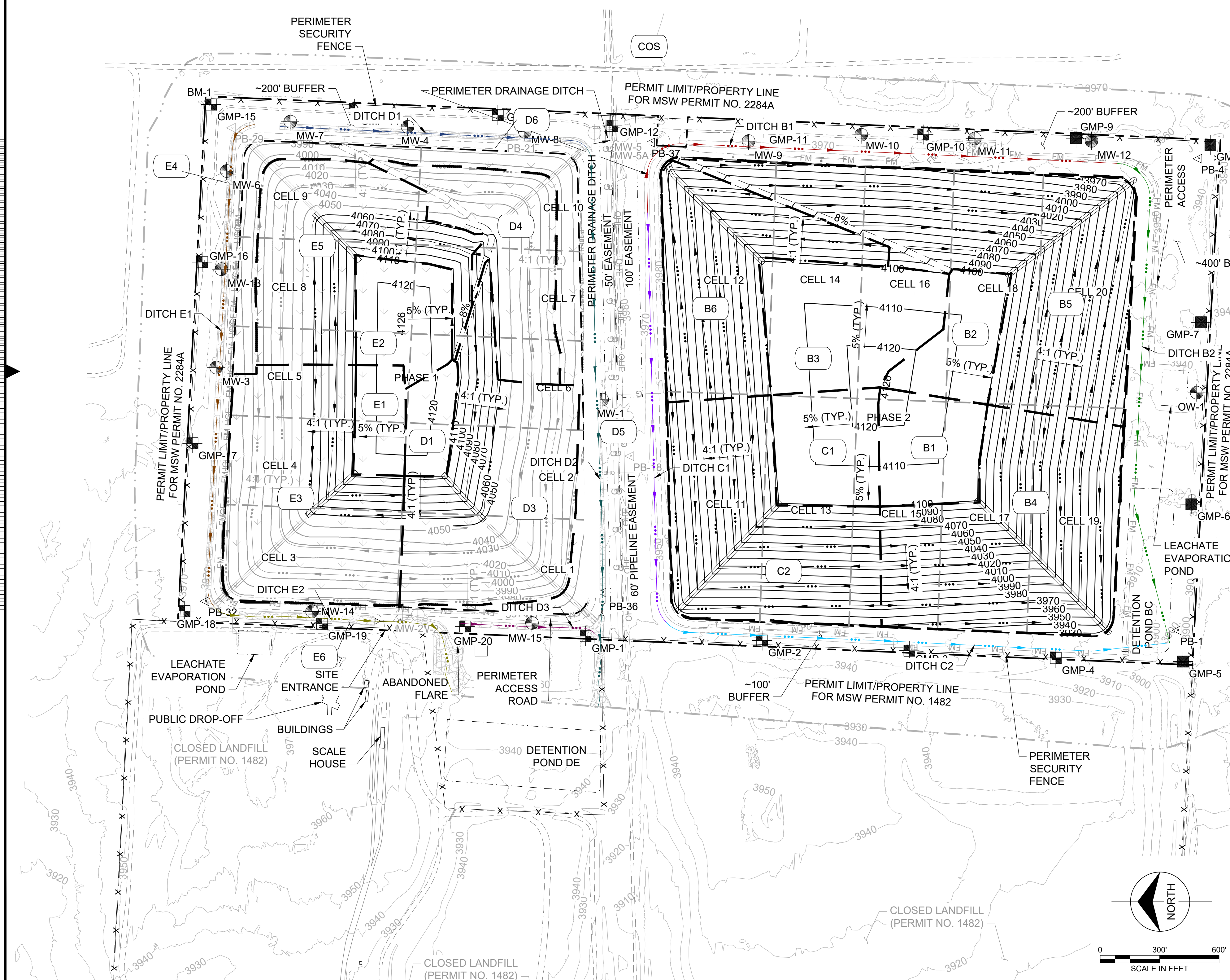
tkoller May 14, 2025 - 8:29am - \\bmcd.burnsmcd.com\dfs\Clients\ENS\cityelpasotx\155488_geplfexpans\Design\CADD\Dwgs\III.B.2 PRE-DEVELOPMENT DRAINAGE CONDITIONS.dwg

no.	date	by	ckd	description
0	5/1/24	TMC	TLK	2284A PERMIT MOD
1	5/16/25	AAN	TJS	TCEQ NOD 1

PLAN LEGEND

- DRAINAGE SUBBASIN
- PERMIT LIMIT
- FLOW DIRECTION
- A DISCHARGE POINT
- B5 DRAINAGE BASIN IDENTIFIER
- STREAM OR DITCH
- CULVERT

NOTE: SEE DRAWING III.A.1 FOR COMPLETE LEGEND.



DEVELOPED CONDITIONS SUMMARY

DISCHARGE	SUBBASIN	AREA (AC.)	DISCHARGE (CFS)
	A1	5	4.7
@A		5	4.7
	B1	17	102.8
	B2	18	103
	B3	19	109
	B4	13	92
	B5	10	50.3
	B6	7	43.7
	B7	19	16.9
	B8	18	57.9
	COS	151	42.3
	C1	19	108.7
	C2	11	65.2
	C3	10	16.5
INFLOW @ POND BC		315	474.75
OUTFLOW @ POND BC			45.4
	D1	10	62.7
	D3	13	66.9
	D4	8	40.7
	D5	25	56.8
	D6	12	46.4
	E1	10	62.1
	E2	11	59.4
	E3	13	70.8
	E4	13	38.5
	E5	8	43.3
	E6	12	49.1
INFLOW @ POND DE		143	383.35
OUTFLOW @ POND DE			18.4

CHANNEL IDENTIFICATION	SIDE SLOPES	CHANNEL SLOPE (FT/FT)	BOTTOM WIDTH (FT)
DITCH B1	3:1	VARIES	8
DITCH B2	3:1	VARIES	8
DITCH C1	3:1	VARIES	8
DITCH C2	3:1	VARIES	8
DITCH D1	3:1	VARIES	8
DITCH D2	3:1	VARIES	8
DITCH D3	3:1	VARIES	8
DITCH E1	3:1	VARIES	8
DITCH E2	3:1	VARIES	8

NOTES:

1. INDEX CONTOUR INTERVAL, 10 FEET.
2. GREATER EL PASO LANDFILL EXISTING SITE TOPOGRAPHY (2284A PERMIT AREA) DERIVED FROM ORTHO-PHOTOGRAPHY FROM AN UNMANNED AERIAL SURVEY TIED TO GROUND CONTROL PANELS PROVIDED BY PARKHILL, SMITH & COOPER, AUGUST 28, 2019. TOPOGRAPHY WITHIN CELLS 11 THROUGH 14 COMPLETED WITH GROUND CONTROL POINTS PROVIDED BY THE CITY OF EL PASO, AUGUST 2022. TOPOGRAPHY OUTSIDE OF THE SURVEY EXTENTS WAS OBTAINED FROM THE TEXAS NATURAL RESOURCES INFORMATION SYSTEM, DATED APRIL 2008.
3. THE SURVEY COORDINATES ARE ON THE TEXAS COORDINATE SYSTEM, CENTRAL ZONE 4203, NAD83. HORIZONTAL DATUM IS NAD83. VERTICAL DATUM IS NAVD88.
4. EXISTING TOP OF FINAL COVER SURFACE FOR PHASE 1 PREPARED BY PARKHILL, SMITH & COOPER, INC. AND REPRESENTS DESIGN FINAL COVER ELEVATIONS. CONTOUR INTERVAL IS 10 FEET. PHASE 1 RECEIVED FINAL COVER IN 2021.
5. DESIGN CONTOURS REPRESENT TOP OF FINAL COVER SURFACE FOR PHASE 1 AND PHASE 2. CONTOUR INTERVAL IS 10 FEET. 2284 PERMITTED DESIGN CONTOURS WERE BASED ON CITY DATUM ELEVATIONS AND WERE ADJUSTED TO NAVD88 BY ADDING 10.39 FEET AS CERTIFIED BY BROCK & BUSTILLOS INC. ON DECEMBER 7, 2023. DATUM CERTIFICATION LETTER INCLUDED IN APPENDIX I/II.B.

FOR PERMITTING PURPOSES ONLY

BURNS McDONNELL
9400 WARD PARKWAY
KANSAS CITY, MO 64114
816-333-9400
Burns & McDonnell Engineering Co, Inc.
FIRM REG. NO. F-845

date: MAY 2024 | detailed: D. KAMBLE
designed: T. CAMMACK | checked: T. KOLLER

EP TX CITY OF EL PASO
City of El Paso, Texas

2284A PERMIT AMENDMENT

POST-DEVELOPMENT DRAINAGE CONDITIONS

project: 155488 | contract: -
drawing: III.B.3 – rev. 1

file: III.B.3 POST-DEVELOPMENT DRAINAGE CONDITIONS.dwg

TONYA L. KOLLER P.E.
LICENSE NO. 133943

jpistorius May 15, 2025 - 5:38pm - \\bmcd.burnsmcd.com\dfs\Clients\ENS\cityelpasotx\155488_geplfexpans\Design\CADD\Dwgs\III.B.3 POST-DEVELOPMENT DRAINAGE CONDITIONS.dwg

no.	date	by	ckd	description
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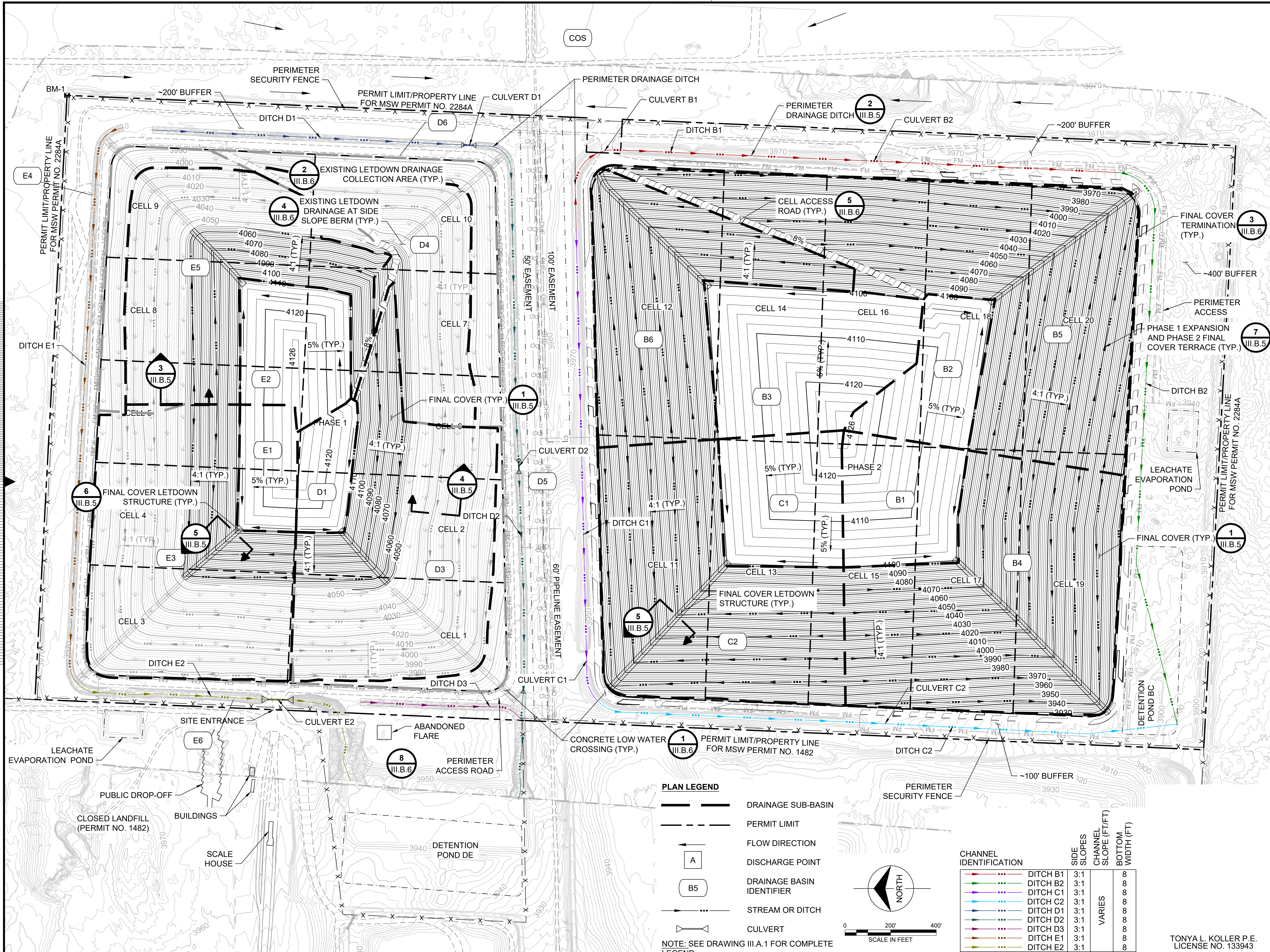
1	5/16/25	AAN	TJS	TCEQ NOD 1



PLAN LEGEND

— — —	DRAINAGE SUB-BASIN
— - —	PERMIT LIMIT
←	FLOW DIRECTION
A	DISCHARGE POINT
B5	DRAINAGE BASIN IDENTIFIER
—▸— •••	STREAM OR DITCH
▷◁	CULVERT

NOTE: SEE DRAWING III.A.1 FOR COMPLETE LEGEND.

CHANNEL IDENTIFICATION	SIDE SLOPES	CHANNEL SLOPE (FT/FT)	BOTTOM WIDTH (FT)
DITCH B1	3:1	VARIES	8
DITCH B2	3:1		8
DITCH C1	3:1		8
DITCH C2	3:1		8
DITCH D1	3:1		8
DITCH D2	3:1		8
DITCH D3	3:1		8
DITCH E1	3:1		8
DITCH E2	3:1		8

TONYA L. KOLLER P.E.
LICENSE NO. 133943

NOTES:

1. INDEX CONTOUR INTERVAL, 2 FEET.
2. GREATER EL PASO LANDFILL EXISTING SITE TOPOGRAPHY (2284A PERMIT AREA) DERIVED FROM ORTHO-PHOTOGRAPHY FROM AN UNMANNED AERIAL SURVEY TIED TO GROUND CONTROL PANELS PROVIDED BY PARKHILL, SMITH & COOPER, AUGUST 28, 2019. TOPOGRAPHY WITHIN CELLS 11 THROUGH 14 COMPLETED WITH GROUND CONTROL POINTS PROVIDED BY THE CITY OF EL PASO, AUGUST 2022. TOPOGRAPHY OUTSIDE OF THE SURVEY EXTENTS WAS OBTAINED FROM THE TEXAS NATURAL RESOURCES INFORMATION SYSTEM, DATED APRIL 2008.
3. THE SURVEY COORDINATES ARE ON THE TEXAS COORDINATE SYSTEM, CENTRAL ZONE 4203, NAD83. HORIZONTAL DATUM IS NAD83. VERTICAL DATUM IS NAVD88.
4. EXISTING TOP OF FINAL COVER SURFACE FOR PHASE 1 PREPARED BY PARKHILL, SMITH & COOPER, INC. AND REPRESENTS DESIGN FINAL COVER ELEVATIONS. CONTOUR INTERVAL IS 2 FEET. PHASE 1 RECEIVED FINAL COVER IN 2021.
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FOR PERMITTING PURPOSES ONLY

BURNS McDONNELL
9400 WARD PARKWAY
KANSAS CITY, MO 64114
816-333-9400
Burns & McDonnell Engineering Co, Inc.
FIRM REG. NO. F-845

date: MAY 2024	detailed: D. KAMBLE
designed: T. CAMMACK	checked: T. KOLLER

City of El Paso, Texas

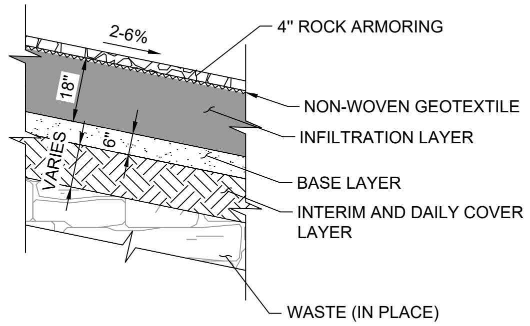
2284A PERMIT AMENDMENT

POST-DEVELOPMENT DRAINAGE MAP

project: 155488	contract: -
drawing: III.B.4	rev.: 1

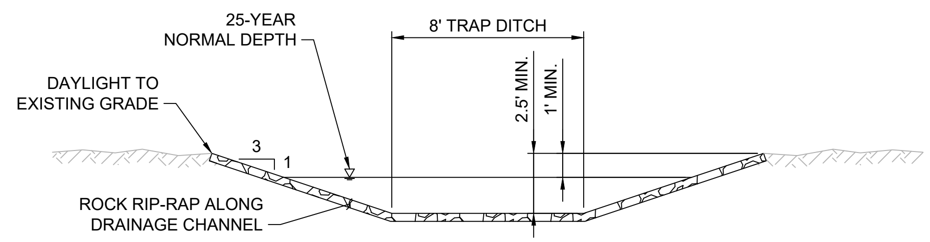
file III.B.4 POST-DEVELOPMENT DRAINAGE MAP.dwg

aanesbitt May 14, 2025 - 7:56am - \\bmcd.burnsmcd.com\dfs\Clients\ENS\cityelpasotx\155488_geplfexpans\Design\CADD\Dwgs\III.B.4 POST-DEVELOPMENT DRAINAGE MAP.dwg

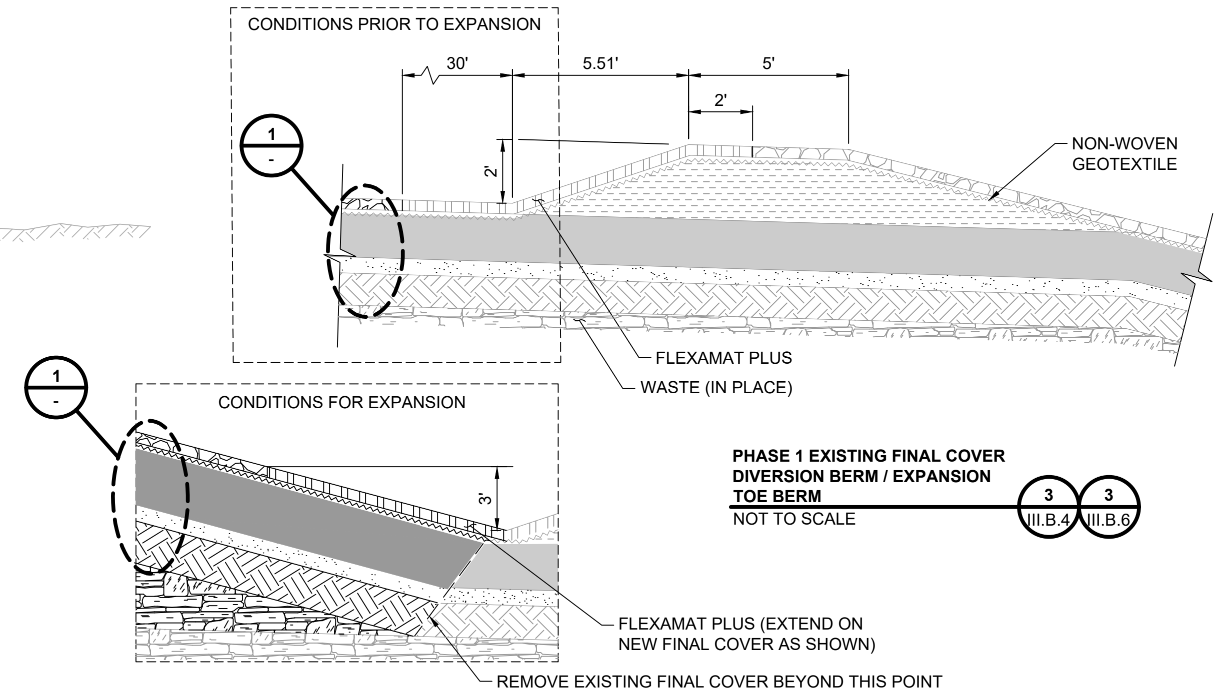


NOTE:
THICKNESS ARE MEASURED PERPENDICULAR TO SURFACE

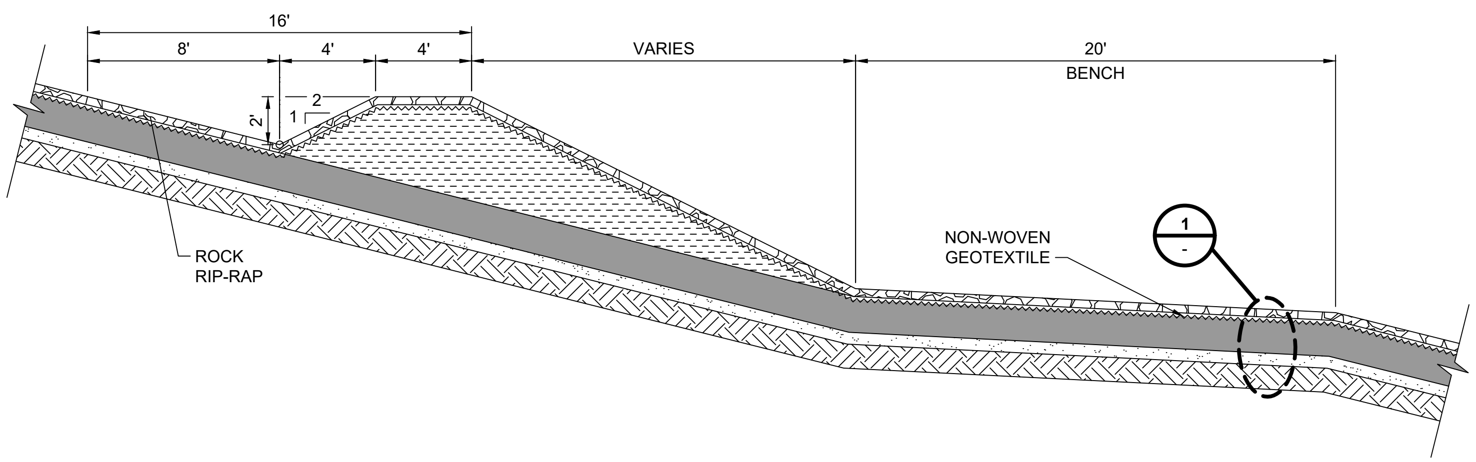
FINAL COVER (TYP.) 1/- 1/III.B.4 1/III.B.6 1/III.B.11 1/III.B.12
NOT TO SCALE



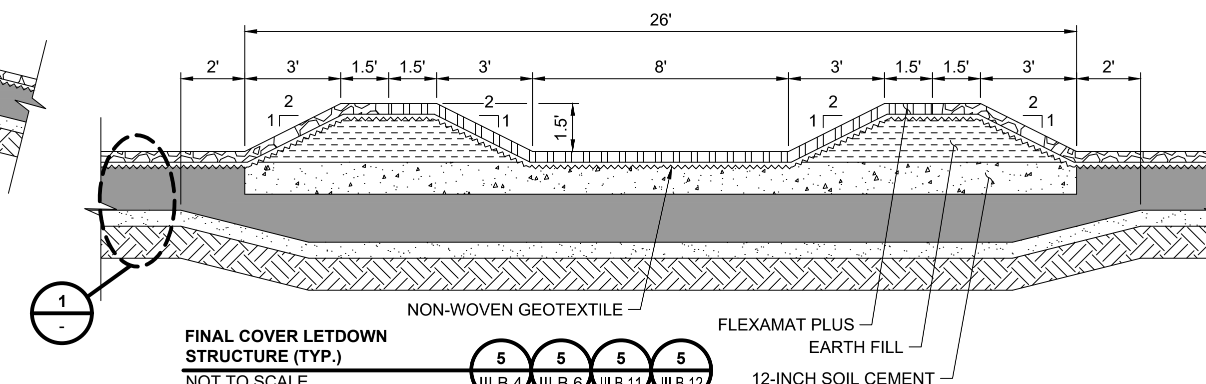
PERIMETER DRAINAGE DITCH (TYP.) 2/III.B.4 2/III.B.11 2/III.B.12
NOT TO SCALE



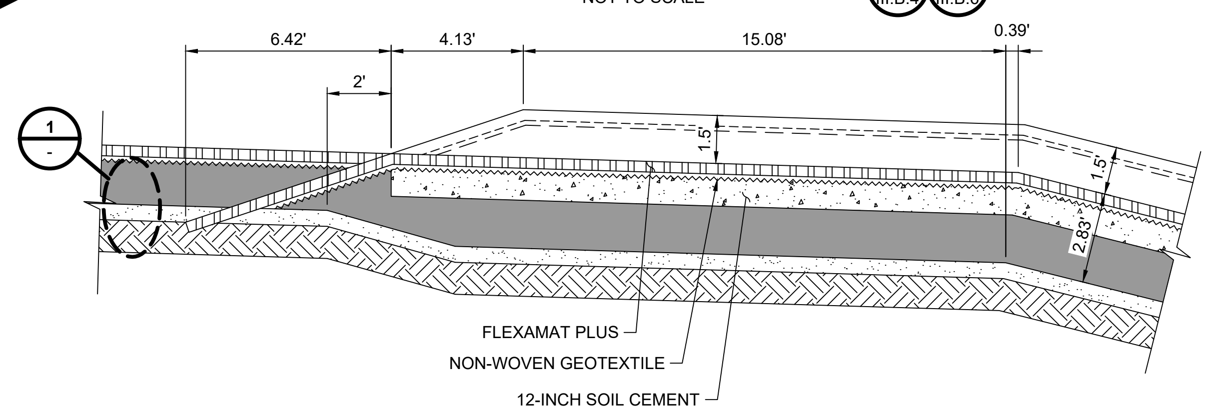
PHASE 1 EXISTING FINAL COVER DIVERSION BERM / EXPANSION TOE BERM 3/III.B.4 3/III.B.6
NOT TO SCALE



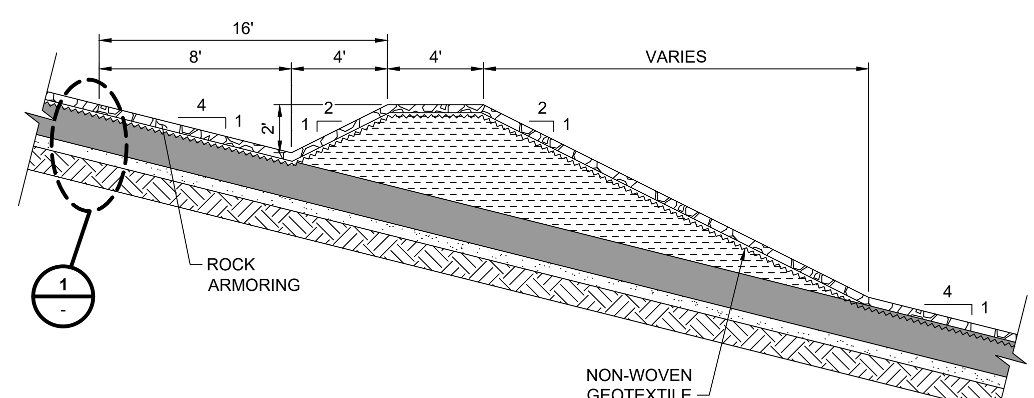
PHASE 1 EXISTING SIDE SLOPE BERM 4/III.B.4 4/III.B.6
NOT TO SCALE



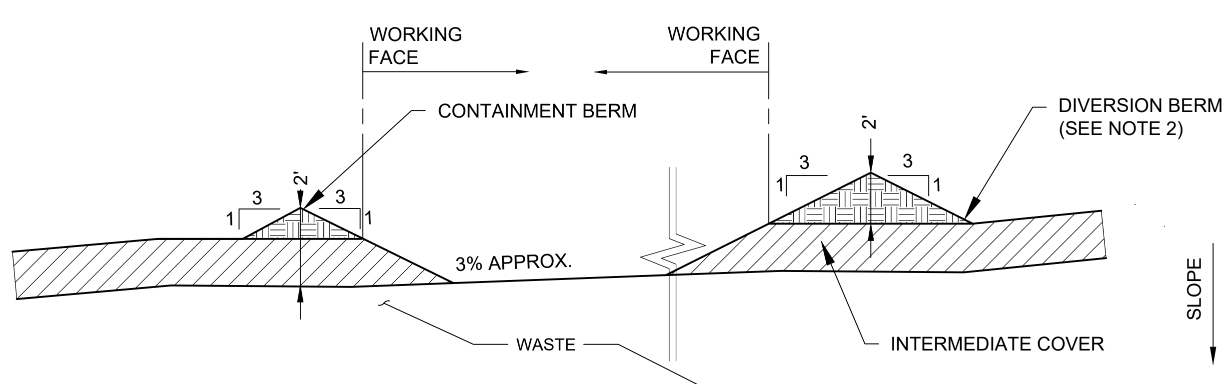
FINAL COVER LETDOWN STRUCTURE (TYP.) 5/III.B.4 5/III.B.6 5/III.B.11 5/III.B.12
NOT TO SCALE



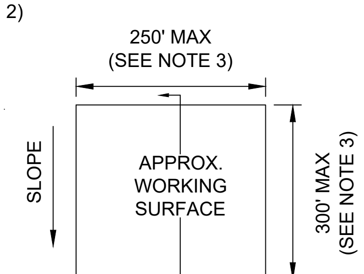
FINAL COVER LETDOWN STRUCTURE (TYP.) 6/III.B.4
NOT TO SCALE



PHASE 1 EXPANSION AND PHASE 2 FINAL COVER TERRACE DETAIL 7/III.B.4 7/III.B.11
NOT TO SCALE



WORKING FACE DIVERSION AND CONTAINMENT BERM 8/III.B.5
NOT TO SCALE



DETAIL 6 KEY

NOTES FOR DETAIL 8:

1. WORKING FACE WILL RELOCATE IN CONJUNCTION WITH CURRENT WASTE FILLING PATTERNS.
2. DIVERSION BERM FLOWLINE SHALL BE 0.5% MINIMUM TO CONVEY UNCONTAMINATED WATER AROUND WORKING FACE.
3. MAXIMUM WORKING FACE DIMENSIONS ARE DEPENDENT UPON WASTE QUANTITY.

TONYA L. KOLLER P.E.
LICENSE NO. 133943

no.	date	by	ckd	description
0	5/1/24	TMC	TLK	2284A PERMIT MOD
1	5/16/25	AAN	TJS	TCEQ NOD 1

FOR PERMITTING PURPOSES ONLY

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date: MAY 2024
detailed: D. KAMBLE
designed: T. CAMMACK
checked: T. KOLLER

City of El Paso, Texas

2284A PERMIT AMENDMENT

DRAINAGE DETAILS, 1 OF 2

project: 155488
contract: -
drawing: III.B.5 – rev. 1

file III.B.5 DRAINAGE DETAILS, 1 OF 2.dwg

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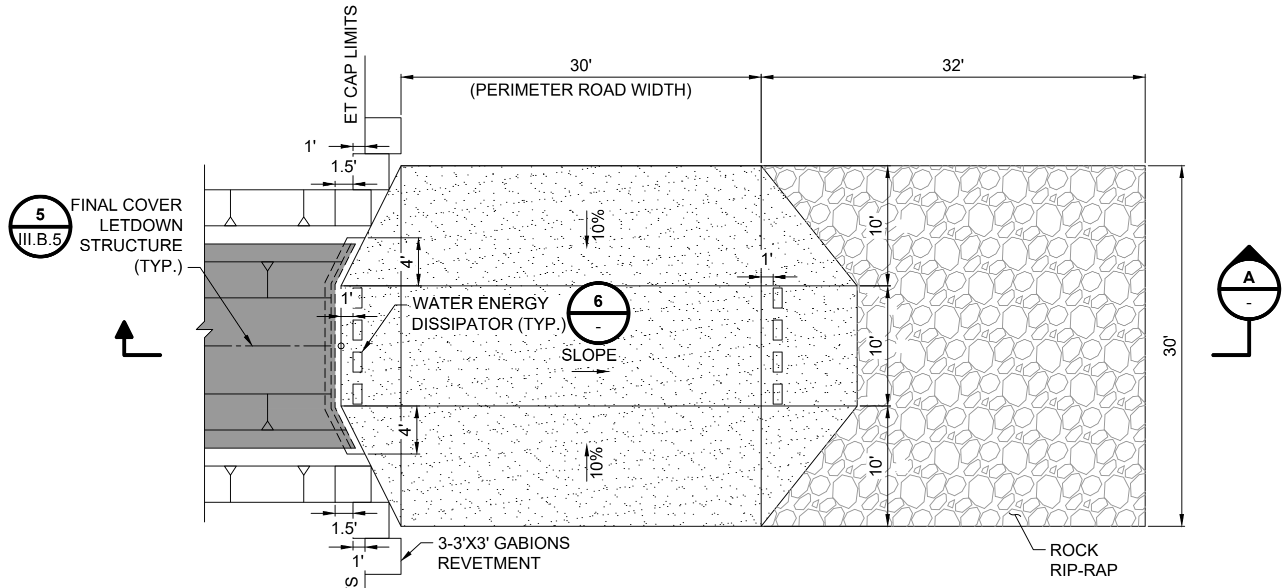
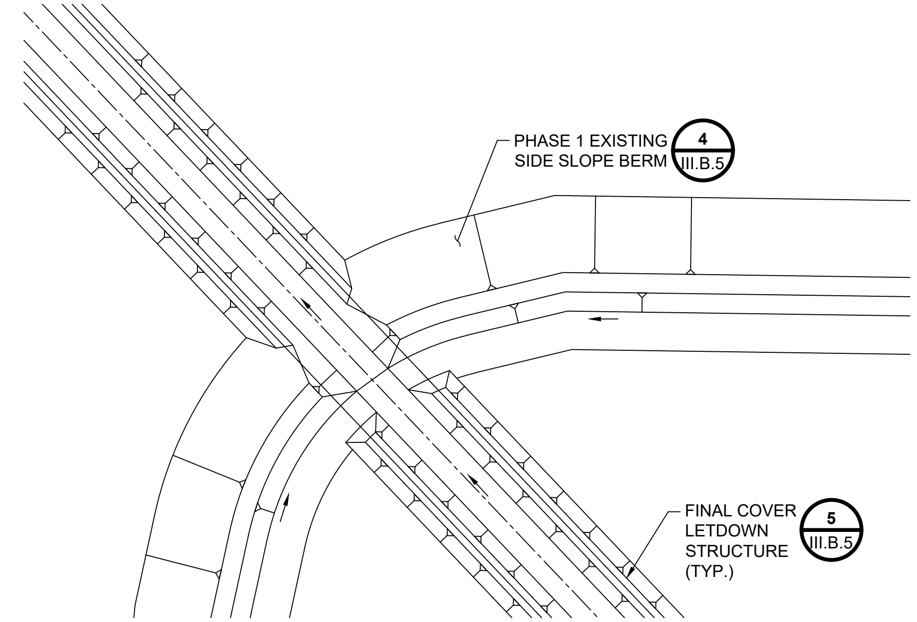
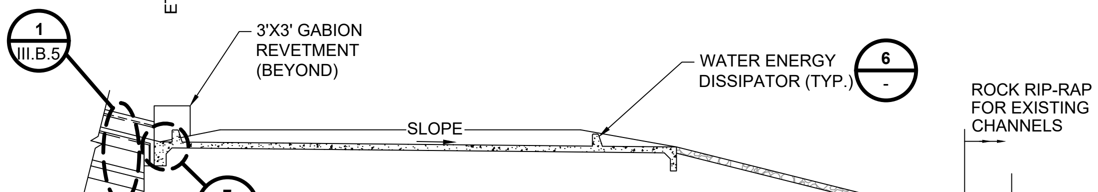
no.	date	by	ckd	description
0	5/1/24	TMC	TLK	2284A PERMIT MOD
1	5/16/25	AAN	TJS	TCEQ NOD 1



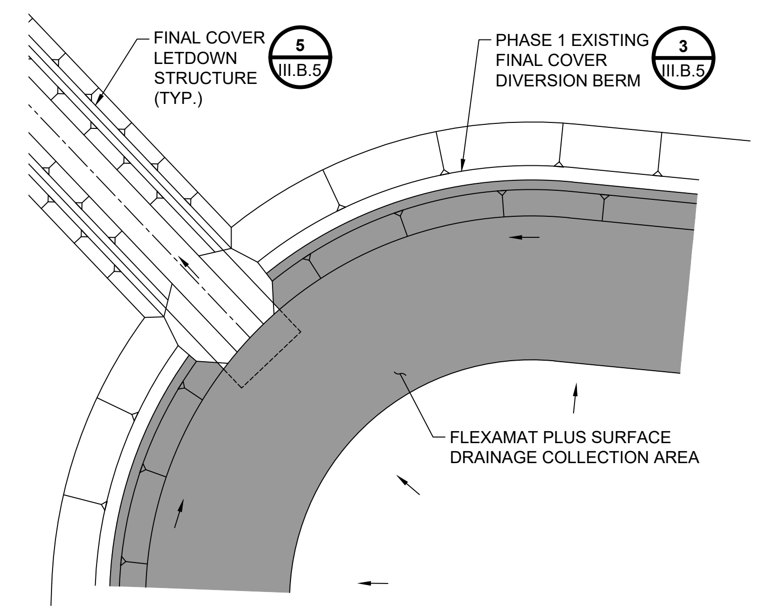
CONCRETE LOW WATER CROSSING PLAN 1 III.B.4 1 III.B.11 1 III.B.12
NOT TO SCALE

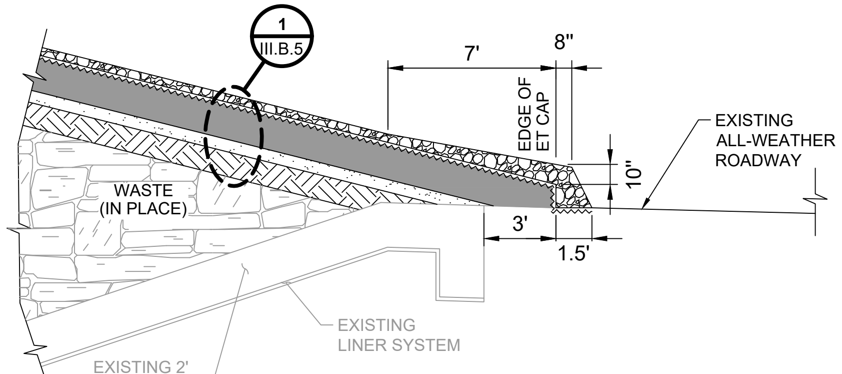


LET-DOWN DRAINAGE COLLECTION AREA (TYP.) 2 III.B.4 2 III.B.11
NOT TO SCALE

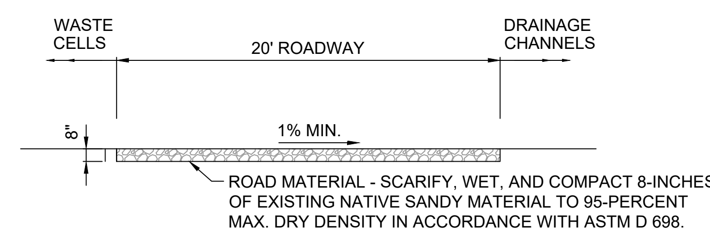


CONCRETE LOW WATER CROSSING SECTION A -
NOT TO SCALE



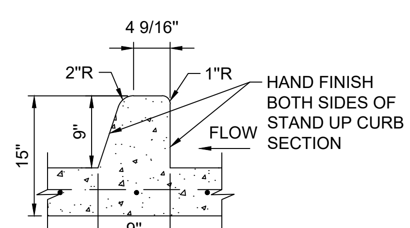


FINAL COVER TERMINATION (TYP.) 3 III.B.4 3 III.B.11 3 III.B.12
NOT TO SCALE



PERIMETER ROAD 8 III.B.4
NOT TO SCALE

LET-DOWN DRAINAGE AT SIDE SLOPE BERM (TYP.) 4 III.B.4
NOT TO SCALE



WATER ENERGY DISSIPATOR (TYP.) SECTION B -
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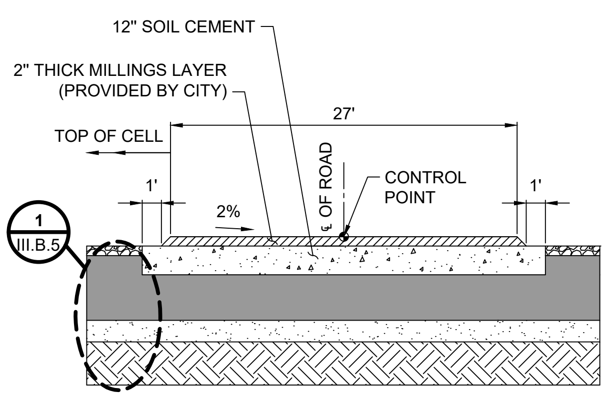
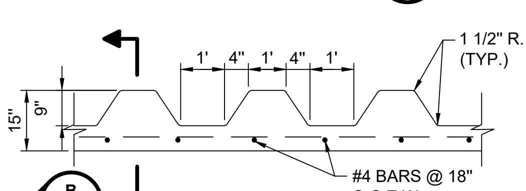
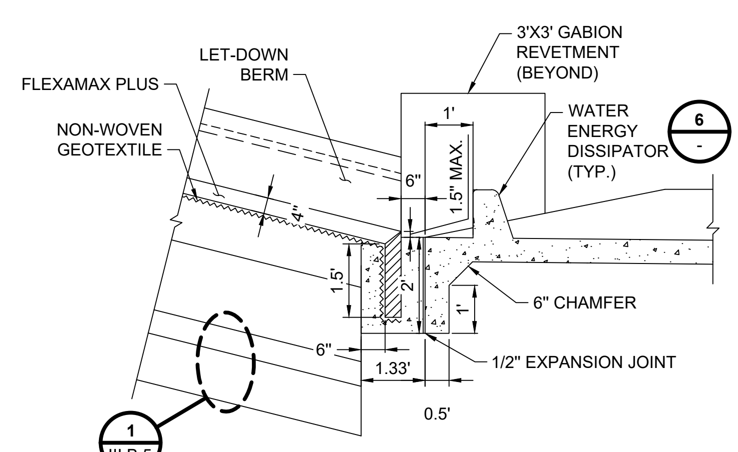


CELL ACCESS ROAD 5 III.B.4
NOT TO SCALE



WATER ENERGY DISSIPATOR (TYP.) 6 -
NOT TO SCALE



LET DOWN CONNECTION 7 -
NOT TO SCALE

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LICENSE NO. 133943

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Burns & McDonnell Engineering Co, Inc.
FIRM REG. NO. F-845

date	detailed
MAY 2024	D. KAMBLE
designed	checked
T. CAMMACK	T. KOLLER

City of El Paso, Texas

2284A PERMIT AMENDMENT

DRAINAGE DETAILS, 2 OF 2

project	contract
155488	-

drawing III.B.6 rev. 1

file III.B.6 DRAINAGE DETAILS 2 OF 2.dwg

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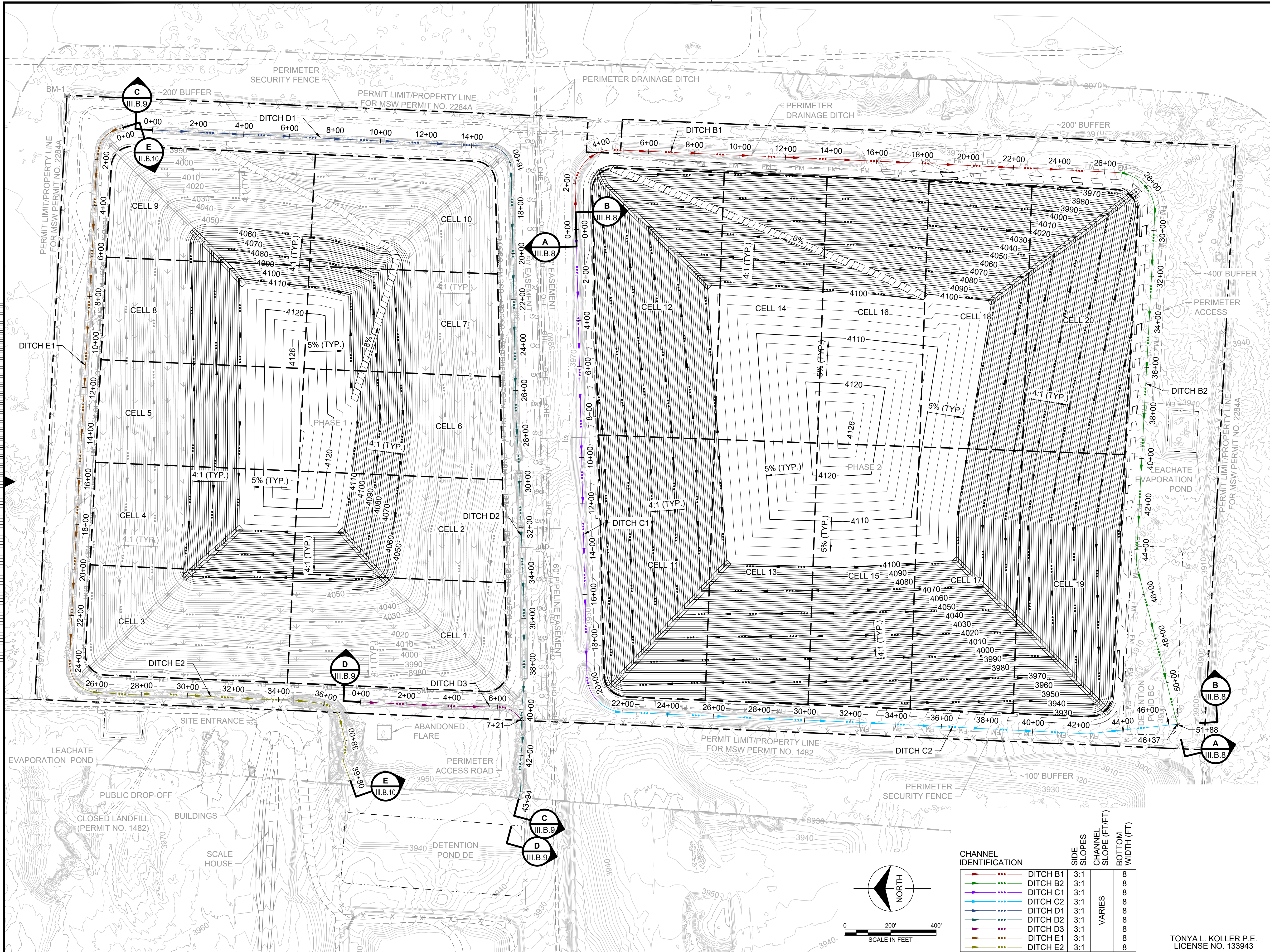
no.	date	by	ckd	description
0	5/1/24	TMC	TLK	2284A PERMIT MOD
1	5/16/25	AAN	TJS	TCEQ NOD 1



CHANNEL IDENTIFICATION	SIDE SLOPES	CHANNEL SLOPE (FT/FT)	BOTTOM WIDTH (FT)
DITCH B1	3:1	VARIES	8
DITCH B2	3:1		8
DITCH C1	3:1		8
DITCH C2	3:1		8
DITCH D1	3:1		8
DITCH D2	3:1		8
DITCH D3	3:1		8
DITCH E1	3:1		8
DITCH E2	3:1		8

TONYA L. KOLLER P.E.
LICENSE NO. 133943

NOTES:

1. INDEX CONTOUR INTERVAL, 2 FEET.
2. GREATER EL PASO LANDFILL EXISTING SITE TOPOGRAPHY (2284A PERMIT AREA) DERIVED FROM ORTHO-PHOTOGRAPHY FROM AN UNMANNED AERIAL SURVEY TIED TO GROUND CONTROL PANELS PROVIDED BY PARKHILL, SMITH & COOPER, AUGUST 28, 2019. TOPOGRAPHY WITHIN CELLS 11 THROUGH 14 COMPLETED WITH GROUND CONTROL POINTS PROVIDED BY THE CITY OF EL PASO, AUGUST 2022. TOPOGRAPHY OUTSIDE OF THE SURVEY EXTENTS WAS OBTAINED FROM THE TEXAS NATURAL RESOURCES INFORMATION SYSTEM, DATED APRIL 2008.
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FIRM REG. NO. F-845

date: MAY 2024 | detailed: D. KAMBLE
designed: T. CAMMACK | checked: T. KOLLER

City of El Paso, Texas

2284A PERMIT AMENDMENT

DRAINAGE PROFILE KEY MAP

project: 155488 | contract: -
drawing: III.B.7 – rev. 1

file III.B.7 DRAINAGE PROFILE KEY MAP.dwg

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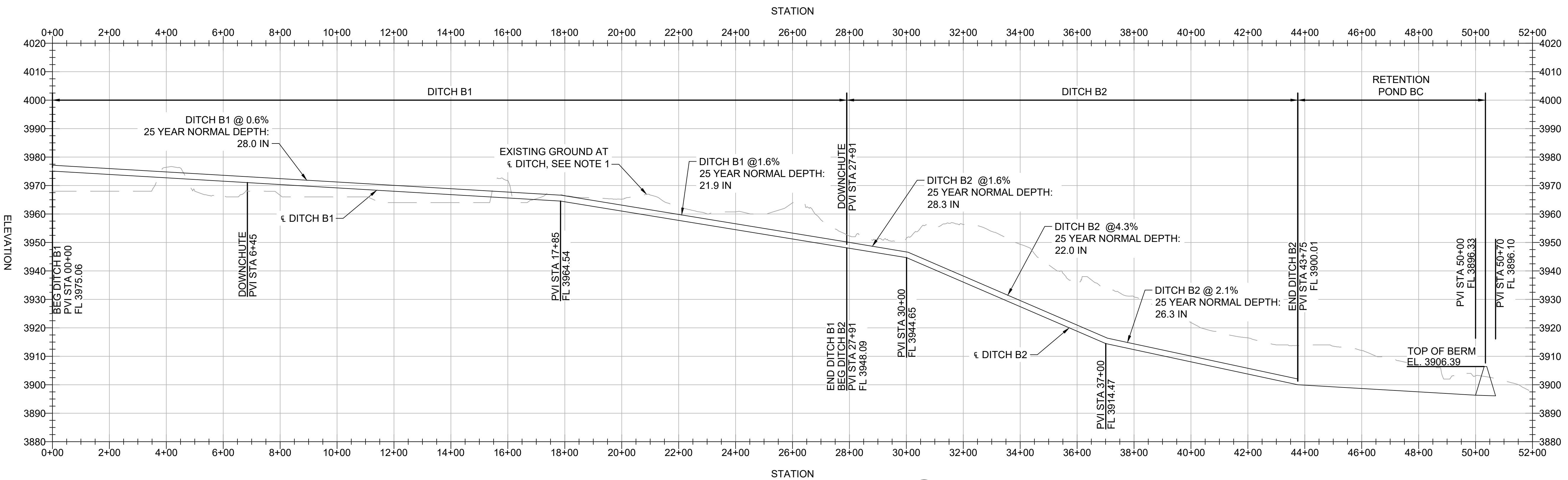
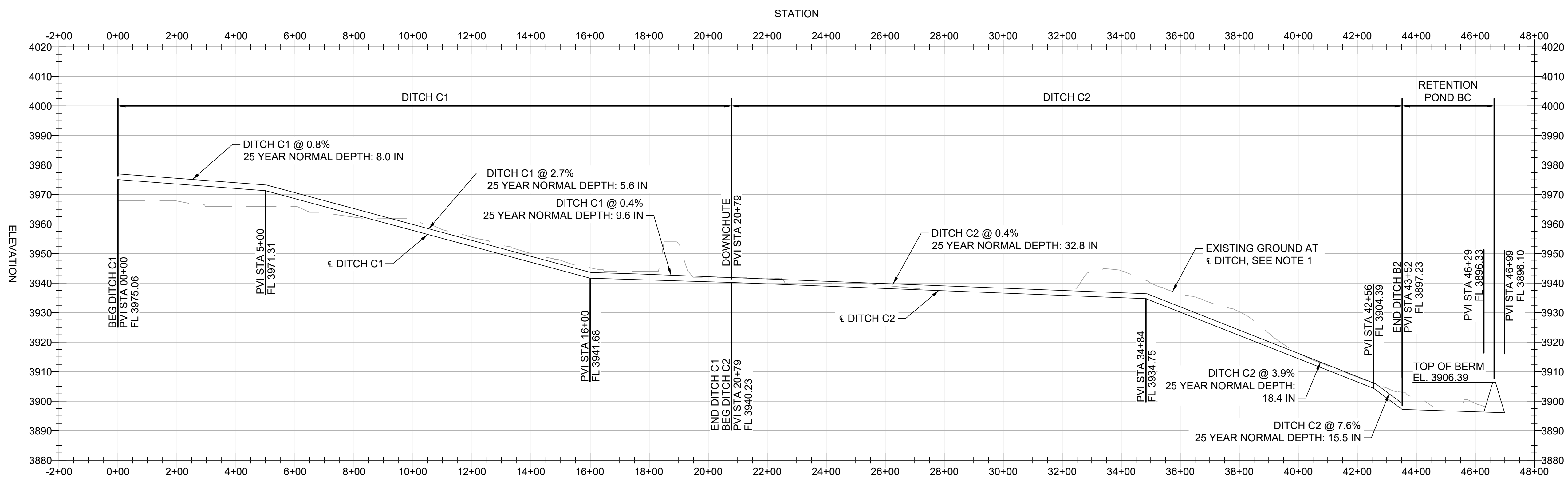


DITCH B1-B2 PROFILE (A / III.B.7)

0 10' 20' 40' SCALE IN FEET

0 200' 400' SCALE IN FEET



DITCH C1-C2 PROFILE (B / III.B.7)

0 10' 20' 40' SCALE IN FEET

0 200' 400' SCALE IN FEET

no.	date	by	ckd	description
0	5/1/24	TMC	TLK	2284A PERMIT MOD
1	5/16/25	AAN	TJS	TCEQ NOD 1

NOTES:

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date	detailed
MAY 2024	D. KAMBLE
designed	checked
T. CAMMACK	T. KOLLER

City of El Paso, Texas

2284A PERMIT AMENDMENT

DRAINAGE PROFILES DITCH B1, B2, C1, C2

project 155488 | contract -

drawing **III.B.8** rev. **1**

file III.B.8 DRAINAGE PROFILES DITCH B1, B2, C1, C2.dwg

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LICENSE NO. 133943

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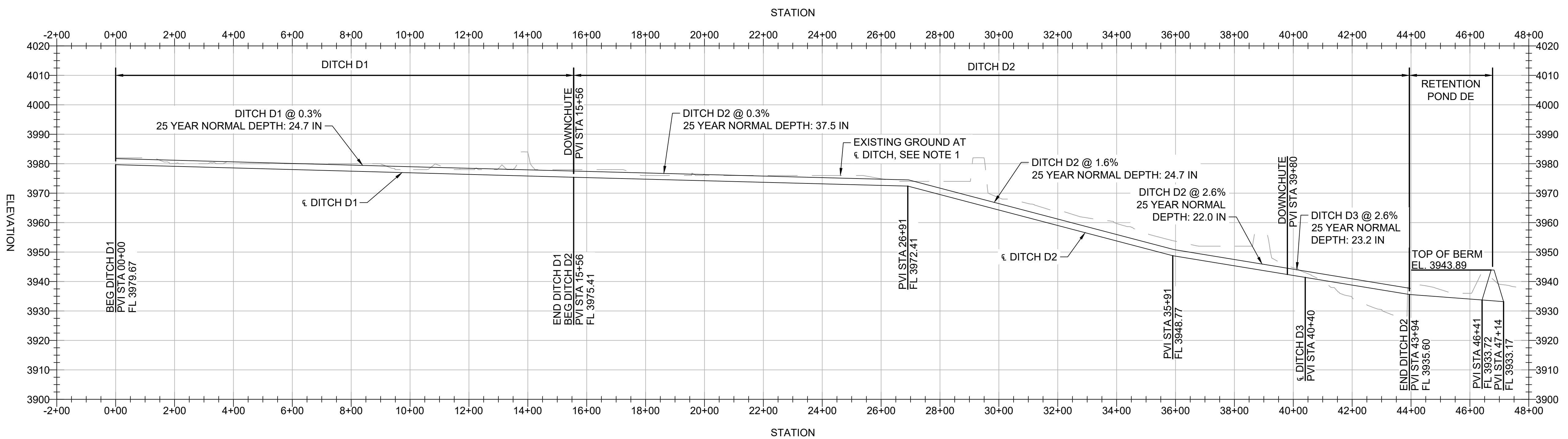
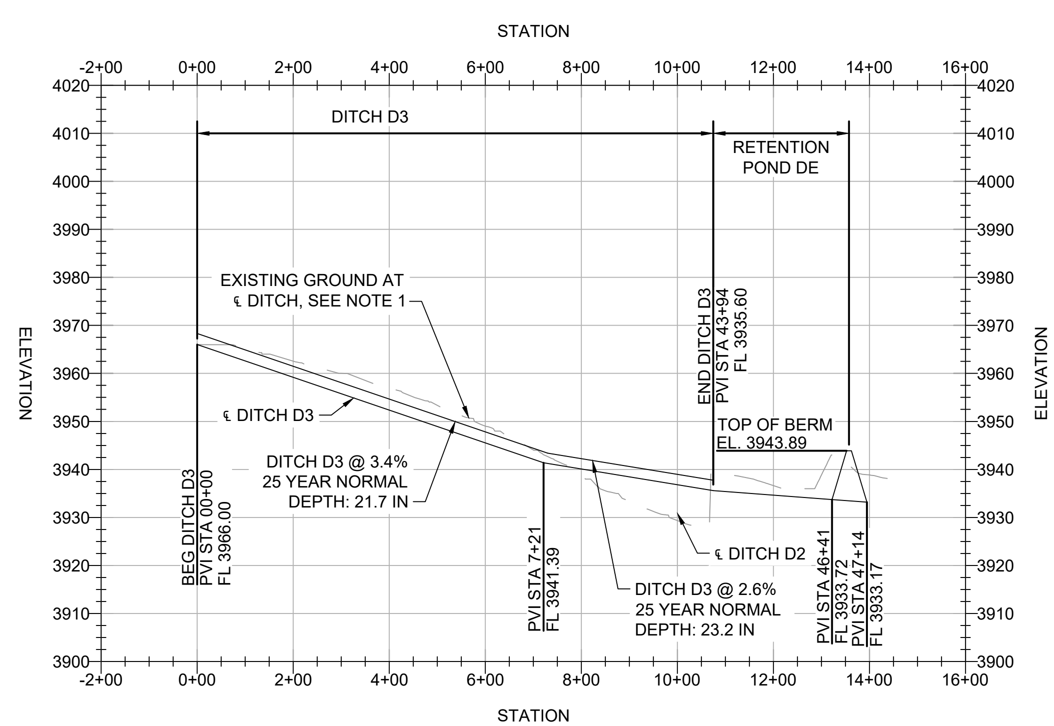
no.	date	by	ckd	description
0	5/1/24	TMC	TLK	2284A PERMIT MOD
1	5/16/25	AAN	TJS	TCEQ NOD 1



DITCH D1-D2 PROFILE C III.B.7

0 10' 20' 40' SCALE IN FEET

0 200' 400' SCALE IN FEET



DITCH D3 PROFILE D III.B.7

0 10' 20' 40' SCALE IN FEET

0 200' 400' SCALE IN FEET

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date	detailed
MAY 2024	D. KAMBLE
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T. CAMMACK	T. KOLLER

City of El Paso, Texas

2284A PERMIT AMENDMENT

DRAINAGE PROFILES DITCH D1, D2, D3

project	contract
155488	-

drawing **III.B.9** – rev. **1**

file III.B.9 DRAINAGE PROFILES DITCH D1, D2, D3.dwg

TONYA L. KOLLER P.E.
LICENSE NO. 133943

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no.	date	by	ckd	description
0	5/1/24	TMC	TLK	2284A PERMIT MOD
1	5/16/25	AAN	TJS	TCEQ NOD 1

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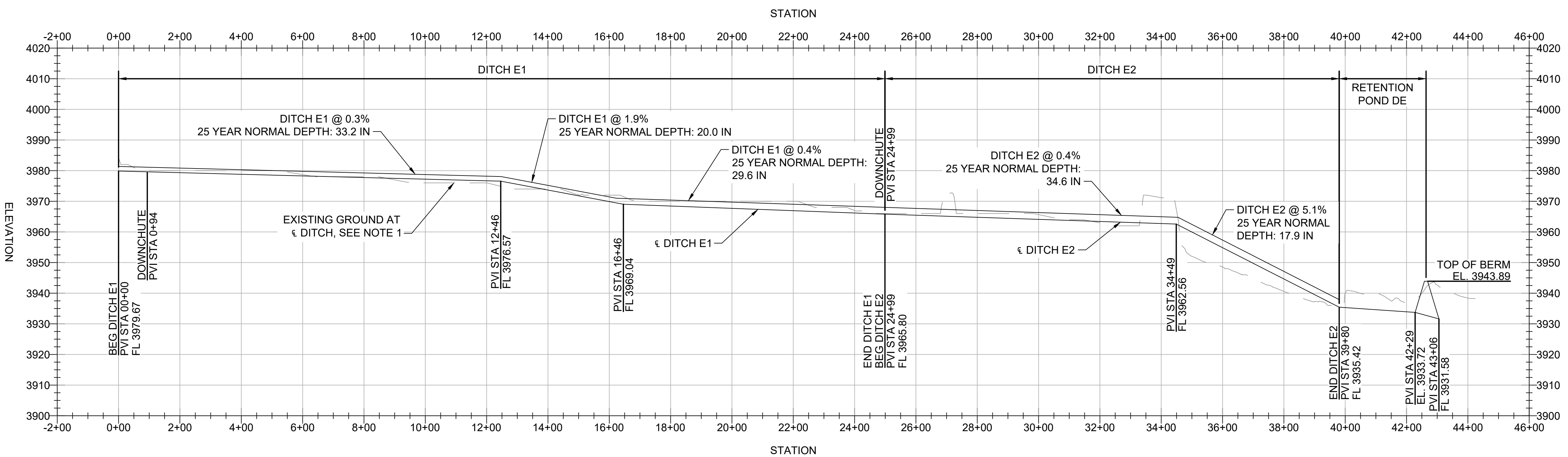

DITCH E1-E2 PROFILE (E / III.B.7)

0 10' 20' 40' SCALE IN FEET

0 200' 400' SCALE IN FEET

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date	detailed
MAY 2024	D. KAMBLE
designed	checked
T. CAMMACK	T. KOLLER

City of El Paso, Texas

2284A PERMIT AMENDMENT

DRAINAGE PROFILES DITCH E1, E2

project	contract
155488	-

drawing **III.B.10** – rev. **1**

file III.B.10 DRAINAGE PROFILES DITCH E1, E2.dwg

TONYA L. KOLLER P.E.
LICENSE NO. 133943

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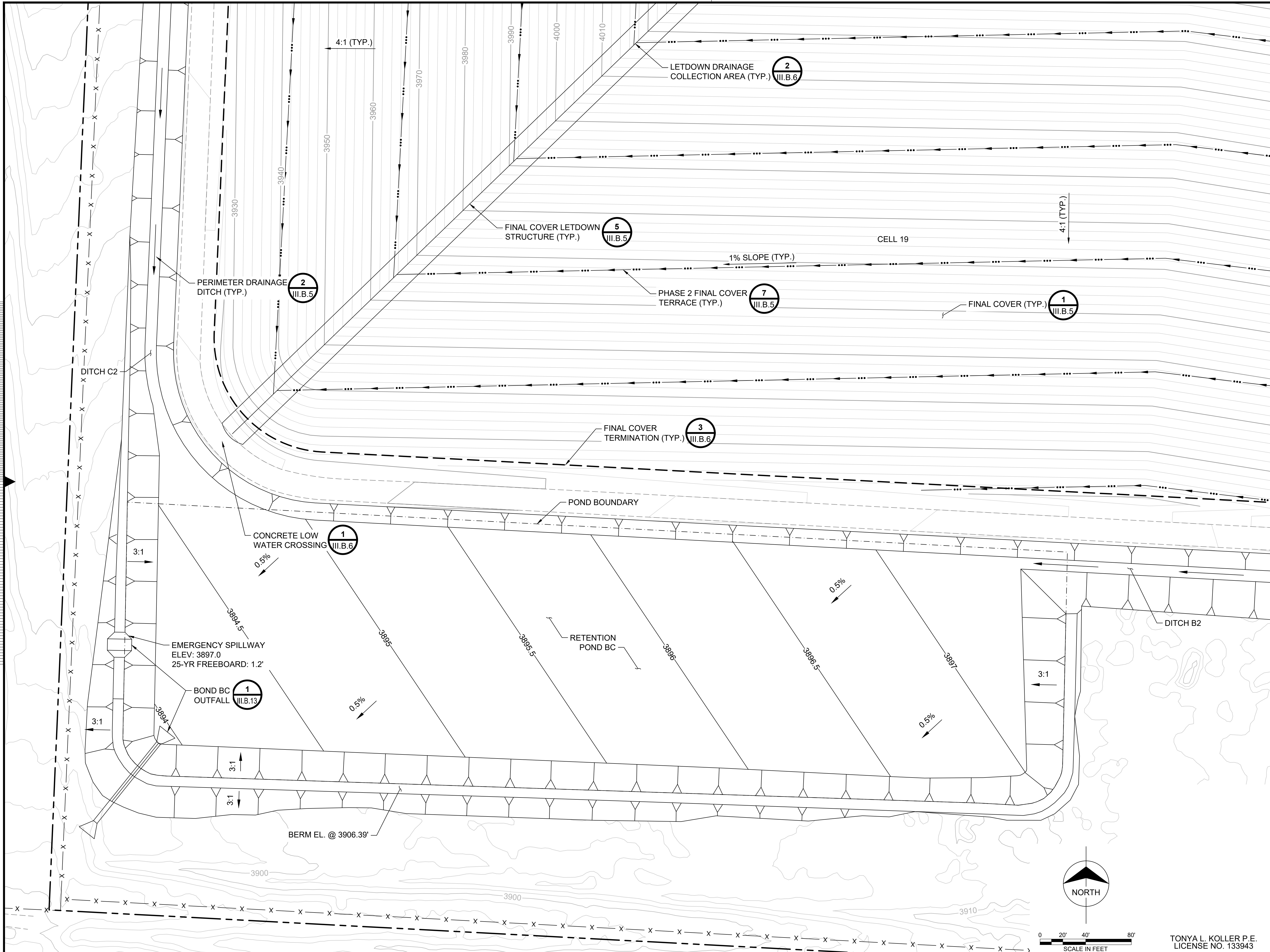

no.	date	by	ckd	description
0	5/1/24	TMC	TLK	2284A PERMIT MOD
1	5/16/25	AAN	TJS	TCEQ NOD 1

NOTES:

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2. GREATER EL PASO LANDFILL EXISTING SITE TOPOGRAPHY (2284A PERMIT AREA) DERIVED FROM ORTHO-PHOTOGRAPHY FROM AN UNMANNED AERIAL SURVEY TIED TO GROUND CONTROL PANELS PROVIDED BY PARKHILL, SMITH & COOPER, AUGUST 28, 2019. TOPOGRAPHY WITHIN CELLS 11 THROUGH 14 COMPLETED WITH GROUND CONTROL POINTS PROVIDED BY THE CITY OF EL PASO, AUGUST 2022. TOPOGRAPHY OUTSIDE OF THE SURVEY EXTENTS WAS OBTAINED FROM THE TEXAS NATURAL RESOURCES INFORMATION SYSTEM, DATED APRIL 2008.
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date	detailed
MAY 2024	D. KAMBLE
designed	**checked**
T. CAMMACK	T. KOLLER

City of El Paso, Texas

2284A PERMIT AMENDMENT

POND BC LAYOUT

project 155488 | contract -

drawing III.B.11 – rev. 1

TONYA L. KOLLER P.E.
LICENSE NO. 133943

file III.B.11 POND BC LAYOUT.dwg

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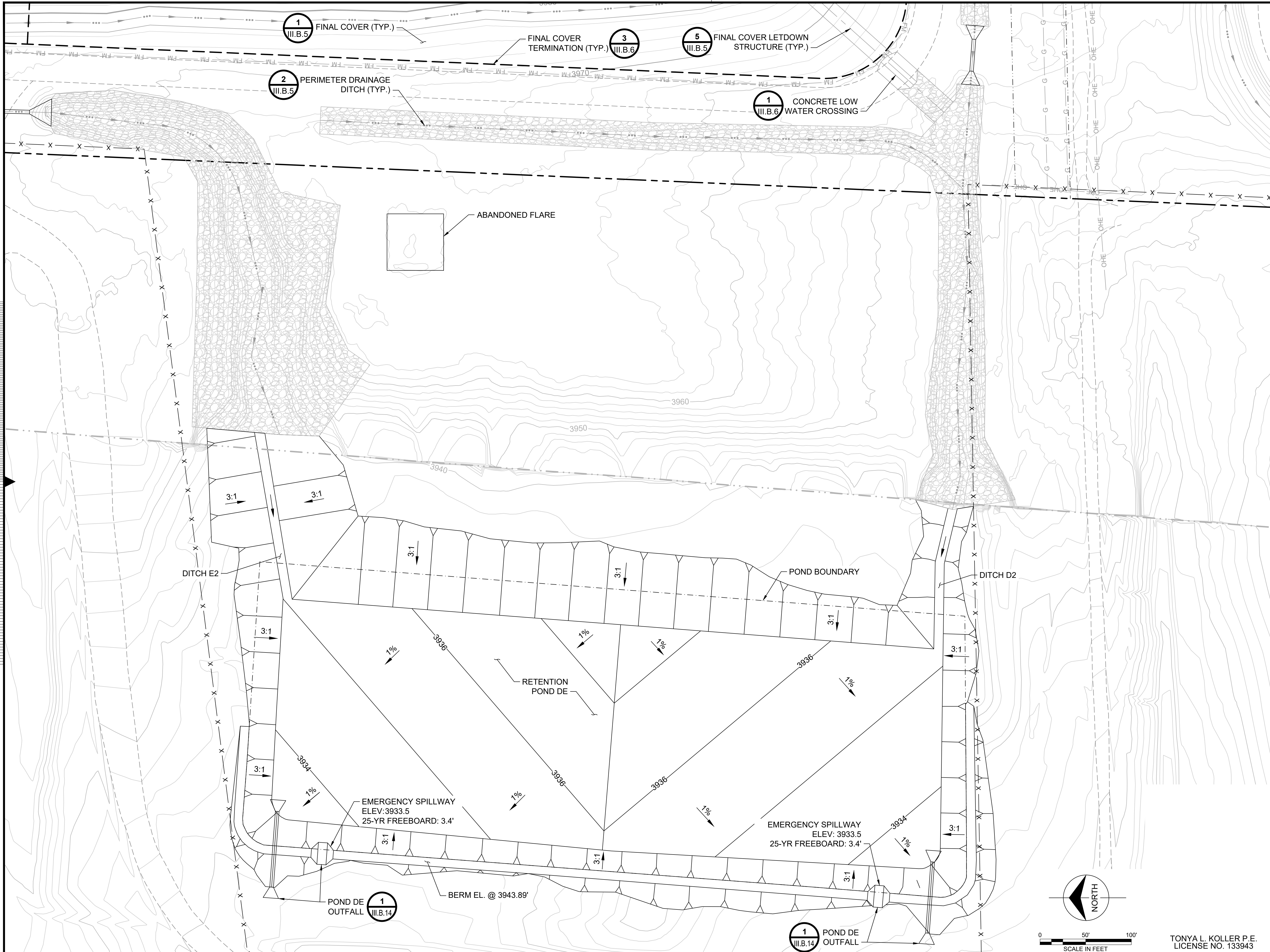

no.	date	by	ckd	description
0	5/1/24	TMC	TLK	2284A PERMIT MOD
1	5/16/25	AAN	TJS	TCEQ NOD 1

NOTES:

1. INDEX CONTOUR INTERVAL, 2 FEET.
2. GREATER EL PASO LANDFILL EXISTING SITE TOPOGRAPHY (2284A PERMIT AREA) DERIVED FROM ORTHO-PHOTOGRAPHY FROM AN UNMANNED AERIAL SURVEY TIED TO GROUND CONTROL PANELS PROVIDED BY PARKHILL, SMITH & COOPER, AUGUST 28, 2019. TOPOGRAPHY WITHIN CELLS 11 THROUGH 14 COMPLETED WITH GROUND CONTROL POINTS PROVIDED BY THE CITY OF EL PASO, AUGUST 2022. TOPOGRAPHY OUTSIDE OF THE SURVEY EXTENTS WAS OBTAINED FROM THE TEXAS NATURAL RESOURCES INFORMATION SYSTEM, DATED APRIL 2008.
3. THE SURVEY COORDINATES ARE ON THE TEXAS COORDINATE SYSTEM, CENTRAL ZONE 4203, NAD83. HORIZONTAL DATUM IS NAD83. VERTICAL DATUM IS NAVD88.
4. EXISTING TOP OF FINAL COVER SURFACE FOR PHASE 1 PREPARED BY PARKHILL, SMITH & COOPER, INC. AND REPRESENTS DESIGN FINAL COVER ELEVATIONS. CONTOUR INTERVAL IS 2 FEET. PHASE 1 RECEIVED FINAL COVER IN 2021.
5. DESIGN CONTOURS REPRESENT TOP OF FINAL COVER SURFACE FOR PHASE 1. CONTOUR INTERVAL IS 2 FEET. 2284 PERMITTED DESIGN CONTOURS WERE BASED ON CITY DATUM ELEVATIONS AND WERE ADJUSTED TO NAVD88 BY ADDING 10.39 FEET AS CERTIFIED BY BROCK & BUSTILLOS INC. ON DECEMBER 7, 2023. DATUM CERTIFICATION LETTER INCLUDED IN APPENDIX I/II.B.

FOR PERMITTING PURPOSES ONLY

BURNS McDONNELL
9400 WARD PARKWAY
KANSAS CITY, MO 64114
816-333-9400
Burns & McDonnell Engineering Co, Inc.
FIRM REG. NO. F-845

date	detailed
MAY 2024	D. KAMBLE
designed	checked
T. CAMMACK	T. KOLLER

EP TX CITY OF EL PASO

City of El Paso, Texas

2284A PERMIT AMENDMENT

POND DE LAYOUT

project	contract
155488	-

drawing III.B.12 – rev. 1

file III.B.12 POND DE LAYOUT.dwg

TONYA L. KOLLER P.E.
LICENSE NO. 133943

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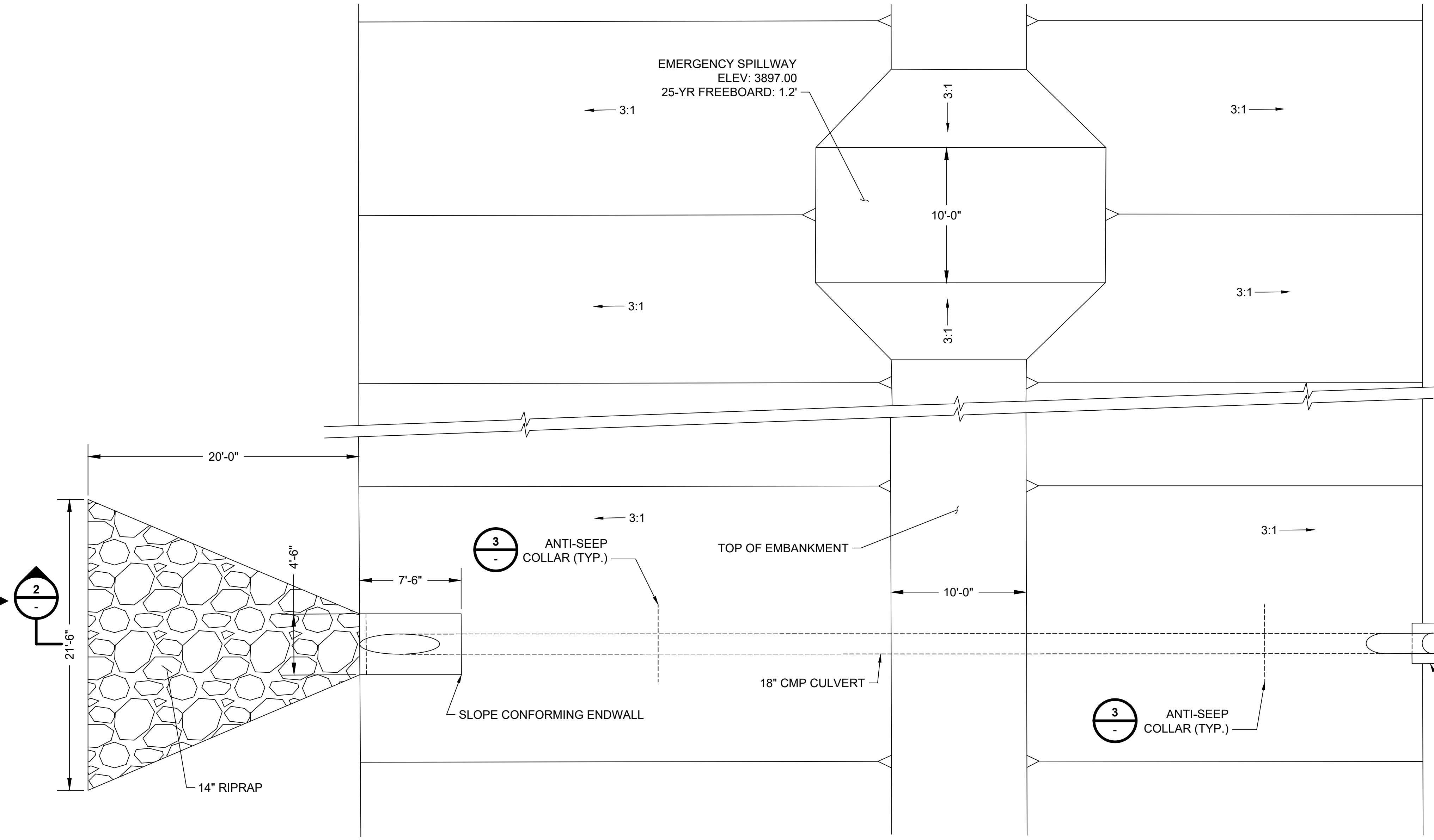
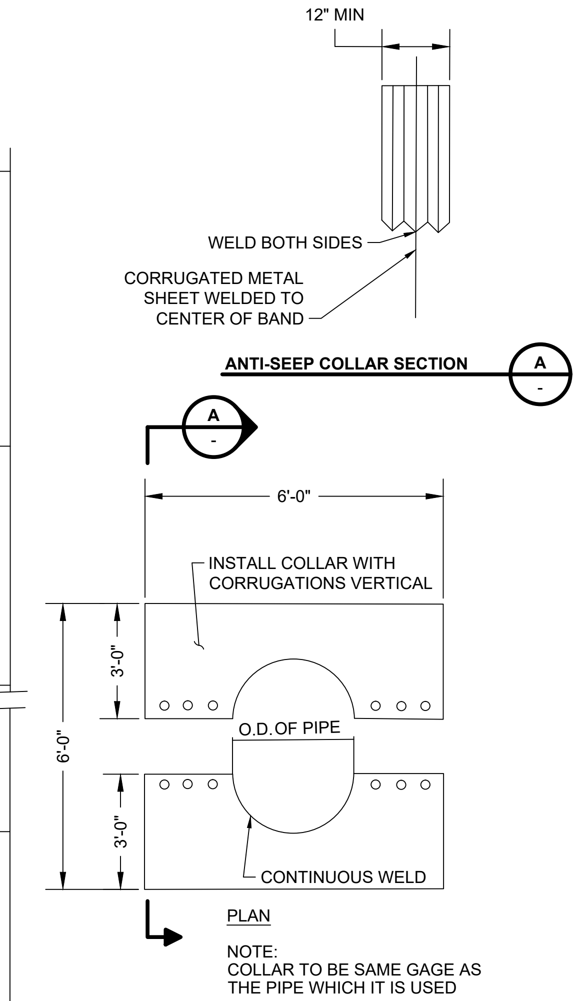
1	5/16/25	AAN	TJS	TCEQ NOD 1



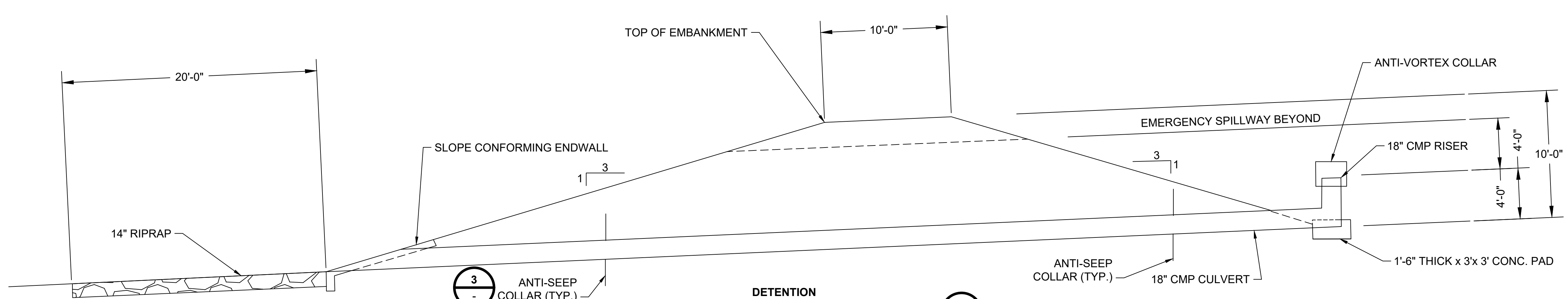
DETENTION
POND BC OUTFALL PLAN
1
III.B.11
0 5' 10'
SCALE IN FEET



ANTI-SEEP COLLAR SECTION
A
-

NOTE:
COLLAR TO BE SAME GAGE AS THE PIPE WHICH IT IS USED

ANTI-SEEP COLLAR (TYP.)
NOT TO SCALE
3
-
3
III.B.14



DETENTION
POND BC OUTFALL SECTION
2
-
0 5' 10'
SCALE IN FEET

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CITY OF EL PASO

City of El Paso, Texas

2284A PERMIT AMENDMENT

POND BC OUTFALL AND SECTIONS

project	contract
155488	-

drawing III.B.13 – rev. 1

file III.B.13 POND BC OUTFALL AND SECTIONS.dwg

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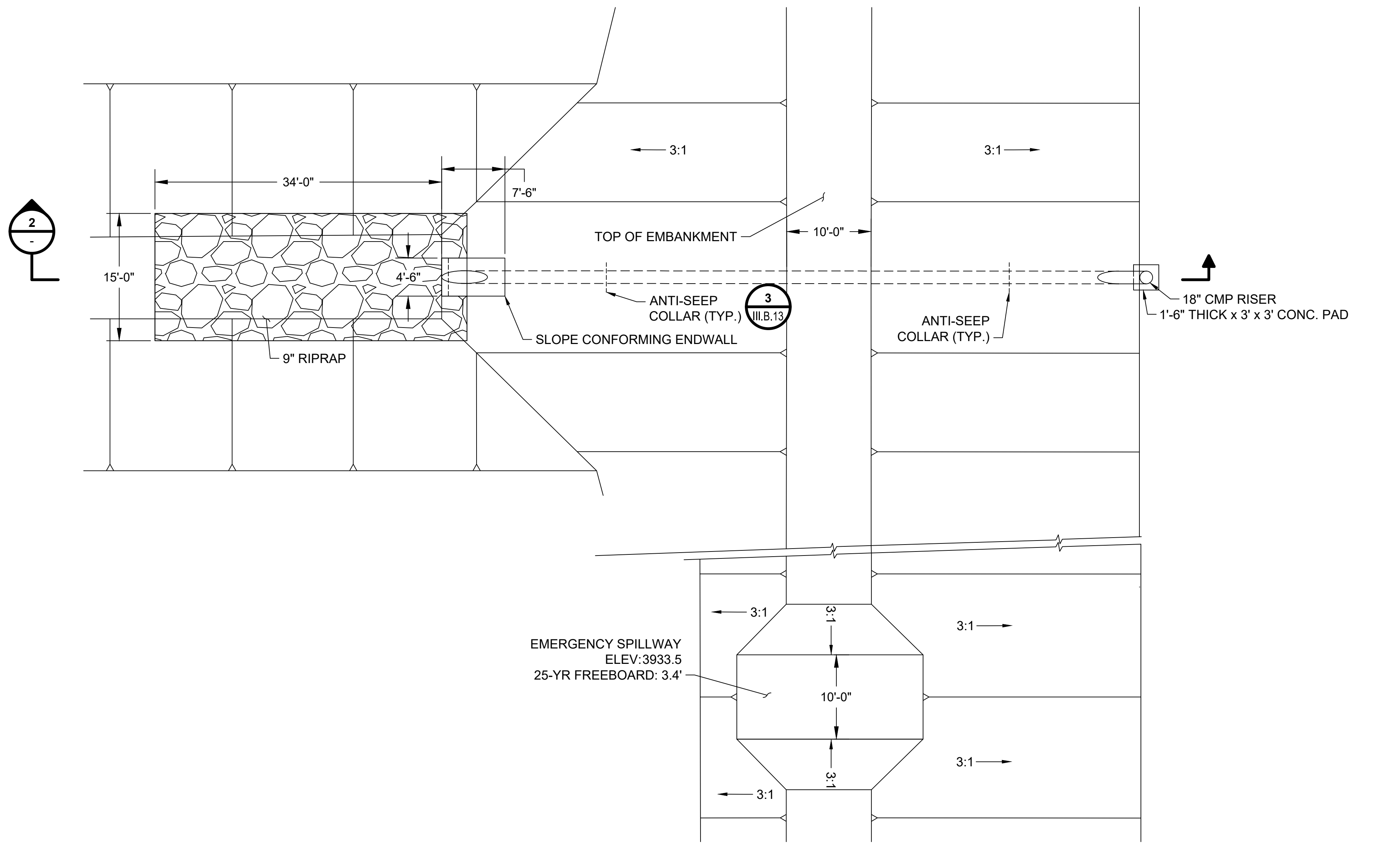
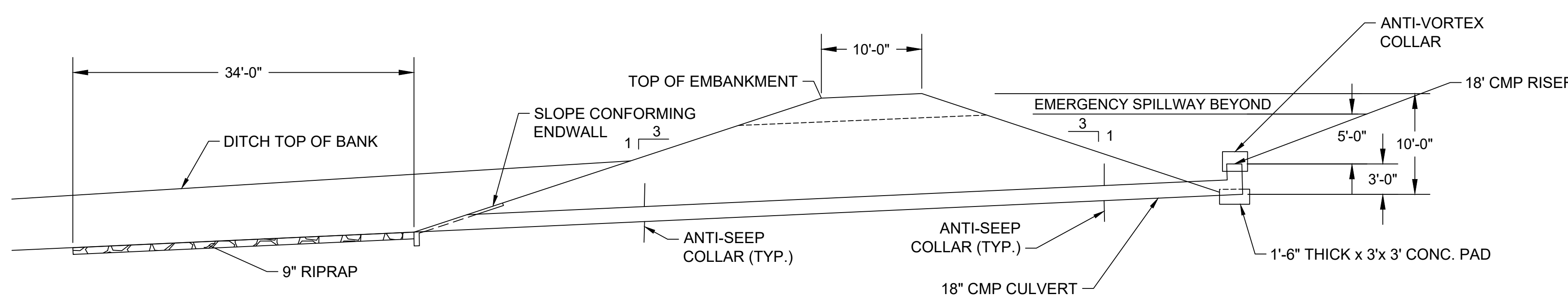
1	5/16/25	AAN	TJS	TCEQ NOD 1



DETENTION POND DE OUTFALL PLAN 1 III.B.12

0 10' 20'
SCALE IN FEET



DETENTION POND DE OUTFALL SECTION 2 -

0 10' 20'
SCALE IN FEET

NORTH

NOT TO SCALE

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Burns & McDonnell Engineering Co, Inc.
FIRM REG. NO. F-845

date	detailed
MAY 2024	D. KAMBLE
designed	checked
T. CAMMACK	T. KOLLER

EPTX CITY OF EL PASO

City of El Paso, Texas

2284A PERMIT AMENDMENT

POND DE OUTFALL AND SECTIONS

project	contract
155488	-

drawing **III.B.14** — rev. **1**

file III.B.14 POND DE OUTFALL AND SECTIONS.dwg

TONYA L. KOLLER P.E.
LICENSE NO. 133943

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Please replace Appendix III.C with the following pages

APPENDIX III.C – LEACHATE AND CONTAMINATED WATER PLAN

MSW AUTH NO. 2284A

APPENDIX III.C – LEACHATE AND CONTAMINATED WATER PLAN

CITY OF EL PASO, TEXAS
GREATER EL PASO LANDFILL MAJOR AMENDMENT
PROJECT NO. 155488

REVISION 1
MAY 16, 2025

Part III, Appendix III.C
Leachate and Contaminated Water Plan
MSW Auth No. 2284A

prepared for

City of El Paso, Texas
Greater El Paso Landfill Major Amendment
El Paso County, Texas

Project No. 155488

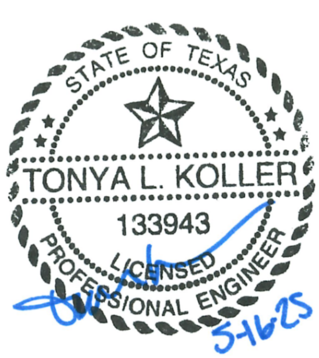
Revision 0, October 31, 2024
Revision 1, May 16, 2025

STATE OF TEXAS
TONYA L. KOLLER
133943
LICENSED
PROFESSIONAL ENGINEER
5-16-25

prepared by

Burns & McDonnell Engineering Company, Inc.
6200 Bridge Point Pkwy, Building 4, Suite 400, Austin, TX 78730
Texas Firm Registration No. F-845

CONTENTS



STATE OF TEXAS
TONYA L. KOLLER
133943
LICENSED
PROFESSIONAL ENGINEER
5-16-25

III.C.1.0 Introduction

This document presents the Leachate and Contaminated Water Plan (LACWP) for the Greater El Paso Landfill Municipal Solid Waste (MSW) Authorization Number 2284A (GEP Landfill) Expansion. This LACWP provides methods to minimize the volume of contaminated water generated, details the leachate collection system design, and describes procedures for storage, treatment, and disposal of the leachate and contaminated water. A discussion of geology and hydrogeology at the GEP Landfill is presented in Part III, Appendix III.E – Geology Report. A discussion of the consideration of local groundwater use, which is not anticipated for use as drinking water, is provided in Part III, Appendix III.E, Section III.E.5.4. Previous appendices to this LACWP included condensate capacity calculations, however the GEP Landfill does not have a landfill gas collection and control system at this time and therefore does not currently produce condensate.

III.C.2.2.2 Leachate Collection Piping

The leachate collection system uses 6-inch diameter perforated collection piping, at a minimum grade of 1 percent. The collection piping is HDPE SDR 17, or approved equal, with perforations and is chemically resistant to the leachate expected to be generated in accordance with 30 TAC §330.333(1). Supplemental information on the chemical resistance of HDPE piping from the 2023 Plastics Pipe Institute Technical Report 19 titled "Chemical Resistance of Plastic Piping Materials" is provided in **Attachment III.C.7**. The perforated collection piping is embedded in granular material. The trench is wrapped with a geotextile to prevent sediment from entering the granular layer and potentially clogging the pipe. Leachate collection piping details are provided on Drawing III.C.3 in **Attachment III.C.1**. The perforated collection piping discharges leachate into the sump area at the base grade low points of the cell area. Leachate collection pipes do not penetrate the liner.

Cleanouts are provided at the top of the side slopes for periodic maintenance of the collection piping. The cleanouts are constructed of a minimum 6-inch diameter non-perforated HDPE pipe joined to the perforated collectors in the sump. The 6-inch pipe size has sufficient cross-sectional area for effective cleaning by pressurized jetting equipment. Refer to Drawing III.C.1 in **Attachment III.C.1** for cleanout locations.

Pipe strength and deformation calculations were performed to demonstrate that the leachate collection piping are of sufficient strength and thickness to prevent collapse under the pressures exerted by overlying wastes, waste cover materials, and any equipment used at the landfill. Pipe strength calculations are provided in **Attachment III.C.4**.

III.C.2.2.3 Leachate Collection Sumps

Leachate entering the geocomposite drainage layer and collection piping is discharged into collection sumps. To allow accumulation of leachate, the sump invert is approximately 3 feet below the pipe invert. The sump can hold up to 4,732 gallons of leachate before it requires pumping based on previously approved sump capacity calculations provided in **Attachment III.C.5**. The information compiled for this attachment was excerpted from the document Permit No. 2284, Part III, Attachment 15, Appendix 3 – Pipe Strength Calculations and Sump Capacity, prepared by HDR, August 2000. Note that the original document has been redacted to only provide the relevant information (i.e., the sump capacity calculations). Leachate collected in the sumps is pumped through a force main into one of two lined evaporation ponds. Drawing III.C.2 in **Attachment III.C.1** shows a plan and section through the sump area and collection system details.

III.C.2.2.4 Leachate Conveyance

Extraction of leachate from the collection sumps is accomplished by submersible pumps, which can be operated manually or automatically. Leachate levels in the collection sumps are monitored to maintain a head buildup of less than 30 centimeters (approximately 1 foot) on the landfill floor adjacent to the sump.

A sump riser pipe is located directly up the side slope from the sump at the disposal area perimeter. Risers are 18-inch diameter HDPE pipe and provide a means for lowering submersible pumps down the 3:1 side slope incline into the collection sumps. The lower portion of the riser within the sump is perforated to allow leachate to flow to the pumps.

The depth of leachate on the liner is measured with an electric liquid level indicator. This indicator is calibrated to reflect the depth of leachate above the liner at the top of the sump. When the liquid level of leachate reaches the top of the sump (i.e., the liner), leachate in the sump is pumped to the evaporation ponds through a force main system.

Backflow prevention is installed at each sump to prevent leachate from flowing into the sumps from the force main system. Occasionally it may be necessary to withdraw leachate from the collection sumps into tanker trucks for transportation to an authorized and permitted facility for treatment and disposal. In this case, spill containment for truck hose connection and loading is provided by a portable trough or similar spill containment device. Protection is provided at hose connection locations.

III.C.2.2.5 Leachate Storage, Treatment and Disposal

Leachate storage is provided on-site in the sumps and the evaporation ponds. Previously approved leachate evaporation pond capacity calculations are provided in **Attachment III.C.6**. The information compiled for this attachment was excerpted from the document Permit Modification – Leachate Evaporation Pond, prepared by Parkhill, Smith & Cooper, Inc., March 2007. Note that the original document has been redacted to only provide the relevant information. The evaporation pond calculations were calculated based on utilizing actual average and maximum actual rainfall for the year versus utilizing a single rain event data point (i.e., 25-year, 24-hour). At the time of the calculation, data from the prior 25 years (1980-2004) was used to determine the average annual rainfall (11.77-inches) and the maximum rainfall (19.41 inches). Historic rainfall data was taken from Station USW00023044 at the El Paso International Airport for the previous 30 years (1994-2024) to determine an average annual rainfall of 8.4-inches and maximum rainfall of 17.51-inches. In addition, it appears the ponds were constructed larger than original calculations, therefore the calculations are considered conservative.

All leachate is managed by the leachate evaporation ponds. The pond and force main layout are shown on Drawing III.C.1 in **Attachment III.C.1**. Pond details are shown on Drawing III.C.5 and III.C.7 in **Attachment III.C.1**. In the event that the evaporation ponds reach their capacity, leachate will be collected in tanker trucks and transported to a permitted facility for treatment and disposal. All leachate transferred to offsite facilities will be handled in compliance with TCEQ requirements in accordance with 30 §TAC 330.207(e).

III.C.2.2.6 Monitoring and Maintenance Activities

Regular maintenance and monitoring for the leachate collection and transfer system is performed and will continue to be performed throughout the development of the GEP Landfill, and for at least 30 years after closure. The following monitoring and maintenance activities are performed:

- Depth of leachate on liner: The depth of leachate is measured with an electric liquid level indicator located in the leachate sump. The depth of fluid (if any) above the liner at the top of the sump is read and recorded monthly and after significant rainfall events during the active life of the GEP Landfill, and will be recorded semi-annually during the post-closure period. Monitors are located at the sump.
- Pump maintenance/replacement: Portable pumps are maintained as appropriate. The permanent sump pumps are checked annually and maintained as necessary. Backup pumps (portable pumps) are provided so the primary pumps may be removed and repaired. Maintenance activities on the pumps will continue to occur during the post-closure period.
- Cleanout: Cleanouts have been provided on all collectors. Cleanout activities occur on an annual basis, or more often as needed, and will continue during the post-closure period.
- Storage facilities: Leachate is pumped to the evaporation ponds. The evaporation ponds are inspected annually for leaks, tears, or damage to the liner. Inspections are performed as outlined in the Site Operating Plan and is completed when the ponds are dry. Any sediment remaining after the ponds are dry is washed or swept to the deepest part of the pond. Following sediment removal, the liner may be thoroughly inspected. A concrete pad at the deep end allows equipment to access the bottom of the ponds and remove any sediment. If the ponds are

unavailable, leachate may be transported to an approved/permitted facility on an as-needed basis during the active life of the GEP Landfill. After closure, the transport frequency requirements will likely decrease. The required transport frequency will be reevaluated after closure and will be based on the actual amount of leachate generated.

III.C.2.3 Leachate Generation

The HELP Model Version 4.0.1 was used in the design and evaluation of the leachate management system. The HELP model is a hydrologic model of water movement across, into, through, and out of landfills. Landfill leachate generation was estimated based on local climatic factors, soil, and design data in a daily sequential analysis that accounts for the effects of surface storage, runoff, infiltration, evapotranspiration, percolation, soil moisture storage, and lateral drainage.

To conduct an evaluation of the liner system, the rate of moisture percolation to the liner and leachate collection systems must first be estimated. Cursory examinations of the water balance for the El Paso, Texas area indicate a significant negative moisture balance. This would seem to indicate that the generation of leachate, particularly given the moisture retention capacity of municipal solid waste, would be non-existent.

The HELP model was used to simulate design conditions to demonstrate adequate performance of the alternate liner and alternative final cover systems. A summary of the HELP model inputs, assumptions, and results is provided in **Attachment III.C.3**.

III.C.2.3.1 Fate and Transport

Fate and transport modeling for the GEP Landfill was provided with the previous application. The modeling included a steady-state pulse load, Gaussian source boundary condition, and a conservative infiltration rate. Historical fate and transport modeling is provided in **Attachment III.C.2**.

III.C.3.0 Contaminated Water Minimization and Management [30 TAC §§330.207(b), (e), (f), 330.227]

Stormwater is managed to limit the quantity that may come into contact with waste. Berms are utilized to segregate uncontaminated rainfall from leachate in parts of the cell area that have not yet received waste. As operations progress to an aerial fill, an intermediate layer of soil is placed over inactive areas that are not filled to final grade. As landfill areas are brought to final grade, final cover will be installed in accordance with Appendix III.D.

The GEP Landfill's leachate collection system collects leachate and conveys it via a force main system to two lined evaporation ponds, as discussed in **Section III.C.2.2.5**. Previously approved leachate evaporation pond capacity calculations are provided in **Attachment III.C.6**. The City tracks operations at the GEP Landfill to evaluate leachate generation.

Containment berms and liner termination berms have been and will be constructed to prevent water from undeveloped areas of the GEP Landfill from entering the lined area. The berms have been designed for the 25-year 24-hour storm event. Refer to Part III, Appendix III.B for berm design calculations and Attachment III.B.3, Drawings III.B.4, III.B7, III.B.8, and III.B.9 for berm locations and profiles. In addition, working face berms are constructed as operations progress to an aerial fill. Any water that comes in contact with waste is confined in the working face area and is collected in the leachate collection system. Should a rainfall event occur whereby the collected contaminated surface water run-off remains on the working face for 48 hours, the excess contaminated water will be pumped out of the area to tanker trucks and transported to the on-site storage facilities (e.g., leachate evaporation ponds) or off-site for proper disposal/treatment. There will be no off-site discharge of contaminated water.

The interim drainage controls help to minimize the amount of water entering the leachate collection system and potential flooding in the developed cell area. Water that is collected outside the working face area, but within the cell area, is considered to be uncontaminated and can be pumped out of the excavated area if water accumulation is excessive (does not evaporate within 48 hours).

ATTACHMENT III.C.3 – HELP MODELING

MSW AUTH NO. 2284A

ATTACHMENT III.C.3 – HELP MODELING

CITY OF EL PASO, TEXAS
GREATER EL PASO LANDFILL MAJOR AMENDMENT
PROJECT NO. 155488

REVISION 1
MAY 16, 2025

CONTENTS

TABLES

List of Abbreviations

Abbreviation	Term/Phrase/Name
GCL	Geosynthetic Clay Liner
Gpm	gallons per minute
HDPE	high density polyethylene
HELP	Hydrologic Evaluation of Landfill Performance
TAC	Texas Administrative Code
USDA	U.S. Department of Agriculture

III.C.3.2.0 Design Criteria

The HELP Model requires climatological, vegetative, soil, and design data specific to the landfill site. The following sections document the basis for data selection, including assumptions, and the layer profiles used in the HELP Model analyses.

III.C.3.2.1 Climatological Data

The required climatological data for the HELP Model includes daily precipitation values, mean monthly temperatures, and solar radiation representative of the landfill site. These values were synthetically generated by the program and were simulated for 30 years. The HELP model synthetic weather generator is based on a routine developed by the U.S. Department of Agricultura (USDA) Agricultural Research Service. Weather parameter values used in the synthetic generator are imported from a database of calculated weather parameters for over 13,000 points located on a 0.25 by 0.25 degree grid across the continental United States developed by the Environmental Protection Agency's Office of Pesticide Programs using two NOAA data products. The program retrieves parameter values from the closest grid point in the dataset based on the latitude and longitude specified for the landfill location.

III.C.3.2.2 Landfill Development

Three stages of landfill development were evaluated to calculate leachate generation rates. The three stages include:

Stage 1 – Active filling. The first stage of landfill development is after the initial 10-foot-thick lift of waste has been placed in the cell.

Stage 2 – Intermediate cover. The second stage of landfill development represents areas that have reached intermediate grades and intermediate cover soils have been placed over the waste. Intermediate waste thicknesses were assumed to be 197-feet-thick, which represents the maximum depth of waste for the areas at intermediate grades.

Stage 3 – Final cover. The final stage of landfill development is when an area has reached final grade and receives its final cover. Two final cover scenarios were run based on varying slopes and their associated infiltration potential. One scenario assessed the side slopes of the landfill (Scenario 3A, 4:1 slope), and one scenario assessed the crown of the landfill (Scenario 3B, 5 percent slope).

III.C.3.2.3 Landfill Design

III.C.3.2.3.1 Final Cover Design

The final cover system includes the following components (from top to bottom):

- 4-inch rock armor layer
- Non-woven geotextile
- 18-inch infiltration layer
- 6-inch base layer
- 12-inch interim and daily cover layer

III.C.3.2.3.2 Liner Design

The composite liner system includes the following components (from top to bottom):

- 24-inch protective cover layer
- Geonet geocomposite drainage layer
- 60-mil high density polyethylene (HDPE) geomembrane liner
- Geosynthetic Clay Liner (GCL)

III.C.3.2.3.3 Additional Design Assumptions

The following additional assumptions were used for the HELP Model analyses:

- Evaporative zone depth of 24 inches.
- SCS runoff curve numbers were determined by the program based on default soil data, vegetative cover, and surface slope.
- The default growing period was used for the landfill location.
- Maximum leaf area index of 0 for bare ground.
- Default soil characteristics were used for total porosity, field capacity, and wilting point.
- Geomembrane placement was assumed to be good with four installation defects per acre and four material defects per acre.

ATTACHMENT III.C.4 – PIPE STRENGTH CALCULATIONS

Pipe Strength Calculations Completed by: EGC Date: 2/21/2025
Greater El Paso Landfill Major Permit Amendment

Calculation 1: Evaluate earth and live loads on leachate collection piping to determine:
a. Ring Deflection
b. Compressive Ring Thrust
c. Constrained (Buried) Pipe Wall Buckling

Approach: Use formulas for "Standard Installation - Trench or Embankment" provided in The Plastics Pipe Institute Handbook of Polyethylene Pipe, 2nd Addition, 2008.

Proposed Pipe: 6" Dia. SDR 11 HDPE

1.a. Ring Deflection Calculation

Use Spangler's Modified Iowa Formula

Design Criteria:		
Recommended Maximum Deflection	5.0%	PPI, pg 218
Allowable Deflection	7.5%	PPI, pg 218

Step 1: Determine Deflection [$\Delta X/D_M$]:

PPI, Equation 3-10, pg 211

$$\frac{\Delta X}{D_M} = \frac{1}{144}\left(\frac{K_{BED}L_{DL}P_E + K_{BED}P_L}{\frac{2E}{3}\left(\frac{1}{DR-1}\right)^3 + 0.061F_S E'}\right)$$

Input Variables:	Value	Units	Source	Notes
Outside Diameter [OD] =	6.625	in	ISCO	
Pipe Bedding Factor [K_{BED}] =	0.1		PPI, pg 211	
Deflection Lag Factor [L_{DL}] =	1		PPI, pg 212	
Pipe Mod of Elasticity [E] =	65,000	psi	PPI, Table B.1.1, pg 99	10 hour loading. Note that material designation code PE 4710 was assumed.
Soil Mod of Reaction [E'] =	3,000	psi	PPI, Table 3-7, pg 214	Crushed rock, mod comp (85 to 95% Proctor)
Waste Depth [W_D] =	0	ft		
Waste Density [W_{DEN}] =	50	pcf		
Sand Depth [S_D] =	0	ft		
Sand Density [S_{DEN}] =	125	pcf		
Aggregate Depth [A_D] =	2	ft		
Aggregate Density [A_{DEN}] =	150	pcf		
Vertical Soil Pressure Due to Earth Load [P_E]	**300**	**psf**		
Vertical Soil Pressure Due to Earth Load [P_E]	**2.08**	**psi**		
Soil Support Factor [F_S]	1		PPI, Table 3-10, pg 216	B_d = 18" D_o = 6.625" (B_d/D_o=2.7); E'_N = 3,000 psi (slightly compact); E'_N/E'=1; F_s=1.0
Mean Diameter [D_M]	6.235	in	ISCO	
Dimension Ratio [DR]	17			

Equipment	F250	289D	D5	D5 LGP	316	
Vertical Soil Pressure Due to Live Load [P_L] (psf)	**434**	**696**	**1038**	**914**	**1680**	See Calculation 2
Vertical Soil Pressure Due to Live Load [P_L] (psi)	**3.01**	**4.83**	**7.21**	**6.35**	**11.66**	
Deflection % [ΔX/DM*100]	**0.26%**	**0.36%**	**0.48%**	**0.44%**	**0.71%**	
Δ X (inch)	**0.02**	**0.02**	**0.03**	**0.03**	**0.04**	
Acceptable per Recommended Max. Deflection?	**YES**	**YES**	**YES**	**YES**	**YES**	
Acceptable per Allowable Max. Deflection?	**YES**	**YES**	**YES**	**YES**	**YES**	

1.b. Compressive Ring Thrust Calculation

Design Criteria:		
Maximum Allowable Compressive Stress	1150 psi	PPI, Table C.1, pg 102 for PE 4710 pipe

Step 1: Determine Compressive Stress [S]:

PPI, Equation 3-13, pg 219

$$S = \frac{(P_E + P_L)DR}{288}$$

Equipment	F250	289D	D5	D5 LGP	316	
Vertical Soil Pressure Due to Live Load [P_L] (psf)	**434**	**696**	**1038**	**914**	**1680**	See Calculation 2
Vertical Soil Pressure Due to Live Load [P_L] (psi)	**3.01**	**4.83**	**7.21**	**6.35**	**11.66**	
Compressive Stress [S] (lb/in^2)	**43**	**59**	**79**	**72**	**117**	

Pipe Strength Calculations Completed by: EGC Date: 2/21/2025

Greater El Paso Landfill Major Permit Amendment

Max Allowable (lb/in^2)	**1150**	**1150**	**1150**	**1150**	**1150**
Acceptable per Allowable Stress?	**YES**	**YES**	**YES**	**YES**	**YES**

1.c. Constrained (Buried) Pipe Wall Buckling

Design Criteria:

Allowable Constrained Buckling Pressure (P_{WC}) is greater than Earth Pressure (P_E) plus Live Load Pressure (P_L) with a Factor of Safety (N) against buckling of 2.

Use the following equations:

Step 1: Determine Allowable Constrained Buckling Pressure (P_{WC}):

PPI, Equation 3-15, pg 221

$$P_{WC} = \frac{5.6}{N}\sqrt{RB'E'\frac{E}{12(DR-1)^3}}$$

Step 2: Determine Buoyancy Reduction Factor (R):

PPI, Equation 3-17, pg 222

$$R = 1 - 0.33\frac{H_{GW}}{H}$$

Step 3: Determine B':

PPI, Equation 3-18, pg 222

$$B' = \frac{1}{1 + 4e^{(-0.065H)}}$$

Input Variables:	Value	Units	Source	Notes
Safety Factor [N]	2		PPI, pg 222	
Pipe Mod of Elasticity [E] =	65,000	psi	PPI, Table B.1.1, pg 99	10 hour loading. Note that material designation code PE 4710 was assumed.
Soil Mod of Reaction [E'] =	3,000	psi	PPI, Table 3-7, pg 214	Crushed rock, mod comp (85 to 95% Proctor)
Dimension Ratio [DR]	17			
Natural Log Base Number [e] =	2.71828			
Height of Groundwater Above Pipe [H_{GW}] =	0.5	ft	Assumed if 1 ft of head on liner	
Depth of Cover [H] =	2.0	ft	2' aggregate	
Buoyancy Reduction Factor [R] =	**0.92**		**Calculated**	
B'	**0.2216**		**Calculated**	
Allowable Constrained Buckling Pressure [P_{WC}] =	**80.2**	**psi**	**Calculated**	
Earth Pressure [P_E]	**2.08**	**psi**		

Live Load Pressure [P_L]

Equipment	F250	289D	D5	D5 LGP	316
Vertical Soil Pressure Due to Live Load [P_L] (psf)	**434**	**696**	**1038**	**914**	**1680**
Vertical Soil Pressure Due to Live Load [P_L] (psi)	**3.01**	**4.83**	**7.21**	**6.35**	**11.66**
Earth Pressure [P_E] + Live Load Pressure [P_L]	**5.10**	**6.92**	**9.30**	**8.43**	**13.75**
Allowable Constrained Buckling Pressure [P_{WC}] =	**80.2**	**80.2**	**80.2**	**80.2**	**80.2**
Is P_{WC} less than [P_E+P_L]?	**YES**	**YES**	**YES**	**YES**	**YES**

Pipe Strength Calculations Completed by: EGC Date: 2/21/2025
Greater El Paso Landfill Major Permit Amendment

Calculation 2: Determine live loads on leachate collection piping from typical construction equipment.

Approach: Use formulas provided in The Plastics Pipe Institute Handbook of Polyethylene Pipe, 2nd Addition, 2008.

2. Live Load Calculation

Step 1: Determine Vertical Soil Pressure Due to Live Load [P_L]:

PPI, Equation 3-2, pg 202

$$\boxed{P_L = \frac{I_f W_w}{a_C}\left(1 - \frac{H^3}{\left(r_T^{\,2} + H^2\right)^{1.5}}\right)}$$

Input Variables:	Value	Units	Source	Notes
Impact factor [I_f]	2		PPI, pg 199, unpaved surface	
Wheel load [W_w]	see below	lb		
Contact area [a_C]	see below	sf		
Equivalent radius [r_T]	see below	ft		

PPI, Equation 3-3, pg 202

$$\boxed{r_T = \sqrt{\frac{a_C}{\pi}}}$$

Depth of cover (H)	2	ft	2' aggregate

Equipment types:	**Wheel load (W_w) (lb)**	**Contact area (a_C) (sf)**	**Equivalent radius (r_T) (ft)**	**P_L (psf)**
Ford F250 (1)	2000	1	0.6	434
Caterpillar 289 D Skid Steer (2)	5300	7.9	1.6	696
Caterpillar D5 Dozer (3)	10157	12.7	2.0	1038
Caterpillar D5 Dozer LGP (3)	10496	16.4	2.3	914
Caterpiller 316 Excavator (4)	19515	16.7	2.3	1680

Sources:
(1) https://www.ford.com/trucks/super-duty/2017/models/f250-xl/
(2) http://www.cat.com/en_US/products/new/equipment/compact-track-and-multi-terrain-loaders/compact-track-loaders/18484366.html
(3) http://www.cat.com/en_US/products/new/equipment/dozers/small-dozers/1000001276.html
(4) http://www.cat.com/en_US/products/new/equipment/excavators/small-excavators/1000026572.html

Pipe Strength Calculations Completed by: EGC Date: 2/21/2025
Greater El Paso Landfill Major Permit Amendment

Calculation 3: Evaluate earth loads on leachate collection piping to determine:
a. Ring Deflection
b. Compressive Ring Thrust
c. Constrained (Buried) Pipe Wall Buckling

Approach: Use formulas for "Deep Fill Installation" provided in The Plastics Pipe Institute Handbook of Polyethylene Pipe, 2nd Addition, 2008.

3.a. Ring Deflection Calculation

Watkins-Gaube Graph

Design Criteria:		
Recommended Maximum Deflection	5.0%	PPI, pg 218
Allowable Deflection	7.5%	PPI, pg 218

Use the following equations:

Step 1: Determine Rigidity Factor [R_F]:

PPI, Equation 3-24, pg 230

$$R_f = \frac{12E_s(DR-1)^3}{E}$$

Step 2: Determine Secant Modulus of the Soil [E_s]:

PPI, Equation 3-26, pg 230

$$E_s = M_s \frac{(1+\mu)(1-2\mu)}{(1-\mu)}$$

Step 3: Determine Soil Strain [ε_s]:

PPI, Equation 3-27, pg 231

$$\varepsilon_s = \frac{wH}{144 E_s}$$

Step 4: Determine Percent Deflection [$\Delta X/D_M$]:

PPI, Equation 3-28, pg 231

$$\frac{\Delta X}{D_M}(100) = D_f \varepsilon_s$$

Input Variables:	Value	Units	Source	Notes
Dimension Ration [DR] =	17		Design factor	
Pipe Mod of Elasticity [E] =	29,000	psi	PPI, Table B.1.1, pg 99	50 year loading. Note that material designatio
Soil Modulus [M_s] =	3,200	psi	PPI, Table 3-12, pg 228	Vertical soil stress of 100 psi, 90% Std. Procto
Poisson's Ratio [μ] =	0.3		PPI, Table 3-13, pg 230	Assumed based on Sand (Dense)
Rigidity Factor [R_f] =	**4,029**		**Calculated**	
Secant Modulus of Soil [E_s] =	**2,377**	**psi**	**Calculated**	

Pipe Strength Calculations Completed by: EGC Date: 2/21/2025

Greater El Paso Landfill Major Permit Amendment

Final Cover Depth [F_D] =	3.33	ft	Final Cover layers are combined
Final Cover Density [F_{DEN}] =	125	pcf	
Waste Depth [W_D] =	197	ft	Max. waste thickness for complete expansion area
Waste Density [W_{DEN}] =	50	pcf	Waste density based on site-specific AUF calculation
Sand Depth. [S_D] =	0	ft	
Sand Density [S_{DEN}] =	125	pcf	
Aggregate Depth [A_D] =	2	ft	
Aggregate Density [A_{DEN}] =	150	pcf	
Soil Strain [ε_s] =	**3.09**	**percent**	**Calculated**
Deformation Factor [D_F] =	1.6		PPI, Figure 3-6, pg 231
Mean Diameter [D_M]	6.235	in	ISCO
Percent Deflection [$\Delta X/D_M$*100]	**4.94**	**percent**	**Calculated**

Is Percent Deflection less than Recommended Max Deflection of 5%? ***YES***

Is Percent Deflection less than Allowable Max Deflection of 7.5%? ***YES***

Total Deflection [ΔX] **0.31 in** **Calculated**

3.b. Compressive Ring Thrust Calculation

Design Criteria:

Maximum Allowable Compressive Stress 1150 psi

PPI, Table C.1, pg 102 for PE 4710 pipe

Use the following equations:

Step 1: Determine Vertical Arching Factor [VAF]:

PPI, Equation 3-21, pg 227

$$VAF = 0.88 - 0.71\frac{S_A - 1}{S_A + 2.5}$$

Step 2: Determine Hoop Thrust Stiffness Ratio [S_A]:

PPI, Equation 3-22, pg 227

$$S_A = \frac{1.43 M_S r_{cent}}{EA}$$

Step 3: Determine Radial Directed Earth Pressure [P_{RD}]:

PPI, Equation 3-23, pg 228

$$P_{RD} = (VAF)wH$$

Step 4: Determine Compressive Stress [S]:

PPI, Equation 3-13, pg 219

$$S = \frac{P_{RD}\,DR}{288}$$

Pipe Strength Calculations Completed by: EGC Date: 2/21/2025
Greater El Paso Landfill Major Permit Amendment

Input Variables:	Value	Units	Source	Notes
Dimension Ration [DR] =	17		Design factor	
Pipe Mod of Elasticity [E] =	29,000	psi	PPI, Table B.1.1, pg 99	50 year loading. Note that material designation code PE 4710 was assumed.
Soil Modulus [M_s] =	3,200	psi	PPI, Table 3-12, pg 228	Vertical soil stress of 100 psi, 90% Std. Proctor
Radius to Centroid Axis of Pipe [r_{cent}] =	3.313	in	ISCO	
Wall Thickness [A] =	0.390	in	ISCO	
Hoop Thrust Stiffness Ratio [S_A] =	**1.340**		**Calculated**	
Vertical Arching Factor [VAF] =	**0.817**		**Calculated**	
Final Cover Depth [FD] =	3.33	ft	Final Cover layers are combined	
Final Cover Density [FDEN] =	125	pcf		
Waste Depth [WD] =	197	ft	Max. waste thickness for complete expansion area	
Waste Density [WDEN] =	50	pcf		
Sand Depth [SD] =	0	ft		
Sand Density [SDEN] =	125	pcf		
Aggregate Depth [AD] =	2	ft		
Aggregate Density [ADEN] =	150	pcf		
Radial Earth Pressure [P_{RD}] =	**8,634**	**psf**	**Calculated**	
	60.0	**psi**	**Calculated**	
Compressive Stress [S] =	**509.6**	**psi**	**Calculated**	

Is Compressive Stress less than Allowable Compressive Stress of 1,150 psi? ***YES***

3.c. Constrained (Buried) Pipe Wall Buckling

Design Criteria:	
Factor of Safety against buckling: Greater than 2	PPI, pg 222

Use the following equations:

Step 1: Determine Critical Constrained Buckling Pressure [P_{CR}]:

PPI, Equation 3-29, pg 233

$$P_{CR} = \frac{2.4\varphi R_H}{D_M}(EI)^{\frac{1}{3}}(E_S^*)^{\frac{2}{3}}$$

Step 2: Determine [E^*_S]:

PPI, Equation 3-29 (notes), pg 233

$$E_S^* = \frac{E_S}{(1-\mu)}$$

Input Variables:	Value	Units	Source	Notes
Calibration Factor [Φ] =	0.55		PPI, pg 233	for granular soils
Geometry Factor [R_H] =	1.0		PPI, pg 233	uniform fill
Pipe Mod of Elasticity [E] =	29,000	psi	PPI, Table B.1.1, pg 99	50 year loading. Note that material designation code PE 4710 was assumed.
Pipe Wall Moment of Inertia [I]	0.005	in^3	ISCO	$I = t^3/12$; where t = wall thick (0.390 in for 6" SDR 17 pipe)

Pipe Strength Calculations Completed by: EGC Date: 2/21/2025

Greater El Paso Landfill Major Permit Amendment

Poisson's Ratio [μ] =	0.3		PPI, Table 3-13, pg 230	Assumed based on Sand (Dense)
Mean Diameter [D_M]	6.235	in	ISCO	
Secant Modulus of Soil [E_s] =	**2,377**	**psi**	**Calculated**	
E^*_S	**3,396**	**psi**	**Calculated**	
Critical Constrained Buckling Pressure [P_{CR}] =	**250.3**	**psi**	**Calculated**	
Safety Factor Against Buckling	**4.18**		**Calculated**	**SF = P_{CR}/P_{RD}**

Is Safety Factor against buckling greater than 2? ***YES***

ATTACHMENT III.C.7 – CHEMICAL RESISTANCE OF PLASTIC PIPING MATERIALS TECHNICAL REPORT FROM THE PLASTICS PIPE INSTITUTE

CHEMICAL RESISTANCE OF PLASTIC PIPING MATERIALS

TR-19

2023

Plastics Pipe Institute

The Voice of an Industry.

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Foreword

This technical report was developed and published with the technical help and financial support of the members of the Plastics Pipe Institute (PPI). These members have shown their commitment to developing and improving quality products by assisting standards development organizations in the development of standards, and also by developing design aids and reports to help engineers, code officials, specifying groups, contractors and users.

The purpose of this technical report is to provide information on the transport of various chemicals using plastic piping materials.

PPI has prepared this technical report as a service to the industry. The information in this report is offered in good faith and believed to be accurate at the time of its preparation, but is offered “as is” without any express or implied warranty, including WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. Additional information may be needed in some areas, especially with regard to unusual or special applications. Consult the manufacturer or material supplier for more detailed information. A list of member manufacturers is available on the PPI website. PPI does not endorse the proprietary products or processes of any manufacturer and assumes no responsibility for compliance with applicable laws and regulations.

PPI intends to revise this technical report within five years, or sooner if required, from the date of its publication, in response to comments and suggestions from users of the document. Please send suggestions of improvements to the address below. Information on other publications can be obtained by contacting PPI directly or visiting our website.

The Plastics Pipe Institute, Inc.

https://www.plasticpipe.org/

This Technical Report, TR-19, was first issued in 1973 and was updated in 1983, 1991, 1999, 2000, 2007, 2020 and April 2023.

Table of Contents

List of Tables

CHEMICAL RESISTANCE OF PLASTIC PIPING MATERIALS

1.0 INTRODUCTION

This technical report has been developed as an informative guide on the resistance of plastic piping and fitting materials to chemical attack.

It is divided into several sections:

- Section 2: How to Interpret the chemical resistance rating provided in Table 3
- Section 3: Chemical resistance in general, and considerations for end use applications
- Section 4: Types of chemical attack on plastics
- Section 5: Other considerations
- Section 6: Chemical Resistance Data for Plastic Piping in Non-Pressure Applications and Data Table
- Section 7: Additional resources

Listings of chemical resistance data are presented in Table 3 for common plastic piping materials applicable to **non-pressure applications**.

Determination of suitability for specific applications under stress (e.g., pressurized service) is beyond the scope of this report. Users should contact the specific pipe or fitting manufacturer for recommendations on pressurized applications.

Note 1: Safety Consideration: Additional engineering and safety considerations exist when transporting liquids above their atmospheric boiling temperature and gases. Both situations constitute piping under pressure and, due to the stored energy of compressed gases, pose a significant danger potentially leading to injury or death.

Note 2: Drinking water, also known as potable water, is water that is safe to drink or to use for food preparation. Across North America, the majority of the drinking water that is provided in public water systems is treated with a disinfectant to control the growth of harmful microorganisms. Potable water disinfectants include chlorine, chloramines, and rarely, chlorine dioxide. Piping materials intended for treated water must be resistant to such disinfectants at various levels, as described in product standards.

For specific information about the resistance of crosslinked polyethylene (PEX) to disinfectants, please see:

- PPI TN-53 ***Guide to Chlorine Resistance Ratings of PEX Pipes and Tubing for Potable Water Applications***,
- PPI TN-67 ***Chlorine Dioxide and Plastic Hot- And Cold- Water Plumbing Distribution Pipes***, and

- PPI Statement A - ***Relative Oxidative Aggressiveness of Chloramines and Free Chlorine Disinfectants on Crosslinked Polyethylene (PEX) Pipes used in Treated Potable Water***

For specific information about the resistance of high-density polyethylene (HDPE) to disinfectants, please see:

- PPI TN-44 ***Long Term Resistance of AWWA C906 Polyethylene (PE) Pipe to Potable Water Disinfectants*** and
- PPI TN-49 ***Recommendations for AWWA C901 Service Tubes in Potable Water Applications***

For specific information about the resistance of chlorinated polyvinyl chloride (CPVC) to disinfectants, please see ***Section 4: Effects of Potable Water Disinfectants on CPVC*** of PPI TN-62 ***Suitability and Fitness of CPVC Piping Systems for Commercial Building Applications***.

2.0 HOW TO INTERPRET THE RATINGS SHOWN IN TABLE 3

The chemical resistance ratings for the pipe and fitting materials and chemicals provided in Table 3 are neither authoritative nor exhaustive. They are only intended as starting point for a proper engineering evaluation. The suitability of a pipe or fitting material in a given application must include the appropriate engineering evaluation of the application including the factors (e.g., temperatures, pressure, chemical concentrations, material stress and expected service life) as discussed in other sections of this document.

As the ratings which are presented are a consolidation of laboratory and field experience from over 50 years of plastic industry experience and not the result of a systematic study, inconsistencies in results may appear in Table 3. It is important to note that a rating (e.g., “R- Resistance”) to a certain temperature or concentration does not imply a lack of resistance above that temperature or concentration. The literature and manufacturers may have other data or experience that supports the use of the material at higher temperatures and this evidence should be considered as part of the engineering analysis.

It is strongly recommended that each user satisfy themselves by means of appropriate tests or from previous experience before a particular plastic piping system is used to transport a specific chemical under the particular conditions of interest. The information in this report is intended to give general guidance only in making tests, and then assessing the results of such tests and experiences.

3.0 CHEMICAL RESISTANCE IN GENERAL

Plastic pipe and fitting materials are generally resistant to attack from many chemicals. This inherent property makes them suitable for use in numerous fluid and gas transport applications.

However, there are certain chemicals that may damage plastic pipes, either through exposure on the outside of the pipe to chemicals, on the internal surface of the pipe during the transport of such chemicals, or with exposure to inert fluids containing chemicals in various concentrations.

Each material has unique resistance to chemicals in various situations. The suitability of a pipe or fitting system for use in a particular fluid or gas application is a function of several factors, described below:

3.1. Pipe and Fitting Materials

The specific plastic material used in pipe and fittings impacts its chemical resistance. This report includes the materials listed in Table 1.

Table 1: Plastic Materials Identification

ABS	acrylonitrile-butadiene-styrene
CPVC	chlorinated polyvinyl chloride
PP	polypropylene
PP-R[1]	polypropylene random copolymer
PP-RCT[1]	polypropylene random copolymer with modified crystallinity and temperature resistance
PVC	polyvinyl chloride
PE	polyethylene (representative of medium density polyethylene [MDPE] and high density polyethylene [HDPE]; not representative of low density polyethylene [LDPE])
PE-RT[2]	polyethylene of raised temperature resistance
PB	polybutylene
PVDF	polyvinylidene fluoride
PEX	crosslinked polyethylene
PA11/ PA12	polyamide 11 / polyamide 12
PA66	polyamide 66
PSU	polysulfone
PPSU	polyphenylsulfone

[1] PP-R and PP-RCT are chemically similar to PP and are grouped together in Table 3; they may be assumed to have similar chemical resistance
[2] PE-RT is chemically similar to MDPE and HDPE and are grouped together in Table 3; they may be assumed to have similar chemical resistance

3.2. Product Design and Joining Systems

Piping dimensions, including wall thickness, construction, and composition (layers, fillers, etc.), can affect chemical resistance.

The type of joining system can also affect the performance of the system in chemical handling applications. Heat fusion and solvent cementing do not introduce different materials into the system. The resistance of solvent cement to certain chemicals can vary from grade to grade.

Other components and appurtenances in the piping system can have different chemical resistances. Certain types of mechanical joints include gaskets using elastomers with their own unique resistances. Some piping systems include other plastic or non-plastic materials used as mechanical fitting components which can have different chemical resistance.

3.3. Operating Conditions - Internal and External

- Chemicals or mixtures of chemicals, and their concentrations.
- Operating temperature — maximum, minimum, and cyclical variations.
- Operating pressure or applied stress — maximum, minimum and cyclical variations.

4.0 TYPES OF CHEMICAL ATTACK ON PLASTICS

In general, chemicals that affect plastics do so in several ways, including solvation, chemical attack, and environmental stress cracking.

4.1. Permeation, Swelling, Plasticization, Solvation, and Extraction

Permeation is the transport of chemicals through the pipe wall via diffusion through the free volume of the polymer matrix without significant change in the material properties. Permeability may be of interest in situations where the pipe is to function as a liner pipe for a less resistant material (e.g., fiberglass or steel), where the pipe is transporting particularly hazardous substances, or where the pipe is installed in contaminated soil.

Permeability of specific plastic piping materials is not addressed in this document. PPI Statement N - ***Barrier Properties of Plastic Pipe Used for Potable Water Service,*** states “In areas of known or suspected contamination, the design of the distribution system should be based on a careful analysis of the situation.

Appropriate technical data and individual manufacturers' recommendations should be consulted on the overall design of a pipe system for these systems."

Note 3: See also ***PPI Comments on Permeation of Water Pipes and on the AWWA-RF Report on Hydrocarbons*** at link

Absorption occurs when a chemical diffuses into the free volume of the polymer matrix and accumulates there. This may result in one or more of the following effects: swelling, plasticization, or solvation. In the case of absorption, physical properties may be affected, but the polymer molecule itself is not chemically changed, degraded or destroyed.

Swelling is an increase in the bulk volume of a material caused by the absorption of liquids or vapors from the environment. It may or may not be accompanied by plasticization, which results in softening and loss of strength in the material.

In extreme cases, the solvating compound can fully dissolve the plastic material.

Sometimes the polymer itself may not be soluble, but it may contain a soluble formulary ingredient that may be extracted from the polymer compound. This is more common in plasticized materials where loss of plasticizer may result in embrittlement. It is not common in plastic materials used for pipes and fittings and is not addressed in this document.

In gas or vapor transmission service, there may be a very slight loss of contents through the pipe wall.

Lastly, a solvating or permeating chemical entrained in the material may be released when heat fusion or solvent cement joining is performed. Thus, heat fusion (e.g., welding) or solvent cement joining may be unreliable if performed on permeated pipes. Caution should be used in performing these processes if solvation or permeation are suspected.

4.2. Direct Chemical Attack

Direct chemical attack occurs when exposure to a chemical causes a chemical alteration of the polymer molecules by chain scission, crosslinking, oxidation, or substitution reactions.

Direct chemical attack frequently causes a severe reduction of mechanical physical properties such as tensile strength, ductility, burst pressure, and impact resistance.

Chemical resistance may vary greatly from one plastic material to another (i.e., PVC, ABS, PE, etc.), and also among different cell classifications of the same plastic type (e.g., PVC 1120 to PVC 2110, PE 3608 to PE 4710, etc.). There may also be slight variations among commercial products having the same cell classification, based on compound ingredients known as stabilizers or “additive packages”.

The chemical resistance of plastic piping and fittings is basically a function of the chemical resistance of the plastic material, including additives and other ingredients in the final compound. In general, the fewer filler ingredients used, the better the chemical resistance.

Plastic pipes with significant filler percentages may be susceptible to chemical attack whereas an unfilled material may be affected to a lesser degree or not at all.

4.3. Environmental Stress Cracking

Environmental stress cracking (ESC) is defined as the “development of cracks in a material that is subjected to stress or strain in the presence of specific chemicals”, as per ASTM F412 S***tandard Terminology for Plastic Piping Systems***.

Environmental stress cracking is a fundamentally different phenomenon than chemical attack, even though they may present similarly (e.g., crazing or whitening of parts, sloughing of material, minor crack formation). ESC does not result in chemical alteration of the polymer molecule. ESC is caused by a chemical agent in combination with inherent and applied stresses. It can often be minimized with proper installation. Direct chemical attack does not require any stress or strain on the material for it to occur, although it may be accelerated in conditions of high stress or strain.

5.0 OTHER CONSIDERATIONS

5.1. Chemical Families

While the effect of each individual chemical is specific, some chemicals can be grouped into general categories based on similarities in chemical characteristics (acids, bases, alcohols, etc.). For example, water-based (aqueous) solutions of neutral inorganic salts generally have the same effect on plastic piping materials as water alone; thus, sodium chloride, potassium alum, calcium chloride, copper sulfate, potassium sulfate and zinc chloride solutions have the same effect as water.

However, at elevated temperatures or high concentrations, some salt solutions may attack some plastic materials through either oxidation or chemical substitution when they would be benign at lower temperatures and concentrations.

5.2. Accelerating factors (concentration, temperature, stress)

Generally, the resistance of a particular plastic to a specific chemical will decrease with an increase in concentration. For example, for some materials, dilute sulfuric acid may be acceptable, whereas 95% sulfuric acid may not.

The resistance of a particular plastic to a specific chemical generally decreases as temperature increases because the rate of chemical phenomenon (i.e., reactivity, permeation rate, solvation) tends to increase. This rate increase is logarithmic with respect to temperature over most plastic functional temperatures and generally follows to the Arrhenius equation.

The chemical resistance of a particular plastic generally decreases with increasing applied stress. This is commonly seen when the presence of certain chemicals causes environmental stress cracking where unstressed parts exhibit good chemical resistance.

The chemical resistance of a particular plastic generally decreases where temperature or applied stress are varied or cycled. These effects can be greater overall in combination. Testing should be conducted if the system is expected to perform across a wide range of temperatures and stresses to determine the overall combined effect.

5.3. Combinations of Chemicals

In some cases, combinations of chemicals may have a synergistic effect on damaging a plastic material, and a mixture may cause damage where the individual chemicals do not. It cannot be assumed that an individual chemical's lack of effect would apply for combinations that include several chemicals. When the possible combined effect of several chemicals is unknown, the material should be tested in the complete chemical mixture(s) in question.

5.4. Multi-Layered (Composite) Piping

Some piping products utilize a multi-layered (composite) construction, in which the pipe wall is constructed of layers of different materials. The layers may consist of both plastic and non-plastic.

For example, PE/AL/PE and PEX/AL/PEX pipes contain mid-wall aluminum layers. Examples of all-plastic composite pipes include PVC/ABS/PVC and fiber-core PP-R or PP-RCT pipes. Layered composite material pipes may have chemical resistance that differs from the chemical resistance of the individual materials.

5.5. Rate of Chemical Attack

Chemicals that attack plastics do so at a certain rate, some slowly and some more quickly. But usually, any chemical attack is increased when temperature or stress are increased, or when temperature or stress are varied. The particular rate of chemical attack must be taken into consideration in the life-cycle evaluation for a particular application. Each combination of material cost, installation cost and service life must be evaluated and judged on its own merits.

In certain cases involving a slow rate of chemical attack, particularly when the application will be pressurized, simple immersion data, like that represented in Table 3, may not adequately characterize performance throughout the intended design life. Longer-term testing to replicate service conditions is advisable to fully measure the effects of these chemicals.

6.0 CHEMICAL RESISTANCE DATA FOR PLASTIC PIPING IN NON-PRESSURE APPLICATIONS AND DATA TABLE

When plastic pipes come into contact with chemical agents it is important to know how the pipe may be affected. For non-pressure applications, where the pipe is not subject to continuous internal pressure or stress, chemical immersion test data may provide suitable information. The pipe manufacturer may have additional data from similar tests, or information on previous installations under similar field conditions.

The following cautions apply to Table 3 *List of Chemical Resistances*:

- ***Data Sources.*** The information in Table 3 has been obtained from numerous sources. The data are based primarily on plastic material test specimens that have been immersed in the chemical and evaluated, and to a lesser degree, on field-experience. In most cases, detailed information on the test conditions (e.g., exposure time), and on test results (e.g., change in weight, change in volume, and change in strength) was not available. Therefore, this information is best used only for comparison of different plastic materials.

- ***Combinations of Chemicals.*** Chemicals that individually do not have an effect may affect the pipe if combined with certain other chemicals. The list of possible combinations of chemicals is endless. Table 3 does not address chemical combinations.
- ***Composite Piping.*** Layered composite piping may have chemical resistance that differs from that of the individual materials in the layers. Table 3 is not applicable to layered composite piping products.
- ***Applicability to fiberglass*** and ***filled materials.*** Table 3 is not applicable to reinforced epoxy resin (fiberglass) pipes, and to plastic pipes containing significant percentages of filler materials.
- ***Concentrations.*** Where no concentrations are given (indicated as '**P**'), the commercially pure material is indicated, except in the case of solids where saturated aqueous solutions are indicated.

See Table 2 for the **Resistance Codes** which are used throughout Table 3.

Table 2: Resistance Codes

Code	Meaning	Typical Result
R to xx°F	Plastic material is generally **Resistant** up to the temperature (°F) indicated by code and may have limited resistance at higher temperatures	Swelling < 3% or weight loss < 0.5% and elongation at break not significantly changed Typical performance properties not significantly affected
L to xx°F	Plastic material has **Limited** resistance at the temperature (°F) indicated by code. Compatibility at lower temperatures should not be assumed	Material may experience swelling in the range of 3 - 8% or weight loss of 0.5 - 5% and/or reduction in elongation at break by < 50% Some effect on performance properties
N	Plastic material is **Not** resistant.	Material may experience swelling > 8% or weight loss > 5% and/or reduction in elongation at break by > 50%
P	**Pure** Concentration	
—	Data not available Check with piping manufacturer	

Chemicals that do not normally affect the properties of an unstressed plastic may cause completely different behavior (such as stress cracking) when under mechanical stress, such as constant internal pressure or mechanical stress cycles.

Unstressed immersion test chemical resistance information is applicable only when the plastic pipe will not be subject to mechanical load or stress that is constant, or cycles frequently.

When the pipe will be subject to a continuous applied mechanical stress or to combinations of chemicals, testing that duplicates the expected field conditions, as closely as possible, should be performed on representative samples of the pipe product to properly evaluate that plastic pipe for use in this application.

7.0 OTHER RESOURCES

The following references provide additional information on chemical compatibility of plastic piping and may provide useful guidance:

- ***PPI Comments on Permeation of Water Pipes and on the AWWA-RF Report on Hydrocarbons***
- PPI Statement A ***– Relative Oxidative Aggressiveness of Chloramines and Free Chlorine Disinfectants on Crosslinked Polyethylene (PEX) Pipes used in Treated Potable Water***
- PPI Statement N ***– Barrier Properties of Plastic Pipe Used for Potable Water Service***
- PPI TN-11 ***– Suggested Temperature Limits for Thermoplastic Pipe Installation and for Non-Pressure Pipe Operation***
- PPI TN-44 ***– Long Term Resistance of AWWA C906 Polyethylene (PE) Pipe to Potable Water Disinfectants***
- PPI TN-49 ***– Recommendations for AWWA C901 Service Tubes in Potable Water Applications***
- ***PPI TN-52 – Guide to High-Temperature Applications of Non-Potable PEX Pipe and Tubing Systems***
- PPI TN-53 ***– Guide to Chlorine Resistance Ratings of PEX Pipes and Tubing for Potable Water Applications***
- ***PPI TN-67 – Chlorine Dioxide and Plastic Hot- And Cold- Water Plumbing Distribution Pipes***
- ISO TR 10358 ***Plastics pipes and fittings for industrial applications — Collection of data on combined chemical-resistance***

******May not be fully applicable to pressurized applications******

Table 3*:* List of Chemical Resistances (°F)

Chemical Formula	Concentration	ABS	CPVC	PP (PP-R, PP-RCT)	PVC	PE (MDPE, HDPE, PE-RT)	PB	PVDF	PEX	PA11, PA12	PA66	PSU	PPSU
Acetaldehyde **CAS# 75-07-0** CH_3CHO	40%	---	N	---	L to 73	R to 73	---	N	R to 73	---	---	---	---
	Pure	---	N	R to 140	N	L to 73	L to 73	---	L to 140	L to 176	---	R to 73	---
Acetamide **CAS# 60-35-5** CH_3CONH_2	5%	R to 120	---	R to 140	---	R to 140	---	R to 75	R to 140	---	---	---	---
Acetic Acid **CAS# 64-19-7** CH_3COOH	vapor	R to 120	R to 180	R to 180	R to 140	R to 140	R to 140	---	R to 140	---	---	---	---
	10%	---	R to 180	---	---	---	---	R to 248	R to 180	R to 176	---	---	---
	25%	N	N	R to 180	R to 140	R to 140	R to 140	---	R to 140	---	---	---	---
	40%	---	---	---	---	---	---	R to 140	---	---	---	---	---
	50%	---	---	---	---	---	---	R to 140	---	L to 68	---	---	---
	60%	N	N	R to 180	R to 73	R to 73	R to 73	R to 104	---	---	---	---	---
	85%	N	N	R to 120	R to 73	R to 73	R to 73	---	---	---	---	R to167	R to 167
	glacial	N	N	R to 120	R to 73	R to 73	R to 73	R to 104	R to 68	---	---	R to 167	R to 167
Acetic Anhydride **CAS# 108-24-7** $(CH_3CO)_2O$	---	N	N	R to 73	N	R to 73	R to 140	N	R to 73	L to 68	---	---	---
Acetone **CAS# 67-64-1** CH_3COCH_3	5%	N	R to 180	R to 73	N	L to 73	R to 140	R to 212	L to 73	L to 140	---	N	---
	10%	---	L to 180	---	---	---	---	R to 122	---	---	---	---	---
	100%	---	N	---	---	---	---	---	---	---	---	---	---
Acetophenone **CAS# 98-86-2** $C_6H_5COCH_3$	---	N	N	R to 120	--	R to 73	---	R to 68	R to 73	---	---	---	---
Acetyl Chloride **CAS# 75-36-5** CH_3COCl	---	N	N	---	N	---	---	R to 125	---	---	---	---	---
Acetylene **CAS# 74-86-2** $HC{\equiv}CH$	gas 100%	R to 73	N	R to 73	N	R to 73	L to 73	R to 250	R to 73	R to 140	---	---	---
Acetylnitrile CAS 75-05-8 $CH_3C{\equiv}N$	---	---	N	---	N	---	---	---	---	---	---	---	---

Chemical Formula	Concentration	ABS	CPVC	PP (PP-R, PP-RCT)	PVC	PE (MDPE, HDPE, PE-RT)	PB	PVDF	PEX	PA11, PA12	PA66	PSU	PPSU
Acrylic Acid **CAS# 79-10-7** $H_2C{=}CHCOOH$	97%	---	N	---	N	R to 140	---	---	R to 140	---	---	---	---
Acrylonitrile **CAS# 107-13-1** $H_2C{=}CHC{\equiv}N$	---	---	N	---	N	R to 140	---	R to 75	R to 140	---	---	---	---
Adipic Acid **CAS#124-04-9** $COOH(CH_2)_4COOH$	Saturated	---	R to 180	R to 140	R to 140	R to 140	R to 73	R to 176	R to 140	---	---	---	---
Allyl Alcohol **CAS# 107-18-6** $CH_2 = CHCH_2\ OH$	96%	---	L to 73	R to 140	R to 73	N	R to 140	R to 125	L to 100	---	---	---	---
Allyl Chloride **CAS# 107-05-1** $CH_2{=}CHCH_2Cl$	--	---	N	---	N	L to 73	---	R to 140	L to 73	---	---	---	---
	Liquid	---	---	---	---	---	---	R to 68	---	---	---	---	---
Aluminum Ammonium Sulfate (Alum) **CAS# 7784-25-0** $AlNH_4\ (SO_4)_2 \cdot 12H_2O$	Saturated	---	R to 180	R to 140	R to 140	R to 140	---	---	R to 140	---	---	---	---
Aluminum Chloride **CAS# 7446-70-0** $AlCl_3$	Saturated	R to 160	R to 180	R to 180	R to 140	R to 140	R to 140	R to 212	R to 140	---	---	---	---
Aluminum Fluoride Anhydrous **CAS# 7764-18-1** AlF_3	Saturated	R to 160	R to 180	R to 180	R to 73	R to 140	R to 140	R to 212	R to 140	---	---	---	---
Aluminum Hydroxide **CAS# 21645-51-2** $Al(OH)_3$	Saturated	R to 160	R to 180	R to 180	R to 140	R to 140	R to 140	R to 212	R to 140	---	---	---	---
Aluminum Nitrate **CAS# 13473-90-0** $Al(NO_3)_3 \cdot 9H_2O$	Saturated	---	R to 180	R to 180	R to 140	R to 140	R to 140	R to 212	R to 140	---	---	---	---
Aluminum Oxychloride **CAS# 1327-41-9**	--	---	R to 180	R to 180	R to 140	---	R to 140	R to 125	---	---	---	---	---
Aluminum Potassium Sulfate (Alum) **CAS# 10043-67-1** $AlK(SO_4)_2 \cdot 12H_2O$	Saturated	R to 160	R to 180	R to 140	R to 140	R to 140	---	R to 212	R to 140	---	---	---	---
Aluminum Sulfate **CAS# 10043-01-3** $Al_2(SO_4)_3$	Saturated	R to 160	R to 180	R to 140	R to 140	R to 140	C to 73	R to 212	R to 140	R to 194	---	---	---

May not be fully applicable to pressurized applications

Chemical Formula	Concentration	ABS	CPVC	PP (PP-R, PP-RCT)	PVC	PE (MDPE, HDPE, PE-RT)	PB	PVDF	PEX	PA11, PA12	PA66	PSU	PPSU
Ammonia Gas CAS# 7664-41-7 NH_3	100%	N	N	R to 140	R to 140	R to 140	R to 140	---	R to 140	R to 140	---	---	---
Ammonium Acetate CAS# 631-61-8 CH_3COONH_4	Saturated	R to 120	R to 180	R to 73	R to 140	R to 140	---	R to 212	R to 140	---	---	---	---
Ammonium Bifluoride CAS# 1341-49-7 NH_4HF_2	Saturated	---	R to 180	R to 180	R to 140	---	R to 140	R to 150	R to 140	---	---	---	---
Ammonium Bisulfide CAS# 12124-99-1 $(NH_4)HS$	---	---	---	---	R to 140	---	---	---	---	---	---	---	---
Ammonium Carbonate CAS# 506-87-6 $(NH_4)_2CO_3$	Saturated	---	R to 180	R to 212	R to 140	R to 140	R to 140	R to 248	R to 140	---	---	---	---
Ammonium Chloride CAS# 12125-02-9 NH_4Cl	Saturated	R to 120	R to 180	R to 212	R to 140	R to 140	R to 140	R to 212	R to 140	---	---	---	---
Ammonium Dichromate CAS# 7789-09-5 $(NH_4)_2Cr_2O_7$	--	---	R to 73	---	R to 73	---	---	R to 250	---	---	---	---	---
Ammonium Fluoride CAS# 12125-01-8 NH_4F	10%	R to 120	R to 180	R to 212	R to 140	R to 140	---	R to 212	R to 140	---	---	---	---
	25%	R to 120	R to 180	R to 212	L to 140	R to 140	R to 73	---	R to 140	---	---	---	---
Ammonium Hydroxide CAS# 1336-21-6 NH_4OH	10%	R to 120	N	R to 212	R to 140	R to 140	R to 140	---	R to 140	---	---	---	---
	30%	---	---	---	---	R to 140	---	---	R to 140	---	---	---	---
	Saturated	---	---	---	---	---	---	---	R to 194	---	---	---	---
Ammonium Metaphosphate CAS# 13446-46-3 NH_3HPO_3	Saturated	--	--	R to 212	R to 140	R to 140	R to 140	R to 248	R to 140	---	---	---	---
Ammonium Nitrate CAS# 6484-52-2 NH_4NO_3	Saturated	R to 120	R to 180	R to 212	R to 140	R to 140	R to 140	R to 212	R to 140	---	---	---	---
Ammonium Persulfate CAS# 7727-54-0 $(NH_4)_2S_2O_8$	---	---	R to 180	R to 140	R to 140	R to 140	R to 140	R to 212	R to 140	---	---	---	---
Ammonium Phosphate (Monobasic) CAS# 7722-76-1 $NH_4H_2PO_4$	---	R to 120	L to 73	R to 212	R to 140	R to 140	R to 140	R to 248	R to 140	---	---	R to 199	R to 199

May not be fully applicable to pressurized applications

Chemical Formula	Concentration	ABS	CPVC	PP (PP-R, PP-RCT)	PVC	PE (MDPE, HDPE, PE-RT)	PB	PVDF	PEX	PA11, PA12	PA66	PSU	PPSU
Ammonium Sulfate **CAS# 7783-20-2** $(NH_4)_2SO_4$	Saturated	R to 120	R to 180	R to 212	R to 140	R to 140	R to 140	R to 212	R to 140	---	---	---	---
Ammonium Sulfide **CAS# 12135-76-1** $(NH_4)_2S$	dilute	R to 120	R to 180	R to 212	R to 140	R to 140	R to 140	R to 200	R to 140	---	---	---	---
	Saturated	---	---	---	---	R to 140	---	R to 125	---	---	---	---	---
Ammonium Thiocyanate **CAS# 1762-95-4** NH_4SCN	50-60%	R to 120	R to 180	R to 212	R to 140	R to 140	R to 140	R to 212	R to 73	---	---	---	---
Amyl Acetate **CAS# 628-63-7** $CH_3COOC_5H_{11}$	--	N	N	N	N	R to 73	---	R to 122	R to 73	C to 194	---	---	---
Amyl Alcohol **CAS# 75-41-0** $C_5H_{11}OH$	--	---	N	---	N	R to 140	R to 140	R to 212	R to 140	---	R to 73	---	---
	100%	---	---	---	---	---	L to 140	---	---	---	---	---	---
n-Amyl Chloride **CAS# 543-59-9** $CH_3(CH_2)_3CH_2Cl$	--	N	N	N	N	L to 73	---	R to 285	L to 73	---	---	---	---
Aniline **CAS# 62-53-3** $C_6H_5NH_2$	--	N	N	---	N	R to 73	L to 140	R to 68	L to 140	---	---	---	---
Aniline Chlorohydrate	--	---	N	---	N	L to 73	N	---	L to 73	---	---	---	---
Aniline Hydrochloride **CAS# 142-04-1** $C_6H_5NH_2 \bullet HCl$	Saturated	---	N	---	N	R to 140	N	R to 75	R to 140	---	---	---	---
Anthraquinone **CAS# 84-65-2** $C_{14}H_8O_2$	--	---	R to 180	---	R to 140	L to 73	L to 73	---	L to 73	---	---	---	---
Anthraquinone Sulfonic Acid **CAS# 82-49-5** $C_{14}H_7O_2 \bullet SO_3 \bullet H_2O$	--	---	R to 180	R to 73	R to 140	R to 140	L to 73	---	L to 73	---	---	---	---
Antimony Trichloride **CAS# 10025-91-9** $SbCl_3$	Saturated	---	R to 180	R to 140	R to 140	R to 140	R to 140	R to 140	R to 140	---	---	---	---
Aqua Regia ` **CAS# 8007-56-5** (Nitrohydrochloric Acid) $HCl+HNO_3$	--	N	R to 73	N	L to 73	N	N	L to 194	N	---	---	N	---
Arsenic Acid **CAS# 7778-39-4** H_3AsO_4	80%	---	R to 180	R to 140	R to 140	R to 140	R to 140	R to 248	R to 140	---	---	---	---

May not be fully applicable to pressurized applications

Chemical Formula	Concentration	ABS	CPVC	PP (PP-R, PP-RCT)	PVC	PE (MDPE, HDPE, PE-RT)	PB	PVDF	PEX	PA11, PA12	PA66	PSU	PPSU
Asphalt **CAS# 8052-42-4**	--	---	N	R to 73	N	R to 73	R to 140	R to 250	R to 73	---	---	---	---
Barium Carbonate **CAS# 513-77-9** $BaCO_3$	Saturated	R to 120	R to 180	R to 140	R to 140	R to 140	R to 140	R to 248	R to 140	---	---	---	---
Barium Chloride **CAS# 10361-37-2** $BaCl2 \cdot 2H_2O$	Saturated	R to 120	R to 180	R to 140	R to 140	R to 140	R to 140	R to 212	R to 140	R to 194	---	---	---
Barium Hydroxide **CAS# 17194-00-2** $Ba(OH)_2$	30%	---	---	---	---	R to 140	---	R to 250	R to 140	---	---	---	---
	Saturated	R to 73	R to 180	R to 140	R to 140	R to 140	R to 140	R to 250	R to 212	---	---	---	---
Barium Nitrate **CAS# 10022-31-8** $Ba(NO_3)_2$	Saturated	R to 73	R to 180	R to 140	R to 73	R to 140	---	R to 250	R to 140	---	---	---	---
Barium Sulfate **CAS# 7727-43-7** $BaSO_4$	Saturated	R to 73	R to 180	R to 140	R to 140	R to 140	R to 140	R to 212	R to 140	---	---	---	---
Barium Sulfide **CAS# 21109-95-5** BaS	Saturated	R to 73	R to 180	R to 140	R to 140	R to 140	R to 140	R to 250	R to 248	---	---	---	---
Beer	--	R to 120	R to 180	R to 180	R to 140	R to 140	R to 140	R to 248	R to 140	R to 68	---	---	---
Beet Sugar Liquors	--	---	R to 180	R to 180	R to 140	R to 73	R to 140	R to 230	R to 73	---	---	---	---
Benzaldehyde **CAS# 100-52-7** C_6H_5CHO	10%	N	N	R to 73	R to 73	R to 73	L to 73	L to 70	R to 73	R to 104	---	---	---
Benzene **CAS# 71-43-2** C_6H_6	--	N	N	N	N	N	N	N	N	---	R to 73	N	---
Benzene Sulfonic Acid **CAS# 98-11-3** $C_6H_5SO_3H$	10%	---	R to 180	R to 180	R to 140	R to 73	---	R to 175	R to 73	---	---	---	---
	10%+	---	N	---	N	---	---	R to 125	---	---	---	---	---
Benzoic Acid **CAS# 65-85-0** C_6H_5COOH	100%	R to 160	R to 180	R to 73	R to 140	R to 140	R to 140	R to 230	R to 140	---	---	---	---
Benzoyl Chloride **CAS# 99-88-4** C_6H_5COCl	Sat. Sol.	---	---	---	---	---	---	L to 68 R to 170 with sunlight protection or pigmented pipe	---	---	---	---	---

Chemical Formula	Concentration	ABS	CPVC	PP (PP-R, PP-RCT)	PVC	PE (MDPE, HDPE, PE-RT)	PB	PVDF	PEX	PA11, PA12	PA66	PSU	PPSU
Benzyl Alcohol CAS# 100-51-6 $C_6H_5CH_2OH$	--	---	N	R to 120	N	R to 140	---	R to 250	R to 140	R to 68	---	---	---
Benzyl Chloride CAS# 100-44-7 C_7H_7Cl	--	---	N	---	---	---	---	R to 285	R to 140	---	---	---	---
Bismuth Carbonate CAS#5892-10-4 $(BiO)_2CO_3$	Saturated	---	R to 180	R to 180	R to 140	R to 140	R to 140	---	R to 140	---	---	---	---
Black Liquor	Saturated	---	R to 180	R to 140	R to 140	R to 120	R to 140	---	R to 120	---	---	---	---
Bleach-See Sodium Hypochlorite													
Borax CAS# 1303-96-4 $Na_2B_4O_7 \cdot 10H_2O$	Saturated	R to 160	R to 180	R to 212	R to 140	R to 140	R to 140	R to 275	R to 140	---	---	---	---
Boric Acid CAS# 10043-35-3 H_3BO_3	Saturated	R to 160	R to 180	R to 212	R to 140	R to 140	R to 140	R to 212	R to 140	---	---	R to 113	---
Bromic Acid CAS# 15541-45-4 $HBrO_3$	Saturated	---	R to 180	N	R to 140	N	R to 140	R to 212	N	---	---	---	---
	10%	---	---	---	---	R to 140	---	---	---	---	---	---	---
Bromine CAS# 7726-95-6 Br_2	Liquid	R to 73	N	N	N	N	N	R to 248	N	N	---	---	---
	vapor 25%	---	R to 180	N	R to 140	N	---	---	N	---	---	---	---
Bromine Water	Saturated	---	R to 180	N	R to 140	N	L to 73	R to 176	N	---	---	---	---
Bromobenzene CAS# 108-86-1 C_6H_5Br	--	---	N	---	N	---	---	R to 150	---	---	---	---	---
Bromotoluene (Benzyl bromide) CAS# 95-46-5 $C_6H_5CH_2Br$	--	---	N	L	N	---	---	R to 175	---	---	---	---	---
Butadiene CAS# 106-99-0 $H_2C{=}CHCH{=}CH_2$	50%	---	---	N	R to 140	R to 73	---	---	R to 73	---	---	---	---
	Gas	---	---	---	---	---	---	R to 212	---	---	---	---	---
Butane CAS# 106-97-8 C_4H_{10}	50%	---	R to 180	R to 140	R to 140	R to 140	N	---	R to 140	---	---	---	---
	Gas	---	---	---	---	---	---	R to 68	---	---	---	---	---
n-Butanol CAS# 71-36-3 C_4H_9OH	Liquid	---	L to 73	---	---	---	---	R to 140	---	---	---	N	---

Chemical Formula	Concentration	ABS	CPVC	PP (PP-R, PP-RCT)	PVC	PE (MDPE, HDPE, PE-RT)	PB	PVDF	PEX	PA11, PA12	PA66	PSU	PPSU
Butyl Acetate **CAS# 123-86-4** $CH_3COOCH_2CH_2CH_2CH_3$	100%	N	N	L to 73	N	L to 73	L to 73	L to 104	L to 73	R to 194	---	---	---
Butyl Alcohol **CAS# 71-36-3** $CH_3(CH_2)_2CH_2OH$	--	---	L to 73	R to 180	R to 140	R to 140	R to 140	R to 200	R to 140	L to 104	---	R to 73	---
Butyl Cellosolve **CAS# 111-76-2** $HOCH_2CH_2O(CH_2)_3CH_3$	--	---	N	---	R to 73	---	---	---	---	---	---	---	---
n-Butyl Chloride **CAS# 109-69-3** C_4H_9Cl	--	N	N	---	---	---	---	---	---	---	---	---	---
Butyl Glycol **CAS# 111-76-2** $HOCH_2CH_2O(CH_2)_3CH_3$	Liquid	---	N	---	---	---	---	R to 212	---	---	---	---	---
Butylene **CAS# 107-01-7** (isomer not specified) $CH_3CH{=}CHCH_3$	Liquid	---	---	N	R to 140	N	---	R to 285	N	---	---	---	---
Butyl Phenol **CAS# 98-54-4** (CH3)3C6H4OH	--	---	---	N	L to 73	R to 73	R to 73	R to 220	R to 73	---	---	---	---
Butyl Phthalate **CAS# 84-74-2** $C_{16}H_{22}O_4$	--	---	N	R to 180	---	---	---	R to 140	---	---	---	---	---
Butyl Stearate **CAS# 123-95-5** $CH_3(CH2)_{16}COO(CH_2)_3CH_3$	--	---	---	---	R to 73	---	---	---	---	---	---	---	---
Butynediol **CAS# 110-65-6** $HOCH_2C{\equiv}CCH_2OH$	--	---	---	---	R to 73	---	---	----	---	---	---	---	---
Butyric Acid **CAS# 107-92-6** $CH_3CH_2CH_2COOH$	--	N	N	R to 180	R to 73	R to 73	R to 73	---	R to 73	---			---
	20%	---	---	---	---	---	---	R to 212	---	---	---	---	---
	Liquid	---	---	---	---	---	---	R to 176	R to 73	---			---
Cadmium Cyanide **CAS# 542-83-6** $Cd(CN)_2$	--	---	R to 180	---	R to 140	---	---	---	---	---	---	---	---
Calcium Bisulfide $Ca(HS)_2 \bullet 6H_2O$	--	---	R to 180	---	N	R to 140	---	---	R to 140	---	---	---	---
Calcium Bisulfite	--	---	R to 180	R to 180	R to 140	N	R to 140	---	N	---	---	---	---

May not be fully applicable to pressurized applications

Chemical Formula	Concentration	ABS	CPVC	PP (PP-R, PP-RCT)	PVC	PE (MDPE, HDPE, PE-RT)	PB	PVDF	PEX	PA11, PA12	PA66	PSU	PPSU
CAS# 13780-03-5 $Ca(HSO_3)_2$	Saturated	---	---	---	---	---	---	R to 248	---	---	---	---	---
Calcium Carbonate $CaCO_3$	Saturated	---	R to 180	R to 180	R to 140	R to 140	R to 140	R to 248	R to 140	---	---	---	---
Calcium Chlorate **CAS# 10137-74-3** $Ca(ClO_3)_2 \bullet 2H_2O$	--	---	R to 180	R to 180	R to 140	R to 140	R to 140	R to 248	R to 140	---	---	---	---
Calcium Chloride **CAS# 10043-52-4** $CaCl_2$	Saturated	R to 120	R to 180	R to 180	R to 140	R to 140	R to 140	R to 248	R to 176	R to 194	---	---	---
Calcium Hydrogen Sulfide **CAS# 9046-53-1** $Ca(H_2S)$	>10%	---	---	---	---	---	---	R to 248	---	---	---	---	---
Calcium Hydroxide **CAS# 1305-62-0** $Ca(OH)_2$	--	R to 160	R to 180	R to 180	R to 140	R to 140	R to 140	R to 275	R to 140	---	---	---	---
	30%	---	---	---	---	R to 140	---	R to 275	R to 140	---	---	---	---
Calcium Hypochlorite **CAS# 7778-54-3** $Ca(OCl)_2$	30%	R to 160	R to 180	R to 140	R to 140	R to 140	R to 140	---	R to 140	---	---	---	---
	Saturated	---	---	---	---	---	---	L to 212	---	---	---	---	---
Calcium Nitrate **CAS# 10124-37-5** $Ca(NO_3)_2$	--	---	R to 180	R to 180	R to 140	R to 140	R to 140	---	R to 140	---	---	---	---
	50%	---	---	---	---	R to 140	---	R to 212	R to 140	---	---	---	---
	Saturated	---	---	---	---	---	---	R to 176	---	---	---	---	---
Calcium Oxide **CAS# 1305-78-8** CaO	--	---	R to 180	---	R to 140	R to 140	---	R to 250	R to 140	---	---	---	---
Calcium Sulfate **CAS# 7778-18-9** $CaSO_4$	--	R to 100	R to 180	R to 180	R to 140	R to 140	R to 140	R to 212	R to 140	---	---	---	---
Camphor **CAS# 76-22-2** $C_{10}H_{16}O$	--	N	---	R to 73	R to 73	R to 73	---	---	R to 73	---	R to 73	---	---
Cane Sugar Liquors (Sucrose) **CAS# 57-50-1** $C_{12}H_{22}O_{11}$	--	---	R to 180	R to 180	R to 140	R to 140	R to 150	R to 275	R to 140	---	---	---	---
Carbitol **CAS# 111-90-0** $CH_3CH_2O(CH_2)_2O(CH_2)_2OH$	--	---	N	---	R to 73	---	---	---	---	---	---	---	---
Carbon Dioxide **CAS# 124-38-9** CO_2	Dry 100%	R to 160	R to 180	R to 140	R to 140	R to 140	---	R to 212	R to 140	---	---	---	---
	Wet	R to 160	R to 180	R to 140	R to 140	R to 140	R to 140	---	R to 140	---	---	---	---

May not be fully applicable to pressurized applications

Chemical Formula	Concentration	ABS	CPVC	PP (PP-R, PP-RCT)	PVC	PE (MDPE, HDPE, PE-RT)	PB	PVDF	PEX	PA11, PA12	PA66	PSU	PPSU
Carbon Disulfide CAS# 75-15-0 CS_2	--	N	N	N	N	L to 140	---	---	L to 73	R to 104	---	N	---
Carbon Monoxide CAS# 630-08-0 CO	Gas	---	R to 180	R to 180	R to 140	R to 140	R to 140	R to 140	R to 140	---	---	---	---
Carbon Tetrachloride CAS# 56-23-5 CCl_4	--	N	N	N	R to 73	L to 73	N	L to 212	L to 68	N	---	N	---
Carbonic Acid CAS# 463-79-6 H_2CO_3	Saturated	R to 185	R to 180	R to 140	R to 140	R to 140	---	R to 275	R to 140	---	R to 73	---	---
Castor Oil CAS# 8001-79	--	---	L to 180	R to 140	R to 140	R to 73	R to 140	R to 285	R to 73	---	---	---	---
Caustic Potash CAS# 1310-58-3 KOH	50%	R to 160	R to 180	R to 180	R to 140	R to 140	R to 73	---	R to 140	---	---	---	---
Cellosolve CAS# 110-80-2	--	---	N	R to 73	R to 73	L to 120	R to 140	---	L to 120	---	---	N	---
Cellosolve Acetate CAS# 111-15-9 $CH_3COOCH_2CH_2OC_2H_5$	--	---	N	R to 73	R to 73	---	---	---	---	---	---	---	---
Chloral Hydrate CAS# 302-17-0 $CCl_3CH(OH)_2$	All	---	---	L to 73	R to 140	R to 120	R to 140	---	R to 120	---	---	---	---
Chloramine CAS# 10599-90-3 NH_2Cl	Dilute	---	R to 180	R to 73	R to 73	R to 73	---	---	R to 73	---	N	---	---
Chloric acid CAS# 7790-93-4 $HClO_3$	10%	---	R to 180	R to 73	R to 140	R to 73	---	---	R to 73	---	---	---	---
	20%	---	R to 185	R to 73	R to 140	R to 73	---	---	R to 73	---	---	---	---
Chlorine Gas CAS# 7782-50-5 Cl_2	0-20 PPM moisture content	N	L to 73	N	L to 73	L to 73	---	R to 200 with sunlight cover or pigmented pipe	L to 73	---	---	---	---
	20-50 PPM moisture content	N	L to 73	N	N	L to 73	---	R to 200 with sunlight cover or pigmented pipe	L to 73	---	---	---	---

Chemical Formula	Concentration	ABS	CPVC	PP (PP-R, PP-RCT)	PVC	PE (MDPE, HDPE, PE-RT)	PB	PVDF	PEX	PA11, PA12	PA66	PSU	PPSU
	50+ PPM moisture content	N	L to 73	N	N	L to 73	---	R to 200 with sunlight cover or pigmented pipe	L to 73	---	---	---	---
Chloroacetic Acid **CAS# 79-11-8** $CH_2ClCOOH$	50%	N	N	L to 73	R to 140	R to 120	N	N	R to 120	---	---	---	---
	>10%	---	---	---	---	---	---	R to 140 with sunlight cover or pigmented pipe	---	---	---	---	---
Chloroacetyl Chloride **CAS# 79-04-9** $ClCH_2COCl$	--	---	N	---	R to 73	---	---	---	---	---	---	---	---
Chlorobenzene **CAS# 108-90-7** C_6H_5Cl	Dry	N	N	R to 73	N	L to 73	N	R to 170 with sunlight cover or pigmented pipe	L to 73	---	---	---	---
	Liquid	---	---	---	---	---	---	R to 170 with sunlight cover or pigmented pipe	R to 68	L to 176	R to 73	---	---
Chlorobenzyl Chloride **CAS# 104-83-6** $ClC_6H_4CH_2Cl$	--	---	N	---	N	L to 120	---	R to 125	L to 120	---	---	---	---
Chloroethanol **CAS# 107-07-3** $ClCH_2CH_2OH$	Liquid	---	N	---	---	---	N	R to 122	---	---	---	---	---
Chloroform **CAS# 67-66-3** $CHCl_3$	Dry	N	N	N	N	L to 73	L to 73	---	N	---	N	N	---
	Liquid	---	---	---	---	---	---	R to 212	N	---	---	---	---
Chloromethane **CAS# 74-87-3** CH_3Cl	Gas	---	N	---	---	---	---	R to 212	---	---	---	---	---

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Chemical Formula	Concentration	ABS	CPVC	PP (PP-R, PP-RCT)	PVC	PE (MDPE, HDPE, PE-RT)	PB	PVDF	PEX	PA11, PA12	PA66	PSU	PPSU
Chloropicrin CAS# 76-06-2 CCl_3NO_2	--	---	N	---	N	R to 73	---	R to 150	R to 73	---	---	---	---
Chlorosulfonic Acid CAS# 7790-94-5 $ClSO_2OH$	--	---	R to 73	N	R to 73	L to 120	N	---	N	---	---	---	---
	50%	---	---	---	---	---	---	R to 68 with sunlight cover or pigmented pipe	---	---	---	---	---
	100%	---	---	---	---	N	---	N	N	---	---	---	---
Chromic Acid CAS# 7738-94-5 H_2CrO_4	Saturated	---	---	---	---	---	---	R to 212	---	---	---	---	---
	10%	R to 73	R to 180	R to 140	R to 140	R to 73	R to 140	R to 212	R to 73	N	---	N	N
	30%	N	R to 180	R to 73	R to 140	R to 73	R to 140	R to 212	R to 73	---	---	N	N
	40%	N	R to 180	R to 73	R to 140	R to 73	R to 73	R to 212	R to 73	---	---	N	N
	50%	N	L to 140	R to 73	N	R to 73	N	R to 212	R to 73	---	---	N	N
Chromium Potassium Sulfate (dodecahydrate) CAS# 7788-99-0 $CrK(SO_4)_2 \cdot 12H_2O$	>10%	---	---	---	---	---	---	R to 212	---	---	---	---	---
	--	---	---	R to 73	---	R to 73	---	---	R to 73	---	---	---	---
	Saturated	---	---	---	---	---	R to 212	---	---	---	---	---	---
Citric Acid CAS# 77-92-9 $C_6H_8O_7$	Saturated	R to 160	R to 180	R to 140	R to 140	R to 140	R to 140	R to 248	R to 140	L to 140	---	---	L
Coconut Oil CAS# 8001-31-8	--	---	L to 180	R to 73	R to 140	R to 73	R to 140	R to 248	R to 73	---	---	---	---
Cod Liver Oil	Work Sol.	---	L to 180	---	---	---	---	R to 248	---	---	---	---	---
Coffee	--	---	R to 180	R to 140	R to 140	R to 140	---	---	R to 140	---	---	R to 203	R to 203
Coke Oven Gas	--	---	---	R to 73	R to 140	R to 140	---	---	R to 140	---	---	---	---
Copper Acetate CAS# 142-71-2 $Cu(C_2H_3O_2)_2 \cdot H_2O$	Saturated	---	R to 73	R to 73	R to 73	---	---	R to 250	---	---	---	---	---
Copper Carbonate CAS # 12069-69-1 $CuCO_3$	Saturated	---	R to 180	---	R to 140	R to 140	---	R to 285	R to 140	---	---	---	---
Copper Chloride CAS# 7447-39-4 $CuCl_2$	Saturated	R to 73	R to 180	R to 140	R to 140	R to 140	R to 140	R to 285	R to 140	---	---	---	---

Chemical Formula	Concentration	ABS	CPVC	PP (PP-R, PP-RCT)	PVC	PE (MDPE, HDPE, PE-RT)	PB	PVDF	PEX	PA11, PA12	PA66	PSU	PPSU
Copper Cyanide **CAS# 544-92-3** $CuCN$	Saturated	---	R to 180	---	R to 140	R to 140	R to 140	R to 212	R to 140	---	---	---	---
Copper Fluoride Dihydrate **CAS# 13454-88-1** $CuF_2 \cdot 2H_2O$	2%	---	R to 180	R to 73	R to 140	R to 140	R to 140	R to 250	R to 140	---	---	---	---
Copper Nitrate **CAS# 3251-23-8** $Cu(NO_3)_2 \cdot 3H_2O$	30%	---	R to 180	R to 140	R to 140	R to 140	R to 140	---	---	---	---	---	---
	50%	---	---	---	---	---	---	R to 212	---	---	---	---	---
Copper Sulfate **CAS#7758-99-8** $CuSO_4 \cdot 5H_2O$	Saturated	R to 120	R to 180	R to 120	R to 140	R to 140	R to 140	R to 212	R to 140	R to 194	---	---	---
Corn Oil **CAS# 8001-30-7**	--	---	L to 180	R to 73	R to 140	R to 120	---	R to 285	R to 120	---	---	R to 200	---
Corn Syrup **CAS# 8029-43-4** C6H12O6	--	---	R to 185	R to 140	R to 140	R to 140	---	R to 250	R to 140	---	---	---	---
Cottonseed Oil **CAS# 8001-29-4**	--	R to 120	L to 180	R to 140	R to 140	R to 140	R to 140	R to 285	R to 140	---	---	---	---
Creosote	--	---	N	R to 73	N	R to 140	---	---	R to 140	---	---	---	---
Cresol **CAS# 95-48-7** $CH_3C_6H_4OH$	90%	N	N	R to 73	N	R to 73	N	R to 68	R to 73	---	---	---	---
Cresylic Acid **CAS# 106-44-5**	50%	---	N	---	R to 140	L to 73	N	R to 150	L to 73	---	---	---	---
Crotonaldehyde **CAS# 123-73-9** $CH_3CH{=}CHCHO$	--	---	N	L to 73	N	---	---	---	---	---	---	---	---
	Liquid	---	---	---	---	---	---	R to 104	--	---	---	---	---
Crude Oil **CAS# 8002-05-9**	--	---	L to 180	R to 140	R to 140	L to 120	L to 73	R to 212	L to 120	R to 140	---	---	---
Cupric Fluoride See Copper Fluoride Dihydrate											---		
Cupric Sulfate **CAS# 7758-99-8** $CuSO_4 \cdot 5H_2O$	Saturated	R to 100	R to 180	R to 73	R to 140	R to 140	---	---	---	---	---	---	---
Cuprous Chloride **CAS# 7758-89-6** $CuCl$	Saturated	R to 70	R to 180	---	R to 140	R to 140	---	R to 250	R to 140	---	---	---	---
Cyclohexane **CAS# 110-82-7** C_6H_{12}	--	R to 73	R to 73	N	N	N	---	R to 275	N	L to 140	---	N	---

Chemical Formula	Concentration	ABS	CPVC	PP (PP-R, PP-RCT)	PVC	PE (MDPE, HDPE, PE-RT)	PB	PVDF	PEX	PA11, PA12	PA66	PSU	PPSU
Cyclohexanol **CAS# 108-93-0** $C_6H_{11}OH$	--	L to 120	L to 73	R to 140	N	R to 73	L to 73	R to 104	R to 73	---	---	---	---
Cyclohexanone **CAS# 108-94-1** $C_6H_{10}O$	Liquid	N	N	R to 73	N	R to 120	N	R to 75	R to 73	L to 140	---	---	---
Detergents (Heavy Duty)	--	---	L to 180	R to 180	R to 140	R to 140	---	---	R to 140	---	---	---	---
Dextrin (Starch Gum) **CAS# 9004-53-9**	Saturated	---	R to 180	R to 140	R to 140	R to 140	R to 140	R to 250	R to 140	---	---	---	---
Dextrose **CAS# 50-99-7** $C_6H_{12}O_6$	Saturated	---	R to 180	R to 140	R to 140	R to 140	R to 140	---	R to 140	---	---	---	---
Diacetone Alcohol **CAS# 123-42-2** $CH_3COCH_2C(CH_3)_2OH$	--	---	N	R to 120	N	---	---	R to 75	---	L to 140	---	N	N
Dibutoxyethyl Phthalate **CAS# 117-83-9** $C_{20}H_{30}O_6$	--	---	N	---	N	---	---	---	---	---	---	---	---
n-Dibutyl Ether **CAS# 142-96-1** $C_4H_9OC_4H_9$	--	---	N	---	---	R to 73	---	---	R to 73	---	---	---	---
Dibutyl Phthalate **CAS# 84-74-2** $C_6H_4(COOC_4H_9)_2$	--	N	N	R to 73	N	R to 73	---	N	R to 73	---	---	N	---
Dibutyl Sebacate **CAS# 109-43-3** $C_4H_9OCO(CH_2)_8OCOC_4H_9$	--	---	N	R to 73	R to 73	R to 73	---	N	R to 73	---	---	---	---
Dichloroacetic Acid **CAS# 79-43-6** $CHCl_2COOH$	50%	---	N	---	---	---	---	R to 176	---	---	---	---	---
Dichlorobenzene **CAS# 25321-22-6** $C_6H_4Cl_2$	--	N	N	L to 73	N	L to 120	---	---	L to 120	---	---	N	---
	Liquid	---	---	---	---	---	---	R to 140	---	---	---	---	---
Dichloroethylene **CAS# 75-35-4** $C_2H_2Cl_2$	--	---	N	L to 73	N	L to 120	---	---	L to 120	---		---	---
	Liquid	---	---	---	---	---	---	R to 248	---	---	---	---	---
Diesel Fuels	--	---	L to 180	R to 140	R to 140	R to 73	L to 73	R to 212	R to 73	---	R to 73	R to 122	R to 122
Diethanolamine **CAS# 111-42-2** $(CH_2CH_2OH)_2NH$	Solid	---	---	---	---	---	---	N	---	---	---	---	---
	20%	---	---	---	---	---	---	---	---	---	---	---	---

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Chemical Formula	Concentration	ABS	CPVC	PP (PP-R, PP-RCT)	PVC	PE (MDPE, HDPE, PE-RT)	PB	PVDF	PEX	PA11, PA12	PA66	PSU	PPSU
Diethylamine **CAS# 109-89-7** $C_4H_{10}NH$	--	N	N	---	N	L to 120	N	N	L to 120	---	---	---	---
Diethyl Ether **CAS# 60-29-7** $C_4H_{10}O$	--	N	N	R to 73	R to 73	L to 140	---	---	L to 140	R to 140	---	N	---
Diglycolic Acid **CAS# 110-99-6** $O(CH_2COOH)_2$	Saturated	---	R to 73	R to 140	R to 140	R to 140	R to 140	---	R to 140	---	---	---	---
	10%	---	---	---	---	---	---	R to 140	---	---	---	---	---
Dimethylamine **CAS# 124-40-3** $(CH_3)_2NH$	--	---	N	R to 73	R to 140	R to 73	N	N	R to 73	---	---	---	---
Dimethylformamide **CAS# 68-12-2** $HCON(CH_3)_2$	--	N	N	R to 180	N	R to 120	---	N	R to 120	---	---	---	---
	Liquid	---	---	---	---	---	---	N	N	---	---	---	---
Dimethylhydrazine **CAS# 57-14-7** $(CH_3)_2NNH_2$	--	---	N	---	N	---	---	---	---	---	---	---	---
Dimethyl Phthalate **CAS# 131-11-3** $C_6H_4(COOCH_3)_2$	--	---	N	---	---	L to 73	---	R to 75	L to 73	---	---	---	---
Dioctyl Phthalate **CAS# 117-81-7** $C_6H_4(COOC_8H_{17})_2$	--	N	N	L to 73	N	L to 73	L to 73	---	L to 73	R to 140	---	R to 73	---
Dioxane **CAS# 123-91-1** $C_4H_8O_2$	--	--	N	L to 140	N	R to 140	---	---	R to 140	---	---	---	---
	Liquid	---	---	---	---	---	---	L to 68	---	---	---	---	---
Diphenyl Oxide **CAS# 101-84-8** $(C_6H_5)_2O$	Saturated	---	---	---	---	L to 73	---	---	L to 73	---	---	---	---
Disodium Phosphate **CAS# 7558-79-4** Na_2HPO_4	--	---	R to 180	R to 140	R to 140	R to 140	R to 140	---	R to 140	---	---	---	---
DOWTHERM A ethyl glycol **CAS# 110-80-5**	--	---	---	---	N	---	---	---	R to 180	---	---	---	---
Ethanol **CAS# 64-17-5** C_2H_5OH	40%	---	L to 140	---	---	---	---	R to 68	---	---	---	---	---
	95%	---	L to 140	---	---	---	---	R to 122	R to 140	---	---	---	---
	Liquid	---	L to 140	---	---	---	---	R to 122	R to 140	---	---	R to 122	---
Ether **CAS# 60-29-7** ROR	--	N	N	L to 73	N	R to 73	N	---	R to 73	---	---	---	---

Chemical Formula	Concentration	ABS	CPVC	PP (PP-R, PP-RCT)	PVC	PE (MDPE, HDPE, PE-RT)	PB	PVDF	PEX	PA11, PA12	PA66	PSU	PPSU
Ethyl Acetate **CAS# 141-78-6** $CH_3COOCH_2CH_3$	--	N	N	L to 140	N	R to 73	L to 73	---	R to 73	R to 140	---	N	---
	Liquid	---	---	---	---	---	---	L to 68	---	---	---	---	---
Ethyl Acetoacetate **CAS# 141-97-9** $CH_3COCH_2COOC_2H_5$	--	N	N	---	N	---	---	L to 75	---	---	---	---	---
Ethyl Acrylate **CAS# 140-88-5** $CH_2{=}CHCOOC_2H_5$	--	---	N	---	N	---	---	L to 75	---	---	---	---	---
Ethyl Alcohol-See Ethanol											---		
Ethyl Benzene **CAS# 100-41-4** $C_6H_5C_2H_5$	--	---	N	L to 73	N	L to 73	---	R to 125	---	---	---	---	---
Ethyl Chloride **CAS# 75-00-3** C_2H_5Cl	Dry	---	N	L to 73	N	L to 73	---	---	L to 73	---	---	---	---
	Gas	---	---	---	---	---	---	R to 212	---	---	---	---	---
Ethyl Chloroacetate **CAS# 105-39-5** $ClCH_2COOC_2H_5$	--	---	N	---	N	---	---	---	---	---	---	---	---
Ethyl Ether **CAS# 60-29-7** $(C_2H_5)_2O$	Liquid	---	N	N	N	N	N	R to 122	N	---	---	---	---
Ethylene Bromide **CAS# 106-93-4** $BrCH_2CH_2Br$	Dry	---	N	---	N	---	N	---	---	---	---	---	---
Ethylene Chloride **CAS# 75-01-4** (Vinyl Chloride) CH_2CHCl	Dry	N	N	L to 73	N	L to 140	---	R to 285	L to 140	---	---	N	---
Ethylene Chlorohydrin **CAS# 107-07-3** $ClCH_2CH_2OH$	--	---	N	R to 73	N	---	N	---	---	---		---	---
	Liquid	---	---	---	---	---	---	L to 68	---	---	---	---	---
Ethylene Diamine **CAS# 107-15-3** $NH_2CH_2CH_2NH_2$	--	N	N	R to 73	N	R to 140	---	---	R to 140	---	---	---	---
Ethylene Dichloride **CAS# 107-06-2** $C_2H_4Cl_2$	Dry	N	N	L to 140	N	L to 73	R to 140	---	L to 73	---	---	---	---
Ethylene Glycol **CAS# 107-21-1** $OHCH_2CH_2OH$	Liquid	R to 73	L to 180	R to 212	R to 140	R to 140	R to 140	R to 212	R to 212	---	---	R to 73	---
	50% Solution	---	R to 180	---	---	---	---	---	---	---	---	R to 248	---

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Chemical Formula	Concentration	ABS	CPVC	PP (PP-R, PP-RCT)	PVC	PE (MDPE, HDPE, PE-RT)	PB	PVDF	PEX	PA11, PA12	PA66	PSU	PPSU
Ethylene Oxide **CAS# 75-21-8** CH_2CH_2O	--	---	N	L to 73	N	R to 73	---	R to 200	R to 73	L to 140	---	---	---
2-Ethylhexanol **CAS# 104-76-7** $CH_3(CH_2)_3CHC_2H_5CH_2OH$	--	---	---	---	---	R to 73	---	R to 250	R to 73	---	---	---	---
Fatty Acids R-COOH	--	R to 160	R to 73	R to 120	R to 140	R to 120	R to 150	R to 285	R to 120	R to 194	---	---	---
Ferric Chloride (Aqueous) **CAS# 10025-77-1** $FeCl_3$	Saturated	R to 120	R to 180	R to 140	R to 140	R to 140	R to 150	R to 212	R to 140	---	---	---	---
Ferric Hydroxide **CAS# 1309-33-7** $Fe(OH)_3$	Saturated	R to 160	R to 180	R to 140	R to 140	R to 140	---	R to 250	R to 140	---	---	---	---
Ferric Nitrate **CAS# 10421-48-4** $Fe(NO_3)_3$	Saturated	R to 160	R to 180	R to 140	R to 140	R to 140	R to 140	R to 212	R to 140	---	---	---	---
Ferric Sulfate **CAS# 10028-22-5** $Fe_2(SO_4)_3$	--	R to 160	R to 180	R to 140	R to 140	R to 140	R to 140	---	R to 140	---	---	---	---
	Saturated	---	---	---	---	---	---	R to 212	---	---	---	---	---
Ferrous Chloride **CAS# 7758-94-3** $FeCl_2$	Saturated	R to 160	R to 180	R to 140	R to 140	R to 140	R to 140	R to 212	R to 140	---	---	---	---
Ferrous Hydroxide **CAS# 18624-44-7** $Fe(OH)_2$	Saturated	R to 160	R to 180	R to 140	R to 140	R to 140	---	R to 250	R to 140	---	---	---	---
Ferrous Nitrate $Fe(NO_3)_2$	--	R to 160	R to 180	R to 140	R to 140	R to 140	---	R to 275	R to 140	---	---	---	---
Ferrous Sulfate **CAS# 7720-78-7** $FeSO_4$	--	R to 160	R to 180	R to 140	R to 140	R to 140	R to 140	---	R to 140	---	---	---	---
	Saturated	---	---	---	---	---	---	R to 212	---	---	---	---	---
Fish Oil **CAS# 8016-13-5**	---	---	L to 180	R to 180	R to 140	R to 140	R to 140	R to 200	R to 140	---	---	---	---
Fluoroboric Acid **CAS# 16872-11-0** HBF_4	---	R to 73	R to 73	R to 140	R to 140	R to 140	---	---	R to 140	---	---	---	---
	Solid	---	---	---	---	---	---	R to 104	---	---	---	---	---
Fluorine Gas (Dry) **CAS# 7782-41-4** F_2	100%	---	L to 73	N	R to 73	L to 73	L to 73	---	L to 73	N	N	---	---
Fluorine Gas (Wet) **CAS# 7782-41-4** F_2	--	N	L to 73	N	R to 73	N	N	---	N	N	N	---	---

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Chemical Formula	Concentration	ABS	CPVC	PP (PP-R, PP-RCT)	PVC	PE (MDPE, HDPE, PE-RT)	PB	PVDF	PEX	PA11, PA12	PA66	PSU	PPSU
Fluorosilicic Acid **CAS# 16961-83-4** H_2SiF_6	30%	---	R to 180	R to 140	R to 140	R to 140	---	R to 212	R to 140	---	---	---	---
	40%	---	R to 180	---	---	---	---	R to 140	---	---	---	---	---
	50%	---	R to 180	R to 73	R to 140	R to 140	R to 140	R to 212	--	---	---	---	---
	Saturated	---	R to 180	---	---	---	---	R to 212	---	---	---	---	---
Formaldehyde **CAS# 50-00-0** HCHO	Dilute	R to 160	R to 73	R to 140	R to 140	R to 140	R to 140	R to 176	---	L to 104	---	---	---
	35%	R to 160	N	R to 140	R to 140	R to 140	R to 140	---	R to 140	---	---	R to 100	---
	37%	R to 160	N	R to 140	R to 140	R to 140	R to 140	R to 212	R to 140	---	---	---	---
	50%	---	N	---	R to 140	R to 140	R to 140	---	R to 140	---	---	---	---
Formic Acid **CAS# 64-18-6** HCOOH	10%	---	R to 180	---	---	---	---	R to 212	R to 140	N	N	---	---
	40%	---	---	---	---	---	---	R to 212	R to 140	---	---	---	---
	50%	---	---	---	---	---	---	R to 176	R to 140	---	---	---	---
	85%	---	---	---	---	---	---	R to 212	---	---	---	R to 122	---
	100%	N	L to 73	R to 140	R to 73	R to 140	R to 150	---	R to 140	---	---	---	---
Freon 11 **CAS# 75-69-4** CCl_3F	100%	N	N	N	R to 140	R to 73	---	---	R to 73	---	---	---	---
Freon 12 **CAS# 75-71-8** CCl_2F_2	100%	---	N	R to 73	R to 140	R to 73	---	---	R to 73	R to 68	---	R to 73	---
	Work. Sol.	---	N	---	---	---	---	R to 212	R to 68	---	---	---	---
Freon 21 **CAS# 75-43-4** $CHCl_2F$	100%	---	N	N	N	L to 120	---	---	L to 120	---	---	---	---
Freon 22 **CAS# 75-45-6** $CHClF_2$	100%	---	N	R to 73	N	L to 120	---	---	L to 120	R to 68	---	N	---
Freon 113 **CAS# 76-13-1** $C_2Cl_2F_3$	100%	---	N	N	R to 140	R to 73	---	---	R to 73	---	---	---	---
Freon 114 **CAS# 76-14-2** $C_2Cl_2F_4$	100%	---	N	N	R to 140	R to 73	---	---	R to 73	---	---	---	---
Fructose **CAS# 57-48-7** $C_6H_{12}O_6$	Saturated	R to 73	R to 180	R to 180	R to 140	R to 140	R to 140	R to 285	R to 140	---	---	---	---
Fruit Juice	Work. Sol.	---	---	---	---	---	---	R to 212	---	R to 104	R to 73	---	---

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Chemical Formula	Concentration	ABS	CPVC	PP (PP-R, PP-RCT)	PVC	PE (MDPE, HDPE, PE-RT)	PB	PVDF	PEX	PA11, PA12	PA66	PSU	PPSU
Furfural **CAS# 98-01-1** C_4H_3OCHO	100%	N	N	N	N	L to 140	---	L to 75	L to 140	L to 140	---	---	---
Gallic Acid **CAS# 149-91-7** $C_6H_2(OH)_3COOH \cdot H_2O$	--	---	R to 180	---	R to 140	R to 73	---	L to 75	R to 73	---	---	---	---
Gasoline, Leaded	--	N	N	N	R to 140	R to 73	N	R to 285	R to 73	---	---	---	---
Gasoline, Unleaded	--	N	N	N	R to 140	R to 73	N	---	R to 73	---	---	---	R to 122
Gasoline (Fuel) **CAS# 8006-61-9**	--	---	---	---	---	---	---	R to 212	---	R to 160	---	---	R to 122
Gasohol	--	N	N	N	R to 140	R to 73	N	---	R to 73	---	---	---	R to 122
Gasoline, Sour	--	N	N	N	R to 140	L to 73	N	R to 285	L to 73	---	---	---	---
Gelatin **CAS# 9000-70-8**	--	---	R to 180	R to 180	R to 140	R to 140	R to 140	---	R to 140	---	---	---	---
Glucose **CAS# 50-99-7** $C_6H_{12}O_6 \cdot H_2O$	--	R to 120	R to 180	R to 212	R to 140	R to 140	R to 140	---	R to 140	---	---	---	---
	10%	---	---	---	---	---	---	R to 248	---	---	---	---	---
Glycerine **CAS# 56-81-5** $C_3H_5(OH)_3$	--	R to 140	R to 180	R to 212	R to 140	R to 140	R to 140	---	R to 140	---	---	R to 73	---
	Liquid	---	---	---	---	---	---	R to 248	---	---	---	---	---
Glycolic Acid **CAS# 79-14-1** $OHCH_2COOH$	Saturated	---	N	R to 73	R to 140	R to 140	---	---	R to 140	---	---	---	---
	10%	---	---	---	---	---	---	R to 212	---	---	---	---	---
	30%	---	---	---	---	---	---	R to 140	---	---	---	---	---
	65%	---	---	---	---	---	---	R to 212	---	---	---	---	---
Glyoxal **CAS# 107-22-2** OCHCHO	--	---	---	---	---	R to 140	---	---	R to 140	---	---	---	---
Grape Sugar **CAS# 50-99-7**	--	---	R to 180	---	R to 140	---	---	---	---	---	---	---	---
Grapefruit Juice	Work. Sol.	---	---	---	---	---	---	R to 122	---	---	---	---	---
Grease	--	---	---	---	---	---	---	R to 250	---	R to 194	---	---	---
Green Liquor	--	R to 160	R to 180	---	R to 140	---	R to 140	---	---	---	---	---	---
n-Heptane **CAS# 142-82-5** C_7H_{16}	Liquid	R to 73	R to 73	N	R to 140	R to 73	N	R to 212	R to 73	---	---	N	---
n-Hexane **CAS# 110-54-3** C_6H_{14}	Liquid	L	R to 73	R to 73	R to 73	---	---	R to 176	---	---	R to 73	R to 73	---

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Chemical Formula	Concentration	ABS	CPVC	PP (PP-R, PP-RCT)	PVC	PE (MDPE, HDPE, PE-RT)	PB	PVDF	PEX	PA11, PA12	PA66	PSU	PPSU
Hexanol, Tertiary Type I **CAS# 25917-35-5** $CH_3(CH_2)_4CH_2OH$	--	---	L to 180	---	R to 140	R to 140	R to 140	R to 175	R to 140	---	---	---	---
Hydraulic Oil (Petroleum)	--	---	---	---	R to 73	R to 73	---	---	R to 73	---	---	---	---
Hydrazine **CAS# 302-01-2** H_2NNH_2	--	---	N	R to 73	N	---	---	R to 200	---	---	---	---	---
Hydrobromic Acid **CAS# 10035-10-6** HBr	20%	R to 73	R to 73	R to 140	R to 140	R to 140	R to 140	R to 212	R to 140	---	---	---	---
	50%	N	---	R to 120	---	R to 140	---	---	R to 140	---	---	---	---
	66%	---	---	---	---	---	---	R to 212	---	---	---	---	---
Hydrochloric Acid **CAS# 7647-01-0** HCl	10%	L to 120	R to 180	R to 140	R to 140	R to 140	R to 140	R to 212	R to 212	L to 104	---	---	---
	20%	---	---	---	---	---	---	R to 212	R to 212	---	---	---	R to 212
	30%	L to 73	R to 180	R to 140	R to 140	R to 140	R to 140	R to 212	R to 140	---	---	R to 140	R to 122
	Conc.	---	---	---	---	---	---	---	R to 140	---	---	---	---
Hydrocyanic Acid **CAS# 74-90-8** HCN	--	R to 160	R to 73	R to 73	R to 140	R to 140	R to 140	---	R to 140	---	---	---	---
	Saturated	---	---	---	---	---	---	R to 248	---	---	---	---	---
	10%	---	---	---	---	---	---	R to 248	---	---	---	---	---
Hydrofluoric Acid **CAS# 7664-39-3** HF	Dilute	R to 73	R to 180	R to 180	R to 73	R to 140	R to 140	R to 212	R to 140	---	---	---	---
	30%	N	L to 180	R to 140	R to 73	R to 140	R to 140	---	R to 140	---	---	---	---
	50%	N	N	R to 73	R to 73	R to 120	R to 140	R to 212	R to 120	---	---	---	---
	60%	---	---	---	---	R to 140	---	R to 140	R to 140	---	---	---	---
	70%	---	---	---	---	---	---	R to 212	---	---	---	---	---
	100%	N	N	L to 73	N	R to 120	---	---	R to 120	---	---	---	---
	Gas	---	---	---	---	---	---	R to 104	---	---	---	---	---
Hydrogen **CAS# 1333-74-0** H_2	Gas	---	R to 73	R to 140	R to 140	R to 140	R to 140	R to 248	R to 140	R to 194	---	---	---
Hydrogen Cyanide **CAS# 74-90-8** HCN	--	---	---	R to 73	R to 140	---	---	R to 275	---	---	---	---	---
Hydrogen Fluoride, Anhydrous **CAS# 7664-39-3** HF	--	---	L	R to 73	N	---	---	R to 200	---	---	---	---	---

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Chemical Formula	Concentration	ABS	CPVC	PP (PP-R, PP-RCT)	PVC	PE (MDPE, HDPE, PE-RT)	PB	PVDF	PEX	PA11, PA12	PA66	PSU	PPSU
Hydrogen Peroxide **CAS# 7722-84-1** H_2O_2	10%	---	R to 180	---	---	---	---	R to 212	---	---	N	---	---
	30%	---	R to 180	---	---	---	---	R to 212	---	L to 104	---	R to 73	R to 73
	50%	---	R to 120	R to 73	R to 140	R to 140	N	R to 212	R to 140	---	---	---	---
	90%	---	---	L to 73	R to 140	R to 73	N	---	R to 73	---	---	R to 73	---
Hydrogen Phosphide (Type I) **CAS # 7803-51-2** PH_3	--	---	R to 73	---	R to 140	R to 140	R to 140	---	R to 140	---	---	---	---
Hydrogen Sulfide **CAS# 7783-06-4** H_2S	Dry	---	R to 180	R to 150	R to 140	R to 140	R to 140	R to 248	R to 140	---	---	---	---
	Wet	---	R to 180	---	R to 140	R to 140	---	---	R to 180, L to 212	---	---	---	---
Hydrogen Sulfite **CAS# 15181-46-1** HO_3S	10%	---	---	---	---	R to 140	---	R to 248	R to 140	---	---	---	---
Hydroquinone **CAS# 123-31-9** $C_6H_4(OH)_2$	Saturated	---	R to 73	---	R to 140	R to 140	R to 140	R to 250	---	R to 140	---	---	---
Hydroxylamine Sulfate **CAS# 10039-54-0** $(NH_2OH) \bullet H_2SO_4$	--	---	---	---	R to 140	R to 140	---	---	R to 140	---	---	---	---
Hypochlorous Acid **CAS# 7790-92-3** HOCl	10%	R to 73	L to 180	R to 73	R to 140	R to 140	R to 140	---	R to 140	---	---	---	---
	70%	---	---	---	---	---	---	R to 212	---	---	---	---	---
Inks	--	---	---	R to 140	---	R to 140	---	---	R to 140	---	---	---	---
Iodine **CAS# 7553-56-2** I_2	10%	N	R to 73	R to 73	N	L to 120	N	R to 176	L to 120	---	---	---	---
IRM 901 Oil (ASTM #1)	--	---	180	L to 140	R to 140	R to 73	R to 140	R to 248	R to 73	---	---	---	---
IRM 902 Oil (ASTM #2)	--	---	180	L to 140	R to 140	R to 73	R to 140	---	R to 73	---	---	---	---
IRM 903 Oil (ASTM #3)	--	---	180	L to 140	R to 140	R to 73	R to 140	---	R to 73	---	---	---	---
Isobutyl Alcohol **CAS# 78-83-1** $(CH_3)_2CHCH_2OH$	--	L to 73	L to 73	R to 73	---	R to 140	---	R to 250	R to 140	---	---	---	---
Isooctane **CAS# 540-84-1** $(CH_3)_3CCH_2CH(CH_3)_2$	Liquid	---	---	L to 73	---	R to 73	---	R to 212	R to 73	---	---	---	---
Isopropyl Acetate **CAS# 108-21-4** $CH_3COOCH(CH_3)_2$	--	N	N	---	---	R to 73	---	---	R to 73	---	---	---	---

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Chemical Formula	Concentration	ABS	CPVC	PP (PP-R, PP-RCT)	PVC	PE (MDPE, HDPE, PE-RT)	PB	PVDF	PEX	PA11, PA12	PA66	PSU	PPSU
Isopropyl Alcohol **CAS# 67-63-0** $(CH_3)_2CHOH$	--	---	L to 180	R to 212	R to 140	R to 140	R to 140	L to 212	R to 140	---	---	---	---
Isopropyl Ether **CAS# 108-20-3** $(CH_3)_2CHOCH(CH_3)_2$	--	---	N	L to 73	N	R to 73	---	R to 125	R to 73	---	---	---	---
JP-4 Fuel	--	---	L to 73	L to 73	R to 140	R to 73	---	R to 200	R to 73	---	---	R to 73	---
JP-5 Fuel	--	---	L to 73	L to 73	R to 140	R to 73	---	R to 200	R to 73	---	---	---	---
Kerosene **CAS# 8008-20-6**	--	R to 73	N	L to 140	R to 140	L to 140	L to 73	R to 285	L to 140	---	---	---	---
Ketchup	--	---	R to 180	---	R to 73	---	---	R to 285	---	---	---	R to 72	---
Ketones	--	N	N	L to 73	N	R to 73	---	---	R to 73	---	---	---	---
Kraft Liquors	--	R to 73	R to 180	---	R to 140	R to 120	R to 140	---	R to 120	---	---	---	---
Lactic Acid **CAS# 50-21-5** $CH_3CHOHCOOH$	10%	---	---	---	---	---	---	R to 140	---	---	---	---	---
	25%	R to 73	R to 180	R to 212	R to 140	R to 140	R to 140	---	R to 140	---	---	---	---
	80%	N	L to 180	R to 140	R to 73	R to 140	---	---	R to 140	---	---	---	---
	Liquid	---	---	---	---	---	---	R to 212	---	R to 194	---	---	---
Lard Oil	--	---	L to 180	---	R to 140	L to 120	R to 73	---	L to 120	---	---	---	---
Latex	--	---	---	R to 140	---	R to 140	---	---	R to 140	---	---	---	---
Lauric Acid **CAS# 143-07-7** $CH_3(CH_2)_{10}COOH$	--	---	L to 180	R to 140	R to 140	R to 120	---	R to 230	R to 120	---	---	---	---
Lauryl Chloride (Type I) **CAS# 112-52-7** $CH_3(CH_2)_{10}CH_2Cl$	--	---	N	---	R to 140	R to 120	R to 73	R to 248	R to 120	---	---	---	---
Lead Acetate (trihydrate) **CAS# 6080-56-4** $Pb(CH_3COO)_2 \cdot 3H_2O$	Saturated	---	R to 180	R to 180	R to 140	R to 140	R to 140	R to 212	R to 140	---	---	---	---
Lead Chloride **CAS# 7758-95-4** $PbCl_2$	--	---	R to 180	R to 140	R to 140	R to 120	---	R to 250	R to 120	---	---	---	---
Lead Nitrate **CAS# 10099-74-8** $Pb(NO_3)_2$	Saturated	---	R to 180	R to 140	R to 140	R to 120	---	R to 250	R to 120	---	---	---	---
Lead Sulfate **CAS# 7446-14-2** $PbSO_4$	--	---	R to 180	R to 140	R to 140	R to 120	---	R to 250	R to 120	---	---	---	---

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Chemical Formula	Concentration	ABS	CPVC	PP (PP-R, PP-RCT)	PVC	PE (MDPE, HDPE, PE-RT)	PB	PVDF	PEX	PA11, PA12	PA66	PSU	PPSU
Lead Tetraethyl **CAS# 78-00-2** $C_8H_{20}Pb$	--	---	---	---	---	---	---	R to 212	---	---	---	---	---
Lemon Oil **CAS# 8008-56-8**	--	---	N	L to 73	---	---	---	R to 250	---	---	---	---	---
Lemon Juice	--	---	---	---	---	L to 140	---	R to 250	L to 140	---	---	R to 122	---
Ligroin (*Petroleum Ether*) **CAS# 8032-32-4**	--	---	---	R to 140	---	---	---	R to 212	---	---	---	---	---
Lime Slurry	--	---	---	---	---	R to 140	---	---	R to 140	---	---	---	---
Lime Sulfur **CAS# 1344-81-6**	--	---	R to 73	R to 73	R to 73	R to 120	R to 140	---	R to 120	---	---	---	---
Linoleic Acid **CAS# 60-33-3** $CH_3(CH_2)_4(CH{=}CHCH_2)_2(CH_2)_6COOH$	--	---	L to 180	R to 180	R to 140	---	R to 73	R to 250	---	---	---	---	---
Linoleic Oil (Type I)	--	---	---	---	R to 140	---	R to 73	---	---	---	---	---	---
Linseed Oil **CAS# 8001-26-1**	--	73	L to 180	R to 140	R to 140	R to 73	R to 73	R to 248	R to 73	R to 194	---	---	---
Liqueurs	--	---	---	R to 140	R to 140	R to 120	R to 140	---	R to 120	---	---	---	---
Lithium Bromide **CAS# 7550-35-8** LiBr	--	---	---	R to 140	R to 140	R to 140	---	R to 230	R to 140	---	---	---	---
	65%	---	R to 180	---	---	---	---	R to 230	---	---	---	R to 212	R to 212
Lithium Chloride **CAS# 7447-41-8** LiCl	--	---	R to 180	R to 140	R to 140	R to 120	---	R to 250	R to 120	---	---	---	---
Lithium Hydroxide **CAS# 1310-65-2** LiOH	--	---	R to 73	R to 140	---	R to 120	---	---	R to 120	---	---	---	---
Magnesium Carbonate **CAS# 546-93-0** $MgCO_3$	--	R to 120	R to 180	R to 212	R to 140	R to 140	R to 140	R to 212	R to 140	---	---	---	---
Magnesium Chloride **CAS# 7786-30-3** $MgCl_2$	Saturated	R to 120	R to 180	R to 140	R to 140	R to 140	R to 140	R to 140	R to 140	---	---	---	---
	50%	---	---	---	---	---	---	R to 212	----	R to 194	---	---	---
Magnesium Citrate **CAS# 6150-80-7** $MgC_6H_8O_7 \cdot 5H_2O$	--	---	R to 180	---	R to 140	R to 140	---	R to 250	R to 140	---	---	---	---
Magnesium Hydroxide **CAS# 1309-42-8** $Mg(OH)_2$	Saturated	R to 160	R to 180	R to 180	R to 140	R to 140	R to 140	R to 212	R to 140	---	---	---	---

Chemical Formula	Concentration	ABS	CPVC	PP (PP-R, PP-RCT)	PVC	PE (MDPE, HDPE, PE-RT)	PB	PVDF	PEX	PA11, PA12	PA66	PSU	PPSU
Magnesium Nitrate **CAS# 10377-60-3** $Mg(NO_3)_2 \cdot 2H_2O$	--	R to 160	R to 180	R to 212	R to 140	R to 140	R to 140	R to 248	R to 140	---	---	---	---
Magnesium Oxide **CAS# 1309-48-4** MgO	--	R to 160	R to 180	---	---	---	---	---	---	---	---	---	---
Magnesium Sulfate **CAS# 7487-88-9** $MgSO_4 \cdot 7H_2O$	--	R to 160	R to 180	R to 212	R to 140	R to 140	R to 140	R to 212	R to 140	---	---	---	---
Maleic Acid **CAS# 110-16-7** HOOCCH=CHCOOH	Saturated	R to 160	R to 180	R to 140	R to 140	R to 140	R to 140	R to 140	R to 140	---	---	---	---
	50%	---	---	---	---	---	---	R to 212	---	---	---	---	---
Malic Acid **CAS# 6915-15-7** $COOHCH_2CH(OH)COOH$	--	---	R to 180	R to 140	R to 140	R to 140	R to 140	R to 250	R to 140	---	---	---	---
Manganese Sulfate **CAS# 7785-87-7** $MnSO_4 \cdot 4H_2O$	--	---	R to 180	R to 180	R to 140	R to 140	---	R to 250	R to 140	---	---	---	---
Margarine	Work Sol.	---	---	---	---	---	---	R to 248	---	---	---	---	---
Mercuric Chloride **CAS# 7487-94-7** $HgCl_2$	--	---	R to 180	R to 180	R to 140	R to 140	R to 140	---	R to 140	---	---	---	---
	Saturated	--	---	---	---	---	---	R to 212	---	---	---	---	---
Mercuric Cyanide **CAS# 592-04-1** $Hg(CN)_2$	Saturated	---	R to 180	R to 140	R to 140	R to 140	R to 140	R to 212	R to 140	---	---	---	---
Mercuric Sulfate **CAS# 7783-35-9** $HgSO_4$	Saturated	---	R to 180	R to 140	R to 140	R to 140	---	---	R to 140	---	---	---	---
Mercurous Nitrate (Dihydrate) **CAS# 14836-60-3** $HgNO_3 \cdot 2H_2O$	10%	---	---	---	---	---	---	R to 212	---	---	---	---	---
	Saturated	---	R to 180	R to 140	R to 140	R to 140	R to 140	---	R to 140	---	---	---	---
Mercury **CAS# 7439-97-6** Hg	Liquid	---	R to 180	R to 140	R to 140	R to 140	R to 140	R to 248	R to 140	R to 194	---	---	---
Methane **CAS# 74-82-8** CH_4	--	N	R to 73	R to 73	R to 140	R to 140	---	R to 285	R to 140	R to 140	---	---	---
Methanol (Methyl Alcohol) **CAS# 67-56-1** CH_3OH	5%	---	R to 180	---	---	---	---	R to 140	---	---	---	---	---
	Liquid	---	N	R to 180	R to 140	R to 140	R to 140	L to 176	R to 140	---	R to 73	R to 73	---

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Chemical Formula	Concentration	ABS	CPVC	PP (PP-R, PP-RCT)	PVC	PE (MDPE, HDPE, PE-RT)	PB	PVDF	PEX	PA11, PA12	PA66	PSU	PPSU
Methoxyethyl Oleate **CAS# 111-10-4** $CH_3OCH_2CH_2OOCC_{17}H_{33}$	--	---	N	---	R to 73	---	---	---	---	---	---	---	---
Methyl Acetate **CAS# 79-20-9** $CH_3CO_2CH_3$	--	N	N	R to 140	N	L to 120	---	R to 100	L to 120	---	---	---	---
Methyl Acrylate **CAS# 96-33-3** $CH_2=CHCOOCH_3$	Tech Pure	---	N	---	---	R to 140	---	R to 100	R to 140	---	---	---	---
Methylamine **CAS# 74-89-5** CH_3NH_2	--	---	N	N	N	---	---	N	---	---	---	---	---
Methyl Bromide **CAS# 74-83-9** CH_3Br	--	---	N	N	N	L to 73	---	R to 285	L to 73	R to 68	---	---	---
Methyl Butyl Ketone **CAS# 591-78-6** $CH_3CO(CH_2)_3CH_3$	Liquid	---	N	---	---	---	---	L to 122	---	---	---	---	---
Methyl Cellosolve **CAS# 109-86-4** $HOCH_2CH_2OCH_3$	--	---	N	R to 73	N	L to 120	---	---	L to 120	---	---	---	---
Methyl Chloride **CAS# 74-87-3** CH_3Cl	Dry	N	N	N	N	L to 120	N	R to 285	L to 120	R to 68	---	---	---
Methyl Chloroform **CAS# 71-55-6** CH_3CCl_3	--	N	N	L to 73	N	L to 120	---	R to 125	L to 120	---	---	---	---
Methyl Ethyl Ketone (MEK) **CAS# 78-93-3** $CH_3COC_2H_5$	100%	N	N	R to 73	N	N	R to 73	L to 68	R to 73	L to 140	---	N	---
Methyl Isobutyl Carbinol **CAS# 108-11-2** $(CH_3)_2CHCH_2CH(CH_3)OH$	--	---	N	---	N	---	---	---	---	---	---	---	---
Methyl Isobutyl Ketone **CAS# 108-10-1** $(CH_3)_2CHCH_2COCH_3$	--	N	N	R to 73	N	R to 73	---	---	R to 73	---	---	---	---
Methyl Isopropyl Ketone **CAS# 563-80-4** $CH_3COCH(CH_3)_2$	--	---	N	---	N	R to 73	---	---	R to 73	---	---	---	---
Methyl Methacrylate **CAS# 80-62-6** $CH_2=C(CH_3)COOCH_3$	--	---	N	---	R to 73	R to 140	---	R to 68	R to 140	---	---	N	---

Chemical Formula	Concentration	ABS	CPVC	PP (PP-R, PP-RCT)	PVC	PE (MDPE, HDPE, PE-RT)	PB	PVDF	PEX	PA11, PA12	PA66	PSU	PPSU
Methyl Sulfate **CAS# 77-78-1** $(CH_3)_2SO_4$	--	---	R to 73	L to 73	R to 73	R to 140	---	---	---	R to 68	---	---	---
Methylene Bromide **CAS# 74-95-3** CH_2Br_2	--	---	N	N	N	L to 120	---	R to 175	L to 120	---	---	---	---
Methylene Chloride **CAS# 75-09-2** CH_2Cl_2	100%	---	N	N	N	N	R to 73	L to 104	N	---	N	N	---
Methylene Chlorobromide **CAS# 74-97-5** CH_2ClBr	--	---	N	--	N	---	---	---	---	---	---	---	---
Methylene Iodide **CAS# 75-11-6** CH_2I_2	--	---	N	N	N	L to 120	---	R to 200	L to 120	---	---	---	---
Methylsulfuric Acid **CAS# 75-93-4** CH_3HSO_4	--	---	---	R to 140	R to 140	---	---	R to 150	---	---	---	---	---
Milk	--	R to 160	L to 180	R to 212	R to 140	R to 140	R to 140	R to 212	R to 140	R to 194	R to 140	R to 200	---
Mineral Oil (Paraffin Oil) **CAS# 8012-95-1**	--	R to 73	R to 180	L to 140	R to 140	R to 73	L to 73	R to 212	L to 176	---	---	---	---
Molasses	--	---	R to 180	R to 140	R to 140	R to 140	R to 140	R to 250	R to 140	---	---	---	---
Monochloroacetic Acid **CAS# 79-11-8** $CH_2ClCOOH$	50%	---	N	R to 140	R to 140	R to 140	---	---	R to 140	---	---	---	---
Monochlorobenzene **CAS# 108-90-7** C_6H_5Cl	Tech Pure	---	N	R to 73	N	L to 120	---	---	L to 120	---	---	---	---
Monoethanolamine **CAS# 141-43-5** $HOCH_2CH_2NH_2$	--	---	N	---	N	---	---	---	---	---	---	---	---
Motor Oil	--	---	R to 73	L to 140	R to 140	R to 140	---	R to 275	R to 140	---	---	---	---
Morpholine **CAS# 110-91-8** C_4H_8ONH	--	---	N	R to 140	---	R to 140	---	L to 75	R to 140	---	---	N	N
Mustard, Aqueous	Work. Sol.	---	---	---	---	---	---	R to 248	---	---	---	R to 72	---
Naphtha **CAS# 8030-30-6**	--	---	R to 73	R to 73	R to 140	R to 73	R to 73	R to 122	L to 176	R to 140	---	---	---
Naphthalene **CAS# 91-20-3** $C_{10}H_8$	--	---	R to 73	R to 73	N	R to 73	R to 73	R to 200	R to 73	R to 194	---	N	---

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Chemical Formula	Concentration	ABS	CPVC	PP (PP-R, PP-RCT)	PVC	PE (MDPE, HDPE, PE-RT)	PB	PVDF	PEX	PA11, PA12	PA66	PSU	PPSU
Natural Gas **CAS# 68410-96-6**	--	R to 73	---	R to 73	R to 140	R to 140	R to 73	---	R to 140	---	---	---	---
Nickel Acetate **CAS# 373-02-4** $Ni(OOCCH_3)_2 \cdot 4H_2O$	--	---	R to 180	R to 73	---	R to 140	---	R to 250	R to 140	---	---	---	---
Nickel Chloride **CAS# 7718-54-9** $NiCl_2$	Saturated	R to 160	R to 180	R to 180	R to 140	R to 140	R to 140	R to 250	R to 140	---	---	---	---
Nickel Nitrate **CAS# 13138-45-9** $Ni(NO_3)_2 \cdot 6H_2O$	Saturated	R to 160	R to 180	R to 180	R to 140	R to 140	R to 140	R to 248	R to 140	---	---	---	---
Nickel Sulfate **CAS# 7786-81-4** $NiSO_4$	Saturated	R to 160	R to 180	R to 180	R to 140	R to 140	R to 140	R to 285	R to 140	---	---	R to 140	---
Nicotine **CAS# 54-11-5** $C_{10}H_{14}N_2$	--	---	---	---	R to 140	R to 140	R to 140	L to 70	R to 140	---	---	---	---
Nicotinic Acid **CAS# 59-67-6** C_5H_4NCOOH	--	---	---	---	R to 140	R to 140	R to 140	R to 212	R to 140	---	---	---	---
Nitric Acid **CAS# 7697-37-2** HNO_3	5%	---	---	---	---	---	---	R to 176	L to 140	N	N	R to 210	---
	10%	L to 73	R to 180	R to 180	R to 140	R to 73	L to 73	R to 212	L to 140	---	---	---	---
	20%	---	---	---	---	---	---	R to 212	L to 140	---	---	---	---
	30%	N	R to 130	R to 140	R to 140	R to 73	N	R to 212	L to 140	---	---	---	---
	40%	N	R to 120	R to 73	R to 140	R to 73	N	L to 248	L to 140	---	---	---	---
	50%	N	R to 110	N	R to 100	L to 73	N	---	L to 140	---	---	---	---
	65%	---	---	---	---	---	---	L to 248	---	---	---	---	---
	70%	N	R to 100	N	R to 73	L to 73	N	---	L to 73	---	---	---	---
	85%	---	---	---	---	---	---	N	---	---	---	---	---
	100%	N	N	N	N	N	N	---	N	---	---	---	---
Nitrobenzene **CAS# 98-95-3** $C_6H_5NO_2$	100%	N	N	L to 140	N	N	---	R to 122	N	---	---	---	---
Nitroglycerine **CAS# 55-63-0** $CH_2NO_3CHNO_3CH_2NO_3$	--	---	N	---	N	R to 73	---	R to 125	R to 73	---	---	---	---
	1%	---	N	---	---	---	---	R to 140	---	---	---	R to 73	R to 73

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Chemical Formula	Concentration	ABS	CPVC	PP (PP-R, PP-RCT)	PVC	PE (MDPE, HDPE, PE-RT)	PB	PVDF	PEX	PA11, PA12	PA66	PSU	PPSU
Nitroglycol **CAS#628-96-6** $NO_3(CH_2)_2NO_3$	--	---	---	---	N	---	---	---	---	---	---	---	---
Nitrous Acid **CAS# 7782-77-6** HNO_2	10%	---	R to 73	L to 73	R to 140	R to 73	---	R to 125	R to 73	---	---	---	---
Nitrous Oxide **CAS# 10024-97-2** N_2O	--	---	R to 73	R to 73	R to 73	R to 73	---	---	R to 73	---	---	R to 68	---
n-Octane **CAS# 111-65-9** C_8H_{18}	--	---	R to 73	---	---	---	---	R to 285	---	---	---	R to 73	---
Oleic Acid **CAS# 112-80-1** $CH_3(CH_2)_7CH=CH(CH_2)_7COOH$	--	R to 160	L to 180	R to 73	R to 140	L to 140	R to 150	R to 248	L to 140	R to 140	---	R to 73	---
Oleum **CAS# 57-06-7** $H_2SO_4 \cdot \boldsymbol{x}SO_3$	--	N	N	N	N	N	N	N	N	---	N	---	---
Olive Oil **CAS# 8001-25-0**	--	R to 160	L to 180	R to 73	R to 140	R to 140	---	R to 248	R to 140	---	---	---	---
Oxalic Acid	50%	R to 160	R to 180	R to 140	R to 140	R to 140	R to 140	---	R to 140	---	---	---	---
CAS# 144-62-7 $HOOCCOOH \cdot 2H_2O$	10%	---	---	---	---	---	---	R to 140	---	R to 140	---	---	---
	Saturated	---	---	---	---	---	---	R to 122	---	---	---	---	---
Oxygen Gas **CAS# 7782-44-7** O_2	--	R to 160	R to 180	N	R to 140	R to 140	---	R to 212	R to 140	R to 140	---	---	---
Ozone **CAS# 10028-15-6** O_3	--	---	R to 180	L to 73	R to 140	L to 120	---	R to 230	L to 120	L to 68	---	---	---
Palm Oil **CAS# 8002-75-3**	--	---	---	R to 73	---	R to 140	---	R to 230	R to 140	---	---	---	---
Palmitic Acid **CAS# 57-10-3** $CH_3(CH_2)_{14}COOH$	10%	R to 73	R to 73	R to 180	R to 140	R to 120	R to 150	R to 250	R to 120	---	---	---	---
	70%	---	R to 73	R to 180	R to 73	R to 120	---	R to 250	R to 120	---	---	---	---
Paraffin **CAS# 8002-74-2** $C_{36}H_{74}$	--	R to 73	R to 180	R to 140	R to 140	L to 140	---	R to 212	L to 140	---	---	---	---
Peanut Oil **CAS# 8002-03-7**	--	---	L to 180	R to 140	---	---	---	R to 275	---	---	---	---	---

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Chemical Formula	Concentration	ABS	CPVC	PP (PP-R, PP-RCT)	PVC	PE (MDPE, HDPE, PE-RT)	PB	PVDF	PEX	PA11, PA12	PA66	PSU	PPSU
n-Pentane **CAS# 109-66-0** $CH_3(CH_2)_3CH_3$	--	N	L to 180	N	L to 140	L to 120	---	---	L to 120	---	---	---	---
Peracetic Acid **CAS# 79-21-0** CH_3COOOH	40%	N	N	R to 73	R to 73	---	---	R to 150	---	---	---	---	---
Perchloric Acid (Type I) **CAS# 7601-90-3** $HClO_4$	10%	---	R to 73	---	---	---	---	R to 212	---	---	---	---	---
	15%	---	---	R to 140	R to 73	R to 140	L to 73	---	R to 140	---	---	---	---
	70%	R to 73	---	L to 73	R to 73	R to 73	N	R to 212	R to 73	---	---	---	---
Perchloroethylene **CAS# 127-18-4** (tetrachloroethylene) $Cl_2C{=}CCl_2$	--	N	N	L to 73	L to 140	L to 120	---	L to 212	L to 120	L to 68	---	N	---
Perphosphate **CAS# 7758-23-8**	--	---	---	R to 140	R to 73	---	---	---	---	---	---	---	---
Petroleum Ether **CAS# 8032-32-4**	--	---	---	R to 140	---	---	---	R to 212	---	---	---	---	---
Phenol **CAS# 108-95-2** C_6H_5OH	--	N	R to 73	R to 73	R to 73	R to 140	R to 73	---	R to 73	N	N	---	---
	5%	---	---	---	---	---	---	---	L to 73	---	---	L to 140	---
	50%	---	---	---	---	---	---	R to 176	---	---	---	---	---
	90%	---	---	---	---	N	---	---	N	---	---	---	---
	Solid	---	---	---	---	---	---	L to 122	---	---	---	---	---
Phenylhydrazine **CAS# 100-63-0** $C_6H_5NHNH_2$	--	---	N	N	N	N	---	R to 104	N	---	---	---	---
Phenylhydrazine Hydrochloride **CAS# 59-88-1** $C_6H_5NHNH_2 \cdot HCl$	10%	---	---	---	---	---	---	R to 140	N	---	---	---	---
Phosphine **CAS# 7803-51-2** PH_3	Gas	---	---	---	---	---	---	R to 104	---	---	---	---	---
Phosphoric Acid **CAS# 7664-38-2** H_3PO_4	10%	---	R to 180	R to 212	R to 140	R to 140	R to 140	---	R to 140	---	---	---	---
	50%	R to 73	R to 180	R to 212	R to 140	R to 140	R to 73	R to 212	R to 140	L to 104	---	---	---
	80%								R to 212		---	---	---
	85%	---	R to 180	R to 212	R to 140	R to 73	---	---	R to 73	---	---	---	---
	90%								R to 212		---	---	---

Chemical Formula	Concentration	ABS	CPVC	PP (PP-R, PP-RCT)	PVC	PE (MDPE, HDPE, PE-RT)	PB	PVDF	PEX	PA11, PA12	PA66	PSU	PPSU
	98%	---	---	---	---	---	---	R to 212	---	---	---	---	---
Phosphoric Anhydride CAS# 1314-56-3 P_2O_5	--	---	R to 73	R to 73	R to 73	---	---	---	---	---	---	---	---
Phosphorous (Red) CAS# 7723-14-0 P	--	---	---	---	R to 73	R to 140	---	L to 75	R to 140	---	---	R to 120	---
Phosphorous (White/Yellow) CAS# 12185-10-3 P4	--	--	---	---	R to 73	R to 140	---	---	R to 140	---	---	R to 120	---
Phosphorus Oxychloride CAS# 10025-87-3 $POCl_3$	Liquid	---	---	---	---	---	---	N	---	---	---	---	---
Phosphorus Pentoxide CAS# 1314-56-3 P_2O_5	--	---	R to 73	R to 73	R to 73	R to 140	---	R to 200	R to 140	---	---	---	---
Phosphorus Trichloride CAS# 7719-12-2 PCl_3	--	--	N	R to 73	N	R to 120	L to 73	R to 200	R to 120	---	---	---	---
Phthalic Acid CAS# 88-99-3 $C_6H_4(COOH)_2$	--	---	N	R to 140	L to 140	R to 140	---	---	R to 140	---	---	---	---
	Susp.	---	N	---	---	---	---	R to 212	---	---	---	---	---
Picric Acid CAS# 88-89-1 $C_6H_2(NO_2)_3OH$	10%	N	N	R to 73	N	R to 73	R to 73	R to 212	R to 73	L to 68	---	---	---
	Saturated.	---	---	---	---	---	---	R to 212	---	---	---	---	---
Pine Oil CAS# 8002-09-3	--	---	N	R to 140	---	R to 73	---	R to 200	R to 73	---	---	---	---
Plating Solutions (Brass)	--	---	R to 180	R to 140	R to 140	R to 140	L to 73	R to 220	R to 140	---	---	---	---
Plating Solutions (Cadmium)	--	---	R to 180	R to 140	R to 140	R to 140	L to 73	R to 220	R to 140	---	---	---	---
Plating Solutions (Chrome)	--	---	R to 180	R to 140	R to 140	R to 140	L to 73	R to 220	R to 140	---	---	---	---
Plating Solutions (Copper)	--	---	R to 180	R to 140	R to 140	R to 140	L to 73	R to 220	R to 140	---	---	---	---
Plating Solutions (Gold)	--	---	R to 180	R to 140	R to 140	R to 140	L to 73	R to 220	R to 140	---	---	---	---
Plating Solutions (Lead)	--	---	R to 180	R to 140	R to 140	R to 140	L to 73	R to 220	R to 140	---	---	---	---
Plating Solutions (Nickel)	--	---	R to 180	R to 140	R to 140	R to 140	L to 73	R to 220	R to 140	---	---	---	---
Plating Solutions (Rhodium)	--	---	R to 180	R to 140	R to 140	R to 140	L to 73	R to 220	R to 140	---	---	---	---
Plating Solutions (Silver)	--	---	R to 180	R to 140	R to 140	R to 140	L to 73	R to 220	R to 140	---	---	---	---
Plating Solutions (Tin)	--	---	R to 180	R to 140	R to 140	R to 140	L to 73	R to 220	R to 140	---	---	---	---

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Chemical Formula	Concentration	ABS	CPVC	PP (PP-R, PP-RCT)	PVC	PE (MDPE, HDPE, PE-RT)	PB	PVDF	PEX	PA11, PA12	PA66	PSU	PPSU
Plating Solutions (Zinc)	--	---	R to 180	R to 140	R to 140	R to 140	L to 73	R to 220	R to 140	---	---	---	---
Potash (Aq)-See Potassium Hydroxide **CAS# 1310-58-3** KOH													
Potassium Alum **CAS# 10043-67-1** $AlK(SO_4)_2 \cdot 12H_2O$	--	---	R to 180	---	R to 140	R to 140	---	R to 285	R to 140	---	---	---	---
Potassium Aluminum Sulfate **CAS# 10043-67-1** $AlK(SO_4)_2 \cdot 12H_2O$	--	---	R to 180	R to 180	R to 140	---	L to 73	---	---	---	---	---	---
Potassium Amyl Xanthate **CAS# 2720-73-2** $CH_3(CH_2)_4OC(=S)$-SK	--	---	---	---	R to 73	---	---	---	---	---	---	---	---
Potassium Bicarbonate **CAS# 298-14-6** $KHCO_3$	Saturated	---	R to 180	R to 140	R to 140	R to 140	R to 140	R to 212	R to 140	---	---	---	---
Potassium Bi- chromate **CAS# 7778-50-9** $K_2Cr_2O_7$	Saturated	---	R to 180	R to 140	R to 140	---	L to 73	R to 212	---	---	---	---	---
	40%	---	---	---	---	---	---	R to 212	---	---	---	---	---
Potassium Bisulfate **CAS# 7646-93-7** $KHSO_4$	--	---	R to 180	R to 212	R to 140	R to 140	---	R to 212	R to 140	---	---	---	---
Potassium Borate **CAS#12045-78-2** $K_2B_4O_7 \cdot 4H_2O$	--	--	R to 180	R to 140	R to 140	R to 140	R to 140	R to 212	R to 140	---	---	---	---
Potassium Bromate **CAS# 7758-01-2** $KBrO_3$	--	---	R to 180	R to 212	R to 140	R to 140	R to 140	R to 212	R to 140	---	---	---	---
	10%	---	---	---	---	---	---	---	R to 180	---	---	---	---
Potassium Bromide **CAS# 7758-02-3** KBr	--	---	R to 180	R to 212	R to 140	R to 140	R to 140	R to 248	R to 140	---	---	---	---
Potassium Carbonate **CAS# 584-08-7** K_2CO_3	--	R to 73	R to 180	R to 180	R to 140	R to 140	R to 140	N	R to 140	---	---	---	---
Potassium Chlorate (Aqueous) **CAS# 3811-04-9** $KClO_3$	--	R to 160	R to 180	R to 212	R to 140	R to 140	R to 140	R to 200 with sunlight cover or pigmented pipe	R to 140	---	---	---	---

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Chemical Formula	Concentration	ABS	CPVC	PP (PP-R, PP-RCT)	PVC	PE (MDPE, HDPE, PE-RT)	PB	PVDF	PEX	PA11, PA12	PA66	PSU	PPSU
Potassium Chloride **CAS# 7747-40-7** KCl	--	R to 160	R to 180	R to 212	R to 140	R to 140	R to 140	R to 212	R to 140	---	---	---	---
Potassium Chromate **CAS# 7789-00-6** K_2CrO_4	--	---	R to 180	R to 212	R to 140	R to 140	R to 140	R to 285	R to 140	---	---	---	---
Potassium Cyanide **CAS# 151-50-8** KCN	--	---	R to 180	R to 180	R to 140	R to 140	R to 140	R to 212	R to 140	---	---	---	---
Potassium Dichromate **CAS# 7778-50-9** $K_2Cr_2O_7$	Saturated	--	R to 180	R to 180	R to 140	R to 140	R to 140	R to 285	R to 140	---	---	---	---
Potassium Ethyl Xanthate **CAS# 140-89-6** $KS_2COC_2H_5$	--	---	---	---	R to 73	---	---	---	---	---	---	---	---
Potassium Ferricyanide **CAS# 13746-66-2** $K_3Fe(CN)_6$	--	---	R to 180	R to 180	R to 140	R to 140	R to 140	R to 248	R to 140	---	---	---	---
Potassium Ferrocyanide **CAS# 13943-58-3** $K_4Fe(CN)_6 \cdot 3H_2O$	--	---	R to 180	R to 180	R to 140	R to 140	---	R to 248	R to 140	---	---	---	---
Potassium Fluoride **CAS# 7789-23-3** KF	--	---	R to 180	R to 180	R to 140	R to 140	R to 140	R to 212	R to 140	---	---	---	---
Potassium Hydroxide **CAS# 1310-58-3** KOH	10%	---	---	---	---	---	---	R to 176	---	---	---	---	---
	20%	---	---	---	---	---	---	R to 176	---	---	---	---	---
	25%	R to 160	R to 180	R to 212	R to 140	R to 140	R to 140	---	R to 140	---	---	---	---
	35%	---	---	---	---	---	---	---	---	---	---	R to 176	---
	50%	---	R to 180	---	---	---	---	R to 176	---	L to 104	L to 73	---	---
Potassium Hydrogen Sulfite **CAS# 10117-38-1** $KHSO_3$	10%	---	---	---	---	---	---	R to 140	---	---	---	---	---
	Saturated	---	---	---	---	---	---	R to 212	---	---	---	---	---
Potassium Hypochlorite **CAS# 7778-66-7** KClO	--	R to 160	R to 180	---	R to 140	R to 120	---	---	R to 120	---	---	---	---
	3%	---	---	---	---	---	---	R to 212	---	---	---	---	---
Potassium Iodide **CAS# 7681-11-0** KI	--	---	R to 180	R to 73	R to 73	R to 140	---	R to 212	R to 140	---	---	---	---
Potassium Nitrate	--	R to 160	R to 180	R to 140	R to 140	R to 140	R to 140	---	R to 140	L to 104	---	---	---

Chemical Formula	Concentration	ABS	CPVC	PP (PP-R, PP-RCT)	PVC	PE (MDPE, HDPE, PE-RT)	PB	PVDF	PEX	PA11, PA12	PA66	PSU	PPSU
CAS# 7757-79-1 KNO_3	50%	---	---	---	---	---	---	R to 212	---	---	---	---	---
Potassium Orthophosphate **CAS# 7778-77-0** H_2KPO_4	Saturated	---	---	---	---	---	---	R to 212	---	---	---	---	---
Potassium Perborate **CAS# 13769-41-0** $KBHO_3$	--	---	R to 180	R to 140	R to 140	R to 140	R to 140	R to 285	R to 140	---	---	---	---
Potassium Perchlorate **CAS# 7778-74-7** $KClO_4$	--	---	R to 180	R to 140	R to 140	R to 140	R to 140	R to 200	R to 140	---	---	---	---
Potassium Permanganate **CAS# 7722-64-7** $KMnO_4$	10%	---	R to 180	R to 73	R to 140	R to 140	R to 140	R to 176	R to 140	---	N	---	---
	20%	---	---	---	---	---	---	R to 212	---	---	---	---	---
	25%	---	R to 180	R to 73	R to 73	R to 140	---	---	R to 140	---	---	---	---
	30%	---	---	---	---	---	---	R to 212	---	---	---	---	---
	Saturated	---	---	---	---	---	---	R to 212	---	---	---	---	---
Potassium Persulfate **CAS# 7727-21-1** $K_2S_2O_8$	--	---	R to 180	R to 140	R to 140	R to 140	R to 140	R to 176	R to 140	---	---	---	---
Potassium Sulfate **CAS# 7778-80-5** K_2SO_4	--	R to 160	R to 180	R to 180	R to 140	R to 140	R to 140	R to 212	R to 140	R to 194	---	---	---
Potassium Sulfide **CAS# 1312-73-8** K_2S	--	---	R to 180	R to 140	---	R to 140	R to 140	R to 200	R to 140	---	---	---	---
Potassium Sulfite **CAS# 10117-38-1** $K_2SO_3 \cdot 2H_2O$	--	---	R to 180	R to 140	---	R to 140	---	R to 200	R to 140	---	---	---	---
Propane **CAS# 74-98-6** C_3H_8	--	---	R to 73	R to 73	R to 140	R to 140	R to 73	R to 248	R to 140	R to 140	---	---	---
Propargyl Alcohol **CAS# 107-19-7** $HC{\equiv}CCH_2OH$	--	---	L to 180	R to 140	R to 140	R to 140	R to 140	---	R to 140	---	---	---	---
Propionic Acid **CAS# 79-09-4** $CH_3CH_2CO_2H$	--	N	N	R to 140	---	R to 140	---	R to 140	R to 140	---	---	N	L to 104
Propyl Alcohol (Type I) **CAS# 71-23-8** $CH_3CH_2CH_2OH$	--	73	L to 73	R to 140	R to 140	R to 140	R to 140	R to 122	R to 140	---	---	---	---

May not be fully applicable to pressurized applications

Chemical Formula	Concentration	ABS	CPVC	PP (PP-R, PP-RCT)	PVC	PE (MDPE, HDPE, PE-RT)	PB	PVDF	PEX	PA11, PA12	PA66	PSU	PPSU
Propylene Dichloride CAS# 78-87-5 $CH_3CHClCH_2Cl$	100%	---	N	N	N	N	---	R to 200	N	---	---	---	---
Propylene Glycol CAS#57-55-6 $C_3H_8O_2$	100					R to 180			R to 180		---		
	50% Aqueous					R to 180			R to 200		---		
Propylene Oxide CAS# 75-56-9 CH_3CHCH_2O	--	---	N	R to 73	N	R to 140	---	N	R to 140	---	---	---	---
Pyridine CAS# 110-86-1 $N(CH)_4CH$	--	---	N	L to 140	N	R to 73	---	R to 68	R to 73	L to 68	---	---	---
Pyrogallic Acid CAS# 87-66-1 $C_6H_3(OH)_3$	--	---	---	---	R to 73	--	--	R to 100	---	---	---	---	---
Quinone CAS# 106-51-4 $C_6H_4O_2$	--	---	---	R to 140	---	R to 140	---	---	R to 140	---	---	---	---
Rayon Coagulating Bath	--	---	R to 180	---	R to 140	R to 140	R to 140	---	R to 140	---	---	---	---
Salicylaldehyde CAS# 90-02-8 C_6H_4OHCHO	--	---	N	R to 73	N	R to 120	---	---	R to 120	---	---	---	---
Salicylic Acid CAS# 69-72-7 $C_6H_4(OH)(COOH)$	--	---	---	R to 140	R to 140	R to 140	---	R to 212	R to 140	---	---	---	---
Selenic Acid Aq. CAS# 13410-01-0 H_2SeO_4	--	---	R to 180	---	R to 140	R to 140	R to 140	R to 150	R to 140	---	---	---	---
Silicic Acid CAS# 10193-36-9 $SiO_2 \cdot nH_2O$	--	---	R to 180	R to 140	R to 140	R to 140	R to 140	R to 212	R to 140	---	---	---	---
Silicone Oil (Polydimethylsiloxane) CAS# 63148-62-9	--	---	R to 180	R to 212	R to 73	R to 73	---	R to 250	R to 73	---	---	---	---
Silver Acetate CAS# 563-63-3 $AgCH_3COO$	Saturated	---	R to 180	---	---	---	---	R to 212	---	---	---	---	---
Silver Chloride CAS# 7783-90-6 AgCl	--	R to 160	R to 180	R to 140	R to 140	---	---	R to 200	---	---	---	---	---

May not be fully applicable to pressurized applications

Chemical Formula	Concentration	ABS	CPVC	PP (PP-R, PP-RCT)	PVC	PE (MDPE, HDPE, PE-RT)	PB	PVDF	PEX	PA11, PA12	PA66	PSU	PPSU
Silver Cyanide **CAS# 506-64-9** $AgCN$	--	---	R to 180	R to 180	R to 140	R to 140	R to 140	R to 212	R to 140	---	---	---	---
Silver Nitrate **CAS# 7761-88-8** $AgNO_3$	--	R to 160	R to 180	R to 180	R to 140	R to 140	L to 73	---	R to 140	---	---	---	---
	50%	---	---	---	---	---	---	R to 212	---	---	---	---	---
Silver Sulfate **CAS# 10294-26-5** Ag_2SO_4	--	R to 160	R to 180	R to 140	R to 140	R to 140	L to 73	R to 250	R to 140	---	---	---	---
Sodium Acetate **CAS# 127-09-3** CH_3COONa	Saturated	---	R to 180	R to 212	R to 140	R to 140	R to 140	R to 212	R to 140	---	---	---	---
Sodium Alum **CAS# 10102-71-3** $AlNa(SO_4)_2 \cdot 12H_2O$	--	---	R to 180	---	R to 140	---	---	---	---	---	---	---	---
Sodium Aluminate **CAS# 1302-42-7** $Na_2Al_2O_4$	30%	---	---	---	---	---	---	---	---	---	---	R to 165	---
	Saturated	---	R to 180	---	R to 140	---	---	---	---	---	---	---	---
Sodium Benzoate **CAS# 532-32-1** C_6H_5COONa	--	---	R to 180	R to 140	R to 140	R to 140	R to 140	---	R to 140	---	---	---	---
	50%	---	---	---	---	---	---	R to 212	---	---	---	---	---
Sodium Bicarbonate **CAS# 144-55-8** $NaHCO_3$	--	R to 73	R to 180	R to 212	R to 140	R to 140	R to 140	R to 212	R to 140	---	---	---	---
Sodium Bisulfate **CAS# 7681-38-1** $NaHSO_4$	--	R to 73	R to 180	R to 140	R to 140	R to 140	R to 140	---	R to 140	---	---	---	---
	50%	---	---	---	---	---	---	R to 212	---	---	---	---	---
Sodium Bisulfite **CAS# 7631-90-5** $NaHSO_3$	--	---	R to 180	R to 140	R to 140	R to 140	---	R to 285	R to 140	---	---	---	---
Sodium Borate (Borax) **CAS# 1303-96-4** $Na_2B_4O_7 \cdot 10H_2O$	1%	---	---	---	---	---	---	---	---	---	---	R to 113	---
	Saturated	R to 160	R to 180	R to 180	R to 140	R to 140	R to 140	---	R to 140	---	---	---	---
Sodium Bromide **CAS# 7647-15-6** $NaBr$	Saturated	R to 120	R to 180	R to 140	R to 140	R to 140	R to 140	---	R to 140	---	---	---	---
	50%	---	--	---	---	---	---	R to 248	---	---	---	---	---
Sodium Carbonate **CAS# 497-19-8** Na_2CO_3	--	R to 73	R to 180	R to 212	R to 140	R to 140	R to 140	N	R to 140	R to 140	---	---	---
	1.70%	---	---	---	---	---	---	---	---	---	---	R to 210	---

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Chemical Formula	Concentration	ABS	CPVC	PP (PP-R, PP-RCT)	PVC	PE (MDPE, HDPE, PE-RT)	PB	PVDF	PEX	PA11, PA12	PA66	PSU	PPSU
Sodium Chlorate **CAS# 7775-09-9** $NaClO_3$	Saturated	---	R to 180	R to 140	R to 73	R to 140	R to 140	R to 250 with sunlight cover or pigmented pipe	R to 140	---	---	---	---
Sodium Chloride **CAS# 7647-14-5** $NaCl$	Saturated		R to 180	R to 140	R to 140	R to 140	R to 140	R to 212	R to 140	R to 194	---	---	---
	10%	---	---	---	---	---	---	R to 212	---	---	---	R to 140	---
Sodium Chlorite **CAS# 7758-19-2** $NaClO_2$	25%	---	R to 180	R to 73	N	R to 140	---	R to 250	R to 140	---	---	---	---
Sodium Chromate **CAS# 7775-11-3** $Na_2CrO_4 \cdot 4H_2O$	--	R to 120	R to 180	R to 140	---	R to 140	---	R to 176	R to 140	---	---	---	---
Sodium Cyanide **CAS# 143-33-9** $NaCN$	--	---	R to 180	R to 180	R to 140	R to 140	R to 140	R to 212	R to 140	---	---	---	---
Sodium Dichromate **CAS# 10588-01-9** $Na_2Cr_2O_7 \cdot 2H_2O$	Saturated	---	R to 180	---	R to 140	---	---	---	---	---	---	---	---
	20%	---	R to 180	R to 180	R to 140	R to 140	R to 140	---	R to 140	---	---	---	---
	50%	---	---	---	---	---	---	R to 212	---	---	---	---	---
Sodium Ferricyanide **CAS#14217-21-1** $Na_3Fe(CN)_6$	Saturated	---	R to 180	R to 140	R to 140	R to 140	R to 140	---	R to 140	---	---	---	---
Sodium Ferrocyanide **CAS# 14434-22-1** $Na_4Fe(CN)_6$	Saturated	---	R to 180	R to 140	R to 140	R to 140	R to 140	---	R to 140	---	---	---	---
Sodium Fluoride **CAS# 7681-49-4** NaF	--	R to 120	R to 180	R to 180	R to 140	R to 140	R to 140	R to 212	R to 140	---	---	---	---
Sodium Hydrogen Sulfite **CAS# 7631-90-5** $NaHSO_3$	50%	---	---	---	---	---	---	R to 212	---	---	---	---	---
Sodium Hydroxide (Caustic Soda) **CAS# 1310-73-2** $NaOH$	5%	---	---	---	---	---	---	L to 68	---	---	---	---	---
	15%	R to 120	R to 180	R to 212	R to 140	R to 140	R to 140	---	R to 140	---	---	---	R to 212
	30%	R to 120	R to 180	R to 212	R to 140	R to 140	R to 140	N	R to 140	---	---	---	---
	50%	R to 120	R to 180	R to 212	R to 140	R to 140	R to 140	---	R to 140	L to 104	---	R to 194	---
	70%	R to 120	---	R to 212	R to 140	R to 140	R to 140	---	R to 140	---	---	---	---
Sodium Hypochlorite	--	R to 120	R to 180	R to 73	R to 73	R to 140	R to 140	---	R to 140	---	---	---	---

Chemical Formula	Concentration	ABS	CPVC	PP (PP-R, PP-RCT)	PVC	PE (MDPE, HDPE, PE-RT)	PB	PVDF	PEX	PA11, PA12	PA66	PSU	PPSU
CAS# 7681-52-9 $NaOCl \cdot 5H_2O$	2% Cl	---	---	---	---	---	---	R to 212	---	---	---	---	---
	5% Cl	---	R to 180	R to 120	R to 140	L to 140	---	---	L to 140	---	---	---	---
	12% Cl	R to 73	R to 180	R to 120	R to 140	R to 73	R to 140	R to 68	R to 73	---	---	R to 190	---
Sodium Iodide **CAS# 7681-82-5** NaI	--	---	R to 180	---	R to 140	---	---	R to 285	---	---	---	---	---
Sodium Metaphosphate **CAS# 10361-03-2** $(NaPO_3)n$	--	---	R to 180	R to 120	R to 140	---	---	---	---	---	---	---	---
Sodium Metasilicate **CAS# 6834-92-0** Na_2SiO_3	100%	---	---	---	---	---	---	---	---	---	---	R to 212	
Sodium Nitrate **CAS# 7631-99-4** $NaNO_3$	Saturated	R to 160	R to 180	R to 180	R to 140	R to 140	R to 140	R to 212	R to 140	---	---	---	---
Sodium Nitrite **7632-00-0** $NaNO_2$	--	R to 160	R to 180	R to 73	R to 140	R to 140	R to 140	R to 212	R to 140	---	---	---	---
Sodium Palmitate **CAS# 408-35-5** $CH_3(CH_2)_{14}COONa$	5%	---	R to 180	R to 140	R to 140	---	---	R to 250	---	---	---	---	---
Sodium Perborate **CAS# 7632-04-4** $NaBO_3 \cdot 4H_2O$	--	R to 120	R to 180	R to 73	R to 140	R to 73	---	---	R to 73	---	---	---	---
Sodium Perchlorate **CAS# 7601-89-0** $NaClO_4$	--	---	R to 180	R to 212	R to 140	R to 140	---	R to 250	R to 140	---	---	---	---
Sodium Peroxide **CAS# 1313-60-6** Na_2O_2	10%	---	R to 180	---	R to 140	R to 140	---	R to 200	R to 140	---	---	---	---
Sodium Phosphate **CAS# 7601-54-9** NaH_2PO_4	Acid	R to 120	R to 180	R to 212	R to 140	R to 140	R to 140	R to 140	R to 140	---	---	---	---
	Alkaline	---	R to 120	R to 180	R to 212	R to 140	R to 140	---	R to 140	---	---	---	---
	Neutral	---	R to 120	R to 180	R to 212	R to 140	R to 140	---	R to 180	---	---	---	---
Sodium Silicate **CAS# 6834-92-0** $2Na_2O \cdot SiO_2$	--	---	R to 180	R to 140	R to 140	R to 140	R to 140	---	R to 140	---	---	---	---
	10%	---	---	---	---	---	---	R to 140	---	---	---	---	---
	50%	---	---	---	---	---	---	R to 212	---	---	---	---	---
	100%	---	---	---	---	---	---	---	---	---	---	R to 194	---
Sodium Sulfate	Saturated	R to 160	R to 180	R to 212	R to 140	R to 140	R to 140	R to 212	---	---	---	---	---

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Chemical Formula	Concentration	ABS	CPVC	PP (PP-R, PP-RCT)	PVC	PE (MDPE, HDPE, PE-RT)	PB	PVDF	PEX	PA11, PA12	PA66	PSU	PPSU
CAS# 7757-82-6 Na_2SO_4	0.10%	---	---	---	---	---	---	R to 140	---	---	---	---	---
Sodium Sulfide **CAS# 1313-82-2** Na_2S	30%	---	---	---	---	---	---	---	---	---	---	R to 165	---
	Saturated	R to 160	R to 180	R to 212	R to 140	R to 140	R to 140	---	R to 140	L to 104	---	---	---
Sodium Sulfite **CAS# 7757-83-7** Na_2SO_3	Saturated	R to 160	R to 180	R to 212	R to 140	R to 140	R to 140	R to 212	R to 140	---	---	---	---
Sodium Thiosulfate **CAS# 7772-98-7** $Na_2S_2O_3 \cdot 5H_2O$	--	---	R to 180	R to 180	R to 140	R to 140	R to 140	---	R to 140	---	---	---	---
	50%	---	---	---	---	---	---	R to 248	---	---	---	---	---
Soybean Oil **CAS# 8001-22-7**	--	---	L to 180	R to 73	---	R to 140	---	R to 275	R to 140	---	---	---	---
Stannic Chloride **CAS# 7646-78-8** $SnCl_4$	Saturated	---	R to 180	R to 140	R to 140	R to 140	R to 140	R to 275	R to 140	---	---	---	---
Stannous Chloride **CAS# 7772-99-8** $SNCl_2$	15%	R to 120	R to 180	R to 140	R to 140	R to 140	R to 140	---	R to 140	---	---	---	---
	Saturated	---	---	---	---	R to 140	---	R to 285 with sunlight cover or pigmented pipe	R to 140	---	---	---	---
Starch **CAS# 9005-25-8**	--	---	R to 180	R to 140	R to 140	R to 140	---	R to 230	R to 140	---	---	---	---
Soluble Starch **CAS# 9005-84-9** $(C_6H_{10}O_5)_n$	Saturated	---	R to 180	---	---	R to 140	---	---	R to 140	---	---	---	---
Stearic Acid **CAS# 57-11-4** $CH_3(CH_2)_{16}COOH$	--	---	R to 73	R to 73	R to 140	R to 120	R to 150	R to 285	R to 120	L to 194	---	---	---
Stoddard's Solvent **CAS# 8052-41-3**	--	---	N	---	N	R to 73	R to 140	---	R to 73	---	---	---	---
Styrene **CAS# 100-42-5** $C_6H_5CH{=}CH_2$	--	---	N	R to 73	---	L to 73	---	R to 175	L to 73	R to 104	---	---	---
Succinic Acid **CAS# 110-15-6** $COOH(CH_2)_2COOH$	--	---	R to 180	R to 140	R to 140	R to 140	---	---	R to 140	---	---	---	---

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Chemical Formula	Concentration	ABS	CPVC	PP (PP-R, PP-RCT)	PVC	PE (MDPE, HDPE, PE-RT)	PB	PVDF	PEX	PA11, PA12	PA66	PSU	PPSU
Sugar **CAS# 50-99-7** $C_6H_{12}O_6$	Aq.	---	R to 180	---	R to 140	R to 140	---	R to 285	R to 140	---	---	---	---
Sulfamic Acid **CAS# 5329-14-6** HSO_3NH_2	20%	--	N	R to 180	N	---	---	---	---	---	---	---	---
Sulfur **CAS# 7404-34-9** S	--	---	R to 180	R to 212	R to 140	R to 140	R to 140	R to 250	---	R to 104	---	---	---
Sulfur Chloride **CAS# 10025-67-9** S_2Cl_2	--	---	---	L to 73	---	---	---	R to 75	---	---	---	---	---
Sulfur Dioxide **CAS# 7446-09-5** SO_2	Gas Dry	N	R to 73	R to 140	R to 140	R to 140	---	R to 175	R to 140	---	---	---	---
	Gas Wet	N	N	R to 140	R to 73	R to 120	R to 73	R to 175	R to 120	---	---	---	---
Sulfur Trioxide **CAS# 7446-11-9** SO_3	Gas Dry	---	---	---	R to 140	N	---	N	N	L to 68	---	---	---
	Gas	---	N	---	R to 73	N	---	N	---	---	---	---	---
Sulfuric Acid **CAS# 7664-93-9** H_2SO_4	20%								R to 237		---		
	30%	R to 120	R to 180	R to 180	R to 140	R to 140	R to 140	R to 248	R to 180, L to 212	---	---	---	---
	50%	R to 73	R to 180	R to 140	R to 140	R to 120	L to 73		R to 140	---	---	---	R to 212
	60%	L to 73	R to 180	R to 73	R to 140	R to 120	L to 73	R to 248	---	---	---	---	---
	70%	L to 73	R to 180	R to 73	R to 140	R to 120	L to 73	---	---	---	---	---	---
	80%	L to 73	R to 180	R to 73	R to 140	R to 120	N	L to 248	R to 140	---	---	---	---
	90%	L to 73	R to 150	R to 73	R to 73	R to 120	N	R to 212	---	---	---	---	---
	93%	N	R to 140	L to 73	R to 73	L to 73	N	---	---	---	---	---	---
	94% - 98%	N	R to 130	L to 73	N	L to 73	N	L to 212	L to 85	---	---	R to 140	R to 140
	100%	N	N	N	N	N	N	---	N	L to 194	---	---	---
Sulfurous Acid **CAS# 7782-99-2** H_2SO_3	--	---	R to 73	R to 140	R to 140	R to 140	R to 140	R to 212	R to 140	---	---	---	---
Tall Oil **CAS# 8002-26-4**	--	---	L to 180	R to 180	R to 140	R to 120	---	R to 285	R to 120	---	--	---	---
Tannic Acid **CAS# 1401-55-4** $C_{76}H_{52}O_{46}$	10%	N	R to 180	R to 73	R to 140	R to 140	R to 140	R to 212	R to 140	---	---	---	---
	Saturated	---	---	---	---	---	---	R to 212	---	---	---	---	---
Tartaric Acid	--	R to 160	R to 180	R to 140	R to 140	R to 140	R to 140	R to 248	R to 140	---	---	---	---

Chemical Formula	Concentration	ABS	CPVC	PP (PP-R, PP-RCT)	PVC	PE (MDPE, HDPE, PE-RT)	PB	PVDF	PEX	PA11, PA12	PA66	PSU	PPSU
CAS# 526-83-0 $HOOC(CHOH)_2COOH$	Saturated	---	---	---	---	---	---	R to 248	---	R to 194	---	---	---
Terpineol **CAS# 8000-41-7** $C_{10}H_{17}OH$	--	---	---	---	L to 140	---	---	---	---	---	---	---	---
Tetrachloroethane **CAS# 79-34-5** $CHCl_2CHCl_2$	--	---	N	L to 73	L to 140	L to 120	---	R to 230	L to 120	---	---	---	---
Tetrachloroethylene **CAS# 127-18-4** $Cl_2C=CCl_2$	--	N	N	L to 73	L to 140	L to 120	---	L to 212	L to 120	L to 68	---	---	---
Tetraethyl Lead **CAS# 78-00-2** $Pb(C_2H_5)_4$	--	---	R to 73	R to 73	R to 73	---	---	R to 285	---	R to 68	---	---	---
Tetrahydrofuran **CAS# 109-99-9** C_4H_8O	--	N	N	L to 73	N	L to 73	L to 73	L to 68	N	---	---	---	---
Tetralin **CAS# 119-64-2** $C_{10}H_{12}$	--	---	N	N	N	N	---	---	N	---	---	---	---
Tetra Sodium Pyrophosphate **CAS# 7722-88-5** $Na_4P_2O_7 \bullet 10H_2O$	--	---	R to 180	---	R to 140	---	---	---	---	---	---	---	---
Thionyl Chloride **CAS# 7719-09-7** $SOCl_2$	--	---	N	N	N	N	R to 140	N	N	---	---	---	---
Tin (II) Chloride **CAS# 7772-99-8** $SnCl_2$	--	---	R to 180	---	---	---	---	R to 212	---	---	---	---	---
Tin (IV) Chloride **CAS# 7646-78-8** $SnCl_4$	--	---	R to 180	---	---	---	---	R to 212	---	---	---	---	---
Titanium Tetrachloride **CAS# 7550-45-0** $TiCl_4$	--	---	---	R to 140	L to 73	R to 120	---	---	R to 120	---	---	---	---
Toluene (Toluol) **CAS# 108-88-3** $CH_3C_6H_5$	--	N	N	L to 73	N	L to 120	N	R to 175	L to 120	R to 140	R to 73	N	N
Tomato Juice	--	---	R to 180	R to 212	R to 140	R to 140	---	R to 250	R to 140	---	---	---	---
Tributyl Citrate **CAS# 77-94-1** $C_{18}H_{32}O_7$	--	---	N	L to 73	R to 73	L to 120	---	---	L to 120	---	---	---	---

May not be fully applicable to pressurized applications

Chemical Formula	Concentration	ABS	CPVC	PP (PP-R, PP-RCT)	PVC	PE (MDPE, HDPE, PE-RT)	PB	PVDF	PEX	PA11, PA12	PA66	PSU	PPSU
Tributyl Phosphate **CAS# 126-73-8** $(C_4H_9)_3PO_4$	--	---	N	L to 140	N	R to 73	---	L to 75	R to 73	R to 194	---	---	---
Trichloroacetic Acid **CAS# 76-03-9** CCl_3COOH	50%	---	N	R to 140	R to 140	R to 140	---	R to 104	R to 140	---	---	---	---
	10%	---	N	---	---	R to 140	---	---	R to 140	---	---	---	---
Trichlorobenzene **CAS# 12002-48-1** $C_6H_3Cl_3$	--	---	N	---	---	---	---	R to 140	---	---	---	---	---
Trichloroethane **CAS# 71-55-6** $C_2H_3Cl_3$	--	---	N	---	---	---	---	R to 150	---	---	R to 73	N	---
Trichloroethylene **CAS# 79-01-6** $CHCl=CCl_2$	--	N	N	N	N	L to 120	N	R to 176	L to 68	L to 68	---	N	---
Triethanolamine **CAS# 102-71-6** $(HOCH_2CH_2)_3N$	--	L to 73	N	R to 140	R to 73	R to 73	R to 73	L to 104	R to 73	---	---	---	---
Triethylamine **CAS# 121-44-8** $(C_2H_5)_3N$	--	---	N	N	R to 140	R to 73	---	R to 125	R to 73	---	---	---	---
Trimethylolpropane **CAS# 77-99-6** $(CH_2OH)_3C_3H_5$	--	---	R to 73	R to 140	R to 73	L to 120	---	---	L to 120	---	---	---	---
Trisodium Phosphate **CAS# 10101-89-0** $Na_3PO_4 \bullet 12H_2O$	--	R to 73	R to 180	R to 140	R to 140	R to 140	R to 140	---	R to 140	---	---	---	---
Turpentine **CAS# 8006-64-2**	--	N	N	N	R to 140	L to 120	L to 73	R to 285	L to 120	R to 140	R to 73	---	---
Urea **CAS# 57-13-6** $CO(NH_2)_2$	--	---	N	R to 180	R to 140	R to 140	R to 140	---	R to 140	---	---	---	---
	10%	---	---	---	---	---	---	R to 212	---	---	---	---	---
	Saturated	---	---	---	---	---	---	R to 176	---	L to 140	---	---	---
Urine	--	R to 160	R to 180	R to 180	R to 140	R to 140	R to 140	---	R to 140	---	---	---	---
Vaseline (Petroleum Jelly) **CAS# 8009-03-8**	--	---	N	R to 140	N	R to 120	---	R to 200	R to 120	---	R to 73	---	---
Vegetable Oil	--	---	L to 180	R to 140	R to 140	R to 140	---	R to 248	R to 140	---	---	---	---
Vinegar **CAS# 64-19-7**	--	R to 73	R to 180	R to 140	R to 140	R to 140	R to 140	R to 250	R to 140	R to 194	---	---	---

May not be fully applicable to pressurized applications

Chemical Formula	Concentration	ABS	CPVC	PP (PP-R, PP-RCT)	PVC	PE (MDPE, HDPE, PE-RT)	PB	PVDF	PEX	PA11, PA12	PA66	PSU	PPSU
Vinyl Acetate **CAS# 108-05-4** $CH_3COOCH{=}CH_2$	--	---	N	R to 73	N	R to 140	---	L to 68	R to 140	---	---	---	---
Water, Acid Mine H_2O	--	R to 160	R to 200	R to 140	R to 140	R to 140	R to 180	R to 300	R to 180	---	---	---	---
Water, Hot Brine H_2O with NaCl)		--	--	--	--	--	--	--	--	--	--	--	--
H_2O with sylvinite (KCl, NaCl))		--	--	--	--	--	--	--	R to 237	--	--	--	--
Water, Deionized H_2O	--	R to 160	R to 200	R to 140	R to 140	R to 140	R to 180	R to 300	R to 180	R to 194	R to 180	---	---
Water, Distilled H_2O	--	R to 160	R to 200	R to 212	R to 140	R to 140	R to 180	R to 300	R to 180	R to 194	R to 180	---	---
Water, Potable H_2O	--	R to 160	R to 200	R to 212	R to 140	R to 140	R to 180	R to 300	R to 180	R to 194	R to 180	---	---
Water, Salt H_2O	--	R to 160	R to 200	R to 212	R to 140	R to 140	R to 180	R to 300	R to 180	R to 194	R to 180	---	---
Water, Sea H_2O	--	R to 160	R to 200	R to 212	R to 140	R to 140	R to 180	R to 300	R to 180	R to 194	R to 180	---	---
Water, Soft H_2O	--	R to 160	R to 200	R to 212	R to 140	R to 140	R to 180	R to 300	R to 180	R to 194	R to 180	---	---
Water, Residential Waste H_2O	--	R to 73	R to 200	R to 212	R to 140	R to 140	R to 180	R to 275	R to 180	R to 194	R to 180	---	---
Whiskey	--	---	R to 180	R to 140	R to 140	R to 140	R to 140	R to 212	R to 140	---	---	---	---
White Liquor	--	R to 73	R to 180	---	R to 140	---	---	---	---	---	---	---	---
Wine	--	R to 73	R to 180	R to 140	R to 140	R to 140	R to 140	R to 212	R to 140	---	---	---	---
Xylene (Xylol) **CAS# 1330-20-7** $C_6H_4(CH_3)_2$	--	N	N	N	N	N	N	L to 140	N	L to 194	L to 73	---	---
Zinc Acetate **CAS# 557-34-6** $Zn(CH_3COO)_2 \cdot 2H_2O$	--	---	R to 180	---	---	---	---	R to 250	---	---	---	---	---
Zinc Carbonate **CAS# 3486-35-9** $ZnCO_3$	--	---	R to 180	R to 140	---	R to 140	---	R to 212	R to 140	---	---	---	---
Zinc Chloride **CAS# 76-46-85-7** $ZnCl_2$	--	R to 120	R to 180	R to 180	R to 140	R to 140	---	---	R to 140	---	---	---	---
	50%	---	---	---	---	---	---	---	---	L to 73	---	---	---
	Saturated	---	---	---	---	---	---	R to 212	---	---	---	---	---
Zinc Nitrate **CAS# 7779-88-6** $Zn(NO_3)_2 \cdot 6H_2O$	Saturated	R to 160	R to 180	R to 180	R to 140	R to 140	R to 140	R to 212	R to 140	---	---	---	---
	20%	---	---	---	---	---	---	---	---	---	---	R to 210	---

May not be fully applicable to pressurized applications

Chemical Formula	Concentration	ABS	CPVC	PP (PP-R, PP-RCT)	PVC	PE (MDPE, HDPE, PE-RT)	PB	PVDF	PEX	PA11, PA12	PA66	PSU	PPSU
Zinc Oxide **CAS# 1314-13-2** ZnO	--	---	R to 180	---	---	---	---	R to 212	---	---	---	---	---
Zinc Stearate **CAS# 557-05-1** $(CH_3(CH_2)_{16}COO)_2Zn$	--	---	---	---	---	---	---	R to 122	---	---	---	---	---
Zinc Sulfate **CAS# 7733-02-0** $ZnSO_4 \cdot 7H_2O$	Saturated	R to 160	R to 180	R to 212	R to 140	R to 140	R to 140	R to 212	R to 140	---	---	---	---
	20%	---	---	---	---	---	---	---	---	---	---	R to 212	---

Please replace Appendix III.D with the following pages

APPENDIX III.D – SOIL LINER QUALITY CONTROL PLAN

MSW AUTH NO. 2284A

APPENDIX III.D – LINER QUALITY CONTROL PLAN

CITY OF EL PASO, TEXAS
GREATER EL PASO LANDFILL VERTICAL EXPANSION
PROJECT NO. 155488

REVISION 1
MAY 16, 2025

Part III, Appendix III.D
Liner Quality Control Plan
MSW Auth No. 2284A

prepared for

City of El Paso, Texas
Greater El Paso Landfill Major Amendment
El Paso County, Texas

Project No. 155488

Revision 0, October 31, 2024
Revision 1, May 16, 2025

STATE OF TEXAS
TONYA L. KOLLER
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CONTENTS

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FIGURES

TABLES

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III.D.5.0 Ballast/Protective Cover

III.D.5.1 General

This section addresses the need for soil or waste ballast at the landfill and as well as covers the work necessary for construction of the protective cover system over the LCS. Two protective cover systems are proposed for use at the landfill. One system uses available soil on-site as the cover material. This system is described in **Section III.D.5.3**. The other system uses on-site soil material for the lower 12-inches and tire chips in the upper 12-inches. The alternative system of soil/tire chips is described in **Section III.D.5.4**.

III.D.5.2 Ballast

The landfill facility is located in a sand desert setting with very deep groundwater beneath the site as described in detail in Part III, Appendix III.E, Geology Report. A discussion of the consideration of local groundwater use is provided in Part III, Appendix III.E, Section III.E.5.0. Groundwater in this area is not anticipated to be used as groundwater, as discussed further in Section III.E.5.4. The northern portion of the facility is relatively flat; however, the southern portion exhibits significant elevation relief as the topography drops towards the distant Rio Grande River. Because of this topographic relief, excavation depths for this site vary from approximately 15 feet to 60 feet below the existing ground surface.

Based on historic measured groundwater depths, the excavated landfill cells will be well above the seasonal high-water table. As a result, ballasting of the cells against hydrostatic uplift will not be required at this facility.

III.D.5.3 Protective Cover Soil

A minimum 2-foot-thick protective cover will be placed above the LCS. The protective cover may use on site soil in combination with the chimneys described in **Section III.D.4.3**. The maximum gravel size shall not exceed two inches. Pre-construction and conformance testing for the protective cover soils will include maximum size gradation with a minimum conformance testing frequency of one grain-size analysis (ASTM D6913) per 5,000 cubic yards (or fraction thereof) of in-place material.

Protective cover does not require compaction control; however, it should be stable for construction and disposal traffic. Care will be exercised in placement so as not to shift, wrinkle, or damage the underlying geosynthetic layers, and the placement methods will be documented. Protective cover will be placed such that the top surface, while spreading, is always at least 2 feet above the geosynthetic layers, unless low ground pressure dozers are used (i.e., track pressure less than 5 psi), in which case at least one foot should be maintained between the dozer and the geosynthetics. A greater thickness will be maintained to support loaded hauling trucks and trailers and for turning areas. Drivers will proceed with caution when on the overlying soil and prevent spinning of tires or sharp turns.

Protective cover will generally be placed in an up-slope direction for sidewalls if the same material is being used. Where the top few feet of sidewall (typically less than 5 feet vertically) is to be protected by a different soil type, such as clay for tying in the final cover soil liner, this material may be placed from the top if adequate care is taken to protect the synthetic liner components.

The required thickness of protective cover will be verified by survey methods on an established grid system with not less than one verification point per 5,000 square feet of surface.

Please replace Appendix III.E with the following pages

APPENDIX III.E – GEOLOGY REPORT

MSW AUTH NO. 2284A

APPENDIX III.E – GEOLOGY REPORT

CITY OF EL PASO, TEXAS
GREATER EL PASO LANDFILL MAJOR AMENDMENT
PROJECT NO. 155488

REVISION 1
MAY 16, 2025

Part III, Appendix III.E
Geology Report
MSW Auth No. 2284A

prepared for

City of El Paso, Texas
Greater El Paso Landfill Major Amendment
El Paso County, Texas

Project No. 155488

Revision 0, October 31, 2024
Revision 1, May 16, 2025

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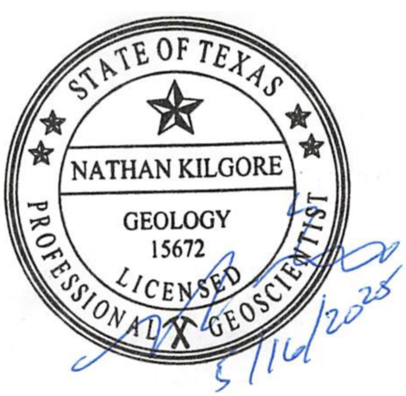
CONTENTS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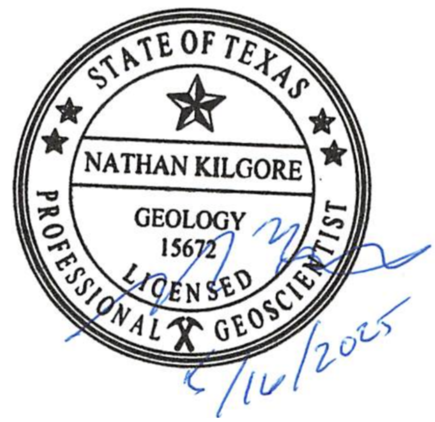
TABLES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III.E.4.0 Geological Processes

III.E.4.1 Regional Geological Processes

III.E.4.1.1 Faults

The Hueco and Mesilla bolsons were primarily formed by normal faulting. These block-faulted grabens are asymmetrical due to downward fault movement being greater on one side of the basin than the other.

Numerous fault scarps of Quaternary age are present in the Hueco Bolson near the facility, as displayed on the Geologic Atlas of Texas, Van Horn-El Paso Sheet which is presented as **Attachment III.E.3**. Several generally north-south trending scarps are present to the east of the facility. The age of faulting in the Hueco Bolson has been dated as less than ½ million years, potentially less than 0.2 million years, based on offset in the Camp Rice Formation and in soils formed on the Camp Rice Formation (Seager, 1980). The USGS' Quaternary Fault and Fold Database of the United States provides the most recent prehistoric deformation for the Hueco Bolson Fault Zone as middle and late Quaternary (<750,000 years) and includes a comment, "Timing of movement is not well constrained, but scarps are present on early to middle Pleistocene deposits (Collins and Raney, 1991 #846). Cross-cutting relationships with younger deposits are unknown." The USGS also lists the age of faulted surficial deposits as "Middle Pleistocene alluvium and soils (Collins and Raney, 1991 # 846); no detailed studies have been conducted to determine if younger (upper Quaternary) deposits are faulted. Collins and Raney (1997 #7419) suggest that stage III-IV calcic horizons capping the early to middle Pleistocene upper Camp Rice Formation could be offset." (Collins and Jochems, compilers, 2016)[10]

Based on the Geologic Atlas of Texas, Van Horn – El Paso sheet, the facility is located approximately ½ mile to the west of the nearest inferred fault line. As documented by the preparer of the initial permit application for this facility, "There is no active fault line observed within the vicinity of the new landfill site. Evidences such as structural damage, surface depression, surface lineations, vegetation changes, and crude oil and natural gas accumulations were not observed during our site observation. No ground movement caused by the existing fault within the landfill site vicinity was recorded for the past 50 years. This section fulfills the requirements of 30 TAC §330.555, Fault Areas."

III.E.4.1.2 Subsidence

Based on the publication titled, "Final Report: Identification of the Vulnerability of the Major and Minor Aquifers of Texas to Subsidence with Regard to Groundwater Pumping TWDB Contract Number 1648302062," "Figure 4-28" illustrates the area of the facility as an area of low to medium risk of subsidence vulnerability due to groundwater pumping of the Hueco-Mesilla Bolsons Aquifer (Furnans et al., 2017)[11]. Subsidence has not been recorded at the facility.

III.E.4.1.3 Erosion

Potential erosion due to surface water processes such as overland flow, channeling, gullying, and fluvial processes is limited due to the climatic conditions and the location of the facility. The facility is located in

[10] Collins, E., and Jochems, A.P., compilers, 2016, Fault number 901, Hueco fault zone, in Quaternary fault and fold database of the United States: U.S. Geological Survey website, https://earthquakes.usgs.gov/hazards/qfaults, accessed 10/30/2023.

[11] Furnans, J., Keester, M., Colvin, D., Bauer, J., Barber, J., Gin, G., Danielson, V., Erickson, L., Ryan, R., Khorzad, K., Worsley, A., & Snyder, G. (2017). Final Report: Identification of the Vulnerability of the Major and Minor Aquifers of Texas to Subsidence with Regard to Groundwater Pumping (TWDB Contract Number 1648302062). LRE Water, LLC, Blanton & Associates, Inc., Wet Rock Groundwater Services, LLC, and GLS Solutions, Inc.

an arid region with typical annual rainfall of less than 9 inches per year. Windblown sands are prevalent at the ground surface at the facility and form dunes.

The Surface Water Drainage Report provided in **Part III, Appendix III.B** incorporates armor, berms, and other measures to mitigate surficial erosion from water flow during the life of the facility. Rainfall data obtained from NOAA Atlas 14, Volume 11 (version 2) is provided in **Part III, Appendix III.B.2.3.1**.

Stream flow during storm events is diverted by either the berms or a perimeter drainage ditch during site development of the landfill. Diversion measures are depicted in **Part III, Appendix III.B, Attachment III.B.4**. A narrative description of erosion control is presented in **Part III, Appendix III.B, Attachment III.B.1**.

III.E.4.1.4 Earthquake

The Seismic Hazard Map, “2014 Seismic Hazard Map – Texas”, published by the United States Geological Survey) indicates that the facility is located in a low to moderate seismic impact area. Seismic impact within this area is expected to be low and the potential for severe damage is anticipated to be low during the service life of the facility. The referenced map is presented as **Attachment III.E.6**.

III.E.4.1.5 Liquification Potential

Based on the density of the sandy soils encountered, the depth to groundwater, lack of surface water, and the designated seismic hazard, the liquefaction potential at this facility is considered negligible.

III.E.4.1.6 Wetlands

This is an existing facility and prior to initial permit issuance, the U.S. Army Corps of Engineers, Albuquerque District, determined that there were no regulated wetlands at the facility. A copy of the U.S. Army Corps of Engineers correspondence is provided in **Part I/II, Appendix I/II.G**.

III.E.5.0 Regional Hydrogeology

III.E.5.1 Regional Aquifers

The major aquifer in the regional area is the Hueco-Mesilla Bolsons Aquifer (see **Attachment III.E.7**). The unconfined aquifer extends from New Mexico into western Texas and is located in El Paso County and Hudspeth County. The aquifer is fault-bounded and unconfined with underlying and surrounding lithologic units that are considered to be impermeable. The sediments in which the aquifer is found consist of unconsolidated to poorly consolidated silt, sand, gravel, and clay from alluvial, fluvial, and lacustrine deposition within the basins, or bolsons. The maximum thickness of the Hueco Bolson is 9,000 feet (TWDB, 2016)[12]. A conceptual cross-section of the Hueco Bolson is depicted in **Attachment III.E.8** . There are no minor aquifers in the region of the facility, as identified by the Texas Water Development Board (TWDB); therefore, the Hueco-Mesilla Bolsons Aquifer is not hydraulically connected to other major or minor aquifers in the vicinity of the facility.

Regional groundwater flow in the aquifer is modeled to be to the south and southeast and the average horizontal hydraulic conductivity in the area is estimated at 33 feet per day with a range of 3 to 164 feet per day. A regional potentiometric surface map with simulated conditions from 1996 is presented as **Attachment III.E.9**. In the vicinity of the facility, the groundwater flow direction is simulated as southeast and is considered to be under water table conditions. Vertical hydraulic conductivities are estimated between 0.02 and 0.07 feet per day and the specific yield of the aquifer is estimated to be 0.18. (Heywood and Yager, 2003)[13]. Groundwater levels in the area of the facility are measured to be between 250 to 400 feet (ft) below ground surface (bgs) below the City of El Paso and less than 70 ft bgs below the Rio Grande. Additionally, well yields of the aquifer in the interior portion of the Hueco Bolson range between 300 and 700 gallons per minute (Sheng et al., 2001)[14].

Since development has grown in El Paso and in Ciudad Juarez, groundwater withdrawal through pumping has caused the Rio Grande River to become a losing stream, when it was previously a gaining stream, and it is now a source of recharge of the aquifer. Additionally, groundwater withdrawals from these metropolitans have caused the groundwater potentiometric surface to change in these areas over the years, causing groundwater to flow towards points of groundwater withdrawal (Heywood and Yager, 2003).

III.E.5.2 Groundwater Composition

The Hueco-Mesilla Bolsons aquifer in the Texas portion of the Hueco Bolson is estimated to contain 9 million acre-feet of fresh water (Bredehoeft, Ford, Harden, Mace, and Rumbaugh, 2004)[15]. Generally, the aquifer contains fresh water in its upper portion and becomes saline with depth. Concentrations of total dissolved solids (TDS) of the aquifer typically range between 1,000 and 3,000 milligrams per liter (mg/L), or slightly saline, with TDS concentrations in the area of the facility ranging from approximately 3,000 to 10,000 mg/L, or moderately saline (TWDB, 2016).

[12] Texas Water Development Board (TWDB). (2016). Texas Aquifer Study: Groundwater Quantity, Quality, Flow, and Contributions to Surface Water. Retrieved from [https://www.twdb.texas.gov/groundwater/docs/studies/TexasAquifersStudy_2016.pdf].

[13] Heywood, C. E., & Yager, R. M. (2003). Simulated ground-water flow in the Hueco Bolson, an alluvial-basin aquifer system near El Paso, Texas. U.S. Geological Survey Water-Resources Investigations Report 02-4108, 55p.

[14] Sheng, Z., Mace, R. E., & Fahy, M. P. (2001). The Hueco Bolson: An Aquifer at the Crossroads. Texas Water Development Board.

[15] Bredehoeft, J., Ford, J. Harden, B., Mace, R. and Rumbaugh, J., 2004, Review and interpretation of the Hueco Bolson groundwater model: report prepared for El Paso Water Utilities, 18p.

Groundwater samples collected from the Hueco Bolson by the TWDB between 2000 and 2015 indicated that arsenic concentrations in some of the samples exceeded applicable drinking water standards. Additionally, concentration of chloride, fluoride, iron, manganese, sulfate, and TDS exceeded respective secondary water quality standards in some samples collected during a previous study.

III.E.5.3 Aquifer Recharge Characteristics

Recharge to the regional aquifer occurs from infiltration or precipitation which falls directly on the surface and runoff from the adjoining bolson surfaces, leakage from the Rio Grande River and numerous canals which traverse the heavily cultivated and irrigated floodplain, and excess irrigation water applied to the area. Additionally, aquifer recharge occurs along the flanks of the Franklin Mountains. The Rio Grande River is not within 5 miles of the facility; however, areas of concentrated surface flows, such as within arroyos or unlined agricultural canals, are within 5 miles of the facility and may provide minor or intermittent recharge to the aquifer (Sheng et al., 2001).

In addition, through a wastewater recycling system at the Fred Hervey Water Reclamation Plant, wastewater is treated to meet water drinking standards and is injected into shallow recharge wells in the Hueco Bolson. The rate of recharge from this operation in 1995 was approximately 1.2 billion gallons per year (Sheng et al., 2001).

III.E.5.4 Aquifer Withdrawal

Groundwater withdrawal from public supply wells and concrete lining of a portion of the Rio Grande River in the City of El Paso has affected the aquifer's recharge-discharge relationships and has caused fluctuations in the direction of groundwater flow. As a result of extensive groundwater withdrawals and modifications of recharge zones, water levels of the aquifer declined several hundred feet from the early 1900s until the late 1980s. Since the late 1980s, data suggests that regional water levels of the aquifer may be stabilizing; however, in the area of the facility, water levels are suggested to have declined between 5 to 10 feet from 2010 to 2015 (latest regional data identified) (TWDB, 2016).

All water wells, excluding groundwater monitoring wells associated with the facility, located within a 1-mile radius of the facility are shown on **Attachment III.E.23**. There are three water wells, used for the withdrawal of water, located within a one-mile radius of the facility, according to the Texas Water Development Board (TWDB) records. A map depicting the locations of these wells is presented as **Attachment III.E.23**. One of these water wells, the Orr well, was located within the facility and is noted as "Plugged or Destroyed" according to TWDB records. TWDB has assigned the other two water wells with State Well Number 4931204 and with State Well Number 4931205. The range of depths of these water wells is between 325 feet to 570 ft bgs. TWDB records related to these water wells are presented as **Attachment III.E.24**. Static water levels in the above-mentioned water wells range from 269 feet to 370 feet. The variation in the recorded depths is due mainly to the difference in surface elevation and topography across the area. Water wells 4931204 and 4931205 are located approximately 1,860 feet west and 3,895 feet northwest of the facility, respectively. Based on an apparent southeastern direction of groundwater flow at the facility, both wells appear to be positioned upgradient to side-gradient, and neither well provides a source of drinking water.

Upon completion of the sampling and drilling operations, the eight soil borings were converted into piezometers. These borings were identified with the designation, “PB.” The piezometers were constructed using 2- or 4-inch diameter Schedule 40 PVC riser and 0.010” machine-slotted screen. The boring annulus was completed using 10-20 filter sand, to a minimum depth of 1-foot above the top of the screen, followed by a 5-foot plug of bentonite. In addition, the wells were grouted to the surface and the casing extended above the ground surface elevation. Piezometer completion included a riser cap, hollow metal box riser protector (with a lock), mounted into a 4-inch x 4-foot x 4-foot concrete pad. Pipe bollard posts were placed around the perimeter of the piezometers. A typical construction diagram of a piezometer boring, as well as a typical construction diagram of a groundwater monitoring well at the facility are presented as **Attachment III.E.16**. The piezometer boring logs are included in **Attachment III.E.12**.

A hot-pressure washer was used to decontaminate the drilling equipment and tools at the facility prior to drilling, between piezometer locations, and before departure from the facility.

The piezometers were developed as required by 30 TAC §330.421(c), at the time of installation.

III.E.6.5 Groundwater Monitoring Well Installation

Groundwater monitoring wells and a groundwater observation well were installed at the facility in accordance with applicable groundwater monitoring requirements. A map depicting the locations of all monitoring wells installed at the facility is presented as **Attachment III.E.17**. Installation of the monitoring wells has taken place during multiple events as the facility has developed. Monitoring well data sheets, which contain information related to the installation and construction of each monitoring well, are presented as **Attachment III.E.18**. Surveyed locations of the monitoring wells are presented in **Attachment III.E.15**. Plugging reports of monitoring wells are presented as **Attachment III.E.19**. Groundwater data and other information related to the groundwater monitored by these wells are described in the following section of this report.

III.E.6.6 Groundwater

As noted on the piezometer and groundwater monitoring well installation logs presented in **Attachment III.E.12**, groundwater at the facility has been encountered at depths ranging from approximately 286 to 378 feet (ft) below ground surface (bgs) with an average depth of approximately 359 ft bgs. In general, collected potentiometric surface data suggests that the groundwater beneath the facility generally flows to the east, southeast, and northeast, which is congruent with the regional groundwater flow direction to the southeast in the area of the facility. Historical groundwater measurements are tabulated in **Attachment III.E.20**, and will be updated with subsequent monitoring events. Additionally, a map depicting the seasonally high-water table is presented as **Attachment III.E.21**.

The uppermost groundwater-water bearing unit beneath the facility, in which the groundwater monitoring wells are installed, is considered to be unconfined and in general, the laboratory-reported total dissolved solids (TDS) concentrations in samples collected from the groundwater monitoring wells are <3,000 milligrams per liter. Laboratory analytical reports with TDS concentrations are presented as **Attachment III.E.22**. The screened intervals of the majority of the groundwater monitoring wells installed at the facility are installed within a brown, soft, clay layer that often contains silt and sand or at the lithological contact of the clay layer and the overlying, fine-grained sand unit.

Water levels have been measured at regular intervals since piezometers were initially installed in January 25, 1999. Measured groundwater elevations are presented in **Attachment III.E.20**.

Sampling of the groundwater monitoring system’s fifteen (15) monitoring wells is conducted on a semi-annual basis as part of the landfill’s current detection monitoring program. All results and associated statistical analyses are reported to the TCEQ. Results from the most recent semi-annual groundwater monitoring events (June 2023, December 2023, and June 2024) are summarized as follows:

During June 2023, toluene was detected in wells MW-1, MW-9, MW-10, MW-11, PB-36, and PB-37, as well as in the field blank. The concentration in the field blank was greater than the concentration of any detection observed in the monitoring wells. It was concluded that toluene was introduced as a field or sample handling contaminant and not sourced from the landfill. Toluene was not detected during the December 2023 semi-annual sampling event at any monitoring well location. Selenium was detected in MW-6 during the December 2023 semi-annual event but did not produce an increasing trend using the TCEQ-approved statistical methods and remains in detection monitoring.

During the June 2024 semi-annual monitoring event, one (1) exceedance was identified for antimony at MW-11. However, a comparison using the TCEQ-approved statistical methods did not identify an increasing trend.

To date, all wells remain in the detection monitoring program, and no significant increases of detection monitoring program constituents have been identified. This indicates that operation of the landfill is not currently impacting the underlying aquifer. All semi-annual groundwater monitoring results are submitted to TCEQ.

III.E.6.6.1 Historical Groundwater Elevation

There are three water wells, used for the withdrawal of water, located within a one-mile radius of the facility, according to the Texas Water Development Board (TWDB) records. A map depicting the locations of these wells is presented as **Attachment III.E.23**. One of these water wells, the Orr well, was located within the facility and is noted as “Plugged or Destroyed” according to TWDB records. TWDB has assigned the other two water wells with State Well Number 4931204 and with State Well Number 4931205. The range of depths of these water wells is between 325 feet to 570 ft bgs. TWDB records related to these water wells are presented as **Attachment III.E.24**. Static water levels in the above-mentioned water wells range from 269 feet to 370 feet. The variation in the recorded depths is due mainly to the difference in surface elevation and topography across the area.

Additionally, a potential vertical conduit was found within the facility during the initial site investigations. This vertical conduit consisted of a cathodic protection system (CPS) for the El Paso Natural Gas (EPNG) pipeline. The CPS was located in right-of-way “571683” and was designated “CPS #301” by EPNG. The City of El Paso and EPNG negotiated relocation of the CPS outside of the facility and the previous CPS location was plugged and abandoned in accordance with applicable regulations. The original location of the CPS is depicted in Part II, Figure I/II.A.3.

III.E.6.6.2 Aquifer Testing

The hydraulic conductivity of the aquifer was estimated by performing a “slug” test in three of the piezometers, specifically, “slug-in” tests. This data was used to approximate the rate of groundwater movement. The slug tests were conducted in accordance with the ASTM D 4044, Standard Test Method for Instantaneous Change in Head – Test for Determining Hydraulic Properties of Aquifers and ASTM D 5912, Standard Test Method for Determining Hydraulic Conductivity of an Unconfined Aquifer by Overdamped Well Response to Instantaneous Change in Head. A copy of the ASTM documentation used for the slug tests is presented as **Attachment III.E.25**. The slug tests were performed with a pressure transducer, measuring tape, and water bailers. The head differences and elapsed time were recorded with a data logger. The results of the testing indicated that the hydraulic conductivity of the underlying aquifer ranged from $1x10^{-4}$ to $1x10^{-6}$ cm/sec. The normalized curves of slug test results and related calculations are presented in **Attachment III.E.26**.

The constant head permeability testing results are presented as **Attachment III.E.27**. Soil sampling results are discussed in the following section.

III.E.6.6.3 Groundwater Flow Direction

Groundwater contour maps have been developed during groundwater monitoring events at the facility and are included in historical groundwater monitoring reports submitted to the TCEQ. Groundwater flow at the facility is generally to the northeast, east, and southeast. Historical groundwater elevation measurements support a generally eastward flow of groundwater beneath the facility with some deviations to the north and south. This groundwater frow direction aligns closely with the inferred groundwater flow direction illustrated on the regional potentiometric surface map, presented as **Attachment III.E.9**.

Hydraulic gradients were determined for the two events that represent the highest groundwater elevations (November 2006) and lowest groundwater elevations (September 2004). The gradients were determined by calculating the difference between the groundwater contours (head difference) and dividing by the horizontal distance between the contours. The values are in ft/ft; multiply by 5,280 for the gradient in feet per mile. Minimum and maximum rates of groundwater movement for each of the two events were estimated using the groundwater velocity equation (Driscoll, 1986):

$$v=2{,}830Ki/ne$$

Where:

v = groundwater velocity (ft/day);
K= hydraulic conductivity (cm/sec);
i = hydraulic gradient (ft/ft);
ne = effective porosity (percent); and
2,830 converts cm/sec to ft/day.

The hydraulic conductivity is estimated to be 1 x 10^{-5} cm/sec based off of the results of the slug tests provided in the previous section. Minimum and maximum hydraulic gradients were estimated for each event. Estimated hydraulic gradients for the September 2004 event ranged from a minimum of 2.6979 x 10^{-4} to a maximum of 3.9303 x 10^{-3}. Estimated hydraulic gradients for the November 2006 event ranged from a minimum of 4.007 x 10^{-4} to 3.6794 x 10^{-3}. The average effective porosity is estimated to be 30 percent, based on values from Freeze and Cherry (1979). Using the equation and the values described above, the estimated minimum and maximum groundwater velocities for the water-bearing zone are:

September 2004

$$v_{min} = \frac{2{,}830 \times 1.00E\text{-}05 \times 2.698E\text{-}04}{0.30}$$

$$v_{min} = 2.545E\text{-}05 \text{ ft/day}$$

and

$$v_{max} = \frac{2{,}830 \times 1.00E\text{-}05 \times 3.930E\text{-}03}{0.30}$$

$$v_{max} = 3.708E\text{-}04 \text{ ft/day}$$

November 2006

$$v_{min} = \frac{2{,}830 \times 1.00E\text{-}05 \times 4.007E\text{-}04}{0.30}$$

$$v_{min} = 3.780E\text{-}05 \text{ ft/day}$$

and

$$v_{max} = \frac{2{,}830 \times 1.00E\text{-}05 \times 3.679E\text{-}03}{0.30}$$

$$v_{max} = 3.471E\text{-}04 \text{ ft/day}$$

The maximum velocity calculated for the two above events is 0.0003708 ft/day, which is equal to 0.135 ft/year.

III.E.6.6.4 Point of Compliance

As stated in 30 TAC §330.3(106), “Point of Compliance” is defined as a “vertical surface located no more than 500 feet from the hydraulically downgradient limit of the waste management unit boundary, extending down through the uppermost aquifer underlying the regulated units, and located on land owned by the owner of the facility.”

The direction of groundwater flow was originally determined for the facility based on collected, water-level measurements from each monitoring well. Based on these measurements, the average flow vector was calculated at each monitoring well. This data was used to establish the Point of Compliance (POC).

As required by 30 TAC §330.403(e)(3) the owner/operator will “notify the Executive Director in writing” if an event or change is likely to affect the direction and rate of groundwater flow and the potential for detecting groundwater contamination. This will be based on evaluation of the groundwater elevations during groundwater monitoring of the landfill. Additional groundwater monitoring wells or sampling points and modification to the site development plan may be required to adequately monitor the groundwater.

III.E.6.6.5 Pollutant Migration

Pollutant migration is dependent upon the thickness of vadose zone, climate, and the soil characteristic within the zone.

The subsurface soil investigation study presented in **Section III.E.6.3** indicated that the existing soil within the vadose zone consists of poorly graded fine to medium sand, gravel, silt, clay, or combinations of these soils. The presence of clayey soils and fine-grained sand intermixed with silt and clay in various thickness may attenuate the vertical and horizontal migration of pollutants. Additionally, the distance between the landfill liner and the underlying groundwater table mitigates the potential of pollutant migration from the landfill to the groundwater.

In accordance with 330.63(e)(6)(K), I have reviewed the groundwater data described in a report submitted with this certification and have found no evidence that the Greater El Paso municipal solid waste landfill located at 2600 Darrington Road, El Paso, Texas 79928 has contaminated groundwater in the uppermost aquifer.

Please replace Appendix III.F with the following pages

APPENDIX III.F – GROUNDWATER SAMPLING AND ANALYSIS PLAN

MSW AUTH NO. 2284A

APPENDIX III.F – GROUNDWATER SAMPLING AND ANALYSIS PLAN

CITY OF EL PASO, TEXAS
GREATER EL PASO LANDFILL MAJOR AMENDMENT
PROJECT NO. 155488

REVISION 1
MAY 16, 2025

Part III, Appendix III.F
Groundwater Sampling and Analysis Plan
MSW Auth No. 2284A

prepared for

City of El Paso, Texas
Greater El Paso Landfill Major Amendment
El Paso County, Texas

Project No. 155488

Revision 0, October 31, 2024
Revision 1, May 16, 2025

prepared by

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CONTENTS

STATE OF TEXAS
NATHAN KILGORE
GEOLOGY
15672
LICENSED
PROFESSIONAL GEOSCIENTIST
5/16/2025

TABLES

STATE OF TEXAS
NATHAN KILGORE
GEOLOGY
15672
LICENSED
PROFESSIONAL GEOSCIENTIST

5/16/2025

III.F.1.0 Introduction

This Groundwater Sampling and Analysis Plan (GWSAP) addresses the groundwater monitoring and sampling program at the existing Greater El Paso Landfill, Municipal Solid Waste (MSW) Authorization Number 2284A (GEP Landfill or Facility) in El Paso County, Texas. This GWSAP has been previously approved and has been updated to comply with Title 30 of the Texas Administrative Code (30 TAC) Chapter 330, Subchapter J: Groundwater Monitoring and Corrective Action. The GWSAP covers the procedures for collecting representative samples from groundwater monitoring wells and the basic laboratory requirements for obtaining valid, defensible data. The GWSAP is limited to sampling and analysis requirements and does not include monitoring well siting, design, construction, or well development procedures. Groundwater monitoring will be conducted at the facility throughout the active life of the facility and through the post-closure care period, pursuant to 30 TAC §330.401(f).

In accordance with 30 TAC §330.403(d), all parts of the previously approved groundwater monitoring system will be operated and maintained so that they perform at least to design specifications through the life of the groundwater monitoring program. Certification of the previously approved groundwater monitoring system is provided in **Attachment III.F.7**.

In accordance with 30 TAC §330.403(e)(3), the owner/operator shall promptly notify the executive director, and any local pollution agency with jurisdiction that has requested to be notified, in writing of changes in facility construction or operations or changes in adjacent property that affect or are likely to affect the direction and rate of groundwater flow and the potential for detecting groundwater contamination from a solid waste management unit and that may require the installation of additional monitoring wells or sampling points. Such additional wells or sampling points require a modification of the site development plan.

There are no known contamination plumes at the facility; however, if contamination plumes are identified, in accordance with 30 TAC §330.63(f)(2), a description of any plume of contamination that has entered the groundwater from an MSW management unit will be included. Additionally, the extent of the plume will be delineated on a map and the concentration of each assessment constituent will be identified.

This is an existing facility. Based on historical groundwater monitoring results of the facility and previous geological investigation of the subsurface of the facility, the most likely pollutant pathway for pollutant migration in the event that the primary barrier liner system is penetrated would be from the waste to the underlying soils and then to the groundwater which has been historically measured at depths ranging from approximately 286 to 378 feet (ft) below ground surface (bgs) at the facility, with an average depth to groundwater measured at approximately 359 ft bgs.

III.F.4.0 Groundwater Sample Collection

Groundwater samples may be collected via the snap sampler (passive) method, which is the preferred method of groundwater sampling at the facility, or via the monitoring well purging method. This section describes the two methods, as well as proper groundwater sample collection, preservation, quality control, and water management from groundwater sampling and equipment decontamination activities. Field filtering of groundwater samples will not be performed, in accordance with 30 TAC §330.405(c)

Prior to conducting the sampling activities, all water quality instrumentation will be calibrated. Calibration of the instruments will be conducted in accordance with the manufacturer's suggested procedures or other industry standard best practices. Calibration shall occur at a minimum of once per day during sampling events, prior to commencement of the scheduled sampling activities. Any malfunctioning instrumentation will be repaired or replaced prior to sampling activities.

III.F.4.1 Snap Sampling Procedures (Passive)

Prior to each sampling event, the groundwater level in each monitoring well and the total well depth will be measured as described in **Section III.F.2.0**. The snap sampling method involves collecting groundwater samples passively without disturbing the groundwater within the well. The monitoring well's groundwater flows in and through the open ends of the sample containers held within the snap sampler assembly until the samples are ready to be collected.

Groundwater samples are collected by closing the deployed sample containers held within the snap sampler assembly using a pneumatic battery powered electric pump. The pump pressurizes the hollow lift tube attached to the snap sampler assembly, to a pressure of above 50 psi which triggers the sampler caps to close, collecting an undisturbed real time sample at each monitoring well. Snap samples must not be collected after any disturbance of groundwater within the monitoring well (i.e. purging), without letting groundwater restabilize. Restabilization refers to the period of time required for groundwater within the monitoring well to reach its ambient state following physical agitation.

The closed snap sampler will be reeled out of the monitoring well using the hollow lift tube attached to the sampler assembly. Samples are collected by detaching the 350-mL polypropylene sample containers from the body of the snap sampler assembly and filling the sample containers. Sample container filling order and procedures are detailed in **Section III.F.4.3**.

The remaining groundwater in the snap sample will be poured in a graduated cylinder, or similar container, and groundwater quality parameters will be recorded. Parameters to be recorded include temperature, specific conductivity, and pH. Excess groundwater and decontamination water will be managed according to the procedures outlined in **Section III.F.3.0**.

Procedures performed after sample collection are described in **Section III.F.4.3**.

Finally, the sample containers will be reattached to the body of the snap sampler assembly, reset to the open position, and redeployed into the monitoring well. As described in **Section III.F.3.0**, the sampler will be decontaminated thoroughly and deployed into the monitoring well, with sample container caps in the open position for the next sampling event, where it must remain a minimum of 2 weeks before the next sampling event. The time period for restabilization is necessary to allow groundwater to reach its ambient state following physical agitation and to reach chemical equilibrium with formation water. Recommended sample containers, preservation, and holding times for the analyses listed in this GWSAP are presented in **Section III.F.5.5**.

III.F.4.2 Monitoring Well Purging Procedures

Prior to each groundwater sampling event, the groundwater level in each groundwater monitoring well and the total well depth will be measured as described in **Section III.F.2.0**. Groundwater sampling will consist of purging or bailing a calculated amount of groundwater from each well, while collecting groundwater quality data, prior to groundwater sample collection. The volume of water to be removed from each well will be based on the well casing volume and the calculated amount of groundwater in the well casing.

The wells will be purged or bailed of at least three calculated well casing volumes or until the well is purged or bailed dry before collecting a groundwater sample. If the well is purged or bailed dry, the sampling personnel will allow the groundwater to adequately recover in the monitoring well before collecting a representative sample. The purging process will continue until the readings stabilize and three volumes have been removed or until the well is purged dry. Parameter stabilization is defined as:

- Specific Conductivity = +/-10% for three (3) consecutive measurements
- pH = +/-0.2 standard pH units for three (3) consecutive measurements
- Temperature = +/-10% for three (3) consecutive measurements

During purging of the well, water quality parameters, including temperature, conductivity, pH, and any other relevant parameters will be collected. The parameters will be measured after each well calculated volume that is removed and prior to sample collection. In the event that a given well is known to purge to dryness prior to removal of three volumes, parameters will be measured at an appropriate rate for the collection of multiple readings prior to the well purging dry (e.g., every one-half well volume).

Well parameter data will be recorded during purging on the Groundwater Sampling Field Data Sheet (or an equivalent form) provided in **Attachment III.F.2**. The Field Data Sheet will include, at a minimum, fields to record the temperature, pH, and specific conductivity. Wells that dewater prior to achieving the three well casing volumes will be evacuated until dry then allowed to recharge. If sufficient recharge occurs the same day as purging, the well will be purged at least a second time. In the event that monitoring wells recharge very slowly, wells will be purged to dryness in order to remove stagnant water from the well casing. Wells will be allowed sufficient time to recover such a groundwater sample is collected. Whenever possible the groundwater level shall be allowed to recover to within 90 percent of the original water-level measurement prior to sampling. In the event that sufficient well volume is not available within seven days of purging, the well will be considered “dry”, and samples will not be collected. The calculated and actual purge volume achieved as well as the field parameters will be recorded on the groundwater sampling report form (or an equivalent form).

The method of well purging for this site will consist of using a portable submersible pump, or equivalent, system for each well. The pump intake will be gently placed within the uppermost part of the well screen to minimize agitating any residual sediment that has collected in the bottom of the well. For wells that sustain continuous pumping without dewatering, the discharge rate on the pump will be set so as to maintain a drawdown in the well of no more than 1-2 feet. Water-level measurements should be collected to determine the amount of drawdown that has occurred during purging. If the drawdown significantly exceeds the groundwater recharge rate, then the pump rate should be reduced until the drawdown in the well is in the range of 1-2 feet. This procedure will minimize any cascading effects that may volatilize constituents in the groundwater entering the well casing and will also minimize agitating sediment collected in the bottom of the well. Proper cleaning of the portable pump, or non-disposable equipment used during sampling activities, will occur to minimize the potential of cross contamination. Decontamination procedures are detailed in **Section III.F.3.0**.

The monitoring wells will be purged of groundwater in a particular order, based on the recharge time required (i.e., wells with slow recharge will be purged prior to wells with faster recharge time in order to allow for adequate recharge time prior to sampling). If the groundwater is suspected to contain contaminants, then the order of purging and sampling will proceed from the well with the lowest contaminant concentrations to the well with the highest concentrations of contaminants, as approved by the executive director.

During the purging operations, a record of the climatic conditions, condition of the wells and surrounding ground surface, water turbidity (visual inspection), color, odors, water level, depth of well and purge rate will be maintained and recorded on the Groundwater Sampling Field Data Sheet (or an equivalent form) provided in **Attachment III.F.2**. The information will be recorded in ink and the field data sheets from each sampling event will be provided in the required groundwater monitoring reports.

Groundwater samples will be collected from the pump discharge or with a bailer. The pump discharge will be regulated at the time of sampling to maintain as slow of a discharge rate as possible (generally 0.1 liter per minute) to minimize cascading and volatilization of potential contaminants as the sample containers are being filled. Once the discharge rate is set for sampling, it will be maintained throughout sample collection. When a bailer is used for sample collection, the bailer will be slowly lowered into the water column to avoid agitation of the groundwater. The bailer will then be removed from the well and water will be slowly released from the bailer directly into the required sample containers. The sample containers will be held as close to the pump discharge or bailer as possible without touching to minimize the potential loss of any volatile organic compounds (VOCs).

Additional groundwater sample collection and handling procedures, including the order of filling sample container and labeling, are described in **Section III.F.4.3**.

III.F.4.3 Groundwater Sample Collection and Handling Procedures

During groundwater sample collection, disposable latex gloves will be worn, and disposed between monitoring wells to minimize cross contamination of samples and to reduce the possibility of sampling personnel coming into direct contact with groundwater containing contaminants. Groundwater samples will be collected using either the purging method (as described in **Section III.F.4.2**) or the snap sampling method (as described in **Section III.F.4.1**).

In accordance with 30 TAC §330.405(b)(2), the monitoring wells will be sampled from the well with the highest groundwater elevation to the well with the lowest groundwater elevation, unless previous analytical data indicates the presence of contaminants in the groundwater. If contamination is suspected, the sampling order may vary upon approval by the executive director. Groundwater samples will be collected within 24 hours following collection of water-level measurements, unless wells do not adequately recover within that timeframe after following the purging procedures detailed in **Section III.F.4.2**. If sufficient recharge does not occur within 7 days following purging, then the well will be considered dry, and a sample will not be collected.

Sample containers, preservation methods, and holding times for the requested analyses will be approved by the laboratory, prior to sample collection. The sample containers will be filled in the following order: 1) VOCs; 2) semi-VOCs, if collected; 3) total metals and 4) inorganics, if collected. A list of the parameters to be analyzed is provided in **Attachment III.F.3**. In accordance with 30 TAC §330.405(c), no field filtering of the groundwater samples will be performed.

Aqueous samples for VOC analyses will be collected without any headspace or air bubbles, or as otherwise prescribed by the laboratory. Sample containers used for VOC analysis will be filled slowly until the liquid forms a meniscus on the rim of the container. The cap will then be gently placed on the container, taking care not to disturb the crown of the liquid (positive meniscus), and firmly closed. The vial will then be examined to verify the absence or minimal presence of all air bubbles. In the event that significant air bubbles, per the laboratory standards, are present, the sample will be recollected. Glass or fragile sample containers will be packaged in foam padding, bubble wrap, or an equivalent material to prevent breakage. All other sample containers will be filled according to laboratory instructions.

Following the filling of each sample container, the container will be labeled with a unique identification number, date and time collected, preservatives used, analyses to be run, and sampler's initials. Sample containers will be placed in zip-locked plastic bags which will be placed in a cooler for delivery to the laboratory.

Once the collected samples have been properly sealed and labeled as described above, they will be recorded on a Chain-of-Custody (COC) form, signed, and dated by the sampling technician(s). COCs will be approved by the laboratory that will be performing the analysis. An example of a typical COC is provided in **Attachment III.F.4**. The COC will accompany the samples to the laboratory. The readings of temperature, conductivity, and pH will be submitted to the laboratory with the samples, upon request. Prior to delivery of the samples to the laboratory, the samples will be placed in a cooler or ice chest (similar to an Igloo ice chest) with ice and will be maintained as close as possible to 4°C until the laboratory analyses are performed. Dry ice is not permitted due to the potential of freezing the samples and breaking the containers. Precautions will be taken to secure the samples in the ice chest to prevent them from breaking during transport. In order to verify that the samples have been maintained at or near 4°C, a temperature blank will be included with the sample shipment, if provided by the laboratory. The samples will be delivered to the laboratory within the respective hold times of the sampling parameters, after collection. For compliance with holding times, samples should be delivered to the laboratory within 24 hours after collection.

III.F.4.4 Quality Assurance and Quality Control Samples

To provide screening of field procedures, additional samples will be collected for quality assurance/quality control (QA/QC). At least one equipment blank will be collected each day of sampling. If dedicated equipment is used for sampling, then an equipment blank will not be collected. The purpose of the equipment blank is to evaluate if non-dedicated sampling equipment is free of contaminants as it was manufactured or decontaminated. Typically, the equipment blank will be collected after sampling the well with the highest concentration of contaminants each day. If contaminants are not detected from any of the wells, then the equipment blank will be taken randomly. The equipment blank will consist of filling laboratory-provided containers with deionized water that has been flushed through or over surfaces of the sampling equipment after decontamination. In addition to the equipment blank, a trip blank will be prepared by the laboratory and will accompany the empty sample containers and collected samples to and from the laboratory. The purpose of the trip blank is to assess whether any of the sample containers or collected samples have been contaminated during the sampling event. Also, a field blank will be collected each day in the field during sampling. The field blanks will consist of filling laboratory-provided containers with deionized water at a sampling location. The purpose of the field blank is to assess whether air-borne contaminants have potentially affected the samples during sample collection. The QA/QC samples will be collected and handled in a similar fashion to the other samples and will be analyzed for VOCs only.

At least one field duplicate sample will be collected for every ten normal samples collected or once per sampling event when fewer than ten normal samples are collected to assess the precision of the

sampling methods and laboratory analytical methods. The duplicate sample(s) will usually be collected from well(s) with the highest concentrations of contaminants, as previously reported. When a duplicate sample is collected, it will be handled in a similar fashion as the other samples but will be labeled in such a manner that the laboratory does not know it is a duplicate sample and cannot associate it with a normal sample for QA/QC purposes. The duplicate sample will be collected immediately after collection of the normal sample. This procedure is to provide for some assurance that the groundwater collected for the duplicate sample is relatively similar to the groundwater collected for the normal sample. Additionally, matrix spike and matrix spike duplicate (MS/MSD) samples may be collected at a rate of 1 MS/MSD per 20 normal samples. MS/MSD samples are typically triple the volume of a normal sample and are labeled with the same information as the associated normal sample. The laboratory may request that MS/MSD samples are collected, or the sampling personnel may decide to collect MS/MSD samples if certain groundwater characteristics (pH, total dissolved solids (TDS), etc.) may interfere with sample analysis.

III.F.4.5 Weather Protocol

Sampling of the monitoring wells will not be permitted during inclement weather, sandstorms, or thunderstorms. Caution should be taken by the sampling personnel when the temperature is below freezing or exceeds 100 ° F.

III.F.4.6 Purged or Decontamination Water Handling Procedures

Purged water during groundwater sample collection and decontamination water will be collected in approved DOT containers and stored at the facility for subsequent disposal. The analytical data will be reviewed to determine the proper disposal procedures.

Table III.F.5-1: QC Specification Limits for the PQL and Lower Limit of Quantitation Check Samples

COC	Precision (% Relative Standard Deviation)	Accuracy (% Recovery)
Metals	10	70-130
Volatiles	20	50-150
Semi-Volatiles	30	50-150

For analytes that the established PQL cannot meet the precision and accuracy requirements in **Table III.F.5-1**, the owner/operator will ensure the laboratory will submit sufficient documentation and information to the TCEQ for alternate precision and accuracy limits on a case-by-case basis. An analytical result reported below the MDL will be reported as less than the established PQL limit that meets these precision and accuracy requirements.

III.F.5.5 Constituents to be Analyzed and Test Methods

III.F.5.5.1 Detection Monitoring Program

In accordance with 30 TAC §330.407(a), groundwater at the facility will be monitored at least semi-annually during the active life of the facility and throughout the closure and post-closure care period as a part of the detection monitoring program. Water levels in all available wells and piezometers will be measured during each sampling event, and groundwater contour maps will be constructed. In order to comply with all applicable rules, the groundwater monitoring system may be modified if future updated groundwater flow direction is not compatible with the current proposed system.

Samples collected as part of the facility's detection monitoring program, as outlined in 30 TAC §330.407, will be analyzed for the constituents specified in 30 TAC §330.419 and 40 CFR 258, Appendix I, as presented in **Attachment III.F.3**. Analyses will be performed using the methods listed on **Table III.F.5-2**, equivalent methods, or updated methods approved by the United States Environmental Protection Agency (EPA).

The sample containers will be filled in the following order:

1. VOCs
2. Total Metals

In the event a Statistically Significant Increase (SSI) is confirmed (see **Section III.F.6.0**), an assessment monitoring program will be established in alignment with 30 TAC §330.409. Constituents and analytical methods associated with the assessment monitoring program are discussed in **Section III.F.5.5.2**.

Statistical methods used to evaluate detection monitoring data are presented in **Section III.F.6.0**. Reporting requirements are presented in **Section III.F.7.0**.

III.F.5.5.2 Assessment Monitoring Program

Within 90 days of determining that a statistically significant increase has occurred, in accordance with 407(b), and not less than annually thereafter, the facility will sample and analyze the groundwater monitoring system for the full set of constituents listed in Appendix II to 40 CFR Part 258, in accordance with assessment monitoring program requirements outlined in 30 TAC §330.409.

A minimum of one (1) sample shall be collected from each point of compliance well and analyzed for the 40 CFR Part 258, Appendix II constituents during each sampling event. The full list of Appendix II constituents is presented in **Attachment III.F.3.** Analyses will be performed using the methods listed on **Table III.F.5-2**, equivalent methods, or updated methods approved by the United States Environmental Protection Agency (EPA).

Table III.F.5-2 presents the analytical methods, recommended containers, preservatives, and holding times for the various analyses. The sample containers will be filled in the following order for collection of Appendix II constituents:

1. VOCs
2. SVOCs
3. Total Metals
4. Inorganics
5. Other

Table III.F.5-2: Sample Collection Guidelines: Containers, Preservatives, and Holding Times

Analysis Type	Constituent Appendix	Method	Recommended Containers	Preservatives	Holding Times
VOCs	Appendix I & Appendix II	8260	40 mL VOA (Volatile Organic Analysis) glass vials	No headspace, sometimes preserved with HCl to pH <2	14 days (refrigerated)
SVOCs	Appendix II	8270	Amber glass jars	Cool and dark storage, sometimes with sodium bisulfate	7 days (refrigerated)
Total Metals	Appendix I & Appendix II	6020	HDPE (high-density polyethylene) or polypropylene sample containers	Preserved with nitric acid (HNO3) to pH <2	180 days (refrigerated)
Herbicides	Appendix II	8151	Amber glass jars, Teflon cap	Cool to at least 6 degrees C	7 days (refrigerated)
Pesticides	Appendix II	8081	Amber glass jars, Teflon cap	Cool to at least 6 degrees C	7 days (refrigerated)
Organophosphorus Pesticides	Appendix II	8141	Amber glass jars	Cool to at least 4 degrees C	7 days (refrigerated)
PCBs	Appendix II	8082	Amber glass jars, Teflon cap	Cool to at least 6 degrees C	1 year (refrigerated)

After sampling all point of compliance wells for Appendix II constituents, the executive director may specify an appropriate subset of wells to be sampled and analyzed for the Appendix II constituents during assessment monitoring and may delete any of the Appendix II constituents for a municipal solid waste management unit if the owner or operator can document that the removed constituents are not reasonably expected to be in or derived from the waste contained in the unit.

The executive director may specify an appropriate alternative frequency for repeated sampling and analysis for the full set of 40 CFR Part 258, Appendix II constituents during the active life and the closure and post-closure care period of the unit considering the following factors:

1. Lithology and hydraulic conductivity of the aquifer and unsaturated zone;
2. Groundwater flow rates;
3. Minimum distance of travel from the waste nearest to any point of compliance monitoring well;
4. Resource value of the uppermost aquifer; and
5. Nature (fate and transport) of any constituents detected in response to this section.

The owner/operator shall, within 90 days of submittal of the results from a sampling event and on at least a semiannual basis thereafter, resample all wells specified by 30 TAC §330.409(a) and conduct analyses for all constituents in 30 TAC §330.419, and for those additional constituents in 40 CFR Part 258, Appendix II that are detected in response to a statistically significant increase per 30 TAC §330.409(b) (see **Section III.F.6.0**). The results must be submitted to the executive director not later than 60 days after the sampling event and shall also be placed in the operating record. At least one sample must be collected and analyzed from each background and point of compliance well at each sampling event. The executive director may specify an alternative monitoring frequency during the active life and the closure and post-closure care period for the constituents referred to in this paragraph. The alternative frequency during the active life and the closure and post-closure care period shall be not less than annual. The alternative frequency shall be based on consideration of the factors described previously.

The facility will establish background concentrations for any additional Appendix II constituents detected in accordance with subsection 30 TAC §330.409(b) and 30 TAC §330.409(d)(1) (see **Section III.F.5.6**).

The facility will establish groundwater protection standards for all constituents in point of compliance wells detected in accordance with 30 TAC §330.409(b) or 30 TAC §330.409(d)(1). The groundwater protection standards shall be established in accordance with 30 TAC §330.409(h) or 30 TAC §330.409(i).

If the concentrations of all 40 CFR Part 258, Appendix II constituents are shown to be at or below background values, using the statistical procedures in 30 TAC §330.405(f) (see **Section III.F.6.0** for more information on statistical methods), for two consecutive sampling events, the facility will notify the executive director in writing and return to detection monitoring if approved.

If the concentrations of any 40 CFR Part 258, Appendix II constituents are above background values, but all concentrations are below the groundwater protection standard established under subsection 30 TAC §330.409(h) or 30 TAC §330.409(i), using the statistical procedures in 30 TAC §330.405(f), the owner or operator will continue assessment monitoring in accordance with this section.

Not later than 60 days after each sampling event, the facility will determine if any 40 CFR Part 258, Appendix II constituents were detected at statistically significant levels above the groundwater protection standard established under subsection 30 TAC §330.409(h) or 30 TAC §330.409(i). If one or more groundwater protection standards have been exceeded, the owner or operator shall notify the executive director and appropriate local government officials in writing within seven days of the determination. The owner/operator shall also:

1. Characterize the nature and extent of the release by installing additional monitoring wells as necessary;

2. Install at least one additional monitoring well between the monitoring well with the statistically significant level and the next adjacent wells along the point of compliance before the next sampling event and sample these wells in accordance with 30 TAC §330.409(d)(1);
3. Notify in writing all persons that own or occupy the land that directly overlies any part of the plume of contamination if contaminants have migrated off-site as indicated by sampling of wells in accordance with 30 TAC §330.409 (d)(1); and
4. Initiate an assessment of corrective measures as required by 30 TAC §330.411 within 90 days of the notice to the executive director.

The owner or operator may demonstrate that a source other than the monitored solid waste management unit caused the contamination or that the statistically significant level results from error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality, as outlined in 30 TAC §330.409(g)(2). The demonstration requires the following:

1. Notification of the ED in writing within 14 days of determining a statistically significant level above the groundwater protection standard at the point of compliance that the facility intends to make a demonstration;
2. Submittal of a report to the ED within 90 days of determining a statistically significant level above the groundwater protection standard that demonstrates that source other than the monitored solid waste management unit caused the contamination or that the statistically significant event resulted from error in sampling, analysis, statistical evaluation or natural variation in groundwater quality. The report will be prepared and certified by a qualified groundwater scientist;
3. No filtration of the groundwater samples for constituents addressed by the demonstration prior to laboratory analysis. Analysis of landfill leachate may be required by the ED to support the demonstration; and,
4. Continued monitoring in accordance with the assessment monitoring program.

If a successful demonstration is made, the facility will continue monitoring in accordance with 30 TAC §330.409 and may return to detection monitoring if the 40 CFR Part 258, Appendix II constituents are at or below background. If the facility determines that the assessment monitoring program no longer satisfies the requirements of 30 TAC §330.409, the facility will submit an application for a permit amendment or modification within 90 days to make any appropriate changes to the program.

The owner or operator shall establish a groundwater protection standard for each 40 CFR Part 258, Appendix II constituent detected in the point of compliance monitoring wells. The groundwater protection standard must be:

1. For constituents for which a maximum contaminant level (MCL) has been promulgated under 40 CFR Part 141, Safe Drinking Water Act (codified), §1412, the MCL for that constituent;
2. For constituents for which MCLs have not been promulgated, the background concentration for the constituent established from wells in accordance with 30 TAC §330.405(d); or
3. For constituents for which the background level is higher than the MCL identified under paragraph (1) of this subsection or health-based levels identified under subsection 30 TAC §330.409(i), the background concentration.

III.F.5.6 Establishment and Updating of Background Data

Per 30 TAC §330.405(b)(3)(A), the number of samples to be collected to establish groundwater quality data will be consistent with the appropriate statistical procedures determined pursuant to 30 TAC §330.405(f).

In accordance with 30 TAC §330.407(a)(1), a minimum of four statistically independent samples from each background and each point of compliance well will be collected and analyzed for the constituents listed in **Attachment III.F.3** to establish background groundwater quality. Initial background sampling will be completed on a quarterly basis unless an alternative schedule is approved by the executive director.

Background datasets may be updated once every two years with semiannual detection monitoring results that are demonstrated to be representative of background groundwater quality. Upon completion of background monitoring and during background updates, the owner or operator will evaluate the background data to ensure that the data are representative of background groundwater constituent concentrations and are not impacted by waste management activities or other sources of contamination.

The background evaluation will be documented in a report and submitted to the executive director before the next groundwater monitoring event following the updated background period. At least one sample from each background and point of compliance well will be collected and analyzed during each subsequent semiannual sampling event.

In the event assessment monitoring is required and constituents from the list provided in 40 CFR Part 258, Appendix II (see **Attachment III.F.3**) are detected during assessment monitoring sampling, a minimum of four statistically independent samples from each background well will be collected and analyzed to establish background levels for the additional constituents, as outlined in 30 TAC §330.409(b).

III.F.5.6.1 Detection Monitoring Sampling Frequency

The detection monitoring sampling schedule will consist of collecting samples from each monitoring well for the constituents presented in **Attachment III.F.3** on a semi-annual basis and after background groundwater quality has been established.

III.F.5.6.2 Groundwater Monitoring System

The groundwater monitoring system is designed to monitor the uppermost saturated zone within the Hueco Bolson Aquifer and was designed in accordance with 30 TAC §330.403. The monitoring well system is comprised of fifteen (15) wells: MW-1, MW-3, MW-4, MW-6, MW-7, MW-8, MW-9, MW-10, MW-11, MW-13, MW-14, MW-15, PB-32, PB-36, and PB-37. The following provides information of the current groundwater monitoring system and a summary of historical details.

The groundwater monitoring system wells were installed in phases based on the timeline for waste placement in designated cells. A permit modification request to revise the groundwater monitoring system was submitted in November 2007 and approved on October 14, 2009. The proposed groundwater monitoring system included existing monitoring wells PB-32, PB-36, PB-37, MW-1, MW-3, and MW-4 and the installation of four (4) new monitoring wells MW-6, MW-7, MW-8, and MW-13. Monitoring well MW-9, which is downgradient of portions of Phase I and adjacent to Phase II, was installed prior to waste placement in Cell 7.

Monitoring wells MW-14 and MW-15 were installed in 2015 following a request for a permit modification in January 2014. The permit modification request was made to redefine the point of compliance boundary based on groundwater flow direction information obtained over a two-year monitoring event outlined in the 2014 modification request. Monitoring well MW-3 was reclassified from a point of compliance well to a background well for Phase II of the system, and PB-32 and PB-36 were reclassified from background wells to point of compliance wells. The request was approved by TCEQ on April 16, 2014.

Monitoring wells MW-10 and MW-11 were installed in 2019, prior to the acceptance of waste in the landfill's Phase II area.

All remaining wells are point of compliance wells.

All point of compliance wells are located no more than 500 feet from the hydraulically downgradient limit of the waste management unit, as defined in 30 TAC §330.3. Well spacing does not exceed 600 feet between any of the point of compliance wells, with the exception of the spacing between PB-37 and MW-8 (see discussion later in this section). The average design distance between point of compliance wells is approximately 562 feet, in compliance with 30 TAC §330.402(a)(2).

Table III.F.5-3 presents a summary of monitoring wells by categorical use.

Table III.F.5-3: Monitoring Well Categories

Point of Compliance Well(s)	Background (Upgradient) Well(s)	Observation/Sidegradient Well(s)
MW-13, MW-6, MW-7, MW-4, MW-8, PB-37, MW-9, MW-10, MW-11, MW-14, MW-15, PB-32, PB-36	MW-3	MW-1

As discussed in the permit modification application submitted on September 3, 2010 to TCEQ, MW-8 was installed along with several wells in June-July 2009. Per 30 TAC §330.403(a)(2), the wells had planned spacing of 600-feet. However, a subsequent field verification event revealed that the distance between MW-8 and the adjacent well, PB-37, is 642-feet. A compete review of the documentation showed that PB-37 was not accurately located on the installation drawing for this well, resulting in the 642-foot spacing.

Due to the installation of MW-9 following the installation of MW-8, relocation of PB-37 the minor distance of 42-feet closer to MW-8 was demonstrated to be impractical and unnecessary. A review of groundwater flow and time of travel characteristics found that the current location of PW-37 is as protective of human health and the environment as a revised location within 600-feet of MW-8. An Alternate Well Spacing Demonstration was performed and concluded that a release from the facility will not be detected in PB-37 during the active life of the facility and the post-closure care period. Likewise, a release will not be detected from a new well located 600-feet south of MW-8. TCEQ accepted the proposed alternate spacing between MW-8 and PB-37 in a letter dated October 26, 2010.

Monitoring well MW-1 was originally used as a point of compliance well when waste placement was limited to cells 1-6 of the Phase I portion of the landfill. Additional wells were installed prior to placement of waste in cells 7-9 of Phase I and cells 11-14 of Phase II. Due to the placement of MW-1 between Phase I and Phase II of the landfill and the addition of more representative point of compliance wells (MW-8 through MW-11), MW-1 is now used as an observation well.

All designs and modifications of the groundwater monitoring system presented in this document were previously sealed and approved by TCEQ. Certification of the approved groundwater monitoring system is provided in **Attachment III.F.7,** including certifications for the additional wells added in 2015 (MW-14 & MW-15) and 2019 (MW-10 & MW-11). Note that certification of this GWSAP does not indicate a recertification of the groundwater monitoring system by the licensed professional. Any modifications proposed in the future, including the addition of new background or point of compliance wells, will be conducted in alignment with 30 TAC §330.403(e)(3), as discussed in **Section III.F.1.0**.

III.F.6.0 Statistical Method to Evaluate Analytical Data

Statistical analyses of groundwater data will be performed in accordance with 30 TAC §§330.405 through 330.409. A statistical analysis plan has been included as **Attachment III.F.6** and has been prepared using generally accepted statistical analysis principles and practices. However, it is not possible to predict all potential future circumstances. Therefore, alternative methods, described in 30 TAC §330.405(e), may be used if deemed more appropriate for the data distribution of the constituents being evaluated. Historical statistical analysis is described and illustrated in groundwater monitoring reports associated with the facility.

III.F.6.1 Statistical Analysis for Detection Monitoring

Not later than 60 days after each detection monitoring sampling event, statistical analyses for the constituents listed in **Attachment III.F.3** will be performed to determine if a statistically significant increase over background of any tested constituent at any monitoring well has occurred. The statistical limit for each constituent will be set equal to the laboratory reporting limit, as presented in **Attachment III.F.3**. If a statistically significant increase over background of any tested constituent at any monitoring well has occurred, a notice will be made to the TCEQ Executive Director (ED), and any local pollution agency with jurisdiction that has requested to be notified, in writing within 14 days of the determination.

Groundwater sampling data will be evaluated using one of the following methods, as presented in 30 TAC §330.405(e)(1-5):

1. A parametric analysis of variance followed by multiple-comparisons procedures, including estimation and testing of the contrasts between each point of compliance well's mean and background mean levels for each constituent;
2. An analysis of variance based on ranks followed by multiple-comparisons procedures to identify statistically significant evidence of contamination, including estimation and testing of the contrasts between each point of compliance well's median and background median levels for each constituent;
3. A tolerance or prediction interval procedure in which an interval for each constituent is established from the distribution of the background data and the level of each constituent in each point of compliance well is compared to the upper tolerance prediction limit;
4. A control-chart approach that gives control limits for each constituent; or,
5. Another statistical test method that meets the performance standards of 30 TAC §330.405(f). Satisfactory justification for an alternative method must be provided to the executive director.

Any selected statistical method will comply with the performance standards described in TAC §330.405(f)(1-6). The statistical method used to evaluate groundwater monitoring data will be appropriate for the distribution of the tested constituents. Per 30 TAC §330.405(f)(2), if an individual well (or sampling point) comparison procedure is used to compare an individual compliance well constituent concentration with background constituent concentrations or a groundwater protection standard, the test shall be done at a Type I error level no less than 0.01 for each testing period. If a multiple-comparisons procedure is used, each testing period shall be no less than 0.05, but the Type I error of no less than 0.01 for individual well comparisons shall be maintained. This performance standard does not apply to tolerance intervals, prediction interval, or control charts.

III.F.6.2 Statistically Significant Constituent Concentrations Observed

An initial statistically significant increase (SSI) will be based on any constituent detected in any monitoring well at a concentration above the specific constituent's statistical limit. In the event of an initial SSI for constituents listed in **Attachment III.F.3**, one of the following options will be implemented: verification resampling in accordance with §330.407(b)(2), an alternate source demonstration (ASD) in accordance with §330.407(b)(3), or both. An initial SSI will be considered a confirmed SSI if no verification resampling is performed or if an ASD is not made to the satisfaction of the executive director within 90 days after the date of the notice. If an ASD is to be prepared, a written notice will be made to the ED, and any local pollution agency with jurisdiction that has requested to be notified, within 14 days of the determination of the SSI.

In the event that one or more constituents are confirmed through verification resampling as an SSI at any monitoring well location and the source cannot be attributed to an error in sampling, analysis, statistical evaluation, natural variation in groundwater quality, or another source per 30 TAC §330.407(b)(3), then an assessment monitoring program will be established in accordance with 30 TAC §330.407(b)(1) and 30 TAC §330.409 no later than ninety (90) days from the date of the SSI notice to the ED. The assessment monitoring requirements are discussed in detail in **Section III.5.5.2**.

III.F.7.0 Reporting Requirements

Statistical analysis will be performed no later than 60 days after each semi-annual sampling event of detection monitoring. In the event that statistical analysis of the groundwater analytical results indicates an initial SSI from background of any tested constituent at any monitor well, a notice in writing to the executive director and any local pollution agency with jurisdiction that has requested to be notified, will be submitted within 14 days after the determination of the SSI (30 TAC §330.407(b)).

Three (3) copies (triplicate) of an annual detection monitoring report describing groundwater sampling and analyses results will be completed on state reporting forms (e.g. TCEQ-0312 or subsequent versions) and will be submitted to the TCEQ no later than ninety (90) days after the facility's last groundwater sampling event in a calendar year and will include information determined since the previously submitted annual report (30 TAC §330.407(c)). In accordance with 30 TAC §§330.407(c)(1) through (c)(6), the following information will be included in the annual detection monitoring report:

- A statement regarding whether a statistically significant increase has occurred over background values in any well during the previous calendar year period and the status of any statistically significant increase events.
- The results of all groundwater monitoring, testing, and analytical work obtained or prepared under the permit requirements, including a summary of background groundwater quality values, groundwater monitoring analyses, statistical calculations, graphs, and drawings.
- The groundwater flow rate and direction in the uppermost aquifer. The groundwater flow rate and direction of groundwater flow shall be established using the data collected during the preceding calendar year's sampling events from the monitoring wells of the Detection Monitoring Program. All documentation used to determine the groundwater flow rate and direction of groundwater flow shall also be included in the annual report.
- A contour map of piezometric water levels in the uppermost aquifer based, at a minimum, upon concurrent measurement in all monitoring wells. All data or documentation used to establish the contour map will be included in the annual report.
- Recommendations for any changes.
- Any other items requested by the executive director.

In the event the facility has an established assessment monitoring program, three copies (triplicate) of an annual assessment monitoring report describing groundwater sampling and analyses results will be completed on state reporting forms (e.g., TCEQ-0312 or subsequent versions) and will be submitted to the TCEQ no later than 60 days after the facility's last groundwater sampling event in a calendar year and will include information determined since the previously submitted annual report (30 TAC §330.409(k)). Data may also be required to be submitted to the TCEQ by an electronic or other format as specified by the TCEQ. In accordance with 30 TAC §§330.409(k)(1) to (k)(6), the following information will be included in the annual assessment monitoring report:

- A statement whether a statistically significant level above a groundwater protection standard (GWPS) established in 30 TAC §330.409(h) or §330.409(i) has occurred in any well during the previous calendar year period and the status of any statistically significant level events.
- The results of all groundwater monitoring, testing, and analytical work obtained or prepared under the permit requirements, including a summary of background groundwater quality values, groundwater monitoring analyses, statistical calculations, graphs, and drawings.

- The groundwater flow rate and direction in the uppermost aquifer. The groundwater flow rate and direction of groundwater flow shall be established using the data collected during the preceding calendar year’s sampling events from the monitoring wells of the Assessment Monitoring Program. All documentation used to determine the groundwater flow rate and direction of groundwater flow shall also be included in the annual report.
- A contour map of piezometric water levels in the uppermost aquifer based, at a minimum, upon concurrent measurement in all monitoring wells. All data or documentation used to establish the contour map will be included in the annual report.
- Recommendations for any changes.
- Any other items requested by the ED.

In accordance with 30 TAC §330.407(d), if the detection monitoring program no longer satisfies the requirements of this section, the facility will, within 90 days of the determination, submit an application for a permit amendment or modification to make any appropriate changes to the program. Examples of amendments or modifications may include, but are not limited to, repair of damaged wells or replacement of an existing well, proposed changes in monitoring frequency, or proposed installation of additional monitoring wells. Additional requirements under 30 TAC §330.407 are presented in the appropriate sections of this plan. Any amendments or modifications to this plan will also be conducted in accordance with the additional permitting and registration conditions for municipal solid waste facilities, as outlined in 30 TAC §§330.73, 305.62, and 305.70.

III.F.8.0 Monitoring Well Construction Specifications

In accordance with 30 TAC §330.421(a), the owner/operator will ensure proper construction of monitoring wells at the facility. This involves maintaining borehole integrity, collecting representative groundwater samples, and preventing water migration within the borehole. The wells will be drilled by a Texas-licensed driller, supervised by a licensed professional familiar with the area's geology. The drilling method will prevent contamination, using clean, treated city water or other approved fluids. The borehole's diameter will be at least four inches larger than the casing, and a detailed log of the boring, prepared by or under the supervision of a licensed professional geoscientist or engineer who is familiar with the geology of the area, will be sealed, signed, and dated by the professional and will be maintained in the operating record.

Casing, screen, filter pack, and annular seals will be installed in accordance with 30 TAC §330.421(a)(2). A high-quality structural-type concrete pad will be installed in accordance with 30 TAC §330.421(a)(3). A protective collar will be installed in accordance with 30 TAC §330.421(a)(4). A protective barrier will be installed in accordance with 30 TAC §330.421(a)(5).

In accordance with 30 TAC §330.421(b), in unusual installation conditions, the owner/operator will obtain written approval from the executive director.

In accordance with 30 TAC §330.421(c), after installation, the well will be developed to remove drilling artifacts and facilitate maximum water flow, continuing until specific field measurements have stabilized.

In accordance with 30 TAC §330.421(d), the owner/operator will have the well's location and elevation surveyed post-construction, with precise measurements relative to mean sea level.

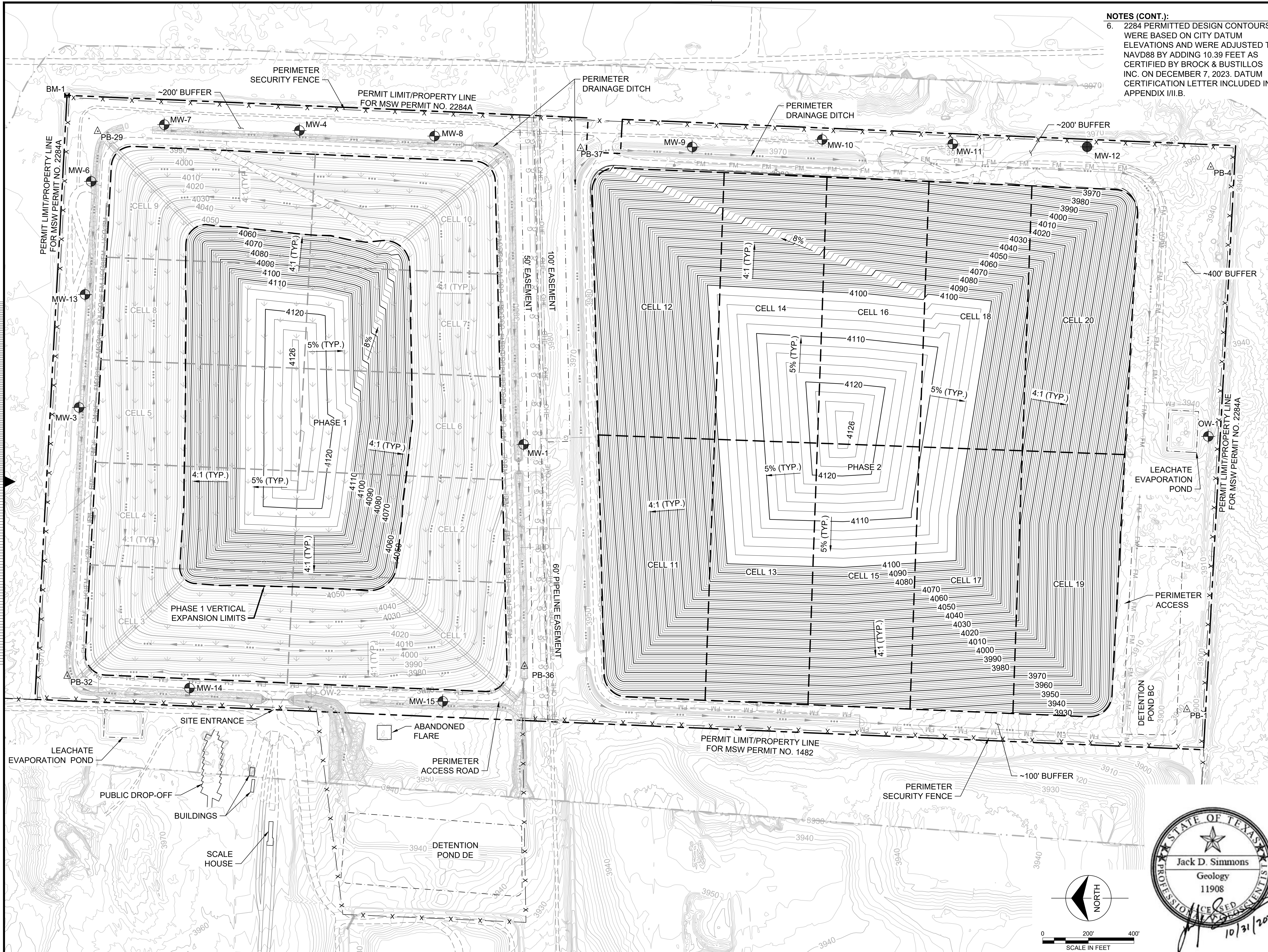
In accordance with 30 TAC §330.421(e), detailed installation and construction reports will be submitted within 60 days of completion along with other required documentation.

In accordance with 30 TAC §330.421(f), if a monitoring well is damaged and becomes unsuitable for sampling, the owner/operator will report this to the executive director for a decision on repair or replacement.

In accordance with 30 TAC §330.421(g), the owner/operator will properly abandon and plug any monitoring well that is no longer in use, following specific technical requirements, in accordance with applicable regulations of Title 16 of the TAC, Chapter 76, and with prior written authorization from the executive director.

ATTACHMENT III.F.1 – GROUNDWATER WELL TOPOGRAPHY MAP

no.	date	by	ckd	description
0	5/1/24	TMC	TLK	2284A PERMIT MOD



NOTES (CONT.):

6. 2284 PERMITTED DESIGN CONTOURS WERE BASED ON CITY DATUM ELEVATIONS AND WERE ADJUSTED TO NAVD88 BY ADDING 10.39 FEET AS CERTIFIED BY BROCK & BUSTILLOS INC. ON DECEMBER 7, 2023. DATUM CERTIFICATION LETTER INCLUDED IN APPENDIX I/II.B.

NOTES:

1. INDEX CONTOUR INTERVAL, 2 FEET.
2. GREATER EL PASO LANDFILL EXISTING SITE TOPOGRAPHY (2284A PERMIT AREA) DERIVED FROM ORTHO-PHOTOGRAPHY FROM AN UNMANNED AERIAL SURVEY TIED TO GROUND CONTROL PANELS PROVIDED BY PARKHILL, SMITH & COOPER, AUGUST 28, 2019. TOPOGRAPHY WITHIN CELLS 11 THROUGH 14 COMPLETED WITH GROUND CONTROL POINTS PROVIDED BY THE CITY OF EL PASO, AUGUST 2022. TOPOGRAPHY OUTSIDE OF THE SURVEY EXTENTS WAS OBTAINED FROM THE TEXAS NATURAL RESOURCES INFORMATION SYSTEM, DATED APRIL 2008. SURVEY LIMITS SHOWN ON DRAWING I/II.B.2.
3. THE SURVEY COORDINATES ARE ON THE TEXAS COORDINATE SYSTEM, CENTRAL ZONE 4203, NORTH AMERICAN DATUM OF 1983 (NAD83). HORIZONTAL DATUM IS NAD 1983. VERTICAL DATUM IS NAVD 1988.
4. EXISTING TOP OF FINAL COVER SURFACE FOR PHASE 1 PREPARED BY PARKHILL, SMITH & COOPER, INC. AND REPRESENTS DESIGN FINAL COVER ELEVATIONS. CONTOUR INTERVAL IS 2 FEET. PHASE 1 RECEIVED FINAL COVER IN 2021.
5. DESIGN CONTOURS REPRESENT TOP OF FINAL COVER SURFACE FOR PHASE 1 AND PHASE 2. CONTOUR INTERVAL IS 2 FEET.

FOR PERMITTING PURPOSES ONLY

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Burns & McDonnell Engineering Co, Inc.
FIRM REG. NO. F-845

date	detailed
MAY 2024	D. KAMBLE
designed	checked
T. CAMMACK	T. KOLLER

EP TX CITY OF EL PASO

City of El Paso, Texas

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11908
LICENSED
PROFESSIONAL GEOSCIENTIST
10/31/2024

2284A PERMIT AMENDMENT

FINAL GROUNDWATER MONITORING PLAN

project	contract
155488	-

drawing: III.F.1 – rev. 0

file III.F.2 FINAL GROUNDWATER MONITORING PLAN.dwg

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ATTACHMENT III.F.2 – GROUNDWATER SAMPLING FORM

ATTACHMENT III.F.3 – PARAMETER LIST

Appendix I
Groundwater Monitoring Well Sampling Parameters
Greater El Paso Landfill

Parameter	Notes	Method [1] [2]	Reporting Limit (RL) [3] (µg/l)
Antimony	(total)	EPA 6020	1
Arsenic	(total)	EPA 6020	5
Barium	(total)	EPA 6020	5
Beryllium	(total)	EPA 6020	1
Cadmium	(total)	EPA 6020	5
Chromium	(total)	EPA 6020	5
Cobalt	(total)	EPA 6020	1
Copper	(total)	EPA 6020	1
Lead	(total)	EPA 6020	1
Nickel	(total)	EPA 6020	1
Selenium	(total)	EPA 6020	5
Silver	(total)	EPA 6020	1
Thallium	(total)	EPA 6020	1
Vanadium	(total)	EPA 6020	2
Zinc	(total)	EPA 6020	10

Volatile Organic Compounds	Method[1] [2]	RL [3](μg/l)
Acetone	8260	10
Acrylonitrile	8260	10
Benzene	8260	2
Bromochloromethane	8260	2
Bromodichloromethane	8260	2
Bromoform	8260	2
Carbon Disulfide	8260	2
Carbon Tetrachloride	8260	2
Chlorobenzene	8260	2
Chloroethane	8260	2
Chloroform	8260	2
Dibromochloromethane	8260	2
1,2-Dibromo-3-chloropropane	8260	5 [4]
1,2-Dibromoethane	8260	1 [4]
1,2-Dichlorobenzene	8260	2
1,4-Dichlorobenzene	8260	2
Trans-1,4-Dichloro-2-Butene	8260	20
1,1-Dichloroethane	8260	2
1,2-Dichloroethane	8260	2
1,1-Dichloroethylene	8260	2
Cis-1,2-Dichloroethylene	8260	2
Trans-1,2-Dichloroethylene	8260	2
1,2-Dichloropropane	8260	2
Cis-1,3-Dichloropropene	8260	2

Volatile Organic Compounds	**Method(1) (2)**	**RL (3) (μg/l)**
Trans-1,3-Dichloropropene	8260	2
Ethylbenzene	8260	2
2-Hexanone	8260	5
Bromomethane	8260	2
Chloromethane	8260	2
Methylene Bromide	8260	2
Methylene Chloride	8260	2
Methyl ethyl ketone	8260	10
Iodomethane	8260	2
4-Methyl-2-Pentanone	8260	5
Styrene	8260	2
1,1,1,2-Tetrachloroethane	8260	2
1,1,2,2-Tetrachloroethane	8260	2
Tetrachloroethylene	8260	2
Toluene	8260	2
1,1,1-Trichloroethane	8260	2
1,1,2-Trichloroethane	8260	2
Trichloroethylene	8260	2
Trichlorofluoromethane	8260	2
1,2,3-Trichloropropane	8260	2
Vinyl Acetate	8260	10
Vinyl Chloride	8260	2
Xylenes (Total)	8260	3

(1) Analyses will be performed using the above listed methods or an equivalent or better EPA-approved method.
(2) Test Methods for Evaluating Solid Waste, Physical/Chemical Method, November, 1986, Third Edition, USEPA, SW-846 and additions thereto.
(3) In order to maintain statistical consistency and prevent potential false positive or false negative errors, the majority of RLs are equal to historical values.
(4) The EPA 8260 method RL is above the established MCL, detectable amounts below the RL and above the MCL will be flagged.

Appendix II
List of Hazardous Inorganic and Organic Constituents
Greater El Paso Landfill

Common Name[1]	CAS RN[2]	Chemical Abstracts Service Index Name[3]
Acenaphthene	83-32-9	Acenaphthylene, 1,2-dihydro-
Acenaphthylene	208-96-8	Acenaphthylene
Acetone	67-64-1	2-Propanone
Acetonitrile; Methyl cyanide	75-05-8	Acetonitrile
Acetophenone	98-86-2	Ethanone, 1-phenyl-
2-Acetylaminofluorene; 2-AAF	53-96-3	Acetamide, N-9H-fluoren-2-yl-
Acrolein	107-02-8	2-Propenal
Acrylonitrile	107-13-1	2-Propenenitrile
Aldrin	309-00-2	1,4:5,8-Dimethanonaphthalene, 1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-(1,4,4a,5,8,8a)-
Allyl chloride	107-05-1	1-Propene, 3-chloro-
4-Aminobiphenyl	92-67-1	[1,1′-Biphenyl]-4-amine
Anthracene	120-12-7	Anthracene
Antimony	(Total)	Antimony
Arsenic	(Total)	Arsenic
Barium	(Total)	Barium
Benzene	71-43-2	Benzene
Benzo[a]anthracene; Benzanthracene	56-55-3	Benz[a]anthracene
Benzo[b]fluoranthene	205-99-2	Benz[e]acephenanthrylene
Benzo[k]fluoranthene	207-08-9	Benzo[k]fluoranthene
Benzo[ghi]perylene	191-24-2	Benzo[ghi]perylene
Benzo[a]pyrene	50-32-8	Benzo[a]pyrene
Benzyl alcohol	100-51-6	Benzenemethanol
Beryllium	(Total)	Beryllium
alpha-BHC	319-84-6	Cyclohexane, 1,2,3,4,5,6-hexachloro-,(1α,2α,3β,4α,5β,6β)-

beta-BHC	319-85-7	Cyclohexane, 1,2,3,4,5,6-hexachloro- ,(1α,2β,3α,4β,5α,6β)-
delta-BHC	319-86-8	Cyclohexane, 1,2,3,4,5,6-hexachloro- ,(1α,2α,3α,4β,5α,6β)-
gamma-BHC; Lindane	58-89-9	Cyclohexane, 1,2,3,4,5,6- hexachloro-,(1α,2α, 3β, 4α,5α,6β)-
Bis(2-chloroethoxy)methane	111-91-1	Ethane, 1,1′-[methylenebis (oxy)]bis [2-chloro-
Bis(2-chloroethyl)ether; Dichloroethyl ether	111-44-4	Ethane, 1,1′-oxybis[2-chloro-
Bis(2-chloro-1-methylethyl) ether; 2,2′-Dichlorodiisopropyl ether; DCIP, See footnote 4	108-60-1	Propane, 2,2′-oxybis[1-chloro-
Bis(2-ethylhexyl) phthalate	117-81-7	1,2-Benzenedicarboxylic acid, bis(2-ethylhexyl)ester
Bromochloromethane; Chlorobromethane	74-97-5	Methane, bromochloro-
Bromodichloromethane; Dibromochloromethane	75-27-4	Methane, bromodichloro-
Bromoform; Tribromomethane	75-25-2	Methane, tribromo-
4-Bromophenyl phenyl ether	101-55-3	Benzene, 1-bromo-4-phenoxy-
Butyl benzyl phthalate; Benzyl butyl phthalate	85-68-7	1,2-Benzenedicarboxylic acid, butyl phenylmethyl ester
Cadmium	(Total)	Cadmium
Carbon disulfide	75-15-0	Carbon disulfide
Carbon tetrachloride	56-23-5	Methane, tetrachloro-
Chlordane	See footnote 5	4,7-Methano-1H-indene, 1,2,4,5,6,7,8,8-octachloro-2,3,3a,4,7,7a-hexahydro-
p-Chloroaniline	106-47-8	Benzenamine, 4-chloro-
Chlorobenzene	108-90-7	Benzene, chloro-
Chlorobenzilate	510-15-6	Benzeneacetic acid, 4-chloro-
		-(4-chlorophenyl)-
		-hydroxy-, ethyl ester.
p-Chloro-m-cresol; 4-Chloro-3-methylphenol	59-50-7	Phenol, 4-chloro-3-methyl-
Chloroethane; Ethyl chloride	75-00-3	Ethane, chloro-

Chloroform; Trichloromethane	67-66-3	Methane, trichloro-
2-Chloronaphthalene	91-58-7	Naphthalene, 2-chloro-
2-Chlorophenol	95-57-8	Phenol, 2-chloro-
4-Chlorophenyl phenyl ether	7005-72-3	Benzene, 1-chloro-4-phenoxy-
Chloroprene	126-99-8	1,3-Butadiene, 2-chloro-
Chromium	(Total)	Chromium
Chrysene	218-01-9	Chrysene
Cobalt	(Total)	Cobalt
Copper	(Total)	Copper
m-Cresol; 3-Methylphenol	108-39-4	Phenol, 3-methyl-
o-Cresol; 2-Methylphenol	95-48-7	Phenol, 2-methyl-
p-Cresol; 4-Methylphenol	106-44-5	Phenol, 4-methyl-
Cyanide	57-12-5	Cyanide
2,4-D; 2,4-Dichlorophenoxyacetic acid	94-75-7	Acetic acid, (2,4-dichlorophenoxy)-
4,4′-DDD	72-54-8	Benzene 1,1′-(2,2-dichloroethylidene) bis[4-chloro-
4,4′-DDE	72-55-9	Benzene, 1,1′-(dichloroethenylidene) bis[4-chloro-
4,4′-DDT	50-29-3	Benzene, 1,1′-(2,2,2-trichloroethylidene) bis[4-chloro-
Diallate	2303-16-4	Carbamothioic acid, bis(1-methylethyl)-, S- (2,3-dichloro-2-propenyl) ester.
Dibenz[a,h]anthracene	53-70-3	Dibenz[a,h]anthracene
Dibenzofuran	132-64-9	Dibenzofuran
Dibromochloromethane; Chlorodibromomethane	124-48-1	Methane, dibromochloro-
1,2-Dibromo-3-chloropropane; DBCP	96-12-8	Propane, 1,2-dibromo-3-chloro-
1,2-Dibromoethane; Ethylene dibromide; EDB	106-93-4	Ethane, 1,2-dibromo-
Di-n-butyl phthalate	84-74-2	1,2-Benzenedicarboxylic acid, dibutyl ester

o-Dichlorobenzene; 1,2-Dichlorobenzene	95-50-1	Benzene, 1,2-dichloro-
m-Dichlorobenzene; 1,3-Dichlorobenzene	541-73-1	Benzene, 1,3-dichloro-
p-Dichlorobenzene; 1,4-Dichlorobenzene	106-46-7	Benzene, 1,4-dichloro-
3,3′-Dichlorobenzidine	91-94-1	[1,1′-Biphenyl]-4,4′-diamine, 3,3′-dichloro-
trans-1,4-Dichloro-2-butene	110-57-6	2-Butene, 1,4-dichloro-, (E)-
Dichlorodifluoromethane; CFC 12	75-71-8	Methane, dichlorodifluoro-
1,1-Dichloroethane; Ethyldidene chloride	75-34-3	Ethane, 1,1-dichloro-
1,2-Dichloroethane; Ethylene dichloride	107-06-2	Ethane, 1,2-dichloro-
1,1-Dichloroethylene; 1,1-Dichloroethene;	75-35-4	Ethene, 1,1-dichloro-
Vinylidene chloride cis-1,2-Dichloroethylene; cis-1,2-Dichloroethene	156-59-2	Ethene, 1,2-dichloro-(Z)-
trans-1,2-Dichloroethylene; trans-1,2-Dichloroethene	156-60-5	Ethene, 1,2-dichloro-, (E)-
2,4-Dichlorophenol	120-83-2	Phenol, 2,4-dichloro-
2,6-Dichlorophenol	87-65-0	Phenol, 2,6-dichloro-
1,2-Dichloropropane	78-87-5	Propane, 1,2-dichloro-
1,3-Dichloropropane; Trimethylene dichloride	142-28-9	Propane, 1,3-dichloro-
2,2-Dichloropropane; Isopropylidene chloride	594-20-7	Propane, 2,2-dichloro-
1,1-Dichloropropene	563-58-6	1-Propene, 1,1-dichloro-
cis-1,3-Dichloropropene	10061-01-5	1-Propene, 1,3-dichloro-, (Z)-
trans-1,3-Dichloropropene	10061-02-6	1-Propene, 1,3-dichloro-, (E)-
Dieldrin	60-57-1	2,7:3,6-Dimethanonaphth [2,3-b]oxirene, 3,4,5,6,9,9-hexachloro-1a,2,2a,3,6,6a,7,7a-octahydro-, (1aα,2β,2aα,3β,6β,6aα,7β,7aα)-
Diethyl phthalate	84-66-2	1,2-Benzenedicarboxylic acid, diethyl ester
O,O-Diethyl O-2-pyrazinyl phosphorothioate; Thionazin	297-97-2	Phosphorothioic acid, O,O-diethyl O-pyrazinyl ester.

Dimethoate	60-51-5	Phosphorodithioic acid, O,O-dimethyl S-[2-(methylamino)-2-oxoethyl] ester
p-(Dimethylamino)azobenzene	60-11-7	Benzenamine, N,N-dimethyl-4-(phenylazo)-
7,12-Dimethylbenz[a]anthracene	57-97-6	Benz[a]anthracene, 7,12-dimethyl-
3,3′-Dimethylbenzidine	119-93-7	[1,1′-Biphenyl]-4,4′-diamine, 3,3′-dimethyl-
alpha, alpha-Dimethylphenethylamine	122-09-8	Benzeneethanamine, α,α-dimethyl-
2,4-Dimethylphenol; m-Xylenol	105-67-9	Phenol, 2,4-dimethyl-
Dimethyl phthalate	131-11-3	1,2-Benzenedicarboxylic acid, dimethyl ester
m-Dinitrobenzene	99-65-0	Benzene, 1,3-dinitro-
4,6-Dinitro-o-cresol; 4,6-Dinitro-2-methylphenol	534-52-1	Phenol, 2-methyl-4,6-dinitro-
2,4-Dinitrophenol	51-28-5	Phenol, 2,4-dinitro-
2,4-Dinitrotoluene	121-14-2	Benzene, 1-methyl-2,4-dinitro-
2,6-Dinitrotoluene	606-20-2	Benzene, 2-methyl-1,3-dinitro-
Dinoseb; DNBP; 2-sec-Butyl-4,6-dinitrophenol	88-85-7	Phenol, 2-(1-methylpropyl)-4,6-dinitro-
Di-n-octyl phthalate	117-84-0	1,2-Benzenedicarboxylic acid, dioctyl ester
Diphenylamine	122-39-4	Benzenamine, N-phenyl-
Disulfoton	298-04-4	Phosphorodithioic acid, O,O-diethyl S-[2-(ethylthio)ethyl] ester
Endosulfan I	959-98-8	6,9-Methano-2,4,3-benzodiox-athiepin, 6,7,8,9,10,10-hexachloro-1,5,5a,6,9,9a-hexahydro-, 3-oxide,
Endosulfan II	33213-65-9	6,9-Methano-2,4,3-benzodioxathiepin, 6,7,8,9,10,10-hexachloro- 1,5,5a,6,9,9a-hexahydro-, 3-oxide, (3α,5aα,6β,9β, 9aα)-
Endosulfan sulfate	1031-07-8	6,9-Methano-2,4,3-benzodioxathiepin, 6,7,8,9,10,10-hexachloro-1,5,5a,6,9,9a-hexahydro-, 3,3-dioxide
Endrin	72-20-8	2,7:3,6-Dimethanonaphth[2,3-b]oxirene, 3,4,5,6,9,9-hexachloro-1a,2,2a,3,6,6a,7,7a-octahydro-, (1aα, 2β,2aβ, 3α,6α,6aβ,7β,7aα)-
Endrin aldehyde	7421-93-4	1,2,4-Methenocyclo-penta[cd]pentalene-5-carboxaldehyde,2,2a,3,3,4,7-hexachlorodecahydro-(1α,2β,2aβ,4β,4aβ,5β,6aβ,6bβ,7R*)-

Ethylbenzene	100-41-4	Benzene, ethyl-
Ethyl methacrylate	97-63-2	2-Propenoic acid, 2-methyl-, ethyl ester
Ethyl methanesulfonate	62-50-0	Methanesulfonic acid, ethyl ester
Famphur	52-85-7	Phosphorothioic acid, O-[4-[(dimethylamino)sulfonyl]phenyl]-O,O-dimethyl ester
Fluoranthene	206-44-0	Fluoranthene
Fluorene	86-73-7	9H-Fluorene
Heptachlor	76-44-8	4,7-Methano-1H-indene,1,4,5,6,7,8,8-heptachloro-3a,4,7,7a-tetrahydro-
Heptachlor epoxide	1024-57-3	2,5-Methano-2H-indeno[1,2-b]oxirene,
		2,3,4,5,6,7,7-heptachloro-1a,1b,5,5a,6,6a,-hexahydro-,(1aα,1bβ,2α,5α,5aβ,6β,6aα)
Hexachlorobenzene	118-74-1	Benzene, hexachloro-
Hexachlorobutadiene	87-68-3	1,3-Butadiene, 1,1,2,3,4,4-hexachloro-
Hexachlorocyclopentadiene	77-47-4	1,3-Cyclopentadiene, 1,2,3,4,5,5-hexachloro-
Hexachloroethane	67-72-1	Ethane, hexachloro-
Hexachloropropene	1888-71-7	1-Propene, 1,1,2,3,3,3-hexachloro-
2-Hexanone; Methyl butyl ketone	591-78-6	2-Hexanone
Indeno(1,2,3-cd)pyrene	193-39-5	Indeno[1,2,3-cd]pyrene
Isobutyl alcohol	78-83-1	1-Propanol, 2-methyl-
Isodrin	465-73-6	1,4,5,8-Dimethanonaphthalene,1,2,3,4,1 0,10-hexachloro-1,4,4a,5,8,8a hexahydro-(1α, 4α, 4aβ,5β,8β,8aβ)-
Isophorone	78-59-1	2-Cyclohexen-1-one, 3,5,5-trimethyl-
Isosafrole	120-58-1	1,3-Benzodioxole, 5-(1-propenyl)-
Kepone	143-50-0	1,3,4-Metheno-2H-cyclobuta-[cd]pentalen-2-one, 1,1a,3,3a,4,5,5,5a,5b,6-decachlorooctahydro-
Lead	(Total)	Lead
Mercury	(Total)	Mercury
Methacrylonitrile	126-98-7	2-Propenenitrile, 2-methyl-
Methapyrilene	91-80-5	1,2,Ethanediamine, N,N-dimethyl-N′-2-pyridinyl-N′-(2-thienylmethyl)-
Methoxychlor	72-43-5	Benzene, 1,1′-(2,2,2,trichloroethylidene)bis [4-methoxy-

Methyl bromide; Bromomethane	74-83-9	Methane, bromo-
Methyl chloride; Chloromethane	74-87-3	Methane, chloro-
3-Methylcholanthrene	56-49-5	Benz[j]aceanthrylene, 1,2-dihydro-3-methyl-
Methyl ethyl ketone; MEK; 2-Butanone	78-93-3	2-Butanone
Methyl iodide; Iodomethane	74-88-4	Methane, iodo-
Methyl methacrylate	80-62-6	2-Propenoic acid, 2-methyl-, methyl ester
Methyl methanesulfonate	66-27-3	Methanesulfonic acid, methyl ester
2-Methylnaphthalene	91-57-6	Naphthalene, 2-methyl-
Methacrylonitrile	126-98-7	2-Propenenitrile, 2-methyl-
Methapyrilene	91-80-5	1,2,Ethanediamine, N,N-dimethyl-N′-2-pyridinyl-N′-(2-thienylmethyl)-
Methoxychlor	72-43-5	Benzene, 1,1′-(2,2,2,trichloroethylidene)bis [4-methoxy-
Methyl bromide; Bromomethane	74-83-9	Methane, bromo-
Methyl chloride; Chloromethane	74-87-3	Methane, chloro-
3-Methylcholanthrene	56-49-5	Benz[j]aceanthrylene, 1,2-dihydro-3-methyl-
Methyl ethyl ketone; MEK; 2-Butanone	78-93-3	2-Butanone
Methyl iodide; Iodomethane	74-88-4	Methane, iodo-
Methyl methacrylate	80-62-6	2-Propenoic acid, 2-methyl-, methyl ester
Methyl methanesulfonate	66-27-3	Methanesulfonic acid, methyl ester
2-Methylnaphthalene	91-57-6	Naphthalene, 2-methyl-
Methyl parathion; Parathion methyl	298-00-0	Phosphorothioic acid, O,O-dimethyl
4-Methyl-2-pentanone; Methyl isobutyl ketone	108-10-1	2-Pentanone, 4-methyl-
Methylene bromide; Dibromomethane	74-95-3	Methane, dibromo-
Methylene chloride; Dichloromethane	75-09-2	Methane, dichloro-
Naphthalene	91-20-3	Naphthalene
1,4-Naphthoquinone	130-15-4	1,4-Naphthalenedione
1-Naphthylamine	134-32-7	1-Naphthalenamine

2-Naphthylamine	91-59-8	2-Naphthalenamine
Nickel	(Total)	Nickel
o-Nitroaniline; 2-Nitroaniline	88-74-4	Benzenamine, 2-nitro-
m-Nitroaniline; 3-Nitroaniline	99-09-2	Benzenamine, 3-nitro-
p-Nitroaniline; 4-Nitroaniline	100-01-6	Benzenamine, 4-nitro-
Nitrobenzene	98-95-3	Benzene, nitro-
o-Nitrophenol; 2-Nitrophenol	88-75-5	Phenol, 2-nitro-
p-Nitrophenol; 4-Nitrophenol	100-02-7	Phenol, 4-nitro-
N-Nitrosodi-n-butylamine	924-16-3	1-Butanamine, N-butyl-N-nitroso-
N-Nitrosodiethylamine	55-18-5	Ethanamine, N-ethyl-N-nitroso-
N-Nitrosodimethylamine	62-75-9	Methanamine, N-methyl-N-nitroso-
N-Nitrosodiphenylamine	86-30-6	Benzenamine, N-nitroso-N-phenyl-
N-Nitrosodipropylamine; N-Nitroso-N-dipropylamine; Di-n-propylnitrosamine	621-64-7	1-Propanamine, N-nitroso-N-propyl-
N-Nitrosomethylethalamine	10595-95-6	Ethanamine, N-methyl-N-nitroso-
N-Nitrosopiperidine	100-75-4	Piperidine, 1-nitroso-
N-Nitrosopyrrolidine	930-55-2	Pyrrolidine, 1-nitroso-
5-Nitro-o-toluidine	99-55-8	Benzenamine, 2-methyl-5-nitro-
Parathion	56-38-2	Phosphorothioic acid, O,O-diethyl-O-(4-nitrophenyl) ester
Pentachlorobenzene	608-93-5	Benzene, pentachloro-
Pentachloronitrobenzene	82-68-8	Benzene, pentachloronitro-
Pentachlorophenol	87-86-5	Phenol, pentachloro-
Phenacetin	62-44-2	Acetamide, N-(4-ethoxyphenyl)
Phenanthrene	85-01-8	Phenanthrene
Phenol	108-95-2	Phenol
p-Phenylenediamine	106-50-3	1,4-Benzenediamine
Phorate	298-02-2	Phosphorodithioic acid, O,O-diethyl S-[(ethylthio)methyl] ester

Polychlorinated biphenyls; PCBs	See footnote 6	1,1′-Biphenyl, chloro derivatives
Pronamide	23950-58-5	Benzamide, 3,5-dichloro-N-(1,1-dimethyl-2-propynyl)-
Propionitrile; Ethyl cyanide	107-12-0	Propanenitrile
Pyrene	129-00-0	Pyrene
Safrole	94-59-7	1,3-Benzodioxole, 5-(2- propenyl)-
Selenium	(Total)	Selenium
Silver	(Total)	Silver
Silvex; 2,4,5-TP	93-72-1	Propanoic acid, 2-(2,4,5- trichlorophenoxy)-
Styrene	100-42-5	Benzene, ethenyl-
Sulfide	18496-25-8	Sulfide
2,4,5-T; 2,4,5-Trichlorophenoxyacetic acid	93-76-5	Acetic acid, (2,4,5- trichlorophenoxy)-
2,3,7,8-TCDD; 2,3,7,8-Tetrachlorodibenzo- p-dioxin	1746-01-6	Dibenzo[b,e][1,4]dioxin, 2,3,7,8-tetrachloro-
1,2,4,5-Tetrachlorobenzene	95-94-3	Benzene, 1,2,4,5-tetrachloro-
1,1,1,2-Tetrachloroethane	630-20-6	Ethane, 1,1,1,2-tetrachloro-
1,1,2,2-Tetrachloroethane	79-34-5	Ethane, 1,1,2,2-tetrachloro-
Tetrachloroethylene; Tetrachloroethene; Perchloroethylene	127-18-4	Ethene, tetrachloro-
2,3,4,6-Tetrachlorophenol	58-90-2	Phenol, 2,3,4,6-tetrachloro-
Thallium	(Total)	Thallium
Tin	(Total)	Tin
Toluene	108-88-3	Benzene, methyl-
o-Toluidine	95-53-4	Benzenamine, 2-methyl-
Toxaphene	See footnote 7	Toxaphene
1,2,4-Trichlorobenzene	120-82-1	Benzene, 1,2,4-trichloro-
1,1,1-Trichloroethane; Methylchloroform	71-55-6	Ethane, 1,1,1-trichloro-
1,1,2-Trichloroethane	79-00-5	Ethane, 1,1,2-trichloro-

Trichloroethylene; Trichloroethene	79-01-6	Ethene, trichloro-
Trichlorofluoromethane; CFC-11	75-69-4	Methane, trichlorofluoro-
2,4,5-Trichlorophenol	95-95-4	Phenol, 2,4,5-trichloro-
2,4,6-Trichlorophenol	88-06-2	Phenol, 2,4,6-trichloro-
1,2,3-Trichloropropane	96-18-4	Propane, 1,2,3-trichloro-
O,O,O-Triethyl phosphorothioate	126-68-1	Phosphorothioic acid, O,O,O-triethyl ester
sym-Trinitrobenzene	99-35-4	Benzene, 1,3,5-trinitro-
Vanadium	(Total)	Vanadium
Vinyl acetate	108-05-4	Acetic acid, ethenyl ester
Vinyl chloride; Chloroethene	75-01-4	Ethene, chloro-
Xylene (total)	See footnote 8	Benzene, dimethyl-
Zinc	(Total)	Zinc
Trichloroethylene; Trichloroethene	79-01-6	Ethene, trichloro-
Trichlorofluoromethane; CFC-11	75-69-4	Methane, trichlorofluoro-
2,4,5-Trichlorophenol	95-95-4	Phenol, 2,4,5-trichloro-
2,4,6-Trichlorophenol	88-06-2	Phenol, 2,4,6-trichloro-
1,2,3-Trichloropropane	96-18-4	Propane, 1,2,3-trichloro-
O,O,O-Triethyl phosphorothioate	126-68-1	Phosphorothioic acid, O,O,O-triethyl ester
sym-Trinitrobenzene	99-35-4	Benzene, 1,3,5-trinitro-
Vanadium	(Total)	Vanadium
Vinyl acetate	108-05-4	Acetic acid, ethenyl ester
Vinyl chloride; Chloroethene	75-01-4	Ethene, chloro-
Xylene (total)	See footnote 8	Benzene, dimethyl-
Zinc	(Total)	Zinc
Trichloroethylene; Trichloroethene	79-01-6	Ethene, trichloro-
Trichlorofluoromethane; CFC-11	75-69-4	Methane, trichlorofluoro-
2,4,5-Trichlorophenol	95-95-4	Phenol, 2,4,5-trichloro-

2,4,6-Trichlorophenol	88-06-2	Phenol, 2,4,6-trichloro-
1,2,3-Trichloropropane	96-18-4	Propane, 1,2,3-trichloro-
O,O,O-Triethyl phosphorothioate	126-68-1	Phosphorothioic acid, O,O,O-triethyl ester
sym-Trinitrobenzene	99-35-4	Benzene, 1,3,5-trinitro-
Vanadium	(Total)	Vanadium
Vinyl acetate	108-05-4	Acetic acid, ethenyl ester
Vinyl chloride; Chloroethene	75-01-4	Ethene, chloro-
Xylene (total)	See footnote 8	Benzene, dimethyl-
Zinc	(Total)	Zinc

(1) Common names are those widely used in government regulations, scientific publications, and commerce; synonyms exist for many chemicals.
(2) Chemical Abstracts Service registry number.
(3) CAS Index names are those used in the 9th Cumulative Index.
(4) Analytical methods for Appendix II constituents are located in **Appendix III.F – Table III.F.5-2.**

ATTACHMENT III.F.7 – CERTIFICATION OF GROUNDWATER MONITORING SYSTEM

(Excerpt from Permit No. 2284 Permit Modification, and Monitor Wells #14 and 15 Installation Report)

GROUNDWATER MONITORING SYSTEM DESIGN CERTIFICATION

General Site Information

Site:	The City of El Paso Clint Landfill
Site Location:	Three and one-half miles east of the town of Clint, Texas.
MSW Permit No.:	2284

Qualified Groundwater Scientist Statement

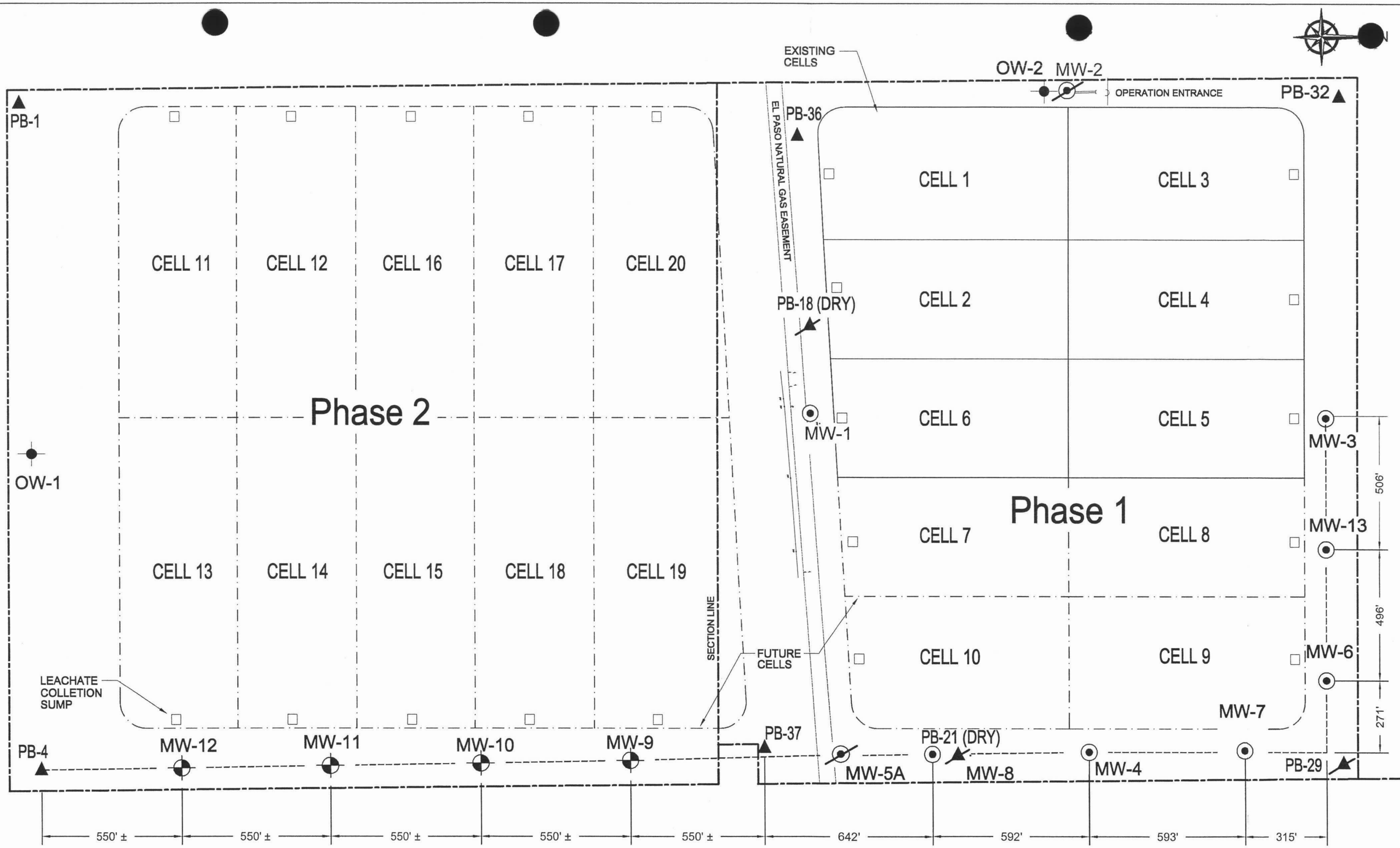
I, Heather R. Keister, am a licensed professional engineer in the State of Texas and a qualified groundwater scientist as defined in 30 TAC §330.3. I have reviewed the groundwater monitoring system and supporting data contained herein. In my professional opinion, the groundwater monitoring system is in compliance with the groundwater monitoring requirements specified in 30 TAC §330.401 through §330.421.

Firm Address: Parkhill, Smith & Cooper, Inc.
4222 85th Street
Lubbock, Texas 79423

STATE OF TEXAS
HEATHER RAE KEISTER
100095
LICENSED
PROFESSIONAL ENGINEER

Signature: Heather Keister
Heather R. Keister, P.E.

Date: 3/24/2009



ROBERT HOLLY HOLDER
59052
LICENSED PROFESSIONAL ENGINEER
STATE OF TEXAS

Robert Holly Holder

F-560
09/02/10

PARKHILL SMITH & COOPER

PSC

The CAREL CORPORATION

136 Pecan Street, Keller, TX 76248

SCALE
0 200 400
FEET

PROPOSED MONITORING NETWORK

THE CITY OF EL PASO TEXAS

CITY OF EL PASO GROUNDWATER PERMIT MODIFICATIONS FOR CLINT LANDFILL

7969 SAN PAULO DRIVE
EL PASO, TEXAS 79907

LEGEND:

- LANDFILL BOUNDARY
- EXISTING GROUNDWATER MONITORING WELL
- PIEZOMETERS
- FUTURE GROUNDWATER MONITORING WELL
- FUTURE OBSERVATION WELL
- DECOMMISSIONED WELL
- POINT OF COMPLIANCE

NO	DATE	DESCRIPTION
1	09/02/10	RESET SPACING ON EXIST MW's LAYOUT PROPOSED MW's

ISSUING OFFICE: CITY PROJECT NO: 07-05-50

FILENAME: L:\TEXAS\Clint\SITE MAPpoc.dwg

DRAWN BY: KTC

DRAFTED BY: TDW

PLATE: 8

Rev 1, May 16, 2025

Drawing File: X:\2010\5151.10\CADD\Z_FROM\Carel Corp\SITE MAPpoc.dwg (GEORGE-M) 9/2/2010 16:43:45

- Monitoring Well Data Sheets
- Geologic Boring Logs
- TCEQ Correspondence
- Material Information and MSDS Safety Sheets
- Groundwater Monitor Well Construction Specifications
- Figure 1 – Vicinity Location Map
- Figure 2 – Monitor Well Layout
- Figure 3 – Typical Well Construction Details
- Figure 4 – Survey

6.0 CERTIFICATION OF GROUNDWATER MONITORING SYSTEM

In the professional opinion of R. Matt Dyer, P.E. as a registered professional engineer in the State of Texas (License No. 92189), the groundwater monitoring system was designed in accordance with TCEQ rules and regulations as published in 30 TAC §330, Subchapter J. To the best of my knowledge, no significant alterations were made by the contractor during actual construction of the wells.

Sincerely,

PARKHILL, SMITH & COOPER, INC.

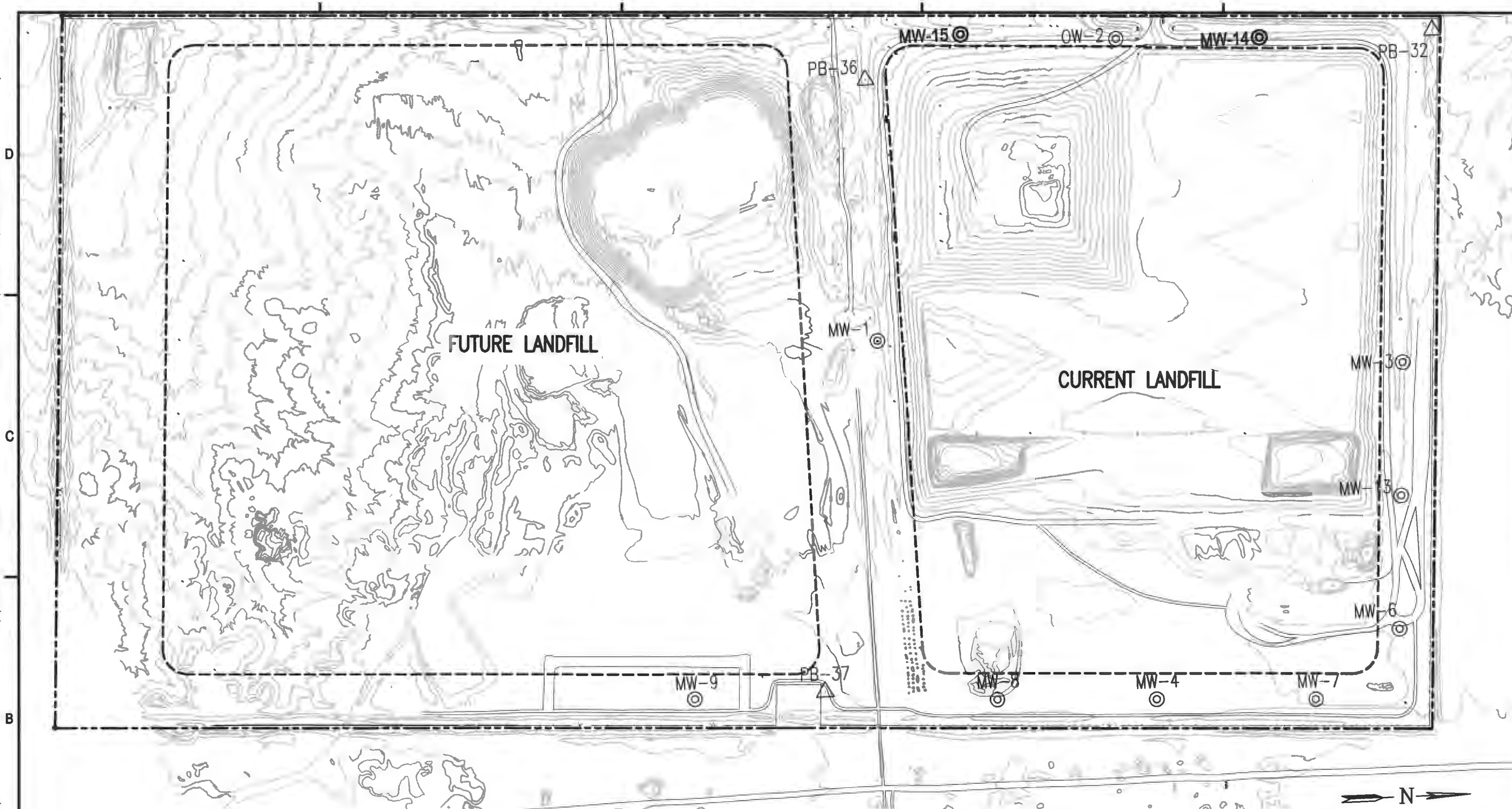
By R Matt Dyer

R. Matt Dyer, P.E.

Firm Principal

PARKHILL, SMITH & COOPER, INC. F-560
STATE OF TEXAS
R. MATT DYER
92189
LICENSED
PROFESSIONAL ENGINEER

4/10/15



LEGEND

—·—·—	PERMITTED BOUNDARY (PERMIT NO. 2284)
——x——	EXISTING FENCE
◎	EXISTING GROUNDWATER MONITORING WELL
△	EXISTING PIEZOMETER WELL
◉	NEW 4" GROUNDWATER MONITORING WELL

WELL COORDINATES

WELL ID	LAT.	LONG.	NORTHING	EASTING	SURFACE ELEV.
NEW WELLS					
MW-14	31°36'01.400"	106°10'18.300"	10,593,494.38	479,723.46	3969.70
MW-15	31°35'50.400"	106°10'18.300"	10,592,384.44	479,665.15	3958.20
EXISTING WELLS					
PB-32	31°36'07.132"	106°10'18.085"	10,594,072.15	479,772.34	3974.82
OW-2	31°35'56.119"	106°10'18.151"	10,592,960.87	479,708.20	3969.29

NOTES:

1. COORDINATES ARE BASED ON THE TEXAS STATE PLANE COORDINATE SYSTEM, CENTRAL ZONE, GRID, NAD 83. COMBINED SCALE FACTOR USED WAS 0.99980117. ELEVATIONS ARE NAVD 88 VERTICAL DATUM.
2. DRILLER SHALL COORDINATE WITH ENGINEER ON EXACT LOCATION FOR EACH WELL PRIOR TO MOBILIZATION.

PARKHILL SMITH & COOPER INC. F-560
STATE OF TEXAS
R. MATT DYER
92189
LICENSED PROFESSIONAL ENGINEER
R Matt Dyer
08/01/14

PSC PARKHILL SMITH & COOPER

THE CITY OF EL PASO TEXAS

GROUNDWATER MONITORING WELLS 14 & 15

GREATER EL PASO LANDFILL
TCEQ MSW PERMIT NO. 2284

7968 SAN PAULO DRIVE
EL PASO, TEXAS 79907

KEY PLAN

NO DATE DESCRIPTION
ISSUING OFFICE: LUBBOCK, TX PROJECT NO: 01.5153.14

WELL CONSTRUCTION LAYOUT PLAN

Xrefs: XTB-5153-14, XSV-5153-14, XCSP-5151-CLINT
8:53:6
8/1/2014
Drawing File: X:\2014\5153.14\BIM_CAD\00_SHEETS\C-101-5153-14.dwg (GEORGE-M)

6.0 GROUNDWATER MONITORING SYSTEM CERTIFICATION

In the professional opinion of Tyler S. Krueger, P.E., as a registered professional engineer in the State of Texas (License No. 130015), the groundwater monitoring system was designed in accordance with TCEQ rules and regulations as published in 30 TAC §330, Subchapter J. To the best of my knowledge, no significant alterations were made by the contractor during actual construction of wells.

PARKHILL, SMITH & COOPER, INC. F-560
STATE OF TEXAS
TYLER S. KRUEGER
130015
LICENSED PROFESSIONAL ENGINEER

5/1/19

Sincerely,

PARKHILL, SMITH & COOPER INC.

By

Tyler S. Krueger, P.E.
Project Engineer

Please replace Appendix III.I with the following pages

APPENDIX III.I – FINAL CLOSURE PLAN

MSW AUTH NO. 2284A

APPENDIX III.I – CLOSURE PLAN

CITY OF EL PASO, TEXAS
GREATER EL PASO LANDFILL MAJOR AMENDMENT
PROJECT NO. 155488

REVISION 1
MAY 16, 2025

Part III, Appendix I
Closure Plan
MSW Auth No. 2284A

prepared for

City of El Paso, Texas
Greater El Paso Landfill Major Amendment
El Paso County, Texas

Project No. 155488

Revision 0, October 31, 2024
Revision 1, May 16, 2025

STATE OF TEXAS
TONYA L. KOLLER
133943
LICENSED
PROFESSIONAL ENGINEER
5-16-25

prepared by

Burns & McDonnell Engineering Company, Inc.
6200 Bridge Point Pkwy, Building 4, Suite 400, Austin, TX 78730
Texas Firm Registration No. F-845

CONTENTS

STATE OF TEXAS
TONYA L. KOLLER
133943
LICENSED
PROFESSIONAL ENGINEER
5-16-25

B. Design Details

Table 6. Design Details of the Final Cover Top and Side Slopes for the Landfill Units.

Landfill Unit Name or Descriptor	Maximum Final Elevation of Waste (feet above mean sea level [ft-msl])	Maximum Elevation of Top of Final Cover (ft-msl)	Minimum Grade of the Final Cover Top Slope (%)	Maximum Grade of the Final Cover Side Slope (%)	Other Information (enter other information as applicable, e.g. above-grade Class 1 Cell Dikes)
Vertical Expansion of Phase 1	4,126.3 (NAVD 88)	4,127.4 (NAVD 88)	5	25	
Phase 2	4,126.9 (NAVD 88)	4,128.1 (NAVD 88)	5	25	

C. Final Cover Drainage Features

Stormwater drainage and erosion and sediment control features incorporated on the final cover of the landfill units to protect the integrity and effectiveness of the final cover system include *(please list and describe the drainage features to be installed on the final cover at or prior to closure for each landfill unit, or list the drainage features and provide cross references on the location(s) of the descriptive and details (drawing) information in other parts of the SDP)*:

Appendix III.B contains the Surface Water Drainage Report. The report describes the drainage controls incorporated into the site, including perimeter ditches, down chutes, benches, and roadway culverts.

Additional drainage features are detailed in Attachment III.B.3. The drainage profiles for ditches are shown in Drawings III.B.8-III.B.10. For post-development drainage, Drawings III.B.3 and III.B.4 display the map and conditions.

Attachment III.B.2 contains the Erosion and Sedimentation Control Plan. To provide long term erosional stability, rock armoring and diversional berms will be added.

Alternative final cover rock armoring is detailed in Attachment III.B.3 (Drawing III.B.5).

IV. Description of the Final Cover System Installation Procedure

A. Mode of Installation

Table 8. Mode of Final Cover Installation on the Landfill Units.

Landfill Unit Name or Descriptor	Largest Area of Unit Ever Requiring Final Cover (Acres)	Check this Column if Final Cover will be Placed in Installments as Permitted Elevation is Reached	Check this Column if Final Cover will be Placed when Entire Unit Area Reaches Permitted Elevation	Final Cover Installation Status
Vertical Expansion of Phase 1	34.6 Acres (Drawing III.A.10)	☐	☒	A portion of Phase 1 Final Cover will be removed with the vertical expansion.
Phase 2	55.2 Acres (Drawing III.A.11)	☒	☐	Final Cover will be installed once Phase 2 reaches final grade.

B. Installation Drawings for Final Cover and Drainage Features

The following attached plan and cross-section drawings show the final cover design details, the largest area requiring final cover, details of the sequence of installation of the final cover system, and all drainage features.

Table 9. List of Attached Installation Drawings for Final Cover and Drainage Features.

Drawings below provided in Appendix III.A and Appendix III.B.

Drawing No.	Drawing Title	Description of Information Contained in Drawing
III.A.6	Sequence of Development Phase 2 (Cells 11-14)	Details of the sequence of landfill development.
III.A.7	Sequence of Development Phase 2 (Cells 15-16)	Details of the sequence of landfill development.
III.A.8	Sequence of Development Phase 2 (Cells 17-18)	Details of the sequence of landfill development.

VII. Professional Engineer's Statement, Seal, and Signature

Name: Tonya Koller

Title: Project Engineer

Date: 5/16/2025

Company Name: Burns & McDonnell

Firm Registration Number: F-845

Professional Engineer's Seal

Signature

BURNS McDONNELL

Memorandum

STATE OF TEXAS
TONYA L. KOLLER
133943
LICENSED PROFESSIONAL ENGINEER
5-16-25

Date	May 16, 2025
To	TCEQ
From	Tonya Koller, PE
Subject	Appendix III.I, Attachment III.1.1
	Alternative Final Cover Design Applicability per RG-494
	Greater El Paso Landfill, MSW Auth No. 2284A

This memorandum provides a comparison of the previously completed Alternative Final Cover Design for the Greater El Paso Landfill, MSW No. 2284A as compared to Texas Commission on Environmental Quality (TCEQ) Regulatory Guidance (RG)-494: Guidance for Requesting a Water Balance (WB) Alternative Final Cover Design for a Municipal Solid Waste Landfill (RG-494).

Previously approved UNSAT-H modeling demonstrating the effectiveness of the alternate final cover profile is provided following this memorandum. The information compiled was excerpted from the document Permit No. 2284, Part III, Attachment 12 - Alternate Final Cover Demonstration, prepared by Parkhill, Smith, & Cooper, Inc., March 2012.

Although the most recent revision of RG-494 (March 2017) was published after the 2012 UNSAT-H modeling, the 2012 modeling appears to be in accordance with RG-494. Compared to the previous version of RG-494 (2012), the updates made to the 2017 version clarified but did not affect the modeling requirements (inputs, outputs, assumptions, and percolation limits) for landfills in arid areas (less than 25 inches of average annual precipitation). In order to provide a comparison to the most recent climatology data, inputs from the 2012 modeling were compared against 2025 data to evaluate their effect on evapotranspiration (ET). The table below summarizes the changes and their associated effects on ET.

Input (units)	2012 UNSAT-H Model Inputs	2025 Data	Source of 2025 Data	Effect on Evapotranspiration (ET)
Annual Precipitation (inches)	9.4	8.4	El Paso International Airport – 1994-2024	Decreased precipitation leads to decreased water retained within the cap
Average Air Temperature (F)	64.1	67.1	El Paso International Airport – 1994-2024	Increased air temperature leads to increased ET
Average Elevation (feet)	3,993	4,049	Based on design changes for vertical expansion	Increased elevation leads to increased ET[1]
Average Pressure (mb)	882	875	NSRDB – 1998-2023	Decreased atmospheric pressure leads to increased ET[1]
Albedo (unitless)	0.49	0.20	NSRDB – 1998-2023	Decreased albedo results in higher surface temperatures, leading to increased ET[1]

NSRBD = National Solar Radiation Database

[1] – Effects on ET based on communications with Inci Demirkanli at Pacific Northwest National Laboratory.

The 2025 data for precipitation, temperature, elevation, pressure, and albedo indicate higher ET potential and, therefore, reduced water retention in the water balance cover compared to the 2012 values. Therefore, the 2012 UNSAT-H model results reflect a conservative estimate of ET for the water balance cover, as current conditions demonstrate greater ET than in the 2012 modeling. The 2012 modeling results in annual percolation rates of less than the allowable 4 millimeters per year. For this reason, the alternative final cover design calculations from 2012 are still sufficient.

Please replace Appendix III.J with the following pages

APPENDIX III.J – POST-CLOSURE PLAN

Texas Commission on Environmental Quality

Post-Closure Care Plan for Municipal Solid Waste Type I Landfill Units and Facilities

This form is for use by applicants or site operators of Municipal Solid Waste (MSW) Type I landfills to provide landfill unit or final facility post-closure care closure plans to meet the requirements in 30 TAC Chapter 330, §330.63(h) and as set out under 30 TAC Chapter 330 Subchapter K for a MSW Type I facility.

If you need assistance in completing this form, please contact the MSW Permits Section in the Waste Permits Division at (512) 239-2335.

I. General Information

Facility Name: Greater El Paso Landfill

MSW Permit No.: 2284A

Site Operator/Permittee Name: City of El Paso/CN601410244

II. Party Responsible for Overseeing and Conducting Post Closure Care Activities

Name (Person or Office Responsible): City of El Paso

Position or Title: Superintendent of Solid Waste

Mailing Address: 7968 San Paulo Drive

City: El Paso

State: Texas

Zip Code: 79915

Telephone Number: 915-621-6702

III. Post-Closure Care Status of Landfill Units at the Facility

Check the applicable box for the post-closure care status of the units at the facility and complete the applicable tables as indicated:

A. ☐ No landfill unit is in post-closure care in this facility at the time this application is submitted (skip Table 1 and complete Table 2 below if you check this item)

B. ☒ This facility includes landfill units currently in post-closure care and landfill units that are not yet in post-closure care (complete Tables 1 and 2 below if you check this item).

C. ☐ This facility contains only landfill units currently in post-closure care (complete Table 1 below if you check this item; do not complete Table 2).

Table 1: Landfill Units Currently in Post-Closure Care

Landfill Unit Name	Drawing Number Showing the Landfill Unit	Date TCEQ Acknowledged Closure of Unit	Date Post-Closure Care Commenced	Projected Date of End of Post-Closure Care
Phase 1	III.A.3 in Appendix III.A	7/14/2023	7/14/2023	7/14/2053

Table 2: Landfill Units Not yet in Post-Closure Care

Category of Landfill Unit (Regarding Status of Waste Receipt)	Landfill Unit Names or Descriptors	Site Development Plan Drawing Titles and Numbers Showing the Units
Stopped Receiving Waste Prior to October 9, 1993		
Received Waste on or after October 9, 1993	**Phase 1 Vertical Expansion and Phase 2**	**Drawing III.A.3 in Appendix III.A**
Proposed to be Constructed		

XI. Engineer’s Seal and Signature

Name: Tonya Koller

Title: Project Engineer

Date: 5/16/2025

Company Name: Burns & McDonnell

Firm Registration Number: F-845

Professional Engineer’s Seal

Signature