# APPENDIX J1: PIPE STRENGTH CALCULATIONS

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| | | | |
|---|---|---|---|
| CLIENT: | Adams County Solid Waste Dept. | PRE: | AGC |
| PROJECT: | Vertical Expansion Feasibility Report Addendum 1 | CHK: | DKS |
| SUBJECT: | Pipe Strength Calculations | DATE: | 7/28/2025 |
| PROJECT NO. | 209-4251247 | | |

# J1 - SCHEDULE 80 PVC PIPE STRENGTH CALCULATIONS

**Purpose:** To evaluate the pipe strength of 6" diameter, Schedule 80 PVC leachate collection piping in the base system of the Adams County Landfill under the maximum overburden stress from the Vertical Expansion.

**Approach:** Use referenced formulas to determine the loads applied to leachate collection piping and determine whether the applied loads are within the required factor of safety for the pipe to adequately perform throughout its service life. The collection pipe with the greatest overburden load under permitted final grades is in the center of proposed Phase 4 (Figure J1).

**References:**
1.) Uni-Bell Handbook of PVC Pipe Design & Construction 6th Edition.
2.) Professional Plastics, Inc. PVC Pipe Specifications, Sizes & Pressure Ratings, (Attachment 1).
3.) Adams County 2018 Plan of Operation Plan Set.
4.) Figure J1: Pipe Strength and Settlement Evaluation.

**Assumptions:**
1.) Live loads are negligible above the piping.
2.) All installed PVC Schedule 80 piping meets the specifications of ASTM D1785; "Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120".
3.) Top of Composite Liner Elevation = 966.63 ft msl
4.) Final Cover Elevation = 1073.49 ft msl
4.) The maximum fill height over the leachate collection pipes is 105.81 feet. This consists of 2.33 feet of bedding material, 97.98 feet of waste, 0.5 feet of grading layer material, 2 feet of clay, 1 foot of granular drainage, 1.5 feet of rooting zone, and 0.5 feet of topsoil.
4.) The unit weight of waste is 90 pounds per cubic foot (pcf) based on final waste grades (after settlement of intermediate waste grades).

**Calculations:**

## Pipe Loading

$$P_y = DL + LL$$

where,

$P_y$ = Pipe Load, lb/in$^2$
$DL$ = Dead Load, lb/in$^2$
$LL$ = Live Load, lb/in$^2$

## Dead Load

$$DL = \sum \frac{\gamma_{fill} * H_{fill}}{144}$$

where,

$\gamma_{fill}$ = Fill Unit Weight, lb/in$^3$

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$H_{fill}$ = Height of Fill, ft
$DL$ = Dead Load, lb/in$^2$

**Calculations: (Continued)** A summary of the height and unit weight of all material covering the leachate collection pipe at its maximum depth is provided below:

| Fill Type | Height, $H_{fill}$ (ft) | Unit Weight, $\gamma_{fill}$ (pcf) | Dead Load (psi) |
|---|---|---|---|
| Topsoil | 0.50 | 105 | 0.36 |
| Rooting Zone | 1.50 | 120 | 1.25 |
| Granular Drainage Layer | 1.00 | 135 | 0.94 |
| Clay / Soil Barrier Layer | 2.00 | 130 | 1.81 |
| Grading Layer | 0.5 | 125 | 0.43 |
| Waste | 97.98 | 90 | 61.24 |
| Pipe Bedding Material | 2.33 | 135 | 2.18 |
| **Total** | **105.81** | - | **68.21** |

In our case the live load (LL) = 0, due to limited live loads above the piping after placement.

Therefore,

$$P_y = DL = 68.21 \text{ lb/in}^2$$

## Deflection

A deflection of 5 to 7.5% has become the standard for limiting deflection in flexible pipes. Based on Figure 7.16 in Uni-Bell, 1992, a vertical strain of greater than 5% will never be reached for flexible pipe bedded in compacted gravel, independent of vertical soil pressure. At 90% compaction the vertical strain will always be less than 2%. The height of fill over the pipe is not a factor when the pipe is well bedded in gravel.

## Wall Crushing

$$\sigma = \frac{T}{A}$$

where,

$A$ = Area of Pipe Wall, in$^2$/in
$T$ = Wall Thrust, lb/in
$\sigma$ = Compressive Stress, lb/in$^2$

and,

$$T = \frac{P_y * D_o}{2}$$

With 6" diameter Schedule 80 PVC piping,
Outer Diameter of Pipe ($D_o$) = 6.625 in
Min. Pipe Wall Thickness ($A$) = 0.432 in
(from Attachment 1)

## CALCULATION SHEET

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**Calculations: (Continued)**

A summary of the calculation is below.

| | |
|---|---|
| **DL, psi** | 68.21 |
| **LL, psi** | 0 |
| **$P_y$, psi** | 68.21 |
| **$D_0$, in** | 6.625 |
| **T, lb/in** | 225.95 |
| **A, $in^2/in$** | 0.432 |
| **$\sigma$, psi** | 523.04 |
| **$\sigma_{allowable}$, psi** | 9600 |
| **Factor of Safety** | 18.35 |

**Result:** The calculated maximum compressive stress for in-place Schedule 80 PVC leachate collection pipes is 523.04 psi. This is below the maximum allowable compressive stress of 9600 psi, by a safety factor of 18.35. The factor of safety against wall crushing of the pipe is acceptable for the existing Schedule 80 PVC 6” diameter pipes.


## PVC Pipe Specifications, Sizes & Pressure Ratings

| PVC Pipe Physical Properties | | |
|---|---|---|
| **GENERAL** | **Value** | **Test Method** |
| Cell Classification | 12454 | ASTM D1784 |
| Maximum Service Temp. | 140°F | |
| Color | White, Dark Gray | |
| Specific Gravity, (g/cu.cm @ 73°F) | 1.40 +/-.02 | ASTM D792 |
| Water Absorption % increase 24 hrs @ 25°C | 0.05 | ASTM D570 |
| Hardness, Rockwell | 110 - 120 | ASTM D785 |
| Poisson's Ratio @ 73°F | 0.410 | |
| Hazen-Williams Factor | C =150 | |
| **MECHANICAL** | | |
| Tensile Strength, psi @ 73°F | 7,450 | ASTM D638 |
| Tensile Modulus of Elasticity, psi @ 73°F | 420,000 | ASTM D638 |
| Flexural Strength, psi @ 73°F | 14,450 | ASTM D790 |
| Flexural Modulus, psi @ 73°F | 360,000 | ASTM D790 |
| Compressive Strength, psi @ 73°F | 9,600 | ASTM D695 |
| Izod Impact, notched, ft-lb/in @ 73°F | 0.75 | ASTM D256 |
| **THERMAL** | | |
| Coefficient of Linear Expansion (in/in/°F) | $2.9 \times 10^{-5}$ | ASTM D696 |
| Coefficient of Thermal Conductivity<br>(Cal.)(cm)/(cm2)(Sec.)(°C)<br>BTU/in/hr/ft.2/°F<br>Watt/m/°K | <br>$3.5 \times 10^{-4}$<br>1.02<br>0.147 | ASTM C177 |
| Heat Deflection Temperature Under Load (264 psi, annealed) | 170 | ASTM D648 |
| Specific Heat, Cal./°C/gm | 0.25 | ASTM D2766 |
| **ELECTRICAL** | | |
| Dielectric Strength, volts/mil | 1,413 | ASTM D149 |
| Dielectric Constant, 60Hz, 30°F | 3.70 | ASTM D150 |
| Volume Resistivity, ohm/cm @ 95°C | $1.2 \times 10^{12}$ | ASTM D257 |
| Harvel PVC Pipe is non-electrolytic | | |
| **FIRE PERFORMANCE** | | |
| Flammability Rating | V-0 | UL-94 |
| Flame Spread Index | <10 | |
| Flame Spread | 0-25 | ULC |
| Smoke Generation | 80-225 | ULC |
| Flash Ignition Temp. | 730°F | |
| Average Time of Burning (sec.) | <5 | ASTM D635 |
| Average Extent of Burning (mm) | <10 | |
| Burning Rate (in/min) | Self Extinguishing | |

# Attachment 1 - PVC Specifications

| | | |
|---|---|---|
| Softening Starts (approx.) | 250°F | |
| Material Becomes Viscous | 350°F | |
| Material Carbonizes | 425°F | |
| Limiting Oxygen Index (LOI) | 43 | ASTM D2863 |
| Clean Room Materials Flammability Test | N/A | FM 4910 |

## SCHEDULE 40 & 80 - DIMENSIONS

### Schedule 40 Dimensions

| Nom. Pipe Size (in) | O.D. | Average I.D. | Min. Wall | Nom. Wt./Ft. | Max. W.P. PSI** |
|---|---|---|---|---|---|
| 1/8" | 0.405 | 0.249 | 0.068 | 0.051 | 810 |
| 1/4" | 0.540 | 0.344 | 0.088 | 0.086 | 780 |
| 3/8" | 0.675 | 0.473 | 0.091 | 0.115 | 620 |
| 1/2" | 0.840 | 0.602 | 0.109 | 0.170 | 600 |
| 3/4" | 1.050 | 0.804 | 0.113 | 0.226 | 480 |
| 1" | 1.315 | 1.029 | 0.133 | 0.333 | 450 |
| 1-1/4" | 1.660 | 1.360 | 0.140 | 0.450 | 370 |
| 1-1/2" | 1.900 | 1.590 | 0.145 | 0.537 | 330 |
| 2" | 2.375 | 2.047 | 0.154 | 0.720 | 280 |
| 2-1/2" | 2.875 | 2.445 | 0.203 | 1.136 | 300 |
| 3" | 3.500 | 3.042 | 0.216 | 1.488 | 260 |
| 3-1/2" | 4.000 | 3.521 | 0.226 | 1.789 | 240 |
| 4" | 4.500 | 3.998 | 0.237 | 2.118 | 220 |
| 5" | 5.563 | 5.016 | 0.258 | 2.874 | 190 |
| 6" | 6.625 | 6.031 | 0.280 | 3.733 | 180 |
| 8" | 8.625 | 7.942 | 0.322 | 5.619 | 160 |
| 10" | 10.750 | 9.976 | 0.365 | 7.966 | 140 |
| 12" | 12.750 | 11.889 | 0.406 | 10.534 | 130 |
| 14" | 14.000 | 13.073 | 0.437 | 12.462 | 130 |
| 16" | 16.000 | 14.940 | 0.500 | 16.286 | 130 |
| 18" | 18.000 | 16.809 | 0.562 | 20.587 | 130 |
| 20" | 20.000 | 18.743 | 0.593 | 24.183 | 120 |
| 24" | 24.000 | 22.544 | 0.687 | 33.652 | 120 |

### Schedule 80 Dimensions

| Nom. Pipe Size (in) | O.D. | Average I.D. | Min. Wall | Nom. Wt./Ft. | Max. W.P. PSI** |
|---|---|---|---|---|---|
| 1/8" | .405 | .195 | 0.095 | 0.063 | 1230 |
| 1/4" | .540 | .282 | 0.119 | 0.105 | 1130 |
| 3/8" | .675 | .403 | 0.126 | 0.146 | 920 |
| 1/2" | .840 | .526 | 0.147 | 0.213 | 850 |
| 3/4" | 1.050 | .722 | 0.154 | 0.289 | 690 |

| | | | | | |
|---|---|---|---|---|---|
| 1" | 1.315 | .936 | 0.179 | 0.424 | 630 |
| 1-1/4" | 1.660 | 1.255 | 0.191 | 0.586 | 520 |
| 1-1/2" | 1.900 | 1.476 | 0.200 | 0.711 | 470 |
| 2" | 2.375 | 1.913 | 0.218 | 0.984 | 400 |
| 2-1/2" | 2.875 | 2.290 | 0.276 | 1.500 | 420 |
| 3" | 3.500 | 2.864 | 0.300 | 2.010 | 370 |
| 3-1/2" | 4.000 | 3.326 | 0.318 | 2.452 | 350 |
| 4" | 4.500 | 3.786 | 0.337 | 2.938 | 320 |
| 5" | 5.563 | 4.768 | 0.375 | 4.078 | 290 |
| 6" | 6.625 | 5.709 | 0.432 | 5.610 | 280 |
| 8" | 8.625 | 7.565 | 0.500 | 8.522 | 250 |
| 10" | 10.750 | 9.493 | 0.593 | 12.635 | 230 |
| 12" | 12.750 | 11.294 | 0.687 | 17.384 | 230 |
| 14" | 14.000 | 12.410 | 0.750 | 20.852 | 220 |
| 16" | 16.000 | 14.213 | 0.843 | 26.810 | 220 |
| 18" | 18.000 | 16.014 | 0.937 | 33.544 | 220 |
| 20" | 20.000 | 17.814 | 1.031 | 41.047 | 220 |
| 24" | 24.000 | 21.418 | 1.218 | 58.233 | 210 |

## SCHEDULE 120 - DIMENSIONS

| Nom. Pipe Size (in) | O.D. | Average I.D. | Min. Wall | Nom. Wt./Ft. | Max. W.P. PSI** |
|---|---|---|---|---|---|
| 1/2" | .840 | .480 | 0.170 | 0.236 | 1010 |
| 3/4" | 1.050 | .690 | 0.170 | 0.311 | 770 |
| 1" | 1.315 | .891 | 0.200 | 0.464 | 720 |
| 1-1/4" | 1.660 | 1.204 | 0.215 | 0.649 | 600 |
| 1-1/2" | 1.900 | 1.423 | 0.225 | 0.787 | 540 |
| 2" | 2.375 | 1.845 | 0.250 | 1.111 | 470 |
| 2-1/2" | 2.875 | 2.239 | 0.300 | 1.615 | 470 |
| 3" | 3.500 | 2.758 | 0.350 | 2.306 | 440 |
| 4" | 4.500 | 3.574 | 0.437 | 3.713 | 430 |
| 6" | 6.625 | 5.434 | 0.562 | 7.132 | 370 |
| 8" | 8.625 | 7.189 | 0.718 | 11.277 | 380 |

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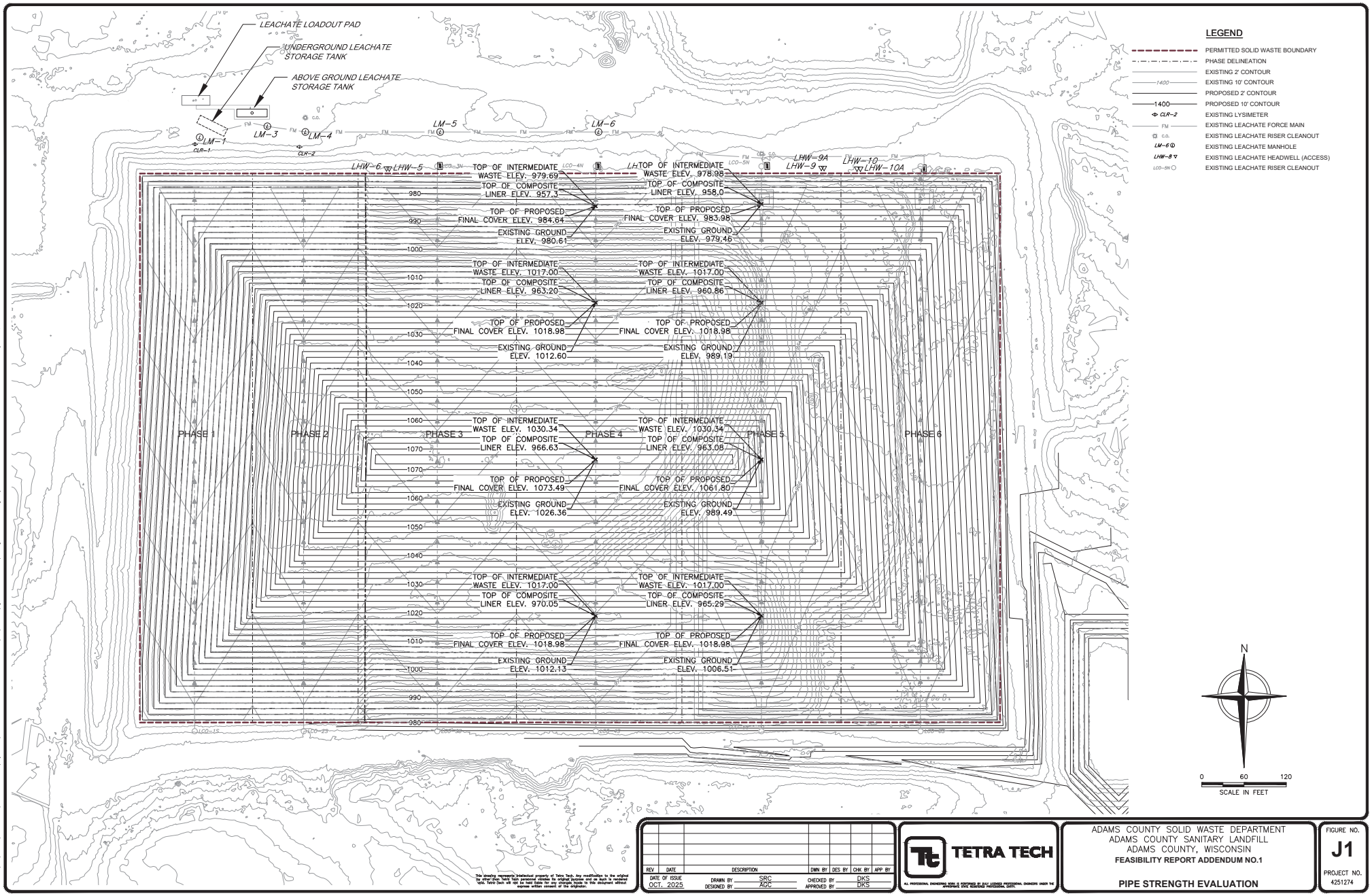


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ADAMS COUNTY SOLID WASTE DEPARTMENT
ADAMS COUNTY SANITARY LANDFILL
ADAMS COUNTY, WISCONSIN
**FEASIBILITY REPORT ADDENDUM NO.1**

**PIPE STRENGTH EVALUATION**

FIGURE NO. **J1**

PROJECT NO. 4251274



1" 1/2" 0" 1"

File: G:_JOB\ACCDocs\Tetra Tech Inc\2025-ADAMS COUNTY\Project Files\4251274-VERTICAL EXPANSION INCOMPLETE\DESIGN\CAD\SheetFiles\Fig_J_4251274_S_PS_PipeStrength-to-Settlement.dwg Layout: J PIPE STRENGTH AND SETTLEMENT EVALUATION User: bvanlueven Oct 30, 2025 - 8:43pm