SAFETY RELATED

ENERCON SERVICES, INC.	PROJECT REPORT	No. TXUT-001-PR-020
		REV. 0
		PAGE NO. 1 of 8

Luminant Inc.

Comanche Peak Nuclear Power Plant Units 3 & 4

Combined Operating License Application Project

Estimation of Conservative Bounding Fill and Infiltration Cap Properties and Determination of Above-Grade Fill Extents

Report Number TXUT-001-PR-020 Revision 0

March 15, 2013

PERFORMED BY:

ENERCON Services, Inc.

Independent Review Required: ______ X (Yes / No)

Prepared by: Randall N. Lantz, P.G. Date: 3/15/2013

Reviewed by: Beth Rowan, P.G. Date: 3/15/2013

Approved by: Project Manager or Designee Date: 3/15/2013

PROJECT REPORT REVISION STATUS

REVISION	DATE	DESCRIPTION
0	3/15/2013	Initial Issue. This project report is a conversion and figure update to the white paper "*Estimation of Conservative Bounding Fill and Infiltration Cap Properties and Determination of Above-Grade Fill Extents*", dated June 2012.

PAGE REVISION STATUS

PAGE NO.	REVISION	PAGE NO.	REVISION
All	0		

ATTACHMENT REVISION STATUS

ATTACHMENT NO.	PAGE NO.	REVISION NO.	ATTACHMENT NO.	PAGE NO.	REVISION NO.
Figures	1-6	0			
Tables	1-2	0			
1	1-2	0			

TABLE OF CONTENTS

Section **Page**

Figures

Tables

1.0 INTRODUCTION

Source material for use as structural ("engineered") granular fill during construction of Comanche Peak Nuclear Power Plant (CPNPP) Units 3 and 4 has not yet been identified. However, hydrogeologic properties of the engineered fill materials are required for use in the postulated accidental release and post-construction groundwater hydrostatic loading analyses. The material properties to be assessed include those for the engineered structural fill (used for both excavation fill and grade build-ups), pipe bedding fill, and the low permeability infiltration cap (placed over areas of excavation fill to limit direct precipitation or stormwater infiltration).

A range of bounding fill properties for hydraulic conductivity (K_h) and effective porosity (η_e) will be used to allow calculation and modeling of post-construction groundwater conditions. Based on descriptions provided in CPNPP Final Safety Analysis Report (FSAR), Revision 2, Subsection 2.5.4.5.4.1.1, a range of particles sizes within the fill can be estimated, thus allowing an estimation of the hydrogeologic properties of hydraulic conductivity (K_h) and effective porosity (η_e). Due to the possible variations in the fill mixtures and placements, it will be assumed for this analysis that all hydrogeologic properties and fill types are homogeneous throughout their in-place volume.

In addition, areas near the plant site that require grade buildup based on a comparison of the post- and pre-construction topographic grading and drainage plans will be addressed.

The material properties and fill extents described in this paper are based on the best available information on post-construction site conditions. This information in this Project Report is being documented to support site modeling assumptions and is not intended for the final design, construction or operation of structures, systems or components. Alterations to this information during planning or required for final design and construction will be reviewed and evaluated as needed to assess potential impacts to the final groundwater modeling effort. Parameters and site construction requirements specified in this paper may also change based on ongoing groundwater modeling efforts.

2.0 FILL MATERIAL PROPERTIES

2.1 Bounding Properties for Fill Cap

CPNPP FSAR Revision 2 does not discuss a low permeability capping material with regards to the general requirements for structural fill. The purpose of such a cap would be to limit surface infiltration from precipitation events into the engineered granular fill if needed.

This section is not intended to specify a design for the low permeability cap, but to specify assumed hydrogeologic properties for the purpose of conservative modeling efforts. Final cap details and designs will be reviewed and modified as necessary during final plant design.

If needed, the cap is assumed to be a compacted low permeability cap similar to a landfill cover. The low permeability cap will extend beyond the areal surface of the granular fill to limit infiltration along the contact between the fill and the native material.

For conservative analysis, two conditions will be assumed:

- For the conservative analysis using maximum infiltration, no low permeability cap will be assumed, resulting in direct exposure of the granular fill at the land surface thereby allowing infiltration into the granular fill.

- If needed for control of surface infiltration, the low permeability cap is assumed to be approximately 3-foot thick with a maximum K_h of $1x10^{-6}$ cm/sec and minimum compacted η_e of 0.04 (EPA 1988).

While the cap is planned to limit surface water infiltration, to address conservatism in the maximum groundwater level analysis, the presence of the cap will be ignored in the initial assessment for the maximum groundwater level. For the groundwater pathway analysis, the presence or absence of the cap has limited influence and will be considered as part of the sensitivity analysis of the pathway model.

2.2 Bounding Properties of Fill Materials

2.2.1 Engineered Fill

CPNPP FSAR Revision 2 Subsection 2.5.4.5.4.1.1 provides a general description for structural (“engineered”) fill, and includes both sub-grade and above-grade fill placements. It is described as being granular in nature, with a well-graded grain size distribution and less than 25 percent by weight passing standard US Sieve No. 200 (ASTM D422 and D1140), and containing particles no larger than 3 inches in maximum dimension, with less than 15 percent by weight larger than 2.5 in. Particles that pass the 200-mesh screen can range from very fine sand to clay size particles. For the purpose of this assessment, it is assumed all particles passing thorough the 200 mesh screen are clay size, based on producing the finest material to fill pore spaces between the coarser materials (those not passing the 200-mesh). Although this assumption describes a poorly graded fill material, it is for conservatism only and the as built engineered fill material will be well graded. Therefore, bounding properties for engineered fill are designated as follows:

- Fill Type EF-1: Mixture of 75% very fine sand (0.075 mm) and 25% clay, evenly mixed (fill having the smallest grain size).
- Fill Type EF-2: Mixture of 80% medium gravel (½-inch) and 20% cobbles (3-inch), evenly mixed (fill having the largest grain size).

2.2.2 Pipe Bedding Fill

CPNPP FSAR Revision 2 Subsection 2.5.4.5.4.1.1 provides a general description for pipe bedding fill as consisting of granular materials which are well graded, with all material passing ½-inch sieve, and at least 95 percent retained on standard US Sieve No. 200 as determined in accordance with ASTM D422. Therefore, the bounding properties for the pipe bedding fill are designated as follows:

- Fill Type PB-1: Mixture of 95% very fine sand and 5% clay, evenly mixed (fill with smallest grain size).
- Fill Type PB-2: 100% medium gravel (fill with largest grain size).

2.3 Fill Material Placement and Layering

The type of engineered granular fill used in the excavations will depend on the amount of pipe bedding fill used. Pipe bedding fill (PB-1 or PB-2 above) is not used in structure excavations (turbine, reactor, and auxiliary buildings) or the ESW pipe tunnel (piping within a concrete structure).

In those excavations where piping is installed without a concrete lined piping tunnel (e.g., the circulating water system piping), CPNPP FSAR Revision 2 Subsection 2.5.4.5.4.1.1 provides a general description for installation of the pipe bedding fill where the height of the fill extends to at least the centerline of the pipe, or preferably 12 inches above the top of the pipe.

Therefore, three fill placement scenarios are anticipated within the onsite excavations:

- Subgrade structures and concrete lined pipe tunnels (ESW Piping Tunnel) – 100% EF-1 or EF-2 (Figure 1).
- Buried piping, minimum pipe bedding – PB-1 or PB-2 to the pipe(s) centerline, remainder EF-1 or EF-2 (Figure 2).
- Buried piping, maximum pipe bedding – PB-1 or PB-2 to the 12 inches above the top of the pipe(s), remainder EF-1 or EF-2 (Figure 2).

For the purpose of modeling the fill materials placed in the onsite excavations, layering as described above will be incorporated into the model construction to the extent practical. Where the model representation becomes too complex or impractical, or creates issues with model convergence, conservative judgment will be used to adjust the model layers and parameters to bound the actual fill placement and properties.

2.4 Summary of Engineered Fill Material Properties

The sources of engineered fill materials (structural, pipe bedding, capping) have not been determined; however, conservative values of K_h and η_e will be assumed to allow for quantitative assessment of the groundwater pathways, travel times, and maximum groundwater elevation within the engineered fill surrounding the reactor and auxiliary buildings. Soil properties were researched from various sources including literature and industry sources. A summary of sources and properties are located in Attachment 1. The assumed values of K_h and η_e will be chosen to provide the most conservative value dependant on the calculation being completed.

2.4.1 Maximum Groundwater Elevation Analysis

For calculation of the maximum groundwater elevation, the assessment would require use of fill material properties that would result in the slowest groundwater movement; therefore, the smallest $K_{h.}$ For slower groundwater movement, the largest η_e could be assumed; however, lower total porosities (η) would limit the total volume that could be accommodated by the fill. Therefore, for the purpose of this assessment, a η_e near the low end of the range of fill materials is chosen for analysis. This allows for a slightly faster groundwater velocity; however, it allows for a smaller assessed groundwater pore volume available (as η_e is smaller than η) for groundwater build-up. The following fill placements will be assumed for the bounding conditions, resulting in the slowest groundwater movement:

- PB-1 to centerline of piping
- Remainder EF-1
- Low permeability cap not installed

Fill type EF-1 is assumed to be a mixture of 75% very fine sand and 25% clay, evenly mixed, texturally classified as a sandy clay loam. The estimated saturated K_h value for sandy clay loam is 1.99 x10^2 m/yr (6.31 x 10^{-4} cm/s) (ANL 1993).

Fill type PB-1 is assumed to be a mixture of 95% very fine sand and 5% clay, evenly mixed, texturally classified as very fine sand. The estimated saturated K_h value for well sorted, very fine sand is 3 $x10^3$ m/yr (9.51 x 10^{-3} cm/s) (ANL 1993).

Estimated η_e values for sand range from 0.16 to 0.46 with an arithmetic mean of 0.32 (ANL, 1993). Addition of clay into the sand would tend to lower the η_e values (η_e of clay ranges from 0.01 to 0.18) because the clay particles would occupy pore spaces between the sand grains (ANL, 1993). Estimates from published literature suggest an η_e value of approximately 0.20 (Maidment, 1992). Although conservative values would tend toward higher porosities (slower groundwater movement), the η_e value for fill types EF-1 and PB-1 will be estimated at 0.20 to account for smaller amounts of void space within the fill.

2.4.2 Postulated Accidental Release Analysis

For the postulated accidental release analysis, the assessment would require use of fill material properties that would result in the fastest groundwater movement within the fill; therefore, the highest K_h and the smallest η_e would be assumed. The following fill placements will be assumed for the bounding conditions, resulting in the fastest groundwater movement:

- PB-2 to 12 inches above piping
- Remainder EF-2
- Presence of low permeability cap not considered

Fill type EF-2 is assumed to be a mixture of 80% medium gravel (½-inch) and 20% cobbles (3-inch), evenly mixed. The estimated saturated K_h value for medium gravel poorly sorted with coarse gravel is 52 $x10^3$ m/yr (0.165 cm/s) (ANL 1993).

Fill type PB-2 is assumed to be 100% medium gravel. The estimated saturated K_h value for well sorted medium gravel poorly sorted with coarse gravel is 45 $x10^3$ m/yr (0.143 cm/s) (ANL 1993).

The estimated η_e value for medium gravel ranges from 0.17 to 0.44 with an arithmetic mean of 0.24. Addition of 20% 3-inch cobbles would not tend to greatly affect the overall porosity of the fill material. The conservative value would tend toward lower porosities (faster groundwater movement); therefore, the η_e value for the fill types EF-2 and PB-2 will be estimated at 0.17.

2.4.3 Compaction Effects on Fill Material Properties

Standard construction practices require that fill material placed in excavations and in above ground build up areas be compacted to within a minimum relative compaction percentage, usually between 95-100 percent (FSAR Subsection 2.5.4.5.4.1.1) of optimal conditions. Compaction will reduce pore volumes and cause soil properties to tend towards the low end of the property ranges. This effect has been taken into consideration as soil properties for the fill materials have been estimated near the lower ends of the ranges for the materials assessed; therefore, compaction effects are addressed in this assessment.

3.0 CONCLUSIONS

3.1.1 Engineered Fill Placement

The following fill placements will be assumed for the bounding conditions:

Hydrostatic loading analysis (slowest groundwater transport)

- PB-1 to centerline of piping
- Remainder EF-1
- Low permeability cap not installed

Postulated accident analysis (fastest groundwater transport)

- PB-2 to 12 inches above piping
- Remainder EF-2
- Presence of low permeability cap not significant

Conservative values of K_h and η_e to be used in initial calculations and modeling efforts are presented in Table 1.

3.1.2 Areas of Above Grade Fill

The topographic elevations depicted on the post-construction grading and drainage plan (MHI, 2012) were compared to the pre-construction topographic elevations. Areas requiring above grade fill build up to support construction operations are depicted in blue outlines on Figures 3 and 4. These figures are considered to be preliminary for modeling purposes only and are not a construction requirement.

3.1.3 Areas of Fill Placements

Figure 5 presents the assumed aerial extent of the various fill areas present on site following construction, including the surface buildup fill (above grade fill), engineered fills (structural and pipe bedding), and the existing swale fills (existing fill). This figure is considered to be preliminary for modeling purposes only and is not a construction requirement.

4.0 REFERENCES

(ANL, 1993) Argonne National Laboratories, Data Collection Handbook to Support Modeling Impacts of Radioactive Material in Soil, Website, http://web.evs.anl.gov/resrad/documents/data_collection.pdf, Accessed 11/2/2011

(Driscoll, 1986) Driscoll, F.G., Groundwater and Wells, 2nd ed., Johnson Filtration Systems, St. Paul, MN, 1986

(EPA, 1988) U.S. Environmental Protection Agency, Determination of Effective Porosity of Soil Materials, EPA/600/S2-88/045, September, 1988

(Fetter, 2001) Fetter, C.W., Applied Hydrogeology, 4th ed., Prentis-Hall, NJ, 2001

(Maidment, 1992) Maidment, D.R., Handbook of Hydrology, McGraw-Hill, 1992

(MHI, 2012) Grading and Drainage Plan, 4CS-CP34-20080060 R4, December 19, 2012

(MHI, 2013) Site Plan and Plot Plan, 4CS-CP34-20080058 R10, February 22, 2013

(Walton, 1987) Walton, W.C., Groundwater Pumping Tests; Design & Analysis, Lewis Publishers, 1987

Figures

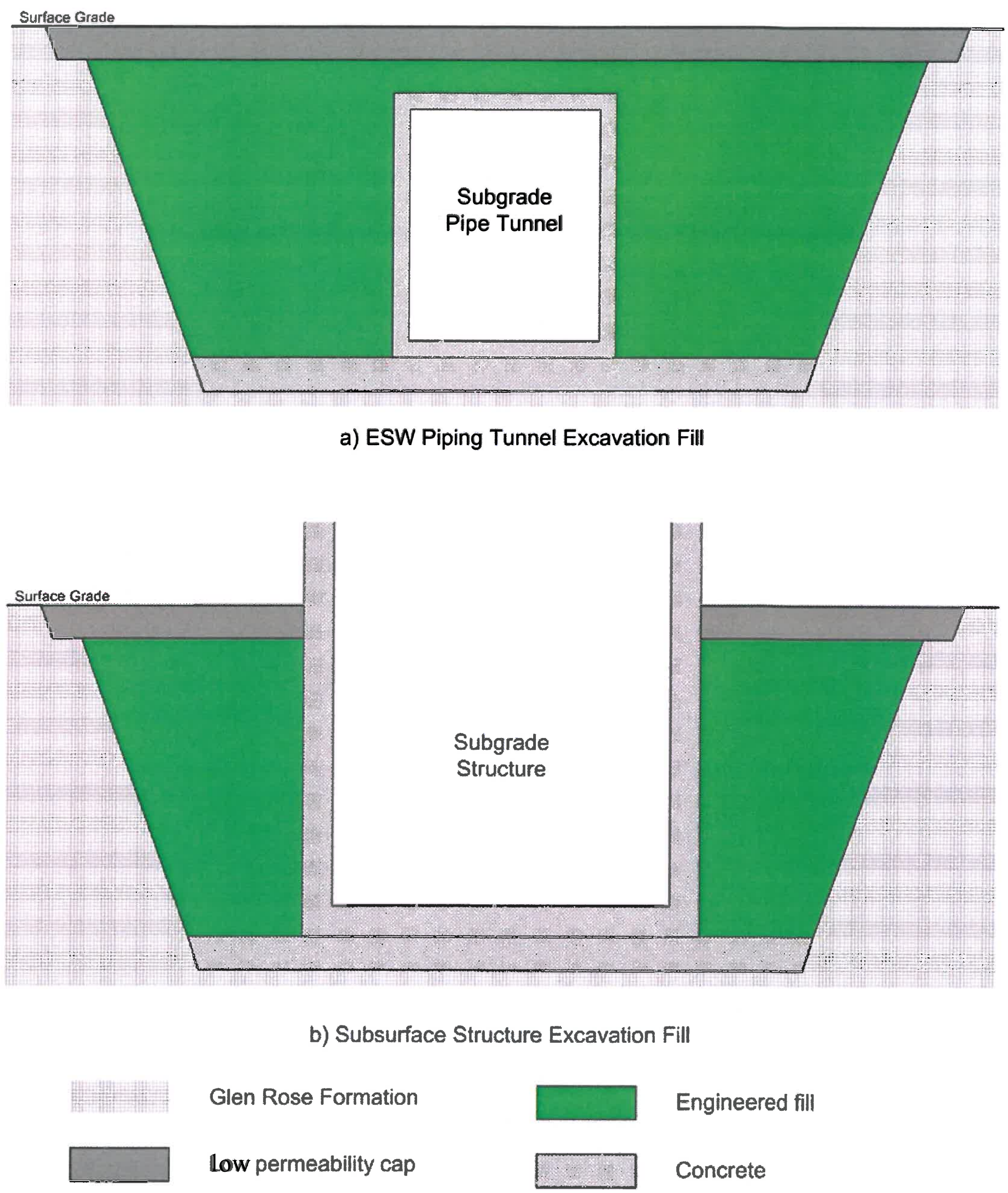
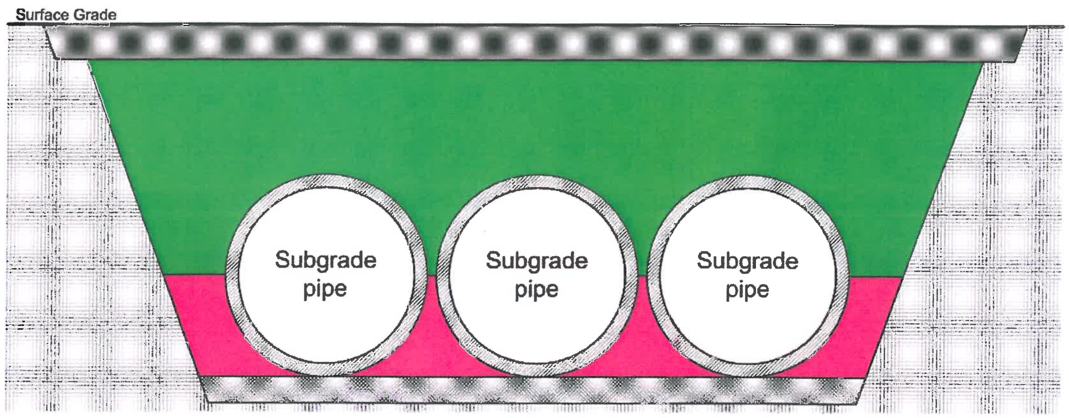
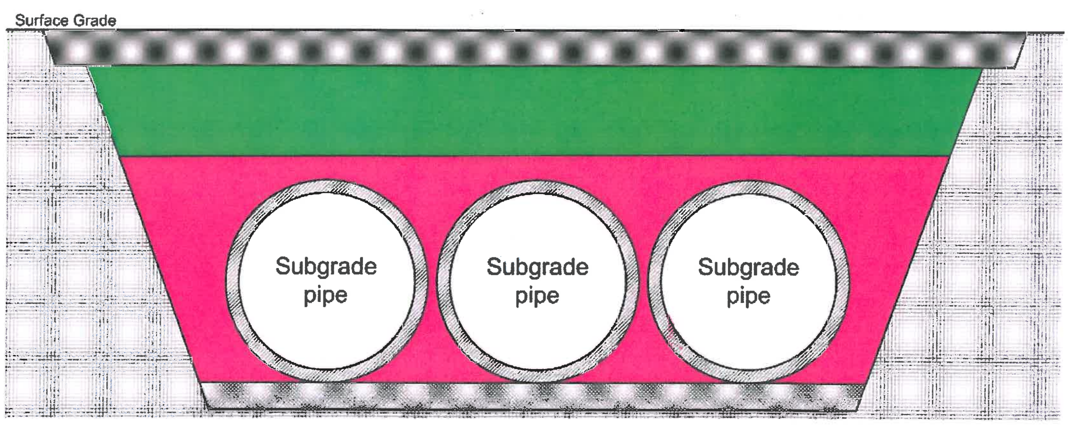


Figure 1- Structural Fill Placement

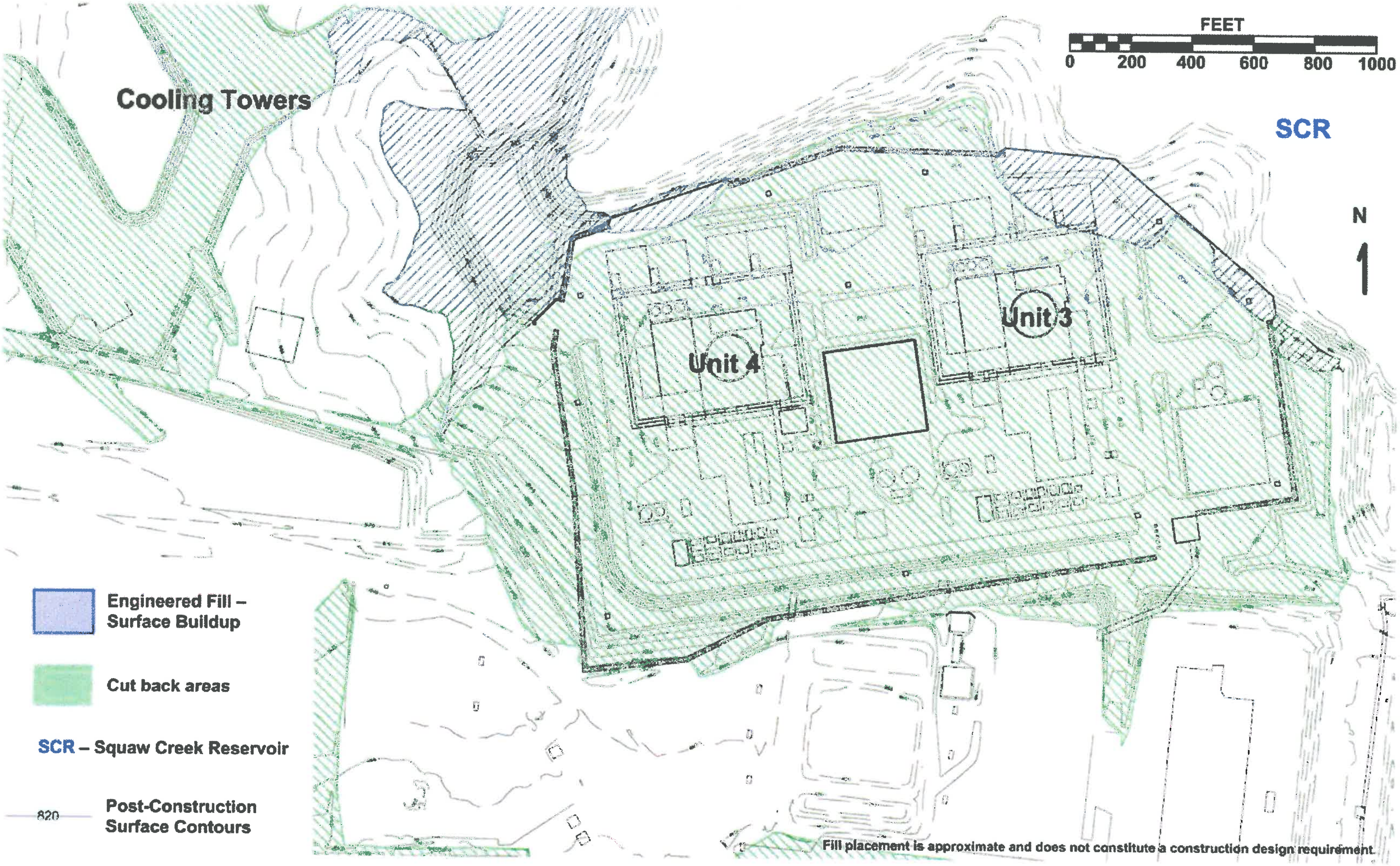


a) Piping Excavation Fill, minimum pipe bedding.



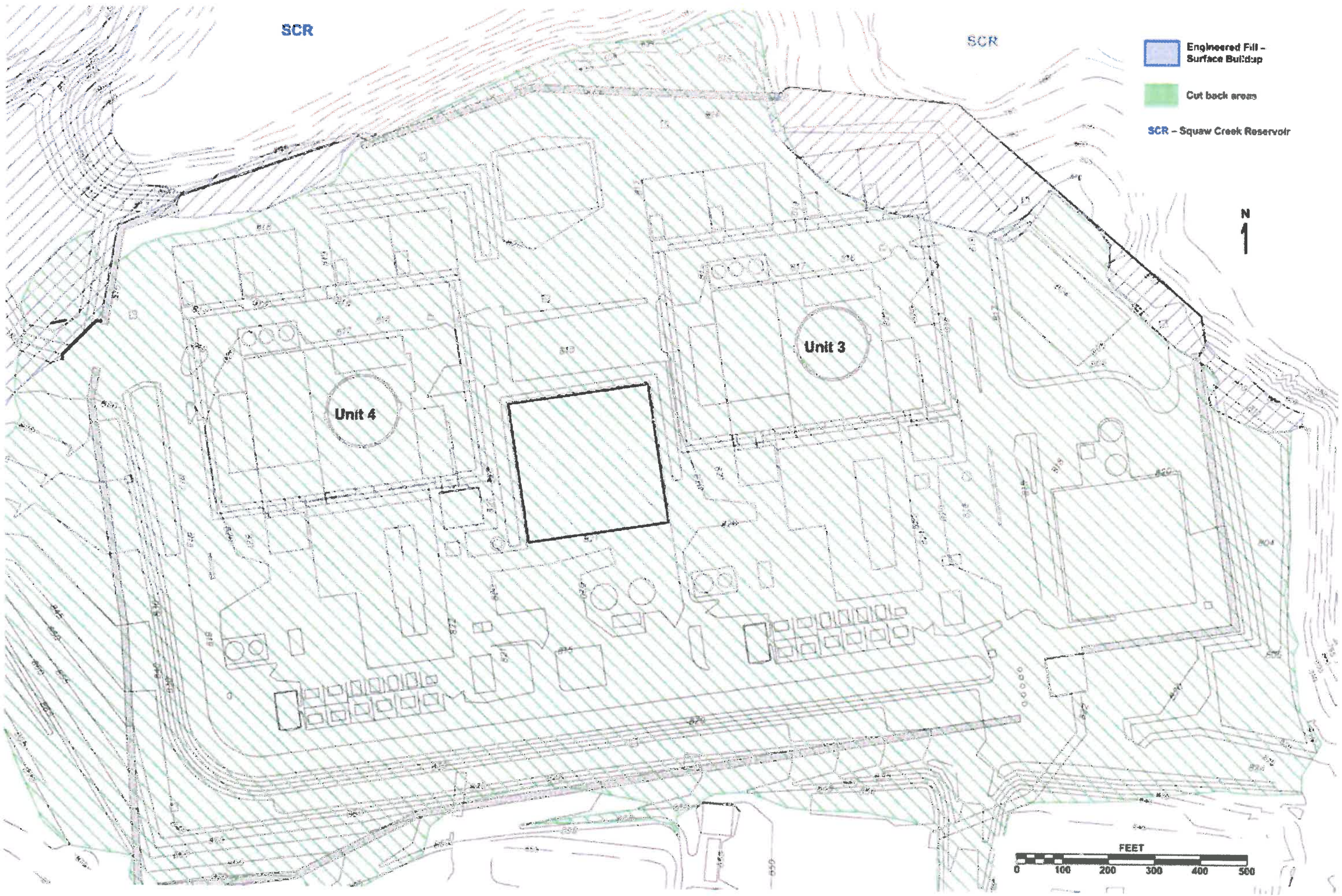
b) Piping Excavation Fill, maximum pipe bedding.

Figure 2- Pipe Bedding Fill Placement



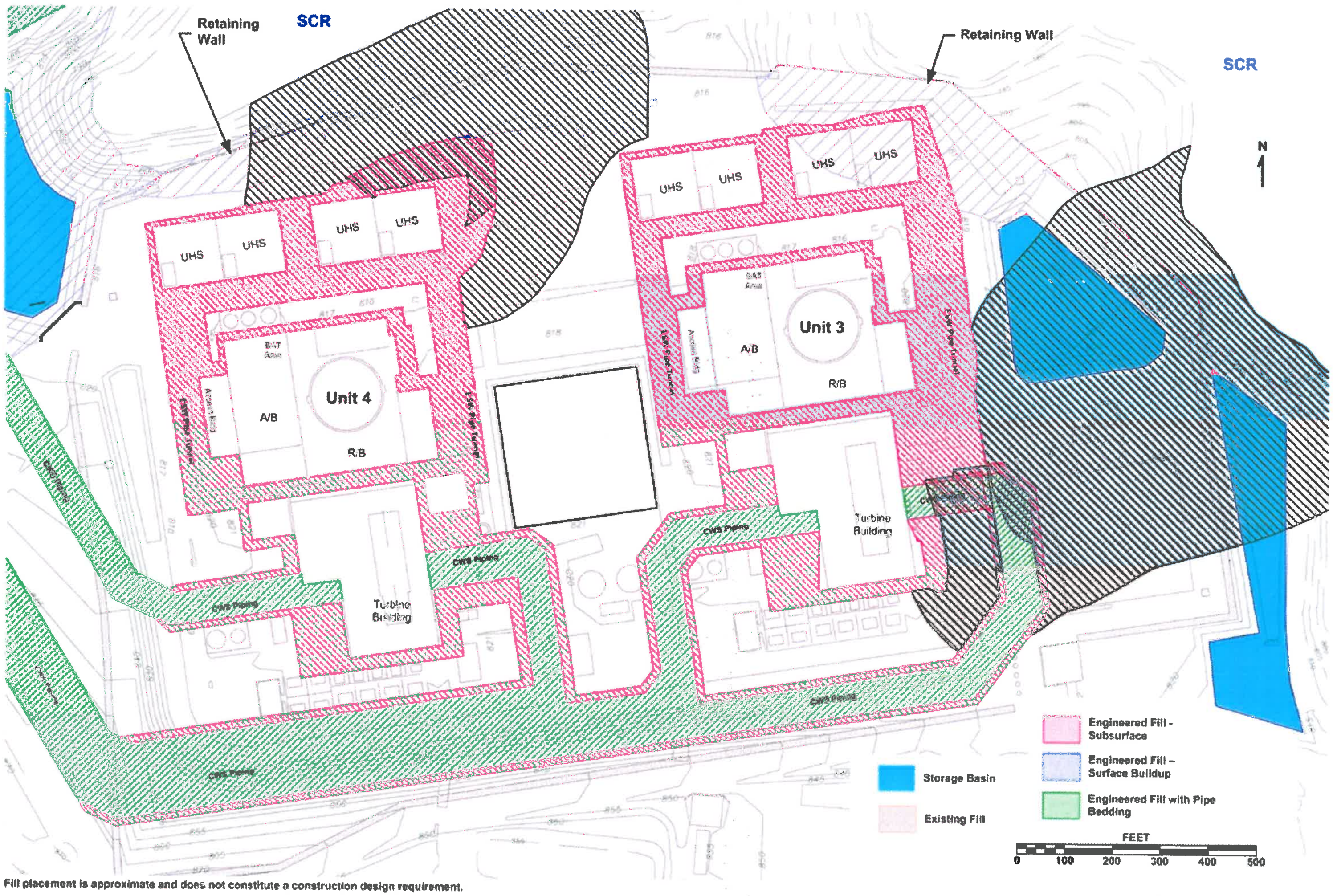
(MHI 2012; MHI 2013)

Figure 3- Cut and Fill Areas



(MHI 2012; MHI 2013)

Figure 4- Cut and Fill Areas in the Vicinity of Units 3 and 4



(MHI 2012; MHI 2013)

Figure 5- Fill Areas and Types in the Vicinity of Units 3 and 4

Tables

Table 1
Engineered Fill Properties

Location		(K_h) (cm/s)	(η_e) (unitless)
Low Permeability Cap	max	N/A	N/A
	min	$1x10^{-6}$	0.04
Subgrade Fill and Above Grade Fill	min (EF-1)	$6.31x10^{-4}$	0.20
	max (EF-2)	0.165	0.17
Pipe Bedding	min (PB-1)	$9.51x10^{-3}$	0.20
	max (PB-2)	0.143	0.17

Attachment 1

Table A-1

Effective porosity values

	ANL, 1993			Fetter, 2001 (Sy)			Driscoll, 1986 (Sy)		Walton, 1987 (Sy)		Maidment, 1992
	min	max	mean	min	max	ave	min	max	min	max	
Clay	0.01	0.18	0.06	0.00	0.05	0.02	0.01	0.10	0.01	0.20	0.01
Sandy Clay				0.03	0.12	0.07			0.03	0.20	0.01
Silt	0.01	0.39	0.20	0.03	0.19	0.18			0.01	0.30	0.10
Clayey Sand											0.20
Sand							0.10	0.30			0.20
Sand (fine)	0.01	0.46	0.33	0.10	0.28	0.21			0.10	0.30	
Sand (medium)	0.16	0.46	0.32	0.15	0.32	0.26			0.15	0.30	
Sand (coarse)	0.18	0.43	0.30	0.20	0.35	0.27			0.20	0.35	
Gravel							0.15	0.30			0.20
Gravel (fine)	0.13	0.40	0.28	0.21	0.35	0.25			0.20	0.35	
Gravel (medium)	0.17	0.44	0.24	0.13	0.26	0.23			0.15	0.25	
Gravel (coarse)	0.13	0.25	0.21	0.12	0.26	0.22			0.10	0.25	

Sy – Specific Yield

References

(ANL, 1993)(Table 3.2)
(Fetter, 2001)(Table 3.5)
(Driscoll, 1986)
(Walton, 1987)
(Maidment, 1992)