Refueling Water Storage Auxiliary Tank - located outside

Chemical Drain Tank - located in the A/B

The Volume Control Tank, the Chemical Drain Tank, and Sump Tanks were eliminated from consideration based on smaller volumes and lower radionuclide contents than the Boric Acid Tank (BAT). The Primary Makeup Water Tank was eliminated from consideration based upon the fact that the Primary Makeup Water Tank stores demineralized water from the Treatment System. and low level radioactive condensate water from the Boric Acid Evaporator. Condensate water contains low levels of radionuclide concentrations. including tritium. Additionally, the Refueling Water Storage Auxiliary Tank (RWSAT) was eliminated from consideration because it stores refueling water. Prior to refueling, tank water is supplied to the refueling cavity where the reactor coolant radionuclide concentration dilutes with refueling cavity water. Radionuclide concentration of cavity water is reduced by the purification system of the Chemical and Volume Control System (CVCS) and the Spent Fuel Pit Cooling and Purification System (SFPCS) during refueling operations. Upon refueling completion, part of the cavity water is returned to this tank where the radionuclide concentration is low. Accordingly. the impact of RWST or Primary Makeup Water Storage Tank failure is small.

After eliminating the tanks described above, the remaining tanks left to consider for the failure analysis are those in the A/B, which is a seismic category II Building. As shown in US-APWR DCD Figure 1.2-29, these tanks are located on the lowest elevation of the A/B at elevation 793 ft ms. In selecting the appropriate tank for the failure analysis, ~~NUREG-0133 and~~the guidance in Branch Technical Position (BTP) 11-6 was utilized based upon the concentrations generated from the RATAF Code for Pressurized Water Reactors~~ were utilized~~. The concentration of the radioactive liquid in the tanks, such as the Boric Acid Evaporator, the Holdup Tank, and the BAT, are larger than the Waste Holdup Tank since they receive reactor coolant water extracted from the Reactor Coolant System. Since the enrichment factor of 50 is considered for the liquid phase of the Boric Acid Evaporator. the radioactive concentrations in the liquid phase of the Boric Acid Evaporator, and in the BAT (which receives the enriched liquid from the Boric Acid Evaporator) becomes large when compared to the other tanks. The BAT has been selected since its volume is larger than the liquid phase of the Boric Acid Evaporator. Credit is taken for the removal effect by demineralizers or other treatment equipment for the liquid radioactive waste prior to entering the tank. No chelating agents are used in the plant system design in order to provide chemical control of the reactor-coolant. Only a very small amount of chelating agents is used in the sampling system for analysis. The sampling drain, which contains only a small amount of chelating agents is directly sent to the dedicated chemical drain tank and treated separately. Chemical agents used in laboratory analysis are also sent to the chemical drain tank for treatment. Therefore, neither the chelating agents nor the chemical agents used in the sampling analysis will have any effect on the transport characteristics of the source term liquid effluent release analysis.

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CTS-01142

The source term concentrations considered for these tanks are identified in DCD Table 11.2-17, and were calculated using NUREG-0133 and the RATAF Code for Pressurized Water Reactors. ~~and show the radioactivity concentrations closest to the nearest potable water supply.~~ The BAT is located in the northeast (NE) corner of the A/B (see DCD Figure 12.3-1). The A/B basemat elevation is at approximately 785 ft msl. The BAT elevation is expected to be at 793 ft msl. Ground level at the site is expected to be at 822 ft msl. The BAT contained the largest concentration and volume of radionuclides that was closest to the effluent concentration limits (ECLs). ~~for Cs-134 and Cs-137, yet well below the 10 CFR 20, Appendix B limits.~~ Isotope concentrations less than 1.0 x 10^{-3} in fraction of concentration limits are excluded from the evaluation. Since credit cannot be taken for liquid retention by unlined building foundations, it is assumed that 80 percent of the content~~s~~ of ~~each~~the tank is released to the environment, consistent with the guidance in BTP 11-6, March 2007. ~~In releasing the contents of one tank, it is assumed that 80 percent of the tank volume is discharged and the dilution factor of each tank is 4.4 x 10^{10} gallons.~~ RCOL2_02.04.13-7 RCOL2_02.04.13-7 RCOL2_02.04.13-7

~~In performing the tank failure analysis, no credit is taken for the distribution of radiological liquid waste to the surrounding subsurface media and groundwater.~~

While groundwater functions as the transport media for fugitive radionuclides, interaction of individual radionuclides with the soil matrix delays their movement. The solid/liquid distribution coefficient, K_d, is, by definition, an equilibrium constant that describes the process wherein a species (e.g., a radionuclide) is partitioned by adsorption between a solid phase (soil) and a liquid phase (groundwater). Soil properties affecting the distribution coefficient include the texture of soils (sand, loam, clay, or organic soils), the organic matter content of the soils, pH values, the soil solution ratio, the solution or pore water concentration, and the presence of competing cations and complexing agents. Because of its dependence on many soil properties, the value of the distribution coefficient for a specific radionuclide in soils can range over several orders of magnitude under different conditions. The measurement of distribution coefficients of radionuclides within the preferential groundwater pathways allows further characterization of the rate of movement of fugitive radionuclides in groundwater.

The site-specific K_d coefficients were selected based upon radionuclides listed in 10 CFR Part 20, Appendix B, Table 2. Three soil borings were chosen for sampling characteristics. Soil and groundwater samples were collected from monitoring wells MW-1201 (located southwest of the Unit 4 nuclear island), MW-1208 (located east of the Unit 3 nuclear island), and MW-1219 (located northeast of the Unit 4 nuclear island) (Figure 2.4.12-207). Soil samples from each monitoring well were collected, based on the availability of recovered soils, at depths ranging from approximately 18 to 54 feet below ground surface. Dry wells exhibiting very slow recharge, and the aquifer testing observations wells were not considered for sampling. Soil boring samples gathered from the two hydraulically upgradient wells and hydraulically downgradient wells were submitted to Argonne National Laboratory for analysis of the radionuclides listed in FSAR Section 2.4.13

based upon the radionuclides listed in 10 CFR Part 20, Appendix B and those radionuclides that would be expected to exist in the tanks were considered for the failure analysis. The soil boring samples were submitted for laboratory analysis of soil distribution characteristics for specific radiological isotopes (i.e., Co-60, Cs-137, Fe-55, I-129, Ni-63, Pu-242, Sr-90, Tc-99, U-235). Results of the K_d analyses are presented in Table 2.4.13-201.

Since the A/B is where the BAT, the Holdup Tank and the Waste Holdup Tanks are to be located at Units 3 and 4, appropriate values were evaluated for "nuclides of interest" (Table 2.4.13-201) based on transport to SCR without retardation or retention through subsurface media. Thus, using the conservative transport time analysis, and considering nuclide decay times, those nuclides which could be expected to challenge 10 CFR Part 20, Appendix B, concentration limits were considered. The BAT was selected as the tank that had the greatest volume and largest concentration of radionuclides~~. Cs-137 and Cs-134 were nuclides of interest in the BAT since~~, where credit is taken for removal equipment and demineralizer beds. ~~Cs-137 was one of the nuclides selected for K_d analysis. Movement of Cs-134 through the subsurface media would be similar to Cs-137 as they have chemically and radiologically similar characteristics.~~ The purpose of the K_d analysis was to estimate the potential migration of accidental releases from the footprint areas of the proposed new units. The K_d results presented in Table 2.4.13-201 indicate that the radionuclides would be delayed in their movement through the groundwater pathway to SCR. The tank failure analysis assumed no distribution of contaminants (no K_d coefficients used) based upon the site-specific hydrogeological characteristics. It is conservatively assumed that the contaminants would transport along the groundwater pathway horizontally to SCR without retardation or retention in the subsurface media, and that there would be no groundwater dilution prior to reaching SCR. RCOL2_02.04.13-7

2.4.13.2 Development of Alternate Conceptual Model and Site-Specific Geological and Hydrogeological Parameters

The alternative conceptual models were used to determine a bounding set of plausible groundwater flow paths by considering the nearest surface water body, SCR, current groundwater elevations measured in wells near the proposed power block area, the measured pool elevation of SCR (gradient to the SCR) and a conservative pathway from a postulated release point to SCR.

After exploring alternative transport pathways, ~~six~~two plausible pathways were determined to bound potential release pathways. Refer to Figure 2.4.13-212 and associated cross section Figures 2.4.12-213 and 2.4.12-214 for the horizontal release pathways~~ 3a, 3b, 4a, 4b~~. Vertical release pathways ~~3c and 3d were~~are eliminated from consideration as discussed in Subsection 2.4.13.4. Alternate horizontal groundwater pathways from each unit moving ~~from~~ south~~west~~ or ~~southeast~~west from the BAT A/B location were eliminated from consideration as this movement would be away from SCR and would not be consistent with the

RCOL2_02.04.13-7
RCOL2_02.04.13-5
RCOL2_02.04.13-7

hydraulic gradients for the area surrounding the CPNPP Units 3 and 4 shown on Figure 2.4.12-210, Sheets 1 through ~~12~~4. RCOL2_02.04.13-7

CPNPP Units 3 and 4 are to be constructed on the Glen Rose Formation. The Glen Rose limestone is essentially impermeable, ranging from 217 to 271 ft thick, and is underlain by the Twin Mountains Formation, which contains the first aquifer beneath the site. Figures 2.5.5-202 and 2.5.5-203 provides a generalized cross section of the pre-construction site conditions. Figures 2.4.12-213 and 2.4.12-214 show the post-construction pathway cross-sections for the shortest distance releases to SCR via groundwater ~~for~~ pathways ~~3a, 3b and 4a, 4b~~. The groundwater flow pathways were developed based on groundwater measured in monitoring wells in the CPNPP Unit 3 and 4 plant area and measured elevations in SCR. Wells were installed across the site in zones to define the groundwater bearing capabilities and properties of the zones, and identify the hydraulic connectivity between the zones, if any. The well zones are defined as A-Zone (regolith or undifferentiated fill material), B-Zone (shallow bedrock) and C-Zone (deeper bedrock) and are described in Subsection 2.4.12.2.4. RCOL2_02.04.13-7

The process used to develop alternative conceptual models of groundwater flow included the following:

- Groundwater flow pathways were developed based on groundwater measured in monitoring wells in the Units 3 and 4 plant area, measured elevations in SCR, surface topography, and observed water levels over time.
- Groundwater measured in all three zones was considered perched based on measurements. Groundwater in the A-zone regolith was attributed to surface water infiltration. Groundwater measured in the undifferentiated fill near SCR was attributed to SCR.
- Groundwater in the B-zone was not continuous across the site Non-equilibrium conditions and the reported dry wells in the B-zone wells indicated that the groundwater was perched. Groundwater located in fill areas near SCR was found to be in communication with SCR.
- Negligible groundwater was gauged in the C-zone wells, representing essentially dry conditions. Consequently, this zone was not considered a groundwater bearing unit.
- Post-construction section configuration of the A/B building, the Ultimate Heat Sink (UHS) cooling tower structure area and other structures were used in identifying the bounding set of plausible pathways. In addition to Figures 2.4.12-213 and 2.4.12-214 horizontal pathway cross sections, the following site plan views and section plans were utilized in identifying the bounding set of plausible pathways:
  - Site Plan View Figure 1.2-1R;

groundwater. Hydrographs from the shallow bedrock wells (B-zone) show a slow and steady increase of water levels over time with little to no fluctuations, also suggesting water levels are related to infiltration from the overlying soils and not actual groundwater. Hydrographs from the regolith/fill material wells (A-zone) indicate some slight fluctuations that may be tied to seasonal rainfall. In some of the A-zone wells there appears to be a slight increase in water levels that may correspond to the spring seasons but there is no significant correlation in the A-zone wells across the site in response to rainfall.

The water levels in the regolith/fill material and the upper zone of the Glen Rose Formation (A-zone and B-zone, respectively) were attributed to surface run-off and were not a true measure of permanent groundwater in the formation. Groundwater steadily increased from December 2006 to July 2007. Water levels remained constant or decreased slightly from August 2007 to February 2008. CTS-01093

Nine of the 16 wells completed in Shallow Bedrock (B – Zone) contained no, or negligible, amounts of water for up to eight months before exhibiting measurable water (greater than 1 ft). The majority of these wells exhibited a slow to steady recharge with no indication of reliable equilibrium conditions over the monitoring period.

Of the ~~13~~14 groundwater monitoring wells screened in Bedrock (C-Zone), ~~eight~~six contained negligible to amounts of water over the monitoring period and ~~six~~eight exhibited a slow to steady recharge with no indication of reliable equilibrium conditions. CTS-01139

The Grading and Drainage Plan shown on Figure 2.4.2-202 was developed based upon the effects of local intense precipitation, as discussed in Subsection 2.4.2.3, and aids in moving precipitation away from structures and buildings considered in the plausible pathways for the liquid effluent release analysis. CTS-01157

Rainfall infiltration is not considered a contributing factor affecting the source term release pathway. No dilution effects of groundwater or rainfall are considered in the liquid effluent release analysis.

2.4.13.4 Vertical ~~Liquid Effluent~~ Release Pathway Elimination RCOL2_02.04.13-5

Both SCR and the Units 1 and 2 restricted potable water supplies wells were considered as receptors. The Units 1 and 2 potable water supply wells are restricted access potable water supply wells completed in the Twin Mountains Formation aquifer and approximately 1990 feet south of the Unit 3 A/B. The nearest unrestricted potable water supplies completed in the Glen Rose Formation are approximately 4 miles south of the Unit 3 A/B. and the nearest unrestricted potable water supply wells completed in the Twin Mountains Formation is approximately 1 mi west of the Unit 4 A/B (~~see~~ FSAR Subsection 2.4.12.3.2 and Figures 2.4.12-204 and 2.4.12-206). The restricted potable water supply wells in Units 1 and 2 (~~see~~ Figure 2.4.1-213) were not considered as possible receptors based upon the following: CTS-011058

The BAT is at elevation 793 ft msl, while the Auxiliary Building basemat elevation is at 785 ft msl. ~~Since~~Because the Auxiliary Building is a Seismic Category II Building, it is assumed that a crack will form in the building during a seismic event or some other physical phenomena, and the radioactive liquid would travel vertically into the surrounding formation. At this basemat elevation of 785 ft msl, the hydrogeologic formation is in the deeper portion of the Glen Rose Formation, which consists primarily of impermeable limestone. For the release to reach the Twin Mountains Formation, which is approximately 150 feet below the Glen Rose Formation, the liquid release would have to travel completely through the Glen Rose Formation. ~~Using the Units 1 and 2 vertical release pathways from the Glen Rose formation to the Twin Mountain formation for the Units 3 and 4 vertical pathways is credible based upon the following:~~Vertical migration pathways are considered improbable due to the thickness (approximately 150 ft) and extremely low hydraulic conductivity of the lower Glen Rose limestone: RCOL2_02.04.13-5

- Packer tests in the power block areas show low hydraulic conductivities (10^{-8} to 10^{-9} cm/sec range, or no water takes) from plant grade elevation (822 ft msl) to 677 ft msl (Table 2.5.4-206).
- Transport of contaminates through formations with hydraulic conductivities less than 10^{-6} cm/sec is controlled by diffusion rather than advection (Reference 2.4-295)
- Units 1 and 2 utilized diffusion for contaminant movement and assumed no groundwater transport.
- Discrete engineering layers in the Glen Rose formation can be traced in the subsurface throughout the site and correlated approximately 2000 feet away in the CPNPP Units 1 and 2 borings and historical excavation photographs.
- Known post-construction excavation limits can be correlated with the stratigraphy exposed in the Glen Rose formation photographs.

A complete discussion of the core borings stratigraphy and CPNPP Units 1 and 2 historical excavation photographs as compared to CPNPP Units 3 and 4 borings is provided in ~~Reference 2.5.4.3.1~~Subsection 2.5.4.3.1. CTS-01154

~~Units 1 and 2 performed an analysis and provided a model of this vertical release path (Reference 2.4-214). The results of the model indicate that the only radionuclide that would travel the length of the Glen Rose Formation was Cs-137, and that it would take approximately 400 years to reach the Twin Mountains Formation.~~ RCOL2_02.04.13-5

The closest Units 1 and 2 potable water supply well is approximately 1.25 miles away (Figure 2.4.1-213) from either the Unit 3 or Unit 4 Auxiliary Building (Figure 2.4.12-208). ~~Considering that t~~The liquid release would be in the Glen Rose formation, which at the level of the BAT is essentially impermiable to groundwater RCOL2_02.04.13-5 flow.~~Formation and the travel time vertically to the Twin Mountains formation is approximately 400 years for Cs-137 (one of the radionuclides considered in the Units 3 and 4 tank failure analysis), it is concluded that the vertical pathway to the Twin Mountains Formation is not plausible and accordingly, was eliminated as a pathway.~~ RCOL2_02.04.13-5

Because the vertical migration pathway was considered implausible, the only plausible release scenario would involve a horizontal release to SCR.~~Units 1 and 2 restricted potable water supplies were eliminated, the time for Cs-137 to travel through the Glen Rose Formation is approximately 400 years, and the nearest unrestricted potable water supply is approximately four miles south of the CPNPP site, the SCR receptor is considered the only plausible horizontal groundwater flow release path. The deeper bedrock is not conductive to groundwater travel due to the impermeable limestone layer.~~ Therefore, the alternate conceptual models chosen were to transport the liquid radioactive release through the engineered fill and undifferentiated fill/regolith ~~and shallow bedrock in a straight line~~ pathway to SCR (as described in Subsection 2.4.12.3.1 and shown on Figures 2.4.12-212 through 2.4.12-214). RCOL2_02.04.13-5

2.4.13.5 ~~Horizontal~~ Liquid Effluent Groundwater Release Pathway to SCR and Summary Analysis Results

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~~Site-specific groundwater flow velocities and travel times are presented in Table 2.4.12-211 and Subsection 2.4.12.1.1. Hydraulic conductivities, porosity, and bulk density of the subsurface soils and bedrock are described in Subsections 2.4.12.2.4, 2.4.12.2.5, 2.4.12.2.5.1. Groundwater pathways are discussed in Subsection 2.4.12.3. Four plausible groundwater pathways were identified.~~

- ~~Unit 3 A/B to SCR through the regolith and undifferentiated fill~~
- ~~Unit 3 A/B to SCR through the Glen Rose limestone~~
- ~~Unit 4 A/B to SCR through the regolith and undifferentiated fill~~
- ~~Units 4 A/B to SCR through the Glen Rose limestone~~

~~In all four pathways, the location of the most limiting tank. the Boric Acid Tank, was the northeast corner of the Auxiliary Building. The four pathways represent the most conservative straight-line flow paths, or worse-case scenarios. The basis for selecting these pathway scenarios is discussed below.~~

~~Due to the planned removal of all overburden material down to plant grade elevation of 822 ft msl, and the sub-grade floor elevation of the A/B at 785 ft msl, the pathways through the regolith and undifferentiated fill are not considered plausible and are not discussed further. Additionally, as discussed previously in Subsection 2.4.13.2, horizontal pathways through groundwater moving southeast or southwest are not considered plausible as this movement would be away from SCR and would not be consistent with the hydraulic gradients for the area~~

surrounding the CPNPP Units 3 and 4 areas shown on Figure 2.4.12-210, Sheets 1 through 12. RCOL2_02.04.13-7

Actual groundwater flow from the postulated release point to SCR is expected to be tortuous and result in longer transport times. To define a conservative worse-case scenario, a simplified, straight-line pathway through the two media was utilized. This simplified approach was selected rather than simulating flow through a complex, three-dimensional flow path. The limestone in C-zone beneath the foundation is considered impermeable. Although groundwater was identified within the undifferentiated fill/regolith and bedrock beneath the CPNPP Units 3 and 4 sites, the groundwater was considered "perched" as evidenced by the lack of equilibrium in the groundwater monitoring wells. The four plausible pathways are presented in Table 2.4.12-211. Determination of the actual tortuous pathway utilizing a three-dimensional analysis would be less conservative than the theorized pathways through the undifferentiated fill/regolith or the shallow bedrock limestone.

To further add conservatism, the highest measured hydraulic conductivity and steepest measured gradient were used in the velocity calculations for transport time to SCR. Actual hydraulic conductivity would be variable along the actual groundwater pathways and would result in a lower effective hydraulic conductivity for the groundwater flow path. The four groundwater pathways and the calculated travel times are presented on Figure 2.4.12-212 and cross section Figures 2.4.12-213 and 2.4.12-214.

To estimate groundwater travel time through the Glen Rose Formation, the site-specific porosity of limestone of 0.119 (see Subsection 2.4.12.2.5.1 for a discussion on selection of this conservative porosity), the highest hydraulic conductivity measured at the site (see Subsection 2.4.12.3 and Table 2.4.12-211), 1.37×10^{-5} cm/s, and the steepest hydraulic gradient measure from the monthly gauging events of the nearest groundwater monitoring wells to the Units 3 and 4 Reactor Buildings were used for the pathway analysis.

- Pathway 3a (Figure 2.4.12-212 and Cross Section Figure 2.4.12-213) — the instantaneous release of the source term from the BAT in the northeast corner of A/B at elevation 785 ft msl traveling northeast towards SCR through the Glen Rose Formation limestone at this depth for 100 lateral feet would encounter engineered fill material at the Unit 3 Ultimate Heat Sink (UHS) and post-construction fill before reaching SCR. Since the engineering fill material design properties may change as the design is finalized and the potential exists for groundwater flow through the fill material of the Unit 3 UHS, it is conservatively assumed that the liquid effluent is instantaneously released to SCR at the time it encounters the engineered fill material at the SE corner of the Unit 3 UHS. The travel time from the Unit 3 A/B through a minimum of 100 feet Glen Rose Formation at this depth to the SE corner of Unit 3 UHS is 3146 days or 8.62 years.

- Pathway 3b (Figure 2.4.12-212 and Cross Section Figure 2.4.12-213) – the instantaneous release of the source term from the BAT in the northeast corner of the Unit 3 A/B at elevation 785 ft msl traveling due east towards the Unit 3 Reactor Building (RB) towards SCR through a minimum of 80 lateral feet of Glen Rose Formation limestone followed by the Unit 3 Essential Service Water (ESW) Pipe Tunnel and an undetermined lateral distance of Glen Rose Formation limestone followed by post-construction engineering fill and undifferentiated fill material before reaching SCR. Since the engineering fill material design properties may change as the design is finalized and the potential exists for groundwater flow through the fill material of the Unit 3 ESW Pipe Tunnel, it is conservatively assumed that the liquid effluent is instantaneously released to SCR at the time it encounters the engineered fill at the Unit 3 ESW Pipe Tunnel. The travel time from the Unit 3 A/B through a minimum of 80 feet of Glen Rose Formation limestone at this depth to the Unit 3 ESW Pipe Tunnel is 2516 days or 6.89 years. RCOL2_02.04.13-7

- Pathway 4a (Figure 2.4.12-212 and Cross Section Figure 2.4.12-214) – the instantaneous release of the source term from the BAT in the northeast corner of Unit 4 A/B at elevation 785 ft msl traveling north-northwest towards SCR at this depth through a minimum of 60 lateral feet of Glen Rose Formation limestone where it would encounter engineered fill at the Unit 4 UHS and engineered fill before reaching SCR. Since the engineering fill material design properties may change as the design is finalized, and the potential exists for groundwater flow through the engineered fill material of the Unit 4 UHS, it is conservatively assumed that the liquid effluent is instantaneously released to SCR at the time it encounters the engineered fill at the Unit 4 UHS. The conservative travel time from the NE corner of the Unit 4 A/B through a minimum of 60 feet of Glen Rose Formation limestone to the Unit 4 UHS is 1916 days or 5.25 years.

- Pathway 4b (Figure 2.4.12-212 and Cross Section Figure 2.4.12-214) – the instantaneous release of the source term from the BAT in the northeast corner of Unit 4 A/B at elevation 785 ft msl traveling northeast towards SCR at this depth through a minimum of 100 lateral feet of Glen Rose Formation limestone where it would encounter engineered fill at the Unit 4 UHS and undocumented fill and engineered fill before reaching SCR. Since the engineering fill material design properties may change as the design is finalized, and the potential exists for groundwater flow through the engineered fill material of the Unit 4 UHS and the undocumented fill, it is conservatively assumed that the liquid effluent is instantaneously released to SCR at the time it encounters the engineered fill at the Unit 4 UHS. The travel time from the Unit 4 A/B through a minimum of 100 feet of Glen Rose Formation limestone to the Unit 4 UHS is 3834 days or 10.50 years.

~~In all plausible groundwater pathways identified, it was considerably conservative to assume a straight-line flow path to SCR with an instantaneous release of the liquid effluent to the SCR once it encountered the engineered fill at either the UHS or the UHS pipe tunnels. The actual groundwater pathways are expected to be tortuous, resulting in longer transport times, and the hydraulic conductivities of the fractures/joints would be or are expected to be lower than the highest measured on site.~~Potential groundwater pathways for the transport of contaminants to possible receptors are discussed in Subsection 2.4.12. These potential groundwater pathways are evaluated for a postulated release of the source term activity from the either CPNPP Unit 3 or 4 BAT in this subsection. RCOL2_02.04.13-7

After evaluating alternative pathways, the most plausible pathway is groundwater transport of source term activity horizontally towards the east from Unit 3, or towards the north from Unit 4, to SCR surface water where the nearest receptor is located (Figure 2.4.12-212). The nearest receptor is considered to be the Roto-cone gravity flow spillway device located at the south end of SCR (Figure 2.4.13-205). An existing Term Permit with the TCEQ, in accordance with the Brazos River Authority, CP-20 (Reference 2.4-296), Section 6.4.1, requires a minimum flow of 1.5 cfs be maintained at the Highway. 144 crossing over Squaw Creek, which eventually flows into the Brazos River. This requires a constant flow from the Roto-cone into Squaw Creek, which is verified at least daily by Luminant. Vertical migration of the source term from a postulated release is evaluated, but not considered a plausible pathway, for groundwater transport to the Twin Mountains Formation aquifer (Subsections 2.4.12.3 and 2.4.13.3). Groundwater transport west and south from either unit are also potential pathways (Subsections 2.4.12.3 and 2.4.13.2), but are not plausible based upon the hydrogeology and hydraulic gradients that exist pre-construction, and would exist post-construction.

The tank failure analysis focuses on the release of the source term from Unit 3 because this pathway has the least amount of time through existing fill, least amount of SCR dilution and mixing volume, and the least amount of transport time to the Roto-cone.

As a result, the tank failure release analysis focuses on the bounding Unit 3 pathway where the BAT source term activity could quickly be drawn into the CPNPP Units 1 and 2 circulating water (CW) intake (short-circuited) and be discharged closer to the release point, the Roto-cone device.

For the bounding Unit 3 pathway (Figure 2.4.12-212), various cases of CW pump operation (no-flow, half-flow or full-flow) were considered to ensure the most bounding scenario is identified, and the resulting effect on mixing and dilution of the source term activity concentration (Table 2.4.13-203).

A postulated source term release from Unit 4 as depicted on Figure 2.4.12-212 is also considered a plausible groundwater pathway to enter SCR. The Unit 4 pathway is groundwater transport via existing fill where it will infiltrate into SCR. The source term activity transports via existing fill groundwater at a velocity of 1.01 ft/day (groundwater velocity) with an overall travel time of 346 days as compared to the Unit 3 pathway, where groundwater velocity is 4.13 ft/day for a travel time of 145 days (Table 2.4.12-211) over the 600 feet through existing fill to SCR (Figure 2.4.12-212). Slower travel time through existing fill with similar characteristics to Unit 3 existing fill results in a greater dispersion of material, and larger water volume dilution effect. As depicted on Figure 2.4.12-214, once the source term activity infiltrates at the groundwater interface, it will slowly diffuse into SCR surface water. As the source term activity diffuses further into SCR surface water, it will be transported southward with surface water flow. As depicted on Figures 2.4.12-212 and 2.4.13-206, the influence of the CPNPP Units 1 and 2 CW pumps affects surface water flow, especially during summer months with very little inflow into SCR. The source term activity would most likely become entrained in the CW intake and exit similarly to the Unit 3 release. Thus, a larger volume of SCR could be credited for this release. RCOL2_02.04.13-7

Because the ECLs are met for the Unit 3 cases of no-flow, full-flow or half-flow of CW pump (Subsections 2.4.13.5.4 through 2.4.13.5.6), the ECLs are also met for the Unit 4 diffusion case since additional diffusion time and SCR surface water volume could be credited.

This tank failure analysis concludes that, using the most conservative analysis, the BAT activity concentration will be sufficiently diluted by a portion of the existing fill groundwater and further diluted and mixed with SCR water to meet the ECLs specified in 10 CFR 20, Appendix B, Table 2.

The following factors or calculations are utilized in assessing the source term activity concentrations from a postulated release from either Units 3 or 4 to the nearest plausible receptor (Roto-cone):

- The source term activity for the BAT was calculated using the RATAF code with 1 percent fuel defect, scaled down to 0.12 percent fuel failure, with appropriate tank factors applied.
- The calculated source term activity concentration remaining after 0.4 years or 145 days of decay is provided in Table 2.4.13-202.
- Potential groundwater pathways are Unit 3 to the east or Unit 4 to the north (Figure 2.4.12-212).
- Groundwater velocity travel time (Table 2.4.12-211).
- Volume of groundwater available for source term activity dilution.
- Volume of SCR surface water available for source term activity dilution.
- Mixing rate in SCR based upon half-flow or full-flow CW pumps.
- Diffusion in SCR with no-flow CW pumps operating.

In developing the most conservative scenarios, the following are not factored into the analysis. If factored into the analysis, these would provide lower concentrations at the receptor: RCOL2_02.04.13-7

- No credit is taken for travel time through the engineered fill into the overall groundwater transport time. This is conservative because travel time increases and allows for additional decay time, dilution, retardation and retention, thereby further reducing the source term activity concentration prior to reaching SCR.

- No credit is taken for retardation, retention or dilution in the engineered fill. This is conservative as these effects would further reduce the source term activity concentration.

- The engineered fill surrounding the ESW tunnel in communication with the existing fill on the east side of the ESW tunnel as depicted on Figures 2.4.12-213 (Unit 3 pathway) and 2.4.12-214 (Unit 4 pathway) is completely saturated. This is conservative because it allows for the source term activity as a slug to be transported to the existing fill where it subsequently infiltrates into SCR. The engineered fill will not likely be in complete communication with the existing fill and it will not likely be completely saturated at all times allowing for retention, retardation and dilution.

- Only a portion (25 percent) of the total available groundwater is assumed to be available for dilution. This is conservative because a considerable amount of groundwater (approximately 9.98E06 gal) can be found in the existing fill that communicates with SCR.

The following subsection describes the bounding Unit 3 pathway scenario to the nearest receptor (Roto-cone gravity drain device).

2.4.13.5.1 Bounding Unit 3 Pathway Scenario

A postulated release from Unit 3 is the most conservative scenario. It is assumed that a physical phenomenon occurs causing the BAT to rupture and its contents spill to the floor or sides of the A/B (El. 785 ft, which is adjacent to the engineered fill outside the A/B). The tank is assumed to be 80 percent full in accordance with BTP 11-6. The bottom of the BAT cubicle is at El. 793 ft. As shown on Figure 2.4.13-201, the engineered fill is just outside of the BAT cubicle area in the A/B and around the R/B. Since the engineered fill has not been specified at this time, it is also assumed that the source term moves as a slug volume through the groundwater in the fully saturated engineered fill. This is very conservative because it is highly unlikely that the engineered fill would be fully saturated throughout the travel pathway. Additionally, travel through the saturated engineered fill increases travel time, and allows for dispersion and retardation that is not credited in the analysis.

The engineered fill surrounding the ESW tunnel is in contact with the existing fill on the east side of the ESW tunnel as depicted on Figure 2.4.12-213. As depicted on Figures 2.4.12-213 and 2.4.13-201, a stormwater retention pond is located east of Unit 3 that has an overflow elevation of approximately 810 ft msl,and a bottom elevation of approximately 800 ft msl. Groundwater elevations within the existing fill will be approximately equal to the surface elevation of SCR. For the purpose of the existing fill groundwater calculation, an SCR minimum operating elevation of 770 ft msl was used. The bottom of the stormwater retention pond is located within the existing fill east of Unit 3, and is approximately 30 feet above the groundwater surface within the existing fill. Therefore, the presence of the stormwater retention pond will not affect the existing fill groundwater volume, nor intercept groundwater impacted by the postulated release from Unit 3. Although not expected, recharge from the stormwater retention pond would serve to produce a shallower groundwater gradient, thereby producing a slower groundwater velocity and travel time for the postulated release and a less conservative analysis of groundwater transport from Unit 3. The existing fill is in communication with the SCR surface water. RCOL2_02.04.13-7

Based upon site-specific hydrogeological data, the groundwater travel time through the existing fill is 145 days. Groundwater velocity within the existing fill material is based on (Table 2.4.12-211):

- The engineered fill surrounding the ESW pipe tunnel is saturated to a maximum groundwater elevation of Elevation High (E_h) = 820 ft msl.
- SCR operating low range is used for volume calculations (before makeup from Lake Granbury) elevation (E_l) = 770 ft msl.
- Distance to SCR (L_G) from the ESW and groundwater interface = 600 ft.
- Groundwater hydraulic gradient (E_h-E_l) / L_G = 0.0833 ft/ft.
- Hydraulic Conductivity (K_h) of the existing fill material = 3.50E-03 cm/sec = 1.15E-04 ft/sec = 9.92 ft/day.
- Effective Porosity (n_e) = 0.2.
- Velocity (V) of groundwater through existing fill = (K_h (E_h-E_l) / L_G) / n_e = 4.13 ft/day.
- Groundwater travel time (T) T = LG / V = 0.4 years or 145 days.

Table 2.4.13-202 shows the source term activity concentration remaining after 145 days of decay from the initial activity concentrations in DCD Table 11.2-17. As shown in Table 2.4.13-202, some of the isotopes are at or below the ECLs. Therefore, any dilution will reduce these concentrations well below the ECLs. From Table 2.4.13-202, the primary radioisotopes of consideration are H-3, Fe-55, Co-58, Co-60, Sr-90, Cs-134, and Cs-137, which are typically the primary radioisotopes contributing to groundwater contamination. RCOL2_02.04.13-7

2.4.13.5.2 Modeling Equations Used in the Tank Failure Analysis

Figure 2.4.13-202 diagram depicts the simple process equations used in modeling the source term activity flow, dilution effects and mixing once the source term activity infiltrates into SCR from the groundwater. The governing differential equations for the time-dependent activity in each compartment are the following:

$$\frac{dA_A}{dt} = S_A + F_{CW,B}[A_B(t)] - (\lambda + F_{env,A} + [F_{CW,A} - F_{env,A}])[A_A(t)] \quad \text{Eq. 1}$$

$$\frac{dA_B}{dt} = -(\lambda + F_{CW,B})[A_B(t)] + ([F_{CW,A} - F_{env,A}])[A_A(t)] \quad \text{Eq. 2}$$

Where:

$F_{CW,i}$ = Normalized circulation water flow for Units 1 and 2 for compartment "i" [1/hr], defined as $F_{CW,i} = F_{CW}/V_i$

$F_{CW,i}$ = Circulation water flow for Units 1 and 2 [gallon/h]

$F_{env,\,i}$ = Normalized flow to the environment for compartment "i" [i/hr], defined as $F_{env,i} = F_{env}/V_i$

F_{env} = Flow to the environment [1/hr],

λ = Decay coefficient [1/hr],

S_A = Constant source for compartment A [μCi/hr], and

A_i = Activity in compartment "i" [μCi].

The following assumptions are included in this model:

- The source term activity infiltration rate into SCR is assumed to be constant.
- The flow to the environment is negligible (conservative for concentration calculations because it retains all of the activity in SCR).
- Only long-lived isotopes are considered; therefore, radioactive decay is neglected prior to the source term being completely infiltrated into SCR.

- SCR is at constant level (no significant changes in volume due to rainwater or other water sources being added provides conservatism because it retains the activity in SCR). RCOL2_02.04.13-7

- Following the release of all the source term, the concentration decreases with time due to mixing with the large SCR bulk volume available for dilution (1.73E10 based upon the CW discharge volume plus the recirculation volume in SCR).

Using these assumptions, the equations simplify to:

$$\frac{dA_A}{dt} = S_A - (F_{CW,A})[A_A(t)] \quad \text{Eq. 3}$$

$$\frac{dA_B}{dt} = F_{CW,A}[A_A(t)] \quad \text{Eq. 4}$$

The SCR mixing volume (Volume "SCR_A") while the source is being added becomes:

$$A_A(t) = A_A(t = 0)e^{-(F_{CW,A})t} + S_A\left[\frac{1 - e^{-(F_{CW,A})t}}{F_{CW,A}}\right] \quad \text{Eq. 5}$$

Because the activity is deposited in the SCR bulk volume, the source is assumed to be constantly added to the volume over the release period. No activity from the tank is assumed to be present in SCR prior to the event; therefore, the final equation during the release phase becomes:

$$A_A = S_A\left[\frac{1 - e^{-(F_{CW,A})t}}{F_{CW,A}}\right] \quad \text{Eq. 6}$$

Based on the above simplified equation, as time progresses, the equilibrium concentration simplifies to:

$$A_{A,eq} = \frac{S_A}{F_{CW,A}} \quad \text{Eq. 7}$$

Because:

$$\lim_{t \to \infty}(1 - e^{-(F_{CW,A})t}) = 1 \quad \text{Eq. 8}$$

Therefore, to calculate the maximum concentration this model Equation is used. Note that this conservatively assumes that equilibrium is achieved prior to the source being depleted.

The equilibrium concentration in compartment A can then easily be determined by: RCOL2_02.04.13-7

$$C_{A,eq} = \frac{A_{A,eq}}{V_A} = \left(\frac{1}{V_A}\right)\left(\frac{S_A}{F_{CW,A}}\right) = \left(\frac{S_A}{(V_A)\left(\frac{F_{CW}}{V_A}\right)}\right) = \frac{S_A}{F_{CW}} \quad \text{Eq. 9}$$

2.4.13.5.3 Infiltration Area of Existing Fill Groundwater and Effect on Volumetric Flow Rate into SCR

Due to the hydrostatic pressure head of SCR pushing against the existing fill surface area (Figure 2.4.12-213), where the groundwater in the existing fill communicates with SCR, it is realistically expected that the groundwater infiltration rate is much, much slower. Groundwater infiltration into SCR from existing fill would most likely occur at times when SCR hydrostatic pressure is decreasing due to a change in level or a considerable temperature change. However, to determine the actual flow infiltration to SCR would require another model and more data acquisition. As a result, the flow into SCR from the existing fill is assumed to occur at the groundwater volumetric flow rate through the existing fill. This is conservative because the groundwater flow rate through the existing fill does not have enough driving force to infiltrate at this rate when compared to the hydrostatic head of SCR. A discussion on the effect of a smaller infiltration surface area and its effect on infiltration rate and dilution in SCR follows.

The existing fill material is an irregular surface. However, the cross sections (Figure 2.4.13-203 and 2.4.13-204) reveal that it is roughly equivalent to one-half of a reposed conical shape with an elliptical base. Therefore, the fill volume below 770 ft msl was conservatively calculated as one-half the volume of an elliptical-based cone with basal surface area twice that of the calculated infiltration area from cross section 3c and a length equivalent to the distance of the farthest existing fill base at 770 ft msl (Figure 2.4.13-203). This results in a total fill volume below 770 ft msl of 6,671,033.8 cu. ft. and a total infiltration surface area of 34,854.49 sq. ft. Elevation 770 ft msl is conservatively chosen as SCR surface water level, which is the lower end of the normal SCR operating range, and provides the least amount of dilution volume and hydrostatic pressure head for the analysis.

Multiplying the total fill volume and infiltration area by the effective porosity of 0.2 yields a groundwater volume of approximately 9.98 million gallons and an effective infiltration surface area of approximately 6970.9 ft^2. This is also a conservative assumption because the slug of source term activity would have to have dispersed across this entire area for this to occur. The infiltration flow rate of groundwater into SCR is given by:

F_{GW} – flow rate of contaminated groundwater to SCR

A_{GW} – Area of existing fill groundwater contribution RCOL2_02.04.13-7

V_{GW} – Velocity of groundwater in existing fill

$F_{GW} = A_{GW} * V_{GW} = 6970.9\ ft^2 * 4.13\ ft/day = 28,789.8\ ft^3/day$ or 149.7 gpm

Using the volumetric flow rate of 149.7 gpm as the infiltration rate into SCR is extremely conservative inasmuch as this was based upon the entire half-elliptical cone surface infiltration area of 6970.9 ft^2, which would have required the source term activity to disperse and dilute throughout the existing fill for this to occur. Using this volumetric flow rate is also conservative because the SCR hydrostatic head is much greater resulting in very little actual infiltration into SCR.

The source term activity, however, is assumed to move as a slug through the existing fill where it would not readily disperse over the entire surface area of the half elliptical cone base. If only the effective surface area of the BAT is considered as infiltration area, the resulting infiltration rate is much slower and longer time to flow into SCR.

The surface area for the BAT is based upon DCD general arrangement drawing Figure 1.2-29 that shows a BAT diameter of approximately 19 feet. Actual dimensions of the BAT have not been designated; however, using an approximate 19 foot diameter tank top or bottom is a close approximation of actual dimensions of the top or bottom of the BAT. Thus, the surface area is $\pi d^2/4 = 283.5\ ft^2$, and can be used to demonstrate the slug surface area form traveling in the existing fill groundwater from the engineered fill.

$F_{GW} = A_{GW} * V_{GW} = 283.5\ ft^2 * 4.13\ ft/day = 1179.1\ ft^3/day$ or 6.12 gpm

The source term slug flow rate into SCR is 24 times slower than the half-elliptical cone infiltration rate of 149.7 gpm where the source term is dispersed across the entire existing fill surface area.

This demonstrates that with the time it takes a smaller surface area of source term activity mixed with the groundwater to flow into SCR, a portion of the activity will combine with the recirculating water flow back to the intake through SCR, providing a much greater dilution volume. It also demonstrates that choosing a high volumetric flow rate as the infiltration rate into SCR is very conservative because this infiltration rate would be indicative of the source term activity dispersing, mixing and diluting with the entire half elliptical cone surface area groundwater. Finally, using the higher infiltration rate of 149.7 gpm is very conservative considering that the actual infiltration rate into SCR is much, much slower due to the hydrostatic head difference between SCR and the existing fill.

2.4.13.5.4 Dilution Effect of the Existing Fill Groundwater

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Because a dispersion model with additional groundwater and soil data would need to be taken to predict the dilution, retardation and retention effects of the existing fill groundwater, only 25 percent of the total amount available is conservatively credited in the tank failure analysis. It is reasonable to credit 25 percent of the existing fill groundwater because the source term activity has been conservatively assumed to be moving as a slug through the engineered fill before it reaches the existing fill with no credit taken for dilution, retardation, retention or dispersion. Once the source term activity reaches the existing fill, it will disperse, mix with and be diluted by some of the existing fill groundwater. As discussed in Subsection 2.4.13.5.3, due to the hydrostatic head difference between the existing fill and SCR, there is a considerably longer stay time in the existing fill groundwater before it would infiltrate into SCR, thus allowing for greater dilution, retardation and dispersion of source term activity. The dilution effect of crediting various quantities of existing fill groundwater is provided in Table 2.4.13-204.

Using the concentration of each radioisotope from the effects of just 25 percent dilution from the existing fill groundwater gives the source term activity concentration into SCR for the conservatively larger infiltration area rate of 149.7 gpm (Table 2.4.13-205).

When it is realistically assumed that some (25 percent) groundwater dilution, retardation and retention occurs, the total activity takes 16666.67 min (277.78 hrs or 11.6 days) to infiltrate into SCR. This conservative infiltration rate for groundwater infiltration over the one-half elliptical shape shows that the infiltration is not instantaneous, that there is some expected retardation and retention by the existing fill groundwater, and that over the 11.6 days to completely infiltrate into SCR, a portion of the activity would be combined with the recirculation flow back to the CW intake; thus, a larger SCR water volume could be credited for the recirculation flow (Figure 2.4.13-206).

2.4.13.5.5 Effects of Circulating Water Pump Operation on Mixing and Dilution

Based upon the simplified Equation 9 in Subsection 2.4.13.5.2, the small dilution effect of Units 1 and 2 CW pumps at maximum capacity (2.0E06 gpm) or one Unit's CW pumps operating at maximum capacity (1.0E06 gpm) reduces the source term activity below the ECLs (Table 2.4.13-206).

The 25 percent dilution effect of the total available existing fill groundwater, with the higher infiltration rate into SCR (149.7 gpm), mixing with the CW intake at 2.0E06 gpm or 1.0E06 gpm, demonstrates that the ECLs are met. The Summation (∑) of the total activity concentration as a ratio of the ECL < 1.0 is shown in Table 2.4.13-207 for the 149.7 gpm infiltration flow rate into SCR from existing fill groundwater for maximum CW pump operation (2.0E06 gpm).

Where:

∑ (Concentration Nuclide / ECL Nuclide) < 1.0 RCOL2_02.04.13-7

∑ (Concentration Nuclide / ECL Nuclide) = 3.2E-01 at the 149.7 gpm infiltration rate is well below 1.0 for all CW pumps operating at 2.0E06 gpm.

For the case of half-flow CW pumps operating at maximum capacity (1.0E06 gpm), the ratio of activity concentration to the ECL is provided in Table 2.4.13-208.

∑ (Concentration Nuclide / ECL Nuclide) = 6.43E-01 at the 149.7 gpm infiltration rate is well below 1.0 for half the CW pumps operating at 1.0E06 gpm.

2.4.13.5.6 Dilution Effect and Mixing of SCR

Once the source term activity infiltrates into SCR through the existing fill (calculated to be approximately 145 days), the source term activity will enter SCR and be drawn into the Units 1 and 2 CW intake pumps and discharged to the south side of the Unit 1 and 2 peninsula at 2 million gpm, where it will eventually encounter the Roto-cone drain to SCR spillway. Because the Roto-cone gravity flow device constantly discharges water to Squaw Creek and ultimately to the Brazos River in order to meet the TCEQ Term Permit CP-20 described previously, the limiting case for dilution becomes when both CPNPP Units 1 and 2 are in operation and the CW pumps are running at 2 million gpm (greatest driving force with least amount of time to reach the Roto-cone gravity flow device). Therefore, the CW discharge point becomes the location for highest source term concentration prior to dilution by SCR discharge volume. The entire 11.6 days release duration is irrelevant because some source term activity would combine with recirculating water back to the CW intake (greater dilution volume) and some activity could potentially reach the Roto-cone and be released to the environment during the first minute. Both CW pumps fully operating provides the greatest driving force and sufficient mixing for the contamination to reach the Roto-cone in the shortest time.

The flow from the CW pumps will potentially reach the Roto-cone fairly rapidly and only be diluted (11,217 ac-ft. or 3.66E09 gallons) by the effect of the small CW intake volume plus the discharge CW volume on the opposite side of the peninsula (Figure 2.4.13-205). The CPNPP Units 1 and 2 CW pumps provide a strong driving and mixing force for the dilution of the source term activity. No-flow conditions are also examined due to the possibility of CPNPP Units 1 and 2 eventually being decommissioned during the life of CPNPP Units 3 and 4, or both Units 1 and 2 in an outage. As shown on Figure 2.4.13-206, no water volume in the inlet areas, intake area or the discharge area is included. A detailed flow model of SCR has not been performed. Thus, only an estimate of this water volume can be attributed to recirculation flow from CW discharge to CW intake.

SCR volume was calculated using bathymetry data from a July 11, 2007 bathymetry study (Reference 2.4.13-297). If the CW pumps were not operating at full capacity or one unit was down, there would be a lower driving force to reach the Roto-cone, and a greater volume of water to dilute the source term activity due to the recirculating water volume east of the existing fill area of SCR plus the water volume north of the Roto-cone plus the discharge point on the south side of the peninsula. This would result in dilution of the source term concentration well below the ECLs prior to discharge at the Roto-cone (Figures 2.4.13-205 and 2.4.13-206). RCOL2_02.04.13-7

The mixing volume for half-flow operations is the mixing volume shown on Figure 2.4.13-207, Area 1 (11,217 ac-ft. or 3.66E09 gallons) plus the mixing volume from Area 3 (41,757 ac-ft. or 1.36E10 gallons) for a total of 1.73E10 gallons. This volume does not include depths in SCR greater than 66 feet. This is a conservative assumption because some mixing would most likely occur at greater depths in SCR, depending on the CPNPP Units 1 and 2 operating conditions, depth in SCR, seasonal fluctuations, rain events or other conditions that effect temperature changes in SCR. As a result, no credit is taken for water dilution at El. 704 ft. or deeper. The volume does not include any contribution from inlets or areas where it is expected that CW discharge would not have a credible effect on diffused dilution or mixing. Recirculation flow time to the intake is unknown and depends on CW flow rate, SCR level, time of year, where in the fuel cycle the unit is operating, and other parameters. However, using the CW pumps in full operation provides the greatest driving force and allows for a simple estimate of the recirculation time:

1.73E10 gal / 2E06 gpm = 8635 min or 143.92 hours or 6 days recirculation time

The time for complete source term activity infiltration into SCR from existing fill is 11.6 days, which is greater than the recirculation flow time. Therefore, additional SCR dilution volume from CW recirculation flow (Figure 2.4.13-206) can be credited.

For no-flow conditions (Figure 2.4.13-206), the source term activity would diffuse with the water volume east of the existing fill and very slowly diffuse southward toward the Roto-cone release point because the Roto-cone discharge rate to Squaw Creek would be the only driving force in this scenario. Using the bathymetry study described previously, an estimated volume of SCR water at no-flow conditions is 41,757 ac-ft. or 1.36E10 gallons. This volume does not include inlet areas close to the existing fill release point, nor does it include depths greater than 66 ft. in SCR where it is not expected that much mixing or diffusion will occur. Additionally, it is unknown how long it would take the diffused source term water volume to flow southward towards the Roto-cone release point.

No-flow conditions would result in the source term activity infiltrating SCR via the existing fill groundwater interface and slowly diffusing into the SCR water adjacent to the east side of CPNPP Unit 3. As shown on Figure 2.4.13-206, no water volume in the inlet areas or intake area is included. The credited volume as discussed previously is 1.36E10 gallons and does not include any water below a depth of 66 feet in the reservoir. The infiltration rate into SCR is discussed previously, but in this case is irrelevant as diffusion throughout SCR surface water would be very slow. The only driving force to reach the Roto-cone area is the discharge through the Roto-cone. An additional model would have to be developed to calculate the diffusion rate of source term activity into SCR and the time to reach the Roto-cone. However, Table 2.4.13-209 shows that the ECLs would be met before any contamination reached the Roto-cone by simple diffusion with the SCR surface water above the 66 ft depth. In this case, no credit is taken for dilution effect of existing fill groundwater. If credit were taken, the resulting ratio of activity to ECL would be further diminished as demonstrated in Subsection 2.4.13.5.5. RCOL2_02.04.13-7

∑ (Concentration Nuclide / ECL Nuclide) = 7.87E-01

2.4.13.5.7 Summary

Considerable conservative assumptions include:

- No credit taken for the dilution, retardation or retention effects of the engineered fill;
- No credit taken for the travel time through the engineered fill that is assumed to be completely saturated;
- The source term activity moves as a slug volume through both the engineered fill and existing fill;
- The infiltration rate into SCR is one-half elliptical cone surface area of the existing fill (149.7 gpm). This flow rate is excessive when compared to actual very slow infiltration into SCR resulting from a decrease in hydrostatic head between SCR and the adjacent existing fill surface area in communication with SCR;
- Crediting only 25 percent of the existing fill groundwater when actually there would be greater dispersion, dilution and retention in the groundwater.
- Using the surface area of the one-half elliptical cone existing fill volume demonstrates that there would have to be greater dispersion in the groundwater; and
- For the limiting case, crediting only the 2 million or 1 million gpm mixing and dilution flow of CW intake when further dilution will occur based upon the CW discharge volume prior to reaching the Roto-cone release point.

Additionally, it has been adequately demonstrated that a smaller infiltration flow rate from the existing fill into SCR results in a longer time for the total activity to infiltrate into SCR. This longer infiltration time (11.6 days) ensures a larger dilution volume because some of the source term activity will combine with recirculation flow and be diluted by the bulk volume of SCR. Furthermore, it has been demonstrated that adequate mixing occurs in SCR using the mixing driving force of the CW pumps only. For no-flow pump conditions, it is demonstrated that simple diffusion and dilution by SCR surface water is adequate to meet the ECLs for the case of either a Unit 3 or 4 tank failure without crediting existing fill groundwater dilution. RCOL2_02.04.13-7

Crediting 25 percent of the existing fill groundwater for dilution of the source term activity prior to entering SCR, combined with the slow infiltration effect of the existing fill groundwater into SCR, and only the mixing and dilution effect of the CW intake of either 1 or 2 million gpm results in meeting the ECLs for all radioisotopes that infiltrate into SCR via the existing fill groundwater. The unrestricted potable water supply receptor location is the Roto-cone discharge area in the southeast portion of SCR near the Squaw Creek dam. All activity concentrations reaching the Roto-cone device have been shown to be below the limits of 10 CFR 20, Appendix B, Table 2, and thus the requirements of 10 CFR 20.1301, 20.1302 and 10 CFR 100 are satisfied.

2.4.13.6 ~~Dilution Effects of Horizontal Liquid Effluent Release Pathway~~

~~The computer code model utilized in the tank failure was the RATAF computer code for pressurized water reactors that is provided in NUREG-0133. The RATAF code defines the Hydrological Travel time as the time it takes for the liquid waste of a failed tank to reach the nearest potable water supply or nearest surface water in an unrestricted area.~~

~~The tank failure analysis, as described in DCD Subsection 11.2.3.2, was performed in accordance with Standard Review Plan (SRP) 2.4.13 and takes no credit for the dilution effects of groundwater nor retention or retardation in the regolith, undifferentiated fill, or the Glen Rose Formation. Because there is no “unrestricted” potable water supply or surface water body in close proximity to the Comanche Peak site, the analysis was conservatively performed by considering the potential for the liquid radioactive release to reach either the Unit 1 and 2 restricted potable water supply wells or Squaw Creek Reservior (SCR). The vertical pathway to the Twin Mountains formation, where the Unit 1 and 2 potable water supplies exist, was eliminated from consideration. The horizontal pathway through the regolith/undifferentiated fill and shallow bedrock was assumed to be a straight line to SCR. In reality, actual grounwater flow from the postulated release point to SCR would be more tortuous, resulting in longer transport times. Therefore, a simplified, straight-line pathway through the two media identified is a more conservative, worse-case scenario than simulating flow through a complex, three-dimensional flow path. The A-zone undifferentiated fill or regolith, and the B-zone shallow bedrock geologic hydrogeologic characteristics indicate that the liquid release will not concentrate in these zones. It is conservatively assumed that the liquid release would travel with the groundwater through the impermeable limestone to SCR.~~

~~The BTP 11-6 tank failure analysis used an equivalent volume of water reported in SCR of 4.4 x 10^{10} gallons. This same dilution volume was used in the Units 1 and 2 Standard Review Plan (SRP) 2.4.13 and 10 CFR 100.20(c)(3) assessment.~~

Additionally, it was conservatively assumed that the travel time to the SCR was 365 days. It was also assumed that there would be no retardation or retention by the subsurface strata, and that groundwater would not dilute the released liquid radioactive waste. There will be no concentration of the release because there is no credible mechanism in these subsurface strata. Therefore, liquid radioactive waste is expected to move slowly and not concentrate in the subsurface media. It should also be noted that no credit is taken in the tank failure analysis for retardation or retention in the subsurface media, or dilution in the groundwater. RCOL2_02.04.13-7

2.4.13.7 Summary of Accidental Releases of Radioactive Liquid Effluent in Ground and Surface Waters

The tank failure analysis described in the US-APWR DCD Subsection 11.2.3.2 was performed in accordance with Branch Technical Position (BTP) 11-6 for the CPNPP Units 3 and 4. The computer code model used in the BTP 11-6 analysis was performed utilizing the RATAF computer code for pressurized water reactors that is provided in NUREG-0133 entitled "Preparation of Radiological Effluent Technical Specification for Nuclear Power Plants". The RATAF code defines the Hydrological Travel time as the time it takes for the liquid waste of a failed tank to reach the nearest potable water supply or nearest surface water in an unrestricted area. Although the nearest potable water supply and the nearest surface water body are located in the restricted areas of the CPNPP site, the potable water supply wells for the CPNPP Units 1 and 3 and SCR, respectively, were conservatively considered in this evaluation.

The BTP 11-6 tank failure analysis used an equivalent volume of water reported in SCR of 4.4×10^{10} gallons. This same dilution volume was used in the Units 1 and 2 Standard Review Plan (SRP) 2.4.13 and 10 CFR 100.20(c)(3) assessments. Additionally, in the BTP 11-6 tank failure analysis, it was conservatively assumed that the travel time to SCR was 365 days, that there is no retardation or retention by the subsurface strata, and that the groundwater did not dilute the released liquid radioactive waste. In the tank failure analysis, the dilution effects of SCR were considered and the concentrations provided in US-APWR DCD Table 11.2-17 show the calculated concentrations based upon the conservative travel time to the SCR of 365 days, with the dilution effects associated with SCR. In this BTP 11-6 evaluation model, it was determined that the BAT contained the largest quantity and concentration of radionuclides that could possibly challenge the 10 CFR 20, Appendix B limits, and that 80 percent of the contents with a 0.12 percent fuel defect level would be delivered to the SCR.

The BAT is located in the northeast (NE) corner of the A/B where the basemat is at an approximate elevation of 785 ft msl. Site specific hydrogeological data discussed in Subsection 2.4.12.1.1, core boring stratigrahy discussed in Subsection 2.5.4.3.1, and Units 1 and 2 FSAR Subsections 2.4.12 and 2.4.13 were then used to discuss whether the vertical travel path to the Twin Mountains Formation was credible and to evaluate the horizontal travel time of groundwater in the shallow limestone bedrock of the Glen Rose Formation. The Glen Rose Formation limestone is considered impermeable beneath the CPNPP site, and groundwater measured in this limestone is considered "perched". However, in order to evaluate the effects of a postulated vertical release to the Twin Mountains aquifer, a conservative mathematical model with simplifying assumptions was used to model the dispersion of a liquid release through the Glen Rose Formation limestone as described in the CPNPP Units 1 and 2 FSAR Section 2.4.12. The results of this simplified analysis indicate that only one radionuclide, Cs-137, would penetrate the entire 150 feet depth of the Glen Rose Formation limestone to reach the Twin Mountains aquifer and it would take 400 years. RCOL2_02.04.13-7

Based upon this evaluation, and the results of the geologic and hydrogeologic investigations conducted at the CPNPP site discussed in Subsection 2.5.4.3.1, vertical transport of the liquid radioactive release through the Glen Rose Formation limestone to the deeper Twin Mountains aquifer is not considered probable. As a result, the vertical travel path was eliminated. Estimated velocity and travel times were calculated based upon CPNPP site specific data where it was determined that it would take 3146 days or approximately 8.62 years for groundwater carrying the liquid effluent from Unit 3 to reach SCR. Estimated velocity and travel times were calculated for the groundwater carrying the liquid effluent from Unit 4 to SCR was 1916 or 5.25 years. Because vertical migration through the impermeable limestone is not probable, a straight-line flow pathway form the postulated release point to SCR was considered a worse-case scenario and used as the bounding condition for the CPNPP Units 3 and 4 site. Evaluation of the site-specific hydrogeological information (porosity, hydraulic conductivity, groundwater gradient, etc, including equations, assumptions and methods), it was determined that the most conservative time for a liquid release from either the Unit 3 or Unit 4 BAT in the NE corner of either the Unit 3 or Unit 4 A/B to travel horizontally through the Glen Rose Formation limestone to reach SCR was approximately 1916 days or 5.25 years.

Since the DCD Section 11.2.3.2 tank failure analysis conservatively chose a travel time of 365 days to reach SCR. The site-specific hydrogeologic data shows a travel time of approximately 1916 days or 5.25 years, no credit is taken for retardation or suspension in subsurface media, or dilution by the groundwater prior to reaching SCR. Therefore, it is concluded that the limits of 10 CFR 20, Appendix B are met for the BAT Cs-134 and Cs-137 liquid release, and the site-specific hydrogeology bounds the US-APWR DCD Section 11.2.3.2 tank failure release analysis assumptions for travel time and dilution effects of SCR. 10 CFR 20, Appendix B states: "The columns in Table 2 of this appendix captured "Effluents," "Air," and "Water," are applicable to the assessment and control of dose to the public, particularly in the implementation of the provisions of §20.1302. The concentration values given in columns 1 and 2 of Table 2 are equivalent to the radionuclide concentrations which, if inhaled or ingested continuously over the course of a year, would produce a total effective dose equivalent of 0.05 rem (50 millirem of 0.5 millisieverts)." The receptor concentrations from the BAT of Cs-134 and Cs-137 in SCR do not exceed the limits of 10 CFR 20, Appendix B, Table 2, and thus the requirements of 10 CFR 20.1301, 20.1302 and 10 CFR 100 are satisfied.

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2.4-295 Cherry, J.A., et. al., Contaminate Transport Through Aquitards: A State-of-the-Science Review, Awwa Research Foundation, 2006. RCOL2_02.04.13-7

2.4-296 Texas Commission on Environmental Quality Term Permit CP-20 to Divert and Use Water Authorized to be Stored, Diverted and Used by the Brazos River Authority.

2.4-297 Boss, Stephen K., PhD, "Bathymetry and Volume Storage of a Portion of Squaw Creek Reservoir, Hood and Somervell Counties, Texas, July 11, 2007.

RCOL2_02.04.13-7

Table 2.4.13-202 (Sheet 1 of 2)
Source Term Activity after 0.4 Years (145 Days) Decay

Radioisotope	ECL Limit		Activity Concentration		145 Days Decay Activity[a]
	(µCi/ml)	(µCi/gal)	(µCi/ml)	(µCi/gal)	(µCi)
H-3	1.00E-03	3.79+E00	7.30E-01	2.76E+03	1.46E+08
Cr-51	5.00E-04	1.89+E00	8.00E-07	3.03E-03	1.60E+02
Mn-54	3.00E-05	1.14E-01	3.00E-05	1.14E-01	6.02E+03
Fe-55	1.00E-04	3.79E-01	3.00E-04	1.14E+00	6.02E+04
Fe-59	1.00E-05	3.79E-02	2.70E-06	1.02E-02	5.39E+02
Co-58	2.00E-05	7.57E-02	1.60E-04	6.06E-01	3.20E+04
Co-60	3.00E-06	1.14E-02	4.50E-04	1.70E+00	8.98E+04
Sr-89	8.00E-06	3.03E-02	1.44E-06	5.45E-03	2.88E+02
Sr-90	5.00E-07	1.89E-03	2.64E-06	9.99E-03	5.27E+02
Y-91	8.00E-06	3.03E-02	4.20E-07	1.59E-03	8.40E+01
Zr-95	2.00E-05	7.57E-02	4.68E-07	1.77E-03	9.35E+01
Nb-95	3.00E-05	1.14E-01	1.80E-07	6.81E-04	3.60E+01
Ru-103	3.00E-05	1.14E-01	7.92E-08	3.00E-04	1.58E+01
Ru-106	3.00E-06	1.14E-02	1.14E-06	4.32E-03	2.28E+02
Te-129m	7.00E-06	2.65E-02	1.44E-06	5.45E-03	2.88E+02
I-131	1.00E-06	3.79E-03	4.68E-09	1.77E-05	9.35E-01
Cs-134	9.00E-07	3.41E-03	9.24E-02	3.50E+02	1.85E+07
Cs-136	6.00E-06	2.27E-02	9.00E-07	3.41E-03	1.80E+02
Cs-137	1.00E-06	3.79E-03	9.96E-02	3.77E+02	1.99E+07
Ce-141	3.00E-05	1.14E-01	5.76E-08	2.18E-04	1.15E+01

RCOL2_02.04.13-7

Table 2.4.13-202 (Sheet 2 of 2)
Source Term Activity after 0.4 Years (145 Days) Decay

Radioisotope	ECL Limit		Activity Concentration		145 Days Decay Activity(a)
	(µCi/ml)	(µCi/gal)	(µCi/ml)	(µCi/gal)	(µCi)
Ce-144	3.00E-06	1.14E-02	3.00E-06	2.76E+03	6.02E+02

Note:

(a) Based upon 52,800 gallons in BAT release.

RCOL2_02.04.13-7

Table 2.4.13-203

Cases Considered in Tank Failure Analysis for Units 3 and 4

Analysis Category	Unit 3	Unit 4
Retardation and retention in engineered fill	None	None
Transported as a slug via groundwater in engineered fill	No groundwater diffusion considered	No groundwater diffusion considered
Transported with the groundwater velocity	145 days	346 days
Radionuclide decay time (days)	145 days	346 days
Dilution volume of total available groundwater	25% (2.5E06 gal)	N/A[a]
Dilution volume of SCR for CW half-flow condition	1E06 gpm (Subsection 2.4.13.5.5)	N/A[a]
Dilution volume of SCR for CW full-flow condition	2E06 gpm (Subsection 2.4.13.5.5)	N/A[a]
Dilution volume of SCR for no-flow condition	1.36E10 gal (Subsection 2.4.13.5.6)	1.36E10 gal

Note:

(a) N/A - Not Applicable - Unit 3 is bounding condition.

RCOL2_02.04.13-7

Table 2.4.13-204 (Sheet 1 of 2)
Dilution Effect of Various Quantities of Existing Fill Groundwater

Radioisotope	Activity Concentration	Existing Fill Groundwater Dilution Percent Credited		
		100%	50%	25%
	(µCi)	(µCi/gal)	(µCi/gal)	(µCi/gal)
H-3	1.46E+08	1.46E+01	2.92E+01	5.85E+01
Cr-51	1.60E+02	1.60E-05	3.21E-05	6.41E-05
Mn-54	6.02E+03	6.03E-04	1.21E-03	2.41E-03
Fe-55	6.02E+04	6.03E-03	1.21E-02	2.41E-02
Fe-59	5.39E+02	5.40E-05	1.08E-04	2.16E-04
Co-58	3.20E+04	3.21E-03	6.41E-03	1.28E-02
Co-60	8.98E+04	8.99E-03	1.80E-02	3.60E-02
Sr-89	2.88E+02	2.88E-05	5.77E-05	1.15E-04
Sr-90	5.27E+02	5.29E-05	1.06E-04	2.11E-04
Y-91	8.40E+01	8.41E-06	1.68E-05	3.36E-05
Zr-95	9.35E+01	9.36E-06	1.87E-05	3.75E-05
Nb-95	3.60E+01	3.60E-06	7.21E-06	1.44E-05
Ru-103	1.58E+01	1.59E-06	3.17E-06	6.35E-06
Ru-106	2.28E+02	2.29E-05	4.57E-05	9.14E-05
Te-129m	2.88E+02	2.88E-05	5.77E-05	1.15E-04
I-131	9.35E-01	9.36E-08	1.87E-07	3.75E-07
Cs-134	1.85E+07	1.85E+00	3.70E+00	7.40E+00
Cs-136	1.80E+02	1.80E-05	3.61E-05	7.22E-05
Cs-137	1.99E+07	1.99E+00	3.99E+00	7.98E+00

RCOL2_02.04.13-7

Table 2.4.13-204 (Sheet 2 of 2)
Dilution Effect of Various Quantities of Existing Fill Groundwater

Radioisotope	Activity Concentration	Existing Fill Groundwater Dilution Percent Credited		
		100%	50%	25%
	(µCi)	(µCi/gal)	(µCi/gal)	(µCi/gal)
Ce-141	1.15E+01	1.15E-06	2.31E-06	4.61E-06
Ce-144	6.02E+02	6.03E-05	1.21E-04	2.41E-04

Note:

Activity Concentration after dilution = Activity (µCi) / 9.98E06 gal x percent credited.

RCOL2_02.04.13-7

Table 2.4.13-205 (Sheet 1 of 2)
Dilution Effect of 25 Percent of Existing Fill Groundwater

Radioisotope	Activity (µCi)	Activity Concentration (µCi/gal)[1]	25% Groundwater Dilution (µCi/gal)[2]	Flow into SCR (µCi/min)[3]
H-3	1.46E+08	2.76E+03	5.85E+01	8.75E+03
Cr-51	1.60E+02	3.03E-03	6.41E-05	9.60E-03
Mn-54	6.02E+03	1.14E-01	2.41E-03	3.61E-01
Fe-55	6.02E+04	1.14E+00	2.41E-02	3.61E+00
Fe-59	5.39E+02	1.02E-02	2.16E-04	3.23E-02
Co-58	3.20E+04	6.06E-01	1.28E-02	1.92E+00
Co-60	8.98E+04	1.70E+00	3.60E-02	5.39E+00
Sr-89	2.88E+02	5.45E-03	1.15E-04	1.73E-02
Sr-90	5.27E+02	9.99E-03	2.11E-04	3.16E-02
Y-91	8.40E+01	1.59E-03	3.36E-05	5.04E-03
Zr-95	9.35E+01	1.77E-03	3.75E-05	5.61E-03
Nb-95	3.60E+01	6.81E-04	1.44E-05	2.16E-03
Ru-103	1.58E+01	3.00E-04	6.35E-06	9.50E-04
Ru-106	2.28E+02	4.32E-03	9.14E-05	1.37E-02
Te-129m	2.88E+02	5.45E-03	1.15E-04	1.73E-02
I-131	9.35E-01	1.77E-05	3.75E-07	5.61E-05
Cs-134	1.85E+07	3.50E+02	7.40E+00	1.11E+03
Cs-136	1.80E+02	3.41E-03	7.22E-05	1.08E-02
Cs-137	1.99E+07	3.77E+02	7.98E+00	1.19E+03
Ce-141	1.15E+01	2.18E-04	4.61E-06	6.91E-04

RCOL2_02.04.13-7

Table 2.4.13-205 (Sheet 2 of 2)
Dilution Effect of 25 Percent of Existing Fill Groundwater

Radioisotope	Activity (µCi)	Activity Concentration (µCi/gal)[1]	25% Groundwater Dilution (µCi/gal)[2]	Flow into SCR (µCi/min)[3]
Ce-144	6.02E+02	1.14E-02	2.41E-04	3.61E-02

Notes:

1. After 145 days of decay and reduced by 52,800 gal.
2. Based upon dilution with 2.5E06 gal of existing fill groundwater.
3. Based upon 25 percent existing fill dilution, and = µCi/gal x 149.7 gpm groundwater flow.

RCOL2_02.04.13-7

Table 2.4.13-206 (Sheet 1 of 2)
Mixing and Dilution Effect of Circulating Water

Radioisotope	Flow into SCR (µCi/min)[1]	Dilution Effect of Full-flow CW (µCi/gal)[2]	Dilution Effect of Half-flow CW (µCi/gal)[3]
H-3	8.75E+03	4.38E-03	8.75E-03
Cr-51	9.60E-03	4.80E-09	9.60E-09
Mn-54	3.61E-01	1.81E-07	3.61E-07
Fe-55	3.61E+00	1.81E-06	3.61E-06
Fe-59	3.23E-02	1.62E-08	3.23E-08
Co-58	1.92E+00	9.60E-07	1.92EE-06
Co-60	5.39E+00	2.69E-06	5.39E-06
Sr-89	1.73E-02	8.63E-09	1.73E-08
Sr-90	3.16E-02	1.58E-08	3.16E-08
Y-91	5.04E-03	2.52E-09	5.04E-09
Zr-95	5.61E-03	2.80E-09	5.61E-09
Nb-95	2.16E-03	1.08E-09	2.16E-09
Ru-103	9.50E-04	4.75E-10	9.50E-10
Ru-106	1.37E-02	6.84E-09	1.37E-08
Te-129m	1.73E-02	8.63E-09	1.73E-08
I-131	5.61E-05	2.80E-11	5.61E-11
Cs-134	1.11E+03	5.54E-04	1.11E-03
Cs-136	1.08E-02	5.40E-09	1.08E-08
Cs-137	1.19E+03	5.97E-04	1.19E-03
Ce-141	6.91E-04	3.45E-10	6.91E-10

RCOL2_02.04.13-7

Table 2.4.13-206 (Sheet 2 of 2)
Mixing and Dilution Effect of Circulating Water

Radioisotope	Flow into SCR (µCi/min)[1]	Dilution Effect of Full-flow CW (µCi/gal)[2]	Dilution Effect of Half-flow CW (µCi/gal)[3]
Ce-144	3.61E-02	1.81E-08	3.61E-08

Notes:

1. Based upon 25 percent existing fill dilution, and = µCi/gal x 149.7 gpm groundwater flow.
2. Based upon 149.7 gpm infiltration flow, and = infiltration flow into SCR (µCi/min) / 2E06 gpm.
3. Based upon 149.7 gpm infiltration flow, and = infiltration flow into SCR (µCi/min) / 1E06 gpm.

RCOL2_02.04.13-7

Table 2.4.13-207 (Sheet 1 of 2)
Ratio of Source Term Concentration to ECL for Full-flow CW

Radioisotope	ECL Limit (µCi/gal)	Dilution Effect of CW (µCi/gal)[(a)]	Ratio of Activity Concentration to ECL
H-3	3.79E+00	4.38E-03	1.15E-03
Cr-51	1.89E+00	4.80E-09	2.54E-09
Mn-54	1.14E-01	1.81E-07	1.58E-06
Fe-55	3.79E-01	1.81E-06	4.76E-06
Fe-59	3.79E-02	1.62E-08	4.26E-07
Co-58	7.57E-02	9.60E-07	1.27E-05
Co-60	1.14E-02	2.69E-06	2.36E-04
Sr-89	3.03E-02	8.63E-09	2.85E-07
Sr-90	1.89E-03	1.58E-08	8.37E-06
Y-91	3.03E-02	2.52E-09	8.31E-08
Zr-95	7.57E-02	2.80E-09	3.70E-08
Nb-95	1.14E-01	1.08E-09	9.46E-09
Ru-103	1.14E-01	4.75E-10	4.17E-09
Ru-106	1.14E-02	6.84E-09	6.00E-07
Te-129m	2.65E-02	8.63E-09	3.26E-07
I-131	3.79E-03	2.80E-11	7.40E-09
Cs-134	3.41E-03	5.54E-04	1.62E-01
Cs-136	2.27E-02	5.40E-04	2.38E-07
Cs-137	3.79E-03	5.97E-04	1.58E-01
Ce-141	1.14E-01	3.45E-10	3.03E-09

Table 2.4.13-207 (Sheet 2 of 2)
Ratio of Source Term Concentration to ECL for Full-flow CW

RCOL2_02.04.13-7

Radioisotope	ECL Limit (µCi/gal)	Dilution Effect of CW (µCi/gal)[(a)]	Ratio of Activity Concentration to ECL
Ce-144	1.14E-02	1.81E-08	1.58E-06
	Σ [Source Term Activity / ECL] =		3.21E-01

Note:

(a) At the infiltration rate of 149.7 gpm, and = infiltration flow into SCR (µCi/min) / 2E06 gpm.

RCOL2_02.04.13-7

Table 2.4.13-208 (Sheet 1 of 2)
Ratio of Source Term Concentration to ECL for Half-flow CW

Radioisotope	ECL Limit (µCi/gal)	Dilution Effect of CW (µCi/gal)[a]	Ratio of Activity Concentration to ECL
H-3	3.79E+00	8.75E-03	2.31E-03
Cr-51	1.89E+00	9.60E-09	5.08E-09
Mn-54	1.14E-01	3.61E-07	3.17E-06
Fe-55	3.79E-01	3.61E-06	9.53E-06
Fe-59	3.79E-02	3.23E-08	8.53E-07
Co-58	7.57E-02	1.92E-06	2.54E-05
Co-60	1.14E-02	5.39E-06	4.72E-04
Sr-89	3.03E-02	1.73E-08	5.70E-07
Sr-90	1.89E-03	3.16E-08	1.67E-05
Y-91	3.03E-02	5.04E-09	1.66E-07
Zr-95	7.57E-02	5.61E-09	7.41E-08
Nb-95	1.14E-01	2.16E-09	1.89E-08
Ru-103	1.14E-01	9.50E-10	8.34E-09
Ru-106	1.14E-02	1.37E-08	1.20E-06
Te-129m	2.65E-02	1.73E-08	6.52E-07
I-131	3.79E-03	5.61E-11	1.48E-08
Cs-134	3.41E-03	1.11E-03	3.25E-01
Cs-136	2.27E-02	1.08E-08	4.76E-07
Cs-137	3.79E-03	1.19E-03	3.15E-01
Ce-141	1.14E-01	6.91E-10	6.06E-09

RCOL2_02.04.13-7

Table 2.4.13-208 (Sheet 2 of 2)
Ratio of Source Term Concentration to ECL for Half-flow CW

Radioisotope	ECL Limit (µCi/gal)	Dilution Effect of CW (µCi/gal)[(a)]	Ratio of Activity Concentration to ECL
Ce-144	1.14E-02	3.61E-08	3.17E-06
	Σ [Source Term Activity / ECL] =		6.43E-01

Note:

(a) At the infiltration rate of 149.7 gpm, and = infiltration flow into SCR (µCi/min) / 1E06 gpm.

RCOL2_02.04.13-7

Table 2.4.13-209 (Sheet 1 of 2)
Ratio of Source Term Concentration to ECL for No-flow Conditions

Radioisotope	Activity Concentration (μCi)[1]	SCR Dilution Effect (μCi/gal)[2]	Ratio of Activity Concentration to ECL
H-3	1.46E+08	1.07E-02	2.83E-03
Cr-51	1.60E+02	1.18E-08	6.22E-09
Mn-54	6.02E+03	4.42E-07	3.88E-06
Fe-55	6.02E+04	4.42E-06	1.17E-05
Fe-59	5.39E+02	3.96E-08	1.04E-06
Co-58	3.20E+04	2.35E-06	3.11E-05
Co-60	8.98E+04	6.60E-06	5.79E-04
Sr-89	2.88E+02	2.11E-08	6.98E-07
Sr-90	5.27E+02	3.88E-08	2.05E-05
Y-91	8.40E+01	6.17E-09	2.04E-07
Zr-95	9.35E+01	6.87E-09	9.07E-08
Nb-95	3.60E+01	2.64E-09	2.32E-08
Ru-103	1.58E+01	1.16E-09	1.02E-08
Ru-106	2.28E+02	1.68E-08	1.47E-06
Te-129m	2.88E+02	2.11E-08	7.98E-07
I-131	9.35E-01	6.87E-11	1.81E-08
Cs-134	1.85E+07	1.36E-03	3.98E-01
Cs-136	1.80E+02	1.32E-08	5.83E-07
Cs-137	1.99E+07	1.46E-03	3.86E-01
Ce-141	1.15E+01	8.46E-10	7.42E-09

RCOL2_02.04.13-7

Table 2.4.13-209 (Sheet 2 of 2)
Ratio of Source Term Concentration to ECL for No-flow Conditions

Radioisotope	Activity Concentration (µCi)[1]	SCR Dilution Effect (µCi/gal)[2]	Ratio of Activity Concentration to ECL
Ce-144	6.02E+02	4.42E-08	3.88E-06
	Σ [Source Term Activity / ECL] =		7.87E-01

Notes:

1. At 145 days of decay.
2. Volume determined from east of existing fill south to Roto-cone and = Activity (µCi) / 1.36E10 gal.

RCOL2_02.04.12-9, 13, 14, and 15
RCOL2_02.04.13-7

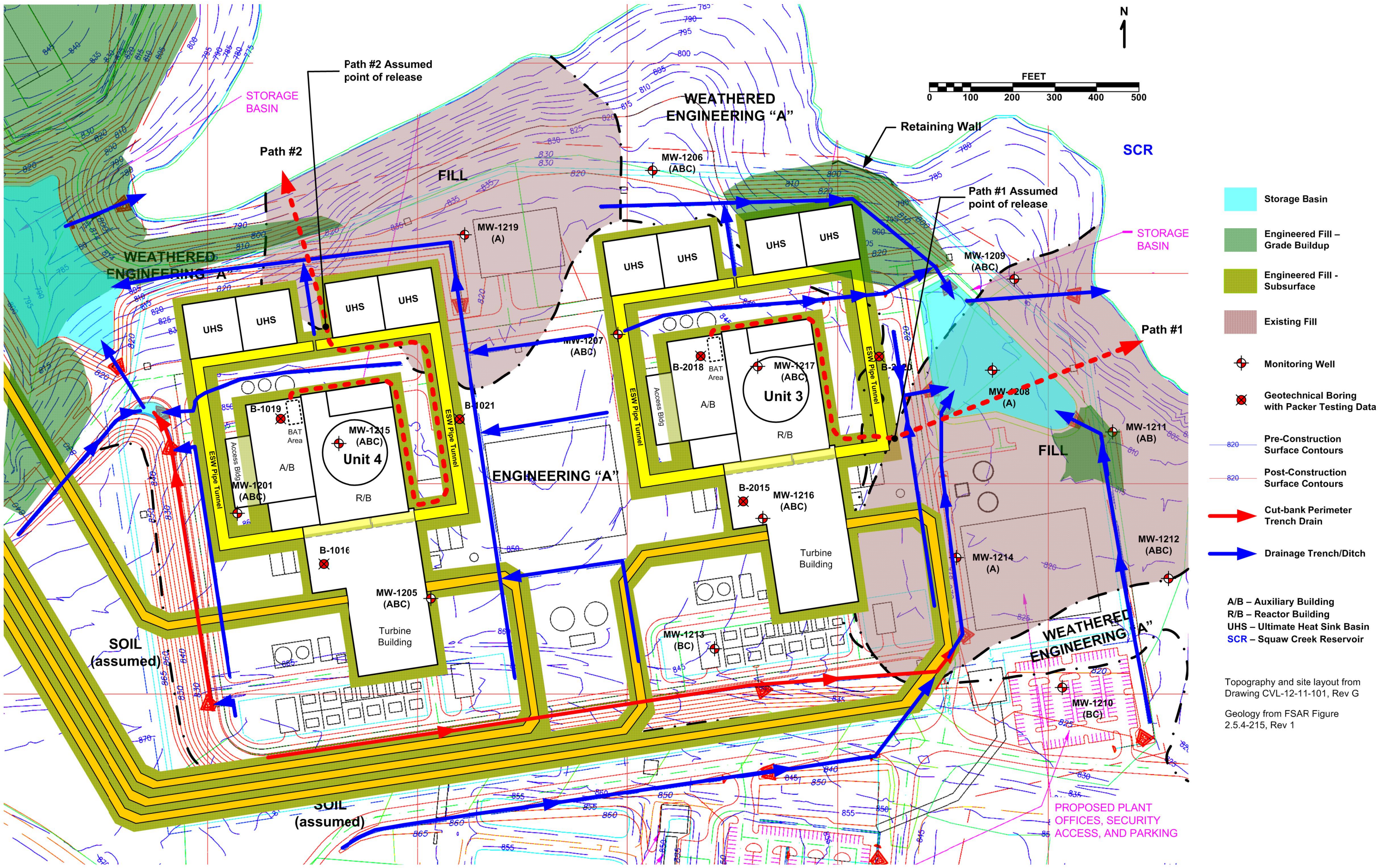

Figure 2.4.12-212 Groundwater Flow Path

RCOL2_02.04.12-9, 13, 14, and 15
RCOL2_02.04.13-7

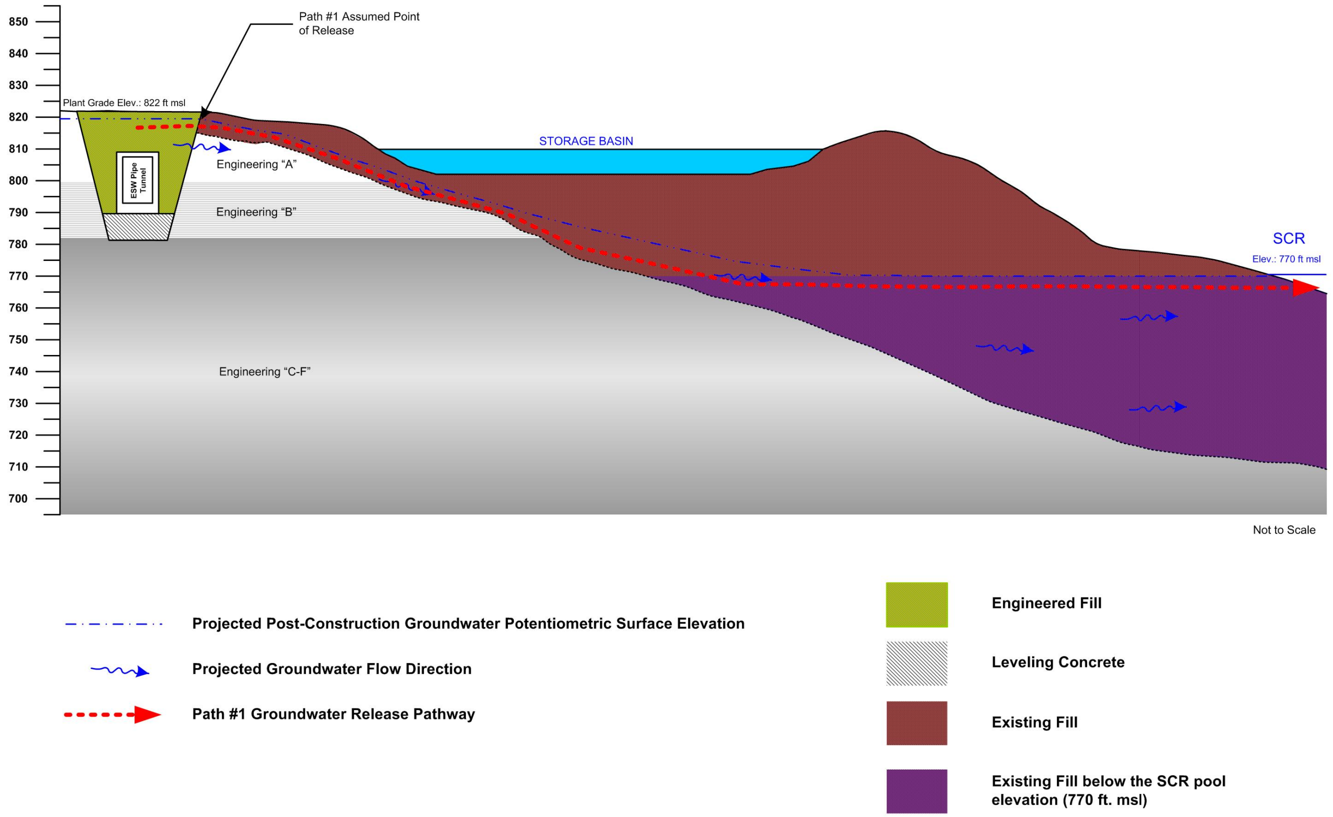

Figure 2.4.12-213 Post Construction Release ~~Flowpath~~Flow Path #1