Energy*Solutions*
Technical Support Document

LC-FS-TSD-002
OPERATIONAL DERIVED CONCENTRATION GUIDELINE LEVELS FOR FINAL STATUS SURVEY

Revision 2

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Summary of Changes in this Revision:

Revision 0 – Initial Issuance
Revision 1 – Revise Buried Pipe Base Case DCGLs and Operational DCGLs to address additions to the list of buried pipe to remain. Corrected minor typographical errors.
Revision 2 – Revise Buried Pipe Circulating Water Discharge Base Case DCGL for Sr-90 from 7.56E+05 to 7.55E+05 and OpDCGL for Sr-90 from 1.59E+05 to 1.58E+05

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LIST OF ACRONYMS AND ABBREVIATIONS

AMCG	Average Member of the Critical Group
BcSOF	Base Case DCGL Sum of Fractions
DCGL	Derived Concentration Guideline Levels
FSS	Final Status Survey
LACBWR	La Crosse Boiling Water Reactor
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
OpDCGL	Operational DCGL
OpSOF	Operational DCGL Sum of Fractions
ROC	Radionuclide of Concern
SOF	Sum-of-Fractions
TEDE	Total Effective Dose Equivalent
TSD	Technical Support Document

1. PURPOSE

Derived Concentration Guideline Levels (DCGL) are established to demonstrate compliance with the 25 mrem/yr unrestricted use criterion in “EnergySolutions Technical Support Document (TSD) RS-TD-313196-004 “LACBWR Soil DCGL and Basement Concrete DCGL, Revision 3” (1). DCGLs are calculated by analysis of various pathways (direct radiation, inhalation, ingestion, etc.), media (e.g., concrete, buried pipe, soil, existing groundwater and standing buildings) and scenarios through which exposures could occur.

RS-TD-313196-004 (1) describes the approach, modeling parameters and assumptions used to develop the DCGLs (referred to as Base Case DCGLs in this TSD) for each Radionuclide of Concern (ROC) that will be used for the Final Status Survey (FSS) of La Crosse Boiling Water Reactor (LACBWR) site. The Base Case DCGLs for each ROC, in each media, represent the concentration that would result in a dose of 25 mrem/yr for that ROC and media independently after adjusting for the dose from insignificant contributor radionuclides. Compliance is demonstrated through the summation of dose from each of the ROCs in each of the five media (basement concrete, soil, buried pipe standing buildings and existing groundwater). The LACBWR basements do not contain embedded pipes or penetrations.

To ensure that the dose summation from the residual radioactivity in each of the five media is 25 mrem/yr or less after all FSS is completed, the Base Case DCGLs for each media are reduced based on an assigned, or *a priori*, fraction of the 25 mrem/yr dose criterion. The reduced DCGLs are designated as “Operational DCGLs”. The summation of the dose from all ROC, in all five media (also referred to as source terms in this TSD), will equal 25 mrem/yr if residual radioactivity is present at the Operational DCGL concentrations.

This TSD describes the derivation of the *a priori* dose fractions and the corresponding Operational DCGLs for each ROC in each of the five media. Also provided are the equations for calculating each term in the Compliance Dose calculation shown in Equation 1.

2. COMPLIANCE DOSE CALCULATIONS

Each radionuclide-specific Base Case DCGL is equivalent to the level of residual radioactivity (above background levels) that could, when considered independently, result in a Total Effective Dose Equivalent (TEDE) of 25 mrem per year to the Average Member of the Critical Group (AMCG). When applied to backfilled basement surfaces below 639 foot elevation the DCGLs are expressed in units of activity per surface area (pCi/m^2). When applied to soil, the DCGLs are expressed in units of activity per unit of mass (pCi/g). For buried piping and above grade buildings, DCGLs are expressed in units of activity per surface area ($dpm/100\ cm^2$). The units for existing groundwater are pCi/L.

The “unity rule” is applied when there is more than one ROC in a given media. The measurement results for each singular ROC present in the mixture are compared against their respective DCGL to derive a dose fraction. The summation of the dose fractions for each ROC produces a Sum-of-Fractions (SOF) for the measurement. When compared against the Base Case DCGL, the term is defined as BcSOF. When compared against the Operational DCGL, the term is defined as OpSOF.

Demonstrating compliance with the dose criterion requires the summation of dose from the five media as shown in Equation 1. Note that there are five media but seven dose terms in Equation 1. The $BcSOF_{GWOB}$ term is calculated using the FSS results from the basement media. The $BcSOFB_{BPS\ OBP}$ term is calculated using the FSS results from the buried pipe media.

Equation 1

$$\text{Compliance Dose} = (\text{Max BcSOF}_{BASEMENT} + \text{Max BcSOF}_{SOIL} + \text{Max BcSOF}_{BURIED\ PIPE} + \text{BcSOF}_{AG\ BUILDING} + \text{GW BcSOF}_{BS\ OB} + \text{GW BcSOF}_{BPS\ OBP} + \text{Max SOF}_{EGW}) \times 25\ \text{mrem/yr}$$

where:

Compliance Dose	=	must be less than or equal to 25 mrem/yr,
Max $BcSOF_{BASEMENT}$	=	Maximum BcSOF (mean of FSS systematic results plus the dose from any identified elevated areas) for backfilled Basements,
Max $BcSOF_{SOIL}$	=	Maximum BcSOF (mean of FSS systematic results plus the dose from any identified elevated areas) for open land survey units,
Max $BcSOF_{BURIED\ PIPE}$	=	Maximum BcSOF (mean of FSS systematic results plus the dose from any identified elevated areas) from buried piping survey units,
Max $BcSOF_{AG\ BUILDING}$	=	Maximum BcSOF (mean of FSS systematic results plus the dose from any identified elevated areas) from above grade standing building survey units,
GW $BcSOF_{BS\ OB}$	=	Groundwater scenario dose from the "Other Basement" (OB) which is defined as the basement not used to generate the Max $BcSOF_{BASEMENT}$ term in Equation 1
GW $BcSOF_{BPS\ OBP}$	=	Groundwater scenario dose from the "Other Buried Pipe" (OBP) which is defined as the buried pipe survey unit not used to generate the Max $BcSOF_{BURIED\ PIPE}$ term in Equation 1
Max SOF_{EGW}	=	Maximum SOF from existing groundwater (EGW)

2.1. Max SOF_{EGW} Term

The dose for the "Max SOF_{EGW}" term will be determined based on the analysis of water samples taken from the active sample wells established at and around LACBWR which are monitored on a routine frequency. These wells will remain active and will be monitored through license termination. The two years of monitoring prior to Final Report submittal will be used to establish the Max SOF_{EGW}. If groundwater contamination is identified during decommissioning (during the period when the wells are active and monitored), then the dose will be calculated using the Groundwater Exposure Factors in RS-TD-313196-004, Revision 3 (1).

The maximum SOF for existing groundwater "Max SOF_{EGW}" will be calculated if radionuclides are positively identified by groundwater monitoring. If groundwater contamination is identified by groundwater monitoring, the maximum SOF will be calculated from the maximum concentration from groundwater sampling for each positively identified ROC in units of pCi/L in accordance with Equation 2:

Equation 2

$$Max\ SOF_{EGW} = \sum_{i=1}^{n} \frac{Conc_{ROC_i} * EF_{GW_i}}{25}$$

where:

$Max\ SOF_{EGW}$	=	Maximum SOF for existing groundwater
$Conc_{ROCi}$	=	Maximum concentration from all groundwater sampling wells collectively for each positively identified ROC_i in units of pCi/L within the most recent two years of sampling. (Note that this has the potential of combining results from various wells if different ROC are positively identified in different wells)
EF_{GWi}	=	Groundwater Exposure Factors for ROC_i in units of mrem/yr per pCi/L

2.2. Max $BcSOF_{SOIL}$ Term

$BcSOF_{SOIL}$ will be derived for each open land survey unit in accordance with Equation 3. This equation is equivalent to Equation 8-2 from section 8.5.2 of NUREG-1575, "Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)" (2). As stated in section 8.5.2, "if there is more than one elevated area, a separate term should be included in each".

Equation 3

$$BcSOF_{Soil} = \sum_{i=1}^{n} \frac{Mean\ Conc\ Soil_{ROC_i}}{Base\ Case\ Soil\ DCGL_{ROC_i}} + \frac{\left(Elev\ Conc\ Soil_{ROC_i} - Mean\ Conc\ Soil_{ROC_i}\right)}{\left[Base\ Case\ Soil\ DCGL_{ROC_i} \times (AF_{ROCi})\right]}$$

where:

$BcSOF_{SOIL}$	=	SOF for open land survey unit using Base Case DCGLs
$Mean\ Conc\ Soil_{ROCi}$	=	Mean concentration for the systematic measurements taken during the FSS of soils in survey unit for ROC_i
$Base\ Case\ Soil\ DCGL_{ROCi}$	=	Base Case DCGL for soils (surface soils [$DCGL_{SS}$] or subsurface soils [$DCGL_{SB}$] as applicable) for ROC_i
$Elev\ Conc\ Soil_{ROCi}$	=	Concentration for ROC_i in elevated area
AF_{ROCi}	=	Area Factor for ROC_i

The "Max $BcSOF_{SOIL}$" term will be the highest $BcSOF_{SOIL}$ determined in accordance with Equation 3 from the FSS of all open land survey units.

2.3.Max $BcSOF_{BURIED\ PIPE}$ Term

$BcSOF_{BURIED\ PIPE}$ for buried pipe will be derived for each buried pipe survey unit in accordance Equation 4. This equation is equivalent to Equation 8-2 from section 8.5.2 of NUREG-1575, "Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)" (2). As stated in section 8.5.2, "if there is more than one elevated area, a separate term should be included in each".

Equation 4

$$BcSOF_{BURIED\ PIPE} = \sum_{i=1}^{n} \frac{Mean\ Conc\ BP_{ROC_i}}{Base\ Case\ BP\ DCGL_{ROC_i}} + \frac{\left(Elev\ Conc\ BP_{ROC_i} - Mean\ Conc\ BP_{ROC_i}\right)}{\left[Base\ Case\ BP\ DCGL_{ROC_i} \times \left(\frac{SA_{SU}}{SA_{Elev}}\right)\right]}$$

where:

$BcSOF_{BURIED\ PIPE}$	=	SOF for buried pipe survey unit using Base Case DCGLs
$Mean\ Conc\ BP_{ROCi}$	=	Mean concentration for the systematic measurements taken during the FSS of buried pipe in survey unit for each ROC_i
$Base\ Case\ BP\ DCGL_{ROCi}$	=	Base Case DCGL for buried pipe ($DCGL_{BP}$) for each ROC_i
$Elev\ Conc\ BP_{ROCi}$	=	Concentration for ROC_i in elevated area
SA_{Elev}	=	surface area of the elevated area
SA_{SU}	=	surface area of FSS unit

The "Max $BcSOF_{BURIED\ PIPE}$" term will be the highest $BcSOF_{BURIED\ PIPE}$ determined in accordance with Equation 4 from the FSS of all buried pipe survey units.

2.4.Max $BcSOF_{AG\ BUILDING}$ Term

$BcSOF_{AG\ BUILDING}$ for above grade buildings will be derived for each above grade building survey unit in accordance with Equation 5.

Equation 5

$$BcSOF_{\text{AG BUILDING}} = \sum_{i=1}^{n} \frac{Mean\ Conc\ AG\ Building_{ROC_i}}{Base\ Case\ AG\ Building\ DCGL_{ROC_i}}$$

where:

$BcSOF_{AG\ BUILDING}$	= SOF for above grade building survey unit using Base Case DCGLs
$Mean\ Conc\ AG\ Building_{ROCi}$	= Mean concentration for the systematic measurements taken during the FSS of above grade buildings in survey unit for ROC_i

Base Case AG Building $DCGL_{ROCi}$ = Base Case DCGL for above grade buildings ($DCGL_{AGB}$) for ROC_i

The "Max $BcSOF_{AG\ BUILDING}$" term will be the highest $BcSOF_{AG\ BUILDING}$ determined in accordance with Equation 4 from the FSS of all buried pipe survey units.

2.5. Max $BcSOF_{BASEMENT}$ Term

A Basement survey unit is comprised of the walls and floors of a Basement. The areal extent of the walls and floors is the "surface area" and includes both volumetric and surface contamination within the defined area. The surfaces are comprised of concrete and the remaining steel liner for the Reactor Building. Each of the Basements to remain (Reactor Building and WGTV) contains one survey unit that includes all walls and floors. $BcSOF_{BASEMENT}$ will be derived for the Basement wall and floor surface survey unit in accordance with Equation 6. This equation is equivalent to Equation 8-2 from section 8.5.2 of NUREG-1575, "Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)" (2). As stated in section 8.5.2, "if there is more than one elevated area, a separate term should be included in each".

Equation 6

$$BcSOF_B = \sum_{i=1}^{n} \frac{Mean\ Conc_{B\,ROC_i}}{Base\ Case\ DCGL_{B\,ROC_i}} + \frac{\left(Elev\ Conc_{B\,ROC_i} - Mean\ Conc_{B\,ROC_i}\right)}{\left[Base\ Case\ DCGL_{B\,ROC_i} \times \left(\frac{SA_{SU}}{SA_{Elev}}\right)\right]}$$

where:

$BcSOF_B$	=	SOF for structural surface survey unit within a Basement using Base Case DCGLs
$Mean\ Conc_{B\ ROCi}$	=	Mean concentration for the systematic measurements taken during the FSS of structural surface in survey unit for each ROC_i
$Base\ Case\ DCGL_{B\ ROCi}$	=	Base Case DCGL for structural surfaces ($DCGL_B$) for each ROC_i
$Elev\ Conc_{B\ ROCi}$	=	Concentration for ROC_i in elevated area
SA_{Elev}	=	surface area of the elevated area
SA_{SU}	=	surface area of FSS unit

2.6. Max GW $BcSOF_{BS\ OB}$ Term

The MAX GW $BcSOF_{BS\ OB}$ is the Groundwater Basement Scenario dose from the "Other Basement" which is defined as the basement that is not used to calculate the MAX $BcSOF_{BASEMENT}$ in Equation 1. For example, if the mean of the FSS data from the Reactor Building survey unit is higher than the mean of the FSS data from the WGTV, then the Reactor Building FSS mean will be used to calculate the Max $BcSOF_{BASEMENT}$ term in Equation 1. The WGTV would therefore be assigned as the "Other Basement".

The dose modeling for the basements includes three scenarios; groundwater, drilling spoils, and excavation. DCGLs are calculated for each scenario separately ($DCGL_{BS}$) and for the summation of dose from all scenarios ($DCGL_B$). The $DCGL_{BS}$ for the drilling spoils and the excavation scenarios are equal for the Reactor Building and WGTV. The MAX $BcSOF_{BASEMENT}$ term therefore maximizes the drilling spoils and excavation pathways for both basements.

The GW $DCGL_{BS}$ for the Reactor Building and WGTV are not equal due to geometry considerations. Each basement was modeled as a separate source term. Conceptually, the modeled groundwater concentrations from the two basements could mix at a location downstream of both basements in such a way as to increase the concentration that would result from each basement separately. To conservatively account for this conceptual possibility, the groundwater pathway dose from the "Other Basement" will be added to the Compliance Dose (Equation 1) through the GW $BcSOF_{BS\ OB}$ term.

GW $BcSOF_{BS\ OB}$ will be calculated for the basement wall and floor surface survey unit of the "Other Basement" in accordance with Equation 7.

Equation 7

$$GW\ BcSOF_{BS\ OB} = \sum_{i=1}^{n} \frac{Mean\ Conc_{OB\ ROC_i}}{Base\ Case\ Basement\ Scenario\ GW\ DCGL_{BS\ OB\ ROC_i}}$$

where:

$GW\ BcSOF_{BS\ OB}$	=	SOF for the groundwater pathway only from the structural surface survey unit in the "Other Basement" using Base Case DCGLs applicable to the groundwater scenario only
$Mean\ Conc_{OB\ ROC_i}$	=	Mean concentration for the systematic measurements taken in the "Other Basement" during the FSS of the structural surface in survey unit for ROC_i
$GW\ DCGL_{BS\ OB\ ROC_i}$	=	Base Case DCGL for Basement Scenario Groundwater (Table 1) in the "Other Basement" for ROC_i

2.7. Max GW $BcSOF_{BPS\ OBP}$ Term

The MAX GW $BcSOF_{BPS\ OBP}$ is the dose from the Groundwater Buried Pipe Scenario (designated as "Insitu" in Table 11) from the "Other Buried Pipe" (OBP) which is defined as the buried pipe survey unit that is not used to calculate the MAX $BcSOF_{BURIED\ PIPE}$ in Equation 1. For example, if the mean of the FSS data from the buried pipe "Group" survey unit is higher than the mean of the FSS data from the buried pipe "Circulating Water Discharge Pipe" survey unit, then the "Group" survey unit FSS mean will be used to calculate the Max $BcSOF_{BURIED\ PIPE}$ term in Equation 1. The "Circulating Water Discharge Pipe" would therefore be assigned as the "Other Buried Pipe".

The dose modeling for the buried pipe includes two scenarios, Insitu (i.e., groundwater) and Excavation. Buried Pipe DCGLs are calculated for each scenario separately ($DCGL_{BPS}$) and for the summation of dose from both scenarios ($DCGL_{BP}$).

Each buried pipe was modeled as a separate source term. Conceptually, the modeled groundwater concentrations from the two buried pipe survey units could mix at a location downstream of both survey units in such a way as to increase the concentration, and corresponding dose, that would result from each basement separately. To conservatively account for this conceptual possibility, the groundwater pathway dose from the "Other Buried Pipe" will be added to the Compliance Dose calculation (Equation 1) through the GW $BcSOF_{BPS\ OBP}$ term.

GW $BcSOF_{BPS\ OBP}$ will be derived for the "Other Buried Pipe" survey unit in accordance with Equation 8.

Equation 8

$$GW\ BcSOF_{BPS\ OBP} = \sum_{i=1}^{n} \frac{Mean\ Conc_{OBP\ ROC_i}}{Base\ Case\ Buried\ Pipe\ Scenario\ GW\ DCGL_{BPS\ OBP\ ROC_i}}$$

where:

$GW\ BcSOF_{BPS\ OBP}$	=	SOF for the groundwater pathway only from the survey unit in the "Other Buried Pipe" using Base Case $DCGL_{BS}$ applicable to the groundwater scenario only (i.e., Insitu).
$Mean\ Conc_{OBP\ ROCi}$	=	Mean concentration for the systematic measurements taken in the "Other Buried Pipe" during the FSS of the survey unit for ROC_i
$GW\ DCGL_{BPS\ OBP\ ROCi}$	=	Base Case $DCGL_{BPS}$ for groundwater scenario ("Insitu" in Table 11) in the "Other Buried Pipe" for ROC_i

3. OPERATIONAL DCGLS

Each Base Case DCGL equates to 25 mrem/yr. To ensure that the summation of dose from each source term in Equation 1 is less than the 25 mrem/yr dose criteria after all FSS is completed, the Base Case DCGLs for each media are reduced to correspond to an assigned, or *a priori*, fraction of 25 mrem/yr. The summation of the assigned *a priori* fractions is required to be one, i.e., correspond to 25 mrem/yr. These derived lower DCGLs are designated as the "Operational DCGLs" (OpDCGL). Since Operational DCGLs by definition are a fraction of the Base Case DCGLs, compliance with the Operational DCGLs will ensure compliance with the Base Case DCGLs in each survey unit. Operational DCGLs are calculated for each ROC, in each media, using Equation 9. The Operational DCGL is then used as the DCGL for the FSS design of the survey unit (calculation of surrogate DCGLs, investigations levels, etc.).

Equation 9

$$Operational\ DCGL\ ROC_{i,m} = f_m * Base\ Case\ DCGL_{ROCi,m}$$

where:

$Operational\ DCGL\ ROC_{m,i}$	=	Operational DCGL for ROC_i in $media_m$
f_m	=	a priori fraction assigned to $media_m$
$Base\ Case\ DCGL_{ROCi,m}$	=	Base Case DCGL for ROC_i in $media_m$

To demonstrate that each survey unit satisfies the Operational DCGL, the ROC concentrations in each systematic sample/measurement taken in each FSS unit for basements, soil, buried pipe and above grade buildings will be divided by the applicable $OpDCGL_B$ for basement surfaces, $OpDCGL_S$ for soil, $OpDCGL_{BP}$ for buried pipe, $OpDCGL_{AGB}$ for above grade buildings. and summed to derive a OpSOF for the sample/measurement. The actual recorded value will be used as the recorded FSS result for all measurement and/or sample values including those that are less than MDC. The OpSOF will be used as the summed value (W_s) for performing the Sign Test. The Sign Test will be performed separately for each survey unit.

If the OpSOF for a systematic sample/measurement (based on the Operational DCGL) exceeds "one" in a Class 1 or Class 2 survey unit, or "0.5" in a Class 3 survey unit, then an investigation will be initiated in accordance with LTP Chapter 5. For basement surfaces, the MDC of the *In Situ* Object Counting System (ISOCS) is more than adequate to detect the ROC at the investigation levels. In Class 3 and Class 2 FSS units, the result of the investigation (confirmed OpSOF greater than 0.5 in a Class 3 FSS unit or greater than one in a Class 2 FSS unit) will prompt the reclassification of the survey unit (or a portion of the survey unit).

The results of any judgmental sample/measurements will also be compared to the OpSOF (based on the Operational DCGL). As with a systematic sample/measurement, any judgmental sample/measurement that exceeds a SOF of one in a Class 1 or Class 2 survey unit, or 0.5 in a Class 3 survey unit, will prompt an investigation, reclassification and/or resurvey as applicable.

The BcSOF calculations described in Equation 3, Equation 4, and Equation 6 for soil, buried pipe, and basements, respectively, include the dose from elevated systematic and/or judgmental measurements where "elevated" is defined as any measurement that exceeds the OpSOF.

In Basements and Buried Pipe, any areas of elevated residual radioactivity exceeding the Base Case $DCGL_B$ will be remediated. In Class 1 open land FSS units, any areas of elevated residual radioactivity above the $DCGL_{EMC}$ will be remediated. The $DCGL_{EMC}$ calculation for soil will use Base Case DCGLs (Table 3). Area Factors from RS-TD-313196-004, Revision 3 (1) and the EMC comparison in accordance with LTP Chapter 5. Note that the soil FSS unit must pass the Sign Test using Operational DCGLs for this to occur.

The BcSOF calculation for above grade buildings, groundwater pathway in "Other Basement" and groundwater pathway in "Other Buried Pipe." (Equation 5, Equation 7, and Equation 8, respectively) do not include a term for elevated areas. Any systematic and/or judgmental measurement in above grade buildings that exceeds the OpSOF will be remediated. Equation 7 will apply the systematic measurements in the "Other Basement" (after the "Other Basement" passes the sign test using the Operational $DCGL_B$ values). Equation 8 will apply the systematic measurements in the "Other Buried Pipe" survey unit (after the "Other Buried Pipe" survey unit passes the sign test using the Operational $DCGL_{BP}$ values).

4. BASIS FOR DETERMINING OPERATIONAL DCGLS

With the exception of the Above Grade Building, the Base Case DCGLs (and existing groundwater exposure factor) are from RS-TD-313196-004, Revision 3 (1). The Base Case DCGLs for Above Grade Buildings are the screening values from US Nuclear Regulatory Commission, NUREG 1757, Vol. 1, Rev. 2, Consolidated Decommissioning Guidance, Final Report, September 2006 (3). The Base Case DCGLs, and the existing groundwater exposure factors, are provided in Table 1 to Table 6.

Table 1 Base Case Basement $DCGL_{BS}$

ROC	Reactor Building $DCGL_{BS}$			Waste Gas Tank Vault $DCGL_{BS}$		
	Groundwater Scenario	Drilling Spoils Scenario	Excavation Scenario	Groundwater Scenario	Drilling Spoils Scenario	Excavation Scenario
	(pCi/m^2)			(pCi/m^2)		
Co-60	1.21E+08	4.75E+08	5.45E+06	6.23E+07	3.86E+08	4.43E+06
Sr-90	1.46E+07	2.70E+11	2.80E+09	6.42E+06	2.20E+11	2.28E+09
Cs-137	1.98E+08	1.94E+09	2.47E+07	1.52E+08	1.58E+09	2.01E+07
Eu-152	2.73E+09	1.00E+09	1.21E+07	2.28E+09	8.16E+08	9.84E+06
Eu-154	1.88E+09	9.43E+08	1.12E+07	1.57E+09	7.67E+08	9.12E+06

Table 2 Base Case $DCGL_B$

ROC	Rx Bldg $DCGL_B$ (pCi/m^2)	WGTV $DCGL_B$ (pCi/m^2)
Co-60	5.16E+06	4.10E+06
Sr-90	1.45E+07	6.40E+06
Cs-137	2.17E+07	1.76E+07
Eu-152	1.19E+07	9.69E+06
Eu-154	1.10E+07	8.97E+06

Table 3 Base Case DCGLs for Soil ($DCGL_S$)

ROC	Adjusted DCGL (pCi/g)
Co-60	1.06E+01
Sr-90	5.47E+03
Cs-137	4.83E+01
Eu-152	2.36E+01
Eu-154	2.19E+01

Table 4 Base Case DCGLs for Buried Pipe ($DCGL_{BP}$)

ROC	Buried Pipe Group (dpm/100 cm^2)	Buried Pipe Circulating Water Discharge (dpm/100 cm^2)
Co-60	7.50E+04	7.75E+04
Sr-90	5.16E+05	7.55E+05

Cs-137	3.18E+05	3.30E+05
Eu-152	1.64E+05	1.67E+05
Eu-154	1.52E+05	1.56E+05

Table 5 Base Case DCGLs for Above Grade Buildings ($DCGL_{AGB}$)

ROC	Above Grade Building (dpm/100 cm^2)
Co-60	7100
Sr-90	8700
Cs-137	28000
Eu-152	12700
Eu-154	11500

Table 6 Exposure Factors for Existing Groundwater

ROC	GW Exposure Factor (mrem/yr per pCi/L)
Co-60	8.80E-03
Cs-137	1.64E-02
Sr-90	4.64E-02
H-3	2.09E-05
Eu-152	2.12E-03
Eu-154	3.12E-03

The Base Case DCGLs represent the 25 mrem/yr dose criteria. Therefore, a reduction is required to ensure compliance with Equation 1 after all FSS is complete. The reduced DCGLs, designated as "Operational" DCGLs, are calculated by multiplying the Base Case DCGLs by the assigned *a priori* fraction of the dose criterion which is calculated by Equation 10.

Equation 10

$$f = \frac{D_{assigned}}{25}$$

where:

f = *a priori* assigned fraction of dose

$D_{assigned}$ = *a priori* assigned dose based on characterization, FSS results to date, process knowledge, the extent of planned remediation, and instrument MDC

25 = 25 mrem/yr dose criterion for unrestricted release

An *a priori* fraction is assigned for each of the terms in Equation 1 (basements, soil, buried pipe, above grade buildings, "Other Basement", "Other Buried Pipe" and existing groundwater) such that the summation of the *a priori* fractions assigned to all media is one as shown in Equation 11.

Equation 11

$$f_{Basement} + f_{Soil} + f_{BP} + f_{AGB} + f_{GWOB} + f_{GWOBP} + f_{EGW} = 1$$

where:

$f_{Basement}$ = *a priori* fraction of dose for maximum basement survey unit
f_{soil} = *a priori* fraction of dose for maximum soil survey unit
f_{BP} = *a priori* fraction of dose for maximum buried pipe survey unit
f_{AGB} = *a priori* fraction of dose for maximum above grade building
f_{GWOB} = *a priori* fraction of groundwater dose for "Other Basement"
f_{GWOBP} = *a priori* fraction of groundwater dose for "Other Buried Pipe"
f_{EGW} = *a priori* fraction of dose for maximum existing groundwater

If the actual dose fraction for any survey unit in any media, based on the mean of FSS results, exceeds the *a priori* fraction listed in this TSD (Revision 0), then additional remediation will be required to reduce the actual maximum dose fraction to a level less than or equal to the *a priori* fraction.

The FSS of the various media (basements, soil, buried pipe, and standing buildings) will be completed at different times as the project proceeds. After FSS is completed for a given media, the actual maximum fraction of allowable dose (i.e., the BcSOF term from Equation 1) will be calculated. The actual dose fraction from the maximum survey unit in the given media will be compared to the *a priori* dose fraction assigned to the media in this TSD (Revision 0). If the difference is large enough to justify an adjustment (i.e., increase) to the *a priori* fractions assigned to one or more of the other Source Term/Media (see Table 7), or other issues arise as the project proceeds that drive the need to adjust the *a priori* fractions and Operational DCGLs in this TSD (Revision 0), then a revision (Revision 1) will be issued.

If Revision 1 of this TSD is issued, the new Operational DCGLs will be applied in subsequent FSS survey design packages and release records. All FSS performed prior to the issuance of Revision 1 (if necessary) will comply with the Operational DCGLs documented in this TSD (Revision 0). Existing FSS packages will be reviewed but revisions will not be required for media where the Operational DCGLs in Revision 1 are higher than those in Revision 0, or for any media that has fully completed FSS and the calculation of Max BcSOF term in Equation 1 is completed, prior to the issuance of Revision 1 (if necessary).

5. DETERMINATION OF *A PRIORI* DOSE FRACTIONS

Using the results of characterization, FSS completed to date, process knowledge, the extent of expected remediation, and instrument MDC, the *a priori* dose fractions assigned to each media are provided in Table 7. The *a priori* fractions in Table 7 are used to calculate the Operational DCGLs in accordance with Equation 9.

Table 7 *a priori* Dose Fractions

FSS Unit	Source Term/Media for FSS	*a priori* Fraction, *f*
Basement	Floor and Walls	0.07
Groundwater "Other Basement"	Floor and Walls	0.01
Soil	Soil	0.36
Buried Pipe	Buried Pipe	0.21
Groundwater "Other Buried Pipe"	Buried Pipe	0.06
Above Grade Building	Floor, Walls, Ceiling	0.16
Existing Groundwater	Groundwater Monitoring Results	0.13
	Sum	1.0

6. OPERATIONAL DCGL VALUES

Operational DCGLs are calculated by multiplying the Base Case DCGLs (Table 1 to Table 6) by the applicable *a priori* fraction of dose in Table 7 as shown in Equation 9.

The operational DCGLs for FSS at LACBWR are provided in Table 8 to

Table 13.

Table 8 Operational DCGLs for Basement Scenarios ($OpDCGL_{BS}$) and Basement ($OpDCGL_{B}$)

ROC	Reactor Building $OpDCGL_{BS}$			Waste Gas Tank Vault $OpDCGL_{BS}$		
	Groundwater Scenario	Drilling Spoils Scenario	Excavation Scenario	Groundwater Scenario	Drilling Spoils Scenario	Excavation Scenario
	(pCi/m^2)			(pCi/m^2)		
Co-60	8.46E+06	3.32E+07	3.81E+05	4.36E+06	2.70E+07	3.10E+05
Sr-90	1.02E+06	1.89E+10	1.96E+08	4.49E+05	1.54E+10	1.60E+08
Cs-137	1.38E+07	1.36E+08	1.73E+06	1.06E+07	1.10E+08	1.41E+06
Eu-152	1.91E+08	7.02E+07	8.47E+05	1.60E+08	5.71E+07	6.89E+05
Eu-154	1.32E+08	6.60E+07	7.85E+05	1.10E+08	5.37E+07	6.39E+05

Table 9 Operational DCGLs for Basements ($OpDCGL_{B}$)

ROC	Rx Bldg $OpDCGL_{B}$ (pCi/m^2)	WGTV $OpDCGL_{B}$ (pCi/m^2)
Co-60	3.61E+05	2.87E+05
Sr-90	1.02E+06	4.48E+05
Cs-137	1.52E+06	1.23E+06
Eu-152	8.33E+05	6.78E+05
Eu-154	7.71E+05	6.28E+05

Table 10 Operational DCGLs for Soil ($OpDCGL_{S}$)

ROC	Soil $OpDCGL_S$ (pCi/g)
Co-60	3.83
Sr-90	1970.45
Cs-137	17.39
Eu-152	8.51
Eu-154	7.89

Table 11 Operational DCGLs for Buried Pipe Scenarios

ROC	Buried Pipe Group $OpDCGL_{BP}$ (dpm/100 cm^2)		Buried Pipe Circulating Water Discharge $OpDCGL_{BP}$ (dpm/100 cm^2)	
	Insitu	Excavation	Insitu	Excavation
Co-60	1.20E+06	1.60E+04	4.74E+07	1.63E+04
Sr-90	1.10E+05	8.50E+06	1.62E+05	8.84E+06
Cs-137	3.44E+06	6.81E+04	1.23E+08	6.94E+04
Eu-152	5.12E+07	3.45E+04	9.61E+13	3.51E+04
Eu-154	3.53E+07	3.20E+04	1.87E+17	3.27E+04

Table 12 Operational DCGLs for Buried Pipe ($OpDCGL_{BP}$)

ROC	Buried Pipe Group $OpDCGL_{BP}$ (dpm/100 cm^2)	Buried Pipe Circulating Water Discharge $OpDCGL_{BP}$ (dpm/100 cm^2)
Co-60	1.57E+04	1.63E+04
Sr-90	1.08E+05	1.58E+05
Cs-137	6.68E+04	6.94E+04
Eu-152	3.44E+04	3.51E+04
Eu-154	3.20E+04	3.27E+04

Table 13 Operational DCGLs for Above Grade Buildings ($OpDCGL_{AGB}$)

ROC	Above Grade Building $OpDCGL_{AGB}$ (dpm/100 cm^2)
Co-60	1136
Sr-90	1392
Cs-137	4480
Eu-152	2032

Eu-154	1840

7. References

1. ***EnergySolutions Techncial Support Document RS-TD-313196-004, Revision 3.***

2. ***U.S. Nuclear Regulatory Commission, NUREG-1575, Revision 1, "Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)," August 2000. August 2000.***

3. ***US Nuclear Regulatory Commission, NUREG 1757, Vol. 1, Rev. 2, Consolidated Decommissioning Guidance, Final Report, September 2006.***