**UNITED STATES ENVIRONMENTAL PROTECTION AGENCY**
**REGION 7**
11201 Renner Boulevard
Lenexa, Kansas 66219

JUL 25 2013

**MEMORANDUM**

**SUBJECT:** Preliminary Remediation Goals (PRGs) for Dioxin in Surface Soil
Proposed Strecker Forest Development
Wildwood, Missouri

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**TO:** Heath Smith
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SUPR/ERSB

As requested, this memorandum provides preliminary remediation goals for the dioxin toxicity equivalence concentration in surface soil for areas of the Proposed Strecker Forest Development, located in Wildwood, Missouri, that will be restricted to recreational use. A dioxin TEQ accounts for the relative toxicity of the various dioxin-like compounds that are present using toxicity equivalence factors (USEPA, 2010), which are weighting factors reflecting the relative potency of each compound in terms of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin. PRGs were derived for youth receptors based on both cancer and non-cancer health effects. The PRG based on a non-cancer hazard index of 1 is 820 ppt, which is between the PRGs of 63 to 6,300 ppt that represent the U.S. Environmental Protection Agency's target cancer risk range of $1 \times 10^{-4}$ to $1 \times 10^{-6}$. In order to be protective for non-cancer health risks, the final cleanup goal cannot be greater than 820 ppt. Cleanup goals less than or equal to 820 ppt will be protective for both non-cancer and cancer risks to current and future recreational receptors. The attached document provides additional information on the derivation and uncertainty of these values. If you have any questions or need further assistance, please contact me at x7963.

| **Preliminary Remediation Goals for Dioxin TEQ in Surface Soil (ppt) – Youth Recreational Receptors.** | |
|---|---|
| Cancer PRG based on Excess Individual Lifetime Cancer Risk = $1 \times 10^{-6}$ to $1 \times 10^{-4}$ | **63 to 6,300** |
| Non-Cancer PRG based on Hazard Index = 1 | **820** |

Attachment

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**Preliminary Remediation Goals for Dioxin in Surface Soil**
**Proposed Strecker Forest Development**
**Wildwood, Missouri**

## 1.0 INTRODUCTION

The Proposed Strecker Forest Development (Strecker Forest) is located in a residential area of Wildwood, Missouri. Previously, dioxin concentrations in a portion of the soil samples collected from the extreme northeastern corner and a small central area (i.e., Decision Unit 19) of the Strecker Forest property were found to exceed a level of concern for future long-term residential use (USEPA, 2012). Subsequently, dioxin-contaminated soil was excavated from DU 19 and disposed of at an off-site landfill.

The objective of this document is to develop Preliminary Remediation Goals for the dioxin contamination in soil in the northeastern corner of the Strecker Forest property. PRGs are risk-based concentrations derived from standardized equations combining exposure assumptions with the EPA toxicity data, which are considered by the Agency to be protective of human health (including sensitive groups). The dioxin PRGs developed in this document are based on a recreational exposure scenario for those areas in which land use controls will be established to restrict future development and prevent residential use. Risk-based values are provided for a non-cancer hazard index (HI) of 1. If the HI is less than 1.0, a compound is considered unlikely to pose a non-cancer health hazard to individuals under the given exposure conditions. PRGs are also derived for a $1 \times 10^{-4}$ to $1 \times 10^{-6}$ excess individual lifetime cancer risk range (i.e., the EPA's target risk range as directed by the National Contingency Plan, USEPA, 1991a), to allow comparison with the PRG based on non-cancer risks. Although the Agency has expressed a preference to establish initial PRGs based on a cancer risk of $10^{-6}$, final cleanup levels may differ as long as they reflect a cancer risk within the target risk range and a non-cancer hazard index of 1 or less (USEPA, 1997).

## 2.0 EXPOSURE

### 2.1 Exposure Scenarios

The EPA considers potential health risks under both current and potential future land use scenarios. Although currently undeveloped, a preliminary plat has been submitted to develop the Strecker Forest property into a residential subdivision. However, a portion of the property where dioxin contamination is present will be subject to deed restrictions in the form of land use controls prohibiting residential development. The PRGs derived in this document are applicable to these restricted areas, in which current and future receptors are limited to recreational users, including visitors and trespassers. Adult and children recreational receptors may be exposed to dioxin-contaminated surface soil, as well as particulates generated by wind erosion, via incidental ingestion, dermal contact, and inhalation. Based on their physiology and activity patterns, exposure to soil by children and adolescents is greater than by adults. Although infants and young children are the most sensitive receptor in a residential setting, older children (i.e., between the ages of 6 to 16 years) are expected to visit the undeveloped Strecker Forest areas more frequently, resulting in greater exposure. Accordingly, the PRGs derived in this document are based on youth trespassers or recreational visitors and are protective for receptors of all ages.

## 2.2 Equations and Exposure Parameters

This section discusses the specific equations and exposure parameters used to derive PRGs for the dioxin toxicity equivalence concentration in surface soil at the Strecker Forest property, based on risks to recreational receptors. The PRGs are based on a non-cancer hazard index of 1 and a $1 \times 10^{-4}$ to $1 \times 10^{-6}$ excess individual lifetime cancer risk range (i.e., the EPA's target cancer risk range as directed by the National Contingency Plan, USEPA, 1991a). In general, the equations used to calculate aggregate exposure, incidental ingestion, and dermal absorption were obtained from the Risk Assessment Guidance for Superfund, Volume I, Part B (USEPA, 1991a), while those for inhalation exposure were taken from the Risk Assessment Guidance for Superfund, Volume I, Part F (USEPA, 2009) and from the EPA's Supplemental Soil Screening Guidance (USEPA, 2002). The exposure parameters were selected to best represent reasonable maximum exposure scenarios. A reasonable maximum exposure (RME) is the highest exposure that is reasonably expected to occur at a site (USEPA, 1989). The definitions, values, and references for the exposure parameters used in this document are provided in Table 1, and the dioxin toxicity values are discussed in Section 3.

Default exposure parameters do not exist for recreational visitors or trespassers. Instead, site-specific exposure parameters were selected, consistent with approaches used by the EPA Region 7 to assess recreational and trespassing scenarios at other sites. Because the PRGs are intended to be protective for long-term exposures, an exposure duration (ED) of 10 years was used to evaluate potential risks to youth receptors between the ages of 6 and 16 years old. An exposure frequency (EF) of 96 days/year was used, which is a reasonable maximum exposure assumption that the youth visit the areas 4 days per week over a period of 24 weeks, roughly when school is out, during May through September. The exposure time (ET) that youth trespassers were expected to visit the site was assumed to be 4 hours per visit. A body weight (BW) of 44.3 kg was used, which is the mean body weight of girls and boys between the ages of 6 and 16 years old (USEPA, 2011). A soil ingestion rate ($IR_s$) of 100 mg/day was used, which is the default residential value for ages 6 years and up (USEPA, 1991b). A soil adherence factor (AF) of 0.2 $mg/cm^2$, representing higher soil contact rates such as playing in wet soil, was used to evaluate dermal contact (USEPA, 2002). The exposed skin surface area (SA) was assumed to be 7,170 $cm^2$, which is the mean total surface area of the head, arms (including both forearms and upper arms), hands, and legs (including both lower and upper legs) of girls and boys between the ages of 6 and 16 years old (USEPA, 2011). Finally, risks were averaged over the duration of exposure for non-cancer health effects (i.e., $AT_{nc}$ = 3,650 days, which is equivalent to 10 years) and over an average lifetime for carcinogenicity (i.e., $AT_{ca}$ = 25,550 days, which is equivalent to 70 years).

| Table 1. Exposure Parameters Used to Calculate Dioxin Preliminary Remediation Goals. | | | | |
|---|---|---|---|---|
| **Parameter** | **Definition** | **Units** | **Value** | **Reference** |
| $ABS_d$ | Fraction of dioxin absorbed dermally from soil | - | 0.03 | USEPA, 2004 |
| AF | Soil adherence factor | $mg/cm^2$ | 0.2 | BPJ; USEPA, 2002 |
| $AT_{ca}$ | Averaging time – cancer | days | 25,550 | USEPA, 1989 |
| $AT_{nc}$ | Averaging time – non-cancer | days | 3,650 | BPJ; USEPA, 1989 |
| BW | Body weight – mean of boys and girls 6 to 16 yrs | kg | 44.3 | USEPA, 2011 |
| ED | Exposure duration | years | 10 | BPJ |
| EF | Exposure frequency | days/yr | 96 | BPJ |
| ET | Exposure time | hrs/day | 4 | BPJ |
| GIABS | Fraction of dioxin absorbed in gastrointestinal tract | - | 1 | USEPA, 2004 |
| $IR_s$ | Ingestion rate of soil | mg/day | 100 | USEPA, 1991b |
| PEF | Particulate emission factor | $m^3/kg$ | $1.36 \times 10^9$ | USEPA, 2002 |
| SA | Skin surface area for dermal contact – mean total surface area of the head, arms, hands, and legs of girls and boys ages 6 – 16 yrs | $cm^2$ | 7,170 | USEPA, 2011 |
| THQ | Target non-cancer hazard index | - | 1 | - |
| TR | Target cancer risk | - | $1 \times 10^{-4}$ to $1 \times 10^{-6}$ | - |

BPJ: Best professional judgment. Default recreational exposure parameters do not exist.

### *2.2.1 Carcinogenic PRG*

Equation 1 was used to derive PRGs for the dioxin TEQ concentrations in surface soil that represent a target cancer risk (TR) of $1 \times 10^{-4}$ and $1 \times 10^{-6}$ to a youth recreational receptor exposed via incidental ingestion, dermal contact, and inhalation of particulates.

$$PRG_{total-ca}(mg/kg) = \frac{1}{\frac{1}{PRG_{ing-ca}} + \frac{1}{PRG_{der-ca}} + \frac{1}{PRG_{inh-ca}}} \quad (1)$$

Equations 1 (incidental ingestion), 2 (dermal absorption), and 3 (inhalation of particulates) were used to derive the route-specific carcinogenic PRGs.

$$PRG_{ing-ca}(mg/kg) = \frac{TR \cdot AT_{ca} \cdot BW}{EF \cdot ED \cdot CSF_o \cdot IR_s \cdot 10^{-6} \frac{kg}{mg}} \quad (2)$$

$$PRG_{der-ca}(mg/kg) = \frac{TR \cdot AT_{ca} \cdot BW}{EF \cdot ED \cdot \frac{CSF_o}{GIABS} \cdot SA \cdot AF \cdot ABS_d \cdot 10^{-6} \frac{kg}{mg}} \quad (3)$$

$$PRG_{inh-ca}(mg/kg) = \frac{TR \cdot AT_{ca}}{EF \cdot ED \cdot ET \cdot \frac{1day}{24hrs} \cdot IUR \cdot 1000 \frac{\mu g}{mg} \cdot \frac{1}{PEF}} \quad (4)$$

### 2.2.2 *Non-carcinogenic PRG*

Equation 5 was used to derive the PRG for the dioxin TEQ concentration in surface soil that represents a target non-cancer hazard index of 1 to a youth recreational receptor exposed via incidental ingestion, dermal absorption, and inhalation of particulates.

$$PRG_{total-nc}(mg/kg) = \frac{1}{\frac{1}{PRG_{ing-nc}} + \frac{1}{PRG_{der-nc}} + \frac{1}{PRG_{inh-nc}}} \tag{5}$$

Equations 6 (incidental ingestion), 7 (dermal absorption), and 8 (inhalation of particulates) were used to derive the route-specific non-carcinogenic PRGs based on a target hazard quotient (THQ) of 1.

$$PRG_{ing-nc}(mg/kg) = \frac{THQ \cdot AT_{nc} \cdot BW}{EF \cdot ED \cdot \frac{1}{RfD} \cdot IR_s \cdot 10^{-6} \frac{kg}{mg}} \tag{6}$$

$$PRG_{der-nc}(mg/kg) = \frac{THQ \cdot AT_{nc} \cdot BW}{EF \cdot ED \cdot \frac{1}{RfD \cdot GIABS} \cdot SA \cdot AF \cdot ABS_d \cdot 10^{-6} \frac{kg}{mg}} \tag{7}$$

$$PRG_{inh-nc}(mg/kg) = \frac{THQ \cdot AT_{nc}}{EF \cdot ED \cdot ET \cdot \frac{1day}{24hrs} \cdot \frac{1}{RfC} \cdot \frac{1}{PEF}} \tag{8}$$

## 3.0 TOXICITY

The PRGs derived in this document are for dioxin TEQ concentrations in surface soil. A dioxin TEQ concentration accounts for the relative toxicity of the various dioxin-like compounds that are present using toxicity equivalence factors (USEPA, 2010). TEFs are weighting factors reflecting the relative potency of each compound in terms of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (USEPA, 2010). As described below, the cancer and non-cancer toxicity values used to derive PRGs for the dioxin TEQ concentrations in surface soil are for the most potent dioxin congener, 2,3,7,8-tetrachlorodibenzo-*p*-dioxin.

### 3.1 Carcinogenic Health Effects

When evaluating the potential carcinogenicity of a chemical, the EPA generally assumes that any exposure to a chemical will increase an individual's risk of developing cancer. In other words, there is no threshold below which the probability of developing cancer is zero. The EPA evaluates carcinogenic effects in two parts. First, the Agency evaluates all available scientific information and assigns a weight-of-evidence classification based on a compound's potential to cause cancer in humans. Second, a toxicity value is calculated to define the quantitative relationship between dose or concentration and carcinogenic response. These values are known as cancer slope factors (CSFs) and inhalation unit risks

(IURs). CSFs and IURs are generally plausible upper-bound estimates of the increased probability of developing cancer following a lifetime of exposure. These toxicity values are used to estimate the increased risk of developing cancer from exposure to potentially carcinogenic chemicals.

The EPA's Office of Solid Waste and Emergency Response (OSWER) Directive 9285.7-53 (USEPA, 2003) provides the hierarchy of human health toxicity values and guidance on the selection of the most appropriate sources of toxicity information that should be used to perform human health risk assessments for Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or "Superfund") sites. Tier 1 toxicity values are those in the EPA's Integrated Risk Information System (IRIS). Tier 2 values are those from the EPA's Provisional Peer Reviewed Toxicity Values (PPRTVs). Finally, Tier 3 values are those from other EPA or non-EPA sources, especially those with the most current information, which are publicly available and transparent regarding the methods and process used to derive the values, and which have been peer-reviewed. According to this hierarchy document, "draft toxicity assessments are not appropriate for use until they have been through peer review, the peer review comments have been addressed in a revised draft, and the revised draft is publicly available."

### 3.1.1 Oral Cancer Slope Factor

Oral cancer slope factors (CSFs) for 2,3,7,8-tetrachlorodibenzo-*p*-dioxin are not available from Tier 1 (IRIS) or Tier 2 (PPRTV) sources. The current version (May 2013) of the EPA's Regional Screening Level (RSL) Table lists a Tier 3 source from CalEPA of $1.3 \times 10^5$ $(mg/kg\text{-}day)^{-1}$. Other Tier 3 values are available, including an oral CSF from the EPA's Office of Health and Environmental Assessment of $1.56 \times 10^5$ $(mg/kg\text{-}day)^{-1}$. The CalEPA CSF was used to derive the PRGs, in order to be consistent with the RSL Table.

### 3.1.2 Inhalation Unit Risk

Inhalation unit risk (IUR) values are not available for TCDD from Tier 1 (IRIS) or Tier 2 (PPRTV) sources. The May 2013 version of the EPA's RSL tables recommends use of 38 $(\mu g/m^3)^{-1}$, from CalEPA.

## 3.2 Non-carcinogenic Health Effects

In general, the EPA assumes that a dose or exposure level exists below which adverse non-carcinogenic health effects will not occur (USEPA, 1989). Below this "threshold," it is believed that exposure to a chemical is tolerated without adverse effects. Adverse health effects occur only when physiologic protective mechanisms are overcome by exposure to doses or concentrations above the "threshold". Non-cancer toxicity values are derived for various durations of exposure, including chronic (up to a lifetime) and subchronic (up to 10% of a lifetime).

### 3.2.1 Oral Reference Dose

Oral reference doses (RfDs) are the toxicity values used in assessing non-carcinogenic effects from ingestion or dermal absorption of contaminants. An RfD is defined as an estimate of a daily exposure level to the human population, including sensitive subgroups, that is likely to be without an appreciable risk of deleterious effects during a lifetime. To derive PRGs in this evaluation, we used the Tier 1 chronic RfD for 2,3,7,8-tetrachlorodibenzo-*p*-dioxin of $7 \times 10^{-10}$ mg/kg-day, which was finalized by the IRIS program in February 2012.

### 3.2.2 Inhalation Reference Concentration

Inhalation reference concentrations (RfCs) are the toxicity values used in assessing non-carcinogenic effects from inhalation of contaminants. RfCs are not available for 2,3,7,8-tetrachlorodibenzo-*p*-dioxin from Tier 1 (IRIS) or Tier 2 (PPRTV) sources. The May 2013 version of the EPA's RSL tables recommends use of 4E-08 $mg/m^3$, from CalEPA.

## 4.0 RISK-BASED PRELIMINARY REMEDIATION GOALS

Preliminary remediation goals were derived based on health risks to youth recreational receptors from exposure to dioxin in surface soil. Risk-based PRGs are provided for the EPA's target risk range of an excess individual lifetime cancer risk between $1 \times 10^{-6}$ and $1 \times 10^{-6}$, as well as for a non-cancer hazard index of 1.

| **Table 2. Preliminary Remediation Goals for Dioxin TEQ in Surface Soil (ppt) – Youth Recreational Receptors.** | |
|---|---|
| **Excess Individual Lifetime Cancer Risk = $1 \times 10^{-6}$ to $1 \times 10^{-4}$** | |
| *Ingestion PRG:* | *9.1E+01 to 9.1E+03* |
| *Dermal PRG:* | *2.1E+02 to 2.1E+04* |
| *Inhalation PRG:* | *5.7E+06 to 5.7E+08* |
| **PRGs based on Target Cancer Risk Range:** | **63 to 6,300** |
| **Non-cancer Hazard Index = 1** | |
| *Ingestion PRG:* | *1.2E+03* |
| *Dermal PRG:* | *2.7E+03* |
| *Inhalation PRG:* | *1.2E+09* |
| **PRG based on Non-cancer Risks:** | **820** |

## 5.0 UNCERTAINTIES

Although we have attempted to minimize the uncertainties in our derivation of risk-based PRGs for dioxin in surface soil at the Strecker Forest property by using a combination of default assumptions and best professional judgment, this section addresses the remaining uncertainties in the exposure parameters and toxicity values used to evaluate the data.

### 5.1 Uncertainties in Exposure Parameters

Because the dioxin PRGs derived in this document are applicable only to areas in which land use controls will be established that restrict future development and residential use, current and future receptors consist only of recreational visitors and trespassers. We expect these receptors will largely consist of children and adolescents, who may find the undeveloped areas appealing to explore when they are not at school or involved in other activities. However, we do not expect the undeveloped sloped terrain to appeal to parents and caregivers as a place for infants and younger children to play. Moreover, there are no features of the areas such as swimming or other recreational activities available in public parks, for example, which would draw frequent visits from adults. Therefore, we judged that the most frequent receptors are and will be between the ages of 6 and 16 years old. Uncertainty is present in that infants and children (i.e., ages 0 to 6 years) could potentially visit more frequently, but based on the characteristics of the areas, this is judged highly unlikely.

To the extent possible, we used the same exposure parameter values to derive the dioxin PRGs that were previously used to assess short-term risks to youth trespassers at Strecker Forest. These include use of a 96 day per year exposure frequency and 4 hour per day exposure time. This is equivalent to visiting

4 hours per day, 4 days per week, over a period of 24 weeks, roughly when school is out, during May through September. Alternatively, this is equivalent to visiting between 1 and 2 days per week, year-round. Although some children living nearby may visit the undeveloped areas this often or more, we judged that it would be unlikely for children to exceed this number of visits every year between the ages of 6 and 16. That is, we expect less frequent visits for the younger children who may be more closely watched by parents or caregivers, more frequent visits for older children, and then less frequent visits by older teenagers. Therefore, while it might be possible for a given child to have more frequent visits for a given year, it was not thought likely that the frequency of visits would be consistently greater than 96 days per year over the entire 10 year time period.

For the soil incidental ingestion rate, we assumed 100 mg soil per day for children over the age of 6 years. Not only is this the value previously used to examine short-term risks to youth trespassers at Strecker Forest, it is also the EPA's standard default value for daily soil ingestion by residential receptors over the age of 6 years. Although unlikely, we have assumed that the entire daily soil ingestion will occur during the four hours that receptors are present in the Strecker Forest areas.

For dermal absorption, we used the mean surface area of the head, arms, hands, and legs for girls and boys between the ages of 6 to 16 years, consistent with the approach previously used at Strecker Forest. This skin surface area is much greater than what is assumed under a residential scenario. It represents children wearing shorts, short-sleeved or sleeveless t-shirts, socks, and shoes, as would be worn during the summer. If children wear pants or long-sleeved shirts, during cooler times of the year or to prevent scratches from brush, the assumed skin surface area is overly conservative (i.e., health-protective). A soil adherence factor of 0.2 $mg/cm^2$ was used, which represents high soil contact rates, such as what would be expected when playing in wet soil. This is the same value used previously at Strecker Forest. It is a more health-protective assumption that what is used under a residential scenario for older children and adults.

Per the EPA guidance (USEPA, 1989) and consistent with the approach previously used at Strecker Forest, the cancer PRGs account for exposure averaged over a lifetime (i.e., $AT_{ca}$ = 25,550 days, or 70 years), and the non-cancer PRGs account for the site-specific duration of exposure (i.e., $AT_{nc}$ = 3,650 day, or 10 years.)

### 5.2 Uncertainties in Toxicity Values

Based on Table 2, the lowest, most-health protective route-specific dioxin PRGs are for the ingestion pathway. We have high confidence in the 2,3,7,8-tetrachlorodibenzo-*p*-dioxin oral non-cancer toxicity value (RfD) finalized in 2012 because it underwent an extensive, independent, and highly public peer review process. We have less confidence in the oral cancer slope factor (CSF), which is a Tier 3 value from CalEPA. However, other CSF values are available, and all are generally the same magnitude as the CalEPA value. Both the inhalation non-cancer value (RfC) and cancer value (IUR) were derived using route-to-route extrapolation. There are many uncertainties with using an oral study to approximate inhalation toxicity values. However, we note that the contribution of inhalation exposure is much less of a concern than oral exposure (ingestion) for dioxin.

## 6.0 CONCLUSIONS

In summary, PRGs were derived for the dioxin toxicity equivalence concentration in surface soil for areas of the Proposed Strecker Forest Development, located in Wildwood, Missouri, that will be restricted to recreational use. A dioxin TEQ accounts for the relative toxicity of the various dioxin-like

compounds that are present using toxicity equivalence factors, which are weighting factors reflecting the relative potency of each compound in terms of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin. PRGs were derived for youth receptors based on both cancer and non-cancer health effects. The PRG based on a non-cancer hazard index of 1 is 820 ppt, which is between the PRGs of 63 and 6,300 that represent the EPA's target cancer risk range of $1 \times 10^{-4}$ to $1 \times 10^{-6}$. In order to be protective for non-cancer health risks, the final cleanup goal cannot be greater than 820 ppt. Cleanup goals less than or equal to 820 ppt will be protective for both non-cancer and cancer risks to current and future recreational receptors.

## 7.0 REFERENCES


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