YMP	**Model Error Resolution Document** *Complete only applicable items.*	QA: QA Page 1 of 4

INITIATION

1. Originator:	2. Date:	3. ERD No.
Kenneth Rehfeldt	April 4, 2008	MDL-MGR-HS-000001 ERD 01

4. Document Identifier:	5. Document Title:
MDL-MGR-HS-000001 REV 00	Irrigation Recycling Model

6. Description of and Justification for Change (Identify applicable CRs and TBVs):

Introduction

This ERD is written to make changes to resolve TBV-9051. The document presents the disposition of the TBV, identifies changes to the model report, and evaluates the impact on the conclusions of the report and any downstream products.

Changes related to TBV-9051, together with additional minor corrections, are presented in the attachment to this ERD.

CONCURRENCE

	Printed Name	Signature	Date
7. Checker	Susan Boggs	SBoggs.	4/9/08
8. QCS/QA Reviewer	Charles Beach	Charles D. Beach	4-9-08
APPROVAL			
9. Originator	Kenneth Rehfeldt	Kenneth Rehfeldt	4/9/2008
10. Responsible Manager	Paul R. Dixon	Paul	4-10-08

I Background Information Summary

TBV-9051. A citation could not be verified because the values cited could not be found in the cited reference. On page 6-42 of *Irrigation Recycling Model*, the total water use for a household of four people is given as 326,000 gal/yr and attributed to Wilkes et al. (2005 [DIRS 181326]). However, that information is not presented in the Wilkes et al. reference.

II Inputs and/or Software

There are three direct inputs to this error resolution document. The first is a document that can be used to calculate the value of the percentage of water consumption that is used indoors for several metropolitan areas across the United States. The document is Mayer et al. 1999 [DIRS 185033]. This is a new reference that is added for this analysis. Two other documents were referenced in the parent report and are used again here. They are SNWA 2007 [DIRS 183400], which provides information specifically to Southern Nevada and Wilkes et al. 2005 [DIRS 181326], which provides the indoor water use values in gallons per day. Data from all three sources are established fact. See revised Section 4.1.2.3 below for the justification of established fact.

No software controlled under IM-PRO-003, *Software Management*, is used in the analysis contained in this error resolution document.

III Analysis and Results of TBV-9051

The fraction of the total amount of water that is used indoors by a household is determined in Section 6.5.3.5.2 of the parent document. That calculation uses data from Wilkes et al. (2005 [DIRS 181326]) to determine the total daily volume of water used indoors and the total water used by a household (again attributed to Wilkes et al.) to calculate the percentage of total water that is used indoors. Because the total water use number could not be verified, the calculated percentage of indoor water use is also not verified.

To resolve this inconsistency, two changes are made to the parent document. First, an alternate source was identified for the mean percentage of indoor water use. The mean percentage is used along with the total gallons used per event per day (mean) (from Table 6.5-2 of the parent document) to determine the total volume of water used per day for a household. Then the data in Table 6.5-2 were used to assign a minimum and maximum percentage to the indoor water use using the mean water use of 301.362 gpd (Table 6.5-2) which represents 34.8% (mean water use percentage). The minimum water use of 165.244 gpd (Table 6.5-2) corresponds then to 19.08%. The lower bound percentage was adjusted using Nevada specific data. The lower limit was multiplied by 0.97 and the final value is 18.5% (same as it was in the original document). The same procedure applies to the maximum limit.

The new source for the mean indoor water percentage is the report by Mayer et al. (1999 [DIRS 185033]). The authors installed water metering devices on several homes in twelve cities around the United States and measured the water consumption. From those measurements, they are able to determine the percentage of the water used that was for indoor purposes.

Changes to the Document

1. Table 4.1-1: Add reference to Mayer et al. 1999 [DIRS 185033] and SNWA 2007 [DIRS 183400] to the sources listed for the indoor water uses data as shown below.

Indoor water uses	Wilkes et al. 2005 [DIRS 181326]; Mayer et al. 1999 [DIRS185033]; SNWA 2007 [DIRS 183400] These data are considered established fact (see Section 4.1.2.3 for details).	Section 6.5.3.4.2

2. Section 4.1.2.3: Add reference to Mayer et al. 1999 [DIRS 185033] and make other changes as necessary. The replacement section 4.1.2.3 is shown below.

4.1.2.3 Indoor Water Use Data

Estimates from *Quantification of Exposure-Related Water Uses for Various U.S. Subpopulations* (Wilkes et al. 2005 [DIRS 181326]) and from *Residential End Uses of Water* (Mayer et al. 1999 [DIRS 185033]) were used to develop the probability distribution for the fraction of water used indoors as described in Section 6.5.3.5. The data from the Southern Nevada Water Authority (SNWA 2007 [DIRS 183400]) were used to adjust the probability distribution to the conditions specific to Nevada. Data provided by Wilkes et al. (2005 [DIRS 181326]) were collected by the EPA and represent the most complete compilation on the indoor water uses. The purpose of this work was to understand population water-use behavior for indoor water-use activities as a function of demographic characteristics. In this report (Wilkes et al. 2005 [DIRS 181326]), frequencies and durations of use of showers, baths, clothes washers, dishwashers, toilets, and faucets are presented and compared for various demographic groups derived from analyses of the National Human Activities Pattern Survey (NHAPS) database, the Residential End Uses of Water Study (REUWS) database, the Residential Energy Consumption Survey (RECS), as well as from current literature and manufacturer information. Volumes and flow rates are also analyzed from REUWS for the various water uses. Furthermore, tap water ingestion data are analyzed for various population groups derived from the Continuing Survey of Food Intake by Individuals (CSFII) as well as from NHAPS and current literature. Typical parameters of indoor water uses are presented and recommended for use in human exposure modeling. The analysis presented by Wilkes et al. (2005 [DIRS 181326]) is substantially based on the data from Mayer et al. (1999 [DIRS 185033]) (REUWS database). The Southern Nevada Water Authority (SNWA) is a cooperative agency formed in 1991 to address Southern Nevada's unique water needs on a regional basis. SNWA officials are charged with managing the region's water resources and providing for Las Vegas Valley area residents' and businesses' present and future water needs. All three sources contain the information that is recognized as an authoritative source on the waster uses and is considered established fact.

3. Section 6.5.3.5.2: Add reference to Mayer et al. 1999 [DIRS 185033] and make other changes as necessary. The replacement section 6.5.3.5.2 is shown below.

6.5.3.5.2 Indoor Fraction

Indoor fraction (F_{ind}) represents a direct input into the irrigation recycling model as described in Section 6.4. Parameter F_{ind} defines how much of the residential water is used indoors. As discussed in Section 6.5.3, the water used outdoors is assumed to be permanently removed from the recycling system.

The EPA studied indoor water uses extensively and reported its findings in *Quantification of Exposure-Related Water Uses for Various U.S. Subpopulations* (Wilkes et al. 2005 [DIRS 181326]). The purpose of their study was to analyze the population behavior for indoor water use activities. Based on this study, the water use parameters are presented and recommended for use in human exposure modeling.

Collected in this study were data on use of baths and showers, faucets, dishwashers, washers, toilets, and water consumption. These data were used to estimate the average indoor water use and the lower and upper limits of that use.

The data provided by Wilkes et al. (2005 [DIRS 181326]) are reported in terms of number of events per person per day and gallons used per event. These data are summarized in Table 6.5-2.

The total gallons used per day shown in Table 6.5-2 are calculated for a household of four people. The lower limit is calculated using the event volume minus 2 standard deviations (if available). The upper limit is calculated using the event volume plus 2 standard deviations (if available).

Table 6.5-2. Summary of Indoor Water Usage

Event	Gallons Used per Event (mean)	Gallons Used per Event (standard deviation)	Number of Events per Day per Person	Total Gallons Used per Event per Day (mean)	Total Gallons Used per Event per Day (upper limit)	Total Gallons Used per Event per Day (lower limit)
Shower	15.8	1.75	1	63.2	77.2	49.2
Bath	40	—	0.32	51.2	51.2	51.2
Faucets	0.7	1	17.4	48.72	187.92	0
Water Consumption	0.15	—	4	0.6	0.6	0.6
Toilets	3.98	1.2	5.2	82.784	132.704	32.864
Dishwasher	8		0.164	5.257	5.257	5.257
Washer	37.74	8.932	0.329	49.601	73.08	26.123
Total	—	—	—	301.362	527.961	165.244

Source: Wilkes et al. 2005 [DIRS 181326].

The average water use indoors estimated by Mayer et al. (1999 [DIRS 185033], Figure 5.6) is 34.8%. This number was determined by adding the values for gallons per capita per day for dishwasher, bath, other domestic, faucet, shower, clothes washer, and toilet for a total of 59.8 gallons per capita per day and dividing that number by the total water use of 171.8 gallons per capita per day to yield a percentage of 34.8% indoor water usage. This value does not include leakage which is estimated by Mayer et al. (1999 [DIRS 185033], Figure 5.6) as 9.5 gallons per capita per day. The value of 34.8% is larger than the data published by the Southern Nevada Water Authority (SNWA 2007 [DIRS 183400]), according to which 30% of water is used indoors in Southern Nevada (26% if leakage is not included). The comparison of these data and the data provided by Wilkes et al. (2005 [DIRS 181326]) is provided in Table 6.5-3. The specific percentages of indoor water use presented by SNWA 2007 [DIRS 183400] are the same as those in Mayer et al (1999 [DIRS 185033], Figure 5.6), therefore both sources are listed in Table 6.5-3. The percentage used for different activities is in good agreement.

Table 6.5-3. Comparison of the Indoor Water Usage

Indoor Water Use Activity	Total Indoor Use (%)	
	SNWA 2007 [DIRS 183400] Mayer et al 1999 [DIRS 185033]	Wilkes et al. 2005 [DIRS 181326]
Shower	16.8	21.0
Faucets	15.7	16.2
Toilets	26.7	27.5
Washers	21.7	16.5
Dishwashers	1.4	1.7
Baths, leaks, and other	17.6	17.0

Sources: Wilkes et al. 2005 [DIRS 181326], Mayer et al. 1999 [DIRS 185400], and SNWA 2007 [DIRS 183400].

NOTE: Data from Wilkes et al. 2005 [DIRS 181326] are calculated using mean values per each indoor use category in Table 6.5-2.

Using the average indoor water use of 34.8% and using minimum and maximum indoor water use values in Table 6.5-2, the range in indoor water use percentage is from 19.08% to 60.97%. The Nevada specific indoor water use percentage is between 26 and 30%. To account for the proportionally smaller indoor water use in Southern Nevada, the range of indoor water use percentages was adjusted downward approximately 3%. The 3% adjustment is smaller that the ratio of Southern Nevada indoor use (26%) and the average value of 34.8% would suggest. However, using the 3% reduction leads to a conservative estimate of the indoor water use fraction because less water is lost from the system. The resulting distribution is a uniform distribution ranging from 0.185 to 0.591 and is defined for the indoor residential fraction (parameter *Indoor_Fr*) in the GoldSim file *Irrigation_Recycling_Model.gsm* (output DTN: SN0703PASZIRMA.001, directory: \Model).

4. Section 9.1: Add reference to Mayer et al. 1999 [DIRS 185033] as shown below.

185033 Mayer, P.B.; DeOreo, W.B.; Opitz, E.M.; Kiefer, J.C.; Davis, W.Y.; Dziegielewski, B.; and Nelson, J.O. 1999. *Residential End Uses of Water*. Denver, Colorado: AWWA Research Foundation and American Water Works Association.

TIC: 260056.

IV Impact Evaluations/Results

The changes to the document remove an unverified reference citation and provide a rationale for the percentage of water used indoors versus outdoors. It does not modify any of the conclusions of the report. Only one report uses the irrigation recycling model as direct input: *Features, Events, and Processes for the Total System Performance Assessment: Analyses* (SNL 2008 DIRS 183041]). The citations in that report (SNL 2008 DIRS 183041]) are unaffected by the changes in this ERD. As a result, there is no impact to the downstream products from the changes in this ERD.