Jon George
Exhibit B

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Potential for Contamination of Domestic Wells, Labadie Bottoms, Franklin County, Missouri

Robert E. Criss
Department of Earth & Planetary Sciences
Washington University in St. Louis

Abstract. The alluvial aquifer in Labadie Bottoms can discharge to the land surface when the Missouri River has a high stage, and can exchange with proximal parts of the Ozark aquifer where the head has been reduced by pumping. These conditions increase the risk of bringing groundwater into contact with waste in the proposed CCP landfill in Labadie Bottoms, as well as the risk of contamination of proximal private wells. The proposed landfill would also increase waterlogging of soils in the agricultural bottomland to the northeast.

Hydrogeologic Setting

Labadie Bottoms is underlain by unconsolidated alluvial sediments with a thickness of about 110 feet, situated above Ordovician dolostone and sandstone units (Fig. 1; Emmett and Jeffery, 1968; Harrison, 1997). The alluvial sediments host the "Alluvial aquifer" that occurs all along the lower Missouri River, while the bedrock hosts the "Ozark aquifer" or Cambrian-Ordovician bedrock aquifer. Both aquifers are extensively used for private, public, agricultural and industrial water supplies in Missouri, and both are important in the area of Labadie Bottoms, where they intersect (Fig. 1).

This alluvial aquifer is typically 80 to 120 feet thick , mostly represented by an upward-fining sequence of unconsolidated sediments underlain by Paleozoic bedrock whose permeability is lower by several orders of magnitude (Emmett and Jeffrey, 1968; Grannemann and Sharp, 1979). The aquifer supplies hundreds of irrigation wells and large well fields supply municipalities including Independence and Columbia, Missouri. Well yields of 500 to 3000 gpm are common (Kelley, 1996). Groundwater flow is predominantly downstream and toward the river. However, the water table in the alluvial aquifer is highly variable, being principally governed by the river level and the amount of recent precipitation (Emmett and Jeffrey, 1968). Thus, the river can either receive water from, or contribute water to, the alluvial aquifer (e.g., Homyk et al., 1967; Grannemann and Sharp, 1979). Available data show that the water table in this highly permeable aquifer adjusts to be well within about ±10 feet of the fluctuating river level, requiring rapid flow of groundwater over large distances, with the flow being either toward or away from the river.

The Ozark aquifer is a thick bedrock aquifer, largely constituted of Cambrian and Ordovician dolostones and sandstones of highly variable permeability, that underlies extensive parts of the Ozarks. The aquifer is unconfined in much of the Salem Plateau (Imes, 1985), though commonly confined elsewhere, and in the Labadie area is about 1500 feet thick (Imes, 1985, 1989). Regional flow in the aquifer is from upland regions toward the stream and river valleys, where the potentiometric head approximates the river level (Imes, 1985). However, local flow systems may be superimposed on this regional flow system, and infiltration can occur where the aquifer crops out along the Missouri River (Imes, 1985, p. 35).

Seep Water

In bottomlands protected by levees, groundwater levels become elevated during high stages of the Missouri River, and can even rise above the land surface (Fig. 2). This condition occurs at Labadie Bottoms, where farmers describe the upward flow of "seep water" from the ground (D. Brunjes, pers. comm., May 14, 2010). The proposed landfill will interact with this high groundwater table in several undesirable ways. First, contamination of the groundwater by direct contact with the waste is possible, with every defect in the landfill underliner providing an avenue for transport. Second, the upflow of groundwater will be impeded directly beneath the large landfill, so upwelling water will be displaced laterally, particularly to the remaining agricultural lands to the northeast. This displaced flow will further increase the water table beneath those fields, increasing waterlogging of the soils, and will impede the use of farm machinery, effectively shortening the growing season.

Infiltration of shallow groundwater into the Ozark aquifer

During periods of high river stage, it is possible for normal hydraulic gradients to be reversed between the alluvial groundwater system and parts of the Ozark aquifer governed by local flow systems. These conditions could also occur if large cones of depression were produced by significant pumpage of private wells. According to the available well records from MODNR (2010), several dozen private wells along the bluffs near Labadie Bottoms could be at risk of contamination (Fig. 1). Table 1 provides several examples of shallow domestic wells that are proximal to and southeast of the proposed CCP landfill, that have low static water levels and short casings. In particular, the water table in the alluvial aquifer is typically above 450 feet and can attain levels of 465 feet MSL or more, and therefore has the hydraulic potential to enter these domestic wells whenever their water levels are lower, especially when those levels are reduced by heavy pumping and below the casing (Fig. 1; Table 1).

Table 1. Examples of Domestic Wells at Risk of Contamination from the Proposed CCP Landfill

Well ID No.	Collar Elevation, ft.	Total Depth, ft.	Casing Length	SWL MSL[2]	Casing MSL[3]
022924	575	310	86	470	489
26189	644	380	81		563
21117	560	382	103	440	457
154295	540	406	84	440	456
000143737	540	315	105	452	435
00053051	580	363	121	480	459
00018725	540	406	84	440	456
00044782	480	410	87	455	393
00078747	510	256	115	415	395
00394501		266	105		
00000966	600	363	60	360	540
00087927[1]	540	400	126	430	414
00011549	600	250	82	460	518

1. use unknown 2. Static water level, reported in ft. rel. MSL 3. Elevation of casing bottom, in MSL

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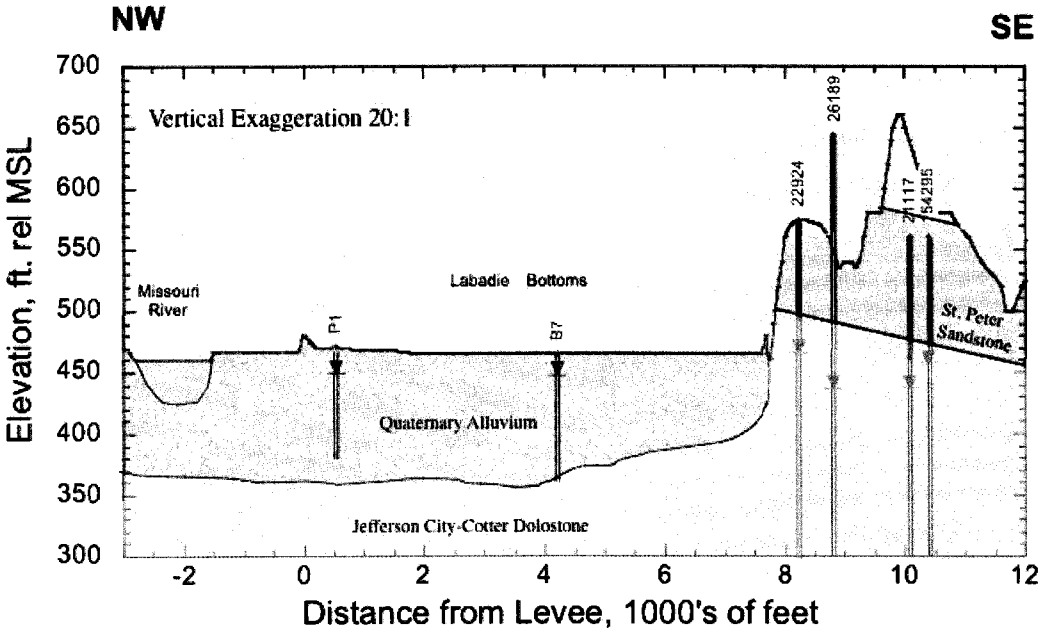

Figure 1. Geologic cross-section of Labadie Bottoms and its southern bluff, showing the location of several wells with geologic logs (MODNR 2010; Reitz and Jens, 2009). The section trends N45°Wand has a vertical exaggeration of 20x; topography is from USGS (1972). The line of the section intersects domestic well 022924 and is within 800 ft. of all other wells except B-7 which is 2300 ft. away. Static water levels at the time of initial well testing are indicated by the inverted triangles; the cased parts of the domestic wells are indicated by the heavy dark lines. Note that the water table of the four domestic wells lies below the cased intervals, and is commonly lower than the groundwater level in the alluvial aquifer in Labadie Bottom.

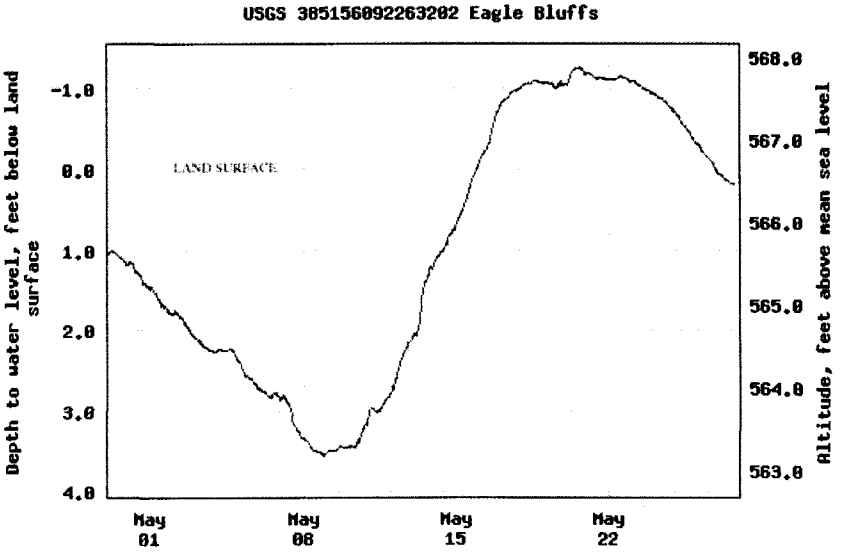

Figure 2. Hydrograph of the groundwater level in the alluvial aquifer near Eagle Bluffs, near river mile 175.9, for May 2010. Note that the water table can rise above the land surface during moderate flooding, when levees are not breached. This condition also occurs at Labadie Bottoms. Data from USGS (2010).