DETERMINING WATER LEVELS IN MAUMEE AND VEDRA VALLES USING EQUILIBRIUM SEDIMENT TRANSPORT THEORY. C. J. Thibodeaux[1], P. A. Washington[1], and R. A. De Hon[1], [1]Department of Geosciences, University of Louisiana at Monroe, Monroe, LA 71209.

Introduction: Ever since the first recognition of channels on Mars, attempts to estimate the flow characteristics of channel systems and their sediment transport consequences have been a holy grail of martian hydrological and sedimentological studies [1-4]. Previous attempts were severely hampered by the lack of sufficiently precise data to perform the necessary calculations. The MOLA data set [5] provides greatly increase accuracy and therefore allows improved estimates of discharge and related parameters.

Maumee and Vedra Valles consist of a collection of anastomosing channels that head on the eastern edge of Lunae Planum, extend across Xanthe Terra uplands, and debouch onto the lower Chryse Planita surface [6, 7]. Flow through the system began as large-scale overland flooding which became channelized. Tributary channels became abandoned as the trunk channel in each of the systems capture the bulk of the discharge. Maumee and Vedra were abandoned as the trans-Xanthe portion of Maja captured the remaining discharge.

Volumes and duration for the discharge through Maumee and Vedra channels were previously estimated [8] using Viking orbiter data and a wide-range of possible water depths. That model for the Maja outflow system was based primarily on the use of a modified Chezy equation to calculate the rate of discharge through a series of deepening spillways with a deceasing head at the source. In this paper we refine water level estimates by application of the Manning equation and Stream-Sediment Equilibrium Theory [9] to much improved topographical data provided by MOLA.

Channel Geometry: Equilibrium Sediment Transport Theory [9-11] postulates that an equilibrium stream achieves the minimum ratio of stream power to sediment load, i.e., that the least possible stream energy is wasted and the maximum sediment load is transported. In achieving this equilibrium, the stream adjusts its channel geometry until the channel hydraulics balance the sediment transport requirements dictated by the nature of the bed, especially the grain-size distribution. The resulting channel geometry has a parabolic (or possibly hyperbolic cosine – which is virtually indistinguishable) cross section [12], with the particular parabolic parameters determined by the energy equilibrium between the channel hydraulics and bed mobility.

Because a parabola has very regular mathematical characteristics, the analysis of an equilibrium channel is possible. To apply the theory to Martian paleochannels, the first challenge is to distinguish which portions of the channels were within the equilibrium channel and which parts lay above the water surface. To do this, it was assumed that the equilibrium conditions, and thus a parabolic cross-sectional profile, were only present within the active channel. The limits of the mathematically identifiable parabola thus defined the limits of the active channel.

Water Levels: Inasmuch as the second derivative of a parabola is a non-zero constant, the limits of the channel-centered profile with a nearly constant second derivative were defined as the boundaries of the equilibrium profile. In analyzing the flow levels within the Maumee and Vedra channels, two obstacles were encountered. First, the MOLA data is iterated, so that there is a spaced set of points. This imposed a limitation on the possible precision in determination of the equilibrium channel boundaries, with the actual channel boundary lying at or beyond the end of the apparent equilibrium profile (Fig. 1). Second, the outflow channels were apparently only in partial equilibrium (the theory assumes sustained constant flow with no bank slumping), with the limits on equilibrium channel geometry lying at significantly different elevations for the two banks. Generally, the discharge rates for the higher limits correlated along the length of the channels.

Beyond the defined edges of the channels, the profiles tend to (1) either flatten out (which deviates from the exponentially steepening profile of the parabola), (2) exhibit a nearly constant first derivative (which produces a near-zero second derivative), or (3) steepen excessively for a very short interval before flattening out. The first of these is interpreted as indicating that the channel was excavated without significantly affecting the adjoining plain surface (except for the minor pre-excavation scour). The second is interpreted as indicating that the bank experienced undercutting with slumping or sliding of sediment into the channel; this interpretation is further strengthened by the occurrence of this geometry along banks where the apparent limits of equilibrium channel lie significantly below the level of the equilibrium geometry on the opposing bank. The last is interpreted as indicating a channel that is incising into partially cohesive materials so the exposed upper bank preserves, to some extent, the surface developed when the channel was nearly bank full.

Within the channels, there are also many deviations from an ideal parabolic profile. In some profiles the deviations are localized and have profiles reminiscent of channel bar deposits. These create a small eccentricity in the otherwise nearly constant second-derivative profile. In other profiles, however, there is a large flat to irregular portion that separates two otherwise consistent parabolic banks. These large flat portions are interpreted as indicating a more resistant substrate with either greater cohesion or much larger grain-size than the bank material. The parabolic banks then represent the equilibrium profile and the flat central channel is ignored except in considering the channel hydraulic and discharge parameters.

Channels tend to decrease in depth headward. Equilibrium discharge in the Vedra Valles trunk channel was 1.33 x 10^6 m^3/s and for the Maumee Valles trunk channel was 1.93 x 10^6 m^3/s; water depths within the channel varied between 100 m and 250 m in Vedra Valles and between 125 and 440 m in Maumee Valles in response to longitudinal variations in channel width. Water levels in the valleys were bank full in their upper portions but significantly below bank-full in their lower portions.

References: [1] Masursky et al, 1977, *JGR, 82,* 4016–4038. [2] Baker, V. R. and R. C. Kochel, 1979, *JGR, 84*, 7961–7984. [3] Robinson, M. S. and K. L. Kanaka , 1990, *Geology, 18*, 902–905. [4] Zimbelman et al, 1992, *JGR 97*, 18,309–18317. [5] Smith D. E. et al., 1998, *Science, 279*, 11686–1692. [6] De Hon, R. A., 1991, *USGS Misc. Inves. Ser. Map I-2203*. [7] Rice J. W. and R. A. De Hon, 1996, *USGS Misc. Inves. Ser. Map I-2421*. [8] De Hon, R. A. and E. A. Pani, 1993, *JGR, 98–Planets*, 9129-9138. [9] White, W. R., R. Bettess,, and E. Paris, 1982*, J. Hydraulics Div. ASCE, 108*, 1179–1193. [10] Lane, E. W., 1955, *Trans. Amer. Soc. Civil Eng., 120*, 1234-1260. [11] Chang, H. H., 1980, *J. Hydraulics Div., ASCE, 105*, 1443-1456. [12] Knighton, D., 1998, *Fluvial Forms and Processes*, Arnold Publ., London, 383 p.

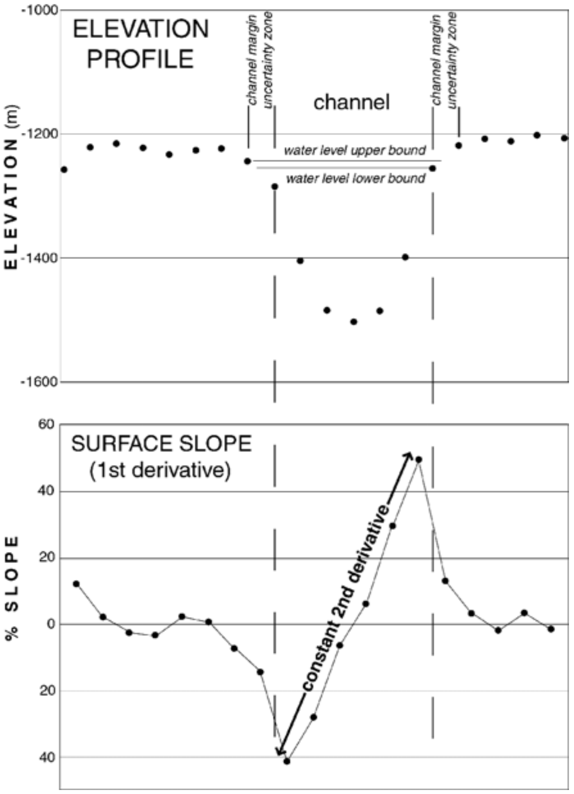

Figure 1. Water level determination for the Maumee channel transect along MOLA orbit AP10900.