JOURNAL OF MARINE RESEARCH

Journal of Marine Research, Sears Foundation for Marine Research, Yale University
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Tide-well Systems III: Improved Interpretation of Tide-well Records[1]

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ABSTRACT

Recent studies of the non-linear response of the conventional tide-well system have pointed out the deficiencies of the system when the tide records are to be used for scientific purposes requiring very accurate data. An experimental method of checking the response of such tide-wells, by means of a drainage test, is described. This provides the basis of a further method, by which the height of the water level in the well may be approximately corrected to give the height of the sea level outside the well. The application of these methods, to a recently advocated linear tide-well system, is also described.

1. Introduction. In a number of papers (e.g. Noye 1970, 1974a,b), the response of several types of tide-well systems has been examined in detail. For the conventional tide well, which has an orifice connecting the water in the well with the sea outside, it was shown that, for a narrow deep well, the governing differential equation has the form

$$dH_w/dt + C_1 |H_w|^{1/2} \operatorname{sgn}(H_w) = dh_0/dt, \tag{1.1}$$

where t is the time and $H_w(t)$ is the head response of the tide well to the fluctuations in sea level, $h_0(t)$.

$$H_w = h_0 - h_w, \tag{1.2}$$

where h_w is the height of water in the well, referred to the same datum as the sea level. C_1 is a constant, depending only on the dimensions of the tide well, viz.,

$$C_1 \simeq C_c (2g)^{1/2} A_p / A_w, \tag{1.3}$$

1. Received: *11 February 1974.*

where A_w is the uniform area of cross-section of the well, A_p is the area of the orifice, g is the acceleration due to gravity and C_c is the contraction coefficient of the orifice, generally taken to be $C_c \simeq 0.6$.

For the tide well with a long horizontal pipe connection near the sea floor, it was shown that, provided a parameter $N \geq 5$, the head response to the fluctuating sea level is given by the following relation, derived assuming steady Poiseuille pipe flow,

$$dH_w/dt + C_2 H_w = dh_0/dt, \tag{1.4}$$

where the tide-well constant, C_2, is given by

$$C_2 = gD_p^4/32vL_pD_w^2. \tag{1.5}$$

Here v is the kinematic coefficient of viscosity of sea water, L_p is the length and D_p the uniform diameter of the pipe connection, D_w is the uniform diameter of the circular well and

$$N = \frac{128v^2 L_p D_w^2}{gD_p^6}.$$

The response of the non-linear system described by equation (1.1) is dependent on the parameter C_1 (Noye, 1974a); the response of the linear system described by equation (1.4) depends on C_2 while, for $N < 5$, unsteady effects in the upper pipe flow produce a more complicated form for the response (Noye, 1974b).

In many tide-well installations, the value of the tide-well constant (C_1 or C_2) is not well known. For instance, the orifice of a conventional tide well might not be sharp edged or exactly circular, so that the contraction coefficient C_c might be unknown, or marine growth might have reduced its area after installation. Methods of determination of the tide-well constants and the response function from drainage tests, in the field or the laboratory, can overcome this problem.

For the conventional tide well, an experimental method for finding C_1 and hence the pseudo-response of the system is described in the next Section. For a linear system with $N \geq 5$, the quasi-steady theory is a good approximation and the method described in Section 2 may be used. For $N < 5$, a more general method is applicable. In addition, two cases which can occur if the well is tested in situ, when the water level outside the well does not remain constant during the tests, are described.

The response of conventional tide wells seems well established for two regimes of sea-level oscillations; there is negligible response to wind waves (apart from "set-down") and unit response with no lag to oscillations of tidal period. For oscillations such as tsunamis and harbour seiches, which have periods between these two regimes, the response varies according to the dimensions of