EFFECT OF THE 1981 FORT GRATIOT GAGE MODIFICATIONS ON THE HYDRAULIC REGIME OF THE ST. CLAIR RIVER[1]

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1. INTRODUCTION

Water level gages located along the Great Lakes connecting channels indicate the distinct hydraulic characteristics of these rivers. The hydraulic characteristics at individual gage locations are reflected in the water surface profiles, but must also satisfy the conservation of energy principles. Thus, changes in the apparent hydraulic regime of the river may be produced not only by gage relocation but also by changes in the gage intake location within the same river cross-section if different velocities are encountered. Hydraulic computations for the derivation of flow equations, calibration of dynamic flow modes, etc., require equivalent hydraulic regimes for individual gages. When changes do occur, the relationship between the water surface profiles measured by the new and old gages must be established and gage corrections applied to the relocated gage readings or the equations and models must be revised to reflect the new readings. Application of gage corrections to the new gage readings offers a more expedient solution, but in either case, the gage relationship between the gages representing both conditions must be known.

Occasional relocation of the Great Lakes connecting channel water level gages or their intakes is necessary for various reasons, such as channel improvements or correction of gage problems associated with silting of the water intakes. Relatively recent gage relocations in the St. Clair River involve the Fort Gratiot and St. Clair, Mich., gages during 1969-70. In late 1969 a new Fort Gratiot gage, No. 4098, was installed upstream of the existing gage, No. 4099. The two gages were operated simultaneously during 1970; then in 1971 the old gage was removed. Similarly, in June 1970 a new St. Clair gage, No. 4080, began operating downstream of the existing gage, No. 4081, and after July 1971 the old gage was removed. The apparent effects of relocation of these gages on the water surface profile of the St. Clair River, with appropriate gage corrections, were determined by Quinn (1976). However, operation of the new Fort Gratiot gage became unsatisfactory during 1978, with frequent interruptions in the records, and after June 1979 this gage stopped operating completely because of blockage of the gage intake by silt. The gage was reactivated in April 1981 with the completion of a new gage intake. On December 27, 1981, a baffle was installed on the new intake. In this study, the apparent effect of the Fort Gratiot gage, No. 4098, 1981 modifications on the water surface profile of the St. Clair River is analyzed and a new correction factor determined.

2. EFFECT OF GAGE MODIFICATIONS

The relationship between the Fort Gratiot gages before and after relocation (Nos. 4099 and 4098, respectively, as given by Quinn, 1976) is based on their mutual relationships with the nearby Dunn Paper gage, No. 4096, using monthly data during the open-water season, May-November. This relationship is summarized by the three following equations for gage elevations in feet above IGLD (1955):

$$\text{Gage } 4099 = 1.0327\ (\text{Gage } 4096) - 18.669 \tag{1}$$

$$\text{Gage } 4098_{70} = 1.0327\ (\text{Gage } 4096) - 18.494 \tag{2}$$

$$\text{Gage } 4099 = \text{Gage } 4098_{70} - 0.18 \tag{3}$$

Eq. (1) is based on a long period of data, 1959-70, and represents a strong relationship. Eq. (2) represents the same slope equation, using available data (1970-75) for the Fort Gratiot gage operating during the 1970's. The intercept of eq. (2) is the median of the intercepts obtained by passing a line with the given slope through each data point. This median of 18.494 compares with the mean value of 18.491 for the 1970-75 period. Eq. (3) is obtained by subtracting eq. (2) from eq. (1) and represents a difference between gages 4099 and 4098 over a wide range of water level conditions. This difference of 0.18 ft is considered more representative than the one obtained from limited simultaneous measurements (0.19 ft for May-November 1970) and was employed in the St. Clair River dynamic flow models.

The same procedure was followed in deriving the effects of the 1981 water intake modifications of the Fort Gratiot gage. Furthermore, since there are no simultaneous records before and after the water intake modifications, the gage relationship method offers the only feasible approach. A second equation was derived for the relationships between gages 4098 and 4096, using the same slope as eq. (1) and the May-November 1981 data. The intercept of the equation, based on the median of the individual data points, is 18.607 and the mean is 18.611. The resulting equation is

$$\text{Gage } 4098_{81} = 1.0327\ (\text{Gage } 4096) - 18.607. \tag{4}$$

The new relationships between gages 4099 and 4098, and between gage 4098 before and after modifications are obtained by subtracting eq. (4) from eqs. (1) and (2), respectively. The resulting equations are

$$\text{Gage } 4099 = \text{Gage } 4098_{81} - 0.06 \tag{5}$$

$$\text{Gage } 4098_{70} = \text{Gage } 4098_{81} + 0.12. \tag{6}$$

Eq. (5) shows that, based on a wide range of water level conditions, 0.06 ft should be subtracted from the present gage 4098 (beginning in 1981) to make it equivalent to gage 4099. Consequently, as shown in eq. (6), 0.12 ft should be added to the present gage 4098 to make it equivalent to this gage in the original installation (during the 1970's). Closer inspection of the intercepts in eq. (2) and (4) indicates that the difference for gage 4098 is actually closer to 0.11 ft, but the value was rounded up to 0.12 ft to

maintain overall agreement. Present determinations are based on only 1 year of open-water data for the new Fort Gratiot gage (May-November 1981) and should be reevaluated when more data become available. Future reevaluation with open-water data is also necessary to determine definitely the effect, if any, of the baffle installation at the new water intake. Preliminary analysis conducted in this study with daily water level data for December 1981 and January 1982 did not produce any definite results. Daily data show considerable short-period variations between gages, and the December-January water levels may be affected by ice concentrations in the lower river, with related backwater effects. Even relatively small ice effects may be more important than the gage adjustments due to water intake modification.

3. RECOMMENDATIONS

It is recommended that water levels from the present Fort Gratiot gage, No. 4098, for 1981 and subsequent years be reduced by 0.06 ft for all hydraulic computations based on discharge equations and model calibrations obtained with flow measurements taken prior to 1970. Before 1981 this adjustment required the reduction of water levels from gage 4098 by 0.18 ft. Consequently, for hydraulic computations based on flow measurements made after 1969, the water levels from the present gage 4098 (after 1980) should be increased by 0.12 ft to make them equivalent to readings taken from the earlier gage (4098) during the 1970-80 period. An alternative correction procedure is to recalibrate discharge equations and models containing the Fort Gratiot gage by adjusting gages 4099 and unmodified 4098 (1970-80) to readings taken from the present gage 4098 during discharge measurements.

4. REFERENCES

Quinn, F. H. (1976): Effect of Fort Gratiot and St. Clair gage relocations on the apparent hydraulic regime of the St. Clair River, GLERL Open File Report, Great Lakes Environmental Research Laboratory, Ann Arbor, Mich. 7 pp.