Technical Memorandum

Project Name:

Task: San Antonio River Improvements Project – Design Conditions Sediment Transport

Title: Design Conditions Sediment Transport Characteristics - Revised

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Introduction
This sediment transport analysis was performed to aid in the evaluation of design condition alternatives for the San Antonio River Improvements Project. It has been produced to compare the sediment transport characteristics of three different design conditions, Design Condition (DC) 1, DC 2, and DC 3B. The design conditions are compared to existing conditions sediment transport characteristics as evaluated in the Geomorphic and Sediment Transport Technical Memorandum (GSTTM). The comparison of sediment transport characteristics includes projecting dominant substrate characteristics for the three different design conditions. The dominant substrate characteristics for the design conditions provide a qualitative assessment with respect to sediment transport to provide supplemental information to the incremental analysis.

The GSTTM developed a South Reach (downstream of the confluence with San Pedro Creek and upstream of Davis Lake) design sediment transport capacity based on existing sediment supply and observed erosion rates. The design transport capacity draws upon sediment transport continuity theory that evaluates a river reach's sediment supply and compares it to the river reach's sediment yield (the amount of sediment leaving the reach). If the sediment yield of the reach is greater than the sediment supply, then the river reach is characterized as an erosive reach, as sediment continuity suggests that the river reach erode to make up the difference between sediment supply and sediment yield. If sediment yield is less than sediment supply, then the river reach is characterized as depositional, since deposition should occur to account for the difference between the sediment supply and sediment yield. Sediment transport continuity is attained when sediment supply and sediment yield are approximately equal. Thus, the design transport capacity recommended in the GSTTM, is approximately equal to an estimation of sediment supply to the South Reach (downstream of the confluence with San Pedro Creek and upstream of Davis Lake).

Sediment Transport Characteristics
Quantifying sediment transport in a river reach is beset with nuance. There are many different empirical relationships that may be used to calculate sediment transport rates that produce different results. As such, quantities provided herein should not be considered absolute. Notwithstanding, special care has been taken in this evaluation to provide a methodology

consistent with the GSTTM to develop a relative comparison between alternative design conditions and provide an assessment of trends.

The GSTTM developed a sediment rating curve for existing conditions in the South Reach (downstream of the confluence with San Pedro Creek and upstream of Davis Lake). The sediment rating curve displays how sediment transport rates vary with flows in the river, where higher magnitude flows are generally able to convey more sediment. Sediment rating curves were developed for DC 1, DC 2, and DC 3B using the same methodology used in the GSTTM to determine existing conditions sediment transport potential. All other variables remained unchanged to assure a valid comparison. For example, only the South Reach, downstream of the confluence with San Pedro Creek and upstream of Davis Lake, was evaluated, and existing sediment supply was used for all design conditions. This allowed for all design conditions to be evaluated on an equal basis with the determination of existing conditions sediment transport potential per the GSTTM. The sediment transport rating curves developed in the GSTTM for existing conditions and for DC1, DC2, and DC3B are shown below in Figures 1 through 4, respectively. The graphs show that Duboys equation was used to estimate sediment transport rates at a variety of flows. Other methods (MPM D50, MPM – HEC-6, and Parker) of calculating sediment transport potential are included for comparison purposes.

Figure 1, Existing Conditions, Sediment Transport Capacity

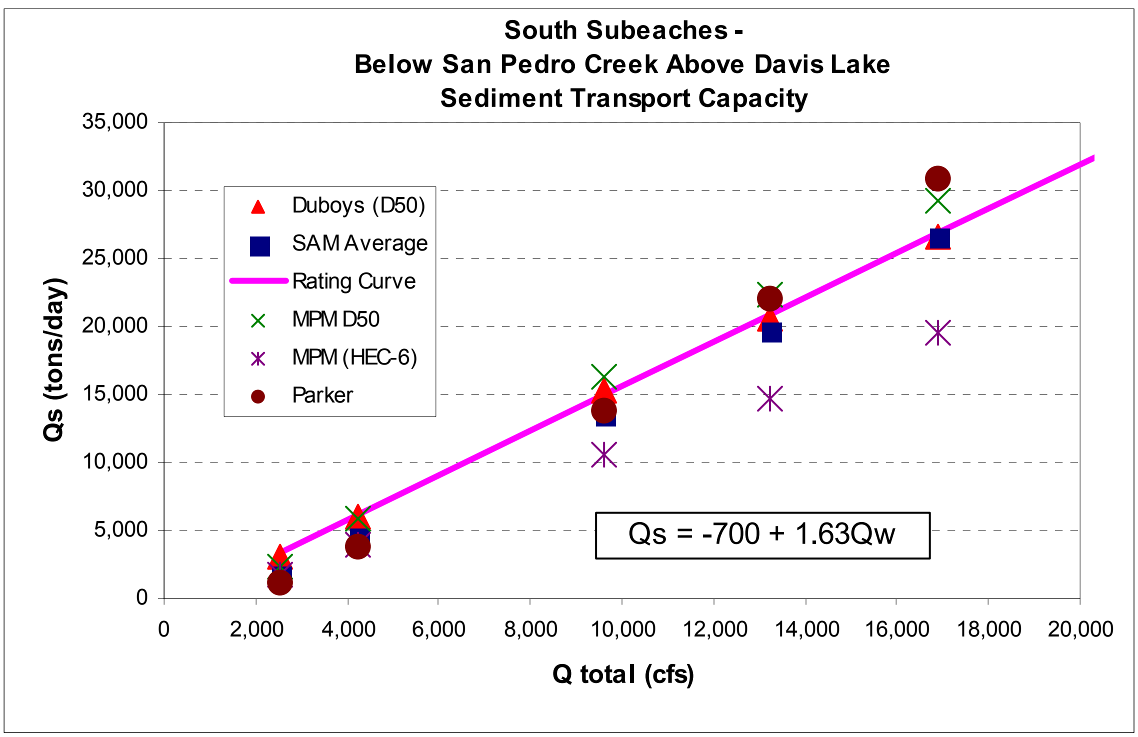


Figure 2, DC 1, Sediment Transport Capacity

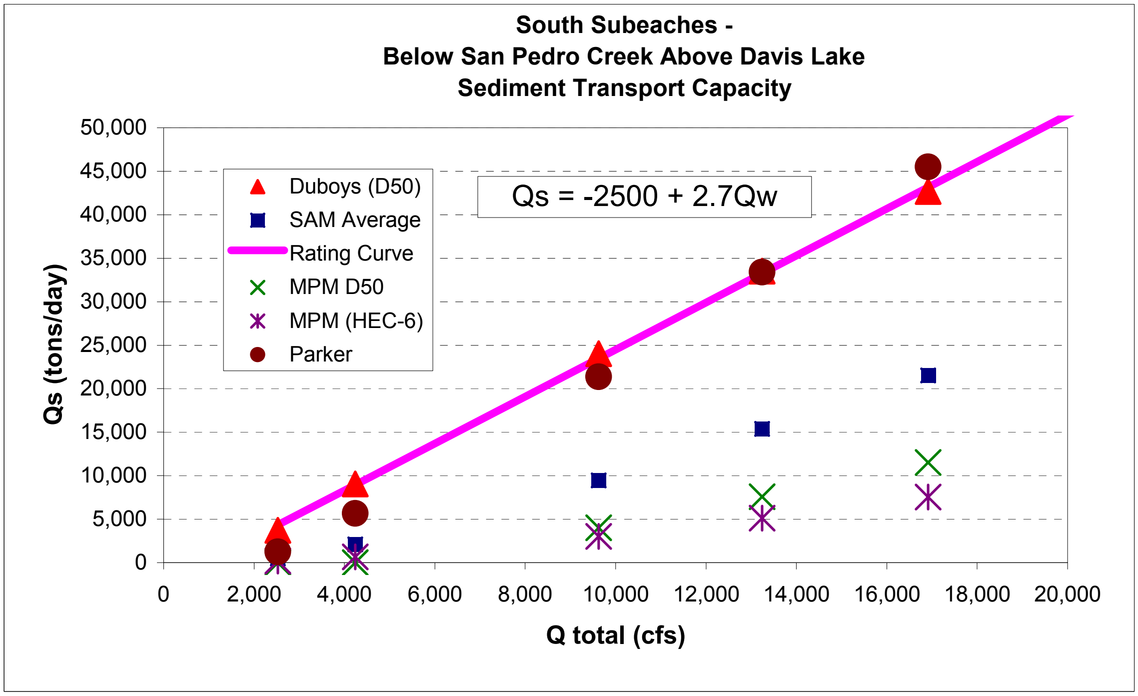


Figure 3, DC 2, Sediment Transport Capacity

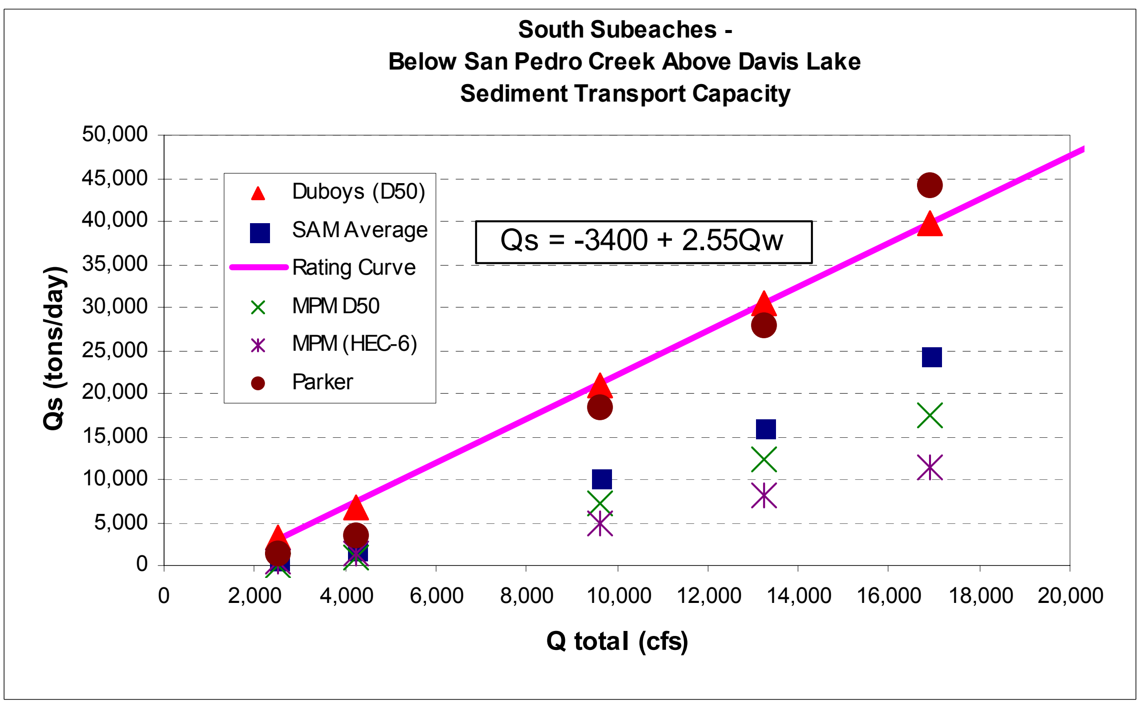
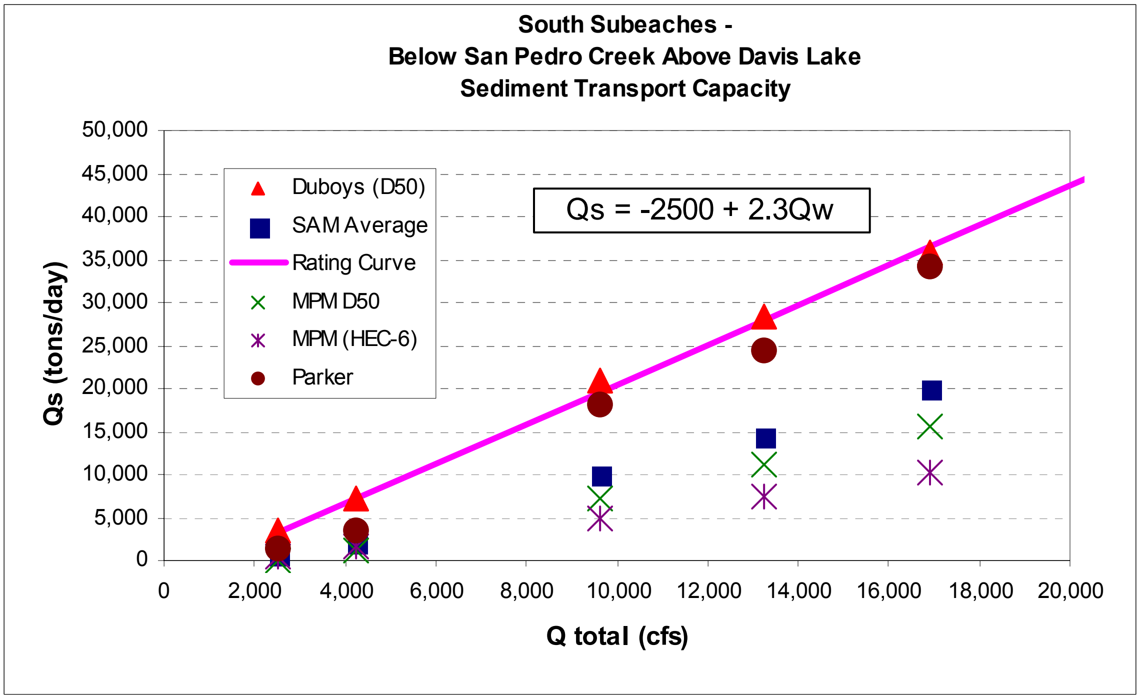


Figure 4, DC 3B, Sediment Transport Capacity



It should be noted that compared to observed erosion rates, the existing conditions rating curve appears to underestimate sediment transport potential. As such, the validity of calculation methods that predict reduced sediment transport capacities (such as both MPM methods) appears suspect.

A linear relationship developed from Duboys equation between sediment transport potential and river flow were developed from the sediment rating curves as shown on each rating curve. These linear relationships show sediment transport potential (Qs) as a function of river flow (Qw). These relationships were used to develop sediment yields for the different design conditions using the same methodology used in the GSTTM to develop average annual sediment yield for existing conditions. Average annual sediment yield of the South Reach was developed through integrating river flows and their probability of occurrence with corresponding sediment transport rates. The linear relationships developed from Duboys equation allowed for calculating sediment transport rates at a variety of flows, which assisted in integrating sediment transport rates with flows and their probability of occurrence. Average annual sediment yields for existing conditions and the three design conditions are provided in Table 1.

Table 1

Design Condition	Average Annual Sediment Yield tons/year	Sediment Yield as a Percentage of Existing Conditions
Existing Conditions	13,096	100 %
Design Condition 1	14,020	107%
Design Condition 2	10,562	81%
Design Condition 3B	10,928	83%

The GSTTM includes an analysis of sediment transport equilibrium conditions, and that the recommended average annual sediment yield for the South Reach is 4526 tons per year. That represents a reduction to approximately 35% of the existing sediment yield for that reach of 13,096 tons per year (per GSTTM). As such, all design conditions are anticipated to represent varying levels of erosive conditions, since they are greater than the anticipated equilibrium condition of 4526 tons per year. This means that erosion may be expected to occur unless the channel is properly armored to resist erosive conditions. DC1 appears to increase erosive conditions while DC2 and DC3B appear to provide reduced erosive conditions when compared to the existing channel.

Although the GSTTM recommends that sediment transport potential be reduced to 35% of the existing sediment yield, it should be considered an ideal and not a practicable result. There can be no sediment transport continuity without sediment supply, and there would be no sediment supply if all upstream reaches provided sediment transport continuity because there would be no erosion to create a sediment source. As such, the ideal of sediment transport continuity is not attainable without discontinuity elsewhere, and it may not be attainable within the South Reach. The most effective way to reduce the sediment transport capacity is to reduce the slope of the channel. This is not practical in the overall sense since it would necessitate enormous cut and fill volumes. However, the channel's slope may be practically reduced by "stair-stepping" the channel bed, creating discrete drops in the riverbed, that also serve to provide grade control that resists erosion of the riverbed. There is a limit to the effect creating discrete drops may have in reducing sediment transport potential, and based on review and manipulation of the hydraulic model that limit appears to have been reached. Also, attaining sediment transport continuity is only one of many design objectives, some of which are conflicting. For instance, reducing sediment transport capacity through reducing slope also reduces conveyance capacity and may have a negative impact on providing flood control. Thus, the reduction in sediment transport capacity represented by Design Conditions 2 and 3B may be all that may be practically attained in light of physical limitations, cost considerations and with consideration of other design objectives.

Dominant Substrate Characteristics

The existing South Reach channel is considered erosive, as its sediment transport capacity is greater than sediment supply of the reach. Most of the South Reach is armored to resist erosion. The armor in the South Reach mainly consists of concrete rubble that is generally 6 to 12 inches in diameter. Some gravel bars do exist within the reach, however, where sediment has deposited resulting from local hydraulics that allow for deposition. These gravel bars are an expression of sediment moving through the system supplied to the South Reach. Sediment samples from these gravel bars show that sediment that is moving through the San Antonio River and supplied to the reach is typically in a size range from coarse sand (~0.1 inch) to small gravel (~1.0 inch). This size range ranks high for habitat quality in the incremental analysis.

It may be argued that dominant substrates for all design conditions must be an armor layer of material of far greater size than provides high quality habitat (according to incremental analysis criteria) or else the riverbed would be unstable due to erosive conditions. It is anticipated that the riverbed must be stable under 100-year flood conditions. As such, substrate sizes required for design conditions to be stable should generally be similar to the size of concrete rubble in the existing channel. This of course will vary with the severity of local hydraulics. Sediment moving through the system that is more desirable from a habitat standpoint should be considered transient in nature. That is the finer sediment being supplied to the South Reach will be deposited (where local hydraulics allow) as floodwaters recede, and will provide habitat until the next substantial flow. After the next substantial flow occurs, a new layer of fine sediment should be deposited (where local hydraulics allow) to replace the fine sediment mobilized at higher flow rates. Thus, the riverbed may be thought of as a conveyor belt moving material during high flows. When flows recede, the conveyor belt stops, and sediment deposits where local hydraulics are less severe. That will likely be the nature of sediment providing high quality habitat for all design conditions. Based on calculations of average annual sediment yield for the various design conditions, it is anticipated that more fine-grained sediments will deposit under DC's 2 and 3B than will deposit under DC1.