APPENDIX A

List of input data records used by GSTARS4

Alphabetic list of the input data records used in GSTARS4

Title of Record Page

The detailed descriptions of the records are given in the following pages. The records are presented in the same order in which they should appear in the GSTARS4 input file.

Record CM

COMMENT

Optional

Comment lines are lines containing informative text usually employed to document the input data files. The input data file can have any number of comment lines anywhere in the file. Any line beginning with the uppercase characters CM will be ignored. Any input record that has an asterisk (‘*’) or a blank character as the first character will also be ignored. Comment lines using CM or an asterisk are echoed to the .DBG output file, but the lines with a blank character in the first column are not.

Field	Variable	Value	Description
0	*ID*	CM	Record identification.
		*	Record identification.
		Blank	Record identification.
1-10			Any ASCII string

Record TT

TITLE OF STUDY

Required

The TT record is used to define a title, i.e., a short text that may be used to identify the study or the datafile. Up to three TT records can be used (they must be present, but they may be left blank). The text typed in fields 1 to 10, including blank spaces, will be echoed to the output files generated by GSTARS4. TT records beyond the third are ignored.

Field	Variable	Value	Description
0	*ID*	TT	Record identification.
1-10	*TITLE*		ASCII text to be echoed in the GSTARS4 output file

Record MT

METRIC UNITS OPTION

Optional

Although the foot (ft) and the pound (lb) are the primary units of length and mass used throughout this manual, GSTARS4 can also use the International System (SI) of units. This is accomplished by including record MT in the input file. Record MT is used to setup GSTARS4 to use the SI units in its input and output files. If this record is used, follow the table below to specify the appropriate units for all of the fields in each record:

If manual reads:	**Use SI unit:**
feet (ft)	meter (m)
cubic foot per second (ft^3/s)	cubic meter per second (m^3/s)
ton per day (ton/day)	tonne per day, i.e., metric ton per day (tonne/day)
pound per cubic foot (lb/ft^3)	kilogram per cubic meter (kg/m^3)
pound per square foot (lb/ft^2) (stress)	Pascal (Pa)
pound per square foot per hour ($lb/ft^2/hr$)	Pascal per hour (Pa/hr)

Table of conversion factors used in GSTARS4

1ft = 0.3048 m	1 m = 3.281 ft
1 ft^2 = 0.0929 m^2	1 m^2 = 10.76 ft^2
1 ft^3 = 0.02832 m^3	1 m^3 = 35.31 ft^2
1 ft^3/s = 0.02832 m^3/s	1 m^3/s = 35.31 ft^3/s
1 lb = 0.4536 kg	1 kg = 2.205 lb
1 ton = 2,000 lb = 907.2 kg = 0.9072 tonne	1 tonne = 1,000 kg = 2,205 lb = 1.102 ton
1 lb/ft^3 = 16.02 kg/m^3	1 kg/m^3 = 0.06243 lb/ft^3
1 lb/ft^2 = 47.88 Pa (stress)	1 Pa = 0.02089 lb/ft^2 (stress)

The units of the following parameters remain unchanged: in record TM, the water temperature units remain as defined; in record SG, the values of *DRL* and *DRU* are always given in mm, but the dry specific weight must be specified in kg/m^3; in record CS,

the unit of *ERMASS* becomes s^2/m/h; in record SE, the value of *OMEGA* is always given in metric units conforming to the values of table 3.3; in record CH, the values of *CS1* and *CS2* are always specified in mg/l, and *CSCOEF3* is always specified in l/mg.

Field	Variable	Value	Description
0	*ID*	MT	Record identification.

Record TR

TRIBUTARY ROUTING OPTION

Optional

The TR record is used to allocate the computational memory for a routing of interchange of water and sediment between the main channel and tributary, as explained in section 2.1.5.2 and 6.6.2.

Field	Variable	Value	Description
0	*ID*	TR	Record identification.

Record NS

NUMBER OF STATIONS

Required

The NS record defines the number of cross sections, or stations, to be used by the program, and the maximum number of discretization points defining the cross sections. GSTARS4 uses dynamic memory allocation, therefore there are no imposed limits on these values.

Field	Variable	Value	Description
0	*ID*	NS	Record identification.
1	*NSTA*	+	Number of cross sections defined in the study
2	*NPTS*	+(≥3), or blank	Maximum number of discretization points for each cross section (default is 50)

Record YX

ALTERNATE COORDINATE ORDER

Optional

The YX record allows the option of using cross-section coordinate input data pairs with the bed elevation (*y* value) followed by the lateral location (*x* value) on the XS record. The default is lateral location followed by bed elevation (see record XS).

Field	Variable	Value	Description
0	*ID*	YX	Record identification.

Record ST

STATION (CROSS SECTION) PROPERTIES

Required

The ST record is used to define a number of cross section properties: its location, number of coordinate points used to define its geometry, type of section (whether it is a control or not), constant modifications to coordinate data, local energy loss coefficient, and transmissivity properties (transmissivity is relevant only for the case when sediment transport is activated, otherwise it has no effect on the backwater computations). The stations are entered in order, in the downstream direction, starting at the farthest upstream cross section. Each station is identified by a set of several records: ST, ND, XS, and RH.

Field	Variable	Value	Description
0	*ID*	ST	Record identification.
1	*STA*	+	Location of the station, i.e., its coordinate measured from a reference station located downstream (ft).
2	*NPOINTS*	+	Total number of points, i.e., coordinate pairs, used in records XS to define the geometry of the cross section.
3	*ISWITCH*	0 or blank	The current station is not a control section; therefore, no boundary condition is imposed there.
		1	The current station is a control section; therefore, the water surface elevation is a known function of the discharge (boundary condition) at this station.
4	*ITYP*	0 or blank	If *ISWITCH* is equal to 0.
		1	If ISWITCH = 1. This information is redundant, but it is kept here to allow for future developments of GSTARS4 without compromising backward datafile compatibility.

Field	Variable	Value	Description
5	*BEC*	0 or blank	No action is taken by GSTARS4.
		+/-	The constant elevation, BEC, will be added to the given bed elevations across the channel at the present station.
6	*XSWF*	0 or blank	No action is taken by GSTARS4.
		+	The scaling factor XSWF is applied to the lateral location of the data points that define the cross section at this station.
7	*CLOSS*	+	Local energy loss coefficient to account for bends or natural and man-made structures upstream or at this cross section.
8	*TRSMSV*	0 or blank	Cross section is not a transmissive cross section.
		1	Cross section is transmissive with no mixing across stream tubes.
		2	Cross section is transmissive with full mixing across stream tubes.

Record ND

NUMBER OF SUBCHANNELS

Required

The ND record is used to define areas of same roughness in the cross section. Its most common use is to define main channel and flood plain locations. The roughness coefficient values corresponding to each channel division are given on the RH record. The subchannels are confined within the lateral locations specified in this record. The first subchannel is defined by the first coordinate pair entered in the XS record and by the first lateral location defined in the ND record. A maximum of 9 channel divisions can be defined. Note that if $XSWF \neq 0$ in record ST, the values of DL will also be multiplied by that factor.

Field	Variable	Value	Description
0	*ID*	ND	Record identification.
1	*NDIVI*	+	Number of channel divisions at the present station.
2-10	*DL*	+/-	Locations of the channel division boundaries. These locations are defined as a distance from a reference point in the cross section. They must be given in order, starting at the point farthest left in the cross section (looking downstream).

Example: if the cross section consists of only one channel, i.e., if the roughness coefficient is the same along the cross section, then *NDIVI* = 1 and DL must be equal to or greater than the last *CROSLOC* value on the XS record(s) defining the cross section. This would be the case if a river consists of main channel only, with no flood plains.

If a river has, say, a main channel, a left, and a right flood plain, then *NDIVI* = 3 which would be followed by 3 locations for the channel division boundaries. The value corresponding to the end point of the left flood plain (looking downstream) would be entered first. The left flood plain would be bounded by this point and by the first *CROSLOC* value of the station's XS record. The point corresponding to the end of the main channel/start of the right flood plain would be entered as the next *DL* value. The main channel would be defined as the perimeter bounded by the first two *DL* values. Finally, a number equal to, or greater than, the last *CROSLOC* value on the XS record would be entered as the last *DL* value to define the right flood plain.

Record XS

CROSS SECTION GEOMETRY

Required

The XS record is used to define the cross section geometry at the given station. The cross section is described by a set of coordinate pairs. Each coordinate pair contains a lateral location and a bed elevation. The set of data points for each cross section must be given starting from the left side of the channel, looking downstream, and progress towards the right-hand side. The maximum number of coordinate points per cross section is defined by variable *NPTS* in record NS.

Field	Variable	Value	Description
0	*ID*	XS	Record identification.
1,3,5,7,9*	*CROSLOC*	+/-	Lateral coordinate, measured from a reference point, of the data points that define the cross-sectional geometry at the current station (ft).
2,4,6,8,10*	*BOTTOM*	+	Vertical coordinate (bottom elevation) of the data points that define the cross-sectional geometry at the current station (ft).

* Note: Input of cross section coordinate data does not require that the pair values fill all available fields. However, fields must be skipped in pairs, i.e., if field 5 (*CROSLOC*) is skipped, then field 6 (the corresponding *BOTTOM*) must also be skipped. The number of XS records per station is not a consideration, but the number of coordinate pairs entered in each station must equal the corresponding *NPOINTS* value in record ST. In addition, if a YX record is included in the input file, the cross section geometry must be input using bottom elevation, lateral location pairs instead of the lateral location and bottom elevation pairs as shown above.

Record RH

ROUGHNESS COEFFICIENTS

Required

Record RH is used to specify the roughness coefficient for each of the channel divisions defined in record ND for each station. The friction factors, or resistance coefficients, used must correspond to the particular roughness equation selected (see RE record description). By default, GSTARS4 uses Manning's equation.

Field	Variable	Value	Description
0	*ID*	RH	Record identification.
1-9	*RN*	+	Friction factor for each of the channel divisions defined in record ND. Values must be entered using the same order as in record ND, i.e., from the left to the right side of the cross section (looking downstream).

Record LI

LATERAL INFLOW OF SEDIMENT AND/OR WATER

Optional

This record is used to indicate that a particular section has a lateral inflow of sediment and/or water. The information regarding the lateral inflows is stored in a separate external file whose name is given to GSTARS4 using record LI. There should be one external data file for each lateral inflow. One record LI should appear at each cross section with lateral inflow.

Field	Variable	Value	Description
0	*ID*	LI	Record identification.
1-5	*FNAME*	string	An alphanumeric text string of up to 40 characters, including extension, with the name of the file containing the data corresponding to the lateral inflow for the section.

Record TI

TRIBUTARY INFLUENCE

Optional

The TI record is used to indicate properties of a tributary to compute interchange of water and sediment between the main channel and a tributary. Volume of a tributary can be defined in the form eq. (2.24) and it can be rewritten as

$$\text{Volume (ft}^3\text{)} = C1\ (\text{water stage at the mouth (ft)} - C3)^{C2} \quad \text{for English unit}$$

$$\text{Volume (m}^3\text{)} = C1\ (\text{water stage at the mouth (m)} - C3)^{C2} \quad \text{for metric unit}$$

If there is/are TI record(s), the TR record (see TR record description) should be included in the input file.

Field	Variable	Value	Description
0	*ID*	TI	Record identification.
1	*C1*	+	Value of coefficient *C1*.
2	*C2*	+	Value of coefficient *C2*.
3	*C3*	+	Value of coefficient *C3*.

Record MX

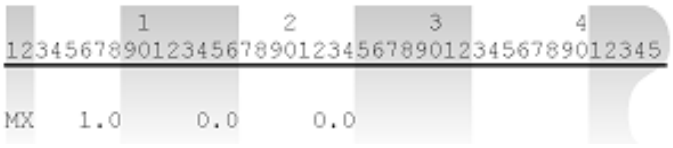
SEDIMENT MIXING ACROSS STREAM TUBES AT LATERAL INFLOW POINTS

Optional (Required if lateral inflows are specified using LI record(s))

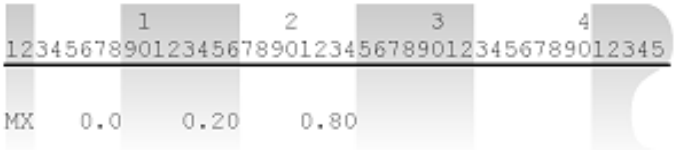
Record MX is used to specify the distribution of sediment across stream tubes at lateral inflow points. The data is entered in tabular format, specifying the percentage of the total incoming sediment (from the lateral inflow only; the sediment coming from the upstream computational reach will not be affected by the data in this record) falling into stream tube. If no sediment transport computations are performed, this record will be ignored.

Field	Variable	Value	Description
0	*ID*	MX	Record identification.
1-5	*PSIST*	+	The percentage of sediment staying in the corresponding stream tube. A maximum number of *NSTUBE* values must be entered, and the sum of all *PSIST* values should be 1.

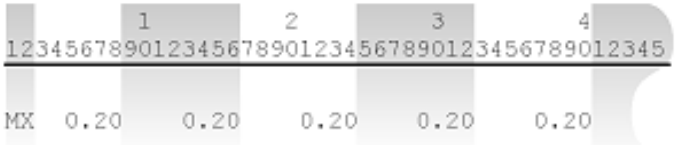
Example: A river reach is being simulated using three stream tubes. If the incoming sediment is coming from the left bank and no mixing is allowed (i.e., no mixing across stream tubes), the following record could be used:



If the incoming sediment is entering from the right bank and if 20% of it is allowed to move into the middle stream tube, the following record may be used:



If five stream tubes are used and the lateral inflow gets fully mixed:



Record RE

ROUGHNESS EQUATION AND FRICTION LOSS CALCULATION

Optional

The RE record is used to select the calculation method for friction loss calculations and the roughness equation. These parameters are used in the backwater computations. The Manning, Darcy-Weisbach, and Chezy equations are available. If present, record RE must be placed after the last cross-sectional set of records, i.e., after the [ST, ND, XS, RH] set for the last cross section. If no RE record is found, the program will default to the Manning equation.

Field	Variable	Value	Description
0	*ID*	RE	Record identification.
1	*IOPTFR*	1 or blank	Compute friction loss using the average slope of the adjacent reaches (default).
		2	Friction loss is computed using the geometric mean slope of the adjacent reaches.
		3	Friction loss is computed using average conveyances.
		4	Friction loss is computed using the harmonic mean slope of the adjacent reaches.
2	*EQROUGH*	MANNING	Use Manning equation; use Manning's roughness coefficients in record RH (default).
		DARCY	Use Darcy-Weisbach equation; use Darcy's friction factors in record RH.
		CHEZY	Use Chezy equation; use Chezy's resistance coefficients in record RH.

Record NT

NUMERICAL TECHIQUE

Required

Number of stream tubes, numerical scheme, and time step for flow simulation scheme should be defined in this record.

The number of calculations performed in GSTARS4 is proportional to the number of stream tubes used, therefore more stream tubes also means longer computation times. In general, three stream tubes provide enough detail across a channel, but up to five stream tubes can be used in GSTARS4.

Field	Variable	Value	Description
0	*ID*	NT	Record identification.
1	*NSTUBE*	1-5	Number of stream tubes to be used in the computations.
2	*ISOLE*	blank	Steady simulation
		2	Unsteady simulation with LPI method (FLDWAV)
		3	Unsteady simulation with LPI method (MIKE 11)
3	*DT*	+	Computation time step (in hour)

Record IT

NUMBER OF ITERATIONS

Required

This record is used to define the desired number of time steps for the run. There are two time stepping procedures in GSTARS4 the water-routing and the sediment-routing procedures. Time steps can be defined for each of these procedures. The number of water routing time steps is defined by *ITIMAX*, and its duration is defined by *DTIME* (all time steps have the same duration in time). The number of sediment-routing time steps is defined by *NITRQS*, and their duration is *DTIME*/*NITRQS*. The number of sediment-routing time steps is a multiple of *ITIMAX*; i.e., several sediment routing time steps can be performed during each water-routing time step. During each of the sediment time steps, the hydraulic parameters are kept constant.

Field	Variable	Value	Description
0	*ID*	IT	Record identification.
1	*ITIMAX*	+	The number of time steps to be performed, pertaining to the water-routing calculations.
2	*NITRQS*	+	The number of sediment-routing time steps to be carried out during each hydraulic time step.
3	*DTIME*	+	Duration of time step for the backwater computations.
4	*TSUNITS*	0, day	Time step unit is a day. This is the default value.
		HOUR	Time step unit is the hour.
		MIN	Time step unit is the minute.
		SEC	Time step unit is the second.

Record QQ

TYPE OF DISCHARGE INPUT

Required

This record is used to specify the type of input format chosen for the water discharge information. There are two options: the discharge values can be given as a table (discharge per time step) or as discretized discharges in time blocks of different durations.

Field	Variable	Value	Description
0	*ID*	QQ	Record identification.
1	-	-	Leave blank
2	*IOPTQ*	TABLE OF DISCHARGE*	Enter the discharges in tabular form. Discharges must be given for each time step. This is the default.
		DISCRETIZED DISCHARGES†	Enter the discharges as time blocks with specified duration.

* TA or 0 in field 2 is also acceptable to select the table of discharges option.
† DI or DD in field 2 is also acceptable to select the discretized discharges option.

Record SS

TYPE OF STAGE INPUT

Required

Record SS is used to define the type of stage input format at the control section(s). There are three options: a rating curve defining a stage-discharge relationship, a table with a list of stage-discharge values, or a table of discharges at the dam outlet.

Field	Variable	Value	Description
0	*ID*	SS	Record identification.
1	-	-	Leave blank
2-3	*IOPTQ*	RATING CURVE	Use a rating curve, as described in the RC record.
		DISCHARGE TABLE	Use a list of stage values with corresponding discharges (see description of SQ record).
		DISCHARGE AT DAM	Use a table of discharges instead of stage values at the outflow boundary.

Record TQ

TABLE OF DISCHARGES

Optional

This record is used when the TABLE OF DISCHARGES option (QQ record) is used in conjunction with the RATING CURVE option (SS record). The TQ record is used to enter a table with the water discharge for each time step. One value of the water discharge must be entered for each time step; i.e., *ITIMAX* values of the water discharge must be given (see IT record). When the TQ record is used, a stage-discharge relationship must be defined using the RC record.

Field	Variable	Value	Description
0	*ID*	TQ	Record identification.
1-10	*QQ*	+	Value of the water discharge for each time step. The number of water discharge values must be equal to the value of *ITIMAX* entered in the IT record (ft^3/s).

Record DD

DISCRETIZED DISCHARGES

Optional

This record is used when the option DISCRETIZED DISCHARGES is used in record QQ. The values of the discharges are entered in time blocks with duration multiple of the time step. The values are entered in a two-column table with the duration of the discharge in field 1 and its value in field 2. The sum of all the values in field 1 must correspond to the total duration of the run; i.e., it must equal the number of time steps for the run (value *ITIMAX* in record IT).

Field	Variable	Value	Description
0	*ID*	DD	Record identification.
1	*NDAY*	+	Number of time steps corresponding to the duration of the discharge defined in field 2.
2	*QI*	+	Value of the water discharge. Note that, for the duration of *NDAY*DTIME*, the system is considered in steady state with the constant discharge given in *QI* (ft^3/s).

Record NC

NUMBER OF RATING CURVES

Optional

The NC record is used to input the number of rating curves used for the reach being modeled. This record must be entered immediately before the RC records with the rating curve information.

Field	Variable	Value	Description
0	*ID*	NC	Record identification.
1	*NCURVES*	+	Number of rating curves defined in the reach.

Record RC

RATING CURVE

Optional

Each RC record contains all the information pertinent to a particular rating curve. Each rating curve is a stage-discharge relationship defined in the form

$$Stage \text{ (ft)} = C1 \ (discharge \ [\text{ft}^3/\text{s}])^{C2} + C3$$

The RC record, which is used when the options RATING CURVE is selected in the SS record, contains the number of the station where the rating curve applies, as well as the values of the coefficients C1, C2, and C3. The total number of rating curves used is defined in the NC record.

Field	Variable	Value	Description
0	*ID*	RC	Record identification.
1	*ISTA*	+	Number of the station where the rating curve applies. Note that the cross section numbering starts at the station farthest upstream and proceeds downstream.
2	*C1*	+/-	Value of the coefficient *C1*.
3	*C2*	+/-	Value of the coefficient *C2*.
4	*C3*	+/-	Value of the coefficient *C3*.

Record TL

CROSS SECTION IDENTIFICATION RECORD FOR THE STAGE-DISCHARGE TABLE

Optional

This record is used when SQ records are used to define pairs of stage-discharge values. Record TL is used to identify the station number for which the SQ records apply. The cross sections are numbered starting from the section furthest upstream (station 1) and proceeding downstream. The last station (farthest downstream) is numbered *NSTA* (see record NS).

Field	Variable	Value	Description
0	*ID*	TL	Record identification.
1	*ITABLE*	+	Number of the station for which the values given in record SQ apply.

Record SQ

STAGE-DISCHARGE TABLE

Optional

The SQ record is used when option TABLE OF DISCHARGES in record QQ is used in conjunction with option STAGE DISCHARGE TABLE in record SS. In this case, SQ records are used to build a table defining water discharges and corresponding stages at the downstream-most end of the reach for each time step. The stage-discharge pairs are entered in each row of the table in the proper time sequence. The same pair can be used for multiple consecutive time steps, but the summation of all *TSCOUNT* values must equal the variable *ITIMAX* defined in the IT record.

Field	Variable	Value	Description
0	*ID*	SQ	Record identification.
1	*QQ*	+	Value of water discharge (ft^3/s).
2	*STAGE*	+	Value of corresponding water elevation (ft).
3	*TSCOUNT*	0,1	Use discharge and stage values for a single time step (default).
		+	Use discharge and stage values for multiple time steps.

Record HR

INITIAL STAGE AT RESERVOIR

Optional (Required for reservoir routing)

This record is used when option DISCHARGE AT DAM is specified in record SS. It is used to define the initial water stage at the dam for reservoir routing computations. Variable *HFREQ* is used to define the frequency at which the reservoir's capacity table is regenerated by GSTARS4., i.e., the number of time steps between updates of the capacity table.

Field	Variable	Value	Description
0	*ID*	HR	Record identification.
1	*HFREQ*	0, blank	Compute the reservoir's capacity table at the first time step only (use this option when there are no sediment routing computations).
		+	Number of time steps between updates of the reservoir's capacity table. *HFREQ* = 1 means that the capacity table is updated at every time step. *HFREQ* > *ITIMAX* (see record IT) means the same as *HFREQ* = 0.
2	*RSTAGE*	+	Stage at the dam for time step 1 (ft).
3	*RSTGMIN*	+	Minimum value of the stage at the dam (ft). During the course of the reservoir routing computations, the stage at the dam will never fall below this level.
4	*RSTGMAX*	+	Maximum value of the stage at the dam (ft). During the course of the reservoir routing computations, the stage at the dam will never rise above this level. Must be ≥ *RSTGMIN*.

Record DR

TABLE OF DISCHARGES FOR RESERVOIR ROUTING

Optional

This record defines a table of river and reservoir discharges for reservoir routing. It is used when the TABLE OF DISCHARGES is used in record QQ and option DISCHARGE AT DAM is used in record SS. The values of the river and dam discharges must be entered in the proper time sequence. The same pair of discharges can be used for multiple consecutive time steps, but the summation of all *NDAY* values must be equal to the variable *ITIMAX* defined in record IT.

Field	Variable	Value	Description
0	*ID*	DR	Record identification.
1	*NDAY*	0, 1, or blank	Use discharge values for one single time step (default).
		+	Use the discharge values for multiple time steps.
2	*QRIVER*	+	Value of inflow water discharge (river discharge) (ft^3/s).
3	*QDAM*	+	Value of outflow water discharge (discharge at the dam) (ft^3/s).

Record RQ

DISCRETIZED DISCHARGES AT A DAM

Optional

Record RQ is when the DISCRETIZED DISCHARGES is used in record QQ and option DISCHARGE AT DAM is used in record SS. It works in similar manner to record DD, but it is used to enter the water discharge at the dam. Values are entered in a two-column table with the duration of the discharge in column 1 (in multiples of the time step) and a corresponding value of the discharge in column 2. All value pairs must be entered in the proper chronological order. The sum of all the *NDAY* values must be equal to the number of time steps in the run (variable *ITIMAX* in record IT).

Field	Variable	Value	Description
0	*ID*	RQ	Record identification.
1	*NDAY*	0, 1, or blank	Use discharge values for one single time step (default).
		+	Use the discharge values for multiple time steps.
2	*QDAM*	+	Value of water discharge at the dam (ft^3/s).

Record UT

UPSTREAM FLOW BOUNDARY CONDITION

(Selection of Option for Upstream Flow Boundary Condition)

Required for Unsteady Flow Simulation

Record UT should be used to specify the upstream boundary condition.

Field	Variable	Value	Description
0	*ID*	UT	Record identification.
1	*KU*	2	Upstream boundary condition is a table (time vs. discharge). Other boundary conditions are not used for this GSTARS4 version.
2	*NULINES*	+	Number of lines for the definition of table. Number of lines used for UB.

Record UB

UPSTREAM FLOW BOUNDARY CONDITION

Required For Unsteady Flow Simulation

Record UB should be used to define upstream boundary condition. UB records define time vs. discharge table of the upstream boundary. Number of UB records should be the same as *NULINES* defines in the UT record.

Field	Variable	Value	Description
0	*ID*	UB	Record identification.
1			Leave the field blank
2	*T1*	+	Time in hour.
3	*ST1*	+	Discharge (cfs or cms) at the upstream at *T1*.

Record DT

DOWNSTREAM FLOW BOUNDARY CONDITION

(Selection of Option for downstream Flow Boundary Condition)

Required For Unsteady Flow Simulation

Record DT should be used to specify the downstream boundary condition.

Field	Variable	Value	Description
0	*ID*	DT	Record identification.
1	*KD*	1	Downstream boundary condition is a table (time vs. stage).
		2	Downstream boundary condition is a table (time vs. discharge).
		9	Downstream boundary condition is a rating curve
2	*NDLINES*	+	Number of lines used for DB.

Record D0

DOWNSTREAM FLOW BOUNDARY CONDITION

(Initial Water Stage at Downstream Boundary)

Required if *KD* = 2 or 9 in DT Option

A D0 record is required to define the initial water surface elevation at the downstream boundary. GSTARS4 calculates the initial flow condition in the channel by steady simulation based on given water surface elevation at the downstream boundary. The calculated flow condition is used as the initial condition for the unsteady flow routing.

Field	Variable	Value	Description
0	*ID*	D0	Record identification.
1	*IWSE*	+	Initial water surface elevation at the downstream boundary.

Record DB

DOWNSTREAM FLOW BOUNDARY CONDITION

Required For Unsteady Flow Simulation

Record DB should be used to define downstream boundary condition. DB records can be either a table or rating curve. If *KD* = 1 or 2 in DT record, DB records define a table of time vs. water stage or discharge, respectively. If the downstream boundary condition is specified with rating curve, KD = 9 in DT records, then a DB record defines a rating curve with coefficient in the form

$$Stage \text{ (ft)} = C1 \ (discharge \ [\text{ft}^3/\text{s}])^{C2} + C3$$

Number of DB record(s) should be the same as *NDLINES* defines in the DT record.

The form of DB record(s) varies with respect to the specified downstream boundary condition. One of DB record(s) form should be used for the input file.

1. Downstream boundary condition is a table with time vs. stage.

Field	Variable	Value	Description
0	*ID*	DB	Record identification.
1			Leave the field blank
2	*TN*	+	Time in hour.
3	*STN*	+	Water stage (ft or m) at the upstream at *TN*.

2. Downstream boundary condition is a table with time vs. discharge.

Field	Variable	Value	Description
0	*ID*	DB	Record identification.
1			Leave the field blank
2	*TN*	+	Time in hour.
3	*STN*	+	Discharge (cfs or cms) at the upstream in *TN*.

3. Downstream boundary condition is a rating curve.

Field	Variable	Value	Description
0	*ID*	UB	Record identification.
1			Leave the field blank
2	*C1*	+	Value of the coefficient *C1*.
3	*C2*	+	Value of the coefficient *C2*.
4	*C3*	+	Value of the coefficient *C3*.

Record SE

SEDIMENT TRANSPORT EQUATION

Required for Sediment Transport

The SE record selects the sediment transport equation used to compute sediment carrying capacities for size fractions greater than 0.0625 mm. This record also allows the control of the active layer thickness.

Field	Variable	Value	Description
0	*ID*	SE	Record identification.
1	*ISED*	+	Variable to choose the sediment transport equation used to compute sediment carrying capacity. The options are:
		1	Meyer-Peter and Muller's method.
		2	Laursen's method.
		3	Toffaleti's method.
		4	Engelund and Hansen's method.
		5	Ackers and White's 1973 method.
		6	Yang's 1973 sand with 1984 gravel methods.
		7	Yang's 1979 sand with 1984 gravel methods.
		8	Parker's method.
		9	Yang's 1996 modified method. (Requires additional wash load parameter input. See SP record.)
		10	Ackers and White's method with the revised (1990) coefficients.
		11	DuBoys' method
		12	Modified Laursen's method (by Madden)
		13	Ashida and Michiue's method
		14	Tsinghua University method (requires additional parameter input in field 3).

Field	Variable	Value	Description
2	*NALT*	0 or blank	Use the default active layer thickness of 14**D*(*LSF*), where *D*(*LSF*) is the geometric mean sediment size of the largest size fraction available (with at least 1%) at a specific cross section for a particular time step.
		+	A user-specified positive multiplication factor for defining the thickness of active layer given as *TAL* = *NALT* **D*(*LSF*).
3	*RFILL*	blank, ≤ 0	Use standard bed change computations (default).
		> 0	Use fill from the bottom for reservoir deposition computations.
4	*OMEGA*[*]	0	Default value of the factor for Tsinghua University's equation (default is 300).
		+	User defined value for the Tsinghua University's equation, following the nomenclature in table 3.3.

[*] Variable *OMEGA* must be specified only if the value of variable *ISED* is set to 14. If *ISED* ≠ 14, specifying a value for *OMEGA* has no effect in the GSTARS4 computations.

Record SP

HIGH CONCENTRATION TRANSPORT PARAMETERS

Optional (with Yang's 1996 modified formula)

The SP record or S1 record(s) allow the user to input the additional parameter values needed by Yang's 1996 modified formula. SP and S1 are mutually exclusive. SP or S1 record(s) must be included in the input file if the *ISED* value on the SE input record is set to select Yang's 1996 modified formula. A SP record or S1 record(s) immediately follows the SE input record. If the additional parameter value is constant then one SP record can be used. On the other hand, S1 records should be used if the additional parameter changes with respect to time.

Field	Variable	Value	Description
0	*ID*	SP	Record identification.
1	*PWASHLD*	+	Percentage of wash load ($0 \leq PWASHLD \leq 1$).

Record S1

HIGH CONCENTRATION TRANSPORT PARAMETERS

Optional (with Yang's 1996 modified formula)

S1 records define the additional parameter in Yang's 1996 formula with respect to time.

S1 records should be given for the entire time step, *ITIMAX* in IT record.

Field	Variable	Value	Description
0	*ID*	S1	Record identification.
1	*PWASHLD*	+	Percentage of wash load ($0 \leq PWASHLD \leq 1$).
2	*DURATION*	+	Duration of *PWASHLD*.

Record NE

NON-EQUILIBRIUM SEDIMENT TRANSPORT

Optional

The NE record is used to input the parameters necessary for non-equilibrium sediment transport calculations. The non-equilibrium calculations are activated if this record is present in the input file.

Field	Variable	Value	Description
0	*ID*	NE	Record identification.
1	*ALPHAD*	0, blank	Use the default value for the recovery factor for deposition (default is 0.25).
		+	User specified value for the recovery factor for deposition.
2	*ALPHAS*	0, blank	Use the default value for the recovery factor for scour (default is 1.0).
		+	User specified value for the recovery factor for scour.

Record N0

VARIABLE NON-EQUILIBRIUM SEDIMENT TRANSPORT PARAMETERS

Optional

The N0 record is used to input the parameters necessary for non-equilibrium sediment transport calculations when the non-equilibrium recovery factors vary along a certain reach. The non-equilibrium calculations are activated if this record is present in the input file. Any number of N0 records can be used, but not to exceed the number of cross sections defined. The records must be given from downstream to upstream, i.e., the records must be specified in the order of increasing *NESTA*. N0 records can be used instead of NE records, but not simultaneously.

Each record defines the recovery factors for deposition and scour at a particular location. The given location does not need to coincide with an actual station defined by a ST record. Stations located in between N0 record locations will have interpolated values of the recovery factors. Stations located outside N0 record ranges will not be extrapolated, i.e., stations located downstream from the first N0 record will have the recovery factors defined by the first N0 record; the stations located upstream from the last N0 record will have the same distribution as the last N0 record.

Field	Variable	Value	Description
0	*ID*	N0	Record identification.
1	*NESTA*	+	The location where the recovery factors are defined (ft).
2	*ALPHAD*	+	Recovery factor for deposition at the current location (no default value).
3	*ALPHAS*	+	Recovery factor for scour at the current location (no default value).

Record NA

VARIABLE NON-EQUILIBRIUM SEDIMENT TRANSPORT PARAMETERS

Optional

The NA record is used to define the parameter necessary for non-equilibrium sediment transport calculation when the recovery factors, α, vary with respect to sediment size. The non-equilibrium sediment transport computation is activated if this record is included in the input file. NA records should be presented as many as number of sediment size fraction defined in SF record. NA records are entered starting from the smallest particle size group and ending with the largest size group.

Each record specifies the recovery factor for scour. The recovery factors for deposition is defined by using a coefficient as

$$\text{Recovery factor for deposition} = C\alpha \times \text{recovery factor for scour}$$

Field	Variable	Value	Description
0	*ID*	NA	Record identification.
1	$C\alpha$	+	Coefficient $C\alpha$.
2	*NAALPHAS*	+	Recovery factor for scour for the corresponding sediment size group.

Record C1

COEFFICIENTS FOR THE DISCRETIZATION OF EXNER'S EQUATION

Optional

This record is used to define the coefficients used to approximate the change in the volume of bed sediment due to deposition or scour, ΔA_d, which is used in the numerical solution of Exner's equation, that is, of the sediment routing equation. ΔA_d is discretized using

$$(\Delta A_d)_i = (aT_{i-1} + bT_i + cT_{i+1})\Delta Z_i$$

where T = top width; i = cross section index ($i - 1$ is upstream, $i + 1$ is downstream); ΔZ = change in bed elevation; and a, b, and c are coefficients that must satisfy $a + b + c = 1$. The values of a, b, and c are entered using this record. If the record is absent from the input data file, GSTARS4 uses the values $a = c = 0.25$ and $b = 0.5$. If the record is present, then all the coefficients must be specified. For the first cross section ($i = 1$) the value of P_{i-1} is not defined, therefore a = 0. The user must specify separately the values for b and c for this particular station, with the requirement that $b + c = 1$. Similarly, P_{i+1} is not defined for the last cross section, therefore $c = 0$ and coefficients a and b must verify $a + b = 1$.

Field	Variable	Value	Description
0	*ID*	C1	Record identification.
1	*C1WP*	+	Value of the coefficient a in the equations above (default is 0.25).
2	*C2WP*	+	Value of the coefficient b in the equations above (default is 0.5).
3	*C3WP*	+	Value of the coefficient c in the equations above (default is 0.25).
4	*C1WPD*	+	Value of the coefficient a for the last cross section (default is 0.25).
5	*C2WPD*	+	Value of the coefficient b for the last cross section (default is 0.75).
6	*C1WPU*	+	Value of the coefficient b for the cross section $i = 1$ (default is 0.75).
7	*C2WPU*	+	Value of the coefficient c for the cross section $i = 1$ (default is 0.25).

Record C2

COEFFICIENTS FOR COMPUTING SEDIMENT TRANSPORT CAPACITY

Optional

The hydraulic parameters used for the computation of sediment transport capacities are values of the cross-sectional area, depth, velocity, and friction slope. These representative values are computed from a weighted average in the following manner:

$\Theta R_i = a\Theta_{i-1} + b\Theta_i + c\Theta_{i+1}$ for interior section ($i < NSTA$)

$\Theta R_i = a'\Theta_{NSTA-1} + b'\Theta_{NSTA}$ for the downstream most section ($i = NSTA$)

$\Theta R_i = b''\Theta_1 + c''\Theta_2$ for the upstream most section ($i = 1$)

where Θ represents the hydraulic property of interest (cross-sectional area, depth, velocity, or friction slope); i = cross section index (i-*1* is upstream, i+*1* is downstream); a, b, and c are coefficients that must satisfy $a + b + c = 1$; a' and b' are coefficients that must satisfy $a' + b' = 1$; and b'' and c'' are coefficients that must satisfy $b'' + c'' = 1$. The values of a, b, c, a', b', b'' and c'' are entered using this record. If the record is absent from the input data file, GSTARS4 uses the values $a = c = 0$, $b = 1$, $a' = 0$, and $b' = 1$. If the record is present, then all the coefficients must be specified.

Field	Variable	Value	Description
0	*ID*	C2	Record identification.
1	*C1Q*	+	Value of the coefficient a in the equations above (default is 0).
2	*C2Q*	+	Value of the coefficient b in the equations above (default is 1).
3	*C3Q*	+	Value of the coefficient c in the equations above (default is 0).
4	*C1QD*	+	Value of the coefficient a' for the last cross section (default is 0).
5	*C2QD*	+	Value of the coefficient b' for the last cross section (default is 1).
6	*C1QU*	+	Value of the coefficient b'' for the cross section $i = 1$ (default is 1).
7	*C2QU*	+	Value of the coefficient c'' for the cross section $i = 1$ (default is 0).

Record QS

SEDIMENT DISCHARGE

Required for Sediment Transport (May be eliminated if QR record is used)

Sediment transport modeling requires specifying the sediment entering the reach being studied. In GSTARS4, the sediment discharge hydrograph must be approximated by a series of bursts having a constant value and a certain duration. The resulting discretized hydrograph is entered in tabular format in QS records. The table has two columns: one for the duration of the constant discharge burst (as a multiple of the time step *DTIME* defined in record IT), another for the value of the sediment discharge. The values are entered sequentially.

Note that record QR can be used instead of record QS, but these two records are mutually exclusive.

Field	Variable	Value	Description
0	*ID*	QS	Record identification.
1	*NDAY*	+	Number of time steps for the specified sediment discharge. Note that the sum of all *NDAY* values must equal the value of *ITIMAX* specified in record IT.
2	*QSI*	+	Sediment discharge entering the study reach for the specified period of time (tons/day, US units of 2,000 lb/day).

Record QR

SEDIMENT DISCHARGE RATING CURVE

Optional

The QR record defines the sediment discharge entering the study reach at the cross section farthest upstream as a function of the water discharge. The assumed relationship between the water discharge and the sediment discharge is of the form:

$$\textit{Sediment discharge}\ [\text{ton/day}] = AQRC \cdot (\textit{Water discharge}\ [\text{ft}^3/\text{s}])^{BQRC}$$

Record QR can also be used to specify the sediment discharge to be equal to the sediment transport capacity of the first cross section of the reach. In this case, the first cross section will not suffer aggradation or scour. This boundary condition should be used only when there is no cohesive sediments in the study reach. In that case, coefficients *AQRC* and *BQRC* should not be specified, Instead, enter the word EQUILIBRIUM anywhere in fields 1 through 10.

Only one QR record is permitted. The QR record can be used instead of record QS, but not at the same time; i.e., the records QR and QS are mutually exclusive.

Field	Variable	Value	Description
0	*ID*	QR	Record identification.
1	*AQRC*	+	Value of the coefficient *AQRC* (no default).
2	*BQRC*	+	Value of the coefficient *BQRC* (no default).
1-10	*EQRC*	EQUILIBRIUM	Used to specify an inflow sediment rating curve from the capacity potential of the first cross section. Used instead of variables AQRC and BQRC. Use all upper case letters.

Record TM

WATER TEMPERATURE

Required for Sediment Transport

Record TM is used to enter the water temperature of the study reach for each time step. The temperatures are entered in a two-field record, with the values of the temperature in field 2 and the number of time steps for which the temperature is valid in field 1. Field 3 may be used to specify the temperature units used (Centigrade or Fahrenheit). The summation of *NDAY* from all the TM records must equal the value of *ITIMAX* defined in the IT record.

Field	Variable	Value	Description
0	*ID*	TM	Record identification.
1	*NDAY*	+	Number of time steps for which the given water temperature (*TEMP*) applies to the study reach.
2	*TEMP*	+	Water temperature of the study reach.
3	*TEMPU*	0, F	Temperature is given in degrees Fahrenheit (default).
		C	Temperature is given in degrees Centigrade.

Record SF

NUMBER OF SEDIMENT SIZE FRACTIONS

Required for Sediment Transport

This record is used to specify the dry specific weight of sediments and the number of sediment size fractions used in the study. A maximum of 10 size fractions is allowed in GSTARS4.

Field	Variable	Value	Description
0	*ID*	SF	Record identification.
1	*NF*	+	Number of size fractions defined for the current study ($1 \le NF \le 10$).
2	*BDINPUT*	0, blank*	Use a dry specific weight default value of 99.26 lb/ft^3.
		+*	Specify a dry specific weight value (lb/ft^3).

* Porosity is calculated from the specified dry specific weight and specific gravity values.

Record SG

SEDIMENT SIZE GROUPS

Required for Sediment Transport

The sediment size groups for the study are defined using SG records. The dry specific weight for individual size groups can also be defined in these records. The number of SG records must equal the value of NF defined in record SF (one SG record is required for each size fraction), and the records must be ordered with increasing sediment sizes.

The lower bound for sand sizes is 0.0625 mm. If a lower mean particle size is given, the cohesive sediment transport methods will automatically be activated, and a CS record is required. For each size group, GSTARS4 computes the geometric mean grain size as $D_{mean} = \sqrt{DRU \times DRL}$.

Field	Variable	Value	Description
0	*ID*	SG	Record identification.
1	*DRL*	+	Lower bound of the particle size for this group (mm).
2	*DRU*	+	Upper bound of the particle size for this group (mm).
3	*BDINPK*	0, blank	Use the default dry specific weight (99.26 lb/ft^3) or the dry specific weight specified in record SF.
		+	Dry specific weight for this size fraction (lb/ft). This value will override the value of *BDINPUT* given in record SF.

Record SL

SEDIMENT DENSITY VARIATION WITH LOCATION

Optional

The SL record is used to input variation of dry specific weight of sediment with respect to cross section location. Conversion between weight and volume of bed sediment requires dry specific weight which depends not only on the size but also on the texture of sediment deposition. In general, dry specific weight of coarse materials, such as sand and gravel, does not vary significantly with respect to flow condition. However, fine materials, such as silt and clay, have various densities depending on the flow condition. For example, clay on a reservoir bottom is usually less dense than that on river bed. Therefore, various dry specific weight with respect to cross section location should be defined if there is significant variation of flow condition.

Each SL record specifies variation of dry specific weight of all sediment size fractions by using a positive multiplier

Dry specific weight of k^{th} size fraction at the current cross section

= $Ck \times$ dry specific weight of defined in SG or SF record.

The number of SL records should be the same as total number of cross section defined in NS record. SL records are entered starting at the upstream-most cross section and proceeding in the downstream direction. Number of field for each must be the same as number of sediment size fraction. The first field of each SL records should define the coefficient for the smallest size group.

Field	Variable	Value	Description
0	*ID*	SL	Record identification.
1-10	*Ck*	+	Coefficient *Ck*.

Record NL

NUMBER OF BED LAYERS

Optional (Required for multiple bed layers)

The NL record is used to specify the number of layers used to describe the bed. In GSTARS4, a maximum of 10 bed layers can be used. Each layer has its own particle size distribution. If record NL is omitted, GSTARS4 assumes that there is only one bed layer. The same number of bed layers must be used for the entire reach being simulated, but the particle size distribution can vary longitudinally within the same bed layer.

Field	Variable	Value	Description
0	*ID*	NL	Record identification.
1	*NLAYER*	+	Number of bed layers (1 ≤ NLAYER ≤ 10).

Record SD

SEDIMENT SIZE DISTRIBUTION

Required for Sediment Transport

SD records are used to specify the bed material composition for each station in the study reach. At each station, the bed composition is defined as the bed material size fractions falling within each one of the size fractions defined in SG records. One SD record must be entered for each cross section of the study reach and for each bed layer. Information for each station is entered beginning with the particle size distribution of the top layer and proceeding downwards. The bottom elevation of each layer is given using EL records immediately below each SD record, except for the last layer (bottom layer), which is assumed to have infinite depth. The sets of *NLAYER* (see record NL) SD and EL records must be entered starting at the upstream-most station and proceeding downstream. Note that records SC or a combination of NB and BG records may be used instead of SD records.

Field	Variable	Value	Description
0	*ID*	SD	Record identification.
1-10	*P*	+	Percentage of bed material falling within each of the size groups defined in SG records. The values of *P* must be entered in order, from the smallest to the largest size fractions defined for the study. A total of *NF* values must be entered in each record (*NF* is defined in record SF). The sum of all *P* values must be equal to 1. ($0 \leq P \leq 1$)

Record EL

BOTTOM ELEVATION OF EACH BED LAYER

Optional (Required for multiple bed layers)

Records EL are used to enter the bottom elevation of each layer of a stratified bed. The last layer is assumed to be infinite, therefore there is no need to use an EL record there. The EL record must appear immediately after the SD record (or SC record, or BG record) to which it applies.

Field	Variable	Value	Description
0	*ID*	EL	Record identification.
1	-	-	Leave blank
2	*ELEV*	+	Bottom elevation of each layer (ft)

Record SC

CUMULATIVE SEDIMENT SIZE DISTRIBUTION

Optional

Record SC can be used instead of record SD to specify the bed composition of each station in the study reach. It differs from records SD in which the cumulative distribution is used, rather that the percentage falling within each of the defined particle size classes. There must be one SC record per bed layer and per cross section. For each cross section, one SC record is required for each bed layer, immediately followed by an EL record (except for the last layer). Layers must be specified from top to bottom. There must be one set of SD and El records for each cross section, and cross section data must be given starting at the upstream-most cross section and proceeding downstream.

Field	Variable	Value	Description
0	*ID*	SC	Record identification.
1-10	*PCM*	+	Cumulative distribution for each of the size groups defined in SG records. The values of PCM must be entered in order, from the smallest to the largest size fractions defined for the study. A total of *NF* values must be entered in each record (*NF* is defined in record SF). Note that $0 \leq PCM \leq 1$ and that $PCM_i \geq PCM_j$, where i and j are consecutive size classes, with $d_i > d_j$ (d_i = particle diameter of class i). Note also that $PCM_{NF} = 1.0$

Record NB

SEDIMENT SIZE DISTRIBUTION LOCATION

Optional

Record NB is used in conjunction with record BG to specify the bed material size fractions for a specific location. Each NB record requires one BG record for each bed layer (followed by an EL record), and a maximum of *NSTA* (record NS) sets of NB/BG/EL records is allowed. The NB/BG/EL records may be used instead of SD or SC records. See description of BG record for more details.

The NB record specifies the location where the bed gradation is known. This location does not have to coincide with an actual computational cross section, as defined in records [ST,ND,XS,RE]. However, the location must be given as a distance from the downstream reference location used for variable *STA* (record ST). The [NB,BG,EL] sets of records must be ordered, starting with the location having the lowest *BGSTA* value and ending with the location having the highest *BGSTA* value.

Field	Variable	Value	Description
0	*ID*	NB	Record identification.
1	*BGSTA*	+	The location where the bed gradation is given (ft).

Record BG

SEDIMENT SIZE DISTRIBUTION FOR SPECIFIC LOCATION

Optional (Required if record NB is present)

Record BG is used to input the bed material size fractions falling within each size group defined by SG records. An EL record must follow each BG record, except for the bottom bed layer. The location where the BG data is defined is given in the associated NB record. GSTARS4 uses [NB,BG,EL] records to determine the bed material size fractions at each computational cross section by interpolation. The records must be given from downstream to upstream; i.e., the records must be specified in the order of increasing *BGSTA*.

The bed material size fractions of the computational cross sections located between two *BGSTA* locations are determined from a linear interpolation of the corresponding values specified in BG records. However, GSTARS4 does not extrapolate values: the stations located downstream from the first [NB,BG,EL] set will have the same distribution as the first BG record; the stations located upstream from the last [NB,BG,EL] set will have the same distribution as the last BG record.

Field	Variable	Value	Description
0	*ID*	BG	Record identification.
1-10	*P*		Percentage of bed material falling within each one of the size groups defined in SG records. The values of *P* must be entered in order, from the smallest to the largest size fractions defined for the study. A total of *NF* values must be entered in each record (NF is defined in record SF). The sum of all *P* values must be equal to 1. ($0 \leq P \leq 1$)

Record CS

TRANSPORT PARAMETERS FOR COHESIVE SEDIMENTS

Optional (Required if sediment size fractions in the silt/clay range are included in the SG record)

The CS record is used for cohesive sediment (clay and silt) transport modeling. If a sediment size group (defined in the SG record) has a geometric mean grain size lower than 0.0625 mm, the cohesive sediment transport methods will be selected for those size groups. The equation specified in record SE will be used for the remaining size groups.

If silt and/or clay group sizes are not present, this record must not be given. This record must not be given when silt and/or clay group sizes are present, but Tsinghua University equation is used (*ISED* = 14 in record SE). Otherwise, the record should be inserted immediately after the last SD (or BG) record. No default values are available for any of the variables in this record.

When *STDEP* is set to a negative value, the silt and clay routines based on shear stress are deactivated. In this circumstance, the carrying capacity of these fractions is computed using the sediment transport equation defined by variable *ISED* (in record SE), and fields 2 through 6 of record CS will be ignored.

Field	Variable	Value	Description
0	*ID*	CS	Record identification.
1	*STDEP*	+	Shear threshold for deposition of clay and silt (lb/ft^2).
		<0	Cohesive sediment transport routines are deactivated.
2	*STPERO*	+	Shear threshold for particle erosion of clay and silt (lb/ft^2).
3	*STMERO*	+	Shear threshold for mass erosion of clay and silt (lb/ft^2).
4	*ERMASS*	+	Slope of the erosion rate curve for mass erosion (1/hr).
5	*ERSTME*	+	Erosion rate of clay and silt when the bed shear stress is equal to STMERO (lb/ft^2/hr).
6	*ERLIM*	+	Threshold value for the percentage of clay in the bed composition above which the erosion rates of gravels, sands, and silts are limited to the erosion rate of clay ($0 \leq ERLIM \leq 1$).

Record C0

VARIABLE PARAMETERS FOR COHESIVE SEDIMENT TRANSPORT

Optional (Required if sediment size fractions in the silt/clay range are included in the SG record)

The C0 record is used for cohesive sediment transport modeling. If a sediment size group (defined in the SG record) has a geometric mean grain size lower than 62.5 μm, the clay/silt transport methods will be selected for those size groups. The equation specified in record SE will be used for the remaining size groups, except when Tsinghua University equation is used (*ISED* = 14 in record SE), in which case no C0 record is allowed. This record can be used instead of record CS, but not simultaneously.

Each record defines the cohesive transport parameters at a particular location. The given location does not need to coincide with an actual station defined by a ST record. Stations located in between C0 record locations will have interpolated values of the parameters. Stations located outside C0 record ranges will not be extrapolated, i.e., stations located downstream from the first C0 record will have the parameters defined by the first C0 record; the stations located upstream from the last C0 record will have the same parameters as the last C0 record.

Any number of C0 records can be used, to a maximum of *NMXSTA* records (*NMXSTA* is the variable that defines the maximum number of cross sections allowed in a particular release of GSTARS4). The records must be given from downstream to upstream, i.e., the records must be specified in the order of increasing *NESTA*.

Field	Variable	Value	Description
0	*ID*	C0	Record identification.
1	*NESTA*	+	The location where the parameters are defined (ft).
2	*STDEP*	+	Shear threshold for deposition of clay and silt (lb/ft^2).
3	*STPERO*	+	Shear threshold for particle erosion of clay and silt (lb/ft^2).
4	*STMERO*	+	Shear threshold for mass erosion of clay and silt (lb/ft^2).
5	*ERMASS*	+	Slope of the erosion rate curve for mass erosion (1/hr).
6	*ERSTME*	+	Erosion rate of clay and silt when the bed shear stress is equal to *STMERO* ($lb/ft^2/hr$).
7	*ERLIM*	+	Threshold value for the percentage of clay in the bed composition above which the erosion rates of gravels, sands, and silts are limited to the erosion rate of clay ($0 < ERLIM \leq 1$).

Record CH

PARAMETERS FOR FALL VELOCITY OF COHESIVE SEDIMENTS

Optional (Required if sediment size fractions in the silt/clay range are included in the SG record)

The parameters entered using this record are used in the calculation of fall velocities of cohesive sediment particles. They are the concentration limits for flocculation and hindered settling, and the parameters M, N, k, and l of eqs. (3.87) and (3.88) (see section 3.8 for more details). The CH record is required if a sediment size group (defined in the SG record) has a geometric mean grain size lower than 62.5 μm, except when Tsinghua University equation is used (*ISED* = 14 in record SE). The CH record must appear immediately after the CS or C0 records. However, do not use the CH record if *STDEP* < 0 in record CS.

Field	Variable	Value	Description
0	*ID*	CH	Record identification.
1	*CS1*	0, +	Concentration lower limit for flocculation (default is 300.0 mg/l).
2	*CS2*	0, +	Lower limit of the concentration for hindered settling (default is 6000 mg/l).
3	*CSCOEF1*	0, +	Coefficient *M* of equation (3.87) (default is 3.281×10^{-6} ft s^{-1} mg^{-N} l^{N}).
4	*CSCOEF2*	+/-	Coefficient *N* of equation (3.87) (default is 1.0).
5	*CSCOEF3*	+/-	Coefficient *k* of equation (3.87) (default is 1.0 l/mg).
6	*CSCOEF4*	+/-	Coefficient *l* of equation (3.87) (default is 5.0).

Note: entering a negative value in fields 4 through 6 activates the default values. Entering a zero or negative value (or leaving blank) in fields 1 through 3 activates the default values.

Record CF

SEDIMENT SIZE DISTRIBUTION FOR TRANSPORT CAPACITY CALCULATIONS

Optional

The CF record defines the C_{factor} coefficient for fractional sediment transport capacity computations:

$$FBB_k = C_{factor}\, FB_k + (1 - C_{factor})FS_k$$

where FB_k = percentage of bed material belonging to size fraction k; FS_k = percentage of incoming sediment belonging to size fraction k; and FBB_k = percentage used to compute the transport capacity of size fraction k.

This parameter may be useful to model situations in which the distribution of the sediment incoming to a reach may be different from the distribution of the sediment present in the bed. This record should be placed after record CH (or after the place where record CH would be, if present).

Field	Variable	Value	Description
0	*ID*	CF	Record identification.
1	*CFACTOR*	+	Value of C_{factor}. Must have a value between 0 and 1. If C_{factor} = 1 (default), only material present in the bed will have non-zero carrying capacity.

Record I1

INPUT SEDIMENT DISTRIBUTION BY TIME

Optional

This record is used to vary the size distribution of the input sediment discharge only with respect to time. It is used with IQ and IS records. The size distribution may be a function of water discharge and time. IQ and IS records construct a table of size distribution as a function of water discharge entering from the upstream boundary and I1 record specifies the duration of the function. One set of the function for the size distribution consists of one I1, one IQ, and IS records. The number of IS for a set is the same as that of the size group defined in SF record. After entering one set of I1, IQ, and IS records, other sets of them have to be entered until the summation of duration is the same as total time steps, *ITIMAX* in IT record.

If the relationship between water discharge and sediment size distribution is fixed in time, then user can use only one set of IQ and IS records with using I1 record.

Field	Variable	Value	Description
0	*ID*	I1	Record identification.
1	*DURATION*	+	Duration for the relationship between water discharge and sediment size distribution. The relationship is defined by IQ and IS records.

Record IQ

INPUT SEDIMENT DISTRIBUTION

Optional

This record is used to vary the size distribution of the input sediment discharge. It is used in conjunction with IS records to construct a table of size distribution as a function of water discharge entering the channel. Record IQ is used to define the water discharges for which sediment size distributions are defined. For values of the discharge between the values defined in record IQ, the sediment size distribution is interpolated from the corresponding size distributions defined in the corresponding fields of IS record(s). See description of IS record.

Field	Variable	Value	Description
0	*ID*	IQ	Record identification.
1	*NDISCH*	1-9	Number of columns in the table, i.e., number of entries for which water discharge is defined. A maximum of nine water discharge entries is allowed.
2-10	*QIC*	+	Water discharge values which will define interpolation segments of the incoming sediment size distribution. A maximum of nine values is permitted. Each value entered must be larger than its predecessor (ft^3/s).

Record IS

INPUT SEDIMENT DISTRIBUTION BY SIZE FRACTION

Optional (Required if record IQ is present)

This record is used in conjunction with record IQ to construct a table of input sediment size distribution as a function of water discharge:

	QIC_1	QIC_2	...	QIC_{NDISCH}
Size fraction 1	$PISED_{1,1}$	$PISED_{2,1}$	...	$PISED_{NDISCH,1}$
Size fraction 2	$PISED_{1,2}$	$PISED_{2,2}$	...	$PISED_{NDISCH,2}$
...	...	...	...	...
Size fraction *NF*	$PISED_{1,NF}$	$PISED_{2,NF}$	...	$PISED_{NDISCH,NF}$

The values QIC_i are the water discharges for which the size distributions of the incoming sediment are known. Using IS records, the percentage of material, $PISED_{i,j}$, for each size fraction defined in the SF and SG records is entered in columns corresponding to each value of QIC_i defined on the IQ record. The size distributions are given in each column in order from the finest to the coarsest size fractions. The number of IS records must equal the number of SG records (i.e., must be equal to *NF*, which is the number of size fractions defined in record SF). The size distributions are interpolated for discharges between the specified *QIC* values. For values of the discharge outside the table, no extrapolation is done; i.e., if $Q < QIC_1$ the size distribution for QIC_1 is used; if $Q > QIC_{NDISCH}$ the size distribution for QIC_{NDISCH} is used.

Field	Variable	Value	Description
0	*ID*	IS	Record identification.
1	*COMNT*	string	A comment, i.e., an alphanumeric ASCII string of up to six characters.
2-10	*PISED*	+	The percentage of the incoming sediment corresponding to the given size fraction and discharge ($0 \le PISED \le 1$).

Example: If three size fractions are specified, for example silt, sand, and gravel (*NF* = 3), and the corresponding distributions are known for three discharges, 100, 1,000, and 10,000 ft^3/s (*NDISCH* = 3), then the following records could be used:

```
         1         2         3         4
12345678901234567890123456789012345678901234
IQ      3    100.   1000.  10000.
IS silt      0.50    0.60    0.90
IS sand      0.40    0.25    0.07
IS gravl     0.10    0.15    0.03
```

Record CV

TRANSPORT OF SEDIMENT ACROSS STREAM TUBE BOUNDARIES

Optional

Record CV is used to define the parameters necessary to perform the computations to determine the amount of sediment exchange across stream tube boundaries. If CV records are omitted, no sediment exchange will take place between stream tubes. Records CV must follow records IS (or the place where records IS would be, if present).

Field	Variable	Value	Description
0	*ID*	CV	Record identification.
1-10*	*RCURV*	0	Radius of curvature of the channel at each cross section (ft). If *RCURV* = 0, only transfer due to transverse bed slope is considered by the GSTARS4 computations.
		+/-	Additionally to transverse bed slope effects, secondary flows due to stream curvature are also considered when calculating the transfer of sediments across stream tube boundaries.

*Note: Not all fields must be filled. Fields may be skipped at will, but a total of *NSTA* (see record NS) values must be given. Multiple CV records may be used.

Record AR

ANGLE OF REPOSE

Optional

The input record AR allows users the option to input bank slope criteria both above and below the calculated water surface. Each time step, the bank slopes will be flattened to the specified angle of repose limits. Mass is conserved in this adjustment.

Field	Variable	Value	Description
0	*ID*	AR	Record identification.
1	*ANGLE1*	90*	Default angle of repose at and above the water surface.
		+	The value of the angle, specified in degrees from horizontal, limits the bank slope at and above the water surface.
2	*ANGEL2*	90*	Default angle of repose below the water surface.
		+	The value of the angle, specified in degrees from horizontal, limits the bank slope below the water surface.

*Note: a negative angle of repose specified for either *ANGLE1* or *ANGLE2* will deactivate the computations and the program will behave as if a 90 degree angle was entered. However, the overall computational time of the run will be reduced.

Record LM

SCOUR AND DEPOSITION LIMITS

Optional

LM records are used to define constraints to bed deposition and/or erosion. They allow to define bed elevations above which cannot be any deposition, or below which there will be no scour. These limits correspond to geological and/or man-made restrictions to the sedimentation processes. There must be one LM record for each cross section. LM records are entered starting at the upstream-most cross section and proceeding in the downstream direction. LM records are optional: their absence from the GSTARS4 input datafile indicates that there are no erosion or deposition limits.

Field	Variable	Value	Description
0	*ID*	LM	Record identification.
1	*CBLI*	+/-	Limit for scour: no scour is allowed below this elevation. (ft)
2	*CBHI*	+/-	Limit for deposition: no deposition is allowed above this elevation. (ft)

If *CBLI* has a negative value, GSTARS4 automatically interprets it as zero, which is the lowest bed elevation permissible during the computations. If *CBHI* has a zero or negative value, GSTARS4 interprets it as a very high value, indicating that there is no vertical limit to deposition.

Record PR

PRINTOUT CONTROL

Required

GSTARS4 output is given in ASCII files with different extensions. Usually, the output of relevant quantities is required at the end of the computer run. The PR record is used to define the level of output generated and its interval, i.e., the amount of information required and the number of time steps elapsing between successive writings to the output files during the run.

Field	Variable	Value	Description
0	*ID*	PR	Record identification.
1	*IPRLVL*	-1	No output is required.
		0	Level 0 output: print only water surface profile and sediment routing tables (default).
		1	Level 1 output: in addition to level 0 output, normal and critical depth tables are generated.
		2	Level 2 output: in addition to level 1 output, stream tube geometry and conveyances are generated.
		3	Level 3 output: in addition to level 2 output, sediment transport capacities are written to the .SED file.
2	*INTPR*	+	Number of time steps between output. If *INTPR* = 1, output takes place at each time step. If *INTPR* > *ITMAX* (record IT), no output is generated.

Record PX

CHANNEL CROSS SECTION PLOTTING

Optional

This record is used to generate cross section data for plotting at certain time intervals during the run. Cross section geometry is written in an external ASCII file with extension .XPL containing the title of the study followed by tables of coordinate pairs. Each table contains bottom elevation and lateral location of the points describing each cross section of the reach. The data can be easily imported into almost any spreadsheet program for graphing purposes. Cross-sectional geometry is printed at specified time step intervals. The first set of cross sections represent the initial conditions at the reach; i.e., they are the cross sections before the run has started (at time step 0).

Field	Variable	Value	Description
0	*ID*	PX	Record identification.
1	*INTPL1*	0	No cross section plots are generated.
		> 0	Cross section plots are generated for all of the stations in the study reach, at time intervals with duration equal to *INTPL1* time steps. If *INTPL1* = 1, output is generated at every time step. If *INTPL1* > *ITIMAX*, no output is generated (except for time step 0).

Record PW

WATER SURFACE PROFILE PLOTTING

Optional

The PW record is used to generate longitudinal profiles with the thalweg and the water surface of the study reach at certain time intervals during the run. The data are written in an external ASCII file with extension .WPL containing the title of the study followed by tables with three entries: station location, bottom elevation, and free surface elevation. Each table contains information for a particular time step of the run, and the information is generated at a specified interval. The first table represents the reach at time step 0, i.e., before the run has started. The data can be easily imported into almost any spreadsheet program for graphing purposes.

Field	Variable	Value	Description
0	*ID*	PW	Record identification.
1	*INTPL2*	0	No profiles are generated.
		> 0	Longitudinal profiles of thalweg and water surface elevation are generated at time intervals with duration equal to *INTPL2* time steps. If *INTPL2* = 1, output is generated at every time step. If *INTPL2* > *ITIMAX*, no output is generated (except for time step 0).

Record MR

STREAM POWER MINIMIZATION

Optional

When the MR record is used, GSTARS4 automatically activates the total stream power minimization routines. Record MR is also used to define bed elevation and width limits for each station in the reach. These limits correspond to restrictions, geological or man-made, to deposition and/or scour. The MR records must be omitted if minimization is not requested. For each time iteration, the total stream power minimization computations are used in the program's logic to decide whether to make scour or deposition adjustments in the lateral or vertical directions. One MR record has to be specified for each station. MR records must be entered in sequential order, starting at the station farthest upstream and proceeding downstream.

Field	Variable	Value	Description
0	*ID*	MR	Record identification.
1	*XLFTI*	+/-	Lateral location beyond which no cross section widening is allowed. This location corresponds to the left-hand side restriction, looking downstream, and is valid for a particular station (ft).
		-9999.	No left-hand side boundary.
2	*XRGHTI*	+/-	Lateral location beyond which no cross section widening is allowed. This location corresponds to the right-hand side restriction, looking downstream, and is valid for a particular station (ft).
		9999.	No right-hand side boundary.
3	*CBLI*	+	Limit for scour in the vertical direction. No scour is allowed below this bottom elevation (ft).

		0	No restrictions for scour in the vertical direction.
4	*CBHI*	+	Limit for deposition in the vertical direction. No deposition is allowed above this bottom elevation (ft).
		9999.	No restrictions for deposition in the vertical direction.

Note: when record LM is used in conjunction with record MR, the values of *CBLI* and *CBHI* set in MR records supersede those set in LM records. In other words, if records MR are used, LM records are ignored.

Record END

END OF INPUT DATA

Required

The END record is required at the end of each input data file to terminate the data input operations.

Field	Variable	Value	Description
0	*ID*	END	Record identification.