HABITAT FUNCTIONS BY LIFE STAGE FOR THE RIO GRANDE SILVERY MINNOW

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September 11, 2000

The information presented in these tables (natural environment) is based upon limited published literature and anecdotal information. Because the Rio Grande has been characterized as harsh and fluctuating, the ranges presented in these tables may be exceeded under certain conditions. In addition, there may be critical functions for a particular life stage that have yet to be identified. It is intended that the design of the naturalized habitat system have enough flexibility to adjust for modifications of each function in the future.

LIFE STAGE: SPAWNING

Size: 41-85 mm

Age: 1+ year

Functions	Natural Environment	Naturalized Habitat System	Accomplished Via
Depth, cm	20-80 Highly Variable	20-80	Deep main channel.
Temperature, °C	14-24	Same as natural environment pending site location. Use 20-24° for spawning.	Filtered river water and/or groundwater with heat exchanger.
Density	Schooling fish - densities unknown.	Provide a minimum of 10,000 adults for spawning purposes.	Collect eggs/larvae from offsite locations and plant in system and/or place adults in system for spawning.
Riparian Vegetation	N/A	N/A	N/A
Water Flow and Quality (velocity cm/s)	40-90 Variable, spring runoff spikes (single pass). Current conditions experience poor water quality.	40-90 Variable, provide highly fluctuating flows (re-circulation). Control water quality through blend of filtered river/ground water.	Mechanical system with oval shape. Variable speed water movement system.
Quantity, l/s	Variable	80	River/ground water makeup flow for evaporative losses. Provide river and ground water sources.
Substrate	Shifting sands (pelagic)	Shifting sands.	Sand substrate over gravel structure.
Geometry	Deep main channel.	Elongated oval main channel.	High velocities in circular motion to simulate extensive drift.
Feed	N/A	N/A	N/A
Predator Avoidance	Behavioral responses and environmental conditions.	No access to predators. Minimize human interaction.	Predator fencing and avian exclusion via netting. River water supply screened. Inaccessible island to humans.

LIFE STAGE: EGG
Size: 3 mm
Age: 1-3 days

Functions	Natural Environment	Naturalized Habitat System	Accomplished Via
Depth, cm	20-80 Highly Variable	20-80	Deep main channel.
Temperature,°C	14-24	Same as natural environment pending site location. Use 20-24°.	Filtered river water and/or groundwater with heat exchanger.
Density	Schooling fish - densities unknown.	Provide a minimum number of eggs to maintain MVP and anticipated mortality until adult stage.	30,000 adults (MVP) + normal mortality (1 year) + mortality from unanticipated causes.
Riparian Vegetation	N/A	N/A	N/A
Water Flow and Quality (velocity,cm/s)	40-90 Variable (single pass). Current conditions experience poor water quality.	40-90 Variable (re-circulation). Control water quality through blend of filtered river/ground water.	Mechanical system with oval shape.
Quantity, l/s	Variable	80	River/ground water makeup flow for evaporative losses. Provide river and ground water sources.
Substrate	Shifting sands (pelagic)	Shifting sands.	Sand substrate over gravel structure.
Geometry	Deep main channel.	Elongated oval main channel.	High velocities in circular motion to simulate extensive drift.
Feed	N/A	N/A	N/A
Predator Avoidance	Behavioral responses and environmental conditions.	No access to predators. Minimize human interaction.	Predator fencing and avian exclusion via netting. River water supply screened. Inaccessible island to humans.

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LIFE STAGE: PELAGIC LARVAE
Size: 4 mm
Age: 4-6 days

Functions	Natural Environment	Naturalized Habitat System	Accomplished Via
Depth, cm	20-80 Highly Variable	20-80	Deep main channel.
Temperature,°C	14-24	Same as natural environment pending site location. Use 20-24°.	Filtered river water and/or groundwater with heat exchanger.
Density	Schooling fish - densities unknown.	Provide a minimum number of eggs to maintain MVP and anticipated mortality until adult stage.	30,000 adults (MVP) + normal mortality (1 year) + mortality from unanticipated causes.
Riparian Vegetation	N/A	N/A	N/A
Water Flow and Quality (velocity,cm/s)	40-90 Variable (single pass). Current conditions experience poor water quality.	40-90 Variable (re-circulation). Control water quality through blend of filtered river/ground water.	Mechanical system with oval shape.
Quantity, l/s	Variable	80	River/ground water makeup flow for evaporative losses. Provide river and ground water sources.
Substrate	Shiftine sands (pelagic)	Shifting sands.	Sand substrate over gravel structure.
Geometry	Deep main channel.	Elongated oval main channel.	High velocities in circular motion to simulate extensive drift.
Feed	N/A	N/A	N/A
Predator Avoidance	Behavioral responses and environmental conditions.	No access to predators. Minimize human interaction.	Predator fencing and avian exclusion via netting. River water supply screened. Inaccessible island to humans.

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LIFE STAGE: YOUNG JUVENILES

Size: 4-20 mm

Age: 7-49 days

Functions	Natural Environment	Naturalized Habitat System	Accomplished Via
Depth, cm	1-30	1-30	Main Channel, Shoreline-Pool. Secondary Channel, Pool.
Temperature, °C	17-26	Same as natural environment pending site location.	Filtered river water and/or groundwater with heat exchanger.
Density	Schooling fish - densities unknown.	50% of recommended densities for extensive rearing of June sucker.	Provide suitable volume.
Riparian Vegetation	Historically contained cottonwood trees.	Mimic vegetation considered to be desirable.	Plantings of cottonwood trees and other suitable understory.
Water Flow and Quality (velocity,cm/s)	1-20 Variable (single pass). Current conditions experience poor water quality.	1-20 Variable (re-circulation). Control water quality through blend of filtered river/ground water.	Mechanical system with oval shape.
Quantity, l/s	Variable	80	River/ground water makeup flow for evaporative losses. Provide river and ground water sources.
Substrate	Silt - 100%	Silt - 40% Sand - 50% Gravel - 5% Cobble - 5%	Application of silt and sand for settling in backwater areas and/or main channel. Substrate is exposed gravel. Cobbles and boulders in strategic locations.
Geometry	Main Channel, Shoreline-Pool. Secondary Channel, Pool. Main Channel, Pool.	Variable shapes and depths.	Variable shapes and depths.
Feed	Epipsammatic algae (algae on sand substrate).	Epipsammatic algae (algae on sand substrate).	Fertilize system prior to spawning.
Predator Avoidance	Behavioral responses and environmental conditions. Use shallow embayments.	Controlled access by predators. Minimize human interaction. Provide shallow habitat areas.	Predator fencing and avian exclusion via netting. Provide predator avoidance training with live organisms. Inaccessible island to humans. Shallow habitat areas.

LIFE STAGE: OLDER JUVENILES
Size: 21-40 mm
Age: 50-240 days

Functions	Natural Environment	Naturalized Habitat System	Accomplished Via
Depth, cm	1-60	1-60	Backwater. Secondary Channel, Pool. Eddy. Main Channel, Shoreline-Pool. Secondary Channel, Run. Main Channel, Pool.
Temperature,°C	4-28	Same as natural environment pending site location.	Filtered river water and/or groundwater with heat exchanger.
Density	Schooling fish - densities unknown.	50% of recommended densities for extensive rearing of June sucker.	Provide suitable volume.
Riparian Vegetation	Historically contained cottonwood trees.	Mimic vegetation considered to be desirable.	Plantings of cottonwood trees and other suitable understory.
Water Flow and Quality (velocity,cm/s)	0-70 70	0-70 Variable (re-circulation). Control water quality through blend of filtered river/ground water.	Mechanical system with oval shape.
Quantity, l/s	Variable	80	River/ground water makeup flow for evaporative losses. Provide river and ground water sources.
Substrate	Silt - 95% Sand - 4% Gravel - 1% Debris cover	Silt - 40% Sand - 50% Gravel - 5% Cobble - 5% Debris cover	Application of silt and sand for settling in backwater areas and/or main channel. Substrate is exposed gravel. Cobbies and boulders in strategic locations. Felled trees anchored to steep bank off island.
Geometry	Backwater. Secondary Channel, Pool. Eddy. Main Channel, Shoreline-Pool. Secondary Channel, Run. Main Channel, Pool.	Variable shapes and depths.	Variable shapes and depths.
Feed	Small crustaceans and small insects.	Small crustaceans and small insects.	Induce growth of natural populations with supplementation of cultural organisms.
Predator Avoidance	Behavioral responses and environmental conditions. Use shallow embayments.	Controlled access by predators. Minimize human interaction. Provide shallow habitat areas.	Predator fencing and avian exclusion via netting. Provide predator avoidance training with live organisms. Inaccessible island to humans. Shallow habitat areas.

LIFE STAGE: ADULTS
Size: 41-85 mm
Age: 241-365 days

Functions	Natural Environment	Naturalized Habitat System	Accomplished Via
Depth, cm	1-80	1-80	Eddy. Secondary Channel, Pool. Secondary Channel, Run. Secondary Channel, Shoreline-Pool. Backwater.
Temperature,°C	4-22	Same as natural environment pending site location.	Filtered river water and/or groundwater with heat exchanger.
Density	Schooling fish - densities unknown.	50% of recommended densities for extensive rearing of June sucker.	Provide suitable volume.
Riparian Vegetation	Historically contained cottonwood trees.	Mimic vegetation considered to be desirable.	Plantings of cottonwood trees and other suitable understory.
Water Flow and Quality (velocity,cm/s)	0-40 Variable (single pass). Current conditions experience poor water quality.	0-40 Variable (re-circulation). Control water quality through blend of filtered river/ground water.	Mechanical system with oval shape.
Quantity, l/s	Variable	80	River/ground water makeup flow for evaporative losses. Provide river and ground water sources.
Substrate	Silt - 75% Sand - 20% Gravel - 3% Cobble - 2% Debris cover	Silt - 40% Sand - 50% Gravel - 5% Cobble - 5% Debris cover	Application of silt and sand for settling in backwater areas and/or main channel. Substrate is exposed gravel. Cobbles and boulders in strategic locations. Felled trees anchored to steep bank off island.
Geometry	Eddy. Secondary Channel, Pool. Secondary Channel, Run. Secondary Channel, Shoreline-Pool. Backwater.	Variable shapes and depths.	Variable shapes and depths.
Feed	Small crustaceans and small insects.	Small crustaceans and small insects.	Induce growth of natural populations with supplementation of cultured organisms.
Predator Avoidance	Behavioral responses and environmental conditions. Use shallow embayments.	Controlled access by predators. Minimize human interaction. Provide shallow habitat areas.	Predator fencing and avian exclusion via netting. Provide predator avoidance training with live organisms. Inaccessible island to humans. Shallow habitat areas.