ATTACHMENT E

WATER QUALITY MODEL RUNS FOR TEMPERATURE, DISSOLVED OXYGEN, AND STILLING BASIN WATER ELEVATION

MODEL RUNS: TEMPERATURE, DISSOLVED OXYGEN, AND STILLING BASIN WATER ELEVATION

A water quality model of Lake Livingston and the Trinity River downstream of the lake identified water temperatures and dissolved oxygen levels that might result from lake releases through the proposed hydropower Project at Lake Livingston Dam. CE-QUAL-W2, which is a widely used two-dimensional (longitudinal/vertical) hydrodynamic and water quality model available from the Corps, was used for this modeling effort. Model development is described in detail in ***Attachment B***. In addition, a rating curve was developed to identify the water elevation between the weir and the dam at various flows.

The model described water temperatures and dissolved oxygen conditions that might result in the stilling basin between the dam and the weir and in the Trinity River downstream of the proposed hydropower discharge. Those model evaluations are illustrated and described below.

Stilling Basin Water Elevation

During periods when lake releases fall below approximately 5,500 cfs, most of the water will be diverted from the spillway gates, causing a substantial drop in water elevation in the stilling basin. The water elevation in the stilling basin will need to be maintained at some minimum level to prevent stranding of fish. A rating curve was developed that predicts the water elevation in the stilling basin (***Figure 1***). At 100-200 cfs, the water elevation in the stilling basin is expected to be 2-3 ft deep.

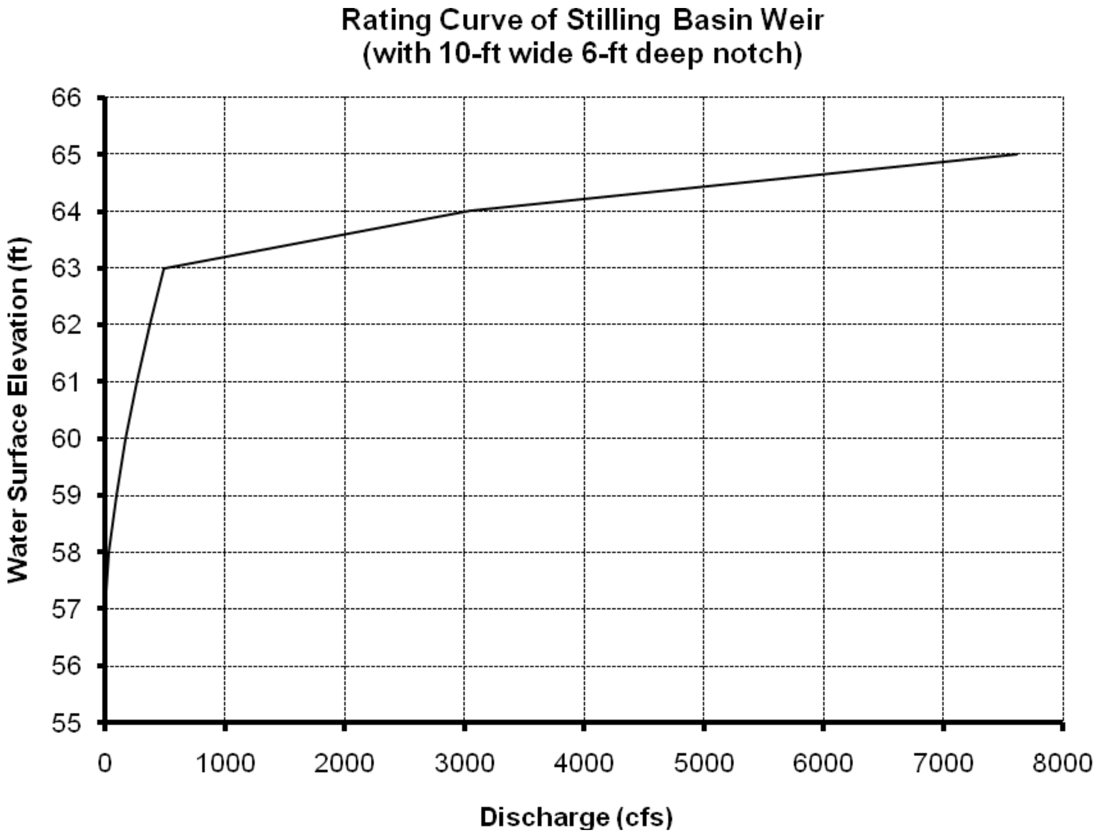


Figure 1. Rating Curve of Stilling Basin Weir (with 10-ft wide, 6-ft deep notch).

Stilling Basin Dissolved Oxygen

It is important to ensure adequate dissolved oxygen in the stilling basin because it is an area where striped bass, blue catfish, and several other species concentrate to feed on fish moving from the lake. The stilling basin will contain water during normal hydropower operations but at a reduced flow.

This model scenario predicts the dissolved oxygen concentrations that would exist in the stilling basin under critical summer conditions (***Figure 2***). The model scenario utilizes predicted oxygen concentrations from the lake release depth of 30 ft, a release rate of 100 cfs from the dam spillway gates into the existing stilling basin, and a fish respiration rate of 10 g/m^2/day. This respiration rate is based on respiration rates in intensive fish culture ponds and, therefore, is considered conservatively high for the stilling basin. Because water released from the spillway gates cascades as a shallow, turbulent, sheet flow down the face of the dam, the dissolved oxygen of water entering the stilling basin from the lake is always near 100 percent saturation, which is illustrated in the figure. Physical reaeration ensures adequate oxygen concentrations in the water entering the stilling basin despite the fact that water released from the spillway gates is commonly hypoxic during summer conditions. Temperature in the stilling basin averaged 26.9°C and ranged from 21.3° C to 30.1° C from May through September 11, 2008.

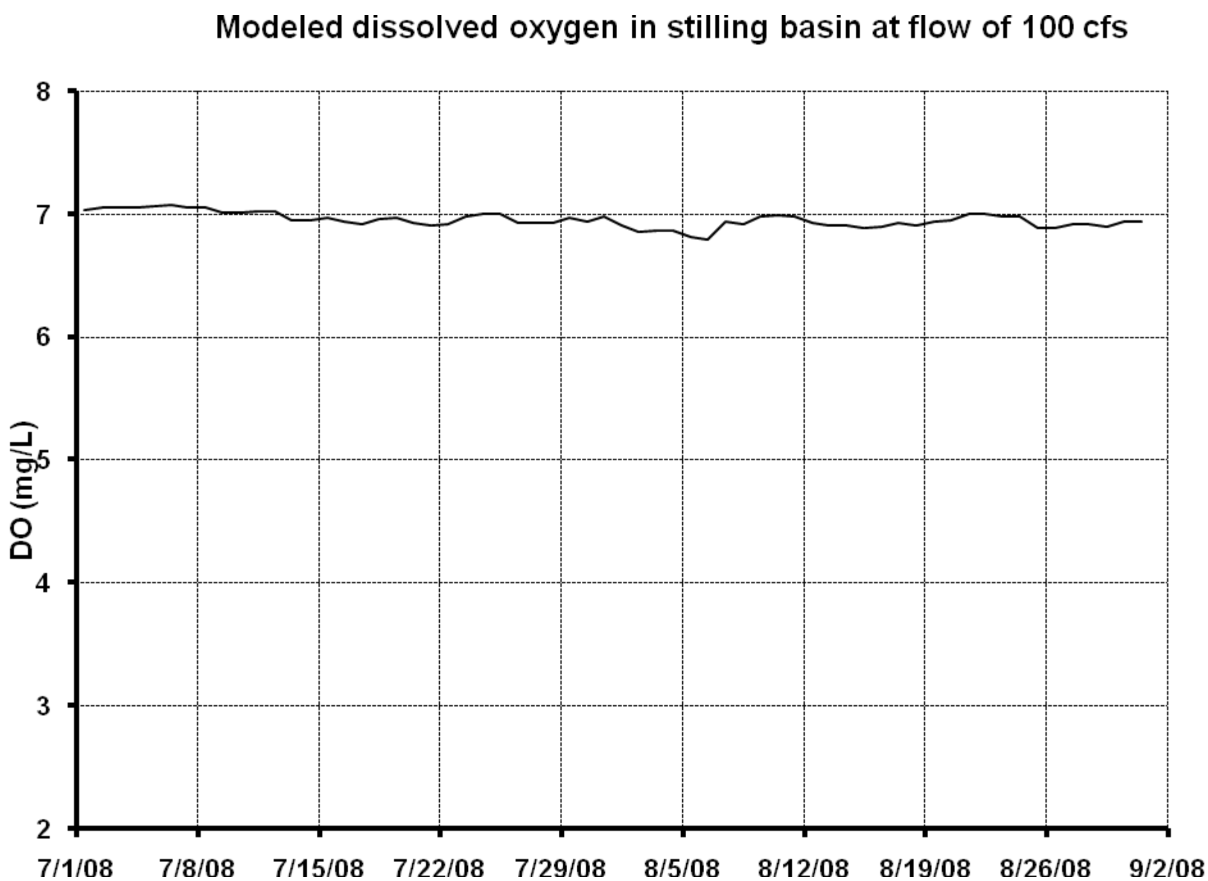


Figure 2. Modeled Dissolved Oxygen in Stilling Basin at Flow of 100 cfs.

The model shows dissolved oxygen would vary over a narrow range of 6.8 to 7.1 mg/l during critical summer conditions of warm temperatures and occasional hypoxic releases. The estimated water retention time in the stilling basin is about 64 minutes at a reservoir release rate of 100 cfs, and dissolved oxygen levels are not expected to drop nor is water temperature expected to increase during the brief time water passes through the stilling basin.

Trinity River Dissolved Oxygen and Temperature

The Trinity River downstream of the proposed hydropower facility release and for some distance downstream is a valued recreational fishing resource for anglers pursuing striped bass, blue catfish, and other species of fish. Therefore it is important to understand the potential changes in water temperature and dissolved oxygen that may occur under the proposed hydropower operation.

These model scenarios predict water temperature and dissolved oxygen during warm temperatures and relatively low oxygen concentrations that may occur from May through September at five locations in the Trinity River (***Figure 3***).

- Immediately downstream of the hydropower facility (Near FM 3278);
- 2.5 miles downstream from the release from the hydropower facility;
- 5.0 miles downstream from the release from the hydropower facility;
- 7.5 miles downstream from the release from the hydropower facility; and
- 10.0 miles downstream from the release from the hydropower facility.

The hydropower facility can generate electricity with flows ranging from 750 cfs (about one-third the capacity of one turbine) to about 5,500 cfs (the combined full capacity of all three turbines). When reservoir releases exceed 5,500 cfs, flows above 5,500 cfs will be released through the spillway gates.

Scenarios were generated under a low flow (750 cfs) and a high flow (5,300 cfs) regime through the turbines (***Figures 4*** through ***7***). Both the low and high flow scenarios, included 200 cfs released through the spillway gates as an example of the flows that might be used to maintain dissolved oxygen and water temperature in the stilling basin at levels similar to the existing conditions. The low and high flow scenarios were evaluated with temperature and dissolved oxygen conditions measured during the summer of 2008 and again with modeled temperatures and dissolved oxygen levels during the summer of 2005. Local weather data for the past 10 years was reviewed and the summer of 2005 was the warmest period. The atmospheric temperature data were used to refine the model for “worst case” temperature conditions.

The existing condition in each scenario illustrates the temperature and dissolved oxygen that would exist in the absence of the facility (e.g. spillway gate release only). The proposed condition in each scenario shows the temperature and dissolved oxygen that might occur with flows through the proposed hydropower facility.

These scenarios indicate water temperature with the proposed hydropower operation would generally be higher because of the release of water from the surface near the east shore of the lake rather than the release of cooler water from a depth of 30 ft. Dissolved oxygen would vary more because there will be little or no physical aeration of the water from the reservoir as it passes through the turbines and discharges into the river. Consequently the dissolved oxygen downstream of the facility would reflect the natural fluctuations of dissolved oxygen in the lake.

As shown in the figures, under low-flow conditions, the differences between conditions with and without the hydropower Project decrease with increasing distance from the facility due to the processes that occur in the river channel. Under higher-flow conditions, differences remain among stations, presumably due to the shorter travel time.

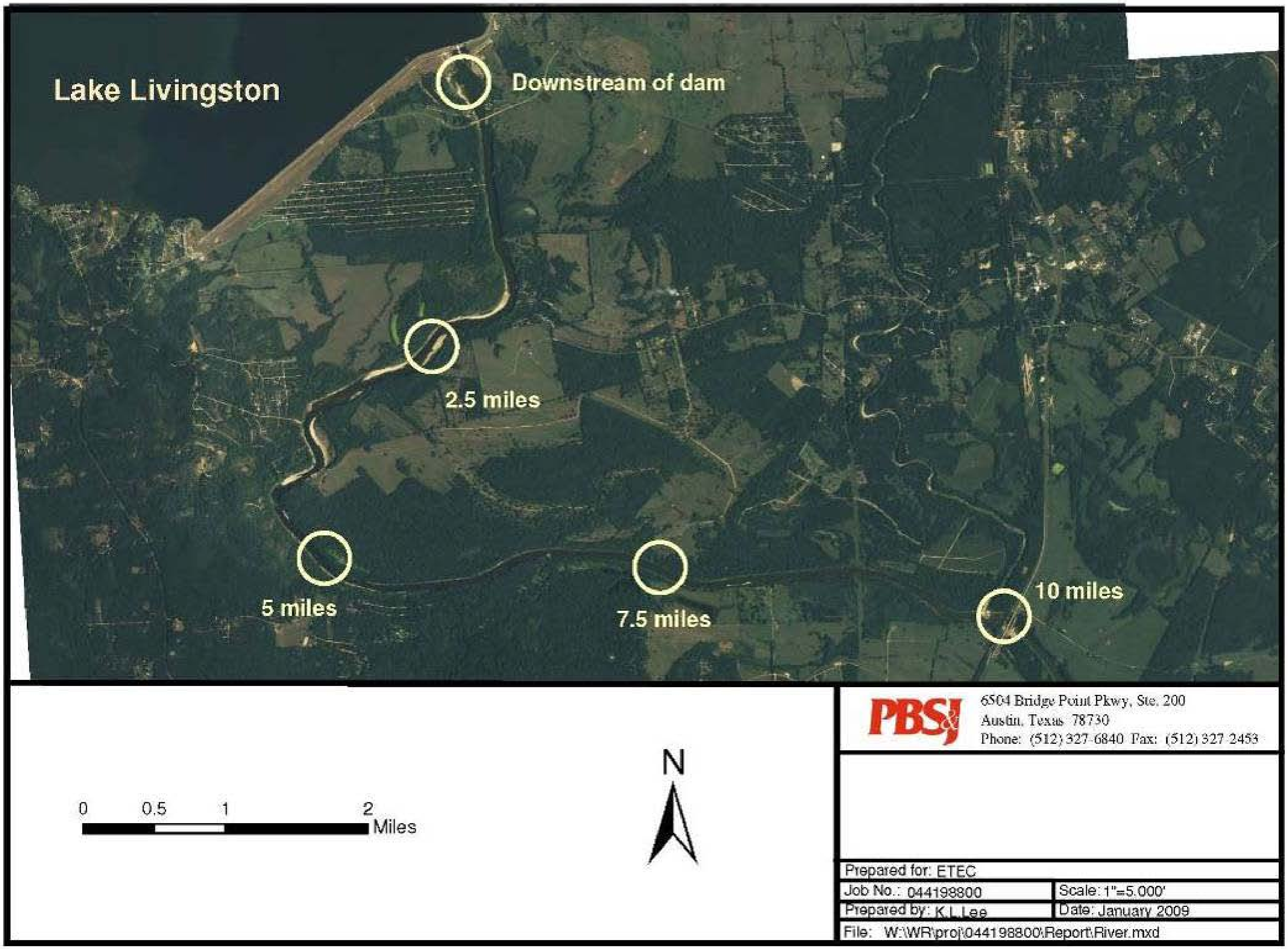
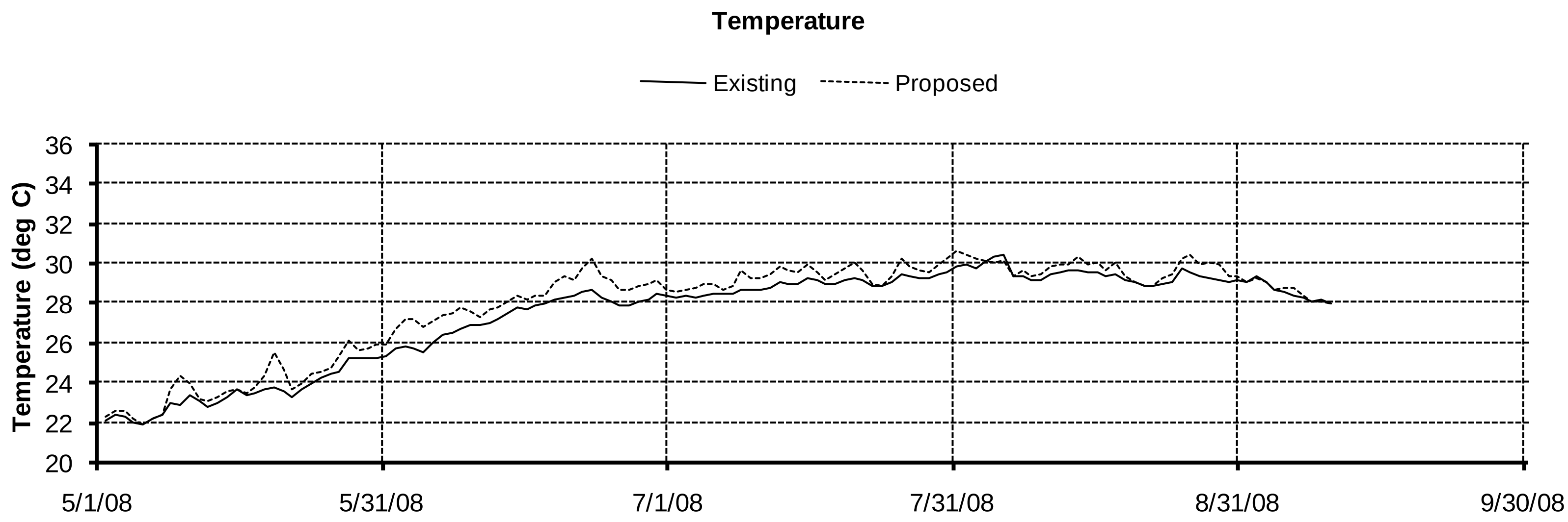


Figure 3. Locations for the model scenarios.



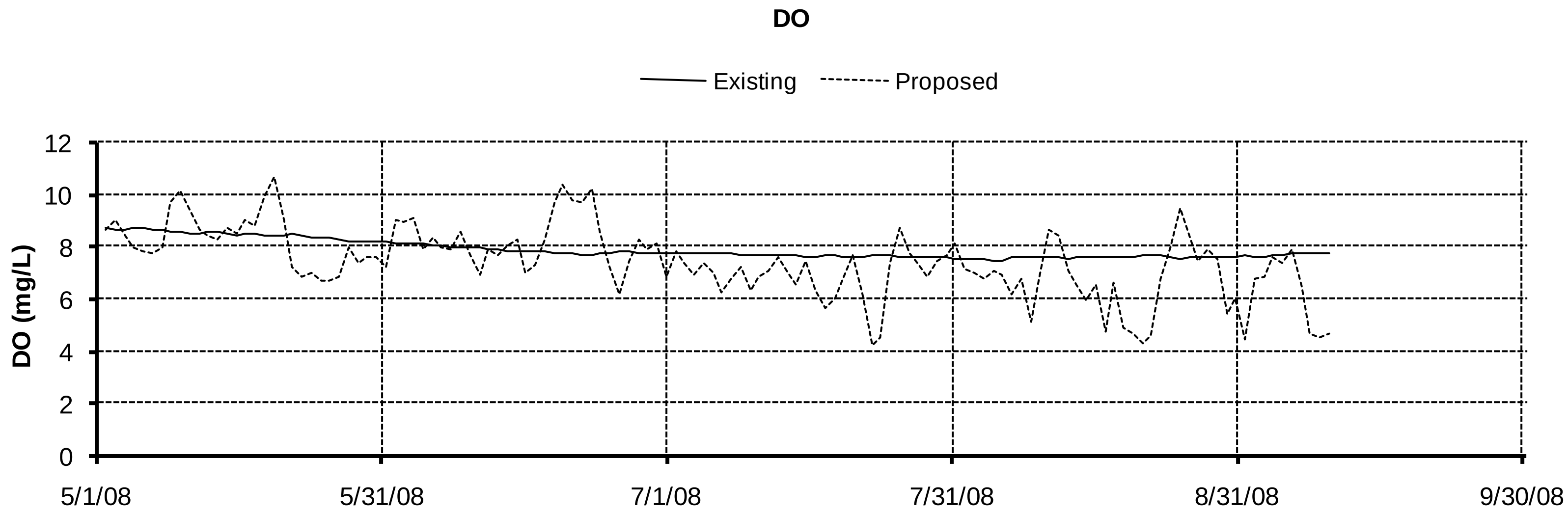
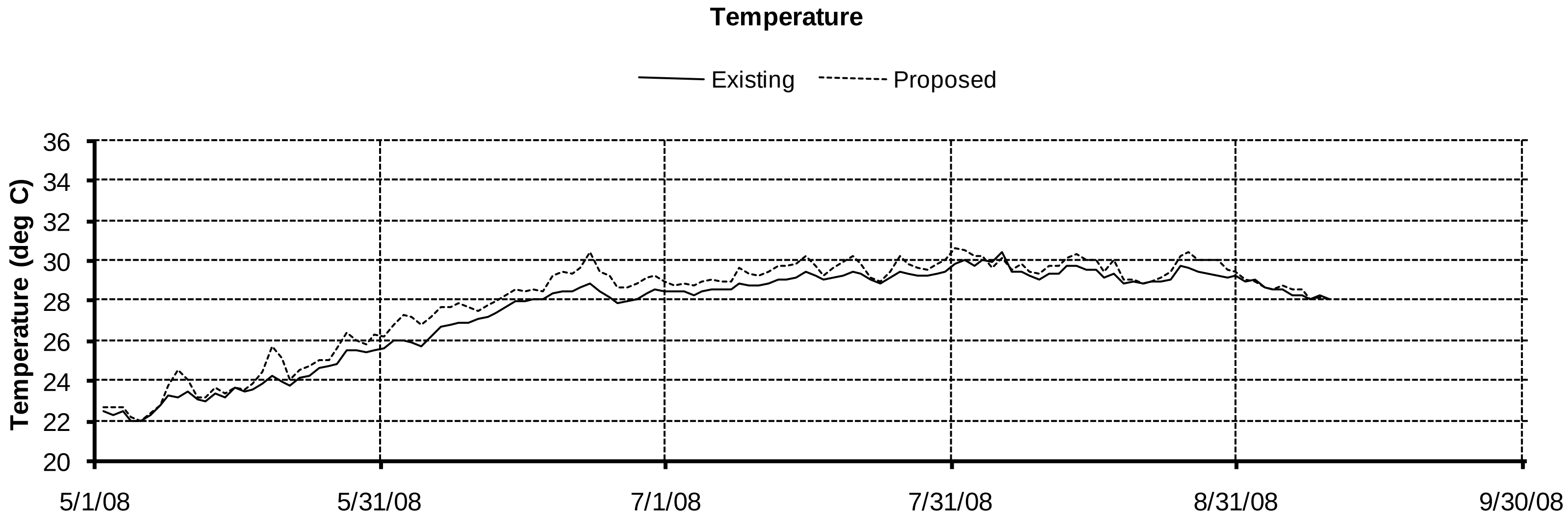


Figure 4a. Comparison between model results of existing and proposed conditions in Trinity River just downstream of dam May-Sep 2008; Existing: spillway gate release = 950 cfs; Proposed: facility flow = 750 cfs, spillway gate release = 200 cfs



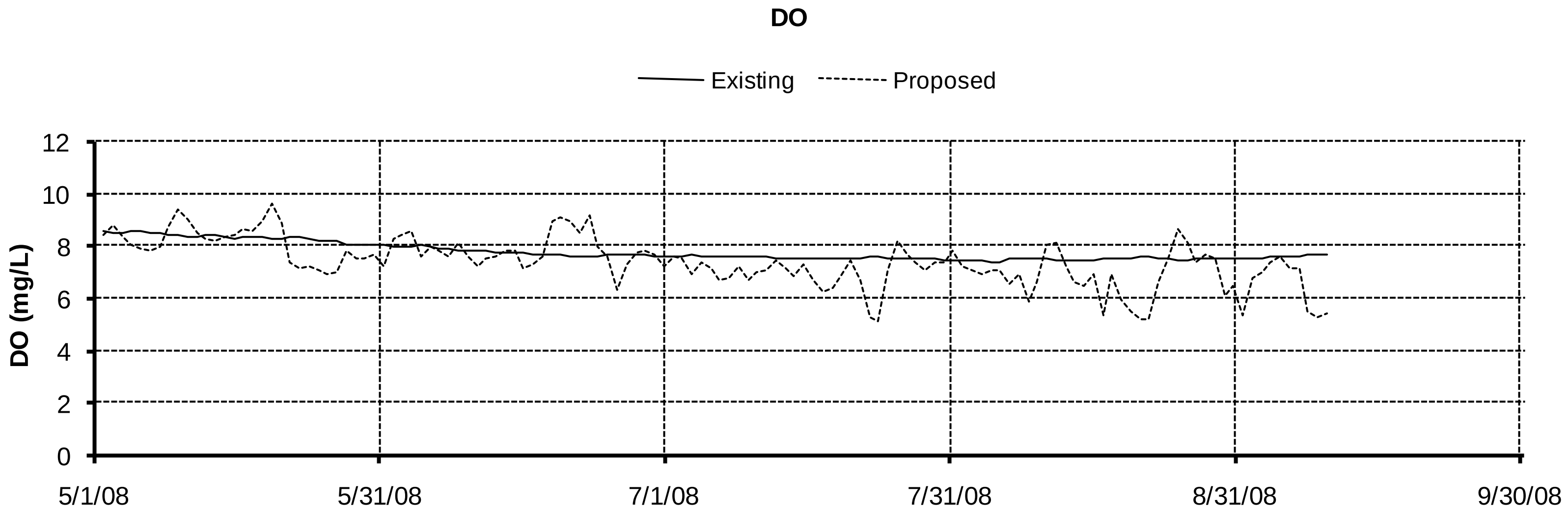
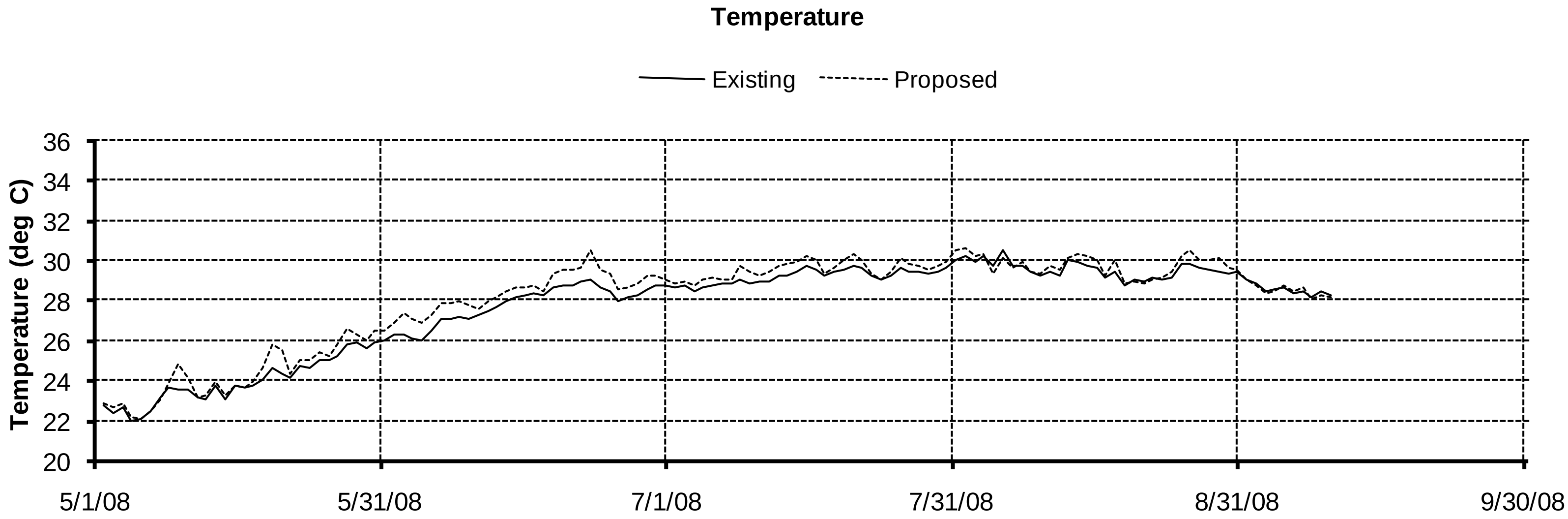


Figure 4b. Comparison between model results of existing and proposed conditions in Trinity River about 2.5 miles from dam. May-Sep 2008; Existing: spillway gate release = 950 cfs; Proposed: facility flow = 750 cfs, spillway gate release = 200 cfs



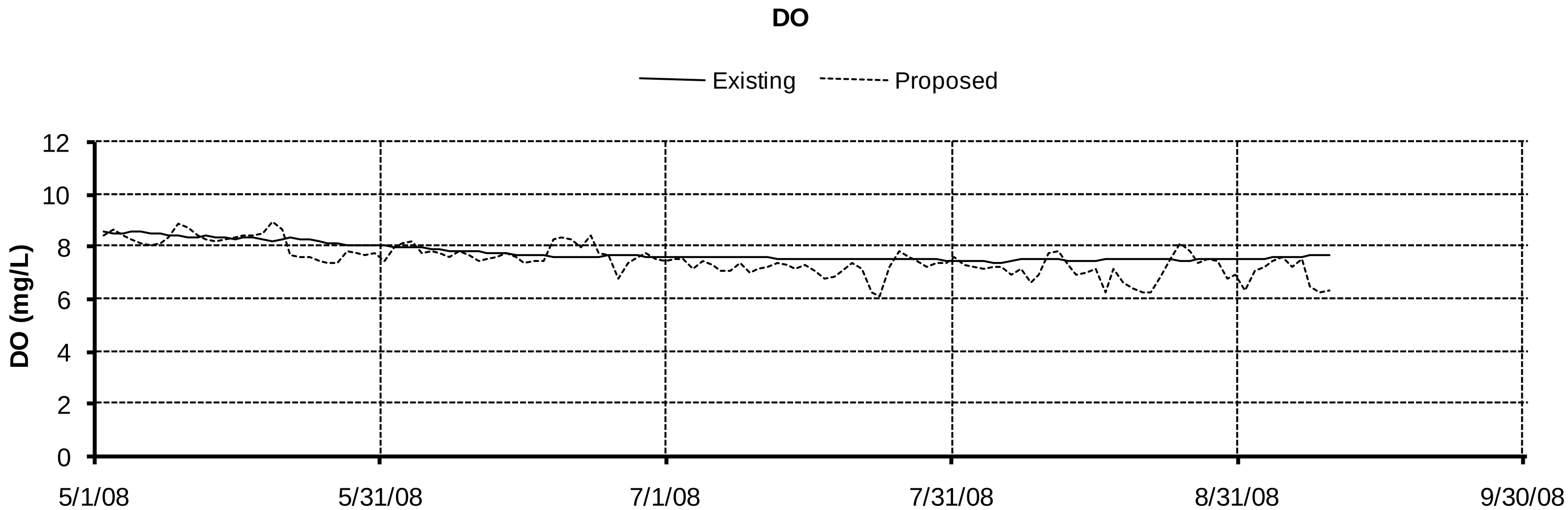
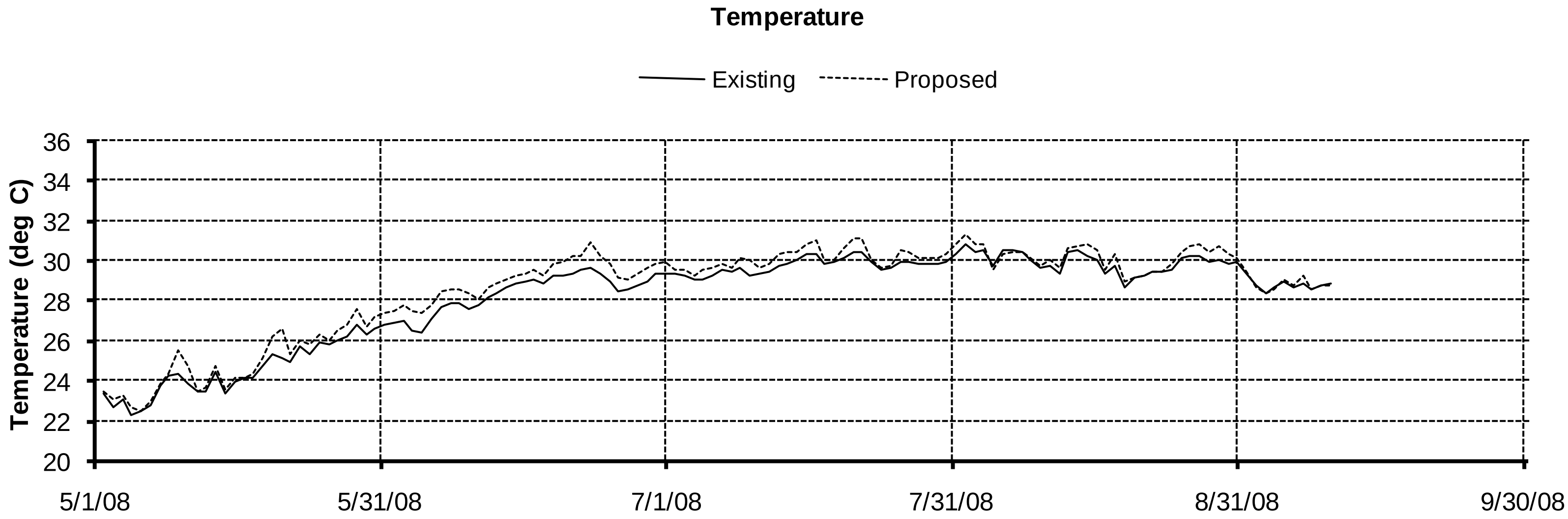


Figure 4c. Comparison between model results of existing and proposed conditions in Trinity River about 5 miles from dam May-Sep 2008; Existing: spillway gate release = 950 cfs; Proposed: facility flow = 750 cfs, spillway gate release = 200 cfs



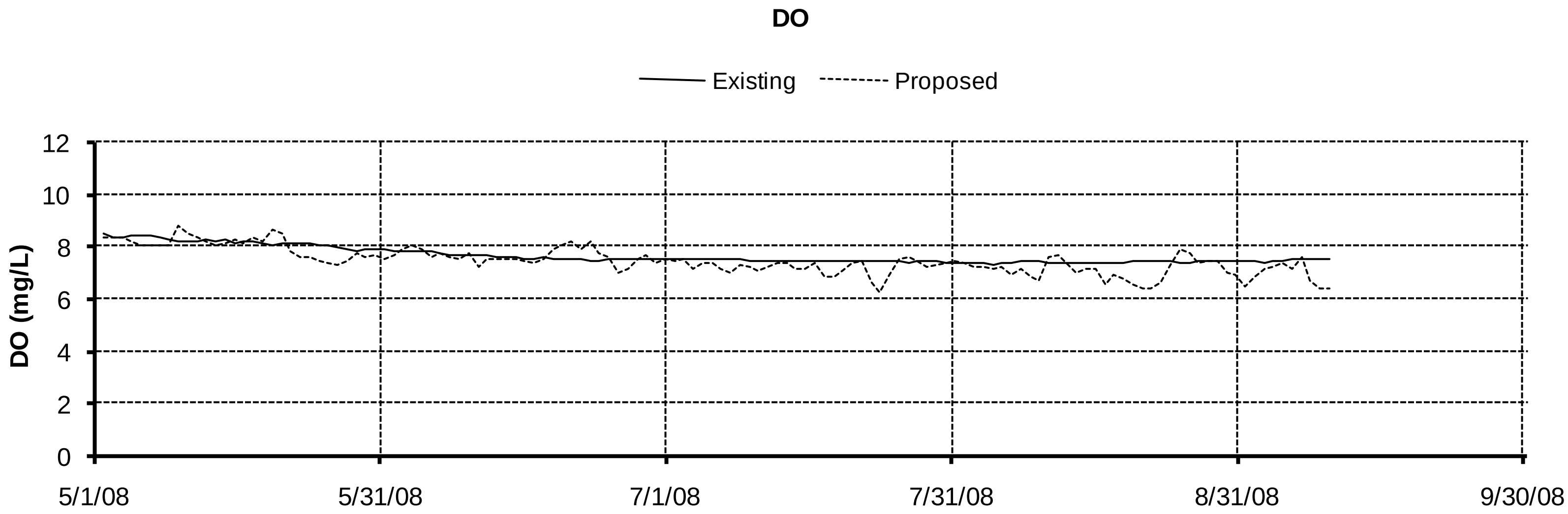
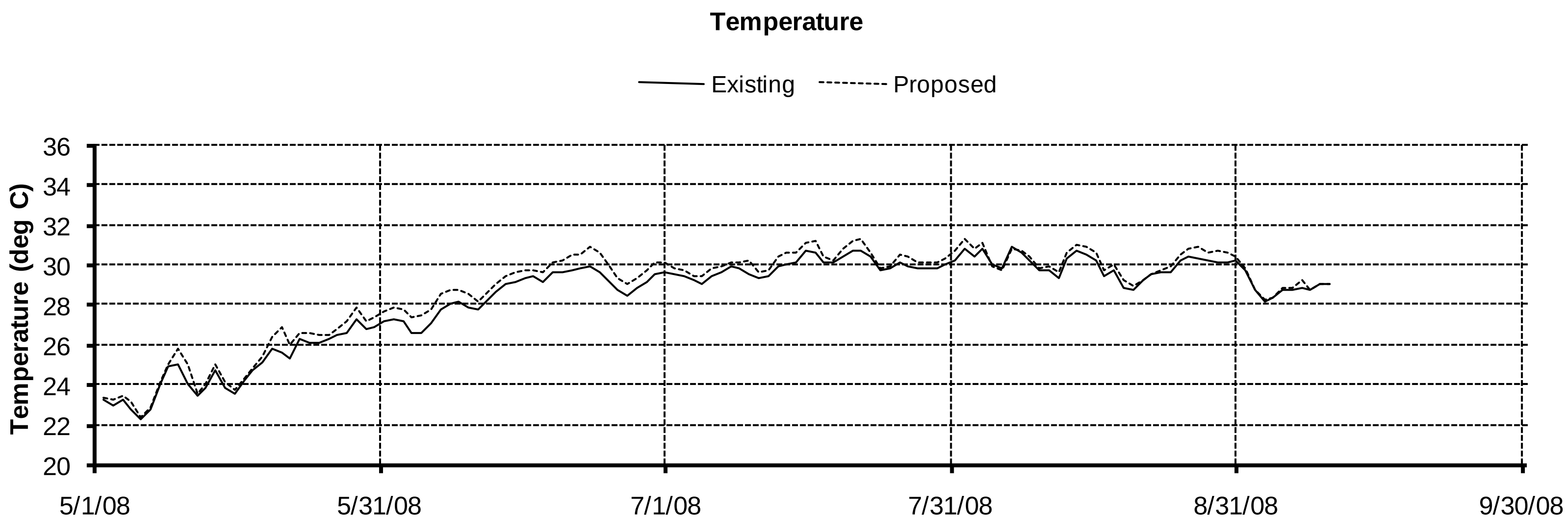
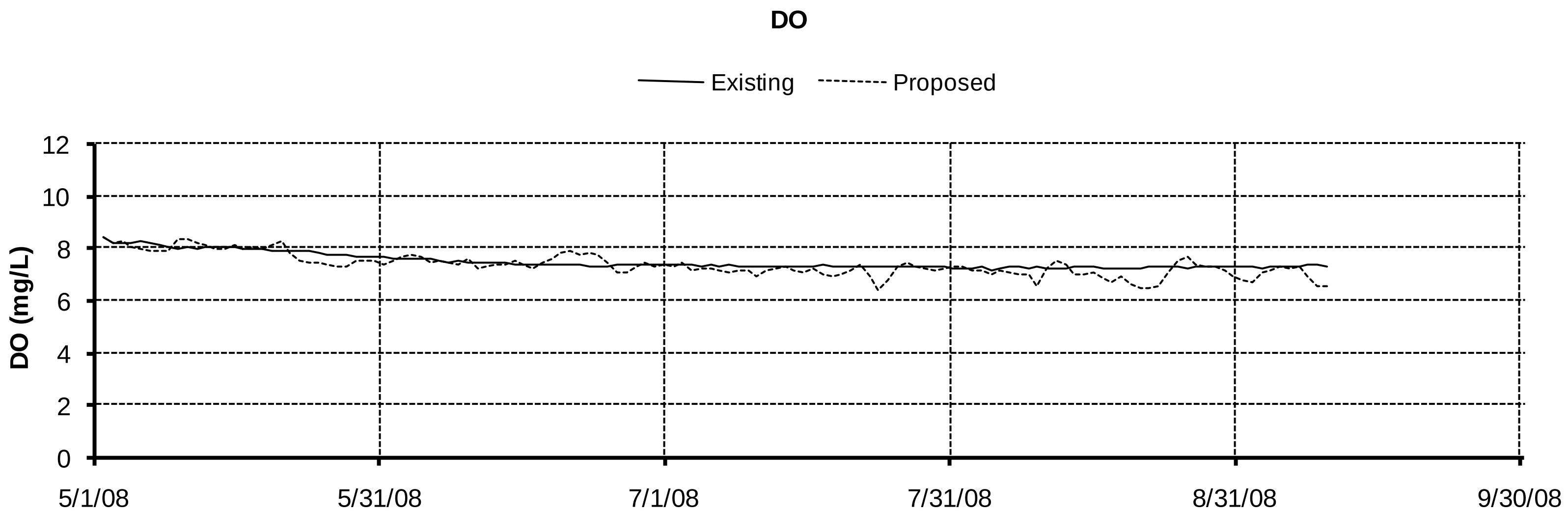


Figure 4d. Comparison between model results of existing and proposed conditions in Trinity River about 7.5 miles from dam. May-Sep 2008; Existing: spillway gate release = 950 cfs; Proposed: facility flow = 750 cfs, spillway gate release = 200 cfs





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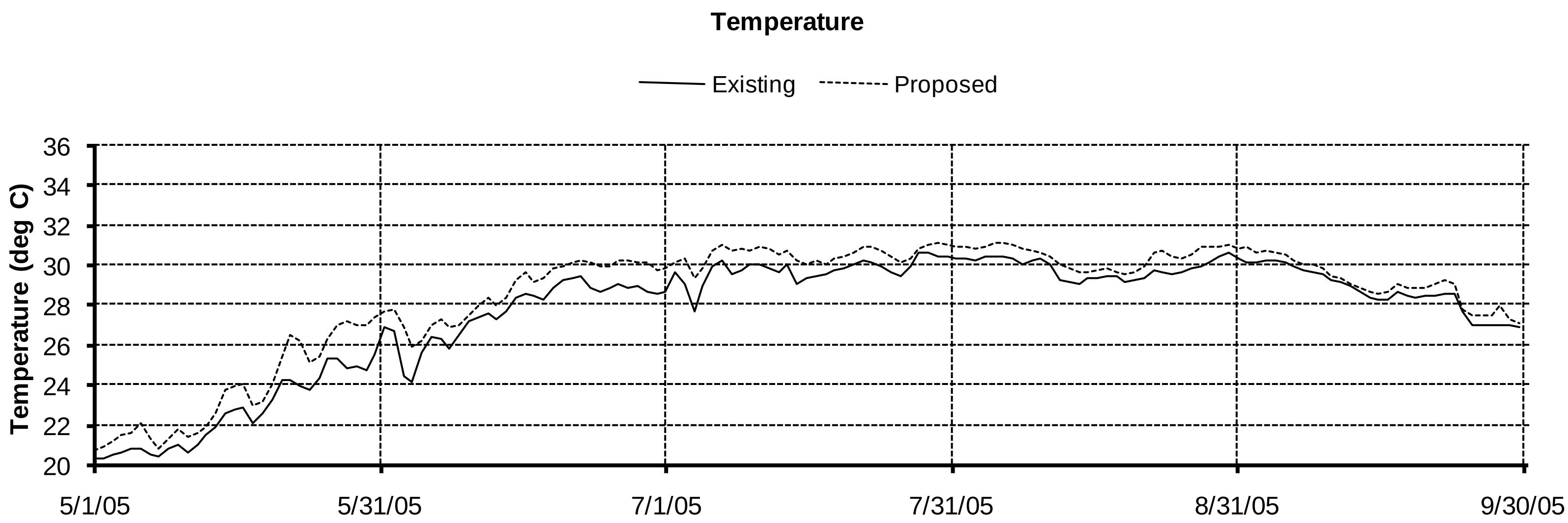


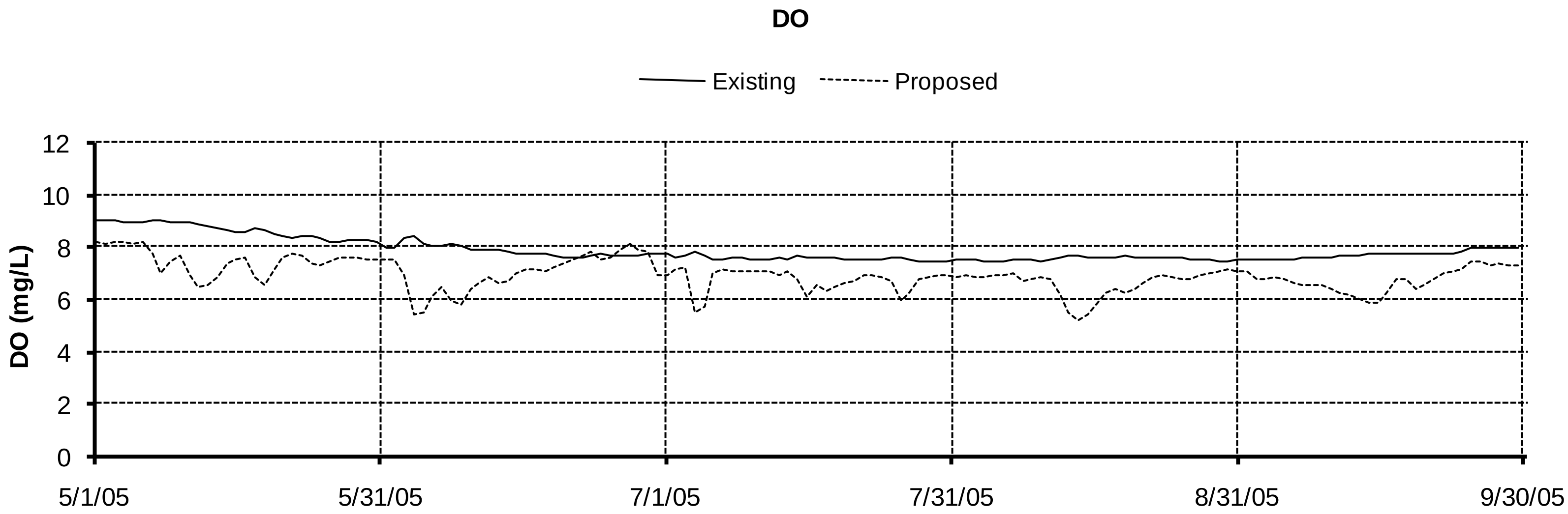


Figure 5a. Comparison between model results of existing and proposed conditions in Trinity River just downstream of dam May-Sep 2005; Existing: spillway gate release = 950 cfs; Proposed: facility flow = 750 cfs, spillway gate release = 200 cfs

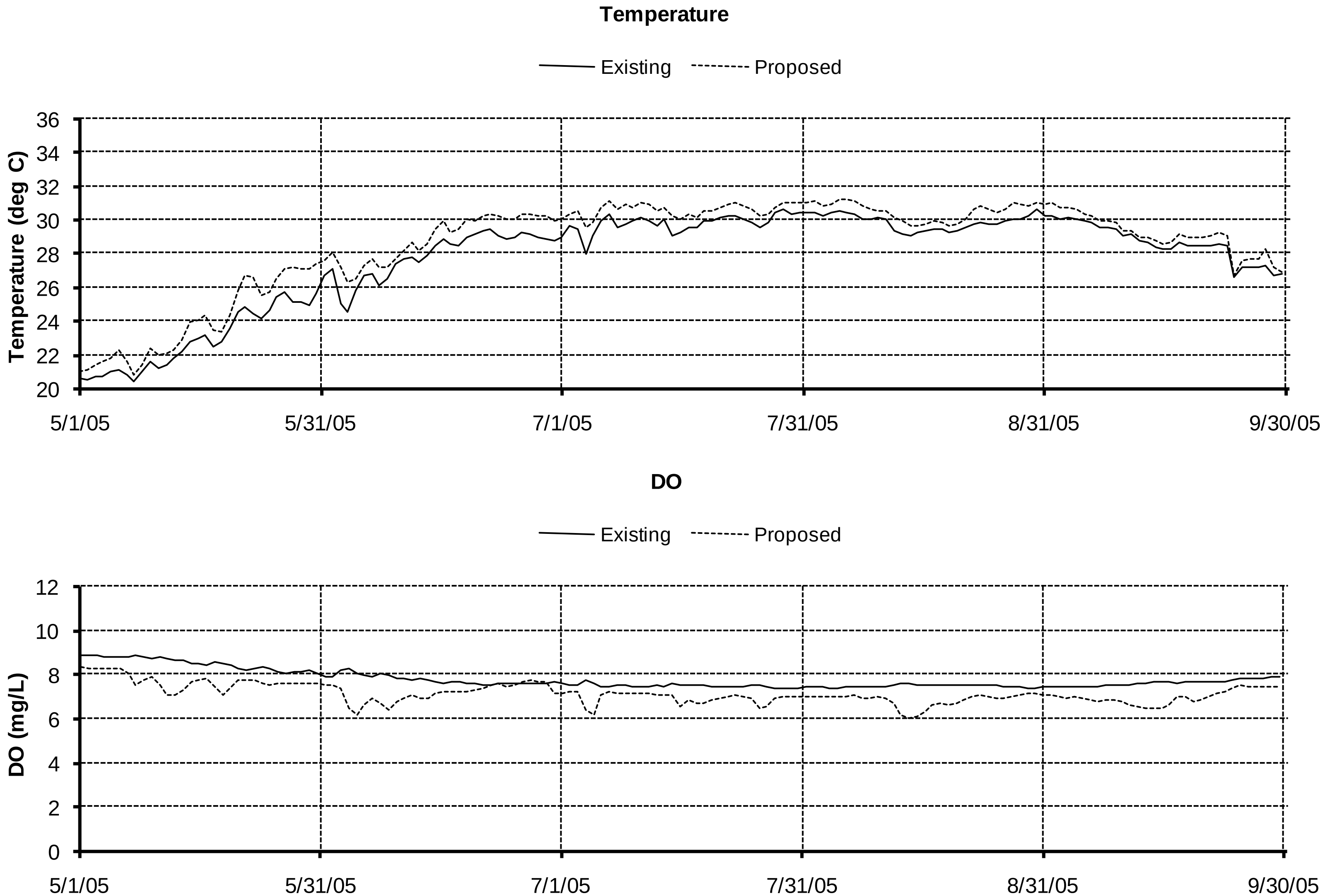
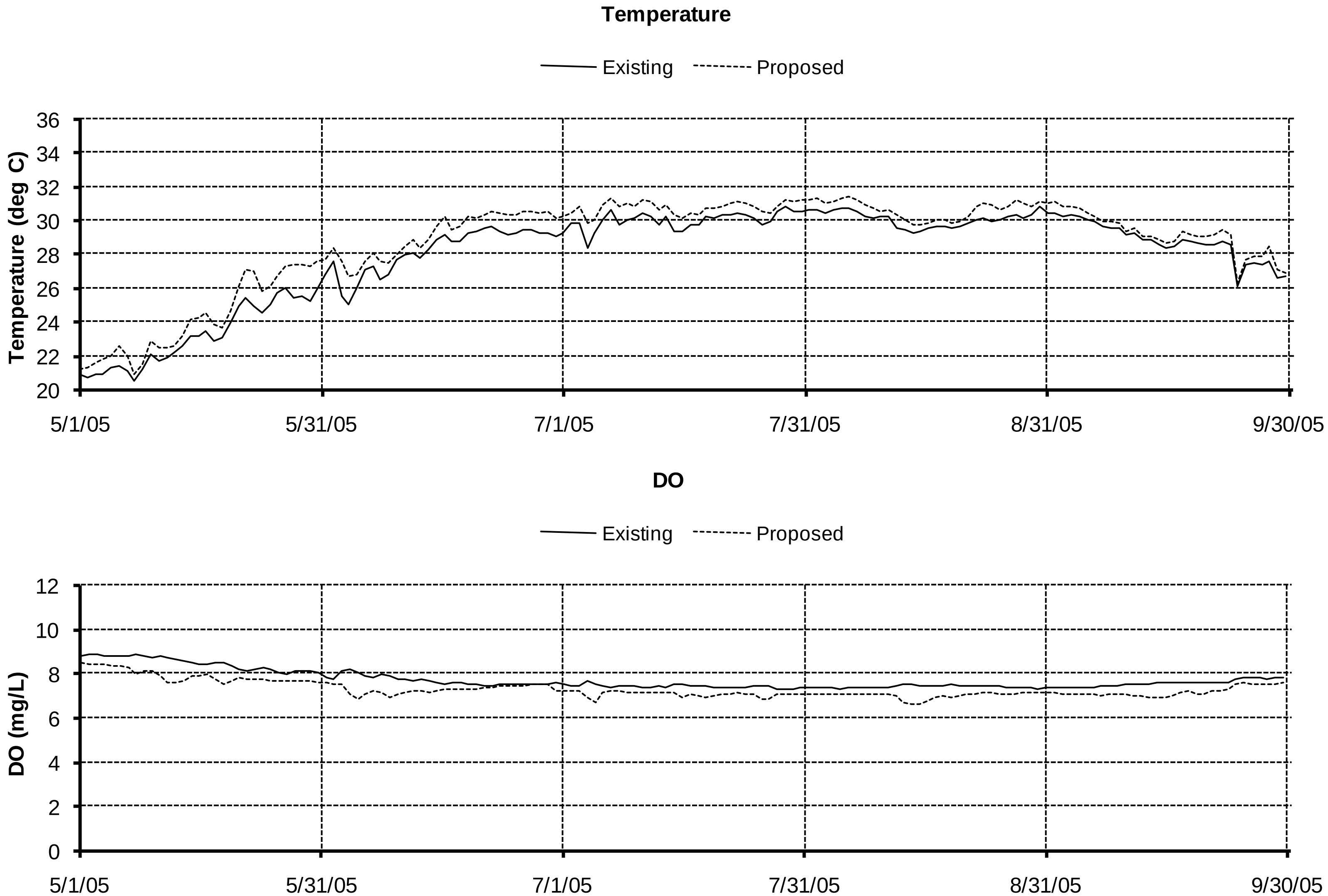


Figure 5b. Comparison between model results of existing and proposed conditions in Trinity River about 2.5 miles from dam May-Sep 2005; Existing: spillway gate release = 950 cfs; Proposed: facility flow = 750 cfs, spillway gate release = 200 cfs



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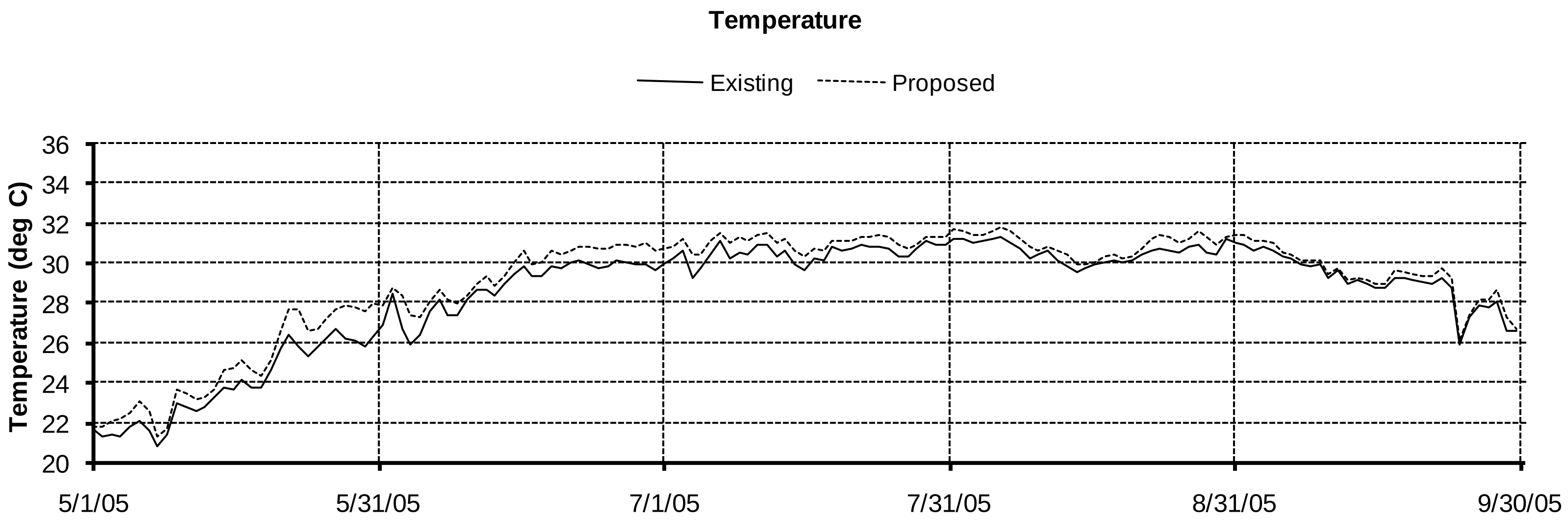

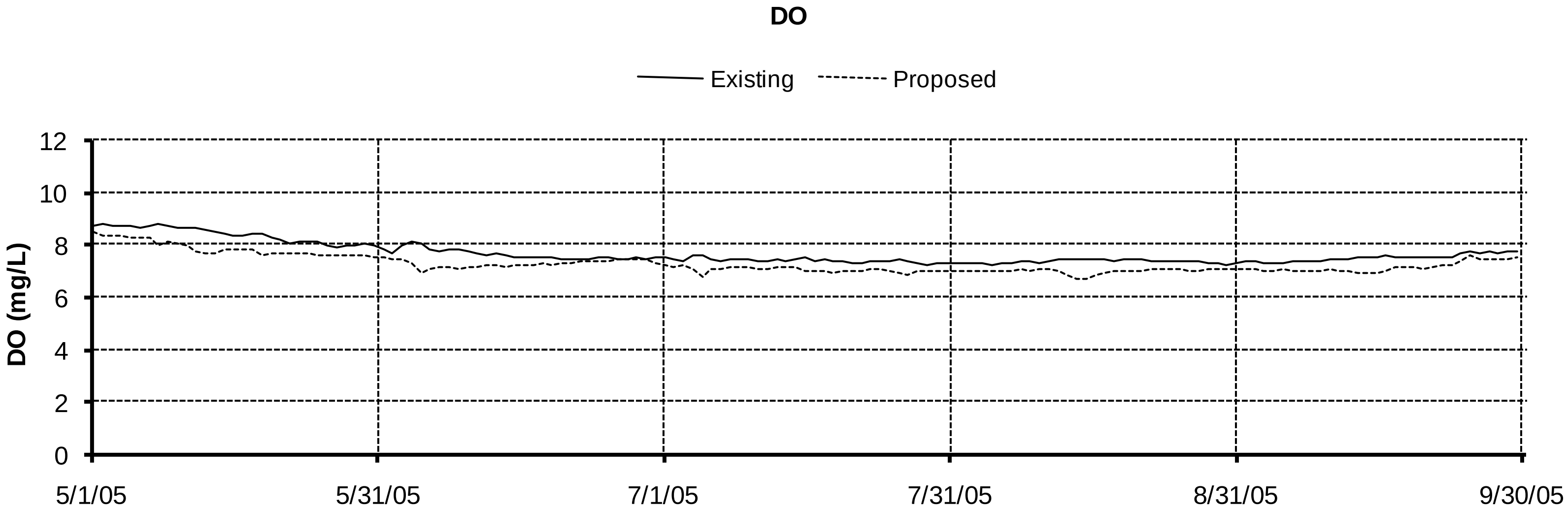

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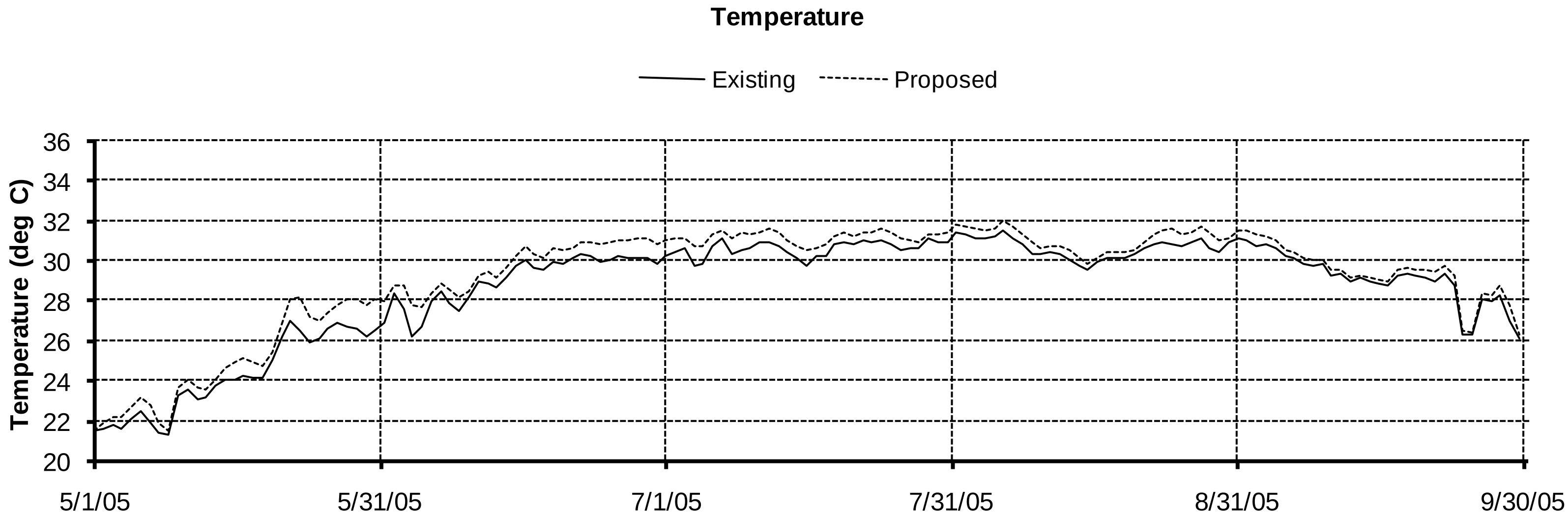

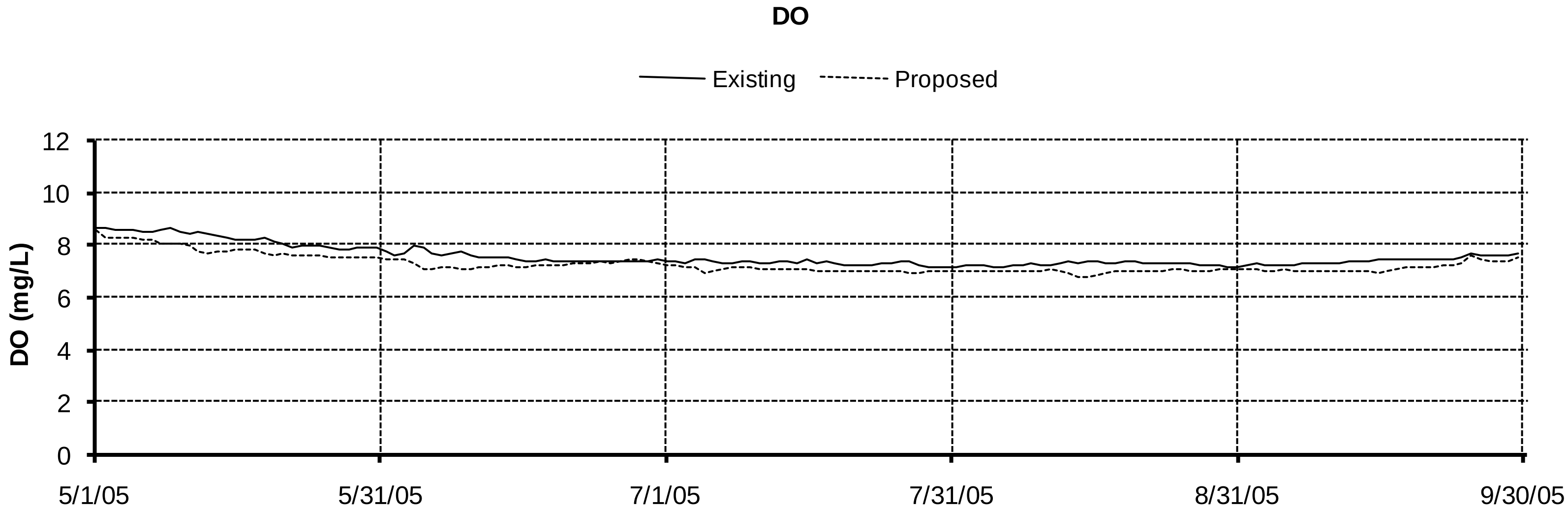

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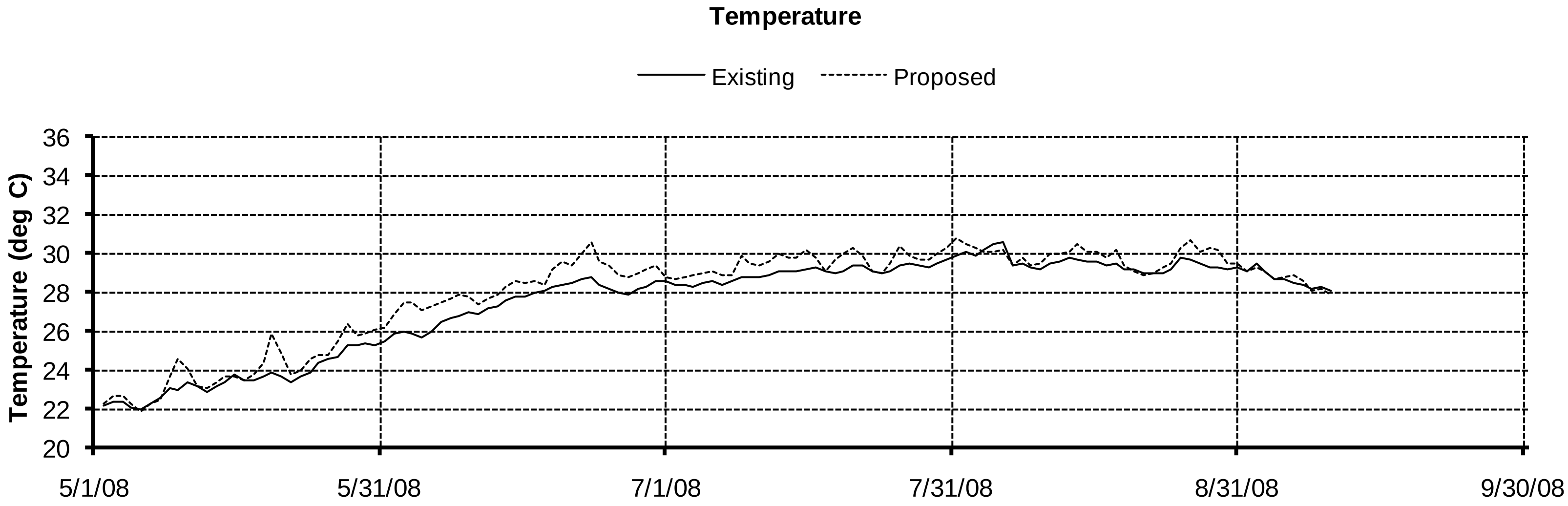

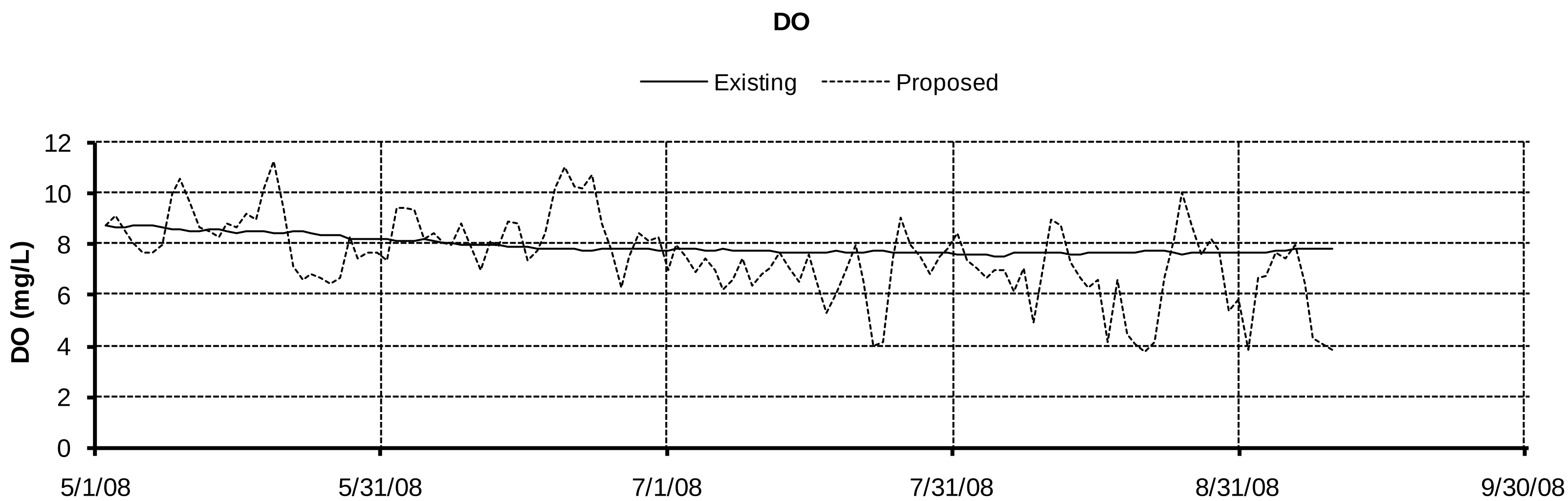

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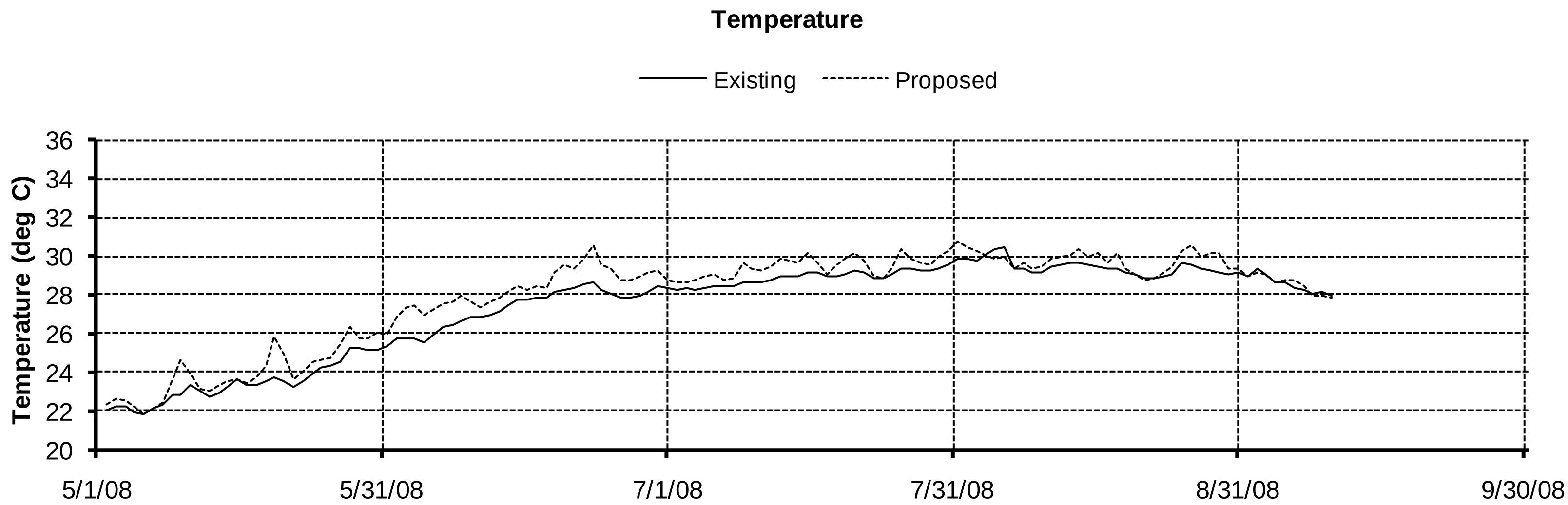

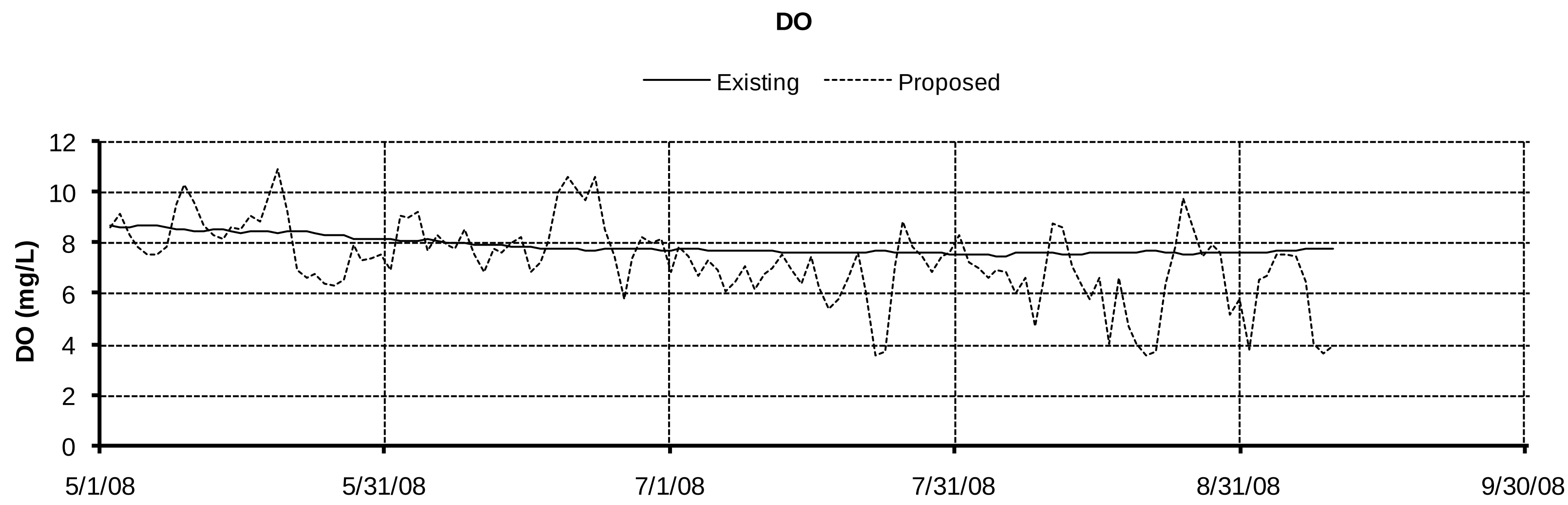

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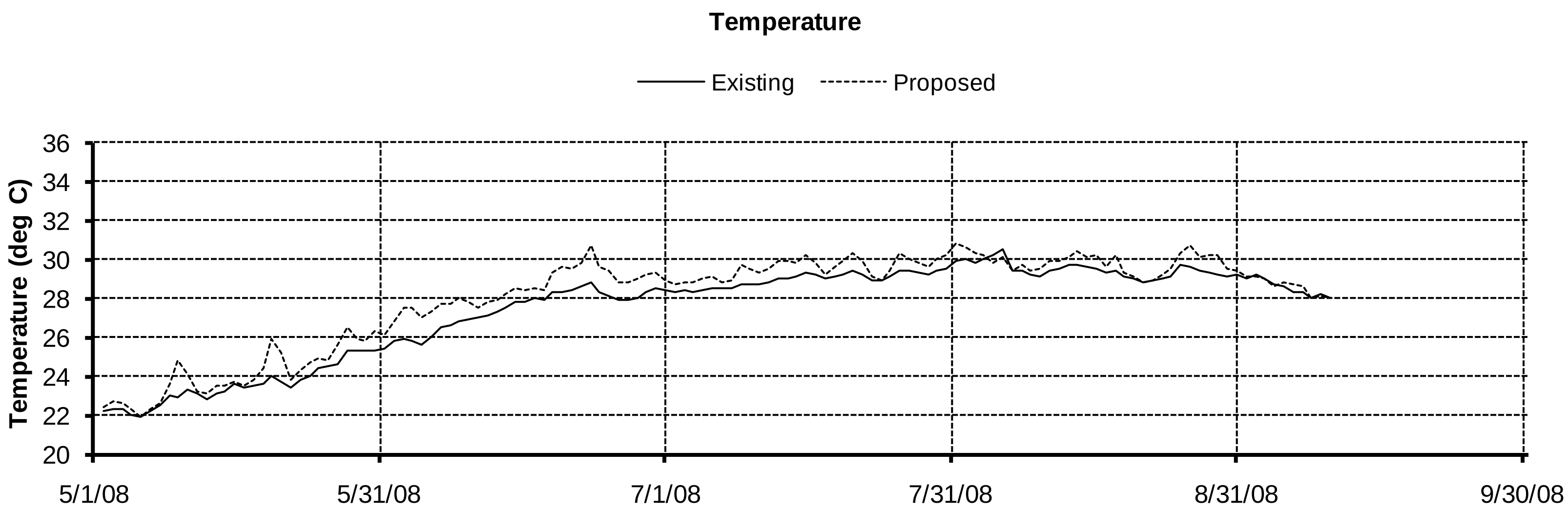

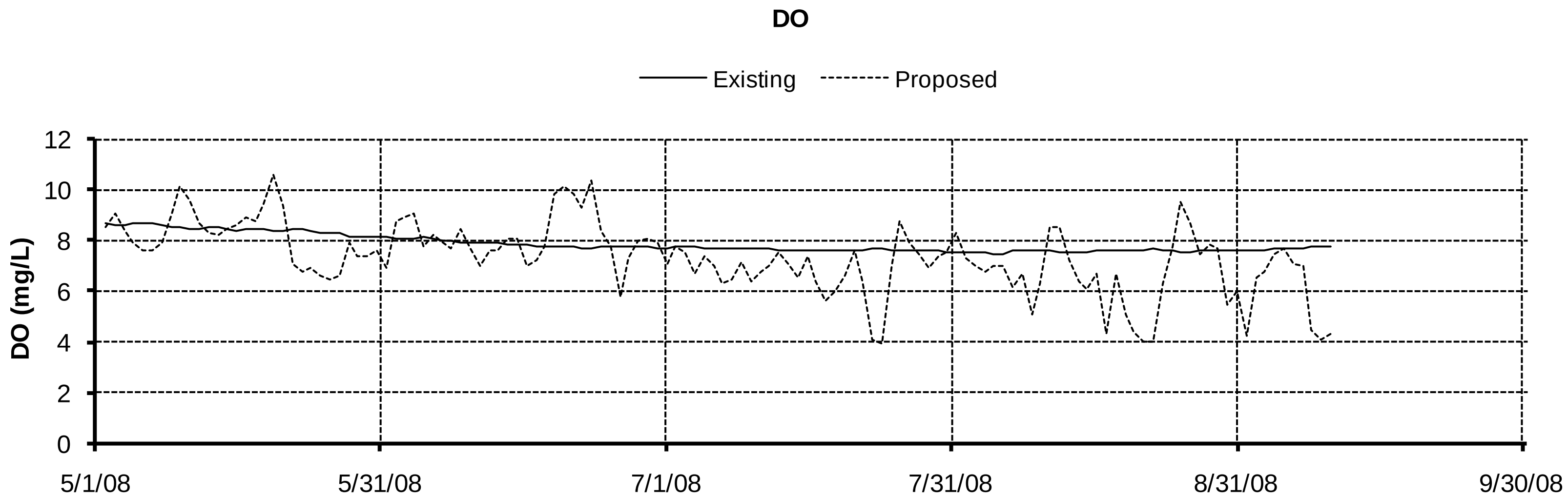

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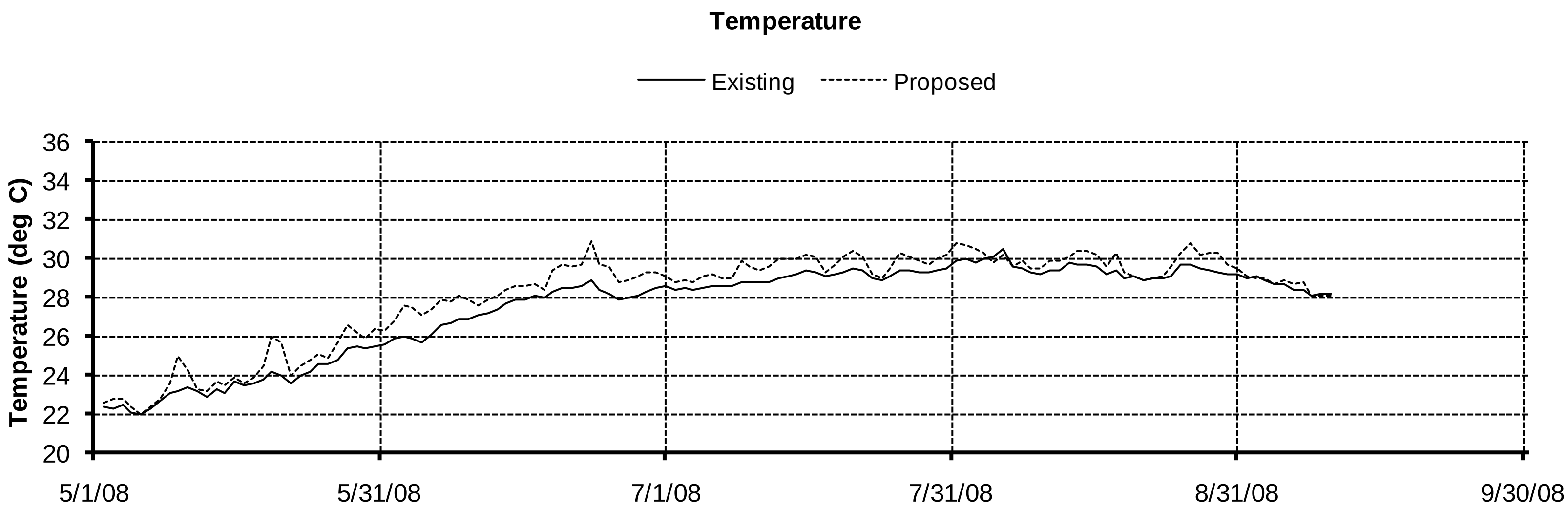

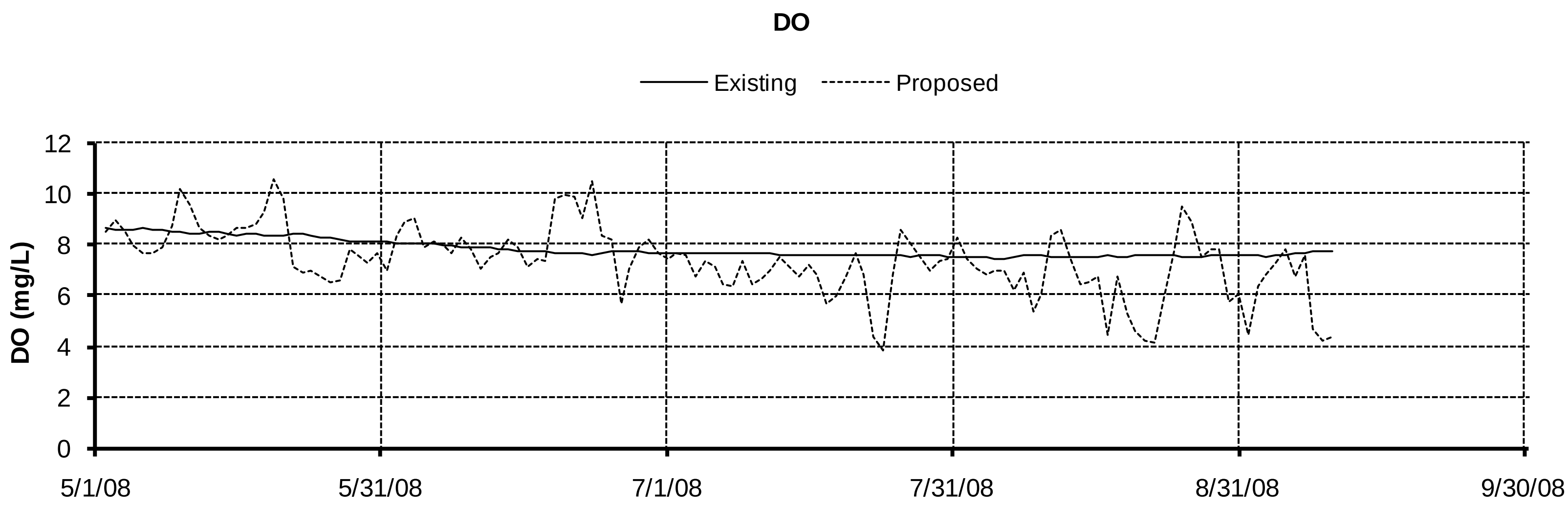

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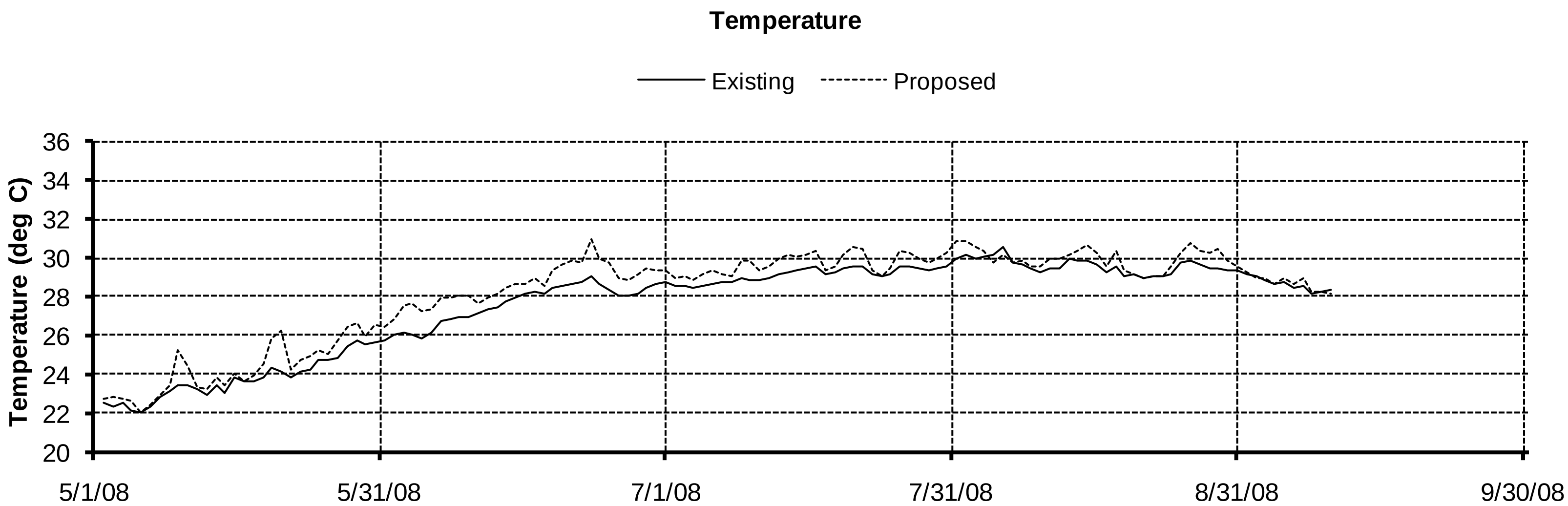

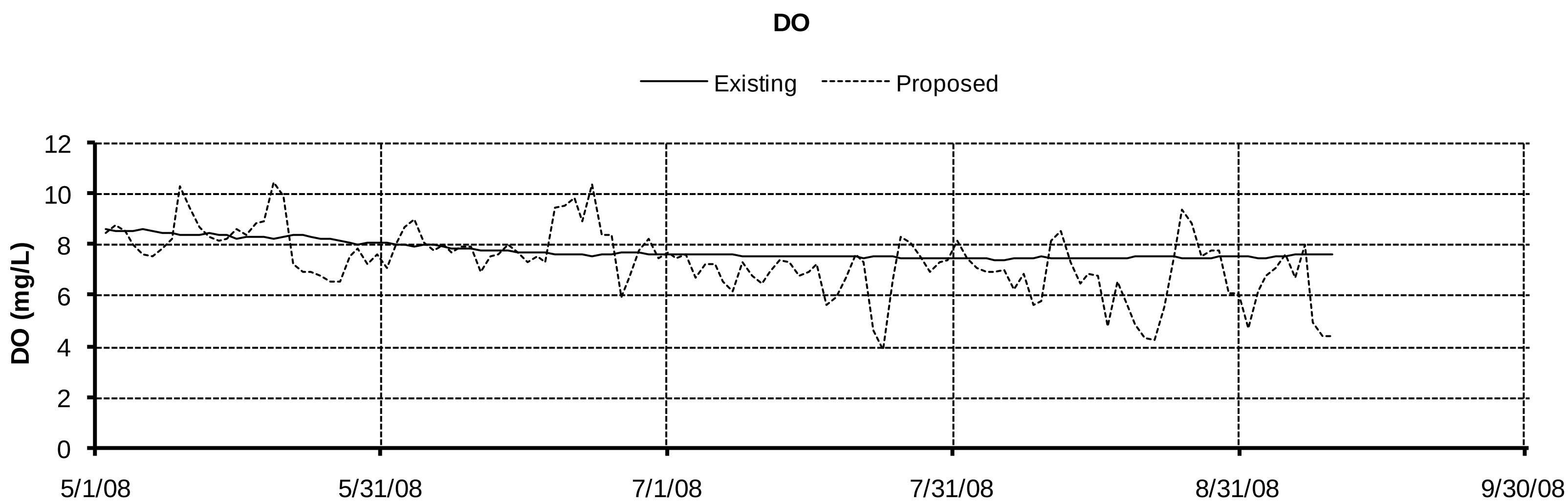

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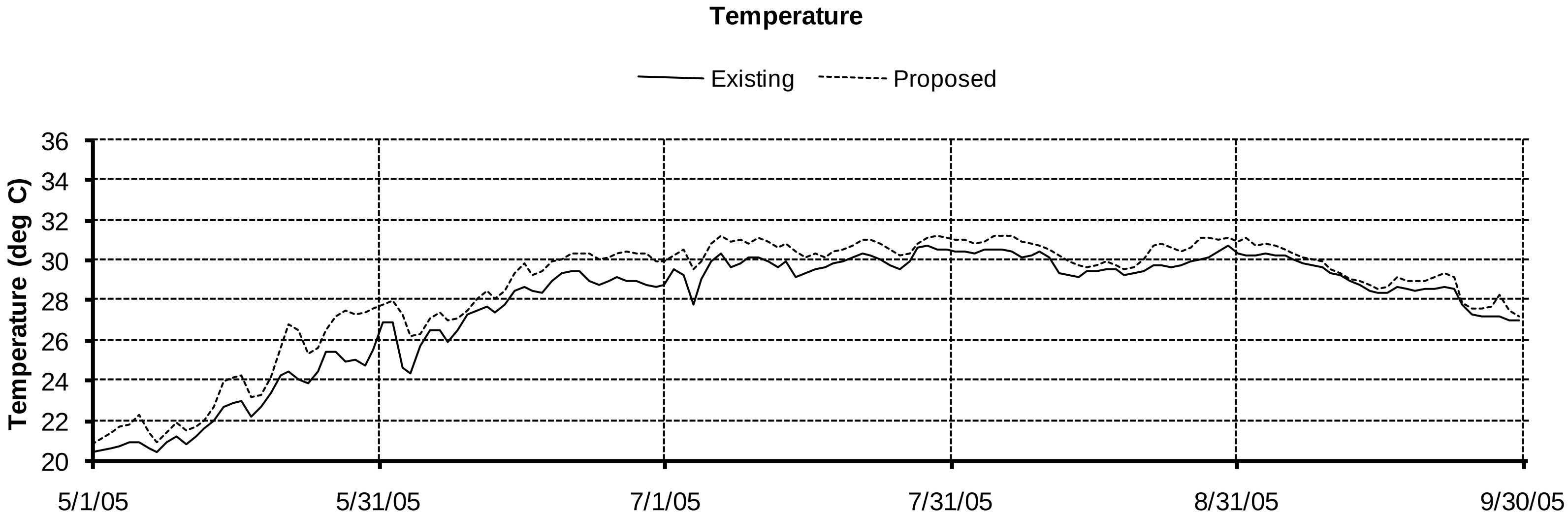

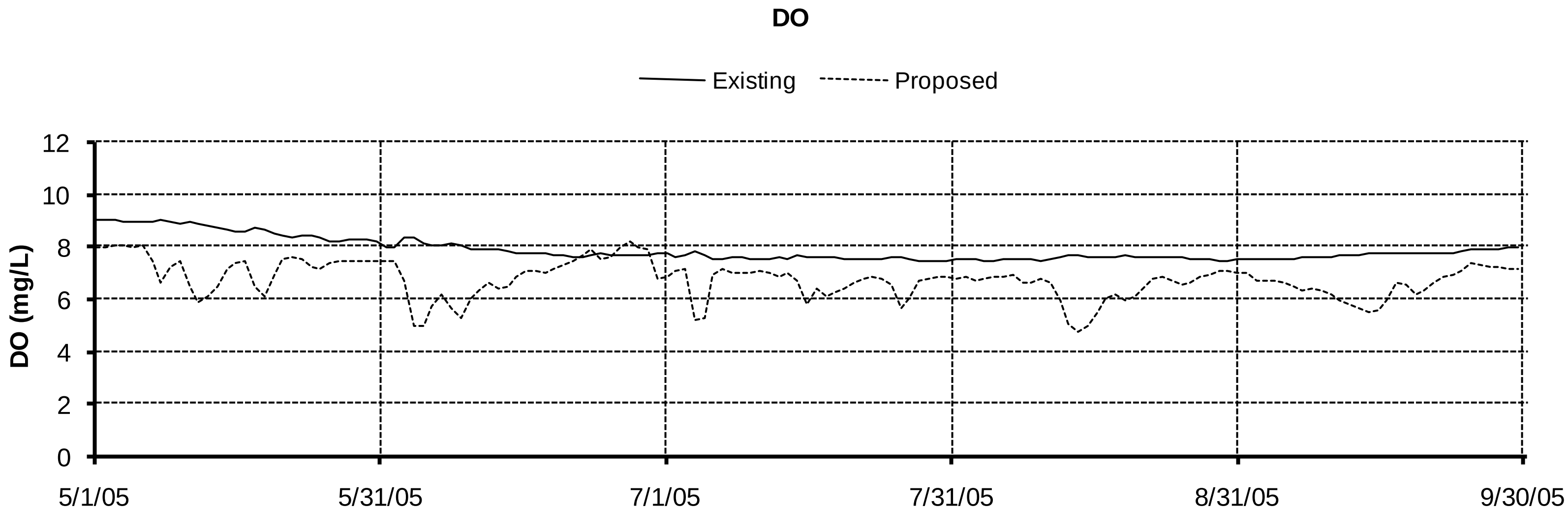

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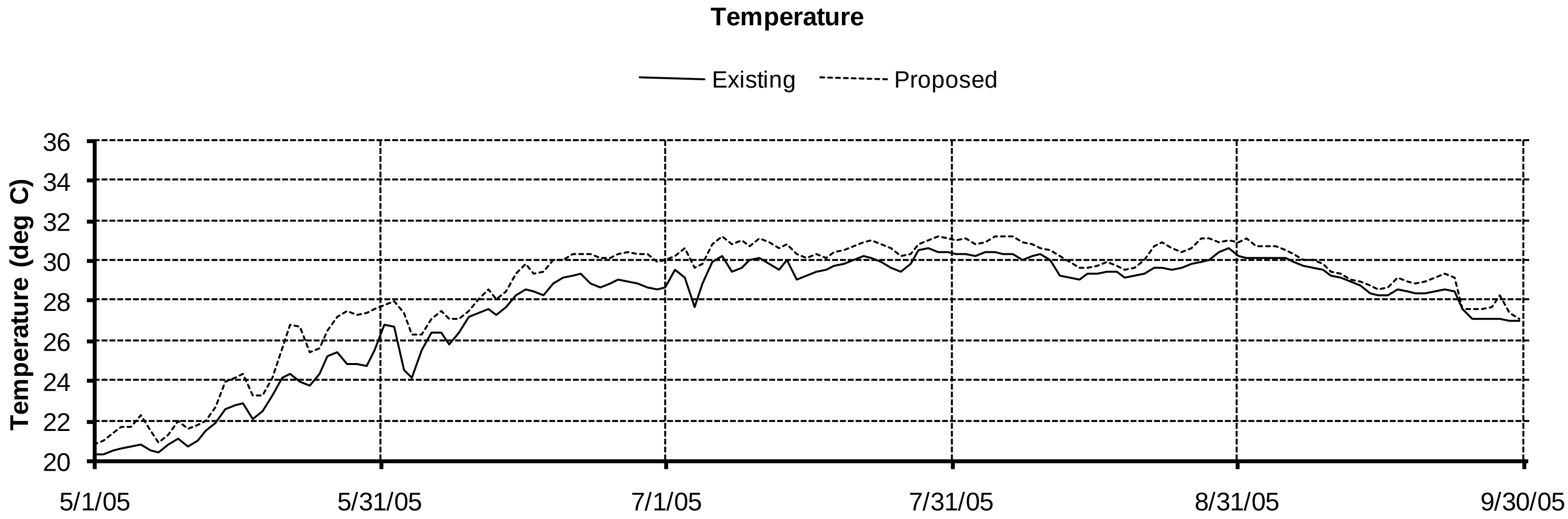


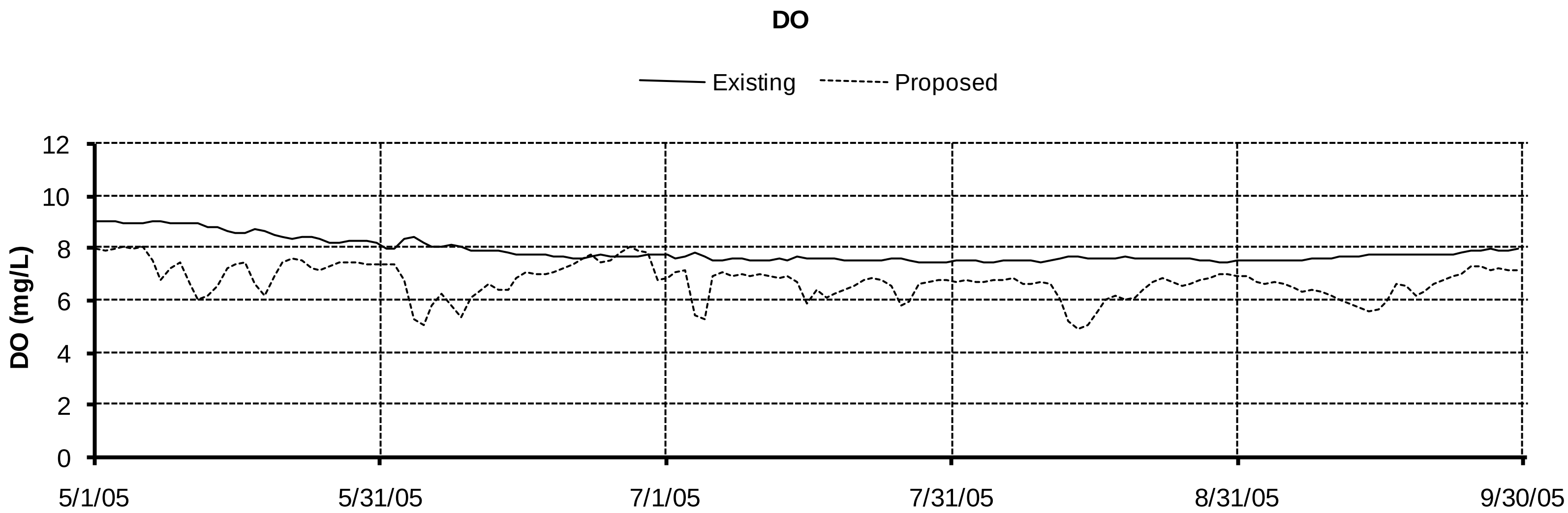
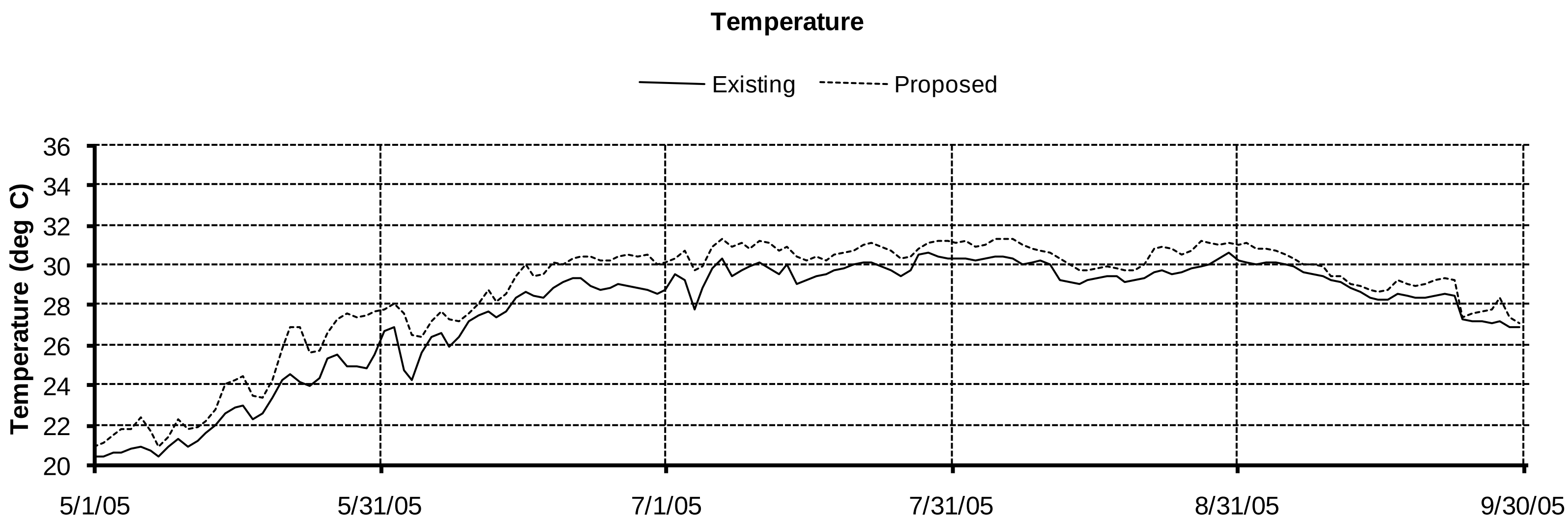
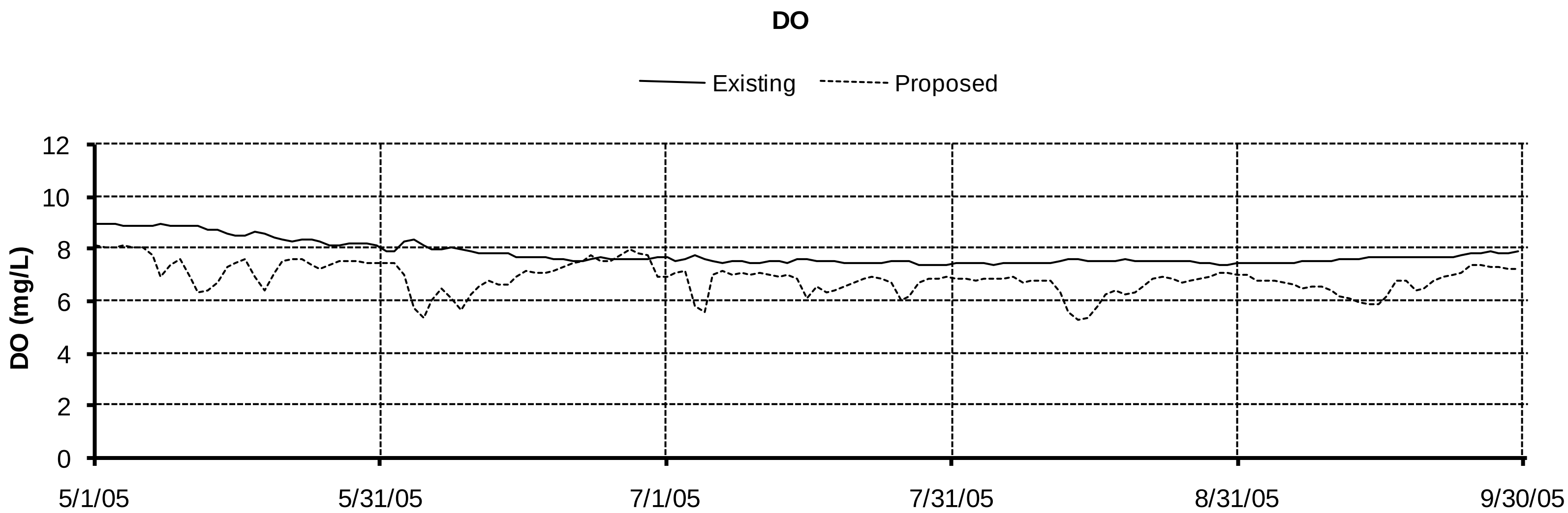


Figure 7b. Comparison between model results of existing and proposed conditions in Trinity River about 2.5 miles from dam May-Sep 2005; Existing: spillway gate release = 5500 cfs; Proposed: facility flow = 5300 cfs, spillway gate release = 200 cfs





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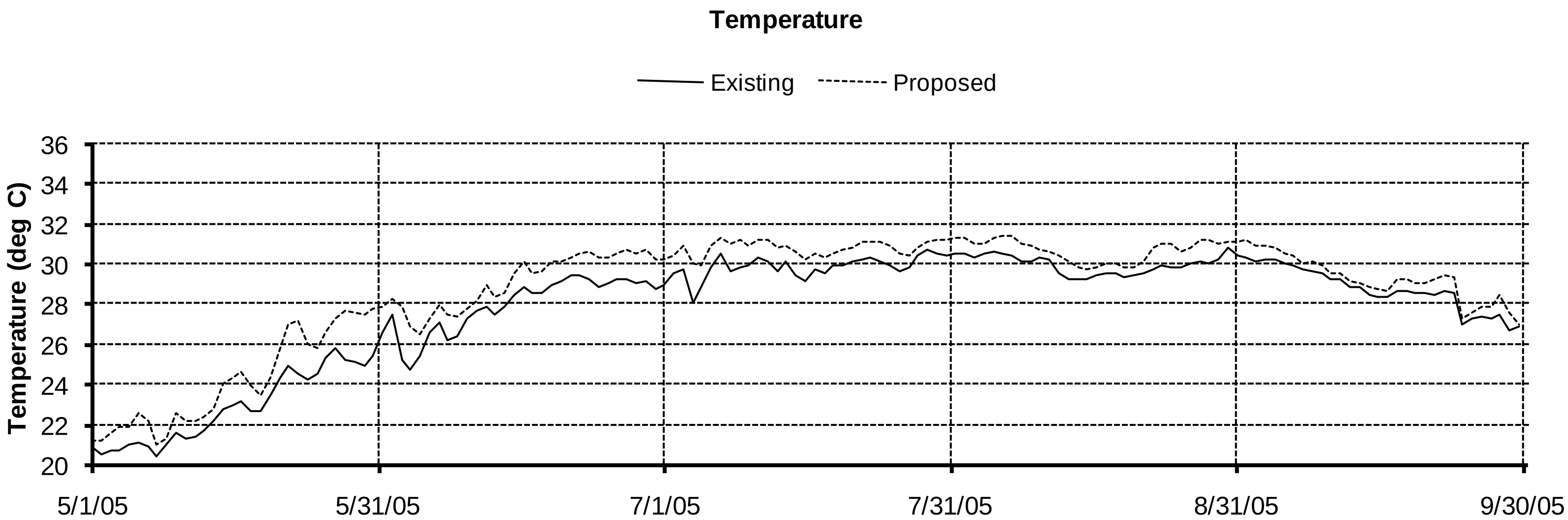

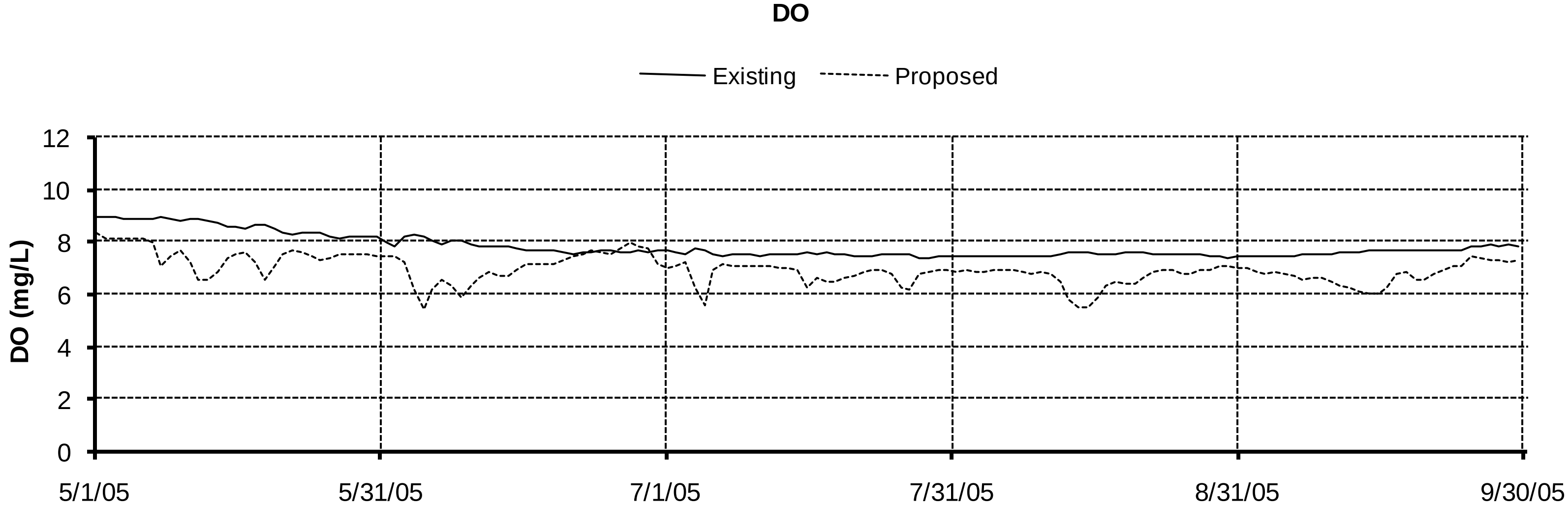

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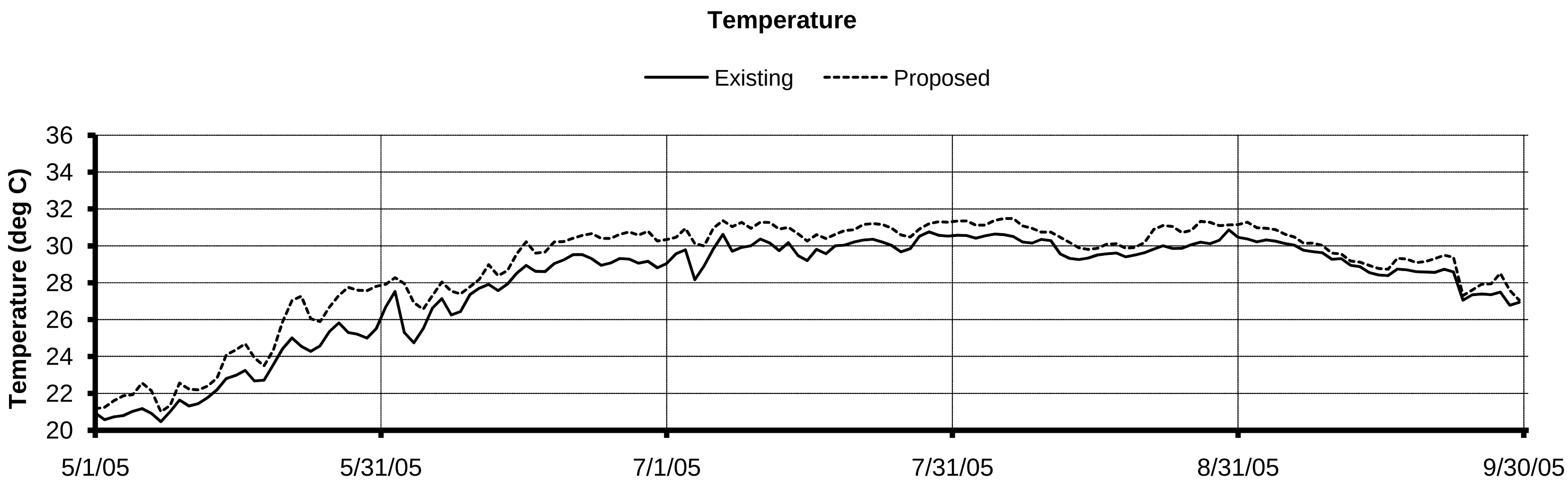

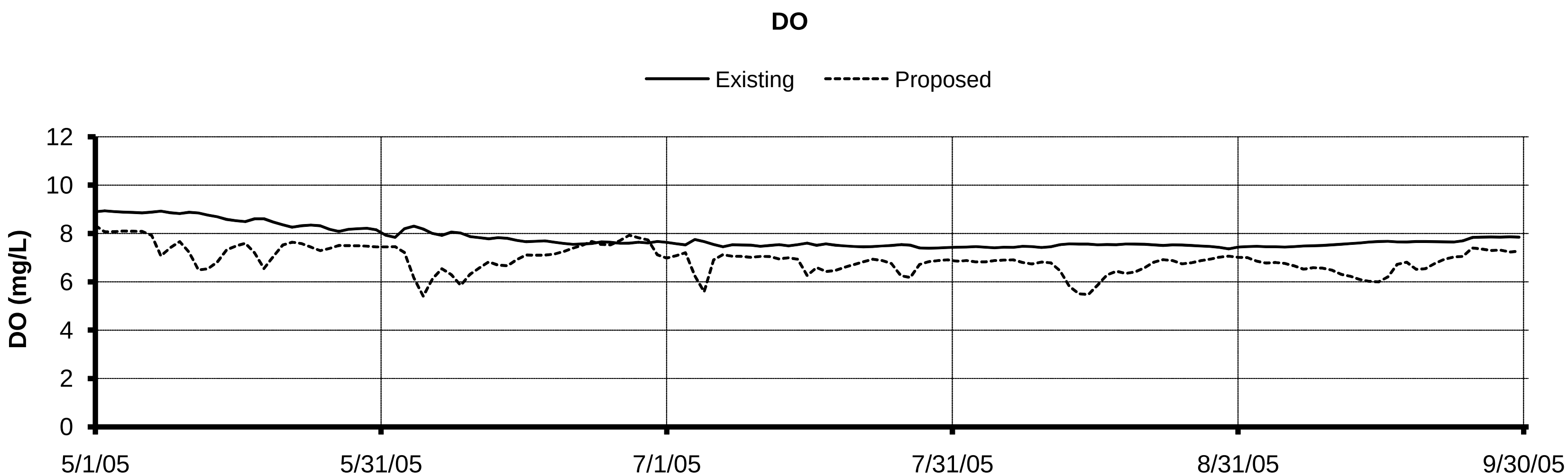

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