Effect of the Pure Water Monterey Groundwater Replenishment Project on Nitrogen Loading to the Bay

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Prepared for:

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1 Executive Summary

The effect of the Monterey One Water Pure Water Monterey project (“GWR project”) on the nitrogen loading to the Monterey Bay is evaluated in this technical memorandum. The GWR project will introduce several changes to the system (described below) and one of these changes is expected to have a significant influence on the nitrogen loading to the Bay: a portion of the tile drainage from the Blanco Drain and Reclamation Ditch will be diverted to the Regional Treatment Plant. To evaluate the influence of these changes on nitrogen loading to the Bay, nitrogen mass balance equations were derived for scenarios with and without the GWR project. These equations demonstrate that the GWR project, as a result of the tile drainage diversion and subsequent treatment the Regional Treatment Plant, will decrease both the nitrogen load to the photic zone and the total nitrogen load to the Bay.

2 Introduction

Monterey One Water (M1W) and the Monterey Peninsula Water Management District (“Project Partners”) are implementing the Pure Water Monterey Groundwater Replenishment Project (“GWR project”). The GWR project involves treating secondary effluent from M1W’s Regional Treatment Plant (RTP) through the Advanced Water Purification Facility (AWPF) and then injecting this highly purified recycled water into the Seaside Groundwater Basin, with subsequent withdrawal for use as a municipal water supply. The Project will also provide additional tertiary recycled water for agricultural irrigation in the northern Salinas Valley through the Salinas Valley Reclamation Plant/Castroville Seawater Intrusion Project (SVRP/CSIP).

Excessive nitrogen levels in the Monterey Bay (“Bay”) have the potential to lead to algal blooms harmful to marine wildlife. The reduction of nitrogen loading to the Bay reduces the potential for harmful algal blooms (HABs). The goal of this technical memorandum is to evaluate the impact of the GWR Project on nitrogen loading to the Bay. The GWR Project has previously been shown to comply with all Ocean Plan water quality objectives and has a certified Final Environmental Impact Report (DD&A 2015).

2.1 Analysis Approach

Nitrogen loading to the Bay, with respect to the GWR project, can be divided into (1) loading to the photic zone and (2) loading through M1W’s existing deep ocean outfall. Sources of nitrogen (“nitrogen sources”) increase the total loading of nitrogen to the Bay, whereas “nitrogen sinks” decrease the total loading of nitrogen to the Bay. The total nitrogen loading to the Bay is equal to the sum of the mass gained via the nitrogen sources minus the mass lost via the nitrogen sinks:

Total nitrogen loading to the Bay = load to photic zone + load to deep outfall
= sum of nitrogen sources – sum of nitrogen sinks

In this technical memorandum, the major flows within the Bay area, and how they change when the GWR project is implemented, will be presented. In addition, the major sinks and sources of nitrogen will be described, as well as how they are expected to change with the GWR project. Finally, the mass balance equations for both scenarios (without the GWR project and with the

GWR project) will be derived and the implications of the GWR project on harmful algae blooms (HABs) will be assessed.

3 Flows

The following sections describe the major flows into Monterey Bay associated with the GWR Project and how those flows vary with the GWR Project.

3.1 Major Flows without the GWR Project

The RTP receives wastewater from the surrounding community and provides primary treatment (screening, grit removal, and clarification) and secondary treatment (biological trickling filters, bio-flocculation, and clarification). During periods of low recycled water demand, secondary effluent from the RTP is discharged to the Bay through the deep ocean outfall. The outfall pipeline was specifically designed to discharge the wastewater deep into the ocean (95-109 feet below the mean surface level of the ocean) and to promote dilution (zone of initial dilution has a dilution factor of approximately 145 or greater at 57 ft above the point of discharge). These design features minimize the amount of concentrated nitrogen that makes it to the photic zone of the Bay.

When recycled water is needed, the secondary effluent is diverted to SVRP/CSIP facilities where it is further treated (treatment includes coagulation, flocculation, filtration with granular media, and disinfection with combined chlorine) and distributed for agricultural irrigation. This irrigation water exits the farms through evapotranspiration, plant uptake, and tile drainage. The tile drainage collects in nearby ditches, including the Tembladero Slough, Blanco Drain, and Reclamation Ditch, during irrigation or storm events. The water then makes its way from these ditches to the ocean via either the Salinas River or the Old Salinas River Channel. The tile drainage enters the near-shore ocean in the photic zone, *i.e.*, the upper portion of the ocean that is exposed to sunlight. Due to density differences of the ocean water and river water (primarily caused by salinity differences), the river water tends to remain near the surface at the point of discharge until ocean currents mix the waters.

3.2 Major Flows with the GWR Project

The GWR project introduces an advanced water purification facility (AWPF) which will produce potable water to supplement drinking water supplies on the Monterey Peninsula. The GWR project will divert a portion of the secondary effluent from the RTP to serve as the influent to the AWPF. The AWPF will produce 5 million gallons per day (MGD) of highly treated recycled water (product water) for groundwater replenishment of the Seaside Groundwater Basin. One of the AWPF processes is reverse osmosis (RO). RO removes salts and other dissolved compounds via physical separation, and as a result, generates two flow streams: purified product water and concentrate. The concentrate will be mixed with RTP effluent and discharged at the existing deep ocean outfall.

A component of the GWR project is the diversion of new source waters. To ensure adequate flows for the AWPF year-round, portions of the tile drainage from the Blanco Drain and Reclamation Ditch will be diverted to the RTP headworks, which decreases the amount of tile drainage that is discharged to the photic zone of the ocean.

4 Nitrogen Sources and Sinks

The following sections describe the nitrogen sources and sinks that are relevant to the GWR Project.

4.1 Nitrogen Sources and Sinks without the GWR Project

There are two main nitrogen sources that load nitrogen to the Bay:

1. **Wastewater –** The RTP influent (raw wastewater) is collected from municipal sewage, industrial processes, and storm water.
2. **Fertilizer –** Currently, much of the nitrogen used for agriculture in the surrounding area is added with fertilizers. During irrigation and storm events, runoff causes the fertilizer to enter the rivers (and subsequently the Bay).

There are two major nitrogen sinks that decrease the nitrogen loading to the Bay:

1. **Solids to Landfill –** Nitrogen consumed by microbes during secondary treatment and nitrogen associated with particles are removed via primary and secondary clarification[1]. The nitrogen ultimately ends up in the solids produced by the RTP, which are dewatered, mixed with wood products, and used for landfill slope cover. The landfill is a contained system that is designed and operated to prevent contamination of groundwater and surface water.
2. **Plant Uptake –** Plants naturally assimilate nitrogen and use the nutrients to grow.

4.2 Nitrogen Sources and Sinks with the GWR Project

With the GWR project in place, there is one new nitrogen source and one new nitrogen sink. Ammonium sulfate (the new source) will be added to the AWPF product water to from chloramines and prevent microbe regrowth in the product water conveyance pipeline. However, all of the product water will be injected into the Seaside Groundwater Basin (a new sink) and thus will not influence the nitrogen loading to the Bay. Therefore, the new source is added directly to the sink, which is assumed to sequester the nitrogen and have a negligible effect on the nitrogen loading to the Bay.

An additional nitrogen sink is created through treatment at the AWPF. A fraction of the total nitrogen in the RO feed passes through the RO membranes and is not concentrated in the RO concentrate[2]. However, it is conservatively assumed that all nitrogen is rejected by the RO and so this sink is not considered further in the analysis.

In addition to the sources and sinks described with the implementation of the GWR project, the magnitude of some of the existing sinks, sources, and flows will change as described below.

- The AWPF treats some of the RTP secondary effluent (reducing the amount of secondary effluent directly discharged to the deep ocean outfall) and in the process generates RO concentrate. The conservative assumption is made that all of the nitrogen present in the

[1] An average total nitrogen removal of 30% (± 2% confidence interval, 95%) was observed through the RTP during a study in October through December 2015.

[2] An average total nitrogen removal of 94% (± 1% confidence interval, 95%) was observed through RO during pilot testing from December through June 2013.

AWPF influent will be rejected by the RO membranes and thus will end up in the concentrate. The concentrate is then discharged through the deep ocean outfall.
- Some of the tile drainage is diverted to the RTP and therefore the nitrogen mass load to the RTP increases. Because the RTP will now treat more water (diverted tile drainage in addition to existing wastewater), the nitrogen mass load of the solids to the landfill will increase.
- As part of the GWR Project, the amount of recycled water used at the farms will increase; however, the increase in the amount of recycled water used at the farms will be less than or equal to the amount of water diverted from tile drainage to RTP. Since some of the nitrogen in the RTP influent is sequestered in the solids-to-landfill sink, the increase in the amount of nitrogen loading in the SVRP will be less than the nitrogen loading in the tile drainage diverted to RTP.
- Note that farms may also use less fertilizer to compensate for the presence of nitrogen in the recycled water, which would further reduce loading to the Bay and to the photic zone; however, it is conservatively assumed that this reduction does not occur.

4.3 Summary of Flows, Sinks, and Sources

The nitrogen flows, sinks, and sources within the Monterey Bay area (with and without the GWR project) are summarized in Figure 1. Each flow is associated with a mass of nitrogen (concentration multiplied by flow rate), where:

N_{WW}	is the mass of nitrogen in the raw wastewater flow
$N_{Fertilizer}$	is the mass of nitrogen in the fertilizer flow
N_{Solids}	is the mass of nitrogen in the RTP solids to landfill flow
N_{Plants}	is the mass of nitrogen up-taken by the plants grown at the farms
N_{Drain}	is the mass of nitrogen in the tile drainage flow
$N_{Sec\ Eff}$	is the mass of nitrogen in the RTP secondary effluent flow
N_{SVRP}	is the mass of nitrogen in the SVRP influent/effluent flow
N_{Div}	is the mass of nitrogen in the tile drainage diverted to the RTP
$N_{Concentrate}$	is the mass of nitrogen in the AWPF RO concentrate flow
$N_{AWPF\ Inf}$	is the mass of nitrogen in the AWPF influent flow
$N_{Solids\ New}$	is the mass of nitrogen in the additional RTP solids to landfill as a result of the additional wastewater influent (diverted tile drainage, with GWR)
$N_{SVRP\ New}$	is the mass of nitrogen in the additional SVRP influent/effluent flow (with GWR; note that the nitrogen in the tile drainage will increase by this amount as well)

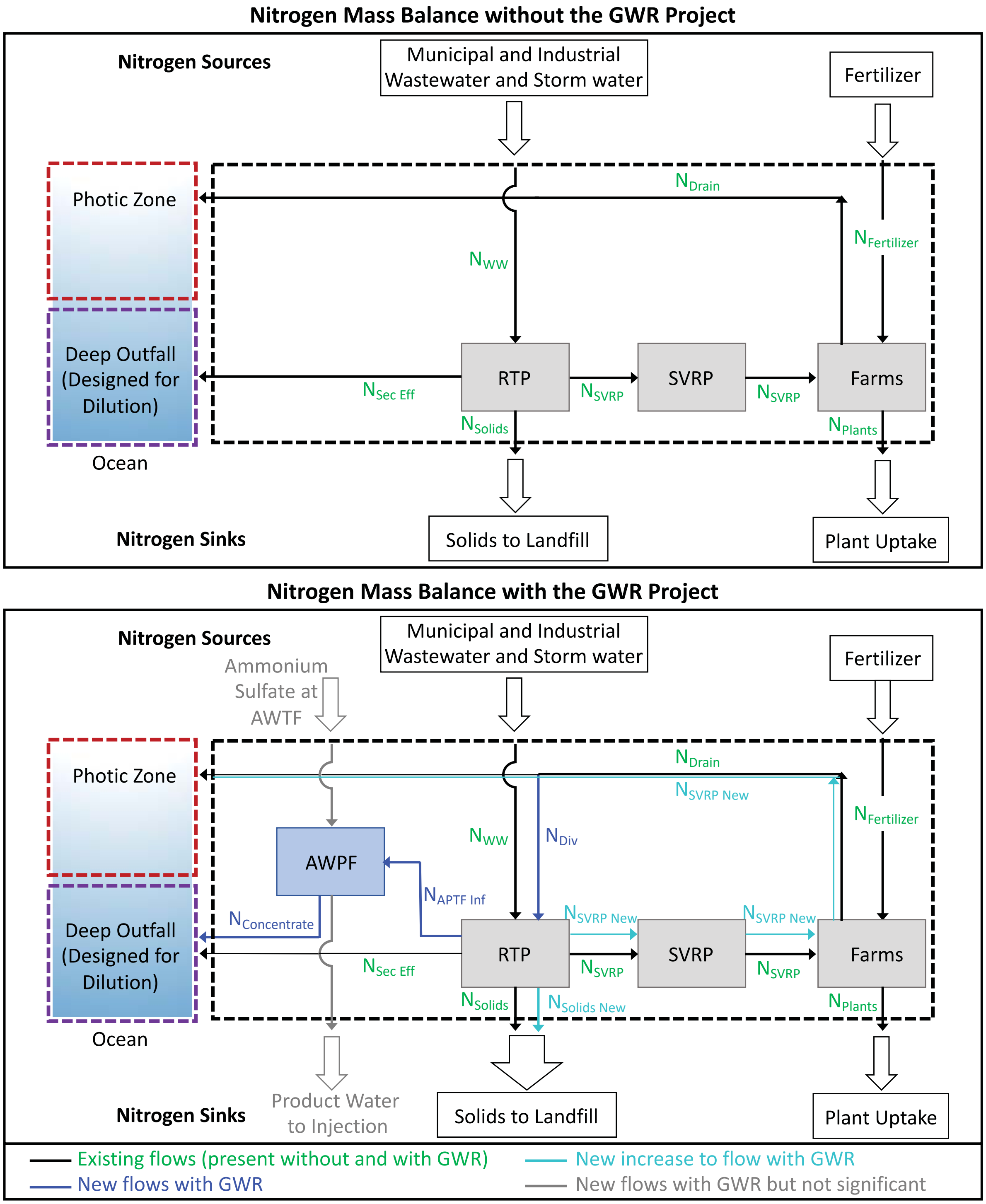

Figure 1. Flows, sinks, and sources of nitrogen in the Monterey Bay area without and with the GWR project. A difference in arrow size between the system without and with the GWR represents the increase/decrease in the mass of nitrogen provided by the flow stream.

5 Derivation of Nitrogen Mass Balance Equations

To compare the nitrogen loading to the Bay before and after the implementation of the GWR project, nitrogen mass balance equations were constructed for both scenarios.

Mass Balance without the GWR Project:
The nitrogen (N) load to the photic zone is equal to the mass of nitrogen in the tile drainage flow.

$$\text{N load to photic zone} = N_{Drain}$$

The nitrogen load to the deep ocean outfall is equal to the mass of nitrogen in the secondary effluent flow. However, for ease of comparison, this equation is written in terms of the system sinks and sources, to the extent possible; the final rearranged equation is given below.

$$\begin{aligned}\text{N load to deep outfall} &= N_{Sec\ Eff} \\ &= N_{WW} - N_{Solids} - (N_{Drain} + N_{Plants} - N_{Fertilizer})\end{aligned}$$

The total nitrogen load to the Bay is the sum of the nitrogen load to the photic zone and the load to the deep ocean outfall.

$$\begin{aligned}\text{Total N load to Bay} &= \text{N load to photic zone} + \text{N load to deep outfall} \\ &= N_{WW} - N_{Solids} - (N_{Plants} - N_{Fertilizer})\end{aligned}$$

Mass Balance with the GWR Project:
The nitrogen load to the photic zone is equal to the mass of nitrogen in the tile drainage flow, plus the mass nitrogen in the additional SVRP flow, minus the mass of nitrogen in the divergent flow to the RTP.

$$\text{N load to photic zone} = N_{Drain} + N_{SVRP\ New} - N_{Div}, \text{ where } N_{SVRP\ New} < N_{Div}$$

The nitrogen load to the deep ocean outfall is equal to the mass of nitrogen in the secondary effluent flow plus the mass of nitrogen in AWPF RO concentrate. However, for ease of comparison, this equation is written in terms of the system sinks and sources, to the extent possible; the final rearranged equation is given below.

$$\begin{aligned}\text{N load to deep outfall} &= N_{Sec\ Eff} + N_{Concentrate} \\ &= N_{WW} - (N_{Solids} + N_{Solids\ New}) - (N_{Drain} + N_{SVRP\ New} + N_{Plants} - N_{Fertilizer}) + N_{Div}, \text{ where } N_{SVRP\ New} < N_{Div}\end{aligned}$$

The total nitrogen load to the Bay is the sum of the nitrogen load to the photic zone and the load to the deep ocean outfall.

$$\begin{aligned}\text{Total N load to Bay} &= \text{N load to photic zone} + \text{N load to deep outfall} \\ &= N_{WW} - (N_{Solids} + N_{Solids\ New}) - (N_{Plants} - N_{Fertilizer})\end{aligned}$$

5.1 Comparison of Nitrogen Mass Balance Equations and Implications for Algal Blooms

A summary of the mass balance equations for the Monterey Bay system, with and without the GWR project, is shown in Table 1.

Table 1. Summary of Mass Balance with and without the GWR Project

Parameter	Without GWR	With GWR	Result
Nitrogen load to the photic zone	N_{Drain}	N_{Drain} + $\mathbf{N_{SVRP\ New}}$ – $\mathbf{N_{Div}}$	Decreases with GWR
Nitrogen load to the deep ocean outfall	$N_{WW} - N_{Solids} - (N_{Drain} + N_{Plants} - N_{Fertilizer})$	$N_{WW} - (N_{Solids} + \mathbf{N_{Solids\ New}}) - (N_{Drain} + \mathbf{N_{SVRP\ New}} + N_{Plants} - N_{Fertilizer}) + \mathbf{N_{Div}}$	May increase with GWR
Total nitrogen load to the Bay	$N_{WW} - N_{Solids} - (N_{Plants} - N_{Fertilizer})$	$N_{WW} - (N_{Solids} + \mathbf{N_{Solids\ New}}) - (N_{Plants} - N_{Fertilizer})$	Decreases with GWR

Note: Differences between the equations for the system without and with the GWR project are **bolded** for clarity, and where, where $N_{SVRP\ New} < N_{Div}$.

As shown in Table 1, the nitrogen load to the photic zone decreases as a result of the GWR project. This decrease occurs because the GWR project diverts some of the tile drainage that would have drained to the photic zone to the RTP facility. While the recycled water usage at the farms will increase, thus resulting in an increase in the amount of nitrogen entering and leaving the farms, the resulting increase in the amount of nitrogen entering and leaving the farms is less than the amount of nitrogen in the diverted flow. Consequently, the nitrogen load to the photic zone is expected to decrease. Conversely, the nitrogen load to the deep ocean outfall may increase with the GWR project.

In addition, the total nitrogen load to the Bay is lower as a result of the GWR project. The total nitrogen load decreases because more of the nitrogen is removed from the system via the solids to landfill sink (more water is treated at the RTP facility as a result of the tile drainage diversion and therefore more solids are generated).

6 Conclusion

The nitrogen mass balance equations derived in this technical memorandum demonstrate that the GWR project will decrease both the nitrogen load to the photic zone and the total nitrogen load to the Bay.

7 References

Trussell Technologies, 2015. Ocean Plan Compliance Assessment for the Pure Water Monterey Groundwater Replenishment Project, April 2015.

DD&A, 2015. Final Environmental Impact Report for the Pure Water Monterey Groundwater Replenishment Project, September 2015.