7. Appraisal of Source Impact

This section should be read in conjunction with Appendix B: which describes the methodology employed, and ongoing progress made, in the development of a three dimensional hydrodynamic and solute transport model for Lough Derg and Parteen Basin, "the water quality model".

The water quality model serves two functions. It has been employed through its development to assist a comparison of potential impact(s) between the various options[24], which were based on a source water abstraction from either Lough Derg or the Parteen Basin waterbody. When finalised, it will be used to inform the assessment, and mitigation, of potential environmental impacts at the abstraction location.

The development of the water quality model is reliant upon collation of datasets from the Lough Derg and Parteen Basin waterbody; sourced from an ongoing continuous monitoring survey across the waterbody. Datasets from the waterbody are being used to ensure agreement and replication of modelled scenarios with recorded in water conditions. These datasets cover a number of measurable parameters on the waterbody, from the year 2015 through to the present, including:

- Water depths (bathymetric survey),
- Water flow and current;
- Water Quality
- Water treatability
- Water temperature
- Meteorological conditions; and
- Aquatic organisms such as establishing plankton levels.

In conjunction with the 'growing' data sets being recorded from these surveys, the water quality model has, and is being refined towards, a final verified model capable of accurate scenario replication of recorded lough conditions. A four step process towards model verification is being followed:

1. Construction of an uncalibrated hydrodynamic model (POAR);
2. Calibration of the hydrodynamic model (post POAR);
3. Solute transport modelling and calibration of the water quality model; and
4. Verification of the water quality model.

The Preliminary Options Appraisal Report (POAR) presented work on the construction of the hydrodynamic model (Step 1), a computational numerical model able to describe or represent the motion of water.

7.1 Hydrodynamic Modelling

The objective of the hydrodynamic model is to assess the existing flushing characteristics[25] in Lough Derg and Parteen Basin, and how an abstraction may impact on it.

[24] Originally, the POAR considered water abstraction from two locations in Lough Derg and a farther location in the Lower Lake. The latter was the 'Emerging Preferred Option', or Option C (Parteen Basin Reservoir Direct)

[25] Flushing, or lake retention, time is a calculated quantity expressing the mean time that water (or some particular dissolved substance) spends in the lake and expresses the amount of time taken for a substance introduced into a lake to flow out of it again.

At the POAR (Stage 3) various abstraction options were assessed; at two locations in Lough Derg and a farther downstream location in Parteen Basin.

The flushing characteristics were assessed for the period from October 1994 to December 1995, this being the reference period for the calibration of models and options appraisal in the original SEA process, and also because it encompassed periods of very high flow on the Shannon (January 1995) as well as periods of extreme low flows (August -September 1995).

To determine if modelled abstraction options resulted in significant changes, flushing characteristics were compared, and difference calculated, from the baseline (no-abstraction) flushing time. Ten modelled scenarios were chosen as eliciting the fullest understanding of the behavioural characteristics within the Lough Derg/ Parteen Basin water body.

When compared, scenarios involving an abstraction from the northeast of Lough Derg exhibited a large increase (maximum +42 days) in flushing times in the middle and southern portion of Lough Derg when compared with baseline conditions (Figure 7-1), whereas scenarios that involved abstraction from Parteen Basin were considerably better (Figure 7-2).

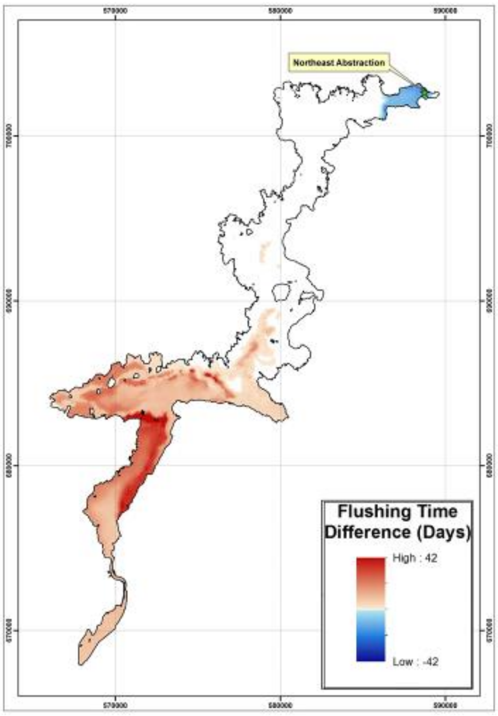

Figure 7-1 Northern Abstraction - Impact on Flushing Times against Baseline Conditions (POAR)

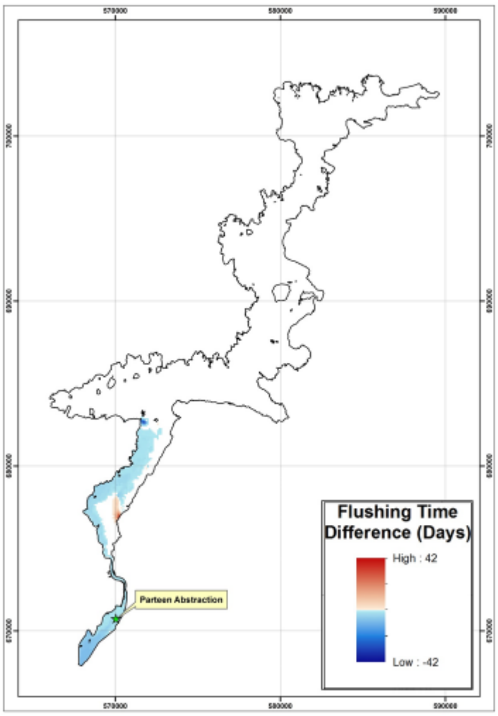

Figure 7-2 Southern Abstraction - Impact on Flushing Times against Baseline Conditions (POAR)

The increase in flushing time associated with abstraction in the north east of Lough Derg was considered likely to cause a change in nutrient concentrations which would affect water quality status. This in turn would impact the distribution of shallow water floral and faunal communities, removing the possibility to say, with certainty, that there would be no negative impact on the conservation status of the SAC.

This potential for negative impact resulting from abstraction in the north east of Lough Derg informed the emerging preference towards abstraction from Parteen Basin.

7.2 Model Development

Since completion of the initial modelling carried out for the POAR, a growing dataset of in lough conditions recorded from deployed instruments within Lough Derg and Parteen Basin has been collated and a detailed Bathymetry Survey (Water Depths) completed.

These datasets provided the baseline on which the hydrodynamic model calibration could commence[26] (step 2). In this process the model was adjusted to take account of critical climatic parameters e.g. wind, evaporation, precipitation and solar radiation and their influence on the hydraulic action of the waterbody.

Through an iterative process of adjustment, model predictions were compared against recorded datasets from instruments, and updated until model functions were found to show good agreement with recorded datasets.

Figure 7-3 provides an example of model agreement reached between recorded data (black line) and simulated model prediction (red line) for both surface water level and current speed parameters.

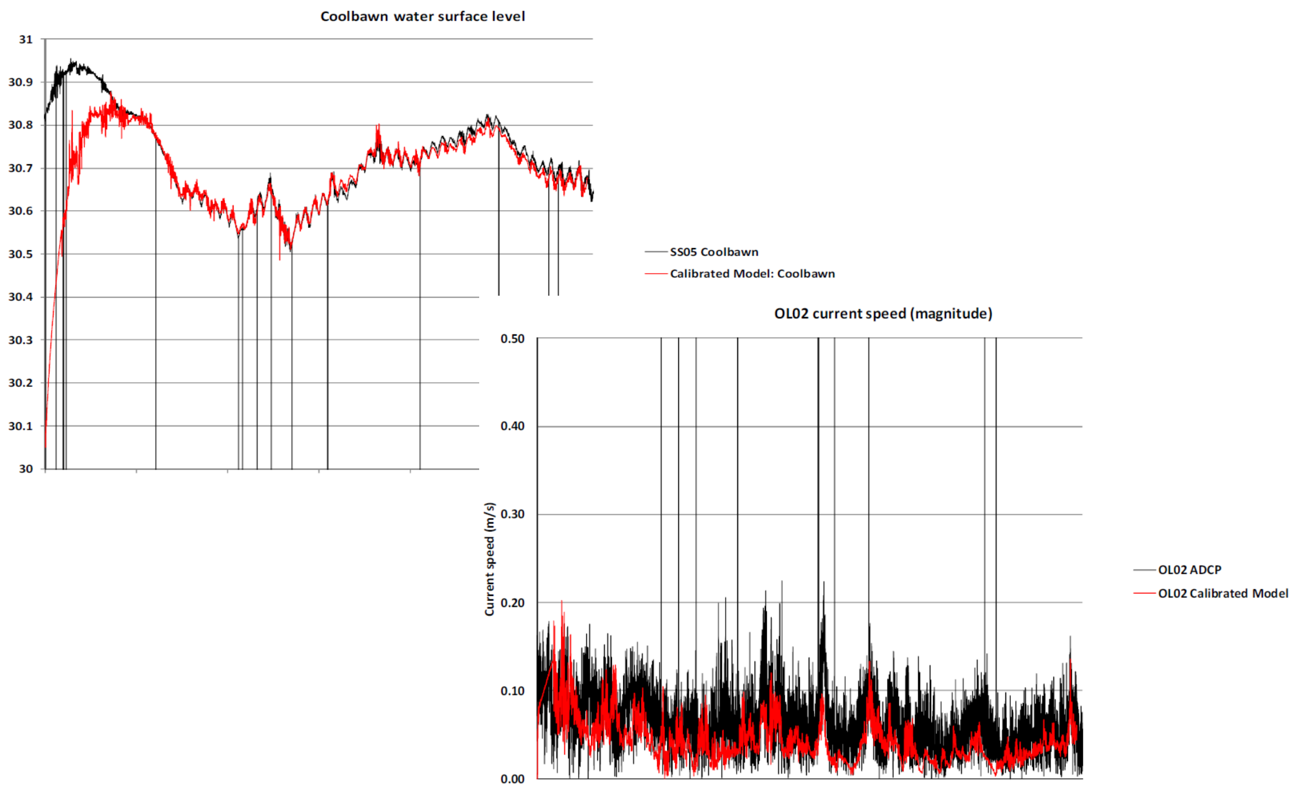

Figure 7-3 Sample Hydrodynamic Model Calibration

[26] Model calibration is the process of adjustment of model parameters to obtain a model representative of hydraulic conditions that satisfies (has a goodness of fit with) available and recorded data.

7.3 Model Scenarios

As previously noted, flushing characteristics were assessed, for a number (10) scenarios, to cover the period from October 1994 to December 1995. The 1995 period being considered to approximate a worst case scenario, as one of the longest recorded periods of drought flows in the river Shannon.

The modelled scenarios considered both a baseline (no abstraction) and abstraction profiles for options sourcing water from the Lough Derg and Parteen Basin namely:

I. Option F2 (North East Lough Derg with Storage)

II. Option B (North East Lough Derg Direct)

III. Option C (Parteen Basin Reservoir Direct)

Scenarios were run for both high flow winter conditions and low flow summer conditions, and expanded to include an expanded winter storage and alternative abstraction location (see Table 7.1).

The prevailing climate of late 2015 and 2016 has been one characterised by above average rainfall levels, peaking through the destructive flooding period late 2015 and early 2016, and continuing on into the spring and summer months of 2016. Reflecting this, recorded hydraulic data is in excess of comparable data recorded through the 1995 period and not representative of drought flows in the river Shannon.

To support a robust assessment of impact, the 1995 data was retained for the purposes of model simulation, but amalgamated with the 2016 calibrated model conditions to represent the most accurate assessment available of flushing characteristics during drought conditions in Lough Derg and Parteen Basin.

Of the ten previously modelled scenarios in the Preliminary Options Appraisal Report, scenarios 1 through 4 considered flushing time characteristics that arise during high flow winter conditions, with little or no changes found, these scenarios were not revisited using the calibrated model. Scenario 10 was also not revisited, with the impact of abstraction established to be largely unaffected by altering the abstraction location in the northern or central areas of Lough Derg.

The remaining 5 were modelled and reported on (see Appendix B). These and their findings are summarised in Table 7.1.

Table 7.1 Abstraction Scenarios Modelled

Scenario No.	Description	Notes	Comment
1	Winter - baseline (no abstraction)	Existing hydrodynamic regime in Lough Derg during winter flow conditions.	Residence times are low in Lough Derg in winter but some spatial variation evident in bays.
2	Winter - constant abstraction (350 Ml/d) in northeast Lough Derg (**Option B**)	Option B - hydrodynamic regime in Lough Derg during winter flow conditions	Low impact on residence times in Lough Derg due to difference in relative magnitude of flows. Slight local reduction in residence time in the immediate vicinity of the abstraction intake.
3	Winter - variable abstraction in northeast Lough Derg (410 Ml/d:50 Ml/d) (**Option F2**)	Option F2 - hydrodynamic regime in Lough Derg during winter flow conditions with variable abstraction.	Abstraction in winter conditions has low impact on residence times in Lough Derg due to difference in relative magnitude of flows. Little difference between variable abstraction and constant abstraction under winter conditions
4	Winter - constant abstraction (350 Ml/d) in Parteen Basin (**Option C**)	Option C - hydrodynamic regime in Lough Derg during winter flow conditions with constant abstraction.	No impact on residence time in Lough Derg.
5	Summer - baseline (no abstraction)	Existing hydrodynamic regime in Lough Derg during summer low flow conditions.	Spatial variation evident in residence time under existing natural conditions from north to south and in lateral bays. Southern section above Killaloe has residence time above average for lake as a whole.
6	Summer - constant abstraction (350 Ml/d) in northeast Lough Derg (**Option B**)	Option B - hydrodynamic regime in Lough Derg during summer low flow conditions with constant abstraction	Worst case residence time impacts of the order of 16 days in the southern region of the lake where baseline residence time is also elevated (see Figure 7-4).
7	Summer - variable abstraction in northeast Lough Derg (410 Ml/d:50 Ml/d) (**Option F2**)	Option F2 - hydrodynamic regime in Lough Derg during summer flow conditions with a variable abstraction.	Two months raw water storage does not appreciably mitigate residence time effects in southern Lough Derg over the Scenario 6 outcome. Prolonged duration of the drought in 1995 would bring about residence time impacts that could not be mitigated by raw water storage (see Figure 7-5).
8	Summer - constant abstraction(350 Ml/d) in Parteen Basin (**Option C**)	Option C - hydrodynamic regime in Lough Derg during summer flow conditions with constant abstraction.	No prolongation of residence times anywhere in Lough Derg. Intake in Parteen Basin would slightly reduce (improve) existing baseline residence time in the Basin and in the area north of Killaloe (see Figure 7-6).
9	Summer (450 Mld:50 Ml/d) variable abstraction in northeast Lough Derg	Hydrodynamic regime in Lough Derg during summer flow conditions with a prolonged variable abstraction. 50% increase in storage at Garryhinch.	Does not produce residence time improvements significantly different from Scenario 7. Duration of the drought in 1995 would still bring about local residence time impacts in the southern section of the lake, even with an increased balancing storage volume.
10	Summer – (410 Ml/d:50 Ml/d) variable abstraction in Youghal Bay	Hydrodynamic regime in Lough Derg during summer flow conditions with a variable abstraction.	Changing the point of abstraction from the north east of Lough Derg to Youghal Bay does not bring about a significant difference compared to Scenario 7.

7.3.1 Option B (North East Lough Derg Direct)

Figure 7-4 presents the distribution of impact on flushing times from continuous abstraction in northeast Lough Derg.

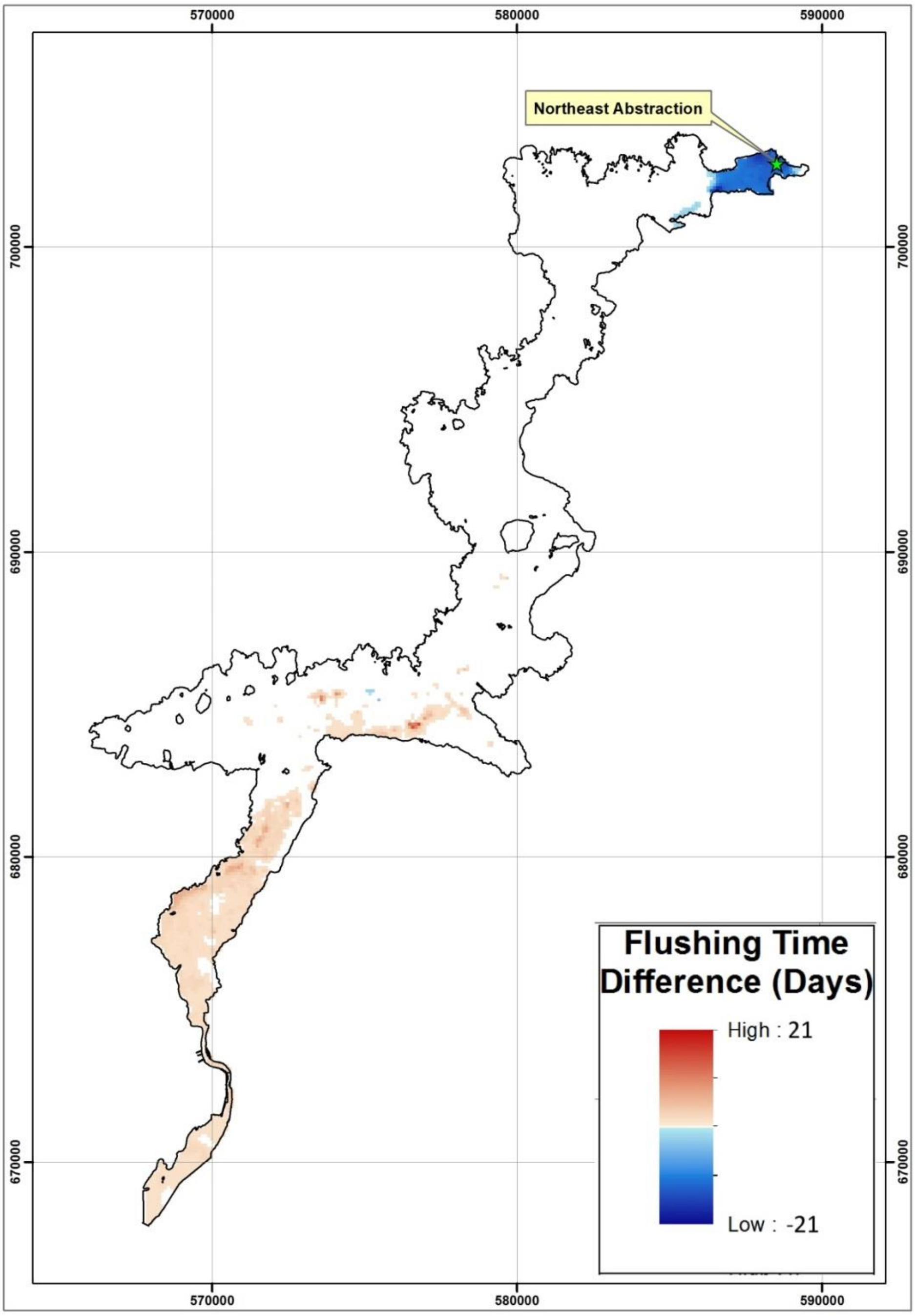

Figure 7-4 Option B – Impact on Flushing Time

7.3.2 Option F2 (North East Lough Derg with Storage)

Figure 7-5 presents the distribution of impact on flushing times from variable abstraction in northeast Lough Derg.

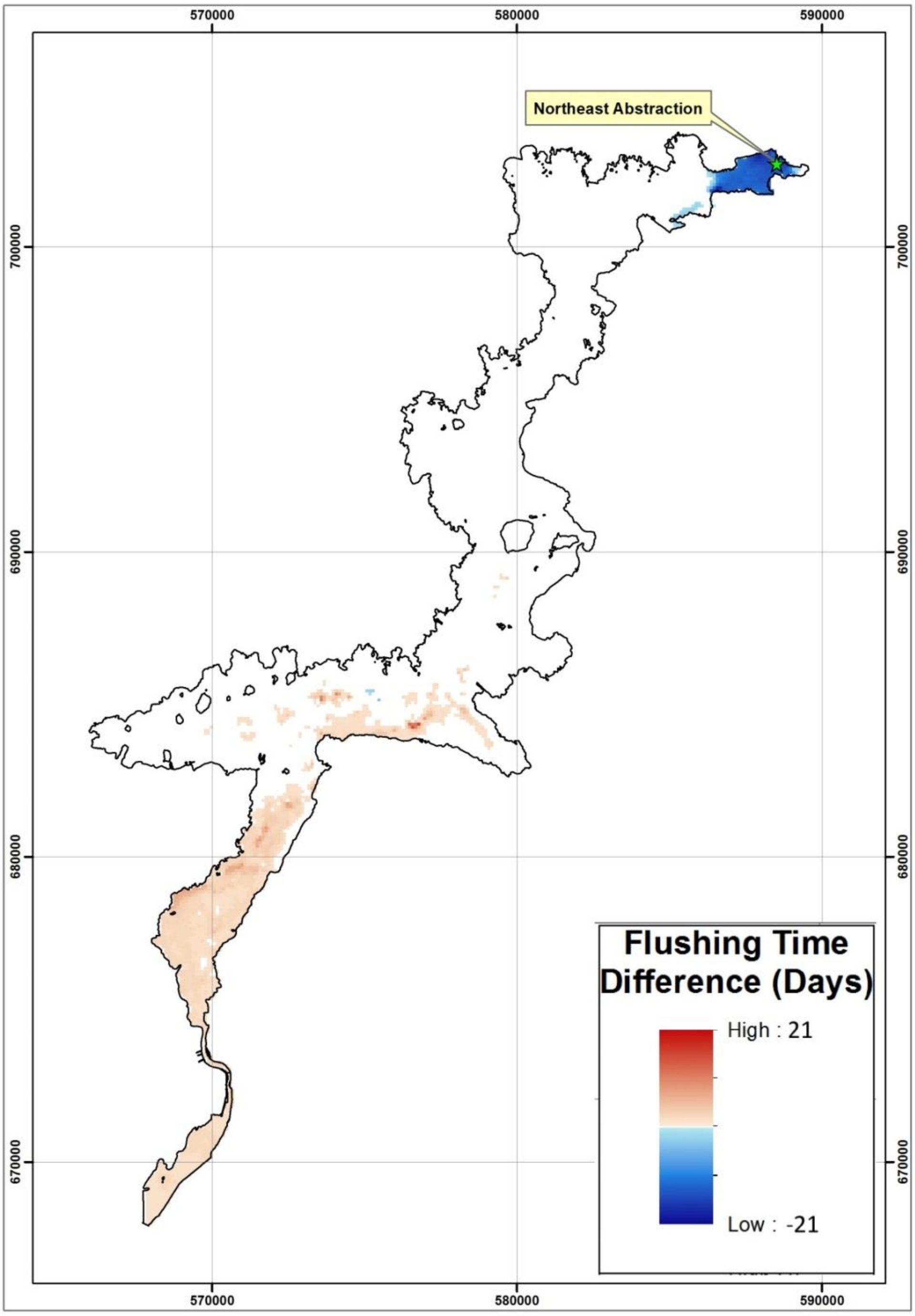

Figure 7-5 Option F2 – Impact on Flushing Time

7.3.3 Option C (Parteen Basin Reservoir Direct)

Figure 7-6 presents the distribution of impact on flushing times from variable abstraction in Parteen Basin.

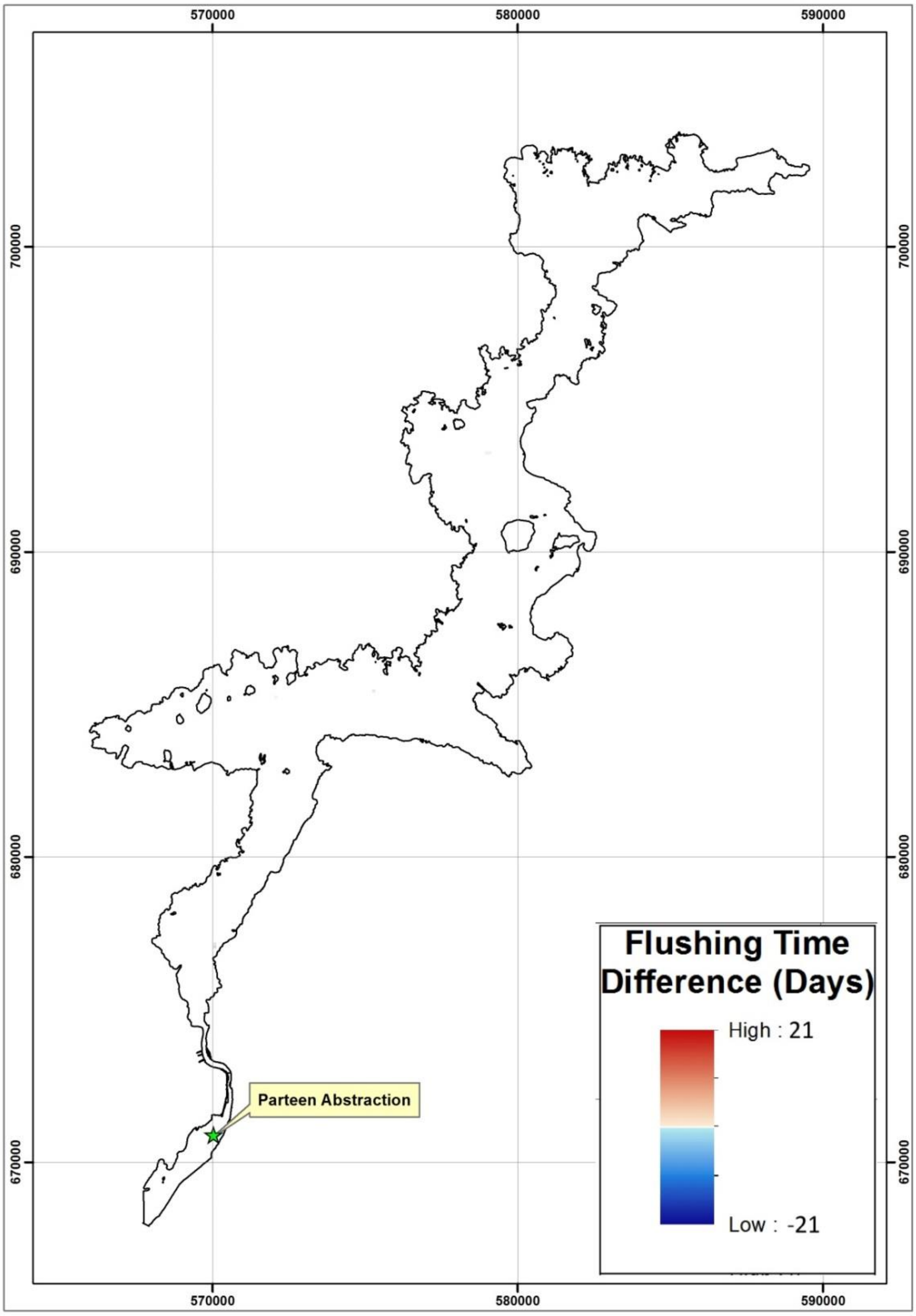

Figure 7-6 Option C – Impact on Flushing Time

The Hydrodynamic Model Report is included in Appendix B. Figure 7-4, Figure 7-5 *and* Figure 7-6 *have been re-produced from this Report; where they are labelled Figure 24, Figure 25 and Figure 26 respectively.*

7.4 Interpretation of model results

Figures 7-4 through 7-6 show the effects of abstracting from Lough Derg / Parteen Basin during the summer (low flow) conditions of 1995 and indicate that there were significant changes in flushing times in Lough Derg /

Parteen Basin when abstracting from the northeast of Lough Derg when compared with the alternative from Parteen Basin.

Scenarios involving an abstraction from the northeast of Lough Derg, at either constant or variable rates, during summer low flow conditions exhibit an increase (maximum +16 days) in flushing times in the southern portions of Lough Derg when compared with the baseline conditions (Figure 7-4 and Figure 7-5). The scenario involving abstraction from Parteen Basin at a constant rate during summer low flow conditions show no change to flushing time characteristics in any region of Lough Derg and Parteen Basin when compared with the baseline conditions (Figure 7-6).

While representing a reduction in impact from a maximum of + 42 days to + 16 days[27], the locations featuring the shorter values of flushing time are predicted to be faster to respond to changes in pollutant concentrations from the principal riverine input, namely the River Shannon. The corollary is that the areas with the longest flushing times were predicted to be the slowest to respond to changing pollutant loadings, and thus susceptible to excess nutrient accumulations, which would affect water quality status in these areas. This in turn would impact the distribution of shallow water floral and faunal communities, removing the possibility to say, with certainty, that there would be no negative impact on the conservation status of the SAC.

This potential for negative impact resulting from abstraction in the north east of Lough Derg confirms the assessments underpinning the preference towards abstraction from Parteen Basin.

7.5 Next Step

At the time of preparing this report, data continues to be gathered from the ongoing survey; for incorporation within the model, and to facilitate continuous improvements to the model, and accuracy of predictions.

Model development will conclude with the calibration and validation of the solute transport model (steps 3 and 4 of the model verification process), that together with the calibrated hydrodynamic model, will form the final water quality model and allow pollutant specific modelling beyond the general physical mixing processes depicted to date. Modelling results will be presented as part of the EIS submission to be provided to An Bord Pleanála.

[27] Model predictions display sensitivity to very small changes in water level (in the order of 5mm). The change in maximum flushing times has been attributed to a recognised discrepancy in modelled water levels in the first pass model (step 1) that has now been corrected in the calibrated hydrodynamic model (step 2).