OXFORDSHIRE COUNTY COUNCIL

REFUSED

DATE: 03/09/2024
APPLICATION No: P21/S3961/CM, (MW.0115/21)

1 March 2023

MW.0115/21: LPA ref

WA/2021/129358/02-L01: EA ref

Ms Mary Hudson
Oxfordshire County Council
Planning Implementation
County Hall New Road
Oxford, Oxfordshire
OX1 1ND

Re: Flood risk assessment (FRA) for Extraction And Processing Of Sand And Gravel Including The Construction Of New Site Access Roads, Landscaping And Screening Bunds, Minerals Washing Plant And Other Associated Infrastructure With Restoration To Agriculture And Nature Conservation Areas, Using Inert Fill

Dear Ms Hudson,

Further to the Environment Agency's letter to Oxfordshire County Council on the 12 January 2023, I have reviewed the Environment Agency's comments relating to the hydraulic modelling and third-party impacts.

In relation to the hydraulic modelling Edenvale Young has completed the EA's review spreadsheet with appropriate answers but there is also discussion within this letter on a number of issues associated with the veracity of the hydraulic modelling and third-party impacts. Accordingly, both documents must be considered together.

As noted above, the Environment Agency has supplied a spreadsheet with their review comments on the hydraulic modelling for the Whitecross Minerals site. The summary of the first page of the review states:

> *"There is one major concern with the model which is the increase in the cell size from 10m to 20m. This is a very large cell size which may not be accurately representing flow paths. Please return the cell size to 10m or provide evidence that the increase in cell size is not negatively impacting the models ability to accurately represent reality (also see amber comment under calibration on comparing with previous model). Please also see other amber (LiDAR date, model boundary glass walling and lowered zpt warning) and green comments for other concerns."*

The following sections discuss the accuracy of the model in relation to a 10m and 20m grid and issues relating to LiDAR. Responses to matters relating to glass walling, zpts and the green comments noted above, are addressed in the responses in the spreadsheet. However, it should be noted that glass walling and many of the green comments are present within the baseline model supplied to Edenvale Young by the Environment Agency.

The Environment Agency have also highlighted the fact that the hydraulic modelling indicates that water levels will increase during the excavation of minerals on the flood plain. The Environment Agency considers this to be unacceptable stating that:

> *"Also, it is stated that the impact on third parties will be negligible, but we cannot accept any increase in flood level and therefore we maintain our position that the applicant should demonstrate there are no offsite impacts."*

The increase in water level in phase 2 of the works was identified in Revision A of the FRA (17 August 2021) and was also reported in Revisions B; the fact that it is only now, some 17 months after it was first reported, considered to be the basis for an objection is frustrating.

I have attempted to address the above concerns in a structured manner; firstly, by taking a step back and explaining the logic as to why it is unlikely that third party impacts will be significant. Secondly, I have provided an explanation as to why model stability is an important factor in the assessment of third-party impacts and thirdly, I have presented information on sensitivity testing associated with grid size and the use of LiDAR.

Finally, the letter considers the impact of reconfiguring the phasing of the works to see if there are any advantages in changing the approach to excavation.

Overview

Before addressing the hydraulic modelling issues in detail, it is worthwhile taking a step back to consider the overall flooding mechanisms, the reasons why flood levels might increase and the potential impacts of the works of flooding as a result of the mineral workings.

The programme of works involves the phased excavation and backfilling of holes within the flood plain to extract sand and gravel. After the completion of each phase each hole will be backfilled such that, the floodplain is restored to its original ground levels. It is not possible to leave open water across the site on completion because of the danger to aircraft using RAF Benson resulting from bird strikes. It should also be noted that works will be undertaken in summer to avoid winter flooding and boggy conditions for plant operating on the flood plain.

The works will be completed in five years at which point the entire site will be restored to original levels. Accordingly, there will be no change in flood risk following the completion of the works by comparison to today. The only concern are changes in flood risk in the temporary condition over the period of five years during the excavation works.

As previously alluded to in my letter of the 19 December 2022, the fact that the development lifetime is five years is hugely significant in relation to flood risk. The probability of 1 in 100 year event occurring or being exceeded in the next 100 years is 63%. However, the probability that a 1 in 100 year event occurring or being exceeded in a period of 5 years is significantly lower at 5% (i.e. the lifetime of the scheme).

Accordingly, the flood risk profile for this scheme, is significantly reduced by comparison to a conventional commercial or housing development which is generally tested for a 50 or 100 year lifespan. The fact that a 1 in 100 year event would have an annual 5% chance of occurring in five years would categorise the scheme as being at low risk of flooding. Due consideration should therefore be given to this fact in evaluating the flood risk to the scheme and third parties.

It is envisaged that mechanism of flooding to the site would be as follows:

- Flood water would rise in the Thames until it overtops the riverbank with flood water flowing across the floodplain to the excavation.
- The excavation would fill with water and continue rising until it reaches a peak. After peak the water levels would fall leaving the excavation full.
- Water within the excavation with gradually infiltrate or evaporate until groundwater levels were reached.

Excavation or lowering of levels on a flood plain will increase the overall flood storage and it is generally accepted that increasing flood storage will decrease flood risk elsewhere and to third parties. This is the well-known principle of flood storage compensation which is used within flood risk management to minimise third party impacts.

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In contrast flood levels would be expected to rise, and adverse third-party impact would occur if:

- There was filling on the floodplain which would displace flood water elsewhere.
- A barrier was constructed on the floodplain which deflected water changing the pattern of flooding. This could include, for example, a flood defence.

The proposed works do not include filling which would displace of flood water. Moreover, there are no proposals to construct embankments or other barriers on the flood plain which would deflect water onto third party land. Given that the mineral working will not incorporate raised features within flood zone 3 it is considered that the scheme should not have an adverse impact on flood levels. The absence of raised features means that there should be no adverse impact upstream.

It should also be recognised that the volume of the excavation works is trivial by comparison to the volume conveyed by the Thames during a flood event and the impact downstream (at say Reading) would be *de minimus*. *Figure 1* shows the hydrograph at Reading for a 1 in 100 year event with a 12% allowance for climate change for the baseline and two excavation phasing scenarios (SP3 and SP2).

Figure 2 shows the difference in flow between the baseline scenario and excavation phases SP2 and SP3. The peak of 438 m^3/s in the baseline scenario compares to 439 m^3/s (SP2) and 437 m^3/s (SP3). This represents a difference of approximately 1m^3/s which is a change of 0.2% on flow which is *de minimus*. The arguments presented above suggests that that should be no increase in flood levels or adverse third-party impacts.

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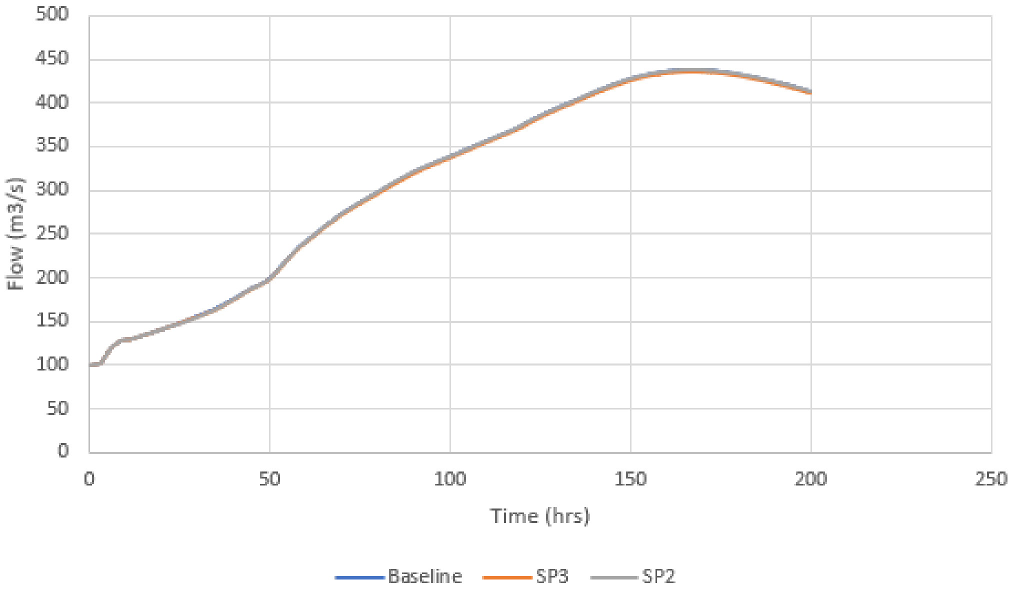


Figure 1: Flow Hydrograph at Reading for baseline and excavation phases SP2 and SP3 for a 1 in 100 year event with 12% climate change.

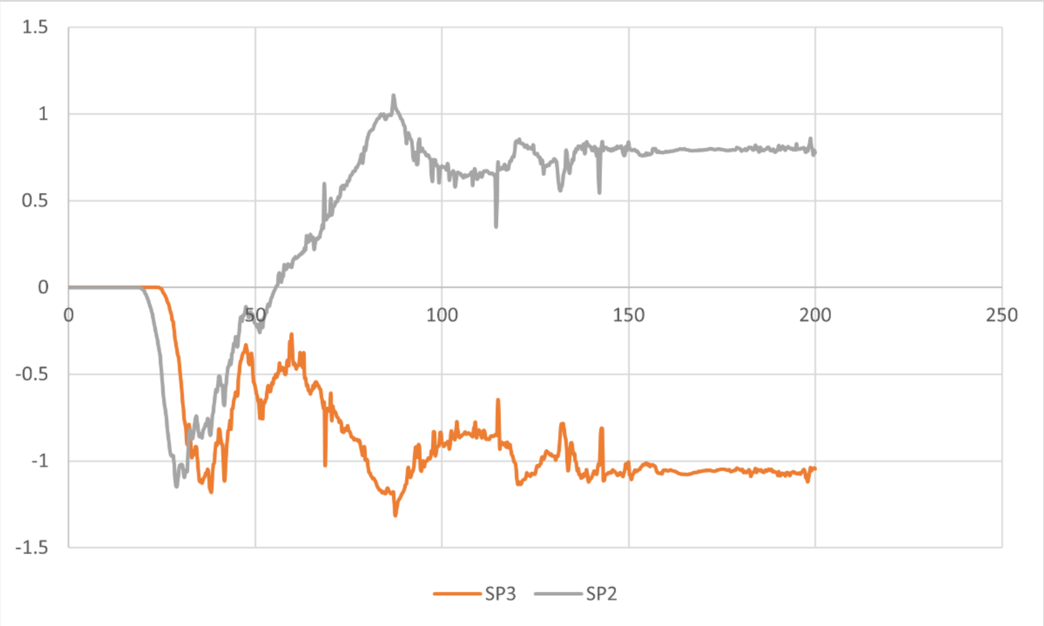


Figure 2: Magnitude of difference in flows between the baseline scenario and excavation phases SP2 and SP3 for a 1 in 100 year event with 12% climate change.

Hydraulic Modelling

It is recognised that the hydraulic modelling and the flood risk assessment (Revision B) did conclude that there would be an increase in water levels from the existing situation to the temporary scenario with the excavations open in the flood plain. The rise in water levels was in the order of 0.018m to 0.025m local to the site. Possible reasons include:

- There is something missing from the above overview which contradicts the argument that the excavation works would reduce peak water levels.
- The model was not able to accurately facilitate comparison of water levels between the baseline and excavation scenarios.

In order to answer the latter of these questions Edenvale Young has reviewed the hydraulic modelling and undertaken:

- A review of model stability.
- A sensitivity analysis on grid size.
- Re-evaluated the phasing of the excavation works.

Model Stability

The underlying equations which drive FMP-TUFLOW are highly complex. In the context of evaluating flood risk to centimetre / millimetre levels of accuracy, it should be recognised that there is no perfect mathematical solution to the equations and the solution is approached through iterations, which necessarily means some degree of inaccuracy enters the system with every timestep.

These errors can, and do, accumulate over the length of a simulation and are the source of most instabilities found in hydraulic models. These can also be mathematically 'chaotic', which means that similar starting and boundary conditions can yield unpredictable different end states.

There are also computational inaccuracies relating to precision which can introduce small errors which add up over time. This is, in essence, the number of decimal places the computer is able to calculate. Precision can be improved from the default level of precision (single precision) to be significantly more precise (double precision), which should reduce these types of errors. The Whitecross model has been run in double precision.

All of the above is known and understood by the industry and is part of why there it is generally accepted that the result of a given model may not be accurate. The TUFLOW's classic solver is known to and is expected to introduce some degree of error over the course of a simulation.

Instabilities can be identified by rapid changes in velocity or water level and increases / decreases in the mass / volume of water within a simulation. Instabilities can be large, localised and can have a significant and noticeable impact on water levels / velocities in the vicinity of the instability. In some cases, water levels can be many metres higher than the surrounding water level, and this can result in radiating waves propagating from the centre of the instability.

However, in most cases instabilities and errors are small and do not significantly affect water levels within a model, nor have an impact on the results, nor conclusions. Instabilities / errors are present in all models including the Environment Agency's Abingdon Flood Schemes Thames Model

In order to assist hydraulic modellers to understand the 'health' of a hydraulic model, the FMP-TUFLOW software outputs the 'mass balance error' variable throughout the simulation. A perfect hydraulic model would be mass conservative. This means that the volume / mass of water within the system at the end of the simulation would equal that at the start, plus all that has entered through boundaries, minus any water that has left through boundaries.

All models lose or accumulate water volume / mass as a result of computational inaccuracies discussed above. A positive mass balance error means that there is an increase in the volume / mass of water in the model which manifests itself as an anomalous increase in water level. Conversely, a negative mass balance error means that there is an anomalous decrease in the volume of water within the model which gives a reduction in water level. It is generally accepted that as long as the mass balance is less than 1% of the overall flow a model may be considered to be healthy.

The Edenvale Young review of the Middle Thames model as supplied by the Environment Agency concluded that there were no large, localised instabilities within the model. However, the incoming FMP-TUFLOW model configured with a 12% climate change allowance on flow had a mass balance error of -1,652,372m^3 at peak water level (See Figure 3 approx. 150hrs simulation time 600 timesteps) for a 1 in 100 year event with a climate change allowance of 12% and a 10m grid using the LiDAR supplied with the model. This is equivalent to an anomalous decrease in water level across the entire model domain of -0.048 m.

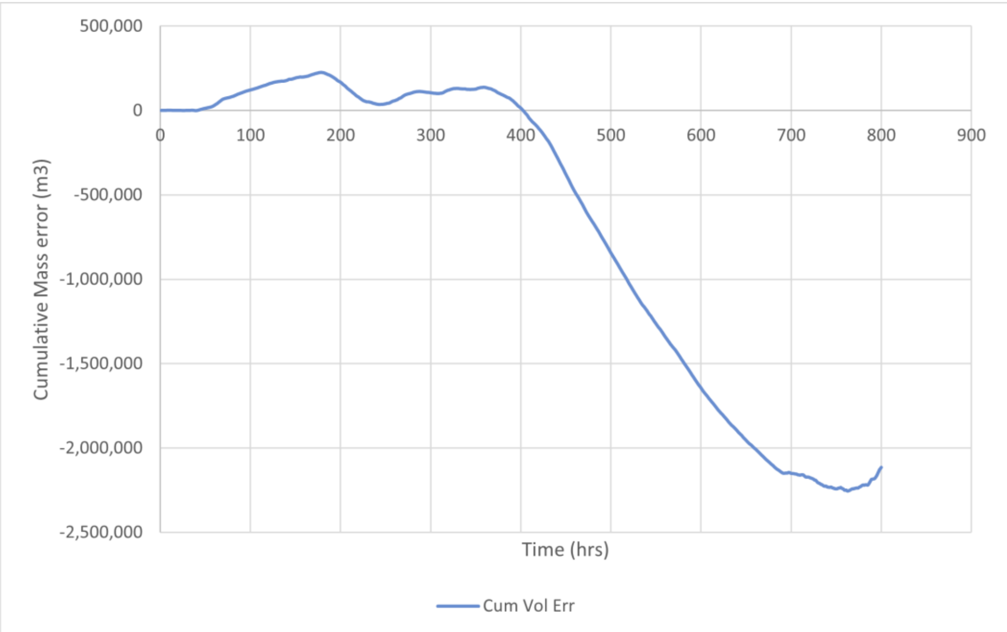
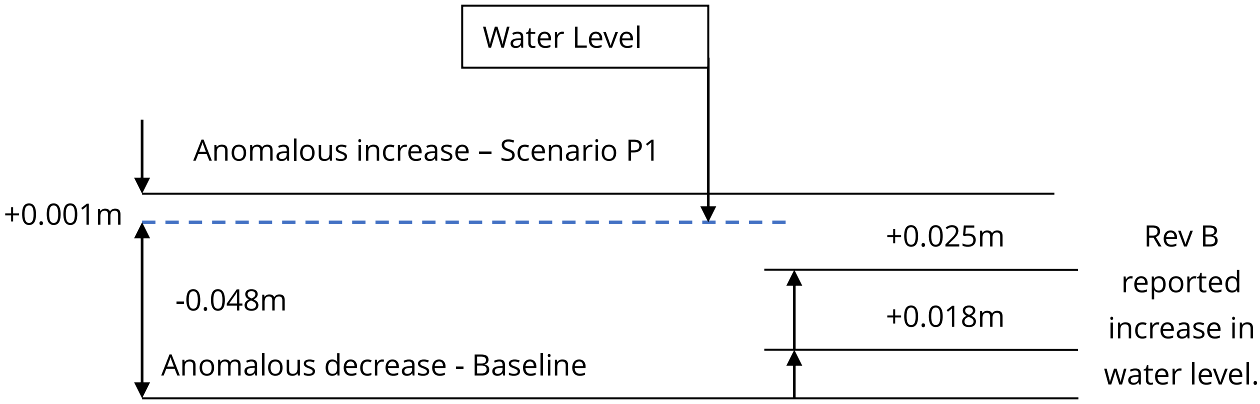


Figure 3: Cumulative Mass Balance Error for a 1 in 100 year event with 12% cc

This contrasts with a mass balance error of 27,632 m^3/s for the first excavation phase (P1) presented in Revision B of the FRA. is equivalent to an anomalous increase, in water level across the entire model domain of +0.001 m.

Accordingly, the limiting accuracy, of the baseline model with the 10m grid is 0.048m. This becomes important when comparing models. The fact that the baseline underreports water levels with a negative mass balance and the Phase 1 excavation model slightly overreports means that the two models are using separate reference levels as shown below.



Importantly, it should also be recognised that the distribution of mass error is not constant throughout the model domain and the magnitude of the error will vary along the length of the river. Unfortunately, TUFLOW does not give an output which quantifies any accumulation of mass error by location. It is highly likely that erroneous volumes resulting from the mass balance error will be greater in some locations and less elsewhere.

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In summary:

- The negative mass balance error indicates that the peak levels within the baseline model have been artificially suppressed by an anomalous loss of volume / mass during the simulation. In contrast, the P1 excavation scenario has a positive mass balance error meaning that peak water levels are artificially increased.
- The magnitude of the loss and hence the average accuracy of the baseline model is in the order of -0.048mm across the whole model domain. This implies that the baseline model of the Thames for the 1 in 100 year scenario with 12% climate change using a grid size of 10m is not suitable for assessing flood risk to the degree of accuracy required.
- The cumulative error, when comparing the baseline and phase 1 models, reported in Revision B of the FRA is in the order of 0.049m but because of the fact that mass balance errors are not distributed evenly along the length of the model and could be chaotic then this error could be larger or smaller than 0.049m.
- When taking into account the mass balance errors for both models, the increase in water levels reported in Revision B of 0.018m and 0.025m could be interpreted as a reduction in water levels rather than an increase.
- The fact that there is a significant difference between the cumulative mass balance errors between the baseline and the P1 excavation scenario means that meaningful comparisons between the model scenarios to millimetre accuracy is not possible.

Sensitivity to Grid Size and LiDAR

A sensitivity check has been made for 10m and 20m grid sizes for the baseline model for a 1 in 100 year event with 12% climate change. In addition, a comparison has also been made of the impact of using newly available LiDAR within the model. Table 1 shows the results of the sensitivity analyses. The mass balance error for to 10m grid is a magnitude greater than the 20m grid and there is very little difference in the application of the old or updated LiDAR.

This result may seem to be incongruous, and it would seem sensible that smaller grid sizes should give "more accurate" results. However, the finite difference scheme employed by TUFLOW Classic uses the water level difference across a cell to drive the calculation. In circumstances where the water surface is comparatively flat (such as the Thames) and there is a significant change in flow or bed slope then the software algorithm may struggle to iterate to a satisfactory solution, and this will result in larger mass balance errors.

The use of a larger grid size inevitably increases the difference in water level across cells and thus reduces potential computational problems within the program algorithm. In Edenvale Young's experience, a larger grid size can lessen the probability of large instabilities forming within the simulation and reduce mass balance errors. The evidence presented in Table 1 would support this conclusion.

Table 1: Sensitivity analysis on grid size and LiDAR

Grid Size	LiDAR	Cumulative Mass Balance Error (m^3)	Average increase in Peak Level (m)
10m	Supplied LiDAR	-1,652,372	-0.048
20m	Supplied LiDAR	112,531	0.003
20m	New LiDAR	93,472	0.003

Finally, it should also be noted that a 20m grid is commensurate with the width and features of the floodplain. At the sand and gravel site the floodplain on the right bank is 340m wide. Accordingly, a 20m grid is perfectly sufficient grid size to represent features in the floodplain.

Reconfiguration of Phasing

The phasing of the works has been reassessed to determine whether there would be any advantage to changing the phasing of the excavation and filling process. *Figure 1* shows the reconfigured excavation phases SP1 to SP10 which increases the number of phases from 4 to 10. As noted in the introduction each area would be opened, minerals reclaimed and backfilled before the next phase. Each phase has been modelled to determine the impact of the works on third parties. Table 2 shows the mass balance errors for each simulation (SP1 to SP10) organised by increasing cumulative mass balance error. The mass balance errors show:

- The baseline scenario with a 20m grid has significantly lower mass balance errors than the baseline scenario with a 10m grid (see Table 1) which reflects the conclusions on the use of the 20m grid above.
- The mass balance errors for SP1, SP4, SP6, SP7, SP8 and SP10 by comparison are within a factor of 2.0 of the baseline.
- The mass balance errors are inconsistent (see Table 2). For example, SP2 and SP3 excavation scenarios are adjacent to each other but give the most positive and negative mass balance. This indicates a degree of chaotic behaviours in the distribution of errors between simulations.
- The cumulative error, when comparing the baseline and phase SP1 to SP10 models, is in the order of 0.012m (0.003m + 0.09m) but because of the fact that mass balance errors are not distributed evenly along the length of the model and could be chaotic then this error could be larger or smaller than 0.012m. However, this is a significant decrease in the error when compared to Revision B (0.049m) reported above.

Table 2: Mass Balance Error for a 1 in 100 year event with 12% climate change allowance for excavation phases SP1 to SP10.

Phase	Grid Size /LiDAR	Cumulative Mass Balance Error (m^3)	Average increase in Peak Level (m)
SP3	20m / New LiDAR	-302,223	-0.009
SP8	20m / New LiDAR	-156,394	-0.005
SP7	20m / New LiDAR	16,295	0.000
SP6	20m / New LiDAR	32,621	0.001
SP10	20m / New LiDAR	97,132	0.003
SP4	20m / New LiDAR	97,937	0.003
SP1	20m / New LiDAR	189,529	0.006
SP9	20m / New LiDAR	227,378	0.007
SP5	20m / New LiDAR	324,267	0.009
SP2	20m / New LiDAR	369,272	0.011

Figure 4: Summary of Model Mass Balance Errors and Level Differences

Eleven reference points have been established to determine the impact of the works on water levels (see Figure 5) with the revised configuration of excavation. Table 3 and 4 and Table 4 show the difference between the water level in the Baseline condition and each of the excavation scenarios (SP1 to SP10). Positive numbers show an averaged increase in water level across the whole model and negative numbers show a decrease in water level. Again, it should be stressed that magnitude of the mass balance error will vary along the length of the river.

Figures 6 and 7 show the difference mapping for the site with the reconfigured excavation programme. The mapping shows the change in flood levels between the baseline and the excavations scenarios SP1 and SP2. The figures show the numeric difference in baseline and the excavation scenarios. Areas shade grey indicate changes (±0.010m) which are within the joint model tolerance of 0.024m (2 x 0.012m) in flood level as a result of the scheme.

Moreover, there are no increases in peak water level greater than 0.006m given in Tables 3 and 4 and all are within the joint model tolerance described above.

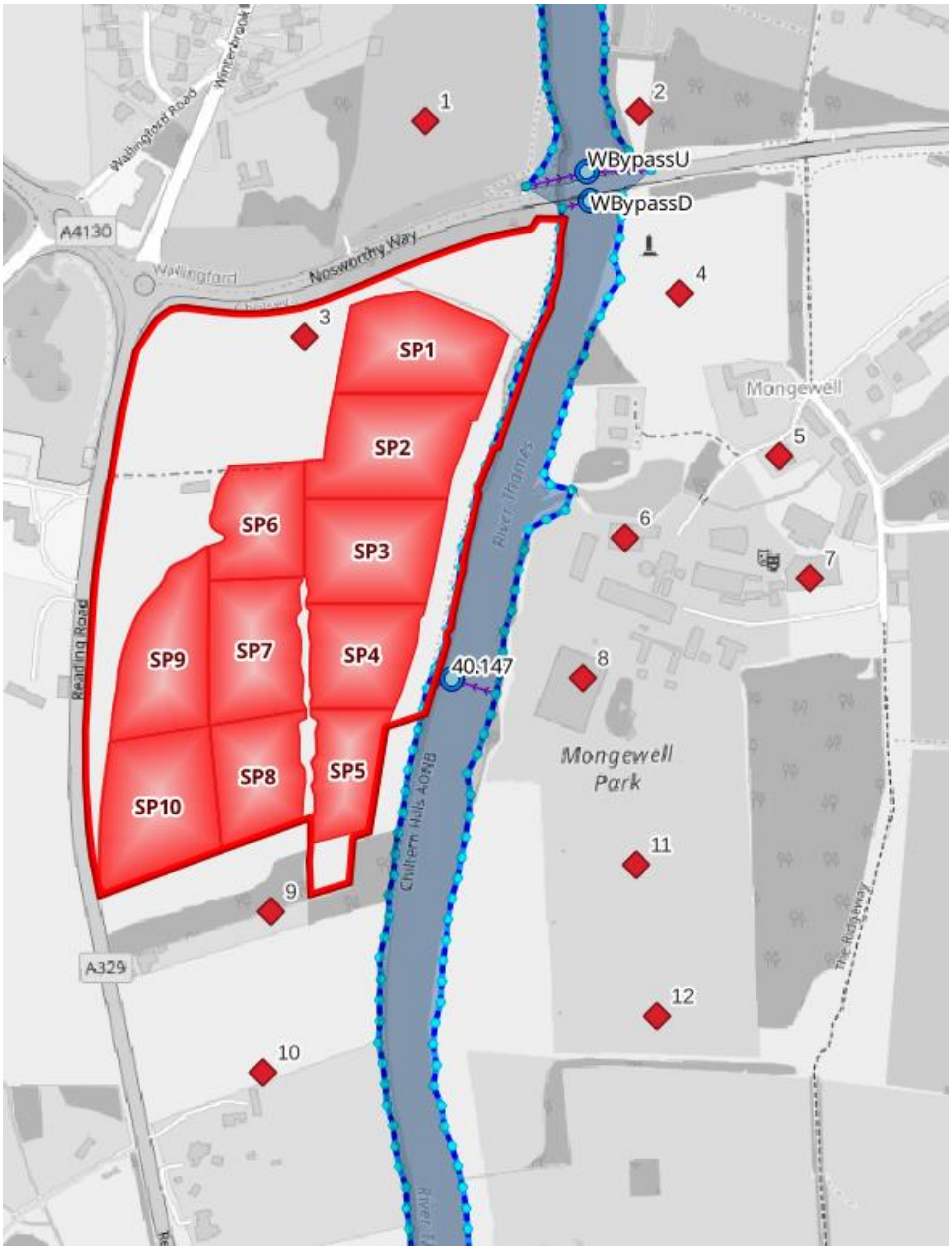

Figure 5: Location of Reference Points

Table 3: Water Level Differences at Reference Points RP1 to RP6

	RP1 (m)	RP2 (m)	RP3 (m)	RP4 (m)	RP5 (m)	RP6 (m)
SP 1	0.001	0.001	0.006	0.002	0.002	0.002
SP 2	0.003	0.003	0.003	0.004	0.004	0.004
SP 3	-0.009	-0.009	-0.009	-0.009	-0.007	-0.006
SP 4	-0.008	-0.008	-0.004	-0.007	-0.002	-0.001
SP 5	-0.005	-0.005	-0.003	-0.004	-0.002	-0.001
SP 6	-0.003	-0.003	-0.003	-0.003	-0.002	-0.002
SP 7	-0.007	-0.007	-0.005	-0.006	-0.004	-0.003
SP 8	-0.008	-0.008	-0.008	-0.008	-0.007	-0.007
SP 9	0.004	0.004	0.005	0.005	0.005	0.005
SP 10	0.000	0.000	0.001	0.001	0.001	0.001

Table 4: Water Level Differences at Reference Points RP7 to RP12

	RP7 (m)	RP8 (m)	RP9 (m)	RP10 (m)	RP11 (m)	RP12 (m)
SP 1	0.001	0.002	0.002	0.002	0.002	0.002
SP 2	0.003	0.005	0.005	0.005	0.005	0.005
SP 3	-0.004	-0.005	-0.005	-0.005	-0.005	-0.005
SP 4	0	0.003	0.004	0.002	0.003	0.002
SP 5	0	0.001	0.003	0.001	0.001	0.001
SP 6	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
SP 7	-0.002	-0.001	-0.001	-0.001	-0.001	-0.001
SP 8	-0.005	-0.007	-0.005	-0.007	-0.007	-0.007
SP 9	0.003	0.006	0.006	0.006	0.006	0.006
SP 10	0.001	0.001	0.002	0.001	0.001	0.001

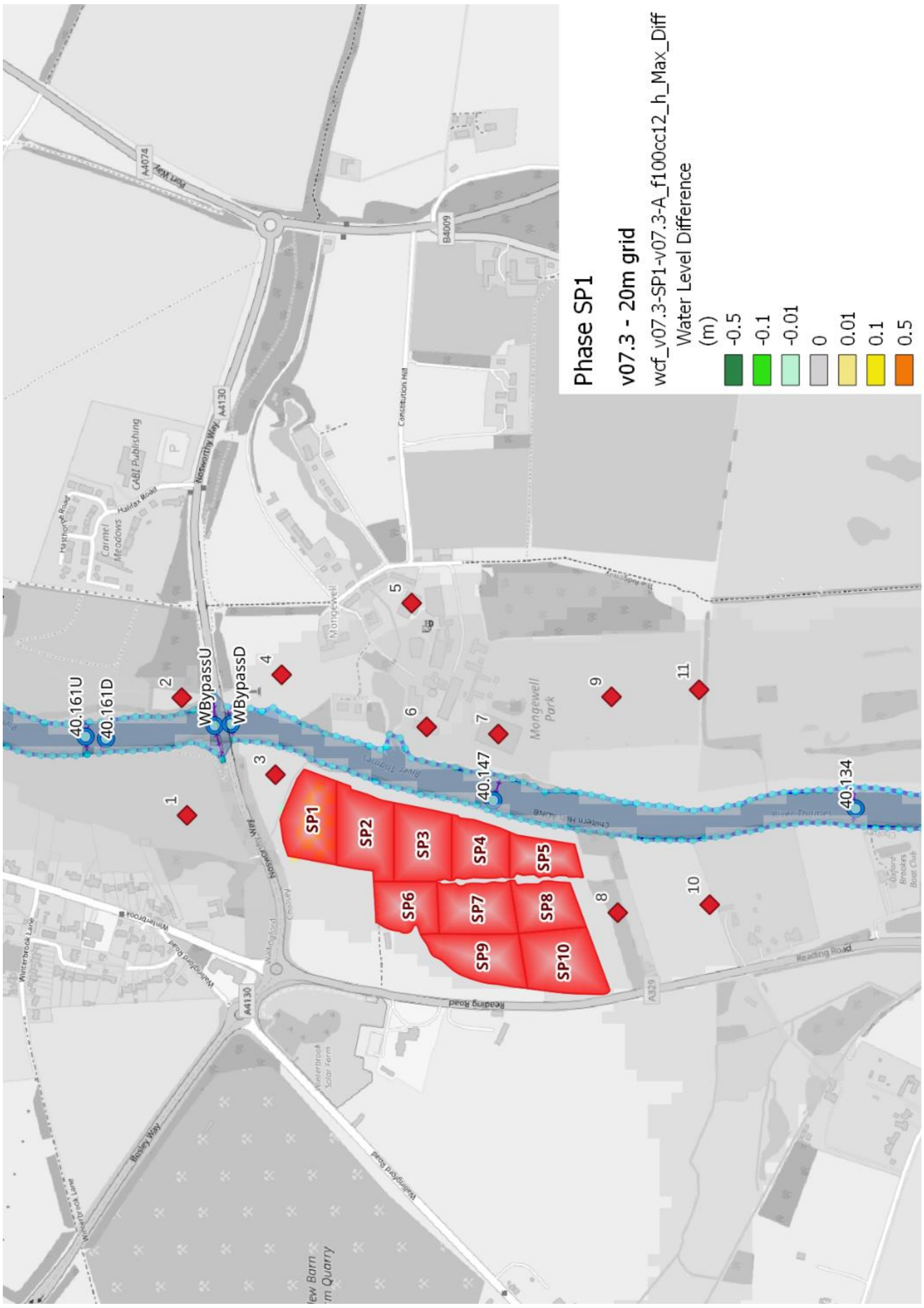

Figure 6: Water level Difference Mapping for 1 in 100 year event with 12% climate change allowance - Phase SP1 - Baseline

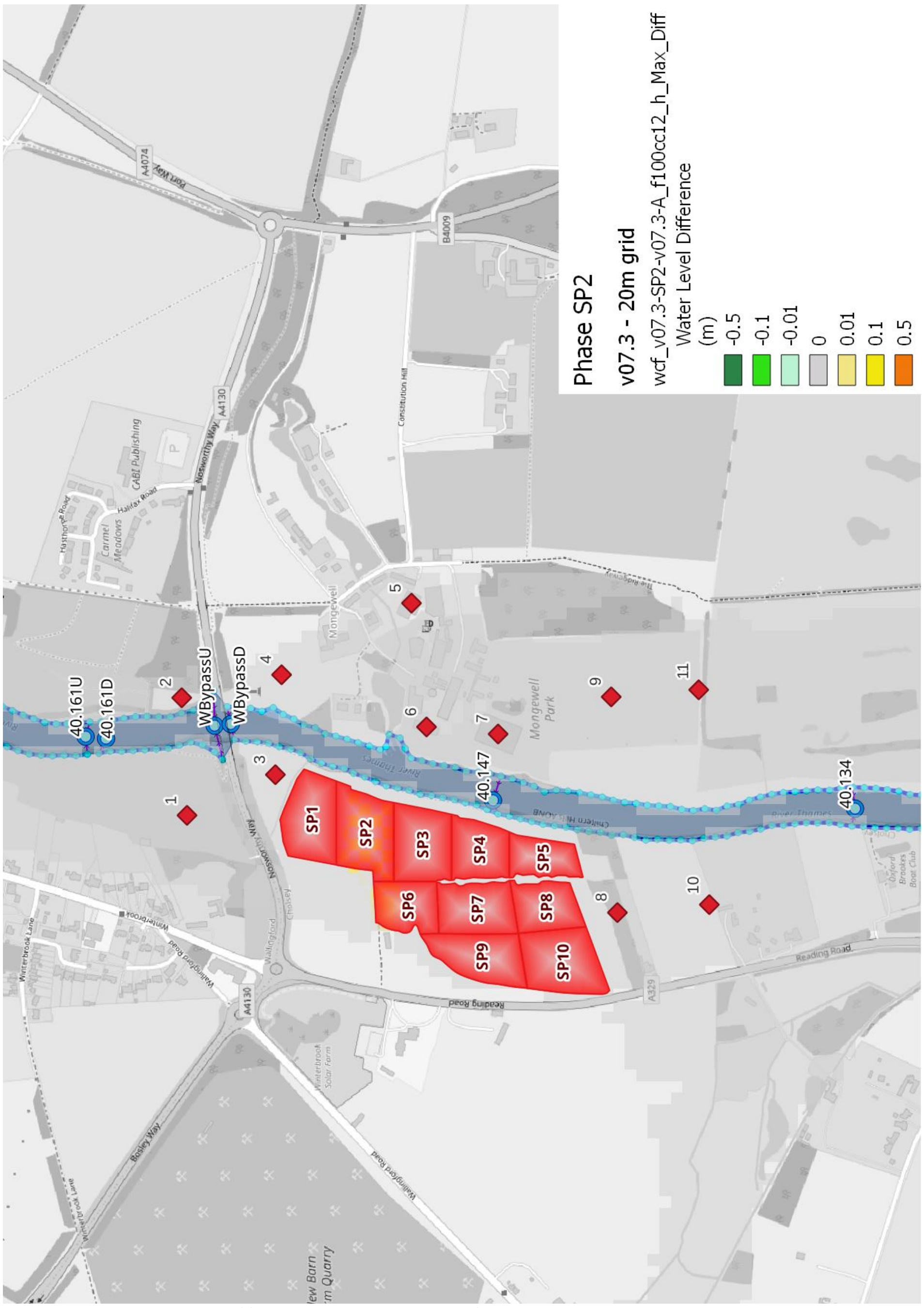

Figure 7: Water level Difference Mapping for 1 in 100 year event with 12% climate change allowance - Phase SP2 - Baseline

Hydraulic Modelling Summary

Mass Balance

- The incoming FMP-TUFLOW model configured with a 12% climate change allowance on flow had a mass balance error of -1,652,372m^3 at peak water level for a 1 in 100 year event with a climate change allowance of 12% and a 10m grid using the LiDAR supplied with the model.
- The negative mass balance error indicates that the peak levels within the baseline model are artificially suppressed by an anomalous loss of volume / mass during the simulation. In contrast, the P1 excavation scenario reported in Revision B of the FRA has a positive mass balance error meaning that peak water levels are artificially increased.
- The magnitude of the loss and hence the average accuracy of the baseline model is in the order of -0.048mm across the whole model domain for a 1 in 100 year scenario with 12% climate change using a grid size of 10m is appropriate for evaluating flood risk within the calibrated range. However, it is not suitable for assessing flood risk to accuracies less than 0.048m.
- The cumulative error (joint model tolerance), when comparing the baseline and phase 1 models, reported in Revision B of the FRA is in the order of 0.049m but because of the fact that mass balance errors are not distributed evenly along the length of the model and could be chaotic then this error could be larger or smaller than 0.049m.
- The fact that there is a significant difference between the cumulative mass balance errors between the baseline and the P1 excavation scenario given in Revision B of the FRA means that meaningful comparisons between models to millimetre accuracy is not possible.
- When taking into account the mass balance errors for both models, the increase in water levels reported in Revision B of 0.018m and 0.025m could be interpreted as a reduction in water levels rather than an increase.

Sensitivity to grid size and LiDAR

- The mass balance error for the 20m grid (112,531 m^3) is significantly lower than the 10m grid (1,652,372m^3). The average accuracy of the baseline model for the 20m grid is equivalent to an anomalous increase in water levels of 0.003m across the whole model domain.
- There is very little difference in the application of the old or updated LiDAR in relation to the mass balance error using a 20m grid.
- A 20m grid is commensurate with the width and features of the floodplain. The floodplain on the right bank is 340m wide. Accordingly, a 20m grid is perfectly sufficient grid size to represent the floodplain.

Reconfiguring the works to incorporate 10 phases of excavation.

- The cumulative error (joint model tolerance), when comparing the baseline and phase SP1 to SP10 models, is in the order of 0.012m (0.003m + 0.09m) but because of the fact that mass balance errors are not distributed evenly along the length of the model and could be chaotic then this error could be larger or smaller than 0.012m.
- There are no increases in the modelled peak water level greater than 0.006m. All water level difference results are within the joint model tolerance. It is considered that it is not appropriate to treat values which are smaller than the joint model tolerance as <u>real</u> increases or decreases in water level.

Flood Risk

There is also a misconception that an increase in water levels represents an increase in risk. The universally accepted definition of risk is the product of probability and consequence. This is acknowledged in the first paragraph of the PPG (Flood risk and coastal change: https://www.gov.uk/guidance/flood-risk-and-coastal-change.).

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In this case, it is important to concentrate on the consequences of flooding because the likelihood of flooding remains the same in baseline and the temporary condition where the excavation works are in progress (i.e 1 in 100 years or 1% Annual probability).

Consequence is a measure of the impact on something or someone. This includes physical damage such as erosion, financial losses and injury. An increase in water level of 0.006m will not result in a measurable increase in physical damage to the land or any buildings on the floodplain. Indeed, an increase of 0.06m would not be observable.

Moreover, I can see no reason why there would be a degradation in the quality of the land or any other reasons why there would be measurable increased financial losses to third party land. Finally, there is no change in flood hazard (i.e. the danger to people). The flood hazard on the majority of the floodplain is classified as extreme at all times and this will not change as a result of the works.

Policy and Guidance

The opening paragraph of the Guidance on Flood Risk and Coastal Change[1] which provides advice on how to take account of and address the risks associated with flooding and coastal change in the planning process states that:

> *"Flood risk is a combination of the probability and the potential consequences of flooding."*

[1] https://www.gov.uk/guidance/flood-risk-and-coastal-change

The definition of risk is the product of probability and consequences which is reflected by the above statement. It is not simply an increase in water level or a change in the probability of flooding. As noted above, it is considered that there would be no measurable change in consequence (i.e. physical damage, financial loss or flood hazard) as a result of the works. Accordingly, there is no increase in the combination of the probability and the consequence of flooding and no change in risk.

The Guidance on Flood Risk and Coastal Change states that:

> *"The objectives of a site-specific flood risk assessment are to establish:*
>
> - *whether it will increase flood risk elsewhere;"*

Policy C3 of the Minerals Local Plan states that:

> *"Minerals and waste development will, wherever possible, take place in areas with the lowest probability of flooding. Where development takes place in an area of identified flood risk this should only be where alternative locations in areas of lower flood risk have been explored and discounted (using the Sequential Test and Exceptions Test as necessary) and where a flood risk assessment is able to demonstrate that the risk of flooding is not increased from any source, including:*

- *an impediment to the flow of floodwater;*
- *the displacement of floodwater and increased risk of flooding elsewhere;*
- *a reduction in existing floodwater storage capacity;*
- *an adverse effect on the functioning of existing flood defence structures; and the discharge of water into a watercourse.*
- *The opportunity should be taken to increase flood storage capacity in the flood plain where possible, particularly through the restoration of sand and gravel workings."*

Conclusions

The final overall conclusions are as follows:

- The proposed works do not include filling which would displace of flood water. Moreover, there are no proposals to construct embankments or undertake filling on the flood plain which would deflect water onto third party land. Given that the mineral working will not incorporate raised features within flood zone 3 it is considered that the scheme should not have an adverse impact on flood levels to third parties.
- The mass balance error for a 20m grid (112,531 m^3) is significantly lower than the 10m grid (1,652,372m^3) in the baseline scenario. The average accuracy of the baseline model for the 20m grid is equivalent to an anomalous increase in water levels of 0.003m across the whole model domain and this is significantly better performance than a 10m grid (-0.048m).
- The fact that there is a significant difference between the cumulative mass balance errors between the baseline and the P1 excavation scenario using the 10m grid (Revision B of the FRA) means that comparisons between the model scenarios to accuracies smaller than the joint model tolerance of 0.049m accuracy is not mathematically possible.
- There is very little difference in the application of the old or updated LiDAR in relation to the mass balance error using a 20m grid. Moreover, a 20m grid is commensurate with the width and features of the floodplain. A 20m grid is sufficient grid size to represent the floodplain and flood risk.
- The presence of numerical errors inherent in the software and hydraulic modelling means that it is not possible to provide a “real” comparison between the baseline and reconfigured excavation modelled water levels where the increases / decreases in water level are less than the joint model tolerance of 0.012m for the reconfigured scheme with 10 phases of excavation.

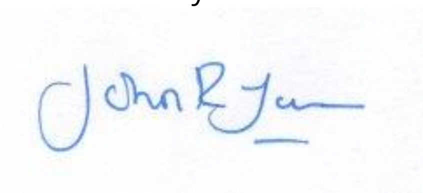
- There are no increases in the modelled peak water level greater than 0.006m and as this is smaller than the joint model tolerance. Any changes in water level smaller than the joint model tolerance is mathematically anomalous.
- There is no increase in the extent of flooding as a result of the works. No additional property or land would be inundated as a result of the excavation works associated with the sand and gravel workings.
- The probability of flooding to properties and land currently located in the floodplain will not change as a result of the works.
- There are no measurable changes to the consequence of flooding as demonstrated by the hydraulic modelling which would lead to increased:
    - Physical damage (i.e. damage to infrastructure, erosion).
    - Financial loss (i.e. to the land or any buildings on the floodplain as a result of increased water levels).
    - Danger to people. (i.e. flood hazard).
- The probability that a 1 in 100 year event occurring or being exceeded in a period of five years is 5% during the lifetime of the scheme. This is considered to be a low probability of occurrence by the EA's definition.
- The probability of a 1 in 100 year event being equalled or exceeded within the five year period is significantly lower than the test applied to a housing development with a 100 year lifespan which is 63%.
- There is no change in flood risk by comparison to the baseline scenario following completion of the works.

It is considered that the discussions above confirm compliance with these tests in that that the proposed workings do not impede flow, there is no displacement of flood water, there is no reduction in flood storage capacity and there is a temporary increase in flood storage. There are no flood defence structures affected by the works.

Accordingly, it is considered that both tests are passed.

I trust that this is sufficient information for you to reconsider the EA's objection to the works. However, if you have any further questions, please do let me know.

Yours sincerely



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