Responses to the comments on the manuscript "From salinity to nanoplastics: redefining safe yield in strip-island aquifers under emerging contaminant threats" by Zheng et al. submitted to *Hydrology and Earth System Sciences*

Dear Anonymous Referee #2,

We are deeply grateful for your careful assessment and valuable feedback on our manuscript. Your positive recognition of the research topic and structure, together with your targeted revision advice, have been crucial for us to refine the novelty, model transparency, terminology consistency, and practical implications of the study. We have fully responded to all your comments with specific revisions as detailed in the following sections.

Comments:

This manuscript develops a coupled numerical model to investigate microplastic migration in idealized strip-island aquifers under pumping conditions, aiming to redefine safe yield by integrating microplastic contamination with traditional salinity intrusion. The research topic aligns well with the scope of HESS, addressing an emerging groundwater pollution issue with practical implications for island freshwater resource management. The manuscript is generally well-structured with clear research objectives, systematic numerical simulations, and multi-scale comparative analysis. However, minor revisions are recommended, with key improvements including:

Response:

Thank you for your positive feedback and the constructive suggestions provided. We will address the issues as follows:

Comment (1): *The introduction adequately identifies research gaps but lacks in-depth discussion on limitations of previous studies (especially on microplastic transport in island freshwater lenses and safe-yield models), weakening the novelty statement.*

Response:

We highly appreciate this insightful comment that helps strengthen the novelty and rationale of our study. We agree that the original introduction lacked sufficient discussion on the limitations of previous research related to nanoplastic transport and safe-yield models in island freshwater lenses.

In response, we have thoroughly revised the relevant paragraph to deeply analyze the deficiencies of existing studies, clarify the interdependence of the two key research gaps, and highlight the unique value of this work. By emphasizing the failure of traditional models to capture nanoplastic- specific transport behaviors and the oversimplification of transition zones, we have significantly improved the expression of novelty and research necessity.

The revised content is shown below: "

Taken together, there are two critical gaps that are interdependent and collectively undermine reliable groundwater management. First, existing safe-yield models oversimplify the freshwater-seawater transition zone by neglecting dispersion-driven mixing. This oversimplification is further exacerbated when combined with the poorly characterized transport of nanoplastics, which exhibit unique migration dynamics that cannot be captured by traditional solute models. Second, the distinct migration behavior of nanoplastics under pumping-induced coning remains poorly understood. Current modeling frameworks, largely derived from solute transport theory, do not adequately capture transient nanoplastic breakthrough or particle-specific transport dynamics. "

Comment (2): *Clarify model assumptions explicitly: State that the aquifer is homogeneous and isotropic, lateral groundwater flow is ignored, and tidal influences are neglected; explain how these simplifications may affect simulation results (e.g., failing to account for tidal effects may* *result in an overestimation of the maximum safe extraction rate of freshwater lenses on islands.).*

Response:

We highly appreciate this insightful comment that helps strengthen the novelty and rationale of our study. We agree that the original introduction lacked sufficient discussion on the limitations of previous research related to nanoplastic transport and safe-yield models in island freshwater lenses.

In response, we have thoroughly revised the relevant paragraph to deeply analyze the deficiencies of existing studies, clarify the interdependence of the two key research gaps, and highlight the unique value of this work. With the exception of lines 116–123, we provide a detailed description of the potential impact of these assumptions in line 606. By emphasizing the failure of traditional models to capture nanoplastic - specific transport behaviors and the oversimplification of transition zones, we have significantly improved the expression of novelty and research necessity.

The revised content is shown below:“

To simplify the problem and enhance computational tractability, the following key assumptions are adopted based on established modeling practices in coastal aquifer studies (Stoeckl and Houben, 2012; Yao et al., 2019): (i) the aquifer is homogeneous and isotropic; (ii) fluid density is solely dependent on groundwater salinity, with thermal effects considered negligible; (iii) the nanoplastic particle density is assumed to be approximately equal to the water density (e.g., some aged nanoplastics); (iv) the saturated zone is initially saturated with seawater, and rainfall infiltration is spatially uniform and temporally constant; (v) groundwater flow is simulated within a two-dimensional vertical profile of the strip island, leveraging the geometric symmetry of the idealized domain; and (vi) tidal influences are neglected, and constant head boundary conditions are imposed at the seawater interface..”

“Several simplifying assumptions were adopted in this study, including homogeneous aquifer properties, idealized boundary conditions, and limited representation of nanoplastic diversity. In practice, aquifer heterogeneity, tidal fluctuations and storm events may further influence the groundwater flow field and, consequently, the transport of substances. Besides, the diverse properties of environmental nanoplastics such as particle size distribution, aging state and surface chemistry will also bring additional impacts on their migration.Moreover, only two synthetic nanoplastic types of synthetic nanoplastics were considered here, whereas natural systems contain a broader and more complex spectrum of particles. Despite these limitations, the present study establishes a mechanistic framework for evaluating nanoplastic transport in coastal freshwater lenses. ”

Comment (3): *Some sentences use microplastics and nanoplastics interchangeably; unify to nanoplastics where appropriate.*

Response:

Thank you for this important suggestion on terminology consistency. We have carefully reviewed the entire manuscript and uniformly standardized inconsistent uses of microplastics / nanoplastics to nanoplastics where appropriate, ensuring clarity and precision throughout the text.

Revisions were made at the following positions:

Line 66, 79, 82, 85, 316

Comment (4): *Table 1: Typo Sympol - Symbol; based on the experimental - complete as based on the experimental data.*

Response:

Thank you for your careful correction. We have fixed the typographical errors in Table 1 as suggested:

Sympol has been revised to Symbol

based on the experimental has been completed to based on the experimental data

All corrections have been implemented in the revised manuscript to ensure accuracy and standardization.

Comment (5): *Clarify the derivation of key time nodes (e.g., stabilization time at laboratory/field scale) and how they are determined via simulation calculation.*

Response:

Thank you for this rigorous suggestion. We have supplemented a clear explanation in Section 2.2 to explicitly clarify the derivation and determination criteria of key stabilization times at both laboratory and field scales.

We have added a formal convergence criterion to define when the system reaches a steady state, making the simulation setup more transparent and reproducible.

The revised content is shown below:"

Stabilization times for laboratory and field simulations were determined using a convergence criterion: the system was considered stable when the relative change in wellhead salinity and nanoplastic concentration was less than 1% over three consecutive time steps. "

Comment (6): *Ensure consistent use of site scale rather than mixing site scale and field scale.*

Response:

Thank you for your valuable comment on terminology consistency. We have carefully reviewed the entire manuscript and uniformly adopted "site scale" throughout the text, replacing all inconsistent uses of "field scale" to ensure standardization and coherence.

All relevant expressions have been revised accordingly, enhancing the formal rigor of the manuscript.

Comment (7): *Further highlight the practical application value: Clarify implications for well design, pumping rate optimization, and groundwater management planning in small island aquifers.*

Response:

We appreciate this insightful suggestion that enhances the practical significance of our work. We have revised the manuscript to further highlight the real-world application value of our findings, with explicit clarification of the implications for well design, pumping rate optimization, and groundwater management planning in small island aquifers.

This revision strengthens the translational relevance of the research and better connects scientific findings to practical coastal groundwater governance.

The revised content in line 615 is shown below:“

Moreover, only two synthetic nanoplastic types of synthetic nanoplastics were considered here, whereas natural systems contain a broader and more complex spectrum of particles. Despite these limitations, the present study establishes a mechanistic framework for evaluating nanoplastic transport in coastal freshwater lenses. By coupling variable-density flow with particle-specific transport processes and quantifying impacts on safe extraction thresholds, this study provides clear practical implications for well design, pumping optimization, and groundwater management on small islands. ”

Comment (8): *Further highlight the practical application value: Clarify implications for well design, pumping rate optimization, and groundwater management planning in small island aquifers.*

Response:

We highly appreciate your constructive suggestion to strengthen the practical implications of our study. We have revised the manuscript to more clearly emphasize the practical application value of our findings, explicitly elaborating their guiding significance for well design, pumping rate optimization, and groundwater management planning in small- island aquifers.

We have supplemented and refined the relevant content in the conclusion sections, highlighting the guidance of this study for actual island groundwater resource development and protection.

The revised content is presented as follows:

Line 606:“

Several simplifying assumptions were adopted in this study, including homogeneous aquifer properties, idealized boundary conditions, and limited representation of nanoplastic diversity. In practice, aquifer heterogeneity, tidal fluctuations and storm events may further influence the groundwater flow field and, consequently, the transport of substances. Besides, the diverse properties of environmental nanoplastics such as particle size distribution, aging state and surface chemistry will also bring additional impacts on their migration. Moreover, only two synthetic nanoplastic types of synthetic nanoplastics were considered here, whereas natural systems contain a broader and more complex spectrum of particles. Despite these limitations, the present study establishes a mechanistic framework for evaluating nanoplastic transport in coastal freshwater lenses. ”

Line618“

Future research should perform heterogeneous aquifer simulations, consider dynamic tidal and sea-level rise scenarios, and adopt more realistic natural micro/nanoplastic properties to further improve prediction accuracy and practical applicability for water security in plastic-polluted coastal environments. ”