Submission to the Consultation on the Draft National Bioresources Strategy

Redrock Bioenergy response to the four consultation questions: plan advanced thermal conversion (ST03) as sized-and-sited capacity at the regional Bioresource Centres, complete the treatment chain on one site rather than hauling digested residue onward, and make complete contaminant destruction, phosphorus recovery and net energy explicit pathway-selection criteria

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To: Uisce Éireann, National Bioresources Strategy consultation
From: Redrock Bioenergy
Date: 22 July 2026
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1. About this submission

Redrock Bioenergy welcomes the opportunity to contribute to and support the draft Strategy and asks for one focused strengthening, in three connected parts. First, plan advanced thermal conversion (ST03) as sized-and-sited capacity on the same horizon as the land route's decline, rather than principally as a demonstration to be evaluated later. Second, site that capacity at the Bioresource Centres themselves, so that the destruction step happens where the sludge is already aggregated and digested, rather than the digested residue being dried, bulked and hauled onward a second time to a separate centralised facility. Third, and governing both, make complete contaminant destruction, phosphorus recovery and net energy explicit pathway-selection criteria, so a route is judged on what it destroys and recovers, not on the volume it reduces. A final movement of the phosphorus-bearing residue remains in either case, but it is a fraction of the mass, and of the Scope 3 burden, of moving the whole dried solids stream.

We are a renewable-energy and resource-recovery developer active in Ireland, the UK and Australia, developing a supercritical fluid gasification (SCFG) module. SCFG is a form of the advanced thermal conversion the draft Strategy identifies at Section 6, and it is the same route the Strategy's long list calls hydrothermal gasification and the literature also calls supercritical water gasification; we use those names interchangeably below. It reduces wastewater sludge to a small, mineral-rich solid residue, takes the PFAS-bearing solids out of the soil-exposure pathway, is designed to achieve pathogen destruction at the selected operating condition, concentrates phosphorus into a residue from which recovery is expected to be practicable, and is designed to return net energy at works-relevant dry matter. It scales by replicating a small module across sites instead of enlarging a single high-pressure vessel. We are developing it for deployment on wastewater sludge at works scale, and we set out the engineering and operational basis behind that work in Section 4.

Our recommendations are not specific to that technology. The case we make for siting destruction at the Bioresource Centres rests on the properties a route must have, not on which route is chosen, and we set those properties out at R6 so that any technology can be assessed against them.

One point of position, since it shapes everything we say below about the land route. Redrock's core business returns nutrients to farmland. We develop anaerobic digestion, and we regard biofertiliser as the right destination for organic residues where the material is clean and a landbank exists. Nothing here is an argument against land application in principle. We argue that the test should be the contaminant profile of the material, not the disposal route in the abstract. Where there is a landbank and no PFAS or comparable persistent pollutant load, spreading is the preferred outcome, and it recovers nutrient value that destruction would forgo. Where a persistent pollutant load is present, destruction is preferred, because spreading in that case transfers the liability to soil instead of resolving it. Wastewater sludge sits on the second side of that line, because it inherits whatever the sewer catchment collects. That distinction is the same one we ask the objectives to adopt at R2.

This response answers each of the four consultation questions in turn. The recommendations are numbered R1 to R8 in the order they appear, and are consolidated against each question in the table at Section 6.

2. Question 1: Challenges

"Do you have views on the identified challenges and are there other challenges to be included?"

We agree with the challenges the draft Strategy identifies in Section 2, including pressure on the agricultural outlet, regulatory and contaminant pressures, and infrastructure and financing needs. The Strategy notes that effectively all treated biosolids are currently reused in agriculture, and that the period of land-spreading availability has been decreasing in recent years. That trend is well evidenced: Uisce Éireann is already, on the public record, considering golf courses, mine restoration, cement and incineration as the agricultural route tightens, with only about 130 farms now taking the material ([Irish Times](https://www.irishtimes.com/environment/2026/06/01/uisce-eireann-eyes-golf-courses-for-spreading-sewage-sludge-as-farmland-options-run-out/)); the Bord Bia Sustainable Dairy Assurance and Sustainable Beef and Lamb Assurance schemes prohibit the spreading of sewage sludge on participating farms, which narrows the practical landbank further ([Bord Bia](https://www.bordbia.ie)); and the nitrates derogation is under pressure from water-quality trends, with nitrogen the principal national driver and phosphorus elevated in localised catchments ([Teagasc](https://teagasc.ie/environment/schemes-regulations/nitrates-derogation/), [EPA](https://www.epa.ie/news-releases/news-releases-2025/epa-publishes-full-monitoring-network-results-of-nitrogen-and-phosphorus-levels-in-irish-waters-for-2024.php)).

We would sharpen or add three challenges.

1. The contaminant gap is not closed by volume management or source control alone, and the SEA already says so. Two responses to the contaminant pressure are sometimes offered as ways to keep the land route open, and both should be distinguished from destruction and not treated as equivalent to it. The first is volume management. The second is upstream source control, meaning catchment interventions that reduce the contaminant load entering the works, on the model of assurance schemes and industrial pre-treatment programmes operating in other jurisdictions. We support source control without reservation, and it is the right first move for the clean-material stream we describe at Section 1: it protects, and can even expand, the landbank for sludge that carries no persistent pollutant load. But source control manages the load arriving at the works from identifiable point sources; it reaches neither the diffuse nor the legacy catchment inputs, infiltration, atmospheric deposition and legacy contaminated ground draining to sewer, so the annual sludge flow does not decline to a spreadable floor however long control runs; the share those sources carry is itself one of the things the R1 monitoring would quantify before any route is sized. It is also specific to the contaminant it targets: microplastics and pharmaceutical residues persist in the solids whatever an upstream PFAS restriction achieves, so a route that destroys the solids resolves those loads together, whereas source control would have to be built and repeated for each of them in turn. Source control and a destruction endpoint are therefore complementary, not alternatives: the first keeps clean material on the clean-material route, and the second resolves the fraction the first cannot reach, sized to whatever load the monitoring at R1 actually reveals, not fixed at the outset. A Strategy that leaned on source control alone would be planning to reduce a load it could not verify it had eliminated, on the same land route whose closure this question already identifies as the central risk. The SEA is direct on the

underlying point: it finds that there are currently no limits for organic pollutants in Irish wastewater sludge, that some Member States have already ceased agricultural use of sewage sludge and diverted it to energy generation and nutrient recovery, and, most tellingly in our reading of it, that conventional methods are not able to remove the emerging contaminants while most advanced thermal conversion technologies have the potential to remove them in addition to pathogens. Anaerobic digestion, including advanced AD, does not destroy these contaminants, so where they are present in the feed they pass through to soil. That is not a criticism of digestion, which does what it is for and recovers energy and nutrients from the organic fraction. It is a statement about what it does not do. A pathway built on AD plus continued land reuse manages volume, and returns nutrients, but where the material carries a persistent contaminant load it leaves that liability in place. This deserves to be named as a challenge in its own right, not only as something to monitor.

2. The narrowing of the land route should be planned for as a challenge, not absorbed as a surprise. The relevant risk is not managing today's volume, it is the cost of a land route that closes: clean-up exposure, lost landbank, and emergency disposal. Australia is the leading indicator. On the release of the draft PFAS National Environmental Management Plan (NEMP 3.0), a major water utility suspended land application of its biosolids and is evaluating on-site thermal treatment among a broader set of management options ([AWA](https://info.awa.asn.au/water-e-journal/thermal-treatment-of-south-east-water-biosolids-to-solve-disposal-challenges)). The lesson is technology-neutral, and it is in the sequence rather than the destination: a tightening PFAS regime moved that utility off land before a replacement route was in place. That is the asymmetry we would see named. A replacement takes years to specify, consent and build, and the lead time to deliver one is longer than the notice a closure is likely to give.
3. Not all thermal routes destroy a contaminant; some only transform it, and the Strategy should be explicit about which it means. This is the most important addition we make to the challenge set, because it cuts both ways and is the point on which a destruction pathway is most reasonably challenged. Thermal treatment at lower or incompletely controlled operating conditions can break a long-chain PFAS molecule down into shorter-chain PFAS and other fluorinated fragments, distributed across the solid residue, the aqueous condensate and the offgas, rather than mineralising it to inorganic fluoride. A route can therefore appear to remove a contaminant from the feed, in the sense that the parent compound is no longer measured in the solid, while in fact having relocated and partially transformed it across new matrices. This concern is correct, and it is a real reservation about the less complete thermal routes; it should not be waved away by anyone advocating thermal conversion, ourselves included. The right response is not to set thermal conversion aside, but to define destruction precisely and hold every route to that definition. Destruction means complete mineralisation, evidenced by a fluorine mass balance in which the aqueous and solid legs close to inorganic fluoride against stated detection limits and the gas-phase leg is explicitly bounded rather than assumed closed, pending the stack method developed under R7, and not the mere disappearance of the parent compound from one matrix. Defined that way, the concern becomes a discriminating test rather than a blanket objection: it separates the routes and operating conditions that genuinely mineralise the contaminant load from those that only rearrange it. We carry that definition into the selection criteria at R2, into the property test at R6, and into the demonstration protocol at R7, and we apply it to our own route on the same terms as to any other.

Recommendation carried from this section:

R1. Begin PFAS and emerging-contaminant monitoring now, on a defined timeline. The Strategy already commits to a national emerging-contaminants monitoring programme (action 2.7) and to consult on PFAS limits (action 2.10). We recommend these be started now and given dates, so the evidence base exists before regulation arrives, and that the assessment weigh the value of a destruction pathway against the contingent liability of a future land-route closure. Building the monitoring baseline is a low-regret action whichever pathway is chosen. As a drop-in amendment, actions 2.7 and 2.10 could add: *"the national emerging-contaminants monitoring programme and the PFAS assessment shall commence on a defined timeline and publish a baseline before any destruction or treatment pathway is sized."*

3. Question 2: Objectives

"Do you have views on these strategic objectives and the associated aims and actions?"

We support the four strategic objectives: sustainable management of wastewater sludge and bioresources (1); protect and restore our environment (2); support our communities, growth, and the bioeconomy (3); and efficient operation of wastewater sludge and bioresources centres (4). Our recommendation is that the aims and actions be made selective on outcome, not neutral on volume. That bears principally on objectives 1 and 2, and we set out at the end of this section how the same criteria also serve objectives 3 and 4.

R2. Make complete contaminant destruction, phosphorus recovery and net energy explicit pathway-selection criteria, with wet-cake acceptance and distributed deployment as the discriminators between routes that meet them. The Strategy is right to be technology-neutral, but neutrality must not score a pathway that merely reduces volume as equivalent to one that also resolves the contaminant and landbank problems, and it must not score a pathway that partially transforms a contaminant as equivalent to one that destroys it. The SEA's own assessment already distinguishes the first of these. We recommend the objectives adopt explicit pathway-selection criteria, applied wherever the aims and actions drive a technology choice, including the advanced thermal conversion actions 1.7 and 4.6. The criteria we propose are five, and they are deliberately technology-neutral, scoring a route on what it does rather than on its category name:

(a) **Destruction toward mineralisation, verified so far as validated methods allow, and not removal of the parent compound.** A route that only partially breaks PFAS, microplastics or pharmaceuticals down, and in doing so generates fluorinated or other daughter products across its solid, aqueous and gaseous outputs, should not be credited as equivalent to one that mineralises them. Completeness is scored now on the matrices where a total-fluorine method is validated, the aqueous and solid streams, against stated detection limits. Any fluorine not accounted for across those measured matrices counts as not mineralised, so a route cannot score as a mineraliser by closing the aqueous and solid legs while a material fluorine fraction remains unaccounted for. The gas phase, for which no validated total-organofluorine stack method yet exists for any thermal route, is therefore held open as a debit against every route, ours included, until R7 delivers a validated method that can close it, and no route may be credited with complete gas-phase mineralisation before then. Where destruction is not the intended outcome, the test is instead the diversion of the contaminant-bearing solids out of the soil-exposure pathway.

(b) **Phosphorus recovery from the residue, weighted by the form the residue leaves in.** The test is not only whether phosphorus is present but how recoverable it is, since the energy and reagent cost of recovering it differs markedly between a mineral residue, a carbonaceous char and a dispersed wet stream.

(c) **Net energy contribution to the works.**

(d) **Acceptance of wet dewatered cake without a dedicated drying step**, since drying is the single largest parasitic load a thermal route can place on the Article 11 balance discussed at R4.

(e) **Suitability for distributed deployment at the Bioresource Centre itself**, rather than viability only at a single centralised facility that requires the dried solids to be hauled to it.

These carry the SEA's finding through into the technology choices the objectives drive, and they build the partial-transformation guard from challenge 3 into the point where pathways are actually chosen. Criteria (a) to (c) are the outcome the Strategy is trying to buy; criteria (d) and (e) are what separate routes that deliver it efficiently and on-site from routes that deliver it only after drying the feed or only at a single distant facility. One thing we state directly, since (d) and (e) are the two on which our own route does well: these five follow from the estate's own energy-neutrality and transport obligations, not from any technology, we would propose the same five whatever route we were developing, and we accept our own route being scored down on any criterion it fails.

As a drop-in amendment, a pathway-selection clause under objectives 1 and 2, governing the technology-selecting actions 1.7 and 4.6, could read: *"Where an aim or action selects a treatment or destruction pathway, pathways shall be assessed against: (a) destruction toward mineralisation, verified on a fluorine balance in which fluorine unaccounted for across the measured matrices counts against the route pending a validated gas-phase method; (b) phosphorus recovery, weighted by the recoverability of the residue form; (c) net energy contribution to the works; (d) acceptance of wet dewatered cake without a dedicated drying step; and (e) suitability for distributed deployment at the Bioresource Centre. Volume reduction alone shall not score a pathway as equivalent to one that also meets criterion (a)."*

R3. Treat phosphorus recovery as a design requirement, consistent with action 2.5. Action 2.5 already commits Uisce Éireann to meet the new requirements of the recast Urban Waste Water Treatment Directive, including energy neutrality and circular economy. That Directive (Directive (EU) 2024/3019, to be transposed by 31 July 2027) introduces new requirements to recover valuable materials from sludge, phosphorus among them ([EUR-Lex](https://eur-lex.europa.eu/eli/dir/2024/3019/oj/eng)). The SEA notes that phosphorus can be recovered from pyrolysis biochar, and that incineration ash is itself a phosphorus-bearing residue from which recovery is possible; advanced thermal conversion in general concentrates phosphorus into the mineral residue, from which recovery is then possible. The forms differ, and so does the ease and energy cost of recovering from each, which is why R2 criterion (b) weighs the form the residue leaves in, not the mere presence of phosphorus. We recommend the objectives make phosphorus-recovery capability an explicit criterion when selecting pathways, not only volume reduction. As a drop-in amendment, action 2.5's material-recovery commitment could add: *"pathway and centre-design selection shall prefer routes that concentrate phosphorus into a form from which recovery is practicable."*

The direction of travel is from good practice towards obligation, and the practical consequence is that Uisce Éireann will need to be in a position to facilitate recovery, not to begin considering it. That is a reason to weigh it now, at the point where pathways and centre designs are being selected, because a pathway that disperses phosphorus back to land, or that produces no concentrated recoverable fraction, forecloses the option instead of deferring it. A route that concentrates phosphorus into a solid from which recovery is possible keeps that option open, and that is the property the objectives should be testing for, as set out at R6.

R4. Treat energy neutrality as a pathway-selection criterion, consistent with action 2.5. Article 11 of the same Directive sets an energy-neutrality obligation across treatment plants of 10,000 p.e. and above, which action 2.5 adopts. Two features of it bear directly on pathway selection. Article 11(2) strikes the balance "at national level", across the total annual energy used by those plants rather than plant by plant, and it counts renewable energy generated by or on behalf of their owners and operators whether that energy is generated on site or off site. And purchased non-fossil energy is available only in a limited amount, capped at 35 per cent in relation to the 2045 objective and subject to the Directive's conditions, so in practice the balance has to be earned by the estate's own generation. Because the balance is struck across the whole estate rather than site by site, the works that generate and export renewable energy carry the neutrality of the works that cannot, and every avoidable energy load at the plants themselves is a direct debit against that same national balance. The SEA records that advanced thermal conversion has a higher energy requirement than conventional methods and still concludes the benefits outweigh that cost. That headline figure is worth reading carefully, because it is dominated by the drying load a route imposes. A route that must first dry the solids to a high dry matter carries a large parasitic demand, and most of that demand is the latent heat of evaporating water, which then leaves with the vapour and is hard to recover. A route that accepts wet dewatered cake does not evaporate that water, so in place of that lost latent-heat load it carries only a sensible-heat load, which it can recover from the hot process effluent. That is why the net balance of a wet-cake route turns on recuperator effectiveness rather than on a drying duty.

Redrock's SCFG design targets a net-energy-positive balance at works-relevant dry matter, meaning the dewatered-cake dry solids typical of a regional centre. It reaches that balance by converting the recalcitrant fraction that anaerobic digestion cannot digest, which is precisely the fraction a digested feed still presents. Because digestion has already exported the readily degradable fraction as biogas, a digested feed carries less gasifiable energy than raw sludge, so the net balance on digested cake turns on recuperator effectiveness and is one of the outputs the R7 demonstration is built to validate. The balance also turns on the feed clearing a minimum organic loading, below which the water fraction of the dewatered cake dominates the heat demand whatever the recuperator achieves; establishing that threshold on digested Irish cake is part of what R7 measures. The compatibility of the thermal step with digested sludge is a strength for mass reduction and on-site integration; it is not a claim that the energy balance is easier on a digested feed. We recommend the objectives assess each pathway on net energy alongside cost and carbon, consistent with R2, and that the drying load a route imposes be counted explicitly within that assessment. As a drop-in amendment, the energy-neutrality commitment under action 2.5 could add: *"the parasitic energy load of any sludge treatment or destruction pathway, drying load included, shall be counted in the Article 11 assessment."*

Objectives 3 and 4. The recommendations above are framed against objectives 1 and 2, but the same criteria serve objectives 3 and 4, and we would see that made explicit, not left implied. Phosphorus recovered into a characterised domestic resource reduces reliance on imported phosphate and gives the bioeconomy a secondary raw material instead of a dispersed loss to land, which serves the growth and bioeconomy objective directly. Replicating a standard module across the centres keeps the build, and the skilled operation of that capacity, in a domestic supply chain. Completing the chain on one site removes a second tanker movement from rural roads and ends the spreading of sewage-derived solids near dwellings, which are community and amenity gains the Natura assessment already weighs. That last point is also the answer to the community-acceptance question that on-site thermal capacity will reasonably raise: the material that would otherwise be spread on land near homes is instead retired inside an engineered, permitted and continuously monitored process, on a site that already receives and handles it, not dispersed across the countryside. And consolidating digestion, destruction and recovery on one site, not a destruction facility operated separately downstream, is the more efficient operating configuration that objective 4 calls for. As a drop-in amendment, a selection clause under objective 3 could add: *"Where an aim or action under objective 3 selects a treatment or destruction pathway, selection shall weigh the pathway's contribution to a domestic bioresource supply chain: the recovery of phosphorus as a characterised secondary raw material displacing imported phosphate, the retention of build, operation and maintenance of replicated on-site capacity within a domestic skills base, and the amenity gain of retiring sewage-derived solids inside a permitted, monitored process instead of spreading them near dwellings."*

4. Question 3: Solutions

"Do you have views on the identified solutions and are there others you would like to see included?"

We welcome that advanced thermal conversion is already in the solution set, as ST03 in the SEA and through actions 1.7 and 4.6 in the Strategy. Our central point is that it should be planned as capacity on a defined horizon, not held principally as a demonstration to be evaluated before implementation.

R5. Plan ST03 as sized-and-sited capacity, building on action 1.7. Action 1.7 commits to an advanced thermal conversion demonstration and, based on the outcome, to implementation. The SEA goes further: it finds all three of ST01, ST02 and ST03 preferred, and recommends that innovation be supported "to ensure there is not an over reliance on any one technology," with ST02 and ST03 scaled up while anaerobic digestion continues. We recommend the Strategy strengthen action 1.7 to commit to evaluate and, where justified, deploy destructive advanced thermal conversion at the regional Bioresource Centres it already identifies, reserving the capacity envelope, footprint and services now and deriving indicative capacity and timing from the R1 baseline as it reports, written into the infrastructure-planning and investment sections as that evidence firms. As a drop-in amendment, action 1.7 could read: *"Demonstrate advanced thermal conversion and, on a successful demonstration, plan and deploy sized-and-sited destructive capacity at the regional Bioresource Centres, with indicative capacity and timing set in the infrastructure and investment plan."* The decline of the land route is foreseeable in direction, though uncertain and probably short-notice in timing. It is the combination of a long build lead time against a closure that may give little warning, not a known date, that makes planning the replacement ahead of time the prudent course. A demonstration commitment and a capacity plan are different instruments, and we suggest the Strategy carry both. This is a planning commitment, not a capital commitment: the monitoring baseline at R1 informs the sizing, and capacity is then added in modules as the evidence and the load require, so the estate neither commits capital ahead of its own data nor is caught behind a closure it could see coming.

R6. Complete the treatment chain at the Bioresource Centre: destroy on site, and move only the phosphorus-bearing residue. We support the Strategy's tiered estate: circa 17 bioresource centres nationally, of which six are to be developed as regional Bioresource Centres with advanced digestion, supported by circa 35 satellite dewatering centres (Section 8; regional centres at Section 9). We note that the Strategy already contemplates advanced thermal conversion at those six, and this recommendation builds on that and does not cut across it. Aggregation is the right model for the digestion step: dewatering at the satellites and hauling to a regional centre concentrates sludge to the dry matter and the scale that both anaerobic digestion and advanced thermal conversion need. Our recommendation concerns what happens after digestion.

Once sludge has been aggregated and digested at a Bioresource Centre, the digested residue should be treated and destroyed on that same site. It should not be bulked, dried and hauled a second time to a separate centralised drying or destruction facility. A second transport leg adds cost, carbon and haulage risk, and it puts a contaminant-bearing material back onto the road network without treating it. Above all it forfeits the energy integration that makes the on-site route work, in which each step feeds the next:

4. Anaerobic digestion first. Biogas is upgraded and injected to the gas network at the hub, where the aggregated volume and the grid connection already justify the upgrading plant. Because Article 11 strikes the neutrality balance nationally, not plant by plant, and counts renewable energy generated by or on behalf of the owners and operators whether it is generated on site or off site, these injecting hubs are the estate's generating assets: the molecule they export is what nets off the energy drawn by the many works of 10,000 p.e. and above that will never generate meaningfully on their own site. Protecting that exported volume is how the estate reaches neutrality. Haulage is a separate matter, and we should be precise about it: haulier diesel sits outside the Article 11 boundary, which is drawn around energy used by the treatment plants. We put the transport argument below on cost, carbon and Scope 3 grounds, not on Article 11.
5. Advanced thermal conversion second, on the same site. Rather than name technologies, we suggest the Strategy specify the properties a route must have to hold this position, and assess any route against them. Four properties matter here, and each maps to one of the R2 criteria. It destroys the organic fraction at Bioresource Centre scale, and does so as a module that sits at the centre, per R2(e). It destroys the contaminant load as far as validated methods can verify, so that what leaves the site is a mineralised residue and a bounded fluorine balance, not a set of transformed daughter products distributed across new matrices, per challenge 3 and R2(a). It meets its own thermal demand, including any drying duty, from heat recovered within the process, not from an imported energy load, per R2(d). And it yields a concentrated solid from which phosphorus recovery is expected to be practicable, to be evidenced under R7 on the same footing as the fluorine balance and weighed against ash-based recovery under R2(b). A route with those properties is substantially self-powering, and needs no energy export infrastructure of its own to be worth siting at the centre. More than one route can meet the test, and the property test is deliberately neutral between them: it is the properties, not the labels, that decide the point. Where routes differ most is on the drying duty, on the completeness of destruction, and on the form phosphorus is left in. A route is scored down on those facts, and not on its category name, if it must dry the feed from an imported energy load, or only partially breaks the contaminant down, or locks phosphorus into a form recoverable only by high-energy downstream processing, or is viable only at a single central facility that requires the dried solids to be hauled to it. The drying objection commonly raised against pyrolysis, to take one example, is weaker than it first appears, because in deployed configurations waste heat is used in the

drying stages; the completeness objection raised against the lower-temperature routes is the more serious of the two, and the test above is framed to answer it.

6. Phosphorus recovery third, from the residue. The residue, whether that is a biochar or a mineral ash, is the phosphorus-bearing stream, consistent with R3 and action 2.5. Whether the recovery step itself sits on the centre or at a shared recovery facility is a separate question, and we deal with its transport consequence below. Concentrating phosphorus into a recoverable solid is the property that matters as recovery moves from good practice to obligation, and it is the fourth of the four properties above.

Each step's output is consumed by the site itself, or by the grid connection already at it. Sludge does not leave, and the contaminant liability is retired where the material is already concentrated, not dispersed further through the network.

Why not the proven default. The most reasonable challenge to any of this is that high-temperature combustion already destroys the contaminant load at scale today, so why not simply mono-incinerate. We take that seriously, because it is true on the first property: combustion is a proven destruction step, and proven-at-scale is a real advantage that a first-of-kind route has to earn against. Our answer is that proven-at-scale operation is a genuine advantage, and one that any new route, ours included, must earn through the R7 evidence rather than assume; but it is not by itself decisive. Treating it as a necessary precondition, rather than as evidence any route can be required to produce, would settle the question by incumbency before the demonstration the Strategy already commits to at action 1.7 has reported. Combustion reliably destroys the organic and pathogen load, and at its temperatures it carries the stronger thermodynamic prior for cleaving the carbon-fluorine bond, which we concede plainly. Its completeness on PFAS is still unmeasured on the gas leg, as it is for every thermal route, so criterion (a) is a threshold each route must clear on the R7 evidence, not a contest that can be scored today. We do not dispute that high-temperature combustion is supported by an established body of destruction-and-removal-efficiency data, which is more than a thermodynamic prior, and we do not ask the regulator to set that aside. Our narrower point is that a total-fluorine balance closing the gas leg to the standard at R2(a) has not yet been demonstrated for any thermal route, combustion included. Among the routes that clear the criterion (a) threshold on that evidence, the choice is made on criteria (d) and (e): the question becomes what destroying the load costs, not merely whether it can be destroyed. It needs the feed dried or held at a high dry matter. Heat-integrated combustion recovers part of that drying energy, as heat-integrated pyrolysis does; but the latent heat of the evaporated water leaves with the vapour and is hard to recover, and it is that irreducible latent-heat penalty a wet-cake route deletes. The penalty is largest on exactly the feed these centres produce: a digested cake has had its readily combustible volatiles exported already as biogas, so it carries a low calorific value and is less likely to combust autothermally, and a combustion route on that feed is therefore more likely, not less, to need a drying step or a support fuel. A modular route matches and phases capacity to each centre's actual load and adds redundancy incrementally, whereas a mono-incinerator's minimum economic size may exceed a single centre's tonnage at some or many centres, re-imposing centralisation and a second haul where it does. Whether a given centre clears the mono-incineration floor is a site-specific question the R1 baseline should test per centre. And it leaves phosphorus in an ash. On phosphorus we are careful not to over-claim: recovery from incineration ash is proven at commercial scale, recovery from a supercritical-water mineral residue is not, so criterion (b) is at best neutral on current evidence and we do not rest the comparison on it. Those are the facts criteria (d) and (e) are there to weigh. Among the routes shown on the R7 evidence to destroy the load, one that avoids those three costs is preferable to one that incurs them; a route that cannot destroy the load does not reach the comparison, and our own route earns its place in it only by passing criterion (a) on that same evidence, not by assumption. That is why the discriminators are shaped by the estate's own energy and transport logic, not by any technology, and it answers the proven-default question on its merits.

The cheaper form of the same challenge is co-incineration in cement kilns or energy-from-waste capacity that already exists, which carries almost no new capital and no throughput floor of its own. Its destruction case rests on the same open gas-phase terms as any thermal route, so it is not exempt from criterion (a), and we do not rest our answer on destruction. We rest it on the two costs co-incineration keeps by being cheap on capital. It needs the feed dried to a high dry matter and hauled off site to a third-party plant, so it carries both the drying load that criterion (d) counts and the transport and Scope 3 burden the on-site model removes. And it disperses phosphorus into a blended ash or clinker from which recovery is not practicable, which fails criterion (b) and forecloses the material-recovery outcome the recast Directive requires and that R3 relies on. Co-incineration is cheap on capital precisely because it exports those two costs, the drying and the lost phosphorus, that the selection criteria are there to weigh.

What this does to the transport burden. We are not suggesting that a Bioresource Centre despatches nothing. A final leg remains: the residue leaves the site for phosphorus recovery. The recommendation rests on the scale of that leg relative to the alternative, and the comparison holds even against the strongest version of the alternative.

The feed to the thermal step at a regional centre is digested sludge. Digestion has already destroyed much of the volatile fraction, which concentrates what remains, so the inorganic fraction of the digested dry solids typically runs in the order of 30 to 50 per cent, and higher where significant chemical conditioning or grit is present, and advanced digestion, which is what is planned at these centres, drives it towards the upper end of that range by destroying more of the volatiles. A biosolid dried to more than 90 per cent dry matter, which still requires destruction somewhere else, carries essentially the whole of those dry solids out of the gate, and does so after paying for the drying. Destroying at the hub means only the residue leaves, so what goes out of the gate falls to the inorganic fraction plus whatever moisture it carries with it. On a dry-solids basis, and on the mineral-residue route, that is a reduction of the order of 50 to 70 per cent across the range above, and because advanced digestion pushes the inorganic fraction up it is prudent to plan on the lower half of that band until site-specific characterisation is available. The reduction in despatched tonnage depends in addition on the dry matter at which the residue leaves the site, which is a matter for that same characterisation. On the pyrolysis route the biochar retains fixed carbon as well as the mineral fraction, so the reduction is smaller again; char yield depends on the operating window and is better established by that same characterisation than assumed here. The character of the movement changes as much as its size: a concentrated product movement to a recovery offtake, rather than a bulk waste movement to a disposal point.

The two routes reach that result differently, and both are worth stating plainly. Where the route is supercritical fluid gasification, the drying step is deleted altogether, since the process takes wet cake directly, and a substantial thermal load comes off the Article 11 balance with it. Where the route is pyrolysis, a drying duty remains, and waste heat is used in the drying stages, so that energy stays inside the site instead of being spent to prepare a solid for export. The property test above is what should decide the point: a route should meet its drying duty from heat recovered within the process, and the extent to which a given pyrolysis configuration does so is a matter for the evidence, not for assertion here. Neither route requires the estate to dry a solid in order to send it somewhere else.

Why this is a reportable difference, not a presentational one. Sludge haulage sits in Scope 3. The scope and timing of Scope 3 disclosure obligations for large undertakings have moved more than once, and we do not rest this on any particular regime or commencement date. The point is simpler than that, and it holds under any of them: haulage that is designed out does not have to be measured, reported or abated later, whereas haulage designed into the shape of the estate has to be carried for the life of the asset. Between a route that hauls the full dried solids mass to an offsite destruction facility and one that destroys on site and moves only the phosphorus-bearing residue, the difference lands in the estate's Scope 3 inventory whenever that inventory is drawn, and it is durable rather than one-off, because it is fixed by where the destruction step sits.

We therefore recommend the centre designs allocate footprint, services, standby power and connection points for advanced thermal modules from the outset, and that the Strategy's infrastructure planning treat destruction as a function of the Bioresource Centre, not a downstream facility sited separately. Whether a given centre reserves that footprint is revisited against the R1 per-centre baseline, so no centre is committed to on-site thermal capacity ahead of its own evidence; the reservation is a low-cost, reversible option, not a build decision. This is a low-cost design decision now that avoids a high-cost retrofit later, and it commits Uisce Éireann to no vendor and no single technology.

On deliverability, on-site advanced thermal capacity is licensable under the EPA's industrial-emissions and waste regime in the ordinary way, and where a route is classed as the thermal treatment of waste the emission-limit and monitoring provisions of the Industrial Emissions Directive 2010/75/EU apply as they would to any such plant. Confirming the classification and licensing route for each candidate route early, so that consenting is scoped before a route is selected, is part of what the R1 baseline and the R7 demonstration should inform. Naming the pathway is not a difficulty for the on-site model; it is the same permitting basis that makes an engineered, monitored destruction step a community-acceptance gain instead of a dispersed land practice.

As a drop-in amendment, the infrastructure-planning provisions for the regional Bioresource Centres (Sections 8 and 9, and action 4.6) could add: *"Centre designs shall allocate footprint, services, standby power and connection points for on-site advanced thermal conversion from the outset, and destruction shall be planned as a function of the Bioresource Centre rather than sited as a separate downstream facility."*

R7. Support an on-site, at-scale demonstration on Irish sludge. Advanced thermal conversion must be evidenced on actual Irish sludge before it is deployed at scale, which is what action 1.7 calls for and the scalability question the SEA raises. Redrock seeks no procurement advantage, exclusivity or commitment from this submission, and would fund and deliver this demonstration independently. We suggest Uisce Éireann publish its action 1.7 evidence criteria openly and technology-neutrally, so that any developer's demonstration, including ours, can be measured against the same dataset. As a drop-in amendment, action 1.7 could add: *"the evidence criteria for the advanced thermal conversion demonstration shall be published openly and applied to every developer's demonstration on the same technology-neutral basis."*

Redrock brings a developed engineering basis to that demonstration, not a concept, and we set it out here so the offer reads as credible, not aspirational, not as a claim to any selection advantage. The design is defined through a completed engineering definition package and process design basis, a developed piping and instrumentation diagram with the hazardous-area classification closed, a specified safety-instrumented system with a full cause-and-effect matrix, severe-service equipment packages specified and out to tender, and a container-based modular general arrangement built to a recognised pressure-equipment code route, with conformity assessment following the regime of the jurisdiction of deployment, which for Ireland is the Pressure Equipment Directive 2014/68/EU. It is engineered around the known failure mode for this chemistry, which is inorganic salt precipitation and chloride-driven corrosion. We have not set the design detail out here. That properly belongs to a supply tender, not to a consultation response, and we would provide it in that context.

On contaminants, the demonstration would produce a PFAS mass balance across the solid, aqueous and gas streams. For the aqueous and solid matrices it would use US EPA Method 1633, for which those matrices are validated. Method 1633 does not cover the gas matrix, and there is at present no validated total-organofluorine stack method, so developing a defensible air-phase total-fluorine measurement is itself one of the things the demonstration would deliver into the common evidence base, not something anyone can claim off the shelf today. That measurement gap is not particular to our route; it is common to every thermal process that could hold the ST03 position. It does not deny combustion its destruction-and-removal-efficiency record; it says only that a closed total-fluorine balance on the gas leg is outstanding for every route, combustion included, so until it exists no route can claim that particular measure over another. Until the method exists, completeness is assessed where the methods are validated, on the aqueous and solid matrices and against stated detection limits, and the gas-phase method is developed in parallel and applied to every route on the same terms. There is, in addition, a route-specific point, put to the same test. For a supercritical-water route the reaction sits in a closed aqueous regime, so the fluorine is expected to report predominantly to the aqueous condensate and the solid residue, where Method 1633 is validated, rather than to an open combustion offgas, and the gas train would additionally capture volatile inorganic fluoride. Its gas-phase exposure should therefore be smaller, pending the gas-phase method that will be applied equally to every route. We are careful not to over-read that: the phase a destruction product lands in is not itself evidence of superior destruction, and inorganic fluoride reporting to the gas phase, hydrogen fluoride among it, is a mineralisation product that must be credited symmetrically for every route once the R7 stack method exists. A sub-combustion operating temperature can itself generate short-chain and volatile fluorinated species, which the same fluorine balance must account for. So we put the smaller exposure forward as a design expectation to be confirmed by direct inorganic-fluoride measurement under R7, not asserted, and we rest SCFG's case on criteria (b), (d) and (e), not on a near-term measurement convenience. The balance would then be closed as far as the methods allow on total fluorine, not on the targeted analyte list alone, because the concern with any thermal route is not whether the parent compounds leave the feed but whether they are mineralised or merely transformed. In practice that means pairing the Method 1633 target list with a total-oxidisable-precursor assay and a combustion-based total-fluorine measurement. Extractable or adsorbable organic fluorine resolves the organic fraction, and inorganic fluoride is measured directly as the endpoint of mineralisation. The ultrashort-chain and volatile species most likely to be missed, trifluoroacetic acid among them, are accounted for explicitly and reported against stated detection limits, not assumed to have been captured. Closing the balance this way is what would allow destruction to be demonstrated as conversion to inorganic fluoride rather than inferred from the disappearance of the parent compound. The same demonstration would characterise the phosphorus speciation of the residue and bench-test its recoverability, so the phosphorus claim is held to the same evidentiary standard as the fluorine claim, not asserted. The programme would carry a dual-laboratory cross-check and a sampling train free of fluoropolymers. That is precisely the evidence base actions 2.7 and 2.10 require. Redrock would ask that any such demonstration be conducted on the basis that its data, methods and results enter the common evidence base on equal terms to all parties, whatever the outcome and whether or not it favours our route, and we would not seek to restrict their release.

On the three solution-level questions the documents themselves raise:

- On maturity and scalability, the SEA's stated reservation. The SEA notes advanced thermal conversion is fairly nascent in Ireland and would need supporting infrastructure to scale, and it is right that sludge-specific operation at works scale is the frontier. Supercritical water gasification has already been demonstrated at industrial, grid-injection scale in the Netherlands, where wet residual streams are converted to green methane injected into the national gas grid ([Gasunie](https://www.gasunie.nl/en/projects/supercritical-water-gasification)). That operation is on mixed wet residual streams rather than on sewage sludge specifically, which is why sludge-specific operation at works scale remains the frontier, and it is exactly the frontier the R7 demonstration is built to close. Pyrolysis is already deployed at municipal wastewater works scale. Redrock's design replicates a small module rather than enlarging a single reactor, which avoids the step-change scale-up risk of a single large high-pressure vessel; site-to-site feed variation is handled by the per-site characterisation programme, not by re-engineering the module. The genuinely open question is durability on real sewage sludge over time, which is what the demonstration in R7 is designed to close.
- On the SEA's pathogen finding for pyrolysis. The SEA notes that pyrolysis does not necessarily remove all pathogens at lower operating temperatures, and that the residue may therefore still carry contaminants. We think that finding is correct, and that it argues for specifying the operating window instead of setting the route aside. It is the same point as challenge 3 in a different register: pathogen destruction, like contaminant destruction, is a function of temperature and residence time, not of the technology label. The safeguard is therefore to make verified pathogen destruction at the selected operating condition a performance requirement, tested on the actual residue, not an assumed property of a technology class. That is consistent with the selection criteria we propose at R2, and it applies equally to any route assessed against the properties at R6, including our own.
- On energy and affordability. The SEA weighs advanced thermal conversion's higher energy requirement and concludes the benefits outweigh it; as noted at R4, that requirement is dominated by the drying load, which a wet-cake route avoids, so a design that returns net energy at works-relevant dry matter narrows the gap the SEA identifies instead of merely accepting it, subject to the validation in R7. On cost, the relevant comparison is not destructive thermal versus today's cheap land reuse, but destructive thermal versus the future cost of a closed land route, and for a bill-funded utility the affordability test is exposure avoided as much as capital committed. The destruction capacity carries its own capital, and we are not suggesting otherwise; that capital is recovered over the asset life through the regulated cost base in the ordinary way, and the point here is that the cost of building it on a planned horizon is lower than the cost of finding it in an emergency, so deferral is not the cheaper option it appears to be. The footprint and monitoring asked for here are low-cost, planning replacement capacity on the land route's foreseeable decline avoids the stranded-asset and emergency-disposal cost of being moved off land before a route exists, and the demonstration at R7 is offered at no cost to the utility. Modular, replicated routes, whoever

delivers them, can add capacity within the window defined by two forces acting together: the narrowing of the land route, and the obligations that transposition of the recast UWWTD will bring into force.

5. Question 4: SEA Environmental Report and Natura Impact Statement

"Do you have any comments on the Strategic Environmental Assessment (SEA) Environmental Report and Natura Impact Statement (NIS)?"

The SEA Environmental Report is candid and, on the central points, we agree with it. Its assessment of the ST01, ST02 and ST03 alternatives finds all three preferred, rejects conventional thermal drying as no longer economically feasible, and records that advanced thermal conversion technologies, unlike conventional methods, can remove emerging contaminants in addition to pathogens. We make four comments.

On the technology set assessed under ST03. The SEA narrows ST03 to the technologies it judges more technically viable for Ireland: mono-incineration, co-incineration, hydrothermal carbonisation, gasification and pyrolysis. Hydrothermal gasification appears in the Strategy's own long list at Section 6 but not in that viable set. We ask that it be reconsidered, and we declare an interest in doing so, since it is the route we are developing. We put the argument on its merits, not on ours, and those merits do not depend on us. Of the routes named anywhere in the Strategy's documents, only two take wet dewatered cake without a drying step in front of them: hydrothermal carbonisation, which is in the viable set, and hydrothermal gasification, which is not. That bears directly on the energy-neutrality obligation discussed at R4 and on the on-site logic at R6. It is distinguished from carbonisation in that it gasifies the organic fraction rather than condensing it into a carbonaceous solid that still needs an outlet, and it concentrates phosphorus into a mineral residue from which recovery is expected to be practicable, to be evidenced under R7 on the same footing as the fluorine balance and weighed against ash-based recovery under R2(b). On contaminant destruction, the expectation rests not on operating temperature, which challenge 3 identifies as the partial-transformation risk zone, but on the closed aqueous reaction regime: hydrolytic defluorination partitions released fluoride to the condensed aqueous and solid phases, where the validated methods can measure it. That is the completeness point from challenge 3 and R2, and, consistent with the standard we set for every route, we put it forward as a design expectation to be demonstrated on the fluorine balance under R7, not as an established property asserted in advance of the evidence. If the reservation is maturity, that is a reason to evidence the route through the demonstration action 1.7 already commits to, which is what R7 offers, instead of screening it out before the evidence exists. We would accept the outcome if the evidence does not support it. As a drop-in amendment, the ST03 viable technology set could be expanded to name hydrothermal gasification alongside the routes already listed, on the same evidence-based footing.

On the assessment of alternatives. We ask that the positive environmental effects of a destructive-thermal pathway be given full weight, not only its scalability and energy-cost reservations, and that the assessment distinguish complete destruction from partial transformation when it weighs those effects, since the two do not deliver the same environmental outcome. Taking PFAS-bearing solids out of the soil-exposure pathway, and recovering phosphorus into a characterised form that can be placed where it is agronomically needed, are material positive effects for water, soil, biodiversity and human health, which the SEA's own matrix already begins to record for ST03. Where a route mineralises the contaminant load, those effects are realised in full; where a route only partially breaks it down, they are not, and the assessment should say so, not credit the category as a whole. As a drop-in amendment, the assessment of alternatives and the NIS pathway comparison could require that routes which mineralise the contaminant load be distinguished from those that only partially transform it.

On the emerging-contaminants baseline. The SEA identifies that Ireland has no limits for organic pollutants in wastewater sludge, and that a national assessment has been recommended. The Strategy responds through actions 2.7 and 2.10. As set out in R1, we recommend these be started now and given a timeline, so the evidence base exists before regulation arrives. The total-fluorine PFAS mass balance described in R7 is offered as a contribution to exactly that evidence base, and as a template for how destruction should be measured, not assumed.

On the Natura Impact Statement. A pathway that removes contaminants and recovers phosphorus reduces the nutrient and micropollutant loadings that reach sensitive waters, including catchments feeding Natura 2000 sites. The land-reuse route, by contrast, keeps phosphorus in circulation in the same catchments where the nitrates derogation is already under pressure. We ask that this difference be reflected where the NIS compares the pathway options.

R8. Carry these Q4 asks into the viable set and the alternatives assessment. Reconsider hydrothermal gasification within the ST03 viable technology set, and require the assessment of alternatives and the NIS pathway comparison to distinguish routes that mineralise the contaminant load from those that only partially transform it. Both are drafted as drop-in amendments above, and both bear directly on whether a complete-destruction route is carried forward through SEA screening. This is the one route we name, and we name it only because the SEA excluded an entire wet-cake route rather than scoring it down; the ask is admission to assessment on the same evidence-gated terms as any other, and we accept screen-out if the R7 evidence does not support it.

6. Summary of recommendations

Ref	Recommendation	Question	Anchor in the documents
R1	Begin PFAS and emerging-contaminant monitoring now, on a defined timeline	Q1 Challenges, Q4 SEA and NIS	Strategy actions 2.7 and 2.10; SEA baseline
R2	Make complete contaminant destruction, phosphorus recovery and net energy explicit pathway-selection criteria, with wet-cake acceptance and distributed deployment as the discriminators	Q2 Objectives	SEA finding on emerging contaminants; Objectives 1 and 2 (selection), 3 and 4 (bioeconomy, efficiency); actions 1.7 and 4.6
R3	Treat phosphorus recovery, weighted by residue form, as	Q2 Objectives	Strategy action 2.5; recast

	a design requirement		UWWTD 2024/3019
R4	Treat energy neutrality, counting drying load explicitly, as a pathway-selection criterion	Q2 Objectives	Strategy action 2.5; recast UWWTD Article 11 (energy neutrality)
R5	Plan ST03 (advanced thermal conversion) as sized-and-sited capacity at the regional Bioresource Centres, not only a demonstration	Q3 Solutions	Strategy action 1.7; SEA ST03 and parallel scale-up
R6	Complete the chain at the Bioresource Centre: digest and destroy on one site, and move only the phosphorus-bearing residue	Q3 Solutions, Q2 Objectives 3 and 4	Strategy Sections 8 and 9 (circa 17 centres, circa 35 dewatering centres)
R7	Support an independently-funded, at-scale demonstration on Irish sludge, with destruction evidenced on a fluorine mass balance closed as far as validated methods allow	Q3 Solutions	Strategy action 1.7
R8	Reconsider hydrothermal gasification within the ST03 viable technology set, and distinguish complete mineralisation from partial transformation in the assessment of alternatives and the NIS	Q4 SEA and NIS	SEA ST03 viable set; SEA and NIS pathway comparison

7. Conclusion

We support the Strategy and ask Uisce Éireann to strengthen it in three connected ways. Plan ST03 advanced thermal conversion as sized-and-sited capacity at the regional Bioresource Centres, building on action 1.7 (R5). Make complete contaminant destruction, phosphorus recovery and net energy explicit pathway-selection criteria, with wet-cake acceptance and distributed deployment as the discriminators that decide the point, carrying the SEA's own finding through into the objectives and distinguishing routes that mineralise a contaminant load from those that only partially transform it (R2, R3, R4). And complete the treatment chain at those centres, digesting and destroying on one site rather than bulking and hauling the digested residue onward to a separate facility, moving only the phosphorus-bearing residue, with footprint and services allocated from the outset so the option is cheap to exercise (R6). Beginning PFAS monitoring now (R1) and using an independently-funded, at-scale demonstration on Irish sludge, with destruction evidenced on a fluorine mass balance closed as far as validated methods allow, as the evidence for Irish conditions (R7) complete the case. We also ask that hydrothermal gasification be reconsidered within the ST03 viable set, and that the assessment of alternatives and the NIS distinguish complete mineralisation from partial transformation (R8). The same recommendations serve objectives 3 and 4 as well as 1 and 2: a domestic phosphorus resource and a domestic build-and-operate supply chain for the bioeconomy, fewer tanker movements and no spreading of sewage-derived solids near homes for communities and amenity, and a single integrated site for operational efficiency. Two points of even-handedness run through the response. Source control is a genuine good and belongs in the Strategy, as the right treatment for the clean-material stream, but it cannot retire a persistent-pollutant load it does not reach, so it complements a destruction endpoint rather than removing the need for one. And the reasonable objection that some thermal routes transform rather than destroy is correct, which is exactly why the Strategy should define destruction as verified mineralisation and hold every route, ours included, to that test on the same terms. Redrock seeks no advantage from this submission beyond a stronger Strategy, and would welcome the chance to contribute its demonstration validation data to the common evidence base.

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