出國報告（出國類別：考察）

我國因應福島第一核電廠 ALPS 處理水排放案之赴日專家觀察團報告

服務機關： 行政院原子能委員會

姓名職稱： 徐献星 副所長等**8**人

派赴國家/地區：日本

出國期間： **111**年**3**月**23**日~**111**年**3**月**27**日

報告日期： **111** 年 **4** 月 **27** 日

摘　要

日本於 2021 年 4 月公布擬排放福島第一核電廠多核種除去設備處理水時(日方簡稱 ALPS 處理水)，行政院原子能委員會謝曉星主任委員，曾向日方提出包括海洋監測數據分享、ALPS 處理水排放符合安全標準之確認、及日本核能管制單位的審查資訊公開等三項訴求，但因台灣非屬國際原子能總署(IAEA)會員國，無法藉由參與 IAEA 視察團在日本的實地視察，因此本次國外出差係由行政院原子能委員會轄下的核能研究所、輻射防護處、綜合計畫處、及輻射偵測中心成員，組成專家觀察團，於 2022 年 3 月 23 日至 27 日赴日本，先參訪電力中央研究所(電中研)，討論擴散模擬技術，再至福島第一核電廠瞭解其 ALPS 處理水之相關設施與未來排放規劃，實地觀察與確認謝主委所提出的這三項訴求。

本公差報告除詳細記錄參訪及觀察過程外，並與日本專家與人員討論福島 ALPS 處理水排放相關的議題，如下所列：

(一) 實地瞭解放射性核種擴散模擬結果

(二) 交流生物氚分析檢測技術

(三) 實地觀察 ALPS 設施及 K4 槽區布建

(四) 實地觀察 ALPS 處理水的海邊排放規劃與現有進度

(五) 實地瞭解 ALPS 處理水的核種化學分析程序

(六) 實地瞭解日本核能管制單位的審查進度

(七) 討論日本的海域環境監測計畫

觀察團於本次赴日本實地觀察與討論後，提出建議如下：

(一) 海洋監測數據分享：日本福島第一核電廠 ALPS 處理水排放之影響評估，須依據放射性核種擴散模擬科學技術，及實際的海洋監測數據驗證。因此，我國應建立相關技術與監測能量，持續與日方以公開及比對的方式進行技術與結果分享，以確保對我國海域及漁獲不會產生不利影響或負面評價。

(二) ALPS 處理水排放符合安全標準之確認：東京電力公司宣稱，福島第一核電廠含氚廢水經 ALPS 淨化後，除處理水的氚須經稀釋外，其他放射性核種活度，亦均須符合安全標準才會排放。因此，我國宜持續與日方

協調經由技術與資訊交流管道及實地觀察方式，以確認福島第一核電廠含氚廢水的處理及排放，確實符合東京電力公司所宣稱的安全目標。

(三) 審查資訊公開：ALPS 處理水排放許可的審查，係日本核能管制機關的權責，但其審查標準須符合國際標準與規範，並公開其審查準則、過程、及結果。因此，我國宜持續要求日本將審查資訊即時公開，藉掌握國際相關規範與發展，以利外界核對資訊，為我國國民健康及權益把關。

關鍵詞：福島第一核電廠、海洋監測、ALPS 處理水排放。

觀察團工作紀要

觀察團赴日期間，依預定行程及參訪重點內容，每日彙整「觀察團工作紀要」回報原能會，以瞭解觀察團最新執行情形，如下說明：

(一)第一天

1. 我國專家觀察團依既定行程規劃啟程赴日，第一天配合日本COVID-19 防疫規定辦理通關程序及接受核酸(PCR)篩檢，團員已全數通過防疫檢查,並全體抵達住宿旅館準備本次行程資料。
2. 今日(3 月 23 日)下午本觀察團行前於松山機場接受日本朝日電視面訪。
3. 次日(3 月 24 日)行程已安排參訪電力中央研究所(預計 10：30~12：00)，拜訪日方專家，進行有關 ALPS 處理水排放海洋之模擬相關技術交流。

(二)第二天

1. 我國專家觀察團第二天(3 月 24 日)由台北駐日經濟文化代表處代表陪同，依既定行程規劃啟程赴千葉縣「一般財團法人電力中央研究所」,拜訪日方專家。
2. 由日方專家進行簡報，主題為「Ocean Dispersion Simulation of Released Treated Water」,接續台日雙邊交流及討論重點彙整如下：

技術交流面：

(1) 目前福島廢水氚濃度於底層處模擬為每公升 0.06 貝克，此偵測低限係目前國內實驗室尚無法達到。為因應未來外界要求取樣比對之需，我國宜規劃精進檢測技術。

(2) 為了提升 ALPS 處理水排放口區域之模擬研究，日方專家將網格大小從原本 1 公里縮小至 200 公尺;在 10 公里 x 10 公里範圍內，表層水的氚濃度(每公升 0.12 貝克)約是底層水濃度(每公升 0.06 貝克)的 2 倍，主要原因在於距離排放口愈遠,海床深度愈深所造成。目前的模擬結果並沒有考慮海水氚與大氣氚之間的交換作用。

(3) 簡報內所示之數據係依據 NRA 所公布之日本環境放射能及放射線網頁資料。(https://www.kankyo-hoshano.go.jp/data/database/) 福島核電廠外海長年(1979 年~2019 年)氚活度監測結果，以 2011 年為分界，2011 年前氚活度變動範圍為每公升 3.18 ~ 0.37 貝克；於 2011 年迄今氚活度變動範圍為每公升 340~0.037 貝克。氚活度最小分析數值降低，判斷可能原因係 2011 年後 NRA 針對福島外海海水取樣計畫，除增加取樣數量外，亦擴大取樣範圍(非 2011 年前定點取樣位置)。

輻射防護面：

(1) 日本政府要求 ALPS 處理水之氚活度濃度不可超過每公升 1500 貝克，年排放總活度為 22 兆貝克/年，故就影響我國而言，宜就輻射安全與環境衝擊影響評估兩方面予以討論，故背景資料庫完整性與國際認同甚為重要。

(2) 鑒於 ALPS 處理水排放海洋事件，日本係肇因國，應就 ALPS 處理水排放之環境影響進行全面性規劃，我方亦要求客觀公開其監測數據公開。

資訊分享面：

(1) 日方專家對氚擴散的模擬運算，其排放口是依據先前的報告所設計，目前東電公司並無釋出較詳細的排放口設計資訊。

(2) 本會執行之海洋整備計畫研究項目亦有海洋擴散評估模式，建議核研所與電力中央研究所，建立技術交流管道，針對模式評估結果，進行比對。

(3) 日方專家接受我方的邀請，參與本所後續規劃的國際研討會。

3. 次日(3 月 25 日)行程已安排考察福島第一核電廠(預計 08：30~16：15)，過程包含視察核電廠、參訪分析化學實驗棟、以及綜合討論。人員安全部分將配合廠方進行換裝、配戴輻射劑量佩章及全身計測。

(三)第三天

1. 我國專家觀察團第三天(3 月 25 日)由台北駐日經濟文化代表處、日本外務省、經產省、東電公司總部之代表陪同，由福島第一核電廠之人員負責接待，安排現勘前交流會議，進行約一小時的福島核一廠除役及 ALPS 處理水排放規劃及進度簡報。會議中，我方即提出希望比照 IAEA 視察模式，於福島第一核電廠內取樣 ALPS 處理水。東電澄清，IAEA 有取樣，現正就其適切的運送方法進行研議中。

2. 接下來，於完成繁雜的進廠人員體內計測及穿著防護衣物後，搭廠內巴士，先後觀察(1)一至四號機災後整備、凍土牆包封、地下水集水井等、(2)ALPS 設施與 K4 槽區、(3)海邊稀釋排放區、及(4)分析化學實驗棟，簡要說明如下：

(1) 一至四號機災後整備、凍土牆包封、地下水集水井

(a) 由東電人員引導，從高處近距離看視一至四號機反應器廠房現況，目前因氫爆損壞的部分及瓦礫等廢棄物大部分皆已移除。

(b) 為防止地下水滲入破損的反應器，東電在廠房周邊以冷凍技術建立深達 30 米的凍土牆，阻絕地下水滲入爐心。

(c) 反應器廠房周邊則挖設地下井，收集凍土牆包封範圍內的雨水，此範圍內的水沒有接觸爐心。集水井的水經由過濾及檢測後，所有核種活度濃度都符合排放規定，才排放入海。

(2) ALPS 設施與 K4 槽區

(a) 接著，再搭車至 ALPS 設施及 K4 槽區。目前廠區現有 ALPS 處理水之儲槽空間僅剩 5%，廠方預估剩餘量僅能維持至 2023 年春季，故明年春季東電規劃實施排放。

(b) 廠區內儲存 ALPS 處理水分為兩類，第一類為未達排放標準(各核種)佔比約 68%，第二類為已達排放標準(除氚以外)佔比約 32%，這些符合標準的處理水，將導入 K4 槽區取樣分析後進行稀釋排放。除了東電公司自行分析

外，亦有第三方取樣分析比對，以確保其符合性。

(3) 海邊稀釋排放區

(a) 接著東電再引導我們到海邊，觀察稀釋排放區。廠方利用 5 號機之海水取水道引入海水，並增設 3 座海水泵輸送海水作為稀釋水源；K4 槽區所排放之 ALPS 處理水經分析確認氚活度後，計算其所需海水量進行稀釋，原則上廠方將提高海水稀釋用量，因此混合後之氚活度濃度預估低於排放標準每公升 1500 貝克。稀釋後之 ALPS 處理水藉水位差引入放水立坑，再以溢流方式藉由地下隧道通往岸外 1 公里處排放。

(b) ALPS 處理水的排放計畫，目前正由 NRA 審查中，根據東電的規劃預計在 2023 年 4 月完成排放前的準備工作，由於計畫還在 NRA 審查中，目前只在施作放水立坑，其他排放所需的引水管路、海水取水設施、混合稀釋設施等硬體設備皆尚未建置。

(c) 東電 ALPS 處理水排放變更計畫之申請時間為 2021 年 12 月，目前 NRA 審查流程，據東電人員說明，約每禮拜召開一次審查會，預估今年 5 月底完成審查，明年 4 月中施工完畢，並接受 NRA 使用前檢查，惟使用前仍需與外界溝通並獲接受，故東電明年春季排放時程，仍有變數。

(4) 分析化學實驗棟

(a) 因該實驗室執行極低微放射性物質化學分析，須阻絕放射性物質污染該實驗室且其空間受限，本團一員代表現場參訪，因應福島第一核電廠周遭環境輻射劑量率高，未免分析受干擾故該實驗室建置於地下室。樣品接收站則位於 1 樓。

(b) 分析的樣品來源包含海水、集水井的地下水、處理後的地下水及 ALPS 處理水，福島每年共需分析八萬件樣品是 311 前的 16 倍，該實驗室需執行其中 1/3 的分析量，

而所有分析結果與數據及時公開在網站上。

(c) 以三大措施來確保分析可靠度，包含(i)ISO/IEC 17025:2017，(ii)與 IAEA 進行分析能力比對並符合 ISO 每年稽核，及(iii)建置智慧眼鏡與 LIMS(Laboratory Information Management Sysmtem)使分析自動化以減少大量分析時的人為失誤。

(d) 於參訪現場拍攝有關氚水之前處理及放射性化學分析作業流程，並實際展示取樣之 ALPS 處理水經分析後得知含每公升 10 萬貝克的氚。

(e) 向東電公司提出參與樣品放射性分析比較實驗可能性，東電回應，東電公司跟是透過委託日本民間公司進行分析，這個委託關係必須是與東電公司沒有任何資本往來的，所以我們稱之為第三方實驗室。

3. 於現場觀察行程結束後，再由上午參加簡報時相同人員，與參觀團進行約 2 小時的現勘後綜合答問。我方再次提出希望比照 IAEA，能取樣 ALPS 處理水。東電說明，也許中長期來看有可能，但目前為止，除了由國內機構進行分析之外，僅接受 IAEA 研究所及 IAEA 選定的機構進行分析。

4. 次日(3 月 26 日)行程已安排返回東京並進行 PCR 篩檢，觀察團預計 15：00 接受日本 NHK 媒體視訊訪談，並彙整本次出國報告所需資料。

(四)第四天

1. 我國專家觀察團第四天(3 月 26 日)，由台北駐日經濟文化代表處陪同，依既定行程返回東京，並依規定進行 PCR 篩檢後，入住下榻飯店，全員皆為陰性反應。

2. 應日本 NHK 媒體之邀請，本團接受 NHK 記者的視訊專訪，於今日下午 15：00 辦理線上會議，全體團員參加，說明本次參訪之目地及觀察概要，過程順利。

(五)第五天

1. 第五天(3月27日)本團將依既定時程,搭乘早班飛機飛返台灣。

2. 返國後全體團員將依防疫規定，進行檢疫及10天的隔離。

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圖目錄

一、目的

日本於 2021 年 4 月公布擬將福島第一核電廠經多核種除去設備(Multi-Nuclide Removal Equipment)處理後，尚無法處理之含氚廢水(日方簡稱 ALPS 處理水)排放於海洋，我國行政院原子能委員會謝曉星主任委員以書面表達反對，並向日方提出包括海洋監測數據分享、ALPS 處理水排放符合安全標準之確認、及日本核能管制單位的審查資訊公開等三項訴求。日本針對含氚廢水海洋排放尋求國際原子能總署（International Atomic Energy Agency, 以下簡稱 IAEA）的協助，IAEA 於 2021 年 7 月與日本政府簽署審查授權範圍（Terms of Reference, ToR），後續由 IAEA 邀集會員國之專家籌組調查團就含氚廢水海洋排放進行相關安全的審查工作，但因台灣非屬 IAEA 會員國，無法藉由參與 IAEA 視察團在日本的實地視察，因此本次國外出差係由行政院原子能委員會轄下的核能研究所、輻射防護處、綜合計畫處、及輻射偵測中心成員，組成專家觀察團，由核能研究所徐獻星副所長擔任團長，於 2022 年 3 月 23 日至 27 日赴日本，先參訪電力中央研究所(電中研)，討論擴散模擬技術，再至福島第一核電廠瞭解其 ALPS 處理水之相關設施與未來排放規劃，實地觀察與確認謝主委所提出的這三項訴求。

觀察團於 3 月 24 日先赴電中研，拜訪曾於 2021 年透過日本台灣交流協會安排，與台灣進行過「處理水的海洋擴散模擬結果及適用模式」及「源自福島第一核電廠事故之放射性銫的食物鏈動態移轉模式」兩場線上技術交流會的日方專家，進行面對面的放射性核種擴散模擬結果討論，及生物氚分析檢測技術交流。

本團接著在隔日 3 月 25 日赴福島第一核電廠實地觀察福島 ALPS 處理設施與其處理水的海邊排放規劃與現有進度，並與日本外務省、經濟產業省、日本台灣交流協會東京本部、東京電力公司(以下簡稱東電)、及福島第一核電廠相關主管與專家，進行技術討論。

本公差報告除詳細記錄參訪及觀察過程外，並與日本專家與東電人員討論福島第一核電廠 ALPS 處理水排放相關的議題，提出心得，如下所列：

(一) 實地瞭解放射性核種擴散模擬結果

(二) 交流生物氚分析檢測技術

(三) 實地觀察 ALPS 設施及 K4 槽區布建

(四) 實地觀察 ALPS 處理水的海邊排放規劃與現有進度

(五) 實地瞭解 ALPS 處理水的核種化學分析程序

(六) 實地瞭解日本核能管制單位的審查進度

(七) 討論日本的海域環境監測計畫

本公差報告最後提出建議，供國內相關單位參考。

二、過程

（一）出國行程

此次行程共計 5 天，3 月 23 日由台北松山機場飛往日本東京羽田機場，當日晚間抵達東京。3 月 24 日離開旅館後即搭乘租用巴士前往福島地區，途中先赴電中研與日方專家進行技術討論交流。3 月 25 日赴「福島第一核能發電廠」，於廠區內實地觀察，包含一號機~四號機外圍區域、多核種除去設備(ALPS)、K4 槽區、ALPS 處理水排放設施，及化學分析棟。結束電廠實地觀察後，於 3 月 26 日搭乘租用巴士返回東京市區進行 PCR 篩檢，下午並接受 NHK 媒體線上專訪。3 月 27 日為觀察團返程，上午由日本東京羽田機場出發返國，下午抵達我國台北松山機場。出國行程如表 1 所示：

表 1、本次國外公差主要行程表

日期	行程內容
3/23(三)	去程：台北→東京 ● 朝日電視台新聞訪問
3/24(四)	路程：東京→福島縣 ● 參訪電中研
3/25(五)	參訪東京電力公司福島第一核能發電廠 ● 廠區(一~四號機) ● 多核種移除設備(ALPS) ● K4 槽區 ● ALPS 處理水排水設備 ● 分析化學實驗棟
3/26(六)	路程：福島縣→東京 ● PCR 採檢 ● NHK 媒體線上專訪
3/27(日)	回程：東京→台北

（二）團員名單

本次觀察團成員共 8 人，包含行政院原子能委員會 2 人、行政院原子能委員會核能研究所 4 人、行政院原子能委員會輻射偵測中心 2 人，觀察團成員名單詳如表 2。

表 2、觀察團成員名單

姓名	單位	職稱
徐獻星(領隊)	行政院原子能委員會核能研究所	副所長
袁明程	行政院原子能委員會核能研究所	保物組副組長
黃君平	行政院原子能委員會核能研究所	工程組副組長
謝賢德	行政院原子能委員會核能研究所	化工組副組長
鄭永富	行政院原子能委員會輻射防護處	保健物理科科長
周曉萍	行政院原子能委員會綜合計畫處	國際科助理研究員
陳婉玲	行政院原子能委員會輻射偵測中心	環境偵測組組長
方鈞屹	行政院原子能委員會輻射偵測中心	環境偵測組技正

（三）啟程及朝日新聞採訪(3 月 23 日)

觀察團 3 月 23 日依既定行程規劃啟程赴日，抵達日本羽田機場後，配合日本 COVID-19 防疫規定辦理通關程序及接受核酸(PCR)採檢，團員全數通過防疫檢查，並由台北駐日經濟文化代表處葉承岳祕書陪同，晚間 10 時許全體抵達住宿旅館準備本次行程資料。

出發前本觀察團發言人(袁明程博士)於松山機場接受日本朝日電視記者面訪(圖 1)，問答內容如下，

1. 日方提問：觀察團赴日的目的？
   我方答覆：實地瞭解福島第一核電廠 ALPS 處理水的相關設備與設施。
2. 日方提問：本次行程安排幾天？
   我方答覆：觀察團已與日方事前安排，整體行程共規劃 5 天。
3. 日方提問：觀察團看的重點是什麼？
   我方答覆：主要會去瞭解 ALPS 處理水之排放作業如何符合相關的標準。
4. 日方提問：如果不符合 IAEA 的標準，會如何因應？
   我方答覆：應會向日方表達關切。
5. 日方提問：有關要派駐 1 名人員到日本的事情，是去做什麼？大概什麼時候過去？
   我方答覆：主要是加速及處理相關資訊的聯繫協調，預估 5 月過去。


トップ > 国際 > 中国 > 記事

台湾　福島第一原発へ調査団を派遣　海洋放出巡り

[2022/03/23 18:15]

台湾当局は東京電力福島第一原発に専門家らを派遣しました。処理水の海洋放出について調査することが目的です。

台湾の原子力研究所などに所属する専門家ら8人で作る調査団が23日、日本に出発しました。

調査団は5日間日本に滞在する予定で、日本の専門家らと意見交換をするほか、25日には福島第一原子力発電所を視察し、処理水の海洋放出の計画について調査するということです。

福島第一原発には先月IAEA（国際原子力機関）が調査団を派遣していましたが、台湾はIAEAに加盟していないため、独自に専門家らを送るため日本と調整を続けていました。

圖1、日本朝日新聞之新聞稿。

備註：新聞稿譯文如下

台灣當局已派專家前往東京電力公司福島第一核電廠，目的是調查ALPS處理水排放海洋之規劃情形。台灣核能研究所等8名專家組成的研究小組於 23 日啟程前往日本。觀察團將在日本停留 5 天的行程，與日本專家交流意見，並於25日參訪福島第一核電廠，實際瞭解 ALPS處理水排放海洋的計畫。IAEA（國際原子能總署）上個月派出調查團前往福島第一核電廠，但由於台灣並非 IAEA會員，因此繼續與日本協調後，編組自己的專家觀察團。

（四）電中研參訪(3 月 24 日)

觀察團於 3 月 24 日依既定行程，由台北駐日經濟文化代表處何坤松副組長陪同，參訪電中研千葉縣分部。去年(2021 年)由日本台灣交流協會協助安排，原能會相關單位針對 ALPS 處理水排放議題與電中研進行了 2 次視訊技術交流會議。第 1 次會議於 2021 年 8 月 27 日舉辦，以「處理水的海洋擴散模擬結果及適用模式(Ocean Dispersion Simulation of Released Treated Water)」為題，與本會進行海洋擴散模擬技術討論；第 2 次會議於 2021 年 11 月 11 日舉辦，邀請日方專家以「源自福島第一核電廠事故之放射性銫的食物鏈動態移轉模式(Dynamic Food Chain Transfer Model for Radioactive Cesium Derived from 1F NPP Accident)」為題發表研究成果心得。

本次觀察團參訪目的係實地瞭解電中研對於東電公司 ALPS 處理水排放後氚放射性活度海洋擴散最新模擬結果，雙方以面對面方式互動，廣泛討論模擬技術細節，了解電中研模擬於排放口外，10 x 10 公里範圍內，海洋中氚每日活度濃度變動、擴散範圍及年累積氚之活度濃度及分布範圍。隨後由電中研邀請參觀該機構所建置之海嘯模擬實驗室。

1. 海洋擴散模擬及生物氚分析技術討論

藉此次參訪與 2 位專家面對面進行交流討論(如圖 2)，主題為海洋放射性核種擴散模擬技術細節項目及含氚 ALPS 處理水排放至海洋，造成其生物圈內放射性累積效應，建立技術交流平台並瞭解日方最新海洋模擬擴散技術層面，進階拓展我方自主研發海洋擴散評估技術，目標朝建立台灣周遭之海域放射性分佈模式，未來規劃搭配實際取樣量測為佐證，可預先定性模擬擴散潛勢及放射性核種擴散定量分析，實際維護台灣海洋資源之輻射安全。

參訪當日由日方專家進行簡報，主題為「Ocean Dispersion Simulation of Released Treated Water」，接續台日雙邊交流及討論重點彙整如下：

(1) 依簡報內容顯示，3D 立體模擬福島外海 10 x 10 公里範圍內，海水中氚活度濃度於底層之模擬結果為每公升 0.06 貝克，低於表層海水中氚活度每公升 0.12 貝克。

(2) 為了驗證日本政府所提氚排放計畫對於環境生態之影響，電中研對於 ALPS 處理水排放計畫中，外海排放口區域進行更細緻之模擬研究，將模擬單位網格大小由先前定義 1 公里範圍縮小至 200 公尺，提升模擬單位解析度且模擬範圍更擴大至 10 公里 x 10 公里；依前述參數運跑模擬結果顯示，表層海水的氚活度濃度為每公升 0.12 貝克，底層海水氚活度濃度為每公升 0.06 貝克，相較之下排放後之氚大多聚集於海水表層，對此模擬結果津旨博士答覆說明：排放口是在距岸 1 公里且深度約 10 公尺的位置，依當地海床地質特性，距離排放口愈遠，海床深度愈深，其間海水分層現象愈加明顯，致使表層含氚海水不易與底層海水混流，造成底層海水氚活度較低之現象。

(3) 為符合日本政府現行公告氚水排放計畫，排放口之氚活度不可超過每公升 1,500 貝克，年排放總活度為 2.2 兆貝克(與福島核電廠事故前機組正常運轉之年排放量相當)，前述數值納入模擬參數，實際模擬運跑結果，以圖面渲染方式呈現模擬範圍內海水氚活度每日變動趨勢。

(4) 我方詢問模擬過程是否考慮到海水氚與大氣氚的交換作用，日方專家說明現有模擬並沒有考慮前述交換因子，然若技術保守估算此交換作用，其對於海水氚濃度影響僅佔 10%左右，影響程度有限。

(5) 簡報模擬結果呈現每日海水氚活度數值範圍在每公升 0 至 3 貝克間，對應日本原子力規制委員會公告之「綜合監測計畫【1】」中氚活度之最小可測值為每公升 0.1 貝克，是否考量實測驗證可行性，

日方專家說明模擬數據範圍係參考公益財團法人日本分析中心所公布之日本環境輻射及放射性活度分析網頁資料[2]，福島核電廠外海長年(1979 年 ~ 2019 年)海水氚活度實際監測結果，以 2011 年為分界，2011 年前氚活度變動範圍為每公升 3.18 ~ 0.37 貝克，2011 年迄今氚活度變動範圍為每公升 340 ~ 0.037 貝克；氚活度最小可測值降低之現象，判斷其原因為 2011 年後原子力規制委員會修訂福島外海海水取樣計畫，除增加取樣數量外，亦擴大取樣範圍(非事故前單點監測)，另精進氚分析技術亦有效降低最小可測值。

(6) 日方專家說明該海水氚擴散的模擬運算中有關排放口徑及流量等參數資料，因東電提交予日本原子力規制委員會審查之氚排放計畫尚未核准，故前述參數尚未確認，待排放計畫核定後將重新模擬運跑。

另外，針對氚水排放模擬計算應用生物放射性核種代謝模式方面，日方專家曾於去年與台灣的視訊技術交流會議中詳盡的說明，此次亦口頭針對相關內容做出補充，綜整來說，海洋生物代謝模式在模擬運算時可區分為「動態模式」與「平衡模式」，並分別透過不同物種的「養殖實驗」取得「動態傳輸係數」；及福島海域「生態採樣」取得的「濃度平衡係數」等平衡態相關數據，當時亦透過一些文獻及網路連結，提供詳盡的檢測數據供我方參考。

前述相關代謝模式計算係數之方法有很大的參考意義，可分別對應至國內開發之「放射性物質擴散預警系統」，並配合應用核研所預計執行之「水產養殖實驗」等數據，建立屬於台灣自有的海洋生物代謝模式資料庫，完善台灣海域生態調查，提升模式預報之準確性。生態調查及養殖實驗之代謝模式對照表如表 3，分別對應到前述平衡態及動態模式，根據使用情境的不同，於擴散模式、劑量評估研究等面向中皆扮演不同的角色，尤其是劑量評估方面，牽涉到數個曝露途徑及關鍵群體，其傳輸參數的運用即扮演十足重要的角色。

另外，日方專家亦針對福島海域漁獲體內放射性物質監測提供說明，提到福島事件後至今，所有檢測數據皆公開上網，透過公開透明的網頁呈現使民眾安心。日方提供之漁獲/食品檢測之揭露網站 ，其顯示圖表包含自福島後該魚種之銫 137 隨時間變化數據，清楚可見整體之變化趨勢及正常變動範圍，此呈現方式為日本自福島事件後數十年資訊揭露之成果，也是此次觀察團針對資訊揭取得的重要參考資料，可做為我國往後資訊公開呈現之參考。

雙方交流討論後，觀察團提到本會執行之海洋整備計畫研究項目中，亦有海洋擴散評估模式之議題，建議建立核研所與電中研之技術交流管道，針對模式評估結果進行比對交流。日方專家欣然接受我方的提議，並可參與核研所後續規劃的國際研討會

圖 2、觀察團赴電中研及技術交流：(A)日方專家進行簡報、(B)雙邊會討論情形、(C)會後交流、及(D)團員合照。

表 3、生物代謝模式之動態及平衡對比

	生態調查	養殖實驗	備註
時間尺度	長	短	時間長短之區分，主要為是否達到平衡
代謝型態	平衡	動態	福島事件為特例，因大量放射性物質排入海洋，在事件發生後的幾年內，生態調查數據仍屬動態代謝。
背景活度控制		優	
食物鏈完整性	優		
適用模擬運算(代謝模式)	Box model	擴散動態計算 Eulerian model Lagrangian model	
可能阻礙	採樣數量受限，可能因背景值過低，檢測數據因 MDA 受限	養殖物種之代表性及食物鏈位置難以確定，如何套用到不同海域區塊之運算需作通盤考量	

2. 海嘯模擬實驗室參訪

在本場技術討論交流後，接著參訪院區內之海嘯模擬實驗室，該實驗室是在日本 311 海嘯發生後才建置的，係位於一棟專用廠房內設置一座大型海嘯之物理模擬設施(Large-scale Tsunami Physical Simulator)，如圖 3。該設施係於 2013 年建置完成，其尺寸為 65 公尺(長)*15 公尺(寬)*12 公尺(高)，配置試驗水道、大型水槽、地下水槽、可動閘門，可供應最大流量為 10 公噸/秒並產生速度約 7 公尺/秒之模擬海嘯。該設施可於水道中放置車輛或漂流木，使用模擬海嘯淹沒水道後，夾帶車輛或漂流木，衝擊水道內之堤防(高度 1.5 公尺)。津旨博士說明，建置海嘯模擬實驗室是為了瞭解海嘯和漂浮物對於建築物之影響，以瞭解海嘯之風險，因此電中研引進了這套設施，以加強核設施在抵禦自然災害的安全性研究與開發。

圖 3、(A)日方專家於海嘯模擬實驗室進行解說及(B)設施參訪情形。

（五）福島第一核電廠現勘(3 月 25 日)

觀察團於 3 月 25 日依既定行程，由台北駐日經濟文化代表處同仁陪同，搭乘租用巴士先抵達福島第一核電廠廢爐資料館後，領取臨時入廠證依規定轉搭廠方準備之巴士前往廠區，而此時是由廠方代表陪同搭乘，沿國道 6 號行駛車程約 20 分鐘左右，沿途經過污染土壤儲存設施，顯示當地的復育工作、土壤除污工作持續進行中。抵達後，團員再以護照辦理入廠手續。

1. 現勘前交流會議

首先，團長代表原能會謝主委，對日方表達感謝之意，雖然我方無法參與 IAEA 視察團，感謝日方安排讓本次觀察團可以順利成行，並期望本次交流可以讓台日雙邊更清楚掌握即時資訊。日方回覆他們重視並理解台方的需求，強調本次台灣觀察團的參訪地點，會比照 IAEA 2 月份現場視察內容，包括 ALPS 設施、K4 槽區、海邊稀釋排放區、分析化學實驗棟等(如補充資料一)，也會在實地現勘後，雙方進行綜合問答以利資訊交流。

隨後由福島第一核電廠廠長致歡迎詞，並簡介廠方目前約有 4,000 名工作人員，當前主要的工作是一號機組、二號機組燃料取出作業的準

備工作、二號機組內破損燃料碎片取出作業的準備工作。一號機組使用水下機器人進行核燃料現況檢測作業等。有關 ALPS 處理水排放，東電公司係依據 2021 年日本政府公布的方針進行準備工作，待取得日本的原子力規制委員會(Nuclear Regulation Authority,以下簡稱 NRA)核准後才會進行具體的工作。

接下來，福島第一核電廠除役推動工作部門負責人說明日本 311 大地震時，一號機組到三號機組當時正在運轉；四號至六號機組則處於停機檢查狀態。受到海嘯衝擊後，福島第一核電廠失去包含外部及柴油發電等所有電源，致使核燃料無法進行冷卻作業。事故以後，半徑 20 公里被設為禁止進入的區域。11 年後的今天，除役工作仍在推動進行中。

後續行程則由溝通中心兼 ALPS 處理水專案部副所長負責詳細說明，表示目前除役最大風險是存放在廠房頂部燃料池內的用過核燃料移除。當初四號機組於發生地震時，正處於停機維護作業中，因而未受到太大影響，燃料棒已在 2014 年 12 月全數取出；三號機燃料棒在 2021 年 2 月亦全數取出，這些取出作業係利用起重機以遠距遙控方式操作，是在現場無人員的情況下進行。然而，三號機組目前仍有核燃料碎片於爐心，輻射量較高，難度較高，因此在廠房頂部先建置了屏蔽體，後續再進行取出作業。一號到三號機組裡面仍有用過燃料碎片，所以用機器人調查裡面的狀況，今年首先從二號機組進行燃料碎片移除作業，用了 22 公尺長的機械手臂取出二號機組裡面的燃料碎片，並作了分析。廠方所提供的紙本資料中，有紀錄廠房內特定位置之水溫，包含反應器壓力槽底部、一次圍阻體容器、燃料池的溫度量測值，及冷卻水的注水量，其目的是為維持爐心冷卻能力。

廠方表示在觀察團赴日前，福島第一核電廠當地於 3 月 16 日又發生較大地震，當時有報導一號機組水位下降，此水位變動現象在之前地震也發生過。廠方對反應爐使用冷卻注水方式，其循環冷卻作業是從

2011 年起就一直持續執行到現在。在經過了 11 年後的今日，廠方表示核燃料衰變餘熱所需之冷卻水量已不用當初那麼多。這些水是因為反應爐破損，而流到反應爐外部。一到三號機組每部機組反應爐破損情況不一，所以水位高度也不同。目前冷卻溫度狀況控制很正常，水位的變化容易引起民眾關注，廠方都會即時公布水位變化資訊。目前一號機組現況因為水位下降而影響使用機器人進行核燃料碎片檢測作業，為了提高水位就需要提高注水量，水位恢復之後才再開始機器人調查工作。

事故發生初期，很多污染水流入港口外部，但是現在已經採取因應措施，因此排到港口外部的污染水量已經很少，遠低於法規允許的濃度。港口內外的檢測工作從 2011 年起一直未中斷，港口內佈有 10 個檢測點，港口外佈有 175 個檢測點。現在港口外部包括排放口附近輻射檢測值低於法規允許濃度，但港口內部還繼續進行監測。污染水的來源是冷卻水與用過燃料接觸後所產生。污染水會透過兩種淨化處理過程，第一種是鍶、銫核種的去除，可回收作為冷卻水循環利用之用水；第二種水淨化後是不循環的，經過 ALPS 處理後存放在儲槽。問題是，這樣的水為什麼一直增加？這些循環利用的冷卻水在正常情況下是不會增加的，但是水位的增加主要是因為地下水和雨水。為了防止水位的上漲，廠方採取了許多因應措施，為防止地下水進入廠房內，廠方設置了集水井與凍土牆，如此每天增加的水量變少了，事故發生初期，污染水每天是 500 立方公尺，現在是 140 立方公尺。每一儲槽容積是 1,000 立方公尺，所以當時每兩天就裝滿一個儲槽。當初為了防止污染水外漏，每天 24 小時一直建新的儲槽，災害發生初期時間很趕，採用的是法蘭盤型儲槽，但此類槽使用螺栓接合鋼材，因為有接縫處，所以容易發生洩漏情形。11 年後，廠方已改為使用焊接型儲槽，已經全部替代所有的法蘭盤型儲槽，現在 ALPS 處理水不會有洩漏情形。但一部分存放雨水及地下水的儲槽仍使用法蘭盤型。

儲槽目前仍是在增加，因為每天還是有 140 立方公尺污染水產生。目前面臨狀況是土地有限，再增加水槽數量會嚴重影響除役工作進行。

ALPS 是透過多核種處理設備，去除水中的 62 個核種。遺憾的是，氚及碳 14 是 ALPS 無法去除的，但碳 14 的核種活度濃度原本就是符合排放標準的，所以，以 ALPS 處理過且檢測完成的水而言，除氚以外的核種活度濃度都是符合排放標準的。目前廠區現在約有 1,000 多餘個儲槽，其中約 32 %存放的 ALPS 處理水已符合國家排放標準，還有約 68 %需再進一步處理，相關統計數據登載於東電公司網站上，實際統計數量會持續更新。

儲槽再處理是針對 62 個核種的去除，再處理後符合排放標準的水，將用海水進行稀釋氚的濃度後進行排放。這樣過濾及海水稀釋的作法是發生事故前福島核電廠正常運轉的氚排放方式。排放採用的標準，廠方也是參考國內外的標準後，最後決定為氚活度濃度每公升 1,500 貝克。廠方說明利用放水立坑來確認海水和 ALPS 處理水經過充分的稀釋，放水立坑內部結構的深度是 18 公尺，目前放水立坑的下游坑正在施工中，其他的配管、隧道、及泵浦等設施，須等 NRA 核准後才開始安裝，有關 ALPS 處理水排放之相關申請內容如補充資料二。

在進入廠區實際觀察前的會議中，徐團長及團員向日方提的問題與日方答覆，概要說明如下：

(1) **我方提問**：請廠方說明簡報所提的告示濃度還有比值總和，其與排放之關係為何？

日方答覆：告示濃度是依據日本法規所訂定的，每個放射性核種都有其專屬的告示濃度，表示當排放該放射核種時，其濃度要低於告示濃度。另外，當多種放射性核種一起排放時，每個核種進一步計算其與告示濃度之比值(實際量測濃度/告示濃度)，再將每個核種與告示濃

度的比值相加，得到「告示濃度比值總和」，依規定比值總和須小於 1 方能排放。

(2) **我方提問**：ALPS 處理水排放係利用海水稀釋後，於放水立坑中通過隧道排放入海，請問廠方的水質檢測是否與第三方檢測結果互相比對後才允許排放？

日方答覆：我們的檢測結果不太可能和第三方檢測結果完全一致，但兩者檢驗結果皆須符合告示濃度比值總和小於 1 之要求。依此要求，放水立坑的水樣分析的結果與國內第三方機構檢驗結果同步進行確認，透過官方網站及新聞媒體即時向社會公布。

(3) **我方提問**：東電的排放計畫什麼時候向 NRA 申請，大概什麼時候會通過排放計畫？若排放計畫通過，東電預估 NRA 會用什麼方式來稽查以確認東電公司有依照規定來處理？

日方答覆：NRA 每週召開排放計畫審查會議，針對計畫有提出具體的審查意見，我們正在進行修訂，估計還需要幾個月才會審查完成。具體排水設備的建置工作會在 NRA 審查通過後才會執行。我們也按照 NRA 稽查的要求去執行。NRA 目前有常駐人員在福島第一核電廠，主要監督除役的工作進展，未來排放作業也會派遣常駐人員。

(4) **我方提問**：我們這次觀察團來到這裡的目的，其中一項是依據我們原能會主委的要求，認為 ALPS 處理水在日本國內有作第三方檢驗，我們也聽說 IAEA 也有取樣檢驗，所以我方希望也能參與第三方檢驗，這樣會讓我們官方有信心說服台灣民眾使其安心，我們之前也有書面告知日方這樣的訴求，而日方的回應是相關資料都有公布在網路資訊。一般來說，我們認為實驗室都有互相比對及第三方驗證，所以我們是否能取回海水及參與第三方驗證？

日方答覆：若要把水樣運送到海外還有一些規定按照日本國內的規範要辦理相關手續，因為含有放射性物質的水樣，是不能任意帶離核電廠。

(5) **我方提問：**這部分日方的解釋可能有誤解。我們看過 IAEA 報告的報導，水樣要送到摩納哥實驗室還有奧地利實驗室去作檢測，也提到明年排放前、中、後 IAEA 還會來持續作檢測，所以我們才會如此提問，請日方再答覆。

日方答覆：該報導是指環境取樣，包含海水等樣品，不是 ALPS 處理水。補充一下，IAEA 在 2021 年 7 月公布的報告所提到的樣品是海水、魚、以及海底土壤沉積物，是帶到摩納哥實驗室進行分析的。

(6) **我方提問**：我們要對台灣民眾有交代，希望能與 IAEA 視察的內容一樣，所以，是否可以讓我們把海水沉積物等環境樣品帶回台灣？我方也有環境試樣的輻射檢測實驗室，也常參與國際的比對。

日方答覆：台方能不能帶回環境樣品我們還要再討論確認。

另外，有關量測技術方面，觀察團提問 ALPS 處理水中各核種濃度的量測方法，東電公司表示，對於占大多數加馬射線放射性核種如銫 137、鈷 60、銪 152 等是以純鍺(Ge)偵檢器，部分貝他射線放射核種如氚、碳 14、鎳 63 等是使用液態閃爍計數器(LSC)，另有部分貝他射線放射核種如鍶 89 及鍶 90 是使用貝他能譜儀(貝他-spc)，少部分核種如鎝 99 和碘 129 是使用感應耦合電漿質譜儀(ICP-MS)。並非所有核種的濃度皆使用直接量測的方式獲得，有部分較難測量的核種如銫 135、鉅 147、鋂 242m 等的濃度，是利用其他較易量測的核種濃度的固定比例計算出，而超鈾元素的濃度則是量測總阿伐活度後再以固定比例去計算，而此固定比例是以反應器運轉時的條件使用電腦模擬評估得出。東電公司根據我方提問，已提供 64 個核種分析方法資料供我觀察團參考，如表 4。依據日方所提供 4 種方法，64 類核種中，42 個核種可實際量測，其中 34 個

核種可用加馬能譜分析量測；8 個其他核種，如氚、碳 14、鎳 63、鍶 89、鍶 90、鎝 99、鎘 113m、碘 129 等，可用 LSC、ICP_MS、或其他能譜量測。8 個阿伐核種只量總阿伐；剩下其餘 14 個核種是用計算方式獲得。

表 4、東電公司提供 64 個核種量測方法[3]

	Nuclide	Analysis method	Outline	Remarks
1	H-3	LSC	After being isolated by distillation, the sample is mixed with a scintillator and measured.	In the measurement by Ge, the lower detection lower limit of nuclides of the low-energy side becomes higher due to the effect of Compton scattering, but the target* detection lower limit is secured by carrying out the measurement for a long time.
2	C-14	LSC	After being isolated by capturing with absorbent, the sample is mixed with a scintillator and measured.	
3	Mn-54	Ge	Homogenized sample is dispensed in Marinelli containers and measured.	
4	Fe-59	Ge	Homogenized sample is dispensed in Marinelli containers and measured.	*Target: Values set for individual nuclides to make sure that the sum of concentration ratios of the radionuclides to regulatory standards is less than 1.
5	Co-58	Ge	Homogenized sample is dispensed in Marinelli containers and measured.	
6	Co-60	Ge	Homogenized sample is dispensed in Marinelli containers and measured.	
7	Ni-63	LSC	After being isolated with resin, the sample is mixed with a scintillator and measured.	
8	Zn-65	Ge	Homogenized sample is dispensed in Marinelli containers and measured.	
9	Rb-86	Ge	Homogenized sample is dispensed in Marinelli containers and measured.	Ge: Ge semiconductor detector
10	Sr-89	β-Spec	After being isolated with resin, the precipitate is collected, mounted, and measured with β-Spec in a stainless steel plate.	LSC: Low background liquid scintillation counter
11	Sr-90	β-Spec	After being isolated with resin, the precipitate is collected, mounted, and measured with β-Spec in a stainless steel plate.	β-Spec: β-nuclide analyzer
12	Y-90	Evaluated value	The concentration is evaluated under radioactive equilibrium with Sr-90.	ICP-MS: Inductively coupled plasma mass spectrometer
13	Y-91	Ge	Homogenized sample is dispensed in Marinelli containers and measured.	ZnS: α automatic measuring device
14	Nb-95	Ge	A homogenized sample is dispensed into Marinelli containers and measured. The half-life of the parent nuclide is used.	
15	Tc-99	ICP-MS	The sample is diluted with HNO3 and measured.	
16	Ru-103	Ge	Homogenized sample is dispensed in Marinelli containers and measured.	
17	Ru-106	Ge	Homogenized sample is dispensed in Marinelli containers and measured.	
18	Rh-103m	Evaluated value	The concentration is evaluated under radioactive equilibrium with Ru-103.	
19	Rh-106	Evaluated value	The concentration is evaluated under radioactive equilibrium with Ru-106.	
20	Ag-110m	Ge	Homogenized sample is dispensed in Marinelli containers and measured.	
21	Cd-113m	LSC	After being isolated by ion-exchange, the sample is mixed with a scintillator and measured.	
22	Cd-115m	Ge	Homogenized sample is dispensed in Marinelli containers and measured.	

	Nuclide	Analysis method	Outline
23	Sn-119m	Evaluated value	The concentration is evaluated using the relative ratio with respect to Sn-123.
24	Sn-123	Ge	Homogenized sample is dispensed in Marinelli containers and measured.
25	Sn-126	Ge	Homogenized sample is dispensed in Marinelli containers and measured.
26	Sb-124	Ge	Homogenized sample is dispensed in Marinelli containers and measured.
27	Sb-125	Ge	Homogenized sample is dispensed in Marinelli containers and measured.
28	Te-123m	Ge	Homogenized sample is dispensed in Marinelli containers and measured.
29	Te-125m	Evaluated value	The concentration is evaluated under radioactive equilibrium with Sb-125.
30	Te-127	Ge	A homogenized sample is dispensed into Marinelli containers and measured. The half-life of the parent nuclide is used.
31	Te-127m	Evaluated value	The concentration is evaluated using the relative ratio with respect to Te-127.
32	Te-129	Ge	A homogenized sample is dispensed into Marinelli containers and measured. The half-life of the parent nuclide is used.
33	Te-129m	Ge	Homogenized sample is dispensed in Marinelli containers and measured.
34	I-129	ICP-MS	A reagent is added to the sample to adjust it to iodate ion, and then the sample is measured.
35	Cs-134	Ge	Homogenized sample is dispensed in Marinelli containers and measured.
36	Cs-135	Evaluated value	The concentration is evaluated using the relative ratio with respect to Cs-137.
37	Cs-136	Ge	Homogenized sample is dispensed in Marinelli containers and measured.
38	Cs-137	Ge	Homogenized sample is dispensed in Marinelli containers and measured.
39	Ba-137m	Evaluated value	The concentration is evaluated under radioactive equilibrium with Cs-137.
40	Ba-140	Ge	Homogenized sample is dispensed in Marinelli containers and measured.
41	Ce-141	Ge	Homogenized sample is dispensed in Marinelli containers and measured.
42	Ce-144	Ge	Homogenized sample is dispensed in Marinelli containers and measured.
43	Pr-144	Evaluated value	The concentration is evaluated under radioactive equilibrium with Ce -144, and the half-life of the parent nuclide is used.
44	Pr-144m	Evaluated value	The concentration is evaluated under radioactive equilibrium with Ce-144.

Remarks

In the measurement by Ge, the lower detection lower limit of nuclides of the low-energy side becomes higher due to the effect of Compton scattering, but the target* detection lower limit is secured by carrying out the measurement for a long time.

*Target: Values set for individual nuclides to make sure that the sum of concentration ratios of the radionuclides to regulatory standards is less than 1.

Ge: Ge semiconductor detector

LSC: Low background liquid scintillation counter

β-Spec: β-nuclide analyzer

ICP-MS: Inductively coupled plasma mass spectrometer

ZnS: α automatic measuring device

e Japanese version shall prevail

	Nuclide	Analysis method	Outline	Remarks
45	Pm-146	Ge	Homogenized sample is dispensed in Marinelli containers and measured.	In the measurement by Ge, the lower detection lower limit of nuclides of the low-energy side becomes higher due to the effect of Compton scattering, but the target* detection lower limit is secured by carrying out the measurement for a long time. *Target: Values set for individual nuclides to make sure that the sum of concentration ratios of the radionuclides to regulatory standards is less than 1. Ge: Ge semiconductor detector LSC: Low background liquid scintillation counter β-Spec: β-nuclide analyzer ICP-MS: Inductively coupled plasma mass spectrometer ZnS: α automatic measuring device
46	Pm-147	Evaluated value	The concentration is evaluated using the relative ratio with respect to Eu-154.	
47	Pm-148	Ge	Homogenized sample is dispensed in Marinelli containers and measured.	
48	Pm-148m	Ge	Homogenized sample is dispensed in Marinelli containers and measured.	
49	Sm-151	Evaluated value	The concentration is evaluated using the relative ratio with respect to Eu-154.	
50	Eu-152	Ge	Homogenized sample is dispensed in Marinelli containers and measured.	
51	Eu-154	Ge	Homogenized sample is dispensed in Marinelli containers and measured.	
52	Eu-155	Ge	Homogenized sample is dispensed in Marinelli containers and measured.	
53	Gd-153	Ge	Homogenized sample is dispensed in Marinelli containers and measured.	
54	Tb-160	Ge	Homogenized sample is dispensed in Marinelli containers and measured.	
55	Pu-238	ZnS	After iron is removed from the sample by ferric coprecipitation, the sample is evaporated to dryness in a stainless steel dish and measured.	
56	Pu-239	ZnS	After iron is removed from the sample by ferric coprecipitation, the sample is evaporated to dryness in a stainless steel dish and measured.	
57	Pu-240	ZnS	After iron is removed from the sample by ferric coprecipitation, the sample is evaporated to dryness in a stainless steel dish and measured.	
58	Pu-241	Evaluated value	The concentration is evaluated using the relative ratio with respect to Pu-238.	
59	Am-241	ZnS	After iron is removed from the sample by ferric coprecipitation, the sample is evaporated to dryness in a stainless steel dish and measured.	
60	Am-242m	Evaluated value	The concentration is evaluated using the relative ratio with respect to Am-241.	
61	Am-243	ZnS	After iron is removed from the sample by ferric coprecipitation, the sample is evaporated to dryness in a stainless steel dish and measured.	
62	Cm-242	ZnS	After iron is removed from the sample by ferric coprecipitation, the sample is evaporated to dryness in a stainless steel dish and measured.	
63	Cm-243	ZnS	After iron is removed from the sample by ferric coprecipitation, the sample is evaporated to dryness in a stainless steel dish and measured.	
64	Cm-244	ZnS	After iron is removed from the sample by ferric coprecipitation, the sample is evaporated to dryness in a stainless steel dish and measured.	

觀察團在福島第一核電廠的第一場會議約進行 1.5 小時，與日本外務省、經產省、日本台灣交流協會、東電公司總部、福島第一核電廠等日方代表充分討論與溝通。接下來，觀察團將進入廠區實地現勘，先配合廠方繁複的進廠程序，進行人員體內計測，並配戴劑量佩章及穿著防護衣物後，換搭廠內巴士進入廠區。

觀察團進入廠區前，日方已提供廠區平面圖及現勘路線，如圖 4、福島第一核電廠之廠區平面圖及現勘路線。福島第一核電廠設置六部機組，其中，一至四號機設置於臨岸之南側區域；五至六號機設置於臨岸之北側區域。鄰近一至二號機的前方是一高地邊坡，已設置觀察點(位置①)，可觀察到各機組之建物外觀及周圍地下水排放迴路設備(位置②)。廠區內設置 2 處 ALPS 設施(位置③、④)，作為廠區放射性污水淨化處理用途。廠區內南側建置許多儲槽，本次行程僅搭車路線經過，並未安排參觀。在 ALPS 設施對面為 K4 槽區(位置⑤)，係為 ALPS 處理水暫時儲存之槽區，提供混合、取樣、及等待排放之用途。另外，廠方提到廠區內集水井抽取之地下水也須透過淨化處理設施進行處理(位置⑥)。目前規劃 ALPS 處理水稀釋排放的設施之一為放水立坑，正在施工中，設置於港灣內靠近五號機處之岸邊(位置⑦)。在 ALPS 處理水排放前，其水質須進行各核種活度濃度之分析，該實驗室設置在分析化學實驗棟(位置⑧)。

廠區實地現勘行程順序安排為(1)一至四號機災後整備、凍土牆包封範圍、範圍內地下水抽離設施等(位置①)；(2)ALPS 設施(位置④)與 K4 槽區(位置⑤)；(3)海邊稀釋排放區(位置⑦)；及(4)分析化學實驗棟(位置⑧)。完成廠區現場觀察行程後，預定再進行綜合問答會議。

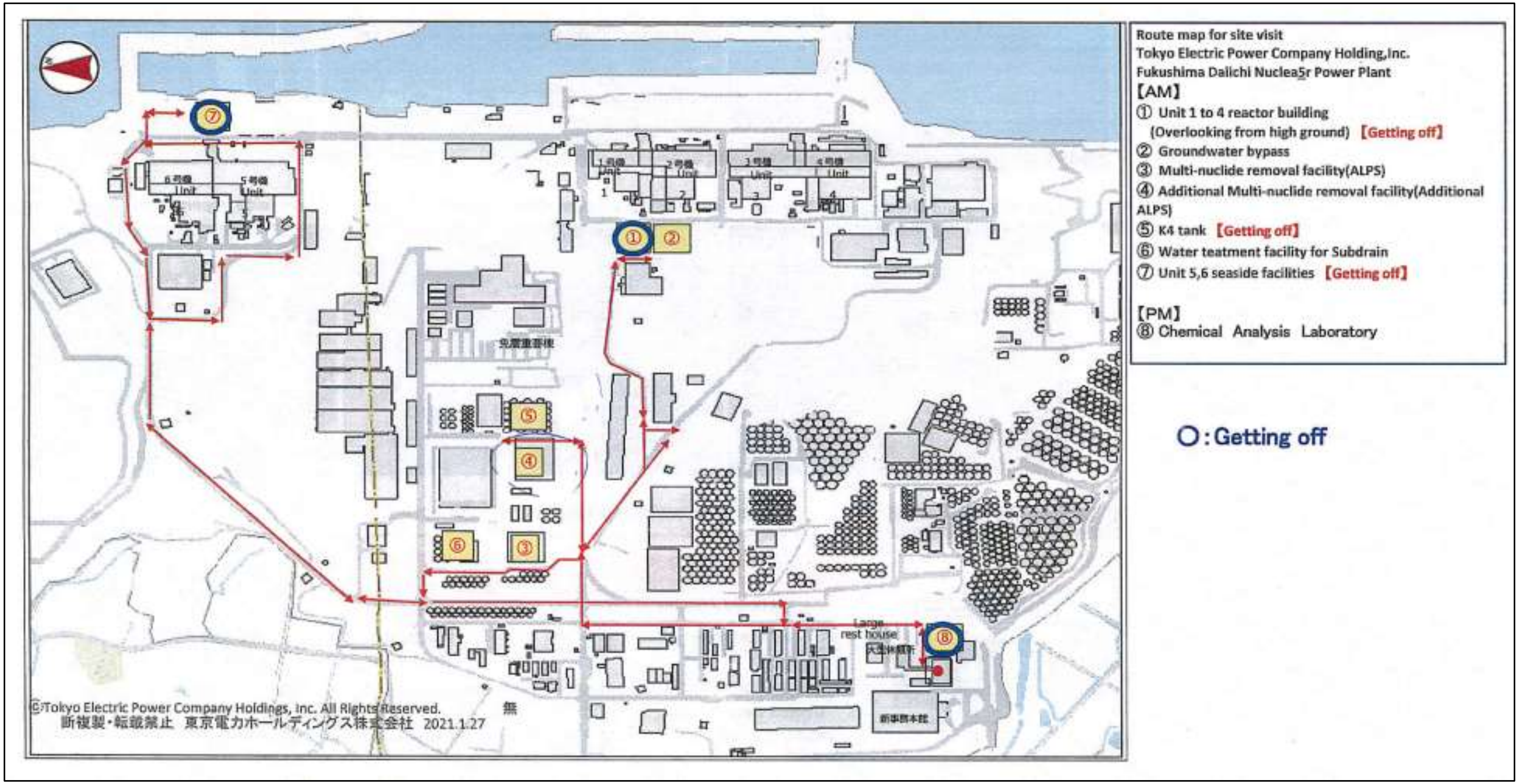


圖 4、福島第一核電廠之廠區平面圖及現勘路線

2. 一至四號機災後整備、凍土牆包封、地下水集水井

廠方引導團員至一處高地邊坡觀察點，高度約 33 公尺，邊坡原本的土壤表層已噴塗水泥防止污染擴散，該處背景輻射劑量率約 100~120 微西弗/時，可清楚且安全的觀看一至四號機，及正在進行的整復與除役作業 (如圖 5)。

福島第一核電廠發生核災事故時，當時為冷卻反應爐爐心，持續挹注冷卻水澆灌殘留於爐心內部受損之結構與燃料，而產生含有放射性物質之污染水；另一方面，由於受損反應器廠房周圍地下水位較高，使得地下水不斷流入反應器廠房內產生污染水，致使福島核電廠內污染水仍不斷增加。為抑制污染水繼續大量產生，福島第一核電廠的反應器廠房周圍增設深度 30 公尺之凍土壁與牆面，阻絕並減少周圍之地下水滲入熔毀的爐心，目前每日污染水產生量已控制在約 140 立方公尺。另外，於現場可觀察到反應器廠房周邊挖設多口集水井，用於收集凍土牆包封範圍內的雨水，使此範圍內的水沒有接觸到爐心，較不具放射性。集水井的水經由過濾及檢測後，所有核種活度濃度都符合排放規定，才排放入海。

福島第一核電廠一至四號機的除役作業，已陸續進行用過核子燃料與燃料碎片取出作業。相較於一般核電廠的除役，其困難度高出許多，廠方透過水下機器人及機械手臂進行放射性物質的取樣分析，此經驗值得我方學習，可應用於我國核電廠除役及放射性廢棄物之取樣分析作業。另外，廠區內設置地表下冷凍牆、集水井等設備，以進行地下水的阻流，其成效顯著，有效控制並減少地下水進入爐心之流量。此技術須搭配水文地質、土木工程及冷凍技術，才能準確定位所需施工之位置並維持凍土牆之狀態，值得我方參考。

圖 5、(A)觀察團於廠區視察一號機至四號機之除役現況、(B)觀察大型起重機作業情形。

3. ALPS 設施與 K4 槽區

接著，再搭車至 ALPS 設施及 K4 槽區，如圖 6 所示。選擇特定觀察 K4 槽區，係因福島第一核電廠發生核災後，因地下水流入反應爐，造成數量龐大之污染水，卻無法排放，故東電建造 K1~K4 槽區存放。惟因應排放前須經分析確認符合規定，東電選擇距 ALPS 系統距離較近之 K4 槽區，改建為「分析確認槽區」，進行攪拌均勻、取樣等程序，故考量各槽區對環境輻射影響之重要性，行前規劃即選擇 K4 槽區為觀察重點。

針對福島第一核電廠核災事故產生污染水之處置，日本東電係透過 ALPS 設施進行污染水之淨化處理，可移除污染水內含之大部分放射性物質，稱為「ALPS 處理水」，但因氚同位素特性與水一樣，無法用 ALPS 移除氚。團員實地勘查時，正逢 ALPS 廠內進行污泥洩除及高完整性容器(High Integrity Container, HIC)桶槽更換作業，因此大門是開啟狀態，據廠方說明 IAEA 視察團到訪時，並無機會看到 ALPS 內部作業情形。正介紹 ALPS 各單元用途時，發生還蠻嚇人的地震，本團團員迅速退出門口至空地，當場東電員工說明可能是 3 月 16 日大地震後的餘震。我們等待地震停止後再繼續聽取廠方說明並觀察內部設施，我們由大門向內觀看，右側為 ALPS 的前處理及碳酸鹽共沉澱處理單元；而左側則是 18 組的放射性核種的吸附塔又稱 ALPS 過濾器。東電公司人員亦展示一瓶近

期取樣的 ALPS 處理水，為透明無色、無懸浮固體及沉澱物之水樣，氚活度分析值約每公升 22 萬貝克。

2021 年 9 月媒體曾報導福島 ALPS 過濾器破損之新聞，廠方說明該事件指的並非 18 組 ALPS 過濾器的破損，而是盛裝前處理單元之污泥和廢吸附劑所用之 HIC 的排氣過濾器破損，是裝載廢棄物時提供排氣過濾功能之元件，因操作壓力過高造成破損。經過逐一檢查更換之後，東電公司亦對此一情事提出詳細報告及說明(如補充資料三)。

K4 槽區位於 ALPS 廠房大門正對面，K4 槽區鄰近 ALPS 設施亦方便於輸送及處理。K4 槽區的每一只儲槽容積為 1,000 立方公尺，東電公司以每 10 只儲槽為一組的方式串接，為使取樣具代表性，每一組內的 10 只儲槽都具有攪拌混合及循環輸送的功能；主要分為三組，第一組用於接收 ALPS 處理水，第二組做為取樣待確認用，第三組則為待排放。

東電人員說明由於 ALPS 處理水經取樣後，進行分析及第三方驗證所需時間約為 1.5 個月；因此，排水必須以上述分組方式調度。廠方在 K4 槽區時進一步說明，當初核災初期為了迅速貯存大量產生的污染水，須在短期內建置許多大型儲槽，採用法蘭盤型儲槽，但因發現會有滲漏情形，目前已改為焊接型儲槽。此外，目前槽區的外圍設置了兩道的攔水堰，主要是預防儲槽洩漏，以避免洩漏後污水直接外排。

雖然 ALPS 處理水中所含絕等大部分放射性核種活度已低於日本國內外釋管制標準，但因氚仍無法透過淨化系統去除，所以 ALPS 處理水之氚含量仍超過日本管制標準(每公升 60,000 貝克)與世界衛生組織(World Health Organization, WHO)所訂之飲用水標準(每公升 10,000 貝克)。東電人員說明，在福島第一核電廠廠區內有 1020 個儲槽儲放 ALPS 處理水與待處理水等，儲存量約為 1.29 百萬立方公尺，氚的總活度為 860 兆貝克。廠區內儲存 ALPS 處理水分為兩類，第一類為除氚外各核種仍未達排放標準，佔比約 68%，第二類為除氚外各核種已達排放標準，佔比約 32%，這些符合標準的處理水，將導入 K4 槽區取樣分析後進行氚

的稀釋後排放。除了東電公司自行分析外，亦有第三方取樣分析比對，以確保其符合性。

廠區現有 ALPS 處理水之儲槽空間僅剩 5%，廠方預估剩餘量僅能維持至 2023 年春季，未來將嚴重影響福島第一核電廠除役作業長程規劃，所以日本政府於 2021 年 4 月 13 日發布《關於處置東京電力公司福島第一核電廠 ALPS 處理水的基本政策方針》[4]，決定將 ALPS 處理水透過海水稀釋，使其氚濃度減低至每公升 1,500 貝克以下，並符合日本國內管制標準與 WHO 飲用水水質準則之情況下，將其排入大海，並將每年氚排放目標值設定為 22 兆貝克，等同於福島第一核電廠於正常運轉期間(事故發生前)之年排放值。

圖 6、(A)ALPS 設施運轉說明、(B)ALPS 處理水樣展示、(C)K4 槽區說明情形。

4. 海邊稀釋排放區

接著，觀察團抵達海邊區域，觀察 ALPS 處理水的稀釋排放區，如圖 7。廠方規劃利用 5 號機之海水取水道引入海水，並增設 3 座海水泵，用以輸送海水作為稀釋水源；K4 槽區預備排放之 ALPS 處理水，經分析確認氚及其他核種的活度濃度後，計算所需的海水量進行稀釋，原則上廠方將提高海水稀釋用量，因此混合後之氚活度濃度預估都會低於每公升 1,500 貝克的排放標準。稀釋後之 ALPS 處理水藉水位差導入放水立坑，再以溢流方式藉由地下隧道通往岸外 1 公里處排放入海。

ALPS 處理水的排放計畫，目前正由 NRA 審查中，根據東電的規劃，預計在 2023 年 4 月完成排放前的準備工作，由於計畫還在 NRA 審查中，目前只施作放水立坑，其他排放所需的引水管路、海水取水設施、混合稀釋設施等硬體設備皆尚未建置。東電公司的 ALPS 處理水排放計畫，於 2021 年 12 月提出申請案，據東電人員表示，依目前 NRA 審查流程，預估今年 4 月底可完成審查，如被核准，其他排放設施開始施工，預計明年 4 月中施工完畢，並接受 NRA 執行使用前檢查，另外，使用前仍需與外界持續溝通並獲得理解。

圖 7、ALPS 處理水之放水立坑施工情形說明。

5． 分析化學實驗棟

廠方考量極低微放射性物質化學分析，須盡量避免人員進出導致放射性物質污染該實驗室，且實驗室空間有限，因此，已先於行前與我方溝通，僅能安排本團一員與一位翻譯進入分析化學棟內部，因此，本團遂指派具相關專長的黃副組長入內參訪。

因應福島第一核電廠周遭環境輻射劑量率高，為避免分析受干擾，樣品接收站位於該棟 1 樓，但該實驗室則建置於地下室，其功能區域分布如圖 8。進入分析化學實驗室與進入前述其他設施不同，必須防範沾有外面的放射性污染物攜入內部，因此成員於更衣間先著一雙東電提供的襪子，戴上布質帽並配戴劑量佩章，再拿著另一雙襪子行走至實驗室外再套上，以防第一層襪子表面沾附污染物。負責解說的是一位負責福島第一核電廠內極低微輻射樣品分析的資深技術人員，該實驗室分析的樣品來源包含海水、集水井的地下水、處理後的地下水、及 ALPS 處理水。福島核電廠每年共需分析八萬件樣品，是 311 事件前的 16 倍，該實驗室需執行其中 1/3 的分析量，而所有分析結果與數據必須即時公開在網站上。

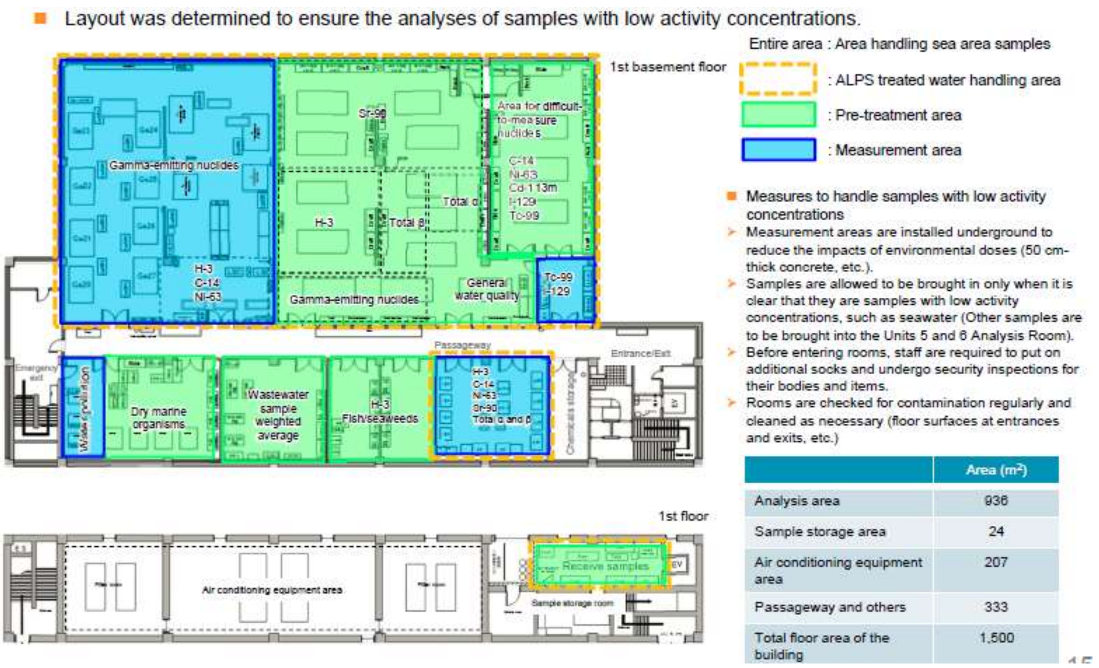


圖 8、福島第一核電廠極低微放射性樣品分析實驗室區域佈置圖[5]。

該實驗室以三大措施來確保分析可靠度(如圖 9)，包含(1)ISO/IEC 17025:2017 對銫 134、銫 137 及氚分析認證、(2)與 IAEA 進行分析能力比對並符合 ISO 每年稽核、(3)建置智慧眼鏡與 LIMS (Laboratory Information Management System)使分析自動化以減少大量分析時的人為失誤。

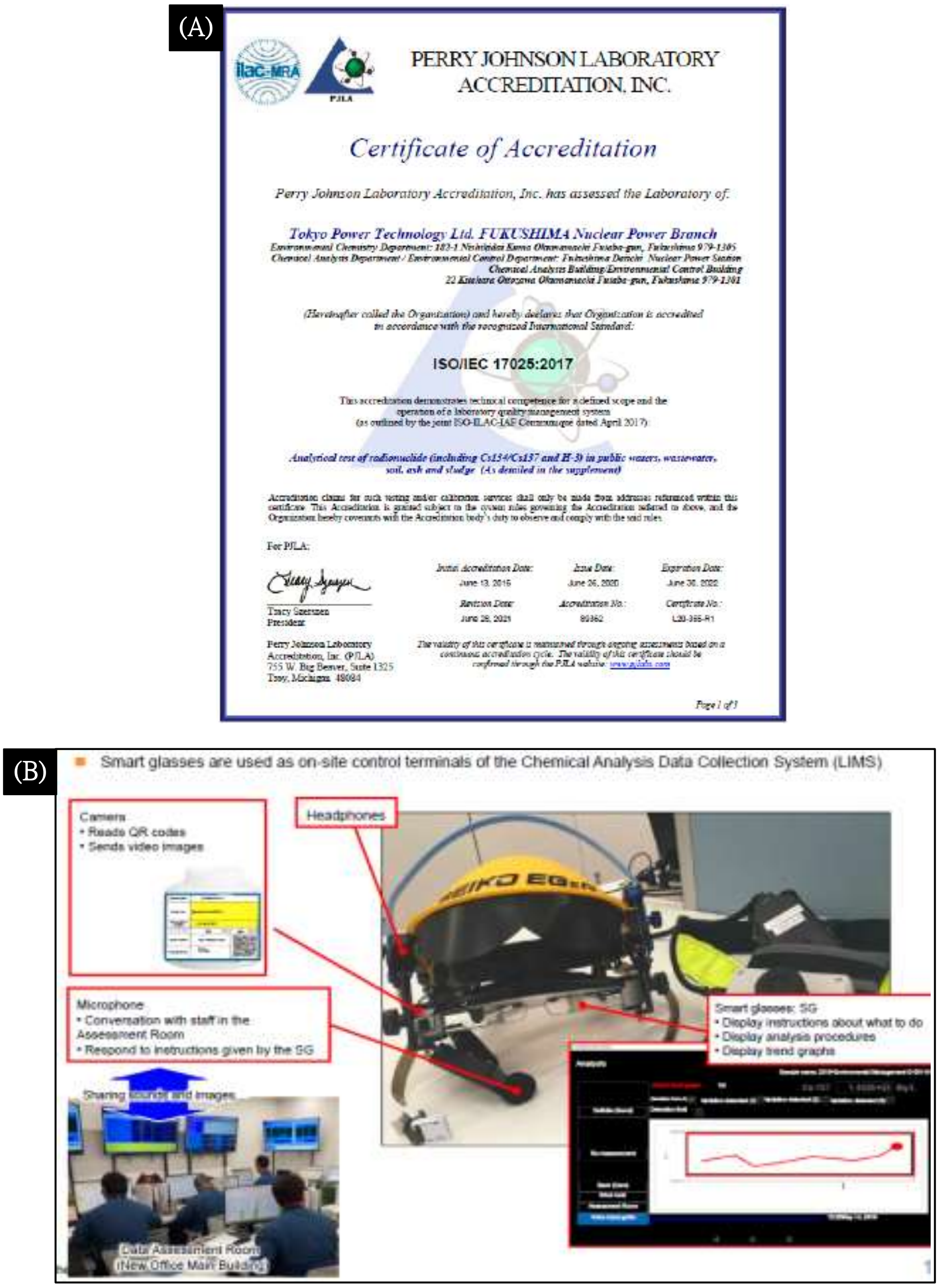


圖 9、(A)ISO/IEC 17025:2017 對銫 134、銫 137 及氚分析認證證書、(B)智慧眼鏡結合 LIMS 系統自動化分析程序示意圖[6]。

接下來，由廠方人員帶領進入三間實驗室，後續依序說明各實驗室在 ALPS 處理水排放規劃中的主要功能。

(1) 進入第一間實驗室，主要進行鍶 90 和總阿伐之放射性化學分析，前者是使用貝他能譜儀(貝他-spc)(圖 10)，後者則是使用 ZnS 偵檢器的儀器測定；經過前處理、去除鹽類及鐵質後再進行分析，經東電人員表示，ALPS 處理水不曾檢測出含有阿伐放射性物質。

圖 10、觀察團成員參訪鍶 90 檢測分析設備。

(2) 第二間實驗室進行碳 14、碘 129 與鎝 99 分析，碳 14 經過預處理成 CO_2 後再加入液體閃爍劑，以液體閃爍偵檢器分析。碘 129 則是經酸化成離子型態後再以 ICP-MS 分析，而鎝 99 則是加入硝酸後再以 ICP-MS 分析(圖 11)。

圖 11、觀察團成員參訪碳 14 與碘 129 前處理實驗室。

(3) 第三間實驗室則是分析氚，由於氚發出低能量貝他射線，為避免分析受到干擾使得分析結果有誤，其樣品的前處理需要經過十多道程序，前處理完畢樣品加入閃爍液仍須置於暗室 12 小時，靜待化學反應產生的光子結束後，再以液體閃爍偵檢器(如圖 12(A))偵測。於參訪現場邀請解說的技術人員一起合影拍攝有關氚水之前處理及放射性化學分析作業流程(圖 12(B))，並實際展示取樣之 ALPS 處理水經分析後得知氚濃度為每公升 10 萬貝克(圖 13(A))。第三間實驗室的另一區則是執行加馬能譜分析(圖 13(B))，主要測量銫 134 及銫 137，可分析的液體樣品容量分別有 2 公升(海水)及 5 公升(ALPS 處理水)，一般測定時間為 4 萬秒。

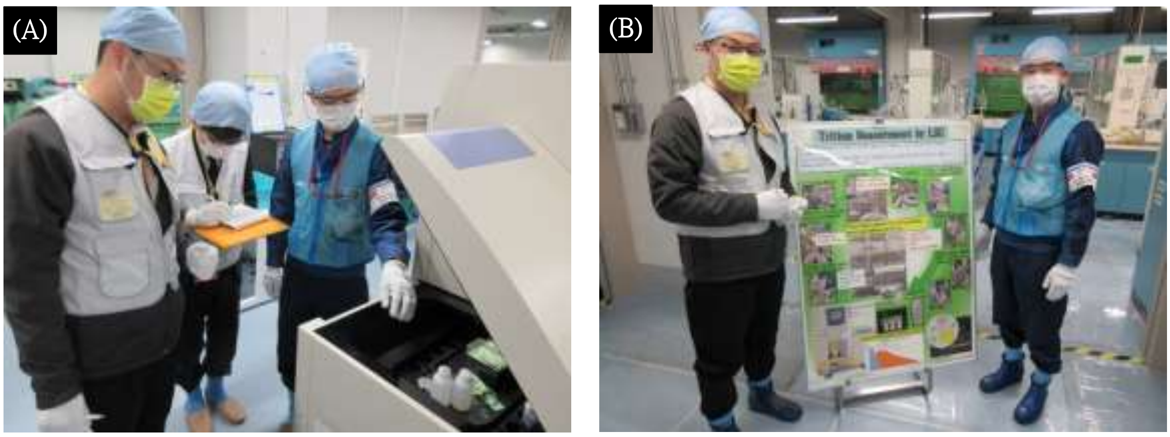


圖 12、觀察團成員參訪(A)氚液體閃爍偵檢設備及量測過程、(B)放射性化學分析之作業流程。

圖 13、(A) ALPS 處理水樣品(氚活度濃度約為每公升 10 萬貝克)、(B)加馬計測設備。

主要放射性分析化學項目參訪結束後，於現場提問有關氚的量測設備及日本國內的檢測能量情形，據東電技術人員說明，氚的檢測程序相當繁瑣，因此智慧眼鏡(Smart Glasses)和 LIMS 有關鍵的貢獻，包含協助實驗人員精準判定樣品量，標準作業程序的下一步驟等，大幅減少人為檢測的失誤；另一方面檢測氚的液體閃爍偵測器，可裝載 100 毫升樣品(目前市售設備為 20 毫升樣品)，樣品並具自動進樣及分析功能，為 Hitachi ALOKA 公司所製造，目前第一間實驗室配置有 4 台，第三間配置有 7 台，預計今年再採購 2 台。東電人員進一步表示，日本國內民間檢測氚的單位很少，現階段正與企業一起合作建置氚的檢測技術及分析量能。另外提問，有關電解濃縮法作為檢測氚的前處理設備是否已建立，能否參觀？東電技術人員表示，該技術是未來分析海水時的重要設備，目前設備還沒建立，規劃今年將進行採購。參訪分析化學棟期間進出每間實驗室均須脫穿工作鞋，並於現場參訪結束後進行全身計測方能離開。

6. 現勘後綜合問答

觀察團結束廠區之現場勘查後，廠方接下來為我方安排一場綜合問答座談，雙方討論時間約為 2 小時，並提供環境衝擊評估相關資料，如補充資料四。首先，廠方作一些補充說明，提出廠區內各種水來源與分類概念，避免造成混淆。最基本概念是說，冷卻循環水進入反應爐裡面接觸到燃料碎片，此類含有很多放射性物質的水稱為「污染水」，須進一步處理。廠方先使用水質淨化設施進行處理(沉澱、過濾)，再以 ALPS 設施去除 62 個核種，這樣的水稱為含氚的「ALPS 處理水」，並儲存於儲槽。因此，廠方的基本想法就是針對不同的水提出對應的作法。污染水含有許多放射性物質，其重點是避免再增加污染水的水量，因此第一個要作的就是避免地下水流進反應爐。基於上述預防措施，在地下水及雨水流入反應爐之前，必須透過集水井(Sub-darin)把地下水抽取至地面上。因為集水井的水並未接觸反應爐，所以廠方沒有把集水井取出的地下水當作污染水。雖然集水井所收集到的水比污染水

的放射性物質含量少很多，但仍含有少量的放射性物質，所以會經過處理並確認已經淨化到標準值之後就會進行海洋排放，這是從過去到現在已經在執行的，截至目前為止約排放 100 萬噸。集水井所取出的地下水，其排放標準是每公升 1,500 貝克，而未來規劃 ALPS 處理水的排放標準也是每公升 1,500 貝克。

接下來，進入雙邊綜合問答及交流討論時間，紀要如下：

(1) **我方提問**：廠方有提到 62 個核種，部分是採用分析方法確認，部分是採用計算的方式確認，廠方是否有詳細資料，例如列表資料，讓觀察團瞭解那些核種是用分析方法、那些核種是用計算方式？

日方答覆：我們提供資料的表格內會呈現每個核種的分析方法[7]，而註記「Evaluated Value」的部分就是用計算的意思。但各個阿伐核種並沒有逐一檢測，是用整體推算阿伐核種輻射的總量，主要原因是廠方沒有量測個別阿伐核種輻射含量的設備。

(2) **我方提問**：很多放射性核種的濃度是用其它核種的比例去換算，請問這些比例是如何獲得？

日方答覆：在核分裂時產生核種的比例是運用福島第一核電廠運轉時所得到的比例值。

(3) **我方提問**：一般來說阿伐核種、貝他核種比較不好量，所以例如用銫137 去推算其它核種，而廠方是把所有的核種用不同的方法去量，所以我們要確認廠方是不是就是這樣的作法？

日方答覆：廠方基本想法與台方一樣，用加馬的數據來推算。

(4) **我方提問**：廠方提到認為地下水沒有進入反應爐所以認為不是污染水，但集水井抽出之地下水的氚排放濃度標準為每公升 1,500 貝克也不是大自然的含量，廠方也說明迄今已排放 100 萬噸了，請問地下水的排放是否有經過 NRA 同意？

日方答覆：是的，福島第一核電廠所有排放的水都需要經過 NAR 的核准。跟 NRA 的部分有個規定，在福島第一核電廠土地面積內，向廠外

環境所釋放出來的輻射量必須低於 1 毫西弗。例如，廠區土地放射性物質所造成的天空散射輻射量、廠房向大氣所釋出的輻射量、及核電廠排放海洋的輻射量等都要進行評估，包含 ALPS 處理水與集水井的水，也是 IAEA 對東電公司的要求。

(5) **我方提問**：所以福島第一核電廠的廠界劑量都小於 1 毫西弗嗎？

日方答覆：是的，這是根據 NRA 的管制要求，過去流到海裡面的雨水含有很高的放射性物質，在當時無法管制，後來廠方採取措施減少雨水污染，但必須承認的是目前仍未能完全避免污染，所以目前仍持續努力採取相關措施。

(6) **我方提問**：0.22 毫西弗是所有核種還是單一氚核種？

日方答覆：前述說明的 0.22 毫西弗的概念，是指在福島第一核電廠的土地面積內的射性物質對環境所釋放出來的放射性物質輻射，其中包含 22%是液體型態排出來的，包含 ALPS 處理水及集水井的水，但不包含雨水。

(7) **我方提問**：當初 311 事件所產生的落塵擴散到廠界外，對環境的影響是否比 1 毫西弗還高？

日方答覆：是的，有這樣的情形。落塵擴散到廠區外圍環境，因此在觀察團來到廠區的國道六號的區域，輻射量是 1.2 微西弗。目前廠區內的管制目標仍是須低於每年 1 毫西弗。

(8) **我方提問**：東電公司除了跟 IAEA 有進行實驗室間的比較試驗以外，是否有跟日本國內的實驗室進行比較實驗？若有的話，台灣實驗室是否可以參與實驗室的比較試驗？

日方答覆：東電公司是透過委託日本民間公司進行分析，這個委託關係必須是與東電公司沒有任何資本往來的，所以我們稱之為第三方實驗室。

(9) **我方提問**：前段時間 IAEA 有取水樣並放在廠區內，媒體報導水樣約 50 公升，是打算委託那些日本公司進行 ALPS 水樣檢測？

日方答覆：廠方也希望將 IAEA 取的水樣送到 IAEA 實驗室，一開始 IAEA 確實是取 50 公升，後續 IAEA 會持續取樣，每次 50 公升，總計會約 200 公升。

(10) **我方提問**：上午簡報時，觀察團也提出希望可以取水樣，廠方回復 IAEA 取的 ALPS 處理水樣品都還放在廠區內，再確認一下是否如此。

日方答覆：是的，現正就其適切的運送方法進行研議中。

(11) **我方提問**：若運送的行政程序可行，台方是否能比照 IAEA 方式辦理？

日方答覆：也許中長期來看有可能，但目前為止，除了由國內機構進行分析之外，僅接受 IAEA 研究所及 IAEA 選定的機構進行分析。

(12) **我方提問**：東電公司是否委託民間公司檢測 ALPS 處理水，是否能提供公司的名稱？還是目前只有東電公司自行檢測？

日方答覆：東電公司還沒有找到固定的民間委託公司，因此無法提供公司名稱，目前水質分析的工作都是東電公司自己在作，有時候是委託多個民間公司執行，但不是委託一個固定的民間公司，針對不同內容會找不同公司，且有分析能力的民間公司不多，大約四到五家。

(13) **我方提問**：未來 ALPS 處理水實際執行排放時，會不會設立一個網站，揭露氚的實際排放量，及在網路上公布水質的檢測結果？

日方答覆：目前已設立一個「處理水入口網站【8】」，已公布 ALPS 處理水的水質分析結果。在排放之前會再次進行分析，這些分析結果、數據與資訊一定會在網站公布。目前廠方設置 137 萬噸容量的儲槽，已接近 95%的儲存量。近期廠方開始試驗養殖比目魚，目前用一般海水來養，秋天開始將使用 ALPS 處理水進行養殖。氚會不會在生物體內累積，廠方希望透過實際養殖生物來作實驗定期分析。

(14) **我方提問**：台方很關心日方排放的時程，是否東電預估五月底 NRA 會通過排放計畫，後續工程約 10 個半月，預定在明年四月經 NRA 同意後就進行排放？

日方答覆：依東電公司立場是希望4月能夠得到NRA的許可，才可以儘早開始工程建設。廠方的工程表有規劃2023年4月就進行排水設備的使用前檢查，因為2021年4月日本政府就發佈的基本方針是在2023年春天開始進行海洋排放，東電公司是依照政府方針執行。東電公司希望儘早得到許可，而NRA也正在加速審查程序，進度上應不會耽誤基本方針規定的時程。實際的工程部分，如同觀察團上午行程所看到的，可以做的部分已經有預先開始進行，得到許可之後馬上進行後續更多的工程，雖然許可後的時間對東電公司來說是個艱難的任務，但希望儘快完成工程，估計完成的時間會在2023年的春天，或許會有些許的延遲。有一個重點特別說明，當所有工程都完整了，未必就可以開始排放。不論是日本政府或東電公司，對社會大眾承諾要排放之前一定要得到整個地區跟社會的理解，但我們承認目前尚未得到足夠的理解，仍然有些人士反對向海洋排放的方針。東電公司正努力處理上述技術上、行政上的程序之外，在日本政府全力的協助之下，對於地方政府及社會進行更多的宣傳工作。

(15) **我方提問**：廠方目前儲槽容量已經達到95%，請問剩下的5%容量可以撐到什麼時候？

日方答覆：按照目前ALPS處理水的數量增加速度來看，大概是2023年春天就會滿了，也要視今年夏天的雨量多寡而定。

(16) **我方提問**：東電公司3月24日於官網公布之加強版海域監測計畫內容(補充資料五)，請說明魚類鍶90之檢測規劃，及擴大海藻取樣範圍至港灣外2公里及新增碘129分析項目之目的？

日方答覆：表格裡面黑字體是指以往至今都有在檢驗的內容，紅字是指今年4月起增加的項目。魚類以檢測銫137為主，並針對銫137檢出活度最高的前五個樣品，追加鍶90的檢測。另外，ALPS處理水規劃在港口外1公里處透過地下隧道排放，所以其範圍內的氚擴散是測量的重點。氚濃度是每公升1,500貝克，已經稀釋很多倍，按照模擬

的結果，在距離 1 公里處氚的濃度已經是背景值，但為了得到社會公眾的信任，所以港灣外的區域也要進行確認，以驗證模擬的結果是正確的。碘 129 是過去沒有檢驗的項目，因為 ALPS 處理水檢測結果有含微量的碘 129(檢出活度小於日本法定限值【9,10】)，且碘 129 容易被海藻吸收，日本人也喜歡吃海藻，所以特別納入海藻類及其碘 129 檢驗的項目。

(17) **我方提問**：目前的加強版的監測計畫都是排放之前的規劃，請問排放後的監測計畫，東電公司是否已經有規劃並送 NRA 審查嗎？

日方答覆：對於海洋監測計畫並沒有針對排放前、後進行改變，排放前執行的監測計畫也適用於排放後。前述問題所提到表格內紅字檢測項目，會在今年四月份開始執行，作為排放前、後的比對。

(18) **我方提問**：廠方提到 62 個核種中，部分難測核種是用比例關係估算，這個比例是用電廠正常運轉狀態下時候取得，請問經過 ALPS 處理過後水樣的比例關係會不會改變？

日方答覆：在某些情況下產生放射性物質的比例，應該在 ALPS 處理之後不會有變化。這些難測放射性核種很多根本檢測不出，東電用最保守的方法推算這些核種仍存在於水中，用比較保守的估算基礎應該是比較可靠的。

(19) **我方提問**：資料提到 2020 年時，日本政府得到 IAEA 承認目前 ALPS 處理水排放海洋是比較可靠且可行的，所以日本政府在 2021 年 4 月 13 日發佈了處理 ALPS 處理水的基本方針，所以東電公司才向 NRA 提出申請。請問東電公司是何時提出申請？我們也看到 2021 年 12 月 21 日有提出變更計畫。

日方答覆：除役計畫是一個很大的計畫，是由很多個計畫組成的。2021 年 12 月 21 日有提出變更計畫是除役計畫的一部分，也包含 ALPS 處理水排放的相關變更。剛開始推動除役計畫規劃的時候，並不是完全瞭解所有的資訊，所以當要作局部的變更時需要提出變更申請，在除

役計畫的大架構下進行變更。在之前討論到 0.22 毫西弗的議題，也是在除役計畫書裡面所提到的。

(20) **我方提問**：上午參訪時，K 區有三種顏色儲槽(待檢測、檢測中、可排放)，廠方說經檢測完 1.5 個月之後，符合標準的就可以排放，是不是檢測標準按照活度的比例跟法定的比例來比，或是有其它標準？

日方答覆：檢測中階段要轉到可排放階段的條件是 62 個核種活度要低於規定的標準值，而且要得到第三方的確定。

(21) **我方提問**：ALPS 處理水排到海洋，氚活度要低於每公升 1,500 貝克，經過檢測之後是要跟海水稀釋混合，所以排放的檢測標準要跟抽海水的泵浦有一定的比例，此標準是如何計算出來的？

日方答覆：每個儲槽的氚活度都不一樣，有些是每公升 10 幾萬貝克，有些是每公升 200 萬到 300 萬貝克，所以在每個槽排放之前要把氚活度確認，以計算要加的海水量，在放水立坑中混合稀釋後再排放。

(22) **我方提問**：有關 ALPS 處理水排放後的氚核種模擬的擴散行為，假設的條件是否可以說明？

日方答覆：針對排放模擬部分，重視的有兩點，第一個是氚活度為每公升 1,500 貝克，第二個是氚活度年總量低於 22 兆貝克。22 兆貝克的標準是來自於福島第一核電廠正常運作時排放的上限，也就是 ALPS 處理水排放不會高於以前福島第一核電廠正常運轉時的排放量。在這兩個前提下進行海洋擴散模擬，所採取的擴散模式是由電中研來建立。

(23) **我方提問**：東電公司所訂的監測計畫有包含海水、魚類及海藻類，是否有指標顯示超過後有問題？若發生此情況，會有什麼因應措施？

日方答覆：目前排放前的環境背景資訊還沒有掌握，2022 年 4 月份起要作更多魚類、海藻類檢測，不只東電公司會作，中央政府、地方政府等也會作類似的檢測，所以若檢測異常要採取什麼措施，今後還要跟中央政府、地方政府一起商量。此部分可能在排放前才會確定。

（六）返回東京 PCR、NHK 專訪(3 月 26 日)

觀察團依 3 月 26 日既定行程規劃，由台北駐日經濟文化代表處同仁陪同，返回東京並依規定進行 PCR 篩檢後，入住下榻飯店，全員皆為陰性反應。

應日本 NHK 媒體之邀請，本團接受 NHK 記者的視訊專訪，於 26 日下午 15：00 以線上方式進行採訪，全體團員及台北駐日經濟文化代表處同仁皆上線參加。根據 NHK 記者提問，由團長說明本次觀察團參訪之目地及觀察概要，並表示針對 ALPS 處理水排放議題，必須從科學面上進行瞭解，本次觀察團於安排的行程內所觀察的內容與見解，預計於 4 月完成出國報告，台方將同時密切注意後續發展趨勢。

（七）返國及檢疫(3 月 27 日)

觀察團依 3 月 27 日既定行程規劃，搭乘早班飛機飛返國，全體團員配合入境檢疫快篩措施，並依規定完成 10 天防疫旅館、居家檢疫，並於檢疫期滿前 1 日完成 PCR 檢測，全數團員為陰性。

三、心得與討論

本次觀察團赴日係台日在核能安全方面交流之重要進展，未來台日雙方除續依 2014 年 11 月簽署之「台日核能管制資訊交流備忘錄」所建置的平台交流管制資訊外，亦在此平台架構下就核災後含氚廢水排放的相關進度資訊，不定期透過線上視訊等非實體方式交換意見和觀點，促進雙方共同在維護海洋環境方面的合作。

此次我國因非 IAEA 會員國而未能參加其組成之調查團執行相關任務，惟透過我國外交部及駐外單位努力向日方爭取下，日本同意我國自行籌組之「專家觀察團」赴日。本次因 COVID-19 疫情及防疫需求，使觀察團行程安排僅限於「電中研」及「福島第一核電廠」等兩處地點，透過會議討論、廠區實地觀察以瞭解最新進展，並與日本外務省、經產省、東電公司總部、福島第一核電廠等日方代表進行討論。本次觀察團所得資訊，有助我國相關單位討論，瞭解福島核災後含氚廢水排放作業設備與相關監測作業狀況，可進一步強化我國因應策略研擬之參據。

此次觀察團就台灣所關心的議題，經過現場實地觀察與討論，共整理出如下七點心得，分述如下：

（一）實地瞭解放射性核種擴散模擬結果

有關放射性核種擴散模擬結果，本團與電中研專家討論後，心得如下：

1. 根據電中研對放射性核種於海洋擴散的模擬運算結果，顯示模擬的結果具參考價值，必要時可做為預報或預測污染擴散範圍與輻射風險之用。
2. 原能會刻正執行之「國家海域放射性物質環境輻射監測及安全評估整備計畫」，及 2023-2026 年度預定執行的「國家海域放射性物質擴散預警及安全評估應對計畫」，皆有放射性物質海洋擴散評估模式相

關研究議題，所以我國計畫執行單位可與日本電中研等單位，建立技術交流管道，針對模式評估結果，進行交互比對與驗證。

（二）交流生物氚分析檢測技術

有關海生物代謝模式及生物氚分析檢測技術，本團與電中研專家討論後，有如下心得：

1. 日方針對生物代謝模擬，係透過不同物種的「養殖實驗」取得「動態傳輸係數」，及福島海域「生態採樣」取得的「濃度平衡係數」等平衡態數據進行驗證分析，此經驗可對應我國計畫執行單位預計執行之「水產養殖實驗」等規劃，建立屬於台灣自有的「海洋生物代謝參數資料庫」。
2. 福島第一核電廠近期已公布，未來預計以含氚 ALPS 處理水進行比目魚人工養殖試驗，我方須持續注意其公布資訊，即時取得相關的養殖經驗、實驗方法、及檢測結果，供我國持續發展的參考。

（三）實地觀察 ALPS 設施及 K4 槽區布建

ALPS 設施係處理含放射性廢水之關鍵設施，先前 K4 槽區亦曾傳出滲漏事件，此情況與輻射安全甚為相關，經本團實地觀察後，心得如下：

1. 東電公司對於福島第一核電廠所產生之各種水樣作適當的分類，包含進到爐心的污染水、經過 ALPS 移除 62 個核種的 ALPS 處理水、及廠區集水井抽取水等。這些放射性廢水透過化學沉澱、核種移除設備(KURION、SARRY、SARRYII 等單元)、及海水淡化系統等，將再打入爐心冷卻用水進行循環利用，有助於該廠的污水減量及後續除役作業，惟長期所累積的二次廢棄物，例如污泥、濾材、吸附劑等，應會衍生後續高額的處理、處置成本。
2. 廠方目前 K4 槽區所使用的儲槽為焊接型儲槽，以避免過去緊急使用的法蘭盤型儲槽出現滲漏的情形，此方面確實是有必要的，因 K4 槽

區盛裝 ALPS 處理水之氚活度濃度遠高於排放標準，應確實做好相關防護。

（四）實地觀察 ALPS 處理水的海邊排放規劃與現有進度

ALPS 處理水排放設施，須考量其系統及相關設備之可靠性與緊急應變機制等，經本團實地觀察並與東電公司討論後，心得如下：

1. 東電公司的 ALPS 處理水排放計畫，於 2021 年 12 月間向 NRA 提出申請，據東電人員說明，NRA 的審查流程，約是每週召開一次審查會，目前已召開多次會議，預估今年 4 月完成審查，福島第一核電廠 ALPS 處理水排放設施之整體工程，預定於明年 4 月中施工完畢，並接受 NRA 使用前檢查。由於計畫還在 NRA 審查中，因此目前只施作放水立坑，其他排放所需的引水管路、海水取水設施、混合稀釋設施等硬體設備皆尚未建置。
2. ALPS 處理水排放前仍需與外界溝通並獲理解，預估明年春季排放的時程，因有當地民眾及社會溝通上的疑慮，仍有變數。然而，目前電廠 ALPS 處理水的剩餘儲存量僅約 5%，此 5%的剩餘儲存量預估亦僅能維持至明年春季，如果明年春季排放的目標無法達成，東電公司屆時將無處儲存 ALPS 處理水及待處理水，因此我方須密切追蹤後續情況發展。

（五）實地瞭解 ALPS 處理水的核種化學分析程序

由於 ALPS 處理水的核種化學分析程序、方法與偵檢設備，對於確認 ALPS 處理水的 62 個核種、氚和碳 14 的活度濃度相當關鍵。碳 14 的核種活度濃度原本就是很低，符合排放標準的，但東電公司針對所有核種都在電廠的分析化學棟內進行精密的量測，以確認所有將排放的 ALPS 處理水(除氚外)所有核種的活度濃度與告示濃度比值和小於 1。在實地參訪並與東電相關技術人員詢答後，心得如下：

1. 東電公司對 ALPS 處理水的核種濃度，並非所有核種皆直接量測，部分核種濃度是採計算其比例的方式獲得，分析其計算方式大致可分為 3 種，此 3 種計算方式亦可作為我國核電廠除役之參考，如下所列：

(1) 利用母核與衰變子核放射活度的長期平衡關係去估計，如釔 90 的活度是由其母核鍶 90 的活度計算出，當達到長期平衡時釔 90 活度與鍶 90 活度相同，因此只要量測鍶 90 活度就可以估算釔 90 活度，此類核種(母核/子核)還有(釕 103/銠 103m)、(釕 106/銠 106)、(銻 125/碲 125m)、(碲 127/碲 127m)、(銫 137/鋇 137m)、(鈰 144/鐠 144)、及(鈰 144/鐠 144m)，由於子核皆是由母核產生，因此即使經過 ALPS 處理，這種母核與子核的長期平衡關係不會被改變。

(2) 利用易測核種與其難測同位素之比例關係，去估計難測同位素的放射活度，而此比例關係則是利用核燃料於原子爐內的燃耗狀況以電腦模擬計算出，此類核種(難測同位素/易測核種)有(碲 127m/碲 127)、(銫 135/銫 137)、(錫 119m/錫 123)、(鈽 241/鈽 238)、及(鋂 242m/鋂 241)，由於同位素有相同的化學性質，因此即使經過 ALPS 處理，同位素間的比例關係不會改變。

(3) 利用易測核種與其化學性質相近的難測核種之比例關係，去估計難測核種的放射活度，而此比例關係亦是使用電腦模擬計算出，此類核種(難測核種/易測核種)有(鉅 147/銪 154)及(釤 151/銪 154)，由於鉅、釤、銪皆是鑭系元素，雖有相似的化學性質，然經過 ALPS 處以後，同位素間的比例關係無法保證不變，須以一較保守的比例值去估算難測核種放射活度。有關此類核種的比例關係，建議持續與日方聯繫取得較詳細的資料。

2. ALPS 處理水中 64 個核種分析方法，包括利用鍺半導體偵檢器(Ge Semiconductor Detector)、低背景液體閃爍計數器(Low

Background Liquid Scintillation Counter)、貝他核種分析儀(Beta Nuclide Analyzer)、誘發耦合電漿質譜儀(Inductively Coupled Plasma Mass Spectrometer)、阿伐自動量測設備(Alpha Automatic Measuring Device, ZnS Scintillation Counter)，與部分利用同位素豐度比例法計算所得的核種活度(Evaluated Value)，這些設備與操作皆需高度的專業，國內應建立及維持這些專業。

3. 本次參訪福島第一核電廠內的分析化學實驗棟，已實地觀察到東電公司執行 ALPS 處理水 64 個核種包括前處理及放射活度分析的設備儀器。由於極低濃度氚的檢測需有高靈敏度分析設備及特殊濃縮技術，東電公司目前已購置多部分析設備，並規劃近期建置海水氚提濃技術，值得關注相關技術發展動態。
4. 應持續關注東電公司投入相關資源的動態及各項設備技術的建置情形，及 IAEA 與 NRA 共同視察管制的報告，以掌握其排放準備與執行狀態，並且透過技術交流厚植我國相關檢測能力。

（六）實地瞭解日本核能管制單位的審查進度

東電 2021 年 12 月 21 日向日本原子力規制委員會(NRA)申請福島第一核電廠特定核子設施實施計畫變更，說明含氚廢水排放設定，及排放設施對於降低整體風險之任務與作用，故此次觀察日本 NRA 現階段審查情況，心得如下：

1. 本次觀察團於赴日前，即蒐集 NRA 審查會議資料研讀，以利觀察 NRA 管制作為與進度。據觀察，日本政府瞭解此議題之敏感性，故審查方式係以公眾審查會議方式進行，即在表明該排放計畫審查之公開及透明，目前審查會議已召開 14 次。雖日本為此福島核災事故國，須負起善後責任，惟觀察日方審查 ALPS 處理水流程尚為公開透明與嚴謹。且本次觀察行程安排與說明，日方皆盡其所能，詳細說明，說明

內容符合其公開資訊網站上所展示的資訊。因此應可相信這些資訊的正確性，及日本政府與東電公司當責的態度，此可供我國相關因應措施研擬之參據。

2. 依據 NRA 所公布的資料與東電公司的說明，NRA 對 ALPS 處理水排放之審查項目包括組織變革、排放標準與機制、輻射劑量評估、設備可靠性與意外處理及設備結構/強度、預防地震和海嘯等自然現象設計、及防止誤操作與可靠性等項目，審查項目與過程可謂嚴謹。惟考量 ALPS 處理水排放對台灣可能造成之影響，我國仍需持續慎重評估，為確保實際情況如日方所規劃，所以我們仍應視情況前往確認。

3. 目前福島第一核電廠環境監測之氚偵測低限已訂為每公升 0.1 貝克。惟此監測標準，目前國內相關實驗室尚無法達到，為因應環境監測資料庫之佐證與比對，我國宜規劃精進偵測技術方案。

4. 東電公開除役相關資料於網頁上提供下載參閱，併同中央管制單位如原子力規制委員會、經濟產業省、外務省、及環境省等亦採相同資訊開放理念，該項措施可大為提升民眾搜尋相關資訊瞭解電廠實情，對於政策推行有相當助益。

5. 日本政府為確保 ALPS 處理水排放處置作業可取信於當地漁民與國際社會，特別是反對福島核電廠處理水排放的周圍國家，故向 IAEA 提出請求協助提供專業意見與第三方驗證。經雙方商議，IAEA 將協助審查日本於廢水排放前、中、後之計畫與作業，確認符合國際安全標準，其查證安全要項包括：排放廢水之輻射特性、與安全有關之廢水排放程序、與排放有關之環境監測、與保護人類及環境有關之輻射環境影響評估、及管制監督(包括授權、視察、審查、及評估)。因 IAEA 審查結果具有公信力，故其進度亦為此次觀察之重點，謹將觀察心得略述如下：

(1) 2022 年 3 月 29 日，原能會與日本相關單位透過視訊，釐清 IAEA 與日方合作情況，得知 2021 年 7 月間，IAEA 與日方簽署一份 TOR

(Terms of Reference)，就日本福島核災含氚廢水排放計畫啟動審查程序，並於 2022 年 2 月 14～18 日赴福島核電廠執行第一次實地審查任務，後於 3 月 21～25 日與 NRA 進行第二次審查會議，蒐集排放計畫相關資訊並釐清必要細節。IAEA 將從科學專業的角度對福島處理水排放作業計畫進行獨立審查，確認是否符合國際安全標準。

(2) 依研判今年 IAEA 將會有兩份報告，第一份報告預估於 4 月份，內容為 IAEA 於 2 月 14～18 日赴福島核電廠執行第一次實地審查任務之訪查結果，第二份報告預估於 5 月份，內容則為 IAEA 與 NRA 討論之結果。

(3) 本次觀察團針對 IAEA 審查 ALPS 處理水進度之蒐集資料與日方於 2022 年 3 月 29 日與台灣專家的視訊說明內容，進行比對，確認 IAEA 目前審查情況，日方說法與本觀察團瞭解情況一致。

（七）討論日本的海域環境監測計畫

為瞭解日本針對 ALPS 處理水排放前後，所規劃執行之海域環境輻射監測計畫內容，本團於 3 月 25 日與東電公司綜合問答座談時，針對東電公司於 3 月 24 日公布之加強版海域監測計畫進行討論，有如下心得：

1. 目前東電公司對福島周邊海域的環境輻射監測計畫，是依據 2021 年 4 月 1 日 NRA 公布的綜合監測計畫來執行，為因應未來 ALPS 處理水的排放，自 2022 年 4 月起，東電公司將施行加強版的海域監測計畫，相對於原計畫，加強版計畫增加了取樣點、取樣頻率、樣本種類與降低最小可測量值。
2. 東電公司藉此計畫將建立 ALPS 處理水排放前，電廠周邊海域關鍵核種活度的基線數據，作為排放後對環境衝擊的比對基礎。此作法與我國現正執行的「國家海域放射性物質環境輻射監測及安全評估整

備計畫」不謀而合，若能建立技術合作管道，分享數據資料，將有助於雙方擴大瞭解海域輻射監測的狀況。

3. 加強版的海域監測計畫實施範圍包含電廠沿岸至福島縣沿岸 20 公里外海域，是 ALPS 處理水排放首先受影響區域，其監測結果是評估 ALPS 處理水對海洋生態環境實際影響的重要資料，後續須密切關注該計畫執行情形及監測結果，作為我國海域監測策略擬定與調整之參據。

4. 廠方為建立 ALPS 處理水排放前、中、後的環境中放射核種濃度數據比較基礎，因此需在排放前即開始執行，而降低氚最小可測量值的目的，除建立比對基礎數據外，也為驗證海洋擴散模擬的結果。我們可持續與東電公司及其委託執行氚水模擬擴散研究單位之電中研，進行技術交流與經驗分享，作為我國放射性物質海域擴散預警系統發展之參考。

5. 我方提出我國檢測實驗室定期參與國際實驗室間能力試驗及比較實驗，例如 IAEA 主辦之 Laboratory Proficiency Testing，檢測能力與國際間相當。因此，我們要求比照 IAEA 取樣海洋環境監測樣品帶回檢測，東電公司回應，這部份需日本政府同意，暫時無法回復，而相關環境採樣或量測比對工作，亦只接受與 IAEA 方面的實驗室間比對(Interlaboratory Comparisons, ILC)活動。我們可持續與日本方面協商，取得 ILC 比對樣品或東電例行檢測樣品，供國內實驗室分析確認。

6. 福島第一核電廠含氚 ALPS 處理水排放限值，日本政府要求氚濃度不可超過每公升 1,500 貝克，年排放總活度上限為 22 兆貝克，故就我國環境衝擊影響評估方面：可就我國鄰近海域或重要漁場海域，進行海水或水產放射核種背景值調查，建立含氚廢水排放前、後之背景資料庫供比對驗證。

7. 福島含氚廢水排放入海後，經模擬評估氚活度於底層海水處約每公升 0.06 貝克，而東電公司加強版海域監測計畫，亦下修氚的最小可測量值至每公升 0.1 貝克，此最小可測量值係目前國內實驗室尚無法達到。為因應未來外界要求取樣比對之需，我國宜規劃精進檢測技術。

8. 東電公司以質譜儀法執行海藻類碘 129 檢測，碘 129 屬易揮發之放射性物質，樣品前處理實驗室需具備抽氣及過濾等輻射防護設備，以確保人員安全及防止環境污染；此外，質譜儀法檢測低活度樣品會有同重素干擾（Isobaric Elemental Interferences）而影響定量準確度，檢驗人員必需受過專業訓練才能確保檢測數據之正確性，因此現階段建議先密切關注東電公司檢測結果，作為我國建立該檢測技術與否之評估依據。

四、建議事項

（一）海洋監測數據分享：日本福島第一核電廠 ALPS 處理水排放之影響評估，須依據放射性核種擴散模擬科學技術，及實際的海洋監測數據驗證。因此，我國應建立相關技術與監測能量，持續與日方以公開及比對的方式進行技術與結果分享，以確保對我國海域及漁獲不會產生不利影響或負面評價。

（二）ALPS 處理水排放符合安全標準之確認：東京電力公司宣稱，福島第一核電廠含氚廢水經 ALPS 淨化後，除處理水的氚須經稀釋外，其他放射性核種活度，亦均須符合安全標準才會排放。因此，我國宜持續與日方協調經由技術與資訊交流管道及實地觀察方式，以確認福島第一核電廠含氚廢水的處理及排放，確實符合東京電力公司所宣稱的安全目標。

（三）審查資訊公開：ALPS 處理水排放許可的審查，係日本核能管制機關的權責，但其審查標準須符合國際標準與規範，並公開其審查準則、過程、及結果。因此，我國宜持續要求日本將審查資訊即時公開，藉掌握國際相關規範與發展，以利外界核對資訊，為我國國民健康及權益把關。

五、結論與未來工作

本次我國組成專家觀察團赴日本東電公司福島第一核電廠，透過現場觀察及台日雙邊交流討論，瞭解其 ALPS 處理水之相關設施與未來排放規劃之目前實際進度，提出之結論如下：

(一) 依據謝主委向日方表達之三項訴求，觀察團透過日方安排，已比照 IAEA 行程於福島第一核電廠進行實地觀察，包括 ALPS 設施及 K4 槽區布建、ALPS 處理水的海邊排放規劃與現有進度、及 ALPS 處理水的核種化學分析程序，實地確認日方在 ALPS 處理水排放前之規劃執行進度。

(二) 針對日本核能管制單位的審查進度、及日本的海域環境監測計畫，與日方進行雙邊交流討論，已蒐集最新資訊及發展，作為我國後續因應方案擬訂之參考，達到觀察團訪日之任務。

(三) 我國仍應持續關注福島第一核電廠有關 ALPS 處理水之相關進展，並與日方保持交流管道，未來視需要再赴日實地瞭解，確認其符合國際規範所訂定之管制標準，以確保我國海域安全。

針對日本政府所公告之福島第一核電廠 ALPS 處理水的基本方針，透過本次觀察團赴日蒐集之相關訊息，彙整提出未來工作規劃，作為我國所需採取應變相關措施之重要方向:

(一) 放射性核種擴散模擬：持續與電中研專家進行技術交流，發展大尺度、中小尺度之海洋擴散的模擬運算模擬，透過執行「國家海域放射性物質環境輻射監測及安全評估整備計畫」，自主開發我國之擴散模擬系統。

(二) 生物氚分析檢驗技術：建立生物組織內自由水氚的標準分析流程，並透過 2023-2026 年度預定執行的「國家海域放射性物質擴散預警及安全評估應對計畫」，規劃魚種篩選(如秋刀魚)及建立人工養殖場，自主發展生物氚分析技術。

(三) ALPS 設施及 K4 槽區布建：持續關注福島第一核電廠 ALPS 設施之運作情形，追蹤待處理污水之淨化結果；密切注意日本發生地震、海嘯等天然災害是否影響 K4 槽區各儲槽之安全性。

(四) ALPS 處理水之海邊排放規劃：持續關注福島第一核電廠 ALPS 處理水排放作業之發展情形及施作放水立坑之執行進度，包括所需的引水管路、海水取水設施、混合稀釋設施等硬體設備，瞭解其設計之合理性。

(五) ALPS 處理水之核種化學分析程序：ALPS 處理水中 64 個核種分析方法需高度的專業，持續關注東電公司投入相關資源的動態及各項設備技術的建置情形。

(六) 日本核能管制單位審查進度：持續關注東電向 NRA 申請福島第一核電廠特定核子設施實施計畫變更之審查情形與結果；持續關注 IAEA 審查日本於廢水排放前、中、後之計畫與作業，確認符合國際安全標準。

(七) 日本海域環境監測計畫：持續關注日本加強版海域監測計畫實施情形及監測結果，作為我國海域監測策略擬定與調整之參據；密切注意東電公司公布之檢測結果。

六、參考資料[1]

1. https://radioactivity.nsr.go.jp/ja/contents/16000/15812/24/204_01_20210401r.pdf
2. https://www.kankyo-hoshano.go.jp/data/database/
3. TEPCO, Installation of New ALPS Treated Water Dilution/Discharge Facilties and Related Facilities, Page 18~20, Feb. 7, 2022
4. https://www.koryu.or.jp/Portals/0/nittaikankei/alps/20210624/0628_%E4%BA%A4%E5%8D%94ALPS%E5%BA%83%E5%A0%B1%E8%B3%87%E6%96%99_%E4%B8%AD%E6%96%87.pdf
5. TEPCO, Installation of New ALPS Treated Water Dilution/Discharge Facilties and Related Facilities, page 15, Feb. 7, 2022
6. TEPCO, Installation of New ALPS Treated Water Dilution/Discharge Facilties and Related Facilities, page 8 and 11, Feb. 7, 2022
7. TEPCO, Installation of New ALPS Treated Water Dilution/Discharge Facilties and Related Facilities, Page 17, Feb. 7, 2022
8. https://www.tepco.co.jp/zh-tw/decommission/progress/watertreatment/index-cn.html
9. 經查東電公司處理水入口網站公布之 ALPS 處理水(除氚之外的告示濃度比總和小於 1)及處理途中水(除氚外告示濃度比總和為 1 以上者)之各儲槽放射能濃度 ，其中 K4 槽區為 ALPS 處理水存放區，查碘-129 濃度為每公升 0.442~3.25 貝克(日本法定告示濃度限值為每公升 9 貝克)。
10. https://www.tepco.co.jp/zh-tw/decommission/progress/watertreatment/images/tankarea_en.pdftankarea_en.pdf

1 備註：參考資料之網址、網站文件資料，其瀏覽日期為 2022/04/28。

七、附錄

（一）觀察團掠影

1. 第一天行程之掠影紀錄

附圖 1、王主秘與趙處長於松山機場與觀察團成員合影。

附圖 2、日本台灣交流協會代表於松山機場與觀察團成員合影。

2. 第二天行程之掠影紀錄

附圖 3、徐博士與電中研日方專家會議前交流情形。

附圖 4、觀察團與電中研日方專家之會議討論情形。

附圖 5、電中研院區平面配置及電力系統陳列模型。


附圖 6、觀察團成員與日方專家步行至海嘯模擬實驗室。

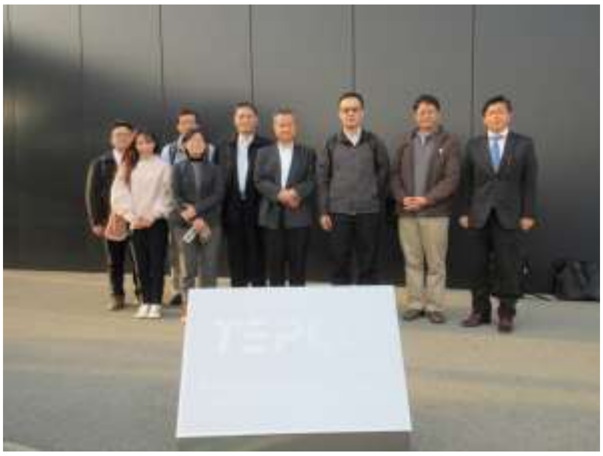

附圖 7、海嘯模擬實驗室之大型水槽及試驗水道。

3. 第三天行程之掠影紀錄


附圖 8、於廠區觀察一至二號機之除役作業情形、與廠方人員合影。


附圖 9、化學實驗棟之內部環境與實驗過程講解


附圖 10、現場人員進行分析化學試驗情形與分析中樣品



附圖 11、觀察團離廠前於福島第一核電廠與日方人員及東電幹部合影

4. 第四天行程之掠影紀錄

附圖 12、觀察團接受 NHK 媒體視訊專訪及後續新聞報導

（二）ALPS 處理流程及技術概要

福島第一核電廠地下水滲入爐心之產生之污染水，現以美國 Energy Solutions 公司研發之「先進廢水處理系統」(或稱多核種除去設備)，處理氚以外之 62 種核種。ALPS 先採共沉澱法去除鐵、鈣、鎂等影響吸附效能離子，再經吸附法去除各核種。

吸附法係選用具選擇性吸附核種之無機吸附劑，其關鍵材料如附表 1，此部分為 ALPS 之核心技術。ALPS 設施之系統架構主要由 3 個處理單元組成，如附圖 13：

1. 鐵共沉澱處理設施：

   主要是藉由加入含鐵沉澱劑(Nickel hexacyanoferrate $M_2NiFe(CN)_6$)與水中核種形成化合物，使其共同沉澱，藉以去除水中之核種。

2. 碳酸鹽共沉澱處理設施：

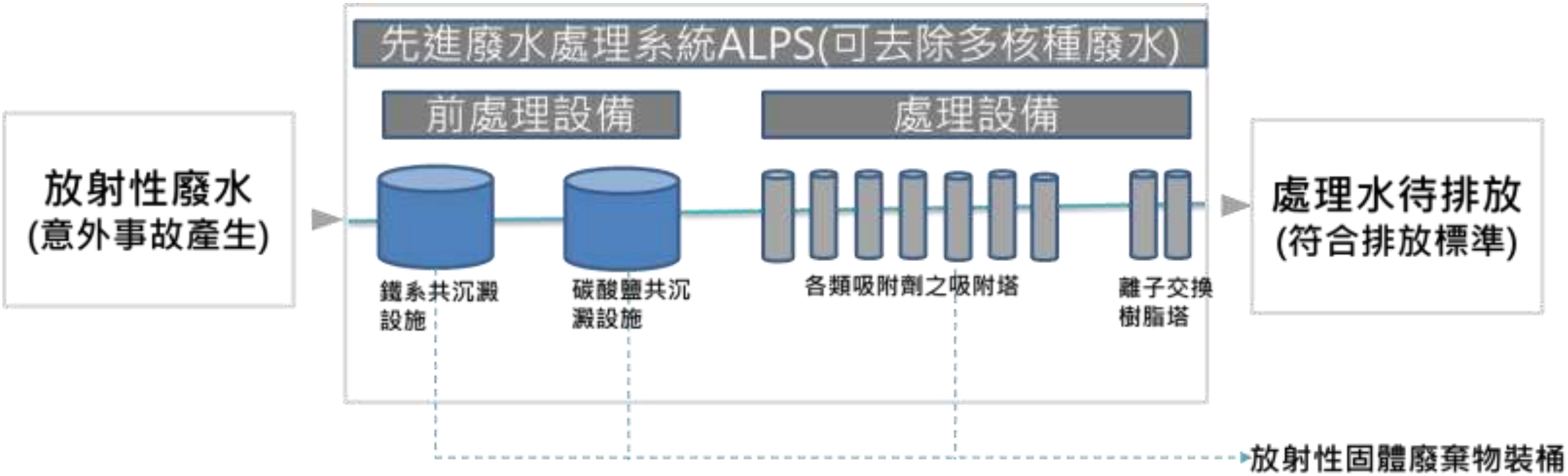
   藉由加入含碳酸鹽沉澱劑，以去除水中所含會妨礙核種吸附作用之鈣、鎂離子。

3. 吸附塔:

   運用 14 個相連的吸附塔，其內部填充活性碳、鈦酸鹽、鐵氰酸鹽等無機吸附劑；再連接 2 個填充塔，其內部填充離子交換樹脂，去除廢水中 62 種放射性核種。

附表 1、ALPS 關鍵處理單元及核心材料

處理單元	共沉劑/吸附劑	去除核種之功效	備註
鐵系共沉澱	亞鐵氰酸鎳鹽 $M_2NiFe(CN)_6$	Alpah 核種、錳 54 等核種	提升處理效能，減少二次廢棄物量
碳酸鹽共沉澱	碳酸鹽	以去除會妨礙吸附作用之鈣、鎂離子	
吸附劑	表面含浸銀活性碳	碘 129	具選擇性之吸附劑
	鐵氰酸鹽系吸附劑	銫 134 等其他單價核種	
	鈦酸鹽系吸附劑	鍶 90 等其他二價或三價核種	
	氧化鈦系吸附劑	銻 125 等	
離子交換樹脂	無選擇性樹脂	所有殘餘微量核種	傳統之水處理材料



附圖 13、ALPS 之主要處理單元及流程

補充資料一、IAEA 2 月份現場視察內容(IAEA review team conducts field inspection during safety review of ALPS treated water at the Fukushima Daiichi Nuclear Power Station)

資料來源：

TEPCO, IAEA review team conducts field inspection during safety review of ALPS treated water (February 15) at the Fukushima Daiichi Nuclear Power Station, Feb. 16, 2022

IAEA review team conducts field inspection during safety review of ALPS treated water (February 15) at the Fukushima Daiichi Nuclear Power Station

<Reference Material>
February 16, 2022
Tokyo Electric Power Company Holdings, Inc.
Fukushima Daiichi D&D Engineering Company

○ A review team from the International Atomic Energy Agency (IAEA) has been in Japan since February 14 to perform a review of the safety of water treated with multi-nuclide removal equipment (ALPS treated water) at the Fukushima Daiichi Nuclear Power Station.

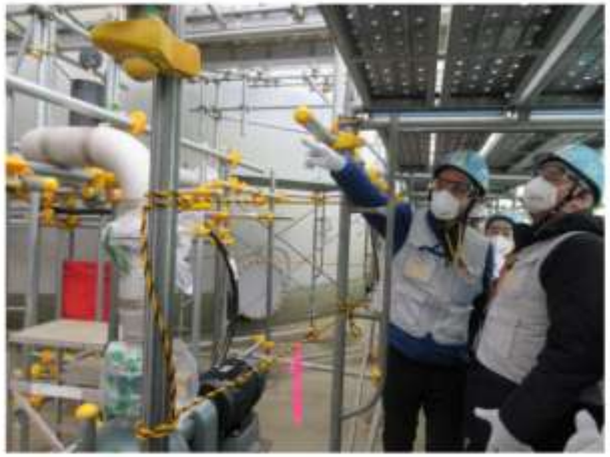
○ On the 15th, the IAEA review team visited the Fukushima Daiichi Nuclear Power Station and conducted a field inspection of ALPS-related facilities, etc.

※Members of the preparatory meeting that arrived in Japan prior to this review conducted a field inspection on February 8.

High-ground area

High-ground area

Photos taken by Tokyo Electric Power Company Holdings, Inc. on February 15, 2022



K4 tank area

Supervising sampling

Sea side of Units 5 and 6

Sampling

Photos taken by Tokyo Electric Power Company Holdings, Inc.
on February 15, 2022

〈Reference〉 Field inspection by IAEA review preparatory meeting members (February 8)

Additionally installed multi-nuclide removal equipment

K4 tank area

Chemical analysis building

← →

Photos taken by Tokyo Electric Power Company Holdings, Inc. on February 8, 2022

補充資料二、ALPS 處理水排放之相關申請內容(Application for approval to amend the Implementation Plan Regarding the Handling of ALPS Treated Water)

資料來源：

TEPCO, Application for approval to amend the Implementation Plan Regarding the Handling of ALPS Treated Water [Overview], Dec. 21, 2021

Attachment 1

Application for approval to amend the Implementation Plan Regarding the Handling of ALPS Treated Water [Overview]

TEPCO

December 21, 2021

Tokyo Electric Power Company Holdings, Inc.

Introduction

TEPCO

- Taking into consideration the Japanese government's basic policy decided in April, a review of details of the design and operation of facilities for the handling of ALPS treated water at Fukushima Daiichi Nuclear Power Station has been in progress with safety as a major premise to take thorough actions to minimize adverse impacts on reputation.
- The status of review has been presented in past the Commission on Supervision and Evaluation of the Specified Nuclear Facilities and in the Status of Review Regarding the Handling of ALPS Treated Water (announced on August 25, 2021).
- The status of review of details of design and operation of facilities to secure safety presented on August 25 have been summarized. Based on this summary, we have submitted the Application documents for Approval to amend the Implementation Plan for Fukushima Daiichi Nuclear Power Station Specified Nuclear Facility to the Nuclear Regulation Authority (NRA).
- TEPCO will continue to carefully listen to the opinions from people in the region and parties concerned and will incorporate opinions into the design and operations of facilities as appropriate.

1. Overview of the Implementation Plan

TEPCO

Ⅱ 2.50 ALPS treated water Dilution/Discharge facility and related facilities

・The details of design of the following major equipment were added to the Implementation Plan.

1. Measurement/confirmation facility
2. Transfer facility
3. Dilution facility
4. Discharge facility

Ⅲ Part 3 Supplementary Explanation of Security

2 Supplementary explanation on radioactive waste management

・The followings regarding the discharge of ALPS treated water into the sea were added

1. Management method
2. Dose assessment
3. Action in response to the Basic Policy on handling of ALPS treated water at the Tokyo Electric Power Company Holdings' Fukushima Daiichi Nuclear Power Station, and the radiological impact assessment on the environment

2-1. Overview of ALPS Treated Water Dilution/Discharge Facility

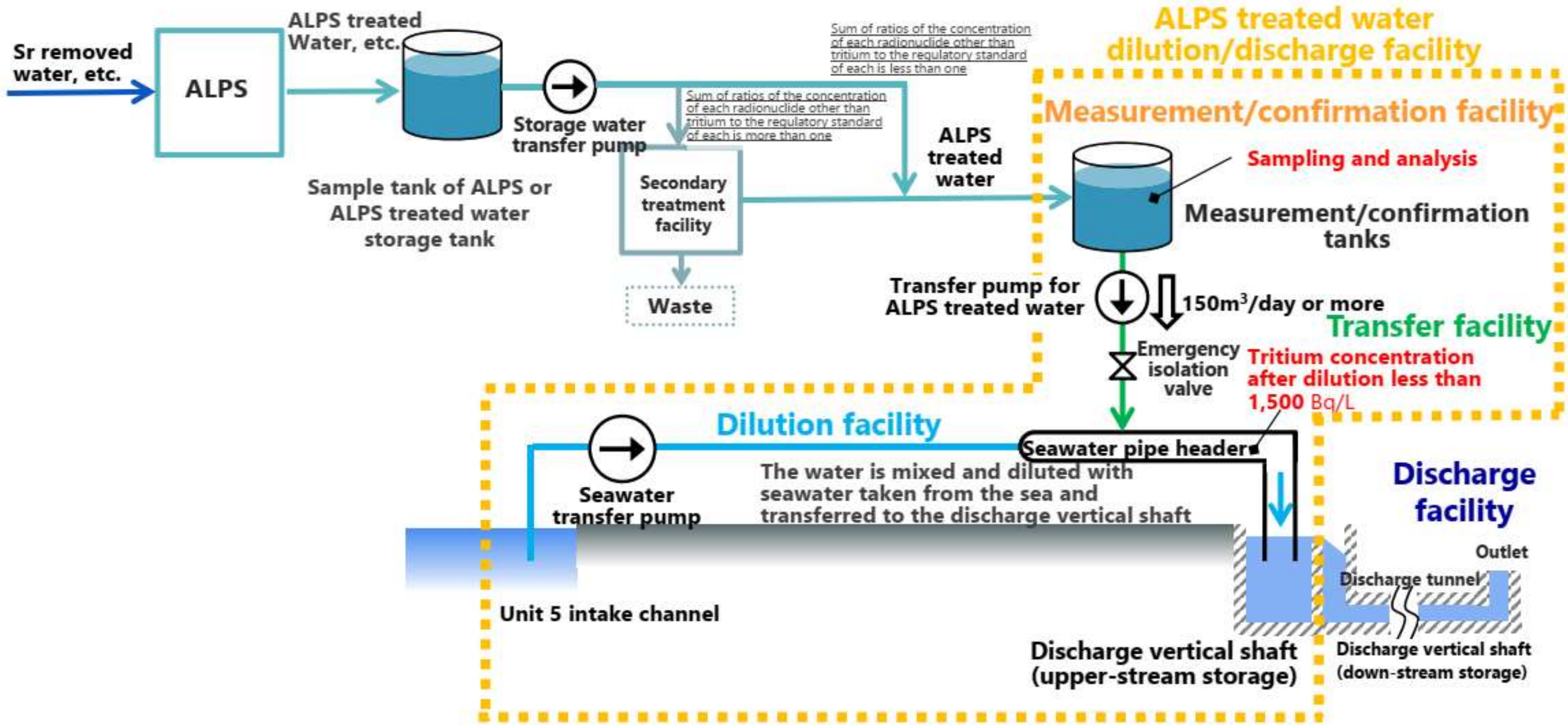
TEPCO

Objective

Water from which radioactive nuclides has been removed using ALPS until the radionuclide concentration is at a sufficiently low concentration, will be diluted with seawater and discharged into the sea after confirming that the water meets the regulatory requirements (water with the sum of ratios of legally required concentrations, excluding tritium, less than 1).

Facility overview

In the measurement/confirmation facility, once the radionuclide in the water in the measurement/confirmation tank are uniformly dispersed, samples are taken and analyzed to confirm the water meets regulatory standards. The ALPS treated water is then transferred to the seawater pipe header using the transfer facility and mixed with the seawater taken from the Unit 5 intake channel using the dilution facility until the tritium concentration is below 1,500 Bq/L. This is then discharged using the discharge facility.



3

2-2. ALPS Treated Water Dilution/Discharge Facility (Measurement/Confirmation Facility)

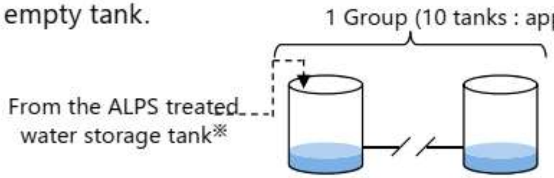
TEPCO

■ Measurement/confirmation facility

- K4 area tanks (total : approx. 30,000 m³) will be co-opted as measurement and confirmation tanks. 10 tanks of each will be taken from groups A, B, and C (each tank has a capacity of around 1,000 m³).
- Each tank group is charged with processes ① through ③ in rotation, and in the ② Measuring/confirmation process, water that has been made uniform through circulating and stirring will be sampled and analyzed.

①Receiving process

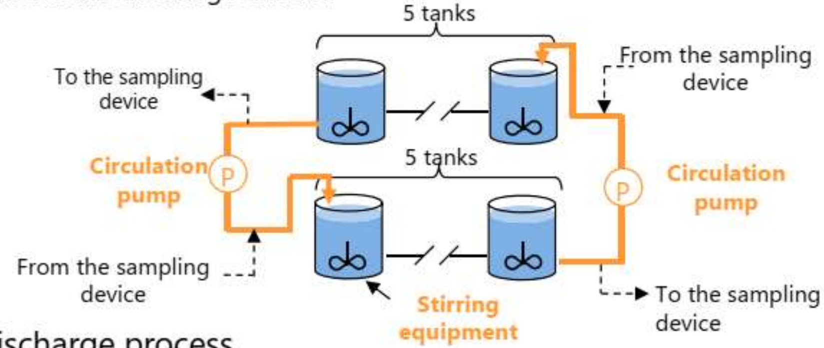
Receive ALPS treated water from the ALPS treated water storage tank into an empty tank.



※Existing transfer pipes will be used in receiving water

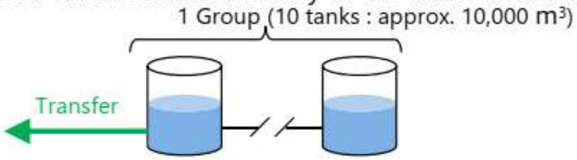
②Measuring/confirmation process

After making the quality of the water in the tanks uniform using the stirring equipment and circulation pumps, samples are taken to see if the water meets the discharge criteria.

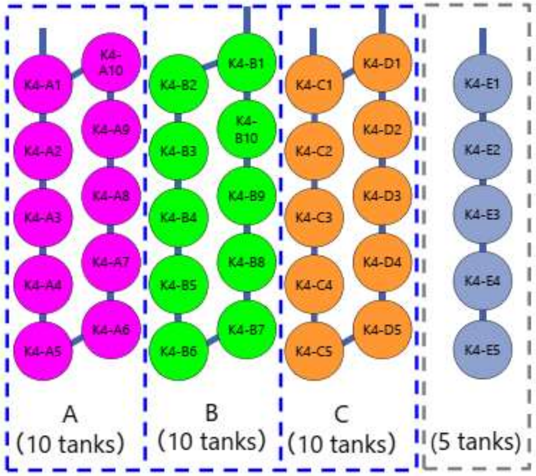


③Discharge process

After confirming the water meets the discharge criteria, the ALPS treated water is transferred via the transfer facility to the dilution facility.



K4 area tanks: 35



2.50 ALPS treated water dilution/discharge facility

2.5 Multi-nuclide treated water storage tanks

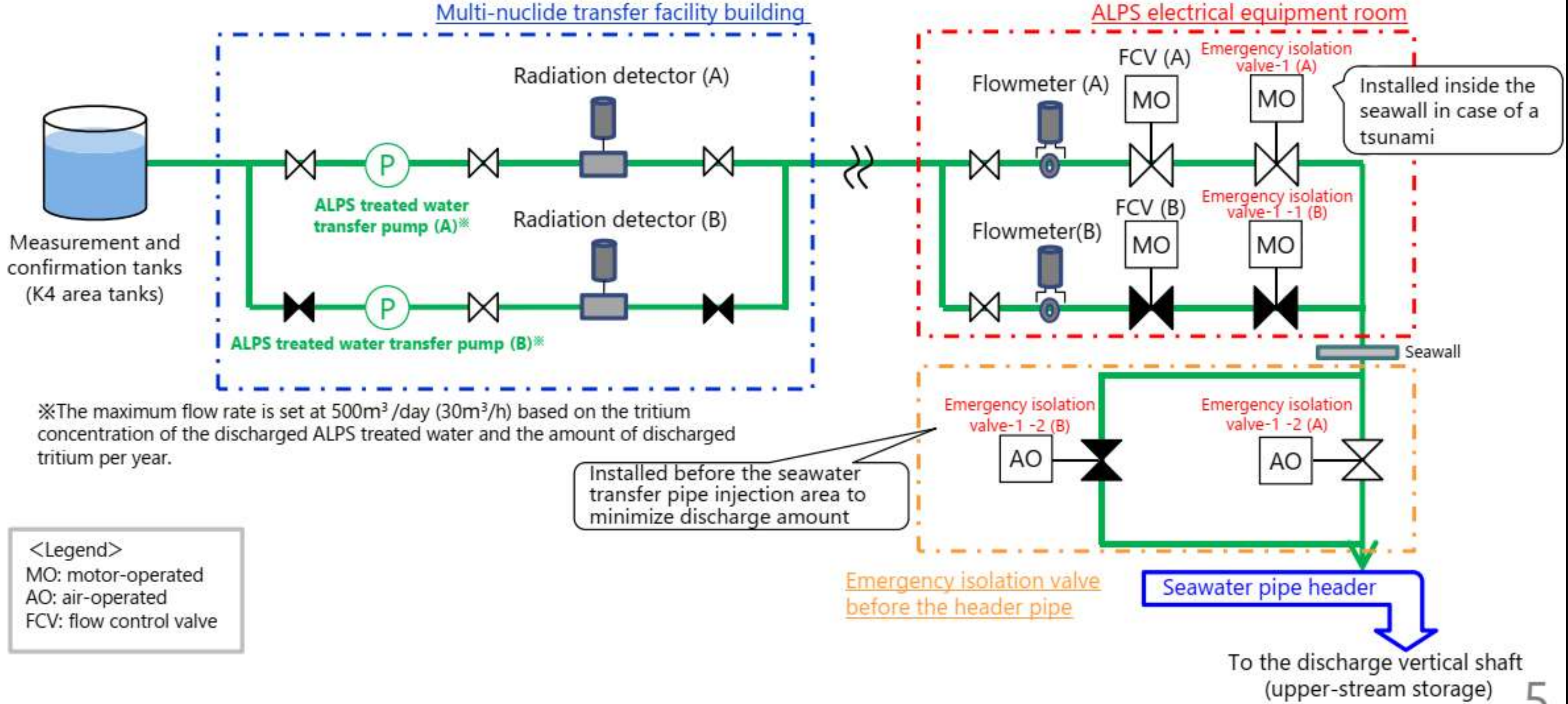
	A	B	C
1st round	Receiving	—	—
2nd round	Measurement and confirmation	Receiving	—
3rd round	Discharge	Measurement and confirmation	Receiving
4th round	Receiving	Discharge	Measurement and confirmation
…	Measurement and confirmation	Receiving	Discharge

4

2-3. ALPS Treated Water Dilution/Discharge Facility (Transfer Facility)

TEPCO

- Transfer facility
  - The transfer facility is comprised of the ALPS treated water transfer pumps and transfer pipes.
  - ALPS treated water transfer pump is comprised of two units, the operating unit and the reserve. It transfers the ALPS treated water from the measurement and confirmation tank to the dilution facility.
  - Two emergency isolation valves will be installed, one before the seawater pipe header to be able to stop transfer swiftly in an emergency and another inside the seawall, as a tsunami measure.



※The maximum flow rate is set at 500m³/day (30m³/h) based on the tritium concentration of the discharged ALPS treated water and the amount of discharged tritium per year.

<Legend>
MO: motor-operated
AO: air-operated
FCV: flow control valve

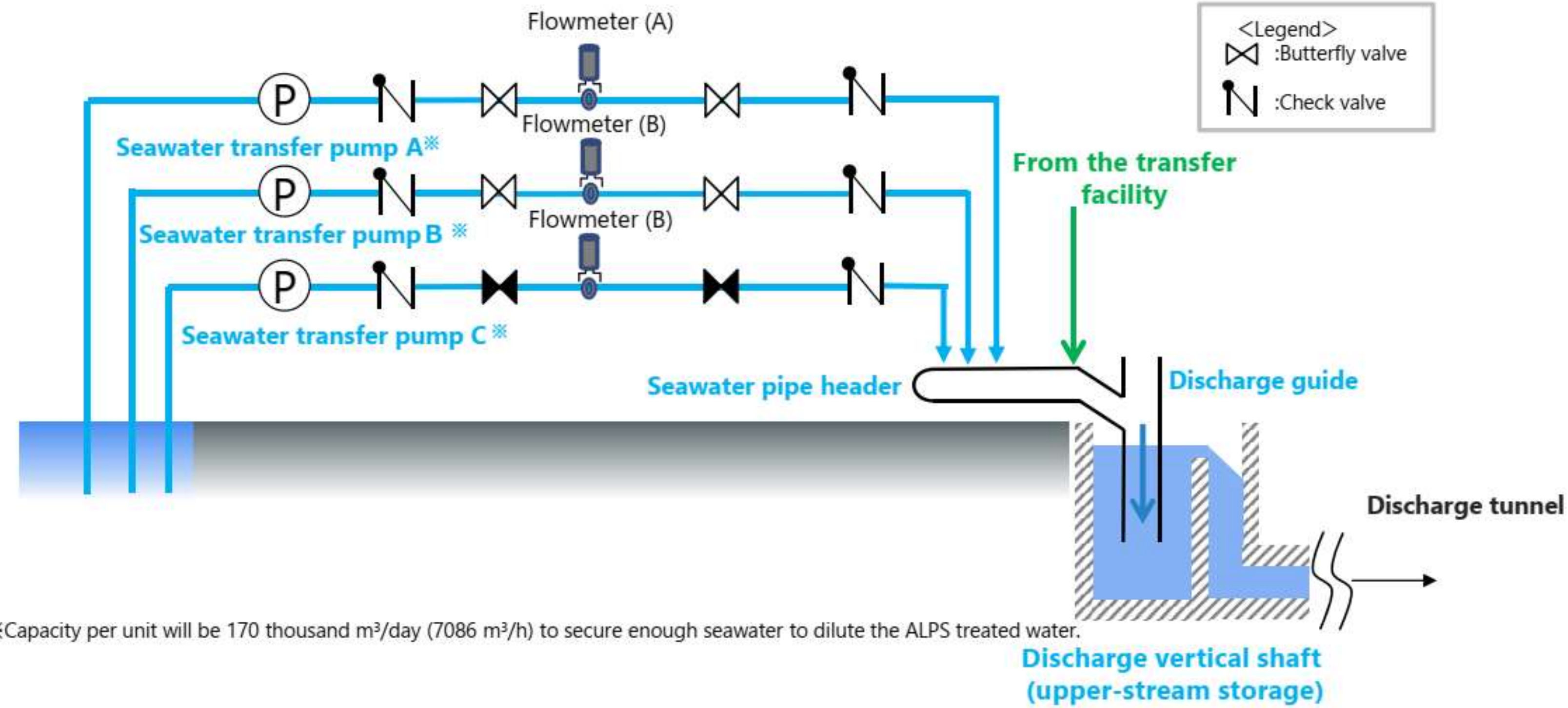
5

2-4. ALPS Treated Water Dilution and Discharge Facility (Dilution Facility)

TEPCO

■ Dilution facility

- The dilution facility is comprised of the seawater transfer pump, seawater pipe (including header pipe), discharge guide, and discharge vertical shaft (upper-stream storage). It will dilute ALPS treated water using sweater and then transfer the diluted water to the discharge vertical shaft (upper-stream storage), and to the discharge facility.
- The seawater transfer pump will have a capacity that allows ALPS treated water transferred using the transfer facility to be diluted by more than 100 times.



※Capacity per unit will be 170 thousand m³/day (7086 m³/h) to secure enough seawater to dilute the ALPS treated water.

6

3-1. Objective and facility overview of related facilities (Discharge Facility)

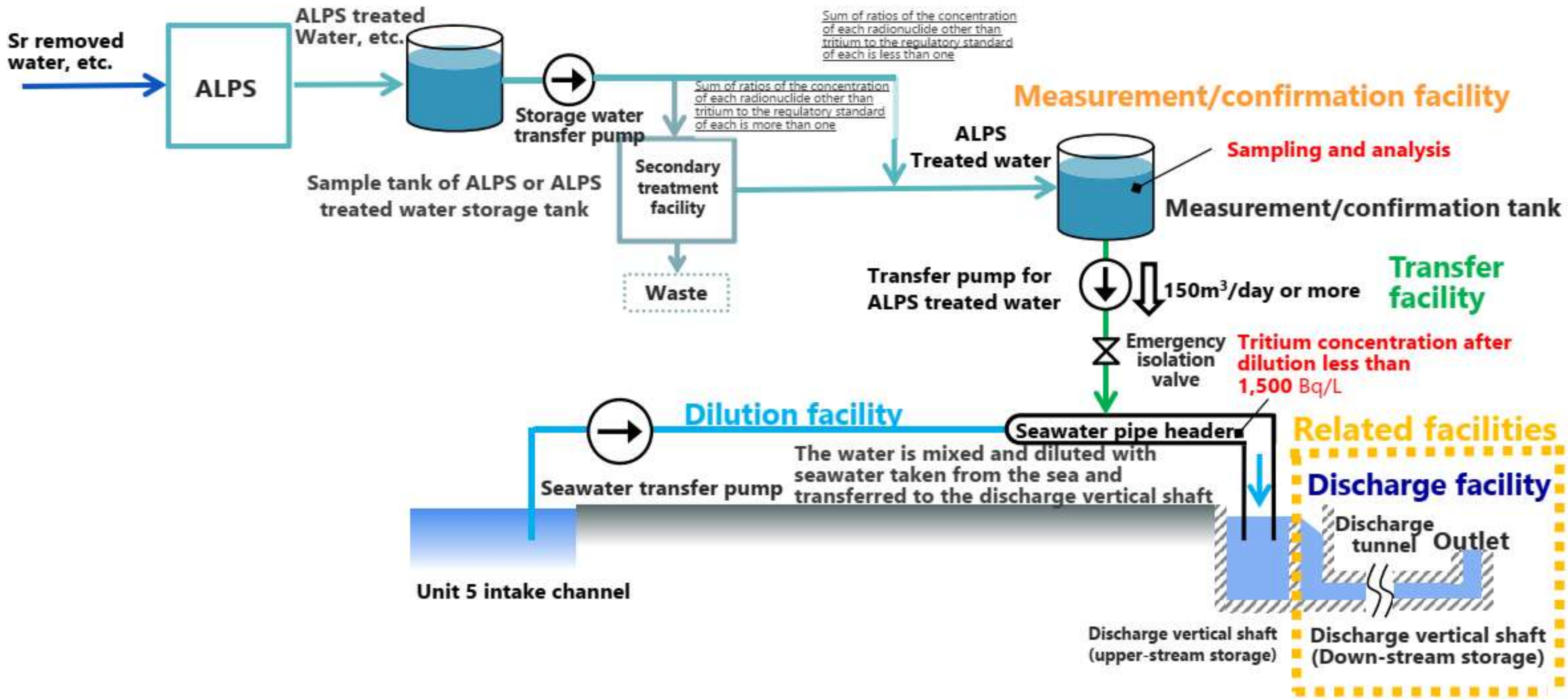
TEPCO

Objective

To discharge the water that is released from the ALPS treated water dilution/discharge facility (water diluted by seawater and has been confirmed to be sum of ratios of legally required concentrations, including tritium, is less than 1) into the sea at a location 1km from the Fukushima Daiichi Nuclear Power Station.

Facility overview

The discharge facility will be comprised of the discharge shaft (down-stream storage), discharge tunnel and discharge outlet to achieve the objective above.

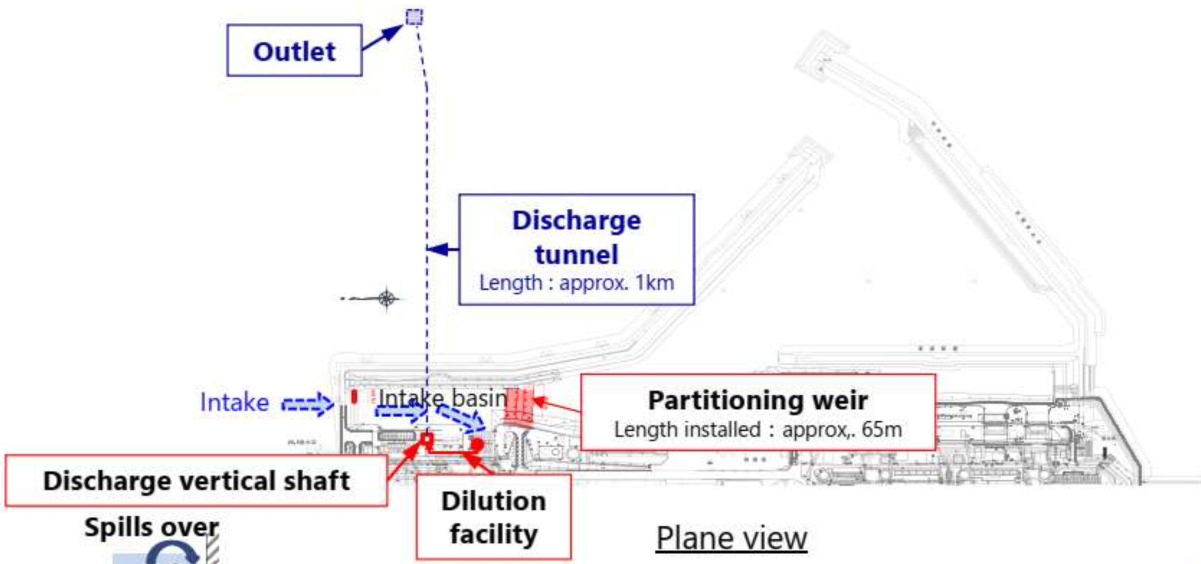


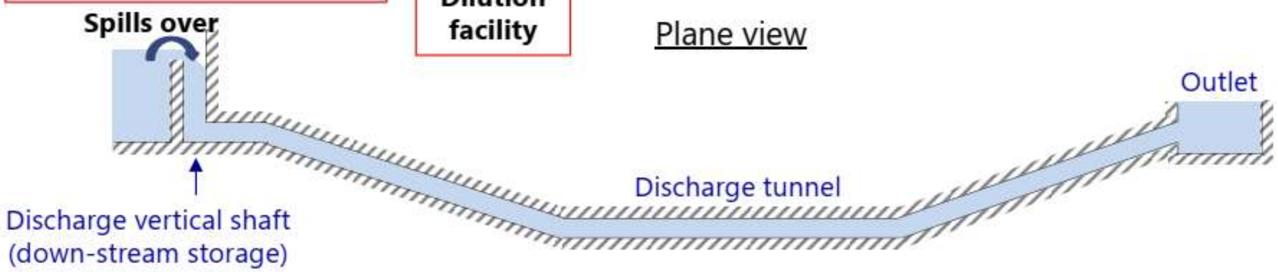
7

3-2. Overview of related facilities (Discharge Facility) (1/2)

TEPCO

- Discharge facility
  - The discharge facility is designed so that the water that has spilled over the partition in the discharge vertical shaft will be transferred to the outlet 1 km away due to the differential head between the discharge vertical shaft (down-stream storage) and sea surface. The design will take into account friction loss and rising water levels in the discharge facility.





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3-3. Overview of related facilities (Discharge Facility) (2/2)

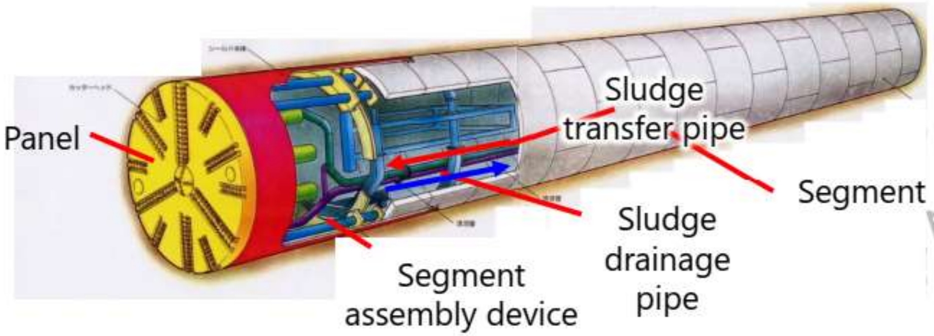
TEPCO

Overview of structural design

- Because it goes through the rock base layer, the structure will be highly resistant against any earthquakes and the risk of water leakage will be low.
- The shield method will be used in construction. It will be made waterproof through the use of two layers of sealing material in the reinforced concrete segment.
- The tunnel structure (segment) is designed considering the effects of typhoons (high waves) and storm surges (sea level rise).

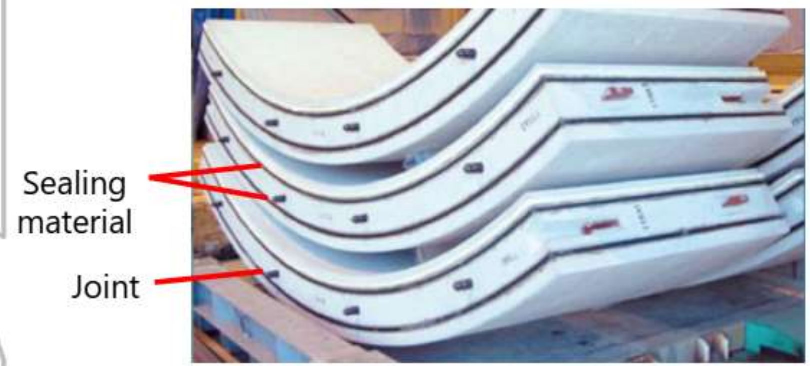
Tunneling (shield method)

- There are many examples of seabed tunnels being built using shield method and therefore the probability of any problems occurring is deemed low by secure construction work.



*The slurry shield tunneling will be used for this project

Overview of shield machine

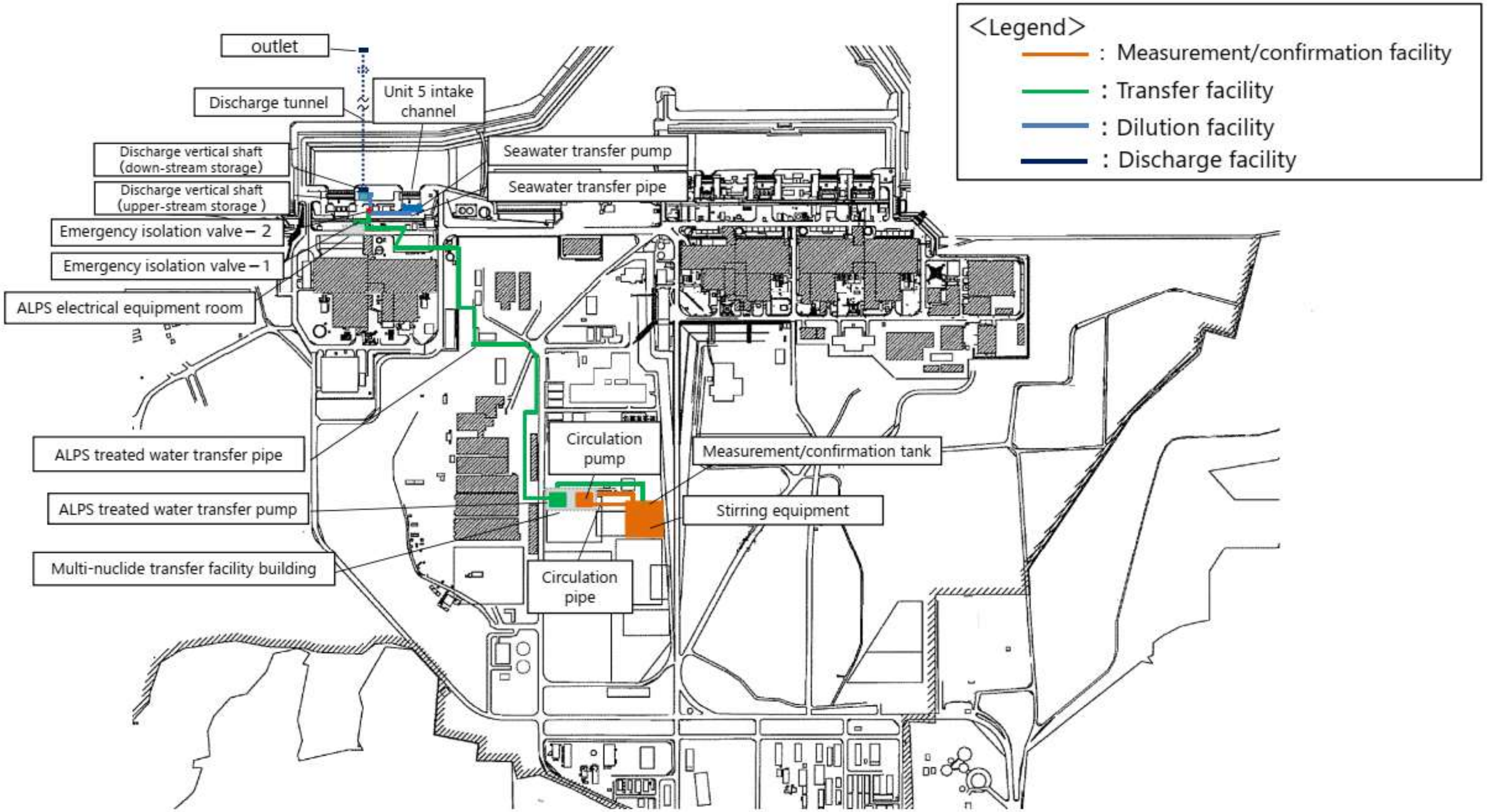


Segment

4. Site plan for the ALPS treated water dilution/discharge facility and related facilities

TEPCO

- The ALPS treated water dilution/discharge facility and related facilities will be located as follows.

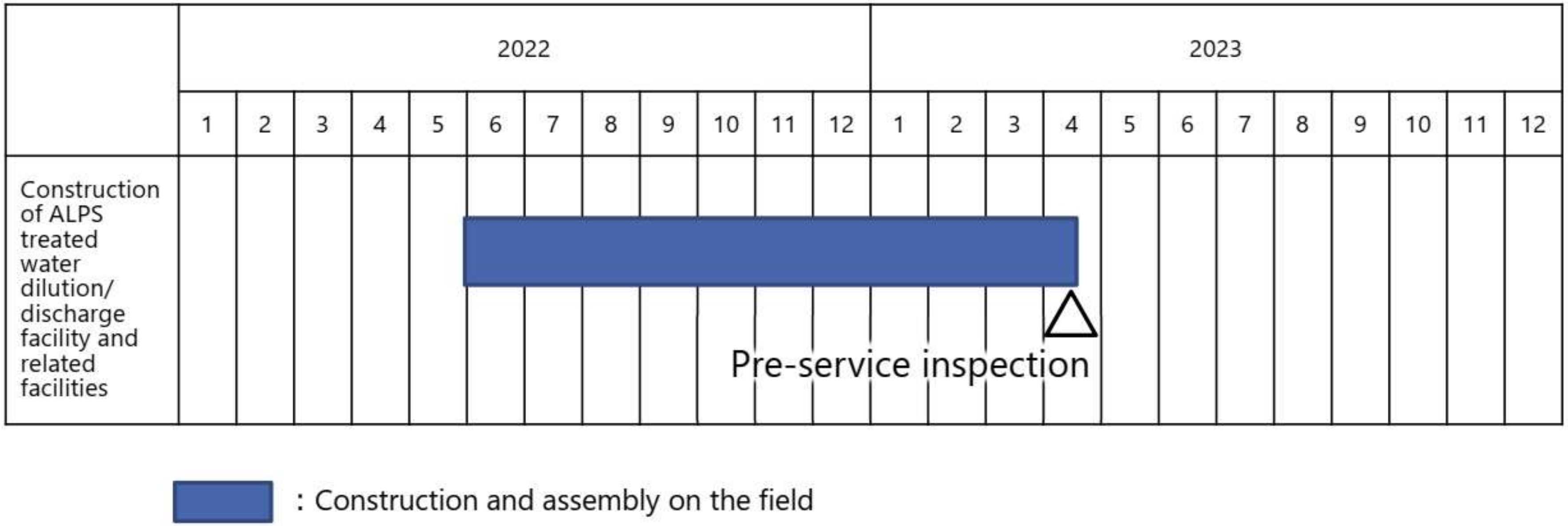


10

5. Construction schedule for the ALPS treated water dilution/discharge facility and related facilities

TEPCO

- Subject to the approval of the Nuclear Regulation Authority (NRA), construction and assembly on the field will begin, and facilities are scheduled to be completed around mid-April 2023.



6. Supplementary explanation regarding radioactive waste management (III)

TEPCO

- Overview

  Management methods to reduce the amount of radionuclide using ALPS in treated water from the contaminated water treatment facility and treatment facility outlet water, and to dilute ALPS treated water (water that meets the criteria that the sum of ratios of legally required concentrations, excluding tritium, is less than 1) with seawater and discharge it, and assessment of the dose at the station site boundary impacted by the discharge of ALPS treated water will be explained here.

- Management method

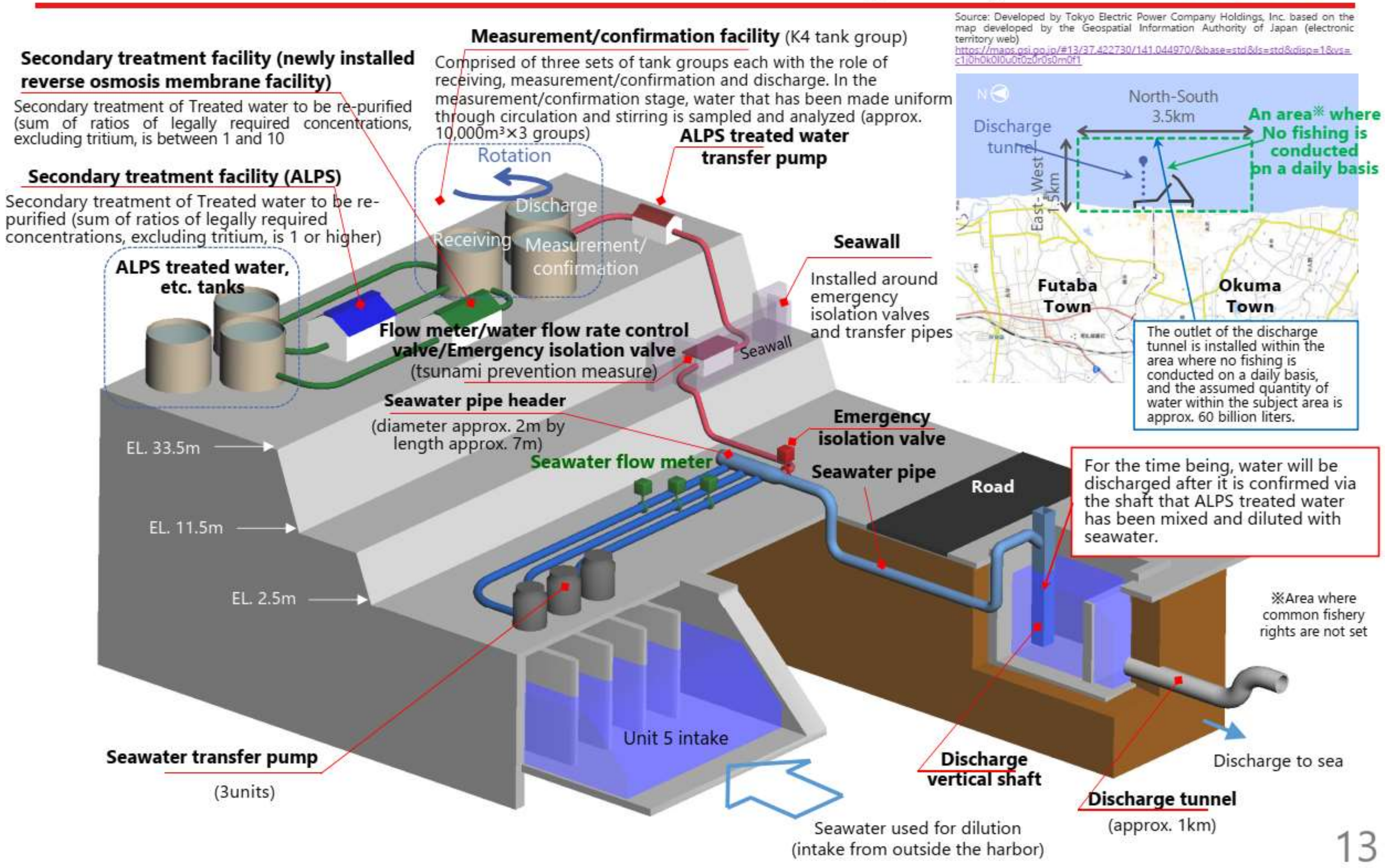
  Samples are taken from the measurement/confirmation facility before discharge, and tritium and other radionuclide are analyzed to confirm that the water meets ALPS treated water criteria. The water is then diluted with seawater in the dilution facility to reduce the tritium concentration, and then discharged.
  - It is confirmed in measurements that the sum of ratios of legally required concentrations, excluding tritium, is less than 1 for ALPS treated water.
  - The discharge flow rate and the diluting seawater flow rate will be set so that the tritium concentration in the discharge vertical shaft (upper-stream storage) is less than 1500Bq/L and the seawater dilutes the ALPS treated water by more than 100 times.
  - The amount of tritium discharged will be less than 22 trillion Bq per year.

- Dose assessment

  The effective dose evaluation value at the site boundary due to the discharge of ALPS treated water is 0.035 mSv/year. As such, there will be no change to the effective dose evaluation value due to the discharge of radioactive liquid waste (0.22mSv/year).
  - Contributions of tritium to the dose are conservatively evaluated to be 0.025 (1500/60,000) as a ratio against the legally required concentration of 60,000 Bq/L, since it will be diluted by seawater until the dose is less than 1500 Bq/L.
  - Contributions of radioactive nuclides other than tritium are conservatively evaluated to be 0.01 (1/100) as a sum of ratios of legally required concentrations, since it will be diluted by more than 100 times with seawater after it is confirmed that the sum of ratios of legally required concentrations in the measurement/confirmation facility is less than 1.

12

(Reference) Overview of facilities for securing safety



補充資料三、ALPS 過濾器破損說明(Multi-nuclide removal equipment and high integrity container exhaust filters)

資料來源：TEPCO, Multi-nuclide removal equipment (ALPS) and high integrity container (HIC) exhaust filters (Update 2), Sep. 21, 2021

Multi-nuclide removal equipment (ALPS) and high integrity container (HIC) exhaust filters (Update 2)

< Reference document >
September 27, 2021 Tokyo Electric Power Company Holdings, Inc. Fukushima Daiichi Decontamination & Decommissioning Engineering Company

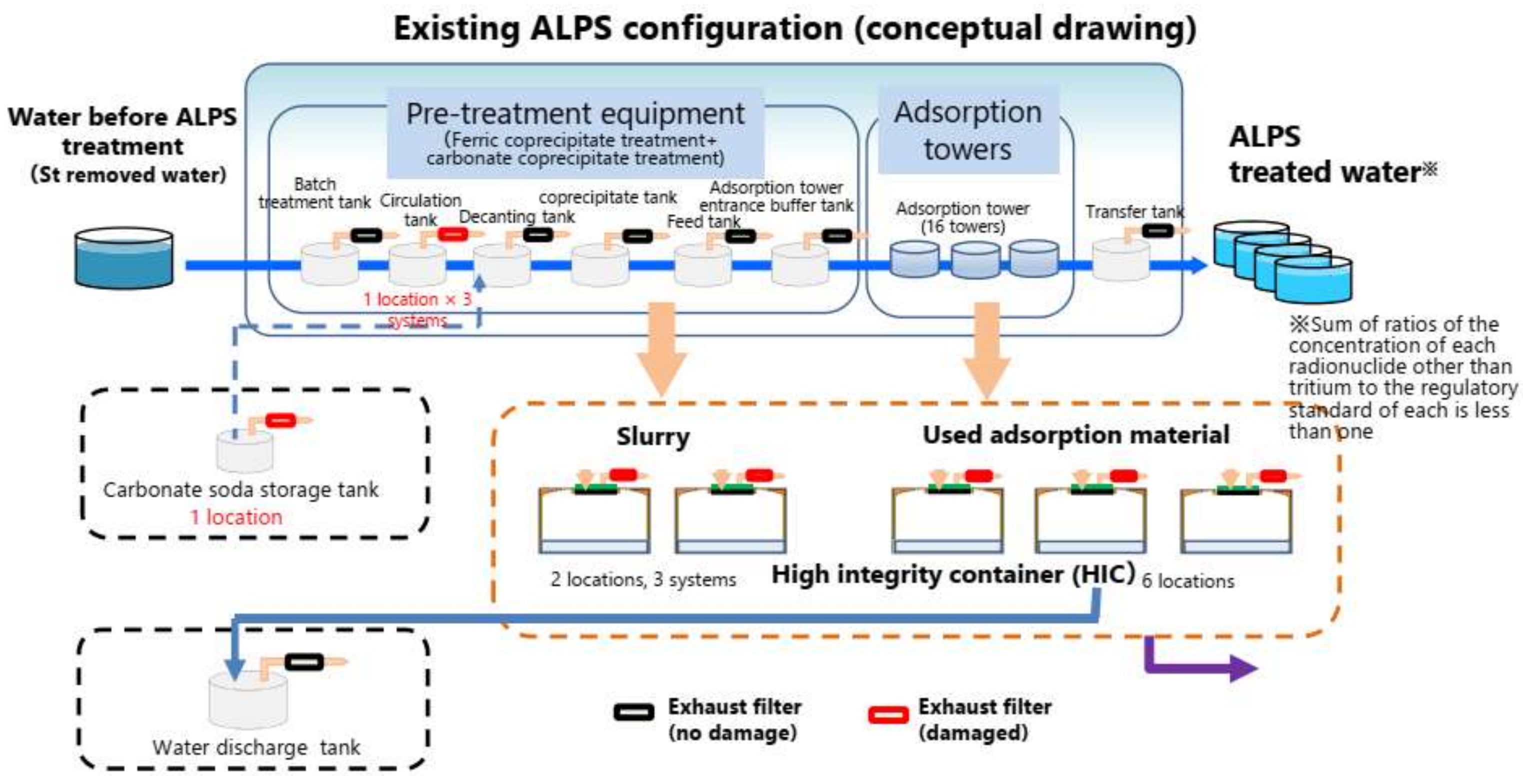
- In light of the damage sustained to the high integrity container (HIC) exhaust filters in multi-nuclide removal equipment (ALPS), inspections of the exhaust filters used in ALPS (Additionally installed ALPS: 18 locations; existing ALPS: 28 locations; high-performance ALPS: 5 locations) were started on September 17.
- Inspections for the additionally installed ALPS were completed by September 20. And filters in 4 out of the 18 locations were found to be damaged.
- Inspections of 11 out of the 28 locations have been completed for existing ALPS as of September 20 and exhaust filters in 1 location has been found to be damaged.

(The above was announced on September 21)

- Inspections of exhaust filters in existing ALPS and high-performance ALPS (including ancillary equipment) were continued after September 20, and all inspections were completed as of September 24.
- Inspections found that exhaust filters in 4 out of the 28 locations*1 (including the 1 location announced on September 21) were damaged. No damage was identified in the filters for high-performance ALPS (5 locations).
- Exhaust filters are an ancillary equipment that is not related to the purifying function. Damage to the exhaust filter does not affect ALPS purification performance or treatment of water.
- The exhaust filters found to be damaged here will be gradually replaced or alternative filters installed. Permanent measures will be implemented in accordance with results of an investigation for the cause of damages.

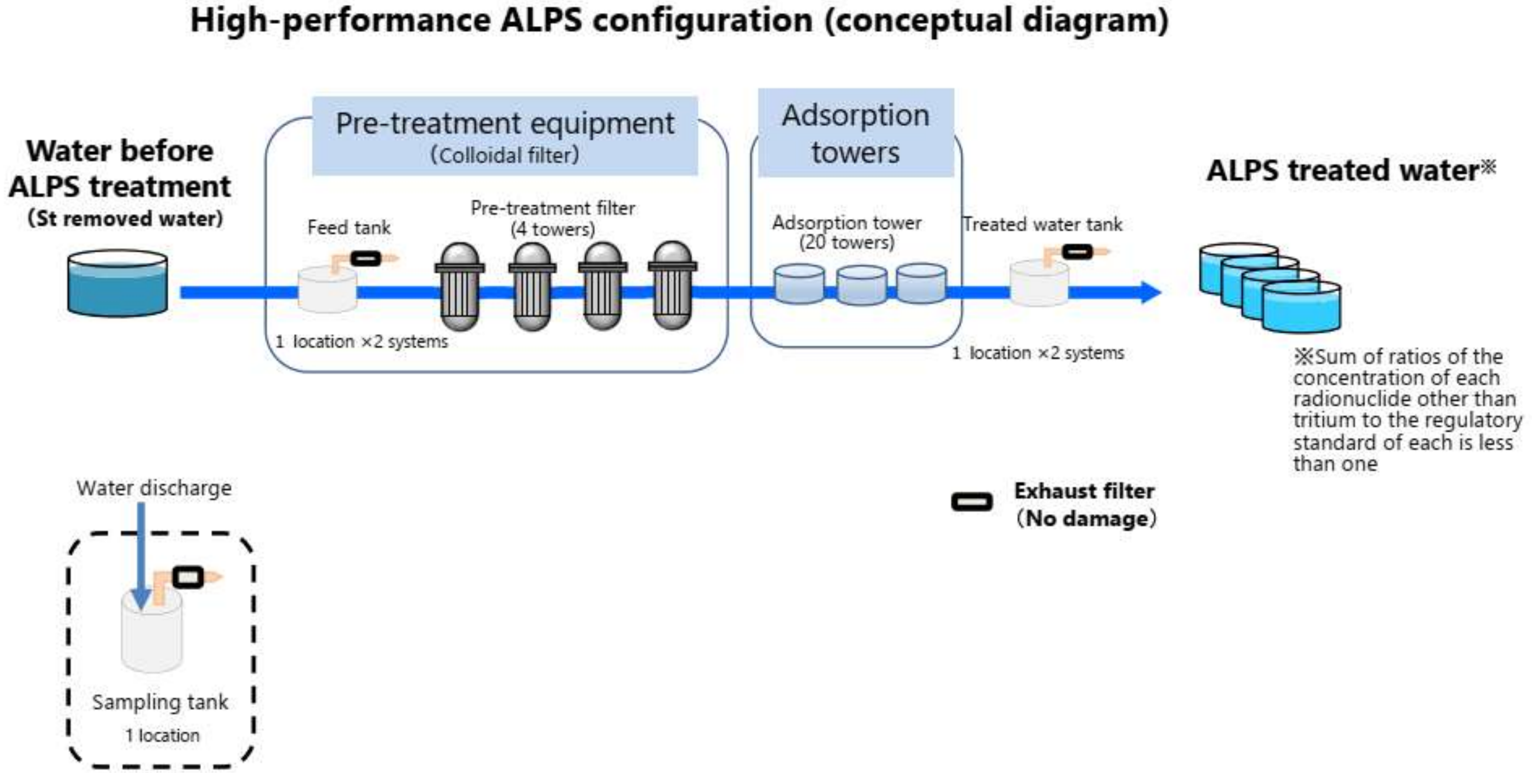
※1 Carbonate soda storage tank: Tank for supplying chemicals used in pretreatment facilities
Circulation tank A, circulation tank B, circulation tank C: tanks that feed ferric coprecipitate slurry generated in the batch processing tank to the cross flow filter

System configuration of the existing ALPS



2

System configuration of high-performance ALPS



3

Exhaust filter inspection results for ALPS facilities

Type of filter	Additionally installed ALPS		Existing ALPS		High-performance ALPS	
	No damage	Damaged	No damage	Damaged	No damage	Damaged
HIC exhaust filter	0	13	1	11	-	-
Other exhaust filters	14	4※2	24	4※1	5	0
Total	14	17	25	15	5	0
	31		40		5	

※1 : Carbonate soda storage tank, circulation tank A, circulation tank B, circulation tank C.
※2 : Carbonate soda storage tank 1, precipitation tank, feed tank, discharge tank

補充資料四、環境衝擊評估相關資料(Radiological Impact Assessment Report Regarding the Discharge of ALPS Treated Water into the Sea [Design stage])

資料來源：TEPCO, Radiological Impact Assessment Report Regarding the Discharge of ALPS Treated Water into the Sea (Design stage) [Overview], Nov. 17, 2021

Attachment 1

Radiological Impact Assessment Report Regarding the Discharge of ALPS Treated Water into the Sea (Design stage*) [Overview]

TEPCO

November 17, 2021

* The assessment in this report will be revised as appropriate based on progress in discussions around design and operation of plans regarding discharged into the sea, opinions from relevant parties, reviews by IAEA experts, and cross check assessments by third parties.

About the Assessment

TEPCO

- Following the Japanese Government's Basic Policy on the Handling of ALPS Treated Water, TEPCO developed a methodology to assess the radiological impact on the public and the environment when discharging ALPS treated water into the sea assuming that designs and operations being considered by TEPCO in accordance with internationally recognized methods (as found in the International Atomic Energy Agency (IAEA) Safety Standard documents and International Commission on Radiological Protection (ICRP) recommendations).
- Assessment following this methodology indicated that effects of the discharge of ALPS treated water into the sea on the public and the environment is minimal as calculated doses were significantly less than the dose limits, dose targets, and the values specified by international organizations for each species.
- As going through the necessary procedures to gain the Nuclear Regulation Authority(NRA)'s approval of the implementation plan, TEPCO will revise the assessment based on IAEA experts' reviews and input/review by relevant parties.
- TEPCO will continue to disseminate, in a transparent manner, scientific information regarding the radiological impact on the public and the marine environment to foster understanding and expel concerns for people at home and abroad.

TEPCO will strictly comply with various laws and regulations and the Government of Japan regulatory standards that conform to international recognized technical documents (IAEA safety standards and ICRP recommendations) on the concentrations of tritium and other radioactive materials in the water to be discharged to secure the safety of the public and the environment.

1

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1. DISCHARGE METHOD OF PRECONDITIONS FOR ASSESSMENT
2. ASSESSMENT METHODS
3. ASSESSMENT RESULTS
4. REFERENCES

Discharge method of Preconditions for Assessment

TEPCO

- The ALPS treated water to be discharged is purified until the sum of the ratios of legally required concentrations*(hereinafter "the sum of the ratios") of 62 radionuclides and Carbon-14, other than tritium, is less than one.
- The concentration of all 64 nuclides are measured and assessed (including measurement and assessment by third parties) before discharge to confirm the water meets the regulatory standard.
- The annual amount of tritium discharged will be less than 22 TBq, the discharge management target for the Fukushima Daiichi Nuclear Power Station (FDNPS) before the Accident.
- In discharge, the ALPS treated water will be diluted by seawater by 100 times or more so that the tritium concentration at the discharge outlet will be less than 1,500 Bq/L. Through this process, "the sum of the ratios" of 62 radionuclides and Carbon 14 other than tritium, will be also diluted to less than 1/100.
- The diluted ALPS treated water will be discharged at the bottom of the sea approx. 1 km off the coast of FDNPS so that the discharged water is less likely to be re-taken in as seawater to dilute the ALPS treated water to be discharged.
- If there is an abnormality with the dilution rate or characteristics of the ALPS treated water, the emergency shut-off valves will be actuated swiftly and the ALPS treated water transfer pumps will be shutdown to stop discharging.

* The sum of the ratios: the sum of the ratios of the concentration of each radionuclide to the legally required concentrations of each when multiple radionuclides are contained in the discharged water. The law stipulates that at Fukushima Daiichi, the sum of the ratios of radionuclides must be less than 1 at the outlet. In discharging ALPS treated water into the sea as planned this time, the water will be treated with ALPS and other equipment for the sum of the ratios of radionuclides other than tritium to be less than one and then diluted by 100 times or more with seawater before discharge until the tritium concentration is 1/40th (1,500 Bq/L) of the legally required concentration of tritium (less than 60,000Bq/L). As a result, the concentrations of radionuclides other than tritium will be far below the legally required concentrations of each.

TEPCO

1. DISCHARGE METHOD OF PRECONDITIONS FOR ASSESSMENT
2. **ASSESSMENT METHODS**
3. ASSESSMENT RESULTS
4. REFERENCES

4

Procedures for the radiological impact assessment

TEPCO

The radiological impact was assessed according to the following procedures based on the IAEA safety standards documents*1.

Impact on the public

1. **Selection of the source terms**
   - Define the type and amount of radioactive materials discharged into the sea of treated water
2. **Modelling of direct irradiation, dispersion and transfer in the environment**
   - Study how the various radioactive materials discharged into the sea diffuse, transfer, and accumulate
3. **Identification of exposure pathways**
   - Study the pathways by which people are exposed to the dispersed and transferred radioactive materials
4. **Identification of the representative person for normal operation**
   - Define the person most exposed in the population being assessed from the exposure pathways identified above
5. **Assessment of the dose to the representative person**
   - Assess the dose for the representative person
6. **Comparison of estimated dose with dose constraints*2 and dose limits**
   - Evaluate after comparing the estimated dose against the station target dose (0.05 mSv/year) and the dose limit for the general public (1mSv/year)

Impact on environmental protection (organisms other than humans)

1. **Select the source terms**
   - Define the type and amount of radioactive materials discharged in treated water sea discharge
2. **Model dispersion and transfer in the environment**
   - Study how the various radioactive materials discharged into the sea disperse, transfer and accumulate
3. **Identify exposure pathways**
   - Study the pathways by which marine animals and plants exposed to the dispersed and transferred radioactive materials
4. **Select reference animals and plants**
   - Select species to be assessed (Flatfish, crabs, brown seaweed were selected based on ICRP documents)
5. **Assess the dose rate for reference animals and plants**
   - Assess dose rates for reference animals and plants
6. **Compare estimated dose rates to with derived consideration reference levels**
   - Evaluate after comparing the derived consideration reference level set out for each species

*1 IAEA GSG-9 "Regulatory Control of Radioactive Discharges to the Environment"
IAEA GSG-10 "Prospective Radiological Environment Impact Assessment for Facilities and Activities"

*2 Dose constraint: A value lower than the dose limit, stipulated by the person responsible for radiation work or the radiation facility to optimize safety in physical protection. Because there is no legal dose constraint in Japan, values in this case were compared to the station target dose.

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Selection of source terms (1)
(type and amount of radioactive material discharged)

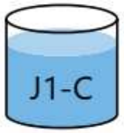
TEPCO

(1) Source term based on the measured value of the 64 radionuclides

The assessment assumes that the ALPS treated water from the three particular tank groups from which the actual measurements for the 64 nuclides have been gathered is diluted by seawater and then continuously discharged during the discharge period.
Furthermore, radionuclides that have not been detected before are assumed to be included at their detection limit.

(1)-1 K4 tank group

Tritium concentration: approx. 190,000 Bq/L
"The sum of the ratios" of radionuclides other than tritium* : 0.29



(1)-2 J1-C tank group

Tritium concentration: approx. 820, 000 Bq/L
"The sum of the ratios" of radionuclides other than tritium : 0.35

(1)-3 J1-G tank group

Tritium concentration: approx. 270,000 Bq/L
"The sum of the ratios" of radionuclides other than tritium : 0.22

All scenarios assume that

- The amount of tritium in discharged treated water is less than 22 TBq per year
- The tritium concentration of the treated water after dilution is less than 1,500 Bq/L

* The sum of the ratios: the sum of the ratios of the concentration of each radionuclide to the legally required concentrations of each when multiple radionuclides are contained in the discharged water. The law stipulates that at Fukushima Daiichi, "the sum of the ratios" of radionuclides must be less than 1 at the outlet. In discharging ALPS treated water into the sea as planned this time, the water will be treated with ALPS and other equipment for the sum of the ratios of radionuclides other than tritium to be less than one and then diluted by 100 times or more with seawater before discharge until the tritium concentration is $1/40^{th}$ (1,500 Bq/L) of the legally required concentration of tritium (less than 60,000Bq/L). As a result, the concentrations of radionuclides other than tritium will be far below the legally required concentrations of each.

Selection of source terms (2)
(type and amount of radioactive material discharged)

TEPCO

(2) Source terms based on the hypothetical ALPS treated water

This extremely conservative scenario assumes that the hypothetical ALPS treated water with only nuclides that comparatively have a larger effect on exposure dose, which does not actually exist, is continuously discharged throughout the discharge period.

- 8 important radionuclides* in exposure assessments for the public are selected and **control concentrations** are set for each (see next slide).
- To maximize assessed dose in this conservative scenario, the radionuclide (Zn-65) that has the largest impact on exposure dose after the 8 radionuclides is added to the ALPS treated water until "the sum of the ratios" is 1 (the ratio to legally required concentration of Zn-65: 0.68) **
- Since the amount of tritium released is less than 22 TBq/year, and the lower the concentration of tritium is, the more other radioactive materials discharged, the tritium concentration of the treated water to be used in the assessment is set at 100,000 Bq/L, below the observed tritium concentration (approx. 150,000 Bq/L), to conservatively maximize the calculated exposure dose.

(2) The hypothetical ALPS treated water
Tritium concentration: 100, 000 Bq/L
"The sum of the ratios" other than tritium：1.00

* Radionuclides that tend to be more concentrated in marine animals and plants, and whose exposure assessment values tend to be relatively higher when emitted at the same ratio to the legally required concentration. (See next slide)

** Since the top 2 radionuclides (Fe-59, Sn-126) are radionuclides subject to management for animals and plants other than humans, the assessment assumes that these 2 radionuclides existed at the maximum of the control concentration ("the sum of the ratios": 0.0025) and the nuclide that has the next largest impact, Pm-148m, comprised the remaining 0. 9975 until "the sum of the ratios" equaled 1.

7

【Reference】Selection of radioactive materials important in assessment

TEPCO

- The discharge of ALPS treated water is managed based on the sum of the ratios. However, even if the sum of the ratios is the same, each radionuclide behaves differently in the environment. To further reduce the impact of the ALPS treated water on the environment, new control concentrations* will be set for the 8 nuclides that have a comparatively large impact on exposure (=exceeds 0.001mSv/year)
- Specifically, hypothetical water containing only the said radionuclides at the legally required concentration limit was set up, and exposure assessments were conducted considering the behavior in the environment (mainly enrichment to fish and shellfish) when this water was discharged, and the top eight radionuclides with the highest assessment values (out of 64) were selected. Based on this policy, hypothetical water containing the top eight radionuclides within the operational control limits and with Zn-65, which has the next highest impact and accounts for the rest of the sum of the ratios that does not reach to one, was set up, and the radiation impact assessment for this water was conducted.

Table E-3 Results of internal exposure assessment when each nuclide is released at the regulatory standard (Adult)
(8 nuclides that exceed 0.001mSv/year were selected to be managed)

No.	Nuclide	Regulatory standard [Bq/L]	Internal exposure dose due to ingestion of seafood (mSv/year)	Notes
1	Sn-126	2.0E+02	2.6E-02	subject to management
2	Sn-123	4.0E+02	2.3E-02	subject to management
3	Sn-119m	2.0E+03	1.9E-02	subject to management
4	Fe-59	4.0E+02	5.6E-03	subject to management
5	Cd-115m	3.0E+02	1.4E-03	subject to management
6	C-14	2.0E+03	1.3E-03	subject to management
7	Cd-113m	4.0E+01	1.3E-03	subject to management
8	Ag-110m	3.0E+02	1.0E-03	subject to management
9	Zn-65	2.0E+02	8.4E-04	
10	Mn-54	1.0E+03	5.2E-04	
11	Co-58	1.0E+03	2.5E-04	
12	Co-60	2.0E+02	2.3E-04	
13	Tc-99	1.0E+03	2.1E-04	

※【Definition of discharge limits】
- For nuclides that have been detected before: twice the maximum detected value
- For nuclides that have not been detected before: 1.2 times the detection limit
- The sum of the ratios of these 8 radionuclide is 0.32

⇒ALPS Treated water which contains nuclides at concentrations that exceed the discharge limits will be treated again until the concentrations satisfy the discharge limits, even if the sum of the ratios of the 63 radionuclides is less than 1,

8

【Reference】 Table of nuclide concentrations for ②the hypothetical ALPS treated water

TEPCO

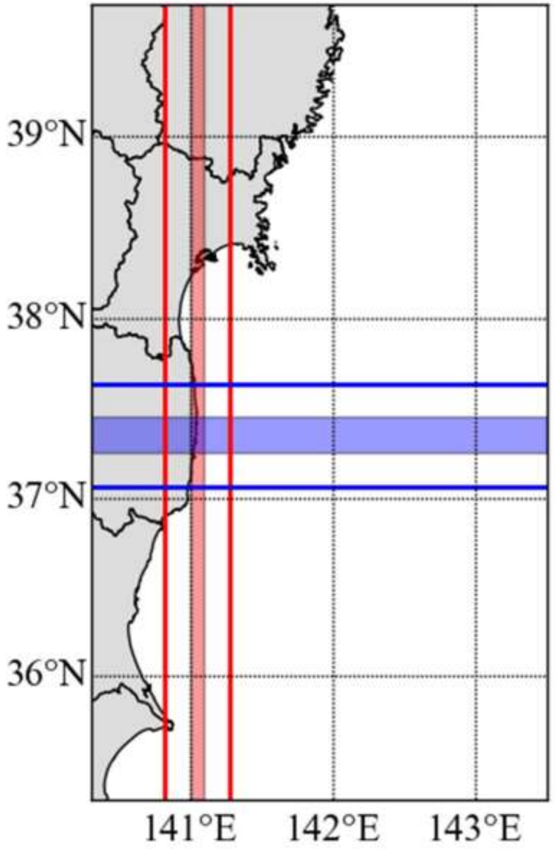
Target nuclides (half life)	Regulatory standard [Bq/L]	Maximum observed value [Bq/L]	Discharge limits [Bq/L]※	Ratios of the legally required concentrations	Notes
Nuclides subject to control					**Sum of the ratios of 8 radionuclides** 0.32
Nuclides that have not been detected					
Fe-59 (approx.45 days)	4.0E+02	<8.66E-02	2.0E-01	5.0E-04	
Ag-110m (approx.250 days)	3.0E+02	<4.26E-02	6.0E-02	2.0E-04	
Cd-113m (approx. 15 years)	4.0E+01	<8.55E-02	2.0E-01	5.0E-03	
Cd-115m (45 days)	3.0E+02	<2.70E+00	4.0E+00	1.3E-02	
Sn-119m (approx. 290 days)	2.0E+03	<4.24E+01	6.0E+01	3.0E-02	
Sn-123 (approx. 130 days)	4.0E+02	<6.59E+00	8.0E+00	2.0E-02	
Sn-126 (approx. 100000 years)	2.0E+02	<2.92E-01	4.0E-01	2.0E-03	
Detected nuclides					
C-14 (approx.5700 years)	2.0E+03	2.15E+02	5.0E+02	2.5E-01	
Other nuclides					**Ratio of the concentration of Zn-65 to the regulatory standard** 1-0.32=0.68 **Concentration of Zn-65** 200[Bq/L]×0.68=136[Bq/L]
Zn-65 (approx. 240 days)	2.0E+02	-	– (Concentration in assessment is set at 1.4E+02)	6.8E-01	
Sum of the ratios of the concentration of 8 radionuclides and Zn-65				1	

※The discharge limit was set at 1.2 times the detection limit for nuclides that have never been detected and 2 times the maximum of the detection limit rounded up to the significant digit for detected nuclides. Other nuclides are expressed by the concentration for assessment instead of discharge limits.

Dispersion and transfer in the environment (dispersion calculations in the sea area)

TEPCO

The assessment used a model that was found to be reproducible based on the repeatability calculations for the cesium concentration in seawater after the accident at the Fukushima Daiichi Nuclear Power Station. In addition, the calculations with higher resolutions was conducted so as to simulate the sea area near the power station in detail.



- Applied the Regional Ocean Modeling System (ROMS) to the sea area off the Fukushima coast
- Sea area flow data
  - Data interpolated from JMA short-term meteorological forecast data[1] was used in the sea surface driving force
  - Ocean reanalysis data (JCOPE2[2]) was used as the source for boundary conditions for the open sea and data assimilation*
- Scope of modeling: The resolution of the sea area 35.30-39.71°N, 140.30-143.50°E (490km×270km); 22.5 km north to south and 8.4 km east to west of the Station was increased gradually
  - Resolution (overall): NS approx.925m x EW approx.735m (approx.1km); 30 layers vertically
  - Resolution (immediate vicinity of the station): NS approx.185m x EW approx.147m (approx.200m); 30 layers vertically (sea area with red and blue hatching in the diagram on the left)
- Meteorological and sea condition data
  - Data from 2014 and 2019

*Data assimilation: a method for incorporating actual measurements in numerical simulations. Also known as nudging.

[1] A. Hashimoto, H. Hirakuchi, Y. Toyoda, and K. Nakaya, "Prediction of regional climate change over Japan due to global warming (Part 1) – Evaluation of Numerical Weather Forecasting and Analysis System (NuWFAS) applied to a long-term climate simulation-" CRIEPI Report, 2010.
[2] Y.Miyazawa, R.Zhang, X.Guo, H.Tamura, D.Ambe, J.-S.Lee, A.Okuno, H.Yoshinari, T.Setou, and K.Komatsu,, "Water mass variability in the western North Pacific detected in a 15-year eddy resolving ocean reanalysis," 2009.

Dispersion and transfer in the environment (calculating concentrations of radioactive materials for the assessment)

TEPCO

- The tritium concentration in the sea area was calculated using the actual annual meteorological/sea conditions data assuming that tritium is discharged evenly throughout the year
- The annual average concentration of tritium was calculated for the 10km by 10km area around the station
- Doses were calculated for the upper layers (external exposure from the sea surface), all layers (external exposure in the sea, internal exposure), and lower layers (exposure of animals and plants)
- The concentrations of the other 63 nuclides were calculated using the calculated tritium concentration and the proportions of each nuclide in the discharged treated water

*Area where common fishery rights are not set

Area diagram for calculating the radiation material concentration in the sea to be used in the assessment

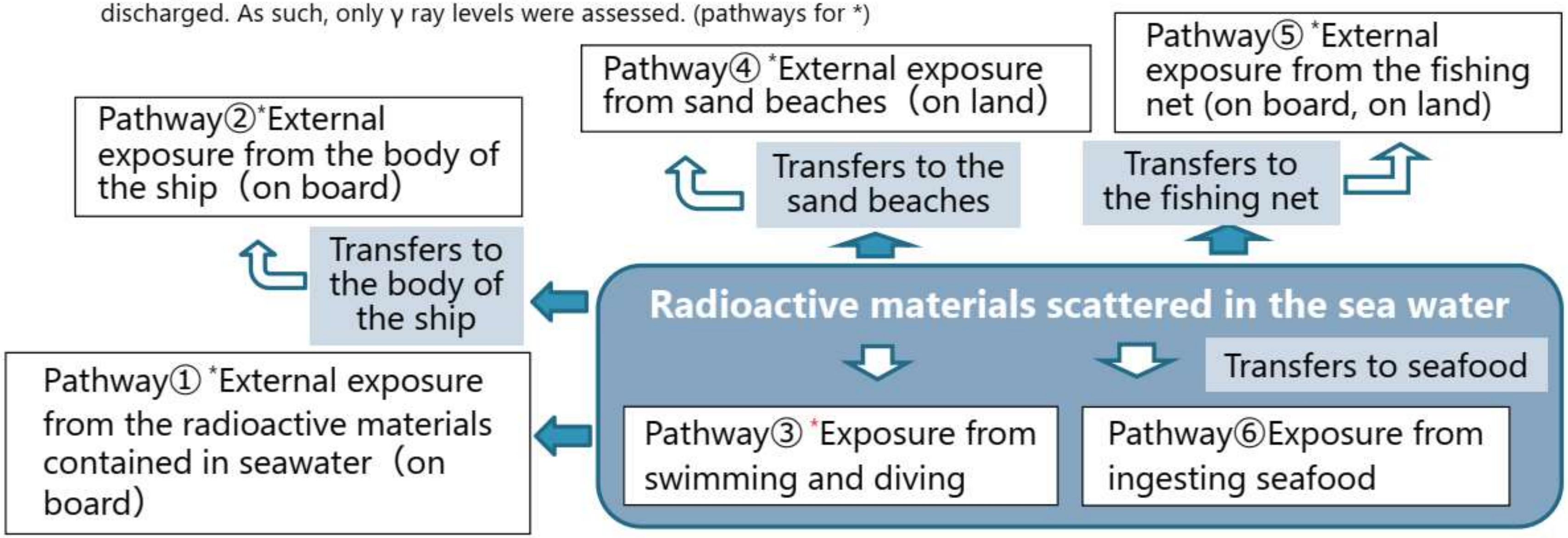
Source: This map was created by Tokyo Electric Power Company Holdings, Inc. based on a map published by the Geographical Survey Institute (Electronic Map Web)
https://maps.gsi.go.jp/#13/37.422730/141.044970/&base=std&ls=std&disp=1&vs=c1j0h0k0l0u0t0z0r0s0m0f1

11

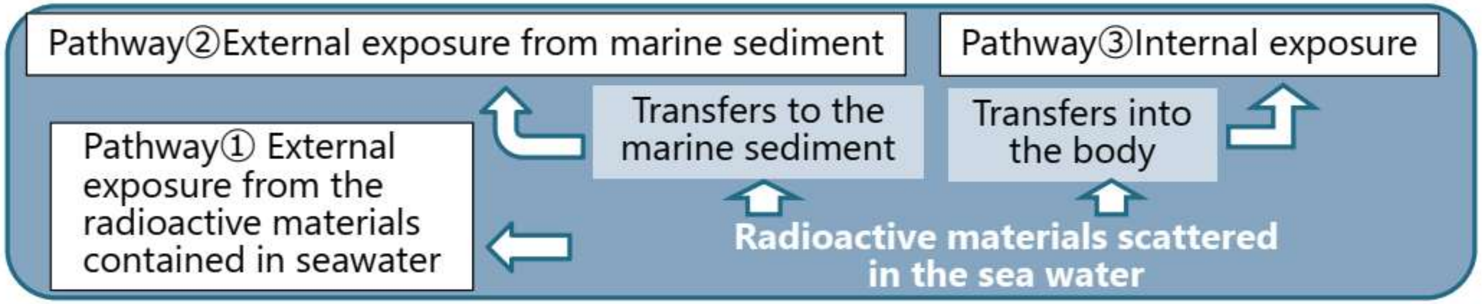
Identifying the exposure pathways (assessment model) TEPCO

（1） Transfer and exposure pathways (human exposure)

The impact of external exposure is expected to be minimal as the concentration of radioactive materials will be diluted and then discharged. As such, only γ ray levels were assessed. (pathways for *)



（2） Transfer and exposure pathways (plants and animals)



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Setting of the representative person and reference animals/plants

TEPCO

(1) Representative person (human exposure)

- The lifestyle of the representative person (external exposure) was taken from the "public dose assessment in safety screening for commercial light-water reactor facilities"
  - Works 120 days (2,880 hours) per year in the fishery, of which 80 days (1,920 hours) are spent working near nets
  - Resides by the seashore 500 hours a year and swims 96 hours a year
- The amount of seafood ingested annually (internal exposure) was taken from the latest data on diet. Two scenarios, one for a person who ingests seafood at the national average and the other for a person who ingests a lot of seafood (mean + 2σ *) were considered

Table 4-8 Amount of seafood ingested by a person who ingests seafood at the national average (g/day)

	Fish	Invertebrate	Seaweed
Adult	58	10	11
Toddler	29	5.1	5.3
Infant	12	2.0	2.1

Table 4-9 Amount of seafood ingested by a person who ingests a lot of seafood (g/day)

	Fish	Invertebrate	Seaweed
Adult	190	62	52
Toddler	97	31	26
Infant	39	12	10

(2) Reference animals and plants (environmental protection)

Reference flatfish, reference crab, reference brown seaweed were selected from the marine environment reference organisms indicated in ICRP Pub.136**.

- Flatfish: Flounders widely inhabit in the surrounding sea area, and are important fish for the local fishery industry
- Crab : Many types of crabs (e.g., portunus trituberculatus, ovalipes punctatus) widely inhabit the surrounding sea area
- Brown seaweed : Many types of seaweed including gulfweed and sea oak widely inhabit the surrounding sea area

* Standard deviation
** ICRP Pub.136 "Dose Coefficients for Non-human Biota Environmentally Exposed to Radiation"

Dose assessment for representative person

TEPCO

External exposure (Pathway ①～⑤)

- Exposure due to radiation from the sea when moving by boat or working in the sea (Pathway ① and ③)

Amount of exposure = Effective dose equivalent coefficient × Concentration of radioactive materials in the seawater

- Exposure due to radiation from the radioactive materials that have moved to the body of the ship or sand beaches from the seawater（pathways②, ④ and ⑤)

Amount of exposure = Effective dose equivalent coefficient ×Transfer coefficient× Concentration of radioactive materials in the seawater

- The effective dose equivalent coefficient that indicates the amount of radiation a person is exposed to from a 1 Bq/L concentration of radioactive material specified in the Handbook on Environmental Impact Assessment for Decommissioning Work*[1] was used here
- The transfer coefficient that describes how much radioactive material transfers from the 1Bq/L concentration of radioactive material in the seawater to the body of the ship or sand beaches was mostly taken from the designated application for reprocessing businesses (Japan Nuclear Fuel Limited,1989)*[2]. The sand beach transfer coefficient specified in the old Nuclear Safety Commission guidelines*[3] was used here.

*1 "Survey on Environmental Impact Assessment Technology for Decommissioning of Commercial Reactors - Survey on Environmental Impact Assessment Parameters (FY2006 Survey Commissioned by Ministry of Economy, Trade and Industry) Appendix: Handbook on Environmental Impact Assessment for Decommissioning Work, Central Research Institute of Electric Power Industry

*2 "Application for designation of the Rokkasho Reprocessing Plant as a reprocessing business", Japan Nuclear Fuel Limited

*3 "Dose assessment for the general public in the safety assessment of light water reactor facilities for power generation", Nuclear Safety Commission

Dose assessment for representative individuals

TEPCO

Internal exposure (Pathway⑥)

Amount of exposure = Effective dose coefficient × Ingestion rate
Ingestion rate = Concentration of radioactive materials in seawater × concentration coefficient × amount of seafood ingested annually

- The effective dose coefficient specified in the ICRP Publication 72[*1] is used here
- The concentration coefficient specified in IAEA TRS No.422[*2] is used here
- Dilution at the seafood market and attenuation of various radioactive materials from collection to ingestion was not considered
- Fish, invertebrates (excluding squid and octopus)[*3], and seaweed are considered seafood here.

Assessment standard (sum of external and internal exposure)

- The result was compared with 1mSv/year, the dose limit for the general public
- As the concept of dose constraints[*4] has not been introduced in Japan, the result was compared to the station dose target of 0.05 mSv/year

*1 ICRP Pub.72, "Age-dependent Doses to Members of the Public from Intake of Radionuclides; Part 5 Compilation of Ingestion and Inhalation Doses Coefficients"

*2 IAEA Technical Report Series No.422, "Sediment Distribution Coefficients and Concentration Factors for Biota in the Marine Environment"

*3 Used a dataset in the ICRP Pub.72 named "Invertebrates (excluding squid and octopus)

*4 Dose constraint: A value lower than the dose limit, stipulated by the person responsible for radiation work or the radiation facility to optimize safety in physical protection. There is no legal dose constraint in Japan.

Dose assessment for reference animals and plants

TEPCO

Animals and plants

- Animals and plants are evaluated using the dose rate in their habitat
- The reference animals and plants and dose conversion coefficient from the ICRP will be used in the formula below to calculate the dose
- Exposure from the seawater and from the seabed are considered in external exposure.

Amount of internal exposure = *Internal dose conversion coefficient* × *Radiation material concentration in seawater* × *concentration ratio* （*Pathway*③）

Amount of external exposure = *0.5×external dose conversion coefficient* × *Radiation material 0concentration in seawater* （*Pathway*①） + *0.5× external dose conversion coefficient* × *Radiation material concentration in seawater* ×*partition coefficient* （*Pathway*②）

- Internal and external dose conversion coefficients specified in ICRP Pub 136*1 and BiotaDC*2 were used here
- The concentration ratio used here is the concentration coefficient specified in ICRP Pub 114*3 and IAEA TRS-422*4
- The partition coefficient specified in IAEA TRS-422（2.3.OCEAN MARGIN *Kd*s）was used here

Assessment standard

- The results are compared with the Derived Consideration Reference Levels (DCRLs)*6 published by the ICRP in Pub.124*5

*1 ICRP Pub.136, "Dose Coefficients for Non-human Biota Environmentally Exposed to Radiation"

*2 ICRP BiotaDC Program v.1.5.1 (http://biotadc.icrp.org/)

*3 ICRP Pub.114, "Environmental Protection: Transfer Parameters for Reference Animals and Plants"

*4 IAEA Technical Report Series No.422, "Sediment Distribution Coefficients and Concentration Factors for Biota in the Marine Environment"

*5 ICRP Pub.124 "Protection of the Environment under Different Exposure Situations"

*6 DCRL (Derived Consideration Reference Level): a band of dose rates with a single-digit range for each species of organisms, defined by the ICRP. In cases where this dose rate level is exceeded, the effect on the organism should be considered.

1. DISCHARGE METHOD OF PRECONDITIONS FOR ASSESSMENT
2. ASSESSMENT METHODS
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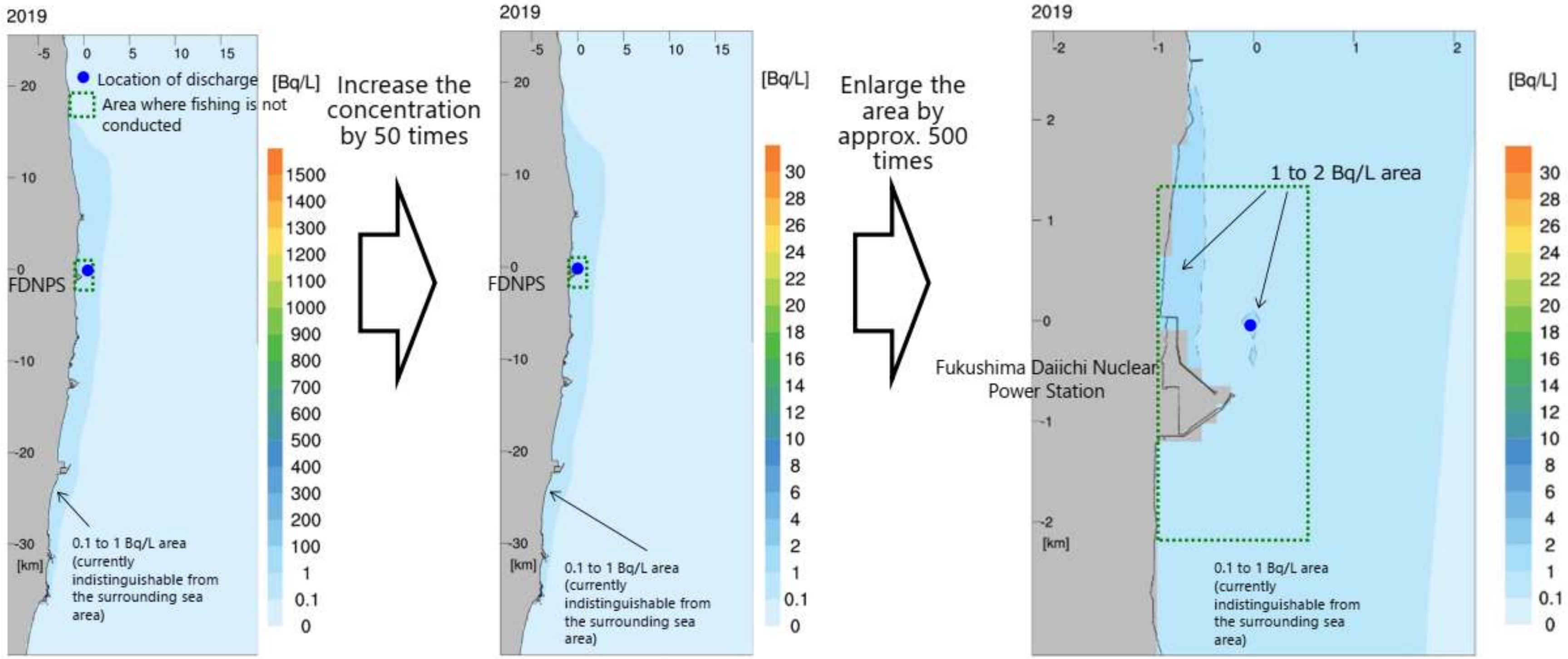
4. REFERENCES

Results of dispersion simulation at sea

TEPCO

Assessment using the meteorological and sea conditions data from 2019 found that the area with higher tritium concentrations than the current surrounding area (0.1-1 Bq/L*) (the area inside the dotted line) will be limited to the area 2 to 3 km from the station.

*1/100 thousandth to 1/10 thousandth of the WHO Guidelines for drinking-water quality (10,000 Bq/L)



Enlarged view of the area off the coast of Fukushima (Largest value in scale at 30 Bq/L)

Enlarged view of the area around the station (Largest value in scale at 30 Bq/L)

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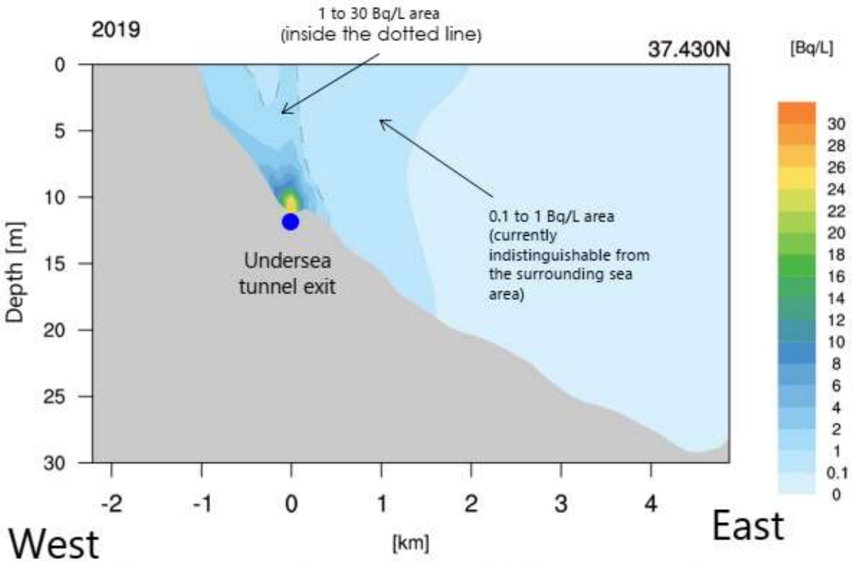
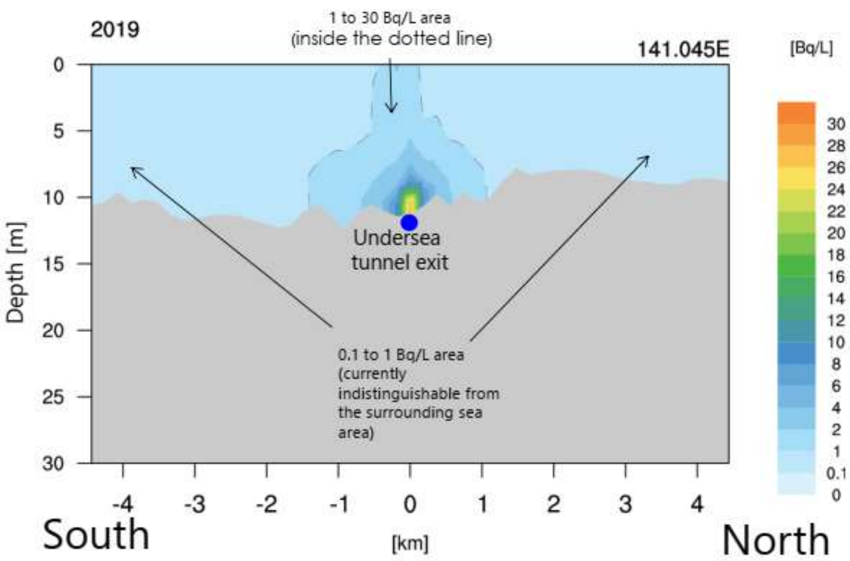
Results of dispersion simulation at sea
(area around the tunnel exit)

TEPCO

While some areas directly above the tunnel exit, before dispersion, show concentrations exceeding 30 Bq/L, the concentration swiftly falls in the surrounding area.
Furthermore, the 30 Bq/L measurement observed in the area directly above the tunnel exit is still significantly below the national regulatory standard (60,000 Bq/L) and the **WHO Guidelines for drinking-water quality (10,000 Bq/L).**



Cross-section view of the tunnel exit (East to west)
(Largest value in scale at 30Bq/L)



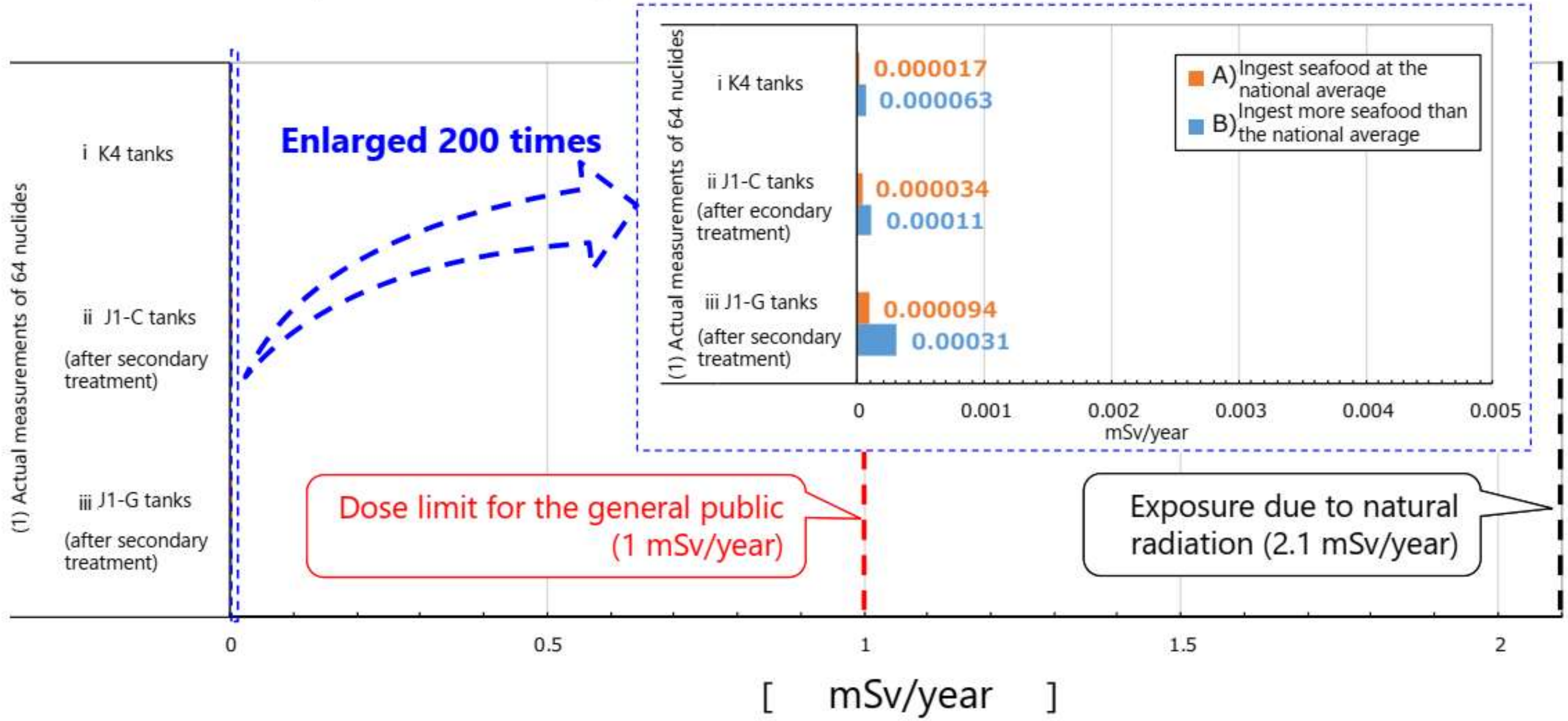
Cross-section view of the tunnel exit (North to south)
(Largest value in scale at 30Bq/L)

*1/100 thousandth to 1/10 thousandth of the WHO Guidelines for drinking-water quality (10,000 Bq/L)

Human exposure assessment results
(design stage, (1) assessment using actual measurements of 64 nuclides)

TEPCO

- Results of an assessment using (1) actual measurements from 64 nuclides found that the **exposure dose for a person who ingests seafood at the national average (general public) was approx. 1/60,000 to 1/10,000 of the dose limit for the general public (1mSv/year) and approx. 1/120,000 to 1/20,000 of natural radiation exposure (2.1 mSv/year).**



(Note) These are figures for adults only. This assessment assumed that nuclides that had never been detected before existed at the lower limit of detection. These are present results and may be updated according to future discussions and internal and external reviews.

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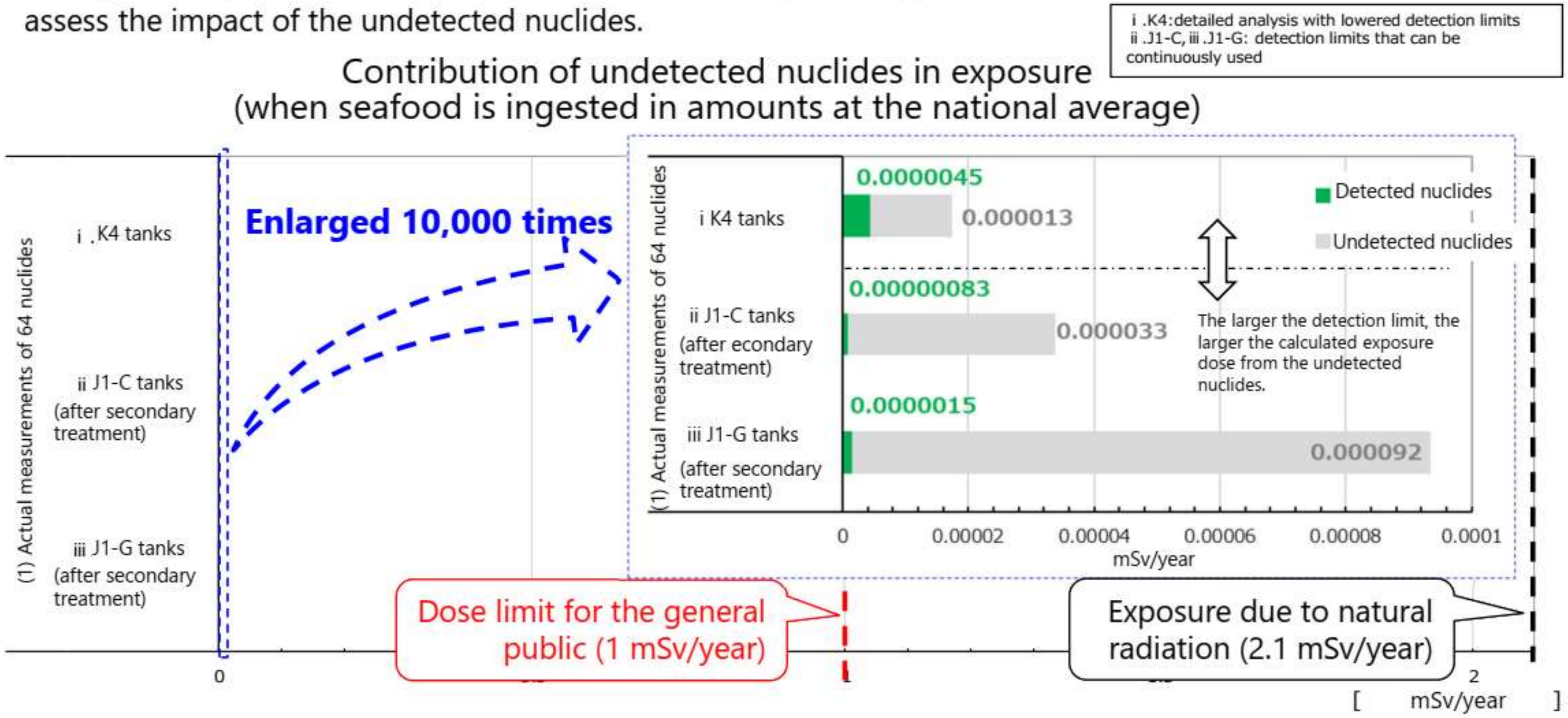
Insights into undetected nuclides in the assessment results
(design stage, (1) assessment using actual measurements)

TEPCO

- (1) Assessment based on actual measurements of 64 nuclides assumed that **"undetected nuclides" that had never been detected in analysis before existed in detection limit amounts. Exposure from these undetected nuclides are assumed to comprise the majority of the calculated exposure dose, and the dose from actual measurements is likely to be much lower.**
  - ✓ Going forward, water samples will be measured once a year using a lower detection limit than normal to assess the impact of the undetected nuclides.

Contribution of undetected nuclides in exposure
(when seafood is ingested in amounts at the national average)



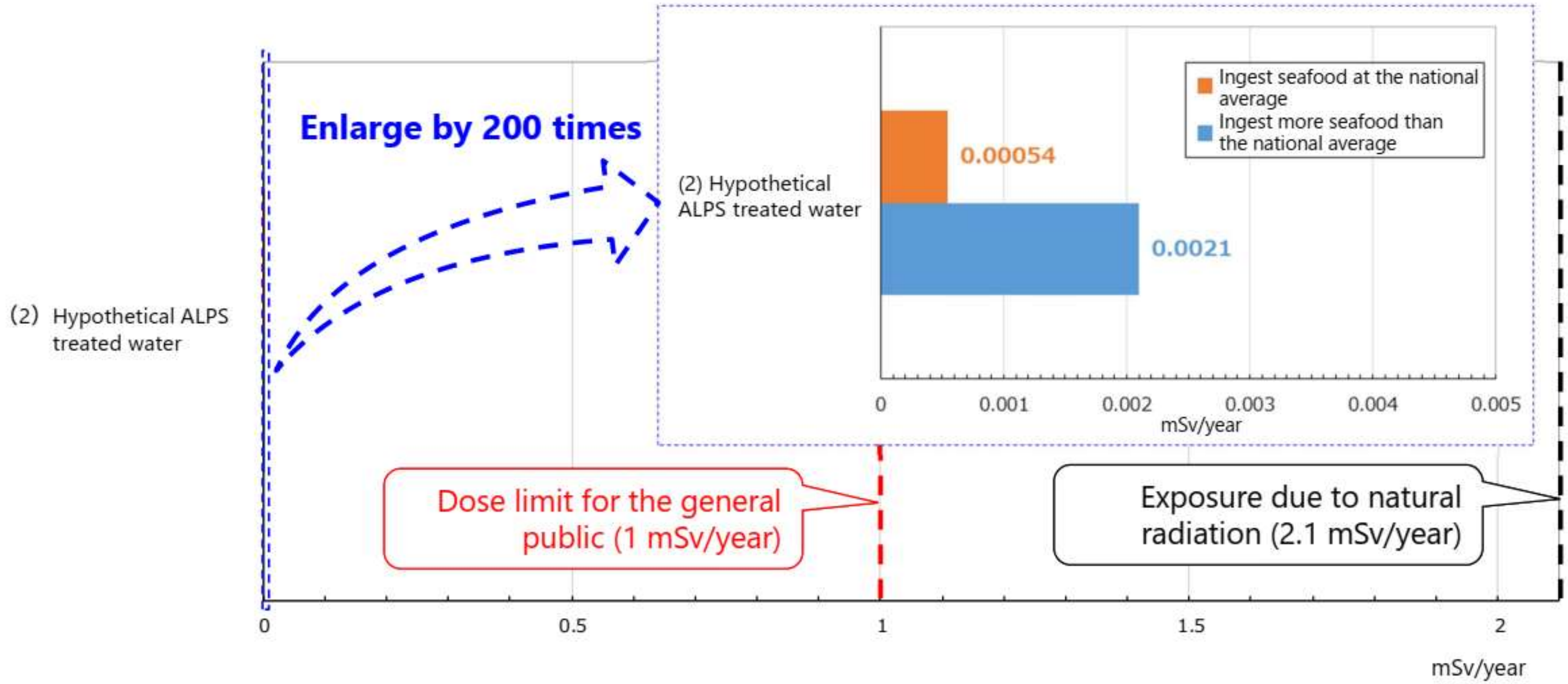
(Note) These are figures for adults only. These are present results and may be updated according to future discussions and internal and external reviews.

Human exposure assessment results

(design stage, (2) Assessment using hypothetical ALPS treated water)

TEPCO

- Even in the most conservative scenario using (2) hypothetical ALPS treated water that only contains nuclides that have a comparatively large impact on exposure, the calculated dose was approximately 1/2,000 to 1/500 of the dose limit for the general public (1mSv/year) and 1/4,000 to 1/1,000 of natural radiation exposure (2.1 mSv/year)



(Note) These are figures for adults only. The results may be updated according to future discussions and internal and external reviews.

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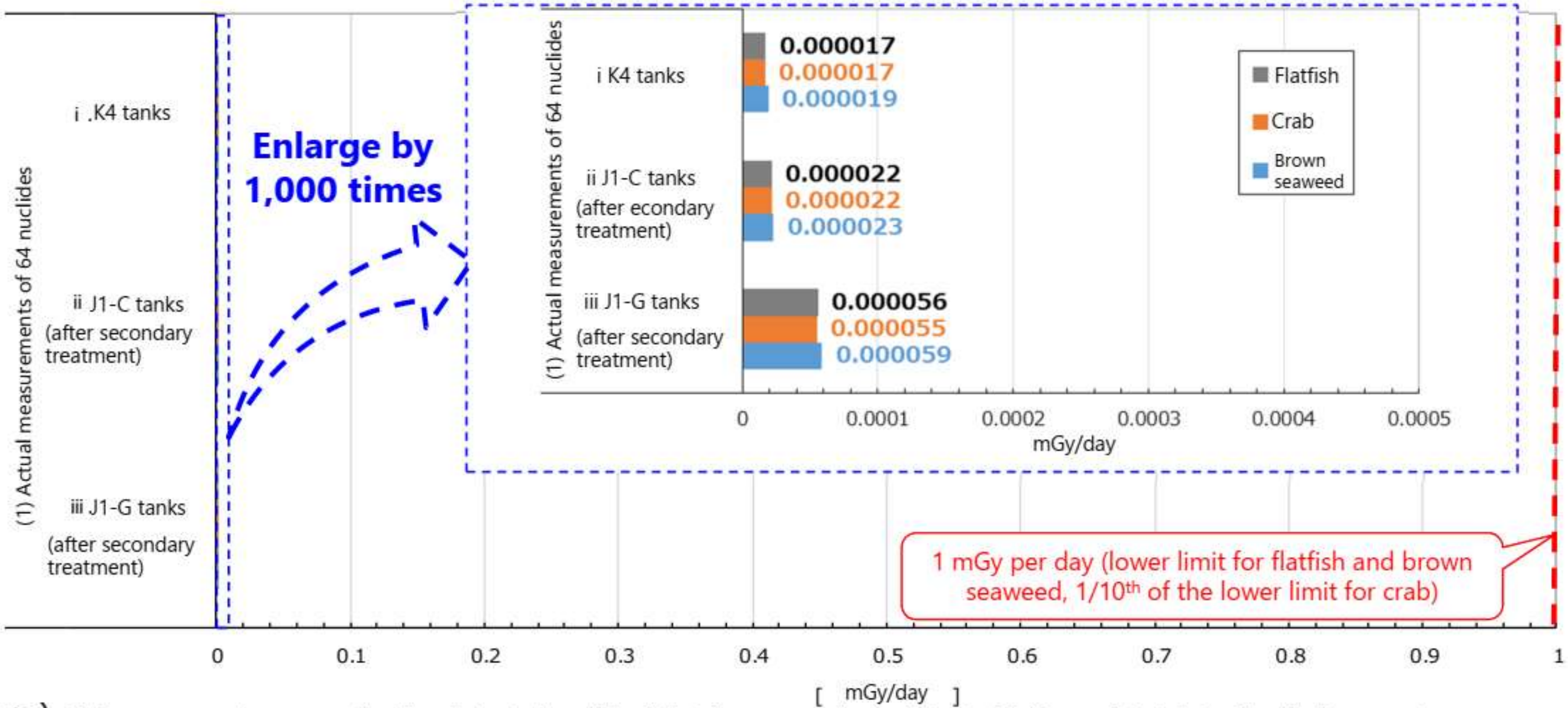
Results of animal and plant exposure assessment
(design stage, (1) assessment using actual measurements of 64 nuclides)

TEPCO

- Results from the (1) assessment using actual measurements of 64 nuclides was approximately 1/60,000 to 1/20,000 (1/600,000 to 1/200,000 for crab) of the lower limit of the derived consideration reference level* (DCRL; 1 to 10 mGy /day for flatfish, 10 to 100 mGy/ day for crab, 1 to 10 mGy/day for brown seaweed) which is considered the standard in assessment.



(Note) This assessment assumes that "undetected nuclides" that have never been detected before exist at detection limit amounts. These are present results and may be updated according to future discussions and internal and external reviews.

- DCRL (Derived Consideration Reference Level): a band of dose rates with a single-digit range for each species of organisms, defined by the ICRP. In cases where this dose rate level is exceeded, the effect on the organism should be considered.
- **Gy (gray) is a unit of energy absorbed by matter. Sv (sievert) is a unit expressing the impact of radiation on the human body. To be accurate, Sv = corrective coefficient × Gy but for gamma rays and beta rays, Sv and Gy are mostly equivalent.

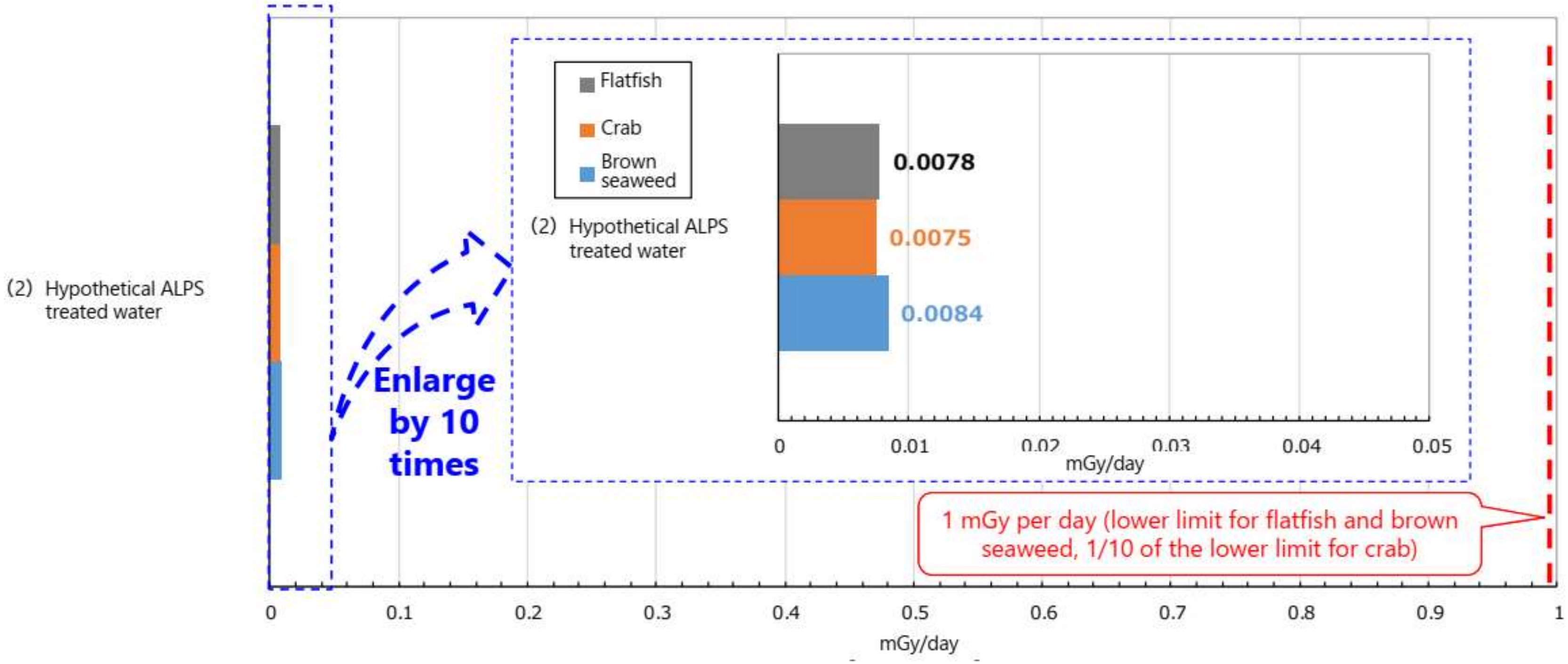
23

Results of animal and plant exposure assessment

(design stage, (2) Assessment using hypothetical ALPS treated water)

TEPCO

- Even in the most conservative scenario using (2) hypothetical ALPS treated water that only contains nuclides that have a comparatively large impact on exposure, the calculated dose is approximately 1/130 to 1/120 (1/1,300 to 1/1,200 for crab) of the derived consideration reference level* (1 to10 mGy /day for flatfish, 10 to 100 mGy/ day for crab, 1 to 10 mGy/day for brown seaweed).



(Note) These are present results and may be updated according to future discussions and internal and external reviews.

* DCRL (Derived Consideration Reference Level): a band of dose rates with a single-digit range for each species of organisms, defined by the ICRP. In cases where this dose rate level is exceeded, the effect on the organism should be considered.

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1. DISCHARGE METHOD OF PRECONDITIONS FOR ASSESSMENT
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補充資料五、東電公司 3 月 24 日於官網公布之加強版海域監測計畫內容(Sea Area Monitoring Plan for the Handling of ALPS Treated Water Fukushima Daiichi Nuclear Power Station)

資料來源：TEPCO, Sea Area Monitoring Plan for the Handling of ALPS Treated Water Fukushima Daiichi Nuclear Power Station, Mar. 24. 2022

Sea Area Monitoring Plan for the Handling of ALPS Treated Water Fukushima Daiichi Nuclear Power Station

<Reference material>
March 24, 2022
Tokyo Electric Power Company Holdings, Inc.
Fukushima Daiichi D&D Engineering Company

○ TEPCO published TEPCO holding's action in response to the Japanese government's policy on the handling of ALPS treated water on April 16, 2021. The response includes strengthening and expansion of its sea area monitoring efforts to minimize adverse impact on reputation that may be sustained a result of discharging ALPS treated water into the sea.

○ TEPCO, as the organization responsible for discharging ALPS treated water, evaluated how the treated water will disperse based using dispersion simulations at sea, and developed a sea area monitoring plan for measuring tritium levels to check on dispersion *2 in seas off the coast of Fukushima near the station where tritium concentrations will likely increase after discharge.*1. This was made public on August 25, 2021.

*1 : Evaluated to be 1 to 2 Bq/L, 1/10000th to 1/5000th of the WHO drinking water guideline reference level of 10,000 Bq/L

*2 : ･Based on the dispersion simulations at sea, TEPCO has decided to take samples from more area and increase the frequency of sampling to ascertain the baseline before discharge.

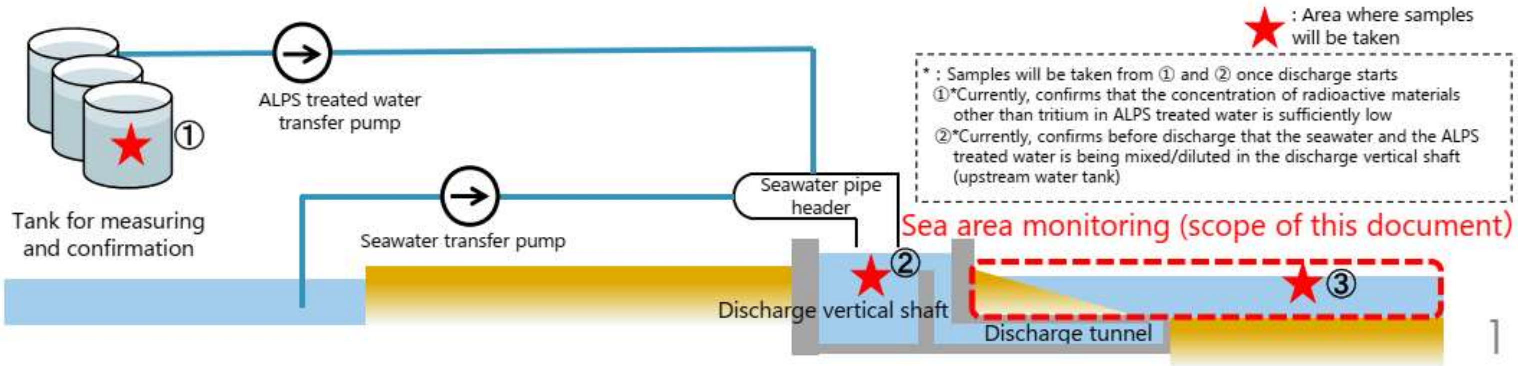
･TEPCO also strengthened monitoring to assess how tritium was showing up in marine organisms

<Announced by August 25, 2021>

○ In response to the Japanese government's Comprehensive Monitoring Plan which is being fortified to address concerns related to the discharge of ALPS treated water into the sea, TEPCO will reinforce the sea area monitoring plan based the results of the August 25, 2021 discussions (increase the number of sampling locations, measured organisms and sampling frequency) and set stricter detectable thresholds. The Plan will be put into effect in April 2022 to continuously confirm from before discharge how tritium and other nuclides are scattering, and how it is impacting marine organisms.

○To secure transparency and objectivity in the sea monitoring, we will ask local agriculture, forestry, fisheries producers and local government officials to participate in and observe sea area monitoring. The results of sea monitoring will be published on our website.

○ The state of substances in the sea area will be disclosed, in cooperation with the Japanese government and related organizations, carefully and in an easy-to-understand manner to alleviate the concerns that the local community, parties concerned, and the society at large.



1

1-1. Government's Comprehensive Monitoring Plan

Current Comprehensive Monitoring Plan (sea area monitoring)

○ The Government set up a Monitoring Coordination Committee under the Nuclear Disaster Response Headquarters to conduct radiation monitoring for the Fukushima Daiichi Nuclear Power Station accident in a planned manner and formulated a Comprehensive Monitoring Plan in August 2011.

○ Based on this plan, ministries, local municipalities, nuclear operators, and other responsible organizations, have been conducting sea area monitoring focusing on cesium 134, cesium 137, strontium 90 to ascertain how the radioactive materials discharged into the environment scatters and transfers to different organisms.

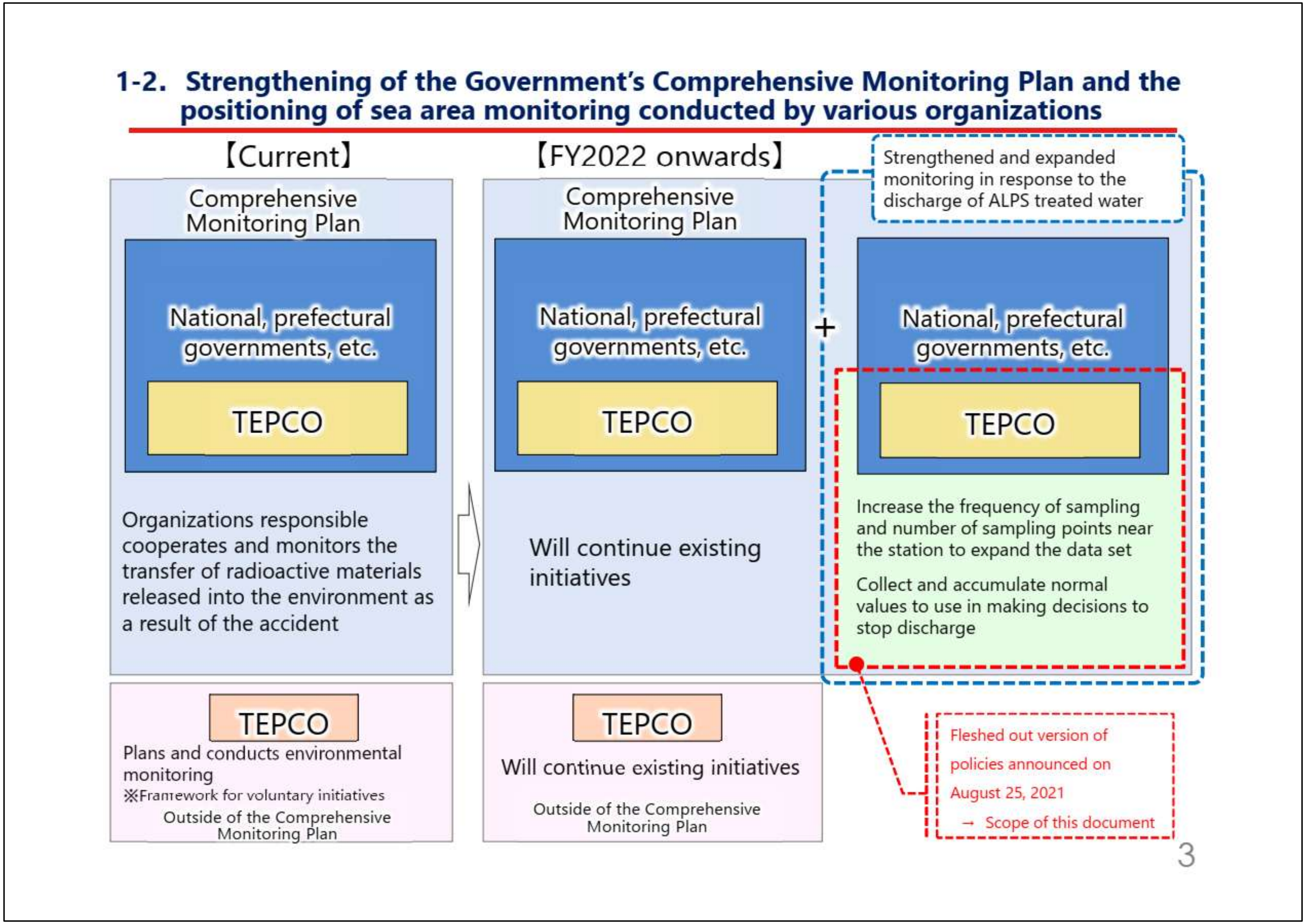
➢ Current Comprehensive Monitoring Plan (revised on April 1, 2021)
See the Nuclear Regulation Authority (NRA) website (in Japanese)
https://radioactivity.nsr.go.jp/ja/list/511/list-1.html#chapter-1

○ Division of roles among responsible organizations (example)

NRA: Formulates and implements monitoring plan, analyzes and evaluates measurements including those taken by other organizations, summarizes analysis and evaluations results, and disseminates them to the public.

Nuclear operator (TEPCO): Conducts monitoring, summarizes and disseminates the results of analysis and assessment of measurements.

2


1-2. Strengthening of the Government's Comprehensive Monitoring Plan and the positioning of sea area monitoring conducted by various organizations
【Current】
【FY2022 onwards】
Strengthened and expanded monitoring in response to the discharge of ALPS treated water
Comprehensive Monitoring Plan
National, prefectural governments, etc.
TEPCO
Organizations responsible cooperates and monitors the transfer of radioactive materials released into the environment as a result of the accident
Comprehensive Monitoring Plan
National, prefectural governments, etc.
TEPCO
Will continue existing initiatives
+
National, prefectural governments, etc.
TEPCO
Increase the frequency of sampling and number of sampling points near the station to expand the data set
Collect and accumulate normal values to use in making decisions to stop discharge
TEPCO
Plans and conducts environmental monitoring
※Framework for voluntary initiatives
Outside of the Comprehensive Monitoring Plan
TEPCO
Will continue existing initiatives
Outside of the Comprehensive Monitoring Plan
Fleshed out version of policies announced on August 25, 2021
→ Scope of this document
3

2-1. Key Points of TEPCO's efforts to strengthen sea monitoring (1/2)

○ **Increase the number of sampling locations, organisms monitored**

- The Expert Sea Area Monitoring Committee established to advise the Government on the appropriateness of its efforts to strengthen sea area monitoring in the Comprehensive Monitoring Plan reviewed the updated plan created by the Ministry of the Environment and the NRA (hereinafter the Government)*.

> *:Tritium is going to be measured near the outlet, near the shore of Fukushima, beaches, southern part of the sea area off the coast of Miyagi, and northern part of the sea area off the coast of Ibaraki, just in case. The seawater will be measured for nuclides other than tritium and fish for tritium and carbon 14, and seaweed for iodine 129 near the outlet.

- TEPCO as the party responsible for ALPS water discharge, will conduct monitoring, focusing on the area near the outlet, and will increase seawater and sampling locations near the station and at the shore of Fukushima for tritium, and will measure tritium and iodine 129 near the station.

- Flounder and flatfish that widely inhabit the sea area around the station have been chosen as fish to be monitored. These fish that inhabit the seabed are also targets of radiation impact assessments in the International Commission on Radiological Protection (ICRP) Recommendations.

4

2-1. Key Points of TEPCO's efforts to strengthen sea monitoring (2/2)

○ **Increase sampling frequency**

・TEPCO will increase the frequency with which seawater is measured for tritium.

・The number of sampling locations will be increased **near the outlet where TEPCO will be focusing its monitoring efforts.** The detectable threshold will be set in line with the national government's targets values. Sampling frequency will be set a numbers considered to be sufficient for ascertaining the situation based on past monitoring data.

○ **The detectable threshold will be set to be in line with the national government's target values.**

・TEPCO has **set the detectable threshold for tritium and iodine 129 to be in line with the government's detectable threshold targets** to ascertain how the seawater is scattering and the state of marine organisms.

We will continue to measure the radioactive materials other than tritium and iodine 129—cesium 134, cesium 137, strontium 90, plutonium 238, plutonium 239, and plutonium 240—as we have in the past.

5

2-2. Strengthened sea area monitoring plan （1/2）

【seawater】

・TEPCO will increase the number of samples taken, frequency of measurement for tritium and set the detectable threshold to be in line with government targets.

Red：Strengthened compared to the current plan

Target	Sampling location (See 2-3. Diagram 1,2,3)	Number of samples taken	Subject of measurement	Frequency	Detectable threshold
Seawater	Inside the harbor	10	Cesium-134,137	Daily	0.4 Bq/L
			Tritium	Weekly	3 Bq/L
	Outside the harbor, within a 2km radius of the station	2	Cesium-134,137	Weekly	0.001 Bq/L
				Daily	1 Bq/L
		5 → 8	Cesium-134,137	Weekly	1 Bq/L
		7 → 10	Tritium	Weekly	1 → 0.4 Bq/L*1
	Within 20 km of the coast	6	Cesium-134,137	Weekly	0.001 Bq/L
			Tritium	Twice a month → Weekly*2	0.4 → 0.1 Bq/L*3
	Within 20 km of the coast (Fish sampling location)	1	Tritium	Monthly	0.1 Bq/L
		0 → 10	Tritium	None → Monthly	0.1 Bq/L*3
	20 km+ off the coast of Fukushima	9	Cesium-134,137	Monthly	0.001 Bq/L
		0 → 9	Tritium	None → Monthly	0.1 Bq/L*3

1：Values will be measured using the electrolytic concentration method as needed.

*2：To be measured monthly when the detectable threshold is at 0.1Bq/L

*3：To be set at 0.4 Bq/L until the electrolytic concentration device is installed.

※：Samples will be taken from the surface level of the sea

*：Concentration method that uses the fact that tritium water is less easily electrolyzed. See reference for details on the electrolytic concentration device.

6

2-2. Strengthened sea area monitoring plan (2/2)

【Fish and seaweed】

・TEPCO will increase the number of samples taken, frequency of measurement and set the detectable threshold to be in line with government targets.

Red : Strengthened compared to the current plan

Target	Sampling location (See 2-3. Diagram 1,2)	Number of samples taken	Subject of measurement	Frequency	Detectable threshold
Fish	Within 20 km of the coast	11	Cesium134,137	Monthly	10 Bq/kg (live)
			Strontium 90 (5 samples with the highest concentrations of cesium)	Quarterly	0.02 Bq/kg (live)
		1	Tritium (tritiated water)	Monthly	0.1 Bq/L
			Tritium (organically bound)		0.5 Bq/L
		0 → 10	Tritium (tritiated water) *1	None → Monthly	0.1 Bq/L*3
			Tritium (organically bound) *2		0.5 Bq/L
Seaweed	Inside the harbor	1	Cesium134,137	Annually → Three times a year	0.2 Bq/kg (live)
	Outside the harbor, within a 2km radius of the station	0 → 2	Cesium134,137	None → Three times a year	0.2 Bq/kg (live)
			Iodine 129	None → Three times a year	0.1 Bq/kg (live)
			tritium (tritiated water)*1	None → Three times a year	0.1 Bq/L*3
			tritium (organically bound) *2		0.5 Bq/L

*1 : Tritium that exists in water form and is excreted similarly to water. Half of the radiation is excreted in around 10 days.

*2 : Tritium ingested bound to organic material such as protein. Most of it is excreted in around 40 days while a portion may take up to a year to be excreted.

*3 : Set at 0.4 Bq/L until the electrolytic concentration device is installed

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2-3. TEPCO sampling locations to be strengthened by TEPCO's sea area monitoring (1/2)

【TEPCO's strengthening plan】

・TEPCO will increase the number of samples taken, frequency of measurement for seawater, fish, and seaweed and set the detectable threshold to be in line with government targets for seawater, fish and seaweed.

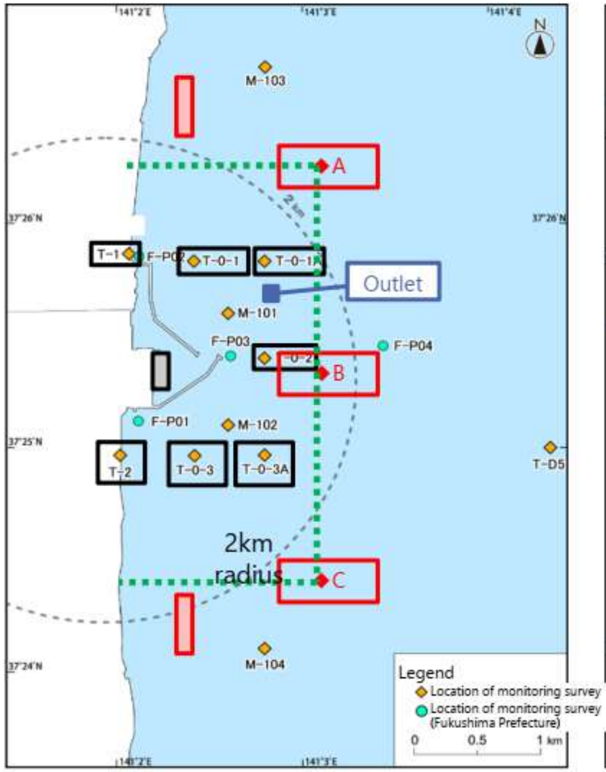

Diagram 1. Near the station

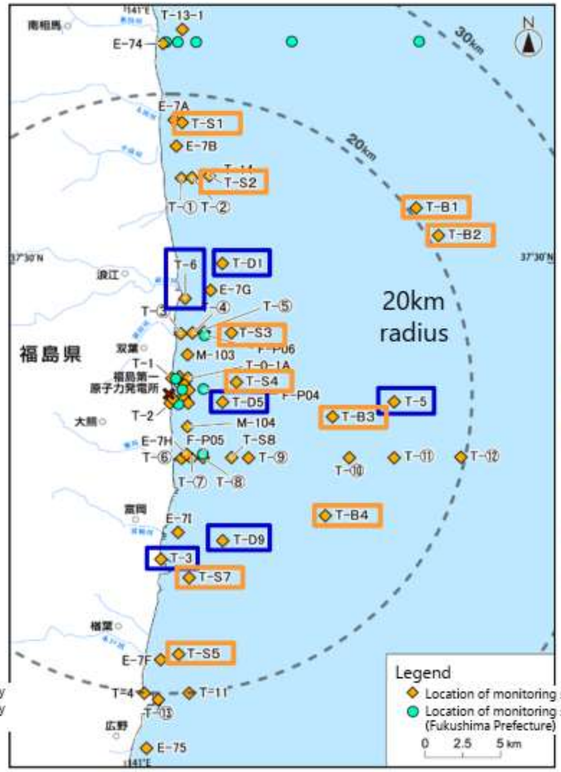

Diagram 2. 20km off the coast of Fukushima

<Legend>

【Current Comprehensive Monitoring Plan】

- NRA M-〇
- Ministry of Environment E-〇
- Fisheries Agency (fisheries products)
- Fukushima Prefecture F-〇
- TEPCO T-〇

【TEPCO's strengthening plan】

- (black box): Locations where the detectable threshold is being revised (seawater)
- (red box): New sampling locations (seawater)
- (blue box): Locations at which sampling frequency will be increased (seawater)
- (orange box): Locations at which tritium will be measured in addition to cesium (fish, seaweed)
- (grey box): Locations with no change(Seaweed)
- (pink box): New sampling locations (Seaweed)
- (green dotted box): Areas where no fishing is being conducted on a daily basis ※ 1.5km (East to West), 3.5 km (South to North)

※ : Area where common fishery rights are not set

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2-3. TEPCO sampling locations to be strengthened by TEPCO's sea area monitoring （2/2）

【TEPCO's strengthening plan】

・TEPCO will increase the number of samples taken for tritium in regards to seawater.

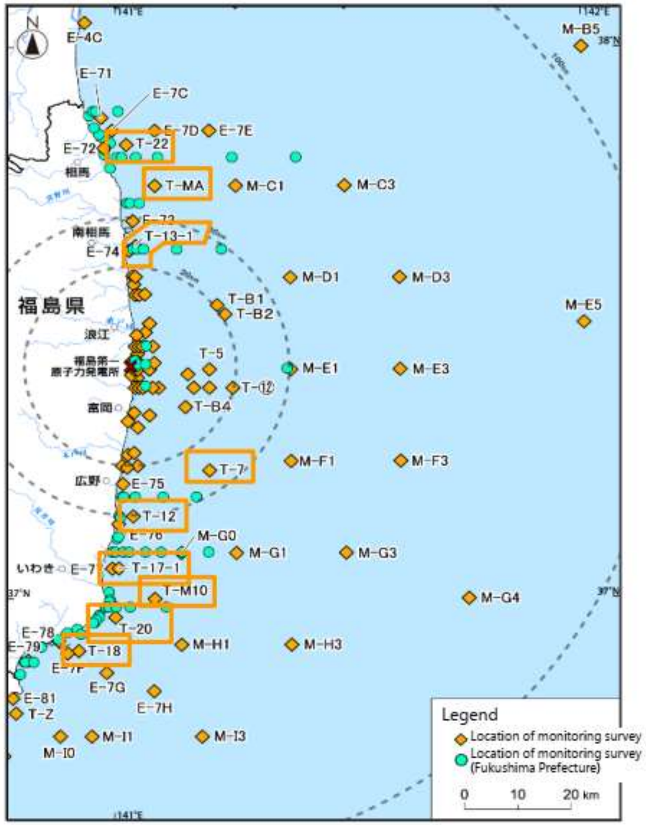

Diagram 3. 20km+ off the coast of Fukushima

<Legend>

【Current Comprehensive Monitoring Plan】

NRA M-○

Ministry of Environment E-○

Fisheries Agency (fisheries products)

Fukushima Prefecture F-○

TEPCO T-○

【TEPCO's strengthening plan】

▭ : Locations at which tritium will be measured in addition to cesium (seawater)

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2-4. Evaluation of sea area monitoring results

○ **Sea area monitoring results will be evaluated as follows.**

【Evaluations before discharge】

・Monitoring data will be gathered starting in April 2022 establish a baseline before discharge (concentrations of tritium and other nuclides in the subdrain and groundwater drain treated water, groundwater bypass water, and seawater in site discharge channels).

【Evaluations after discharge】

・We will ascertain how the seawater dispersed and the impact on marine organisms.

・We will compare the results against sea dispersion simulation results and concentrations used in radiation impact assessments to confirm that seawater dispersion behavior and material concentrations are within the expected range.

・If measurements exceed the fluctuation range observed in pre-discharge baseline values, we will investigate the cause after checking our measurements with other monitoring organizations.

・If measurements grossly exceed the fluctuation range observed in pre-discharge baseline values *, then sea discharge will be stopped. Measurements will be taken again from the relevant location and the state of scope and frequency of monitoring will be temporarily expanded to ascertain the state of the surrounding sea area.

*: To be set based on data collected starting in April 2022

【Evaluations to be conducted before and after discharge】

・If measurements differ among the various monitoring organizations, we will cooperate with organization to determine what is causing the discrepancy.

・If TEPCO's processes or facilities is determined to be the cause of the discrepancy, we will check our processes and improve them as needed.

3. Securing transparency and objectivity in sea area monitoring results

○ **We will confirm the appropriateness of our monitoring results by comparing our measurements with the monitoring results of other organizations conducted according to the Comprehensive Monitoring Plan.**

○ **We will implement the following to secure transparency and objectivity in measurements.**

・We will continue to have our staff take analytical skill tests and participate in intercomparative analyses conducted by domestic and overseas laboratories so that we can objectively confirm our analytical skills from a third-party perspective.

[E.g., participate in the international intercomparison analysis program for radioactivity analysis (hosted by the International Atomic Energy Agency (IAEA)), conduct intercomparison analysis with the Radioactivity Measurement and Analysis Technology Committee, Japan Chemical Analysis Center, and other organizations]

・ We will ask local agriculture, forestry, fisheries producers and local government officials to participate in and observe sea area monitoring (e.g., radioactivity measurement, sample collection).

・We will establish a system to objectively confirm our measurement values by having a company certified by the International Organization for Standardization (ISO) for environmental radioactivity analysis (ISO/IEC 17025) participate in sea area monitoring and measure the same samples as our company as a third party. For the time being, we will have them start with measuring cesium, and as soon as we are ready, will gradually expand the scope include the measurement of tritium, which we are aware is of great interest in the discharge of ALPS treated water.

4. Policy for disclosing the results of sea area monitoring

○ **We will disclose information as follows to further foster understanding internationally and domestically.**

- As soon as the results are ready, we will disclose them on our website in an accurate and timely manner.
- Data will be disclosed in a form that is easy-to-understand for local residents and domestic consumers.
- We will also explain what the values mean and how it confirms the safety of the discharged ALPS treated water.

○ **The report on the sea area monitoring results will be as follows.**

- We will summarize the results of our sea area monitoring and the evaluation results in a report on our website. A new report will be published every quarter.
- In the evaluation, we will check whether the measurement results are within the range predicted in the sea dispersion simulation results and whether the concentrations are equivalent to those in the radiation impact assessment. The results of the evaluation will be expressed in an easy-to-understand manner.
- The report will be presented at a meeting where people from the local government and academic experts will confirm and evaluate the results.